

BARNACLES (CRUSTACEA: CIRRIPIEDIA) OF THE SOLENT & ISLE OF WIGHT

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To coincide with the bicentenary of the birth of the naturalist Charles Darwin (1809-1889) a list of barnacles (Crustacea: Cirripedia) recorded from around the Solent and Isle of Wight coast is presented, including notes on their distribution. Following the *Beagle* expedition, and prior to the publication of his seminal work *Origin of Species* in 1859, Darwin spent eight years studying barnacles. During this time he tested his developing ideas of natural selection and evolution through precise observation and systematic recording of anatomical variation. To this day, his monographs of living and fossil cirripedia (Darwin 1851a, 1851b, 1854a, 1854b) are still valuable reference works. Darwin visited the Isle of Wight on three occasions (P. Bingham, *pers.com*) however it is unlikely he carried out any field work on the shore. He does however describe fossil cirripedia from Eocene strata on the Isle of Wight (Darwin 1851b, 1854b) and presented specimens, that were supplied to him by other collectors, to the Natural History Museum (Appendix).

Barnacles can be the most numerous of macrobenthic species on hard substrata. The acorn and stalked (pedunculate) barnacles have a familiar sessile adult stage that is preceded by a planktonic larval phase comprising of six naupliar stages, prior to the metamorphosis of a non-feeding cypris that eventually settles on suitable substrate (for reviews on barnacle biology see Rainbow 1984; Anderson, 1994). Additionally, the Rhizocephalans, an ectoparasitic group, are mainly recognisable as barnacles by the external characteristics of their planktonic nauplii. Within the 200m depth contour around British seas there are 66 species of barnacles including four known only from fouling on ships and 26 Rhizocephalans (Southward, 2008).

The region covered in this review broadly extends from Chichester Harbour in the east to the Needles at the western end of the Isle of Wight (Fig 1). Sub-littoral species have not been as well recorded as those in the intertidal due to fewer surveys and difficulties with *in situ* identification. The Isle of Wight coast offers better habitat for barnacles than the adjacent mainland because of the greater prevalence of rocky platforms. Yet hard structures such as sea walls, pier piles and floating platforms occur on most coasts including harbours. In recent years, new sea defences consisting of blocks of granite and limestone have increased potential settlement sites in areas of otherwise unfavourable soft-sediment habitat. Growth in recreational boating has encouraged the construction of marinas and pontoon facilities, all of which provide habitat for barnacles, as of course do the undersides of boat hulls – at great cost to local boat owners!

The earliest species records of barnacles from the Isle of Wight are found in *A Guide to the Natural History of the Isle of Wight* (Morey, 1909), only two species were included; *Semibalanus balanoides* (as *Balanus balanoides*) and *Lepas anatifera*. Morey acknowledged that other species were likely to occur around our shores or thrown up on drift wood.

Since the mid 20th century, the Solent region has been a ‘hot spot’ for barnacle biologists. Studies of barnacles and other fouling organisms were carried out by Admiralty scientists on test panels and rafts in Chichester and Langstone Harbour (Bishop 1947, Stubbings & Houghton 1964). These investigations led to the discovery of the Australasian immigrant species *Elminius modestus* Darwin in British waters.

From a biogeography perspective, interest in the region’s barnacles also developed as a result of surveys of the Channel coast by Fischer-Piette (1936) and by Professors Dennis Crisp and Alan Southward (Crisp & Southward, 1958). Their important observations established further evidence of a geographic boundary occurring approximately between the Isle of Wight and Cherbourg, with warm temperate (Lusitanian) species in the west and cold temperate (Boreal) species to the east. The Isle of Wight was found to be the most eastern locality of the Lusitanian barnacles *Chthamalus* spp. and *Perforatus perforatus* (Crisp & Southward, 1958). These observations and subsequent investigations along the south coast of England later contributed to a series of impor-

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tant papers on the influences of temperature and climate on the distribution of intertidal organisms and in particular, the association between sea temperature and relative abundance of the barnacles *Semibalanus balanoides* and *Chthamalus* spp. (Southward 1967, 1991; Southward & Crisp 1954, 1956). Several field trips to the Isle of Wight are recorded between the 1950s and 1975 (Crisp & Southward 1958; Crisp *et al.* 1981) with the pair sometimes staying at a campsite near St. Catherine's Point (AJ Southward *pers.comm*). In recent years, new surveys have been carried out along the south coast of England because of increasing interest in the effects of climate change on the distribution of intertidal marine species and ecosystems (Herbert *et al.* 2003, 2007, 2009; Mieczkowska *et al.* 2005; Hawkins *et al.* 2008).

In establishing barnacle records it is easy to overlook their pelagic phase in the plankton. Studies on barnacle larvae have been mainly carried out in Southampton Water (Soares, 1958; Raymond & Carrie, 1964) and most recently by Muxagata (2005) who identified ten species. At Crac-knore, in the upper part of the estuary, it was noted that after copepods, barnacle larvae were the second most abundant mesoplanktonic group averaging up to 13% of the total population.

International shipping and the intensity of leisure boating greatly increases the chance of non-native introductions. Should the current rise in sea temperatures continue, successful spawning and recruitment of southern and sub-tropical species may occur (Southward, 1995), whereas those with a predominantly boreal distribution e.g. *Semibalanus balanoides* may retreat eastwards and northwards (Poloczanska *et al.* 2008)

In addition to our own and others' fieldwork and personal observations of specimens, records published in this review have originated from historical literature, consultancy reports where there was evidence of species verification, and searches on the National Biodiversity Network (NBN) Gateway. A record of the northern species *Balanus balanus* from the outer part of Southampton Water in 1986, contained within the Marine Nature Conservation Review database, was dismissed as no voucher material was available. A total of 19 species have been included.

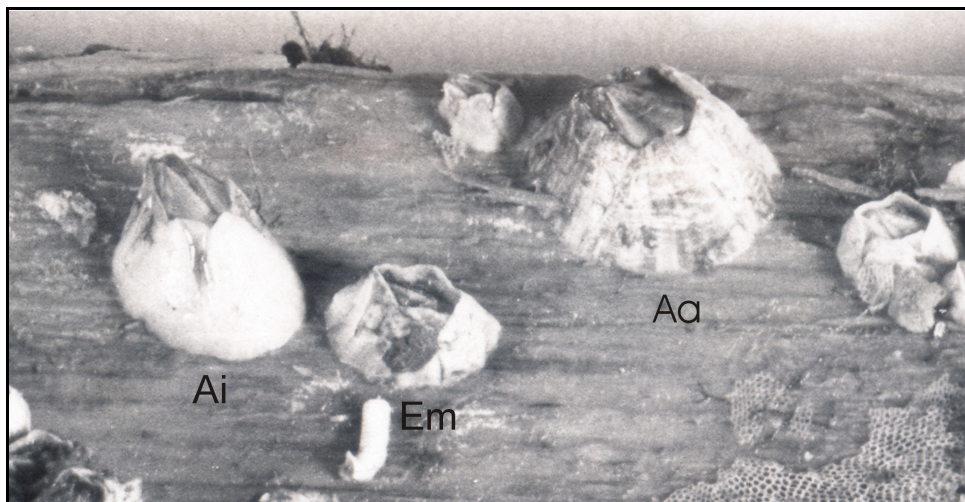


Plate 1. Barnacles on softwood settlement panel deployed at the Royal Pier, Southampton in the summer of 1976 and recovered 11th October 1976 (see Coughlan 1977 for further details). Ai: *Amphibalanus improvisus*; Em: *Elminius modestus*; Aa: *Amphibalanus amphitrite*. Surrounding area partially cleaned for photography. Photo scanned from an original provided courtesy of Jack Coughlan.

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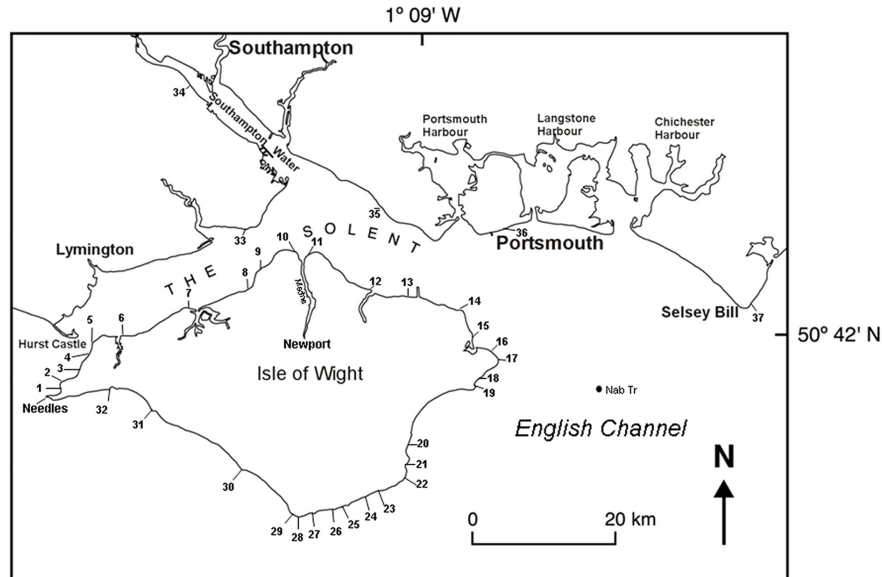


Fig 1. The study area with survey locations indicated in Table 1.

Table 1. Survey locations

1. Alum Bay	20. Horse Ledge
2. Hatherwood Point	21. Luccombe
3. Colwell Bay	22. Bonchurch
4. Fort Albert	23. Ventnor
5. Fort Victoria	24. Steephill Cove
6. Yarmouth	25. Woody Point
7. Hamstead Ledge	26. Binnel Point
8. Thorness Bay	27. Reeth Bay
9. Gurnard Ledge	28. St Catherine's Point
10. Cowes	29. Watershoot Bay
11. East Cowes	30. Atherfield Ledge
12. Woodside	31. Brook (Hanover Point)
13. Pelhamfield	32. Freshwater Bay (West)
14. Seaview	33. Lepe
15. Nodes Point	34. Cracknore
16. Bembridge (Lifeboat Stn.)	35. Lee-on-Solent
17. Foreland	36. Southsea Castle
18. Black Rock	37. Selsey Bill
19. Culver Cliff	

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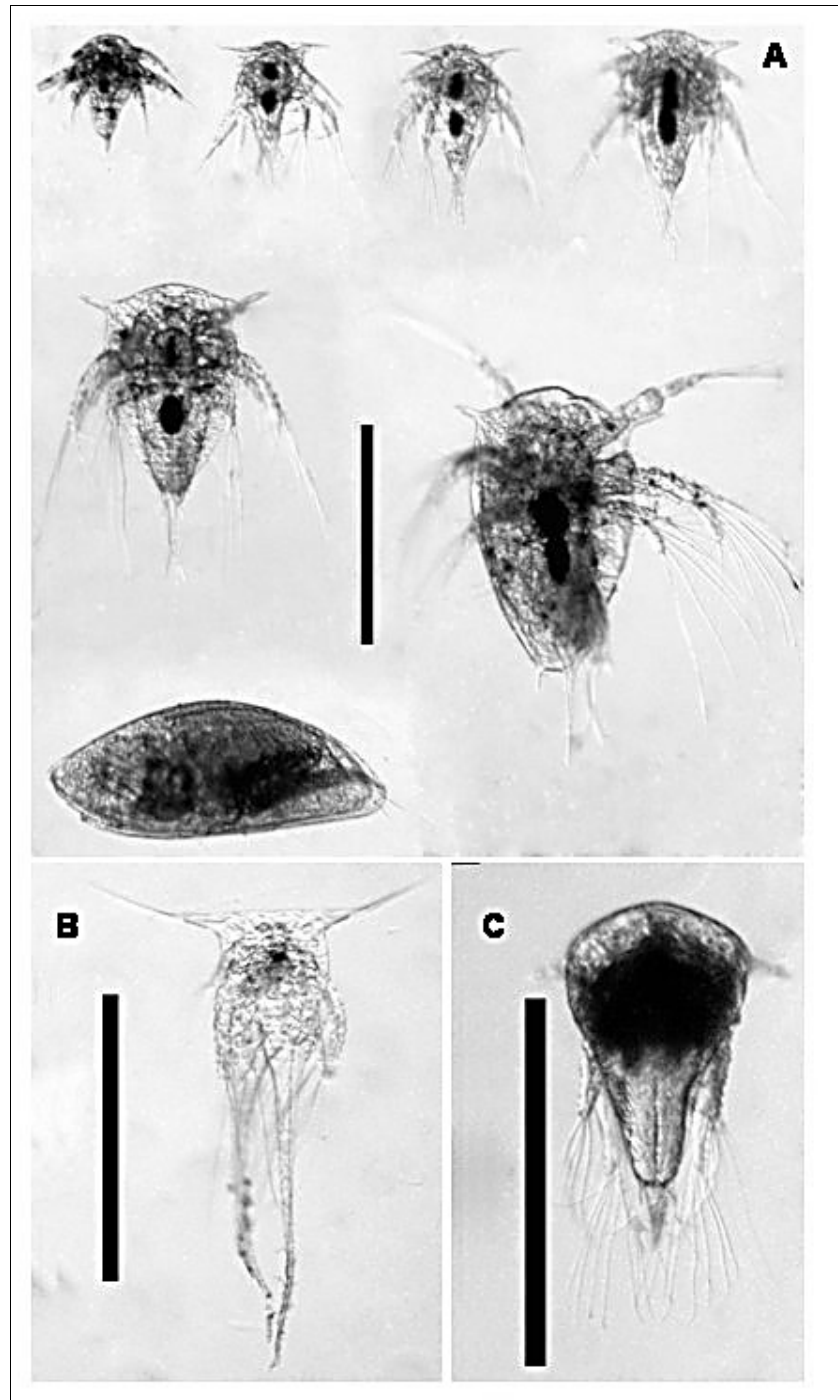


Plate 2. A: *Balanus crenatus* nauplii 1-6 and cypris (bottom left)

B: Nauplius of *Conchoderma* sp.

C: Nauplius of *Trypetesa* sp.

All Southampton Water. Scale bar 500 μ m.

Photos - Dr Erik Muxagata.

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SPECIES RECORDED:

The order and taxonomy follows that of Southward (2008).

SUPERORDER THORACICA

Order PEDUNCULATA

Family Lepadidae

Lepas anatifera (L.1758)

The common 'goose' barnacle is found attached to flotsam such as wood and old bottles washed up on the shore. Morey (1909); Brook, Freshwater Bay 1985; Bembridge & Yaverland 2004. Hurst Spit, Keyhaven, 12/2/2008, 17/8/2008; Lepe Country Park beach 17/8/2008 (JM).

Lepas pectinata Spengler, 1793

This smaller goose barnacle species was found attached to a bottle washed up on Hurst Spit at Keyhaven (17/8/2008) along with *L. anatifera* and *D. fascicularis* (JM).

Dosima fascicularis (Ellis & Solander, 1786)

The 'Buoy Barnacle'. A group of five were found washed up at Castle Haven (Isle of Wight) after south-westerly gales 6/9/1992 (Herbert, 1994). Hurst Spit, Keyhaven 17/8/2008. (JM).

Conchoderma sp. Olfers, 1814

A single nauplius of *C. ?auritum* was found in a plankton haul from NW Netley (Plate 2), Southampton Water, in April 2002 (Muxagata, 2005). This species is occasionally found on ships entering British waters, on other floating structures and whales (Dally & Crisp 1981; Southward, 2008). Although this is the first record from the Solent, there are specimens of *C. virgatum* (Spengler, 1789) that had attached to a trigger fish (*Balistes capricus*) collected from Bournemouth in August 1950 (Natural History Museum, London. No. 1950/8/10/1).

Family Scalpellidae

Scalpellum scalpellum (L.1758)

Found at depth of 10.5m south-east of Culver Cliff (50°39.19'N; 01°04.75'W), 21/5/1988 (Collins *et al.* 1990). Near Nab Tower and south of the Isle of Wight (CEFAS records, NBN 2009). *Scalpellum* sp. recorded in eastern Solent near Nab at 15-18m 31/8/2007 (NBN, 2009).

Order SESSILIA

Family Verrucidae

Verruca stroemia (O.F. Müller, 1776)

Recorded at Alum Bay and Bembridge (Crisp & Southward, 1958); at Warden Ledge at LWST 27/9/1992; common beneath small cobbles at Hamstead Ledge 5/2/1993; Bembridge south of lifeboat station at densities of 20 per 400cm² quadrat 7/3/1993; Western Solent, sublittoral between Yarmouth and Gurnard, 12/2/2008 (JM). Larvae are usually found in Southampton Water during early spring (Muxagata *et al.* 2004; Muxagata, 2005).

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Family Chthamalidae

Chthamalus stellatus (Poli, 1795)

This Lusitanian species was considered a single taxon until Southward (1976) distinguished the two British species of *Chthamalus*. Previously all specimens were named *C. stellatus* and recorded at several localities around the Isle of Wight but not on the Hampshire coast (Fischer Piette, 1936; Crisp & Southward, 1958). In 1975, the species' eastern border along the south coast of England was at Hanover Point (Brook) (Crisp *et al.* 1981). In 1992, two individuals were found at Black Rock near Bembridge but so far there have been no records further east on the Channel coast. The species' vertical distribution is normally observed to extend below that of *C. montagui*, but on exposed shores on the south coast of the Isle of Wight, specimens may also be found above *C. montagui* near High Water Spring Tide mark (Fig 3). Crisp *et al.* (1981) noted a similar distribution at the species' extreme northern limits in north-east Scotland. The species has also been found on flints at Freshwater Bay along with *C. montagui* (Herbert & Hawkins, 2006). Stage II nauplii of *C. stellatus* were recorded in Southampton Water in 2001 (Muxagata *et al.* 2004; Muxagata, 2005). The species distribution on the Isle of Wight is shown in Fig 2.

Chthamalus montagui Southward, 1976

On the south coast of England this Lusitanian species currently has its eastern border on the Isle of Wight, along with *C. stellatus* (Herbert *et al.* 2007). Crisp *et al.* (1981) noted two individuals on boulders at Bonchurch on the south-east coast of the Isle of Wight. More recently, the species has been found on chalk at Culver Cliff and singly amongst *E. modestus* and *S. balanoides* 500m south of Bembridge lifeboat station (25/10/2001, 7/6/2005). Mean densities reach a maximum of 0.05 per cm² on shores between Hanover Point and Ventnor. A pulse of high recruitment recorded at Hanover Point in 2000 may have occurred because of warm settled conditions and a high incidence of onshore breezes (Herbert *et al.* 2007).

Family Archaeobalanidae

Elminius modestus Darwin, 1854

This immigrant Australasian species was first recorded in the British Isles at Chichester Harbour in 1945 (Bishop, 1947) although its prior occurrence in the Portsmouth area was confirmed from the examination of earlier material by Stubbings (1950). It is unlikely however that the species was present in local waters prior to the outbreak of World War II and may have been introduced via shipping convoys operating between Britain and Australia (Crisp & Chipperfield, 1948; Crisp, 1958). Observations in the 1950s suggested that there was some displacement of the native *S. balanoides* by *Elminius* in Chichester Harbour (Houghton & Stubbings, 1963; Stubbings & Houghton, 1964). The species has now spread throughout Britain and is currently found on all Solent coasts and in estuaries on hard intertidal and subtidal substrata. The current regional adult distribution is shown in Herbert *et al.* (2007). Due to its tolerance of low salinity the species may be found in the upper Medina estuary as far as Coppins Bridge, Newport. On the more exposed south coast of the Isle of Wight the species is less common. Subtidal specimens have been recorded in the mid Solent. The species is the most abundant larval cirripede in Southampton Water occurring in all months with peaks in June, July and August (Muxagata *et al.* 2004; Muxagata, 2005). Peak settlement in Chichester Harbour recorded between June and September (Stubbings & Houghton, 1964).

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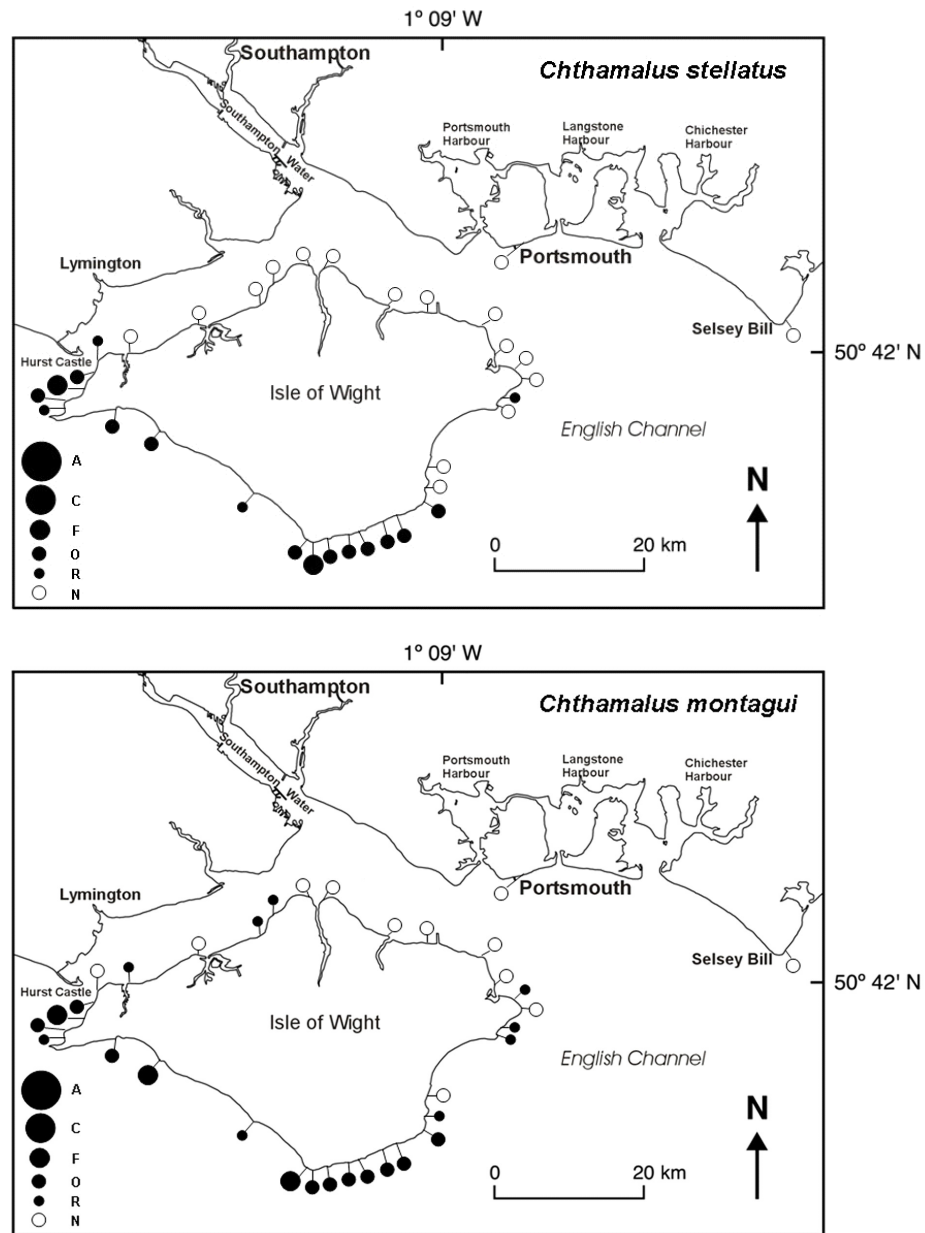


Fig 2. Highest mean shore density of the two *Chthamalus* species in the region recorded 1993-2008. Currently the Isle of Wight is the eastern limit for the species in the Channel. All shores initially surveyed in 1993 and intermittently in subsequent years. Freshwater Bay (W), Brook, Water-shoot Bay and Bembridge surveyed annually. A minimum of ten 400cm² quadrats placed at HWN, MTL and LWN. Average density across tidal levels was calculated and assigned to following categories (Crisp & Southward, 1958): > 1 per cm², A-Abundant: 0.1-1 per cm²; C-Common: 0.01-0.1 per cm²; F-Frequent: 0.001-0.01 per cm²; O-Occasional; R-Rare, few found in 30 minutes search; N-Not found in 30 minutes search.

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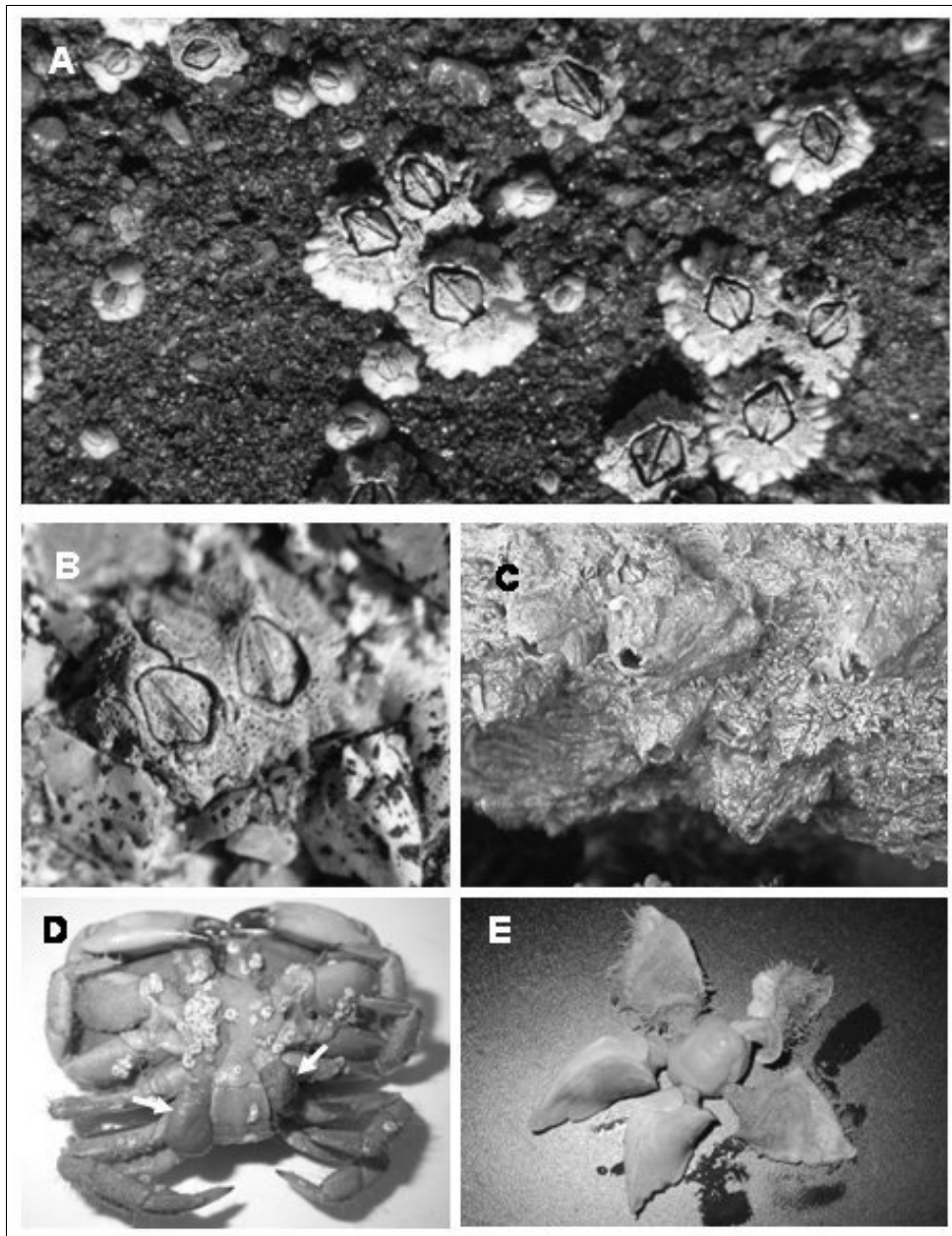


Plate 3. A: An adult *Elminius modestus* with *Semibalanus balanoides* adults and spat, Horse Ledge, Shanklin 4/5/1993.

B: *Chthamalus montagui* on concrete at Freshwater Bay.

C: *Perforatus perforatus* on Yarmouth Pier pile, April 2008.

D: *Sacculina triangularis* on Edible Crab *Cancer pagurus*, Bembridge arrows indicate growths.

E: *Dosima fascicularis*, Castle Haven 6/9/1992.

Photos Dr. Roger J H Herbert.

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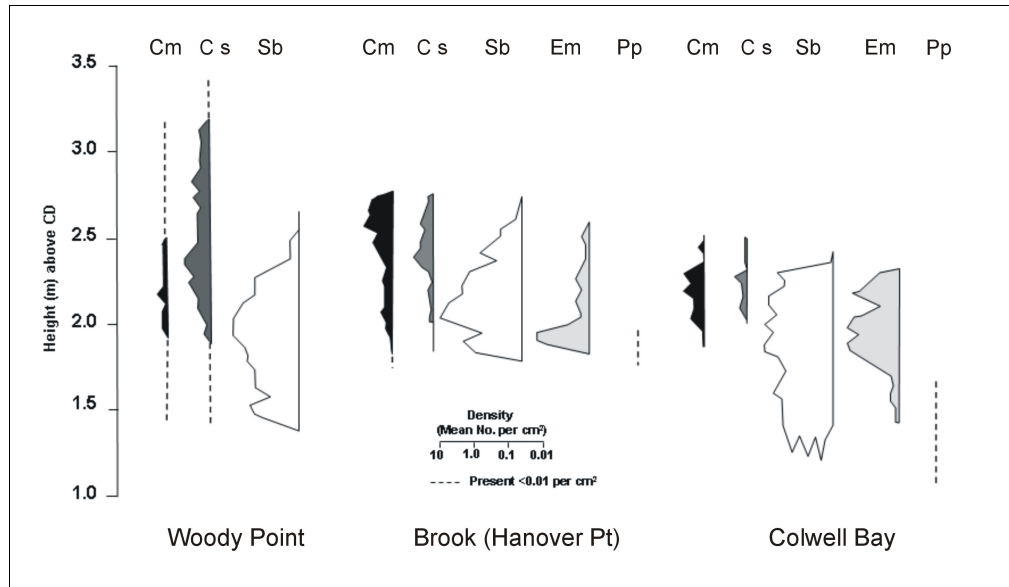


Fig 3. Vertical intertidal distribution of barnacle species at three locations on the Isle of Wight surveyed in 1993. Data shows mean density along four continuous belt transects surveyed at each location using a 5 x 20cm 'quadrat'. All transects were on vertical surfaces that had a seaward aspect; Woody Point (30/8/1993), south facing upper greensand boulders; Brook (31/8/1993), south facing sandstone; Colwell Bay (1/9/1993), west facing concrete sea wall. **Cm**-*Chthamalus montagui*; **Cs**-*Chthamalus stellatus*; **Sb**-*Semibalanus balanoides*; **Em**-*Elminius modestus*; **Pp**-*Perforatus perforatus*. Note density log-scale.

Semibalanus balanoides (L. 1758)

As *Balanus balanoides*, the only species within this Order recorded on the Isle of Wight by Morey (1909). The species is currently ubiquitous on intertidal hard substrata throughout the region, including chalk. Recorded on several rocky shores around the Isle of Wight by Crisp & Southward (1958); Osborne Bay (Herbert, 1991); close to bridge at Old Mill Pond, Wootton, Isle of Wight. In Chichester Harbour settlement was recorded February-April (Stubbings & Houghton, 1964). The current distribution on the English south coast is shown in Herbert *et al.* (2007). In Southampton Water, peak abundance of larvae is during early spring (Muxagata *et al.* 2004; Muxagata, 2005) with settlement observed on the shore between March and May.

Family Balanidae

Balanus crenatus Bruguière, 1789

Found abundantly at and below Low Water Spring Tide mark all around the coast and as fouling on boats and other floating structures. Previously recorded at several localities by Crisp & Southward (1958); Chichester and Langstone Harbour (Stubbings & Houghton 1964); intertidal and sublittoral in River Medina (Withers, 1979). Larvae (Plate 2) are found in Southampton Water between January and August (Muxagata *et al.* 2004; Muxagata, 2005).

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Amphibalanus amphitrite (Darwin, 1854)

Syn: *Balanus amphitrite* subsp. *amphitrite*

A breeding population of this sub-tropical fouling species was established off the power station outfall in Portsmouth Harbour 1958-1965 (D. Houghton *pers. comm* in Coughlan, 1977) where cooling water caused local warming. Settlement observed on boat hulls and on panels deployed in Chichester Harbour and Langstone Harbour during the period was believed to have originated from this source (Stubbings & Houghton, 1964; Coughlan, 1977). It is also possible that there had been larval drift from a population established in a cooling pond at the power station at Shoreham to the east, which was first noted in 1937 (Crisp & Molesworth, 1951). In Southampton Water it was observed on university field courses between 1955-1960 and later on softwood settlement panels deployed at the Royal Pier in Southampton Water during the exceptionally warm summer of 1976 (Coughlan 1977; Coughlan *pers.comm*, Plate 1). Two specimens were found and their similar size suggested settlement in August or September. A few dead specimens were seen on structures beneath the pier in March 1977. It is likely that high water temperatures, elevated further by cooling water from nearby Marchwood Power Station, facilitated breeding, larval survival and settlement. Although now recognised as a single taxon, Darwin originally divided the species into nine varieties and British specimens were named var. *denticulata*.

Amphibalanus improvisus (Darwin, 1854)

Syn. *Balanus improvisus*

The adults have not been commonly recorded in recent years. However larval abundance at the head of Southampton Water was second only to *E. modestus* with peaks in June and August (Muxagata *et al.* 2004; Muxagata, 2005). Peak settlement in Chichester Harbour is in August but extends to October (Stubbings & Houghton 1964). It is possible that the species has been displaced in some estuaries by *Elminius modestus*. Recorded in River Medina (Withers, 1979) and found in the eastern Solent between 1980-82 at the *Mary Rose* wreck site (Collins & Mallinson, 1982).

Perforatus perforatus (Bruguière, 1789)

Syn. *Balanus perforatus*

This large Lusitanian species was recorded at several Isle of Wight localities by Crisp & Southward (1958) including Bembridge. The most eastern records on the English coast were from submerged test panels in Chichester Harbour, although there was a permanent population in Langstone Harbour (Stubbings & Houghton 1964). During the severe winter of 1962-63, populations on the Isle of Wight were killed, as were others in eastern localities (Crisp, 1964). In 1993 the species was recorded on most rocky shores on the south coast of the Isle of Wight on hard substratum. Basal diameter of animals at Colwell was 3-18mm but generally smaller at St. Catherine's Point (Herbert *et al.* 2003). In 1994, specimens were found on the Sussex coast (Herbert *et al.* 2003) and at Folkestone in 2008 (Herbert unpub). In 2007, patches of contiguous individuals were seen on the outer ledges at Bembridge by the lifeboat station, the highest density recorded here. Large contiguous individuals were recorded on wooden piles removed during the restoration of Yarmouth Pier in 2008. Also recorded sublittorally in the Western Solent between Gurnard and Yarmouth 12/2/2008 (JM).

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SUPERORDER ACROTHORACICA

Order APYGOPHORA

Family Trypetesidae

Trypetesa sp. Norman, 1910

A single nauplius of *T. ?lampas* (Plate 2) was recorded in Southampton Water at Calshot in July 2001 (Muxagata, 2005). This is the first record of this burrowing species for the region.

SUPERORDER RHIZOCEPHALA

Order KENTROGONIDA

Family Peltogastridae

Peltogaster paguri Rathke, 1842

This parasitic species was found on the hermit crab *Pagurus bernhardus* at Bembridge (Juniper, 1963) and in Southampton Water in 2002 (Muxagata, 2005). Larvae can be found throughout the year in Southampton Water with maximum abundances occurring over the winter and spring (Muxagata *et al.* 2004; Muxagata, 2005).

Peltogastrella sulcata (Lilljeborg, 1859)

Found on a hermit crab during survey work in the Western Solent 16/8/2006. (JM).

Family Sacculinidae

Sacculinidae sp.

Unconfirmed specimens of *?Drepanorchis neglecta* Boschma, 1927 on the spider crab *Macropodia* sp., Lee-on-Solent, 13/6/2008 and *?Sacculina gerbei* Bonnier, 1887, on hairy crab *Pilumnus hirtellus*, Western Solent, 11/3/2008 (JM).

Sacculina carcini Thompson, 1836

Infected male shore crabs *Carcinus maenas* can occasionally be found at Bembridge south of the lifeboat station at MTL and below. The smallest parasitized *Carcinus* so far recorded had a carapace width of 31mm. Also, sublittoral in the Western Solent between Gurnard and Yarmouth, 12/2/2008; 11/3/2008 (JM). Larvae in Southampton Water are present throughout the year with a peak in August (Muxagata *et al.* 2004; Muxagata, 2005).

Sacculina triangularis Anderson, 1862

This is an uncommon species and the only rhizocephalan known to infest juvenile edible crab *Cancer pagurus*. The species was first recorded on the lower shore at Bembridge in 1993 (Herbert, 1997). Other records: Bembridge on male crab (carapace width 53mm) 3/9/1995; Bembridge 3/2000; Bembridge 4/8/2003. Recorded only from a few localities on the north coast of France, Devon and Isle of Man (Høeg & Lützen, 1985; Høeg & Lützen *pers. comm.*).

Aknowledgements

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APPENDIX. Fossil barnacles from the Isle of Wight presented by Charles Darwin to the Natural History Museum, London. Information provided by Dr M.Munt.

Species	Accession No., Location and Notes
<i>Aporolepis reflexa</i> (Sowerby, 1829)	BMGD In.32301 (formerly 38430) Bembridge Limestone Formation, Gurnard.
<i>Aporolepis reflexa</i> (Sowerby, 1829)	BMGD In.32302 (formerly 38431) Bembridge Marls Member, Thorness Bay, Whitecliff Bay.
<i>Aporolepis reflexa</i> (Sowerby, 1829)	BMGD In.32303 (formerly 38432) Venus Bed, Colwell Bay Member, Colwell Bay, Whitecliff Bay. Presented in 1954.
<i>Balanus unguiformis</i> Sowerby, 1829	BMGD 38424 Isle of Wight BMGD 38475 Headon Hill BMGD 38476 Headon Hill (presumably all Colwell Bay Member).
<i>Balanus unguiformis</i> var. <i>erisma</i> Sowerby, 1829	BMGD 38477 Headon Hill. This specimen is possibly pl. 2 Fig 4.d of Darwin's monograph (1854b). Position in NHM registers indicates they were presented in 1858.

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