Balanus crenatus and/or *Spirobranchus triqueter* with spirorbid worms and coralline crusts on severely scoured vertical infralittoral rock

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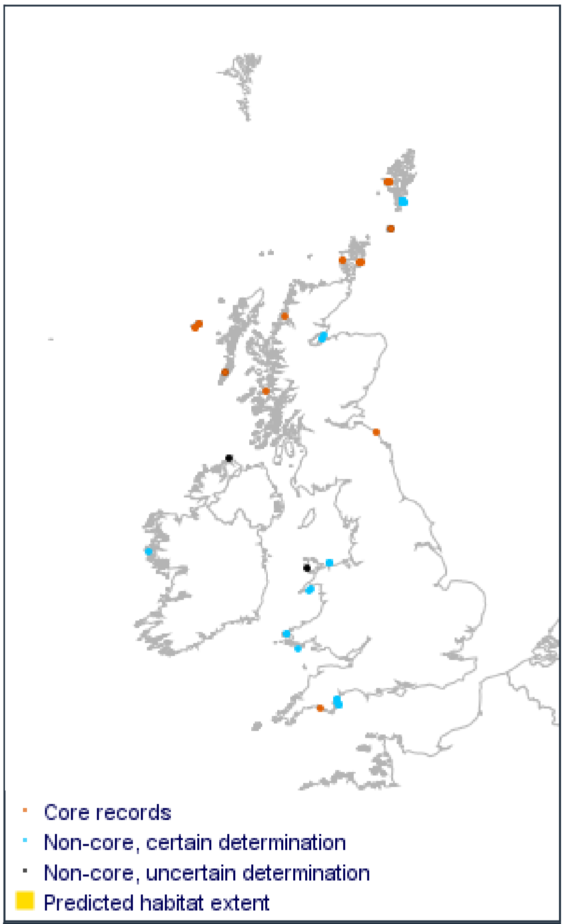

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Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by Eliza Gibson-Hall **Refereed by** This information is not refereed.

Summary

UK and Ireland classification

EUNIS 2008	A3.7161	*Balanus crenatus* and/or *Pomatoceros triqueter* with spirorbid worms and coralline crusts on severely scoured vertical infralittoral rock
JNCC 2015	IR.FIR.SG.CC.BalSpi	*Balanus crenatus* and/or *Spirobranchus triqueter* with spirorbid worms and coralline crusts on severely scoured vertical infralittoral rock
JNCC 2004	IR.FIR.SG.CC.BalPom	*Balanus crenatus* and/or *Pomatoceros triqueter* with spirorbid worms and coralline crusts on severely scoured vertical infralittoral rock
1997 Biotope	IR.EIR.SG.CC.BalPom	*Balanus crenatus* and/or *Pomatoceros triqueter* with spirorbid worms and coralline crusts on severely scoured vertical infralittoral rock

Description

This biotope is found on steep wave-surged, scoured rocks in caves, tunnels or gullies. It often looks rather bare and may be characterized by a limited scour-tolerant fauna of *Balanus crenatus* and/or *Spirobranchus triqueter* with spirorbid polychaetes. In areas where sufficient light is available and scour is severe, encrusting coralline algae may cover the rock surface as it is long-lived, and tolerant of abrasion, giving a pink appearance. The rock may be abraded by the movement of the boulders and cobbles in heavy surge. This biotope most commonly occurs where abrasion by cobbles and stones is severe, especially during winter.

The faunal community also consists of the anemones *Urticina felina* and *Sagartia elegans* which are able to grow within more-sheltered cracks. More mobile fauna include the echinoderms *Asterias rubens* and the crab *Cancer pagurus*. Other scour-tolerant species, such as encrusting bryozoans may also be common. During periods of relative stability in the summer, small quantities of foliose red seaweeds and opportunistic kelps may occur where sufficient light is available; The seaweeds, however, do not dominate (compared with EIR.FoSwCC) (JNCC, 2015).

Typically sponge crusts and ascidians with a hydroid-bryozoan turf will occur in the outer to mid section (CrSpAsAn, CrSpAsDenB); sponge crusts and dense ascidians in the outer to rear section (DenCcor); and low-growing sponge crusts at the rear of caves (CrSp). At some sites, CC.BalPom can form a zone towards the rear of the cave, beyond the sponge crust zone.

Depth range

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

Additional information

-

Listed By

- none -

Further information sources

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Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

This biotope is a sub biotope grouped within coralline crusts in surge gullies and scoured infralittoral rock (SG.CC), similar to coralline crusts on mobile boulders in severely scoured caves (CC.Mo). The main cover organisms are restricted to calcareous tube worms such as *Spirobranchus triqueter*, small barnacles including *Balanus crenatus*, spirorbid worms, and coralline algal crusts. Scour from the movement of mobile substrata, such as pebbles and stones, via wave action prevents the colonization of more delicate species.

Anemones and sponges may be associated with this biotope, but these are present in low abundances inside crevices in the rock and are not considered within the assessments as characterizing species. Severe abrasion resulting from scouring by cobbles and pebbles is the key factor structuring the biotope and significant alteration to scouring is likely to change the character of the biotope. Where pressures may alter this factor, this is identified and discussed within the sensitivity assessments.

Resilience and recovery rates of habitat

Spirorbids are rapid colonizers but poor competitors and, hence, are maintained in this biotope by the high levels of physical disturbance. Recovery may be within as little as three months for these species, based on their rapid settlement on artificial panels (James & Underwood, 1994; Saunders & Connell, 2001).

Populations of *Spirobranchus triqueter* have a spring reproductive maxima from March-April, although breeding can occur throughout the year. Populations of *Spirobranchus 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 (Dons, 1927; Hayward & Ryland, 1995a). *Spirobranchus triqueter* is considered to be a primary fouling organism (Crisp, 1965) colonizing artificial 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 2-3.5 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 produces 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 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. 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. Off Chesil Bank, the epifaunal community dominated by *Spirobranchus 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 triqueter* and *Balanus crenatus*.

Although ubiquitous in marine coastal systems, little is understood about the taxonomy, biology and ecology of the associated crustose corallines (Littler & Littler, 2013). 'Coralline crust' is a generic term 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), *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.

For example, 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.

Resilience assessment. *Balanus crenatus, Spirobranchus triqueter* and spirorbid worms are rapid colonizers and are likely to recover quickly, probably within months. During winter storms many individuals are removed due to the high levels of abrasion. However, species recolonize within a year. Therefore, resilience, of these species, is assessed as '**High**' for any level of perturbation. Even in instances where resistance is '**Medium**', '**Low**' or '**None**', and the key characterizing crustose corallines are likely to be removed, resilience is still assessed as '**High**' due to the rapid rejuvenation of the characterizing species. As a recognizable assemblage would be present without encrusting corallines, the biotope resilience assessments are based on *Balanus crenatus* and *Spirobranchus triqueter*.

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

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.

Balanus crenatus is described as a boreal species (Newman & Ross, 1976) and is found throughout the North East Atlantic from the Arctic to the west coast of France as far south as Bordeaux; the 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 experienced in the UK. *Spirobranchus triqueter* occurs from the Arctic, the eastern North Atlantic up to the Mediterranean. The Adriatic, Black and the Red Seas, the English Channel, the whole North Sea, Skagerrak, Kattegat, the Belts and Öresund up to the Bay of Kiel (De Kluijver *et al.*, 2016).

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.

Spirorbids are distributed circumglobally, with some differences in range between taxonomic groups (Knight-Jones *et al.*, 1991). The biotope classification does not specify species or families and therefore it is considered that a spirorbid group may be able to colonize this biotope regardless of temperature changes.

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'** but resilience is '**High**' and biotope sensitivity is, therefore, assessed as **'Low'**.

Temperature 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 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.

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), that 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 was unaffected during the severe winter of 1962-63, when average temperatures were 5 to 6°C below normal for the British Isles and much of Europe (Crisp, 1964a). Meadows (1969) noted decreased temperatures in Newcastle (England) during the severe winter of 1962-63. *Balanus crenatus* was amongst the fauna on the settlement panels deployed in the area and not affected. The temperature tolerance of *Balanus crenatus* collected from the lower intertidal in the winter (and thus acclimated to lower 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.

The characterizing *Spirobranchus triqueter* is found in both warmer and colder waters experienced in the UK. *Spirobranchus triqueter* occurs from the Arctic, the eastern North Atlantic up to the Mediterranean. Also in the Adriatic, Black and the Red Seas, 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 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. Intertidal populations of *Spirobranchus triqueter* were reported to suffer 50% mortality at Mumbles, on the Gower after the extreme winter of 1962-63 (Crisp, 1964b), however, the decrease in temperature exceeds the pressure benchmark.

The encrusting coralline *Lithophyllum incrustans* is close to the northern edge of its 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).

Spirorbids are distributed circumglobally, with some differences in range between taxonomic groups (Knight-Jones *et al*., 1991). The biotope classification does not specify species or families and therefore it is considered that a spirorbid group may be able to colonize this biotope regardless of temperature changes.

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, *Lithophyllum 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 '**High**' and resilience as '**High**' and the biotope is assessed as **'Not sensitive'**.

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

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 culture of *Balanus crenatus* eggs, found that viable nauplii larvae were obtained between 25-40% seawater 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 eggs were exposed to salinities of 50%, and 60% at an early developmental stage, viable larvae were not produced and, again, only a small proportion (7% and 1%, respectively) of eggs exposed at a later developmental stage produced nauplii- these were deformed and probably non-viable. There was no development at 70% (Barnes & Barnes, 1974).

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 vulnerable to extremes of local environmental temperature and salinity changes, for example than asexual plants.

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). Resistance is therefore assessed as '**Low**' and recovery as '**High**' (following restoration of usual salinity). Sensitivity is therefore 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 reduced salinity (18-30 ppt) is assessed. Some of the characterizing species are found in a similar biotope, CR.MCR.EcCr.UrtScr., that is present in variable salinities (Connor *et al*., 2004). It is therefore likely that the characterizing species will tolerate a reduction in salinity from full to reduced.

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 into a "salt sleep" (Barnes & Barnes, 1974). In this state the animals may survive 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% seawater 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" (Barnes & Barnes, 1974), 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 not be tolerant 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).

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 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).

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). Some losses of sensitive species such as *Electra pilosa* and other bryozoans may occur but over the course of a year, this is not considered to significantly alter the biotope assemblage from the description.

Water flow (tidal current) 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 occurs in sites with 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 and spirorbids 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) and was considered 'Not sensitive' at the pressure benchmark (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). Scour is a key factor structuring this biotope (Connor *et al*., 2004), changes in flow exceeding the pressure benchmark may increase or decrease to associated scour may lead to indirect changes in the character of the biotope.

Sensitivity assessment. A reduction in flow speed could temporarily allow the growth of less fragile organisms but once tidal flow returns to 'normal' these organisms will be killed, returning to the particular biotope. In addition, wave action (surge) is the main source of the scour that structures the biotope (Connor et al., 2004). 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. NB. 100% mortality could be expected in adult *Spirobranchus 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: Low C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

This biotope is recorded from locations that are judged to range from very well exposed to well exposed (Connor *et al.*, 2004).

Balanus crenatus, *Spirobranchus triqueter* and other characterizing species are firmly attached to the substratum and are unlikely to be dislodged by an increase in wave action at the pressure benchmark. *Balanus crenatus* and *Spirobranchus triqueter* 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). The crustose corallines and spirorbids associated with this biotope have a flat growth form and are unlikely to be dislodged by increased wave action.

Sensitivity assessment. The biotope is characterized by wave action and surge resulting in physical disturbance by coarse sediments. However, wave height will not have a significant effect on this biotope, therefore, it has a '**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) 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.

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 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 a fairly high level 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 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 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. 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	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	High Q: High A: Low C: Medium	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

As this biotope occurs in areas that are shallow and wave exposed re-oxygenation is likely, limiting the effects of any de-oxygenation events. However, this may mean that the species 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: Medium A: Medium C: Medium	High Q: High A: High C: High	Not sensitive Q: Medium A: Medium C: Medium

Nutrient enrichment at the pressure benchmark is unlikely to affect the fauna within this biotope, albeit, no direct evidence was found to assess this pressure. A slight increase in nutrient levels could be beneficial for barnacles by promoting the growth of phytoplankton levels and therefore increasing zooplankton levels. *Balanus crenatus* was the dominant species on pier pilings, which were subject to urban pollution (Jakola & Gulliksen, 1987). Limpets and other grazers would also benefit from the increased growth of benthic microalgae. However, Holt *et al.* (1995) predicted that smothering of barnacles by ephemeral green algae was possible under eutrophic conditions.

Over geological timescales, periods of increased nutrient availability have seen 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. *Corallina officinalis* has been identified worldwide as species that occur in areas subject to increased nutrient input within the vicinity of sewage outfalls and at intermediately polluted sites (Littler & Murray, 1975; May, 1985; Brown *et al*., 1990; Bellgrove *et al*., 1997, Arévalo *et al*., 2007; Bellgrove *et al*., 2010). For example, Kindig & Littler (1980) demonstrated that *Corallina officinalis var. chilensis* in South California showed equivalent or enhanced health indices, highest productivity and lowest moralities (amongst the species examined) when exposed to primary or secondary sewage effluent. *Corallina elongata* and the crusting 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, which assumes compliance with good status as defined by the WFD.

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 reducing the level of exposure. 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, the characterizing 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).

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.

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. 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 that represents organic enrichment and, therefore, '**High**' resilience. 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.

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

This biotope is characterized by the hard rock substratum to which the characterizing and associated species can firmly attach (Connor *et al.*, 2004). 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

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 re-classification 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**'. Sensitivity, based on combined resistance and resilience is, therefore, 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)	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 are epifauna 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	Low Q: Low A: NR C: NR	High Q: High A: High C: High	Low Q: Low A: Low C: Low

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) 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 each month for 24 months. Un-brushed 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 triqueter*. Off Chesil Bank, the epifaunal community dominated by *Spirobranchus 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 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). Experimental trawling carried out in shallow, wave disturbed areas using a toothed, clam dredge, which found that *Spirobranchus triqueter*. 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).

Sensitivity assessment. The evidence for the effects of severe scour and trawling on *Balanus crenatus* and *Spirobranchus triqueter* suggests vulnerability and the assemblage may, therefore, depend on rapid recovery rather than high resistance (Gorzula, 1977). The location of this biotope means it is likely to be out of range of fishing and trampling activities but will still be constantly eroded by abrasion from wave action and other debris. Resistance is, therefore, '**Low**' but with 'low' confidence. Resilience is **'High'** due to the rapid colonization ability of the characterizing species and sensitivity is, therefore assessed, as '**Low**'.

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. Therefore, this pressure is '**Not relevant'**.

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

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).

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 & Ballerstedt, 2005). Stubbings & Houghton (1964) recorded *Spirobranchus triqueter* in Chichester Harbour, which is a muddy environment. However, *Spirobranchus 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 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 categorised as '**High**' (by default) as adults are likely to remain in situ from which recruitment can occur. The biotope is considered to be **'Not sensitive'** to decreased suspended solids.

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

This biotope is described as severely scoured bedrock (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 *'Balanus-Pomatoceros'* assemblage on 'hard surfaces subjected to periodic severe scour and 'deep submergence by sand or gravel' in the English Channel. They inferred that the *'Balanus-Pomatoceros'* 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 1 cm for 25 days, with the centre of the disposal ground exposed to 6.5 cm 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, 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 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 flow 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: High	High Q: Medium A: Medium C: Medium	Low Q: Medium 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 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*, *Spirobranchus triqueter* and spirorbids. Holme & Wilson (1985) described a *'Balanus-Pomatoceros'* assemblage on 'hard surfaces subjected to periodic severe scour and 'deep submergence by sand or gravel' in the English Channel. They inferred that the *'Balanus-Pomatoceros'* 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*. Biotope sensitivity is therefore 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	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'.

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

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). *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).

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). 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.

Sensitivity assessment. The key characterizing species colonize a broad range of light environments, from intertidal to deeper subtidal and shaded understorey habitats. However, the biotope is considered to have '**High**' resistance and, by default, '**High**' resilience and, therefore, is '**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 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.

Sensitivity assessment. Resistance to this pressure is assessed as '**High**', but with 'low' confidence, 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

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).

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 visual disturbance at the benchmark level. This pressure is, therefore, assessed as **'Not relevant'.**

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

The 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, *Elminius) 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).

Two non-native spirobids – *Dexiospira oshoroensis* and *Pileolaria rosepigmentata* - were found on the non-native algae *Sargassum muticum* in Portsmouth (Knight-Jones *et al*., 1975). Invasive tubeworms are reported from UK harbours (Thorp *et al*., 1986) and are likely to be well established in areas with large volumes of ship traffic.

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	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

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 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).

Despite the above information **'No evidence'** was found that these pathogens are impacting temperate coralline habitats and **'No evidence'** was found that microbial pathogens cause high levels of disease or mortality in this biotope.

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

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

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

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