Branchiostoma lanceolatum in circalittoral coarse sand with shell gravel

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

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2016-06-29

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

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This review can be cited as:
Tillin, H.M. 2016. [Branchiostoma lanceolatum] in circalittoral coarse sand with shell gravel. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom.
DOI https://dx.doi.org/10.17031/marlinhab.244.1

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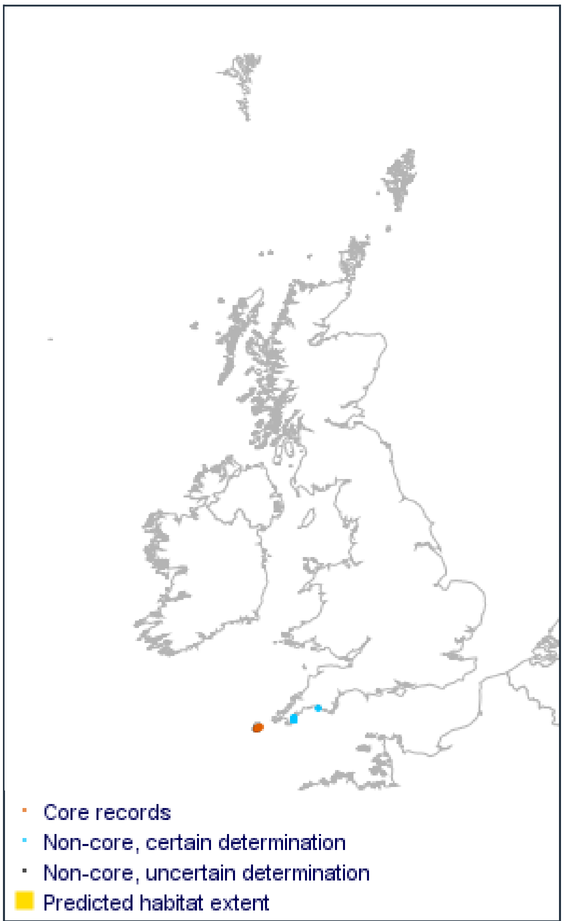
***Branchiostoma lanceolatum* on circalittoral coarse sand with shell gravel**
Photographer: Keith Hiscock



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

Researched by Dr Heidi Tillin **Refereed by** Admin

Summary

UK and Ireland classification

EUNIS 2008	A5.145	*Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel
JNCC 2015	SS.SCS.CCS.Blan	*Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel
JNCC 2004	SS.SCS.CCS.Blan	*Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel
1997 Biotope	SS.CGS._.Ven.Bra	Venerid bivalves and *Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel

Description

Gravel and coarse sand with shell gravel often contains communities of robust venerid bivalves (SCS.MedLumVen). Shallower examples, such as the biotope presented here, may support a significant population of *Branchiostoma lanceolatum*. Other conspicuous infauna may include *Echinocyamus pusillus*, *Glycera lapidum*, *Polygordius*, *Pisione remota* and *Arcopagia crassa* (in the south of UK). Sessile epifauna are typically a minor component of this community. This biotope has been described from a limited number of records and as such may need revising when further data become available. This biotope is related to the 'Boreal Offshore Gravel Association' and 'Deep *Venus* Community' described by other workers (Ford, 1923; Jones, 1951), and may also be closely allied (the same?) as the '*Venus fasciata*' community of Cabioch (Glemarec, 1973). This biotope may be an epibiotic overlay of the biotope SCS.MoeVen or SCS.MedLumVen (JNCC, 2015).

Depth range

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

Additional information

-

Listed By

- none -

Further information sources

Search on:

G G G JNCC

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotope description and characterizing species were taken from JNCC (2015). The biotope is described from a limited number of records and may be an 'epibiotic overlay' of the coarse gravel biotopes SCS MoeVen or SCS.MedLumVen. The key species defining this biotope is *Branchiostoma lanceolatum*, the biotope often contains communities of robust venerid bivalves (SCS.MedLumVen) and may include *Echinocyamus pusillus*, *Glycera lapidum*, *Polygordius*, *Pisione remota* and *Arcopagia crassa* (in the south of UK). Sensitivity assessments for the associated infaunal biotopes SCS.MoeVen or SCS.MedLumVen are presented on this website. As *Branchiostoma lanceolatum* is a key species distinguishing this biotope from other coarse gravel biotopes, the sensitivity assessments are largely based on this species as its loss would lead to biotope reclassification.

Resilience and recovery rates of habitat

This biotope is characterized by the presence of the Cephalochordate *Branchiostoma lanceolatum*. This genus has been of particular interest to scientists working on evolution of developmental mechanisms as the group is a close extant ancestor to vertebrates (Delsuc *et al*., 2008). As a test organism, there has been interest in natural reproductive cycles and environmental tolerance in order to cultivate this species for experiments (Fuentes *et al*., 2004; Theodosiou *et al*., 2011). Some aspects of the biology of this group are therefore well-studied but the general ecology is less understood.

The natural breeding cycle in the wild appears to be 2 months of spawning in the spring and summer (Stokes & Holland, 1996a; Whittaker, 1997). The sexes are separate; fertilisation is external and spawning occurs at or after sunset (Tung *et al*., 1958; Ruppert & Barnes, 1994; Stokes & Holland, 1996b; Theodosiou *et al*., 2011) and animals spawn in at least partial synchrony (Fuentes *et al*., 2004; Benito-Gutiérrez *et al*., 2013). Mediterranean populations of *Branchiostoma lanceolatum* have been observed to be bivoltine with two spawning peaks (Fuentes *et al*., 2004; Kehayias, 2015). Planktonic larvae were present in the surface plankton at Helgoland during late August and early September showing that in some years larvae may be found in the plankton for three months (Courtney, 1975a). In Amvrakikos Gulf (western Greece), *Branchiostoma lanceolatum* larvae were present in zooplankton samples for all months except September and February (Kehayias, 2015). The lifespan of *Branchiostoma* spp. is 2–5 years depending on the species, *Branchiostoma lanceolatum* have been estimated to live to 5 years in southern France (Desdevises *et al*., 2011) and six years in Helgoland (Courtney, 1975b).

Recovery of impacted populations may occur through recovery of damaged individuals, migration of adults or by colonization by planktonic larvae. *Branchiostoma lanceolatum* can regenerate portions, particularly parts of the tail and recover from injuries (Somorjai *et al*., 2012). Injuries to the anterior and critical structures such as the pharynx are more likely to lead to fatalities as these portions are not regenerated or are regenerated with defects (Somorjai *et al*., 2012). The presence of adult *Branchiostoma* spp. in the water column is rare but some instances have been recorded (Boschung & Shaw, 1988) and some migration by adults in the water column is possible. Adult *Branchiostoma lanceolatum* swim when disturbed and small-scale migration of adults from surrounding populations may occur. Storm events that mobilise surface sediment layers may also transport adults.

Sarda *et al.* (2000) reported that recolonization of dredged shallow soft bottoms (10 to 30 m depth) of the Tordera River (Catalonia) was rapid. Density values rose sharply during the following spring and autumn with exceptionally large numbers of *Branchiostoma lanceolatum* recorded. This evidence suggests that recolonization of disturbed habitats by *Branchiostoma lanceolatum* can be rapid and recovery potential may be high. However, the applicability of recovery rates from Mediterranean to UK populations is unclear .

The same study found that *Glycera* spp. had not recovered within two years (Sardá *et al*., 2000). *Glycera* are monotelic having a single breeding period towards the end of their life but may recover through migration and may persist in disturbed sediments through their ability to burrow (Klawe & Dickie, 1957). *Glycera* spp. have a high potential rate of recolonization of sediments, but the relatively slow growth-rate and long lifespan suggests that recovery of biomass following initial recolonization by post-larvae is likely to take several years (MES, 2010).

No evidence was found to assess resilience of *Echinocyamus pusillus*.

Resilience assessment. *Branchiostoma* is likely to recruit as adults from surrounding habitats due to its mobility, where the impact footprint is small (resistance is assessed as 'Medium'), recovery in this instance will be assessed as 'High'. Where resistance is 'None' or 'Low' recovery may depend on reproduction and migration and resilience is assessed as 'Medium'.

Hydrological Pressures

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

The characterizing species *Branchiostoma lanceolatum* is widely distributed along north-east Atlantic coasts, from northern Norway (67°N) to the Mediterranean Sea and Black Sea (may be absent from the Atlantic Spanish coasts). *Branchiostoma lanceolatum* entered the Indian Ocean after passage through the Suez Canal; widely distributed in the northern Indian Ocean and tropical south-western Indian Ocean along the east African coast (Poss & Boschung, 1996). *Echinocyamus pusillus* has a wide distribution and is reported from the north-east Atlantic, Kattegat, Iceland, Norway, Mediterranean, and south and west coasts of Africa among others (WoRMS, 2015). OBIS (2014) report maximum and minimum seawater temperatures as 19.21°C and 6.81°C but the derivation of these temperatures is not clear. *Glycera lapidum* is found in the north-eastern Atlantic, Mediterranean, North Sea, Skagerrak and Kattegat (Marine Species Identification Portal).

The winter temperatures of the North Sea exert lethal and sub-lethal effects upon the population at Helgoland (Courtney, 1974). There is no growth in the winter months when the temperature is less than 10°C whereas growth is continuous in the Mediterranean populations and the oxygen uptake profiles show that the animal is adapted to temperatures of 10-25°C (Courtney & Newell, 1965). The effects of the cold winter of 1962/63 on *Branchiostoma lanceolatum* populations was assessed by Courtney & Webb (1964). Water temperatures fell to below zero and remained around this temperature for 8 weeks (minimum temperature recorded at 20 m was -1.3°C). Based on living *Branchiostoma lanceolatum* and isolated notochords from deceased individuals, it appeared that an estimated 50% of the population had died, with mortality more severe in younger (smaller) individuals and larger individuals (Courtney & Webb, 1964).

In populations cultivated in aquaria that were collected from Helgoland (Germany), Roscoff or Argele`s-sur-mer (France), lowering the temperature 3°C from the natural range increased survival rates (Benito-Gutiérrez *et al*., 2013). *Branchiostoma lanceolatum* is best adapted for life between 10°C and 20°C and can survive in waters up to 27°C and between 10°C and 3°C. Laboratory experiments found that mortality of *Branchiostoma lanceolatum* occurred at -5°C but short-term exposure 15 minutes to temperatures of -1.7°C (Courtney & Webb, 1964). Failure to clear the mouth at temperatures <3°C may lead to blocking and mortalities, especially as mucus production does not cease and may increase at lower temperatures (Courtney & Webb, 1964). In sediments, the interstitial water may be relatively unmixed with the overlying water column providing some buffering against decreases in temperatures, particularly for deeper buried individuals.

Sensitivity assessment. Overall, short-term acute or long-term chronic changes in temperature at the pressure benchmark are considered unlikely to adversely affect *Branchiostoma lanceolatum* as the distribution records suggest these species can potentially adapt to a wide range of temperatures experienced in both northern and southern waters. Resistance is therefore assessed as 'High' and resilience as 'High'. This group is therefore considered to be 'Not sensitive'.

Temperature decrease (local)	Low Q: High A: High C: Medium	High Q: High A: Low C: Medium	Low Q: High A: Low C: Medium

The characterizing species *Branchiostoma lanceolatum* is widely distributed along north-east Atlantic coasts, from northern Norway (67°N) to the Mediterranean Sea and Black Sea (may be absent from the Atlantic Spanish coasts). *Branchiostoma lanceolatum* entered the Indian Ocean after passage through the Suez Canal; widely distributed in the northern Indian Ocean and tropical south-western Indian Ocean along the east African coast (Poss & Boschung, 1996). *Echinocyamus pusillus* has a wide distribution and is reported from the north-east Atlantic, Kattegat, Iceland, Norway, Mediterranean, and south and west coasts of Africa among others (WoRMS, 2015). OBIS (2014) report maximum and minimum seawater temperatures as 19.21°C and 6.81°C but the derivation of these temperatures is not clear. *Glycera lapidum* is found in the north-eastern Atlantic, Mediterranean, North Sea, Skagerrak and Kattegat (Marine Species Identification Portal).

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Sensitivity assessment. Overall, long-term chronic changes in temperature at the pressure benchmark are considered unlikely to adversely affect *Branchiostoma lanceolatum* as the distribution records suggest these species can potentially adapt to a wide range of temperatures experienced in both northern and southern waters, and laboratory experiments suggest a change at the pressure benchmark would fall within the tolerated range. An acute change in temeprature during winter when water temperatures are coldest may lead to mortalities. Resistance is therefore assessed as 'Low' and resilience as 'High'. Sensitivity is therefore 'Low'.

Salinity increase (local)	None	Medium	Medium
	Q: High A: High C: High	Q: High A: Low C: Medium	Q: High A: Low C: Medium

This biotope is found in full salinity (30-35 psu) (JNCC, 2015). Binyon (1979) suggested that *Branchiostoma lanceolatum* was a stenohaline invertebrate capable of withstanding limited dilution of its environment, but being unable to control the osmotic pressure of its body fluids. Salinity profiles of Mediterranean seawater from sites where *Branchiostoma lanceolatum* is found fluctuate from 36.5-38.5 psu (Somorjai *et al*., 2008), indicating some tolerance for small fluctuations in salinity.

A study from the Canary Islands indicates that exposure to high salinity effluents (47-50 psu) from desalination plants alter the structure of biological assemblages, reducing species richness and abundance (Riera *et al*., 2012). Bivalves and amphipods appear to be less tolerant of increased salinity than polychaetes and were largely absent at the point of discharge. Polychaetes, including species or genera that may occur infaunally in this biotope, such as *Spio filicornis*, *Glycera* spp. and *Lumbrineris* sp., were present at the discharge point (Riera *et al*., 2012).

Sensitivity assessment. Based on the inability of *Branchiostoma lanceolatum* to osmoregulate this species is considered to be restricted to fully marine environments and are judged to have 'No' resistance to an increase in salinity at the pressure benchmark. Resilience (following restoration to full salinity) is assessed as 'Medium' (2-10 years) as recruitment may be episodic or slow. Sensitivity is therefore assessed as 'Medium'. Polychaete species may be more tolerant than bivalves so that an increase in salinity may lead to a shift in community composition in the infaunal species associated with this biotope, so that the biotope may alter to resemble the polychaete dominated SS.SCS.CCS.MedLumVen that occurs in similar conditions.

Salinity decrease (local)	None	Medium	Medium
	Q: High A: High C: Medium	Q: High A: Low C: Medium	Q: High A: Low C: Medium

Binyon (1979) suggested that *Branchiostoma lanceolatum* was a stenohaline invertebrate capable of withstanding limited dilution of its environment, but being unable to control the osmotic pressure of its body fluids. Further experimental work, found that flagella and gill cilia activity decreases 'abruptly' around 18 ‰. Adults could survive exposure to 24 ‰ for two weeks although the exposed animals became opaque and were less able to burrow but would swim if gently stroked (Binyon, 1981). *Branchiostoma lanceolatum* has been recorded from at least two habitats recorded as 'brackish': Amvrakikos Gulf, western Greece (Kehayias, 2015), and Pulicat lake area, Tamil Nadu, India (Raveen *et al*., 2016). Salinity profiles were not provided for these habitats and the population at Pulicat lake has disappeared, possibly due to declines in water quality (Raveen *et al*., 2016).

The pea urchin *Echinocyamus pusillus* was reported to occur in environments at 14.8 ‰ in the Sado estuary, Portugal (Russell, 2013).

Sensitivity assessment. Based on the inability of *Branchiostoma lanceolatum* to osmoregulate, these species are considered to be restricted to fully marine environments and are judged to have 'No' resistance to a decrease in salinity at the pressure benchmark**.** Resilience (following restoration to full salinity) is assessed is 'Medium' (2-10 years) as recruitment may be episodic or slow. Sensitivity is therefore assessed as 'Medium'.

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

No information on tidal streams was presented in the biotope description from JNCC (2015). This biotope occurs in clean sands and gravels. Sands are less cohesive than mud sediments and a change in water flow at the pressure benchmark may alter sediment transport patterns within the biotope. Hjulström (1939) concluded that fine sand (particle diameter of 0.3-0.6 mm) was easiest to erode and required a mean velocity of 0.2 m/s. Erosion and deposition of particles greater than 0.5 mm require a velocity >0.2 m/s to alter the habitat. The topography of this habitat is shaped by currents and wave action that influence the formation of ripples in the sediment. Specific fauna may be associated with troughs and crests of these bedforms which may form following an increase in water flow, or disappear following a reduction in flow.

Sensitivity assessment. This biotope probably occurs in areas subject to moderately strong water flows that are a key factor maintaining the clean sand habitat. Changes in water flow may alter the topography of the habitat and may cause some shifts in abundance. However, a change at the pressure benchmark (increase or decrease) is unlikely to affect biotopes that occur in mid-range flows and biotope resistance is therefore assessed as 'High', resilience is assessed as 'High', and the biotope is considered to be 'Not sensitive'.

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

'Not relevant' to subtidal biotopes.

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 habitats that are moderately exposed or sheltered from wave action (JNCC, 2015). As this biotope occurs in infralittoral habitats, it is not directly exposed to the action of breaking waves. Associated polychaete species that burrow are protected within the sediment but bivalves would be exposed to oscillatory water flows at the seabed. They and other associated species may be indirectly affected by changes in water movement where these impact the supply of food or larvae or other processes. No specific evidence was found to assess this pressure.

Sensitivity assessment. The range of wave exposures experienced by the biotope is considered to indicate, by proxy, that the biotope would have 'High' resistance and by default 'High' resilience to a change in significant wave height at the pressure benchmark. The biotope is therefore classed as 'Not sensitive'.

Chemical Pressures

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

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

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.

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

A 12-month zooplankton survey (September 2008 to August 2009) in the hypoxic, stratified and seasonally eutrophic Amvrakikos Gulf (western Greece) revealed that the vertical and horizontal distribution of *Branchiostoma lanceolatum* larvae in the water column was strongly related to oxygen levels. The lower limit of the oxygen concentration for the survival of the larvae seems to have been the hypoxia threshold (2 mg/l) (Kehayias, 2015).

Riedel *et al.* (2012) assessed the response of benthic macrofauna to hypoxia advancing to anoxia in the Mediterranean. The hypoxic and anoxic conditions were created for 3-4 days in a box that enclosed *in-situ* sediments. In general, molluscs were more resistant than polychaetes, with 90% surviving hypoxia and anoxia, whereas only 10% of polychaetes survived. Exposed *Glycera* spp. died. In general, epifauna were more sensitive than infauna, mobile species more sensitive than sedentary species and predatory species more sensitive than suspension and deposit feeders.

Sensitivity assessment. The larval observations and the mortalities of *Glycera* spp. suggest that de-oxygenation at the pressure benchmark may be relevant to larval supply and survival of adults. Biotope resistance is assessed as 'Low' and resilience as 'High', so sensitivity is assessed as 'Low'.

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

This pressure relates to increased levels of nitrogen, phosphorus and silicon in the marine environment compared to background concentrations. The pressure benchmark is set at compliance with Water Framework Directive (WFD) criteria for good status, based on nitrogen concentration (UKTAG, 2014).

Declines in the abundance of *Branchiostoma lanceolatum* have been linked to eutrophication and organic pollution, although separating direct and indirect effects such as change in sediment type has not been possible. Declines have been recorded along the north-eastern Atlantic coast and Mediterranean (Konsulova, 1992 cited from Kehayias, 2015; Antoniadou *et al.*, 2004; Rota *et al.*, 2009) and in lake populations in India (Raveen *et al.*, 2016).

Sensitivity assessment. As this biotope is structured by the sediments and water flow rather than nutrient enrichment and is not characterized by macroalgae (although some may be present), the biotope is considered to have 'High' resistance to this pressure and 'High' resilience, (by default) and is assessed as 'Not sensitive'.

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

The biotope occurs in mobile sand sediments where sediment disturbance leads to particle sorting and *in-situ* primary production is restricted to microphytobenthos. An input of organic matter could provide a food subsidy to the deposit feeding polychaetes. Borja *et al.* (2000) and Gittenberger & Van Loon (2011) assigned *Glycera alba* and *Glycera lapidum* to their AMBI Group III, defined as: 'Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations)' (Borja *et al.*, 2000; Gittenberger & Van Loon, 2011).

No direct evidence was found for *Echinocyamus pusillus*. However, this species lives in areas of high water movement and wave action, so that excess matter silted on the surface is considered to be rapidly removed. Borja *et al.* (2000) and Gittenberger & Van Loon (2011) in the development of an AMBI index to assess disturbance (including organic enrichment) both assigned *Echinocyamus pusillus* to their Ecological Group I: 'Species very sensitive to organic enrichment and present under unpolluted conditions (initial state)' (Borja *et al.*, 2000; Gittenberger & Van Loon, 2011).

Declines in the abundance of *Branchiostoma lanceolatum* have been linked to eutrophication and organic pollution, although separating direct and indirect effects such as change in sediment type has not been possible. Declines have been recorded along the north-eastern Atlantic coast and Mediterranean (Konsulova, 1992 cited from Kehayias, 2015; Antoniadou *et al*., 2004; Rota *et al*., 2009) and in lake populations in India (Raveen *et al*., 2016).

Branchiostoma lanceolatum traps particles on a mucous filter (Riisgård & Svane 1999). Riisgård & Svane (1999) observed that while filter-feeding *Branchiostoma lanceolatum* 'coughs' periodically by closing the excurrent opening and contracting the body to dislodge excess detritus clogging its filter and force it back out of the mouth. Coughing may allow this species to tolerate inputs of organic matter. Gross pollution (at levels greater than the pressure nbenchmark) is likely to reduce habitat suitability, resulting in the loss of *Branchiostoma lanceolatum*.

Sensitivity assessment. At the pressure benchmark, organic inputs are likely to represent a food subsidy for the associated deposit feeding species such as *Glycera* spp. and are unlikely to significantly affect the structure of the biological assemblage or impact the physical habitat. An increase greater than the pressure benchmark is likely to reduce habitat suitability for *Branchiostoma lanceolatum* and *Echinocyamus pusillus*. Biotope sensitivity is assessed as 'High' and resilience as 'High' (by default), and the biotope is therefore considered to be 'Not sensitive' (at the pressure benchmark).

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

The biotope is characterized by the sedimentary habitat (JNCC, 2015), so a change to an artificial or rock substratum would alter the character of the biotope leading to reclassification and the loss of the sedimentary community including the characterizing species that live buried within the sediment.

Sensitivity assessment. Based on the loss of the biotope, resistance is assessed as 'None', recovery is assessed as 'Very Low' (as the change at the pressure benchmark is permanent and sensitivity is 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

The biotope description from JNCC (2015) defines this biotope as occurring in coarse sand habitats. A change in sediment type would alter the biotope from the classification. The key characterizing species and the associated biological assemblage have narrow sediment preferences and would also be lost if the sediment change.

Branchiostoma lanceolatum prefer coarse sand with fairly fast water flow and do not inhabit silty sediments (Berrill, 1987). Antoniadou *et al*. (2004) studied 'Amphioxus' sands from the eastern Mediterranean. The amphioxus (*Branchiostoma lanceolatum*) assemblage was usually found on gravel and coarse sands with shell fragments. The expansion of muddy sediments following eutrophication and organic pollution led to reductions in *Branchiostoma lanceolatum* density and changes in community structure. Similarly, Desprez (2000) reported on the loss of *Branchiostoma lanceolatum* dominated communities following aggregate extraction that resulted in a change from gravels and gravelly sands to a fine sand habitat. The habitat had declined in extent from the 1970's. In Racou beach (southern France), *Branchiostoma lanceolatum* preferred sandy sites (Desdevises *et al*., 2011).

Telford *et al*. (1983) report that in the Firth of Lorne, Scotland, *Echinocyamus pusillus* was found most abundantly in highly variable, poorly sorted substrata but absent in fine sediments in sheltered areas. Wolff (1968, cited in Telford *et al*., 1983) reported that *Echinocyamus pusillus* was abundant in the North Sea in relatively coarse sands with a median grain size of 210-460 µm.

Sensitivity assessment. *Branchiostoma lanceolatum* appears to occur in a relatively restricted range of sediment types, related to burrowing, feeding and other characteristics and is therefore considered to have 'No' resistance to a change in sediment. Resilience is assessed as 'Very Low' as a change at the benchmark is permanent and sensitivity is assessed as 'High'.

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

This biotope is characterized by shallowly buried species. The lancelet, *Branchiostoma lanceolatum* is usually partially or fully buried in the sand filtering microscopic food particles from the water (Riisgard & Svane, 1999).

Recovery of sediments will be site-specific and will be influenced by currents, wave action and sediment availability (Desprez, 2000). Except in areas of mobile sands, the process tends to be slow (Kenny & Rees, 1996; Desprez, 2000 and references therein). Boyd *et al*. (2005) found that in a site subject to long-term extraction (25 years), extraction scars were still visible after six years and sediment characteristics were still altered in comparison with reference areas with ongoing effects on the biota. The strongest currents are unable to transport gravel. A further implication of the formation of these depressions is a local drop in current strength associated with the increased water depth, resulting in deposition of finer sediments than those of the surrounding substrate (Desprez *et al*., 2000 and references therein).

Sensitivity assessment. Within the extraction footprint all individuals would be removed and hence resistance is assessed as 'None'. Resilience is predicted to be 'Medium' (within 2-10 years) and to occur largely through larval recolonisation. Sensitivity is, therefore, assessed as 'Medium'.

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

The lancelet, *Branchiostoma lanceolatum* is usually partially buried in the sand filtering microscopic food particles from the water (Riisgard & Svane, 1999). When disturbed they quickly leave their burrow and swim fast a short distance, then rapidly burrow again posterior end first into the sand (Lambert, 2005). Where sediments are coarse and permeable *Branchiostoma lanceolatum* may live buried several centimetres and rarely come to the surface (Courtney & Webb, 1964). Depth of burial depends on ability to displace sediment grains and the ability of *Branchiostoma lanceolatum* to set up a current through the pharynx in the interstitial water (Courtney & Webb, 1964). Smaller and larger individuals may be buried closer to the surface, due to sediment sorting by lancelet activity, so that a fine sand layer limits depth of penetration for small lancelets and requirements for large ciliary currents by larger lancelets (Courtney & Webb, 1964).

A number of authors describe collecting *Branchiostoma lanceolatum* for laboratory cultivation by dredging and subsequently sieving sediments (Fuentes *et al*., 2004; Somorjai *et al*., 2008). No mortality/damage rates were provided but as this technique successfully captures live individuals it is considered to indicate that the animals are relatively robust.

Sensitivity assessment. As members of this ecological group are generally buried within the sediment this will provide some protection, resistance is assessed as 'Medium' (<25 % mortality). Resilience is assessed as 'High' (based on repair of damaged individuals, inward migration by adults from adjacent populations and recolonization by larvae). Biotope sensitivity is therefore assessed as 'Low'.

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

No direct evidence for the sensitivity of this ecological group to abrasion and penetration of the seabed below the surface was found. A number of authors describe collecting *Branchiostoma lanceolatum* for laboratory cultivation by dredging and subsequently sieving sediments (Fuentes *et al*., 2004; Somorjai *et al*., 2008). No mortality/damage rates were provided but as this technique successfully captures live individuals it is considered to indicate that the animals are relatively robust.

The fragility of the tests of *Echinocyamus pusillus* means that these species have little protection from abrasion that is coupled with penetration and disturbance of the seabed. Evidence to assess the sensitivity of this ecological group is provided by studies on by-catch damage, comparisons between areas with different levels of fishing activities and re-sampling of areas after exposure to directly estimate mortality. No evidence was found for impacts on *Echinocyamus pusillus.* This species may be too small to be retained as by-catch and *in-situ* assessments have not been carried out.

Sensitivity assessment. Based on expert judgement, resistance is assessed as 'Low' (loss of 25-75 % of individuals) and resilience as 'High' (recovery within 2-10 years). Sensitivity is therefore 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

No empirical evidence was found regarding the effects of turbidity on *Branchiostoma lanceolatum* and this biotope. This biotope is not characterized by primary producers and direct effects from changes in light penetration are not relevant. Increases or decreases in organic suspended solids and other particles may affect epifauna through abrasion and affect feeding by filter feeders. Riisgård & Svane (1999) observed that while filter-feeding, *Branchiostoma lanceolatum* "coughs" periodically by closing the excurrent opening and contracting the body to dislodge excess detritus clogging its filter and force it back out of the mouth.

The sedimentary habitats where *Branchiostoma lanceolatum* and the associated species are found, may experience periodic high levels of suspended particles. The burrowing habit of infauna may mediate exposure, however, species such as *Branchiostoma lanceolatum* and *Glycymeris glycymeris* that depend on inhalant currents from the surface for respiration may be affected where fine particles are deposited in interstitial spaces (see physical change and siltation pressures). Increased organic matter in suspension or that is subsequently deposited may enhance food supply to suspension feeders. The feeding apparatus of *Branchiostoma lanceolatum* are considered more robust than the more delicate structures of, for example, filter feeding molluscs, although no evidence was found regarding the likelihood of clogging.

Sensitivity assessment. Resistance is therefore assessed as 'High' and resilience as 'High' (no effect to recover from). This group is therefore assessed as 'Not sensitive'.

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

Little evidence was found to assess the impacts of this pressure on this ecological group. *Branchiostoma lanceolatum* are not found in silty sediments and as the pressure benchmark refers explicitly to fine sediments, this species may be unsuited to burrowing through the deposited overburden which would be different in composition to its usual habitat.

Bijkerk (1988, results cited from Essink 1999) indicated that the maximal overburden through which *Echinocardium* could migrate was approximately 30 cm in sand. No further information was available on the rates of survivorship or the time taken to reach the surface. No information was found regarding the sensitivity of *Echinocyamus pusillus*. *Glycera alba* and *Glycera lapidum* have been categorized through expert judgement and literature review as AMBI sedimentation Group II: 'Species sensitive to high sedimentation. They prefer to live in areas with some sedimentation, but don't easily recover from strong fluctuations in sedimentation' (Gittenberger & Van Loon, 2011).

Sensitivity assessment. Although some individuals may reposition within sediments, resistance is assessed as 'Low' (loss of 25-75 % of exposed individuals) at the pressure benchmark due to the depth of the overburden. Resilience is assessed as 'High' (following sediment restoration). Sensitivity is therefore categorised as 'Low'.

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

Little evidence was found to assess the impacts of this pressure on this ecological group. *Branchiostoma lanceolatum* are not found in silty sediments and as the pressure benchmark refers explicitly to fine sediments, this species may be unsuited to burrowing through the deposited overburden which would be different in composition to its usual habitat.

Bijkerk (1988, results cited from Essink 1999) indicated that the maximal overburden through which *Echinocardium* could migrate was approximately 30 cm in sand. No further information was available on the rates of survivorship or the time taken to reach the surface. No information was found regarding the sensitivity of *Echinocyamus pusillus*. *Glycera alba* and *Glycera lapidum* have been categorized through expert judgement and literature review as AMBI sedimentation Group II: 'Species sensitive to high sedimentation. They prefer to live in areas with some sedimentation, but don't easily recover from strong fluctuations in sedimentation' (Gittenberger & Van Loon, 2011).

Sensitivity assessment. Although some individuals may reposition within sediments, resistance is assessed as 'Low' (loss of 25-75 % of exposed individuals) at the pressure benchmark due to the depth of the overburden. Resilience is assessed as 'High' (following sediment restoration). Sensitivity is therefore categorised as 'Low'

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

Not assessed.

Electromagnetic changes	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

Not relevant.

Introduction of light or shading	Low Q: High A: Low C: High	High Q: High A: Low C: Medium	Low Q: High A: Low C: Medium

Amphioxus have photoreceptors along their entire length (Lacalli, 2004) and will move away from light when disturbed (Somorjai *et al*., 2008; Fuentes *et al*., 2004). Wild amphioxus populations spawn after sunset, a change in lighting could affect this (Benito-Gutiérrez *et al*., 2013).

Sensitivity assessment. Changes in light levels may alter spawning cues and behaviour of the characterizing species *Branchiostoma lanceolatum*. Biotope resistance based on this characterizing species is assessed as 'Low' and resilience is assessed as 'High', following restoration of the usual light environment. Biotope sensitivity is therefore assessed as 'Low'.

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' 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	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

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

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

No evidence. In aquaria populations the major cause of mortality is bacterial infection (Benito-Gutiérrez *et al*., 2013). Courtney & Webb (1964) noted that damaged lancelets and animals in poor condition are subject to attack from ciliate protozoa leading to mortality.

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

No evidence.

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

'Not relevant'.

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

The loss of the key characterizing species *Branchiostoma lanceolatum* through unintentional removal would alter the character of the biotope and may lead to reclassification to a similar, infaunal biotope such as SS.SCS.ICS.MoeVen or SS.SCS.CCS.MedLumVen. The ecosystem services such as secondary production provided by this species would be lost.

Sensitivity assessment. Biotope resistance to loss of the characterizing species is assessed as 'Low', as the burrowing lifestyle and mobility of *Branchiostoma lanceolatum* mean that a proportion of the population may escape removal. Resilience is assessed as 'High' based on *in-situ* recovery and migration from adjacent populations, and sensitivity is therefore assessed as 'Low'.

Bibliography

Antoniadou, C., Krestenitis, Y. & Chintiroglou, C., 2004. Structure of the “Amphioxus sand” community in Thermaikos bay (Eastern Mediterranean). *Fresenius Environmental Bulletin*, **13**, 1122-1128.

Benito-Gutiérrez, È., Weber, H., Bryant, D.V. & Arendt, D., 2013. Methods for generating year-round access to amphioxus in the laboratory. *Plos One*, **8** (8), e71599.

Berrill, N.J., 1987. Early chordate evolution part 2. Amphioxus and ascidians to settle or not to settle. *International Journal of Invertebrate Reproduction and Development*, **11** (1), 15-27.

Bijkerk, R., 1988. Ontsnappen of begraven blijven: de effecten op bodemdieren van een verhoogde sedimentatie als gevolg van baggerwerkzaamheden: literatuuronderzoek: RDD, Aquatic ecosystems.

Binyon, J., 1979. *Branchiostoma lanceolatum* - a freshwater reject? *Journal of the Marine Biological Association of the U.K.*, **59** (1), 61-67.

Binyon, J., 1981. The effects of lowered salinity upon *Branchiostoma lanceolatum* from the English Channel. *Journal of the Marine Biological Association of the United Kingdom*, **61**, 685-689.

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

Boschung, H.T. & Shaw, R.F., 1988. Occurrence of planktonic lancelets from Louisiana's continental shelf, with a review of pelagic *Branchiostoma* (Order Amphioxi). *Bulletin of Marine Science*, **43** (2), 229-240.

Boyd, S., Limpenny, D., Rees, H. & Cooper, K., 2005. The effects of marine sand and gravel extraction on the macrobenthos at a commercial dredging site (results 6 years post-dredging). *ICES Journal of Marine Science: Journal du Conseil*, **62** (2), 145-162.

Courtney, W.A., 1975a. Reproductive cycle and the occurrence of abnormal larvae in *Branchiostoma lanceolatum* at Helgoland. *Helgoländer wissenschaftliche Meeresuntersuchungen*, **27** (1), 19-27.

Courtney, W.A., 1975b. The temperature relationships and age-structure of North Sea and Mediterranean populations of *Branchiostoma lanceolatum*. In *Symposia of the Zoological Society of London*, Volume 36, pp. 213-233. London.

Courtney, W.A. & Newell, R., 1965. Ciliary activity and oxygen uptake in *Branchiostoma lanceolatum* (Pallas). *Journal of Experimental Biology*, **43** (1), 1-12.

Courtney, W.A. & Webb, J.E., 1964. The effects of the cold winter of 1962/63 on the Helgoland population of *Branchiostoma lanceolatum* (Pallas). *Helgoländer wissenschaftliche Meeresuntersuchungen*, **10** (1-4), 301-312.

Courtney, W.A.M., 1975. Reproductive cycle and the occurrence of abnormal larvae in *Branchiostoma lanceolatum* at Helgoland. *Helgoländer Wissenschaftliche Meeresuntersuchungen*, **27** (1), 19-27.

Delsuc, F., Tsagkogeorga, G., Lartillot, N. & Philippe, H., 2008. Additional molecular support for the new chordate phylogeny. *Genesis*, **46** (11), 592-604.

Desdevises, Y., Maillet, V., Fuentes, M. & Escriva, H., 2011. A snapshot of the population structure of *Branchiostoma lanceolatum* in the Racou beach, France, during its spawning season. *Plos One*, **6** (4), e18520.

Desprez, M., 2000. Physical and biological impact of marine aggregate extraction along the French coast of the Eastern English Channel: short- and long-term post-dredging restoration. *ICES Journal of Marine Science*, **57** (5), 1428-1438.

Desprez, M., Pearce, B. and Le Bot, S., 2010. The biological impact of overflowing sands around a marine aggregate extraction site: Dieppe (eastern English Channel). *ICES Journal of Marine Science: Journal du Conseil*, **67**, 270-277

Essink, K., 1999. Ecological effects of dumping of dredged sediments; options for management. *Journal of Coastal Conservation*, **5**, 69-80.

Ford, E., 1923. Animal communities of the level sea-bottom in the water adjacent to Plymouth. *Journal of the Marine Biological Association of the United Kingdom*, **13**, 164-224.

Fuentes, M., Schubert, M., Dalfo, D., Candiani, S., Benito, E., Gardenyes, J., Godoy, L., Moret, F., Illas, M., Patten, I., Permanyer, J., Oliveri, D., Boeuf, G., Falcon, J., Pestarino, M., Fernandez, J.G., Albalat, R., Laudet, V., Vernier, P. & Escriva, H., 2004. Preliminary observations on the spawning conditions of the European amphioxus (*Branchiostoma lanceolatum*) in captivity. *Journal of Experimental Zoology, Part B: Molecular and Developmental Evolution*, **302B** (4), 384-391.

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

Glémarec, M., 1973. The benthic communities of the European North Atlantic continental shelf. *Oceanography and Marine Biology: an Annual Review*, **11**, 263-289.

Hjulström, F., 1939. Transportation of detritus by moving water: Part 1. Transportation. Recent Marine Sediments, a Symposium (ed. P.D. Trask), pp. 5-31. Dover Publications, Inc.

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

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

Jones, N.S., 1951. The bottom fauna of the south of the Isle of Man. *Journal of Animal Ecology*, **20**, 132-144.

Kehayias, G., 2015. Spatial and temporal variation of *Branchiostoma lanceolatum* larvae (Cephalochordata) in a hypoxic bay. *Biologia*, **70** (9), 1234-1244.

Kenny, A.J. & Rees, H.L., 1996. The effects of marine gravel extraction on the macrobenthos: results 2 years post-dredging. *Marine Pollution Bulletin*, **32** (8-9), 615-622.

Klawe, W.L. & Dickie, L.M., 1957. Biology of the bloodworm, *Glycera dibranchiata* Ehlers, and its relation to the bloodworm fishery of the Maritime Provinces. *Bulletin of Fisheries Research Board of Canada*, **115**, 1-37.

Konsulova, T., 1992. Seasonal structure and ecological status of Varna Bay (Black Sea) sandy and muddy macrozoobenthic coenoses. *Rapport Commission Internationale De La Mer Mediterranee*, **33**, 42.

Lacalli, T.C., 2004. Sensory systems in amphioxus: a window on the ancestral chordate condition. *Brain, behavior and evolution*, **64** (3), 148-162.

Lambert, G., 2005. Ecology and natural history of the protochordates. *Canadian Journal of Zoology*, **83** (1), 34-50.

MES, 2010. *Marine Macrofauna Genus Trait Handbook*. Marine Ecological Surveys Limited. http://www.genustraithandbook.org.uk/

OBIS 2014. Data from the Ocean Biogeographic Information System. Intergovernmental Oceanographic Commission of UNESCO. [online]. Available from: http://www.iobis.org

Poss, S.G. & Boschung, H.T., 1996. Lancelets (Cephalochordata: Branchiostomatidae): How many species are valid? *Israel Journal of Zoology*, **42** (1), S13-S66.

Raveen, R., Samuel, V. & Samuel, T., 2016. Disappearance of *Branchiostoma lanceolatum* (Pallas) from Pulicat lake area, Tamil Nadu, India. *International Journal of Fauna and Biological Studies*, **3** (1), 55-57.

Riedel, B., Zuschin, M. & Stachowitsch, M., 2012. Tolerance of benthic macrofauna to hypoxia and anoxia in shallow coastal seas: a realistic scenario. *Marine Ecology Progress Series*, **458**, 39-52.

Riera, R., Tuya, F., Ramos, E., Rodríguez, M. & Monterroso, Ó., 2012. Variability of macrofaunal assemblages on the surroundings of a brine disposal. *Desalination*, **291**, 94-100.

Riisgård, H.U. & Svane, I., 1999. Filter feeding in lancelets (amphioxus), *Branchiostoma lanceolatum*. *Invertebrate Biology*, **118 (4)**, 423-432

Rota, E., Perra, G. & Focardi, S., 2009. The European lancelet *Branchiostoma lanceolatum* (Pallas) as an indicator of environmental quality of Tuscan Archipelago (Western Mediterranean Sea). *Chemistry and Ecology*, **25** (1), 61-69.

Ruppert, E.E. & Barnes, R.D., 1994. *Invertebrate zoology* (6th ed.). Fort Worth, USA: Saunders College Publishing.

Russell, M., 2013. Echinoderm Responses to Variation in Salinity. *Advances in Marine Biology*, **66**, 171-212.

Sardá, R., Pinedo, S., Gremare, A. & Taboada, S., 2000. Changes in the dynamics of shallow sandy-bottom assemblages due to sand extraction in the Catalan Western Mediterranean Sea. *ICES Journal of Marine Science*, **57** (5), 1446-1453.

Somorjai, I.M., Camasses, A., Rivière, B. & Escrivà, H., 2008. Development of a semi-closed aquaculture system for monitoring of individual amphioxus (*Branchiostoma lanceolatum*), with high survivorship. *Aquaculture*, **281** (1), 145-150.

Somorjai, I.M., Somorjai, R.L., Garcia-Fernàndez, J. & Escrivà, H., 2012. Vertebrate-like regeneration in the invertebrate chordate amphioxus. *Proceedings of the National Academy of Sciences*, **109** (2), 517-522.

Stokes, M. & Holland, N., 1996b. Life-history characteristics of the Florida lancelet, *Branchiostoma floridae*: some factors affecting population dynamics in Tampa Bay. *Israel Journal of Zoology*, **42** (sup1), S67-S86.

Stokes, M.D. & Holland, N.D., 1996a. Reproduction of the Florida lancelet (*Branchiostoma floridae*): spawning patterns and fluctuations in gonad indexes and nutritional reserves. *Invertebrate Biology*, **115** (4), 349-359.

Telford, M., Harold, A.S. & Mooi, R., 1983. Feeding structures, behavior, and microhabitat of *Echinocyamus pusillus* (Echinoidea: Clypeasteroida). *Biological Bulletin, Marine Biological Laboratory, Woods Hole*, **165** (3), 745-757.

Theodosiou, M., Colin, A., Schulz, J., Laudet, V., Peyrieras, N., Nicolas, J.F., Schubert, M. & Hirsinger, E., 2011. Amphioxus spawning behavior in an artificial seawater facility. *Journal of Experimental Zoology Part B: Molecular and Developmental Evolution*, **316** (4), 263-275.

Tung, T., Wu, S. & Tung, Y., 1958. The development of isolated blastomeres of Amphioxus. *Scientia Sinica*, **7** (12), 1280.

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

Wolff, W.J., 1968. The Echinodermata of the estuarine region of the rivers Rhine, Meuse and Scheldt, with a list of species occurring in the coastal waters of the Netherlands. *The Netherlands Journal of Sea Research*, **4**, 59-85.

WoRMS, 2015. World Register of Marine Species. (11/04/2007). http://www.marinespecies.org