Styela gelatinosa, *Pseudamussium peslutrae* and solitary ascidians on sheltered deep circalittoral muddy sediment

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

John Readman & Dr Keith Hiscock

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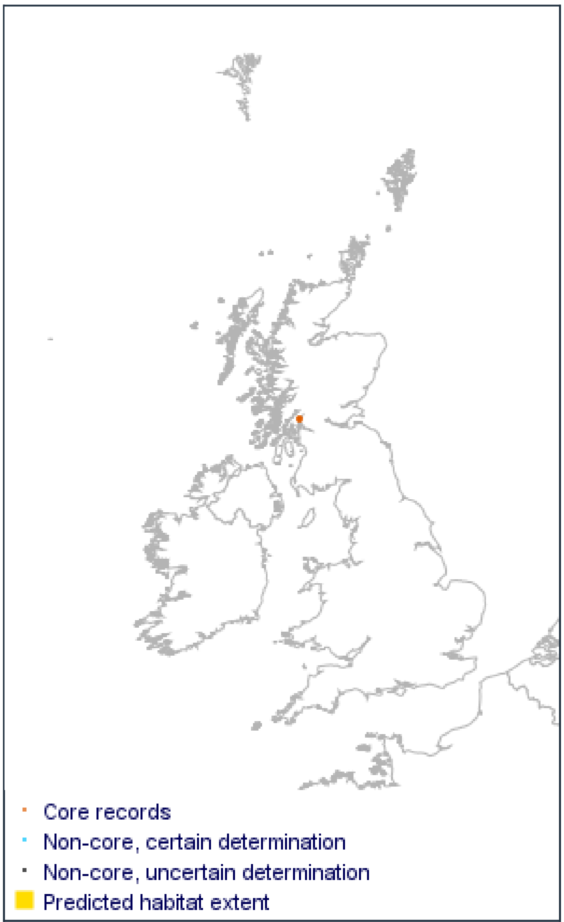

17-09-2018
Biotope distribution data provided by EMODnet Seabed Habitats (www.emodnet-seabedhabitats.eu)

Researched by John Readman & Dr Keith Hiscock **Refereed by** This information is not refereed.

Summary

UK and Ireland classification

EUNIS 2008	A5.373	*Styela gelatinosa*, *Pseudamussium septemradiatum* and solitary ascidians on sheltered deep circalittoral muddy sediment
JNCC 2015	SS.SMu.OMu.StyPse	*Styela gelatinosa*, *Pseudamussium peslutrae* and solitary ascidians on sheltered deep circalittoral muddy sediment
JNCC 2004	SS.SMu.OMu.StyPse	*Styela gelatinosa*, *Pseudamussium septemradiatum* and solitary ascidians on sheltered deep circalittoral muddy sediment
1997 Biotope	COS.COS.Sty	*Styela gelatinosa* and other solitary ascidians on sheltered deep circalittoral muddy sediment

Description

This biotope is known only from deep water in Loch Goil (Clyde sealochs) in fine mud at 65 m with terrigenous debris. Large numbers of solitary ascidians, including *Styela gelatinosa*, *Ascidia* *conchilega*, *Corella parallelogramma* and *Ascidiella* spp., are characteristic of this biotope together with the bivalve *Pseudamussium septemradiatum*. Terebellid worms, the bivalve Abra alba and the polychaete *Glycera tridactyla* may also occur. It is possibly an ice age relict biotope. (Information from Connor *et al.*, 2004).

Depth range

-

Additional information

There appear to be no closely similar biotopes.

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Habitat review

Ecology

Ecological and functional relationships

- The characterizing and other species in this biotope occupy space in the habitat but their presence is most likely primarily determined by the occurrence of a suitable substratum rather than by interspecific interactions.
- Various species including the ascidian species characteristic of this biotope may attach to the clam *Pseudamussium septemradiatum*. Fourteen species are listed by Allen (1953a) as attached to live individuals of *Pseudamussium septemradiatum* from the Clyde Sea area including five foramaniferans, one sponge, two polychaetes, one bryozoan, two barnacles, two small bivalves but only one ascidian, *Styela clava*. Allen (1953a) notes that dead shells had very little attached and suggested that movement of the scallop was important in retaining surfaces clear of silt for settlement of attached fauna.
- The biotope supports some burrowing bivalve species and the sea cucumber *Paracucumaria hyndmani*.

Seasonal and longer term change

One of the key factors affecting benthic habitats is disturbance which in deep sediment habitats such as COS.Sty is minimal and so communities may be relatively stable. However, there may be some seasonal changes in the biotope including recruitment of young, growth rates and abundance of adults. Also, species in the biotope may be attached to terrigenous debris that may degenerate and many of the species in the biotope are short-lived (see 'Recruitment Processes') so that their abundance from year-to-year may vary depending on success of breeding and recruitment.

Habitat structure and complexity

The biotope most likely has very little structural complexity. However, terrigenous debris, especially if that includes twigs and branches, may create some complexity. There is no evidence from the very limited survey data available of burrowing activity that might create complexity in the sediment habitat or burrows that cryptic species can use.

Productivity

Productivity in subtidal sediments is often quite low. Macroalgae and, most likely, microalgae are absent from COS.Sty and so productivity is secondary, derived from detritus and organic material. Organic material is derived from terregenous debris (vegetation) and water column sources (e.g. plankton, detritus). Organic material is degraded by micro-organisms and the nutrients are recycled.

Recruitment processes

The species in this biotope predominantly have planktotrophic larvae and are potentially able to recruit from fairly distant sources (>10 km). Critically, no information has been found on recruitment processes of *Styela gelatinosa* although (Millar, 1963b) *Styela coriacea* produces tadpole larvae that can swim but appear to settle rapidly as do *Ascidiella scabra*where settlement time is estimated to be 2-10 days (see Berill, 1950). No information was found for reproduction in

Pseudamussium septemradiatum but scallops generally have a long planktonic stage (for instance 28 days+ for *Pecten maximus*: Beaumont & Barnes, 1992). In an enclosed sea loch such as Loch Goil, there is most likely some retention of larvae, local recruitment of species with short-lived larvae such as some ascidians and possibly little recruitment from open coast populations.

Time for community to reach maturity

The community probably has a high turnover rate within individuals of the component species reflecting the likely transitory nature of the biogenic hard substrata available for settlement. For instance, *Ascidiella scabra* has a high fecundity and settles readily, probably for an extended period from spring to autumn. Svane (1988) describes it as "an annual ascidian" and demonstrated recruitment onto artificial and scraped natural substrata. The occurrence and longevity of most large solitary ascidians appears similar to that of *Ascidiella scabra*. Allen (1953a) demonstrated that *Pseudamussium septemradiatum* has a lifespan of about 3.5 years in populations sampled in the Firth of Clyde. Other species that are recorded as rare or occasional in the biotope (*Abra alba*, *Ciona intestinalis*, *Metridium dianthus*, *Protanthea simplex*, *Sabella pavonina*) are all known to settle onto new surfaces within a year or a very few years. Unfortunately, no information has been found for *Styela gelatinosa* that can be used to estimate longevity or settlement frequency. Nevertheless, it appears that the community would reach maturity rapidly (possibly within a year or a very few years) after new substrata became available.

Additional information

Very little information is available on the biology of *Styela gelatinosa* has been found and inferences have to be drawn from knowledge of the biology of other ascidians.

Preferences & Distribution

Habitat preferences

Depth Range	
Water clarity preferences	
Limiting Nutrients	No information found
Salinity preferences	
Physiographic preferences	Enclosed coast / Embayment
Biological zone preferences	
Substratum/habitat preferences	
Tidal strength preferences	
Wave exposure preferences	Very sheltered
Other preferences	See additional information.

Additional Information

The biotope occurs in an area with terrigenous debris that most likely provide a hard substratum on which large solitary sea squirts can settle and grow in conditions that experience no wave action and only weak tidal flows. The presence of suitable settlement surfaces may be essential to the development of the community which has not been recorded in other areas of the Clyde sea lochs despite extensive sampling from studies undertaken by the Scottish Marine Biological

Association and now the University Marine Biology Station based on Cumbrae (for instance, Allen, 1953a).

Species composition

Species found especially in this biotope

- *Styela gelatinosa*

Rare or scarce species associated with this biotope

- *Styela gelatinosa*

Additional information

The MNCR recorded 17 species in the single record of this biotope (JNCC, 1999).

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

This biotope is dominated by large solitary ascidians (including *Styela gelatinosa*, *Ascidiella* spp., *Ascidia conchilega*) as well as the bivalve *Pseudamussium peslutrae (previously Pseudamussium septemradiatum)*. Information for the characterizing species *Styela gelatinosa* is sparse and assessments for other large solitary ascidians (including *Ascidia mentula* and *Ascidiella scabra*) is presented where appropriate. The biotope contains terrigenous debris (leaves, branches and other material derived from terrestrial sources) which is likely to be important in providing suitable substrata for settlement of the ascidians.

The shells of the small scallop *Pseudamussium septemradiatum* are also likely to provide an important hard substratum for other species to settle and so is considered a important structural species. Whilst little information was found for *Pseudamussium septemradiatum*, it is likely to share characteristics of reproduction and larval biology with other more researched scallops (e.g. *Pecten maximus*, *Aequipecten opercularis*) and these have been used in assessing sensitivity.

This biotope has only been recorded in Loch Goil, an enclosed sea loch with a sill at 16m (Edwards *et al*., 1986) and is believed to be a glacial relict (Connor *et al*., 2004). In the British Isles, the characterizing *Styela gelatinosa* has only been recorded in this Loch (NBN, 2015). Loss of the Styela gelatinosa population would result in loss of the biotope. Therefore, the sensitivity of biotope is dependent on the sensitivity of *Styela gelatinosa.*

Resilience and recovery rates of habitat

SS.SMu.OMu.StyPse has only been recorded in Loch Goil on the west coast of Scotland and may be a glacial relict (Connor *et al*., 2004).

The biotope is characterized by *Styela gelatinosa*, a large solitary ascidian which, in the British Isles, has only been recorded in Loch Goil (Connor *et al*., 2004; NBN, 2015). The closest populations of *Styela gelatinosa* occur in the Faroe Isles (Nolso, 2006) or Norway (Millar, 1966). Repopulation following total loss is therefore unlikely. Little information was found on the biology of *Styela gelatinosa* and inferences have been drawn from knowledge of the biology of other ascidians.

For example, *Ascidiella scabra* is highly fecund and settles readily, probably for an extended period from spring to autumn. Svane (1988) describes it as "an annual ascidian" and demonstrated recruitment onto artificial and scraped natural substrata.

Styela coriacea produces tadpole larvae that can swim but appear to settle rapidly (Millar, 1963b),as do *Ascidiella scabra* where settlement time is estimated to be 2-10 days (Berill, 1950).*Ascidia mentula* is a large (up to 18 cm long) and long lived (up to 7 years) ascidian (Rowley, 2008). Recruitment has been 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 in ascidians (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. Ascidians such as Dendrodoa carnea, Molgula manhattensis and Aplidium spp. achieved significant cover in less than a year and reached pre-clearance levels of cover after 2 years. Therefore, where neighbouring populations of ascidians are present recruitment may be rapid but recruitment from distant populations may take a long time.

No information was found for reproduction in *Pseudamussium septemradiatum* but scallops generally have a long planktonic stage, e.g. 28 days or more for *Pecten maximus* (Beaumont & Barnes, 1992). Allen (1953a) reported that *Pseudamussium septemradiatum* has a lifespan of about 3.5 years in populations sampled in the Firth of Clyde. Blyth *et al.* (2004) compared sites that were trawled for scallops to those that were untrawled or previously trawled (but not in the 18-24 months prior to the study) and found that significantly fewer scallops were caught in the trawled sites. They suggested that at least a two year period was necessary for the benthic community to recover to a state that was indistinguishable from non-trawled areas.In general, mature scallops spawn over the summer months from April or May to September. Estimates of gamete emission range from 15 - 21 million oocytes per emission for a three year old (Le Pennec *et al.*, 2003). A bi-modal spawning pattern has been reported in the British Isles, with spawning times in the spring and again in the autumn (Gibson, 1956; Mason, 1983).

The community probably has a high turnover rate within individuals of the component species reflecting the likely transitory nature of the hard substrata available for settlement (including shells and terrigenous debris).

Resilience assessment. *Styela gelatinosa* is likely to exhibit good local recruitment but if lost form the biotope has no other populations in the UK from which to recruit. It the population was completely removed or lost, then it could not recover. Therefore, for resistance of 'None' (decline of 75% or greater), a resilience of **Very low** was recorded. Whilst ascidians are generally opportunistic and are likely to recover rapidly, recovery of *Pseudamussium peslutrae* is likely to be slightly longer, with *Pecten maximus* reaching maturity at ca 2 years (Marshall & Wilson, 2008). Therefore for resistance assessments of 'Low' (loss of 25-75 %), resilience has been assessed as '**Medium**' (recovery within 2-10 years). Recovery is likely to be rapid following less severe declines, and for resistance scores of 'Medium', resilience has been assessed as '**High**' (recovery within 2 years).

Hydrological Pressures

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

*Styela gelatinosa*is a northern species, only occurring in Loch Goil in the British Isles (NBN, 2015) and is therefore likely to be susceptible to temperature increases. Should the entire population of the characteristic species *Styela gelatinosa* be lost, the biotope would be unlikely to recover and require reclassification as the nearest recorded populations of *Styela gelatinosa* are in deep water off the Faroe Islands and in Norway (Nolso, 2006; Millar, 1966).

Within the British Isles, *Pseudamussium peslutrae* is typically found in Scotland (NBN, 2015), but has been recorded (as *Pseudamussium septemradiatum*) from Norway to the Mediterranean and north west Africa (Hayward & Ryland, 1996).

Ascidia mentula is found from Norway to the Mediterranean (Picton & Morrow, 2015).

Sensitivity assessment. Whilst specific evidence for *Styela gelatinosa*is lacking, it is considered a northern species at its most southerly distribution in Scotland and is therefore likely to be severely damaged by a high temperature event. However, it may be buffered form sea surface temperature changes by its depth, unless exposed to thermal effluents. Resistance is assessed as '**Low**' with resilience of '**Medium**' and sensitivity as '**Medium**'.

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

All characterizing species are northern, or widespread species (NBN, 2015; Nolso, 2006; Millar, 1966; Picton & Morrow, 2015) and the biotope may be a glacial relict (Connor *et al.*, 2004). It is unlikely that a decrease in temperature would negatively affect the biotope.

Therefore resistance is '**High'**, resilience is '**High'** and the biotope is '**Not Sensitive'** at the benchmark level.

Salinity increase (local)	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

SS.SMu.OMu.StyPse is a circalittoral, full salinity habitat and an increase at the benchmark level would result in hypersaline conditions. **'No evidence'** for the characterizing species in hypersaline conditions was found.

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

.SMu.OMu.StyPse occurs in full salinity (Connor *et al.*, 2004). Loch Goil is an enclosed sea loch and, while dilution of the Loch may occur during periods of heavy rain, the biotope occurs at depth (50-100 m) and freshwater is less dense and therefore floats.

A reduction in salinity at the benchmark level, from full to variable, would be unlikely to affect *Ascidiella scabra* which occurs in reduced salinity conditions (Connor *et al.*, 2004). Other ascidian species (with the exception *of Styela gelatinosa* for which no information was found) are found in variable salinity (Connor *et al.*, 2004). Overall, the biotope is likely to be tolerant of some lowering of salinity.

Pecten maximus was described as highly vulnerable to low salinity stress (Bricelj & Shumway, 1991). Christophersen & Strand (2003) found that in the laboratory, the shells of spat held in water with a low salinity (20 ppt) became thin and easily damaged which ultimately led to a negative shell growth rate. Paul (1980) described mortality of *Chlamys opercularis* after 24 hours of exposure to salinities ranging from 16 to 28‰, depending on size and temperature.

Sensitivity assessment. Whilst specific evidence for the characterizing species is lacking, based on similar species, *Pseudamussium peslutrae* is likely to experience some mortality in the event of a reduction to 18 ‰ as scallops do not completely close their valves. It should be noted that, as an enclosed Loch, the biotope may periodically experience lower salinities following heavy rain.

An assessment of '**Medium**' resistance is recorded, resilience is '**High**' and sensitivity is '**Low**'.

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

This biotope occurs in the enclosed Loch Goil in the presence of terrigenous debris and only experiences weak water flow (Connor *et al*., 2004). Significant increase in water flow rate is likely to affect the nature of the substratum as fine particles and terrigenous debris are washed away (together with attached fauna) and a coarser sediment type including shell debris would remain. Hiscock (1983) found that, for the solitary ascidian *Ascidia mentula*, siphons closed when the current velocity rose above about 15 cm/sec. It seems likely therefore that some reduction in feeding would occur with increased water flow rate although that would result in slower growth and loss of condition but not mortality.

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 the non-characterizing ascidian *Ciona intestinalis* (Riisgård *et al*., 1996). Hiscock (1983). No information for *Pseudamussium peslutrae* was found.

Sensitivity assessment. SS.SMu.OMu.StyPse is found in a sea loch with weak water flow (<0.5 m/sec). Whilst the characterizing ascidians would probably be resistant to changes in water flow, movement of terrigenous substrata and thus the attached epifauna could result in mortality. But an increase at the benchmark level would probably not be significant. Resistance is assessed as **'High'**, resilience as **'High'** and the biotope is **'Not sensitive'** at the benchmark level.

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

Changes in emergence are '**Not relevant'** to this biotope as it is restricted to fully subtidal 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

This biotope occurs in very sheltered conditions, at 50-100 m depth. Hiscock (1983, Figure 2) estimated that a force 8 gale over a gently sloping seabed could result in oscillatory water movement of ca 0.4 m/s at 50 m and 0.09 m/s at 80 m. But in a deep sheltered loch, it is unlikely that wind driven wave action would be this extreme or penetrate so deep. And a further decrease in wave action is unlikely to be significant due to the depth of the biotope.

Therefore, resistance has been assessed as '**High**', resilience has been assessed as '**High**' and sensitivity has been 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

Trace metals (particularly mercury and copper) have been found to affect embryogenesis and larval settlement in the solitary ascidian *Ciona intestinalis* (Bellas *et al*., 2004).

Pesch *et al*. (1979) reported that the scallop *Argopecten irradians* was quite sensitive to copper toxicity with exposure to 5 µg/l resulting in 10% mortality after 42 days. Mortality was greater than 50% when exposed to concentrations over 11µg/l. Nevertheless, this pressure is **Not assessed**.

	Resistance	Resilience	Sensitivity
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.

	Resistance	Resilience	Sensitivity
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.

Ascidians may be intolerant of synthetic chemicals such as tri-butyl-tin anti-foulants. Rees *et al.* (2001) observed that six ascidian species were recorded at one station in 1997 compared with only two at the same station in 1987, shortly following the banning of TBT in antifouling paints. Also, there was a marked increase in the abundance of ascidians especially *Ascidiella aspersa* and *Ascidia conchilega* in the estuary after the ban on TBT was introduced. Although there is no direct evidence for effects of synthetic chemicals on *Pseudamussium septemradiatum*, TBT-based antifouling paint was shown to be detrimental to growth and survival of juvenile *Pecten maximus* scallops (Paul & Davies, 1986), and there is some evidence that recruitment to inshore scallop beds may have been affected by TBT used in anti-fouling paints (Minchin *et al*., 1987).

	Resistance	Resilience	Sensitivity
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

Whilst studies have been made of the presence of radionuclides in Loch Goil sediments (Swan *et al*., 1982; Shimmield, 1993), **'No evidence'** on the effects on the characterizing species could be found.

	Resistance	Resilience	Sensitivity
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**.

	Resistance	Resilience	Sensitivity
De-oxygenation	Medium Q: Low A: NR C: NR	High Q: Low A: NR C: NR	Low Q: Low A: Low C: Low

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. Mazouni *et al.* (2001) noted that a biofouling community, dominated by the ascidian *Ciona intestinalis*, suffered heavy mortality during short-term exposure to periods of anoxia whilst oysters (*Magallana gigas*) survived (Thau Lagoon, France). It should be noted, however, that ascidians are 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.

Pseudamussium septemradiatum is more likely to be adversely affected especially in the still conditions. Scallops, as sublittoral, epifaunal bivalves are incapable of sustaining prolonged valve closure, and are relatively intolerant of anoxia (Bricelj & Shumway, 1991). Brand & Roberts (1973) found that scallops transferred to de-oxygenated water (13 mm Hg) for three hours experienced rapid bradychardia (reduced heart rate), but effects are likely to be more severe when exposed to longer lasting hypoxic events.

Sensitivity assessment. SS.SMu.OMu.StyPse is a typically low energy biotope; a hypoxic event is likely to remain for some time, depending on local conditions. The characterizing species (particularly the ascidians) may be resistant to a change at the benchmark level, although mortality of *Pseudamussium septemradiatum* could not be ruled out. Resistance is therefore assessed as '**Medium**', resilience as '**High**' and sensitivity as **'Low'**. Due to the lack of specific data for these species, confidence is recorded 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

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 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). But no information on the effects of nutrient enrichment of other characterizing species was found.

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

There is some suggestion that there are possible benefits to the ascidians from 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). Ascidians have been reported to dominate harbours enriched by organic pollutants in Turkey and are frequently found in polluted environments (Carver *et al*., 2006 Kocak & Kucuksezgin (2000). *Ascidia mentula* has been reported in Iberian bays subject to both nutrient-rich upwelling events and anthropogenic organic pollution (Aneiros *et al*., 2015).

Zhou *et al*., (2006) described filtering and biodeposition in a eutrophic Bay in China by the scallop *Chlamys farreri* and concluded that commercially suspension-cultured bivalves may simultaneously and potentially aid in mitigating eutrophication pressures on coastal ecosystems subject to anthropogenic N and P loadings, serving as a eutrophic-environment bioremediator.

Sensitivity assessment. Evidence suggests that, as filter feeders, both scallops and ascidians tolerate organically enriched habitats. Resistance is assessed as 'High', resilience as 'High' and the biotope is assessed as 'Not Sensitive' but with 'Low' confidence due to the lack of direct evidence.

Physical Pressures

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

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

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

If sediment were replaced with rock or artificial substrata, this would represent a fundamental change to the biotope. All the characterizing species within this biotope can grow on rock biotopes (Birkett *et al*., 1998b; Connor *et al*., 2004), however SS.SMu.OMu.StyPse is, by definition, a muddy ciralittoral biotope, and change to rock would result in change to a rock based habitat, and the biotope would need to be reclassified.

Sensitivity assessment. Resistance to the pressure is considered '**None**', and resilience '**Very low**'. Sensitivity has been assessed as '**High**'

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

SS.SMu.OMu.StyPse is characterized as a circalittoral muddy biotope (Connor *et al*., 2004). The characterizing species of SS.SMu.OMu.StyPse are likely to be resistant to a change in one Folk class from, for example, mud to sandy mud (based on the Long, 2006 simplification). However, this would represent a fundamental change in the character of the biotope, with re-classification of the biotope necessary. Resistance is therefore assessed as '**None', r**esilience as '**Very Low'**, and the biotope is considered to have '**High'** sensitivity to a change in seabed type by one Folk class.

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

Sedimentary communities are likely to be highly intolerant of substratum removal, which will lead to partial or complete defaunation, exposure of underlying sediment which may be anoxic and/or of a different character and lead to changes in the topography of the area (Dernie *et al*., 2003). Any remaining species, given their new position at the sediment / water interface, may be exposed to unsuitable conditions.

All characterizing species in this biotope exist on the seabed surface and removal of 30 cm of sediment would result in loss of all ascidians, including *Styela gelatinosa*, which would not be able to repopulate.

It should be noted that the ascidian component is likely to rely on terrigenous debris in providing suitable for settlement.

Sensitivity assessment. Extraction of 30 cm of sediment will remove the characterizing biological component of the biotope. Resistance is assessed as '**None**' and biotope resilience is assessed as '**Very Low**'. Sensitivity is therefore assessed as '**High**'.

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

Styela gelatinosa and *Ascidia mentula* are large, emergent, sessile ascidians, and physical disturbance is likely to cause damage, with mortality likely. 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).

On a sedimentary seabed, physical disturbance may crush a minority of species but is most likely to displace substrata including burying individual in a population.

Scallop dredging can cause damage to the scallop shells and in particular to the growing edge. Ansell *et al.* (1991) stated that up to 19 % of the scallops left behind by a dredge are affected to some extent. Effects might include shell damage, burial, increased stress and feeding difficulties associated with the increased suspended sediment produced by the action of the dredge. Individuals with damaged shells are more prone to predation. In addition, the energy budget would be altered so that energy previously reserved for spawning would be allocated to new shell growth and therefore reduce the viability of the population. However, Jenkins *et al.* (2001) reported that, during dredging, more than 90 % of *Pecten maximus* that came into contact with a dredge (including those landed, discarded and left behind by the dredge) were in good condition overall and showed little or no shell damage. It is possible that some smaller individuals may be crushed and killed by a scallop dredge although for the majority of the population it is unlikely that it will have an adverse effect. Similarly (Bergmann *et al.* 2001) found that most (98%) of queen scallops *Aequipecten opercularis* were undamaged when retained in otter trawl hauls in the Clyde Seas *Nephrops* fishery. The differences between reported rates of effect may be due to different classification systems used to score impacts.

Sensitivity assessment. Given the sessile, emergent nature of both *Styela gelatinosa* and *Ascidia* *mentula*, damage and mortality following a physical disturbance effect are likely to be significant, although recovery is likely to be rapid.

Whilst no information on abrasion effects on *Pseudamussium peslutrae* was found, it is likely to be more resistant to abrasion effects based on evidence for other scallops. Sensitivity is therefore based on the impact to the ascidians. Resistance has been assessed as '**Low**', resilience as '**Medium**'. Sensitivity has been assessed as '**Medium**'.

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

All characterizing species in this biotope exist on the seabed surface and penetration type damage is likely to be analogous to the abrasion pressure.

Sensitivity assessment

Given the sessile, emerged nature of both *Styela gelatinosa* and *Ascidia mentula*, damage and mortality following a physical disturbance effect are likely to be significant, although recovery is likely to be rapid.

Whilst no information on abrasion effects on *Pseudamussium peslutrae* was found, it is likely to be more resistant to abrasion effects based on evidence for other scallops. Sensitivity is therefore based on the impact to the ascidians.

Resistance has been assessed as '**Low**', resilience as '**Medium**'. Sensitivity has been assessed as '**Medium**'.

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

Increases in turbidity through increased inorganic particulate matter may reduce efficiency for the filter feeding characterizing species.

While no evidence was found for *Styela gelatinosa*, ascidians occur in habitats close to harbours and marinas with high levels of silt and suspended matter (Carver *et al.*, 2006; Kocak & Kucuksezgin, 2000). 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).

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.

No information for *Pseudamussium peslutrae* was found. Growth rates of adult *Pecten maximus* are adversely affected by increases in suspended sediments concentrations (Bricelj & Shumway, 1991) and excessive particle bombardment may threaten the viability of the feeding apparatus (Gibson, 1956), thereby potentially decreasing ingestion rates. Bivalves may compensate for increased turbidity from suspended inorganic particles by increasing the rate of pseudofaeces. Where the pressure results from an increase in suspended organic matter this would be beneficial to this ecological group by providing increased food material.

For example, Last *et al.* (2011) studied the response of *Aequipecten opercularis* to two levels of suspended particulate matter (SPM) (high SPM (~71 mg/l) and low SPM (~12 mg/l). No mortalities were recorded in response to changes in SPM. Shell closure events were significantly increased under both low and high SPM when compared to control conditions and is likely to be a reflection of increased efforts to clear the mantle of sediment. Significantly more 'claps' (considered an escape response) and 'coughs' (thought to be a mechanism for the expulsion of sediment) were also recorded in animals under high SPM when compared to control conditions. All three behaviours: shell closure events, clapping and coughing will confer energetic cost (Last *et al.*, 2011). Szostek *et al.* (2013) exposed juvenile *Pecten maximus* to low (50-100 mg/l SPM) and high (200-700mg/l SPM) suspended particulate material conditions for 18 days. Movement and shell clamps were more evident in the highly sedimented conditions, whilst growth rates were significantly lower under both low and high conditions relative to control, however survival was not affected over the 18 days of the study Szostek *et al.* (2013).

Sensitivity assessment. Whilst there is no information for the characterizing *Styela gelatinosa* or *Pseudamussium peslutrae*, similar species have been reported to tolerate turbidity. Based on evidence for other scallops, it is likely that *Pseudamussium peslutrae* would exert more effort in clearing mechanisms, but mortality would be unlikely. Mortality has been recorded in ascidians exposed to very high sediment loads (600 mg/l) (Robbins, 1984a). Loch Goil is an enclosed sea loch (Edwards *et al*., 1986) subject to freshwater runoff with a muddy terragenous substrata. Assuming a change from intermediate turbidity to medium turbidity, the characterizing species are likely to be resistant to an increase at the benchmark level, albeit with 'Low' confidence. Reistsance is assessed as **'High'**, resilience as **'High'** and the biotope is **'Not sensitive'** at the benchmark level.

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

The solitary ascidians considered in this report are permanently attached to the substratum and are active suspension feeders. *Styela gelatinosa and Ascidia mentula* grow to 4 and 18 cm respectively (Hiscock & Pizzolla, 2002; Rowley, 2008). Replacement of the terrigenous substrata following a burial event would be required before the ascidians would be able to recover.

Pseudamussium peslutrae is capable of movement and would probably lift itself clear in the event of burial. Young scallops remain attached by the byssus, later becoming unattached and are then able to swim freely (Carter, 2008). A burial event would result in mortality of the attached juveniles.

Sensitivity assessment. *Styela gelatinosa and Ascidia mentula* grow to 4 and 18 cm respectively (Hiscock & Pizzolla, 2002; Rowley, 2008) and smothering by 5 cm would cover the majority of *Styela gelatinosa.* Whilst adult *Pseudamussium peslutrae* capable of free swimming would not be affected, attached juveniles would probably be intolerant.The potential mortality of large proportion of *Styela gelatinosa* results in a resistance of '**Low**', resilience of '**High**' and '**Low**' sensitivity.

Smothering and siltation rate changes (heavy)	None Q: Low A: NR C: NR	Very Low Q: Low A: NR C: NR	High Q: Low A: NR C: NR

The solitary ascidians considered in this report are permanently attached to the substratum and are active suspension feeders. *Styela gelatinosa* and *Ascidia mentula* grow to 4 and 18 cm respectively (Hiscock & Pizzolla 2002; Rowley, 2008). Replacement of the terrigenous substrata following a burial event would be required before the ascidians would be able to recover.

Pseudamussium peslutrae is capable of movement and would probably lift itself clear in the event of burial. Young scallops remain attached by the byssus, later becoming unattached and are then able to swim freely (Carter, 2008). A burial event would result in mortality of the attached juveniles.

Sensitivity assessment. *Styela gelatinosa and Ascidia mentula* grow to 4 and 18 cm respectively (Hiscock & Pizzolla 2002; Rowley, 2008) and smothering by 30 cm would cover the entire *Styela gelatinosa* population and in the sheltered depths of loch, deposited sediment is likely to remain Whilst adult *Pseudamussium peslutrae* capable of free swimming would not be affected, attached juveniles would probably be intolerant.

The potential mass mortality of *Styela gelatinosa* is probable and results in a resistance of '**None**', resilience of '**Very Low**' and '**High**' sensitivity.

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	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'.

Introduction of light or shading	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

This is a deep circalittoral biotope, light is **'Not relevant'**.

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

Loch Goil is an enclosed sea loch with a sill at 16 m (Edwards *et al.*, 1986). The species in this biotope occur at depth of 50-100 m, and whilst some scallop larvae may migrate to the Loch, the characterizing ascidian is only found within the Loch (NBN, 2015). It is therefore likely that the biotope is self-sustaining and a barrier to movement already exists. Resistance is therefore '**High**', resilience is '**High**' and the biotope is '**Not sensitive**' at the benchmark level.

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

'No evidence' of genetic modification or translocation for the characterizing species was found.

Introduction or spread of invasive non-indigenous species	Low Q: Low A: NR C: NR	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

This biotope is classified as circalittoral and therefore no algal species have been considered.

Of the non-native species known from British waters, only the sea squirt *Styela clava*, *Didemnum vexillum* and the slipper limpet *Crepidula fornicata* could potentially threaten this biotope. However, at present, no non-native species are known from the biotope. *Styela clava* was first recorded in the UK at Plymouth in 1952 (Eno *et al.*, 1997). *Styela clava* has been reported to compete aggressively with other species and has resulted in decline of native ascidians in locations where it occurs. (Lutzen, 1999; Clarke & Therriault, 2007).

Dijkstra & Nolan (2011) reported that the scallops *Placopecten magellanicus*, overgrown with the invasive tunicate *Didemnum vexillem*, showed changes in escape potential. Scallops covered by *Didenmnum vexillum* became exhausted more quickly, and were not able to swim as far in either the horizontal or vertical direction as the control sea scallops without *Didemnum vexillum* encrustation. The authors conclude that the expansion of *Didemnum vexillum* into scallop habitat may increase the vulnerability of sea scallops to predation and limit their ability to access food rich habitats. No evidence was available to quantify the potential effect on *Pecten maximus*. *Didemnum vexillum* has also been reported to overgrow marine fauna, including ascidians and it is, therefore, of potential threat to *Styela gelatinosa*.Presently *Didemnum vexillum* is isolated to several sheltered locations in the UK (NBN, 2015), and whilst it has not been recorded in Loch Goil or the Clyde, it has been found in other Scottish lochs.

The slipper limpet *Crepidula fornicata* was reported to alter the substratum due to build-up of its pseudofaeces and faeces, as it spatially competes and lowers recruitment of *Pecten maximus* and *Aequipecten opercularis* in the Bay of Brest, France (Frésard & Boncoeur, 2006). Although adult scallops that settle amongst *Crepidula fornicata* beds are not affected, juvenile scallops cannot settle in areas of high *Crepidula fornicata* density (Chauvaud *et al.* 2003, cited in Frésard & Boncoeur 2006), and the *Crepidula fornicata* beds threatened the sustainability of the ongoing scallop restocking program in the area. It should be noted that *Crepidula fornicata* is a southern species and it is unlikely that this species could survive as far north as Loch Goil.

No evidence was available to quantify the potential effect on *Pseudamussium peslutrae*. Whilst evidence that *Crepidula fornicata* had an adverse effect on scallop beds in France suggests the potential for impact in the UK, however, it is unlikely that *Crepidula fornicata* could survive as far north as Loch Goil.

Whilst neither *Styela clava* or *Didendum vexillum* have been reported in Loch Goil, they have been found in other Scottish lochs (NBN, 2015) and could present a threat to the scallops and, in particular, the ascidians of the biotope. In the event of overgrowth or aggressive competition from these invasive ascidians, *Styela gelatinosa* may be lost and resistance is therefore assessed as **'Low'**, resilience as **'Medium'** resulting in a sensitivity of **'Medium'**.

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

There is little research into ascidian diseases, which is particularly sparse for Atlantic species. The parasite *Lankesteria ascidiae* 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).

McGladdery *et al*. (2006) reviewed the diseases and parasites of scallops. The majority of diseases resulted in non-lethal or no effects on the host scallop, however mass mortalities of adult *Argopecten irradians* were recorded in Chinese hatcheries (Zhang *et al.*, 1998; Wang *et al.*, 1998 both cited in McGladdery *et al.*,2006). Bower *et al.* (1999) described disease caused by *Perkinsus qugwadi* resulting in mass mortalities (loses exceeding 90%) in aquacultures of the Japanese scallop *Mizuhopecten yessoensis* introduced to Canada. It should be noted that the native scallops *Chlamys rublda* and *Chlamys hastata* were resistant.

No evidence for disease in the characterizing species was found. Whilst evidence of mortality does exist for scallops, no evidence of mortality in the British isles was found. However, based on the records of ascidian disease, a precautionary resistance of '**Medium**' is suggested but with 'Low' confidence. Resilience is probably '**High**' and sensitivity is assessed as '**Low**'.

Removal of target species	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

There is a limited amount of trawling and creeling for *Nephrops norvegicus* in Loch Goil (Wilding *et al.*, 2005), however none of the characterizing species are targeted. Targeted removal is therefore '**Not relevant'** to this biotope.

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

There is a limited amount of trawling and creeling for *Nephrops norvegicus* in Loch Goil (Wilding *et al.*, 2005), however none of the characterizing species are targeted.

This biotope may be removed or damaged by static or mobile gears that are targeting other species. 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.

Whilst no information on *Styela gelatinosa* was found, *Pseudamussium peslutrae* has been identified as among the top ten by-catch species in demersal otter trawling for Nephrops in Sweden Ottosson (2008). And the incidental removal of the characteristic species would result in a change in the character of the biotope. Resistance is recorded as '**Low**', resilience is recorded as **'Medium'** and sensitivity is **'Medium'**.

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