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Survey to elucidate the distribution of the 'lagoon snail' *Paludinella littorina* in England

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Survey to elucidate the distribution of the Lagoon Snail *Paludinella littorina* in England

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Summary

This report describes a survey to elucidate the distribution of the 'lagoon snail' *Paludinella littorina* in England.

Paludinella littorina (delle Chiaje, 1828) is a marine prosobranch snail which is a member of the supralittoral fauna in interstitial, rock and crevice habitats. It is protected under Schedule 5 of the Wildlife and Countryside Act (1981), scheduled in 1992, and is listed in the British Red Data Book (Bratton 1991) as RDB3, Rare.

Prior to the most recent survey, work by the authors over the past 10 years has demonstrated that although *P. littorina* is a south-western species in Britain and is commoner than previously believed, there are still large gaps in the distributional knowledge. In addition, published information on the species' ecology is largely based upon the Fleet population and, therefore, does not have a wide application for species' conservation and site management elsewhere.

Further work has been carried out in 2000 with support from English Nature research funding with the following principal objectives:

1. To carry out further survey of selected areas in southern England focusing on the Isle of Wight, the Lizard and Land's End peninsulas, the Fal and Fowey estuaries and the Isles of Scilly. Several of the proposed sites are within Special Areas of Conservation (SAC), are Sites of Specific Scientific Interest (SSSI) or have other conservation status.

2. To provide a more comprehensive picture of the species' true distributional range in Britain and allow a more informed conservation and management policy to be developed. The latter is particularly important in SACs.

3. To review the position of *P. littorina* on the Wildlife & Countryside Act.

This survey has yielded 24 new sites for *P. littorina* which have filled in gaps within the known distributional area. The results show that two areas support significant numbers of *P. littorina* populations: the west coast of the Lizard peninsula and the Isles of Scilly. On the Isles of Scilly *P. littorina* is now known from a total of 22 sites on the five main islands of St Mary's, St Martin's, St Agnes, Tresco and Bryher, with an additional site on Gugh. On the basis of the number and concentration of sites, the Isles of Scilly must be considered to be the species' stronghold in the UK. *P. littorina* was found at 5 sites on the Lizard, all in cave habitats, and in a gully at Sennen Cove (confirming a 90 year old shell record). A new site was also discovered at Whitecliff bay, IOW in a Chalk cave. The survey also yielded 2 new sites in Cornwall for the Red Data Book prosobranch *Truncatella subcylindrica*.

There appear to be very few threats to most of the English *P. littorina* populations (except perhaps in the Fleet). A significant number of the British *P. littorina* sites are within SSSI and SAC or very close to SSSI boundaries and are afforded some protection from their location, but in most cases the sites are in relatively remote places that are unlikely to be affected by developments. The most obvious potential threat is from a major oil spill and the effects of the subsequent use of dispersants or from a physical clean-up (e.g. removal of

substrate). However, a survey in Pembrokeshire and Caldey Island following the *Sea Empress* spill showed that there was no obvious evidence of damage to populations at the known sites by oil contamination.

In light of the number and location of sites, there do not appear to be any special conservation or management measures necessary to ensure the survival of *P. littorina* populations. Although there is no requirement under present conservation criteria, a programme of monitoring would be desirable at selected sites.

This, and previous surveys by the authors, have demonstrated that *P. littorina* covers a wider range of supralittoral habitats, and is much more widespread within its known geographical area, than previously believed. Given the inaccessibility of many potentially suitable sites and habitats, it is likely that the species is still under-recorded. There appear to be very few threats, particularly from development, at the majority of sites and few of the populations could be considered vulnerable. Furthermore, given that *P. littorina* is a difficult animal to locate, we do not consider damage to populations from collection to be an issue. On the basis of this information, the continued inclusion of *P. littorina* on Schedule 5 of the Wildlife & Countryside Act (WCA) should be reviewed.

1. Background and objectives

The 'lagoon snail' *P. littorina* (delle Chiaje, 1828) is a marine prosobranch snail which is a component of the supralittoral fauna in interstitial, rock and crevice habitats, although it is frequently referred to as a lagoonal species (Downie 1996). It is protected under Schedule 5 of the Wildlife and Countryside Act (WCA) (1981), scheduled in 1992, and is listed in the British Red Data Book (Bratton 1991) as RDB3, Rare.

P. littorina has a north-east Atlantic distribution from the Azores, Madeira and Canaries, northwards to the Iberian peninsula, France and south-west Britain (Figure 1). It also extends eastwards into the Mediterranean as far as the Adriatic, although the true distribution is unclear owing to the presence of other similar species whose taxonomic position requires further research (see Appendix 1).

When the species was classified for the Red Data Book and scheduled under the WCA, the only site in the UK at which it was known to be living was in the Fleet, where it was rediscovered after a hiatus of approximately 100 years (Light 1986). The only other sites from which there had been live records prior to 1986 were at Whitecliff Bay, Isle of Wight (Forbes & Hanley 1853) and possibly Exmouth (Clark 1855). The species was also known as dead shells from a few other disjunct locations in southern England from the Isle of Wight to Land's End, from Pembrokeshire (Caldey Island) and from the Channel Islands. A chronology of historical records and their sources is shown in Table 1.

As part of marine molluscan biogeographical studies carried out by the authors since 1986, part of our effort has focused on specifically searching for *P. littorina*. As a result the species has been recorded from several other locations in southern England and south Wales (see Table 1). Early attempts to locate the species at other sites focused on searching habitat types similar to that in the Fleet where it lives at HWM buried in shingle with organic detritus particularly below bushes of *Suaeda maritima* and *S. fruticosa*. However, following location of living populations in a cave at Woody Bay, north Devon (Light 1991) and interstitially in an open marine environment at Whitecliff Bay (Light 1992) the focus of our subsequent work changed and revealed that *P. littorina* is commoner in habitats which are rather different from the Fleet. Thus the two principal habitat types in which the species is found are:

1. upper shore caves;
2. shores with a supra-littoral zone comprising cobble and boulders with stable interstitial gravels, often with a silty component, beneath.

Whilst our recent work has demonstrated that *P. littorina* is a south-western species in Britain and is commoner than previously believed, there are still gaps in our distributional knowledge. In addition, published information on the species' ecology (e.g. in the Red Data Book) is largely based upon the Fleet population and, therefore, does not have a wide application for species' conservation and site management elsewhere.

Further work has been carried out with support from English Nature research funding with the following principal objectives:

1. To carry out further survey of selected areas in southern England focusing on the Isle of Wight, the Lizard and Land's End peninsulas, the Fal and Fowey estuaries and the

Isles of Scilly. Several of the proposed sites are within candidate SACs, are SSSI or have other conservation status.

2. To provide a more comprehensive picture of the species' true distributional range in Britain and allow a more informed conservation and management policy to be developed.

3. To review the position of *P. littorina* as a species scheduled on Wildlife & Countryside Act.

This report describes the results of the present work and also includes data gathered from other sites from 1990 to date.

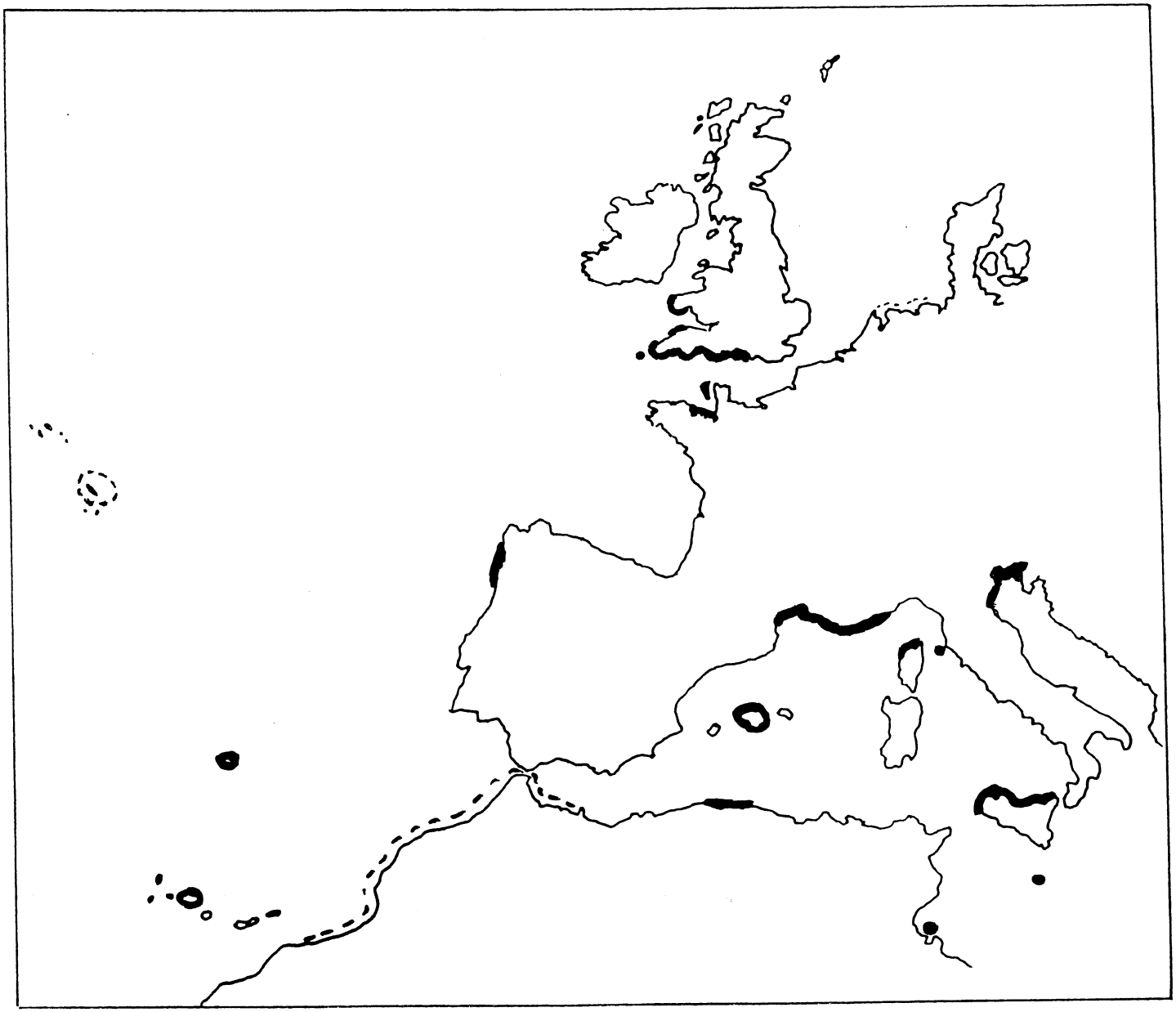

Figure 1: European distribution of *Paludinella* (all taxa)

Table 1: Chronology of British *Paludinella* records

Date	Details	Reference
pre 1844	Weymouth as *Cingula ? globularis* Metcalfe MS	Thorpe 1844
c. 1852	From the estuary near Portland (i.e. the Fleet) by William Thompson. Living with *Leucophytia bidentata* and *Truncatella subcylindrica*, "near high water mark, under stones kept moist by a deepish layer of dead *Zostera* weed"	Forbes & Hanley 1853
Nov 1852	Whitecliff Bay, Isle of Wight. Living "in crevices of fresh water limestone, near high water mark.....in company with *Leucophytia bidenata*"	Forbes & Hanley 1853
June 1853	Exmouth, Devon. Presumably living but no details of habitat.	Clark 1855
pre 1869	Sark, and Land's End (Hockin) - no details whether live or dead	Jeffreys 1869
1888	'Weymouth' no locality details. Common living under stones with *Cingula, Ovatella, Leucophytia* and *Lasaea.*	Sykes 1890
1903	Caldey Island, shell only	Williams Vaughan 1905
pre 1913	Guernsey, Sennen Cove and the Lizards, Torbay and Dartmouth. All records shell only, most material in National Museum of Wales Cardiff	Marshall 1913
1985	The Fleet - fresh shells	Seaward 1986
May 1986 1987	The Fleet - first living record from Britain since 1888 Chichester Harbour, Sussex - dead shell	Light 1986 Goodchild pers. comm.
1991	Woody Bay, north Devon	Light 1991
1992	Whitecliff Bay, IOW - rediscovered at Forbes & Hanley's site	Light 1992
1992 - 1997	Broad Haven, Pembrokeshire and Caldey Island	Killeen & Light 1994; Light & Killeen 1997
1998	Beer Regis, Devon	Killeen & Light 1998b
1998	Near Brixham, Devon	Light 1998
1998	Jersey (two sites)	Unpublished
1998	Fowey estuary, Cornwall (shells only)	Unpublished
1998	Poldhu Cove, Lizard, Cornwall	Killeen & Light 1999
1999	Scilly (Gugh, St Agnes, St Marys, Tresco)	Killeen & Light 1999

2. *P. littorina* habitat and ecology

Whilst it has been demonstrated from our previous survey work that *P. littorina* may live in either rock fissures in caves, or in interstitial shingle/small cobbles near high water mark on the shore, the species appears to demonstrate a number of rather more precise biological and environmental requirements. From field observations it appears that the majority of individuals do not appear to stray far from the margins of rock fissures and crevices which are laterally continuous and often appear to have some depth resulting from faulting in the rocks. In the case of snails associated with unconsolidated substrates such as shingle, cobbles or boulders, they are often located at a depth of at least 30cm, or under stable, embedded rocks, suggesting that there is a requirement for protection from the immediate effects of turbulent water action. At cave sites where *P. littorina* is found, the associated substratum is frequently colonised by green and red algal film and soft crusts and in some cases a dull lilac-coloured crustose coralline alga. In particular, identification of the dark red soft crustal alga/algae probably requires examination of microscopic features; however, two *Hildenbrandia* spp. form extensive and ubiquitous reddish brown coatings on hard rock, of which *H. rubra* is common, (Hiscock 1986).

Observations at Broad Haven, Pembrokeshire (Light & Killeen 1997) and at other sites strongly suggest that the ability to locate *P. littorina* in cave habitats is dependent upon the length of time that has elapsed since occurrence of high tide. Timed counts at Broad Haven showed that the number of snails that could be counted on the cave walls declined with time. This implied that the snails are negatively phototactic and had been inhibited by the bright beam of torches. (Indeed, during the present survey this observation has been supported by the quick reaction time of snails which, having been detected by torch beam, retreat into crevices and out of sight in the interval needed to retrieve a paintbrush or forceps from pocket or equipment bag!) However, over tidal cycle timescales, as with many other organisms which live in the littoral, the snails are likely to have circadian rhythms which govern their locomotory and feeding behaviour.

It has already been noted by us (Killeen & Light, 1994) that (particularly in caves) *P. littorina* is more likely to be found in the field in moist weather conditions: on warm humid days in spring and summer and foggy or rainy days at other times of the year. A small marine prosobranch showing an ecological requirement for shelter is unlikely to be tolerant of exposure to hot dry conditions.

3. Site selection

Site selection was based upon the following criteria:

1. Sites from where there were old records e.g. Sennen Cove and the Lizard, Cornwall.

2. Sites with potentially suitable habitats as suggested by Stella Turk and the Environmental Records Centre for Cornwall and the Isles of Scilly (ERCCIS).

3. Speculative searching of sites which we considered might support suitable habitat. This was exclusively the case on Scilly where extensive walking of the coasts of each island was carried out in order to locate these habitats.

4. Sites known to us which supported potentially suitable habitat but which had not been previously searched specifically for *Paludinella* (e.g. Isle of Wight).

A total of 68 sites were searched during the present survey. For completeness and the purposes of this report we have incorporated 8 sites in Cornwall and Scilly surveyed in 1999, and the three known sites in Devon, giving a total of 79 individual survey sites. Locations, Grid References and brief descriptions of each site are given in Table 2. The sites were located either by GPS or from 1:25,000 Ordnance Survey map. The field data sheets with more detail and comments on each site are given in Appendix 4 of this report.

The fieldwork was carried out by the authors during July and September 2000.

4. Methodology

In the case of cave habitats surveying and sampling strategy consisted of a close examination of walls and roofs at the height estimated to coincide with upper shore/splash zone as well as regions immediately above and below this point. At this shore height the walls are often abundantly colonised by a green algal film and non-calcareous red algal crust. Presence of the splash zone winkle, *Melarhaphe neritoides* assists in pinpointing the correct zone to search. Particular attention was paid to fissures, cavities and crevices in the walls. A powerful torch beam is essential for searching in cave interiors; a head-torch allows hands to be kept free. A fine paintbrush or soft-touch forceps are needed to temporarily remove snails from crevices for confirmation and replacing.

As discussed in Section 2 we believe that the ability to find *Paludinella* in caves is dependent upon the length of time that has elapsed since occurrence of high tide. Therefore, searches of cave habitats were attempted as soon after high tide as the cave entrance became safely accessible. However, in many cases access was not possible until the tide had been receding for 2-3 hours.

Searching in interstitial shingle/cobble on upper shores requires a more specific approach with respect to habitat selection and search technique. On such shores we seek out gullies or sheltered areas on platforms where there is a stable accumulation of cobbles. At more open sites, for example on Scilly where all *P. littorina* habitats occur on the rugged granite boulder shores, the targetted zone could be characterised as the interface of large stable granite boulders supporting tufts of *Pelvetia canaliculata* with the boulders slightly higher on shore which are colonised by the lichens *Ramalina* spp., *Caloplaca* sp and *Xanthoria* sp. All these habitats, having lattices of varying scale, must be free draining. Generally there is a vertical gradation through the substrate from large scoured cobble to a stable habitat of smaller pebbles with interstitial sediments and organic detritus. These cobbles and pebbles may have to be carefully removed to some depth (perhaps 30cm) to reach a zone which is deep enough but still sufficiently distant from the underlying non-interstitial water/substratum interface. Once the appropriate zone is reached, both the undersides and tops of the rocks are carefully examined. On shores with a wider size range of rocks and cobble, large embedded or semi-embedded slabs provide suitable *P. littorina* habitat. Again, the slabs must be resting on a free draining substrate with an element of silty sediment and organic detritus. *P. littorina* is most often found on the undersides of the slab or rock particularly in crevices and cavities.

Although *P. littorina* has been found at certain sites (identified herein) where the combination of caves and the favourable faulting and fissile nature of the rock creates optimum habitat, we have also had surprisingly little success in finding the species at a number of other prime sites where there is apparently similar habitat. Such sites are exemplified by the ledges and drangs (deep gullies) at Wembury and Portscatho and the promontories, recesses and caves at Cape Cornwall. These sites often support typical associates such as *Otina ovata* and *Leucophytia bidentata*. Similarly, loosely mortared sea walls support associated mollusc species but curiously not *P. littorina*. These habitats have generally only been investigated where no other suitable habitat has been available on site. These observations are considered in Section 5 of this report.

Voucher reference material has been collected under License No. 20000819 [IJK] and No. 20000820 [JML] during this study and will be deposited in the Mollusca collections at the National Museum of Wales, Cardiff.

Table 2: Location of sites and general descriptions (* = positive *Paludinella* sites)

A - Cornwall, River Fowey

Site No.	Site	Grid Ref	Habitat Type	Description
1	Mixtow, N side of inlet	SX130530	interstitial	Muddy gravel shore with walls and fissile rock outcrops at HWM
2	Mixtow, S side of inlet	SX130529	sea wall	Loosely mortared sea wall with deep crevices and interstices.
3	Golant	SX124550	causeway	Causeway constructed of clay and rubble.
4	Fowey quay	SX124515	sea wall	Loosely mortared sea wall with deep crevices and interstices.

B - Cornwall, Fal Estuary

Site No.	Site	Grid Ref	Habitat Type	Description
5	St Anthony: Cellars Beach	SW851323	interstitial	Creek within estuary system. Upper shore of gravel & cobble with loose rocks and embedded slabs.
6	St Anthony	SW858329	interstitial	Creek within estuary system. Upper shore with large accumulations of embedded rocks, and cobble with sediment and organic detritus.
7	Percuil	SW859340	interstitial	Small area of old low walls and shale rock outcrops
8	St Just in Roseland	SW845356	interstitial/sea wall	Loose mortar at base of sea wall plus accumulations of embedded rocks, and cobble with sediment and organic detritus.
9	St Just in Roseland	SW847359	interstitial	Bank/ridge with tumbled blocks, slabs and interstitial sediments.
10	Turnaware Point	SW835383	interstitial	Gravel shore with rocky outcrops and embedded rocks at HWM
11	Pill Point	SW829381	interstitial/sea wall	Gravel shore with sea walls, rocky outcrops and occasional embedded slabs.

Table 2 continued: Location of sites and general descriptions

C - Cornwall, Lizard

Site No.	Site	Grid Ref	Habitat Type	Description
12	Maenporth	SW791297	Caves	3 caves in shale cliffs with fissures, moist wall and red algal film. Also embedded slabs in entrances.
13	Maenporth	SW791295	Caves	4 caves searched - only 2 with typical attributes. Embedded slabs in cave entrances also checked.
14	Helford, W of Passage Cove	SW758270	Interstitial	Few upper shore slabs and crevices, suitable habitat very sparse.
15	Helford, Men Aver	SW794250	Cave	Small cave with moist walls and algal film.
16	Cadgwith Cove	SW722145	Cave/crevices	Cliffs with fractured blocks and small recesses. Deep fissures and crevices examined.
17	Church Cove	SW715127	Cave	Rather exposed cave in serpentine with very few crevices.
18	Housel Bay	SW708119	Caves	Sandy bay backed by cliffs - some cave development but were inaccessible from the shore.
*19	Vellan Drang	SW701115	Caves - several	3 caves searched E and W of slipway. 2 deeply cut back into the cliffs with moist walls and algal film.
20	Caerthillian/Pentreath	SW693127	Crevices	Sandy bay with some gully and cave development at either end. Access difficult except at low water. Fissures in serpentine searched at N end of bay.
21	Kynance	SW683133	Caves/Crevices	Complex of bays with cliffs, stacks and occasional caves. Access difficult but occasional caves and crevices with suitable habitat.
*22	Mullion Cove	SW667178	Caves/Crevices	Gullys and caves to north and south of quay. One cave/surge gully with good fissure and crevice development and red algal film at S end. Other caves & gullys to scoured or too dry.
*23	Pollurian Cove/Pedn-y-ke	SW669187	Cave/Crevices	Small upper shore gully with recess at end. Front of recess protected by boulders. Recess moist with algal film.
*24	N of Polbream Point	SW667189	Cave	Deep cave with entrance low on shore. Walls with dark hard lithology and narrow crystalline veins.
*25	Poldhu Cove	SW664198	Cave	Small cove with caves on north and south margins. North-facing cave on south side with crevices formed by crystalline vein running through wall of cave.
26	Church Cove	SW662204	Cave	Sandy bay with small cave development at S end. Cave high on shore, scoured, dry and terrestrial towards rear.

Table 2 continued: Location of sites and general descriptions

D - Cornwall, 'Land's End Peninsula'

Site No.	Site	Grid Ref	Habitat	Description
*27	Rinsey Head	SW590269	Interstitial	Caves present but too high on shore. Upper shore of large boulders, cobble with interstitial sediments and organic detritus.
28	Praa/Little Castle	SW573280	Caves/Crevices	Platform with drang and cave development. Numerous crevices and fissures from faulting and vein development.
29	Bessy's Cove	SW557279	Caves	3 caves searched, 1 with moist walls and algal film, some interstitial boulder habitat on cave floor.
30	Porth Curno	SW389223	None suitable	Small cove with scored granite cliffs and little crevice development.
31	Porthgwarra	SW371216	Caves	Coarse boulder shore with 2 high shore caves/tunnels.
32	Nanjizal	SW358236	Cave/Crevices	High energy cove with large upper shore cavern and an isolated stack. Cave had no suitable habitat, stack had few crevices.
*33	Sennen Cove	SW350263	Interstitial in gully	Boulder shore with rocky promontories and deep gullys. One gully with boulders & cobble with interstitial sediment and organic detritus.
34	Cape Cornwall	SW353320	Caves/Interstitial	High energy environment on N side of Cape. Some caves with suitable habitat and gullys with boulders and interstitial habitat.
35	Portheras Cove	SW386357	None suitable	Shell sand cove backed by granite cliffs. 2 caves at W end but high energy with falls across entrances.

E - Isles of Scilly - Gugh

Site No.	Site	Grid Ref	Habitat Type	Description
*36	Porth Conger, N side of Bar	SV887085	Interstitial	Granite boulders and cobble with chippings, interstitial sediment & detritus beneath
37	Porth Conger, S side of Bar	SV888083	Interstitial	As above

Table 2 continued: Location of sites and general descriptions

F - Isles of Scilly - St Agnes

Site No.	Site	Grid Ref	Habitat Type	Description
*38	Porth Conger, N side of Bar	SV885084	Crevice	Crevices in upper shore boulders & rock faces.
*39	Porth Conger, S side of Bar	SV885083	Interstitial	Granite boulders and cobble with chippings, interstitial sediment & detritus beneath
40	S end of Periglis	SV876083	Interstitial	As for 39.
41	Porth Coose, S end	SV874086	Crevice	Granite outcrops with crevices, and slabs in gullys.
*42	Porth Coose, E end	SV877087	Interstitial	Bank of granite boulders with cobble, chippings, interstitial sediment & detritus beneath
*43	Porth Killier	SV880086	Interstitial	Bank of granite boulders, some embedded with silt & detritus beneath.

G - Isles of Scilly - St Mary's

Site No.	Site	Grid Ref	Habitat Type	Description
*44	Porth Cressa	SV906099	Interstitial	Granite boulders and cobble with chippings, interstitial sediment & detritus beneath
*45	Old Town	SV914101	Interstitial	Platform and massive granite blocks. Small gulley with cobble, pebbles and detritus.
*46	Porth Hellick	SV927107	Interstitial	Granite boulders and cobble with chippings, interstitial sediment & detritus beneath
*47	Toll's Island	SV930120	Interstitial	As for 46.
*48	Block House Point	SV924125	Interstitial	As for 46.
*49	Innisidgen	SV922128	Interstitial	Platform and very large boulders. Gaps with cobble, pebbles and detritus.
*50	W of Bar Point	SV912128	Interstitial	Bank of cobble with large accumulations of dead algae. Man made slipway with occasional semi-embedded slabs adjacent.
51	Toll's Porth, N end	SV908124	Interstitial	Boulders and cobble mostly resting on coarse sand - no suitable interstitial habitat.

Table 2 continued: Location of sites and general descriptions

H - Isles of Scilly - St Martin's

Site No.	Site	Grid Ref	Habitat Type	Description
52	Bull's Porth, E end	SV936159	Interstitial	Granite platform with large rounded boulders and cobble - very little interstitial habitat.
*53	Cove west of St Martin's head	SV937159	Interstitial	Boulder & cobble shore with semi-consolidated raised beach deposit. Semi-embedded slabs with interstitial sediments and detritus beneath
*54	Porth Seal	SV918166	Interstitial	Granite boulders and cobble with chippings, interstitial sediment & detritus beneath
55	Scilly Point	SV924168	Crevice/Interstitial	Upper shore granite platform and massive blocks - some crevice development but very little interstitial habitat.

I - Isles of Scilly - Tresco

Site No.	Site	Grid Ref	Habitat Type	Description
56	Carn Near	SV892134	Interstitial	Sandy shore with platforms, boulders and slabs. Most cobble and slabs had sand underneath, no suitable interstitial habitat.
*57	Old Grimsby	SV894159	Interstitial	Boulder shore with semi-embedded slabs with interstitial sediments and detritus beneath.
58	Gimble Porth, S end	SV891160	Crevice	Granite platform with some crevice development - unsuitable habitat.
*59	Gimble Porth, N end	SV888163	Interstitial	Boulder shore with semi-embedded slabs with interstitial sediments and detritus beneath.
*60	Castle	SV882160	Interstitial	Granite platform and boulders with cobble, chippings, interstitial sediment & detritus beneath
61	South of Castle	SV884157	Interstitial	Boulder/cobble shore with many embedded slabs.
*62	New Grimsby	SV886154	Interstitial	Cobble shore with semi-embedded slabs and boulders.

Table 2 continued: Location of sites and general descriptions

J - Isles of Scilly - Bryher

Site No.	Site	Grid Ref	Habitat Type	Description
*63	Hangman's Island	SV880156	Interstitial	Steeply sloping boulder & cobble shore - semi-embedded slabs with interstitial sediments and detritus beneath.
64	Popplestone Neck, N end	SV874152	Interstitial	Gently sloping shore with slabs and boulders on coarse sand - very little suitable habitat beneath.
*65	Popplestone Neck, S end	SV873150	Interstitial	Granite boulders and cobble with chippings, interstitial sediment & detritus beneath
*66	Great Porth, N end	SV874147	Interstitial	Granite platform with shallow gullys filled with cobble, chippings, interstitial sediment & detritus.
*67	Stony Porth	SV873142	Interstitial	Gently sloping boulder & cobble shore - semi-embedded slabs with interstitial sediments and detritus beneath.
*68	N of Works Point	SV880143	Interstitial	Boulder shore with large semi-embedded slabs.

K - Isle of Wight

Site No.	Site	Grid Ref	Habitat Type	Description
69	Bonchurch	SZ581781	Interstitial	Flint cobble, shingle and loose sandstone blocks beneath landslides.
70	Steephill Cove	SZ550768	Interstitial	Very coarse, boulder, rubble and slab shore at HWM comprised principally of Upper Greensand and chloritic marl.
71	Freshwater Bay (W side of Bay)	SZ345855	Caves	3 caves in close proximity. Upper Chalk with flints, minor faults and fissures. Damp wall with covering of micro algae.
72	Freshwater Bay (E side of Bay)	SZ348855	Cave	Large cavern in the Upper Chalk. Drier and with less algal growth than site 71.
73	Freshwater Gate	SZ348871	Causeway/Sea wall	Loosely mortared slabs at base of road causeway at upper end of estuary, with saltmarsh.
74	Nodes Point	SZ638900	Interstitial	Bembridge Limestone outcrop with loose cobbles between slabs.
*75	Black Rock, N end of Whitecliff	SZ645865	Interstitial	Bembridge Limestone ledge with fissures, and large limestone rocks embedded in shingle.
*76	The Nostrils, Culver Cliff	SZ638854	Caves	2 caves in the Upper Chalk. The northernmost with fissures and moist, algal-covered walls. The southern cave was too high on the shore and had little marine influence.

Table 2 continued: Location of sites and general descriptions

L - Devon Previous sites

Site No.	Site	Grid Ref	Habitat Type	Description
*77	Woody Bay	SS677491	Cave	Upper shore west-facing cave in cliffs of Devonian Lynton slate. Faults dipping 30° inland create suitable crevice habitat. Cave relatively shallow but dark.
*78	Beer	SY227888	Caves	2 caves in Upper Chalk where sheltered aspect moist walls, and ceilings, with crevices have microalgal films present Snails found at crevice openings.
*79	St Mary's Bay, Brixham	SX932555	Cave	Cave with curtain of water dripping from cliff of Mid-Devonian fissured thinly bedded metamophosed limestone shales. Freshwater seepage and travertine deposition within cave.

5. Results & discussion

5.1 Distribution

This survey has yielded 24 new sites for *P. littorina*. These are summarised in Table 3 below. The results are also shown in Table 4 along with eight other Cornish/Scilly sites discovered in 1998/99. The distribution in Cornwall and Scilly is shown in Figures 2 and 3 respectively.

Table 3: positive sites for *P. littorina* discovered during the present survey

Area	Site No.	Site
Cornwall - Lizard	19	Vellan Drang
	22	Mullion Cove
	23	Pollurian Cove/Pedn-y-ke
	24	N of Polbream Point
Cornwall, 'Land's End Peninsula'	27	Rinsey Head
	33	Sennen Cove
Isles of Scilly - St Agnes	39	Porth Conger, S side of Bar
	42	Porth Coose, E end
	43	Porth Killier
Isles of Scilly - St Mary's	45	Old Town
	48	Block House Point
	49	Innisidgen
	50	W of Bar Point
Isles of Scilly - St Martin's	53	Cove west of St Martin's head
	54	Porth Seal
Isles of Scilly - Tresco	57	Old Grimsby
	59	Gimble Porth, N end
	60	Cromwell's Castle
Isles of Scilly - Bryher	63	Hangman's Island
	65	Popplestone Neck, S end
	66	Great Porth, N end
	67	Stony Porth
	68	N of Works Point
Isle of Wight	76	The Nostrils, Culver Cliff

Table 4: Molluscs recorded at each sample site (key on last page of table)

A - Cornwall, River Fowey

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
1	Mixtow, N side of inlet	shells in 99	X	X						X	
2	Mixtow, S side of inlet	-	X							X	*Truncatella subcylindrica*
3	Golant	-									
4	Fowey quay	-									

B - Cornwall, Fal Estuary

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
5	St Anthony: Cellars Beach	-	X	X				X		X	*Truncatella subcylindrica*
6	St Anthony	-	X	X		X		X		X	*Truncatella subcylindrica*
7	Percuil	-	X	X		X					
8	St Just in Roseland	-	X	X		X		X		X	*Onoba aculeus*
9	St Just in Roseland	-	X	X		X		X			*Onoba aculeus*
10	Turnaware Point	-									
11	Pill Point	-	X	X		X	X	X			

Table 4 continued: Molluscs recorded at each sample site

C - Cornwall, Lizard

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
12	Maenporth	-	X	X	X	X	X	X	X	X	*Onoba aculeus*
13	Maenporth	-	X	X	X	X	X	X	X	X	
14	Helford, W of Passage Cove	-	X	X		X		X			
15	Helford, Men Aver	-									
16	Cadgwith Cove	-									
17	Church Cove	-				X	X	X			
18	Housel Bay	-				X	X	X			
19	Vellan Drang	LIVE	X	X	X	X	X	X			
20	Caerthillian/Pentreath	-		X	X	X	X	X		X	
21	Kynance	-			X	X	X	X			
22	Mullion Cove	Fr Shell	X	X	X	X	X	X		X	
23	Pollurian Cove/Pedn-y-ke	LIVE		X	X	X	X	X		X	
24	N of Polbream Point	LIVE			X	X	X	X			
25	Poldhu Cove	LIVE									
26	Church Cove	-				X	X	X			

Table 4 continued: Molluscs recorded at each sample site

D - Cornwall, 'Land's End Peninsula'

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
27	Rinsey Head	LIVE				X	X	X		X	
28	Praa/Little Castle	-		X	X	X	X	X	X	X	
29	Bessy's Cove	-	X		X	X	X	X			
30	Porth Curno	-				X	X	X			
31	Porthgwarra	-				X	X	X			
32	Nanjizal	-				X	X	X		X	
33	Sennen Cove	LIVE				X	X	X	X	X	
34	Cape Cornwall	-	X		X	X	X	X			
35	Portheras Cove	-				X	X	X			

E - Isles of Scilly - Gugh

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
36	Porth Conger, N side of Bar	LIVE									
37	Porth Conger, S side of Bar	-		X		X		X	X		

Table 4 continued: Molluscs recorded at each sample site

F - Isles of Scilly - St Agnes

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
38	Porth Conger, N side of Bar	LIVE									
39	Porth Conger, S side of Bar	LIVE	X	X		X		X	X	X	
40	S end of Periglis	-				X	X	X			
41	Porth Coose, S end	-				X	X	X	X		
42	Porth Coose, E end	LIVE				X		X			
43	Porth Killier	LIVE	X	X		X		X		X	

G - Isles of Scilly - St Mary's

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
44	Porth Cressa	LIVE									
45	Old Town	LIVE	X			X		X			
46	Porth Hellick	LIVE									
47	Toll's Island	LIVE									
48	Block House Point	LIVE									
49	Innisidgen	LIVE	X	X		X	X	X	X		
50	W of Bar Point	LIVE		X		X		X	X		
51	Toll's Porth, N end	-				X		X		X	

Table 4 continued: Molluscs recorded at each sample site

H - Isles of Scilly - St Martin's

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
52	Bull's Porth, E end	-		X		X		X	X		
53	Cove west of St Martin's head	LIVE		X		X		X	X		
54	Porth Seal	LIVE	X	X		X		X			
55	Scilly Point	-				X		X		X	

I - Isles of Scilly - Tresco

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
56	Carn Near	-				X	X	X			
57	Old Grimsby	LIVE	X	X		X		X	X	X	
58	Gimble Porth, S end	-				X	X	X		X	
59	Gimble Porth, N end	LIVE		X		X	X	X			
60	Cromwell's Castle	LIVE		X		X	X	X		X	
61	South of Castle	-	X	X		X	X	X	X	X	
62	New Grimsby	LIVE									

Table 4 continued: Molluscs recorded at each sample site

J - Isles of Scilly - Bryher

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
63	Hangman's Island	LIVE	X	X		X		X	X	X	
64	Popplestone Neck, N end	-		X	X	X		X	X	X	
65	Popplestone Neck, S end	LIVE				X		X		X	
66	Great Porth, N end	LIVE	X	X		X		X		X	
67	Stony Porth	LIVE		X		X		X	X	X	
68	N of Works Point	LIVE		X		X		X	X		

K - Isle of Wight

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
69	Bonchurch	-									
70	Steephill Cove	-	X			X					
71	Freshwater Bay (W side of Bay)	-	X		X	X	X	X			
72	Freshwater Bay (E side of Bay)	-	X		X	X					
73	Freshwater Gate	-	X	X		X					*Truncatella subcylindrica*
74	Nodes Point	-	X	X		X	X				
75	Black Rock, N end of Whitecliff	LIVE	X	X		X					
76	The Nostrils, Culver Cliff	LIVE	X	X	X	X	X	X			

Table 4 continued: Molluscs recorded at each sample site

L - Devon Previous sites

Site No.	Site	*Paludinella*	*Ova myo*	*Leu bid*	*Otina ov*	*Lit sax*	*Mel ner*	*Pat vul*	*Cin tri*	*Las ada*	Others
77	Woody Bay	LIVE									
78	Beer	LIVE									
79	St Mary's Bay, Brixham	LIVE									

Key: *Ova myo = Ovatella myosotis; Leu bid = Leucophytia bidentata; Otina ov = Otina ovata; Lit sax = Littorina saxatilis Mel ner = Melarhaphe neritoides; Pat vul = Patella vulgata; Cin tri = Cingula trifasciata; Las ada = Lasaea adansoni*

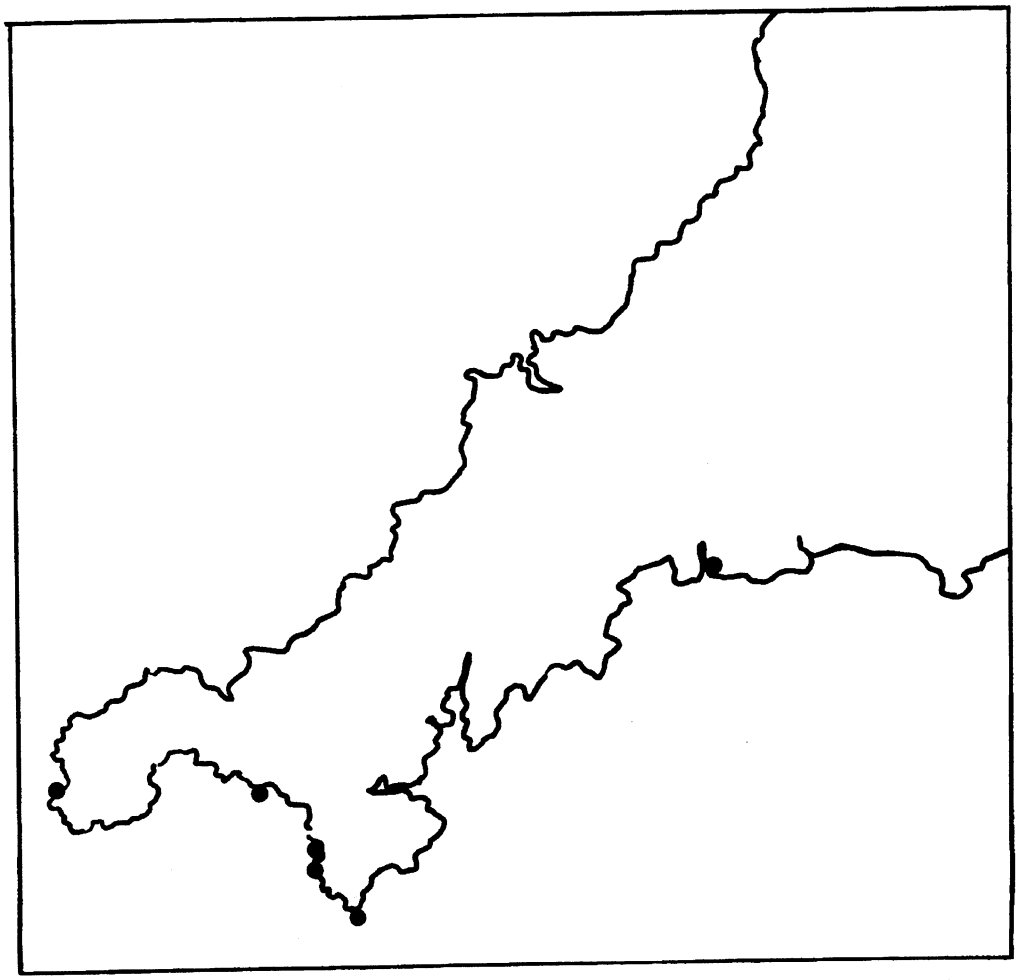

Figure 2: Distribution by site of P. littorina in Cornwall

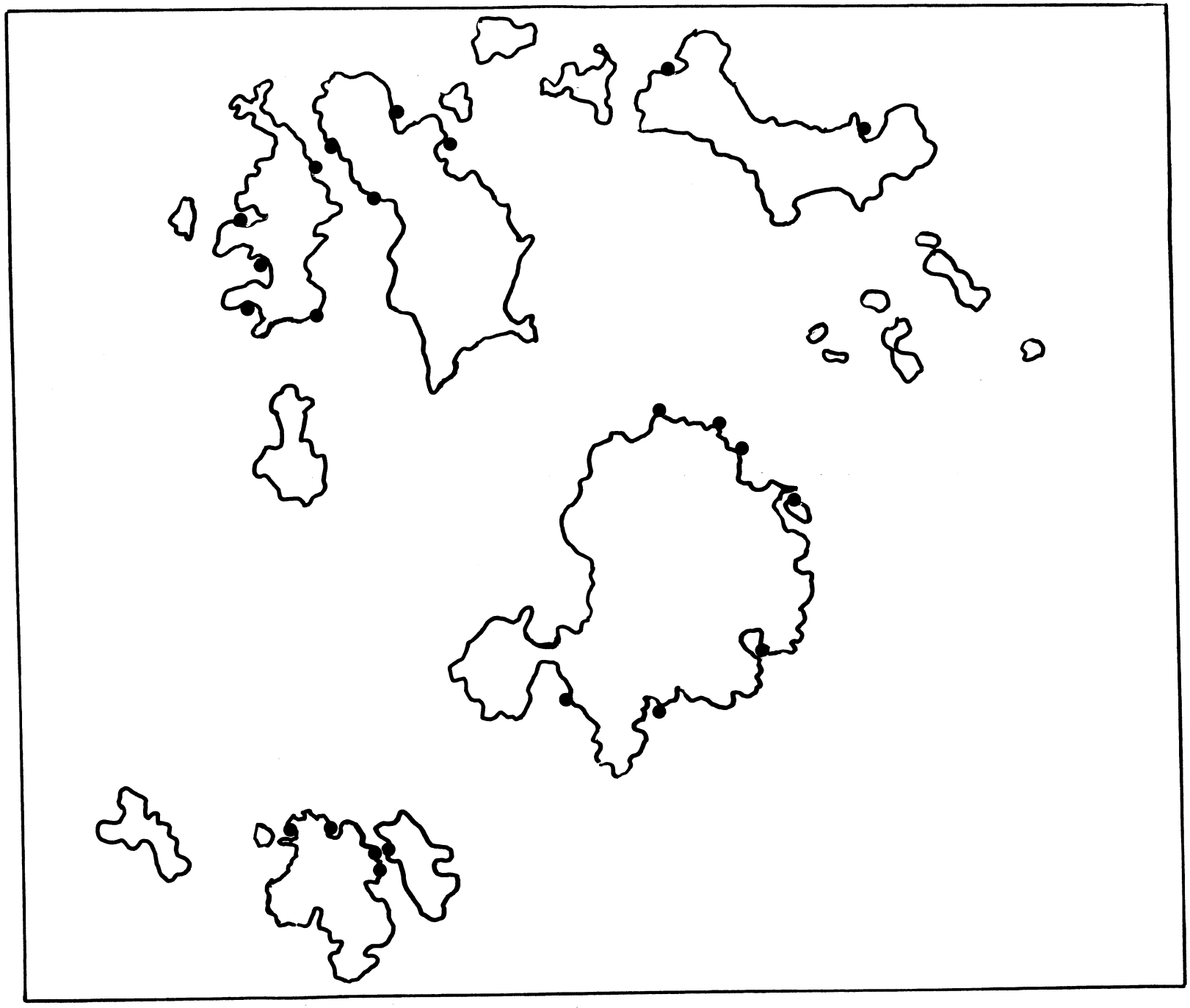

Figure 3: Distribution by site of *P. littorina* in the Isles of Scilly

Figure 4 shows the complete known distribution of *P. littorina* in the British Isles (by 10km square). This shows a typical south-western distribution with a range extending from the Isles of Scilly, eastwards along the Channel coast of England as far as the eastern end of the Isle of Wight (IOW), and northwards on the north coast of Devon and the coast of Pembrokeshire. Although no attempt has been made (within the present survey) to determine if the species lives outside the currently identified boundaries, we can be reasonably confident that this represents a true geographical distribution, and is not merely a function of recording effort. Extensive fieldwork by ourselves on the south coast of England (east of the IOW), Nunn in Ireland and Smith in Scotland have yielded no records. However, the species may well be at other sites in SW Wales, north Cornwall and Devon, and may possibly occur in S/SW Ireland.

The present survey has filled in gaps within the known distributional area on the south coast of England only. The results show that two areas support significant numbers of *P. littorina* populations: the west coast of the Lizard peninsula and the Isles of Scilly.

On the west coast of the Lizard *P. littorina* was found at 5 sites from Vellan Drang on Lizard Point to Poldhu Cove, all in cave habitats. At Polurrian Cove (site 23), *P. littorina* was also found in a crevice outside the cave - a rather atypical site (see section 4). A single living individual was found in the crevice of a small, fist-sized block of serpentine prised off from the vertical gully face. The only other species present was the bivalve *Lasaea adansoni*. A single specimen was also found in a crevice of a granite block on St Agnes, Scilly (site 38). This habitat is always searched by us during general shore surveys but rarely yields *P. littorina*, suggesting that this is not the optimum habitat and the occasional specimen may be an adventive derived from adjacent cave or interstitial populations.

On the Isles of Scilly *P. littorina* was found at a total of 22 sites on the five main islands of St Mary's, St Martin's, St Agnes, Tresco and Bryher, with an additional site on Gugh. The sites were all very similar in character: shores with granite boulders, cobbles and chippings, interstitial sediment and detritus beneath. There were few sites at which the species was not found and the majority of those were at sites where prime habitat occurred. On the basis of the number and concentration of sites, the Isles of Scilly must be considered to be the species' stronghold in the UK.

Populations of *P. littorina* could be located only at two sites on the Land's End peninsula, namely, Rinsey Head and Sennen Cove; the latter confirming Marshall's pre-1913 shell only record. The habitats were generally similar; upper shore with gullies and accumulations of large boulders and cobbles with interstitial sediments and organic detritus. Only a single live specimen could be found at each.

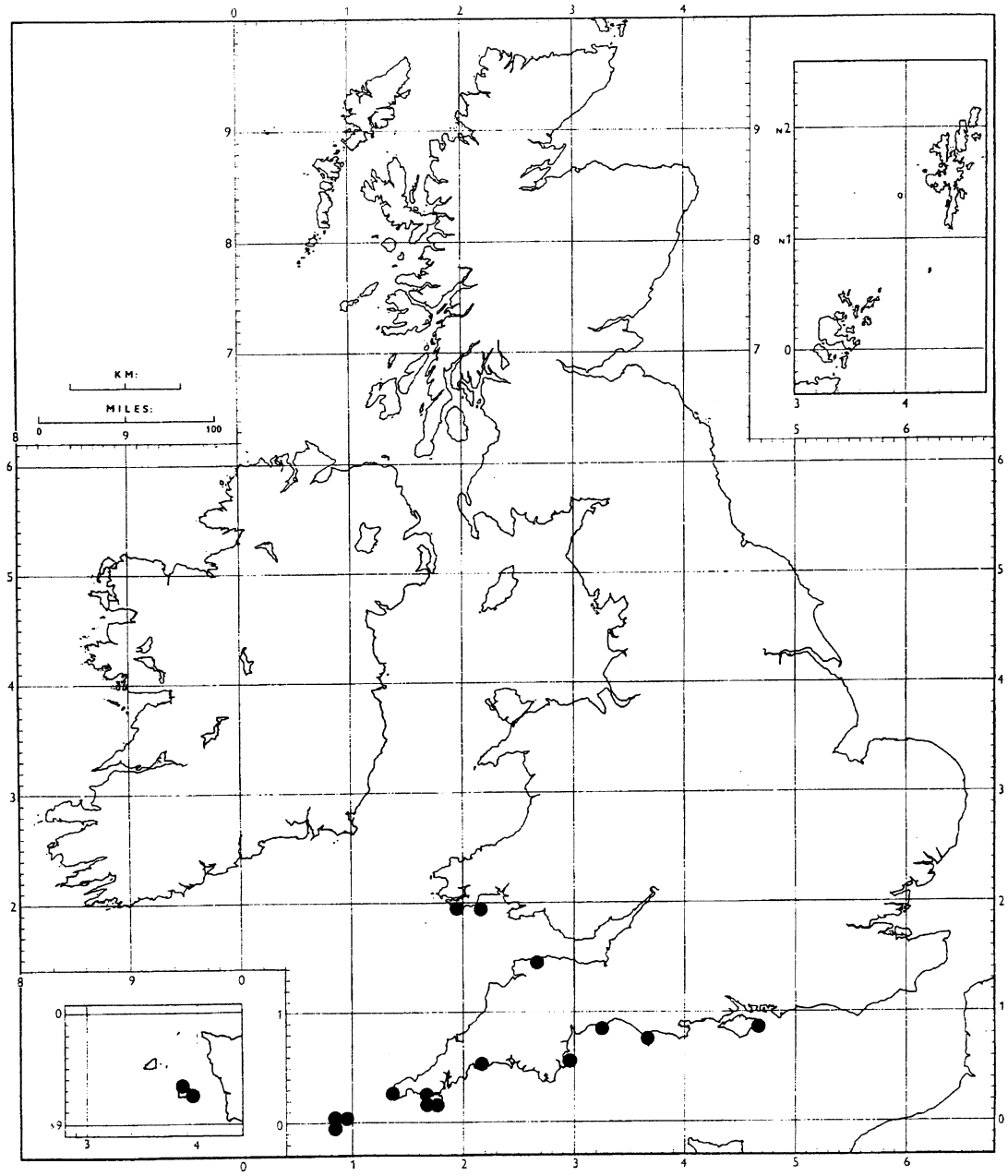

Figure 4: Distribution by 10km square of *P. littorina* in the British Isles

Dead shells of *P. littorina* were found in the Fowey estuary at Mixtow (site 1) in October 1998, from a sample of sediment and organic detritus collected from an aggregation of cobble and rubble at the base of an old sea wall. However, searching of the site during the present survey failed to yield any further specimens, dead or alive. Therefore, we cannot be certain whether the species continues to live at the site. More extensive searching of the site would resolve its present status but would inevitably result in the destruction of a significant portion of the available suitable habitat. At Mixtow the upper shore is bounded either by the eroding fissile Devonian schist outcrop or a low, loosely mortared wall below the residential properties which run along the landward margin. Given the success at locating a number of sites elsewhere, such action is not justified.

On the Isle of Wight, *P. littorina* was again confirmed to be living at Forbes & Hanley's (1852) site at Whitecliff Bay. In addition, a thriving population was discovered in one of the caves (known as the Nostrils) in the Upper Chalk on Culver Ledge. The site was already known to us as a site for *Otina ovata* - the most easterly site in the English Channel - but we had not previously observed *P. littorina* (see factors discussed in section 2).

5.2 Fauna associated with *P. littorina*

Table 4 also shows the other species of molluscs recorded from the supralittoral zone at each survey site. Species such as *Patella vulgata* and *Melarhaphe neritoides* are features of the zone but are not considered to be associates of *P. littorina*. *Littorina saxatilis* is present in caves to the limit of light penetration, and is present in interstitial habitats but less often on the undersides of embedded rocks or deep in the interstitial lattice. The most frequently associated species in caves is the small pulmonate *Otina ovata*. This species was present in all of the cave sites which supported *P. littorina*, on the Lizard, Whitecliff Bay, IOW, and the 3 previously known sites in Devon. *O. ovata* is also present in the Pembrokeshire and Caldey Island cave sites. The other mollusc considered an associate of *P. littorina* in caves is the elobiid *Ovatella myosotis*. In interstitial habitats the mollusc species most usually associated are the elobiids *Ovatella myosotis* and *Leucophytia bidentata*. Whilst these species co-occur they show slight differences in zonation. *L. bidentata* extends further down the shore (beyond the *Ovatella* and *P. littorina* zone), and where it lives with the rissoid *Cingula trifasciata*. Crevice habitats in rock faces and platforms support *L. bidentata, C. trifasciata, Otina ovata* and *Lasaea adansoni*.

In addition to the mollusc species which can occur with *P. littorina*, there is a suite of other organisms which were frequently observed to be associated with **the zone** in which *P. littorina* was sought and often found. These are given in Table 5.

Table 5: Non-molluscan species associated with *P. littorina*

Classification	Taxon
Platyhelminthes, Turbellaria	*Procerodes littoralis*
Crustacea, Isopoda	*Ligia oceanica, Sphaeroma serratum*
Crustacea, Amphipoda	*Orchestia* sp., *Talitrus saltator*
Acarina, Bdellidae	snout mites: *Bdella* sp., *Neomolgus* sp.
Chilopoda, Geophilomorpha	*Strigamia maritima*
Collembola, Neanuridae	*Anurida maritima*

In cave habitats the most frequent associates are *Ligia oceanica* and the red snout mites of the family Bdellidae. In particular the red mites are a good indicator that the correct zone is

being searched and they also occur in the interstitial habitat of upper shore shingle or granite boulders described in this report. Although *Ligia* is also a good zonal indicator species, some caves were found to support large numbers of individuals in upper shore/splash zone crevices. These crevices often contained substantial amounts of organic detritus, for example small fragments of rotting algae and *Ligia* faecal material. In habitat where *Ligia* appeared to be dominant, *P. littorina* was absent.

Bdellid mites are also associated with *P. littorina* on the open shore, as are individuals of *Procerodes littoralis*. Neither of these organisms was observed to occur in significant numbers in *P. littorina* habitat. At many sites on the open shore, in addition to those species, upper shore species of isopod and amphipod (Table 5) occur at the height on the shore where *P. littorina* may be found. However, as with cave habitats, we believe large numbers of these crustaceans to be contraindicators of *P. littorina*'s likely presence. Some organisms which inhabit the targeted zone of the shores searched, for example *Anurida maritima*, were less widespread in distribution in relation to the sites visited during the present survey. At some sites on St Martin's, Tresco and Bryher, the undersides of suitable granite slabs supported dense, apparently breeding, colonies of *A. maritima* but *P. littorina* was never found in these locations. This implied exclusion of *P. littorina* by *A. maritima* (and the large numbers of isopods and amphipods) was borne out at site 63 (east coast of Bryher) where after extensive but fruitless searching of a stretch of granite boulder shore where amphipods, isopods and Anurida were conspicuous, a shift of some 30-40m north, to habitat with the same physical properties at a similar level on the shore, resulted in finds of *P. littorina* without the suite of organisms occurring further south. At some sites, solitary centipede individuals occurred with *P. littorina* when it was found at the upper limit of the zone in which it was believed to be likely to occur.

5.3 Population structure and abundance

A feature of many of the positive sites was the low numbers of *P. littorina* individuals found. No attempt was made to quantify the populations as once the animals were located at one site, the authors moved on to a different site in order to maximise the search time within the potential distributional range both from the tidal cycle point of view, and within the overall time allocation for the project. Additionally, further searching of locations with embedded slabs results in unnecessary habitat destruction. At most of the cave sites less than 5 individuals were seen, and in some cases, only one. Only occasionally was *P. littorina* seen in larger numbers, namely in one cave at site 76 (The Nostrils, Whitecliff Bay) and at site 78 (Beer Regis, Devon). This might imply that the populations at many of the cave sites are small. However, given the species' cryptic habitat, possible circadian rhythms, difficulty of access to the microhabitat, this is unlikely to be the case. Higher numbers of individuals were recorded from interstitial habitats particularly when found on large embedded or semi-embedded rocks and slabs, e.g. a single rock in the cove on the north coast of St Martins, Scilly (site 53) supported 20 specimens.

5.4 Life cycle

Little is known about the breeding and growth of *P. littorina* (Fretter & Graham 1982). The animals are probably annuals and the relatively broad diameter of the juvenile shell (protoconch) indicates that the animals develop directly from the eggs rather than have a free larval stage. We must presume that the eggs are laid deep in crevices, and probably in low numbers. All of the animals found during this survey in July (Isle of Wight) and September

(Cornwall and Scilly) had shells of adult or near adult size. However, during a previous survey of sites in Pembrokeshire carried out in early March 1997, snails at varying stages of maturity were observed (Light & Killeen 1997). Although the majority of snails noted were adults (and this may well reflect the visibility advantage of greater size), several animals when removed from the substrate and viewed with a handlens were noted to be sub-adult and one very small individual of 1.5 whorl size was seen at one site. Based on this limited evidence we nevertheless hypothesise that *P. littorina* breeds in late winter/early spring and completes its growth in a relatively short period of time, perhaps 2-3 months. The presence of adults at most times of year also suggests that the populations may be perpetuated by a more than one annual breeding event.

5.5 Other potential sites

Whilst this survey has demonstrated that *P. littorina* is more widespread and common in south-west England than previously known, we believe that the species remains under-recorded. There are numerous cave sites which can be seen from the air or cliff tops, or identified from maps, which cannot be accessed from the shore or which can only be accessed on extreme low spring tides. It is therefore also very likely that *P. littorina* lives, but remains undetected, at sites which have been investigated by the present survey. Although one cannot expect the species to live at every site with apparently suitable habitat, there are several prime sites at which it was not found (e.g. sites 12/13, Maenporth; site 15 Men Aver; site 29, Bessy's Cove, and sites 71/72, Freshwater Bay) which may have been accessed and searched at a time when the animals were hidden in their crevices. However, this and previous surveys have revealed that there are also sections of the south Cornish coast where no suitable habitat exists. Similarly there are also significant sections of the Devon and Dorset coasts which do not support suitable *P. littorina* habitat.

5.6 Coexistence of *P. littorina* and *Truncatella subcylindrica*

This survey has also revealed further populations of another upper shore Red Data Book (RDB2) prosobranch *Truncatella subcylindrica* (see Appendix 3). Whilst both *T. subcylindrica* and *P. littorina* live in very similar habitats within the supralittoral zone, it is of note that the only site in Britain at which the two are associated is the Fleet in Dorset. Although in Britain, *T. subcylindrica* shows a preference for sheltered, estuarine habitats, and *P. littorina* prefers more open marine habitats, we have found both species together in both types of habitat in Europe e.g. the Rance estuary in Brittany, France, and on open coasts of Madeira. Without further information on the food preferences, and sensitivity to temperature and pollution (for *T. subcylindrica* in particular) this phenomenon cannot be explained.

6. Conservation and management

6.1 Current site protection

A significant number of the British *P. littorina* sites are within SSSI (and in some cases SAC) or very close to SSSI boundaries. All sites on the west coast of the Lizard are included, the Rinsey Head site is just outside the SSSI boundary but the Sennen Cove site is not designated. With a few exceptions (e.g. St Martin's Flats), much of the Isles of Scilly SSSI is terrestrial with Mean High Water Mark (MHWM) given as the boundaries in the Citations. Given that *P. littorina* can live around MHWM, it is open to interpretation as to which side of

the SSSI boundaries many of the *Paludinella* sites lie SSSI. The Isle of Wight sites lie within (or very close to) the boundaries of the South Wight Maritime SAC.

6.2 Threats

There appear to be very few threats to most of the English *P. littorina* populations (except perhaps in the Fleet, see advice package EN1999). Threats potentially arise from construction of sea defences, coastal developments, slipways and landclaim. However, most of the sites are in relatively remote places that are less likely to come under such threats. Several sites are also afforded some protection from their location in SSSI. The most obvious potential threat is from a major oil spill or the affects of the subsequent use of dispersants. However, a survey in Pembrokeshire and Caldey Island following the *Sea Empress* spill showed that there was no obvious evidence of damage to populations at the known sites by oil contamination (Light & Killeen 1997). Oiling also occurred in Porth Hellick, St Mary's (Scilly) from the wreck of the *Cita* in March 1997 (Roger Covey pers. comm.). Bunkers and light fuel oil covered the beach extensively. Rocks were scrubbed manually, whilst gravel and sand material was removed and for mechanical cleaning and then replaced. The survival of *P. littorina* at these impacted sites suggests that interstitial habitats, particularly those protected by large rocks or boulders may be so stable as to be unaffected by surface oil coatings.

6.3 Monitoring & further survey

Although there is no requirement under present conservation criteria, a programme of monitoring would be desirable at selected sites, although it does present problems. It has been shown that weather, state of tide, possible circadian rhythms, in addition to the species' small size and cryptic habitat all affect the ability to locate *P. littorina*. Although the basis of a monitoring programme is essentially to detect unacceptable change, interpretation of results must be based on detailed knowledge of the species' habitat requirements. Therefore a simple observational method merely to confirm continued survival of populations would be adequate. Cave habitats provide the best opportunities for monitoring as examination of the same interstitial sites cannot be repeated due to the disturbance caused. For *P. littorina*, unacceptable change may be defined as a decline in abundance or disappearance from a site. Given the problems with surveying, numerical abundance cannot be used to reliably detect change. We suggest that if the snail could not be found on 3 consecutive occasions, then there may be cause for concern, but with our present knowledge, we are unable to suggest positive actions to arrest any declines. If, as suspected, the animal is a direct developer and lays only a few eggs, it is likely to have poor powers of dispersal, and the chances of recolonisation from distant populations are low.

We would also encourage English Nature staff and others where appropriate to seek out new sites for the species. Details of species recognition are given in Appendix 2 and descriptions of the characterising fauna and flora at *P. littorina* sites are given in sections 2 and 5. If a monitoring programme option is chosen, we recommend that a one day training course is provided to assist with site selection, field location and identification skills of the snails.

6.4 Conservation requirements & status

In light of the number and location of sites, there do not appear to be any special conservation or management measures necessary to ensure the survival of *P. littorina* populations.

This, and previous surveys by the authors, have demonstrated that *Paludinella* covers a wider range of supralittoral habitats, and is much more widespread within its known geographical area, than previously believed. Given the inaccessibility of many potentially suitable sites and habitats, it is likely that the species is still under-recorded.

There appear to be very few physical threats at the majority of sites and few of the populations could be considered especially vulnerable. Furthermore, given that *P. littorina* is a difficult animal to locate, we do not consider damage to populations from collection to be an issue.

Excluding the Channel Islands, *P. littorina* is known living in fifteen 10km squares (Figure 4) in Britain. As such, the species still fulfils the criteria for its status as an RDB3 - Rare species (Bratton 1991). The continued inclusion of *P. littorina* on Schedule 5 of the Wildlife & Countryside Act is no longer merited on the basis of rarity or specific threat. However, the presence of a Schedule 5 species adds to the SSSI protection and provides an additional conservation issue when objecting to proposed developments. We recommend that its position on the WCA is reviewed.

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Appendix 1. Notes on the taxonomy of *Paludinella*

There is a consensus that there is more than one species currently assigned to the taxon *P. littorina*. Various authors (e.g. Sabelli *et al* 1990) have expressed doubt as to whether populations found in Britain are the same species as those found in the Mediterranean. Many of the reasons for this confusion are based upon a series of interpretations and references in systematic lists and papers (e.g. Nordsieck 1972). Over the last 20 years several workers have acknowledged the existence of more than one species of *Paludinella* but none has resolved the problem.

We have examined material from many NE Atlantic and Mediterranean localities either collected by ourselves, held in UK and French museums, and in private collections. Results based on characters such as shell morphology, genital anatomy and radulae have been used to assess the taxa within the species complex.

The results have shown that the snail currently referred to as *P. littorina* might be an aggregate of as many as four species. They are placed into two main groups according to the size of their protoconch. There are those with broad, well-defined protoconchs indicating direct development, and those with narrower protoconchs indicating a free-larval stage.

Atlantic populations (Britain, Channel Islands, northern France, Madeira, Spain) all have a broad protoconch and have little difference in shell size and shape. The genital anatomy and radulae of English and Madeiran specimens appear to be morphologically identical. It is suggested that populations of *Paludinella* in the Atlantic are the same species.

Populations in the Mediterranean, and Sicily in particular, present more difficulties. Both wide- and narrow-protoconch forms are present and it is unclear how many species are involved. Narrow-protoconched forms differ anatomically form Atlantic wide-protoconched forms, but shell biometrics indicate there may be more than one species. Wide-protoconched forms from northern Italy and Sicily have been examined but without anatomical study it cannot be established whether these are the same as the Atlantic forms, or indeed, as each other.

The problem of nomenclature remains. Delle Chiaje described *P. littorina* from Sicily, but his type material is no longer extant. Therefore we do not know which form was described (the description is so short that it is unenlightening) and there will be a need to redesignate type material. This could also result in a name change for the Atlantic forms, for which *P. globularis* (Metcalfe in Thorpe, 1844) is the earliest available.

A paper addressing these taxonomic problems and is in preparation.

Appendix 2. Aspects of identification and field recognition

(from Light & Killeen 1997)

Two main problems exist in searching for *P. littorina* in the field:

1. Small size - maximum shell height 2mm, maximum breadth 1.75mm.
2. Ability to distinguish it from juvenile *Littorina saxatilis*.

Figures 5 - 8 are provided to assist with identification of *P. littorina* and should be consulted in conjunction with the following notes.

Diagnostic characters of *P. littorina* are provided by Graham (1988). The shell is small, glossy and semitransparent. The protoconch is relatively broad, the spire is short and the last (body) whorl is large. The aperture is oval and a small umbilicus is present, Figure 5. The animal is pale grey and appears whitish through the shell. The snout is broad, bifid and the tentacles are short and stubby with eyes seen as two black dots at the base of the tentacles, Figure 6.

Juveniles of *Littorina saxatilis* differ in the following respects:

1. The overall shell shape is different in that the protoconch is proportionately narrower appearing as a dark bead on the apex of the shell, and the body whorl is proportionately larger, Figure 7. The aperture is more rounded.

2. The shell of *Littorina saxatilis* is not glossy but rather opaque, and the region of the animal which occupies the upper portion of the shell is darkly pigmented thus the upper half of the shell is dark even in pale specimens which might superficially resemble *Paludinella*. In *P. littorina* the whole specimen appears uniformly pale horn-coloured.

3. Even in very small *Littorina* shells, there are traces of the development of spiral sculpture which are visible running from the outer lip (margin of the aperture) around the body whorl.

4. The head is black to grey in adults but may be unpigmented in juveniles. Tentacles may be dark or pale with longitudinal black stripes but they are proportionately longer in *L. saxatilis* than the distinctive stubby tentacles in *Paludinella.*

Other potential obstacles to locating *Paludinella* in the field arise from the possibility that the state of the tide in relation to time of search may affect success in locating the species because the tidal cycle may in some way control the snail's locomotory/feeding behaviour.

Another difficulty may arise if the rock surface is coated in a residual water film or is subject to seepage from the cave walls. Small snails moving through this water film are even more difficult to spot because the shell morphology is masked.

A further caveat should be considered. The small pulmonate, *Otina ovata*, has been observed to co-occur in *Paludinella* zones in caves. Although the shell shape is quite different, Figure 8, small individuals of the former species are similar in size to *Paludinella* and *Otina* animals may have horn-coloured semitransparent, glossy shells. (Some populations of *Otina* may have reddish to purplish brown shells). The body colour varies but in paler shelled forms is pale grey. Care should be taken during timed counts and general searching for *Paludinella*, to ensure that *Otina* is not mistakenly included in observations. This is particularly important where individuals are spotted within crevices and not removed for checking. In addition to artificial lighting, the most useful piece of equipment is a fine, good quality paintbrush for handling specimens.

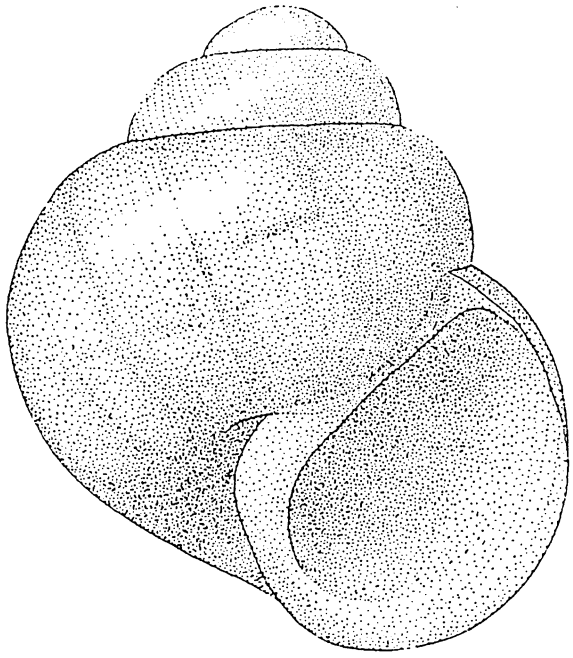

Figure 5: *Paludinella littorina* (delle Chiaje) drawn by D. G. Guntrip. x60.

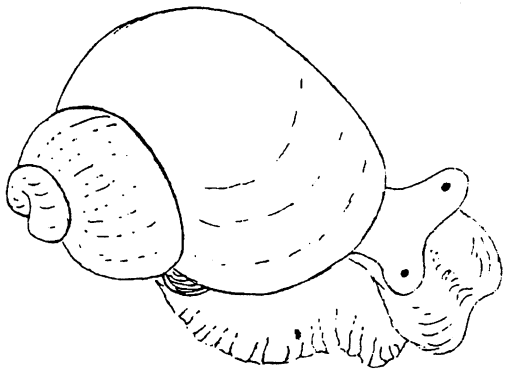

Figure 6: *Paludinella littorina* showing animal crawling. Note bifid snout and short stubby tentacles with anterior eyes, and edge of operculum on upper surface of posterior region of foot. Drawn by J. M. Light. Shell height 1.5mm; shell width 1.3mm.

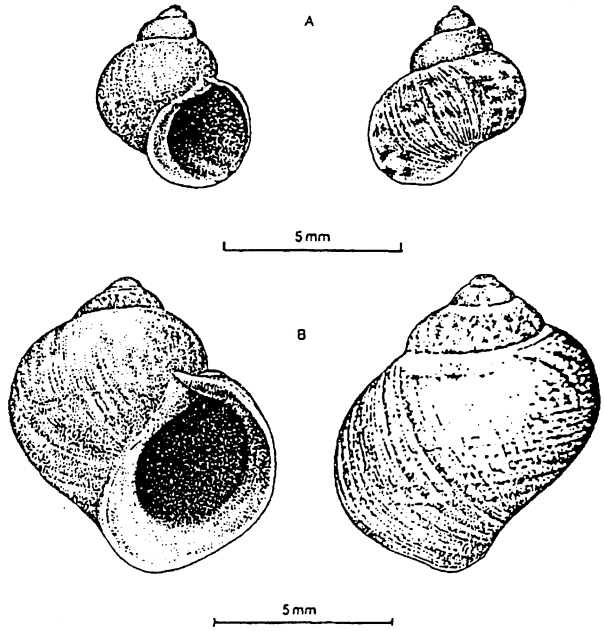

Figure 7: *Littorina saxatilis* (Olivi)
A: Small thin-shelled morph
B: Large thick-shelled morph
2 varieties from Graham, 1988

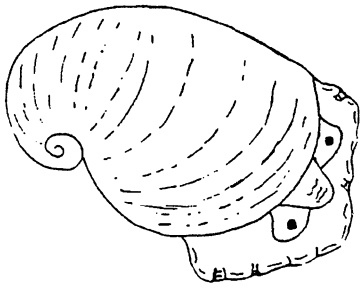

Figure 8: *Otina ovata* (Brown). Note blunt proboscisform head with eyes in the centre of short lobate tentacles. Foot is relatively large and broad anteriorly. Maximum shell dimension from edge of aperture 2mm, breadth 1.5mm.

Figure 5: *Palundinella littorina* (delle Chiaje)

Figure 6: *Paludinella littorina* showing animal crawling

Figure 7: *Littorina saxatilis* (Olivi)

Figure 8: *Otina ovata* (Brown)