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Coralline crusts and crustaceans on mobile boulders or cobbles in surge gullies

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

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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/156]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

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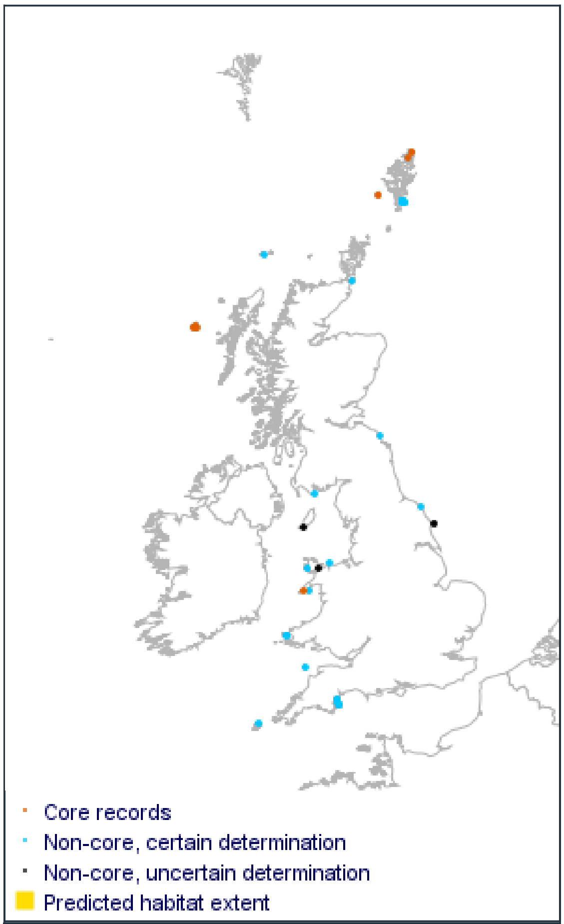

29-01-2020
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Dr Heidi Tillin **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A3.7162	Coralline crusts and crustaceans on mobile boulders or cobbles in surge gullies
JNCC 2015	IR.FIR.SG.CC.Mo	Coralline crusts and crustaceans on mobile boulders or cobbles in surge gullies
JNCC 2004	IR.FIR.SG.CC.Mo	Coralline crusts and crustaceans on mobile boulders or cobbles in surge gullies
1997 Biotope	IR.EIR.SG.CC.Mob	Coralline crusts and crustaceans on mobile boulders or cobbles in surge gullies

Description

Highly mobile and scoured boulders and cobbles found on cave and gully floors and which often appear bare. Where there are sufficient light and stability, however, the boulders are encrusted by coralline algal crusts. Barnacles *Balanus crenatus* and keel worms *Spirobranchus* (syn. *Pomatoceros*) *triqueter* may survive in areas protected from severe abrasion. Crabs such as *Cancer pagurus* and *Carcinus maenas* may occur, often beneath and between the rocks, along with the gastropod *Calliostoma zizyphinum*. The anemone *Actinia equina* may be present in low numbers. The slightly less-scoured walls often found above this biotope in caves and gullies are generally characterised by a similar, but richer community of scour-tolerant *Balanus crenatus*, *Spirobranchus triqueter* coralline crusts and spirorbid worms (CC.BalSpi). This impoverished biotope may form an intermediate between barren gravel and slightly more stable larger pebbles and cobbles which are covered by algae that are often found in the mouths of caves (FoSwCC). Winter storms periodically mobilise the boulders and cobbles, causing abrasion to any seasonal biota that may have developed over the calmer summer months. (Information taken from Connor *et al*., 2004; JNCC, 2015).

Depth range

0-5 m, 5-10 m, 10-20 m

Additional information

-

Listed By

- none -

Further information sources

Search on:

JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

Coralline crusts on mobile boulders in severely scoured caves (IR.FIR.SG.CC.Mo) is a sub-biotope of IR.FIR.SG.CC (Coraline crusts in surge gullies and scoured infralittoral rock). Severe abrasion resulting from scouring by cobbles and pebbles are key factors structuring these biotopes and significant alteration to scouring is likely to change the character of the biotope. In particular, this sub-biotopes is characterized by mobile substrata including boulders and cobbles with pebbles and gravel. Therefore, the fauna is particularly sparse, characterized by transient opportunists such as tubeworms and barnacles, and scour resistant encrusting corallines. Hence, the sensitivity assessments presented for this biotope, focus on the barnacle, tubeworm and coralline crusts. Although other species may be associated with this biotope, such as anemones and sponges, these are present in low abundances in refuges from the scour and are not considered to be characterizing and are not considered within the assessments. Where pressures may alter scour, this is identified and discussed within the sensitivity assessments.

Resilience and recovery rates of habitat

Although ubiquitous in marine coastal systems, little is understood about the taxonomy, biology and ecology of the associated crustose corallines (Littler & Littler, 2013). A 'coralline crust' is a generic term in the UK biotopes that refers to non-geniculate (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) as well as *Lithothamnion* spp. and *Phymatolithon* spp. The assessments for encrusting corallines are generic due to the lack of evidence for individual species, although species-specific information is presented where available. Edyvean & Ford (1984a & b; 1986; 1987) describe aspects of reproduction and growth of 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 fewer 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 (1984a) 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, 1984a). 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.

Populations of *Spirobranchus triqueter* have a spring reproductive maxima from March-April, although breeding can occur throughout the year. Populations of *Spirobranchus* (studied as *Pomatoceros*) *triqueter* in Bantry Bay, Ireland exhibited an extended reproductive season, with numerous small scale peaks, the timing of which varied between years (Cotter *et al*., 2003). *Spirobranchus triqueter* is a protandrous hermaphrodite, with older, larger individuals more likely to be female (Cotter *et al*., 2003). *Spirobranchus triqueter* lives for 2 to 4 years (Dons, 1927; Castric-Fey, 1983; Hayward & Ryland, 1995a) and matures at 4 months (Hayward & Ryland, 1995a; Dons, 1927). *Spirobranchus triqueter* is considered to be a primary fouling organism (Crisp, 1965) colonizing artificial commercially important structures such as buoys, ships hulls, docks and offshore oil rigs (OECD, 1967). *Spirobranchus triqueter* is commonly the initial recruit to new substrata (Sebens, 1985; Sebens, 1986; Hatcher, 1998). For example, *Spirobranchus triqueter* colonized artificial reefs soon after deployment in summer (Jensen *et al*., 1994), colonized settlement plates within 2 to 3.5 months and dominated spring recruitment (Hatcher, 1998). Hiscock (1983) noted that a community, under conditions of scour and abrasion from stones and boulders moved by storms, developed into a community consisting of fast-growing species such as *Spirobranchus triqueter*.

Balanus crenatus produce a single, large brood annually with peaks in April –May (Luther, 1987); although subsidiary broods may be produced, the first large brood is the most important for larval supply (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 settlement rate of larvae on artificial panels (Miron *et al*., 1996), so that surviving adults enhance recovery rates.

Spirobranchus triqueter and *Balanus crenatus* are both relatively short-lived species that mature rapidly and have long reproductive seasons and produce pelagic larvae. *Balanus crenatus* and *Spirobranchus* (studied as *Pomatoceros*) *triqueter* can utilise a variety of substrata including artificial and natural hard substratum, bivalves and other animals. The life-history traits and broad habitat preferences mean that populations of both species can recover rapidly following disturbance. Off Chesil Bank, the epifaunal community dominated by *Spirobranchus triqueter*, *Balanus crenatus* and *Electra pilosa*, decreased in cover in October as it was scoured away in winter storms, and was recolonized in May to June (Warner 1985). Warner (1985) reported that the community did not contain any persistent individuals, being dominated by rapidly colonizing organisms. While larval recruitment was patchy and varied between the years studied, recruitment was sufficiently predictable to result in a dynamic stability and a similar community was present in 1979, 1980 and 1983 (Warner, 1985). Holme & Wilson (1985) suggested that the fauna of the *Balanus-Pomatoceros* assemblage in the central English Channel was restricted to rapid growing colonizers able to settle rapidly and utilize space in short periods of stability in the summer months.

Resilience assessment. Where resistance is ‘Medium’ or Low’, and parts of the crustose corallines remain, then resilience is assessed as **‘High’.** However, where resistance is ‘Low’ or ‘None’ and the key characterizing crustose corallines are likely to be removed then resilience is assessed as **‘Medium’**. Where resistance is ‘High’, resilience is assessed as ‘High’ by default. Both *Balanus crenatus* and *Spirobranchus triqueter* are rapid colonizers and likely to recover quickly, probably within months. Therefore, resilience, of these species, is assessed as **'High’** for any level of perturbation.

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

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. In general, populations can acclimate to prevailing conditions which can alter tolerance thresholds and care should, therefore, be used when interpreting reported tolerances.

The encrusting coralline, *Lithophyllum incrustans*, is close to the northern edge of its reported distribution range in the UK (Kain, 1982; Guiry & Guiry, 2015) and is therefore considered likely to be tolerant of an increase in temperature, particularly in this subtidal biotope, where it is protected from desiccation.

Balanus crenatus is described as a boreal species (Newman & Ross, 1976) it is 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 increased water temperature in Queens Dock is greater than an increase at the pressure benchmark (2-5°C). *Balanus crenatus* has a peak rate of cirral beating at 20°C and all spontaneous activity ceases at about 25°C (Southward, 1955). The tolerance of *Balanus crenatus*, collected in the summer (and thus acclimated to higher temperatures), to increased temperatures, was tested in the laboratory. The median upper lethal temperature tolerance was -25.2°C (Davenport & Davenport, 2005) confirming the observations of Southward (1955).

The characterizing *Spirobranchus triqueter* are found in both warmer and colder waters than experienced in the UK. *Spirobranchus triqueter* occurs from the Arctic, the eastern North Atlantic up to the Mediterranean, Adriatic, Black and the Red Sea, the English Channel, the whole North Sea, Skagerrak, Kattegat, the Belts and Öresund up to Bay of Kiel (De Kluijver *et al*., 2016)

Sensitivity assessment. Typical surface water temperatures around the UK coast vary, seasonally from 4-19°C (Huthnance, 2010). The biotope is considered to tolerate a 2°C increase in temperature for a year. An acute increase at the pressure benchmark may be tolerated in winter, but a sudden return to typical temperatures could lead to mortalities among acclimated animals. No evidence was found to support this assessment, however. An acute increase of 5°C in summer would be close to the lethal thermal temperature for *Balanus crenatus* and loss of this species would alter the character of the biotope. Biotope resistance is, therefore, assessed as **'Medium'** and resilience as **'High'** and biotope sensitivity is, therefore **'Low'**.

Temperature decrease (local)	Medium Q: High A: Medium C: High	High Q: High A: High C: Medium	Low Q: High A: Medium C: Medium

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. In general, populations can acclimate to prevailing conditions which can alter tolerance thresholds and care should, therefore, be used when interpreting reported tolerances.

Lithophyllum incrustans are close to the northern edge of their reported distribution range in the UK (Guiry & Guiry, 2015). 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).

Within the biotope, the key characterizing barnacles *Balanus crenatus* have a more northern distribution and are absent from warmer Mediterranean and equatorial waters. *Balanus crenatus* is described as a boreal species (Newman & Ross, 1976), it is 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. *Balanus crenatus* is relatively tolerant of lower temperatures. *Balanus crenatus* was unaffected during the severe winter of 1962-63, when average temperatures were 5 to 6°C below normal (Crisp, 1964a,b). 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). An acute or chronic decrease in temperature, at the pressure benchmark, is therefore unlikely to negatively affect this species. Meadows (1969) noted that the severe winter of 1962-63 decreased sea temperatures at Newcastle but did not affect fauna, including *Balanus crenatus*, on settlement panels that were deployed in the area.

The characterizing *Spirobranchus triqueter* are found in both warmer and colder waters than experienced in the UK. *Spirobranchus triqueter* occurs from the Arctic, the eastern North Atlantic up to the Mediterranean, Adriatic, Black and the Red Sea, the English Channel, the whole North Sea, Skagerrak, Kattegat, the Belts and Öresund up to Bay of Kiel (De Kluijver *et al*., 2016). Thomas (1940) noted that *Spirobranchus* (as *Pomatoceros*) *triqueter* could not form tubes below 7°C, however, this effect is not considered to lead to mortality in adults at the duration of the acute pressure benchmark.

Sensitivity assessment. Overall, a long-term chronic change in temperature at the pressure benchmark is considered likely to fall within natural variation and to be tolerated by the characterizing and associated species although, *Lithothyllum incrustans* may experience reduced growth (as it is primarily a southern species). An acute change at the pressure benchmark is considered unlikely to adversely affect the biotope as the characterizing species can potentially adapt to a wide range of temperatures experienced in both northern and southern waters (*Spirobranchus triqueter*) or are found primarily in colder, more northern waters (*Balanus crenatus*). *Lithophyllum incrustans* may be less tolerant, but reductions in growth, rather than mortalities may result. Biotope resistance is, therefore, assessed as **'Medium'** and resilience as **'High'** so that sensitivity is assessed as **'Low'**.

Salinity increase (local)	Low Q: High A: Medium C: Medium	High Q: High A: High C: Medium	Low Q: High A: Medium C: Medium

This biotope is recorded in full salinity (30-35 ppt) habitats (Connor *et al*., 2004) and the sensitivity assessment considers an increase from full to >40 ppt.

The crustose corallines that occur in this biotope may also be found on rocky shores and 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).

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). 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. Some increases in salinity may be tolerated by the characterizing species however the biotope is considered to be sensitive to a persistent increase in salinity to >40 ppt (based on species distribution, Barnes & Barnes, 1974 & Edyvean & Ford (1984b). Therefore, resistance is assessed as **'Low'** and resilience as **'High'** (following the restoration of prior salinity) so that sensitivity is assessed as **'Low'**.

Salinity decrease (local)	High Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

This biotope is recorded in full salinity (30-35 ppt) (Connor *et al*., 2004). At the pressure benchmark, a change from full to variable salinity (18-30 ppt) is assessed. The characterizing species are found in a similar biotope (CR.MCR.EcCr.UrtScr), is present in variable salinities (Connor *et al*., 2004). It is therefore likely that the characterizing species will tolerate a reduction in salinity form full to reduced.

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 the relevant thresholds was 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 occur (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 into 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).

Spirobranchus triqueter has not been recorded from brackish or estuarine waters. Therefore, it is likely that the species will be very intolerant of a decrease in salinity. However, Dixon (1985, cited in Riley & Ballerstedt, 2005) views the species as able to withstand significant reductions in salinity. The degree of reduction in salinity and time that the species could tolerate those levels were not recorded. Therefore, there is insufficient information available to assess the intolerance of *Spirobranchus triqueter* to a reduction in salinity and the assessment is based on its presence in the biotope CR.MCR.EcCr.UrtScr which occurs in variable salinity (as well as full) habitats (Connor *et al*., 2004).

Sensitivity assessment. As the characterizing species are found in biotopes in both full and variable salinity habitats, the biotope is considered 'Not sensitive' to a decrease in salinity from full to variable. Biotope resistance is therefore assessed as 'High' and resilience is assessed as 'High' (by default) and the biotope is assessed as 'Not sensitive'.

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

This biotope occurs across a range of flow speeds, from very weak (negligible) to moderately strong (0.5-1.5 m/s) (Connor *et al*., 2004). The suspension feeders within the biotope benefit from high water flow supplying food. 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). *Spirobranchus triqueter* is found in biotopes exposed to flow speeds varying from very weak to moderately strong (negligible - >1.5m/s) (Tillin & Tyler-Walters, 2014). *Balanus crenatus* is found in a very wide range of water flows (Tillin & Tyler-Walters, 2014), although it usually occurs in sites sheltered from wave action (Eckman & Duggins, 1993) and can adapt feeding behaviour according to flow rates. In the absence of any current, the barnacle rhythmically beats its cirri to create a current to collect zooplankton. The growth of *Balanus crenatus* (measured as an increase in basal area), maintained for 69 days at constant flow speeds in laboratory experiments, was greatest at intermediate flow speeds (0.08 m/s) and decreased at higher speeds (Eckman & Duggins, 1993). Over the entire range of flow speeds measured (0.02 m/s – 0.25 m/s), *Balanus crenatus*, was able to control the cirrus with little or no deformation by flow observed (Eckman, & Duggins, 1993).

Sensitivity assessment. Scour is a key factor structuring this biotope (Connor *et al*., 2004) so that changes in flow exceeding the pressure benchmark may increase or decrease sediment transport and associated scour may lead to indirect changes in the character of the biotope. However, the scour and mobility of the substratum is probably dominated by wave action rather than water flow. As the biotope and the associated species can occur in a range of flow speeds, the 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

Not relevant to subtidal biotopes. However, 100% mortality could be expected in adult *Spirobranchus* (as *Pomatoceros) triqueter* after 24.1 h and 35.4 h when exposed to air at 7°C and 13°C respectively (Campbell & Kelly, 2002).

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 range from 'very exposed' to 'moderately exposed' to wave action (Connor *et al*., 2004). The crustose corallines associated with this biotope have a flat growth form and are unlikely to be dislodged by increased wave action. *Balanus crenatus* and *Spirobranchus triqueter* 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 wave sheltered to very wave exposed (Tillin & Tyler-Walters, 2014).

Sensitivity assessment. Scour is a key factor structuring this biotope (Connor *et al.*, 2004) and the mobility of the substratum and, hence scour, is probably dominated by wave action. Therefore, changes in wave action (wave exposure) could result in significant changes to this biotope. Any activity or pressure, that redirected, blocked or mitigated wave energy reaching the biotope could result in a reduction in scour and reclassification of the biotope, probably to a faunal dominated cave and gully biotope, e.g. IR.FIR.SG.FoSwCC. However, a 3-5% reduction in significant wave height (the benchmark) is unlikely to significantly reduce wave energy reaching a biotope that occurs in moderately wave exposed to very wave exposed conditions. Therefore, resistance is assessed as **'High', r**esilience as **'High'**, by default, and the biotope is assessed as **'Not sensitive'** at the benchmark level.

Chemical Pressures

	Resistance	Resilience	Sensitivity
Transition elements & organo-metal 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 any evidence is presented where available.

No information was found concerning the effects of heavy metals on 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.

Contamination at levels greater than the pressure benchmark may adversely impact the biotope. Barnacles accumulate heavy metals and store them as insoluble granules (Rainbow, 1987). Pyefinch & Mott (1948) recorded a median lethal concentration of 0.19 mg/l copper and 1.35 mg/l mercury, for *Balanus crenatus* over 24 hours. Barnacles may tolerate fairly high levels of heavy metals in nature, for example, they are found in Dulas Bay, Anglesey; where copper reaches concentrations of 24.5 µg/l, due to acid mine waste (Foster *et al.*, 1978).

Hydrocarbon & PAH 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 any evidence is presented where available

Where exposed to direct contact with fresh hydrocarbons, encrusting coralline algae appear to have a high intolerance. 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.

No information is available on the intolerance of *Balanus crenatus* to hydrocarbons. However, other littoral barnacles generally have a high tolerance to oil (Holt *et al.*, 1995) and were little impacted by the *Torrey Canyon* oil spill (Smith, 1968), so *Balanus crenatus* is probably fairly resistant to oil.

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 any evidence is presented where available.

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 and that intertidal populations of *Corallina officinalis* occurred in significant numbers only 600 m east of the effluent. 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.

Barnacles have a low resilience to chemicals such as dispersants, dependant on the concentration and type of chemical involved (Holt *et al*., 1995). They are less intolerant than some species (e.g. *Patella vulgata*) to dispersants (Southward & Southward, 1978) and *Balanus crenatus* was the dominant species on pier pilings at a site subject to urban sewage pollution (Jakola & Gulliksen, 1987). Hoare & Hiscock (1974) found that *Balanus crenatus* survived near to an acidified halogenated effluent discharge where many other species were killed, suggesting a high tolerance to chemical contamination. Little information is available on the impact of endocrine disrupters on adult barnacles. Holt *et al.* (1995) concluded that barnacles are fairly sensitive to chemical pollution, therefore intolerance is reported as high. The species is an important early colonizer of sublittoral rock surfaces (Kitching, 1937) and it heavily recolonized a site that was dredged for gravel within seven months (Kenny & Rees, 1994). Therefore, recovery is predicted to be high.

Most pesticides and herbicides were suggested to be very toxic for invertebrates, especially crustaceans (amphipods isopods, mysids, shrimp and crabs) and fish (Cole *et al*., 1999).

Radionuclide contamination	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

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	High Q: High A: Low C: Medium	High Q: High A: High C: High	Not sensitive Q: High A: Low C: Medium

Specific information concerning oxygen consumption and reduced oxygen tolerances were not found for the key characterizing species within the biotope. It is likely that as this biotope occurs in areas that are shallow and tidally flushed that re-oxygenation is likely, limiting the effects of any de-oxygenation events. However, this may mean that the speices present have little exposure to low oxygen and may be sensitive to this pressure. *Balanus crenatus*, however, respires anaerobically so it can withstand some decrease in oxygen levels. When placed in wet nitrogen, where oxygen stress is maximal and desiccation stress is minimal, *Balanus crenatus* has a mean survival time of 3.2 days (Barnes *et al*., 1963) and this species is considered to be 'Not sensitive' to this pressure.

Sensitivity assessment. Based on *Balanus crenatus* and mitigation of de-oxygenation by water movements, this biotope is considered to have **'High'** resistance and '**High'** resilience (by default) and is, therefore, assessed as 'Not sensitive'.

Nutrient enrichment	High Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

Nutrient enrichment at the pressure benchmark is unlikely to affect the fauna within this biotope. 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. The encrusting coralline *Lithophyllum incrustans* were present at sites dominated by *Ulva* spp. in the Mediterranean exposed to high levels of nutrient enrichment from domestic sewage (Arévalo *et al*., 2007).

A slight increase in nutrient levels could be beneficial for barnacles and other suspension feeders by promoting the growth of phytoplankton and, therefore, increasing food supplies. *Balanus crenatus* was the dominant species on pier pilings, which were subject to urban pollution (Jakola & Gulliksen, 1987).

Sensitivity assessment. The pressure benchmark is relatively protective and the biotope is considered to have **'High'** resistance and **'High'** resilience (by default) and is judged to be 'Not sensitive' at the benchmark level.

Organic enrichment	High Q: High A: High C: High	High Q: High A: High C: High	Not sensitive Q: High A: High C: High

As the biotope occurs in tide-swept or wave exposed areas (Connor *et al*., 2004), water movements will disperse organic matter and reduce the level of exposure to this pressure. 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), suggesting the encrusting corallines are not sensitive to this pressure.

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 ecological groups based on tolerances to organic pollution, characterizing animal species; *Balanus crenatus and Spirobranchus triqueter* 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. It is not clear whether the pressure benchmark would lead to enrichment effects in this dynamic, scoured habitat. High water movements would disperse organic matter particles, mitigating the effect of this pressure. This biotope is probably 'Not sensitive' to this pressure, based on the AMBI categorisation (Borja *et al*., 2000, Gittenberger & Van Loon, 2011). Although species within the biotope may be sensitive to gross organic pollution resulting from sewage disposal and aquaculture, they are considered to have **'High'** resistance to the pressure benchmark which represents organic enrichment and therefore **'High'** resilience so that the biotope is assessed as **'Not Sensitive'**.

Physical Pressures

	Resistance	Resilience	Sensitivity
Physical loss (to land or freshwater habitat)	None Q: High A: High C: High	Very Low Q: High A: High C: High	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.

	Resistance	Resilience	Sensitivity
Physical change (to another seabed type)	None Q: High A: High C: High	Very Low Q: High A: High C: High	High Q: High A: High C: High

This biotope is characterized by the hard rock substratum (boulders, cobbles, and pebbles) to which the characterizing and associated species can firmly attach. Changes to a sedimentary habitat or an artificial substratum would significantly alter the character of the biotope through the loss of habitat.

Tillin & Tyler-Walters (2014) used records from the MNCR database as a proxy indicator of the resistance to physical change by *Balanus crenatus* and *Spirobranchus triqueter*. These species were reported from a variety of substratum types including fine (muddy sand, sandy mud and fine sands) and coarse sediments, where some hard surfaces (such as pebbles or shells) are present for the attached species.

Balanus crenatus and *Spirobranchus triqueter* are fouling organisms and occur on a wide variety of substrata (Harms & Anger, 1983; Andersson *et al*., 2009). As well as artificial and natural hard substrata *Balanus crenatus* and *Spirobranchus triqueter* also encrust a range of invertebrates; for example, *Spirobranchus triqueter* has been recorded on the hermit crab, *Pagurus bernhardus* (Fernandez-Leborans & Gabilondo, 2006) among other species. Similarly, *Balanus crenatus* has been reported to encrust empty shells of the invasive non-indigenous species *Ensis americanus* (Donovan, 2011) and *Carcinus maenas* (Heath, 1976).

Sensitivity assessment It should be noted that the basis of the sensitivity assessment for this pressure is the sensitivity of the biotope to changes in substratum type, rather than the sensitivity of the species. A permanent change in substratum type to artificial or sedimentary would lead to the reclassification of the biotope. Biotope resistance to this pressure is therefore assessed as **'None'** (loss of >75% of extent), as the change at the benchmark is permanent, resilience is assessed as ‘**Very low**’. Therefore, sensitivity is assessed as ‘**High**’.

Physical change (to another sediment type)	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

Not relevant to biotopes occurring on bedrock.

Habitat structure changes - removal of substratum (extraction)	None Q: Low A: NR C: NR	High Q: High A: High C: Medium	Medium Q: Low A: Low C: Low

The species characterizing this biotope are epifauna occurring on the boulders, cobbles and pebbles that characterize this biotope (Connor *et al*., 2004). Removal of the substratum would remove both the habitat (boulders, cobbles and pebbles) and the characterizing, attached species. In areas where large amounts of gravel have been extracted, *Balanus crenatus* has been observed to rapidly recolonize within months (Kenny & Rees, 1996). *Spirobranchus triqueter* and *Balanus crenatus* are both relatively short-lived species that mature rapidly and have long reproductive seasons and produce pelagic larvae. *Balanus crenatus* and *Spirobranchus* (studied as *Pomatoceros*) *triqueter* can utilise a variety of substrata including artificial and natural hard substratum, bivalves and other animals. The life-history traits and broad habitat preferences mean that populations of both species can recover rapidly following disturbance. Off Chesil Bank, the epifaunal community dominated by *Spirobranchus triqueter*, *Balanus crenatus* and *Electra pilosa*, decreased in cover in October as it was scoured away in winter storms, and was recolonized in May to June (Warner 1985). Warner (1985) reported that the community did not contain any persistent individuals, being dominated by rapidly colonizing organisms. While larval recruitment was patchy and varied between the years studied, recruitment was sufficiently predictable to result in a dynamic stability and a similar community was present in 1979, 1980 and 1983 (Warner, 1985).

Sensitivity assessment. Therefore, biotope resistance is assessed as ‘**None**’ (in the extraction footprint) but resilience (assuming habitat restoration e.g as similar substratum is deposited from the surrounding area by wave action) is assessed as ‘**High**’. Hence, sensitivity is assessed as ‘**Medium**’. Recovery will be prolonged (and sensitivity greater) where all the habitat is removed and restoration (artificial or natural) to the previous state does not occur.

Abrasion/disturbance of the surface of the substratum or seabed	Low Q: High A: High C: High	High Q: High A: High C: Medium	Low Q: High A: High C: High

The species characterizing this biotope occur on the rock and, therefore, have no protection from surface abrasion. High levels of abrasion from scouring by mobile sands and gravels is an important structuring factor in this biotope (Connor *et al*., 2004) and prevents replacement by less scour-tolerant species, such as red algae. Mechanical abrasion from scuba divers was 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) manipulated surface abrasion on a range of encrusting algae experimentally including *Lithophyllum impressum*. Crusts were brushed with either a nylon or steel brush for 1 minute each 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).

Hiscock (1983) noted that a community, under conditions of scour and abrasion from stones and boulders moved by storms, developed into a community consisting of fast-growing species such as *Spirobranchus* (formerly *Pomatoceros*) *triqueter*. Off Chesil Bank, the epifaunal community dominated by *Spirobranchus* (as *Pomatoceros) triqueter* and *Balanus crenatus* decreased in cover in October as it was scoured away in winter storms, but recolonized in May to June (Gorzula 1977). Warner (1985) reported that the community did not contain any persistent individuals but that recruitment was sufficiently predictable to result in a dynamic stability and a similar community, dominated by *Spirobranchus* (as *Pomatoceros triqueter*), *Balanus crenatus* and *Electra pilosa*, (an encrusting bryozoan), was present in 1979, 1980 and 1983 (Riley and Ballerstedt, 2005).

Re-sampling of fishing grounds that were historically studied (from the 1930s) indicated that some encrusting species including serpulid worms and several species of barnacles had decreased in abundance in gravel substrata subject to long-term scallop fishing (Bradshaw *et al*., 2002). These may have been adversely affected by the disturbance of the stones and dead shells on to which they attach (Bradshaw *et al*., 2002). Where individuals are attached to mobile pebbles, cobbles and boulders rather than bedrock, surfaces can be displaced and turned over preventing feeding and leading to smothering. This observation is supported by experimental trawling, carried out in shallow, wave disturbed areas using a toothed, clam dredge, which found that *Spirobranchus* sp. decreased in intensively dredged areas over the monitoring period (Constantino *et al*., 2009). In contrast, a study of *Spirobranchus* spp. aggregations found that the tube heads formed were not significantly affected by biannual beam trawling in the eastern Irish Sea (Kaiser *et al*., 1999). No changes in the number or size of serpulid tube heads were apparent throughout during the study, and no significant changes were detectable in the composition of the tube head fauna that could be attributed to fishing disturbance (Kaiser *et al*., 1999). Subsequent laboratory experiments on collected tube heads found that these were unlikely to resettle on the seabed in an orientation similar to that prior to disturbance (Kaiser *et al*., 1999). This may lead to the death of the resident serpulids and sessile associated fauna.

Sensitivity assessment. The impact of surface abrasion will depend on the footprint, duration and magnitude of the pressure. High levels of abrasion from scouring by mobile cobbles and pebbles is an important structuring factor in this biotope (Connor *et al*., 2004) but the persistence of the assemblage may depend on rapid recovery rather than high resistance (Gorzula, 1977). The evidence for the effects of severe scour and trawling on *Balanus crenatus and Spirobranchus triqueter*, suggest that resistance, to a single abrasion event, is **'Low'** but resilience is **'High'** so that sensitivity is assessed as **'Low'**, based upon the information for these species and the characterizing *Coralline* spp.

Penetration or disturbance of the substratum subsurface	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

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 Q: High A: Medium C: High	High Q: High A: High C: High	Not sensitive Q: High A: Medium C: High

This biotope occurs in scoured habitats and it is likely, depending on local sediment supply, 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).

The biotope occurs in shallow waters where light attenuation due to increases in turbidity is probably low and the characterizing animals are unlikely to be affected by increased or decreased clarity. Red algae and encrusting coralline algae especially, are known to be shade tolerant and are common components of the understorey on seaweed dominated shores. Therefore, an increase or decrease in light intensity is unlikely to adversely affect the crustose corallines as plants can acclimate to different light levels.

An increase in turbidity could be beneficial if the suspended particles are composed of organic matter, however high levels of suspended solids with increased inorganic particles may reduce filter-feeding efficiencies. A reduction in suspended solids will reduce food availability for filter-feeding species in the biotope (where the solids are organic), although effects are not likely to be lethal over the course of a year. A reduction in light penetration could also reduce the growth rate of phytoplankton and so limit zooplankton levels. However, light penetration itself is unlikely to be an important factor as both *Balanus crenatus* and *Spirobranchus triqueter* are recorded from the lower eulittoral or the lower circalittoral.

Available evidence indicates that *Spirobranchus triqueter* is tolerant of a wide range of suspended sediment concentrations (Riley and Ballerstedt, 2005). Stubbings and Houghton (1964) recorded *Spirobranchus* (as *Pomatoceros*) *triqueter* in Chichester harbour, which is a muddy environment. However, *Spirobranchus* (as *Pomatoceros*) *triqueter* has been noted to also occur in areas where there is little or no silt present (Price *et al*., 1980).

Barnes & Bagenal (1951) found that the growth rate of *Balanus crenatus* epizoic on *Nephrops norvegicus* was considerably slower than animals on raft exposed panels. This was attributed to reduced currents and increased silt loading of water in the immediate vicinity of *Nephrops norvegicus*. In dredge disposal areas in the Weser estuary, Germany, where turbidity is 35% above the natural rate of 10-100 mg/l, the abundance of *Balanus crenatus* was lower than in reference areas (Witt *et al*., 2004). Separating the effect of increased suspended solids from increased sedimentation and changes in sediment from sediment dumping is problematic, however (Witt *et al*., 2004). Balanids may stop filtration after silt layers of a few millimetres have been discharged (Witt *et al*., 2004), as the feeding apparatus is very close to the sediment surface.

Sensitivity assessment. Overall biotope resistance is assessed as **'High'** to an increase in suspended solids. Resilience is assessed as **'High'** (by default) as adults are likely to remain *in* *situ* from which recruitment can occur. Hence, the biotope is assessed as **'Not sensitive'** to decreased suspended solids.

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

This biotope is described as sand covered or sand scoured (Connor *et al*., 2004). The characterizing and associated species are therefore likely to tolerate intermittent episodes of sediment deposition.

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 the 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. Crustose corallines declined at medium and high levels of sedimentation (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.

As small, sessile species attached to the substratum, siltation at the pressure benchmark would bury *Balanus crenatus* and *Spirobranchus triqueter*. Holme & 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 & 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 presence of the characterizing and associated species in biotopes subject to sedimentation and scour (such as CR.MCR.EcCr.UrtScr), biotope resistance to this pressure, at the benchmark, is assessed as **'High'**, resilience is assessed as **'High'** (by default) and the biotope is assessed as **'Not sensitive'.** The assessment considers that sediments are rapidly removed from the biotope and that the scour tolerance of the characterizing animal species and encrusting corallines 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)	Medium Q: High A: Medium C: Medium	High Q: High A: High C: Medium	Low Q: High A: Medium C: Medium

This biotope is described as subject to scouring (Connor *et al*., 2004). The characterizing species occur in biotopes subject to sedimentation and scour (such as CR.MCR.EcCr.UrtScr) and are therefore likely to tolerate intermittent episodes of sediment movement and deposition. At the pressure benchmark 'heavy deposition' represents a considerable thickness of deposit and complete burial of the characterizing species 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 and the nature of the deposit.

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 the 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. Crustose corallines declined at medium and high levels of sedimentation (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.

As small, sessile species attached to the substratum, siltation at the pressure benchmark would bury *Balanus crenatus* and *Spirobranchus triqueter*. Holme & 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 & 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. Resistance is assessed as **'Medium'** as the biotope is exposed to frequent abrasion and scouring (the impact may be mitigated by rapid removal of the deposit) but some removal and mortalities may occur. Resilience is assessed as ‘**High**’ based on re-growth from the scour-tolerant, surviving bases of the encrusting corallines and larval recolonization by *Balanus crenatus* and *Spirobranchus triqueter*. Therefore, biotope sensitivity is assessed as **'Low'.**

Litter	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

Not assessed.

Electromagnetic changes	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

No evidence.

Underwater noise 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

Not relevant

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

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). Other red algae in the biotope are flexible with regard to light levels and can also acclimate to different light levels.

Spirobranchus triqueter is found in a variety of light environments from shallow sublittoral biotopes where light levels are relatively high, to deeper sites that are aphotic (De Kluijver, 1993). *Balanus crenatus* possesses a rudimentary eye and can detect and respond to sudden shading which may be an anti-predator defence (Forbes *et al*., 1971). *Balanus crenatus* tend to orient themselves when settling, with the least light sensitive area directed towards the light (Forbes *et al*., 1971), so that the more sensitive area can detect shading from predator movements in the area where light availability is lower (Forbes *et al*., 1971).

Sensitivity assessment. The key characterizing species colonize a broad range of light environments, from intertidal to deeper subtidal and shaded understorey habitats. Therefore, the biotope is assessed to have a ‘**High**’ resistance and, by default, ‘**High**’ resilience and to be ‘**Not sensitive**’ to this pressure.

Barrier to species movement	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive 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 the tidal excursion are not considered relevant to the characterizing crusting corallines 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) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (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) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Many invertebrate species within the biotope probably respond to light levels, detecting shade and shadow to avoid predators and day length in their behavioural or reproductive strategies. However, their visual acuity is probably very limited and they are unlikely to respond to a visual disturbance at the benchmark level. This pressure is, therefore, assessed as **'Not relevant'**.

Balanus crenatus possesses a rudimentary eye and can detect and respond to sudden shading which may be an anti-predator defence (Forbes *et al*., 1971). *Balanus crenatus* tend to orient themselves when settling, with the least light sensitive area directed towards the light (Forbes *et al*., 1971), so that the more sensitive area can detect shading from predator movements in the area where light availability is lower (Forbes *et al*., 1971).

Biological Pressures

	Resistance	Resilience	Sensitivity
Genetic modification & translocation of indigenous species	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

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 Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

The high levels of scour in this biotope will limit the establishment of all but the most scour resistant invasive non-indigenous species (INIS) from this biotope and no direct evidence was found for effects of INIS on this biotope.

Increased warming has allowed the Australian barnacle *Austrominius* (formerly, *Elminiusi) modestus*, to dominate sites previously occupied by *Semibalanus balanoides* and *Balanus crenatus* (Witte, 2010). However, on settlement panels deployed in SW Ireland, *Austrominius modestus* initially dominated panels in the lower subtidal but post-recruitment mortality over a year allowed *Balanus crenatus* to become the dominant barnacle (Watson *et al*., 2005). *Balanus crenatus* and *Austrominius modestus* have shown recruitment differences, which may alter the seasonal dominance patterns (Witte, 2010). Free-living aggregations (Balanuliths) of *Balanus crenatus* have been observed growing on shell fragments of the INIS, *Ensis directus* (Cadée, 2007).

Sensitivity assessment. As scouring of this biotope by mobile sediments limits establishment of all but robust 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 Q: High A: High C: High	High Q: High A: High C: High	Not sensitive 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 1990s 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 it was 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 pathogens are impacting temperate coralline habitats.

Sensitivity assessment. Based on the lack of reported mortalities of the characterizing species and the available evidence for the characterizing coralline crust, the biotope is judged to have **'High'** resistance to this pressure. By default, resilience is assessed as **'High'** and the biotope is classed as **'Not sensitive'** at the pressure benchmark.

Removal of target species	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

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 characterizing or associated species are described in the literature. Hence, this pressure is considered to be **'Not relevant'.**

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

Incidental removal of the key characterizing species would alter the character of the biotope, resulting in reclassification and the loss of species richness. The ecological services such as primary and secondary production, provided by characterizing and associated species, would also be lost.

As most species present in this biotope are relatively large, conspicuous and either sedentary or attached to rock surfaces they have little protection against removal.

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. Therefore, resistance is assessed as **‘Low’** and resilience as **‘Medium’** (based on the removal of coralline crusts), so that biotope sensitivity is assessed as **'Medium’.**

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