Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles

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

Dr Heidi Tillin & Dr Harvey Tyler-Walters

2016-02-12

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

Please note. This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [https://www.marlin.ac.uk/habitats/detail/177]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

This review can be cited as:
Tillin, H.M. & Tyler-Walters, H., 2016. [Spirobranchus triqueter] with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. DOI https://dx.doi.org/10.17031/marlinhab.177.1
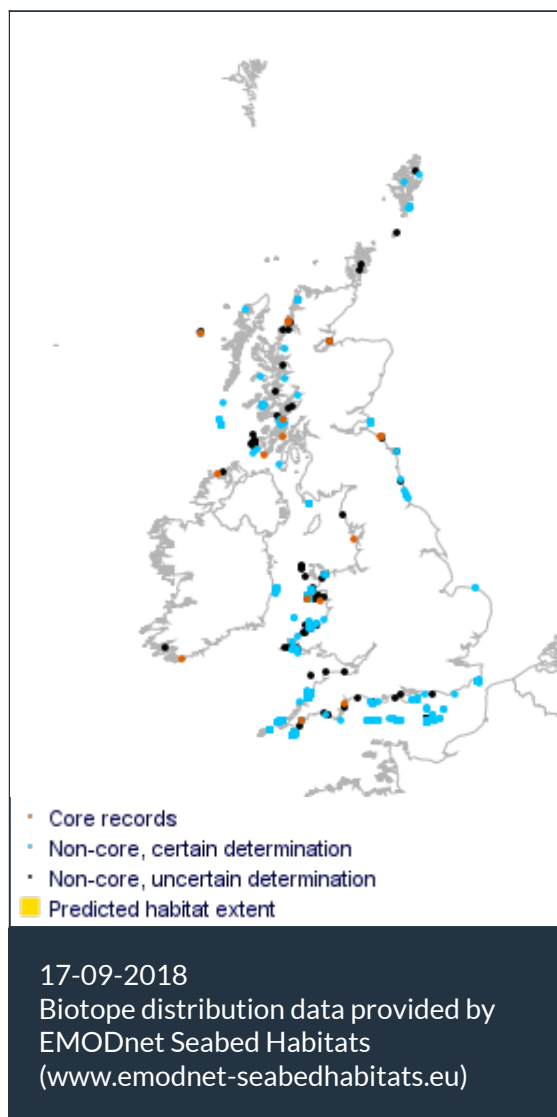
(page left blank)

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

Ophiocomina on cobbles and sediment (ECR.PomByC).
Photographer: Sue Scott
Copyright: Joint Nature Conservation Committee (JNCC)

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

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by   Dr Heidi Tillin & Dr Harvey Tyler-Walters   **Refereed by**   This information is not refereed.

Summary

≡ UK and Ireland classification

EUNIS 2008	A5.141	*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
JNCC 2015	SS.SCS.CCS.SpiB	*Spirobranchus triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
JNCC 2004	SS.SCS.CCS.PomB	*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
1997 Biotope	CR.ECR.EFa.PomByC	*Pomatoceros triqueter*, *Balanus crenatus* and bryozoan crusts on mobile circalittoral cobbles and pebbles

🏷 Description

This biotope is characterized by a few ubiquitous robust and/or fast growing ephemeral species which are able to colonise pebbles and unstable cobbles and slates which are regularly moved by

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

wave and tidal action. The main cover organisms tend to be restricted to calcareous tube worms such as *Spirobranchus triqueter* (formerly *Spirobranchus triqueter* (or *Spirobranchus lamarcki)*, small barnacles including *Balanus crenatus* and *Balanus balanus*, and a few bryozoan and coralline algal crusts. Scour action from the mobile substratum prevents colonisation by more delicate species. Occasionally in tide-swept conditions tufts of hydroids such as *Sertularia argentea* and *Hydrallmania falcata* are present. This biotope often grades into SMX.FluHyd which is characterized by large amounts of the above hydroids on stones also covered in *Spirobranchus* and barnacles. The main difference here is that SMX.FluHyd, seems to develop on more stable, consolidated cobbles and pebbles or larger stones set in sediment in moderate tides. These stones may be disturbed in the winter and therefore long-lived and fragile species are not found (Connor *et al.*, 2004; JNCC).

↓ Depth range

5-10 m, 10-20 m, 20-30 m, 30-50 m

🏛 Additional information

None entered.

✔ Listed By

- none -

🔗 Further information sources

Search on:

G 🅖 G JNCC

Habitat review

⟳ Ecology

Ecological and functional relationships

This biotope is characterized by an impoverished fauna, dominated by fast growing epifauna such as the tubeworms, encrusting bryozoans and barnacles. The dominant species probably compete for space on the available hard substrata. While *Spirobranchus triqueter* may overgrow encrusting bryozoans, encrusting bryozoans tolerate overgrowth and probably subsequently grow over the calcareous tube of *Spirobranchus triqueter* (Gordon, 1972; Rubin, 1985). Encrusting bryozoans and encrusting corallines also probably compete for space. But this biotope experiences seasonal and sporadic cycles of severe scour that will free space for colonization, so that competition is probably limited. Numerous species have been recorded within this biotope but most are probably opportunistic or are species that are fortunate to find temporary sheltered niches from scour, and the species present probably vary with location. Overall, the community is primarily opportunistic and ephemeral.

- Primary productivity is provided by encrusting corallines although few species present can probably graze them and few other algae are likely to survive scour in the long-term.
- The dominant species are suspension feeders on phytoplankton, zooplankton and organic particulates, e.g. the tubeworm *Spirobranchus triqueter*, barnacles *Balanus crenatus* and *Balanus balanus*, encrusting bryozoans (e.g. *Parasmittina trispinosa*), occasional erect Bryozoa (e.g. Crissiidae, *Flustra foliacea* and *Scrupocellaria* species), and occasional hydroids e.g. *Sertularia argentea*, *Nemertesia* species and *Hydrallmania falcata*).
- Where present, *Urticina felina* is a passive predator of zooplankton and small invertebrates.
- Mobile predators on epifauna include the starfish *Asterias rubens* and occasional *Echinus esculentus* feeding on epifaunal crusts, encrusting corallines, hydroids and bryozoans.
- Starfish and hermit crabs (e.g. *Pagurus bernhardus*) are probably generalist predators and scavengers within the biotope.

Seasonal and longer term change

This biotope probably experiences seasonal variation in scour, which is most severe in winter storms. Holme & Wilson (1985) suggested that the fauna of his *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. The biotope will probably exhibit spring and summer peaks in hydroids, erect bryozoa and fast growing ascidians. Species richness is probably highest in the spring and summer. Inter-annual variation in storms and wave action is likely to remove the majority of epifauna in some years but allow more species to become established in others. However, the biotope is dominated by opportunistic species and effectively annual and ephemeral. Off Chesil Bank, the epifaunal communities dominated by *Spirobranchus* (syn. *Pomatoceros*) *triqueter*, *Balanus crenatus* and *Electra pilosa*, decreased in cover in October, 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 but, 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.

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

Habitat structure and complexity

The surface of cobbles and pebbles support tubes of *Spirobranchus* species, encrusting coralline algae, encrusting bryozoans and barnacles. Boulders and more stable hard substrata may support more delicate species such as the hydroids, erect bryozoans (e.g. *Bugula* spp. and *Flustra foliacea*) and fast growing ascidians (e.g. *Ascidiella* species and *Dendrodoa grossularia*). Patches of gravel and sand overlying bedrock may support the large dahlia anemone *Urticina felina*. The sand and gravel infauna probably supports meiofauna and some polychaetes but no information was found. Mobile species such as squat lobster (e.g. *Galathea* spp.) may use spaces between boulders as temporary refuges. Brittlestars (e.g. *Ophiocomina nigra* and *Ophiothrix fragilis*) may utilize spaces between cobbles and pebbles. The biotope may be surrounded by more species rich biotopes. For example, the biotope may grade into MCR.Flu.SerHyd with increasing substratum stability (Connor *et al.*, 1997a). Holmes & Wilson (1985) noted that raised bedrock, above the main area affected by scour, in the English Channel was characterized by *Flustra foliacea* communities (see MCR.Flu for more information).

Productivity

This biotope is dominated by secondary producers. Food in the form of phytoplankton, zooplankton and organic particulates from the water column together with detritus and abraded macroalgal particulates from shallow water ecosystems are supplied by water currents and converted into faunal biomass. Their secondary production supplies higher trophic levels such as mobile predators (e.g. starfish, sea urchins, and fish) and scavengers (e.g. starfish and crabs) and the wider ecosystem in the form of detritus (e.g. dead bodies and faeces). In addition, reproductive products (sperm, eggs, and larvae) also contribute to the zooplankton (Hartnoll, 1998). No estimates of productivity were found in the literature but the biotope is impoverished so that productivity is likely to be low.

Recruitment processes

Spirobranchus triqueter probably breeds throughout the year with a peak in spring and summer, although breeding was reported to only occur in April at Port Erin (Moore, 1937; Segrove, 1941; Hayward & Ryland, 1995). Larvae are pelagic for about 2-3 weeks in the summer. However, in the winter this amount of time increases to about 2 months (Hayward & Ryland, 1995). Settlement was reported to be rare in winter but maximum settlement occurred in April, June, August and Sept-Oct (Castric-Fey, 1983). Once settled juveniles grow at about 1.5mm/month, and become sexually mature with about 4 months (see *MarLIN* review). *Spirobranchus triqueter* may live for up to 4 years, although 1.5-2.5 years is probably more usual and most die after reproduction (Castric-Fey, 1983; Hayward & Ryland, 1995), so that lifespan probably depends on location and environmental conditions. Dispersal potential is high, depending on local hydrographic condition, and tubeworms, such as spirorbids and *Spirobranchus triqueter* are commonly the initial recruits to new substrata (Sebens, 1985, 1986; Hatcher, 1998). For example, *Spirobranchus triqueter* colonized artificial reefs soon after deployment in summer (Jensen *et al.*, 1994), settlement plates within 2-3.5 months and dominated spring recruitment (Hatcher, 1998). However, in the mobile stone communities of Chesil Bank, Warner (1985) suggested that *Spirobranchus (syn. Pomatoceros) triqueter* did not reach sexual maturity in the population he studied.

The barnacle *Balanus crenatus* reproduces between February and September, larvae settling in a peak from April to October. Once settled, *Balanus crenatus* matures within 4 months, so that April

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

settled individuals can produce larvae by July, reaching full size before their first winter (Rainbow, 1984). *Balanus crenatus* has a lifespan of only 18 months so that the population requires continuous recruitment. Therefore, dispersal potential is high, depending on the local hydrographic regime. *Balanus crenatus* also colonized settlement plates or artificial reefs within 1-3 months of deployment in summer, (Brault & Bourget, 1985; Hatcher, 1998), and became abundant on settlement plates shortly afterwards (Standing, 1976; Brault & Bourget, 1985).

The brooded, lecithotrophic coronate larvae of many bryozoans (e.g. *Flustra foliacea*, *Parasmittina trispinosa*, and *Bugula* species), have a short pelagic lifetime of several hours to about 12 hours (Ryland, 1976). Recruitment is dependant on the supply of suitable, stable, hard substrata (Eggleston, 1972b; Ryland, 1976; Dyrynda, 1994). However, even in the presence of available substratum, Ryland (1976) noted that significant recruitment in bryozoans only occurred in the proximity of breeding colonies. Other species, such as *Electra* and *Crisia* release long-lived planktonic larvae. *Electra pilosa* has a planktonic larvae with a protracted life in the plankton and potentially extended dispersal and can colonize a wide variety of substrata. It is probably adapted to rapid growth and reproduction (r-selected), capable of colonizing ephemeral habitats, but may also be long lived in ideal conditions (Hayward & Ryland, 1998). In settlement studies, *Einhornia crustulenta* (as *Electra crustulenta*) recruited to plates within 5 -6months of deployment (Sandrock *et al.*, 1991). Jensen *et al.* (1994) reported that encrusting bryozoans colonized an artificial reef within 6-12months. Keough (1983) noted that *Parasmittina raigii* colonized settlement plates annually. Overall, encrusting bryozoans are probably rapid colonizers of available hard substrata.

Hydroids are often initial colonizing organisms in settlement experiments and fouling communities (Jensen *et al.*, 1994; Gili & Hughes, 1995; Hatcher, 1998). The hydroids (e.g. *Hydrallmania falcata* and *Sertularia argentea*) lack a medusa stage, releasing planula larvae. Planula larvae swim or crawl for short periods (e.g. <24hrs) so that dispersal away from the parent colony is probably very limited (Sommer, 1992; Gili & Hughes, 1995). However, *Nemertesia antennina* releases planulae on mucus threads, that increase potential dispersal to 5 -50m, depending on currents and turbulence (Hughes, 1977). Most species of hydroid in temperate waters grow rapidly and reproduce in spring and summer. Few species of hydroids have specific substrata requirements and many are generalists. Hydroids are also capable of asexual reproduction and many species produce dormant, resting stages, that are very resistant of environmental perturbation (Gili & Hughes, 1995). But Hughes (1977) noted that only a small percentage of the population of *Nemertesia antennina* in Torbay developed from dormant, regressed hydrorhizae, the majority of the population developing from planulae as three successive generations. Rapid growth, budding and the formation of stolons allows hydroids to colonize space rapidly. Fragmentation may also provide another route for short distance dispersal. Hydroids may potentially disperse over a wide area in the long-term as dormant stages, or reproductive adults, rafting on floating debris or hitch-hiking on ships hulls or in ballast water (Cornelius, 1992; Gili & Hughes, 1995).

Overall, the dominant species in the biotope, i.e. the tubeworms, encrusting bryozoans and barnacles, are good initial colonizers of hard substrata, capable of rapid growth and reproduction (*r*-selected) and adapted to ephemeral habitats.

Time for community to reach maturity

This biotope has a impoverished community consisting of rapid colonizing, rapid growing and reproducing species (see above). After winter storms or other severe disturbance, the dominant species would probably recolonize the habitat within a few months, and the community probably develops annually by recruitment from surviving individuals or colonies and recruitment from

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

adjacent or upstream habitats. The biotope would probably be recognizable within less than 6 months. Hydroids and erect bryozoans may take longer to establish, probably from surviving fragments or hydrorhizae but would either regrow or re-colonize within 6-12 months in most cases. Holme & Wilson (1985) suggested that the fauna of his *Balanus-Pomatoceros* assemblage was restricted to rapid growing colonizers able to settle rapidly and utilize space in short periods of stability in the summer months, and develop within less than a year.

Additional information

None entered

🖼 Preferences & Distribution

Habitat preferences

Depth Range	5-10 m, 10-20 m, 20-30 m, 30-50 m
Water clarity preferences	
Limiting Nutrients	
Salinity preferences	Full (30-40 psu)
Physiographic preferences	
Biological zone preferences	Circalittoral
Substratum/habitat preferences	Cobbles, Pebbles
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Strong 3 to 6 knots (1.5-3 m/sec.)
Wave exposure preferences	Exposed, Moderately exposed, Very exposed
Other preferences	Mobile hard substrata and scour

Additional Information

This biotope characterizes hard mobile substrata such as cobbles, pebbles and boulders with sand or gravel in areas of considerable water movement either due to wave action or tidal streams. The biotope occurs in very wave exposed to moderately wave exposed habitats, and/or in areas of strong to very weak tidal streams (Connor *et al.*, 1997a; JNCC, 1999). Scour of the cobbles, pebbles and boulders by sand, or by mobilization of the cobbles and pebbles themselves results in a scour resistant or ephemeral fauna. For example, in the mouth of the Teign, Devon, ECR.PomByC occurs on cobbles sitting on coarse sand and gravel in a scour pit. This biotope is probably very similar to the impoverished *Balanus-Pomatoceros* assemblage described on hard substrata subject to severe scour or deep submergence by sand or gravel reported by Holme & Wilson (1985) in tide-swept areas of the central English Channel.

🐾 Species composition

Species found especially in this biotope

- *Balanus crenatus*
- *Pomatoceros triqueter*

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

Rare or scarce species associated with this biotope

-

Additional information

The MNCR recorded 265 species in 9 records of this biotope. But only a few dominant species occurred in any abundance and most species were only occasional or rare, and not all species occurred in all records of the biotope.

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotope description and characterizing species is taken from Connor *et al.*, (2004). This biotope is characterized by a few ubiquitous robust and/or fast growing ephemeral species which are able to colonize pebbles and unstable cobbles and slates which are regularly moved by wave and tidal action. The main cover organisms tend to be restricted to calcareous tube worms such as *Spirobranchus triqueter* (or *Pomatoceros lamarcki*), small barnacles including *Balanus crenatus* and *Balanus balanus*, and a few bryozoan and coralline algal crusts. Scour action from the mobile substratum prevents colonization by more delicate species. The sensitivity assessments are based on the characterizing species *Balanus crenatus*, *Spirobranchus triqueter* and generic assessments for encrusting corallines and bryozoan crusts.

The mobile substrata preventing colonization by larger, long-lived and more sensitive species is a key factor structuring the biotope and significant alteration to the mobility of the cobble/pebble/ slate substrata 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

This biotope is considered to have a high recovery potential. Sebens (1985, 1986) noted that calcareous tube worms, encrusting bryozoans and erect hydroids and bryozoans covered scraped areas within 4 months in spring, summer and autumn. Most of the epifauna is probably subject to severe physical disturbance and scour during winter storms and probably develops annually, through recolonization from any surviving individuals and from adjacent habitats. Therefore, recovery is likely to be very high, the biotope developing within less than year and probably no more than 6 months in spring and summer.

Populations of *Spirobranchus triqueter* have a spring reproductive maxima from March-April, although reproduction 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, 1995b) and matures at 4 months (Hayward & Ryland, 1995; Dons, 1927). *Spirobranchus triqueter* is considered to be a primary fouling organism (Crisp, 1965), and colonizes a wide range of artificial structures such as buoys, ships hulls, docks and offshore oil rigs (OECD 1967). *Spirobranchus triqueter* are commonly the initial recruits 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 with *Spirobranchus triqueter* among them.

Balanus crenatus produce a single, large brood annually with peak larval supply in April –May (Salman, 1982). Although subsidiary broods may be produced, the first large brood is the most important for larval supply (Salman, 1982; Barnes & Barnes, 1968). *Balanus crenatus* has a lifespan of 18 months (Barnes & Powell, 1953) and grows rapidly (except in winter). *Balanus crenatus* is a

typical early colonizer of sublittoral rock surfaces (Kitching, 1937); for example, it heavily colonized a site that was dredged for gravel within 7 months (Kenny & Rees, 1994). *Balanus crenatus* colonized settlement plates or artificial reefs within 1-3 months of deployment in summer, and became abundant on settlement plates shortly afterwards (Brault & Bourget, 1985; Hatcher, 1998). The ship, *HMS Scylla*, was colonized by *Balanus crenatus* 4 weeks after sinking in March. The timing of the sinking in March would have ensured a good larval supply from the spring spawning. The presence of adult *Balanus crenatus* enhances the settlement rate of larvae on artificial panels (Miron *et al.*, 1996), so that surviving adults enhance recovery rates.

In temperate waters most bryozoan species tend to grow rapidly in spring and reproduce maximally in late summer, depending on temperature, day length and the availability of phytoplankton (Ryland, 1970). The brooded larvae of many bryozoans (e.g. *Flustra foliacea*, *Parasmittina trispinosa*, and *Bugula* species), have a short pelagic lifetime of several hours to about 12 hours (Ryland, 1976), limiting dispersal. Recruitment is dependent on the supply of suitable, stable, hard substrata (Eggleston, 1972b; Ryland, 1976; Dyrynda, 1994). However, even in the presence of available substratum, Ryland (1976) noted that significant recruitment in bryozoans only occurred in the proximity of breeding colonies and recovery will therefore be influenced by the survival of colonies to supply larvae to a habitat. Other species, such as *Electra* and *Crisia* release long-lived planktonic larvae. *Electra pilosa* has planktonic larvae with a protracted life in the plankton and potentially extended dispersal and can colonize a wide variety of substrata. It is probably adapted to rapid growth and reproduction (r-selected), capable of colonizing ephemeral habitats, but may also be long lived in ideal conditions (Hayward & Ryland, 1998). In settlement studies, *Einhornia crustulenta* (as *Electra crustulenta*) recruited to plates within 5 -6months of deployment (Sandrock *et al.*, 1991). Jensen *et al.* (1994) reported that encrusting bryozoans colonized an artificial reef within 6-12months. Keough (1983) noted that *Parasmittina raigii* colonized settlement plates annually. Overall, encrusting bryozoans are probably rapid colonizers of available hard substrata, although the composition of the bryozoan assemblage may change in response to different levels of disturbance, depending on whether colonies of species with low dispersal ability survive.

Spirobranchus triqueter and *Balanus crenatus* are both relatively short-lived species, that mature rapidly, have relatively extended reproductive seasons and produce pelagic larvae. This ensures a good larval supply to support recolonization of disturbed patches, without relying on the presence of local populations. *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 are expected to recover rapidly following disturbance. In some highly disturbed areas, these species dominate the assemblage and recover regularly from severe disturbances. Warner (1985) described how adjacent to Chesil Bank, England, the epifaunal assemblage dominated by *Spirobranchus triqueter*, *Balanus crenatus* and *Electra pilosa*, decreased in cover in October as it was scoured away in winter storms. The habitat was recolonized in May to June (Warner 1985). Although 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. Such communities are therefore not resistant of disturbance but instead, persist in the same area through high recovery rates.

Although ubiquitous in marine coastal systems, little is understood about the taxonomy, biology

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

and ecology of the associated crustose corallines (Littler & Littler, 2013). Coralline crust is a generic term that in UK biotopes refers to nongeniculate (crustose) species from the family *Corallinacea* that could include *Lithophyllum incrustans* which is noted to form thick crusts in tidepools, especially in the south west (Adey & Adey, 1973), *Lithothamnion* spp. And *Phymatolithon* spp. Due to the lack of evidence for species the assessments for encrusting corallines are generic, although species specific information is presented where available. A number of papers by Edyvean & Ford (1984a & b; 1986; 1987) describe aspects of reproduction and growth of encrusting coralline, *Lithophyllum incrustans*. Studies by Edyvean & Forde (1987) in populations of *Lithophyllum incrustans* in Pembroke south-west Wales suggest that reproduction occurs on average early in the third year. Reproduction may be sexual or asexual. Populations release spores throughout the year but abundance varies seasonally, with the populations studied in Cullercoats Bay and Lannacombe Bay (North East and South West England, respectively) producing less spores in the summer. Spore release is initiated by changes in temperature or salinity (see relevant pressure information) at low tide so that spore dispersal is restricted to within the tide pool enhancing local recruitment. Within subtidal biotopes this is not possible and recruitment success may be altered (although this may be compensated by avoidance of desiccation). Spore survival is extremely low with only a tiny proportion of spores eventually recruiting to the adult population (Edyvean & Ford, 1986). The spores are released from structures on the surface called conceptacles; these are formed annually and subsequently buried by the new layer of growth. Plants can be aged by counting the number of layers of conceptacles. Edyvean & Ford (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. Where resistance is 'High', resilience is assessed as 'High' by default. Bryozoans, *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. Where resistance is 'Medium' or Low', and parts of the crustose corallines remain, then recovery is also assessed as 'High'. However where resistance is 'Low' or 'None' and the key characterizing crustose corallines are likely to be removed, then resilience of this species is assessed as 'Medium'. As a recognizable assemblage would be present without encrusting corallines, the biotope resilience assessments are based on the bryozoans, *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

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

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	High	Low
	Q: High A: High C: High	Q: High A: High C: High	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), it is found throughout the northeast Atlantic, from the Arctic to the west coast of France, as far south as Bordeaux, and 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 species *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, Adriatic, Black and 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).

Most of the encrusting bryozoan species occurring in the biotope are distributed to the north and south of Britain and Ireland. E.g. the bryozoans *Electra pilosa* and *Parasmittina trispinosa* are considered unlikely to be affected by long-term changes in temperature. Acclimation to temperatures is possible. Menon (1972), for example, reported that the upper lethal temperature and median lethal temperature of *Electra pilosa* varied significantly with acclimation temperature, e.g. 24 hr upper lethal temperature was ca 25 °C in colonies acclimated to 5 °C but ca 29 °C when acclimated to 22 °C (Menon, 1972). An acute temperature change may affect growth, feeding and hence reproduction in bryozoans.

The encrusting coralline, *Lithophyllum incrustans*, occurs 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.

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

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)	High	High	Not sensitive
	Q: High A: High C: High	Q: High A: High C: High	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), 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 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* were among the fauna on the settlement panels that were deployed in the area and not affected.   The temperatures tolerances 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^{o}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, Adriatic, Black and 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. 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 bryozoan *Electra pilosa* is widely distributed in temperate seas, occurring as far north as the Barents Sea within the Arctic Circle (Gontar & Denisenko, 1989). Menon (1972) reported that individual zooids on the growing rim of colonies survived when kept at -4 °C for 14 days, although the inner zooids died. Menon (1972) demonstrated that all the zooids on the rim of colonies acclimated to 6 °C for 6 months before being kept in ice at -4 °C for 14 days, although apparently

killed regenerated when returned to 6 °C. Therefore, *Electra pilosa* is unlikely to be adversely affected by long-term temperature changes in British waters. Hyman (1959) reported that a reduction in temperature of only 3 °C was enough to interrupt feeding, and that *Electra pilosa* colonies became un-responsive at 4 °C. Therefore, acute short-term decreases in temperature may interfere with feeding and reproduction of bryozoans.

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).

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 'High' and resilience as 'High' and the biotope is therefore considered to be 'Not sensitive'.

Salinity increase (local)	Low	High	Low
	Q: High A: Low C: Medium	Q: High A: Low C: High	Q: High A: Low 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 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 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. As they occured with greater

frequency at sites where temperature and salinity were more stable (Edyvean & Ford, 1984b).

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	High	Not sensitive
	Q: High A: High C: High	Q: High A: High C: High	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., 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 in to 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 ‰ 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 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 *Spirobrannchus 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 were provided (Edyvean & Ford, 1984b). Populations of *Lithophyllum incrustans* were less stable in tide pools with a smaller volume of water that were more exposed to temperature and salinity changes due to lower buffering capacity. Sexual plants (or the spores that give rise to them) were suggested to be more susceptible than asexual plants to extremes of local environmental variables (temperature, salinity etc.) as they occur with greater frequency at sites where temperature and salinity were more

stable (Edyvean & Ford, 1984b).

Ryland (1970) stated that, with a few exceptions, bryozoans were fairly stenohaline and restricted to full salinity (ca 35 psu) and noted that reduced salinities result in an impoverished bryozoan fauna.

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

This biotope occurs across a range of flow speeds, from strong to moderately strong (0.5-1.5 m/s) (Connor *et al.*, 2004). The suspension feeders within the biotope benefit from high water flows supplying food and the mobility of the sediment prevents other species colonizing and outcompeting the characterizing species present.Scour from sediment mobility is a key factor structuring this biotope (Connor *et al.*, 2004); changes in flow exceeding the pressure benchmark may increase or decrease movement of cobbles, pebbles and slates resulting in indirect changes in the character of the biotope.

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. Growth of *Balanus crenatus* (measured as 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).

The bryozoan and 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).

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

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

Not relevant to subtidal biotopes. **NB**. 100% mortality could be expected in adult *Spirobranchus*

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

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

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

Balanus crenatus and *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 associated with this biotope have a flat growth form and are unlikely to be dislodged by increased wave action.

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

⚗ Chemical Pressures

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

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

Contamination at levels greater than the pressure benchmark may adversely impact the biotope. Barnacles accumulate heavy metals and store them as insoluble granules as a detoxification pathway (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 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).

Bryozoans are common members of fouling communities and amongst those organisms most resistant to antifouling measures, such as copper containing anti-fouling paints. Bryozoans were also shown to bioaccumulate heavy metals to a certain extent (Soule & Soule, 1979; Holt *et al.*, 1995).

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.

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

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

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.

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.

But bryozoans may be highly intolerant of the effects of oil spills and possibly hydrocarbons).

Little information on the effects of hydrocarbons on bryozoans was found. Ryland & de Putron (1998) did not detect adverse effects of oil contamination on the bryozoan *Alcyonidium* spp. or other sessile fauna in Milford Haven or St. Catherine's Island, south Pembrokeshire. Houghton *et al.* (1996) reported a reduction in the abundance of intertidal encrusting bryozoa (no species given) at oiled sites after the *Exxon Valdez* oil spill. Soule and Soule (1979) reported that the encrusting bryozoan *Membranipora villosa* was not found in the impacted area for 7 months after the December 1976 *Bunker C* oil spill in Los Angeles Harbour. Additionally, Soule and Soule (1979) reported that *Bugula neritina* was lost from breakwater rocks in the vicinity (in December 1979) of the *Bunker C* oil spill and had not recovered within a year. However, *Bugula neritina* had returned to a nearby area within 5 months (May 1977) even though the area was still affected by sheens of oil. Furthermore, only three of eight recorded species two weeks after the incident were present in April within the affected breakwater area. By June all the species had been replaced by dense growths of the erect bryozoan *Scrupocellaria diegensis*.

Mohammad (1974) reported that *Bugula* spp. and *Membranipora* spp. were excluded from settlement panels near a Kuwait Oil terminal subject to minor but frequent oil spills. Encrusting bryozoans are also probably intolerant of the smothering effects of acute hydrocarbon contamination and pollution, resulting in suffocation of colonies and communities may be lost or damaged. Circalittoral communities are likely to be protected from the direct effects of oil spills by their depth. However, the biotope may be exposed to emulsified oil treated with dispersants, especially in areas of turbulence, or may be exposed to water soluble fractions of oils, PAHs or oil adsorbed onto particulates (Tyler-Walters, 2002).

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

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

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.

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. Furthermore, intertidal populations of *Corallina officinalis* occurred in significant abundance only 600m 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.

Bryan & Gibbs (1991) reported that there was little evidence regarding TBT toxicity in Bryozoans with the exception of the encrusting *Schizoporella errata*, which suffered 50% mortality when exposed for 63 days to 100ng/l TBT. Hoare & Hiscock (1974) suggested that the Bryozoa, were amongst the most intolerant species to acidified halogenated effluents in Amlwch Bay, Anglesey, e.g. *Electra pilosa* occurred at low abundance on laminarian holdfasts within the bay, compared to sites outside the affected area. Rees *et al.* (2001) reported that the abundance of epifauna (including bryozoans) had increased in the Crouch estuary in the five years since TBT was banned from use on small vessels. This last report suggests that bryozoans may be at least inhibited by the presence of TBT.

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

No evidence.

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

This pressure is **Not assessed**.

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

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

biotope due to lack of evidence.

It should be noted that *Balanus crenatus* 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

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

Nutrient enrichment at the pressure benchmark is unlikely to affect the fauna within this biotope. In general, at the pressure benchmark the characterizing invertebrates are unlikely to be affected by changes in plant nutrient levels. A slight increase in nutrient levels could be beneficial for barnacles and other suspension feeders by promoting 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).

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) have suggested 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).

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'.

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

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 AMBI index), the characterizing animal species; *Balanus crenatus and Spirobranchus triqueter* and bryozoans (*Electra pilosa*) 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 crustose coralline *Lithophyllum incrustans* was 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 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 habitat. High water movements would disperse organic matter particles, mitigating the effect of this pressure. Based on the AMBI categorisation (Borja *et al*., 2000, Gittenberger & Van Loon, 2011), the characterizing species are assessed as 'Not Sensitive' to this

pressure based on 'High' resistance and 'High' resilience.

Physical Pressures

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

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

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

This biotope is characterized by the hard rock substratum to which the characterizing and associated species can firmly attach to (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. 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 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'.

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

This biotope is characterized by the hard substratum provided by the pebbles and cobbles to which the key characterizing species barnacles, tube worms and encrusting corallines can firmly attach to (Connor *et al*., 2004). A change to a mobile gravel or soft sedimentary substratum would significantly alter the character of the biotope. The biotope is considered to have 'No' resistance to

this pressure based on a change to a soft sediment substratum, recovery of the biological assemblage (following habitat restoration) is considered to be 'High'. However, the pressure benchmark is considered to refer to a permanent change and recovery is therefore 'Very low'. Sensitivity is therefore assessed as 'High'.

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

The species characterizing this biotope are epifauna occurring on the cobbles and pebbles that characterize this biotope (Connor *et al*., 2004). Removal of the substratum would remove both the habitat (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).

Sensitivity assessment. Biotope resistance is assessed as 'None' (in the extraction footprint), resilience (following habitat restoration, or where the underlying substratum remains the same) is assessed as 'High'. Sensitivity is therefore 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	High	Low
	Q: High A: High C: High	Q: High A: High C: High	Q: High A: High C: High

The species characterizing this biotope occur on the rock surface 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. Where individuals are attached to mobile pebbles, cobbles and boulders rather than bedrock, surfaces can be displaced and turned over leaing to smothering of attached algae and animals or at least reducing photosynthesis, respiration, feeding efficiency and fertilization of gametes in the water column.

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* (as *Pomatoceros*) *triqueter*. Off Chesil Bank, the epifaunal community dominated by *Spirobranchus* (as *Pomatoceros) triqueter*, *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* spp. 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 was apparent throughout the course of 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.

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 a month for 24 months. Unbrushed controls grew by approximately 50 % where the cover of nylon brushed crusts and steel brushed crusts decreased by approximately 25 % and 40 % respectively (interpreted from figures in Dethier, 1994). In laboratory tests on chips of *Lithophyllum impressum,* brushing with a steel brush for 1 minute once a week for 3 weeks, resulted in no cover loss of two samples while a third 'thinned and declined' (Dethier, 1994).

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). 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' and recovery is 'High', so that sensitivity is assessed as 'Low'.

Penetration or disturbance of the substratum subsurface	Low	High	Low
	Q: High A: High C: High	Q: High A: High C: High	Q: High A: High C: High

This biotope is characterized by mobile pebbles and cobbles, pressures that lead to penetration and disturbance could damage associated species through abrasion and by overturning surfaces could result in smothering of attached algae and animals or reductions in photosynthesis, respiration, feeding efficiency or fertilization of gametes in the water column. The biotope is, however, likely to be exposed to at least seasonal movement of substrata and this movement and scour maintains this biotope by preventing species that require more stable habitats from colonizing and developing stable populations (Connor *et al.*, 2004). Evidence presented above for surface abrasion is considered equally relevant to this pressure as abrasion in this biotope is likely to lead to movement and displacement of mobile substrata.

Sensitivity assessment. The impact of pressures that disturb and penetrate the mobile substrata 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). 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' and recovery is 'High', so that sensitivity is assessed as 'Low'.

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

This biotope occurs in 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).

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 growth rate of phytoplankton and so limit zooplankton levels and food supply to filter feeders such as *Balanus crenatus*. 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. 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.

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). Encrusting bryozoans may be more intolerant, although *Electra pilosa* is relatively tolerant of suspended sediment, for example Moore (1973c; 1977a) regarded *Electra pilosa* to be ubiquitous with respect to turbidity in subtidal kelp holdfasts in north east England

Barnes and 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 in this example is, however,

problematic (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.

An increase in light reaching the biotope (following decreased turbidity and scour) may benefit encrusting corallines and may encourage the growth of ephemeral algae, especially in the summer months. Hiscock (1986c) described ephemeral algal communities inhabiting pebbles off Skomer (southwest Wales). Several species were only present in summer, while others were abundant in summer but survived as small creeping fragments or sporelings during winter (e.g. *Polyneura gmelinii*, *Polysiphonia* spp, *Lomentaria orcadensis* and *Rhodophyllis divaricata*). Other species, such as *Cladophora* spp., *Bryopsis plumosa* and *Ulva* spp. showed seasonal variation (Hiscock, 1986c). Decreased turbidity may allow similar ephemeral algal to colonize the biotope, especially in its more shallow extent. Therefore, the biotope may be altered and a proportion of the biotope as described lost.

Sensitivity assessment. Overall biotope resistance is assessed as 'High' to an increase or decrease in suspended solids. Resilience is categorised as 'High' (by default). The biotope is considered to be 'Not sensitive' to decreased suspended solids.

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

As small, sessile species that are attached to the substratum, siltation at the pressure benchmark would bury *Balanus crenatus* and *Spirobranchus triqueter* and encrusting bryozoans and corallines. Holme and Wilson (1985) described a *Pomatoceros-Balanus* assemblage on 'hard surfaces subjected to periodic severe 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 that were able to establish in short periods of stability during summer months, as all fauna were removed in the winter months (Holme & Wilson, 1985). 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 10 mm 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 as a result of sediment dumping was problematic (Witt *et al*., 2004).

In a review of the effects of sedimentation on rocky coast assemblages, Airoldi (2003) outlined the evidence for the sensitivity of encrusting coralline algae to sedimentation. The reported results are contradictory with some authors suggesting that coralline algae are negatively affected by sediments, while others report that encrusting corallines are often abundant or even dominant in a variety of sediment impacted habitats (Airoldi, 2003 and references therein). Crustose corallines have been reported to survive under a turf of filamentous algae and sediment for 58 days (the duration of experiment) in the Galapagos (species not identified, Kendrick, 1991). The crustose coralline *Hydrolithon reinboldii*, has also been reported to survive deposition of silty sediments on subtidal reefs off Hawaii (Littler, 1973). In an experimental study, Balata *et al*. (2007) enhanced sedimentation on experimental plots in the Mediterranean (close to Tuscany) by adding 400 g of fine sediment every 45 days on plots of 400 cm^2 for 1 year. Nearby sites with higher and lower levels of sedimentation were assessed as control plots. Some clear trends were observed. Crustose

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

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.

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

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.

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

In a review of the effects of sedimentation on rocky coast assemblages, Airoldi (2003) outlined the evidence for the sensitivity of encrusting coralline algae to sedimentation. The reported results are contradictory with some authors suggesting that coralline algae are negatively affected by sediments while others report that encrusting corallines are often abundant or even dominant in a variety of sediment impacted habitats (Airoldi, 2003 and references therein). Crustose corallines have been reported to survive under a turf of filamentous algae and sediment for 58 days (the duration of experiment) in the Galapagos (species not identified, Kendrick, 1991). The crustose

coralline *Hydrolithon reinboldii,* has also been reported to survive deposition of silty sediments on subtidal reefs off Hawaii (Littler, 1973). In an experimental study, Balata *et al.* (2007) enhanced sedimentation on experimental plots in the Mediterranean (close to Tuscany) by adding 400 g of fine sediment every 45 days on plots of 400 cm^2 for 1 year. Nearby sites with higher and lower levels of sedimentation were assessed as control plots. Some clear trends were observed. 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.

Sensitivity assessment. Resistance is assessed as 'Medium' as the biotope is exposed to frequent abrasion and scouring (the impact may therefore be mitigated by rapid removal of the deposit) but some of the characterizing species may die. 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)	Not assessed (NA)	Not assessed (NA)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Not assessed.

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

No evidence.

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

Not relevant.

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

Spirobranchus triqueter and *Balanus crenatus* also 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).

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).

Sensitivity assessment. As the key characterizing species colonize a broad range of light environments, from intertidal to deeper sub tidal and shaded understorey habitats; the biotope is

considered to have 'High' resistance and, by default, 'High' resilience and therefore is 'Not sensitive' to this pressure.

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

Barriers that reduce the degree of tidal excursion may alter larval supply to suitable habitats from source populations. Conversely the presence of barriers may enhance local population supply by preventing the loss of larvae from enclosed habitats. No direct evidence was found to assess this pressure. As the larvae of *Balanus crenatus* and *Spirobranchus triqueter* are planktonic and are transported by water movements, barriers that reduce the degree of tidal excursion may alter larval supply to suitable habitats from source populations. However the presence of barriers may enhance local population supply by preventing the loss of larvae from enclosed habitats. As both species are widely distributed and have larvae capable of long distance transport, resistance to this pressure is assessed as 'High' and resilience as 'High' by default. This biotope is therefore considered to be 'Not sensitive'. 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.

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

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

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

Not relvant. *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). However, this species and others within the biotope are not considered sensitivite to visual disturbance from passing ships or othe disturbances and this pressure is considered to be 'Not relevant'.

🐚 Biological Pressures

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

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

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

The high levels of scour in this biotope will limit 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 *et al*, 2010). However, on test settlement panels deployed in SW Ireland, *Austrominius modestus* initially dominated panels in the lower subtidal. Yet post-recruitment mortality observed over a year allowed *Balanus crenatus* to become the dominant barnacle (Watson *et al*., 2005). *Balanus crenatus* and *Austrominus modestus* recruit at different times of the year in some sites and this alters seasonal dominance patterns (Witte *et al*., 2010).

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

No evidence was found that microbial pathogens cause high levels of disease or mortality in this biotope.

The commensal ciliate *Trichodina pediculus* was observed in "fair numbers" moving over the branchial crown of *Spirobranchus* (syn. *Pomatoceros*) *triqueter* (Thomas, 1940). Parasites found in the worm include gregarines and ciliated protozoa, as well as parasites that had the appearance of sporozoan cysts. However, no information was found about the effects of these parasites on *Spirobranchus triqueter*.

Diseased encrusting corallines were first observed in the tropics in the early 1990's when the bacterial pathogen Coralline Lethal Orange Disease (CLOD) was discovered (Littler & Littler, 1995). All species of articulated and crustose species tested to date are easily infected by CLOD and it has been increasing in occurrence at sites where first observed and spreading through the tropics. Another bacterial pathogen causing a similar CLOD disease has been observed with a greater distribution and a black fungal pathogen first discovered in American Samoa has been dispersing (Littler & Littler, 1998). An unknown pathogen has also been reported to lead to white 'target-shaped' marks on corallines, again in the tropic (Littler *et al*., 2007). No evidence was found that these 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)	Not relevant (NR)	Not relevant (NR)
	Q: NR A: NR C: NR	Q: NR A: NR C: 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

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

harvesting of characterizing or associated species was described in the literature, this pressure is therefore considered to be 'Not relevant'.

Removal of non-target species	Low	High	Low
	Q: Low A: NR C: NR	Q: High A: Low C: High	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 species, would also be lost.

Sensitivity assessment. Removal of a large percentage of the characterizing species resulting in bare rock would alter the character of the biotope, species richness and ecosystem function. Resistance is therefore assessed as 'Low' and recovery as 'High', so that biotope sensitivity is assessed as 'Low'.

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

Bibliography

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

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

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

Andersson, M.H., Berggren, M., Wilhelmsson, D. & Öhman, M.C., 2009. Epibenthic colonization of concrete and steel pilings in a cold-temperate embayment: a field experiment. *Helgoland Marine Research*, **63**, 249-260.

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

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

Barnes, H. & Bagenal, T.B., 1951. Observations on *Nephrops norvegicus* and an epizoic population of *Balanus crenatus*. *Journal of the Marine Biological Association of the United Kingdom*, **30**, 369-380.

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

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

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

Barnes, H., Finlayson, D.M. & Piatigorsky, J., 1963. The effect of desiccation and anaerobic conditions on the behaviour, survival and general metabolism of three common cirripedes. *Journal of Animal Ecology*, **32**, 233-252.

Boney, A.D., 1971. Sub-lethal effects of mercury on marine algae. *Marine Pollution Bulletin*, **2**, 69-71.

Borja, A., Franco, J. & Perez, V., 2000. A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. *Marine Pollution Bulletin*, **40** (12), 1100-1114.

Bradshaw, C., Veale, L.O., Hill, A.S. & Brand, A.R., 2002. The role of scallop-dredge disturbance in long-term changes in Irish Sea benthic communities: a re-analysis of an historical dataset. *Journal of Sea Research*, **47**, 161-184.

Brault, S. & Bourget, E., 1985. Structural changes in an estuarine subtidal epibenthic community: biotic and physical causes. *Marine Ecology Progress Series*, **21**, 63-73.

Brazier, D.P., Holt, R.H.F., Murray, E. & Nichols, D.M., 1999. *Marine Nature Conservation Review Sector 10. Cardigan Bay and North Wales: area summaries.* Peterborough: Joint Nature Conservation Committee. [Coasts and seas of the United Kingdom. MNCR Series.]

Bryan, G.W. & Gibbs, P.E., 1991. Impact of low concentrations of tributyltin (TBT) on marine organisms: a review. In: *Metal ecotoxicology: concepts and applications* (ed. M.C. Newman & A.W. McIntosh), pp. 323-361. Boston: Lewis Publishers Inc.

Bryan, G.W., 1984. Pollution due to heavy metals and their compounds. In *Marine Ecology: A Comprehensive, Integrated Treatise on Life in the Oceans and Coastal Waters,* vol. 5. *Ocean Management,* part 3, (ed. O. Kinne), pp.1289-1431. New York: John Wiley & Sons.

Cadée, G.C., 2007. Balanuliths: free-living clusters of the barnacle *Balanus crenatus*. *Palaios*, **22**, 680-681.

Campbell, D.A. & Kelly, M.S., 2002. Settlement of *Pomatoceros triqueter* (L.) in two Scottish lochs, and factors determining its abundance on mussels grown in suspended culture. *Journal of Shellfish Research*, **21**, 519-528.

Castric-Fey, A., 1983. Recruitment, growth and longevity of *Pomatoceros triqueter* and *Pomatoceros lamarckii* (Polychaeta, Serpulidae) on experimental panels in the Concarneau area, South Brittany. *Annales de l'Institut Oceanographique, Paris*, **59**, 69-91.

Chamberlain, Y.M., 1996. Lithophylloid Corallinaceae (Rhodophycota) of the genera *Lithophyllum* and *Titausderma* from southern Africa. *Phycologia*, **35**, 204-221.

Cole, S., Codling, I.D., Parr, W., Zabel, T., 1999. Guidelines for managing water quality impacts within UK European marine sites [On-line]. *UK Marine SACs Project*. [Cited 26/01/16]. Available from: http://www.ukmarinesac.org.uk/pdfs/water_quality.pdf

Colhart, B.J., & Johanssen, H.W., 1973. Growth rates of *Corallina officinalis* (Rhodophyta) at different temperatures. *Marine Biology*, **18**, 46-49.

Connor, D., Allen, J., Golding, N., Howell, K., Lieberknecht, L., Northen, K. & Reker, J., 2004. The Marine Habitat Classification for Britain and Ireland Version 04.05 JNCC, Peterborough. ISBN 1 861 07561 8.

Connor, D.W., Dalkin, M.J., Hill, T.O., Holt, R.H.F. & Sanderson, W.G., 1997a. Marine biotope classification for Britain and Ireland. Vol. 2. Sublittoral biotopes. *Joint Nature Conservation Committee, Peterborough, JNCC Report* no. 230, Version 97.06., *Joint Nature Conservation Committee, Peterborough, JNCC* Report no. 230, Version 97.06.

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

Constantino, R., Gaspar, M., Tata-Regala, J., Carvalho, S., Cúrdia, J., Drago, T., Taborda, R. & Monteiro, C., 2009. Clam dredging effects and subsequent recovery of benthic communities at different depth ranges. *Marine Environmental Research*, **67**, 89-99.

Cornelius, P.F.S., 1992. Medusa loss in leptolid Hydrozoa (Cnidaria), hydroid rafting, and abbreviated life-cycles among their remote island faunae: an interim review.

Cotter, E., O'Riordan, R.M & Myers, A.A. 2003. Recruitment patterns of serpulids (Annelida: Polychaeta) in Bantry Bay, Ireland. *Journal of the Marine Biological Association of the United Kingdom*, **83**, 41-48.

Crisp, D.J., 1965. The ecology of marine fouling. In: *Ecology and the Industrial Society, 5th Symposium of the British Ecological Society, 99-117* (ed. G.T. Goodman, R.W. Edwards & J.M. Lambert).

Crump, R.G., Morley, H.S., & Williams, A.D., 1999. West Angle Bay, a case study. Littoral monitoring of permanent quadrats before and after the *Sea Empress* oil spill. *Field Studies*, **9**, 497-511.

Davenport, J., 1976. A comparative study of the behaviour of some balanomorph barnacles exposed to fluctuating sea water concentrations. *Journal of the Marine Biological Association of the United Kingdom*, **5**, pp.889-907.

Davenport, J. & Davenport, J.L., 2005. Effects of shore height, wave exposure and geographical distance on thermal niche width of intertidal fauna. *Marine Ecology Progress Series*, **292**, 41-50.

Davies, C.E. & Moss, D., 1998. European Union Nature Information System (EUNIS) Habitat Classification. *Report to European Topic Centre on Nature Conservation from the Institute of Terrestrial Ecology, Monks Wood, Cambridgeshire.* [Final draft with further revisions to marine habitats.], Brussels: European Environment Agency.

De Kluijver, M.J., 1993. Sublittoral hard-substratum communities off Orkney and St Abbs (Scotland). *Journal of the Marine Biological Association of the United Kingdom*, **73** (4), 733-754.

Dethier, M.N., 1994. The ecology of intertidal algal crusts: variation within a functional group. *Journal of Experimental Marine Biology and Ecology*, **177** (1), 37-71.

Devlin, M.J., Barry, J., Mills, D.K., Gowen, R.J., Foden, J., Sivyer, D. & Tett, P., 2008. Relationships between suspended particulate material, light attenuation and Secchi depth in UK marine waters. *Estuarine, Coastal and Shelf Science*, **79** (3), 429-439.

Dixon, D.R., 1985. Cytogenetic procedures. *Pomatoceros triqueter*: A test system for environmental mutagenesis. In *The effects of stress and pollution in marine animals.*

Donovan, S.K., 2011. Postmortem encrustation of the alien bivalve *Ensis americanus* (Binney) by the barnacle Balanus crenatus Brugière in the North Sea. *Palaios*, **26**, 665-668.

Dons, C., 1927. Om Vest og voskmåte hos *Pomatoceros triqueter*. *Nyt Magazin for Naturvidenskaberne*, **LXV**, 111-126.

Dyrynda, P.E.J., 1994. Hydrodynamic gradients and bryozoan distributions within an estuarine basin (Poole Harbour, UK). In *Proceedings of the 9th International Bryozoology conference, Swansea, 1992. Biology and Palaeobiology of Bryozoans* (ed. P.J. Hayward, J.S. Ryland & P.D. Taylor), pp.57-63. Fredensborg: Olsen & Olsen.

Eckman, J.E. & Duggins, D.O., 1993. Effects of flow speed on growth of benthic suspension feeders. *Biological Bulletin*, **185**, 28-41.

Edyvean, R.G.J. & Ford, H., 1987. Growth rates of *Lithophyllum incrustans* (Corallinales, Rhodophyta) from south west Wales. *British Phycological Journal*, **22** (2), 139-146.

Edyvean, R.G.J. & Ford, H., 1984a. Population biology of the crustose red alga *Lithophyllum incrustans* Phil. 2. A comparison of populations from three areas of Britain. *Biological Journal of the Linnean Society*, **23** (4), 353-363.

Edyvean, R.G.J. & Ford, H., 1984b. Population biology of the crustose red alga *Lithophyllum incrustans* Phil. 3. The effects of local environmental variables. *Biological Journal of the Linnean Society*, **23**, 365-374.

Edyvean, R.G.J. & Ford, H., 1986. Population structure of *Lithophyllum incrustans* (Philippi) (Corallinales Rhodophyta) from south-west Wales. *Field Studies*, **6**, 397-405.

Eggleston, D., 1972b. Factors influencing the distribution of sub-littoral ectoprocts off the south of the Isle of Man (Irish Sea). *Journal of Natural History*, **6**, 247-260.

Fernandez-Leborans, G. & Gabilondo, R., 2006. Taxonomy and distribution of the hydrozoan and protozoan epibionts on *Pagurus bernhardus* (Linnaeus, 1758) (Crustacea, Decapoda) from Scotland. *Acta Zoologica*, **87**, 33-48.

Forbes, L., Seward, M.J. & Crisp, D.J., 1971. Orientation to light and the shading response in barnacles. In: *Proceedings of the 4th European Marine Biology Symposium.* Ed. Crisp, D.J., Cambridge University Press, Cambridge. pp 539-558.

Foster, B.A., 1970. Responses and acclimation to salinity in the adults of some balanomorph barnacles. *Philosophical Transactions of the Royal Society of London, Series B*, **256**, 377-400.

Foster, P., Hunt, D.T.E. & Morris, A.W., 1978. Metals in an acid mine stream and estuary. *Science of the Total Environment*, **9**, 75-86.

Gili, J-M. & Hughes, R.G., 1995. The ecology of marine benthic hydroids. *Oceanography and Marine Biology: an Annual Review*, **33**, 351-426.

Gittenberger, A. & Van Loon, W.M.G.M., 2011. Common Marine Macrozoobenthos Species in the Netherlands, their Characterisitics and Sensitivities to Environmental Pressures. GiMaRIS report no 2011.08. DOI: 10.13140/RG.2.1.3135.7521

Gontar, V.I. & Denisenko, N.V., 1989. *Arctic Ocean Bryozoa*. In *The Arctic Seas. Climatology, oceanography, geology, and biology* (ed. Y. Herman), pp.341-371. New York: Van Nostrand Reinhold Co.

Gordon, D.P., 1972. Biological relationships of an intertidal bryozoan population. *Journal of Natural History*, **6**, 503-514.

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

Gorzula, S., 1977. A study of growth in the brittle-star *Ophiocomina nigra*. *Western Naturalist*, **6**, 13-33.

Guarnieri, G., Terlizzi, A., Bevilacqua, S. & Fraschetti, S., 2012. Increasing heterogeneity of sensitive assemblages as a consequence of human impact in submarine caves. *Marine Biology*, **159** (5), 1155-1164.

Guiry, M.D. & Guiry, G.M. 2015. AlgaeBase [Online], National University of Ireland, Galway [cited 30/6/2015]. Available from: http://www.algaebase.org/

Harms, J. & Anger, K., 1983. Seasonal, annual, and spatial variation in the development of hard bottom communities. *Helgoländer Meeresuntersuchungen*, **36**, 137-150.

Hartnoll, R.G., 1998. Circalittoral faunal turf biotopes: an overview of dynamics and sensitivity characteristics for conservation management of marine SACs, Volume VIII. *Scottish Association of Marine Sciences, Oban, Scotland*. [UK Marine SAC Project. Natura 2000 reports.]

Hatcher, A.M., 1998. Epibenthic colonization patterns on slabs of stabilised coal-waste in Poole Bay, UK. *Hydrobiologia*, **367**, 153-162.

Hayward, P.J. & Ryland, J.S. 1998. *Cheilostomatous Bryozoa. Part 1. Aeteoidea - Cribrilinoidea*. Shrewsbury: Field Studies Council. [Synopses of the British Fauna, no. 10. (2nd edition)]

Hayward, P.J. & Ryland, J.S. (ed.) 1995b. *Handbook of the marine fauna of North-West Europe.* Oxford: Oxford University Press.

Heath, D., 1976. The distribution and orientation of epizoic barnacles on crabs. *Zoological Journal of the Linnean Society*, **59**, 59-67.

Hiscock, K., 1983. Water movement. In *Sublittoral ecology. The ecology of shallow sublittoral benthos* (ed. R. Earll & D.G. Erwin), pp. 58-96. Oxford: Clarendon Press.

Hiscock, S., 1986c. Skomer Marine Nature Reserve subtidal monitoring project. Algal results. August 1984 to February 1986. *Nature Conservancy Council, Peterborough, CSD Report* no. 620., Peterborough, Nature Conservancy Council. (CSD Report No. 620.)

Hoare, R. & Hiscock, K., 1974. An ecological survey of the rocky coast adjacent to the effluent of a bromine extraction plant. *Estuarine and Coastal Marine Science*, **2** (4), 329-348.

Holme, N.A. & Wilson, J.B., 1985. Faunas associated with longitudinal furrows and sand ribbons in a tide-swept area in the English Channel. *Journal of the Marine Biological Association of the United Kingdom*, **65**, 1051-1072.

Holt, T.J., Jones, D.R., Hawkins, S.J. & Hartnoll, R.G., 1995. The sensitivity of marine communities to man induced change - a scoping report. *Countryside Council for Wales, Bangor, Contract Science Report*, no. 65.

Houghton, J.P., Lees, D.C., Driskell, W.B., Lindstrom & Mearns, A.J., 1996. Recovery of Prince William Sound intertidal epibiota from *Exxon Valdez* oiling and shoreline treatments, 1989 through 1992. In *Proceedings of the* Exxon Valdez *Oil Spill Symposium. American Fisheries Society Symposium*, no. 18, *Anchorage, Alaska, USA, 2-5 February 1993*, (ed. S.D. Rice, R.B. Spies, D.A., Wolfe & B.A. Wright), pp.379-411.

Hughes, R.G., 1977. Aspects of the biology and life-history of *Nemertesia antennina* (L.) (Hydrozoa: Plumulariidae). *Journal of the Marine Biological Association of the United Kingdom*, **57**, 641-657.

Huthnance, J., 2010. Ocean Processes Feeder Report. London, *DEFRA on behalf of the United Kingdom Marine Monitoring and Assessment Strategy (UKMMAS) Community.*

Hyman, L.V., 1959. *The Invertebrates*, vol. V. *Smaller coelomate groups.* New York: McGraw-Hill.

Irvine, L. M. & Chamberlain, Y. M., 1994. *Seaweeds of the British Isles,* vol. 1. *Rhodophyta*, Part 2B *Corallinales, Hildenbrandiales.* London: Her Majesty's Stationery Office.

Jakola, K.J. & Gulliksen, B., 1987. Benthic communities and their physical environment to urban pollution from the city of Tromso, Norway. *Sarsia*, **72**, 173-182.

Jensen, A.C., Collins, K.J., Lockwood, A.P.M., Mallinson, J.J. & Turnpenny, W.H., 1994. Colonization and fishery potential of a coal-ash artificial reef, Poole Bay, United Kingdom. *Bulletin of Marine Science*, **55**, 1263-1276.

JNCC, 2015. The Marine Habitat Classification for Britain and Ireland Version 15.03. (20/05/2015). Available from https://mhc.jncc.gov.uk/

JNCC (Joint Nature Conservation Committee), 1999. *Marine Environment Resource Mapping And Information Database (MERMAID): Marine Nature Conservation Review Survey Database.* [on-line] http://www.jncc.gov.uk/mermaid

Kain, J.M., 1982. The reproductive phenology of nine species of the Rhodophycota in the subtidal region of the Isle of Man. *British Phycological Journal*, **17**, 321-331.

Kain, J.M., 1987. Photoperiod and temperature as triggers in the seasonality of *Delesseria sanguinea*. *Helgolander Meeresuntersuchungen*, **41**, 355-370.

Kaiser, M.J., Cheney, K., Spence, F.E., Edwards, D.B. & Radford, K., 1999. Fishing effects in northeast Atlantic shelf seas: patterns in fishing effort, diversity and community structure VII. The effects of trawling disturbance on the fauna associated with the tubeheads of serpulid worms. *Fisheries Research (Amsterdam)*, **40**, 195-205.

Kendrick, G.A., 1991. Recruitment of coralline crusts and filamentous turf algae in the Galapagos archipelago: effect of simulated scour, erosion and accretion. *Journal of Experimental Marine Biology and Ecology*, **147** (1), 47-63

Kenny, A.J. & Rees, H.L., 1994. The effects of marine gravel extraction on the macrobenthos: early post dredging recolonisation. *Marine Pollution Bulletin*, **28**, 442-447.

Keough, M.J., 1983. Patterns of recruitment of sessile invertebrates in two subtidal habitats. *Journal of Experimental Marine Biology*

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

and Ecology, **66**, 213-245.

Kitching, J.A., 1937. Studies in sublittoral ecology. II Recolonization at the upper margin of the sublittoral region; with a note on the denudation of *Laminaria* forest by storms. *Journal of Ecology*, **25**, 482-495.

Littler, M. & Littler, D.S. 2013. The nature of crustose coralline algae and their interactions on reefs. *Smithsonian Contributions to the Marine Sciences*, **39**, 199-212

Littler, M.M., 1973. The population and community structure of Hawaiian fringing-reef crustose Corallinaceae (Rhodophyta, Cryptonemiales). J*ournal of Experimental Marine Biology and Ecology*, **11** (2), 103-120.

Littler, M.M. & Littler, D.S., 1995. Impact of CLOD pathogen on Pacific coral reefs. *Science*, **267**, 1356-1356.

Littler, M.M., Littler, D.S. & Brooks, B.L. 2007. Target phenomena on south Pacific reefs: strip harvesting by prudent pathogens? *Reef Encounter*, **34**, 23-24

Meadows, P.S., 1969. Sublittoral fouling communities on northern coasts of Britain. *Hydrobiologia*, **34** (3-4), pp.273-294.

Menon, N.R., 1972. Heat tolerance, growth and regeneration in three North Sea bryozoans exposed to different constant temperatures. *Marine Biology*, **15**, 1-11.

Miron, G., Bourget, E. & Archambault, P., 1996. Scale of observation and distribution of adult conspecifics: their influence in assessing passive and active settlement mechanisms in the barnacle *Balanus crenatus* (Brugière). *Journal of Experimental Marine Biology and Ecology*, **201** (1), 137-158.

Mohammad, M-B.M., 1974. Effect of chronic oil pollution on a polychaete. *Marine Pollution Bulletin*, **5**, 21-24.

Moore, H.B., 1937. *Marine Fauna of the Isle of Man.* Liverpool University Press.

Moore, J., Smith, J. & Northen, K.O., 1999. *Marine Nature Conservation Review Sector 8. Inlets in the western English Channel: area summaries.* Peterborough: Joint Nature Conservation Committee. [Coasts and seas of the United Kingdom. MNCR Series.]

Moore, P.G., 1973c. Bryozoa as a community component on the northeast coast of Britain. In *Living and fossil Bryozoa. Recent advances in research* (ed. G.P. Larwood), pp. 21-36.

Naylor, E., 1965. Effects of heated effluents upon marine and estuarine organisms. *Advances in Marine Biology*, **3**, 63-103.

Newman, W. A. & Ross, A., 1976. Revision of the Balanomorph barnacles including a catalogue of the species. *San Diego Society of Natural History Memoirs*, **9**, 1–108.

OECD (ed.), 1967. *Catalogue of main marine fouling organisms.* Vol. 3: *Serpulids.* Paris: Organisation for Economic Co-operation and Development.

Picton, B.E. & Costello, M.J., 1998. *BioMar* biotope viewer: a guide to marine habitats, fauna and flora of Britain and Ireland. [CD-ROM] *Environmental Sciences Unit, Trinity College, Dublin.*

Price, J.H., Irvine, D.E. & Farnham, W.F., 1980. *The shore environment. Volume 2: Ecosystems.* London Academic Press.

Pyefinch, K.A. & Mott, J.C., 1948. The sensitivity of barnacles and their larvae to copper and mercury. *Journal of Experimental Biology*, **25**, 276-298.

Rainbow, P.S., 1984. An introduction to the biology of British littoral barnacles. *Field Studies*, **6**, 1-51.

Rainbow, P.S., 1987. Heavy metals in barnacles. In *Barnacle biology. Crustacean issues 5* (ed. A.J. Southward), 405-417. Rotterdam: A.A. Balkema.

Riley, K. & Ballerstedt, S., 2005. *Spirobranchus triqueter. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom:. [cited 08/01/2016]. Available from: https://www.marlin.ac.uk/species/detail/1794

Rubin, J.A., 1985. Mortality and avoidance of competitive overgrowth in encrusting Bryozoa. *Marine Ecology Progress Series*, **23**, 291-299.

Ryland, J.S. & De Putron, S., 1998. An appraisal of the effects of the *Sea Empress* oil spillage on sensitive invertebrate communities. *Countryside Council for Wales Sea Empress Contract Report*, no. 285, 97pp.

Ryland, J.S., 1970. *Bryozoans.* London: Hutchinson University Library.

Ryland, J.S., 1976. Physiology and ecology of marine bryozoans. *Advances in Marine Biology*, **14**, 285-443.

Salman, S., 1982. Seasonal and short-term variations in abundance of barnacle larvae near the south-west of the Isle of Man. *Estuarine, Coastal and Shelf Science*, **15** (3), 241-253.

Sandrock, S., Scharf, E-M., von Oertzen, J.A., 1991. Short-term changes in settlement of micro- and macro-fouling organisms in brackish waters. *Acta Ichthyologica et Piscatoria*, **21**(Suppl.), 221-235.

Sebens, K.P., 1985. Community ecology of vertical rock walls in the Gulf of Maine: small-scale processes and alternative community states. In *The Ecology of Rocky Coasts: essays presented to J.R. Lewis, D.Sc.* (ed. P.G. Moore & R. Seed), pp. 346-371. London: Hodder & Stoughton Ltd.

Sebens, K.P., 1986. Spatial relationships among encrusting marine organisms in the New England subtidal zone. *Ecological Monographs*, **56**, 73-96.

Segrove, F., 1941. The development of the serpulid *Pomatoceros triqueta L. Quarterly Journal of Microscopical Science*, **82**, 467-540.

Smith, J.E. (ed.), 1968. 'Torrey Canyon'. *Pollution and marine life.* Cambridge: Cambridge University Press.

Sommer, C., 1992. Larval biology and dispersal of *Eudendrium racemosum* (Hydrozoa, Eudendriidae). *Scientia Marina*, **56**, 205-211.

Date: 2016-02-12

Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles - Marine Life Information Network

[*Proceedings of 2nd International Workshop of the Hydrozoan Society, Spain, September 1991. Aspects of hydrozoan biology* (ed. J. Bouillon, F. Cicognia, J.M. Gili & R.G. Hughes).]

Soule, D.F. & Soule, J.D., 1979. Bryozoa (Ectoprocta). In *Pollution ecology of estuarine invertebrates* (ed. C.W. Hart & S.L.H. Fuller), pp. 35-76.

Southward, A.J. & Southward, E.C., 1978. Recolonisation of rocky shores in Cornwall after use of toxic dispersants to clean up the *Torrey Canyon* spill. *Journal of the Fisheries Research Board of Canada*, **35**, 682-706.

Southward, A.J., 1955. On the behaviour of barnacles. I. The relation of cirral and other activities to temperature. *Journal of the Marine Biological Association of the United Kingdom*, **34**, 403-432.

Standing, J.D., 1976. Fouling community structure: effect of the hydroid *Obelia dichotoma* on larval recruitment. In *Coelenterate ecology and behaviour* (ed. G.O. Mackie), pp. 155-164. New York: Plenum Press.

Stubbings, H.G. & Houghton, D.R., 1964. The ecology of Chichester Harbour, south England, with special reference to some fouling species. *Internationale Revue der Gesamten Hydrobiologie*, **49**, 233-279.

Thomas, J.G., 1940. *Pomatoceros*, *Sabella* and *Amphitrite*. LMBC Memoirs on typical British marine plants and animals no.33. University Press of Liverpool. Liverpool

Tillin, H. & Tyler-Walters, H., 2014. Assessing the sensitivity of subtidal sedimentary habitats to pressures associated with marine activities. Phase 2 Report – Literature review and sensitivity assessments for ecological groups for circalittoral and offshore Level 5 biotopes. *JNCC Report* No. 512B, 260 pp. Available from: www.marlin.ac.uk/publications

UKTAG, 2014. UK Technical Advisory Group on the Water Framework Directive [online]. Available from: http://www.wfduk.org

Warner, G.F., 1985. Dynamic stability in two contrasting epibenthic communities. In *Proceedings of the 19th European Marine Biology Symposium, Plymouth, Devon, UK, 16-21 September, 1984* (ed. P.E. Gibbs), pp. 401-410.

Watson, D.I., O'Riordan, R.M., Barnes, D.K. & Cross, T., 2005. Temporal and spatial variability in the recruitment of barnacles and the local dominance of *Elminius modestus* Darwin in SW Ireland. *Estuarine, Coastal and Shelf Science*, **63** (1), pp.119-131.

Witt, J., Schroeder, A., Knust, R. & Arntz, W.E., 2004. The impact of harbour sludge disposal on benthic macrofauna communities in the Weser estuary. *Helgoland Marine Research*, **58** (2), 117-128.

Witte, S., Buschbaum, C., van Beusekom, J.E. & Reise, K., 2010. Does climatic warming explain why an introduced barnacle finally takes over after a lag of more than 50 years? *Biological Invasions*, **12** (10), 3579-3589.