



# MarLIN

## Marine Information Network

Information on the species and habitats around the coasts and sea of the British Isles

## Starlet sea anemone (*Nematostella vectensis*)

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

Dr Harvey Tyler-Walters, Charlotte Marshall, & Angus Jackson

2017-03-08

A report from:

The Marine Life Information Network, Marine Biological Association of the United Kingdom.

**Please note.** This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [<https://www.marlin.ac.uk/species/detail/1136>]. All terms and the MarESA methodology are outlined on the website (<https://www.marlin.ac.uk>)

This review can be cited as:

Tyler-Walters, H., Marshall, C.E. & Jackson, A. 2017. *Nematostella vectensis* Starlet sea anemone. 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/marlin.sp.1136.2>



The information (TEXT ONLY) provided by the Marine Life Information Network (MarLIN) is licensed under a Creative Commons Attribution-Non-Commercial-Share Alike 2.0 UK: England & Wales License. Note that images and other media featured on this page are each governed by their own terms and conditions and they may or may not be available for reuse. Permissions beyond the scope of this license are available [here](https://www.marlin.ac.uk). Based on a work at [www.marlin.ac.uk](https://www.marlin.ac.uk)

(page left blank)



*Nematostella vectensis*, one individual removed from the substratum.

Photographer: Dennis R. Seaward

Copyright: Dennis R. Seaward

See online review for  
distribution map

Distribution data supplied by the Ocean Biogeographic Information System (OBIS). To interrogate UK data visit the NBN Atlas.

<b>Researched by</b>	Dr Harvey Tyler-Walters, Charlotte Marshall, & Angus Jackson	<b>Refereed by</b>	Dr Simon Davy & Dr Martin Sheader
<b>Authority</b>	Stephenson, 1935		
<b>Other common names</b>	-	<b>Synonyms</b>	-

## Summary

### 🔍 Description

A tiny anemone rarely more than 1.5 cm in length. The column is usually between 0.4 and 1.6 cm in length but specimens can occasionally reach 4.1 cm when fully extended. Translucent and colourless in appearance except for variable patterns of opaque white on the column and disk. Tentacles large in proportion to the body, colourless and translucent with pale tips and with faint transverse bars and irregular flecks of white. The 9-16 tentacles are very strongly adhesive and arranged in two cycles, the outer ones longer than the inner.

### 📍 Recorded distribution in Britain and Ireland

Recorded from the north coast of Norfolk, the east coast of Suffolk, the Blackwater Estuary and Hamford Water in Essex, the Hampshire coast, the south coast of Dorset, Sand Bay in the Bristol Channel, and St' Bees Head, Cumbria.

### 📍 Global distribution

In North America from Nova Scotia to Georgia on the Atlantic coast, from Florida to Louisiana in the Gulf of Mexico and from California to Washington on the Pacific coast. In Europe, it is restricted to the south and east coast of England.

## Habitat

Lives in isolated or semi-isolated brackish pools in saltmarsh and lagoons, in ditches and on mudflats in saltmarshes and shallow estuaries at or above high water, typically in mud, muddy sand and muddy shingle but is also found on vegetation (M. Sheader, pers. comm.; Fincham, 2016a&b).

## ↓ Depth range

High to low water

## 🔍 Identifying features

- Column differentiated into physa, scapus and capitulum.
- No nemathybomes (nematocyst bearing sacs in the column).
- Unusual, ciliated, spherical bodies called nematosomes, occur in the coelenteron.
- Tentacles in two cycles, the outer longer than the inner.

## Additional information

*Nematostella vectensis* is a model organism for the study of developmental genetics and evolution, and has a dedicated genomics database (Darling *et al.*, 2005; Sullivan *et al.*, 2006; Tarrant *et al.*, 2015; Layden *et al.*, 2016). However, a discussion of developmental genetics is outside the scope of this review.

## ✓ Listed by



## Further information sources

Search on:



## Biology review

### ☰ Taxonomy

Phylum	Cnidaria	Sea anemones, corals, sea firs & jellyfish
Class	Anthozoa	Sea anemones, soft & cup corals, sea pens & sea pansies
Order	Actiniaria	
Family	Edwardsiidae	
Genus	Nematostella	
Authority	Stephenson, 1935	
Recent Synonyms	-	

### 🌿 Biology

Typical abundance	Moderate density
Male size range	1-2 cm
Male size at maturity	1-2 cm
Female size range	1-2 cm
Female size at maturity	1-2 cm
Growth form	Cylindrical
Growth rate	See additional information
Body flexibility	High (greater than 45 degrees)
Mobility	Temporary attachment
Characteristic feeding method	Predator
Diet/food source	Carnivore
Typically feeds on	Small free-living macrofauna e.g. copepods, ostracods, juvenile littorinids, hydrobiids and larvae
Sociability	Not relevant
Environmental position	Epifaunal
Dependency	Independent.
Supports	None
Is the species harmful?	No

### 🏛️ Biology information

*Nematostella vectensis* uses the adhesive rugae on its column to anchor and move in the sediment and to climb on macroalgae (e.g. *Chaetomorpha* spp.) and macrophytes (e.g. *Ruppia* spp.). However, less than 5% of the population was observed on macrophytes in the Fleet, Pennington and Gilkicker lagoons (Shedder *et al.*, 1997).

#### Growth rate and size

The column is usually between 0.4 and 1.6 cm in length but specimens can occasionally reach 4.1 cm when fully extended (Williams, 1975). In the field they are usually less than 2 cm long, typically with a column diameter of only 0.2 cm, and a crown of tentacles 0.8-1 cm across (Williams, 1983; Hand & Uhlinger, 1994). In the laboratory, excessively well-fed specimens can reach over 16 cm in length (Hand & Uhlinger, 1992). Food availability, salinity and temperature probably limit size,

growth rates and abundance of this species under natural conditions (Hand & Uhlinger, 1992, 1994; Sheader *et al.*, 1997). In the laboratory, Hand & Uhlinger (1992) found that young anemones varied in size but could grow to 1 mm long in 10 days, 2 mm in 2 weeks, 4 mm in three weeks and, in the extreme, reach 2.5 cm in a month. The second set of four tentacles arrive after 2-3 weeks and the month-old individuals typically have 12 tentacles and can extend to 1-2 cm in length. The anemones approach sexual maturity after two months and are 2-5 cm long and have 16 tentacles (Hand & Uhlinger, 1992). Adult spawning can occur in a little as 55-69 days after fertilization, in the laboratory (Hand & Uhlinger, 1992, 1994). However, in the field individuals tend to be smaller, and once disturbed contract into small white masses rarely more than a few millimetres long, that are easily mistaken for pieces of polychaete or nemertean (Hand & Uhlinger, 1994).

### Population dynamics

*Nematostella vectensis* can reach high abundance in favourable conditions. For example, Williams, unpubl. (cited in Williams, 1983) noted that more than 12,500 /m<sup>2</sup> were found in a Norfolk pool in September 1974, and estimated that a single pool could contain over 5 million individuals. Similarly, Hand & Uhlinger (1994) cite a report of ca 80,000 individuals /m<sup>2</sup> in a single isolated pool in Nova Scotia. However, abundance varies with geographic area and time of year (Hand & Uhlinger, 1994; Sheader *et al.*, 1997) and in the field, abundances are typically much lower (Reitzel *et al.*, 2008).

In Pennington Lagoon, Hampshire, winter abundance was low (at <120 /m<sup>2</sup>), rose slightly in April with a peak in abundance of up to 2700 individuals /m<sup>2</sup> was seen from September to October. In the Fleet, Dorset, the population peaked at around 1500 individuals /m<sup>2</sup>, in November and December and then fell back to their original spring/summer abundance of 100-400/m<sup>2</sup> (Sheader *et al.*, 1997). In the Gilkicker Lagoon, Hampshire, the abundance remained low in 1987 (at <175/m<sup>2</sup>) with a slight peak in June but the abundance was higher in 1988 (ca 200 /m<sup>2</sup>) with a peak of (1130 /m<sup>2</sup>) in October. In UK lagoons the abundance was low over winter and the beginning of the year and peaked in the later part of the year, although the exact season varied between lagoon (Sheader *et al.*, 1997).

Sheader *et al.* (1997) also noted that the peak abundances in their studied populations coincided with an increase in the proportion of smaller size classes and suggested that the peaks were due to asexual reproduction, especially as no males were found in their samples. The peak in abundance also coincided with peaks in macrofaunal numbers, and hence food availability for *Nematostella vectensis*.

Only females were found in the south coast populations of England (Sheader *et al.*, 1997) and there seems to be only asexual reproduction in the UK (M. Sheader, pers. comm). Unisexual populations are common in this species and recorded from the Pacific and Atlantic coasts of the USA (Hand & Uhlinger, 1994; Reitzel *et al.*, 2008).

### Feeding

*Nematostella vectensis* is a passive predator that captures passing prey. It has been reported to feed on hydrobiid snails, juvenile littorinids, copepods, chironomid larvae, egg masses (probably from copepods), ostracods, nematodes and small polychaetes, corixids, possibly rotifers, and the pediveligers of *Macoma*, mussels and oysters (Frank & Bleakney, 1978, Posey & Hines, 1991; Hand & Uhlinger, 1992, 1994; Sheader *et al.*, 1997).

## Habitat preferences

<b>Physiographic preferences</b>	Estuary, Isolated saline water (Lagoon)
<b>Biological zone preferences</b>	Not relevant
<b>Substratum / habitat preferences</b>	Macroalgae, Mud, Muddy gravel, Muddy sand, Saltmarsh
<b>Tidal strength preferences</b>	Very Weak (negligible)
<b>Wave exposure preferences</b>	Ultra sheltered
<b>Salinity preferences</b>	Low (<18 psu), Variable (18-40 psu)
<b>Depth range</b>	High to low water
<b>Other preferences</b>	No text entered
<b>Migration Pattern</b>	Non-migratory / resident

## Habitat Information

### Distribution in Britain and Ireland

*Nematostella vectensis* is found on the north coast of Norfolk, the east coast of Suffolk, the Blackwater Estuary and Hamford Water in Essex (Carol Reid, English Nature, pers. comm.), the Hampshire coast and on the south coast of Dorset, Sand Bay in the Bristol Channel, and St' Bees Head, Cumbria. *Nematostella vectensis* was first described as a new species from brackish pools on the Isle of Wight (Stephenson, 1935).

### Habitat preferences

*Nematostella vectensis* is regarded as a eurythermal and euryhaline species. In the UK, *Nematostella vectensis* is recorded from coastal brackish ponds or lagoons. The species is usually found in water less than 1 m deep, a few live down to 2 m water depth (M. Sheader, pers. comm.). It has a wider distribution in North America where it is recorded from permanent brackish/saline ponds, salt marsh creeks and subtidally in certain estuaries (Hand & Uhlinger, 1994; Sheader *et al.*, 1997). Recent records from Norfolk and Suffolk estuaries and lagoons suggest that its habitat in the UK is probably very similar to that in the USA, as it has been recorded from pools, ditches and mudflats in salt marsh and estuaries (Fincham, 2016a).

In English populations of *Nematostella vectensis*, the salinity in the vast majority of sites ranged between 2-42 ppt with the greatest abundance in ponds with seasonally varying salinity between 16-32 ppt. (Sheader *et al.*, 1997). Williams (1983; cited by Hand & Uhlinger, 1992,1994) noted that it was usually found in brackish marsh pools of between 10 and 25 ppt but that it was recorded in salinities between 8.96 ppt and 51.54 ppt. Hand & Uhlinger (1992, 1994) noted asexual division at salinities of 7 to 42 ppt and sexual reproduction in salinities of 12 to 34 ppt. *Nematostella vectensis* was also recorded in pools in Nova Scotia at -1.5°C and 28°C where the low temperature coincided with the pool thickly covered with ice, and in Georgia (USA) in pools at 32.5°C (Hand & Uhlinger, 1994). Reitzel *et al.* (2013) concluded that, while eurythermal, *Nematostella vectensis* occupied sites (on the western Atlantic coast of the USA) close to their physiological limit. Specimens survived at experimental temperatures up to 39°C but almost all life stages died at 41°C. Temperature also had a significant effect on growth and regeneration rates, which also varied between specimens from higher or lower latitudes at 29°C (Reitzel *et al.* 2013). Hand & Uhlinger (1994) and Posey & Hines (1991) also noted that *Nematostella vectensis* was never found where the salinity is permanently high, and suggested that predation (e.g. by shrimp or nudibranchs) prevented their survival at full salinity.

Sheader *et al.* (1997) noted that *Nematostella vectensis* occupied pools with very low or negligible water flow. They noted that it could be abundant below 0.1 cm/s (0.01 m/s) but was absent above

ca 0.18 cm/s (0.018 m/s). *Nematostella vectensis* can also use macrophytes (e.g. *Ruppia* sp. or *Chaetomorpha* sp.) as substrata (Williams, 1991; Sheader *et al.*, 1997).

### Non-native status

The restricted distribution of *Nematostella vectensis* in the UK led Sheader *et al.* (1997) to suggest that it was introduced from the USA. Subsequent genetic studies using a range of genetic markers have concluded that *Nematostella vectensis* was probably introduced from the southeastern coast of the USA (Pearson *et al.*, 2002; Darling *et al.*, 2004, 2009; Reitzel *et al.*, 2008). Darling *et al.* (2004, 2009) concluded that anthropogenic transport was most likely, rather than rafting (i.e. on floating debris or macrophytes), probably via the transport of gear and as fouling communities on watercraft, rather than ballast water. Sheader *et al.* (1997) suggested that it may have been introduced by accidental transfer with imported North American shellfish (e.g. *Crassostrea* spp. and *Mercenaria mercenaria*) into the area of the Solent in the 20th century, and Reitzel *et al.* (2008) note that it was first recorded on the Isle of Wight in the 1930s.

## Life history

### Adult characteristics

Reproductive type	Asexual, Budding, Fission, Gonochoristic (dioecious), Sexual
Reproductive frequency	Annual episodic
Fecundity (number of eggs)	100-1,000
Generation time	<1 year
Age at maturity	>10 weeks
Season	Not relevant
Life span	Insufficient information

### Larval characteristics

Larval/propagule type	Planula
Larval/juvenile development	See additional information
Duration of larval stage	2-10 days
Larval dispersal potential	Very limited (<1 m)
Larval settlement period	Insufficient information

## Life history information

*Nematostella vectensis* is able to reproduce both sexually and asexually. In the USA, it is easy to collect in the wild and easy to culture under laboratory conditions so that its development is well documented and it is suited to studies of developmental genetics and genomics (Williams, 1975; Frank & Bleakney, 1978; Hand & Uhlinger, 1992, 1994, 1995; Darling *et al.*, 2005; Sullivan *et al.*, 2006; Reitzel *et al.*, 2007; Reitzel *et al.*, 2013; Tarrant *et al.*, 2015; Layden *et al.*, 2016). Key points are summarised below.

### Sexual reproduction

- In the laboratory, *Nematostella vectensis* became sexually mature at 3-4 months old and at column lengths of between 1.5-3.5 cm. Gametes were found to be produced at all times of the year (Hand & Uhlinger, 1992, 1994).
- Fritzenwanker & Technau (2002) found that, in the laboratory, a combination of feeding regime, dark-light cycle and temperature shift synergistically induced gametogenesis in adult polyps from the Rhode River in America. They concluded that the combination of 4 days of feeding in the dark at 18°C followed by illumination at 24 °C produced the highest number of eggs.
- The number of eggs is dependent on adult size. Large individuals reared in the laboratory can produce up to 2000 eggs (Hand & Uhlinger, 1992,1994).
- Eggs are 170-240 µm in diameter and are released embedded in a gelatinous mucoid mass that sticks to the bottom (Hand & Uhlinger, 1992).
- In the laboratory, spherical ciliated planula larvae (200-250 µm in length) emerge from the egg masses between 3-4 days after fertilization. They bear an apical tuft of cilia at the oral end, which is lost as they develop and become pear-shaped. Planulae are active swimmers from the age of about 3 days old but spend periods of inactivity on the bottom of culture dishes unless disturbed (Hand & Uhlinger, 1992; Darling *et al.*, 2005; Reitzel *et al.*, 2007). Planulae and juveniles 'glide' over the surface of the substratum (in the laboratory) but most cease gliding before they are 1 mm long (Hand & Uhlinger, 1992).
- They develop four tentacle buds in 4-5 days and settle as 250-500 µm juveniles with four tentacles within 7 to 10 days of fertilization (Hand & Uhlinger, 1992; Darling *et al.*, 2005; Reitzel *et al.*, 2007). However, settlement and metamorphosis into the juvenile can take at least two weeks or be prolonged for up to 135 days (Hand & Uhlinger, 1994)
- In the laboratory, Hand & Uhlinger (1992) found that young anemones varied in size but could grow to 1 mm long in 10 days, 2 mm in 2 weeks, 4 mm in three weeks and, in the extreme, reach 2.5 cm in a month. The second set of four tentacles arrives after 2-3 weeks and the month-old individuals typically have 12 tentacles and can extend to 1-2 cm in length.
- The anemones approach sexual maturity after two months and are 2-5 cm long and have 16 tentacles (Hand & Uhlinger, 1992).
- Adult spawning can occur in a little as 55-69 days after fertilization, in the laboratory (Hand & Uhlinger, 1992, 1994). Hand & Uhlinger (1992) suggested that pulses of food and/or changes in water stimulated spawning.

In the laboratory, *Nematostella vectensis* was able to spawn repeatably and predictably at ca seven-day intervals up to Hand & Uhlinger (1992, 1994). The ease of growth and rapid generation time (2-3 months) in the laboratory allow classic genetic studies to be undertaken (Darling *et al.*, 2005). Hand & Uhlinger (1992) also noted that it underwent its full range of development at a wide range of salinities but that growth was inhibited and sexual reproduction and metamorphosis stopped at salinities greater than 34 ppt.

### Asexual reproduction

*Nematostella vectensis* is able to reproduce by transverse fission and budding (Hand & Uhlinger, 1992, 1994, 1995; Frank & Bleakney, 1978; Reitzel *et al.*, 2007). The vegetative asexual reproduction results in genetically identical clones; for example, a single isolated male individual gave rise to 96 individuals, and an isolated female gave rise to 38 individuals in the laboratory. The male and female clones were then able to breed successfully (Hand & Uhlinger (1992).

**Transverse fission.** Transverse fission is known in only four other sea anemones (Shick, 1991, cited

in Hand & Uhlinger, 1994). In the laboratory, most transverse fission (across the column) was found to take place at night and only in well-expanded individuals. The fragment produced by fission is usually shorter than the oral piece and sometimes multiple fission occurs, producing two or three fragments. Some fragments regenerated and were able to feed within three days and, if well fed, completed growth to the adult spawning stage within a few more weeks (Hand & Uhlinger, 1995). Although asexual division becomes common at about 10 weeks, it has been noted as early as seven weeks. Increased food intake leads to an increase in the frequency of fission and starvation can suppress the process (Hand & Uhlinger, 1992, 1995; Reitzel *et al.*, 2007).

**Budding.** Anemones with multiple oral-crowns are common in both natural and laboratory reared populations of *Nematostella vectensis* (Williams, 1975; Frank & Beakney, 1978; Hand & Uhlinger, 1995; Reitzel *et al.*, 2007). This is caused by polarity reversal, in which a new oral crown develops at the aboral end of the column (physa) (Reitzel *et al.*, 2007). Fission (within weeks or months) by such individuals produces normal single-crowned anemones. This is known as budding and is extremely rare in anemones (Hand & Uhlinger, 1995; Reitzel *et al.*, 2007).

**Regeneration.** Hand & Uhlinger (1995) and Reitzel *et al.* (2007) note that *Nematostella vectensis* has good regeneration capability. Complete bisection of the column normally results in two complete adults (Reitzel *et al.*, 2007). However, injuries and anomalous fission can result in a range of anomalous individuals, e.g. with multiple crowns and Y-shaped individuals (Hand & Uhlinger, 1995; Reitzel *et al.*, 2007).

## Population structure

The relative proportion of sexual and asexual reproduction in natural populations is uncertain but sexual reproduction rates are probably much lower in nature than in the laboratory (Hand & Uhlinger, 1992, 1994). This is borne out by the number of single-sex populations and high levels of genetic differentiation between populations. For example, Hand & Uhlinger (1994) noted that 6 of the 21 populations they studied contained both sexes while the other 15 were single sexed. In the UK, only female populations were recorded (Hand & Uhlinger, 1994; Sheader *et al.*, 1997). Darling *et al.* (2004) found that five or nine populations studied were asexual.

Genetic studies have shown that *Nematostella vectensis* populations show a mixture of sexual and asexual reproduction, with numerous asexual only population, and extraordinarily high levels of genetic differentiation, sometimes over the space of less than 100m, which is consistent with low gene flow, poor dispersal and/or bottlenecks (where few individuals survive environmental perturbation, e.g. the drying up of pools), and sporadic, discontinuous dispersal by random events and anthropogenic transport (Sheader *et al.*, 1997; Pearson *et al.*, 2002; Darling *et al.*, 2004, 2009; Reitzel *et al.*, 2008). In the UK, Pearson *et al.* (2002) found that the English population was dominated (61% of individuals) by a single genotype (RAPD (random amplified polymorphic DNA) haplotype). DNA fingerprinting and mitochondrial DNA (mtDNA) studies of populations from the Atlantic and Pacific coasts of the USA and the UK (Darling *et al.*, 2004, 2009; Reitzel *et al.*, 2008) revealed higher genetic diversity on the Atlantic coasts of the USA than of the Pacific coast or in England, and concluded that populations on both the Pacific and English coasts were introduced from the Atlantic coasts, most probably by human activity. The English population probably originated in southeastern USA (Reitzel *et al.*, 2008), possibly by a single individual, or few individuals and subsequent bottlenecks (Pearson *et al.*, 2002; Darling *et al.*, 2004). Genetic differentiation was extremely high. In rare cases, individuals were significantly genetically distinct from members of the same population, or any other population (Reitzel *et al.*, 2008). Similarly, significant genetic differentiation was observed between subpopulations separated by <100 m at a

single site, e.g. in Sippewissett Marsh (Darling *et al.*, 2004). Reitzel *et al.* (2008) also noted that males may exist at low numbers in populations previously thought to be all female.

## Sensitivity review

### Resilience and recovery rates

*Nematostella vectensis* is a very small sea anemone that lives in the surface of muddy sediments in very sheltered conditions. It is able to reproduce both sexually and asexually. It grows rapidly in the laboratory and has a short generation time (2-3 months), although sexual reproduction in the wild is probably less frequent, probably annual, and does not occur in all populations (Hand & Uhlinger, 1992, 1994, 1995; Darling *et al.*, 2005). Asexual reproduction allows this species to generate clones that can rapidly colonize a suitable habitat. The rapid seasonal increases in abundance reported in UK lagoons are probably due to rapid asexual proliferation in response to food availability (Sheader *et al.*, 1997). But while it can occur in huge numbers its normal abundance is probably low (Hand & Uhlinger, 1994; Sheader *et al.*, 1997; Reitzel *et al.*, 2008). Sexual reproduction, coupled with asexual proliferation provides this species with the ability to develop genetic clonal lines that are highly adapted to the local conditions (Darling *et al.*, 2004, 2009; Reitzel *et al.*, 2008). Local adaptation with varied levels of asexual reproduction and founder effects (bottlenecks due to die back in populations) partly explain the high levels of genetic differentiation seen between populations. However, numerous studies (Sheader *et al.*, 1997; Person *et al.*, 2002; Darling *et al.*, 2004, 2009; Reitzel *et al.*, 2008) concluded that the extraordinarily high levels of genetic differentiation was explained by low gene flow due to poor dispersal and/or bottlenecks and sporadic, discontinuous dispersal by random events and anthropogenic transport.

Effective dispersal is probably extremely poor. Darling *et al.* (2004) noted high levels of genetic differentiation between isolated pools separated by less than 100 m. Although the planulae are able to swim, in the laboratory, they spend most of their time stationary unless disturbed (Hand & Uhlinger, 1992; Reitzel *et al.*, 2007, 2008). Stocks & Grassle (2001) recorded that very few *Nematostella vectensis* colonized experimental salt marsh pond mesocosms in their 60-day study, even though it was found in the surrounding sediment. Thomas & Thorp (1994) also noted that *Nematostella vectensis* was lost from the Emsworth millpond complex (a brackish lagoon is south-east England) in 1987, probably due the poor summer of 1985 and extreme winter of 1985/86, and had not returned by 1991.

Adults bear sticky rugae and sticky tentacles (Williams, 1975; Hand & Uhlinger, 1994) so may be dispersed passively. It is also eurythermal, euryhaline, and capable of surviving long periods of starvation, for example, Williams (1976) starved adults for 80 days without ill effects, and Hand & Uhlinger (1994) reported that individuals survived 6 months without food, although they became smaller. In UK lagoons, a small percentage of the population was recorded from vegetation (Sheader *et al.*, 1997) so that it is possible that they could raft on floating vegetation or debris. However, Darling *et al.* (2004, 2009) concluded that anthropogenic transport was most likely, rather than rafting (i.e. on floating debris or macrophytes), because rafting in other species resulted in lower levels of genetic differentiation than observed in this species and did not explain the high levels of genetic differences (lack of shared genotypes) between neighbouring locations in the USA. Darling *et al.* (2004, 2009) and Reitzel *et al.* (2008) concluded that dispersal was an episodic and idiosyncratic process probably via the transport of gear and as fouling communities on watercraft, rather than ballast water. Sheader *et al.* (1997) suggested that it may have been introduced to England by accidental transfer with imported North American shellfish (e.g. *Crassostrea* spp. and *Mercenaria mercenaria*) into the area of the Solent in the 20th century.

**Resilience assessment.** *Nematostella vectensis* can reproduce asexually and sexually, depending on

location and, where present, can reach high densities seasonally, probably due to asexual reproduction. Therefore, where an existing population suffered some mortality (i.e. Medium resistance) it could probably recover within the next season (several months). Similarly, if an existing population experienced significant mortality (i.e. Low resistance) then the survivors could repopulate within two years. For example, Pearson *et al.* (2002) and Reitzel *et al.* (2008) suggested that the introduction of *Nematostella vectensis* could have been due to a single individual, or few individuals followed by subsequent bottlenecks. Hence, as long as members of the population survive, resilience is probably 'High'. However, if a population is removed or lost (i.e. resistance is 'None') then recolonization would depend on either human transportation (or intervention) or random, unpredictable, events and take anywhere from a few years to never. In this instance, a resilience of 'Very low' (negligible or prolonged recovery) is recorded.

## Hydrological Pressures

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

*Nematostella vectensis* is very tolerant to temperature change. It has been recorded at temperatures ranging from -1 to 28°C (Williams, 1983, 1991). *Nematostella vectensis* was also recorded in pools in Nova Scotia at -1.5°C and 28°C where the low temperature coincided with the pool thickly covered with ice, and in Georgia (USA) in pools at 32.5°C (Hand & Uhinger, 1994). The species has reportedly survived freezing at -5 °C for 48 hours (M. Sheader, pers. comm.).

Temperatures above 28°C were found to adversely affect the animals in the laboratory (Fritzenwanker & Technau, 2002), although no further information was given. Reitzel *et al.* (2013) noted that *Nematostella vectensis* occupied habitats that experienced large daily (> 20°C) and seasonal (>25°C) fluctuations in temperature. For example, the high marsh pools occupied by this species in Great Sippewisset Marsh, Massachusetts, varied in temperature from 1.3°C at the end of October to 43.7°C in mid-July. Reitzel *et al.* (2013) concluded that, while eurythermal, *Nematostella vectensis* occupied sites (on the western Atlantic coast of the USA) close to their physiological limit. Specimens survived at experimental temperatures up to 39°C but almost all life stages died at 41°C (measured at exposures of 0.5 to 6 hr). Embryos and larval stages exhibited the same response but were significantly lower than juveniles by 1°C. In the field, four high temperature events exceeded the LT50 for developmental stages one site in July. Temperature also had a significant effect on growth and regeneration rates at 29°C (but not at 13°C or 21°C). Clones from the north regenerated slower than clones from the south at 29°C, which indicated a level of latitudinal adaptation to temperature (Reitzel *et al.* 2013). Reitzel *et al.* (2013) suggested that climate change might threaten southern USA populations.

**Sensitivity assessment.** *Nematostella vectensis* is a eurythermal species adapted to extreme fluctuations in temperature. Therefore, a short-term change in temperatures of 5°C or a change in 2°C for a year is unlikely to adversely affect populations of this species in UK waters. Therefore, a resistance of 'High' is suggested so that resilience is also 'High' and the species is assessed as 'Not sensitive' at the benchmark level.

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

*Nematostella vectensis* is very tolerant to temperature change. It has been recorded at temperatures ranging from -1 to 28°C (Williams, 1983, 1991). *Nematostella vectensis* was also recorded in pools in Nova Scotia at -1.5°C and 28°C where the low temperature coincided with the pool thickly covered with ice, and in Georgia (USA) in pools at 32.5°C (Hand & Uhinger, 1994). The species has reportedly survived freezing at -5°C for 48 hours (M. Sheader, pers. comm.).

Temperatures above 28°C were found to adversely affect the animals in the laboratory (Fritzenwanker & Technau, 2002), although no further information was given. Reitzel *et al.* (2013) noted that *Nematostella vectensis* occupied habitats that experienced large daily (> 20°C) and seasonal (>25°C) fluctuations in temperature. For example, the high marsh pools occupied by this species in Great Sippewisset Marsh, Massachusetts, varied in temperature from 1.3°C at the end of October to 43.7°C in mid-July. Reitzel *et al.* (2013) concluded that, while eurythermal, *Nematostella vectensis* occupied sites (on the western Atlantic coast of the USA) close to their physiological limit. Specimens survived at experimental temperatures up to 39°C but almost all life stages died at 41°C (measured at exposures of 0.5 to 6 hr). Embryos and larval stages exhibited the same response but were significantly lower than juveniles by 1°C. In the field, four high temperature events exceeded the LT50 for developmental stages one site in July. Temperature also had a significant effect on growth and regeneration rates at 29°C (but not at 13°C or 21°C). Clones from the north regenerated slower than clones from the south at 29°C, which indicated a level of latitudinal adaptation to temperature (Reitzel *et al.* 2013). Reitzel *et al.* (2013) suggested that climate change might threaten southern USA populations.

**Sensitivity assessment.** *Nematostella vectensis* is a eurythermal species adapted to extreme fluctuations in temperature. Therefore, a short-term change in temperatures of 5°C or a change in 2°C for a year is unlikely to adversely affect populations of this species in UK waters. Therefore, a resistance of 'High' is suggested so that resilience is also 'High' and the species is assessed as 'Not sensitive' at the benchmark level.

#### Salinity increase (local)

Medium

Q: High A: Medium C: Medium

High

Q: High A: Medium C: Medium

Low

Q: High A: Medium C: Medium

*Nematostella vectensis* is a euryhaline species and, in England, has been recorded from 8.96 to 51.54 ppt (Williams, 1991), although the greatest abundances have been found in ponds varying seasonally between 16-36 ppt (Sheader *et al.*, 1997). In laboratory cultures from American specimens, salinity had a pronounced effect on both reproduction and the health of the animal itself (Hand & Uhlinger, 1992). For example, up to 20% of anemones in 10 and 20‰ (ca 3.5 and 7 ppt) seawater were deflated and had their mesenteries everted through their mouths within 5 weeks. At the other extreme, anemones in 125‰ (ca 43.7 ppt) seawater had decreased in size after 4 months and only spawned once, although asexual reproduction was not markedly less effective than at 33‰ (ca 11.5 ppt) seawater. Overall, the American studies found that asexual division was recorded, albeit at varying levels of success, at salinities between 7-42‰ and sexual reproduction between 12-34‰ (Hand & Uhlinger, 1992). Hand & Uhlinger (1994) noted that *Nematostella vectensis* was never found where salinities were permanently high (i.e. fully marine) and suggested that their restriction to estuaries (and by implication other variable salinity habitats) was due to predation by marine species, e.g. shrimp and nudibranchs.

Salinity varies depending on the geographical location of each population. At Keyhaven-Pennington in Hampshire, for example, salinity varies from 2-25 ppt whereas, at the Fleet in Dorset, salinity varies between 18-32 ppt. Field observations indicate that above 40 ppt, tentacles are retracted and feeding ceases (Sheader *et al.*, 1997). In the laboratory, Sheader *et al.* (1997)

noted that feeding ceased (i.e. tentacles were withdrawn) at 10-12 ppt (at 15°C). Sheader *et al.* (1997) suggested that low and high salinity interfered with feeding and hence long-term fitness, which explained their higher abundance between 16-36 ppt. Sheader *et al.* (1997) also noted that, while the salinity of brackish pools and lagoons in the UK vary, salinity was generally higher in summer and lower in winter.

**Sensitivity assessment.** *Nematostella vectensis* is a euryhaline species recorded from low, reduced and variable salinity habitats. An increase in salinity (>40 psu) is likely to reduce feeding, although this species can survive starvation for up to 6 months (Hand & Uhlinger, 1994; Sheader, *et al.*, 1997). Nevertheless, is most abundant in the UK lagoons and pools between 16-36 ppt (Sheader, *et al.*, 1997). Therefore, it may be reduced in abundance by hypersaline conditions and resistance is recorded as 'Medium'. Resilience is probably 'High' so that sensitivity is assessed as 'Low'.

### Salinity decrease (local)

**Low**

Q: High A: Medium C: Medium

**High**

Q: High A: Medium C: Medium

**Low**

Q: High A: Medium C: Medium

*Nematostella vectensis* is a euryhaline species and, in England, has been recorded from 8.96 to 51.54 ppt (Williams, 1991), although the greatest abundances have been found in ponds varying seasonally between 16-36 ppt (Sheader *et al.*, 1997). In laboratory cultures from American specimens, salinity had a pronounced effect on both reproduction and the health of the animal itself (Hand & Uhlinger, 1992). For example, up to 20% of anemones in 10 and 20% (ca 3.5 and 7 ppt) seawater were deflated and had their mesenteries everted through their mouths within 5 weeks. At the other extreme, anemones in 125% (ca 43.7 ppt) seawater had decreased in size after 4 months and only spawned once, although asexual reproduction was not markedly less effective than at 33% (ca 11.5 ppt) seawater. Overall, the American studies found that asexual division was recorded, albeit at varying levels of success, at salinities between 7 and 42‰ and sexual reproduction between 12-34 ‰ (Hand & Uhlinger, 1992). Hand & Uhlinger (1994) noted that *Nematostella vectensis* was never found where salinities were permanently high (i.e. fully marine) and suggested that their restriction to estuaries (and by implication other variable salinity habitats) was due to predation by marine species, e.g. shrimp and nudibranchs.

Salinity varies depending on the geographical location of each population. At Keyhaven-Pennington in Hampshire, for example, salinity varies from 2-25 ppt whereas, at the Fleet in Dorset, salinity varies between 18-32 ppt. Field observations indicate that above 40 ppt, tentacles are retracted and feeding ceases (Sheader *et al.*, 1997). In the laboratory, Sheader *et al.* (1997) noted that feeding ceased (i.e. tentacles were withdrawn) at 10-12 ppt (at 15°C). Sheader *et al.* (1997) suggested that low and high salinity interfered with feeding and hence long-term fitness, which explained their higher abundance between 16-36 ppt. Sheader *et al.* (1997) also noted that, while the salinity of brackish pools and lagoons in the UK vary, salinity was generally higher in summer and lower in winter.

**Sensitivity assessment.** *Nematostella vectensis* is a euryhaline species recorded from low (< 18 psu), reduced (18-30 psu) and variable (18-40 psu) salinity habitats. It is adapted to habitats with fluctuating salinities and may be excluded from areas that experience stable and full salinity conditions, i.e. fully marine conditions. Therefore, a reduction in salinity from variable to reduced or from reduced to low is unlikely to have an effect on the population. However, populations that occur in low salinity will be more sensitive, as a reduction in salinity from low to freshwater for a year may result in loss of the population. Therefore, a resistance of 'Low' is suggested. Resilience is probably 'High' and sensitivity is assessed as 'Low'.

**Water flow (tidal current) changes (local)****None**

Q: High A: High C: Medium

**Very Low**

Q: High A: Medium C: Medium

**High**

Q: High A: Medium C: Medium

All English populations of *Nematostella vectensis* are found in brackish and saline lagoons and ponds at or above high water (Sheader *et al.*, 1997). It has a wider distribution in North America where it is recorded from permanent brackish/saline ponds, salt marsh creeks and subtidally in certain estuaries (Hand & Uhlinger, 1994; Sheader *et al.*, 1997). In the English sites, the saline lagoons are usually shallow (less than 1 m deep), in fine sand and muds with a mixture or overlay of shingle, with a high organic content, and very low near-bottom water flow rates. Extreme shelter is needed as it allows a layer of fine mud to build up, in which the animal burrows (Williams, 1983). *Nematostella vectensis* populations remain submerged at all times (Sheader *et al.*, 1997). *Nematostella vectensis* is usually found in water less than 1 m deep, although a few live down to 2 m water depth (M. Sheader, pers. comm.).

Sheader *et al.* (1997) examined the effect of water flow on the abundance of *Nematostella vectensis* at five sites of the south coast of England. They noted that it could be abundant below 0.1 cm/s (0.01 m/s) but was absent above ca 0.18 cm/s (0.018 m/s). The rates were measured during the maximum flood on spring tides at a height of 2 cm above the sediment surface, so probably represent the upper limit of the range of water flow at those sites. Sheader *et al.* (1997) noted that water flow was dependent on tidal exchange, riverine input and wind driven currents.

**Sensitivity assessment.** The lagoonal habitat is dependent on very low to negligible water flow. An increase in water flow of 0.1-0.2 m/s (the benchmark) for a year is a significant (order of magnitude) change and likely to result in the removal of the surface of the sediment, the population of *Nematostella vectensis*, the removal or reworking of the lagoonal pool habitat. Therefore, a resistance of 'None' is suggested. Resilience is probably 'Very low' so that sensitivity is assessed as 'High'.

**Emergence regime changes****None**

Q: High A: Medium C: Medium

**Very Low**

Q: High A: Medium C: Medium

**High**

Q: High A: Medium C: Medium

All English populations of *Nematostella vectensis* are found in brackish and saline lagoons and ponds at or above high water (Sheader *et al.*, 1997). It has a wider distribution in North America where it is recorded from permanent brackish/saline ponds, salt marsh creeks and subtidally in certain estuaries (Hand & Uhlinger, 1994; Sheader *et al.*, 1997). In the English sites, the saline lagoons are usually shallow (less than 1 m deep), in fine sand and muds with a mixture or overlay of shingle, with a high organic content, and very low near-bottom water flow rates. *Nematostella vectensis* populations remain submerged at all times (Sheader *et al.*, 1997). *Nematostella vectensis* is usually found in water less than 1 m deep, although a few live down to 2 m water depth (M. Sheader, pers. comm.).

Williams (1991) suggested that desiccation was likely to be a limiting factor in the distribution of this species. In the laboratory, Williams (1976) found that the animals had contracted their tentacles after eight hours without water and after 31 hours, had withdrawn into their burrow. After 4 days without water, 70% of the animals were still alive but trapped in the dried sediment and by 6 days, none had survived (Williams, 1976). Therefore, the drying up of the pools or lagoons in which the species live is likely to destroy the population.

**Sensitivity assessment.** *Nematostella vectensis* is found in shallow lagoons pools, where it is permanently submerged. Changes in emergence that result in the lowering of the water table and

increase the risk of drying out of the pools will probably result in loss of the population. Therefore, a resistance of '**None**' is recorded and, as resilience is probably '**Very low**', sensitivity is assessed as '**High**'.

<b>Wave exposure changes (local)</b>	<b>None</b> Q: Medium A: Medium C: Medium	<b>Very Low</b> Q: High A: Medium C: Medium	<b>High</b> Q: Medium A: Medium C: Medium
--------------------------------------	--	--	--

All English populations of *Nematostella vectensis* are found in brackish and saline lagoons and ponds at or above high water (Sheader *et al.*, 1997). It has a wider distribution in North America where it is recorded from permanent brackish/saline ponds, salt marsh creeks and subtidally in certain estuaries (Hand & Uhlinger, 1994; Sheader *et al.*, 1997). In the English sites, the saline lagoons are usually shallow (less than 1 m deep), in fine sand and muds with a mixture or overlay of shingle, with a high organic content, and very low near-bottom water flow rates. Extreme shelter is needed as it allows a layer of fine mud to build up, in which the animal burrows (Williams, 1983) and wave action is probably a limiting factor in the distribution of the species (Williams, 1991). *Nematostella vectensis* populations remain submerged at all times (Sheader *et al.*, 1997). *Nematostella vectensis* is usually found in water less than 1 m deep, although a few live down to 2 m water depth (M. Sheader, pers. comm.).

**Sensitivity assessment.** Sheader *et al.* (1997) noted that wind-driven currents were one source of water flow in lagoons but that their magnitude depended on local topography, shelter by terrestrial vegetation and submerged macrophytes. Increased storminess may result in increased wind-driven wave generation and storm-driven waves may also damage the lagoons seaward extent or breach retaining structures (e.g. spit or wall). Nevertheless *Nematostella vectensis* is abundant in extremely wave sheltered habitats with very low near bottom water flow rates. Therefore, an increase in wave action as low as the benchmark (3-5% of significant wave height) is probably enough to remove the population of this species, rework the sediment and destroy the pools in which it lives. Hence a resistance of '**None**' is recorded. Resilience is probably '**Very low**' so that sensitivity is assessed as '**High**'.

## Chemical Pressures

	Resistance	Resilience	Sensitivity
<b>Transition elements &amp; organo-metal contamination</b>	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**.

<b>Hydrocarbon &amp; PAH contamination</b>	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**.

<b>Synthetic compound contamination</b>	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**.

<b>Radionuclide contamination</b>	No evidence (NEv)	Not relevant (NR)	No evidence (NEv)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

No evidence was found.

<b>Introduction of other substances</b>	Not Assessed (NA)	Not assessed (NA)	Not assessed (NA)
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

This pressure is **Not assessed**.

<b>De-oxygenation</b>	Medium	High	Low
	Q: Low A: NR C: NR	Q: High A: Medium C: Medium	Q: Low A: Low C: Low

Fluctuation in oxygen levels in shallow lagoonal pools is normal. however, lagoon environments frequently have a high macroalgal production which can result in anoxic conditions on the sediment - water interface. Sheader *et al.* (1997) noted that the sediment and near-bottom water of pools occupied by *Nematostella vectensis* may occasionally become anoxic but that the oxygen concentration in the water column was usually high. This species, along with several other lagoon species, can move up onto the algal mats to avoid the anoxic conditions. Maas *et al.* (2016) examined respiration and circadian rhythms in *Nematostella vectensis*. They noted that respiration rates were highest in the light part of the light: dark or dark: light cycles in the laboratory. They reported that *Nematostella vectensis* maintained a constant respiration rate down to 25% oxygen saturation (2.5 mg/l). Williams (1991) suggested that extreme hypoxia is likely to be a limiting factor in the distribution of this species. Furthermore, anemones recovered from anoxic mud in the field were 'very sick' (Williams, 1976).

**Sensitivity assessment.** *Nematostella vectensis* is probably adapted to fluctuating oxygen levels and experiences periods of anoxia in the organic-rich sediment. It is unclear at what level of hypoxia mortality, if any, may occur, although anoxia may be detrimental. Therefore, a precautionary resistance of '**Medium**' is recorded but with 'Low' confidence. As resilience is probably '**High**' a sensitivity of '**Low**' is recorded.

<b>Nutrient enrichment</b>	High	High	Not sensitive
	Q: Low A: NR C: NR	Q: High A: High C: High	Q: Low A: Low C: Low

Nutrient enrichment may result in increased macrophyte growth and, hence, increase food for this species, or may result in algal mats that smother the benthos, and algal blooms, that on death result in increased hypoxia and anoxia, to the detriment of the species. However, no evidence on the direct effect on this species was found. Nevertheless, this species is probably '**Not sensitive**' at the benchmark level (resistance and resilience are '**High**') set at compliance with Water Framework Directive (WFD) criteria for good status, based on nitrogen concentration (UKTAG, 2014).

<b>Organic enrichment</b>	Medium	High	Low
	Q: Low A: NR C: NR	Q: High A: Medium C: Medium	Q: Low A: Low C: Low

*Nematostella vectensis* occurs in organic-rich muddy sediments in saline or brackish pools (Sheader *et al.*, 1997). Further organic enrichment may increase the frequency and extent of anoxic events but no direct evidence about this species was found. *Nematostella vectensis* is probably adapted to fluctuating oxygen levels and experiences periods of anoxia in the organic-rich sediment. It is

unclear at what level of hypoxia mortality, if any, may occur, although anoxia may be detrimental. Therefore, a precautionary resistance of '**Medium**' is recorded but with 'Low' confidence. As resilience is probably '**High**' a sensitivity of '**Low**' is recorded.

## A Physical Pressures

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

A change from sediment to hard rock substratum would result in loss of the habitat for this species. Therefore, resistance is assessed as '**None**'. The change is defined as permanent so that resilience is assessed as '**Very low**' and sensitivity is assessed as '**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 sediment type)	<b>None</b> Q: High A: High C: High	<b>Very Low</b> Q: High A: High C: High	<b>High</b> Q: High A: High C: High

*Nematostella vectensis* is recorded from muddy sediments (mud, muddy sand and muddy gravel). A change in sediment type, e.g. to clean sands and gravels) would result in loss of its habitat. Therefore, resistance is assessed as '**None**'. The change is defined as permanent so that resilience is assessed as '**Very low**' and sensitivity is assessed as '**High**'.

	Resistance	Resilience	Sensitivity
Habitat structure changes - removal of substratum (extraction)	<b>None</b> Q: Low A: NR C: NR	<b>Very Low</b> Q: High A: Medium C: Medium	<b>High</b> Q: Low A: Low C: Low

*Nematostella vectensis* is a small burrowing anemone that lives in the surface of the sediment. Removal of the sediment to a depth of 30 cm (the benchmark) would remove the entire population of this species within the affected area. Therefore, a resistance of '**None**' is recorded. This species has very poor active dispersal capability and its ability to recolonize an area is dependent on unpredictable events (storms, human transport etc), and lagoonal habitats are often isolated. Hence, resilience is likely to be '**Very low**' and sensitivity is assessed as '**High**'.

	Resistance	Resilience	Sensitivity
Abrasion/disturbance of the surface of the substratum or seabed	<b>Medium</b> Q: Low A: NR C: NR	<b>High</b> Q: High A: Medium C: Medium	<b>Low</b> Q: Low A: Low C: Low

*Nematostella vectensis* is a small (1-2 cm in length) burrowing anemone that lives in the surface of

the sediment. When disturbed, the anemone shrinks down to a small white mass seldom more than a few millimetres in length (Hand & Uhlinger, 1994). Therefore, disturbance of the sediment surface (e.g. by trampling or vehicle access, or fishing gear) has the potential to kill a proportion of this soft-bodied species, depending on the extent, frequency and duration of the impact. Therefore, a resistance of '**Medium**' is suggested. As a proportion of the population will probably survive, and its preferred habitat remains, resilience is probably '**High**' and sensitivity is assessed as '**Low**'.

**Penetration or disturbance of the substratum subsurface**

**Medium**

Q: **Low** A: **NR** C: **NR**

**High**

Q: **High** A: **Medium** C: **Medium**

**Low**

Q: **Low** A: **Low** C: **Low**

*Nematostella vectensis* is a small (1-2 cm in length) burrowing anemone that lives in the surface of the sediment. When disturbed, the anemone shrinks down to a small white mass seldom more than a few millimetres in length (Hand & Uhlinger, 1994). Therefore physical disturbance that penetrates the surface of the sediment (e.g. fishing gear, tractor towed rakes or dredges) has the potential to kill a proportion of this soft-bodied species, depending on the extent, frequency and duration of the impact. Therefore, a resistance of '**Medium**' is suggested. As a proportion of the population will probably survive, and its preferred habitat remains, resilience is probably '**High**' and sensitivity is assessed as '**Low**'.

**Changes in suspended solids (water clarity)**

**Medium**

Q: **Low** A: **NR** C: **NR**

**High**

Q: **High** A: **Medium** C: **Medium**

**Low**

Q: **Low** A: **Low** C: **Low**

*Nematostella vectensis* lives in the surface of muddy sediments. It is probably adapted to the localised resuspension of sediment by the tide and occurs in depositional habitats with very low near bottom flow rates. As a predator it is not dependent on light, however, Sheader *et al.* (1997) noted suggested that its seasonal abundance was linked with the growth of macroalgae and, hence, the grazers which form part of its food chain. Increases in suspended sediment may affect its food supply, although it can survive for months without food (Hand & Uhlinger, 1992, 1994). Therefore, a precautionary resistance of '**Medium**' is suggested, although resilience is probably '**High**' and sensitivity is '**Low**'.

**Smothering and siltation rate changes (light)**

**Low**

Q: **Low** A: **NR** C: **NR**

**High**

Q: **High** A: **Medium** C: **Medium**

**Low**

Q: **Low** A: **Low** C: **Low**

*Nematostella vectensis* lives in the surface of muddy sediments. It is probably adapted to the localised resuspension of sediment by the tide and occurs in depositional habitats with very low near bottom flow rates. It probably routinely readjusts its position in the sediment as sediment is moved and deposited at each tidal cycle. However, the sudden deposition of 5 cm of sediment (the benchmark) will smother the population, and the sediment will remain in the isolated, wave sheltered habitats occupied by this species. No information on its ability to burrow was found. Therefore, smothering has the potential to remove a significant proportion of the population (especially smaller juveniles) and a resistance of '**Low**' is suggested but with '**Low**' confidence. Resilience is probably '**High**' and sensitivity is assessed as '**Low**'.

**Smothering and siltation rate changes (heavy)**

**Low**

Q: **Low** A: **NR** C: **NR**

**High**

Q: **High** A: **Medium** C: **Medium**

**Low**

Q: **Low** A: **Low** C: **Low**

*Nematostella vectensis* lives in the surface of muddy sediments. It is probably adapted to the localised resuspension of sediment by the tide and occurs in depositional habitats with very low near bottom flow rates. It probably routinely readjusts its position in the sediment as sediment is moved and deposited at each tidal cycle. However, the sudden deposition of 30 cm of sediment (the benchmark) will smother the population, and the sediment will remain in the isolated, wave sheltered habitats occupied by this species. No information on its ability to burrow was found. Therefore, smothering has the potential to remove a significant proportion of the population (especially smaller juveniles) and a resistance of 'Low' is suggested but with 'Low' confidence. Resilience is probably 'High' and sensitivity is assessed as 'Low'.

<b>Litter</b>	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

<b>Electromagnetic changes</b>	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 was found.

<b>Underwater noise changes</b>	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.** *Nematostella vectensis* probably reacts to localised vibration but is unlikely to react to the noise from passing vessels etc.

<b>Introduction of light or shading</b>	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low
---	----------------------------	---------------------------------	---------------------------------------

As a passive predator, *Nematostella vectensis* is not dependent on light, however, Sheader *et al.* (1997) noted suggested that its seasonal abundance was linked with the growth of macroalgae and, hence, the grazers which form part of its food chain. Shading may the growth of some macroalgae and influence its food supply, however, it can survive for months without food (Hand & Uhlinger, 1992, 1994). Therefore, a resistance of 'High' is suggested. As resilience is 'High', 'Not sensitive' is recorded.

<b>Barrier to species movement</b>	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
------------------------------------	--	--	--

*Nematostella vectensis* has very poor dispersal capability and occupies isolated habitats. It is thought that its dispersal is due to unpredicted events and human transportation, especially on the Pacific coasts of the USA and in the UK (Pearson *et al.*, 2002; Darling *et al.*, 2004, 2009; Reitzel *et al.*, 2008). The addition of physical barriers to dispersal is unlikely to change its already high level of isolation. However, the dispersal of larval stages or propagules is not considered under the pressure definition and benchmark.

<b>Death or injury by collision</b>	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 interaction with bottom towed fishing gears and

moorings are addressed under 'surface abrasion'.

<b>Visual disturbance</b>	<b>Not relevant (NR)</b>	<b>Not relevant (NR)</b>	<b>Not relevant (NR)</b>
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

**Not relevant.** *Nematostella vectensis* probably reacts to localised shading but is unlikely to react to the visual disturbance from passing vessels etc.

## Biological Pressures

	<b>Resistance</b>	<b>Resilience</b>	<b>Sensitivity</b>
<b>Genetic modification &amp; translocation of indigenous species</b>	<b>No evidence (NEv)</b>	<b>Not relevant (NR)</b>	<b>No evidence (NEv)</b>
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

Hand & Uhlinger (1994) noted that viable offspring could be obtained from crosses of specimens of *Nematostella vectensis* from the UK and USA. *Nematostella vectensis* is thought to have been introduced (translocated) from the southeastern Atlantic coast of the USA. But no evidence of translocation, breeding or hybridization with other species was found.

<b>Introduction or spread of invasive non-indigenous species</b>	<b>No evidence (NEv)</b>	<b>Not relevant (NR)</b>	<b>No evidence (NEv)</b>
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

No evidence of the interaction of *Nematostella vectensis* with other non-native or native species was found.

<b>Introduction of microbial pathogens</b>	<b>No evidence (NEv)</b>	<b>Not relevant (NR)</b>	<b>No evidence (NEv)</b>
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

No evidence was found.

<b>Removal of target species</b>	<b>Not relevant (NR)</b>	<b>Not relevant (NR)</b>	<b>Not relevant (NR)</b>
	Q: NR A: NR C: NR	Q: NR A: NR C: NR	Q: NR A: NR C: NR

*Nematostella vectensis* has been collected from the wild by scientists in areas where it is readily abundant (see Layden *et al.*, 2016). However, it is readily cultured in the laboratory for experiments in developmental genetics and genomics. It is not known to be targeted commercially. Therefore, this pressure (as defined by the benchmark) is '**Not relevant**'.

<b>Removal of non-target species</b>	<b>Medium</b>	<b>High</b>	<b>Low</b>
	Q: Low A: NR C: NR	Q: High A: Medium C: Medium	Q: Low A: Low C: Low

Incidental removal of the *Nematostella vectensis* (e.g. from harvesting of other species) could result in loss of a proportion of the population, depending on the nature of the activity. however, the species is very small, so a proportion of the population is likely to remain. Therefore, a resistance of '**Medium**' is suggested. Resilience is probably '**High**' so sensitivity is assessed as '**Low**'. It should also be noted that *Nematostella vectensis* can stick to macrophytes and other substate so that the removal and subsequent transport of sediment, other species, or equipment used in the process

may introduce *Nematostella vectensis* into new areas.

## Importance review

### Policy/legislation

Wildlife & Countryside Act	Schedule 5, section 9
UK Biodiversity Action Plan Priority	<input checked="" type="checkbox"/>
Species of principal importance (England)	<input checked="" type="checkbox"/>
IUCN Red List	Vulnerable (VU)
Features of Conservation Importance (England & Wales)	<input checked="" type="checkbox"/>

### ★ Status

<b>National (GB) importance</b>	Not rare/scarce	<b>Global red list (IUCN) category</b>	Vulnerable (VU)
---------------------------------	-----------------	--	-----------------

### Non-native

<b>Native</b>	Non-native		
<b>Origin</b>	Southeastern U.S.A.	<b>Date Arrived</b>	1930s

### Importance information

In England, *Nematostella vectensis* is under threat because it is recorded from only a few restricted areas and these areas are especially vulnerable (Williams, 1991). If a salt marsh became polluted or dried up, for example, the entire population of *Nematostella vectensis* could be lost together with the the habitat. At Gilkicker Point in Hampshire, several lagoons have already been infilled (Williams, R.B., 1976). Current threats to this species include:

- loss and damage to lagoons and other sheltered brackish water habitats caused by factors including pollution, drainage and other activities.
- isolation of pools leading to fragmentation of populations;
- coastal defence works and associated infilling (Anonymous, 1999k); and
- coastal squeeze due to sea-level rise.

Williams (1983) stated that it had been proposed to transfer individuals to unbounded open marshes free from human influence so that the population could spread naturally. However, experimental tranlocation studies in the Cley marsh lagoons, Norfolk proved to be inconclusive due to the difficulty of establishing a control site within the study area (Fincham, 2016a&b).

## Bibliography

- Anonymous, 1999k. Starlet sea anemone (*Nematostella vectensis*). Species Action Plan In *UK Biodiversity Group. Tranche 2 Action Plans. English Nature for the UK Biodiversity Group, Peterborough., English Nature for the UK Biodiversity Group, Peterborough.*
- Carlgren, O., 1949. A survey of the Ptychodactiaria, Corallimorpharia and Actiniaria. *Kungliga Svenska Vetenskapsakademiens Handlingar, Series 4*, **1**, 16-110.
- Darling, J.A., Kuenzi, A. & Reitzel, A.M., 2009. Human-mediated transport determines the non-native distribution of the anemone *Nematostella vectensis*, a dispersal-limited estuarine invertebrate. *Marine Ecology Progress Series*, **380**, 137-146.
- Darling, J.A., Reitzel, A.M. & Finnerty, J.R., 2004. Regional population structure of a widely introduced estuarine invertebrate: *Nematostella vectensis* Stephenson in New England. *Molecular Ecology*, **13** (10), 2969-2981.
- Darling, J.A., Reitzel, A.R., Burton, P.M., Mazza, M.E., Ryan, J.F., Sullivan, J.C. & Finnerty, J.R., 2005. Rising starlet: the starlet sea anemone, *Nematostella vectensis*. *BioEssays*, **27** (2), 211-221.
- Fincham, J., 2016a. Norfolk's starlet anemone: a brief population update. In *Biodiversity News*, **73**, 28-30. Peterborough: Defra.
- Fincham, J., 2016b. Starlet sea anemone: Suffolk. In *White Admiral*, **94**, 29-31. Ipswich: Suffolk Naturalists Society.
- Frank, P.G. & Bleakney, J.S., 1978. Asexual reproduction, diet, and anomalies of the anemone *Nematostella vectensis* in Nova Scotia. *The Canadian Field-Naturalist*, **92**, 259-263.
- Fritzenwanker, J.H. & Technau, U., 2002. Induction of gametogenesis in the basal cnidarian *Nematostella vectensis* (Anthozoa). *Development Genes and Evolution*, **212**, 99-103.
- Hand, C. & Uhlinger, K.R., 1992. The culture, sexual and asexual reproduction, and growth of the sea anemone, *Nematostella vectensis*. *Biological Bulletin, Marine Biological Laboratory, Woods Hole*, **182**, 169-176.
- Hand, C. & Uhlinger, K.R., 1994. The unique, widely distributed, estuarine sea anemone, *Nematostella vectensis*, Stephenson: A review, new facts and questions. *Estuaries*, **17**, 501-508.
- Hand, C. & Uhlinger, K.R., 1995. Asexual reproduction by transverse fission and some anomalies in the sea anemone *Nematostella vectensis*. *Invertebrate Biology*, **114**, 9-18.
- Howson, C.M. & Picton, B.E., 1997. *The species directory of the marine fauna and flora of the British Isles and surrounding seas*. Belfast: Ulster Museum. [Ulster Museum publication, no. 276.]
- Layden, M.J., Rentzsch, F. & Röttinger, E., 2016. The rise of the starlet sea anemone *Nematostella vectensis* as a model system to investigate development and regeneration. *Wiley Interdisciplinary Reviews: Developmental Biology*, **5** (4), 408-428.
- Manuel, R.L., 1988. *British Anthozoa*. London: Academic Press.[Synopses of the British Fauna, no. 18.]
- Pearson, C.V.M., Rogers, A.D. & Sheader, M., 2002. The genetic structure of the rare lagoonal sea anemone, *Nematostella vectensis* Stephenson (Cnidaria; Anthozoa) in the United Kingdom based on RAPD analysis. *Molecular Ecology*, **11** (11), 2285-2293.
- Posey, M.H. & Hines, A.H., 1991. Complex predator-prey interactions within an estuarine benthic community. *Ecology*, **72**, 2155-2169.
- Reitzel, A.M., Burton, P.M., Krone, C. & Finnerty, J.R., 2007. Comparison of developmental trajectories in the starlet sea anemone *Nematostella vectensis*: embryogenesis, regeneration, and two forms of asexual fission. *Invertebrate Biology*, **126** (2), 99-112.
- Reitzel, A.M., Chu, T., Edquist, S., Genovese, C., Church, C., Tarrant, A.M. & Finnerty, J.R., 2013. Physiological and developmental responses to temperature by the sea anemone *Nematostella vectensis*. *Marine Ecology Progress Series*, **484**, 115-130.
- Reitzel, A.M., Darling, J.A., Sullivan, J.C. & Finnerty, J.R., 2008. Global population genetic structure of the starlet anemone *Nematostella vectensis*: multiple introductions and implications for conservation policy. *Biological Invasions*, **10** (8), 1197-1213.
- Reitzel, A.M., Sullivan, J.C. & Finnerty, J.R., 2010. Discovering SNPs in protein coding regions with stellasp: Illustrating the characterization and geographic distribution of polymorphisms in the estuarine anemone *Nematostella vectensis*. *Estuaries and Coasts*, **33** (4), 930-943.
- Sheader, M., Suwailem, A.M. & Rowe, G.A., 1997. The anemone, *Nematostella vectensis*, in Britain: considerations for conservation management. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **7**, 13-25.
- Stefanik, D.J., Friedman, L.E. & Finnerty, J.R., 2013. Collecting, rearing, spawning and inducing regeneration of the starlet sea anemone, *Nematostella vectensis*. *Nature Protocols*, **8** (5), 916-923.
- Stephenson, T.A., 1935. *The British Sea Anemones*, vol. 2. London: Ray Society.
- Stocks, K.I. & Grassle, J.F., 2001. Effects of microalgae and food limitation on the recolonization of benthic macrofauna into in situ saltmarsh-pond mesocosms. *Marine Ecology Progress Series*, **221**, 93-104.
- Sullivan, J.C., Ryan, J.F., Watson, J.A., Webb, J., Mullikin, J.C., Rokhsar, D. & Finnerty, J.R., 2006. StellaBase: The *Nematostella vectensis* Genomics Database. *Nucleic Acids Research*, **34** (suppl 1), D495-D499.
- Tarrant, A.M., Gilmore, T.D., Reitzel, A.M., Levy, O., Technau, U. & Martindale, M.Q., 2015. Current directions and future perspectives from the third *Nematostella* research conference. *Zoology*, **118** (2), 135-140.
- Tarrant, A.M., Reitzel, A.M., Kwok, C.K. & Jenny, M.J., 2014. Activation of the cnidarian oxidative stress response by ultraviolet radiation, polycyclic aromatic hydrocarbons and crude oil. *Journal of Experimental Biology*, **217** (9), 1444-1453.
- Williams, R.B., 1976. Conservation of the sea anemone *Nematostella vectensis* in Norfolk, England, and its worldwide distribution.

*Transactions of the Norfolk and Norwich Naturalists Society*, **23**, 257-266.

Williams, R.B., 1983. *Nematostella vectensis*. In *The IUCN invertebrate red data book* (ed. S.M. Wells, R.M. Pyle and N.M. Collins), pp. 43-46. Gland: IUCN.

Williams, R.B., 1991. *Nematostella vectensis*. In *British Red Data Books. III. Invertebrates other than insects* (ed. J.H. Bratton), pp. 32-33. Peterborough: Joint Nature Conservation Committee.

## Datasets

Bristol Regional Environmental Records Centre, 2017. BRERC species records recorded over 15 years ago. Occurrence dataset: <https://doi.org/10.15468/h1ln5p> accessed via GBIF.org on 2018-09-25.

Dorset Environmental Records Centre, 2017. Dorset SSSI Species Records 1952 - 2004 (Natural England). Occurrence dataset: <https://doi.org/10.15468/vcjzts> accessed via GBIF.org on 2018-09-25.

Isle of Wight Local Records Centre, 2017. IOW Natural History & Archaeological Society Marine Invertebrate Records 1853-2011. Occurrence dataset: <https://doi.org/10.15468/d9amhg> accessed via GBIF.org on 2018-09-27.

National Trust, 2017. National Trust Species Records. Occurrence dataset: <https://doi.org/10.15468/opc6g1> accessed via GBIF.org on 2018-10-01.

NBN (National Biodiversity Network) Atlas. Available from: <https://www.nbnatlas.org>.

Norfolk Biodiversity Information Service, 2017. NBIS Records to December 2016. Occurrence dataset: <https://doi.org/10.15468/jca5lo> accessed via GBIF.org on 2018-10-01.

OBIS (Ocean Biogeographic Information System), 2019. Global map of species distribution using gridded data. Available from: Ocean Biogeographic Information System. [www.iobis.org](http://www.iobis.org). Accessed: 2019-03-21

Suffolk Biodiversity Information Service., 2017. Suffolk Biodiversity Information Service (SBIS) Dataset. Occurrence dataset: <https://doi.org/10.15468/ab4vwo> accessed via GBIF.org on 2018-10-02.