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Semibalanus balanoides, *Fucus vesiculosus* and red seaweeds on exposed to moderately exposed eulittoral rock

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

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2018-03-26

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/140]. 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. & Hill, J.M., 2018. [Semibalanus balanoides], [Fucus vesiculosus] and red seaweeds on exposed to moderately exposed eulittoral rock. 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.140.1

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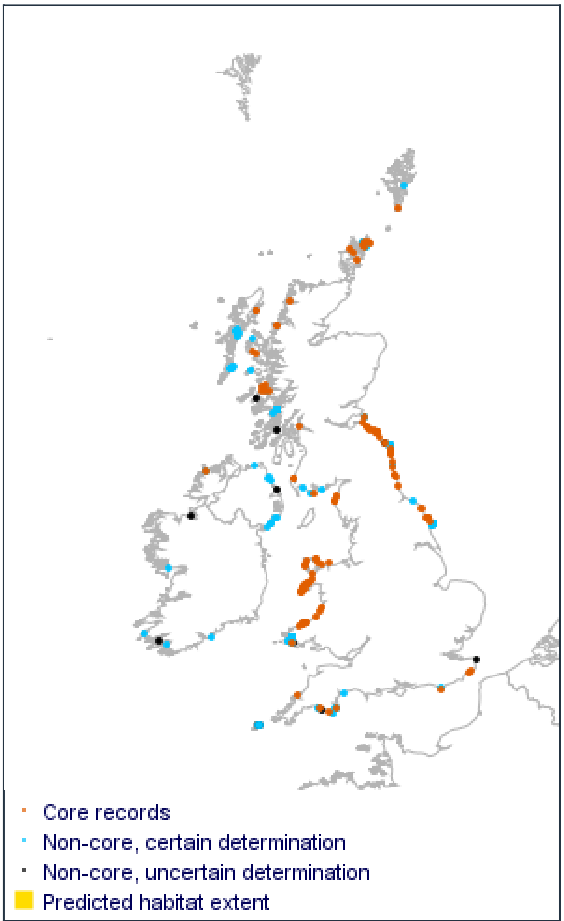
***Semibalanus balanoides*, *Fucus vesiculosus* and red seaweeds on exposed to moderately exposed eulittoral rock**
Photographer: Keith Hiscock



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

Researched by Dr Heidi Tillin & Jacqueline Hill **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A1.1132	*Semibalanus balanoides*, *Fucus vesiculosus* and red seaweeds on exposed to moderately exposed eulittoral rock
JNCC 2015	LR.HLR.MusB.Sem.FvesR	*Semibalanus balanoides*, *Fucus vesiculosus* and red seaweeds on exposed to moderately exposed eulittoral rock
JNCC 2004	LR.HLR.MusB.Sem.FvesR	*Semibalanus balanoides*, *Fucus vesiculosus* and red seaweeds on exposed to moderately exposed eulittoral rock
1997 Biotope	LR.ELR.MB.BPat.Fvesl	Barnacles, *Patella spp.* and *Fucus vesiculosus f. linearis* on exposed eulittoral rock

Description

Exposed and moderately exposed upper and mid eulittoral bedrock characterised by the barnacle *Semibalanus balanoides*, the limpet *Patella vulgata* and the whelk *Nucella lapillus* with a sparse community of seaweeds. Turfs of the wrack *Fucus vesiculosus* can be present on the more horizontal parts of the shore though usually in low abundance (Occasional). Individuals of *Fucus vesiculosus* can lack the characteristic twin air bladders due to environmental stress (i.e. wave exposure). A sparse seaweed community consisting of foliose red seaweeds such as *Osmundea pinnatifida* and *Mastocarpus stellatus* are usually present along with the *Corallina officinalis* and the green seaweed *Ulva intestinalis.* The algal community is usually restricted to fissures and cracks in the bedrock surface. Moist cracks and crevices also provide a refuge for small individuals of the mussel *Mytilus edulis* and the winkles *Littorina saxatilis* and *Littorina littorea*. These crevices can also be occupied by encrusting coralline algae and the anemone *Actinia equina* (Information from Connor *et al*., 2004; JNCC, 2015).

Depth range

Mid shore

Additional information

-

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotope description and information on the associated species are all taken from Connor *et al*., (2004) unless referenced otherwise. The key characterizing species for this biotope, on which the sensitivity assessments are based, are the barnacle *Semibalanus balanoides* and the limpet *Patella vulgata*. *Patella vulgata* is considered a key structuring species for this biotope, as its grazing controls the establishment of other species on the rock surface. *Patella vulgata* grazing can control the character of the shore by grazing algae and newly settled barnacle larvae. Even a small, localised temporary absence of limpets (Southward, 1964; Hawkins, 1981; Hawkins *et al*., 1983) can alter the biological assemblage. Significant limpet kills resulting from the widespread use of dispersants after the *Torrey Canyon* oil spill dramatically altered rocky shore communities. *Laminaria digitata*, for example, was able to extend 2 m upshore in the absence of limpets and there were dense growths of ephemeral green seaweeds followed by equally dense growth of fucoids (Southward & Southward, 1978; Hawkins & Southward, 1992). The hard rock substratum and exposure to wave action are key environmental factors structuring this biotope and are therefore considered, where relevant, in the sensitivity assessments.

The biotope has a relatively low diversity of associated species; cracks and crevices in the rock can provide a refuge for small individuals of the mussel *Mytilus edulis*, the winkle *Littorina saxatilis* and the whelk *Nucella lapillus*. Seaweeds are usually not found in high numbers though turfs of Fucus vesiculosus may develop on more horizontal shores and fissures and crevices in the bedrock can hold a sparse algal community including *Mastocarpus stellatus* and *Osmundea pinnatifida and* the green seaweed *Ulva intestinalis*. As these species occur in low numbers and are characteristic of many types of rocky shores they are not considered to be of specific importance to this biotope. On some shores, particularly those which are moderately exposed to wave action, temporal fluctuations in the abundance of limpets, barnacles and fucoid seaweeds may occur controlled by the interplay of environmental factors such as storm events and biological factors such as grazing. As a result, over a number of years, a single shore may cycle between the barnacle-*Patella vulgata* dominated biotope and a *Fucus vesiculosus*-dominated biotope.

Resilience and recovery rates of habitat

Recovery of the attached characterizing species *Semibalanus balanoides* and the algal turfs will depend on recolonization by larvae. *Patella vulgata* is mobile, but the ability to relocate depends on the shore type and roughness (as described below). All the characterizing animals species and others that are present, such as *Mytilus edulis* produce pelagic larvae. As these are common, widespread species, where the footprint of the impact is relatively small, larval supply from adjacent populations should support recolonization. Where source populations are very distant due to regional impacts or habitat discontinuities, larval supply and recovery could be affected. Changes and recovery trajectories following the removal of key species are unpredictable and interactions between the key species may be positive or negative. Limpets and littorinds may enhance barnacle settlement by grazing and removing algae (Hawkins, 1983) or by depositing pedal mucus trails that attract barnacle larvae (Holmes *et al*., 2005). Barnacles and small clumps of *Mytilus edulis* may enhance survival of small limpets by moderating environmental stresses but they may also have negative effects on recruitment by occupying space and by limiting access to grazing areas (Lewis & Bowman (1975). Dense coverings of mussels and fucoids, however, inhibit settlement of larvae through competition for space or prevention of settlement (Lewis & Bowman, 1975). Limpets may also crush and displace newly settled individuals (Safriel *et al*., 1994). Barnacles may enhance survival of small limpets by moderating environmental stresses but they may also have negative effects on recruitment by occupring space and by limiting access to grazing areas. On the wave exposed shores that this biotope occurs on, grazing may limit initial settlement of macroalgae but wave action will limit the presence of adults and larger species through, breakage and drag effects leading to loss. Mrowicki *et al*. (2014) found that limpet and barnacle removal allowed ephemeral and fucoid macroalgae to establish on sheltered and wave exposed shores in Ireland. Unlike the animal species macroalgae have short dispersal distances, over tens of metres (Dudgeon *et al*., 2001) and therefore recovery will require the presence of adults.

Recovery rates. Recolonization of *Patella vulgata* on rocky shores is rapid as seen by the appearance of limpet spat 6 months after the Torrey Canyon oil spill reaching peak numbers 4-5 years after the spill. Similarly, following creation of a new rocky shore in the Moray Firth, *Patella vulgata* was present in quadrats after three years (Terry & Sell, 1986). However, although recolonization was rapid on the oil impacted shores, the alteration to the population structure (size and age class) persisted for about 15 years because of the complex cycles of dominance (see below) involving limpets, barnacles and algae (Hawkins & Southward, 1992; Lewis & Bowman, 1975). Hence the establishment of fucoids if *Patella vulgata* and other grazers were absent may lead to longer term exclusion of this species.

On rocky shores, barnacles are often quick to colonize available gaps, although a range of factors, as outlined above, will influence whether there is a successful episode of recruitment in a year to re-populate a shore following impacts. Bennell (1981) observed that barnacles that were removed when the surface rock was scraped off in a barge accident at Amlwch, North Wales returned to pre-accident levels within 3 years. Petraitis & Dudgeon (2005) also found that *Semibalanus balanoides* quickly recruited (present a year after and increasing in density) to experimentally cleared areas within the Gulf of Maine, that had previously been dominated by *Ascophyllum nodosum* However, barnacle densities were fairly low (on average 7.6% cover) as predation levels in smaller patches were high and heat stress in large areas may have killed a number of individuals (Petraitis *et al*., 2003). Following the creation of a new shore in the Moray Firth, *Semibalanus balanoides* did not recruit in large numbers until 4 years after shore creation (Terry & Sell, 1986).

Life histories and reproduction. In northern England, limpets reached sexual maturity in their second year (Blackmore, 1969) and thereafter reproduce annually. Limpets may change sex during their lifetime, with younger animals being male and older animals tending to be female (Blackmore, 1969). In Robin Hood's Bay, Lewis & Bowman (1975) observed spawning of *Patella vulgata* in the Autumn, with spatfall occurring in winter when dessication pressures were lower.

The rate and density of colonization are affected by the presence of other species. Lewis & Bowman (working in Robin Hood's Bay in North England) observed that mussels promote settlement of *Patella vulgata*. Settlement was also higher amongst barnacles and light coverings of algae. Dense coverings of mussels and fucoids, however, inhibit settlement through competition for space or prevention of settlement.

Semibalanus balanoides brood egg masses over autumn and winter and release the nauplii larvae during spring or early summer, to coincide with phytoplankton blooms on which the larvae feed. Local environmental conditions, including surface roughness (Hills & Thomason, 1998), wind direction (Barnes, 1956), shore height, wave exposure (Bertness *et al*., 1991) and tidal currents (Leonard *et al*., 1998) have been identified, among other factors, as factors affecting settlement of *Semibalanus balanoides*. Biological factors such as larval supply, competition for space, the presence of adult barnacles (Prendergast *et al*., 2009) and the presence of species that facilitate or inhibit settlement (Kendall, *et al*., 1985, Jenkins *et al*., 1999) also play a role in recruitment. Mortality of juveniles can be high but highly variable, with up to 90 % of *Semibalanus balanoides* dying within ten days (Kendall *et al*., 1985).

Successful recruitment of a high number of *Semibalanus balanoides* individuals to replenish the population may be episodic (Kendall *et al*., 1985). After settlement, the juveniles are subject to high levels of predation as well as dislodgement from waves and sand abrasion depending on the area of settlement. *Semibalanus balanoides* may live up to 4 years in higher areas of the shore (Wethey,1985). Predation rates are variable (see Petraitis et al., 2003) and are influenced by a number of factors including the presence of algae (that shelters predators such as the dog whelk, Nucella lapillus, and the shore crab, *Carcinus maenas* and the sizes of clearings (as predation pressure is higher near canopies (Petraitis *et al*., 2003).

The turf forming red algae may recover through repair and regrowth of damaged fronds or via recolonization of rock surfaces where all the plant material is removed. The red algae have complex life histories and exhibit distinct morphological stages over the reproductive life history. Alternation occurs between asexual spore producing stages (tetrasporophytes) and male and female plants producing sexually. Life history stages can be morphologically different or very similar. The tetrasporophyte phase of *Mastocarpus stellatus* is known as the Petrocelis and is a flat crust, capable of growing laterally and covering extensive areas. Other red algae found within the biotope also have life stages that include prostrate creeping bases e.g. encrusting corallines, *Corallina officinalis* and *Osmundea pinnatifida*. The basal crusts and crustose tetrasporphytes are perennial, tough, resistant stages that may prevent other species from occupying the rock surface and allow rapid regeneration. They may therefore provide a significant recovery mechanism. For some red algae, such as *Corallina officinalis*, the basal crust is more resistant to some pressures than the fronds and provides a mechanism for recovery following exposure to pressures that remove the fronds. The physiological tolerances of the crust and gametophytes of *Mastocarpus stellatus* varied widely (Dudgeon *et al*., 1995). Where holdfasts and basal crusts are removed, recovery will depend on recolonization via spores. Norton (1992) reviewed dispersal by macroalgae and concluded that dispersal potential is highly variable, recruitment usually occurs on a much more local scale, typically within 10 m of the parent plant. Hence, it is expected that the algal turf would normally rely on recruitment from local individuals and that recovery of populations via spore settlement, where adults are removed, would be protracted.

Resilience assessment. No evidence for recovery rates was found specifically for this biotope. The evidence suggests that the size of the footprint of an impact and the magnitude will influence the recovery rates by mediating settlement and post-settlement recruitment. Barnacles are attracted to settle in the presence of adults of the same species (Prendergast et al., 2009; so that the presence of adults will facilitate recovery. Resilience is assessed as **'High'** (within 2 years) where resistance is 'High' (no significant impact) or 'Medium' (<25% of characteristic biotope removed, basal crusts and holdfasts of algae remain although >25% of fronds may be removed). A resistance of medium assumes that either a large proportion of the biotope is unimpacted or that the entire biotope is impacted but only a proportion of the characterizing species are removed, with unimpacted areas or individuals supporting recovery. Resilience is assessed as '**Medium'** (2-10 years) where resilience is 'None' or 'Low' (and algae bases and holdfasts are removed) as recruitment may be episodic and the age structure of the limpet population will require more time to recover.

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

Hydrological Pressures

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

Intertidal species are exposed to extremes of high and low air temperatures during periods of emersion. They must also be able to cope with sharp temperature fluctuations over a short period of time during the tidal cycle. In winter air temperatures are colder than the sea, conversely in summer air temperatures are much warmer than the sea. Species that occur in the intertidal are therefore generally adapted to tolerate a range of temperatures, with the width of the thermal niche positively correlated with the height of the shore that the animal usually occurs at (Davenport & Davenport, 2005).

At Great Cumbrae the median upper lethal temperature limit in laboratory tests on *Semibalanus balanoides* was approximately 35 °C (Davenport & Davenport, 2005). Although adults may be able to withstand acute and chronic increases in temperature at the pressure benchmark, increased temperatures may have sub-lethal effects on the population by impacting the success of reproduction phases. The distribution of both the key characterizing species, *Semibalanus balanoides* and *Patella vulgata* are 'northern' with their range extending from Portugal or Northern Spain to the Arctic circle. Populations in the southern part of England are therefore relatively close to the southern edge of their geographic range.

Long-term time series show that successful recruitment of *Semibalanus balanoides* is correlated to sea temperatures (Mieszkowska, *et al*., 2014) and that due to recent warming its range has been contracting northwards. Temperatures above 10 to 12 °C inhibit reproduction (Barnes, 1957, 1963, Crisp & Patel, 1969) and laboratory studies suggest that temperatures at or below 10 °C for 4-6 weeks are required in winter for reproduction, although the precise threshold temperatures for reproduction are not clear (Rognstad *et al*., 2014). Observations of recruitment success in *Semibalanus balanoides* throughout the South West of England, strongly support the hypothesis that an extended period (4-6 weeks) of sea temperatures <10 °C is required to ensure a good supply of larvae (Rognstad *et al*., 2014, Jenkins *et al*., 2000). During periods of high reproductive success, linked to cooler temperatures, the range of barnacles has been observed to increase, with range extensions in the order of 25 km (Wethey *et al*., 2011), and 100 km (Rognstad *et al*., 2014). Increased temperatures are likely to favour chthamalid barnacles rather than *Semibalanus balanoides* (Southward *et al*., 1995). *Chthamalus montagui* and *Chthamalus stellatus* are warm water species, with a northern limit of distribution in Britain so are likely to be tolerant of long-term increases in temperature. Similarly, the limpet Patella depressa is a southern species, and is therefore considered more tolerant of increased temperature. Thus, an increase in temperature over longer timescales could lead to a change in the dominant species of barnacle and limpet, particularly in more southern regions.

The body temperature of *Patella vulgata* can exceed 36 °C in the field, (Davies, 1970), adults become become non-responsive at 37-38 °C and die at temperatures of 42 oC (Evans, 1948). Lower temperatures enhance feeding rates in adults (Thompson et al., 2004). Juvenile tolerance of warm air temperatures and dessication may be lower than adults. Juveniles require damp areas of rock (Lewis & Bowman, 1975) and the bare rock surfaces typical of this biotope, present a harsher habitat than the associated crevices and cracks. Long-term time studies in southern England suggest that *Patella vulgata* have become scarcer following warmer summers, while *Patella depressa* increase in abundance (Southward *et al*., 1995). Increased temperatures may alter spawning cues and reproduction success in *Patella vulgata* populations. Observations suggest that spawning is initiated in autumn storms with greater wave action when seawater temperatures drop below 12 °C (Bowman 1985, Bowman & Lewis, 1986, LeQuesne, 2005). In Northern Portugal warming seas appear to be linked to a shortening of the reproductive period and the lack of multiple spawning events in *Patella vulgata* and other northern species (Ribeiro *et al*., 2009).

Most of the other species within the biotope are eurythermal (e.g. *Nucella lapillus* and *Mytilus edulis*) and are hardy intertidal species that tolerate long periods of exposure to the air and consequently wide variations in temperature (Davenport & Davenport, 2005). In addition, most species are distributed to the north of south of the British Isles and unlikely to be adversely affected by long-term temperature changes at the benchmark level. *Corallina officinalis*, however, experienced severe damage during the unusually hot summer of 1983 (Hawkins & Hartnoll, 1985).

Sensitivity assessment. Adult *Semibalanus balanoides* and *Patella vulgata* are considered likely to be able to tolerate an acute or chronic change, however, if an acute change in temperature occurred in autumn or winter it could disrupt reproduction, while a chronic change could alter reproductive success if it exceeded thermal thresholds for reproduction. The effects would depend on the magnitude, duration and footprint of the activities leading to this pressure. However, barnacle populations are highly connected, with a good larval supply and high dispersal potential (Wethey *et al*., 2011, Rognstad *et al*., 2014). Similarly *Patella vulgata* are common, widespread species and therefore larvae are likely to be supplied by local populations to counteract local reproductive failures. Resistance is therefore assessed as '**High**' and resilience as '**High'** (by default). This biotope is therefore considered to be **'Not sensitive'** at the pressure benchmark. Sensitivity to longer-term, broad-scale perturbations such as increased temperatures from climate change would however be greater, based on the extent of impact and the reduction in larval supply.

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

Many intertidal species are tolerant of freezing conditions as they are exposed to extremes of low air temperatures during periods of emersion. They must also be able to cope with sharp temperature fluctuations over a short period of time during the tidal cycle. In winter air temperatures are colder than the sea, conversely in summer air temperatures are much warmer than the sea. Species that occur in the intertidal are therefore generally adapted to tolerate a range of temperatures, with the width of the thermal niche positively correlated with the height of the shore that the animal usually occurs at (Davenport & Davenport, 2005).

The tolerance of *Semibalanus balanoides* collected in the winter (and thus acclimated to lower temperatures) to low temperatures was tested in the laboratory. The median lower lethal temperature tolerance was -14.6 °C (Davenport & Davenport, 2005) A decrease in temperature at the pressure benchmark is therefore unlikely to negatively affect this species. The same series of experiments indicated that median lower lethal temperature tolerances for *Littorina saxatilis* was -16.4 °C .

The distribution of both the key characterizing species, *Semibalanus balanoides* and *Patella vulgata* are 'northern' with their range extending from Portugal or Northern Spain to the Arctic circle. Over their range they are therefore subject to lower temperatures than in the UK, although distributions should be used cautiously as an indicator of thermal tolerance (Southward *et al.*, 1995). The barnacle *Semibalanus balanoides* is primarily a 'northern' species with an arctic-boreal distribution. Long-term time series show that recruitment success is correlated to lower sea temperatures (Mieszkowska *et al*., 2014). Due to warming temperatures its range has been contracting northwards. Temperatures above 10 to 12°C inhibit reproduction (Barnes, 1957, 1963, Crisp & Patel, 1969) and laboratory studies suggest that temperatures at or below 10°C for 4-6 weeks are required in winter for reproduction, although the precise threshold temperatures for reproduction are not clear (Rognstad *et al*., 2014). A decrease in temperature at the pressure benchmark is therefore unlikely to negatively affect this species. The limpet, *Patella vulgata* can also tolerate long periods of exposure to the air and consequently wide variations in temperature. Adults are also largely unaffected by short periods of extreme cold. Ekaratne & Crisp (1984) found adult limpets continuing to grow over winter when temperatures fell to -6°C, and stopped only by still more severe weather. However, loss of adhesion after exposure to -13°C has been observed with limpets falling off rocks and therefore becoming easy prey to crabs or birds (Fretter & Graham, 1994). However, in the very cold winter of 1962-3 when temperatures repeatedly fell below 0°C over a period of 2 months large numbers of *Patella vulgata* were found dead (Crisp, 1964). Periods of frost may also kill juvenile *Patella vulgata*, resulting in recruitment failures in some years (Bowman & Lewis, 1977).

The associated species *Mytilus edulis* is a eurytopic species found in a wide temperature range and in areas which frequently experience freezing conditions and are vulnerable to ice scour (Seed & Suchanek 1992). After acclimation of individuals of *Mytilus edulis* to 18°C, Kittner & Riisgaard (2005) observed that the filtrations rates were at their maximum between 8.3 and 20°C and below this at 6°C the mussels closed their valves. However, after being acclimated at 11°C for five days, the mussels maintained the high filtration rates down to 4°C. Hence, given time, mussels can acclimatise and shift their temperature tolerance. Filtration in *Mytilus edulis* was observed to continue down to -1°C, with high absorption efficiencies (53-81 %) (Loo, 1992).

The associated species, *Mastocarpus stellatus*, has a broad geographical distribution (Guiry & Guiry, 2015) and throughout the range experience wide variation in temperatures (although local populations may be acclimated to the prevailing thermal regime). Photosynthesis in *Mastocarpus stellatus* recovered after experimental freezing (Dudgeon *et al*., 1989, 1995) where *Mastocarpus stellatus* were subjected to a periodic freezing regime (3 hours/day at -5°C for 36 days) with no effect on photosynthesis or growth.

Other species associated with the biotope are able to tolerate decreases in temperature. Lüning (1990) reported that *Corallina officinalis* from Helgoland survived 0 °C when exposed for one week. New Zealand specimens were found to tolerate -4 °C (Frazer *et al*., 1988). *Ulva* spp. are eurytopic, found in a wide temperature range and in areas which frequently experience freezing conditions and are vulnerable to ice scour (Seed & Suchanek 1992).

Sensitivity assessment. Based on the wide temperature tolerance range of *Patella vulgata* it is concluded that the acute and chronic decreases in temperature described by the benchmark would have limited effect. Similarly, based on global temperatures and the link between cooler winter temperatures and reproductive success, *Semibalanus balanoides* is also considered to be unaffected at the pressure benchmark. Based on the characterizing species and *Mytilus edulis* this biotope is considered to have **'High**' resistance and **'High'** resilience (by default) to this pressure and is therefore considered to be '**Not sensitive**'.

Salinity increase (local)	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence, not assessed.

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

Biotopes found in the intertidal will naturally experience fluctuations in salinity where evaporation increases salinity and inputs of rainwater expose individuals to freshwater. Species found in the intertidal are therefore likely to have some form of behavioural or physiological adaptations to changes in salinity. As this biotope is present in full salinity (30-35 ppt, Connor et al., 2004), the assessed change at the pressure benchmark is a reduction in salinity to a variable regime (18-35 ppt) or reduced regime (18-30 ppt).

Patella vulgata can tolerate varying salinities and its distribution extends into the mouths of estuaries surviving in salinities down to about 20psu. However, growth and reproduction may be impaired in reduced salinity. Little *et al.* (1991), for example, observed reduced levels of activity in limpets after heavy rainfall and in the laboratory activity completely stopped at 12psu. The species can endure periods of low salinity and was found to die only when the salinity was reduced to 3-1psu (Fretter & Graham, 1994). In experiments where freshwater was trickled over the shell Arnold (1957) observed limpets withdrawing and clamping the shell onto the substratum. There appears to be an increasing tolerance of low salinities from the lower to the upper limit of distribution of the species on the shore (Fretter & Graham, 1994).

Semibalanus balanoides are tolerant of a wide range of salinity and can survive periodic emersion in freshwater, e.g. from rainfall or freshwater run-off, by closing their opercular valves (Foster, 1971b). They can also withstand large changes in salinity over moderately long periods of time by falling into a "salt sleep" and can be found on shores (example from Sweden) with large fluctuations in salinity around a mean of 24 (Jenkins *et al.*, 2001).

Similarly, most of the associated species (e.g. *Mytilus edulis*) are found in a wide range of salinities and are probably tolerant of variable or reduced salinity. The intertidal interstitial invertebrates and epifauna probably experience short-term fluctuating salinities, with reduced salinities due to rainfall and freshwater runoff when emersed. Prolonged reduction in salinity, e.g. from full to reduced due to e.g. freshwater runoff, is likely to reduce the species richness of the biotope due to loss of less tolerant red algae and some intolerant invertebrates. However, the dominant species will probably survive and the integrity of the biotope is likely to be little affected. Areas of freshwater runoff in the intertidal promote the growth of ephemeral greens, probably due to their tolerance of low salinities and inhibition of grazing invertebrates.

Sensitivity assessment. Based on reported distributions and the results of experiments to assess salinity tolerance thresholds and behavioural and physiological responses in *Patella vulgata* and *Semibalanus balanoides* it is considered that the benchmark decrease in salinity (from full to variable) would not result in mortality of the characterizing species in biotopes that were previously fully marine. Resistance is therefore assessed as '**High**' and resilience as '**High**', based on no effect to recover from and the biotope is considered to be '**Not sensitive**'.

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

The biotope is characteristic of exposed to moderately wave exposed conditions where water movement from wave action will greatly exceed the strength of any possible tidal flow. Evidence is presented for the tolerance of the key characterizing species, *Semibalanus balanoides* and *Patella vulgata* to changes in water flow. However, it should be noted that wave action, is more significant as an environmental factor than flow for this biotope.

Growth and reproduction of *Semibalanus balanoides* is influenced by food supply and water velocity (Bertness *et al*., 1991). Laboratory experiments demonstrate that barnacle feeding behaviour alters over different flow rates but that barnacles can feed at a variety of flow speeds (Sanford *et al*., 1994). Flow tank experiments using velocities of 0.03, 0.07 and 0.2 m/s showed that a higher proportion of barnacles fed at higher flow rates (Sanford *et al*., 1994). Feeding was passive, meaning the cirri were held out to the flow to catch particles; although active beating of the cirri to gernerate feeding currents occurs in still water (Crisp & Southward, 1961). Field observations at sites in southern New England (USA) that experience a number of different measured flow speeds, found that *Semibalanus balanoides* from all sites responded quickly to higher flow speeds, with a higher proportion of individuals feeding when current speeds were higher. Barnacles were present at a range of sites, varying from sheltered sites with lower flow rates (maximum observed flow rates <0.06- 0.1 m/s), a bay site with higher flow rates (maximum observed flows 0.2-0.3 m/s) and open coast sites (maximum observed flows 0.2-0.4 m/s). Recruitment was higher at the site with flow rates of 0.2-0.3 m/s (although this may be influenced by supply) and at higher flow microhabitats within all sites. Both laboratory and field observations indicate that flow is an important factor with effects on feeding, growth and recruitment in *Semibalanus balanoides* (Sanford *et al*., 1994, Leonard *et al*., 1998), however, the results suggest that flow is not a limiting factor determining the overall distribution of barnacles as they can adapt to a variety of flow speeds.

Patella vulgata inhabits a range of tidal conditions and is therefore, likely to tolerate a change in water flow rate. The streamlined profile of limpet shells is of importance in increasing their tolerance of water movement, and this is undoubtedly one factor in determining the different shape of limpets at different exposures. With increasing exposure to wave action the shell develops into a low profile reducing the risk of being swept away. The strong muscular foot and a thin film of mucus between the foot and the rock enables *Patella vulgata* to grip very strongly to the substratum (Fretter & Graham, 1994). The ability of limpets to resist accelerating, as distinct from constant currents, may set a limit to the kind of habitat which they can occupy and limit the size to which they can grow.

The crevice fauna of littornids and th brown and red algal turf have some protection from increases in water flow and are unlikely to be affected by decreases.

Sensitivity assessment. The biotope is characteristic of exposed to moderately wave exposed conditions where water movement from wave action will greatly exceed the strength of any possible tidal flow. Based on the available evidence the characterizing species *Patella vulgata* and *Semibalanus balanoides* are able to adapt to high flow rates and the biotope is therefore considered to be **'Not sensitive'** to an increase in water flow. A decrease in water flow may have some effects on recruitment and growth, but this is not considered to be lethal at the pressure benchmark and resistance is therefore assessed as '**High**' and resilience as '**High**' by default, so that the biotope is considered to be '**Not sensitive**'. A decrease in water flow, exceeding the pressure benchmark, coupled with a decrease in wave action, may however alter the character of the biotope to LR.MLR.MusF.MytFR or LR.MLR.MusF.MytFves, where brown seaweeds were able to proliferate and the edible periwinkle *Littorina littorea* was able to colonize.

Emergence regime changes	Low Q: Low A: NR C: NR	Medium Q: High A: Low C: Medium	Medium Q: Low A: Low C: Low

Emergence regime is a key factor structuring this (and other) intertidal biotopes. Increased emergence may reduce habitat suitability for characterizing species through greater exposure to dessication and reduced feeding opportunities for the barnacles which feed when immersed. *Semibalanus balanoides* is less tolerant of dessication stress than *Chthamalus* barnacles species and changes in emergence may therefore lead to species replacement and the development of a *Chthamalus* sp. dominated biotope, more typical of the upper shore may develop. Records suggest that, typically, above this biotope on the shore there may be a *Verrucaria maura* zone, or a band of *Chthamalus sp.* (Connor *et al*., 2004). Changes in emergence may therefore eventually lead to replacement of this biotope to one more typical of the upper shore.

Decreased emergence would reduce dessication stress and allow the attached suspension feeders more feeding time. Predation pressure on mussels and barnacles is likely to increase where these are submerged for longer periods and to prevent colonisation of lower zones. *Semibalanus balanoides* was able to extend its range into lower zones when protected from predation by the dogwhelk, *Nucella lapillus* (Connell, 1961). Competition from large fucoids and red algal turfs can also prevent *Semibalanus balano*ides from extending into lower shore levels (Hawkins, 1983). Below this biotope a community dominated by the wrack *Himanthalia elongata* and various red seaweeds such as *Corallina officinalis*, *Mastocarpus stellatus* and *Osmundea pinnatifida* often occurs (Connor *et al*., 2004). Decreased emergence is likely to lead to the habitat the biotope is found in becoming more suitable for the lower shore species generally found below the biotope, leading to replacement.

The mobile species present within the biotope, including the characterizing species, *Patella vulgata* and *Nucella lapillus*, and the Littorinids would be able to relocate to preferred shore levels. Although the success of relocation by *Patella vulgata* may depend on shore rugosity and shell fit (see resilience section for further information).

Sensitivity assessment. Where this biotope occurs on the mid-shore it will be more sensitive to increased emergence, whereas lower shore examples may be more sensitive to decreased emergence, as the changed conditions occur towards the margins of habitat tolerance. As emergence is a key factor structuring the distribution of animals on the shore, resistance to a change in emergence (increase or decrease) is assessed as '**Low**'. Recovery is assessed as '**Medium**', and sensitivity is therefore assessed as '**Medium**'.

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

No direct evidence was found to assess the sensitivity of this biotope to changes in wave exposure at the pressure benchmark. This biotope is recorded from locations that are judged to range from moderately exposed or exposed (Connor *et al*., 2004). The degree of wave exposure influences wave height, as in more exposed areas with a longer fetch waves would be predicted to be higher. As this biotope occurs across two wave exposure categories, this was therefore considered to indicate, by proxy, that biotopes in the middle of the wave exposure range would tolerate either an increase or decrease in significant wave height at the pressure benchmark. An increase or decrease in wave action, exceeding the pressure benchmark, may however alter the character of the biotope. Where wave action was significantly reduced a biotope more typical of sheltered shores would be predicted to develop, e.g. LR.MLR.MusF.MytFR or LR.MLR.MusF.MytFves, where brown seaweeds were able to proliferate on the rock surfaces and the edible periwinkle *Littorina littorea* was able to colonize. A decrease in wave exposure may ultimately reduce *Patella vulgata* abundance because the species does not favour thick algal cover that is often present on very sheltered shores. Alternatively an increase in significant wave height, linked to increased exposure, may result in population changes with fewer macroalgae present and with the limpet *Patella ulyssiponensis* present, or present in greater numbers, rather than P*atella vulgata* (Thompson, 1980) and *Chthamalus* sp. replacing *Semibalanus balanoides* (Ballantine, 1961).

Sensitivity assessment. The natural wave exposure range of this biotope is therefore considered to exceed changes at the pressure benchmark and this biotope is considered to have 'High' resistance and 'High' resilience (by default), to this pressure (at the benchmark).

Chemical Pressures

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

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

Contamination at levels greater than the benchmark may impact this biotope. However, Barnacles, may tolerate fairly high level of heavy metals in nature, for example they possess metal detoxification mechanisms and are found in Dulas Bay, Anglesey, where copper reaches concentrations of 24.5 µg/l, due to acid mine waste (Foster *et al*., 1978; Rainbow, 1984).Bryan (1984) suggested that gastropods are also rather tolerant of heavy metals. In the Fal estuary *Patella vulgata* occurs at, or just outside, Restronguet Point at the end of the creek where metal concentrations are in the order: Zinc (Zn) 100-2000 µg/l, copper (Cu) 10-100 µg/l and cadmium (Cd) 0.25-5 µg/l (Bryan & Gibbs, 1983). However, in the laboratory *Patella vulgata* was found to be intolerant of small changes in environmental concentrations of Cd and Zn by Davies (1992). At concentrations of 10µg/l pedal mucus production and levels of activity were both reduced, indicating a physiological response to metal concentrations. Exposure to Cu at a concentration of 100 µg/l for one week resulted in progressive brachycardia (slowing of the heart beat) and the death of limpets. Zn at a concentration of 5500 µg/l produced the same effect (Marchan *et al*.,1999).

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

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

Hydrocarbon contamination, at levels greater than the benchmark, e.g. from spills of fresh crude oil or petroleum products, may cause significant loss of component species in the biotope, through impacts on individual species viability or mortality, and resultant effects on the structure of the community (Suchanek, 1993; Raffaelli & Hawkins, 1999). In areas of moderate oil deposit, up to about 1/2cm thick, on rocks after the Torrey Canyon oil spill, limpets had survived unscathed over a month after the event and feeding continued even though a coating of oil smothered their food source of algae and diatoms (Smith, 1968). Limpets can ingest thick oil and pass it through their gut. However, thick layers of oil smothering individuals will interfere with respiration and spoil normal food supplies for *Patella vulgata*. Limpets are unable to remain closed off from the environment for very long, the adductor muscles relax occasionally, lifting the shell very slightly. After the Braer oil spill, in common with many other oil spills, the major impact in the intertidal zone was on the population of limpets and other grazers. In West Angle Bay, where fresh oil from the Sea Empress tanker reached rocky shores within one day of the spill, limpet mortality was 90% (Glegg *et al*., 1999). Thus *Patella vulgata* has higher intolerance to fresh oil which has a high component of volatile hydrocarbons remaining. A significant reduction in the density of juvenile limpets was also observed at all sites known to have been oiled by the Sea Empress spill (Moore, 1997). In longer term studies into the environmental effects of oil refinery effluent discharged into Littlewick Bay, Milford Haven, the number of limpets, usually found in substantial numbers on this type of shore, were considerably reduced in abundance on areas close to the discharge (Petpiroon & Dicks, 1982). In particular only large individuals were found close to the outfall point and juveniles were completely absent, suggesting that observed changes in abundance resulted from effluent effects on larval stages rather than upon adults directly.

Littoral barnacles (e.g. *Semibalanus balanoides*) have a high resistance to oil (Holt et al., 1995) but may suffer some mortality due to the smothering effects of thick oil (Smith, 1968).

However, laboratory studies of the effects of oil and dispersants on several red algae species (Grandy, 1984 cited in Holt et al. 1995) concluded that they were all sensitive to oil/ dispersant mixtures, with little differences between adults, sporelings, diploid or haploid life stages. O'Brien & Dixon (1976) suggested that red algae were the most sensitive group of algae to oil or dispersant contamination.

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

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

Synthetic compound contamination, at levels greater than the benchmark, is likely to have a variety of effects depending the specific nature of the contaminant and the species group(s) affected. Barnacles have a low resilience to chemicals such as dispersants, dependant on the concentration and type of chemical involved (Holt *et al*., 1995). Hoare & Hiscock (1974) reported that the limpet *Patella vulgata* was excluded from sites within 100-150m of the discharge of acidified, halogenated effluent in Amlwch Bay. Limpets are also extremely intolerant of aromatic solvent based dispersants used in oil spill clean-up. During the clean-up response to the *Torrey*

Canyon oil spill nearly all the limpets were killed in areas close to dispersant spraying. Viscous oil will not be readily drawn in under the edge of the shell by ciliary currents in the mantle cavity, whereas detergent, alone or diluted in seawater, would creep in much more readily and be liable to kill the limpet (Smith, 1968). A concentration of 5ppm killed half the limpets tested in 24 hours (Southward & Southward, 1978; Hawkins & Southward, 1992). Acidified seawater affects the motility of *Patella vulgata*. At a pH of 5.5 motility was reduced whilst submerged but individuals recovered when returned to normal seawater. At a pH of 2.5 total inhibition of movement occurred and when returned to normal seawater half had died (Bonner *et al*., 1993). Reduced motility reduces time for foraging and may result in decreased survival of individuals. Acidified seawater can also change the shell composition which will lead to a decrease in its protective nature and hence survival (Bonner *et al*., 1993). Short periods (48 hours) are unlikely to have much effect on a population but long periods (1 year) may cause reduced grazing and an increase in algal growth. However, seawater is unlikely to reach pH 2.5 therefore intolerance to slight changes in pH will be low. Gastropod molluscs are known to be intolerant of endocrine disruption from synthetic chemicals such as tri-butyl tin (Cole *et al*., 1999). However no information on the specific effects of tri-butyl tin on *Patella vulgata* was found. Hoare & Hiscock (1974) reported that in Amlwch Bay *Patella vulgata* was excluded from sites within 100-150m of the discharge of acidified, halogenated effluent.

Red algae are probably intolerant of chemical contamination. O'Brien & Dixon (1976) suggested that red algae were the most sensitive group of algae to oil contamination, although the filamentous forms were the most sensitive. Laboratory studies of the effects of oil and dispersants on several red algae species, including *Palmaria palmata* (Grandy, 1984 cited in Holt *et al*., 1995) concluded that they were all sensitive to oil/ dispersant mixtures, with little differences between adults, sporelings, diploid or haploid life stages. Cole *et al*. (1999) suggested that herbicides, such as simazina and atrazine were very toxic to macrophytes. In addition, Hoare & Hiscock (1974) noted that almost all red algae were excluded from Amlwch Bay, Anglesey by acidified halogenated effluent discharge.

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

No evidence.

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

This pressure is **Not assessed**.

De-oxygenation	High Q: High A: Low C: High	High Q: High A: High C: High	Not sensitive Q: High A: Medium C: High

An oxygen concentration at the level of the benchmark, 2 mg/l, is thought likely to cause adverse effects in marine organisms. In laboratory experiments a reduction in the oxygen tension of seawater from 148 mm Hg (air saturated seawater) to 50 mm Hg rapidly resulted in reduced heart rate in limpets of the genus *Patella* (Marshall & McQuaid, 1993). Heartbeat rate returned to normal in oxygenated water within two hours. Limpets can survive for a short time in anoxic seawater; Grenon & Walker, (1981) found that in oxygen free water limpets could survive up to 36 hours, although Marshall & McQuaid (1989) found a lower tolerance for *Patella granularis*, which survived up to 11 hours in anoxic water. Therefore, some individuals may survive for one week at an oxygen concentration of 2 mg/l. However, *Patella vulgata* is an intertidal species, being able to respire in air, so would only be exposed to low oxygen in the water column intermittently during periods of tidal immersion. In addition, in areas of wave exposure and moderately strong current flow low oxygen levels in the water are unlikely to persist for very long.*Littorina littorea* are also able to respire in air, mitigating the effects of this pressure during the tidal cycle. *Littorina littorea* can easily survive 3-6 days of anoxia (Storey *et al*., 2013).

Semibalanus balanoides can respire anaerobically, so they can tolerate some reduction in oxygen concentration (Newell, 1979). When placed in wet nitrogen, where oxygen stress is maximal and desiccation stress is low, *Semibalanus balanoides* have a mean survival time of 5 days (Barnes *et al*., 1963).

The effects of reduced oxygenation on algae are not well studied. Plants require oxygen for respiration, but this may be provided by production of oxygen during periods of photosynthesis. Lack of oxygen may impair both respiration and photosynthesis (see review by Vidaver, 1972). A study of the effects of anoxia on another red alga, *Delesseria sanguinea*, revealed that specimens died after 24 hours at 15°C but that some survived at 5°C (Hammer, 1972). This biotope would only be exposed to low oxygen in the water column intermittently during periods of tidal immersion. In addition, in areas of wave exposure and moderately strong current flow low oxygen levels in the water are unlikely to persist for very long as oxygen levels will be recharged by the incorporation of oxygen in the air into the water column or flushing with oxygenated waters. No evidence was found to assess this pressure for the red algae turfs. However, the associated species are unlikely to be impacted by this pressure, at the benchmark. Experiments have shown that thallus discs of *Ulva lactuca* plants can survive prolonged exposure to anoxia and hypoxia (Vermaat & Sand-Jensen, 1987; Corradi *et al*., 2006).

Sensitivity assessment. The characterizing species *Patella vulgata and Semibalanus balanaides* are considered to be 'Not Sensitive' to deoxygenation at the pressure benchmark. Resistance is therefore assessed as 'High' and resilience as 'High' (no effect to recover from), resulting in a sensitivity of 'Not sensitive'. However, as this biotope occurs in the intertidal, emergence will mitigate the effects of hypoxic surface waters as will the exposure to wave action and water flows and this pressure is considered to be 'Not relevant'.

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

No direct evidence was found to assess this pressure for the characterizing invertebrate species. A slight increase in nutrient levels could be beneficial for barnacles and mussels by promoting the growth of phytoplankton levels and therefore increasing zooplankton levels. Limpets and other grazers would also benefit from increased growth of benthic microalgae. However, Holt *et al.* (1995) predict that smothering of barnacles by ephemeral green algae is a possibility under eutrophic conditions. However, if nutrient loading is excessive this can have a detrimental effect on algal productivity and hence limpet growth.

Atalah & Crowe (2010) added nutrients to rockpools. The rockpools were occupied by a range of algae including encrusting corallines, turfs of *Mastocarpus stellatus*, *Chondrus crispus* and *Corallina officinalis* and green and red filamentous algae. Nitrogen and phosphorous enhancement was via the addition of fertilisers, as either 40 g/litre or 20 g/litre. The treatments were applied for seven months and experimental conditions were maintained every two weeks. The experimental treatments do not directly relate to the pressure benchmark but indicate some general trends in sensitivity. Nutrients had no significant effect on the cover of crustose coralline algae or the cover of red turfing algae. However, the cover of green filamentous algae increased where grazers were removed (Atalah & Crowe, 2010).

Sensitivity assessment. The pressure benchmark is set at a level that is relatively protective and based on the evidence and considerations outlined above the biological assemblage, are considered to be 'Not sensitive' at the pressure benchmark. Resistance and resilience are therefore assessed as 'High'.

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

Organic enrichment may lead to eutrophication with adverse environmental effects including deoxygenation, algal blooms and changes in community structure (see nutrient enrichment and de-oxygenation). The biotopes occurs in tide swept or wave exposed areas (Connor *et al*., 2004) preventing a build up of organic matter, so that the biotope is considered to have a low risk of organic enrichment at the pressure benchmark. Little evidence was found to support this assessment, Cabral-Oliveira *et al*., (2014), found that filter feeders such as *Mytilus* sp. and the barnacle *Chthamalus montagui*, were more abundant at sites closer to a sewage treatment works, as they could utilise the organic matter inputs as food. On the same shores, higher abundances of juvenile *Patella* sp. and lower abundances of adults were found closer to sewage inputs, Cabral-Oliveira *et al*., (2014) suggested the structure of these populations was due to increased competition closer to the sewage outfalls.

Sensitivity assessment. Little empirical evidence was found to support an assessment for *Semibalanus balanoides* and *Patella vulgata* within this biotope. As organic matter particles in suspension or re-suspended could potentially be utilised as a food resource by filter feeders present within the biotope (Cabral-Oliveira *et al*., 2014) with excess likely to be rapidly removed by wave action, overall resistance of the biological assemblage within the biotope is considered to be 'High' and resilience was assessed as 'High', so that this biotope is judged to be 'Not sensitive'. Limpets may be sensitive to even low levels of deposition (see siltation pressure), so that impacts from this pressure will depend on the duration of input and any deposits.

Physical Pressures

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

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

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

This biotope is characterized by the hard rock substratum to which the key characterizing species barnacles, *Semibalanus balanoides*, and limpets, *Patella vulgata*, and other species such as *Mytilus edulis* and algal turfs can firmly attach. A change to a sedimentary substratum would significantly alter the character of the biotope. Changes in substratum type can also lead to indirect effects. For example, Shanks & Wright (1986) observed that limpet mortalities were much higher at sites where the supply of loose cobbles and pebbles were greater, leading to increased abrasion through wave action 'throwing' rocks onto surfaces. The biotope is therefore considered to have '**No**' resistance to this pressure, resilience is **Very low** (the pressure is a permanent change) and sensitivity is assessed as **High**.

Physical change (to another sediment type)	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

'**Not relevant**' to biotopes occurring on bedrock.

Habitat structure changes - removal of substratum (extraction)	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

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

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

The barnacles and limpets that are the key characterizing species within this biotope typically occur on the rock surfaces where they will be exposed to abrasion. Although both species are protected by hard shells or plates, abrasion may damage and kill individuals or detach these. All removed barnacles would be expected to die as there is no mechanism for these to reattach. Removal of limpets may result in these being displaced to a less favourable habitat and injuries to foot muscles may prevent reattachment. Evidence for the effects of abrasion is provided by a number of experimental studies on trampling (a source of abrasion) and on abrasion by wave thrown rocks and pebbles.

The effects of trampling on barnacles appear to be variable with some studies not detecting significant differences between trampled and controlled areas (Tyler-Walters & Arnold, 2008). However, this variability may be related to differences in trampling intensities and abundance of populations studied. The worst case incidence was reported by Brosnan and Crumrine (1994) who reported that a trampling pressure of 250 steps in a 20x20 cm plot one day a month for a period of a year significantly reduced barnacle cover at two study sites. Barnacle cover reduced from 66% to 7% cover in 4 months at one site and from 21% to 5% within 6 months at the second site. Overall barnacles were crushed and removed by trampling. Barnacle cover remained low until recruitment the following spring. Long *et al*. (2011) also found that heavy trampling (70 humans km^{-1} shoreline

h^{-1}) led to reductions in barnacle cover. Single step experiments provide a clearer, quantitative indication of sensitivity to direct abrasion. Povey & Keough (1991) in experiments on shores in Mornington peninsula, Victora, Australia, found that in single step experiments 10 out of 67 barnacles, (*Chthamlus antennatus* about 3mm long), were crushed. However, on the same shore, the authors found that limpets may be relatively more resistant to abrasion from trampling. Following step and kicking experiments, few individuals of the limpet C*ellana trasomerica*, (similar size to *Patella vulgata*) suffered damage or relocated (Povey & Keough, 1991). One kicked limpet (out of 80) was broken and 2 (out of 80) limpets that were stepped on could not be relocated the following day (Povey & Keough, 1991). Trampling may lead to indirect effects on limpet populations, Bertocci *et al*., (2011) found that the effects of trampling on *Patella* sp. increased the temporal and spatial variability of in abundance. The experimental plots were sited on a wave-sheltered shore dominated by *Ascophyllum nodosum*. On these types of shore, trampling in small patches, that removes macroalgae and turfs, will indirectly enhance habitat suitability for limpets by creating patches of exposed rock for grazing.

Shanks & Wright (1986), found that even small pebbles (<6 cm) that were thrown by wave action in Southern California shores could create patches in *Chthamalus fissus* aggregations and could smash owl limpets (*Lottia gigantea*). Average, estimated survivorship of limpets at a wave exposed site, with many loose cobbles and pebbles allowing greater levels of abrasion was 40% lower than at a sheltered site. Severe storms were observed to lead to the almost total destruction of local populations of limpets through abrasion by large rocks and boulders.

Little information is available on the effects of abrasion on intertidal red algae. Brosnan & Crumrine (1994) noted that trampling significantly reduced algal cover within 1 month of trampling. Foliose algae were particularly affected and decreased in cover from 75% to 9.1% in trampled plots. *Mastocarpus papillatus* decreased in abundance from 9% to 1% in trampled plots but increased in control plots.

Sensitivity assessment. The impact of surface abrasion will depend on the footprint, duration and magnitude of the pressure. Surface abrasion may directly crush and remove *Semibalanus balanoides and Patella vulgata*. Resistance is therefore assessed as '**Low**' for barnacles and limpets. Populations are predicted to remover within 2 -10 years, so that resilience is considered to be '**Medium**' and sensitivity is '**Medium**'.

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

The species characterizing this biotope group are epifauna or epiflora occurring on rock, which is resistant to subsurface penetration. Therefore, 'penetration' is **'Not relevant'**. The assessment for abrasion at the surface only is, therefore, considered to equally represent sensitivity to this pressure'. Please refer to 'abrasion' above.

Changes in suspended solids (water clarity)	Medium Q: Low A: NR C: NR	High Q: High A: Low C: High	Low Q: Low A: Low C: Low

In general, increased suspended particles may enhance food supply (where these are organic in origin) or decrease feeding efficiency (where the particles are inorganic and require greater filtration efforts). Very high levels of silt may clog respiratory and feeding organs of the suspension feeding *Semibalanus balanoides* and clog the gills of *Patella vulgata*. In addition, increased turbidity will decrease light penetration reducing photosynthesis by macroalgae within this biotope. Increased levels of particles may increase scour and deposition in the biotope depending on local hydrodynamic conditions, although changes in substratum are assessed through the physical change (to another seabed type) pressure. Gyory *et al.* (2013) found that increased turbidity triggered the release of larvae by *Semibalanus balanoides*, a response that may allow larval release to be timed with high levels of phytoplankton and at times where predation on larvae may be lowered due to the concentration of particles. Storm events that stir up sediments are also associated with larval release (Gyory & Pineda, 2011).

A significant decrease in suspended organic particles may reduce food input resulting in reduced growth and fecundity of the suspension feeding barnacles. However, local primary productivity (phytoplankton and diatom films) may be enhanced where suspended sediments decrease, increasing food supply to both characterizing species. Decreased suspended sediment may increase macroalgal competition, enhancing diversity, but is considered unlikely to significantly change the character of the biotope as colonisation by larger brown macroalgae and turfs is likely to be limited by wave action and grazing in this biotope rather than light limitation.

Sensitivity assessment. The benchmark for this pressure refers to a change in turbidity of one rank on the Water Framework Directive (WFD) scale. Where changes in suspended sediment supply were linked to decreased wave action and water flow to enhance settlement, limpets would be sensitive to deposition (see siltation pressures). The biotope is considered to be be 'Not sensitive' to a decrease in suspended solids. An increase in inorganic suspended sediments may negatively affect the feeding of *Semibalanus balanoides* with some impacts on growth and survival. Resistance is therefore assessed as '**Medium**' and resilience as '**High**' so that sensitivity is assessed as '**Low**'.

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

More direct evidence to assess this pressure was found for the characterizing species *Patella vulgata*, than *Semibalanus balanoides*. However, the lower limits of *Semibalanus balanoides* (as *Balanus balanoides*) appear to be set by levels of sand inundation on sand-affected rocky shores in New Hamshire (Daly & Mathieson, 1977).

Field observations and laboratory experiments have highlighted the sensitivity of limpets to sediment deposition (see also the 'heavy' siltation pressure for further information). Airoldi & Hawkins (2007) tested the effects of different grain sizes and deposit thickness in laboratory experiments using *Patella vulgata*. Sediments were added as a 'fine' rain to achieve deposit thicknesses of approximately 1mm, 2 mm, and 4 mm in controlled experiments and grazing and mortality observed over 8-12 days. Limpets were more sensitive to sediments with a higher fraction of fines (67% silt) than coarse (58% sand). Coarse sediments of thicknesses approximately 1, 2 and 4 mm decreased grazing activity by 35, 45 and 50 % respectively. At 1 and 2 mm thicknesses, fine sediments decreased grazing by 40 and 77 %. The addition of approximately 4 mm of fine sediment completely inhibited grazing. Limpets tried to escape the sediment but lost attachment and died after a few days (Airoldi & Hawkins, 2007).

Observations on exposed and sheltered shores with patches of sediment around Plymouth in the south-west of England found that *Patella vulgata* abundances were higher where deposits were absent. The limpets were locally absent in plots with 50-65% sediment cover (Airoldi & Hawkins, 2007). Littler *et al*. (1983) found that the another limpet species, *Lottia gigantea* on southern Californian shores was restricted to refuges from sand burial on shores subject to periodic inundation by sands.

Chandrasekara & Frid (1998) specifically tested the siltation tolerance of *Littorina littorea*. Approximately half of the test individuals could not regain the surface from 1cm of burial except in the most favourable conditions (low temperatures, high water, high silt when a majority (10 out of 15) of the test cohort surfaced. Field observations support the findings that *Littorina littorea* are generally unable to survive smothering. Albrecht & Reise (1994) observed a population of *Littorina littorea* in a sandy bay near the Sylt island in the North Sea. They found that the accretion of mud within *Fucus* strands and subsequent covering of *Littorina* by the sediment resulted in them suffocating and a significant reduction in their abundance.

Recently settled propagules, regenerating holdfasts and small developing plants would be buried by 5 cm of sediment and be unable to photosynthesize. For example, Vadas *et al.* (1992) stated that algal spores and propagules are adversely affected by a layer of sediment, which can exclude up to 98% of light.

Atalah & Crowe (2010) added sediment to rockpools. The rockpools were occupied by a range of algae including encrusting corallines and turfs of *Mastocarpus stellatus*, *Chondrus crispus* and *Corallina officinalis* and green and red filamentous algae. Sediment treatment involved the addition of a mixture of coarse and fine sand of either 300 mg/cm^2/month or 600 mg/cm^2 every 15 days. The treatments were applied for seven months and experimental conditions were maintained every two weeks. The experimental treatments do not directly relate to the pressure benchmark but indicate some general trends in sensitivity. Sedimentation led to an increase in the mean cover of red turfing algae (*Mastocarpus stellatus* and *Chondrus crispus* and *Corallina officinalis*) from 11.7% (±1.0 S.E.) in controls to 26.1% (±4.7 S.E.) in sedimented assemblages, but there were no differences between the two levels of sedimentation (Atalah & Crowe, 2010).

Sensitivity assessment. *Semibalanus balanoides* is found permanently attached to hard substrates and is a suspension feeder. This species, therefore, has no ability to escape from silty sediments which would bury individuals and prevent feeding and respiration. However, no direct evidence for sensitivity to siltation was found. Resistance is assessed as 'Medium' as wave action on rocky shores is likely to rapidly mobilise and remove deposits alleviating the effect of smothering. Resilience is assessed as 'High' and sensitivity is therefore considered to be 'Low'. Even small deposits of sediments are likely to result in local removal of limpets. The level of impact will depend on the magnitude and duration of impact. It should be noted that the level of exposure may be reduced by wave action or water flows so that site-specific vulnerability will be lower where sediments do not accumulate. Resistance to siltation is assessed as '**Low**' for *Patella vulgata* based primarily on observations and experiments of Airoldi & Hawkins, (2007), who demonstrated negative effects at deposit thicknesses far lower than the pressure benchmark. Small patches subject to a single impact may recover rapidly via adult migration. However, based on the prolonged recovery times experienced on more wide-ranging impacts, resilience is assessed as '**Medium**' (2-10 years) and sensitivity is therefore assessed as '**Medium**'. This more precautionary assessment is presented for the biotope, rather then the lower sensitivity of *Semibalanus balanoides*. Repeated deposition events, coupled with changes in water flow and wave action may lead to the establishment of turf forming algae on horizontal surfaces that trap sediments, this would significantly alter the character of the biotope.

Smothering and siltation rate changes (heavy)	None Q: High A: High C: High	Medium Q: High A: Medium C: High	Medium Q: High A: Medium C: High

More direct evidence to assess this pressure was found for the characterizing species *Patella vulgata*, than *Semibalanus balanoides*. However, the lower limits of *Semibalanus balanoides* (as *Balanus balanoides*) appear to be set by levels of sand inundation on sand-affected rocky shores in New Hampshire (Daly & Mathieson, 1977). Barnacle feeding may be affected however by smothering, wave action on rocky shores is likely to rapidly mobilise and remove deposits alleviating the effect of smothering. However, the lower limits of *Semibalanus balanoides* (as *Balanus balanoides*) appear to be set by levels of sand inundation on sand-affected rocky shores in New Hamshire (Daly & Mathieson, 1977).

Field observations and laboratory experiments have highlighted the sensitivity of limpets to sediment deposition (see also the 'heavy' siltation pressure for further information). Airoldi & Hawkins (2007) tested the effects of different grain sizes and deposit thickness in laboratory experiments using *Patella vulgata*. Sediments were added as a 'fine' rain to achieve deposit thicknesses of approximately 1mm, 2 mm, and 4 mm in controlled experiments and grazing and mortality observed over 8-12 days. Limpets were more sensitive to sediments with a higher faction of fines (67% silt) than coarse (58% sand). Coarse sediments of thicknesses approximately 1, 2 and 4 mm decreased grazing activity by 35, 45 and 50 % respectively. At 1 and 2 mm thicknesses, fine sediments decreased grazing by 40 and 77 %. The addition of approximately 4 mm of fine sediment completely inhibited grazing. Limpets tried to escape the sediment but lost attachment and died after a few days (Airoldi & Hawkins, 2007). Observations on exposed and sheltered shores with patches of sediment around Plymouth in the south-west of England found that *Patella vulgata* abundances were higher where deposits were absent. The limpets were locally absent in plots with 50-65% sediment cover (Airoldi & Hawkins, 2007). Littler *et al*., (1983) found that another limpet species, *Lottia gigantea* on southern Californian shores was restricted to refuges from sand burial on shores subject to periodic inundation by sands.

At the level of the benchmark (30 cm of fine material added to the seabed in a single event), smothering is likely to result in death and removal of red algal fronds and germlings.

Sensitivity assessment. Sensitivity to this pressure will be mediated by site-specific hydrodynamic conditions and the footprint of the impact. Where a large area is covered sediments may be shifted by wave and tides rather than removed. *Semibalanus balanoides* is found permanently attached to hard substrates and is a suspension feeder. This species, therefore, has no ability to escape from silty sediments which would bury individuals and prevent feeding and respiration. Resilience is assessed as 'Medium' and sensitivity is therefore considered to be 'Medium'. No direct evidence for sensitivity to siltation was found. However, mortality will depend on the duration of smothering, where wave action rapidly mobilises and removes fine sediments, survival may be much greater. Even small deposits of sediments are likely to result in local removal of limpets. Resistance to siltation at the benchmark level is assessed as '**None**' for *Patella vulgata* based primarily on the observations and experiments of Airoldi & Hawkins, (2007), who demonstrated negative effects at deposit thicknesses far lower than the pressure benchmark. Small patches subject to a single impact may recover rapidly via adult migration. However, based on the prolonged recovery times experienced on more wide-ranging impacts, resilience is assessed as '**Medium**' (2-10 years) and sensitivity is therefore assessed as '**Medium**'. This more precautionary assessment is presented for the biotope, rather than the lower sensitivity of *Semibalanus balanoides*. Repeated deposition events, coupled with changes in water flow and wave action may lead to the establishment of turf forming algae on horizontal surfaces, not just in crevices, that trap sediments, this would significantly alter the character of the biotope.

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

Thompson *et al*., (2004) demonstrated that *Semibalanus balanoides*, kept in aquaria, ingested microplastics within a few days. However, the effects of the microplastics on the health of exposed individuals have not been identified. There is currently no evidence to assess the level of impact.

Electromagnetic changes	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence.

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

Not relevant. Wave action on exposed shores is likely to generate high levels of underwater noise. Other sources are not considered likely to result in effects on the biotope.

Introduction of light or shading	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

Semibalanus balanoides sheltered from the sun grew bigger than unshaded individuals (Hatton, 1938; cited in Wethey, 1984), although the effect may be due to indirect cooling effects rather than shading. Barnacles are also frequently found under algal canopies suggesting that they are tolerant of shading. Light levels have also been demonstrated to influence a number of phases of the reproductive cycle in *Semibalanus balanoide*s. In general, light inhibits aspects of the breeding cycle. Penis development is inhibited by light (Barnes & Stone, 1972) while Tighe-Ford (1967) showed that constant light inhibited gonad maturation and fertilization. Davenport & Crisp (unpublished data from Menai Bridge, Wales, cited from Davenport *et al*., 2005) found that experimental exposure to either constant darkness, or 6 h light: 18 h dark photoperiods induced autumn breeding in *Semibalanus*. They also confirmed that very low continuous light intensities (little more than starlight) inhibited breeding. Latitudinal variations in the timing of the onset of reproductive phases (egg mass hardening) have been linked to the length of darkness (night) experienced by individuals rather than temperature (Davenport *et al*., 2005). Changes in light levels associated with climate change (increased cloud cover) were considered to have the potential to alter the timing of reproduction (Davenport *et al*., 2005) and to shift the range limits of this species southward. However, it is not clear how these findings may reflect changes in light levels from artificial sources, and whether observable changes would occur at the population level as a result. There is, therefore, '**No evidence**' on which to base an assessment.

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

No direct evidence was found to assess this pressure. As the larvae of *Patella vulgata* and *Semibalanus balanoides* 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 red algal 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) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

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

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

Not relevant.

Biological Pressures

	Resistance	Resilience	Sensitivity
Genetic modification & translocation of indigenous species	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

The characterizing species, *Semibalanus balanoides* and *Patella vulgata* and other common rocky shores species within the biotope, with the exception of *Mytilus edulis* which occurs in low densities, are not subject to translocation or cultivation. Commercial cultivation of Mytilus edulis involves the collection of juvenile mussel 'seed' or spat (newly settled juveniles ca 1-2cm in length) from wild populations, with subsequent transportation around the UK for re-laying in suitable habitats. As the seed is harvested from wild populations from various locations the gene pool will not necessarily be decreased by translocations. Movement of mussel seed has the potential to transport pathogens and non-native species (see sensitivity assessments for *Mytilus edulis* bed biotopes). A review by Svåsand *et al*. (2007) concluded that there was a lack of evidence distinguishing between different *Mytilus edulis* populations to accurately assess the impacts of hybridisation with the congener *Mytilus galloprovincialis* and in particular how the gene flow may be affected by aquaculture. Therefore, it cannot be confirmed whether farming will have an impact on the genetics of wild sindividuals beyond a potential for increased hybridisation.

No information was found on current production of *Mastocarpus stellatus*, *Chondrus crispus* or other turf forming red seaweeds in the UK and it is understood that wild harvesting rather than cultivation is the method of production for these and littorinids. No evidence was found for the effects of gene flow between cultivated species and wild populations. Although cultivation of different genotypes may lead to gene flow between wild and cultivated populations the limited dispersal may reduce exposure. Some negative effects may arise from hybridisation between very geographically separated populations but there is no evidence to suggest that gene flow between different UK haplotypes would lead to negative effects.

Sensitivity assessment. No direct evidence was found regarding the potential for negative impacts of translocated mussel seed on wild *Mytilus edulis* populations. While it is possible that translocation of mussel seed could lead to genetic flow between cultivated beds and local wild populations, there is currently no evidence to assess the impact (Svåsand *et al.*, 2007).

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

The Australasian barnacle *Austrominius* (previously *Elminius) modestus* was introduced to British waters on ships during the second world war. However, its overall effect on the dynamics of rocky shores has been small as *Austrominius modestus* has simply replaced some individuals of a group of co-occurring barnacles (Raffaelli & Hawkins, 1999). Although present, monitoring indicates it has not outnumbered native barnacles in the Isle of Cumbrae (Gallagher *et al*., 2015) it may dominate in estuaries where it is more tolerant of lower salinities than *Semibalanus balanoides* (Gomes-Filho, *et al*., 2010).

Space pre-emption by holdfasts may prevent settlement of INIS until disturbance events create gaps for invasion. However, in the Mediterranean crustose corallines and algal turfs facilitate attachment of *Caulerpa racemosa* by providing a more complex substratum than bare rock (Bulleri & Benedetti-Cecchi, 2008).

Algal species which may have overlapping habitat requirements include the green seaweed *Codium fragile* subsp *tormentosoides* (now renamed as *Codium fragile fragile*) and the red seaweed *Heterosiphonia japonica*, neither of these have so far been recorded in nuisance densities (Sweet, 2011j). Wireweed, *Sargassum muticum and Grateloupia turuturu* grow best on sheltered shores and in rockpools (Sewell, 2011c, 2011g) and the wave exposed habitats where this biotope occurs may not be suitable for establishment. The red seaweeds *Heterosiphonia japonica* and *Neosiphonia harveyi* may also occur in this biotope but, again, no impacts have been reported.

Sensitivity assessment. Overall, there is little evidence of this biotope being adversely affected by non-native species, resistance is therefore assessed as 'High', and resilience as 'High' (by default), and the biotope is considered to be 'Not sensitive'.

Introduction of microbial pathogens	Medium Q: High A: Low C: Low	High Q: High A: Low C: Medium	Low Q: High A: Low C: Low

The characterizing species *Semibalanus balanoides* and *Patella vulgata* are considered subject to persistent, low levels of infection by pathogensa nd parasites. Barnacles are parasitised by a variety of organisms and, in particular, the cryptoniscid isopod *Hemioniscus balani* , in which heavy infestation can cause castration of the barnacle. At usual levels of infestation these are not considered to lead to high levels of mortality. *Patella vulgata* has been reported to be infected by the protozoan *Urceolaria patellae* (Brouardel, 1948) at sites sheltered from extreme wave action in Orkney. Baxter (1984) found shells to be infested with two boring organisms, the polychaete *Polydora ciliata* and a siliceous sponge *Cliona celata*. No evidence for mortality resulting from microbial pathogens was found for the red algae.

Sensitivity assessment. Based on the characterizing species, *Semibalanus balanoides* and *Patella vulgata*, and the lack of evidence for widespread, high-levels of mortality due to microbial pathogens the biotope is considered to have **'High'** resistance to this pressure and therefore **'High'** resilience (by default), the biotope is therefore considered to be **'Not sensitive'**.

Removal of target species	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

The species *Mytilus edulis* is too small and patchy in this biotope to be targeted for commercial harvesting. However, some, unregulated recreational hand-gathering of this species, littorinids and the limpet *Patella vulgata*, may occur. Gathering of *Mytilus edulis* is not considered to affect the biotope as this species is present in low densities, as small individuals in cracks and crevices and is therefore not a key characterizing or structuring species. *Patella vulgata*, however, is a key characterizing and structuring species within this biotope. *Patella vulgata* grazing can control the character of the shore by grazing algae and newly settled barnacle larvae. Even a small, localised temporary absence of limpets (Southward, 1956; Southward, 1964; Hawkins, 1981; Hawkins *et al*., 1983) can alter the biological assemblage. Significant limpet kills resulting from the widespread use of dispersants after the *Torrey Canyon* oil spill dramatically altered rocky shore communities. *Laminaria digitata*, for example, was able to extend 2 m upshore in the absence of limpets and there were dense growths of ephemeral green seaweeds followed by equally dense growth of fucoids (Southward & Southward, 1978; Hawkins & Southward, 1992).

Mastocarpus stellatus and *Osmundea pinnatifida* are also collected by hand commercially and recreationally for consumption. Removal of other associated algae will reduce the presence of turf forming red algae in this biotope and would result in the provision of benefits to other species, such as reduction of dessication, shelter and grazing.

Sensitivity assessment. The resistance of red algae and *Patella vulgata* to removal is 'Low' as these species are relatively large and immobile or sedentary and therefore easily found and removed. As the algal turf is not dominant in this biotope and removal of *Patella vulgata* may maintain this biotope LR.HLR.MusB.Sem.FvesR, rather than allowing an algal dominated biotope to develop on moderately exposed shores, resistance to removal is assessed as **'High',** resilience as **'High'** (by default) so that the biotope is considered to be **'Not Sensitive'** to this pressure.

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

The characterizing species *Mytilus edulis* is too small and patchy in this biotope to be targeted for commercial harvesting. However, some hand-gathering of this species and the edible periwinkle *Littorina littorea* may occur. As *Littorina littorea* are present only in low densities and the biotope is wave exposed, ecological effects such as the proliferation of algae are not predicted to arise from its removal. Removal of the characterizing species, *limpets* and barnacles and the red seaweeds accidentally would alter the character of the biotope.

Sensitivity assessment. Removal of a large percentage of the characterising species would alter the character of the biotope, so that it was bare rock. Resistance is therefore assessed as 'Low' and recovery as 'Medium', so that sensitivity is assessed as 'Medium'.

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