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Novocrania anomala and *Protanthea simplex* on sheltered circalittoral rock

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

John Readman & Angus Jackson

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Circalittoral cliff face with dense brachiopods *Neocrania anomala* and *Terebratulina retusa*, the anemone *Protanthea simplex* and the ascidian *Ciona intestinalis*. Loch Duich, Highland.

Photographer: Sue Scott

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- 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 John Readman & Angus Jackson Referred by Admin

Summary

☰ UK and Ireland classification

EUNIS 2008	A4.314	<i>Neocrania anomala</i> and <i>Protanthea simplex</i> on sheltered circalittoral rock
JNCC 2015	CR.LCR.BrAs.NovPro	<i>Novocrania anomala</i> and <i>Protanthea simplex</i> on sheltered circalittoral rock
JNCC 2004	CR.LCR.BrAs.NeoPro	<i>Neocrania anomala</i> and <i>Protanthea simplex</i> on sheltered circalittoral rock
1997 Biotope	CR.SCR.BrAs.NeoPro	<i>Neocrania anomala</i> and <i>Protanthea simplex</i> on very sheltered circalittoral rock

🔍 Description

This biotope typically occurs in full to variable salinity conditions on very wave-sheltered circalittoral bedrock and boulder slopes subject to negligible tidal streams (this tends to be in the

landward, very sheltered basins of fjordic sealochs). This biotope is characterized by often dense populations of the anemone *Protanthea simplex*, growing on the silty bedrock. The underlying rock surfaces are usually covered by encrusting red algae, the polychaete *Spirobranchus triqueter*, the brachiopods *Novocrania anomala* and *Terebratulina retusa*, the saddle oyster *Pododesmus patelliformis* and the polychaete *Sabella pavonina*. Scattered colonies of *Alcyonium digitatum* and the hydroid *Bougainvillia ramosa* may occasionally be recorded. A diverse range of ascidians including *Ciona intestinalis*, *Ascidia mentula*, *Corella parallelogramma*, *Ascidia virginea*, *Polycarpa pomaria* and *Dendrodoa grossularia* are also occasionally recorded. Echinoderms such as the common brittlestar *Ophiothrix fragilis* are frequently reported with their arms protruding from crevices in the rock, whilst the starfish *Asterias rubens*, *Henricia oculata*, and the sea urchin *Echinus esculentus* and *Psammechinus miliaris* are occasionally found on the boulder/rock surface. The whelk *Buccinum undatum* is often present but in very low numbers. The squat lobster *Munida rugosa* may be seen hiding in crevices. The hermit crab *Pagurus bernhardus* may also be recorded. (Information from Connor *et al.*, 2004; JNCC, 2105).

↓ Depth range

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

🏛️ Additional information

CR.LCR.BrAS.NeoPro includes two sub-biotopes (NeoPro.FS and NeoPro.VS) depending on the salinity regime. Both are found in similar physical habitats but *Dendrodoa grossularia* becomes common in the variable salinity sub-biotope (NeoPro.VS) and *Protanthea simplex* exhibits a higher abundance in the full salinity sub-biotope (NeoPro.FS) (JNCC, 2014).

✓ Listed By

- none -

🔗 Further information sources

Search on:



Habitat review

🔄 Ecology

Ecological and functional relationships

In this circalittoral biotope and similar sub-biotopes there are few algal species and limited primary production. The fauna is dominated by encrusting / attached species such as anemones, hydroids, brachiopods and solitary ascidians. The fauna consists predominantly of passive and active suspension feeders. There are a few errant predators and scavengers such as *Cancer pagurus*, and *Asterias rubens*. Particularly dense assemblages with abundant solitary sea squirts may provide shelter for other small fauna. Additional shelter may be provided by large sponges, particularly in the sub-biotopes.

Seasonal and longer term change

Ciona intestinalis is typically an annual species, particularly in reduced salinity water although reproduction can occur throughout the year. There will be some temporal changes in the coverage and shelter provided by this species. Otherwise, it is unlikely that there will be any seasonal or other temporal changes in the biotope.

Habitat structure and complexity

The sheltered conditions of the landward basins of sea lochs can allow quite species-rich assemblages to develop. Several tube worm species, including *Chaetopterus variopedatus* can be used by *Protanthea simplex* as a substratum. Larger species, including sponges and solitary ascidians provide greater spatial complexity. Higher densities of the hard, permanently attached *Novocrania anomala* may exclude other species.

Productivity

Primary productivity in this biotope is low although coralline algae were recorded in more than half of the records of this biotope and the brown algae *Pseudolithoderma extensum* in approximately one quarter of all records (JNCC, 1999). However, quite high densities of encrusting or attached organisms, primarily brachiopods, sea loch anemones, solitary ascidians and tube worms can result in quite high secondary productivity through suspension feeding.

Recruitment processes

Recruitment is primarily through pelagic larvae. Intense local recruitment can occur with *Ciona intestinalis* where sticky mucus strings containing eggs and larvae are trapped round nearby adults or other objects. Dispersal ability of *Novocrania anomala* may be limited and only occur from local populations. *Protanthea simplex* with its long-lived pelagic larval stage has considerable dispersal potential.

Time for community to reach maturity

None of the main characterizing species are particularly long lived. *Novocrania anomala* survives for possibly up to 10 years. *Ciona intestinalis* lives typically only for a year and populations can reproduce throughout the year. Large sponges may have considerably greater longevity and

slower growth. It may take over five years for the community to reach maturity.

Additional information

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Preferences & Distribution

Habitat preferences

Depth Range	5-10 m, 10-20 m, 20-30 m, 30-50 m
Water clarity preferences	Poor clarity / Extreme turbidity, Very high clarity / Very low turbidity, See additional information
Limiting Nutrients	Data deficient
Salinity preferences	Full (30-40 psu)
Physiographic preferences	Enclosed coast / Embayment
Biological zone preferences	Circalittoral
Substratum/habitat preferences	Bedrock, Large to very large boulders, Small boulders
Tidal strength preferences	Very Weak (negligible), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Extremely sheltered, Sheltered, Very sheltered
Other preferences	

Additional Information

The two sub-biotopes included within this assessment are characterized by variable, reduced or low salinity which may influence biotope structure. The two sub-biotopes have some similarities although SCR.NeoPro.Den is more species rich and may occur in more open lochs (so far it has only been recorded from Loch Etive). The temperature preferences of the individual species selected to represent the biotope are quite different to the temperatures in which the biotope occurs in Britain and Ireland. For instance, *Ciona intestinalis* has a world-wide distribution and optimal growth occurs at between 15-20 degrees C, considerably higher than water temperatures on the west coast of Scotland. *Protanthea simplex* extends further north into colder waters. No information is available regarding limiting nutrients.

Species composition

Species found especially in this biotope

Rare or scarce species associated with this biotope

-

Additional information

The biotope assessment also covers two sub-biotopes. *Ciona intestinalis* is not one of the characterizing species in SCR.NeoPro.CaTw. However, *Ciona intestinalis* is assumed to form a

suitable surrogate, representing the sensitivity of the various other solitary ascidians in the sub-biotope.

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

CR.LCR.BrAs.NovPro and its sub-biotopes CR.LCR.BrAs.NovPro.FS and CR.LCR.BrAs.NovPro.VS occur on steep or vertical sheltered bedrock and boulder slopes in the circalittoral, typically in fjordic sealochs. CR.LCR.BrAs.NovPro experiences full or variable salinity, and its two sub-biotopes differ in salinity; the low to full salinity NovPro.VS (salinity between <18-35 psu) and the full salinity NovPro.FS (salinity of between 30-35 psu).

The brachiopod *Novocrania anomala* (previously *Neocrania anomala*) is the characterizing species for this group. The anemone *Protanthea simplex* is a characterizing species of the full salinity NovPro.FS, but is only occasionally seen in the variable salinity NovPro.VS. In the variable salinity sub-biotope (NovPro.VS), a diverse range of ascidians, including *Dendrodoa grossularia*, *Ciona intestinalis* and *Ascidia mentula* become more dominant. *Sarcodictyon roseum* is present in the CR.LCR.BrAs.NovPro.VS, although the description and species list only record species as occasionally present and is considered where appropriate. Other species present in these biotopes are considered transient, mobile or ubiquitous and are therefore not considered significant to assessment of the sensitivity of these biotopes. Sensitivity assessments therefore focus on *Novocrania anomala*, *Protanthea simplex* and the ascidians (including *Dendrodoa grossularia*, *Ciona intestinalis* and *Ascidia mentula*).

Resilience and recovery rates of habitat

Novocrania anomala (previously *Neocrania anomala*) is an inarticulate brachiopod that cements its lower shell to the hard substrata (and is therefore sessile) following a pelagic larval stage (Nielsen, 1991, Alvarez & Emig 2000). Brachiopods tend to grow quickly initially, in order to increase survival in the early, most vulnerable life stage. Growth subsequently becomes more stable, diminishing in the latest stages. In general, brachiopods to live up to about 10 years (Alvarez & Emig, 2000). *Novocrania anomala* possesses no pedicle, cementing its ventral valve directly to the substratum instead and orientating with the dorsal side up, the anterior margin directed upwards away from the substratum (Ruppert & Barnes, 1994). The species is free-spawning and fertilization is external in the surrounding water column. The eggs are denser than seawater and hatch into a free-swimming larval stage. The larvae are fully developed within three days and settle out in no more than a few days, limiting the dispersal range. Although the species may inhabit areas with water flow rates of up to 3 knots, it is often restricted to sheltered habitats such as sea lochs, which may reduce dispersal ability (Jackson, 2000). No information was available about fecundity. Reproduction occurs annually and over an extended period of time (Long & Stricker, 1991; James *et al.*, 1992) with spawning reported between April and October in the South of France and Scotland (Joubin, 1886; Rowell, 1960 cited in James *et al.*, 1992). *Novocrania anomala* is also capable of recovery from considerable damage to the shell and soft tissue, the adults can be maintained quite well in aquaria and are generally hardy organisms (James *et al.*, 1992).

Protanthea simplex is a small (2 cm high), delicate anemone (Jackson, 2008) commonly found in Scottish lochs (Wood, 2005), which appears to be the southern limit to this species' distribution (NBN, 2016), although one record exists off Connemara, Ireland (Seeley, 2006). This anemone is sociable and beds of up to 2000 per m² are found in Scandinavia (Wood, 2005). *Protanthea simplex* has a long-lived pelagic larval stage (15-20 days, at 10-12°C, in the plankton before settling) and therefore has considerable dispersal potential, with breeding taking place between September and October in Sweden (Jackson, 2008). Fragments of tissue in this species (except the tentacles) are

capable of regenerating into complete anemones, a form of vegetative, asexual reproduction (Manuel, 1988). Anemones are not completely sessile and are capable of slow movement. For example, Sebens (1981) observed immigration to cleared patches of the long-lived anemone *Anthopleura xanthogrammica* as the primary driver towards recovery. Sebens (1981) cleared intertidal patches of *Anthopleura xanthogrammica* at Mukkaw Bay, WA observing the effects over four years. Even after four years, cleared areas were not back to pre-removal population densities. Chia & Spaulding (1972) studying the anemone *Tealia crassicornis* found no sign of gonad development at 14 months old.

Solitary ascidians are discrete creatures which do not fuse with others (unlike colonial ascidians), but may still form dense beds (e.g. up to 5000 individuals/m² for *Ciona intestinalis*) (Naylor, 2011). *Dendrodoa grossularia*, *Ascidia mentula* and *Ciona intestinalis* occur across the western, northern and southern coasts of the UK, with more scattered records on the eastern coast (NBN, 2015). *Dendrodoa grossularia* is a small solitary ascidian (1.5-2 cm diameter (Miller, 1954)). Settlement occurs from April-June, by the following summer individuals reach their maximum size. Life expectancy is expected to be 18-24 months. Sexual maturity is reached within the second year of growth and the release of gametes occurs from spring-autumn, with peaks in early spring and another in late summer. Gamete release is reduced at temperatures above 15°C and totally suppressed above ca. 20°C (Miller, 1954). Kenny & Rees (1994) observed *Dendrodoa grossularia* was able to recolonize rapidly following aggregate dredging. Following experimental dredging of a site off the English coast, which extracted an area of 1-2 m wide and 0.3-0.5 m deep, *Dendrodoa grossularia* was able to recolonize and attained 40% of pre-dredge abundance and 23% of biomass within 8 months. This recover rate combined with the ability of this species to reach sexual maturity within its first year suggests that *Dendrodoa grossularia* can recover from disturbance events within two years.

In *Ciona intestinalis*, spawning has been reported as year-round in temperate conditions (MBA, 1957, Yamaguchi, 1975, Caputi *et al.*, 2015) with seasonal spawning observed in colder climates from May to June on the Canadian coast (Carver *et al.*, 2006) and in shallower habitats in Sweden (Svane & Havenhand, 1993). Oviparous solitary ascidians generally spawn both oocytes and sperm into the water column, where the resultant fertilized eggs develop into free-swimming, non-feeding larvae. The eggs are negatively buoyant and slightly adhesive and are either released freely or in mucus strings that are especially adhesive. These strings have a tendency to settle close to or on the parent ascidian. *In vitro* studies conclude that fertilization proceeds normally whether in the water column or attached to the mucus string. The hatched free-swimming larvae settle nearby, are held by the mucus string until settlement or escape as plankton. Retention in the mucus string may explain the dense aggregations of adults found (Svane & Havenhand, 1993). *In vitro* studies indicate that both spawning and settlement are controlled by light. However, *Ciona intestinalis* has been observed *in vivo* to spawn and settle at any time of the day (Whittington, 1967; Svane & Havenhand, 1993). In the Mediterranean, population collapses of *Ciona intestinalis* were observed, followed by recovery within 1-2 years (Caputi *et al.*, 2015). The collapses are still poorly understood, although low salinity (Pérès, 1943) and temperature (Sabbadin, 1957) were suggested as possible drivers.

Ascidia mentula is a larger (up to 18 cm long) and longer lived (up to seven years) ascidian compared to *Ciona intestinalis* (Rowley, 2008). Recruitment was reported to occur year round in Sweden at depths greater than 20 m, with seasonal spawning occurring at 15 m (where sea temperature variability is much greater). Both active larvae settlement distribution and passive deposition of larvae (i.e. purely hydrodynamic processes) have been proposed (Havenhand & Svane, 1991 see also Meadows & Campbell, 1972; Scheltema, 1974; Butman, 1987). Long-term data from

populations of the ascidian *Ascidia mentula* on subtidal vertical rock indicated that recruitment of *Ascidia mentula* larvae was positively correlated with adult population density, and then by subsequent active larval choice at smaller scales. Factors influencing larval settlement have been listed as light, substratum inclination and texture (Havenhand & Svane, 1989). Sebens (1985, 1986) described the recolonization of epifauna on vertical rock walls. Rapid colonizers such as encrusting corallines, encrusting bryozoans, amphipods and tubeworms recolonized within 1-4 months. Ascidiators such as *Dendrodoa carnea*, *Molgula manhattensis* and *Aplidium* spp. achieved significant cover in less than a year, and, together with *Halichondria panicea*, reached pre-clearance levels of cover after two years. A few individuals of *Alcyonium digitatum* and *Metridium senile* colonized within four years (Sebens, 1986) and would probably take longer to reach pre-clearance levels.

Sarcodictyon roseum forms small colonies on rock surfaces and occasionally on shell, with polyps that reach up to 1 cm in height. It is found from the intertidal to ca 100m and from the Mediterranean to the North Sea (Bay-Nouailhat, 2007; Hayward & Ryland, 1995b). It is found across the western coasts of the British Isles from the Channel Isles to the north coast of Scotland (NBN, 2016) and, more widely, from the Mediterranean to Sweden (Dyntaxa, 2013; van Ofwegen et al., 2001, cited from van Ofwegen, 2015). Very little information is available for this species.

Resilience assessment. The ascidiators are likely to recover from any level of mortality relatively quickly, however, *Novocrania anomala* and *Protanthea simplex* are longer lived, slower growing and are unlikely to fully recover from significant mortality within two years. When resistance is None or Low, resilience is classed as 'Medium', but when resistance is Medium or High, resilience is classed as 'High'.

Hydrological Pressures

	Resistance	Resilience	Sensitivity
Temperature increase (local)	Low Q: High A: Medium C: Medium	Medium Q: Medium A: Medium C: Medium	Medium Q: Medium A: Medium C: Medium

Novocrania anomala extends as far south as the Mediterranean. Radolović *et al.* (2015) describe the gregarious settlement of *Novocrania anomala* in a cave in the Adriatic coast of Croatia. Despite this geographical range, Hiscock (1985 cited in Hartnoll, 1998), noted that seasonal shallow thermoclines may form, particularly in sheltered areas such as sea lochs, and extend down to 15 m. Some animals such as the brachiopods *Crania* (syn. *Novocrania*) and *Terebratulina* seem restricted to below this thermocline. It is, therefore, possible that geographical populations may acclimate to local temperature (Hartnoll, 1998).

Protanthea simplex is a northerly species, with its southern distribution limit typically in Scotland, although one record exists off Connemara, Ireland (Seeley, 2006). *Protanthea simplex* experienced a marked long-term decline in Swedish and Norwegian sites between 1972 and 1982, experiencing ca 50% mortality (density of ca 600 to ca 300) at 20 m and virtual population collapse at 15 m (reduction in density from 400-500 to <50) over ten years (Heip *et al.*, 1985). This decline appeared to coincide with a warm period between 1973 and 1978 of up to ca +2°C deviation and an increase in *Novocrania anomala* (Heip *et al.*, 1985).

Ciona intestinalis is considered a cold water or temperate species but has been found as far south as Cape Verde, although these tropical populations are likely transitory (Monniot & Monniot, 1994). Temperature tolerance varies among geographical populations or ecotypes. Adult *Ciona intestinalis*

is reported as tolerant of temperatures up to 30°C (Dybern, 1965; Therriault & Herborg, 2008), although Petersen & Riisgard (1992) noted that filtration rates declined above 21°C, which suggested thermal stress, and indicated that long-term survival was likely to require temperatures lower than the 30°C. Other studies also indicated that *Ciona intestinalis* exhibits a decline in ammonia excretion rate and oxygen consumption rate above 18°C (Zhang and Fang 1999, Zhang *et al.*, 1999).

The effect of higher temperatures on *Ascidia mentula* is not as well researched. It is distributed from Norway through to the Mediterranean and the Black Sea, and the species appears to tolerate a broad range of temperatures. Svane (1984) found that in Sweden, whilst lower temperatures decreased recruitment, populations responded positively to the “warm period” of 1972-1976 (Glantz, 2005), with an increase in population density across all sites in the study and a gradual decrease during the ensuing “cold period”, and minor fluctuations throughout. Unusually high mean temperatures in 1975 did result in higher recruitment, with colder temperatures in January 1976 and spring 1979 coinciding with very little recruitment. Svane (1984) found that, unlike recruitment, mortality was regulated locally and independent of temperature within the range of the study (mean monthly deviation of $\pm 3^\circ\text{C}$)(Svane, 1984).

Sensitivity assessment. Whilst *Novocrania anomala* and the ascidians are unlikely to be affected by a temperature increase at the benchmark level, *Protanthea simplex*, already at its southern-most limit, is unlikely to tolerate a long-term increase in temperature e.g. 2°C for a year. Population collapse has been recorded at 15 m in Sweden during an extended warm period (longer than the benchmark level). Resistance has therefore been assessed as ‘Low’, Resilience has been assessed as ‘Medium’ and sensitivity is therefore recorded as ‘Medium’.

Temperature decrease (local)

High

Q: Medium A: Medium C: Medium

High

Q: High A: High C: High

Not sensitive

Q: Medium A: Medium C: Medium

The characterizing brachiopod *Novocrania anomala* has been recorded as far north as Svalbard (Greig, 1924, cited in Prestrud *et al.*, 2004) and the anemone *Protanthea simplex* is a northerly species, occurring in Scandinavia and recorded in across Scotland (Wood, 2005; NBN, 2015). A reduction in temperature would probably be beneficial and could result in distribution expansion of *Protanthea simplex*.

Tolerance for low temperatures varies among geographical populations of ascidians. In the Mediterranean, most adult *Ciona intestinalis* die when temperatures fall below 10°C, and the population is maintained by the survival of younger individuals, which are more tolerant of colder temperatures (Marin *et al.*, 1987). Observation of Scandinavian populations indicated a higher mortality rate of *Ciona intestinalis* during the coldest period of the year (temperatures down to 1°C) (Dybern, 1965).

In Scandinavian populations, normal egg development requires 8-22°C and larval development occurs between 6-24°C (Dybern, 1965). Larval temperature tolerances may play a part in successful recruitment in unseasonable temperature fluctuations. *Ciona savigny* larvae were found to acclimate to temperature, with embryos collected in the summer dividing normally between 14 - 27°C and embryos collected in the winter dividing normally between 10 - 20°C (Nomaguchi *et al.*, 1997).

Ascidia mentula is distributed from Norway through to the Mediterranean and the Black Sea, and the species appears to tolerate a broad range of temperatures. Svane (1984) found that in

Sweden, whilst lower temperatures (of $\pm 3^{\circ}\text{C}$ of the monthly mean) decreased recruitment, mortality did not significantly increase. Shallow populations (15 m) experiencing much greater seasonal variability did exhibit seasonal spawning rather than year-round spawning that occurs in more temperate and deeper populations (Svane, 1984).

Populations responded positively to the 'warm period' of 1972-1976 (Glantz, 2005), with an increase in population density across all sites in the study and a gradual decrease during the ensuing 'cold period', with minor fluctuations throughout. Unusually high mean temperatures in 1975 did result in higher recruitment, with colder temperatures in January 1976 and spring 1979 coinciding with very little recruitment. Svane (1984) found that, unlike recruitment, mortality was regulated locally and independent of temperature within the range of the study (mean monthly deviation of $\pm 3^{\circ}\text{C}$).

Sensitivity assessment. None of the characterizing species for this biotope are at their northern distribution limit and are unlikely to be affected by a reduction in temperature at the benchmark level. Resistance is therefore assessed as '**High**', Resilience as '**High**' and Sensitivity is therefore recorded as '**Not Sensitive**'.

Salinity increase (local) **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

Novocrania anomala occurs in biotopes ranging across all salinity regimes – from Low (< 18 ppt) through to Full (30-35 ppt). No literature could be found relating to this brachiopod in hypersaline conditions. *Protanthea simplex* prefers full salinity habitats over lower salinity as, whilst it is characterizing in NovPro.FS, it is only occasionally found in the variable salinity biotope NovPro.VS (Connor *et al.*, 2004). No evidence could be found for the effect of hypersaline conditions.

Ciona intestinalis has been classified as euryhaline with a high salinity tolerance range (12-40‰) although it typically occurs in full salinity conditions (>30‰) (Tillin & Tyler-Walters, 2014). *Ciona intestinalis* has been found in salinities ranging from 11 to 33 PSU in Sweden, although the same study found that parent acclimation to salinity (high or low) has an overriding and significant effect on larval metamorphic success, independent of parent origins (Renborg, 2014).

Sensitivity assessment. NovPro and NovPro.FS are found in full salinity, but '**No evidence**' for the characterizing species in hypersaline conditions could be found.

Salinity decrease (local) **Medium** **High** **Low**
 Q: Medium A: Medium C: Medium Q: Medium A: Medium C: Medium Q: Medium A: Medium C: Medium

Novocrania anomala occurs in biotopes ranging across all salinity variants, from Low (< 18 ppt) through to full (30-35 ppt). Whilst *Novocrania anomala* and the ascidians are likely to be unaffected by a decrease in salinity at the benchmark level, the reduced presence of *Protanthea simplex* from the variable salinity NovPro.VS indicates that it is at least partially intolerant of salinity decrease. It should also be noted that, given the biotope descriptions, a change from NovPro.FS to NovPro.VS would occur in the event of a permanent salinity reduction at the benchmark level. Whilst no evidence could be found directly for *Novocrania anomala*, Hammond (1983) reported that *Lingula anatina* could tolerate salinities ranging from 20‰ to 50‰ for prolonged periods (more than four weeks) and survived in salinities as low as 5‰ for short periods of time (snap response failed at 1 day) and 11.5‰ for 19 days. Other studies report tolerances of ca 16 to 18‰

(Emig, 1997 and references therein) reported more conservative tolerance. It should be noted that the ability for brachiopods to respire anaerobically within their closed shell would enable them to survive short-term changes (James *et al.*, 1992). *Ciona intestinalis* has been classified as euryhaline with a high salinity tolerance range (12-40‰) although it typically occurs in full salinity conditions (>30‰) (Tillin & Tyler-Walters, 2014) but has been found in Scandinavian waters in salinities as low as 11 PSU (Renborg, 2014, Dybern, 1967). Adult acclimation to salinity was shown to have an overriding and significant effect on larval metamorphic success, independent of parent origins (Renborg, 2014). 'Massive die-offs' of *Ciona intestinalis* were observed following winter rains in Californian harbours with 'massive recolonizations usually following in the spring' (Lambert & Lambert, 1998). Population collapses of *Ciona intestinalis* in the Mediterranean have also been reported, and whilst the drivers for these events are not well understood, it has been postulated that low salinity could play a part (Péres, 1943; Caputi *et al.*, 2015). Oxygen consumption rate has been shown to decline with decreasing salinity and ceased at 19‰ with siphons tightly closed. (Shumway, 1978). *Ascidia mentula* is found on the West coast of Norway in salinities greater than 20‰ (Dybern, 1969) and found in a brackish lake in Corsica with a salinity gradient of 6.5 to 18.5‰ Cl⁻ (Verhoeven, 1978). *Dendrodoa* was observed as one of the dominant species in a study area in Lübeck Bay, Norway, where salinity was recorded as between 11.1 -15.0‰ (Gulliksen, 1977).

Sensitivity assessment. The abundance of *Protanthea simplex* is reduced from NovPro.FS (Full salinity of 35 ppt) to NovPro.VS (Low- Variable salinity, <18– 35ppt) while the abundance of *Dendrodoa grossularia* increases (JNCC, 2014). Therefore, resistance is assessed as 'Medium', resilience as 'High' and sensitivity as 'Low'.

Water flow (tidal current) changes (local)

High

Q: Medium A: High C: High

High

Q: High A: High C: High

Not sensitive

Q: Medium A: High C: High

The CR.LCR.BrAs.NovPro biotope exists in weak to negligible tidal flow conditions (<0.5 m/sec.) Connor *et al.* (2004). High flow rates may reduce the abundance of *Novocrania anomala* and *Protanthea simplex*, although *Novocrania anomala* may inhabit areas with water flow rates of up to 3 knots (Jackson, 2000; 2008b). Decreases in water flow are unlikely to have any effect but increases in flow rate above weak may prevent the animals from maintaining posture and interfere with feeding. Increased flow rates may also sweep individuals off the substratum.

As sessile filter feeders, ascidians generally require a reasonable water flow rate in order to ensure sufficient food availability. It was shown that in stagnant water, phytoplankton density became reduced in a 20-30 cm layer immediately above a dense colony of *Ciona intestinalis* (Riisgård *et al.*, 1996). However, *Ciona intestinalis* has been recognised as tolerant of low water flow environments which it uses as a competitive advantage in areas with minimal water exchange and renewal such as harbours, marinas and docks, (Carver *et al.*, 2006).

Whilst *Ciona intestinalis* is typically found in areas of low flow, it can reportedly withstand flow rates up to 3 knots (1.5 m/s) (Jackson 2008b). If dislodged, juveniles and adults have a limited capability to re-attach, given calm conditions and prolonged contact with the new substrata (Millar 1971; Carver *et al.*, 2006; Jackson, 2008). Hiscock (1983) found that, for the solitary ascidian *Ascidia mentula*, siphons closed when current velocity rose above about 0.15 m/s.

Sensitivity assessment. Significant increases in water flow are likely to negatively affect the characterizing species, but mortality at the benchmark level is unlikely. Therefore, resistance is

assessed as '**High**', resilience as '**High**' and the biotope is considered '**Not sensitive**' at the pressure benchmark.

Emergence regime changes	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR
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Changes in emergence are **not relevant** to this biotope as it is restricted to fully subtidal/circalittoral conditions - the pressure benchmark is relevant only to littoral and shallow sublittoral fringe biotopes.

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
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The NovPro biotope complex is found in sheltered to extremely sheltered wave exposure conditions. *Novocrania anomala* is unlikely to tolerate wave action and is found in sheltered. Increases in wave exposure above moderately exposed would probably cause death (Jackson, 2000).

High energy wave action can be detrimental to ascidian populations. This is mainly through physical damage to the sea squirts and through the abrasive action of suspended sediment (Jackson, 2008). *Ciona intestinalis* is often dominant in highly sheltered areas such as harbours (Carver *et al.*, 2006). Decreases in wave exposure are unlikely to have any effect. If dislodged, juvenile and adult *Ciona intestinalis* have a limited capability to re-attach, given calm conditions and prolonged contact with the new substratum (Millar 1971; Carver *et al.*, 2006; Jackson 2008;) but increases in wave exposure above moderately exposed are likely to cause a proportion of the population to die, especially in the shallower examples of the biotope if the cobbles and pebbles on which the biotope occurs are mobilized by wave action. *Ascidia mentula* has rarely been recorded at depths shallower than 15 m (Svane, 1984), it is possible that damage could occur if subjected to increased wave exposure.

Sensitivity assessment. Whilst the characterizing species are likely to be affected by an increase in wave exposure, the NovPro biotope complex is found in sheltered to extremely sheltered wave exposure conditions and a change at the benchmark level is unlikely to increase mortality. Resistance is therefore assessed as '**High**', with resilience as '**High**' and the biotope is therefore assessed as '**Not sensitive**' at the benchmark level.

Chemical Pressures

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

Mercier *et al.* (1998) studied response to TBT exposure of temperate anemones (*Metridium senile* and *Bunodactis stella*), which metabolised and regulated butyl-tin uptake, and accumulated less than mussels (Fent, 1996) or symbiotic anemones (Mercier *et al.*, 1996). Regulation of butyl-tin compounds in temperate sea anemones seemed to parallel that of trace metals (Mercier *et al.*, 1998). Nevertheless, this pressure is **Not assessed**.

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.

CR.LCR.BrAs.NovPro is a sub-tidal biotope (Connor *et al.*, 2004). Oil pollution is mainly a surface phenomenon its impact upon circalittoral turf communities is likely to be limited. However, as in the case of the *Prestige* oil spill off the coast of France, high swell and winds can cause oil pollutants to mix with the seawater and potentially negatively affect sublittoral habitats (Castège *et al.*, 2014). Filter feeders are highly sensitive to oil pollution, particularly those inhabiting the tidal zones that experience high exposure and show correspondingly high mortality, as are bottom dwelling organisms in areas where oil components are deposited by sedimentation (Zahn *et al.*, 1981). Smith (1968) studied the aftermath of the *Torrey Canyon* oil spill and subsequent use of dispersants in that area. The beadlet anemone *Actinia equine* and the dahlia anemone *Tealia felina* were considered some of the most resistant animals on the shore, being commonly found alive, and on 26th April they were found in pools between the tide-marks which appeared to be devoid of all other animals. Some *Anemonia sulcata*, *Sagartia elegans* and *Cereus pedunculatus* were found dead; few survived. Little evidence for brachiopod resistance to hydrocarbon contamination could be found.

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.

Radionuclide contamination

No evidence (NEv)

Q: NR A: NR C: NR

No evidence (NEv)

Q: NR A: NR C: NR

No evidence (NEv)

Q: NR A: NR C: NR

No evidence

Introduction of other substances

Not Assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

This pressure is **Not assessed**.

De-oxygenation

Medium

Q: High A: Low C: Medium

High

Q: Medium A: Medium C: Medium

Low

Q: Medium A: Low C: Medium

The brachiopod *Terebratulina unguicula* is dominant in a fjord that shows annual upwelling of anoxic waters; it is one of the few animals found in areas with oxygen levels frequently below 0.1 ml/l (Tunncliffe & Wilson, 1988). The inarticulate *Crania californica* has a restricted distribution that may be a function of low dispersal. Over a number of years, one monitored brachiopod population was stable although a gradual retreat from the low oxygen waters was observed (Tunncliffe & Wilson, 1988).

The brachiopod *Terebratulina septentionalis* has been shown to survive in anoxic conditions for 3.5 days (through anaerobic respiration), however, its activity may be reduced (Hammen, 1977, cited

in James et al., 1992). Thayer (1981) found that the brachiopods *L. californianus* and *Terebratulina unguicula* survived more than two weeks in anoxic conditions.

Ellington(1982) reviewed the effects of hypoxia and anoxia on anemones and noted that survival was several days to weeks depending on species. Mazouni *et al.* (2001) noted that whilst oysters (*Magallana gigas*) can survive short-term exposure to periods of anoxia (Thau Lagoon, France), the associated biofouling community dominated by *Ciona intestinalis* suffered heavy mortality. It should be noted, however, that this species is frequently found in areas with restricted water renewal where oxygen concentrations may drop (Carver *et al.*, 2006). While adverse conditions could affect health, feeding, reproductive capability and could eventually lead to mortality, recovery should be rapid.

In general, respiration in most marine invertebrates does not appear to be significantly affected until extremely low concentrations are reached. For many benthic invertebrates, this concentration is about 2 ml/l (Herreid, 1980; Rosenberg *et al.*, 1991; Diaz & Rosenberg, 1995). Cole *et al.* (1999) suggest possible adverse effects on marine species below 4 mg/l and probable adverse effects below 2 mg/l.

The ability of solitary ascidians to withstand decreasing oxygen levels has not been well documented.

Hiscock & Hoare (1975) reported an oxycline forming in the summer months (Jun-Sep) in a quarry lake (Abereddy, Pembrokeshire) from close to full oxygen saturation at the surface to <5% saturation below ca 10 m. During these summer events, no echinoderms or *Ascidia mentula* were recorded at depths below 10 - 11 m.

Sensitivity assessment. No direct evidence was found on the effect of hypoxia on *Novocrania anomala* or *Protanthea simplex*. Based on the evidence of other brachiopods, and anemones, a proportion of the community is likely to be able to survive a short-term anoxic episode. An event at the benchmark level is likely to cause limited mortality among all the characterizing species. Resistance is, therefore recorded as '**Medium**', resilience as '**High**' and sensitivity as '**Low**'.

Nutrient enrichment

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not sensitive

Q: NR A: NR C: NR

James *et al.* (1992) conducted a review of brachiopod literature, including brachiopod sensitivity to turbidity and cited Rhodes & Thayer (1991), highlighting the ability of brachiopods to sort and reject particles. The rejected material was removed using mucous streamers, although the extra energy cost of this mechanism was noted. The importance of dissolved organic matter is debated (see James et al., 1992). Steele & Petrovic (1975, 1976, 1979) and Thayer (1986) discussed the importance of the unfused lophophore tentacles in adaptation to highly turbid environments, although whether this makes them better suited to excessive turbidity than bivalves is questioned (Thayer, 1991). *Ascidia mentula* has been reported in Iberian bays subject to both nutrient-rich upwelling events and anthropogenic pollution (Aneiros *et al.*, 2015). There is some suggestion that there are possible benefits to ascidians from the increased organic content of water; ascidian 'richness' in Algeciras Bay was found to increase in higher concentrations of suspended organic matter (Naranjo *et al.* 1996). Nevertheless, this biotope is considered to be '**Not sensitive**' at the pressure benchmark, that assumes compliance with good status as defined by the WFD.

Organic enrichment

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

Rhodes & Thayer (1991, cited in James *et al.*, 1992) highlighted the ability of brachiopods to sort and reject particles. The rejected material was removed using mucous streamers, although the extra energy cost of this mechanism was noted. The importance of dissolved organic matter is debated (see James *et al.*, 1992). The lophophore in some brachiopods appears to be able to absorb directly dissolved organic matter from seawater (Storch & Welsch, 1976 cited in Emig, 1997). Steele & Petrovic (1975, 1976, 1979) and Thayer (1986) discussed the importance of the unfused lophophore tentacles in adaptation to highly turbid environments, although whether this makes them better suited to excessive turbidity than bivalves is questioned (Thayer, 1991).

Shick (2012) reviewed the uptake of dissolved organic matter in sea anemones and noted (citing Robbins & Shick, 1980) that this feeding mechanism is likely to be particularly important for small anemones, which have a proportionally large tentacle surface area.

There is some suggestion that there are possible benefits to the ascidians from the increased organic content of water. Ascidian 'richness' in Algeciras Bay was found to increase in higher concentrations of suspended organic matter (Naranjo *et al.* 1996). Kocak & Kucuksezgin (2000) noted that *Ciona intestinalis* was one of the rapid breeding opportunistic species that tended to be dominant in Turkish harbours enriched by organic pollutants and was frequently found in polluted environments (Carver *et al.*, 2006). *Ascidia mentula* has been reported in Iberian bays subject to both nutrient-rich upwelling events and anthropogenic organic pollution (Aneiros *et al.*, 2015).

Sensitivity assessment. All of the characterizing species are filter feeders and dissolved organic matter is an important food source. However, organic enrichment can lead to eutrophication or hypoxia. But 'No evidence' as to the effects of organic enrichment in sublittoral rock was found.

A 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: High C: High

High

Q: High A: High C: High

The replacement of rock by sediment would be a fundamental change the physical character of the biotope, which would be lost. Resistance to the pressure is considered 'None', and resilience 'Very low' (a permanent change). Sensitivity has been assessed as 'High'.

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

'Not relevant' to biotopes occurring on bedrock.

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

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

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

Novocrania anomala is a sessile brachiopod protected by a calcified shell. However its shell is not massively strong and physical disturbance (such as a passing scallop dredge) will probably cause damage and death (Long & Stricker, 1991; James *et al.*, 1992; Jackson, 2000). *Protanthea simplex* is delicate and soft-bodied. Abrasion is highly likely to cause mortality. Both *Ciona intestinalis* and *Ascidia mentula* are large, emergent, sessile ascidians, and physical disturbance is likely to cause damage and mortality. Emergent epifauna are generally very intolerant of disturbance from fishing gear (Jennings & Kaiser, 1998). However, studies have shown *Ascidia spp.* to become more abundant following disturbance events (Bradshaw *et al.*, 2000).

Sensitivity assessment. Whilst the hard shell of *Novocrania anomala* would afford some protection from a lighter abrasion event, both the ascidians and the soft-bodied *Protanthea simplex* are likely to be significantly affected. Resistance is, therefore, assessed as '**Low**', resilience as '**Medium**', and sensitivity as '**Medium**'.

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

The species characterizing this biotope group are epifauna or epiflora occurring on rock which is resistant to subsurface penetration. The assessment for abrasion at the surface only is therefore considered to equally represent sensitivity to this pressure. This pressure is thought '**Not Relevant**' to hard rock biotopes

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

Rhodes and Thayer's (1991, cited in James *et al.*, 1992) highlighted the ability of brachiopods to sort and reject particles. The rejected material was removed using mucous streamers, although the extra energy cost of this mechanism was noted. The importance of dissolved organic matter as a food source was debated (see James *et al.*, 1992). Steele-Petrović (1975, 1976, 1979) and Thayer

(1986) discussed the importance of the unfused lophophore tentacles in adaptation to turbid environments, although whether this makes them better suited to excessive turbidity than bivalves was questioned (Thayer, 1991). Whilst brachiopods appear well suited to cope with turbid conditions, Rudwick (1965, 1970, cited in James *et al.*, 1992) noted that the sessile brachiopods, unable to maintain themselves at the surface of a rapidly accreting substratum, would not tolerate sedimentation. Increased siltation may clog the anemone's tentacles and interfere with feeding. Clearing the sediment will require increased energetic expenditure and loss of condition may result. *Ciona intestinalis* frequently occurs in habitats close to harbours and marinas with high levels of silt and suspended matter (Carver *et al.*, 2006; Kocak & Kucuksezgin, 2000). Naranjo *et al.* (1996) described *Ciona intestinalis* as having a large body and siphons that have wide apertures that helps prevent blocking. Increased suspended sediment may potentially have some detrimental effects in clogging up feeding filtration mechanisms, however, there are possible benefits from increased suspended sediment as ascidian 'richness' in Algeciras Bay was found to increase in higher concentrations of suspended organic matter (Naranjo *et al.* 1996). In high (up to 300 mg/l of inorganic and 2.5×10^7 cells/l) suspended particulate concentrations, the active rejection mechanism (squirting) is increased in *Ciona intestinalis* with no discrimination between organic and inorganic particulates observed in any of the ascidians in the study (Robbins, 1984a). Despite these observations, the turbidity tolerance level for this species is not well established. Robbins (1985a) found that continual exposure to elevated levels of inorganic particulates (>25 mg/l) arrested the growth rate of *Ciona intestinalis* and exposure to 600 mg/l resulted in 50% mortality after 12-15 days and 100% mortality after 3 weeks. It was suggested that because this species can only "squirt" to clear the branchial sac, it may be vulnerable to clogging under heavy sediment loads. *Ascidia mentula* has been shown to decrease absolute (instantaneous) rate of pumping in high suspended particulate concentrations, whilst filtration efficiency remained unchanged (Robbins, 1984a). However, specific data on the sensitivity to suspended sediment is lacking.

Sensitivity assessment. Whilst increase in turbidity may result in increased energy expenditure for some of the characterizing species, all have methods to cope with increased turbidity. Assuming the biotope typically occurs in intermediate turbidity (10-100 mg/l), an increase at the benchmark level (to medium, 100-300 mg/l) is unlikely to cause significant mortality amongst the characterizing species and resistance is assessed as '**High**', Resilience as '**High**' and the biotope is considered to be '**Not sensitive**'.

Smothering and siltation rate changes (light)

Medium

Q: High A: Medium C: Medium

High

Q: Medium A: Medium C: Medium

Low

Q: Medium A: Medium C: Medium

Protanthea simplex is a small (2 cm high), delicate anemone (Jackson, 2008). Smothering with 5 cm of sediment is likely to cause physical damage to the anemone as well as restricting respiration and preventing feeding. In the event of burial, *Novocrania anomala* is up to 1.5 cm in size (Jackson, 2000), can close their shell and survive in low oxygen concentrations, which can be tolerated for a few days (Thayer, 1981 cited in James *et al.*, 1992). Longer term, smothering by sediment will prevent feeding and result in anoxic conditions, eventually resulting in mortality. Adults are sessile, being permanently cemented to the substratum (Jackson, 2000) and Rudwick (1965, 1970, cited in James *et al.*, 1992) noted that the sessile brachiopods, unable to maintain themselves at the surface of a rapidly accreting substratum, would not tolerate sedimentation. The solitary ascidians considered in this report are permanently attached to the substratum and are active suspension feeders. Smothering with 5 cm of sediment is likely to only affect a small proportion of the population because the adults reach up to 15 cm and 18 cm in length for *Ciona intestinalis* and

Ascidia mentula respectively (Rowley, 2008; Jackson, 2008) and frequently inhabit vertical surfaces (Jackson, 2008), Recovery should be rapid, facilitated by the remaining adults.

Sensitivity assessment. Smothering by 5 cm of sediment is likely to impact the characterizing species of this biotope including the sessile ascidians and *Novocrania anomala*. The biotope often occurs on vertical walls which would protect the characterizing species from sedimentation effects. In flatter areas where sedimentation could occur, given the low water flow rates experienced by these biotopes (Weak to very weak), it is unlikely that the sediment would be removed very rapidly and it is unlikely that *Novocrania anomala* could survive. Resistance has been assessed as 'Medium', resilience as 'High' and sensitivity has been assessed as 'Low' at the benchmark level.

Smothering and siltation rate changes (heavy)

Low

Q: High A: Medium C: Medium

Medium

Q: Medium A: Medium C: Medium

Medium

Q: Medium A: Medium C: Medium

Protanthea simplex is a small (2 cm high), delicate anemone (Jackson, 2008). Smothering with 30 cm of sediment is highly likely to cause physical damage to the anemone as well as restricting respiration and preventing feeding. In the event of burial, the dorsal valve of *Novocrania anomala* is up to 1.5 cm in size (Jackson, 2000), can close their shell and survive in low oxygen concentrations, which can be tolerated for a few days (Thayer, 1981 cited in James *et al.*, 1992). Longer term, smothering by sediment will prevent feeding and result in anoxic conditions, eventually resulting in mortality. Adults are sessile, being permanently cemented to the substratum (Jackson, 2000) and Rudwick (1965, 1970, cited in James *et al.*, 1992) noted that the sessile brachiopods, unable to maintain themselves at the surface of a rapidly accreting substratum, would not tolerate sedimentation. The solitary ascidians considered in this report are permanently attached to the substratum and are active suspension feeders. Smothering with 30 cm of sediment is likely to affect a proportion of the population because, although the adults reach up to 15 cm and 18 cm in length for *Ciona intestinalis* and *Ascidia mentula* respectively (Rowley, 2008; Jackson, 2008), they frequently inhabit vertical surfaces (Jackson, 2008). Recovery should be rapid, facilitated by the remaining adults.

Sensitivity assessment. Smothering by 30 cm of sediment is likely to impact the characterizing species of this biotope especially the sessile ascidians and *Novocrania anomala*. The biotope often occurs on vertical walls which would protect the characterizing species from sedimentation effects. In flatter areas where sedimentation could occur, given the low water flow rates experienced by these biotopes (weak to very weak), it is unlikely that the sediment would be removed very rapidly and few *Novocrania anomala* and ascidians would survive. The resilience assessment assumes removal of the sediment, however, depending on the conditions, this may not be possible. Resistance has been assessed as 'Low', resilience as 'Medium' and sensitivity has been assessed as 'Medium' at the benchmark level.

Litter

Not Assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

Not assessed

Electromagnetic changes

No evidence (NEv)

Q: NR A: NR C: NR

No evidence (NEv)

Q: NR A: NR C: NR

No evidence (NEv)

Q: NR A: NR C: NR

No evidence

Underwater noise changes

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

No evidence could be found for the effects of noise or vibrations on *Novocrania anomala* or *Protanthea simplex* but they are considered unlikely to be sensitive to this pressure. McDonald (2014) studied the effect of generator noise on fouling of four vessels by *Ciona intestinalis* and found that fouling was highest at locations closest to the generators and lowest furthest away from the generators. Subsequent *in vitro* experiments demonstrated that larvae settled much faster in the presence of noise (2 h- 20 h compared with 6 h-26 h for control), underwent metamorphosis more rapidly (between 10 and 20 h compared with ca 22 h) and had a markedly increased survival rate to maturity (90-100% compared with 66%). Other studies also reported that noise emissions from vessels promoted fouling by organisms including ascidians (Stanley *et al.*, 2016).

Sensitivity assessment: Resistance to this pressure is assessed as 'High' and resilience as 'High'. This biotope is therefore considered to be 'Not sensitive'.

Introduction of light or shading

High

Q: Medium A: Medium C: Medium

High

Q: High A: High C: High

Not sensitive

Q: Low A: NR C: NR

Whilst most brachiopods are believed to detect light, the means of detection has been questioned and few studies have been undertaken (James *et al.*, 1992). It should be noted that McCammon (1973) reported that *Magellania venosa* was not sensitive to light. Anemones have been reported to respond to light (Parker, 1919 cited in Sebens, 1981). The ascidian *Dendrodoa* spp. larvae do not possess an eye spot, and light does not appear to affect locomotion (Mackie & Bone, 1976).

Sensitivity assessment. Whilst there is evidence that some characterizing species respond to light, either as larvae or as adults, change at the benchmark level is unlikely to cause mortality among any of the species assessed, and resistance and resilience are both recorded as 'High', and the biotope is considered 'Not sensitive' to this pressure.

Barrier to species movement

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, barriers and changes in tidal excursion are not relevant to biotopes restricted to open waters.

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

Ciona intestinalis is considered a fouling species and adheres readily to the hulls of vessels, and is considered an invasive species in the USA, Chile, Western Australia, New Zealand, Canada and South Africa (Millar 1966; McDonald 2004; Blum *et al.* 2007; Ramsay *et al.* 2008, 2009; Dumont *et al.*, 2011). Whilst there have been novel proposals to farm *Ciona intestinalis* as a potential feedstock for aquaculture in Sweden (Laupsa, 2015), there is no evidence to suggest such farming exists. No evidence for *Novocrania anomala* or *Protanthea simplex* could be found. Therefore, there is currently 'No evidence' on which to assess this pressure.

Introduction or spread of invasive non-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
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This biotope is classified as circalittoral and therefore no algal species have been considered. *Didemnum vexillum* is an invasive colonial sea squirt native to Asia which was first recorded in the UK in Dartmouth Marina, Dartmouth in 2005. *Didemnum vexillum* can form extensive mats over the substrata it colonizes, binding boulders, cobbles and altering the host habitat (Griffith *et al.*, 2009). *Didemnum vexillum* can also grow over and smother the resident biological community. Recent surveys within Holyhead Marina, North Wales have found *Didemnum vexillum* growing on and smothering native tunicate communities, including *Ciona intestinalis* (Griffith *et al.*, 2009). Due to the rapid-re-colonization of *Didemnum vexillum* eradication attempts have to date failed. Presently *Didemnum vexillum* is isolated to several sheltered locations in the UK (NBN, 2015), however, *Didemnum vexillum* has successfully colonized offshore in Georges Bank, USA (Lengyel *et al.*, 2009). *Styela clava*, another INIS ascidian, was first recorded in the UK at Plymouth in 1952 (Eno *et al.*, 1997).

There is 'No evidence' at present that this biotope has been affected by INIS, however, *Didemnum vexillum* could pose a potential threat. Due to the constant risk of new invasive species, the literature for this pressure should be revisited.

Introduction of microbial pathogens	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR
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Little is known about brachiopod disease, therefore there is 'No evidence' on which to base an assessment. However, James *et al.* (1992) highlighted significant shell and soft tissue regenerative capabilities. McCammon (1973) recorded infection of the lophophore tentacles of *Magellania venosa* by an unidentified protist which destroyed connective tissues and ultimately resulted in death. McCammon (1972) also observed brachiopods subject to stress being prone to fungal infection which exhibited black spots forming on the shell. More generally, James *et al.* (1992) discussed brachiopod success in aquaria and suggests that they are relatively hardy. No evidence

for diseases affecting *Protanthea simplex* could be found. There appears to be little research into ascidian diseases, particularly in the Atlantic. The parasite *Lankesteria ascidia* targets the digestive tubes and can cause 'long faeces syndrome' in *Ciona intestinalis* (although it has also been recorded in other species). Mortality occurs in severely affected individuals within about a week following first symptoms. (Mita *et al.*, 2012). There is '**No evidence**' to support an assessment of this pressure.

Removal of target species

Low

Q: Low A: NR C: NR

Medium

Q: Medium A: Medium C: Medium

Medium

Q: Low A: Low C: Low

Among brachiopods, only the lingulids (*Lingula* spp.) have been fished commercially, and on a very small scale (Printrakoon & Kamlung-ek, 2013). No evidence for brachiopod extraction in the British Isles was found. Whilst unlikely, should targeted extraction occur, it is likely to have a significant impact on the characterizing species. Whilst anemones are not sessile, they are very slow moving and are therefore likely to be as exposed to extraction as the sessile *Novocrania anomala* and ascidians. '**Not relevant**' as none of the characterizing species are targeted.

Removal of non-target species

Low

Q: Low A: NR C: NR

Medium

Q: Medium A: Medium C: Medium

Medium

Q: Low A: Low C: Low

The characteristic species probably compete for space within the biotope, so that loss of one species would probably have little if any effect on the other members of the community. Removal of the characteristic epifauna due to by-catch is likely to remove a proportion of the biotope and change the biological character of the biotope. These direct, physical impacts 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 non-target species on this biotope. Therefore, resistance is assessed as '**Low**', resilience as '**Medium**' and sensitivity assessed as '**Medium**'. This biotope may be removed or damaged by static or mobile gears that are targeting other species (see physical pressures above).

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