Recovery of a Biodiversity Action Plan Species in Northwest England: possible role of climate change, artificial habitat and water quality amelioration

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Cover Photo: Extensive cover of *Sabellaria alveolata* at Tarn Bay, Cumbria. Matthew Frost.

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EXECUTIVE SUMMARY

General Introduction

The honeycomb reef worm *Sabellaria alveolata* is recognised as being an important component of intertidal communities. It is a priority habitat within the UK Biodiversity Action Plan and as a biogenic reef forming species is covered by Annex 1 of the EC habitats directive. *S. alveolata* has a lusitanean (southern) distribution, being largely restricted to the south and west coasts of England. A broad-scale survey of *S. alveolata* distribution along the north-west coasts was undertaken in 2003/2004. These records were then compared with previous distribution records, mainly those collected by Cunningham in 1984. More detailed mapping was carried out at Hilbre Island at the mouth of the River Dee, due to recent reports that *S. alveolata* had become re-established there after a long absence.

Surveys

The broad-scale survey showed *S. alveolata* to have appeared at new sites, as well as increasing in abundance at many sites where it had previously been recorded. On Hilbre, *S. alveolata* was found to be well established, with colonies on the northeast, north and southwest side of Hilbre and Little Hilbre Islands. On the northeast side, *S. alveolata* formed a patchy sheet reef whereas on the north and southwest sides it tended to be found more often as hummocks. The faunal community associated with *S. alveolata* at Hilbre was found to be impoverished.

Overview

Data from the Marine Biodiversity and Climate Change Project (MarClim), used in conjunction with new data collected as part of the broad-scale survey, can be compared with past data in order to examine changes in distribution. Although the geographic range of *S. alveolata* is fairly stable, there is a degree of fluctuation in distribution and abundance within this range. Recent increases in abundance and the establishment of *S. alveolata* in new areas may indicate the effect of climate change: Potential influencing factors include milder winters and increases in sediment supply as a result of increased storminess. Artificial habitat such as sea defence structures also plays a crucial role as it enables the establishment of *S. alveolata* in areas where it would have previously been excluded due to lack of suitable substrate. This artificial habitat has been present for some time before the establishment of new *S. alveolata* colonies, however, and it is likely that water quality amelioration which is a more recent phenomenon is the other factor influencing the establishment of *S. alveolata* in these areas.

Activity Report

Broad-scale mapping - The MarClim team (Nova Mieszkowska, Jain Bennet) undertook a survey in North Wales in August 2003. A further visit to North Wales and North West England was made in December 2003 and Dr Matthew Frost and Jefferson Murua completed the survey of North West England in March 2004. In addition, other MarClim data entries were used and sites sampled by Cunningham et al. (1984) revisited.

Detailed mapping - A visit to Hilbre Island and the Wirral foreshore was made by Prof SJ Hawkins and Dr P Moschella in August 2003. This included briefing the local contact (Mrs Christine Smyth) on resurvey methods. Christine Smyth started mapping the Wirral *Sabellaria alveolata* beds in liaison with the Warden at Hilbre Island. Dr Matthew Frost and Christine Smyth completed this mapping in March 2004.

General Introduction

Background

The honeycomb reef worm *Sabellaria alveolata* is recognised as being an important component of intertidal communities (Holt et al., 1998). Historically, there has been a great deal of research into its ecology. Much of the early research in the UK was carried out by Douglas Wilson from the Marine Biological Association who investigated the ecology of *S. alveolata* larvae (Wilson, 1929; Wilson, 1968a; Wilson, 1968b; Wilson, 1970) as well as studying its long term growth and distribution patterns at a site at Duckpool in North Cornwall (Wilson, 1971; Wilson, 1974; Wilson 1976). The ability of *S. alveolata* to form extensive reefs means that it also constitutes an unusual habitat that can have an associated rich fauna (Gruet, 1982) and its role as a 'bioconstructor' has more recently begun to generate interest from biogeomorphologists (Naylor & Viles, 2000).

The restricted distribution of *S. alveolata* in the UK where it is at the northern end of its range, along with its vulnerability to disturbance has led to its inclusion as a priority habitat within the UK Biodiversity Action Plan. Biogenic reefs were also selected as one of the sub features of the marine habitats listed in Annex 1 of the Europeans Union's "Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora" (Habitats Directive). A report on the dynamics and sensitivity of biogenic reefs for the UK marine SACs project identified *S. alveolata* as one of the most important biogenic reef forming species in inshore British Waters (Holt et al., 1998).

Although having a Lusitanean distribution in the UK, *S. alveolata* is generally restricted to the south and West coasts of England (Bamber & Irving, 1997). It does, however, extend reasonably far north along the West coast of the UK, being reliably recorded as far north as the outer Solway Firth (Cunningham et al., 1984). Overall, however, the *S. alveolata* biotope is considered rare in the UK as it covers less than 0.5 % of the total UK coastline (Sanderson, 1996).

Aims

The aims of the present report are as follows:

a) *Broad-scale survey* – To map the present distribution and abundance of *S. alveolata* from The Great Orme (Anglesey) to St. Bees on the Cumbrian coast and compare this with previous records of its distribution.

b) *Detailed mapping* – To detail the extent, abundance and type of *S. alveolata* growth on Hilbre Island at the mouth of the River Dee, including details of the associated community.

c) *Overview* – To place all of the information gathered for this report into a spatial and historical context and discuss the role of potential influences on *S. alveolata* distribution.

Study Area

The area studied as part of the investigation into the broad-scale distribution of *S. alveolata* stretched from Great Orme, North Wales and included the area northwards as far as St Bees Head on the Cumbrian coast of England (on the eastern side of the Irish Sea Basin). This stretch of coast therefore occurs within the OSPAR Celtic Seas region (Weighell et al., 2000). The physical processes in the Irish Sea are dominated by the large tidal range, which increases from west to east with Liverpool Bay having an average tidal range of 8.4 m (Taylor & Parker, 1993).

Within the above area, a more detailed mapping exercise was carried out at Hilbre Island, Little Hilbre Island and Little Eye which form the Hilbre Islands group. These three tidal islands occur at the mouth of the Dee Estuary and constitute one of the few rocky areas in Liverpool Bay; they have therefore been fairly intensively sampled over the years (Mills, 1998). The Hilbre Island group has been designated a local nature reserve and a SSSI.

Broad-scale survey

Introduction

Review of past data in North-west England and North Wales

The most extensive review of the distribution and local abundance of *S. alveolata* was undertaken by Cunningham et al. (1984). This review used past records from the literature, data from new shore surveys and reports via correspondence from other marine scientists. As a result of this exercise, changes in the extent of *S. alveolata* distribution over a period of approximately 100 years were documented. In order to evaluate long-term temporal variability in *S. alveolata* distribution and abundance, the data were divided into three arbitrary periods: pre-1963 (before the cold winter of 1962/1963), 1964-1979 and 1980-1984 (Cunningham et al., 1984). A summary of this information (and other records up to 2002), that are relevant to the area under investigation for the present study is given below.

Pre 1963: Up to this point there were only three sites in North West England and North Wales where *S. alveolata* had been reported (although there are relatively few surveys available for this period). The first record from Wilson in the 1950s was from Colwyn Bay, North Wales. *S. alveolata* was recorded as abundant at Hilbre Island at the mouth of the River Dee by Herdmann (1919) and was also recorded from Heysham in Morecambe Bay in 1959-1961.

1964 -1979: There were no records of *S. alveolata* from the North Wales coast from this period and it had also disappeared from Heysham and become very rare at Hilbre Island. It had, therefore, largely vanished from the study area. However, north of the study area, it was recorded for the first time at Allonby Bay on the southern side of the outer Solway Firth and at a site in Scotland on the Isle of fleet on the northern side of the Solway Firth.

1980 – 1984: In Cunningham et al.'s resurvey, *S. alveolata* was still found to be completely absent from Anglesey to Barrow in Furness but was found further north along the Cumbrian coast from

Annaside Banks up to St Bees. North of the present study area, *S. alveolata* was again found in Allonby Bay. *S. alveolata* had also spread since 1979 from its sites in the Solway Firth, now being recorded further west as far as Luce Bay.

1985 – 2002: The only information for the present study area is from St Bees (Allen et al, 1991) and *S. alveolata* is recorded as being absent. *S. alveolata* was recorded north of the study area however, as far north as Maryport (Allen et al., 1991).

North-west England and North Wales resurvey, 2003 - 2004.

A survey was undertaken in 2003/2004 to compare the present distribution and local abundances of *Sabellaria alveolata* with the data from past records, mainly from Cunningham et al. (1984).

Methods

Each site was visited and a thorough search was made using the site and grid reference information from the previous survey (Cunningham et al., 1984). If *S. alveolata* was not found at the specified grid reference but other suitable substrate at the site was found, then this was also searched. The modified form of the SACFOR abundance scale used by Cunningham et al. (1984) to record *S. alveolata* was also used here. This scale is shown in Table 1. Photographs were also taken at each site (see appendix 1 for full list) and put onto a CD ROM (appendix 3).

Table 1. Scale of abundance used to record *Sabellaria alveolata*. Taken from Cunningham et al. (1984).

Abundance	**Description**
N	Absent
R	Rare, <10 found in 30 minute search
O	Occasional, scattered individuals, no patches
F	Frequent, many scattered individuals and small patches
C	Common, large sheets or patches at some shore levels (not forming large hummocks)
A	Abundant, large colonies, forming hummocks over 1 ft across – more than 20% cover overall at shore levels of peak abundance
SA	Super-abundant, massive reefs – colonies 2-3 ft thick - >50% cover at level of maximum abundance

Results

A table comparing the distribution and abundance of *S. alveolata* in the present study with previous records is shown below (Table 2).

Table 2. Past data on *Sabellaria alveolata* maximum abundance in Northwest England and Wales, with recent resurveys included. N = absent, R = rare, O = occasional, F = frequent, C = common, A = abundant and SA = super-abundant (massive reefs). P = recorded as present but abundance not known. From Cunningham et al. (1984) and resurvey.

Location	**OS reference**	***Sabellaria alveolata abund.***				**Comments**
		Pre-1963	**1964-79**	**1980-84**	**2003/4**	
Penmon	SH634805			N	N	
Great Orme's Head	SH7583			N	N	
Little Orme's Head	SH820825			N	N	
Rhos-on-Sea	SH842812			N	N	
Colwyn Bay	SH8778	P		N	R	
Hilbre Island	SJ1887	A	R	N	A	
Wirral Foreshore					A	
Lytham Pier	SD3327			N	N	Pier no longer present
St Annes Pier	SD3129			N	N	
Fleetwood, Rossall Pt	SD312479			N	F	
Heysham*	SD4060	F-O		N	N	
Holme Island	SD4060			N	N	
Humphrey Head	SD421780			N	N	
Wadhead, Scar	SD392732			N	N	
Walney Island	SD313744			N	N	
Annaside Bank	SD090849			A	SA	
Tarn Bay	SD073903			A-SA	SA	
Drigg	SD041983			A	SA	
Seascale	NY032011			O	SA	
Sellafield	NY0103			O	A-SA	
Nethertown	NX986073			A	A	
St Bees	NX955117			O	C-A	Recorded as N in 1991 by Allen et al.

In the present study, *S. alveolata* was only recorded once in North Wales. at Colwyn Bay. This site is also where the only previous record for North Wales occurred although it was recorded as absent in the survey by Cunningham et al. (1984). Also, after a long period of absence (60 – 80 years, see Craggs (1982)), *S. alveolata* is again abundant on Hilbre Island. It is also widespread on the sea defences of the Wirral foreshore, an area for which there are no previous records. Along the Lancashire coastline *S. alveolata* is still largely absent although it was found in the present study at Rossal Point in Fleetwood (Figures 1 & 2), a new record for this site.

Figure 1. Small patch of *S. alveolata* (highlighted by white circle) at Rossall Point, Fleetwood.

Figure 2. General view of shore at Rossall Point, Fleetwood.

Along the Cumbrian coastline up to St Bees, *S. alveolata* is present in vast quantities. Although it has previously been recorded along this stretch of coast, it appears to have increased in abundance. Examples of *S. alveolata* reefs at Tarn Bay, Cumbria, are shown in Figures 3 and 4.

Figure 3. Extensive cover of *S. alveolata* at Tarn Bay, Cumbria

Figure 4. *S. alveolata* reefs at Annaside Banks. Senior author included to show height of *S. alveolata* reef.

S. alveolata was mainly recorded growing on sea defences on The Wirral foreshore (Table 3). These records are important as the sea defence structures in this area represent new habitat for *S. alveolata*. Thus, it is able to occur in new areas where previously there was no suitable substrate.

Table 3. New research from additional sites surveyed by Prof SJ Hawkins and Dr P Moschella on Wirral, August 2003

Location	**Lat / Long**	***S. alveolata***	**Comments**
Lighthouse N. Brighton	53°26’ 39. 3” N 003°02’ 33. 7”N	F-C	On sea defence structures
Kings Parade	53°26’ 26. 5” N 003°03’ 45. 5”N	C	On 1 of 2 sea defence structures
Leasowe lighthouse	53°25.305N 03°06.443W (dd)	R	On groyne to west
Leasowe BW east	53°25.468N 03°05.896W (dd)	N	

It can therefore be seen (Tables 2 and 3) that *S. alveolata* has increased in terms of both the number of sites at which it is present in the study area and in terms of abundance at those sites. The only exception to this is at Heysham where *S. alveolata* was formerly present but was not found in the present survey. It is intended to make one further return visit to the area as there are anecdotal records from a former technician at the University of Lancaster.

Detailed mapping: the distribution of the Honeycomb worm *Sabellaria alveolata* on the Hilbre Islands, West Kirby.

Introduction

Sabellaria alveolata was last reliably recorded at Hilbre Island by Herdman in 1919. Cunningham et al. (1984) lists *S. alveolata* as absent from Hilbre both in 1940 and in the re-survey of 1984. Wallace (1982) also commented on the loss of *S. alveolata* which he said had once been abundant thoughout. There is one unconfirmed report of it at Hilbre in 1979 when it was recorded as ‘rare’ but it is generally assumed to have been completely absent from the area since at least the 1940’s and probably earlier (Craggs, 1982). In response to recent reports of *S. alveolata* being re-established in significant quantities on Hilbre, the Marine Biological Association of the United Kingdom were asked to undertake a detailed survey of the area in liaison with local Wirral Borough Council (Christine Smyth) and Liverpool City Council (Adam King).

For the present study, the extent of *S. alveolata* at Hilbre was mapped along with its form and abundance. The associated community was also surveyed (briefly, due to time constraints) in order to gain an idea of the type of species associated with *S. alveolata* habitat.

Methods

Initial mapping to determine the extent of the *S. alveolata* was carried out in September 2003. The detailed survey was completed between 07th and the 10th March 2004 at a period coinciding with low spring tides. A photographic record of the survey (showing site locations etc) was kept; Details of photographs can be found in appendix 2. Photographs are attached on a CD ROM (Appendix 3).

Distribution

The location and extent of *S. alveolata* on the Hilbre Islands was first mapped. Maps were drawn by hand using recognisable boundary features in order to show as accurately as possible the boundaries of the areas in which *S. alveolata* occurs.

Type and abundance

To obtain a more accurate impression of the form (i.e. hummock, sheet, massive reef) and abundance of the *S. alveolata* within these boundaries, transects were then established throughout the areas previously identified as representing the extent of *S. alveolata* distribution. 3 transects (A-C) were established on the northeast side of Hilbre Island (designated ‘Area 1’) and 7 transects (A-G) on the southwest side of Hilbre and Little Hilbre Island (designated ‘Area 2’) and a more detailed survey carried out. Location of transects was determined in such a way as to give an even spread of detailed mapping points across the areas where *S. alveolata* occurs. Transect location was recorded with reference to identifiable features for future mapping. Where this was not possible, then GPS readings (Lat / long) were taken to determine transect location.

Transects were not used in Shell Bay on the northern side of Hilbre Island (designated ‘Area 3) as the *S. alveolata* here only occurred in two narrow strips, one of which was underneath an overhang.

Once a transect had been established, a search was carried out moving down the transect towards the sea, in order to ascertain the beginning of the occurrence of *S. alveolata*. Once this point had been found, then a second tape of 10m was used to lie across the first tape at right angles, with the 5m mark being at the intersection of the tapes. This was done in order to establish 10 sampling points at the station. The presence or absence of *S. alveolata* was then recorded at 1m intervals along the second tape, working along the tape from 1m to 10m. A ‘0’ was used to record the absence of *S. alveolata* and its presence was designated by ‘X’. As well as the presence or absence of *S. alveolata* at each point, information on the depth of the *S. alveoata* and the size of the patch or hummock was also recorded. This exercise was repeated down the transect at 5m intervals until the end of the *S. alveolata* zone had been reached (N.B. This was often concomitant with the end of the extent of rocky shore).

Associated community

At 10m intervals along the transects, three 0.1 m^2 random quadrats were used to record the associated community. This was only done for the transect stations previously recorded as being in the band where *S. alveolata* was present. For example, on transect A at Area 1, *S. alveolata* was only recorded between 50 and 90 m; sampling of the associated community was therefore carried out at 50, 60, 70, 80 and 90 m height. Any area of the shore above and below this band was not included in the survey. A fairly brief search was then made at each of these heights to make sure no species were missed by the quadrats or hadn't been found in the quadrat examinations (i.e. cryptic species). Due to lack of time, the mapping of associated fauna was only done for one transect (A) on the northeast side (Area 1) and two transects (C and G) on the southwest side (Area 2).

Results

Distribution

S. alveolata was found to be present only in a relatively small area on the northeast side of Hilbre Island (Area 1) (Figure 5). It was, however, found along most of the southwest side of Hilbre and Little Hilbre Island (Area 2). It was also present on the northern side of Hilbre Island at Shell Bay (Area 3). A map showing the distribution of *S. alveolata* and the location of transects within the separate areas is supplied as appendix 4. Transect locations and descriptions are given in appendix 5.

Type and abundance

S. alveolata was mainly present in sheets on the northeast side (Area 1) but hummocks were more common on the southwest side (Area 2). On the north of the Island in Shell Bay, *S. alveolata* occurred in clumps (hummock form) under overhangs on the northern side of the bay but mainly as a reef up to 30 cm deep along the southern edge of the bay.

A detailed description of each of the areas where *S. alveolata* was found and a brief description of *S. alveolata* type and abundance is given below.

Area 1: Northeast side of Hilbre Island

In this area, the sandstone bedrock extends eastward away from the main island. The rock has been eroded by the sea into a flattened convex area, gradually sloping away from the island, with gullies and crevices present. The area was colonised by fucoids, winkles, barnacles and cockles. The upper part of the shore was heavily grazed the periwinkle *Littorina littorea* which occurs in vast numbers (see Craggs, 1982).

Throughout Area 1 (Transects A to Transect C) there was a remarkable homogeneity in the *S. alveolata* cover. This was an area of patchy sheet reef which tended to start with small patches at the edge and then form a continuous patch across the shore down to the edge of the channel. *Mytilus edulis* also occurred frequently among the *S. alveolata*. The *S. alveolata* patch was actually a mosaic with frequent gaps and large gaps occurring where there were pools and gullies. It could therefore be described as having more or less continuous cover broken up occasionally by gullies and pools (Figure 6). The gaps tended to be bare grazed rock, patches of barnacles, silty rockpools

Figure 5. Area 1: NE side of Hilbre showing heavily grazed upper shore. Area of *S. alveolata* (golden-brown strip) is lower down on the shore nearer the water line.

Figure 6. Area 1: NE Hilbre – view W to top shore (transect A) – showing extensive *S. alveolata* with *M. edulis*.

Figure 7. Area 1: NE Hilbre – close up showing *S. alveolata* cover broken up by areas of silt covered rock (transect A).

or silt covered rock surfaces (Figure 7). The size of a patch was often estimated as greater than 1 m, due to the fact that it was really a connected patch with frequent gaps rather than lots of isolated clumps. *S. alveolata* occasionally occurred in 'hummock' form with the tubes radiating upwards from the surfaces in clumps but often the depth of the *S. alveolata* was very shallow (i.e. only 1 - 3 cm deep) and it was of sheet form. Overall *S. alveolata* is *common to abundant* on this side as it covers most of the intertidal at its area of peak abundance (>50%) but rarely forms hummocks being mainly of sheet form. Full results from transects A – C are shown in tables 4 - 6.

Table 4. Transect A: Presence (X) or absence (0) of *S. alveolata* for each station at each transect hieght. Numbers in parenthesis = approximate depth of patch (cm). A= area of patch: >1 (i.e. metre) generally means that the patch was considered part of the continuous patch that covered this part of the shore in Area 1.

Distance from top of shore (m)	**Transect Point**										**Total cover at each station (%)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
50	0	0	0	0	0	0	X (3)	X (1) A=40x20	0	X (2)	**30**
55	0	0	0	0	X (2) A=60x 20	0	X (3) A=>1 m	X (3) A=>1	X (7) A=>1	X (6) A=> 1	**40**
60	X (3) A=>1	X (3) A=>1	X (2) A=>1	0	X (2) A=20x 20	0	X (5) A=>1	X (7) A=>1	0	X (3) A=> 1	**60**
65	X (2) A=10 x5	0	X (3) A=>1	0	0	X (5) A=>1	0	X (4) A=>1	0	X (3) A=> 1	**50**
70	0	0	0	X (4) A=>1	0	0	X (2) A=>1	X (3) A=>1	X (2) A=>1	0	**40**
75	X (3) A=>1	X (6) A=>1	X (7) A=>1	0	0	0	0	0	0	0	**30**
80	X (7) A=>1	X (3) A=>1	X (8) A=>1	X (5) A=>1	X (3) A=>1	X (3) A=>1	X (8) A=>1	0	X (8) A=>1	0	**80**
85	X (3) A=>1	X (2) A=>1	X (6) A=>1	X (9) A=>1	0	X (5) A=>1	X (4) A=>1	0	X (5) A=>1	0	**70**
90	X (4) A=>1	0	0	0	0	X(11) A=>1	X(11) A=>1	X(12) A=>1	X(11) A=>1	0	**50**

Table 5. Transect B: Presence (X) or absence (0) of *S. alveolata* for each station at each transect hieght. Numbers in parenthesis = approximate depth of patch (cm). A= area of patch: >1 (i.e. metre) generally means that the patch was considered part of the continuous patch that covered this part of the shore in Area 1.

Distance from top of shore (m)	**Transect Point**										**Total cover at each station (%)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
60	0	0	0	0	0	0	0	X (4) A=>1	X (9) A=>1	X (5) A=>1	**30**
65	0	0	0	0	0	X (6) A=>1	X (2) A=>1	X (2) A=>1	X (2) A=>1	0	**40**
70	0	X (2) A=>1	X (4) A=>1	X (5) A=>1	0	X (5) A=>1	X (2) A=>1	X (9) A=>1	X (4) A=>1	0	**70**
75	X (3) A=>1	0	X (3) A=>1	X (3) A=>1	0	X (3) A=>1	0	0	0	0	**30**
80	X (4) A=>1	X (3) A=>1	0	0	0	0	0	X (2) 50x30	0	X(12) A=>1	**40**
85	X (4) A=>1	X (3) A=>1	X (4) A=>1	X (3) A=>1	X (1) A=4x10	X (5) A=>1	X(10) A=>1	X (8) A=>1	X(12) A=>1	X(10) A=>1	**100**
90	X (7) A=>1	X (6) A=>1	X (8) A=>1	X (5) A=>1	0	X (8) A=>1	0	X (7) A=>1	X (5) A=>1	X(10) A=>1	**80**

Table 6. Transect C: Presence (X) or absence (0) of *S. alveolata* for each station at each transect hieght. Numbers in parenthesis = approximate depth of patch (cm). A= area of patch: >1 (i.e. metre) generally means that the patch was considered part of the continuous patch that covered this part of the shore in Area 1.

Distance from top of shore (m)	**Transect Point**										**Total cover at each station (%)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
35	0	0	0	0	0	0	0	0	0	X (2) A=>1	**10**
40	0	0	X (2) A=5x5	X (5) A=>1	0	X (3) A=>1	X (2) A=>1	0	0	0	**40**
45	X (3) A=>1	X (4) A=>1	X (4) A=>1	0	0	X (3) A=>1	X (2) A=>1	0	0	0	**50**
50	0	0	0	0	0	0	0	0	X (2) A=5 x5	X (2) A=10 x10	**20**
55	0	0	0	0	0	0	0	0	0	0	**0**
60	0	0	0	0	0	0	0	0	0	0	**0**
65	0	0	X (2) A=>1	X (1) A=>1	X (1) A=>1	X (1) A=>1	0	0	0	0	**40**
70	0	X (3) A=>1	X (2) A=>1	X (5) A=>1	X (2) A=>1	X (2) A=>1	0	0	0	0	**50**
75	X (7) A=>1	X (7) A=>1	X (5) A=>1	X (5) A=>1	0	X(10) A=>1	X(12) A=>1	X(10) A=>1	X (6) A=> 1	X (1) A=>1	**90**

<u>Area 2 – Southwest side of Hilbre Island and Little Hilbre Island.</u>

The southwest side of Hilbre is a series of steep cliffs (up to 20m) made up of clearly bedded red sandstone. The cliffs are well eroded and broken but access to the shore is only possible at certain points. The intertidal area itself is far steeper than the northeast side (Area 1) with deeper pools and gullies. There is a far greater cover of algae (*Enteromorpha* at the top and *Fucus* at the bottom) with no sign of the mass grazing by periwinkles that was seen on the northeast side of the Island (Figure 8).

Figure 8. Area 2: SW side of Hilbre. View west along Transect C. Fucoid covered rocks with heavily silted areas.

Figure 9. Area 2: SW side of Hilbre – *S. alveolata* hummocks and fucoid covered rocks - looking N along Transect E.

Overall, the cover of *S. alveolata* is not as extensive along this side of Hilbre (Area 2: transect A to transect G) but it tends to form large hummocks and reefs more often (Figure 9). Overall, it is abundant (Cunningham et al., 1984). The largely flat bedrock of the northeast side of the Island (Area 1) may contribute to *S. alveolata* occurring more often in 'sheet' form on that side. On the southwest side, however, *S. alveolata* occurs more often under boulders and in gullies. Full results for transects A to G are shown in tables 7 - 13. Additional transect information can be found in appendices 6 – 12.

Table 7. Transect A: Presence (x) or absence (0) for each sample at each station. Numbers in parenthesis = approximate depth of patch (cm). A= area of patch: >1 = (>1 metre). OH = under overhang.

Distance from top of shore (m)	**Transect Point**										**Total cover at each station (%)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
50	0	0	0	0	0	0	X (4) A=>1	X (4) A=>1	X (<1) A>1	X (4) A=>1	**40**
55	0	0	0	X (1) A=5x4	X (1) A=2x3	X (8) OH	0	X (1) A=10x5	0	0	**40**
60	0	X(<1) A=4x5	0	0	0	0	0	0	0	0	**10**
65	0	0	0	0	0	0	0	X (1) A=60x40 (+OH)	0	0	**10**
70	0	0	0	0	0	0	0	0	0	0	**0**

Table 8. Transect B: Presence (x) or absence (0) for each sample at each station. Numbers in parenthesis = approximate depth of patch (cm). A= area of patch: >1 = (>1 metre). OH = under overhang.

Distance from top of shore (m)	**Transect Point**										**Total cover at each station (%)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
10	0	0	0	0	0	0	0	0	0	X (1) A=20x 5	**10**
15	0	0	0	0	0	0	0	0	0	0	**0**
20	X (1) A=5x3	0	X (1) Ind.	0	0	X(<1) A=>1	X (4) A=>1	X(>1) A=>1	X (15) A=>1	0	**60**
25	X(<1) A=>1	X (1) A=>1	0	0	0	0	0	0	X(<1) A=50x10	0	**30**
30	0	0	0	0	0	0	0	0	0	X(<1) 5x3	**10**
35	0	0	0	0	0	0	X(<1) A=>1 +OH	X(<1) A=>1	0	X(<1) A=>1	**30**
40	0	0	0	0	0	0	0	0	0	0	**0**
45	0	0	0	0	X (2) 4x4	0	0	0	0	0	**10**

Table 9. Transect C: Presence (x) or absence (0) for each sample at each station. Numbers in parenthesis = approximate depth of patch (cm). A= area of patch: >1 = (>1 metre). OH = under overhang.

Distance from top of shore (m)	**Transect Point**										**Total cover at each station (%)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
0	X (5) A=30 x30	0	0	0	0	0	0	0	0	0	**10**
5	X (5) A=20 x10	X (4) A=>1	X (2) A=>1	X (1) A=10x 5	0	X(<1) A=>1	X(10) A=>1	0	X (6) A=> 1	0	**70**
10	X (12) A=>1	X (15) A=>1	0	0	0	0	0	0	0	0	**20**
15	0	0	0	0	0	0	0	0	X (4) OH	X (3) OH	**20**
20	0	0	0	0	0	0	0	0	0	0	**0**
25	X (4) A=>1	X (1) A=>1	0	X (4) OH	0	X(17) A=>1	X(10) A=>1	X (3) A=>1	X (8) A=> 1	X (10) A=> 1	**80**
30	0	0	0	0	X (10) A=>1	X(<1) Ind.	X(<1) A=>1	X(<1) A=>1	X (3) A=> 1	X (2) A=> 1	**60**

Table 10. Transect D: Presence (x) or absence (0) for each sample at each station. Numbers in parenthesis = approximate depth of patch (cm). A= area of patch: >1 = (>1 metre). OH = under overhang.

Distance from top of shore (m)	**Transect Point**										**Total cover at each station (%)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
60	0	0	0	0	0	X(10) A=>1	0	X (3) A=>1	X(<1) A=>1	0	**30**
65	0	0	X (4) A=>1	X (5) A=>1	X (2) A=>1	0	X(<1) A=>1	X(10) A=>1	X (6) A=>1	0	**60**
70	X (1) A=5x3	0	X(15) A=>1	X(15) A=>1	X(15) A=>1	X(15) A=>1	X(10) A=>1	0	X (6) A=30x20	X(10) A=10x7	**80**
75	0	0	X (2) A=5x10	0	0	X (6) A=60x40	0	0	0	X (2) A=10x4	**30**
80	0	0	0	0	X (5) OH	0	X(<1) A=>1	0	X (1) A=>1	0	**30**
85	0	0	X(<1) A=>1	0	X(<1) A=>1	X(<1) A=>1	X(3) A=>1	X (3) A=>1	X (5) A=>1	X (3) A=>1	**70**
90	0	0	0	X (4) A=>1	0	0	X(<1) A=>1	0	X (<1) A=>1	0	**30**
95	0	0	0	0	0	X(<1) A=>1	X(<1) A=>1	X (4) A=>1	X (3) A=>1	X (6) A=>1	**50**
100	0	0	X(<1) A=>1)	X (1) A=>1	0	0	0	0	0	0	**20**

Table 11. Transect E: Presence (x) or absence (0) for each sample at each station. Numbers in parenthesis = approximate depth of patch (cm). A= area of patch: >1 = (>1 metre). OH = under overhang.

Distance from top of shore (m)	**Transect Point**										**Total cover at each station (%)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
50	0	0	0	0	0	X(<1) Ind.	0	0	0	X (15) A=>1	20
55	0	X (1) A=>1	X (2) A=>1	X (1) A=10x5	0	X(<1) A=>1	X(10) A=>1	0	X (6) A=>1	0	60
60	0	0	0	0	0	0	0	0	0	0	0
65	X(2) A=>1	X (2) A=>1	X (8) A=>1	0	X (2) A=>1	0	X(12) A=>1	X(12) A=>1	0	X (6) A=>1	70
70	0	0	X (2) A=>1	X (1) Ind.	0	0	0	0	0	0	20
75	X (2) A=>1	X (2) A=>1	X (3) Ind.	0	0	0	0	0	0	0	30
80	0	0	0	0	X (2) A=10x 15	0	X (3) A=>1	X (1) A=>1	X (12) A=>1	X (12) A=>1	50
85	0	0	0	X(<1) A=5x5	0	0	X (3) A+>1	X(10) A=>1	X (1) A=>1	0	40
90	X (>25) A=>1	X (>25) A=>1	X (>25) A=>1	X (>25) A=>1	X (>25) A=>1	X (>25) A=>1	X (>25) A=>1	X (>25) A=>1	0	0	80
95	0	0	0	0	0	0	0	0	0	0	0

Table 12. Transect F: Presence (x) or absence (0) for each sample at each station. Numbers in parenthesis = approximate depth of patch (cm). A= area of patch: >1 = (>1 metre). OH = under overhang.

Distance from top of shore (m)	**Transect Point**										**Total cover at each station (%)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
65	0	0	0	0	X (1) A=>1	X (5) A=30x40	0	X(3) A=20x40	0	0	**30**
70	0	0	0	0	0	0	0	0	0	0	**0**
75	0	0	X (1) A=>1	X (1) A=>1	0	0	0	0	0	0	**20**
80	0	0	0	0	0	0	0	0	0	0	**0**

Table 13. Transect G: Presence (x) or absence (0) for each sample at each station. Numbers in parenthesis = approximate depth of patch (cm). A= area of patch: >1 = (>1 metre). OH = under overhang.

Distance from top of shore (m)	**Transect Point**										**Total cover at each station (%)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
70	X(<1) A=>1	X (3) A=20x30	0	0	0	0	0	0	0	0	**20**
75	0	0	0	0	0	0	0	0	0	0	**0**
80	0	0	0	0	0	0	0	0	0	0	**0**

<u>Area 3: North side of Hilbre Island (Shell Bay)</u>

This area consists of a muddy sand bay with an extensive rocky reef along its southern edge and cliffs along its northern edge (Figure 10). There are many boulders and cobbles on the sandy part of the bay and there is also some sublittoral fringe reef which is unique on the island and therefore well known for certain species such as nudibranchs.

Figure 10. Area 3: North side of Hilbre: Shell Bay. View East across bay. *S. alveolata* reef is visible along edge of *Fucus serratus* covered rock area.

No transects were taken in Shell Bay for reasons previously stated but it was observed that the *S. alveolata* along the southern edge of the area of sand in the bay was a narrow reef up to 30 cm deep (Figure 11).

Figure 11. Area 3: North side of Hilbre: Shell Bay. *S. alveolata* reef along south side of sandy area of Bay. View Looking from north to south.

A number of large patches (the two largest patches being approximately 6 x 3 m and 10 x 1.5 m) of *S. alveolata* were observed underneath the overhang on the northern side of the bay. *S. alveolata* was mainly in hummock form here but with some sheets present.

Associated Community (Areas 1 and 2)

<u>Area 1: Northeast side of Hilbre Island - transect A</u>

Diversity was relatively low here (Figure 12) with a total of 13 taxa being recorded from the random quadrats (including *S. alveolata*). *Mytilus edulis* appeared to be the main species growing on the *S. alveolata* (often in the crevices). Barnacles (mainly *Elminius modestus*) were common predominantly on the *Mytilus*. The area was very silty so the pools which on many rocky shores are areas of diversity were largely barren with a layer of silt in them (Figure 13).

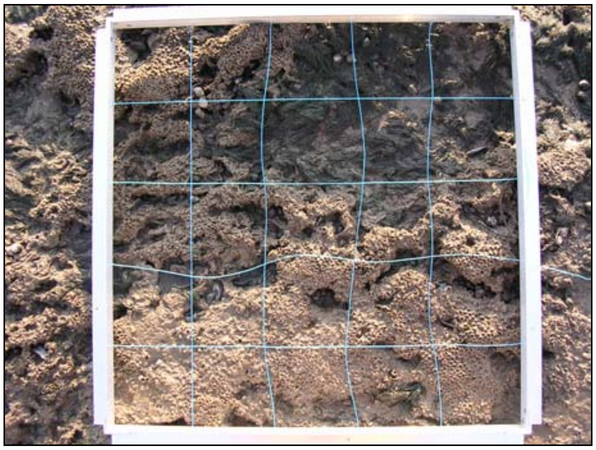


Figure 12. Area 1: NE side of Hilbre. Transect A. Close up of quadrat being used to examine associated fauna. Notice overall low diversity.

Figure 13. Area 1: NE side of Hilbre. Rockpool with thick layer of silt. *S. alveolata* clearly visible around pool.

The only species observed other than those found in the quadrats was a species of hydroid. A full list of species for Area 1- transect A is given in table 14.

Table 14. List of species found in quadrats and extra species found as a result of the general search on Transect A in Area 1 (northeast Side).

Species	Quadrat	General search
Hydroid indet.		✓
Sabellaria alveolata	✓	
Elminius modestus	✓	
Mytilus edulis	✓	
Littorina littorea	✓	
Littorina sp.	✓	
Littorina saxatalis	✓	
Cladophora rupestris	✓	
Enteromorpha sp.	✓	
Ulva lactuca	✓	
Fucus sp.	✓	
Fucus serratus	✓	
Fucus vesiculosus	✓	
Porphyra	✓	

Area 2: Southwest side of Hilbre Island and Little Hilbre Island - transect A

This transect on the seaward side also yielded a very low number of species (6). There was a layer of sand over much of the shore at this point and in many of the quadrats species were covered completely by the sand (i.e. 100% sand cover). This may have contributed to the low overall diversity. Also, *S. alveolata* wasn't as abundant here as on other transects so didn't occur in the random quadrats. A full list of species for Area 2 transect A is given in table 15.

Area 2: Southwest side of Hilbre Island and Little Hilbre Island - transect C

Only 8 species were found at this transect location which was on a fairly narrow stretch of rocky shore. Whereas on transect A many species appeared smothered by sand, it was the large amount of silt that was noticeable here. A full list of species for Area 2 - transect C is given in table 15.

Area 2: Southwest side of Hilbre Island and Little Hilbre Island - transect G

A total of 5 species were found in the quadrats at this transect location although only one station was examined as the band of *S. alveolata* was very narrow. A general search of the station yielded no extra species. A full list of species for Area 2 transect G is given in table 15.

Table 15. List of species found in quadrats and extra species found as a result of the general search for transects in Area 2 (Southwest Side).

Species	**Transect A**		**Transect C**		**Transect G**	
	Quadrat	**General search**	**Quadrat**	**General search**	**Quadrat**	**General search**
Sabellaria alveolata			✓			
Elminius modestus	✓		✓		✓	
Mytilus edulis	✓			✓		
Amphipoda indet					✓	
Littorina littorea		✓				
Enteromorpha sp.	✓				✓	
Ulva lactuca	✓		✓		✓	
Fucus serratus	✓		✓			
Fucus vesiculosus			✓		✓	
Aoudinella			✓			
Rhodophyta indet				✓		

Overview

Broad scale:

Within the area investigated for the present study, *S. alveolata* was found to be present at most of the sites where it has previously been recorded (e.g. Cunningham, 1984) and at many of these sites it appears also to have increased in abundance. *S. alveolata* has re-appeared in areas where it has been absent for many years (Hilbre and Colwyn Bay) and has spread to areas for which there are no known previous records (North Wirral, Rossal Point). In only one area was *S. alveolata* not found where there are previous records (Heysham). It was actually recorded at Heysham fairly recently where it was reported to be one of the organisms cementing together the cobble and boulder shore (Hawkins, 1993). It was noted in the UK Biodiversity Action Plan (1994) that *S. alveolata* reefs had recently developed 2 hectares of boulder scar at Heysham despite having been absent for 30 years before this. The failure to find *S. alveolata* at Heysham in the present study is therefore considered to be as a result of the specific search area being incorrectly identified, as *S. alveolata* is currently present in large quantities (Jim Andrews, University of Lancashire – Pers. Comm).

Hawkins (1993) suggested that *S. alveolata* was declining along the Cumbrian coast but the present study found it to be abundant or super-abundant at most sites. The records from the present study therefore seem to confirm the observation made by others that *S. alveolata* shows a great deal of temporal variability within a fairly constant geographic range (e.g. Cunningham et al, 1984). Even on a shore where *S. alveolata* is continually present, there is a great deal of variability in terms of abundance and 'within shore' distribution. For example, long term studies at Duckpool in North Cornwall (Wilson, 1971; 1974; 1976) and in Normandy, France (Gruet, 1986) have revealed a great deal of variability over the years in the distribution and abundance of *S. alveolata* colonies within sites. In the last ten years, there has been some evidence of the decline of *S. alveolata* at Duckpool compared with its previous abundance (S. Hawkins – Pers. obs.).

In order to examine the overall range of *S. alveolata*, data from the MarClim project can also be used. The MarClim project entails surveying the intertidal communities of rocky shores throughout Great Britain and Ireland, and has resulted in an accurate record of the present distribution of *S. alveolata*. This data is shown in appendix 13. From this data we can see that there has been little overall change in *S. alveolata* distribution when compared with previous surveys. Cunningham (1984) stated that the distribution of *S. alveolata* in Britain had hardly changed since records began up to 1984 other than a small contraction of its range along the south coast. The new data from the present study and MarClim seems to reveal a similar pattern, i.e. there is still little change in its overall distribution despite some variation within its range. There are only two historical records from Scotland in 1958 where Alan Southward has recorded it from the north side of the Solway Firth. Other studies suggest that *S. alveolata* is completely absent from the east coast of Scotland and any occasional records are probably more likely to be *S. spinulosa* (Cunningham et al., 1984). On the south coast, the furthest east that *S. alveolata* is recorded by MarClim is Lyme Regis (SJH has found it at Charmouth) where it is abundant but there appears to be no extension of range eastwards from that recorded previously.

The abundance and distribution of *S. alveolata* has shown a degree of fluctuation within this range, however. For example, the present study showed that *S. alveolata* abundance seems to be increasing along the coast of Cumbria after fairly recent reports of its decline in the same area (Hawkins, 1993). It was noticeable at some sites on the coast of Cumbria such as Annaside Banks that the *S. alveolata* reefs consisted of old basal crust, with a new layer on top. It has been observed previously that the largest colonies such as the ones seen on the Cumbrian coast are the result of two or three successive settlements and consist of worms one, two or more years apart (Wilson, 1969). It seems therefore that surveys as part of the present study may have coincided with a period after which a number of successful successive settlements had occurred.

Hilbre Island Survey – detailed mapping:

Some of the earliest records of *S. alveolata* are from Hilbre where it was recorded as abundant by Herdman (1919). It had, however, disappeared entirely by the 1940's (Cragg, 1982). The present survey again found *S. alveolata* to be common to abundant at both Hilbre Island and Little Hilbre Island. It does not compare with the Cumbrian coast in terms of massive reef formation (it is generally a lot thinner than the Cumbrian reefs – see tables 4 to 13) and is not quite as extensive in coverage (mainly because there is less intertidal area available). It nevertheless represents a considerable amount of *S. alveolata* considering it has been entirely absent for many years. As it has only been recently observed, then it probably still represents the earlier stages of settlement and may continue to develop.

The fact that the colonies of *S. alveolata* are a relatively new at Hilbre may be reflected in the rather impoverished asssociated faunal communities. It has been observed that when *S .alveolata* forms extensive reefs, then there may often be a rich fauna associated with the cracks and crevices but this is partly dependent on the both the type of reef and its stage of development (Gruet, 1982). Cunningham et al. (1984) observed species diversity could increase as a result of 1) the creation of ridges as a result of the form of *Sabellaria*, which may prevent water drainage, leading to the formation of standing pools, 2) slightly older colonies showing signs of senescence and decay thus providing a range of habitats for crevice fauna, 3) the stabilization of small boulders and rocks preventing scouring occurring, 4) a general increase in heterogeneity on a shore and / or the provision of suitable habitat for species settlement on shores such as sand scoured rocks on the edge of bays. Diversity of the associated faunal community can decrease, however, as a result of 1) colonies still actively growing, as these colonies tend to dominate the littoral community, 2) the actively growing colonies forming 'placages' thus decreasing the number of habitats available for crevice fauna. Faunal diversity at Hilbre was seen to be very low, however, for a number of reasons. Firstly, it has been noted (see UK Biodiversity Action Plan) that in the first two years of settlement, there are few associated species; the *S. alveolata* colonies at Hilbre are relatively new. Also, Hilbre has always had a fairly impoverished fauna; indeed, it was this factor (and in particular the lack of tunicates) that led to the first marine station of the Liverpool Marine Biology Committee being built on Puffin Island in 1887 rather than the original choice of Hilbre (Cragg, 1982).

Another reason for the low diversity of the associated fauna is that the rocky shore community of Hilbre has always had a relatively low diversity. One of the reasons for this is that the rocky shore community at Hilbre is unusual in having its lower seaweed border truncated by sand (Russell, 1982). Hilbre has over 300, 000 m^2 of rocky intertidal area but the area of rock available becomes less and less as you move from west to east until Little Eye has a very small amount indeed. This leads to the shore showing a two zone pattern (Russel, 1982) rather than the classical three zones occurring on most rocky shores (Hawkins, 1993). Limpets are scarce due to their vulnerability to siltation and to lack of larval supply (the nearest being Great Orme) (Greenwood, 1999). Siltation has also been suggested as the main reason for the lack of other common rocky shore taxa such as chitons, top shells, tunicates and sponges (Greenwood, 1999) and the main reason for the disappearance of most of the species previously recorded at Hilbre (Cragg, 1982). This is not a recent phenomena however and in 1854 rising sedimentation levels were blamed for the disappearance of Lobsters (Byerley, 1854). Russell (1982) also states that the import into the intertidal of coarse and fine sand grains from the sea has little influence on the intertidal vegetation. The river-borne clay and silt particles, however, are recorded as having an overwhelming detrimental effect on biodiversity due to the smothering of small juvenile plants. It creates an unstable platform for plants and animals to attach and smothering by sediment has affected the invertebrate fauna. In all other respects (wave exposure etc), Hilbre is similar to many other rocky shores and despite being at the mouth of the Dee Estuary, the salinity is nearly full, being only slightly less than the Irish Sea (Russell, 1982). A very slight reduction, however, is put forward by Craggs (1982) as another possible reason for low diversity.

Recovery of *S. alveolata*

The main question from the present study therefore is what factors are likely to be driving the long-term variability observed in *S. alveolata* distribution and abundance and its dramatic recovery at sites like Hilbre? Three possible influences are now briefly discussed, namely, climate change, the role of artificial habitat and the role of water quality amelioration.

Climate change

There have been suggestions that climate could have a strong influence on *S. alveolata* distribution. A report produced for the MONARCH (Modelling natural resource responses to climate change) project suggests that *S. alveolata* may benefit from increased temperatures as a result of global warming (Harrison et al., 2001) as it is particularly vulnerable to cold winters. In fact Crisp et al (1964) found that *S. alveolata* colonies were devastated by the cold winter of 1962-63 and suggested therefore that *S. alveolata* is badly affected by frost. Crisp et al (1964) proposed that *S. alveolata* was restricted in its distribution (i.e. range) by limits set by cold winter temperatures and that the absence of a cool winter period leads to increased growth. Other studies have indeed shown that the main factor influencing distribution of *S. alveolata* is temperature, with *S. alveolata* growth being inhibited at temperatures below 5°C (Gruet, 1982). The optimum temperature for growth appears to be 15 – 20°C with growth being reduced at c. 10°C and absent below the critical threshold of 5°C (Bamber & Irving, 1997). Temperature therefore has a clear direct influence on *S. alveolata* adult populations as it is the reduced temperatures in winter that inhibit its metabolism and tube building activity (Bamber & Irving, 1997).

Climate can also have an indirect effect on *S. alveolata* due to possible increases in storminess due to global warming. *S. alveolata* colonies need a degree of exposure (they are absent from sheltered shores) as they need sand to be transported for growth. Indeed, turbulent sediment laden water is a main requirement for growth provided it is coarse sand rather than mud (Naylor & Viles, 2000). As rough water is a stimulating factor in settlement of larvae (Wilson, 1968) an increase in storminess may therefore be beneficial in certain cases. If conditions become too exposed, however, then *S.*

alveolata colonies can not withstand the force of the waves. Increased storminess may therefore lead to a loss of *S. alveolata* in other places (Wilson, 1969).

There are other potential negative effects of global warming on *S. alveolata* colonies. For example, rising sea levels in the south and south-west of the UK in particular could reduce the amount of substrate available and its sediment supply leading to a reduction in growth in some areas (Harrison et al., 2001).

To summarise, it is well established that *S. alveolata* distribution is heavily influenced by temperature and this is a critical factor along the northwest coast of England where *S. alveolata* reaches its northern limit. However, the fact that *S. alveolata* has maintained a fairly stable range since records began suggests that it is not yet increasing its range in response to global warming. It is increasing in abundance at sites where it currently occurs and appearing at new sites within its present range. This is not to say that climate induced range extension will not be observed in the future, however.

Artificial habitat

One possible factor in the spread of *S. alveolata* is the role of artificial structures such as sea defences in acting as 'stepping stones' to allow the species to spread. These can provide suitable habitat for the settlement of various species more generally associated with hard substrate. Long stretches of coastline with no rocky shore habitat can lead to gaps in a species distribution or signal the limit of a species range (Hiscock, 1998) so the addition of artificial substrate can therefore reduce these gaps and lead to an increase in range. This has been observed with species such as *Gibbula umbilicalis* which has increased its range along the south coast of the UK, recently being found on sea defences at Elmer (Mieszkowska et al, *in prep*.).

There is in fact little suitable substrate for *S. alveolata* in the study area as the area is largely dominated by sand and mudflats due to the large tidal range, and hence the depositing nature of the environment (Hawkins, 1993). Cobble and boulder shores are more extensive along the Cumbrian coast from Walney Island to St Bees but Hilbre and St Bees represent the only two areas with a proper rocky shore (Hawkins, 1993). There is no doubt that *S. alveolata* is excluded from many sites within the study area due to lack of suitable habitat. Some of the areas where *S. alveolata* has not been recorded either in this survey or previous surveys such as the sites occurring from Holme Island to Walney Island, were found to be totally unsuitable to the presence of *S. alveolata*.

Although there is suitable substrate there, the sites occur in areas that are otherwise characterised by low salinity sand and mudflats. In fact this whole area is has seen a significant increase in the amount of saltmarsh developing over the last few years (Grange Tourist information - Pers. Comm.) so some sites such as Holme Island that was investigated as part of the Cunningham survey are now at the top of areas of developing saltmarsh (Figures 14 and 15).

Figure 14. West side of Holme Island, looking South. Only *Enteromorpha* present on rock.

Figure 15. Newly developed saltmarsh and mudflats west of Holme Island.

Even for some of the areas where artificial substrate is present such as St Anne's Pier, other factors such as the position on the shore (the pier is restricted to the area of EHW) would preclude the establishment of *S. alveolata*. In contrast to this, the sea defence structures on the Wirral have allowed *S. alveolata* to establish itself in an area where it might otherwise be excluded. This may be important not just for the Wirral sites but also for other areas such as Hilbre, as availability of a larval source along with hydrodynamics is one of the most important factors for the establishment and maintenance of *S. alveolata* populations (Gruet, 1986). Larval recruitment is of the utmost importance in regulating colony height and allowing maximum occupation of the substratum (Gruet, 1986). The clockwise circulation in the Irish Sea means that the nearest extensive rocky shores at Great Orme and Anglesey are unlikely to supply larvae for recruitment for intertidal invertebrate populations at Hilbre (Craggs, 1982). This lack of larval supply is crucial. For example, *S. alveolata* used to be present (in 1927) at Whitsand Bay in Cornwall but *S. alveolata* larvae have long been absent from Plymouth Sound and *S. alveolata* is therefore completely absent from this whole area (Wilson, 1968). The presence of populations on sea defence structures at New Brighton on the Wirral is therefore important as a potential source of larvae. As yet, however, *S. alveolata* is possibly not abundant enough at New Brighton to provide a larval supply and it is possible that establishment occurred at the same time or after *S. alveolata* became established at Hilbre, being provided by the same larval pool.

The role of artificial habitat is obviously important, therefore, allowing *S. alveolata* to occur in areas where it would otherwise be absent and this could eventually, in combination with other factors such as climate change, lead to range extensions in other areas around the coast where lack of suitable habitat is an issue (i.e. south coast).

Water quality amelioration

The sea defence structures at New Brighton were built in 1984 -1985 and have therefore been present for a number of years before the recent reappearance of *S. alveolata*. It would appear therefore, that other factors also need to be looked at which might have an effect on both The Wirral foreshore and on Hilbre. One potential influencing factor is the improvement in water quality. The River Mersey was once considered the most polluted estuary in Europe (Clark, 1989) although the River Dee, in which Hilbre is situated, has been impacted to a much lesser extent (Hawkins et al, 1999). Hilbre Island, although at the mouth of the River Dee, will still be influenced by the water quality of Liverpool Bay as the bay and all the estuaries have to be viewed as one interconnected system (Hawkins et al, 1999). The Mersey has improved much in terms of water quality due to amelioration initiatives such as the Mersey Basin Campaign (Hawkins et al, 1999). Hawkins et al. (1999) point to a significant increase in the diversity of fish, fish–eating birds and marine invertebrates in the last 20 years. Hawkins et al. (1999) also suggests that the return of certain populations of marine invertebrates after a long absence can be accounted for by the improvement in water quality. By the same reasoning, it would seem an obvious factor in the return of *S. alveolata* to the area and its presence on The Wirral foreshore. The improvements in water quality may also be partly responsible for the return of *S. alveolata* to Hilbre.

It is important to note that there may be other factors not yet discussed that have also contributed to the recovery of *S. alveolata* at Hilbre. Craggs (1982) actually predicted that *S. alveolata* would return to Hilbre, just as other species that had vanished had also inexplicably re-appeared. For Hilbre, another factor that is important is siltation which is often related to offshore activities. As previously discussed, Hilbre has long had a problem with excessive amounts of silt in the intertidal and too much mud plugs up individual tubes and leads to a decline in *S. alveolata* colonies (Naylor & Viles, 2000). Craggs (1982) lists siltation along with disease and frost as possible culprits for the disappearance of *S. alveolata* at Hilbre. The reappearance of *S. alveolata* at Hilbre could be due to an increased input of coarser grained sediment causing new growth. *S. alveolata* needs sand rather than mud (Larissa & Naylor, 2000) has been seen to preferentially select a larger grain size than the sediment around it (Naylor & Viles, 2000). Wilson (1970) stated that adults tended to build mainly with shell particles if these were available. Any lack of availability of sand above a certain diameter would therefore prevent *S. alveolata* colonies being established. It would therefore be of the utmost interest to investigate further the possibility of an increase in larger grained sediment supply to Hilbre.

Summary

On the northwest coast of England, *S. alveolata* has become established at sites where there are no previous records and increased in abundance at sites where it has previously been recorded. It appears that factors linked to climate change may be responsible, along with water quality amelioration. Water quality amelioration may be a major factor in *S. alveolata* becoming established on the North Wirral foreshore. The presence in this area of new habitat in the form of artificial substrate is also a crucial factor in the establishment of *S. alveolata* colonies.

Overall, *S. alveolata* maintains a remarkably stable geographic range but this study has shown that there can be significant variation in abundances at sites and distribution within its geographic range. Although certain factors such as those discussed above can be assumed to be having an effect on *S. alveolata* colonies, there is still much more specific research needed to understand how the various factors interact in controlling the distribution of *S. alveolata*, particularly as it has natural cycles of variation in abundance.

Acknowledgements

The authors wish to thank the warden at Hilbre (Dave Cavanagh) for all his assistance with the survey work and with arranging accommodation and transport in order to make the survey possible. Thanks are also extended to Di Bennet for help with the Hilbre survey and again for help with transport to the Island.

APPENDICES

Appendix 1

A description of photographs taken as part of the broad-scale survey of *Sabellaria alveolata* distribution.

Picture number	Date - time taken	Location - NGR	Description
1	18/03/04 - 1508	St Anne's, Lancs - SD3158 2841	St Anne's Pier – barren other than occasional barnacle
2	18/03/04 - 1509	St Anne's, Lancs - SD3158 2841	St Anne's Pier, bottom part– barren other than occasional barnacle
3	18/03/04 - 1602	Lytham, Lancs -SD3360 2725	Assessing potential substrate for *S. alveolata* on foreshore – none found
4	18/03/04 - 1602	Lytham, Lancs -SD336 272	View south along Seawall – completely barren
5	18/03/04 - 1712	Rossal Point, Fleetwood, Lancs -SD3083 4766	Small patch of *S. alveolata* (top right of picture) – numerous patches of this size found
6	18/03/04 - 1712	Rossal Point, Fleetwood, Lancs -SD3083 4766	General view of shore at Rossal Point, Fleetwood
7	19/03/04 - 1320	Holme Island, Cumbria -SD 4219 7800	Newly developed saltmarsh and mudflats west of Holme Island
8	19/03/04 - 1320	Holme Island, Cumbria -SD 4219 7800	West side of Holme Island, looking South. Only *Enteromorpha* on rock.
10	19/03/04 - 1416	Humphrey Head, Cumbria -SD3921 7333	Southern tip of Humphrey head, surrounded by sand / mudflats
11	19/03/04 - 1416	Humphrey Head, Cumbria -SD3921 7333	Cliffs (with Lichens) on Western side of Humphrey Head, surrounded by sand / mudflats
12	19/03/04 - 1521	Wadhead Scar, Cumbria -SD3113 7519	Looking out towards Wadhead Scar
13	19/03/04 - 1542	Wadhead Scar, Cumbria -SD3113 7519	Wadhead scar. *Enteromorpha* covered rocks and pebbles in sandy mud.
14	19/03/04 - 1542	Wadhead Scar, Cumbria -SD3113 7519	Close up of boulder scar. *Enteromorpha* covered rocks and pebbles in sandy mud.
15	19/03/04 - 1709	Hilpsford Scar, S Walney Island, Cumbria -SD2174 6144	Hilpsford Scar, Barren cobbles at South Walney Island. View up the shore.

Appendix 1 – continued

Picture number	Date - time taken	Location - NGR	Description
16	19/03/04 - 1709	Hilpsford Scar, S Walney Island, Cumbria -SD2174 6144	Hilpsford Scar, Barren cobbles at South Walney Island. View down the shore towards lower shore sand.
17	19/03/04 - 1709	Hilpsford Scar, S Walney Island, Cumbria -SD2174 6144	Hilpsford Scar, Barren cobbles at South Walney Island. Close up.
18	20/03/04 – 1424	Nethertown, Cumbria -NX9871 0726	General view of shore, Nethertown. Upper shore cobbles, lower shore with rocks and extensive *S. alveolata*.
19	20/03/04 – 1434	Nethertown -NX9871 0726	*S. alveolata* on rocks around pools.
20	20/03/04 – 1441	Nethertown -NX9871 0726	*S. alveolata* on rocks around pools.
21	20/03/04 – 1536	Sellafield, Cumbria -NY0151 0358	*S. alveolata* reefs becoming exposed as tide falls
22	20/03/04 – 1536	Sellafield, Cumbria -NY0151 0358	General view of shore at Sellafield. Lower shore boulders.
23	20/03/04 – 1614	Seascale, Cumbria -NY0359 0057	Extensive *S. alveolata* reef visible (golden-brown colour) on boulder shore
24	20/03/04 – 1615	Seascale -NY0359 0057	*S. alveolata* hummocks clearly visible (golden-brown colour) on boulder shore
25	20/03/04 – 1615	Seascale -NY0359 0057	*S. alveolata* hummocks close up.
27	20/03/04 – 1645	Drigg, Cumbria -SD0423 9836	Beginning of *S. alveolata* near top of shore. Achieved complete cover further down
28	20/03/04 – 1731	Tarn Bay, Cumbria -SD0756 9018	General view of shore, Tarn Bay
29	20/03/04 – 1732	Tarn Bay, Cumbria -SD0756 9018	Extensive cover of *S. alveolata* at Tarn Bay
30	20/03/04 – 1732	Tarn Bay, Cumbria -SD0756 9018	*S. alveolata* reefs at Tarn Bay
31	20/03/04 – 1753	Annaside Banks, Cumbria -SD0842 8656	View down shore showing extensive areas of *S. alveolata* (golden-brown colour)
32	20/03/04 – 1756	Annaside Banks, Cumbria -SD0842 8656	*S. alveolata* reefs at Annaside Banks
33	20/03/04 – 1758	Annaside Banks, Cumbria -SD0842 8656	*S. alveolata* reefs at Annaside Banks

Appendix 1 – continued

Picture number	Date - time taken	Location - NGR	Description
34	20/03/04 – 1758	Annaside Banks, Cumbria -SD0842 8656	*S. alveolata* reefs at Annaside Banks – Close up
35	20/03/04 – 1801	Annaside Banks, Cumbria -SD0842 8656	*S. alveolata* reefs at Annaside Banks – Close up. Surveyor (Matt Frost) to show height of *S. alveolata* growth.
36	21/03/04 – 0736	Heysham, Cumbria -SD4096 6084	General view of shore, Heysham
37	21/03/04 – 0736	Heysham, Cumbria -SD4096 6084	Close – up of *Fucus*. Heysham
38	06/12/03 – 1323	Heysham, Cumbria -SD4096 6084	Upper Shore Heysham – view South – no *S. alveolata* found
39	06/12/03 – 1331	Heysham, Cumbria -SD4096 6084	Heysham – no *S. alveolata* found
40	06/12/03 - 1349	Heysham, Cumbria -SD4096 6084	Heysham – no *S. alveolata* found
41	05/12/03 - 1511	Penmon, Anglesey, N. Wales -SH631 803	Penmon general view of shore – *S. alveolata* not found
42	05/12/03 - 1513	Penmon, Anglesey, N. Wales -SH631 803	Penmon – *S. alveolata* not found
43	07/12/03 - 1451	St Bees, Cumbria -NX955 117	Approach to site
44	07/12/03 - 1507	St Bees, Cumbria -NX955 117	*S. alveolata* on rocks
45	07/12/03 - 1508	St Bees, Cumbria -NX955 117	*S. alveolata* on rocks
46	07/12/03 - 1509	St Bees, Cumbria -NX955 117	*S. alveolata* on rocks
47	07/12/03 - 1513	St Bees, Cumbria -NX955 117	*S. alveolata* in between boulders
48	07/12/03 - 1514	St Bees, Cumbria -NX955 117	*S. alveolata* in between boulders

Appendix 1 – continued

Picture number	Date - time taken	Location - NGR	Description
49	07/12/03 - 1514	St Bees, Cumbria -NX955 117	*S. alveolata* in between boulders
50	07/12/03 - 1515	St Bees, Cumbria -NX955 117	*S. alveolata* on boulders
51	07/12/03 - 1516	St Bees, Cumbria -NX955 117	*S. alveolata* on boulders
52	07/12/03 - 1517	St Bees, Cumbria -NX955 117	*S. alveolata* in between boulders
53	07/12/03 - 1518	St Bees, Cumbria -NX955 117	*S. alveolata* in between boulders
54	07/12/03 - 1543	St Bees, Cumbria -NX955 117	General view of shore at St Bees

Appendix 2

A description of photographs taken as part of the detailed survey of Sabellaria alveolata distribution on Hilbre island.

Picture number	Date - time taken	Location	Description
DSCN0259	07/03/04 - 1216	Hilbre Islands	View Across to Hilbre Islands from West Kirby at low tide
DCSN0260	07/03/04 – 1216	Hilbre Islands	View Across to Hilbre Islands from West Kirby at low tide
DCSN0261	07/03/04 - 1710	Hilbre	Area 1 – NE Hilbre C. Smyth – view looking NNW
DCSN0263	07/03/04 – 1710	Hilbre	Area 1 – NE Hilbre – view W to top shore (transect A) – showing extensive *S. alveolata* with *M. edulis*.
DCSN0264	07/03/04 - 1711	Hilbre	Area 1 – NE Hilbre – close up of silt covered rock between *S. alveolata* patches on transect A
DCSN0271	08/03/04 - 0845	Hilbre	Area 2 – SW side of Hilbre – *S. alveolata* hummocks and fucoid covered rocks - looking N alongTransect E
DCSN0272	08/03/04 - 0845	Hilbre	Area 2 – SW side of Hilbre – *S. alveolata* hummocks and fucoid covered rocks - looking N alongTransect E
DCSN0274	08/03/04 - 0901	Hilbre	Area 2 – SW side of Hilbre – *S. alveolata* patches (but not on transect) and fucoid covered rocks - Transect E
DCSN0279	08/03/04 - 1335	Hilbre	Southern tip of Hilbre, looking towards Little Hilbre Island.
DCSN0280	08/03/04 - 1336	Hilbre	Southern tip of Hilbre, looking towards Little Hilbre Island, Little Eye and West Kirby
DCSN0285	08/03/04 - 1542	Hilbre	Area 1 – NE side of Hilbre showing heavily grazed upper shore.
DCSN0286	08/03/04 – 1600	Hilbre	Area 1 – NE side of Hilbre. Extensive *S. alveolata* cover on transect A.
DCSN0287	08/03/04 - 1600	Hilbre	Area 1 – NE side of Hilbre. Transect A. Close up of *S. alveolata* hummock surrounded by silt covered rock.
DCSN0288	08/03/04 - 1608	Hilbre	Area 1 – NE side of Hilbre. Transect A. Close up of quadrat being used (at 50 m) to examine associated fauna.
DCSN0289	08/03/04 – 1631	Hilbre	Area 1 – NE side of Hilbre. Transect A. Close up of S. alveolata.
DCSN0290	08/03/04 – 1632	Hilbre	Area 1 – NE side of Hilbre. Transect A. Looking South along bottom of shore (i.e. at 90 m on transect A)
DCSN0292	08/03/04 – 1632	Hilbre	Area 1 – NE side of Hilbre. Transect A. Bottom of shore (i.e. at 90 m on transect A) – close up of hummocks.
DCSN0293	08/03/04 – 1654	Hilbre	Area 1 – NE side of Hilbre. Silted up Rockpool surrounded by S. alveolata.
DCSN0294	08/03/04 – 1654	Hilbre	Area 1 – NE side of Hilbre. Silted up Rockpool surrounded by S. alveolata.
DCSN0296	09/03/04 – 0656	Hilbre	Area 2 – SW side of Hilbre. View west along Transect C. Fucoid covered rocks with heavily silted areas.
DCSN0297	09/03/04 – 0656	Hilbre	Area 2 – SW side of Hilbre. Silted up areas near top of transect C.

Appendix 2 – continued

Picture number	Date - time taken	Location	Description
DCSN0298	09/03/04 – 0725	Hilbre	Area 2 – SW side of Hilbre. *S. alveolata* at the 70 m point on transect D (S tip of Hilbre).
DCSN0299	09/03/04 – 0725	Hilbre	Area 2 – SW side of Hilbre. *S. alveolata* at the 70 m point on transect D (S tip of Hilbre).
DCSN0303	09/03/04 – 1608	Hilbre	Area 1 – NE side of Hilbre. View SE towards West Kirby.
DCSN0304	09/03/04 – 1608	Hilbre	Area 1 – NE side of Hilbre. View North. Grazed upper shore with area of *S. alveolata* visible from about c. 50 m down the shore.
DCSN0305	09/03/04 – 1608	Hilbre	Area 1 – NE side of Hilbre. View E. Grazed upper shore with area of *S. alveolata* visible from about c. 50 m down the shore
DCSN0313	10/03/04 – 0651	Hilbre	Shell Bay at N tip of Hilbre.
DCSN0315	10/03/04 – 0653	Hilbre	Shell Bay at N tip of Hilbre. Area of *S. alveolata*.
DCSN0316	10/03/04 – 0653	Hilbre	Shell Bay at N tip of Hilbre. *S. alveolata* hummocks.
DCSN0317	10/03/04 – 0654	Hilbre	Shell Bay at N tip of Hilbre. *S. alveolata* hummocks.
DCSN0318	10/03/04 – 0654	Hilbre	Shell Bay at N tip of Hilbre. Strip of *S. alveolata* on W side of Bay.
DCSN0319	10/03/04 – 0655	Hilbre	Shell Bay at N tip of Hilbre. Strip of *S. alveolata* on W side of Bay.
DCSN0322	10/03/04 – 0706	Hilbre	Shell Bay at N tip of Hilbre. Rockface on E side of Bay heavily encrusted by *M. edulis*.
DCSN0324	10/03/04 – 0706	Hilbre	Shell Bay at N tip of Hilbre. Rockface on E side of Bay heavily encrusted by *M. edulis*.
DCSN0326	10/03/04 – 0731	Hilbre	Shell Bay at N tip of Hilbre. View E across bay. Strip of *S. alveolata* is visible along edge of *Fucus* covered rock area.
DCSN0327	10/03/04 – 0741	Hilbre	Shell Bay at N tip of Hilbre. Strip of *S. alveolata* on W side of Bay. Looking South.
DCSN0328	10/03/04 – 0741	Hilbre	Shell Bay at N tip of Hilbre. Strip of *S. alveolata* on W side of Bay. Looking South. Close-up.
DCSN0329	10/03/04 – 0741	Hilbre	Shell Bay at N tip of Hilbre. Strip of *S. alveolata* on W side of Bay. Close-up showing silted up pool.
DCSN0330	10/03/04 – 0741	Hilbre	Shell Bay at N tip of Hilbre. Strip of *S. alveolata* on W side of Bay. Close-up showing silted up pools.

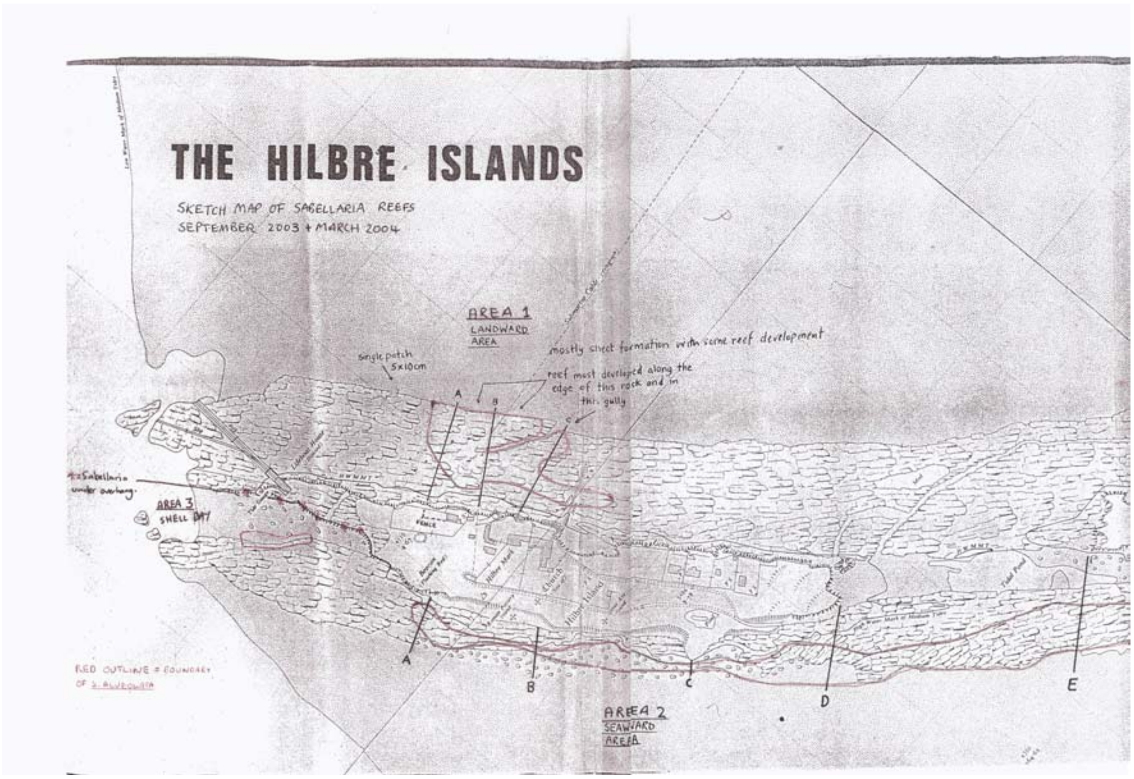
Appendix 3

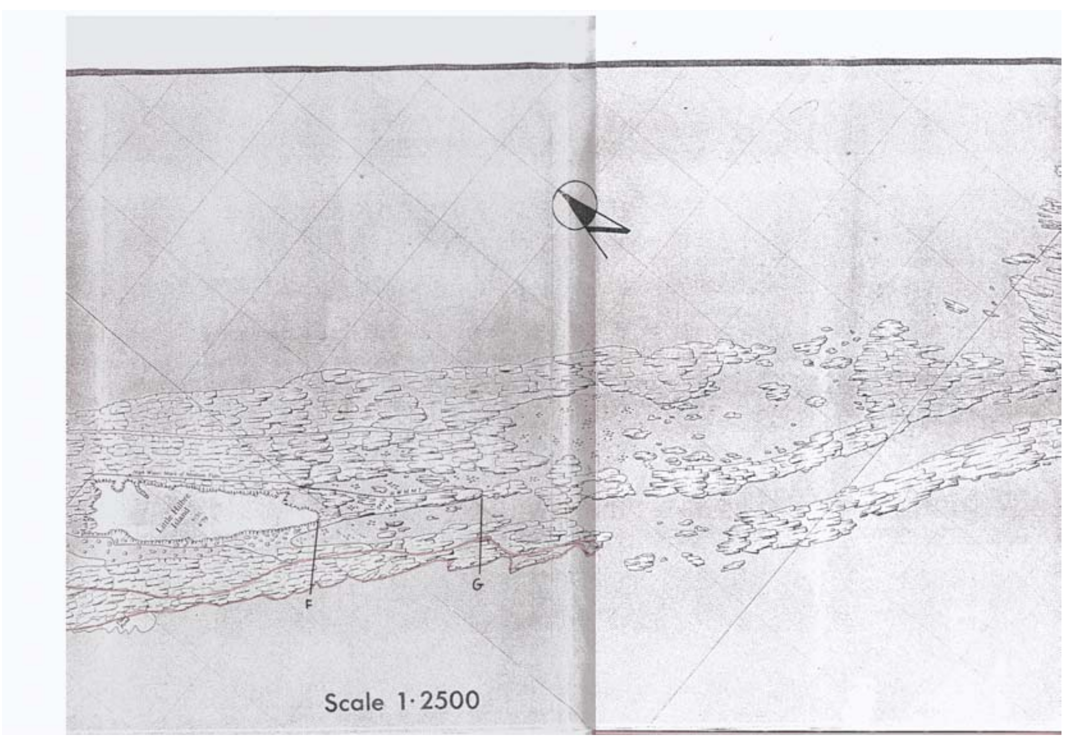
On CD ROM (attached):

- Photographs taken as part of broad scale survey – with index.
- Photographs taken on Hilbre Island as part of detailed survey – with index.

Appendix 4

ATTACHED: Map showing extent of *Sabellaria alveolata* cover on the Hilbre Islands. Area designations and transect locations are also shown.





Appendix 5

Transect description / locations.

Area 1 transect descriptions

Transect A: from drain at base of wall below the north end of the canoe club along a sight-line to the tip of the Wirral mainland.

Transect B: from the base of the sandstone wall eastward along the centre of the telephone cable gully.

Transect C: from the boat tethering ring below Telegraph House steps to the centre of a cylindrical fuel tank and beyond to the shore.

Note – GPS readings not taken for Area 1.

Area 2 transect descriptions

Transect A: Base of cliff, c.20m east of the lighthouse at a bearing of c.260°. GPS top of transect 53º 22.979 N 003º 13.708W.

Transect B**:** Taken at a bearing of c.270° from base of cliff using the southern edge of the bouymasters house complex as a mark. GPS (top) = 53° 22.919 N 003° 13.684 W.

Transect C**:** Base of tip of western facing promontory that is adjacent to the pond above. It is not against the undercut of the cliff, the measurement was from below the point at a bearing of 248°. GPS top of transect - 53° 22.855 N, 003° 13. 607 W

Transect D**:** From south western most tip of Hilbre at a bearing of 242°. GPS top of transect - 53° 22.815 N, 003° 13.480 W

Transect E: Taken at northern tip of Little Hilbre Island. GPS top of transect - 53° 22. 737 N, 003° 13.325 W. GPS bottom of transect 53° 22.704 N, 003° 13.388 W.

Transect F**:** From south western most tip of little Hilbre island (little eye) at a bearing of 242°. GPS top of transect - 53° 22.636 N, 003° 13.152 W

Transect G: From south of little Hilbre island (little eye) at point of rocks marked on map at a bearing of 242°. GPS top of transect - 53° 22.582 N, 003° 13.048 W

Appendix 6

Additional transect notes for transect A, southwest side of Hilbre (Area 2). See table 7 in report for full transect results.

Note: on **Transect A** the *Sabellaria* was clearly different from the landward side. It was a lot thinner where it occurred and was in sheet form (i.e. the tubes lay along the substrate). Although it could occur in large patches, there were lots of areas where it was absent and there were far more isolated patches and individuals, meaning it was more likely to not be recorded on the transect. It was also more cryptic and occurred under algae or overhangs whereas the landward *Sabellaria* was all visible on horizontal rock surfaces.

Appendix 7

Additional transect notes for transect B, southwest side of Hilbre (Area 2). See table 8 in report for full transect results.

Distance from top of shore (m)	Notes
10	
15	Lots of patches at this height despite not being recorded at transect
20	Station 9 was a large hummock.
25	As above
30	Lots of small patches and individuals
35	
40	Lots of patches at this height despite not being recorded at transect
45	Lots of patches at this height despite not being recorded at transect

Note – on **Transect B** the *Sabellaria* is almost identical to A in terms of form and distribution, with lots of thin sheets and scattered patches and individuals. One large hummock was observed.

Appendix 8

Additional transect notes for transect C, southwest side of Hilbre (Area 2). See table 9 in report for full transect results.

Distance from top of shore (m)	Notes
0	
5	Station 1 is hummock.
10	Stations 1 and 2 are hummocks. Very silty here.
15	
20	Mainly bare rock but *Sabellaria* is around.
25	Lots of hummock shape (i.e. pointing up) but very thin. Occasional clear hummocks such as station 6 and 10.
30	Lots of hummock shape (i.e. pointing up) but very thin. Occasional clear hummocks such as station 5. *Sabellaria* very extensive at this height.

Note – Lots of bare muddy rock on this transect and very silty. Also, extensive cover of *Fucus* and barnacles on the open rock faces. It appears that transects A and B on this side differ in that from transect C onwards the amount of silt increases massively, getting progressively muddier as you mouth south along the seaward side of the island. Unlike A and B, there are more hummocks / reefs at this transect.

Appendix 9

Additional transect notes for transect D, southwest side of Hilbre (Area 2). See table 10 in report for full transect results.

Distance from top of shore (m)	Notes
60	This point is just below where the shore drops in height abruptly by about 1.7m. station 6 is clearly a hummock.
65	Shows difficulty of classification - Stations 3, 7 and 5 are sheet form but 4 is hummock form despite still being relatively thin.
70	Tape across large reef so stations 3 – 7 and 9 – 10 are all hummock form..
75	Station 10 clearly sheet.
80	
85	Stations 3 –6 one large thin sheet and 8 – 10 are hummocks.
90	Stations 4 – 9 all very thin sheet.
95	Stations 6-8 are part of a thin sheet but 10 is part of a large reef.
100	

Note – this transect was again (like C) very muddy and had far more large hummocks and reefs than transects A and B.

Appendix 10

Additional transect notes for transect E, southwest side of Hilbre (Little Hilbre Island) (Area 2). See table 11 in report for full transect results.

Distance from top of shore (m)	Notes
50	At 50 – 55 m mark *Sabellaria* was very extensive all around (i.e. v.abundant). Station 10 clearly a hummock.
55	At 50 – 55 m mark *Sabellaria* was very extensive all around (i.e. v.abundant). Station 7 and 9 clearly hummocks.
60	Pool.
65	Station 8 and 10 clearly Hummocks.
70	At 70 – 75 m mark *Sabellaria* still very extensive despite absence at tape points.
75	At 70 – 75 m mark *Sabellaria* still very extensive despite absence at tape points.
80	Stations 7 – 9 clearly hummocks.
85	
90	This transect point was at one huge reef (hummock?) of about 25 cm and more depth that was found from stations 1 –8.
95	Extremely extensive above the tape!

Appendix 11

Additional transect notes for transect F, southwest side of Hilbre (Little Hilbre Island) (Area 2). See table 12 in report for full transect results.

Distance from top of shore (m)	Notes
65	
70	The main part of the shore ends at about 67m so this falls in the gap before another rock outcrop at 75-80
75	
80	*Sabellaria* present here (very thin sheet from 75-80) but not on tape.

Note – By this point, the band of shore with *Sabellaria* is very thin and the reef / hummocks have disappeared.

Appendix 12

Additional transect notes for transect G, southwest side of Hilbre (Little Hilbre Island) (Area 2). See table 13 in report for full transect results.

Distance from top of shore (m)	Notes
70	
75	None
80	none

Note – By this point, the band of shore with *Sabellaria* is very thin and the reef / hummocks have disappeared.

Appendix 13

Data from the MarClim project showing distribution of *S. alveolata* around Britain. Data is presented in chronological order.

*MarClim, Marine Biological Association of the United Kingdom, The Laboratory, Citadel Hill, Plymouth, PL1 2PB. Website: www.mba.ac.uk/marclim

Date	**Site**	**Grid Reference**	***S. alveolata* abundance *NS = not seen**	**Region**
30/01/02	Lyme Regis	SY329908	A	South
13/02/02	Hartland	SS221248	A	Southwest
13/02/02	Welcombe Mouth	SS211178	NS*	Southwest
14/02/02	Prawle	SX776351	NS	Southwest
29/03/02	Polkerris	SX091522	C	Southwest
10/04/02	Brixham	SX937568	NS	Southwest
10/04/02	Torbay	SX909632	OC	Southwest
11/04/02	Newquay	SW802628	NS	Southwest
11/04/02	Trevone	SW886758	NS	Southwest
12/04/02	Salcombe	SX734380	NS	Southwest
25/04/02	Lyme Regis	SY345920	C	South
25/04/02	Seaton	SY256896	NS	South
25/0402	West Bay	SY455909	NS	South
26/04/02	Lulworth Cove	SY824797	R	South
26/04/02	Osmington	SY735816	NS	South
26/04/02	Swanage	SZ040786	NS	South
27/04/02	Alum Bay	SZ305858	NS	South
27/04/02	Hanover Point	SS221248	NS	South
27/04/02	Kimmeridge	SY904791	NS	South
27/04/02	Totland	SZ874879	NS	South
28/04/02	Bembridge	SZ659897	NS	South
28/04/02	Bonchurch	SN605888	NS	South
28/04/02	Freshwater Bay	SZ345855	NS	South
28/04/02	Ventnor	SZ558773	NS	South
29/04/02	St. Catherines Point	SZ504754	NS	South
01/05/02	Start Point	SX831372	NS	Southwest
02/05/02	Looe	SX257525	NS	Southwest
02/05/02	West Looe	SX252519	NS	Southwest
05/05/02	Hartland	SS221248	NS	Southwest
08/05/02	Renny Rocks	SX491486	NS	Southwest
10/05/02	Hope Cove	SX673399	NS	Southwest
11/05/02	Lizard	SW700115	NS	Southwest
11/05/02	Porthleven	SW625254	NS	Southwest
12/05/02	Cape Cornwall	SW351320	NS	Southwest
12/05/02	St. Ives	SW522411	NS	Southwest

Appendix 13 - continued

Date	Site	Grid Reference	*S. alveolata* abundance *NS = not seen	Region
15/05/02	Duckpool	SS198116	A	Southwest
16/05/02	Thurlestone	SX668420	NS	Southwest
23/05/02	Balintore	NH868758	NS	Scotland
23/05/02	Helmsdale	ND002151	NS	Scotland
24/05/02	Gills Bay		NS	Scotland
25/05/02	Dounreay	SX322538	NS	Scotland
25/05/02	Frescoe	NC959657	NS	Scotland
25/05/02	Frescoe West	NC959663	NS	Scotland
25/05/02	Murkle Bay	ND174695	NS	Scotland
25/05/02	Wick (North Head)	ND384508	NS	Scotland
26/05/02	Farr	NC714637	NS	Scotland
26/05/02	Kempie by Brock	NC445582	NS	Scotland
26/05/02	Skerray	NC660641	NS	Scotland
27/05/02	Clashnessie	NC062315	NS	Scotland
27/05/02	Culkein	NC042335	NS	Scotland
27/05/02	Stoer	NC003036	NS	Scotland
28/05/02	Achmelvich	NC053250	NS	Scotland
28/05/02	Clachtoll	NC038268	NS	Scotland
28/05/02	Scourie	NC148449	NS	Scotland
29/05/02	Achnahaird	NC016142	NS	Scotland
29/05/02	Alltain Duibh	NB982115	NS	Scotland
29/05/02	Reiff	NB963143	NS	Scotland
11/06/02	Criccieth	SH494376	NS	Wales
11/06/02	Porth Dinllaen	SH274415	NS	Wales
11/06/02	Porth Oer	SH165298	NS	Wales
12/06/02	Penaenmawr	SH699763	NS	Wales
12/06/02	Porth Neigwll	SH288245	NS	Wales
13/06/02	Bulls Bay	SH427945	NS	Wales
13/06/02	Moelfre	SH513859	NS	Wales
13/06/02	Penmon North	SH641813	NS	Wales
13/06/02	Point Lynas	SH484929	NS	Wales
14/06/02	Cemlyn	SH332938	NS	Wales
14/06/02	Porth Dafarch	SH233798	NS	Wales
14/06/02	Rhosneiger	SH313728	NS	Wales
26/06/02	Nanjizal	SW354237	NS	Southwest
26/06/02	Sennen Cove	SY256896	NS	Southwest
26/06/02	WhitEsand Bay	SW362278	NS	Southwest
27/06/02	Lamorna Cove	SW451237	NS	Southwest
27/06/02	Mousehole	SW472265	NS	Southwest
27/06/02	Porthgwarra	SW372213	NS	Southwest
27/06/02	Tinside	SX479537	NS	Southwest
28/06/02	Bantham	SZ659897	OC	Southwest
28/06/02	Penzance	SW476298	NS	Southwest
28/06/02	Poldhu Cove	SW664199	NS	Southwest
28/06/02	Polkerris	SX091522	F	Southwest

Appendix 13 - continued

Date	**Site**	**Grid Reference**	***S. alveolata* abundance *NS = not seen**	**Region**
25/07/02	Langerstone Point	SX783353	NS	Southwest
25/07/02	Maenporth	SW794295	NS	Southwest
26/07/02	Newquay (Fistral Beach)	SW798626	NS	Southwest
26/07/02	Portland	SY677681	NS	Southwest
27/07/02	Downderry (Bass Rock)	SX322538	NS	Southwest
28/07/02	Flushing	SW810335	NS	Southwest
07/08/02	Aberaeron	SN457633	NS	Wales
07/08/02	Aberystwth	SN582828	A	Wales
08/08/02	Borth	SN605888	A	Wales
08/08/02	Clarach	NC062315	A	Wales
21/08/02	Aberporth	SN260518	A	Wales
21/08/02	Gwbert	SZ379837	C	Wales
22/08/02	Abercastle	SM851338	NS	Wales
22/08/02	Abereiddy	SM792315	NS	Wales
23/08/02	Broadhaven	SM859144	NS	Wales
23/08/02	West Angle Bay	SM848038	NS	Wales
24/08/02	Saundersfoot (Monkstone Point)	SS150033	NS	Wales
24/08/02	St. Govans Chapel	SR967929	NS	Wales
25/08/02	Littlewick Bay	SM864066	NS	Wales
05/09/02	Budleigh Salterton	SY079818	NS	Southwest
05/09/02	Sidmouth	SY122869	A	Southwest
11/09/02	Cellar	SX531477	NS	Southwest
13/0902	Porth Eilian	SH477929	NS	Wales
15/09/02	Cemlyn Bay (East)	SH337934	NS	Wales
15/09/02	Llanbadrig (Cemaes Bay)	SH375945	NS	Wales
22/09/02	Duckpool	SS198111	A	Southwest
05/10/02	Dale	SM824052	NS	Southwest
06/10/02	Blue Anchor	ST034438	C	Southwest
06/10/02	Stolford	ST231461	NS	Southwest
06/10/02	Swill Point	ST099436	NS	Southwest
07/10/02	Gore Point	SS859485	NS	Southwest
07/10/02	Hurlestone Point	SS898493	NS	Southwest
07/10/02	Minehead	SS972471	OC	Southwest
23/10/02	Mothercome	SX608472	A	Southwest
04/11/02	Swanage	SZ040786	NS	South
05/11/02	Clay Ope Cove	SY681723	NS	South
05/11/02	Portland	SY677681	NS	South
05/11/02	Portland (Pulpit Rock)	SY675682	NS	South
06/11/02	Lulworth Cove	SY824798	NS	South
06/11/02	Osmington	SY735816	NS	South
07/11/02	Kimmeridge	SY904791	NS	South
07/11/02	Kimmeridge	SY905793	NS	South
07/02/03	Wembury	SX518482	NS	Southwest
04/03/03	Reiff	NB963143	NS	Scotland

Appendix 13 - continued

Date	Site	Grid Reference	*S. alveolata* abundance *NS = not seen	Region
04/03/03	Scourie	NC148449	NS	Scotland
05/03/03	Rispond	NC454653	NS	Scotland
06/03/03	Fresgoe	NC959657	NS	Scotland
06/03/03	Port Skerra	NC870661	NS	Scotland
11/04/03	Seaford	TV491978	NS	South
18/04/03	Bude	SS199072	A	Southwest
19/04/03	Hartland	SS221248	R	Southwest
19/04/03	Welcombe Mouth	SS211178	A	Southwest
20/04/03	Crackington Haven	SX138969	NS	Southwest
28/04/03	Looe	SX257525	NS	Southwest
30/04/03	Hartland	SS221248	NS	Southwest
30/04/03	Welcombe Mouth	SS211178	C	Southwest
01/05/03	Crackington Haven (North Headland)	SX138969	NS	Southwest
01/05/03	Widemouth Bay	SX191010	NS	Scotland
25/05/03	White Ball Head		NS	Ireland
31/05/03	Lizard	SW700115	NS	Southwest
31/05/03	Porthleven	SW625254	NS	Southwest
31/05/03	St. Ives	SW522411	NS	Southwest
01/06/03	Cape Cornwall	SW351320	NS	Southwest
01/06/03	Lyme Regis	SY345920	A	South
01/06/03	Sennen Cove	SY256896	NS	Southwest
15/06/03	St. Ives	SW522411	NS	Southwest
14/07/03	Osmington	SY735816	NS	South
15/07/03	Lyme Regis	SY329909	F	South
18/07/03	Colliston	NK044287	NS	Scotland
18/07/03	Cruden Bay	NK098355	NS	Scotland
20/07/03	Cove Bay	NJ957005	NS	Scotland
20/07/03	Johnshaven	NO798669	NS	Scotland
20/07/03	Stonehaven	NO893866	NS	Scotland
11/08/03	Great Orme	SH749834	NS	Wales
12/08/03	Penmon North	SH641813	NS	Wales
12/08/03	Porth Swtan	SW372213	NS	Wales
13/08/03	Aberdaron	SH166261	R	Wales
13/08/03	Abersoch	SN582828	NS	Wales
13/08/03	Menai	SH548717	NS	Wales
13/08/03	Porth Oer	SH165298	NS	Wales
14/08/03	Llanbedrog	SH335311	NS	Wales
14/08/03	Porth Neigwll	SH288245	NS	Wales
15/08/03	Criccieth	SH494376	NS	Wales
27/08/03	Broadhaven	SM859144	NS	Wales
27/08/03	West Angle Bay	SM848038	NS	Wales
28/08/03	Martins Haven	SM759091	NS	Wales
29/08/03	North Haven	SM735093	NS	Wales
18/09/03	Cellar	SX531477	NS	Southwest

Appendix 13 - continued

Date	**Site**	**Grid Reference**	***S. alveolata* abundance *NS = not seen**	**Region**
23/09/03	Bangor	J497825	NS	IOM & NI
23/09/03	Donaghadee	J587807	NS	IOM & NI
24/09/03	Marconis Cottage	D151419	NS	IOM & NI
24/09/03	Marconis Cottage	D151419	NS	IOM & NI
24/09/03	Portrush	C854414	NS	IOM & NI
24/09/03	Portrush	C854414	NS	IOM & NI
25/09/03	Garron Point	D303238	NS	IOM & NI
25/09/03	Giants Causeway	C947448	NS	IOM & NI
25/09/03	Larne	SM864066	NS	IOM & NI
25/09/03	Portmuck	D460024	NS	IOM & NI
26/09/03	Ballywalter	J632688	NS	IOM & NI
26/09/03	Townhead	J664633	NS	IOM & NI
27/09/03	Ardglass	J562364	NS	IOM & NI
27/09/03	Ballyquintin Point	J624453	NS	IOM & NI
27/09/03	Kearney	J644511	NS	IOM & NI
27/09/03	Kilclief	J601448	NS	IOM & NI
28/09/03	Annalong	J376193	NS	IOM & NI
28/09/03	Annalong	J378197	NS	IOM & NI
28/09/03	Rosstrevor	J179180	NS	IOM & NI
28/09/03	St. Johns Point	J530335	NS	IOM & NI
29/09/03	St. Johns Point	J530335	NS	IOM & NI

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