Dense foliose red seaweeds on silty moderately exposed infralittoral rock

MarLIN – Marine Life Information Network
Marine Evidence–based Sensitivity Assessment (MarESA) Review

Dr Heidi Tillin

2016-03-30

A report from:
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/habitats/detail/1090]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

(page left blank)

- Core records
- Non-core, certain determination
- Non-core, uncertain determination
- Predicted habitat extent

17-09-2018
Biotope distribution data provided by
EMODnet Seabed Habitats
(www.emodnet-seabedhabitats.eu)
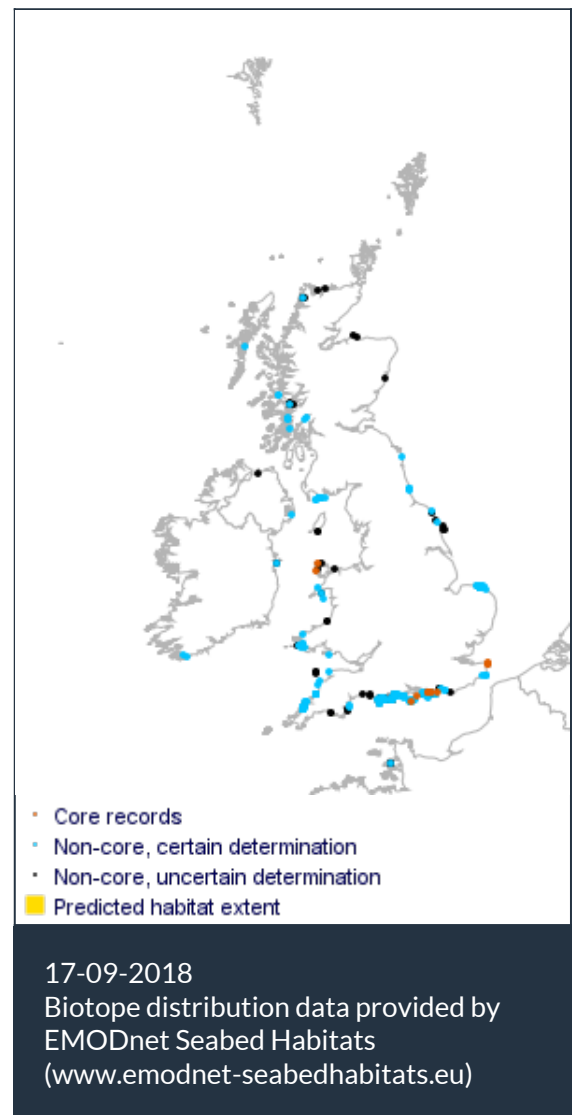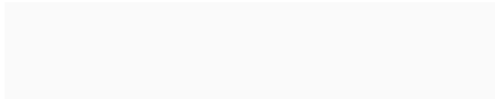
Researched by Dr Heidi Tillin   **Refereed by** Admin

Summary

☰ UK and Ireland classification

EUNIS 2008	A3.215	Dense foliose red seaweeds on silty moderately exposed infralittoral rock
JNCC 2015	IR.MIR.KR.XFoR	Dense foliose red seaweeds on silty moderately exposed infralittoral rock
JNCC 2004	IR.MIR.KR.XFoR	Dense foliose red seaweeds on silty moderately exposed infralittoral rock
1997 Biotope		

🏷 Description

Upward-facing surfaces of shallow, infralittoral bedrock and boulders in areas of turbid water dominated by dense red seaweeds, with the notable absence of kelp. The stable rock, which can be cobbles or boulders but is more typically bedrock, is usually silted. Individual species of foliose red

seaweeds such as *Plocamium cartilagineum* or *Calliblepharis ciliata* often dominate. Other red seaweeds likely to be present include *Phyllophora crispa*, *Rhodymenia holmesii*, *Halurus flosculosus*, *Cryptopleura ramosa*, *Hypoglossum hypoglossoides*, *Heterosiphonia plumosa* and coralline crusts. The brown seaweed *Dictyota dichotoma* is sometimes present, although never abundant. This biotope does not generally occur below kelp park but rather occurs on shallow, silted rock on which kelp would normally grow in less turbid conditions. The fauna can be variable but is generally typified by the presence of silt-tolerant animals such as encrusting sponges, particularly *Dysidea fragilis* and *Halichondria panicea*, the hydroid *Tubularia indivisa*, bryozoan crusts and scattered *Sabellaria spinulosa* and *Balanus crenatus*. In the summer months the seaweeds can become heavily encrusted with the bryozoan *Electra pilosa* and the ascidian *Molgula manhattensis* which can also form dense mats on the rock. The polychaete *Lanice conchilega* can be present, where sandy and muddy patches occur. Where this biotope occurs on chalk bedrock, such as off the Sussex coast, the piddock *Pholas dactylus* is often found bored into the rock. This biotope is recorded from the English Channel, off Kent, Sussex and the Isle of Wight. Please notice that individual sites of this biotope can vary significantly in the species composition (JNCC, 2015).

↓ Depth range

5-10 m, 10-20 m

🏛 Additional information

-

✔ Listed By

- none -

⬡ Further information sources

Search on:

G 𝔤 G JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotope description and characterizing species are taken from JNCC (2015). This biotope occurs in areas of turbid water dominated by dense foliose red seaweeds and often dominated by species such as *Plocamium cartilagineum* or *Calliblepharis ciliata*. Other red seaweeds likely to be present include *Phyllophora crispa*, *Rhodymenia holmesii*, *Halurus flosculosus*, *Cryptopleura ramosa*, *Hypoglossum hypoglossoides*, *Heterosiphonia plumosa* and coralline crusts. The brown seaweed *Dictyota dichotoma* is sometimes present, although never abundant. The sensitivity assessments focus on the key characterizing algae, although it should be noted the evidence available for each species is relatively limited.

The fauna is typified by the presence of silt-tolerant animals such as encrusting sponges, particularly *Dysidea fragilis* and *Halichondria panicea*, the hydroid *Tubularia indivisa*, bryozoan crusts and scattered *Sabellaria spinulosa* and *Balanus crenatus*. In the summer months the seaweeds can become heavily encrusted with the bryozoan *Electra pilosa* and the ascidian *Molgula manhattensis* which can also form dense mats on the rock. The polychaete *Lanice conchilega* can be present, where sandy and muddy patches occur. Where this biotope occurs on chalk bedrock, such as off the Sussex coast, the piddock *Pholas dactylus* is often found bored into the rock. These species are not considered to characterize the biotope as their presence or absence is unlikely to alter the biotope classification. The sensitivity of these species is discussed generally in the assessments where appropriate: further information on species sensitivity can be found in other biotopes on this website where these are key species.

Resilience and recovery rates of habitat

The red algae (Rhodophyta) and the brown algae *Dictyota dichotoma* that characterize this biotope have complex life histories and exhibit distinct morphological stages over the reproductive life history. Alternation occurs between asexual spore producing stages (tetrasporophytes) and male and female plants producing sexually. Life history stages can be morphologically different or very similar. Red algae life stages may include prostrate creeping bases that function as a holdfast as in *Calliblepharis ciliata* (Guiry & Guiry, 2015) and *Plocamium cartilagineum* whereas in other species present in the biotope such as *Hypoglossum hypoglossoides* and *Phyllopohora* spp. the thallus or fronds arise from small discoid holdfasts. The spores of red algae are non-motile (Norton, 1992) and therefore entirely reliant on the hydrographic regime for dispersal. Norton (1992) reviewed dispersal by macroalgae and concluded that dispersal potential is highly variable, recruitment usually occurs on a much more local scale, typically within 10 m of the parent plant. Hence, it is expected that the red algal turf would normally rely on recruitment from local individuals and that recovery of populations via spore settlement, where adults are removed, could be protracted.

Some species found in this biotope, such as *Phyllophora* sp. exhibit annual growth and die back patterns as in this biotope where growth is removed annually by abrasion or water action leading to breakage. Similarly *Plocamium cartilagineum* loses blades in winter in wave exposed conditions while the crustose bases survive and spread laterally (Kain, 1982, 1984, 1987).

Some temporal variation in abundance and biomass is therefore normal within this biotope. Macroalgae characterizing the biotope are either species with strategies to resist disturbance, e.g. growing back from more resistant crustose bases or short-lived species that can reproduce annually and maintain presence in disturbed areas via germlings. The brown algae, *Dictyota*

dichotoma, for example, is an annual plant in North Carolina where plants reach maturity and die back within a year and population maintenance is via young germlings that survive over the winter (Richardson, 1979).

Seasonality of reproduction varies between the red algal species within the site (Kain, 1982), so that timing of impacts will coincide with different phases of reproduction within species and may alter short-term recovery trajectories with effects on composition. In the Isle of Man, approximately 90% of *Plocamium cartilagineum* and *Cryptopleura ramosa* plants were fertile in late summer but less than 10% in Spring, although some fertile plants were always present. *Phycodrys rubens* was present epiphytically and was fertile during the first half of the year (Kain, 1982). The encrusting coralline *Cruoria pellita* on the same shores showed little seasonal variation (Kain, 1982).

Although ubiquitous in marine coastal systems little is understood about the taxonomy, biology and ecology of the characterizing crustose corallines (Littler & Littler, 2013). Coralline crust is a generic term that in UK biotopes refers to nongeniculate (crustose) species from the family Corallinacea that could include *Lithophyllum incrustans* which is noted to form thick crusts in tidepools, especially in the south west (Adey & Adey, 1973), *Lithothamnion* spp. and *Phymatolithon* spp. Due to the lack of evidence for species the assessments for encrusting corallines are generic, although species specific information is presented where available. A number of papers by Edyvean & Ford (1984a & b; 1986; 1987) describe aspects of reproduction and growth of intertidal encrusting coralline, *Lithophyllum incrustans*. Studies by Edyvean & Forde (1987) in populations of *Lithophyllum incrustans* in Pembroke south-west Wales suggest that reproduction occurs on average early in the third year. Reproduction may be sexual or asexual. Populations release spores throughout the year but abundance varies seasonally, with the populations studied in Cullercoats Bay, and Lannacombe Bay (North East and South West England, respectively) producing less spores in the summer. Spore release is initiated by changes in temperature or salinity (see relevant pressure information) at low tide so that spore dispersal is restricted to within the tide pool enhancing local recruitment. Within subtidal biotopes this is not possible and recruitment success may be altered (although this may be compensated by avoidance of desiccation). Spore survival is extremely low with only a tiny proportion of spores eventually recruiting to the adult population (Edyvean & Ford, 1986). The spores are released from structures on the surface called conceptacles; these are formed annually and subsequently buried by the new layer of growth. Plants can be aged by counting the number of layers of conceptacles. Edyvean & Ford (1984) found that the age structure of populations sampled from Orkney (Scotland) Berwick (northern England) and Devon (England) were similar, mortality seemed highest in younger year classes with surviving individuals after the age of 10 years appear relatively long-lived (up to 30 years). In St Mary's Northumberland, the population was dominated by the age 6-7 year classes (Edyvean & Ford, 1984). Growth rates were highest in young plants measured at Pembroke (south-west Wales) with an approximate increase in diameter of plants of 24 mm in year class 0 and 155 mm in year 1 and slowing towards an annual average horizontal growth rate of 3mm/year (Edyvean & Ford, 1987).

Some repair of damaged encrusting coralline occurs through vegetative growth. Chamberlain (1996) observed that although *Lithophyllum incrustans* was quickly affected by oil during the *Sea Empress* spill, recovery occurred within about a year. The oil was found to have destroyed about one third of the thallus thickness but regeneration occurred from thallus filaments below the damaged area. Recolonization by propagules is an important recovery mechanism. Airoldi (2000) observed that encrusting coralline algae recruited rapidly on to experimentally cleared subtidal rock surfaces in the Mediterranean Sea, reaching up to 68% cover in 2 months.

The associated epifauna are typically sponges, barnacles, hydroids and ascidians that are opportunistic colonizers of gaps. These species may recruit annually via larvae or asexual reproduction and growth *in-situ*. Some sponges are known to be highly resilience to physical damage with an ability to survive severe damage, regenerate and reorganize to function fully again, however, this recoverability varies between species (Wulff, 2006). *Halichondria panicea* is an opportunistic species, found in wide range of niches on rock or any other hard substrate (Ackers *et al.*, 1992). Barthel (1986) reported that *Halichondria panicea* in the Kiel Bight went through annual cycles, with growth occurring between March and July. Reproductive activity occurred In August and September with young colonies appearing in early autumn. Adult *Halichondria panicea* degenerated and disintegrated after reproduction. Fish & Fish (1996), however, suggested a lifespan of about 3 years and Vethaak *et al.*, (1982) reported that, unlike *Halichondria bowerbanki*, *Halichondria panicea* survives the winter in a normal, active state in the Oosterschelde.

Hydroids exhibit rapid rates of recovery from disturbance through repair, asexual reproduction and larval colonization. Sparks (1972) reviewed the regeneration abilities and rapid repair of injuries. Many hydroid species also produce dormant, resting stages that are very resistant of environmental perturbation (Gili &Hughes 1995). Although colonies may be removed or destroyed, the resting stages may survive attached to the substratum and provide a mechanism for rapid recovery (Cornelius, 1995a; Kosevich & Marfenin, 1986). Hydroids as a general group are thought of as early colonizers of bare surfaces (Whomersley & Picken, 2003; Zintzen *et al.*, 2008). *Tubularia spp.* specifically are considered to be opportunistic species and are often the first to colonize bare surfaces and to reach sexual maturity rapidly. In some habitats *Tubularia spp*, are transient and are replaced by more competitive species, however in other tide swept or scoured habitats (e.g. CR.HCR.FaT.CTub.Adig) they represent a permanent feature of an annual cycle and tend to dominate in specific seasons e.g. spring-autumn (Zintzen *et al.*, 2008; Hiscock *pers comm*). Observations of *Tubularia indivisa* from the spring settlement cohort indicate that reproduction can occur within 6-8 weeks, however autumn cohorts are likely to persist throughout the winter and begin reproduction the following spring. *Tubularia indivisa has* a large larval dispersal capacity, and larvae can potentially settle 1-10km from the parental source (Zintzen *et al.*, 2008).

Balanus crenatus produces a single, large brood annually with peak larval supply in April –May (Salman, 1982). Although subsidiary broods may be produced, the first large brood is the most important for larval supply (Salman, 1982; Barnes & Barnes, 1968). *Balanus crenatus* has a lifespan of 18 months (Barnes & Powell, 1953) and grows rapidly (except in winter). *Balanus crenatus* is a typical early colonizer of sublittoral rock surfaces (Kitching, 1937); for example, it heavily colonized a site that was dredged for gravel within 7 months (Kenny & Rees, 1994). *Balanus crenatus* colonized settlement plates or artificial reefs within 1-3 months of deployment in summer, and became abundant on settlement plates shortly afterwards (Brault & Bourget, 1985; Hatcher, 1998). The ship, *HMS Scylla*, was colonized by *Balanus crenatus* 4 weeks after sinking in March. The timing of the sinking in March would have ensured a good larval supply from the spring spawning. The presence of adult *Balanus crenatus* enhances the settlement rate of larvae on artificial panels (Miron *et al.*, 1996), so that surviving adults enhance recovery rates.

Sebens (1985; 1986) described the recolonization of epifauna on vertical rock walls. Rapid colonizers such as encrusting corallines, encrusting bryozoans, amphipods and tubeworms recolonized within 1-4 months. Ascidians such as *Dendrodoa carnea*, *Molgula manhattensis* and *Aplidium* spp. achieved significant cover in less than a year, and, together with *Halichondria panicea*, reached pre-clearance levels of cover after 2 years (Sebens, 1986).

Resilience assessment. The biotope is likely to undergo annual changes in algal biomass and

assemblage structure with the silt tolerant and perennial species including crustose corallines and red algae with crustose bases (*such as Plocamium cartilagineum*) likely to be the more stable elements. Where resistance is 'High' resilience is assessed as 'High' by default. Where resistance is 'Medium' then recovery is considered to be 'High' based on recolonization from the remaining population of annuals and perennial and vegetative growth and spread of perennial algae. Where resistance is 'Low' but crustose bases of red algae and parts of the Corallinacea remain then recovery is also assessed as 'High'. However where resistance is 'Low' or 'None' and the key characterizing crustose corallines and the crustose bases of *Corallina officinalis* and other holdfasts are likely to be removed then resilience is assessed as 'Medium'. The associated sponge species, Balanus crentus and Tubularia indivisa, ascidians and bryozoans are opportunistic colonizers of bare rock and are likely to recover rapidly following impacts. Although some changes in species richness, biomass and diversity may occur following an impact, the inherent variability of this biotope means that recovery may be considered to have occurred where foliose red algae, rather than the associated invertebrate species have recolonized.

NB: The resilience and the ability to recover from human induced pressures is a combination of the environmental conditions of the site, the frequency (repeated disturbances versus a one-off event) and the intensity of the disturbance. Recovery of impacted populations will always be mediated by stochastic events and processes acting over different scales including, but not limited to, local habitat conditions, further impacts and processes such as larval-supply and recruitment between populations. Full recovery is defined as the return to the state of the habitat that existed prior to impact. This does not necessarily mean that every component species has returned to its prior condition, abundance or extent but that the relevant functional components are present and the habitat is structurally and functionally recognizable as the initial habitat of interest. It should be noted that the recovery rates are only indicative of the recovery potential.

⚓ Hydrological Pressures

	Resistance	Resilience	Sensitivity
Temperature increase (local)	High	High	Not sensitive
	Q: High A: Medium C: Medium	Q: High A: High C: High	Q: High A: Medium C: Medium

The key characterizing red algal species found in this biotope have a range of geographic distributions with some having a 'southern distribution' with their range encompassing warmer waters and others having a 'northern' distribution. Temperature tolerances are therefore likely to vary between species so that long-term changes in temperature have the potential to shift the species composition of this biotope to one more suited to the prevailing thermal regime. This biotope occurs in the subtidal and is therefore protected from exposure to air so that the thermal regime is more stable and desiccation is not a factor. Examples of distribution and thermal tolerances tested in laboratory experiments are provided as evidence to support the sensitivity assessment. Populations can acclimate to prevailing conditions (Davison, 1991; Lohrmann *et al.*, 2004) which can alter tolerance thresholds and care should therefore be used when interpreting reported tolerances.

A number of the characterizing species found in the biotope such as *Plocamium cartilagineum*, *Cryptopleura ramosa*, and *Lithophyllum incrustans* are close to the northern edge of their reported distribution range in the UK (Kain, 1982; Guiry & Guiry, 2015). *Cryptopleura ramosa*, for example, is more common on southern shores of the UK (see MarLIN) and its distribution appears to be southern with worldwide records but none, from Canada, Scandinavia, Russia the Arctic or

Antarctic (Guiry & Guiry, 2015) suggesting that it is likely to tolerate increased temperatures more successfully than decreased. The brown alga *Dictyota dichotoma* is also considered to be a warm-temperate species and is found throughout the NE Atlantic and Bermuda with the northern range extending to southern Norway and North Carolina (Van den Hoek, 1982; Tronholm *et al.*, 2010; Richardson, 1979). Based on the geographic range these species are considered more likely to tolerate chronic and acute increases in temperature at the pressure benchmark and a long-term change exceeding the pressure benchmark may increase habitat suitability. For example *Hypoglossum hypoglossoides* has recently expanded its range to Norway in response to warming temperatures (Husa, 2007). Tolerances within the southern group of red algae may vary, *Cryptopleura ramosa*, for example, is capable of surviving at 27 °C, while other characterizing species such as *Callophyllis laciniata, Plocamium cartilagineum,* died within 12 hours in seawater at 27 °C (Gessner, 1970). (It should be noted that this temperature increase exceeds that of the benchmark level).

Other species within the biotope such as *Phycodrys rubens* are distributed both north and south of the UK (Guiry & Guiry, 2015).   *Phycodrys rubens* are likely to tolerate changes in temperature at the pressure benchmark. Experiments with isolates of *Phycodrys rubens* collected at different latitudes and the Baltic Sea/North Sea population group (Helgoland, Kiel, Barents Sea, the Kattegat, Ireland and Brittany) found that thermal tolerances were similar across the range (Voskoboinikov *et al.*, 1996). All isolates died at 20°C after 1-4 weeks and survived low temperatures (-1.5°C) without obvious damage (Voskoboinikov *et al.*, 1996). Isolates from southern populations were slightly more tolerant of warmer temperatures, growing well at 18°C when overall optimum growth for all samples was at 5-10°C (Voskoboinikov *et al.*, 1996).

Balanus crenatus is a boreal species (Newman & Ross, 1976) it found throughout the northeast Atlantic from the Arctic to the west coast of France as far south as Bordeaux; east and west coasts of North America and Japan. In Queens Dock, Swansea where the water was on average 10°C higher than average due to the effects of a condenser effluent, *Balanus crenatus* was replaced by the subtropical barnacle *Balanus amphitrite*. After the water temperature cooled *Balanus crenatus* returned (Naylor, 1965). The upper temperature limit for this species is about 25°C (Southward, 1955; (Davenport & Davenport, 2005). *Tubularia indivisa* is recorded from the Arctic ocean to the Mediterranean (WORMS, 2015). Across this latitudinal gradient this species is likely to experience a range of temperatures.

Sensitivity assessment. Typical surface water temperatures around the UK coast vary, seasonally from 4-19°C (Huthnance, 2010). The characterizing foliose red algae are considered likely to be tolerant of an acute or chronic change at the pressure benchmark, with most species, particularly those with a southern distribution, able to tolerate an acute increase in temperature greater than the pressure benchmark (Gessner, 1970). An acute increase of 5°C in summer would be close to the lethal thermal temperature for *Balanus crenatus* but loss of this species would not alter the character of the biotope. Biotope resistance is assessed as **'High'** based on the red algae and resilience as **'High'** (by default). This biotope is therefore considered to be **'Not sensitive'** at the pressure benchmark.

Temperature decrease (local)	High	High	Not sensitive
	Q: High A: Medium C: Medium	Q: High A: High C: High	Q: High A: Medium C: Medium

The key characterizing red algal species found in this biotope have a range of geographic distributions with some having a 'southern distribution' with their range encompassing warmer

waters and others having a 'northern' distribution. Temperature tolerances are therefore likely to vary between species so that long-term changes in temperature have the potential to shift the species composition of this biotope to one more suited to the prevailing thermal regime. Examples of distribution and thermal tolerances tested in laboratory experiments are provided as evidence to support the sensitivity assessment. Populations can acclimate to prevailing conditions (Davison, 1991; Lohrmann *et al*., 2004) which can alter tolerance thresholds. During experimental attempts to adapt red algae to cold by maintaining them at -1°C to + 1°C for several months, a drop in the lethal temperature tolerance of *Delesseria sanguinea* and a few other species was detected, in the order of 1 to 2°C (Gessner, 1970). Care should therefore be used when interpreting reported tolerances.

A number of the red algal species found in the biotope such as *Plocamium cartilagineum*, *Cryptopleura ramosa*, *Callophyllis laciniata* and *Lithophyllum incrustans* are close to the northern edge of their reported distribution range in the UK (Kain, 1982, Guiry & Guiry, 2015). *Cryptopleura ramosa*, for example, is more common on southern shores of the UK (see MarLIN) and its distribution appears to be southern with worldwide records but none, from Canada, Scandinavia, Russia the Arctic or Antarctic (Guiry & Guiry, 2015) suggesting that it is likely to tolerate increased temperatures more successfully than decreased. The brown alga *Dictyota dichotoma* is also considered to be a warm-temperate species and is found throughout the NE Atlantic and Bermuda with the northern range extending to southern Norway and North Carolina (Van den Hoek, 1982; Tronholm *et al*., 2010, Richardson, 1979) and may be sensitive to decreased temperatures. Richardson (1979) demonstrated that the young germling stage of *Dictyota dichotoma* can overwinter in North Carolina at the northern edge of its distribution where winter water temperatures are less than 10°C, providing a survival strategy. Edyvean & Forde (1984b) suggest that populations of *Lithophyllum incrustans* are affected by temperature changes and salinity and that temperature and salinity 'shocks' induce spawning but no information on thresholds was provided (Edyean & Ford, 1984b). Tolerance of reductions in temperature will vary within this group. In experiments, *Cryptopleura ramosa* were partially or completely killed at 5 °C. Other species had a greater cold tolerance with *Plocamium cartilagineum* surviving at -2 °C (Gessner, 1970).

Species that occur north and south of the UK are considered to be eurythermal and tolerant of a range of temperatures. Laboratory experiments have demonstrated that *Phycodrys rubens* has a greater tolerance of freezing temperatures than species with a southern distribution as mortality occurred only at temperatures of -3°C to -5°C (Gessner, 1970).

Crisp (1964) studied the effects of an unusually cold winter (1962-3) when average temperatures were 5 to 6°C below normal on the marine life in Britain. *Balanus crenatus* were unaffected but *Pachymastia johnstonia* and *Halichondria panicea* were wholly or partly killed by frost. The tolerance of *Balanus crenatus* collected from the lower intertidal in the winter (and thus acclimated to lower temperatures) to low temperatures was tested in the laboratory. The median lower lethal temperature tolerance was -1.4°C (Davenport & Davenport, 2005).

Sensitivity assessment. The characterizing red are considered to be tolerant of an acute or chronic decrease in temperature at the pressure benchmark, with some species, particularly those with a northern distribution, able to tolerate an acute decrease in temperature greater than the pressure benchmark (Gessner, 1970). Changes in temperature may result in some shifts in community structure where thermal tolerances are exceeded and more sensitive species die but these changes are not considered to alter the overall character of the biotope. Resistance is therefore assessed as 'High' and resilience as 'High' (by default) based on the red algae. This biotope is

therefore considered to be 'Not sensitive' at the pressure benchmark.

Salinity increase (local)

Low	Medium	Medium
Q: Low A: NR C: NR	Q: High A: Low C: Medium	Q: Low A: Low C: Low

This biotope is recorded in full salinity habitats (Connor *et al*., 2004). The characterizing crustose corallines are found in rockpools where salinities may fluctuate markedly during exposure to the air. Edyvean & Ford (1984b) suggest that populations of *Lithophyllum incrustans* are affected by temperature changes and salinity and that temperature and salinity 'shocks' induce spawning but no information on thresholds was provided (Edyvean & Ford, 1984b). Populations of *Lithophyllum incrustans* were less stable in rockpools with a smaller volume of water that were more exposed to temperature and salinity changes due to lower buffering capacity. Sexual plants (or the spores that give rise to them) were suggested to be more susceptible than asexual plants to extremes of local environmental variables (temperature, salinity etc.) as they occur with greater frequency at sites where temperature and salinity were more stable (Edyvean & Ford, 1984b).

Rietema (1991) found that *Phycodrys rubens* from the Baltic kept in a salinity regime grew and survived at all salinities from 33ppt to 7.5 ppt with maximum growth in the range from 23 down to 16.5 ppt, however *Phycodrys rubens* from the North Sea, where salinities are higher, grew and survived in a more limited range (33-16.5 ppt), with maximum growth between 33 and 23 ppt. This study demonstrates that acclimation is an important factor mediating species sensitivity to salinity changes.

The only empirical evidence for sensitivity to this pressure is for an associated sponge species. Marin (1997) describes the presence of *Dysidea fragilis* in a hypersaline coastal lagoon (42-47 g/l) in La Mar Menor, Spain.

The barnacle Balanus crenatus occurs in estuarine areas and is therefore adapted to variable salinity (Davenport, 1976). Early stages may be more sensitive than adults. Experimental culturing of *Balanus crenatus* eggs, found that viable nauplii larvae were obtained between 25-40‰ but eggs did not develop to viable larvae when held at salinities above 40‰ and only a small proportion (7%) of eggs exposed at later stages developed into viable nauplii and these were not vigorous swimmers (Barnes & Barnes, 1974). When exposed to salinities of 50‰, and 60‰ eggs exposed at an early developmental stage did not produce viable larvae and, again, only a small proportion of eggs (7% and 1%, respectively) exposed at a later developmental stage produced nauplii- these were deformed and probably non-viable. There was no larval development at 70‰ (Barnes & Barnes, 1974).

Sensitivity assessment. No evidence was found to assess the tolerance of the characterizing red algae to hypersalinity at the pressure benchmark. Although some increases in salinity may be tolerated by the associated species present, this biotope is considered to be sensitive to a persistent increase in salinity to > 40 ppt. Resistance is therefore assessed as 'Low' and recovery as 'Medium' (following restoration of usual salinity). Sensitivity is therefore assessed as 'Medium'.

Salinity decrease (local)

Low	Medium	Medium
Q: High A: Low C: Medium	Q: High A: Low C: Medium	Q: High A: Low C: Medium

This biotope is recorded in full salinity habitats (Connor *et al*., 2004). Salinity tolerances vary between species, the sponge *Halichondria panicea* and the red algae *Cryptopleura ramosa*

and. *Hypolglossum hypoglossoides* occur in variable salinity on tide-swept biotopes (IR.MIR.KT.FilRVS) and would probably survive a reduction in salinity at the pressure benchmark. However other species within the biotope are likely to be more sensitive and a change at the pressure benchmark is considered likely to reduce species richness and result in the loss of characterizing species. Available evidence for sensitivities is described below.

A comparative study of salinity tolerances of macroalgae collected from North Zealand in the South Kattegat (Denmark) where salinity is 16 psu. Showed that species generally had a high tolerance (maintained more than half of photosynthetic capacity in short-term exposures (4 days) to salinities lower than 3.7 psu. However, tolerances varied between species with *Phyllophora pseudoceranoides* exhibiting greater tolerance than *Phycodrys rubens* which was the least tolerant species tested (Larsen & Sand-Jensen, 2006). However, *Phycodrys rubens* can still tolerate low salinities with populations in the Balttic Sea common where salinities are as low as 15 ppt (Van Oppen *et al*., 1995), suggesting that local acclimation is possible.

Edyvean & Ford (1984b) suggest that populations of the crustose coralline *Lithophyllum incrustans* are affected by temperature changes and salinity and that temperature and salinity 'shocks' induce spawning but no information on thresholds were provided (Edyvean & Ford, 1984b). Populations of *Lithophyllum incrustans* were less stable in tide pools with a smaller volume of water that were more exposed to temperature and salinity changes due to lower buffering capacity. Sexual plants (or the spores that give rise to them) were suggested to be more susceptible than asexual plants to extremes of local environmental variables (temperature, salinity etc.) as they occur with greater frequency at sites where temperature and salinity were more stable (Edyvean & Ford, 1984b).

Balanus crenatus occurs in estuarine areas and is therefore adapted to variable salinity (Davenport, 1976). When subjected to sudden changes in salinity *Balanus crenatus* closes its opercular valves so that the blood is maintained temporarily at a constant osmotic concentration (Davenport, 1976). Acclimation to different salinity regimes alters the point at which opercular closure and resumption of activity occurs (Davenport, 1976). *Balanus crenatus* can tolerate salinities down to 14 psu if given time to acclimate (Foster, 1970). At salinities below 6 psu motor activity ceases, respiration falls and the animal falls in to a "salt sleep". In this state the animals may survive (Barnes & Barnes, 1974) in freshwater for 3 weeks, enabling them to withstand changes in salinity over moderately long periods (Barnes & Powell, 1953). Larvae are more sensitive than adults. In culture experiments, eggs maintained below 10‰ rupture, due to osmotic stress (Barnes & Barnes, 1974). At 15-17‰ there is either no development of early stages or the nauplii larvae are deformed and "probably not viable", similarly at 20‰ development occurs, but about half of the larvae are deformed and not viable. (Barnes & Barnes, 1974). Normal development resulting in viable larvae occurs between salinities of 25-40 ‰ (Barnes & Barnes, 1974).

The effects of deceases in salinity on *Tubularia indivisa* are unclear. *Tubularia indivisa* is recorded as abundant at a number of locations within the Mersey estuary (Bassindale, 1938). However, the majority of hydroids are subtidal and, although some brackish water species exist (Gili & Hughes, 1995) they are probably intolerant of prolonged decreases in salinity.

Sensitivity assessment. The available evidence illustrates that responses to this pressure will vary between species and that a change at the pressure benchmark is likely to alter the composition of the red algal turf that characterizes the biotope and may alter the biomass and density of more tolerant species. Resistance is therefore assessed as 'Low' (loss of 25-75% of individuals). Resilience (following the removal of this pressure) is assessed as 'Medium' (2-10 years) based on

loss of characterizing coralline crusts and sensitivity is therefore assessed as 'Medium'.

Water flow (tidal current) changes (local)	High	High	Not sensitive
	Q: High A: Medium C: High	Q: High A: High C: High	Q: High A: Low C: High

This biotope occurs where tidal streams are moderately strong (0.5-1.5 m/s).   As water velocity increases foliose macroalgae can flex and reconfigure to reduce the size of the alga when aligned with the direction of flow, this minimises drag and hence the risk of dislodgement (Boller & Carrington, 2007). These characteristics allow these species to persist in areas that experience a range of flow speeds. Biogenic habitat structures, including the fronds of algae, reduce the effects of water flows on individuals by slowing and disrupting flow. Boller and Carrington (2006) found that the canopy created by a turf of *Chondrus crispus* reduced drag forces on individual plants by 15-65%. The compact, turf forming growth of the algal species characterizing this biotope will therefore reduce water flow and the risk of displacement through turbulence and friction.

 The coralline crusts characterizing this biotope are securely attached and as these are flat they are subject to little or no drag compared to upright growth forms of algae. Colonies of *Lithophyllum incrustans* appear to thrive in conditions exposed to strong water movement (Irvine & Chamberlain,1994). The suspension feeders within the biotope will also benefit from high water flows bringing food.

Siltation is a key factor structuring this biotope (Connor *et al.*, 2004), changes in the flow may increase or decrease sediment transport and associated scour and siltation. Changes at the pressure benchmark are only likely to affect examples of this biotope that occur in sheltered areas with lower levels of water movement. Reductions in flow in areas where currents are weak may lead to increased deposition of silts and alter the character of the biotope, whereas an increase in water flow at the pressure benchmark may re-suspend and remove sand particles which are less cohesive than mud particles. The level of impact will depend on site specific hydrodynamic and sediment conditions. Some periodic movement of sediments and changes in coverage is part of the natural temporal variation and periodic disturbances from storms may be more important than water flow in maintaining the character of the biotope, particularly in sheltered areas. At the level of the pressure benchmark a change in water flow is considered unlikely to affect the level of siltation that maintain the habitat.

Tubularia indivisa and the barnacles, sponges and ascidians are suspension feeders relying on water currents to supply food. These taxa thrive in conditions of vigorous water flow e.g. around Orkney and St Abbs, Scotland, where the community may experience tidal currents of 3 and 4 knots during spring tides (Kluijver, 1993). *Tubularia indivisa* is also a dominant species on the wreck of *Kilmore*, Belgium, where tidal velocities can vary between 0.86-0.5 m/s (Zintzen *et al.*, 2008). Hiscock, (1979) assessed feeding behaviour of *Tubularia indivisa* in response to different flow rates. At flow rates <0.05 m/s, polyps actively moved tentacles. Increasing the flow rate to 0.2 m/s increased capture rates but at higher flow rates from 0.5-0.9 m/s the tentacles were extended down current and pushed together and feeding efficiency was reduced. In general, flow rates are an important factor for feeding in hydroids and prey capture appears to be higher in more turbulent conditions that prevent self-shading by the colony (Gili & Hughes, 1995). The capture rate of zooplankton by hydroids is correlated with prey abundance (Gili & Hughes, 1995), thus prey availability can compensate for sub-optimal flow rates. Water movements are also important to hydroids to prevent siltation which can cause death (Round, 1961). Tillin & Tyler-Walters (2014) suggest that the range of flow speeds experienced by biotopes in which hydroids are found indicate that a

change (increase or decrease) at the pressure benchmark in the maximum water flow experienced by mid-range populations for the short periods of peak spring tide flow would not have negative effects on this ecological group. *Balanus crenatus* is found in a very wide range of water flows (Tillin & Tyler-Walters, 2014), and can adapt feeding behaviour according to flow rates (Eckman & Duggins, 1993).

Sensitivity assessment. As the biotope can occur in a range of flow speeds, resistance of the biotope to changes in water flow is assessed as 'High' and resilience as 'High' (by default) so that the biotope is assessed as 'Not sensitive'.

Emergence regime changes	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Changes in emergence are not relevant to this biotope (group) which is restricted to fully subtidal habitats.

Wave exposure changes (local)	High Q: High A: Medium C: High	High Q: High A: High C: High	Not sensitive Q: High A: Medium C: High

This biotope is recorded from locations that are moderately exposed (Connor *et al*., 2004). As water movement from wave action increases, foliose macroalgae can flex and reconfigure to reduce the size of the alga when aligned with the direction of flow, this minimises drag and hence decreases the risk of breakage and dislodgement (Boller & Carrington, 2007). These characteristics allow these species to persist in areas that experience a range of flow speeds resulting from wave action. The crustose corallines associated with this biotope have a flat growth form and are unlikely to be dislodged by increased wave action. Colonies of *Lithophyllum incrustans* appear to thrive in conditions exposed to strong water movement (Irvine & Chamberlain, 1994).

A decrease in wave exposure at the pressure benchmark is unlikely to affect the red algae directly. Decreases greater than the pressure benchmark that lead to reductions in siltation and associated, abrasion and scour may lead to changes in the assemblage as species more characteristic of areas with less wave exposure are likely to colonize.

The associated species, including suspension feeders such as *Halichondria panicea* occur across a range of wave exposures and are unlikely to be affected by a change in wave exposure at the pressure benchmark. B*alanus crenatus* are firmly attached to the substratum and are unlikely to be dislodged by an increase in wave action at the pressure benchmark. These species are found in biotopes from a range of wave exposures from extremely sheltered to very exposed and were therefore considered 'Not sensitive' to this pressure (at the pressure benchmark, by a previous review (Tillin & Tyler-Walters, 2014).

Sensitivity assessment. The biotope is found across a range of wave exposures, mid-range populations are considered to have 'High' resistance to a change in significant wave height at the pressure benchmark. Resilience is assessed as 'High', by default, and the biotope is considered 'Not sensitive'.

⚗ Chemical Pressures

	Resistance	Resilience	Sensitivity

Transition elements & organo-metal contamination	Not Assessed (NA)	Not assessed (NA)	Not assessed (NA)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

This pressure is **Not assessed** but evidence is presented where available.

Contamination at levels greater than the pressure benchmark may adversely impact the biotope. No information was found concerning the effects of heavy metals on turf forming and encrusting coralline algae. Bryan (1984) suggested that the general order for heavy metal toxicity in seaweeds is: organic Hg> inorganic Hg > Cu > Ag > Zn> Cd>Pb. Contamination at levels greater than the pressure benchmark may adversely impact the biotope. Cole *et al.* (1999) reported that Hg was very toxic to macrophytes. The sub-lethal effects of Hg (organic and inorganic) on the sporelings of an intertidal red algae, *Plumaria elegans,* were reported by Boney (1971). 100% growth inhibition was caused by 1 ppm Hg.

Uptake of heavy metals from solution by seaweed is influenced by factors such as light, algal nitrogen content, frond age, length of emersion, temperature, salinity, season of the year and presence of other pollutants in the surrounding water (see Lobban & Harrison, 1997) and consequently seaweeds may not accurately reflect metal concentrations in the surrounding water. The order of metal toxicity to algae varies with the algal species and the experimental conditions, but generally the order is Hg>Cu>Cd>Ag>Pb>Zn (Rice *et al.*, 1973; Rai *et al.*, 1981).

Hydrocarbon & PAH contamination	Not Assessed (NA)	Not assessed (NA)	Not assessed (NA)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

This pressure is **Not assessed** but evidence is presented where available

However contamination at levels that exceed the benchmark may lead to greater impacts. Where exposed to direct contact with fresh hydrocarbons, encrusting coralline algae appear to be highly intolerant. Crump *et al.* (1999) described 'dramatic and extensive bleaching' of '*Lithothamnia*' following the *Sea Empress* oil spill. Observations following the *Don Marika* oil spill (K. Hiscock, pers. comm.) were of rockpools with completely bleached coralline algae. However, Chamberlain (1996) observed that although *Lithophyllum incrustans* was affected in a short period of time by oil during the *Sea Empress* spill, recovery occurred within about a year. The oil was found to have destroyed about one third of the thallus thickness but regeneration occurred from thallus filaments below the damaged area.

Following the *Torrey Canyon* oil spill in 1967, oil and detergent dispersants affected high shore specimens of *Corallina officinalis* more than low shore specimens. Plants in deep pools were afforded some initial protection, although probably later affected by contaminated runoff. In areas of heavy spraying, however, *Corallina officinalis* was killed (Smith 1968).

O'Brien & Dixon (1976) concluded that red algae were the most sensitive group of algae to hydrocarbon or dispersant contamination, possibly attributable to the susceptibility of the photosynthetic pigment phycoerythrin to chemical damage. Following a series of laboratory and field experiments Grandy (1984) reported *Delesseria sanguinea, Cryptopleura ramosa, Phycodrys rubens* and *Plocamium cartilagineum* to be sensitive to oil/dispersant mixtures; *Cryptopleura ramosa* and *Plocamium cartilagineum* were the most sensitive and *Phycodrys rubens* the least sensitive. In toxicity experiments, Smith (1968) found *Delesseria sanguinea* to be particularly intolerant of the oil

dispersant BP 1002; 10 ppm of BP 1002 was lethal to the species. Heavy mortality of *Delesseria sanguinea* was also observed down to a depth of 12 m after the *Torrey Canyon* oil spill (Drew *et al.*, 1967). However, experience during the *Torrey Canyon* oil spill seems to be exceptional. As after the *Esso Bernicia* spill in 1978 in the Sullom Voe and heavy use of dispersants on significant quantities of oil, practically no damage to shallow (< 5 m) red algae could be found in Martins Haven (K. Hiscock, pers. comm.). Following the Sea Empress oil spill the most dramatic effect on the seaweeds was the marked bleaching of the encrusting coralline algae Lithothamnion incrustans and *Phymatolithon purpureum*. *Corallina officinalis*, *Chondrus crispus* and *Mastocarpus stellatus* also showed signs of bleaching. The encrusting corallines, however, recovered quickly, suggesting that the damage had been restricted to the surface layers (Y. Chamberlain, pers. comm. to Crump *et al.*, 1999). At the depth at which this biotope occurs, only in the most severe conditions would damage probably occur to the characterizing species.

Synthetic compound contamination	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed** but evidence is presented where available.

Contamination at levels greater than the pressure benchmark may adversely impact the biotope. Cole *et al*. (1999) suggested that herbicides were (not surprisingly) very toxic to algae and macrophytes. Hoare & Hiscock (1974) noted that with the exception of *Phyllophora* species, all red algae including encrusting coralline forms, were excluded from the vicinity of an acidified halogenated effluent discharge in Amlwch Bay, Anglesey. Chamberlain (1996) observed that although *Lithophyllum incrustans* was quickly affected by oil during the *Sea Empress* spill, recovery occurred within about a year. The oil was found to have destroyed about one third of the thallus thickness but regeneration occurred from thallus filaments below the damaged area.

O'Brien & Dixon (1976) report that red algae are effective indicators of detergent damage since they undergo colour changes when exposed to relatively low concentrations. Smith (1968) reported that 10 ppm of the oil dispersive detergent BP 1002 killed the majority of specimens in 24hrs in toxicity tests. However, the effects take several days to manifest; when killed the algae turn bright orange.

Radionuclide contamination	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence.

Introduction of other substances	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed.**

De-oxygenation	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

Specific information concerning oxygen consumption and reduced oxygen tolerances were not found for the key characterizing species within the biotope. This pressure is not assessed due to

lack of evidence.

Nutrient enrichment   High   High   Not sensitive

Q: High A: Low C: High   Q: High A: High C: Medium   Q: High A: Low C: Medium

Over geological timescales periods of increased nutrient availability have experienced increases in the distribution of crustose coralline species at the expense of corals (Littler & Littler, 2013), suggesting that this group have some tolerance for enhanced nutrient levels. Overall, Littler & Littler (2013) suggest that corallines as a group can tolerate both low and elevated levels of nutrients. Increased eutrophication of the Skagerrak has been linked to an increase in abundance of the characterizing species *Phycodrys rubens*, increases in this species have also been observed with local eutrophication in shallow bays in the Baltic (Pedersén & Snoeijs 2001), suggesting this species is tolerant of some enrichment.

Sensitivity assessment. The pressure benchmark is relatively protective and may represent a reduced level of nutrient enrichment in previously polluted areas and may limit the growth of ephemeral green algae (although these are also inhibited by turbidity in this biotope). Due to the tolerance of high levels of nutrient input demonstrated generally by encrusting corallines and red algal turfs, resistance to this pressure is assessed as 'High' and resilience as 'High' so that the biotope is assessed as 'Not sensitive'.

Organic enrichment   High   High   Not sensitive

Q: High A: Medium C: High   Q: High A: High C: High   Q: High A: Medium C: High

The crusting coralline *Lithophyllum incrustans* were present at sites dominated by *Ulva* spp. in the Mediterranean exposed to high levels of organic pollution from domestic sewage (Arévalo *et al.*, 2007). As turfs of red algae can trap large amounts of sediment (ant the biotope is exposed to siltation and high turbidity) the red algae are not considered sensitive to the sedimentation element of this pressure. Within trapped sediments associated species and deposit feeders such as *Lanice conchilega* or the piddock *Pholas dactylus* in areas of chalk would be able to consume inputs of organic matter.

The animals found within the biotope may be able to utilise the input of organic matter as food, or are likely to be tolerant of inputs at the benchmark level. In a recent review, assigning species to groups based on tolerances to organic pollution, the sponge *Halichondria panicea* were assigned to AMBI Group II described as 'species indifferent to enrichment, always present in low densities with non-significant variations with time, from initial state, to slight unbalance' (Gittenberger & van Loon, 2011).

Sensitivity assessment. Based on resistance to sedimentation, exposure to wave action, and the dominance of red algal turfs in areas subject to sewage inputs, resistance is assessed as 'High' and resilience as 'High' (by default). The biotope is therefore considered to be 'Not sensitive' to this pressure at the benchmark.

⚔ Physical Pressures

Resistance   Resilience   Sensitivity

Physical loss (to land or freshwater habitat)

None	Very Low	High
Q: High A: High C: High	Q: High A: High C: High	Q: High A: High C: High

All marine habitats and benthic species are considered to have a resistance of 'None' to this pressure and to be unable to recover from a permanent loss of habitat (resilience is 'Very Low'). Sensitivity within the direct spatial footprint of this pressure is therefore 'High'. Although no specific evidence is described confidence in this assessment is 'High', due to the incontrovertible nature of this pressure.

Physical change (to another seabed type)

Low	Very Low	High
Q: High A: High C: High	Q: High A: Low C: High	Q: High A: Low C: High

The loss of hard substratum would alter the habitat and sediments would be unsuitable for the red algae that characterize this biotope. Other associated species such as sponges would also be lost as these are associated with rock habitats. Artificial hard substratum may also differ in character from natural hard substratum, so that replacement of natural surfaces with artificial may lead to changes in the biotope through changes in species composition, richness and diversity (Green *et al.*, 2012; Firth *et al.*, 2013) or the presence of non-native species (Bulleri & Airoldi, 2005). Many species have specific preferences for substratum type. The red algae *Corallina officinalis* shows optimal settlement on finely rough artificial substrata (0.5 - 1 mm surface particle diameter). Although spores will settle and develop as crustose bases on smooth surfaces, fronds were only initiated on rough surfaces. *Corallina officinalis* settled on artificial substrata within one week in the field in summer months in New England (Harlin & Lindbergh 1977). However, in the laboratory only fronds grew from bases attached to smooth surfaces (Wiedeman pers comm. Previous MarLIN review).

Sensitivity assessment. Based on the loss of suitable habitat, resistance is assessed as 'None' recovery is assessed as 'Very Low' as the change at the pressure benchmark is permanent. Sensitivity is therefore 'High'.

Physical change (to another sediment type)

Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Not relevant to biotopes occurring on bedrock.

Habitat structure changes - removal of substratum (extraction)

Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

The species characterizing this biotope are epifauna or epiflora occurring on rock and would be sensitive to the removal of the habitat. However, extraction of rock substratum is considered unlikely and this pressure is considered to be 'Not relevant' to hard substratum habitats.

Abrasion/disturbance of the surface of the substratum or seabed

Medium	High	Low
Q: High A: Low C: Medium	Q: High A: Low C: Medium	Q: High A: Low C: Medium

The species characterizing this biotope occur on the rock and therefore have no protection from abrasion at the surface. Little direct evidence was found to assess this pressure and evidence from intertidal studies on trampling on algal turfs has been used as a proxy. In general, studies show that *Corallina* and other turf forming algae appear to be relatively resistant to single events and low levels of trampling. Brosnan & Crumrine (1994), for example, found that in experimentally trampled plots the cover of foliose and canopy forming species declined while turf forming algae were relatively resistant. Similarly, a comparison of rocky intertidal ledges that received different amounts of visitors in Dorset, England, found that *Corallina officinalis* and encrusting corallines were present on both heavily visited and less visited ledges suggesting that these species has some resistance to trampling (Pinn & Rodgers, 2005).   Povey & Keough (1991) in Mornington Peninsula, Australia investigated the effects of sustained trampling on intertidal coralline algal mats where upright branching *Corallina* spp. formed a turf with other red algae with sand and encrusting coralline algae between turfs. The experimental strips were 2 m long and 0.5 m wide. The percentage cover of upright *Corallina* spp. was significantly affected by 25 passages of a strip per day after 12 and 33 days. The algae appeared flattened and were shorter (1-2 cm high) compared with the low intensity and control plots (3-4 cm high). However low intensity trampling within a strip (2 passages/ day) did not significantly affect the Coralline turf. Fletcher and Frid (1996b; 1996a) noted a decrease in the understorey algal community of encrusting coralline algae and red algae, which was probably an indirect effect due to increased desiccation after removal of the normally protective fucoid canopy (Hawkins & Harkin, 1985) by trampling.

Mechanical abrasion from scuba divers has been reported to impact encrusting corallines, with cover of *Lithophyllum stictaeforme* greater in areas where diving was forbidden than visited areas (abundance, 6.36 vs 1.4; it is presumed this refers to proportion of cover, although this is not clear from the text, Guarinieri *et al.*, 2012). Dethier (1994) experimentally manipulated surface abrasion on a range of encrusting algae including *Lithophyllum impressum*. Crusts were brushed with either a nylon or steel brush for 1 minute a month for 24 months. Unbrushed controls grew by approximately 50% where the cover of nylon brushed crusts and steel brushed crusts decreased by approximately 25% and 40% respectively (interpreted from figures in Dethier, 1994). In laboratory tests on chips of *Lithophyllum impressum* brushing with a steel brush for 1 minute once a week for 3 weeks, resulted in no cover loss of two samples while a third 'thinned and declined' (Dethier, 1994).

In a recent review, assigning species to groups based on tolerances to bottom disturbance from fisheries, the sponge *Halichondria panicea* were assigned to AMBI Fisheries Group II, described as 'species sensitive to fisheries in which the bottom is disturbed, but their populations recover relatively quickly' (Gittenberger & van Loon, 2011).

Sensitivity assessment. The impact of surface abrasion will depend on the footprint, duration and magnitude of the pressure. Based on evidence from intertidal step experiments and the relative robustness of encrusting corallines and associated red algal species, resistance, to a single abrasion event is assessed as 'Medium' and recovery as 'High', so that sensitivity is assessed as 'Low'. Resistance and resilience will be lower (and hence sensitivity greater) to abrasion events that exert a greater crushing force and remove the bases than the trampling examples the assessment is based on). Resistance is therefore assessed as 'Low' and recovery as 'Medium' so that the sensitivity of the biotope defined by this species is assessed as 'Medium'.

Penetration or disturbance of the substratum subsurface	Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

The species characterizing this biotope group are epifauna or epiflora occurring on rock which is resistant to subsurface penetration. The assessment for abrasion at the surface only is therefore considered to equally represent sensitivity to this pressure.

Changes in suspended solids (water clarity)	High	High	Not sensitive
	Q: High A: Medium C: High	Q: High A: High C: High	Q: High A: Medium C: High

This biotope occurs in habitats exposed to siltation and it is likely that the biotope is exposed to chronic or intermittent episodes of high-levels of suspended solids as local sediments are re-mobilised and transported. A significant increase in suspended solids may result in smothering (see siltation pressures) where these are deposited. Based on Cole *et al.* (1999) and Devlin *et al.* (2008) this biotope is considered to experience intermediate turbidity (10-100 mg/l) based on UK TAG (2014). An increase at the pressure benchmark refers to a change to medium turbidity (100-300 mg/l) and a decrease is assessed as a change to clear (<10 mg/l) based on UK TAG (2014).

In general, this biotope is considered to be relatively tolerant of high levels of suspended solids as increases in the cover of sediment trapping, turf forming algae at the expense of canopy forming species has been observed worldwide, in temperate systems, linked to increased suspended solids resulting from human activities (Airoldi, 2003). An accumulation of sediment within the turf may attract more sediment dwelling interstitial invertebrates such as nematodes, harpacticoids and polychaetes, although in more wave exposed locations accumulation of sediment is likely to be minimal as wave action removes sediments.

The critical depth for the growth of kelp plants is at about 1% of surface illumination, and for foliose red algae about 0.1% (Luning & Dring, 1979). An increase in light penetration due to reduced turbidity could either allow kelps to establish or a decrease could reduce habitat suitability for the characterizing red algae leading to the development of an animal dominated (circalittoral) assemblage type.

Increased suspended sediments may also result in increased scour, which may adversely affect foliose red algae, and interfere with settling spores and recruitment of the factor is coincident with their major reproductive period. Tolhurst *et al.* (2007) found that *Ulva intestinalis* germlings kept in tanks and exposed to 100 mg/l of suspended sediment showed reduced growth. Similarly, Hyslop & Davies (1998) found that the green alga *Ulva lactuca* lost weight when kept in flasks with 1 g/l of colliery waste that was shaken for 1 hour every day for 8 days. The experimental solids level, however, exceeds the pressure benchmark and Ulva are very thin species and are probably more susceptible to scour damage than red algae. Coralline algae, especially the crustose forms are thought to be resistant of sediment scour (Littler & Kauker, 1984), and will probably not be adversely affected at the benchmark level.

Increases in suspended sediments may impact filter feeders such as *Halichondria panicea* within the biotope by reducing feeding efficiency, however, an increase in organic solids would supply more food*. Halichondria panicea* is found in highly turbid areas associated with biotopes such as CR.MCR.SfR.Pol (Connor *et al.*, 2004) and are therefore considered to be unaffected by an increase in turbidity at the benchmark. Many encrusting sponges appear to be able survive in highly sedimented conditions (Schönberg, 2015; Bell & Barnes 2000; Bell & Smith 2004). Castric-Fey & Chassé (1991) conducted a factorial analysis of the subtidal rocky ecology near Brest, France and rated the distribution of species in varying turbidity (corroborated by the depth at which laminarians disappeared); *Dysidea fragilis*, had a strong preference for turbid water. Storr (1976) observed the sponge *Sphecispongia vesparium* back washing to eject sediment and noted that other

sponges (such as *Condrilla nucula*) use secretions to remove settled material. The hydroids *Tubularia indivisa* is also likely to tolerate increases in suspended solids. Survey reports document abundant *Tubularia indivisa* in habitats around the Isle of Thanet, which is an area characterized by poor underwater visibility due to high levels of suspended solids (Howson *et al.,* 2005).

Sensitivity assessment. Overall biotope resistance is assessed as 'Medium' to an increase in suspended solids, as increased scour may reduce the biomass of red algae and may remove some individuals or species that are more sensitive. However, the encrusting corallines and some red algae are considered likely to survive. Resilience is categorised as 'High' as some adults are likely to remain *in situ* from which recruitment can occur. The biotope is considered to be 'Not sensitive' to decreased suspended solids where scour and abrasion are unaffected. A reduction in turbidity and scour may allow less scour tolerant species and those adapted to higher light levels, such as kelps, to colonize the biotope. Resistance to a decrease in suspended solids, accompanied by a significant reduction in scour is assessed as 'Medium' as space pre-emption by red algae is likely to limit colonization. Resilience (following a return to previous habitat conditions) is assessed as 'High'. Sensitivity is therefore assessed as 'Low'.

Smothering and siltation rate changes (light)	High	High	Not sensitive
	Q: High A: High C: Medium	Q: High A: High C: High	Q: High A: High C: Medium

This biotope occurs on silted areas where high levels of turbidity exclude kelps (JNCC, 2015) and the red algae and other associated species are tolerant of low-levels of siltation. Increased abundance of red algal turfs worldwide has been linked to sediment perturbations although not all the pathways and mechanisms of these effects are clear (see review by Airoldi, 2003). However, even tolerant organisms would eventually suffer from inhibition and mortality following smothering although the thresholds for these effects have has not been identified (Airoldi, 2003).

 Airoldi (2003) identified a number of morphological, physiological and life history traits that conferred high levels of tolerance to sedimentation. Those shared by characterizing red algal species in the biotope are the regeneration of upright fronds from a perennial basal crust resistant to burial and scour, , apical meristems, large reproductive ouptuts, lateral vegetative growth and slow growth rates (Airoldi, 2003). Algae with tough thalli such as *Phyllophora pseudoceranoides* are more resistant to sedimentation and scour (Pedersén & Snoeijs 2001). In a review of the effects of sedimentation on rocky coast assemblages, Airoldi (2003) outlined the evidence for the sensitivity of encrusting coralline algae to sedimentation. The reported results are contradictory with some authors suggesting that coralline algae are negatively affected by sediments while others report that encrusting corallines are often abundant or even dominant in a variety of sediment impacted habitats (Airoldi, 2003 and references therein). Crustose corallines have been reported to survive under a turf of filamentous algae and sediment for 58 days (the duration of experiment) in the Galapagos (species not identified, Kendrick, 1991). The crustose coralline *Hydrolithon reinboldii*, has also been reported to survive deposition of silty sediments on subtidal reefs off Hawaii (Littler, 1973).

In an experimental study, Balata *et al*. (2007) enhanced sedimentation on experimental plots in the Mediterranean (close to Tuscany) by adding 400 g of fine sediment every 45 days on plots of 400 cm^2 for 1 year. Nearby sites with higher and lower levels of sedimentation were assessed as control plots. Some clear trends were observed. *Dictyota dichotoma* was more abundant at sites with lower sedimentation (mean 2 and 6% of cover) and present in lower abundances (<1 %) at sites where sediments were added and at sites with naturally high sediment loads (Balata *et al.,*

2007). Foliose algae, in general, were present in much greater abundances in areas with low sedimentation (mean cover of approximately 13% and 19%) and much reduced at experimental sites and those with high natural sedimentation (mean cover of approximately 2-3 %). Crustose corallines declined at medium and high levels of sedimentation but were still major space occupiers (100% cover). Some species of filamentous algae increased where sediment loads were naturally high or experimentally enhanced (Balata *et al*., 2007). The experiment relates to chronic low levels of sedimentation rather than a single acute event, as in the pressure benchmark, however the trends observed are considered to have some relevance to the pressure assessment. Foliose algae within the biotope are likely to be more sensitive to sedimentation than the characterizing encrusting corallines, however the presence of these, including *Dictyota dichotoma* in sand scoured biotopes suggest these have some tolerance of sedimentation and associated scour.

As small, sessile species attached to the substratum, siltation at the pressure benchmark would bury *Balanus crenatus* and *Spirobranchus triqueter*. Holme and Wilson (1985) described a *Pomatoceros-Balanus* assemblage on 'hard surfaces subjected to periodic sever scour and 'deep submergence by sand or gravel' in the English Channel. They inferred that the *Pomatoceros-Balanus* assemblage was restricted to fast-growing settlers able to establish themselves in short periods of stability during summer months (Holme and Wilson, 1985), as all fauna were removed in the winter months. Barnacles may stop filtration after silt layers of a few millimetres have been discharged as the feeding apparatus is very close to the sediment surface (Witt *et al*., 2004). In dredge disposal areas in the Weser estuary, Germany, where the modelled exposure to sedimentation was 10mm for 25 days, with the centre of the disposal ground exposed to 65 mm for several hours before dispersal, *Balanus crenatus* declined in abundance compared to reference areas. (Witt *et al*., 2004). However, separating the effect of sedimentation from increased suspended solids and changes in sediment from sediment dumping was problematic (Witt *et al*., 2004).

Sensitivity assessment. Based on the biotope exposure to wave and water flow which will remobilise sediments and remove these, the growth form of the characterizing foliose red algae and the presence of these algae and sponges in biotopes subject to sedimentation and scour (including the assessed biotope), biotope resistance to this pressure, at the benchmark, is assessed as 'High', resilience is assessed as 'High' (by default) and the biotope is considered to be 'Not sensitive'. The assessment considers that sediments are rapidly removed from the biotope and that the scour tolerance of the red algae and other species would prevent significant mortalities although some damage and abrasion may occur. However, if the deposit remained in place; i.e. due to the scale of the pressure or where biotopes were sheltered, or only seasonally subject to water movements or where water flows and wave action were reduced e.g. by the presence of tidal barrages, then resistance would be lower and sensitivity would be greater.

Smothering and siltation rate changes (heavy)	Low	High	Low
	Q: High A: Low C: Medium	Q: Low A: NR C: NR	Q: Low A: Low C: Low

The available evidence for siltation pressures is outlined for the 'light' deposition pressure. At the pressure benchmark 'heavy deposition' represents a considerable thickness of deposit. Complete burial of algal turf and encrusting corallines and associated animals would occur. Removal of the sediments by wave action and tidal currents would result in considerable scour. The effect of this pressure will be mediated by the length of exposure to the deposit.

Sensitivity assessment. Resistance is assessed as 'Low' as the impact on the characterizing and associated red algal species could be significant but may be mitigated by rapid removal. Resilience is assessed as 'High' based on vegetative re-growth from the scour-tolerant surviving bases of the characterizing species. Biotope sensitivity is therefore assessed as 'Low'.

Litter	Not Assessed (NA)	Not assessed (NA)	Not assessed (NA)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Not assessed.

Electromagnetic changes	No evidence (NEv)	No evidence (NEv)	No evidence (NEv)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

No evidence.

Underwater noise changes	Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Not relevant.

Introduction of light or shading	High	High	Not sensitive
	Q: High A: Medium C: Medium	Q: High A: High C: High	Q: High A: Medium C: Medium

The red algae are generally flexible in terms of light requirements and can acclimate to different levels of light intensity and quality. Red algae are shade tolerant, often occurring under a macroalgal canopy that reduces light penetration. Encrusting corallines can occur in deeper water than other algae where light penetration is limited. Samples of *Lithophyllum impressum* suspended from a raft and shaded (50-75% light reduction) continued to grow over two years (Dethier, 1994). Similarly *Plocamium cartilagineum* grows in shaded conditions beneath laminarian canopies: where irradiance is greater, growth is lower and it appears that light levels of 0.5 mmol/m^2/s are inhibitory (Kain, 1987). In areas of higher light levels, the fronds and bases may be lighter in colour due to bleaching (Colhart & Johansen, 1973).

The critical depth for the growth of kelp plants is at about 1% of surface illumination, and for foliose red algae about 0.1% (Luning & Dring, 1979). An increase in light penetration could either allow kelps to establish or a decrease would reduce habitat suitability for the characterizing red algae leading to the development of an animal dominated (circalittoral) assemblage type.

Sensitivity assessment. As the key structuring and characterizing red algae species colonize a broad range of light environments, from intertidal to deeper sub tidal and shaded understorey habitats, the biotope is considered to have 'High' resistance and, by default, 'High' resilience and is therefore is 'Not sensitive' to this pressure. However, extreme changes in the light environment may allow colonization by kelps or result in a loss of red algae.

Barrier to species movement	High	High	Not sensitive
	Q: NR A: NR C: NR	Q: High A: High C: High	Q: Low A: Low C: Low

Barriers that reduce the degree of tidal excursion may alter larval supply to suitable habitats from source populations. Conversely the presence of barriers may enhance local population supply by preventing the loss of larvae from enclosed habitats. Barriers and changes in tidal excursion are not considered relevant to the characterizing red algae as species dispersal is limited by the rapid rate of settlement and vegetative growth from bases rather than reliance on recruitment from outside of populations. Resistance to this pressure is assessed as 'High' and resilience as 'High' by default. This biotope is therefore considered to be 'Not sensitive'.

Death or injury by collision	Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Not relevant' to seabed habitats. NB. Collision by grounding vessels is addressed under surface abrasion.

Visual disturbance	Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Not relevant.

🐚 Biological Pressures

	Resistance	Resilience	Sensitivity
Genetic modification & translocation of indigenous species	Not relevant (NR)	Not relevant (NR)	Not relevant (NR)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Key characterizing species within this biotope are not cultivated or translocated. This pressure is therefore considered 'Not relevant' to this biotope group.

Introduction or spread of invasive non-indigenous species	High	High	Not sensitive
	Q: High A: Low C: Low	Q: High A: High C: High	Q: High A: Low C: Low

The high levels of turbidity and silt in this biotope will limit establishment of all but silt resistant invasive non-indigenous species (INIS) from this biotope and no direct evidence was found for effects of INIS on this biotope. A number of invasive red algae have been recorded in the UK, from reported habitat preferences *Bonnemaisonia hamifera* does not appear to be present in turbid environments and is most abundant in unshaded intertidal pools (Guiry & Guiry, 2015). The harpoon weed, *Asparagopsis armata* is found in sandy pools and in the subtidal (Guiry & Guiry, 2015) suggesting some tolerance of turbidity and scour. In North America *Grateloupia turuturu* is a major competitor of *Chondrus crispus*, although *Grateloupia turuturu* is present in the UK, this large foliose species may not be able to colonize this silted biotope.

The invasive red algae *Lophocladia lallemandi* that grows on *Dictyota dichotoma* in Mallorcan coastal waters results in an increase in antioxidant biomarkers indicating stress and cellular damage that could lead to increased mortality (Tejada & Sureda, 2014). This species is not currently present in the UK but illustrates a potential effect on INIS on native species.

The tunicates *Didemnum vexillum* and *Asterocarpa humilis*, the hydroid *Schizoporella japonica* and the bryozoan *Watersipora subatra* (Bishop, 2012c, Bishop, 2015a & b; Wood, 2015) are currently only recorded from artificial hard substratum in the UK and it is not clear what their established range and impacts in the UK would be. The tunicate *Stylea clava* appears to prefer more sheltered conditions than this biotope (Bishop, 2012d).

Didemnum vexillum is an invasive colonial sea squirt native to Asia which was first recorded in the UK in Darthaven Marina, Dartmouth in 2005. *Didemnum vexillum* can form extensive mats over the substrata it colonizes; binding boulders, cobbles and altering the host habitat (Griffith *et al.*, 2009). *Didemnum vexillum* can also grow over and smother the resident biological community. Recent surveys within Holyhead Marina, North Wales have found *Didemnum vexillum* growing on and smother native tunicate communities (Griffith *et al.*, 2009). Due to the rapid-re-colonization of *Didemnum vexillum* eradication attempts have to date failed. Presently *Didemnum vexillum* is isolated to several sheltered locations in the UK (NBN, 2015), however *Didemnum vexillum* has successfully colonized the offshore location of the Georges Bank, USA (Lengyel *et al.*, 2009) which is more exposed than the locations which *Didemnum vexillum* have colonized in the UK. It is therefore possible that *Didemnum vexillum* could colonize more exposed locations within the UK and could therefore pose a threat to CR.HCR.FaT.CTub.Adig.

Sensitivity assessment. As siltation and turbidity expereinced by this biotope limits establishment of all but tolerant species, resistance to INIS is assessed as 'High' and resilience as 'High' (by default) so that the biotope is considered to be 'Not sensitive'.

Introduction of microbial pathogens	High	High	Not sensitive
	Q: High A: High C: High	Q: High A: High C: High	Q: High A: High C: High

No evidence was found that microbial pathogens cause high levels of disease or mortality in this biotope. Diseased encrusting corallines were first observed in the tropics in the early 1990's when the bacterial pathogen Coralline Lethal Orange Disease (CLOD) was discovered (Littler & Littler, 1995). All species of articulated and crustose species tested to date are easily infected by CLOD and it has been increasing in occurrence at sites where first observed and spreading through the tropics. Another bacterial pathogen causing a similar CLOD disease has been observed with a greater distribution and a black fungal pathogen first discovered in American Samoa has been dispersing (Littler & Littler, 1998). An unknown pathogen has also been reported to lead to white 'target-shaped' marks on corallines, again in the tropic (Littler *et al.*, 2007). No evidence was found that these are impacting temperate coralline habitats.

It is likely that populations within this biotope suffer some low-levels of infection of microbial pathogens and parasites. Specific examples include the red algal hemiparasite *Gonimophyllum buffhamii*, which occurs occasionally on subtidal *Cryptopleura ramosa* on southern and western coasts (Guiry & Guiry, 2015). However, algae have natural chemical defences against pathoges. Extracts of some red and brown algae show antimicrobial (Hornsey & Hide, 1974), antiviral or antifungal properties. For example, extracts of *Dictyota dichotoma* have antibiotic properties (Hornsey & Hide, 1974) and antiviral properties (Rabanal *et al.*, 2014).

Decaying patches and white bacterial film were reported in the sponges *Haliclona oculata* and *Halichondria panicea* in North Wales, 1988-89, (Webster, 2007) but no mass mortalities of sponges have been reported from UK waters.

Sensitivity assessment. Based on the available evidence for the characterizing coralline crust, *red*

algae and other associated species the biotope is judged to have 'High' resistance to this pressure as no significant mortalities have been recorded. By default resilience is assessed as 'High' and the biotope is classed as 'Not sensitive' at the pressure benchmark.

Removal of target species	Low	Medium	Medium
	Q: Low A: NR C: NR	Q: High A: Low C: Medium	Q: Low A: Low C: Low

Direct, physical impacts from harvesting are assessed through the abrasion and penetration of the seabed pressures. The sensitivity assessment for this pressure considers any biological/ecological effects resulting from the removal of target species on this biotope. No commercial application or harvesting of encrusting corallines was described in the literature. The key characterizing foliose red algal species are not commercially targeted but have been investigated as alternative sources of the phycocolloid substances alginates and agar (Mathieson *et al*., 1984; Maggs, 1990) and in the future may be subject to harvesting.

Sensitivity assessment. The foliose red algae species that could potentially be harvested, in this biotope are all attached or sedentary and relatively conspicuous. A single event of targeted harvesting could therefore efficiently remove individuals and resistance is assessed as 'Low'. Resilience of the red seaweeds is assessed as 'Medium' (based on some damage occurring to perennial holdfasts and bases although see caveats in the resilience section) and biotope sensitivity is assessed as 'Medium'. This assessment refers to a single collection event, long-term harvesting over wide spatial scales will lead to greater impacts, with lower resistance and longer recovery times.

Removal of non-target species	Low	High	Low
	Q: Low A: NR C: NR	Q: High A: High C: High	Q: Low A: Low C: Low

Incidental removal of the key characterizing red algal species species and associated species would alter the character of the biotope resulting in reclassification and the loss of species biomass. The ecological services such as primary production and the habitat provided by these species would also be lost. The high levels of turbidity and siltation expereinced by this biotope prevent colonization by kelps. Based on the observations of Sebens (1986) it is likely that rapid colonization (depending on the time of year) by ascidians, sponges, barnacles and hydroids would occur with later re-establishment of foliose red seaweeds (depending on dispersal and fottprint of impact).

Sensitivity assessment. Removal of a large percentage of the characterizing species resulting in bare rock would alter the character of the biotope, species richness and ecosystem function. Resistance is therefore assessed as 'Low' and recovery as 'Medium' (based on removal of bases and holdfasts), so that biotope sensitivity is assessed as 'Low'.

Bibliography

Ackers, R.G.A., Moss, D. & Picton, B.E. 1992. *Sponges of the British Isles (Sponges: V): a colour guide and working document.* Ross-on-Wye: Marine Conservation Society.

Adey, W.H. & Adey, P.J., 1973. Studies on the biosystematics and ecology of the epilithic crustose corallinacea of the British Isles. *British Phycological Journal*, **8**, 343-407.

Airoldi, L., 2003. The effects of sedimentation on rocky coast assemblages. *Oceanography and Marine Biology: An Annual Review*, **41**,161-236

Airoldi, L., 2000. Responses of algae with different life histories to temporal and spatial variability of disturbance in subtidal reefs. *Marine Ecology Progress Series*, **195** (8), 81-92.

Arévalo, R., Pinedo, S. & Ballesteros, E., 2007. Changes in the composition and structure of Mediterranean rocky-shore communities following a gradient of nutrient enrichment: descriptive study and test of proposed methods to assess water quality regarding macroalgae. *Marine Pollution Bulletin*, **55** (1), 104-113.

Atalah, J. & Crowe, T.P., 2010. Combined effects of nutrient enrichment, sedimentation and grazer loss on rock pool assemblages. *Journal of Experimental Marine Biology and Ecology*, **388** (1), 51-57.

Balata, D., Piazzi, L. & Cinelli, F., 2007. Increase of sedimentation in a subtidal system: effects on the structure and diversity of macroalgal assemblages. *Journal of Experimental Marine Biology and Ecology*, **351**(1), 73-82.

Barnes, H. & Barnes, M., 1974. The responses during development of the embryos of some common cirripedes to wide changes in salinity. *Journal of Experimental Marine Biology and Ecology*, **15** (2), 197-202.

Barnes, H. & Barnes, M., 1968. Egg numbers, metabolic efficiency and egg production and fecundity; local and regional variations in a number of common cirripedes. *Journal of Experimental Marine Biology and Ecology*, **2**, 135-153.

Barnes, H. & Powell, H.T., 1953. The growth of *Balanus balanoides* and *B. crenatus* under varying conditions of submersion. *Journal of the Marine Biological Association of the United Kingdom*, **32**, 107-127.

Barthel, D., 1986. On the ecophysiology of the sponge *Halichondria panicea* in Kiel Bight. I. Substrate specificity, growth and reproduction. *Marine Ecology Progress Series*, **32**, 291-298.

Bassindale, R., 1938. The intertidal fauna of the Mersey estuary. Journal of the Marine Biological Association of the United Kingdom, 23 (01), 83-98.

Bell, J.J. & Barnes, D.K., 2000. The distribution and prevalence of sponges in relation to environmental gradients within a temperate sea lough: inclined cliff surfaces. *Diversity and Distributions*, **6** (6), 305-323.

Bell, J.J. & Smith, D., 2004. Ecology of sponge assemblages (Porifera) in the Wakatobi region, south-east Sulawesi, Indonesia: richness and abundance. *Journal of the Marine Biological Association of the UK*, **84** (3), 581-591.

Bishop, J. 2012c. Carpet Sea-squirt, *Didemnum vexillum.Great Britain Non-native Species Secretariat* [On-line]. [cited 30/10/2018]. Available from: http://www.nonnativespecies.org/factsheet/factsheet.cfm?speciesId=1209

Bishop, J. 2012d. Leathery sea squirt, *Styela clava*. *Great Britain Non-native Species Secretariat*. [cited 16/06/2015]. Available from: