

Coral Cay Conservation Sub-Aqua Club

Isles of Scilly 1999 Expedition Report

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Supported by



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ABSTRACT

During the week of 24th -30th July 1999, six volunteer divers from Coral Cay Conservation Sub-Aqua Club took part in an expedition to the Isles of Scilly. During this time they surveyed seven beds of *Zostera marina*, five of which had been surveyed in previous expeditions and two additional beds at Bar Point, St. Mary's and Rushy Bay, Bryher.

Variations in the plant density, amount of infection with the slime mould *Labyrinthula*, epiphyte cover and maximum plant length are discussed and analysed with respect to previous surveys. The maximum plant density was once again recorded at Higher Town Bay, St. Martin's with increases in plant density recorded in two of the beds and a reduction in density at the other three previously surveyed beds. The most dramatic fall of these was recorded at Old Grimsby Harbour, Tresco, which, if this trend continues, must be considered to be under threat. Amounts of *Labyrinthula* and epiphyte cover remain comparable with earlier years.

A survey to establish the amount of the japweed, *Sargassum muticum* in one of the *Zostera* beds was undertaken in addition to a repeat survey of the channel between Tresco and Bryher.

An extended work programme for 2000 is suggested to better understand the dynamics of *Zostera* growth in the various beds around the Isles of Scilly.

1 Introduction

Lying 40km south-west of Lands End, the Isles of Scilly are the most westerly land mass of Great Britain, comprising an archipelago of approximately 200 granite islands and rocks separated by a shallow sea. The five main islands - St Mary's, St Martin's, Bryher, Treco and St Agnes - are inhabited, and support farming, fishing and tourist industries.

The combination of the physical environment and the climate has dictated the very individual composition of the natural history of the Islands. Rare indigenous plants, as well as exotics characteristic of subtropical climates, thrive on the Islands. The almost complete absence of traffic and plentiful windbreak hedges and pines, provide ideal conditions for supporting one of Britain's most important areas for bird life.

The shallow, sheltered marine environment surrounding the Islands supports a variety of marine plants and animals that make up some of the most important marine communities to be found in Britain.

So different are the rocky shores of the western Islands that the scientific classification of shore-types had to be extended to include a special category for Scilly - the 'super-exposed'. Below the low-water mark, only those species that are able to withstand periodic inundation of the full force of the Atlantic are able to survive. On the more protected eastern seaboard by contrast, sheltered, deep-water habitats are home to colonies of various delicate species such as sea fans and branching sponges which often have southerly distributions.

At the opposite end of the scale of exposure to the battered western shores, the sea bed inside the archipelago is very sheltered. Sediments derived from the granite bedrock are carried by tides and waves into the sheltered inter-island basin and deposited there.

The relatively coarse local sediments settle rapidly and this, combined with the absence of river-born silts, leaves the water clean and clear. This encourages the growth of plants and algae that require clear waters through which adequate sunlight can pass for photosynthesis. These clear waters encourage the growth of extensive beds of sea grass (*Zostera marina*) on sandy sediments and fast-growing kelp forests on harder substrata, and are home to some rare algal species.

Although deprived of the nutrient sources that are common to the inshore waters of mainland Britain, the waters around Scilly support a wealth of marine life, including numerous commercial species and an important colony of the Grey Seal (*Halichoerus grypus*). More exotic, though rarely seen visitors include the Basking Shark (*Cetorhinus maximus*), Pilot Whales (*Globicephala melaena*) and even the Killer Whale (*Orcinus orca*). The Common Dolphin (*Delphinus delphis*) and Common Porpoise (*Phocaena phocaena*) are both frequent visitors to the Islands. Records of passing Mediterranean-Atlantic 'vagrants' are not uncommon, and include the Sea Horse (*Hippocampus* sp.), Trigger-Fish (*Ballistes capriscus*), Blue Marlin (*Makaira nigricans*) and various species of turtle. Not all such vagrants are welcome: the Jap weed (*Sargassum muticum*) has now taken a firm hold in Scilly and may out-compete indigenous species for available space and sunlight for photosynthesis.

The Isles of Scilly Environmental Trust

The Isles of Scilly Environmental Trust was established in the mid-1980s for the sole purpose of "*protecting the beautiful Isles of Scilly and preserving them undamaged and, as far as may be possible, unchanged for the enjoyment and appreciation of this and future generations*". All the untenanted land of the Islands (including the uninhabited islands) and most of the Heritage Coast of Scilly has been leased to the Trust by the Duchy of Cornwall and the Trust is mandated to manage and conserve these areas.

The archipelago of Scilly has been defined as that group of islands and rocks contained within the fifty-metre depth contour (Figure 1). This entire area has been declared a Marine Park and has been placed under the management of the Isles of Scilly Marine Park Committee consisting of representatives of the Isles of Scilly Environmental Trust, the Duchy of Cornwall, the Sea Fisheries Committee and English Nature. It aims to "*conserve and protect the ecological, archaeological historical and environmental heritage contained within the park's boundaries and ensure its harmonious coexistence with traditional local activities to the mutual benefit of the marine environment, the local community and visitors to the islands*".

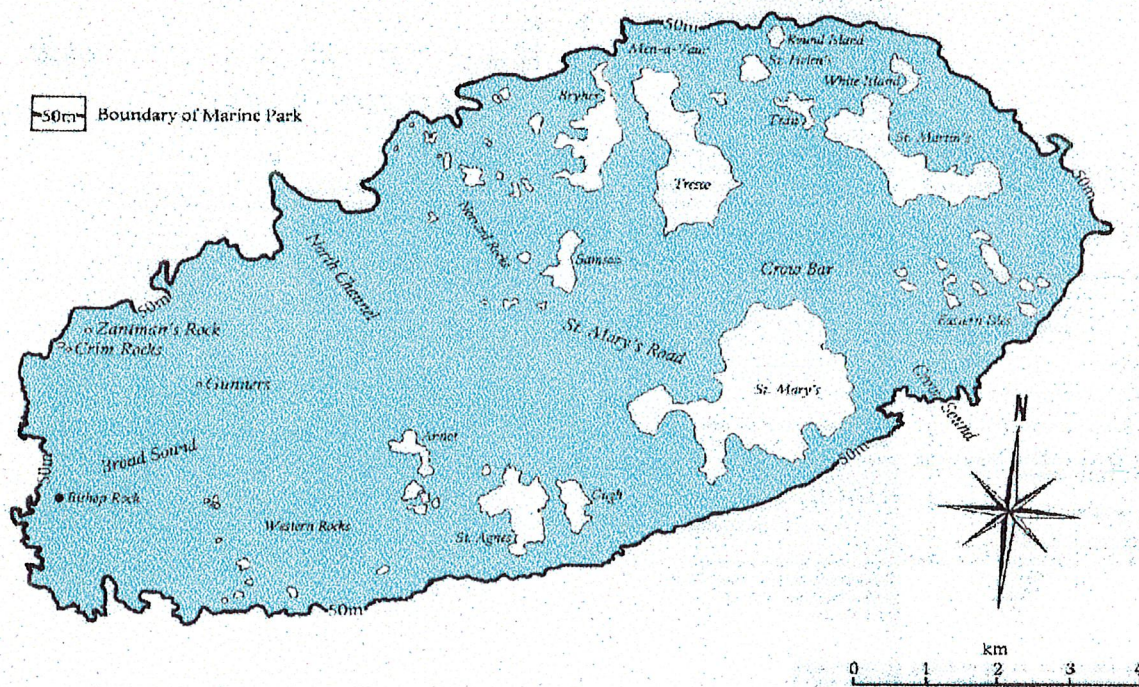


Figure 1 *The Isles of Scilly Marine Park*

The Trust also has an educational and scientific aim - "*to control and co-ordinate opportunities and facilities for marine biological study and research, for the guidance, education and enjoyment of all those interested in the marine environment.*"

Although Scilly has thus far escaped many anthropogenic disasters such as major oil spills or chemical pollution, an essential component of the Trust's work is ensuring that the unique coastal

resources of the Islands are protected from these potential dangers and the destruction that accompanies insensitive tourism and uncontrolled exploitation. The Trust has published a comprehensive Code of Conduct governing the management of the Marine Park and ensures that this is distributed to all users of the Island's marine resources, including visiting tourists.

Coral Cay Conservation Expeditions

Coral Cay Conservation (CCC) is a UK-based non-profit organisation with an associated charitable trust (CCC Trust: Charity Number 1025534). Each year CCC recruits hundreds of volunteers to undertake coastal zone surveys on behalf of government organisations, and is financed almost exclusively by voluntary donations from participating volunteers. CCC has offices in the UK, US, Honduras, Australia, Indonesia and the Philippines.

CCC began as a small group of diving enthusiasts who in 1986, decided to mount an expedition to undertake baseline surveys of the Belize barrier reef. Using basic techniques, the expedition team surveyed three sites and reported their results to the Belize Fisheries Department. These sites were resurveyed by a second CCC expedition in 1987. Since then, over 1,000 volunteers have joined CCC expeditions to Belize, Indonesia and the Philippines. Some of these have set up a special branch of the British Sub-Aqua Club, CCC-SAC.

The Expedition

1999 was the eighth consecutive year in which members of the CCC-SAC have visited the Isles of Scilly. The 1999 expedition lasted for one week and consisted of a smaller team than in previous years. However, the majority of members were experienced Scillies volunteers and the team was able to cover a considerable amount of work.

Unfortunately, the accommodation used in the previous two years was not available due to a prior booking, though we were able to secure the use of the drama hall at Carn Thomas. Although somewhat basic, the hall provided a comfortable base for the week. Cooking facilities were on a camping stove brought along for the purpose and toilet and showering facilities were kindly provided by the Isle of Scilly Sailing club.

Once again we were able to use the Duchy of Cornwall boathouse on Porth Mellon beach as a dive store.

During the 1999 expedition the CCC-SAC volunteers had only one main objective. This was:

- Repeat surveys of the *Zostera* beds surveyed previous years and to investigate the bed discovered during the 1998 survey of Bar Point, St. Mary's and investigate the presence of a *Zostera* bed survey during the 1996 expedition.

Management of the Expedition

In 1999 Kevan Cook and Tom Reid planned and led various aspects of the expedition. Once again, during the course of the expedition the Diving and Scientific Officer Kevan Cook oversaw all

aspects of the diving and ensured that the highest standards of safety were known and adhered to. This was achieved by publication of the CCC-SAC Diving Rules, an abridged version of which was issued to each volunteer prior to the expedition.

The other CCC-SAC volunteer divers carried out all other activities associated with the expedition.

Expedition Team

The 1999 expedition team was composed of a number of experienced Isles of Scilly Expedition volunteers, supported by new members. Many of the team members were volunteer divers who had been sent out by CCC Expeditions to Belize where they received training in underwater survey techniques and marine identification skills.

Expedition Members

Chris Ashelby
Claudia Eckardt
Tom Reid

Kevan Cook
Harry Ram
Ranjit Wijetunge

Expedition Finance

The expedition was part financed by a grant from English Nature with the balance of funds raised by contributions from the participating volunteers. Assistance from the Isles of Scilly Steamship Company, in the form of subsidised transportation for equipment and personnel, has also helped the expedition to achieve its objectives.

2 *Zostera marina* Monitoring

Introduction

Seagrass beds were identified under Agenda 21 as being of vital importance and worthy of preservation. They are ecosystems of high productivity and are found in sheltered shallow marine conditions. They are also environmentally susceptible to natural and human related activities, such as climatic changes, sea level rise, dredging and fill activities, sedimentation, sewage discharge and shoreline development. *Zostera marina* is an important species both ecologically and economically because it provides critical habitat for a range of invertebrates and fish, it protects coastlines from erosion, it causes increased sedimentation leading to enhanced recycling of nutrients and improves water clarity (IGC, 1996).

Species Conservation

The south west regional Biodiversity Action Plan identifies all three of the *Zostera* species (*marina*, *angustifolia* and *noltii*) as being nationally scarce (occurring in between 16-100, 10 km squares in the UK).

Identified in the report are current factors affecting the habitat:

1. A lack of ecological information including:
distribution and extent, community diversity and abundance, reproductive strategies, population dynamics/interactions, population stability and susceptibility to natural and human influence.
2. Anchoring and mooring issues.
3. The potential spread of the non-native brown algae *Sargassum muticum*
4. Coastal development including coastal protection and beach cleaning.
5. Shellfish collection and bait digging.
6. Dredging and dumping issues.
7. Water quality (pollution/eutrophication).

The UK Seagrass Beds Costed Habitat Action Plan proposes to:

- Maintain extent and distribution of seagrass beds in UK waters.
- Assess feasibility of restoration of damaged or degraded seagrass beds.
- Until surveys assess the extent of the seagrass resource, it will not be possible to assess whether restoration is necessary, or to specify a final target. An interim target of 1,000 ha has been costed.

The South-West biodiversity objectives and proposed targets are:

OBJECTIVE 1 TARGET: by 2002

Increase knowledge of the distribution, extent and quality of *Zostera* beds in the South-West.

OBJECTIVE 2 TARGET **by 1997 *ongoing
Identify and quantify natural* and human factors** affecting seagrass beds in the South-West

OBJECTIVE 3 TARGET ongoing
Seek to halt any decline in *Zostera* populations in the South-West resulting from human impacts.

OBJECTIVE 4 TARGET ongoing
Seek to increase the current size of the *Zostera* resource in the South-West.

OBJECTIVE 5 TARGET ongoing
Raise the profile and increase public awareness of seagrass beds and their associated species.

Species Description

Zostera marina is a marine angiosperm and the only marine flowering plant found in UK waters. The flowering plants appear markedly different from the non-flowering ones in that they have extended stems containing the flowers growing from the rhizomes with small leaves off the main stem. The leaves of the plants die back at the end of each summer / autumn and then regrow in the spring with the rhizomes, the root system, remaining in place. However, although *Zostera* can reproduce both sexually and vegetatively Grassle and Grassle (1978) suggest that due to the vigorous rhizomatic growth of this and other seagrasses, and their wide distributions and ecological success, vegetative reproduction generally prevails. Flowering stems have been noted on several *Zostera* plants within the beds surveyed, however it is not known whether any of the resulting seeds are viable.

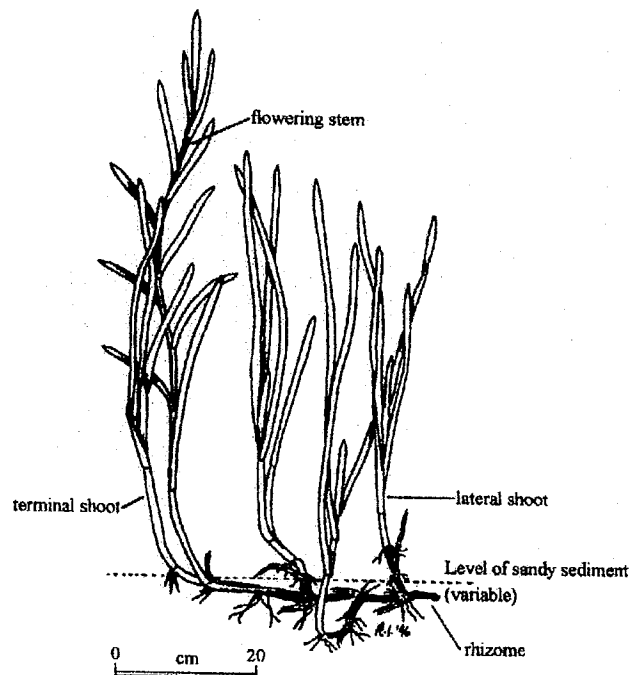


Figure 2 *Zostera marina*

The distribution of *Zostera* along the south coast extends from the beds in the Scilly Isles eastwards along the channel as far as Studland Bay in Dorset in full marine but sheltered conditions in sand or mud substrates. However, it can also be found in some brackish lagoons such as the Fleet in Dorset.

Annual surveys of the *Zostera* beds around the Scilly Isles were begun in 1984 by the Nature Conservancy Council and were continued until 1988. Following a gap of two years, 1988 and 1989, when no studies were carried out a further limited survey was done in 1991 (Fowler & Pilley, 1992). Since then volunteers from Coral Cay Conservation Sub-Aqua Club have carried out surveys every year from 1992 to 1998 (Raines *et al.*, 1993; Cleator *et al.*, 1996; Mackenzie & Rickards, 1996; Irving *et al.* 1996, Irving and Mackenzie, 1997, Irving *et al.*, 1998, Cook *et al.*, 1999). The initial surveys were only carried out on two sites, English Island, East Higher Town Bay, St. Martin's and at Old Grimsby Harbour on the east side of Treco. Since then additional sites at East Broad Ledge, St Martin's and West Broad Ledge, Treco were added and following the investigation of a site identified by aerial survey carried out in September 1996, a further *Zostera* bed was surveyed at Little Arthur (formally known as Great Ganilly) in the Eastern Isles. A further two beds, at Bar Point, St. Mary's and Rushy Bay, Bryher were also added this year. The Bar Point bed was discovered during the sediment survey that took place there during the 1998 expedition whilst that at Rushy Bay was surveyed following the investigation of a bed that was surveyed during the 1996 expedition.

In addition to the initial concerns relating to the population and concentration of the plants within the beds it was noted in the surveys of the beds between 1988 and 1991 that the plants were infected with the parasitic slime mould of the genus *Labyrinthula* sp. more commonly known as wasting disease. The infection of the *Zostera* plants with *Labyrinthula* caused widespread loss in many areas during the 1930s and 1940s including the Isles of Scilly and various other beds in the south-west (den Hartog, 1987). The surveys carried out by the Nature Conservancy Council during the years 1984 to 1988 reported no incidences of *Labyrinthula* within the beds surveyed (Fowler & Pilley, 1992). Although no formal surveys of the beds were carried out in the years 1989 and 1990, Fowler (1992) reported that during the years 1988 to 1991, the health of the beds had shown a marked deterioration. The cause of this was attributed to *Labyrinthula* and this was later confirmed by the Coral Cay Conservation Sub-Aqua Club expedition to the islands in 1992 (Raines *et al.*, 1993).

It is unclear what caused the reoccurrence of the infection in the beds in the Isles of Scillies although Cleator *et al.* (1996) suggested a worsening in environmental conditions i.e. changed water temperature water flow and sedimentation or even changes in irradiance. Whatever the cause it was thought, however, that the increase in occurrence of *Labyrinthula* was due to metabolic stress making the individual *Zostera* plants more susceptible to infection by reducing the amount of organic compounds involved in the resistance of disease and the growth of epiphytes on the leaves.

The disease first becomes apparent with the appearance of small black spots on the leaves. These then spread along the length of the leaf until the leaf can become so infected that photosynthesis is no longer possible and the leaf dies. If the infection is not severe the plant will remain viable and continue to grow. However, should the infection continue for a number of years the leaf loss may

cause the rhizomes to also become infected and cause the plant to die (den Hartog, 1989). This die back has yet to be confirmed in the beds around the Isles of Scilly.

Factors for *Zostera* growth

As a marine angiosperm, *Zostera marina* has a range of environmental conditions that are conducive to growth. As discussed above, it has been suggested that one of the causes of infection within the seagrass beds by *Labyrinthula* is environmental stress caused as a result of anthropogenic inputs. In a study to investigate the seasonal response of *Zostera marina* to varying conditions of light and nutrient enrichment, Moore and Wetzel (2000) showed that the prime controlling factor in growth rates is water column light availability. This study was linked to the effect that epiphytic growth had on growth rate and in a series of controlled experiments they showed that in moderately turbid environments and given adequate levels of epiphyte grazers increased levels of nutrients are unlikely to lead to a reduction in *Zostera* growth.

The prime controlling factor in *Zostera* growth is the amount of available light though temperature, salinity and nutrient availability are also important.

Zostera Sampling

The surveys carried out during the 1999 expedition followed on from those undertaken in earlier years and the aims were:

- To assess the plant density of different beds by surveying randomly selected samples.
- To count the number of leaves per plant and measure the maximum leaf length.
- To assess the amount of *Labyrinthula* infection within the beds.
- To assess the amount of epiphytic cover on each plant.

As an additional aim, it was planned to survey the amount of the japweed, *Sargassum muticum* found within one of the beds to assess the level of threat it posed to the *Zostera* from shading.

Locations

Seven locations were surveyed during the 1999 expedition, five of which continued the work of previous years and the remaining two, off Bar Point, St. Mary's and Great Rushy Bay, Bryher, were added for comparison and record.

Site	Latitude N	Longitude W	Date Surveyed
Old Grimsby Harbour, Tresco	49° 57.57'	006° 19.69'	25th July
Higher Town Bay, St Martin's	49° 57.37'	006° 16.28'	26th July
East Broad Ledge, Tresco	49° 56.44'	006° 19.27'	26th July
West Broad Ledge, St. Martin's	49° 57.52'	006° 18.16'	28th July
Little Arthur, Eastern Isles	49° 56.89'	006° 15.81'	29th July
Bar Point, St. Mary's	49° 56.10'	006° 18.11'	29th July
Great Rushy Bay, Bryher	49° 56.66'	006° 21.23'	28th July

Method

At each site a central line was lowered to the sea floor to act as a datum from which all bearings and distances were measured. The position of this line was chosen by eye to be approximately central in the bed to be surveyed. The position of this central marker was fixed by means of bearing taken from the surrounding coastline features. Pairs of divers were then sent to take samples from points at randomly selected distances, between 0 and 30m, and bearing, between 0° and 359°, from the central line. At each of the sites, a 0.25m² quadrat, constructed of a 0.5m by 0.5m square constructed from copper tubing.

The bearing was measured using a standard divers compass and the distance from the central line was measured using a marked tape. The quadrat was placed to the left of the line at the indicated distance such that the bottom right hand corner was against the tape at the indicated distance with the right hand edge of the quadrat along the tape. All the plants within the bottom right hand quarter were then cut above the rhizomes and stored in a plastic bag for later analysis. Care was

taken to ensure that only the plants with their rhizomes directly under the quarter square were taken by ensuring that all leaves were traced to the base.

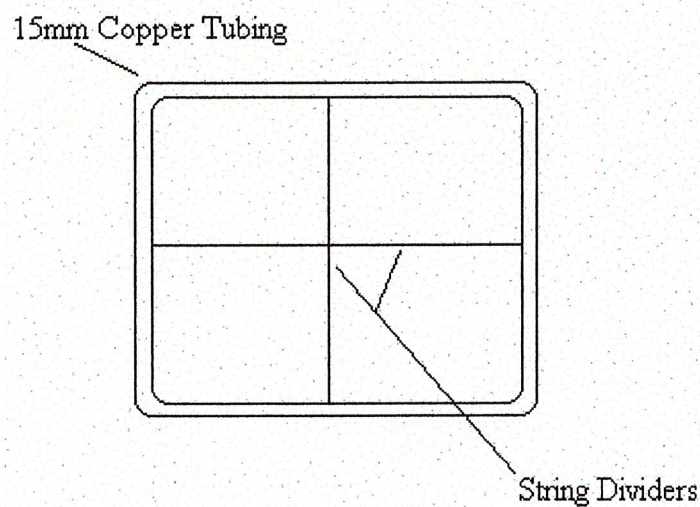


Figure 3 *A Quadrat*

In the event that there were no plants present in the quadrat when placed at the given distance and bearing, the bag was tied closed to indicate a empty bag. This data was then used in the calculation of overall bed plant density.

Score	Amount of Infection	Percentage of Infection	Diagrammatic Representation of Infection
0	Uninfected	0%	
1	Some infection apparent	<10%	
2	As much as half the leaf infected	10 - 50%	
3	Over half the leaf infected	50 - 80%	
4	Almost all the leaf infected	>80%	

Table 1 *Zostera Leaf Infection Scoring System*

Data Analysis

For each sample bag, the following variables were recorded:

- Bearing and distance at which sample was taken
- Number of plants per bag
- Maximum plant length
- Amount of *Labyrinthula* infection
- Number of leaves showing infection
- Amount of Epiphytic cover
- Number of leaves showing cover
- Number of flowering plants

The data for infection and epiphyte cover was recorded using the score system shown in Table 1. The data were initially recorded on a preformatted sheet and then loaded into an Excel spreadsheet for further analysis where the following was calculated:

- The density of plants per 0.0625m²
- The proportion of infected leaves expressed as a percentage of the total number of leaves together with a mean infection and epiphyte cover score.
- One-way Analysis of Variance (ANOVA) on maximum leaf length and percentage of infected leaves between the different sites surveyed to examine if any significant difference (with a 95% confidence level) exists between the five sites.
- Correlation matrix of the variable listed above to investigate the existence of any relationship between these variables.
- Frequency analysis of longest leaf length to investigate the population structure at the seven sites.

Site Descriptions and Results

The sampling of the seven sites took place during the period 24th July to 30th July, 1999 from the English Nature launch *Melza*.

Old Grimsby Harbour, Tresco

Situated on the east side of Tresco this is one of the most sheltered *Zostera* beds found within the Isles of Scilly. There is little or no tidal movement of water around the bay as the main flow of water is along the channel between Tresco and the smaller islands to the east and the bay is also sheltered from the prevailing south-westerly winds. The small embayment formed by Block House Point to the south and Long Landing Point to the north is used extensively by cruising yachts and also local pleasure boats. There are a number of mooring buoys which are fixed *in situ* by means of heavy chains attached to permanent blocks. These chains are free to move about their radius as they are pulled by the mooring buoys. This in turn drags the chains through the *Zostera* bed causing plants to be crushed and even dislodging the rhizomes. At the western extreme of the bed, the water becomes very shallow at low tide and is close to the sand dunes that form a well used sheltered

pleasure beach. It is possible that some trampling occurs here from the number of holiday makers that use this area though the author has no direct evidence of this.

Higher Town Bay, St. Martin's

Higher Town Bay lies to the south of St. Martins and the *Zostera* bed lies to the eastern end of this bay. The eastern edge of the bed is defined by English Island, an outcrop of rock that is covered only at extreme high tide. The whole area is swept by strong tidal streams and the *Zostera* is therefore important in maintaining the sediments in the bay. The beds are marked by a rise in the level of the sediment, fine to medium sand, of approximately 10cm to 25cm. At the eastern edge of the bed towards the rock outcrops of English Island, the *Zostera* is occasionally covered by species of algae that are removed from the rock and deposited there by the tidal currents.

East Broad Ledge, Tresco

East Broad ledge, lies to the south east of Tresco and the bed lies just to the east of this in a mixture of medium to coarse sand and some pebbles to small cobbles. Attached to these are some strands of the japweed, *Sargassum muticum* which compete for light with the *Zostera*. However, the number of japweed plants is low and as the majority of plants are attached to small stones they are mobile across the bed.

West Broad Ledge, St. Martin's

This bed lies just to the west of the intertidal ledge off the southern shore of St. Martin's and is sheltered from the main tidal flow between St. Martin's and Tresco. Although the area is used by the pleasure boats which transport tourists between the islands, the bed is largely undisturbed. This bed is also comprised of a mixture of medium to coarse sand mixed with small gravel, pebbles and cobbles. The bed also contains some *Sargassum muticum* plants. Following the survey of the *Zostera* within the bed, the divers also measured the number and length of *Sargassum* plants. This is discussed at greater length in Chapter 3.

Little Arthur, Eastern Isles (formally known as Great Ganilly)

This bed lies in the sheltered water between Little Arthur to the west and the Great Ganilly to the east in the eastern isles. It is also the deepest bed found within the archipelago and lies in a patch of sand deposited in this small area that experiences almost no tidal flow. The bed is surrounded by rock outcrops that are extensively covered by macro algal species. This is probably due to the fact that the water at this location carries less suspended material and is therefore clearer.

Bar Point, St. Mary's

This bed was noted during the 1998 sediment survey made of Bar Point and surveyed for the first time in 1999. The bed lies in the small bay to the west of Bar Point. The bed is confined to the shallow water out of the main tidal channel between the island and Crow Rock. This is probably due to the fact that the sediment suitable for *Zostera* growth is found only within this bay as the

smaller sand required for establishment of rhizomes has been eroded away (Cook *et al.*, 1999). At the start of the survey the area covered by the bed was not known and therefore a standard set of samples were planned. This, however, proved to be a failing as the northern edge of the bed reached on several of the sample swims and therefore no samples were taken. These data have been excluded from the total plant density figures for this bed.

Rushy Bay, Bryher

This was a new site for the Isles of Scilly survey and due to the patchy nature of the bed, only 17 samples were taken. The results are included for comparison. Rushy Bay lays at the southern corner of Bryher and is the smallest of all the beds surveyed. There are however, small and highly sparse growths of *Zostera* eastwards from the bay along the channel towards the Tresco flats. These were not surveyed in detail although a visual survey from the surface using mask and snorkels revealed occasional sparse outcrops of growth over the whole length of channel between the Tresco flats, Yellow Rock and Great Rushy Bay.

	Old Grimbsy Harbour, Tresco	Higher Town Bay, St. Martin's	East Broad Ledge, Tresco	West Broad Ledge, St. Martin's	Little Arthur, Eastern Isles	Bar Point, St. Mary's	Great Rushy Bay, Bryer
Total Number of Quadrats	26	25	23	26	25	18	17
Total Number of Plants	94	255	211	133	246	133	78
Total Number of Leaves	383	1106	844	527	1157	578	476
Percentage Leaves Infected	59.63	66.60	70.62	69.32	51.84	55.37	68.78
Mean Infection Score	0.86	0.89	1.02	0.96	0.62	0.83	0.84
Mean Epiphyte Score	1.33	0.88	0.08	0.77	0.32	0.57	1.08
Mean Plant Length (mm)	37.47	45.84	40.44	64.5	78.95	58.17	66.5
Standard Deviation	14.56	18.39	14.52	22.97	22.41	25.84	19.5
Mean Plant Density /0.062m ²	3.62	10.20	9.17	5.12	9.84	7.39	4.59

Table 2 *Summary of Zostera analysis, 1999 survey*

It should be noted that the 1999 survey took place a week earlier than the surveys in the previous years. However, it is assumed that the majority of plant growth will have occurred by this date and that the data from this year are comparable with the preceding years.

The plant density figures reveal a wide difference in coverage of *Zostera*. The highest concentration of plants (10.20) was recorded at Higher Town Bay, St. Martin's with Little Arthur, Eastern Isles (9.84) and East Broad Ledge, Tresco (9.17) also high. The lowest density (3.62) was

recorded at Old Grimsby harbour, Tresco which was also the site with the highest Epiphyte cover, a mean score 1.33. The site with the lowest epiphyte score (0.08) was East Broad Ledge off Tresco. This is significantly lower than any other site though the Little Arthur Site in the Eastern Isles was also low at 0.32.

Leaf Infection, Epiphyte cover and Plant Density

Comparison of 1999 percentage leaf infection data for the five sites surveyed in previous years shows an increase in three of the sites with Higher Town Bay, St. Martin's constant at 67% and Little Arthur a decrease from 65% in 1998 to only 52% of leaves infected, the lowest of all the sites surveyed. At the two sites for which data exists since 1993, Old Grimsby Harbour and Higher Town Bay, St. Martin's, the percentage infection with *Labyrinthula* although marked higher than the low levels recorded in 1997, are comparable with the preceding years with the exception of June 1995.

	Old Grimsby Harbour, Tresco	Higher Town Bay, St. Martin's	East Broad Ledge, Tresco	West Broad Ledge, St. Martin's	Little Arthur, Eastern Isles
August '99	60	67	71	69	52
August '98	57	67	76	61	65
August '97	43	37	44	49	na
July '96	69	63	61	na	na
June '95	63	42	na	na	na
August '94	57	79	na	na	na
July '93	59	65	na	na	na

Table 3 *Percentage Leaf Infection at different sites 1993 - 1999.*

<i>Source of Variation</i>	<i>SS</i>	<i>Df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	20.98	6	3.50	23.10	7.8E-26	2.11
Within Groups	172.90	1142	0.15			
Total	193.89	1148				

Table 4 *ANOVA - Percentage Leaf Infection between all sites.*

The one-way analysis of variance for the null hypothesis that 'there is no significant difference in the amount of leaf infection between sites' shows that this null hypothesis must be rejected as the

calculated F value of 23.10 is greater than the F-Critical value of 2.11 which indicates that there is a significant difference.

Observations on the pattern of infection spots on the *Zostera* leaves seem to indicate that it is limited to the older external leaves only while the younger newer leaves remain uninfected. However, as no effort was made to record this, there is no direct evidence for this hypothesis. Future surveys should attempt to record the leaves in order such that the position of the leaves on the plant may be correlated with the amount of infection.

	Old Grimsby Harbour, Tresco			Higher Town Bay, St. Martin's			East Broad Ledge, Tresco			West Broad Ledge, St. Martin's			Little Arthur, Eastern Isles		
	IS	ES	Den	IS	ES	Den	IS	ES	Den	IS	ES	Den	IS	ES	Den
August '99	0.86	1.33	3.62	0.89	0.88	10.20	1.02	0.08	9.17	0.96	0.77	5.12	0.62	0.32	9.84
August '98	0.87	1.41	7.32	0.81	1.74	14.08	0.94	0.29	4.20	0.71	1.05	7.36	0.71	0.96	8.28
August '97	0.57	0.62	6.78	0.45	0.50	11.79	0.57	0.41	4.83	0.61	0.43	9.52	na	na	na
July '96	1.03	1.57	7.17	0.92	1.32	15.96	0.83	0.25	7.50	na	na	na	na	na	na

IS - Mean Infection Score

ES - Mean Epiphyte Score

Den - Mean Plant Density

Table 5 *Mean Infection and Epiphyte Score and Mean Plant Density at various sites, 1996 - 1999*

The analysis of Mean Infection Score, Mean Epiphyte Cover Score and Mean Plant Density over the past four years, for those sites where data is available shows that there is a difference between the long-term trends of variables at different sites. Old Grimsby Harbour has had the highest amount of epiphyte cover (with the exception of 1997) over the four years whereas East Broad Ledge has the lowest. However, there does not seem to be any direct link between this and mean infection score as the East Broad Ledge, Tresco site along with Higher Town Bay, St. Martin's has had consistently high scores.

Plant Size Distribution

The plant size distribution, measured as the length of the longest leaf, is illustrated in Figure 4

Distribution of Maximum Plant Length

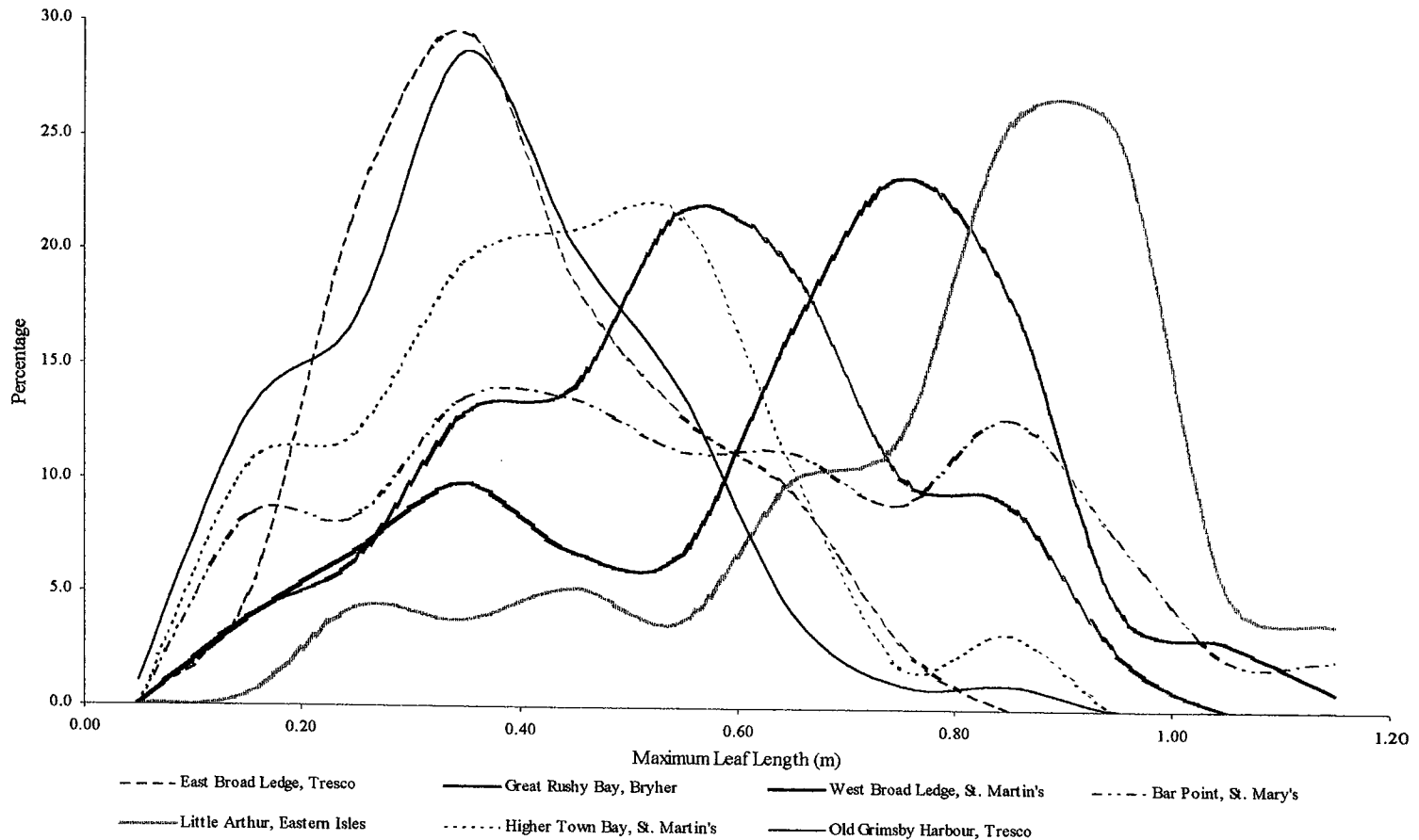


Figure 4 *Zostera* Plant Size Distribution at Different Sites

The analysis of the distribution of maximum plant length shows three main groups. The distributions for Little Arthur, Eastern Isles and West Broad Ledge, St. Martin's are skewed towards the longer leaf lengths, though the latter shows a bimodal distribution with means of approximately 0.36m and 0.76m. The skew seen in the Little Arthur site is not as extreme as that seen in 1998. The distributions for Old Grimsby Harbour and East Broad Ledge, Tresco both show a marked skew towards the smaller leaf lengths though the skew at Old Grimsby Harbour is not as severe as that in 1998. The remaining three sites show a better range of leaf lengths throughout their distribution. Bar Point St. Mary's has a general distribution with a range of maximum leaf lengths with frequencies between 7.5% and 15%. The distribution of plants at Rushy Bay, Bryher is almost normal as is that for Higher Town Bay, St. Martin's though it does have a slight skew towards the shorter leaf lengths.

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	248950.27	6	41491.71	103.05	1.02E-103	2.11
Within Groups	459825.64	1142	402.65			
Total	708775.91	1148				

Table 6 *ANOVA - Maximum Plant Length*

From Table 6, the Null Hypothesis that 'no significant' difference existed between the maximum leaf lengths from plants at the seven sites' is not supported with the F value of 103.05 being larger than the F-critical value of 2.11 supporting the evidence shown in Figure 4 that the distributions at the seven sites are markedly different.

Correlation of variables recorded.

Old Grimsby Harbour, Tresco				
	% Infected	Infection	Epiphyte Cover	Plant Length
% Infected	1			
Infection	0.79	1		
Epiphyte Cover	0.39	0.33	1	
Plant Length	0.31	0.36	0.14	1
Higher Town Bay, St Martin's				
	% Infected	Infection	Epiphyte Cover	Plant Length
% Infected	1			
Infection	0.75	1		
Epiphyte Cover	0.16	0.30	1	
Plant Length	0.05	-0.04	0.21	1
East Broad Ledge, Tresco				
	% Infected	Infection	Epiphyte Cover	Plant Length
% Infected	1			
Infection	0.74	1		
Epiphyte Cover	-0.10	-0.09	1	
Plant Length	0.05	0.06	0.10	1
West Broad Ledge, St. Martin's				
	% Infected	Infection	Epiphyte Cover	Plant Length
% Infected	1			
Infection	0.76	1		
Epiphyte Cover	0.08	0.18	1	
Plant Length	0.02	0.19	0.24	1
Little Arthur, Eastern Isles				
	% Infected	Infection	Epiphyte Cover	Plant Length
% Infected	1			
Infection	0.79	1		
Epiphyte Cover	0.13	0.13	1	
Plant Length	-0.15	-0.18	0.09	1
Bar Point, St. Mary'				
	% Infected	Infection	Epiphyte Cover	Plant Length
% Infected	1			
Infection	0.77	1		
Epiphyte Cover	0.32	0.50	1	
Plant Length	-0.03	-0.01	0.13	1
Great Rushy Bay, Bryher				
	% Infected	Infection	Epiphyte Cover	Plant Length
% Infected	1			
Infection	0.68	1		
Epiphyte Cover	0.16	0.32	1	
Plant Length	-0.05	0.15	-0.12	1

Significant Positive Correlation

Table 7 Correlation of *Zostera* Variables at Different Sites

The strongest correlation between variables is that between the percentage leaf infection and the mean infection score. Each site shows strong positive correlation between these two variables, repeating the pattern seen in previous years although the correlation for the bed at Old Grimsby Harbour was described only as modest in 1998 (Cook *et al.*, 1999). Also, the modest correlation seen at Old Grimsby Harbour between the percentage of leaves infected and the Mean Epiphyte Score (0.66 in 1998) is now only 0.39 and therefore not significant.

3 **SARGASSUM MUTICUM RECORDING**

The introduction to the Isles of Scilly of the foreign species *Sargassum muticum* (commonly referred to as Japweed) was probably on the currents that flow between the islands and the mainland of Cornwall. It was first reported in the UK by Farnham *et al.* (1973) round the Isle of White where it thought to been transported in a consignment of oysters. Since then it has spread throughout the English Channel and can be found in many of the sheltered harbours. It was first reported in the Isles of Scilly in 1991. The plant attaches to small shells, stones or cobbles and is supported on the surface of the water by small air sacs. Once attached to a suitable substrate it grows rapidly and by this method it can shade any other species under its fronds. After the first sightings of *Sargassum* it was feared that its introduction would lead to a decrease in the amount of native species including *Zostera* through this competition. These initial fears do not seem have proved true and *Sargassum* now forms part of the that flora around our coast. During the 1996 expedition the group undertook a survey of the amount of *Sargassum* within the bed at east broad ledge, Tresco and also noted its presence or absence along the channel between Bryher and Tresco (Irving and Mackenzie, 1996). In order to update this work , it was decided to carry out a similar survey during the 1999 expedition.

Location

As in 1996, the group investigated the presence or absence of *Sargassum* between the islands of Bryher and Tresco and also recorded the number of plants found within one of the seagrass beds, West Broad Ledge, St. Martin's. The central point used for the survey was that used for the *Zostera* survey at 49° 57.52'N 006° 18.16'W.

Method

The survey between the islands of Bryher and Tresco was conducted by means of surface observations made by divers equipped with mask, fins and snorkels dropped at various points along the channel.

The survey of the number and length of plants in the *Zostera* bed at West Broad Ledge was carried out with the plants *in situ*. Pairs of divers were given bearings between 0° and 360° at 60° degree intervals and asked to measure, using a tape measure, the length of any plants found on this bearing from 0m to a maximum distance of 30m from the central marker and 1m either side of the central line. This was achieved by one of the pair holding the end of the tape fast at the base of the plant while the second diver measured the length to the tip of the plant. This was then recorded on a slate for later analysis. This method was preferred to that used in 1996, removing the plants from the water and measuring them on the side of the boat, as the airsacs within the plants themselves tend to hold the plant taught making measuring far easier and more accurate.

Data Analysis

The plant lengths were entered into an Excel spreadsheet and their mean length and standard deviation calculated.

Results

Visual survey

As was found during the survey in 1996, *Sargassum muticum* plants were recorded around both Plumb and Merrick Island to the south of New Grimsby Harbour but were absent from either side of the channel between Cromwell's castle and New Grimsby Harbour and also from the eastern side of Bryher. The shallow waters here are covered with dense growths of the brown algae *Himanthalia elongata* with probably out compete for holdfasts and light.

West Broad Ledge, St. Martin's

	Bearings from Central Point					
Plant length (mm)	0	60	120	180	240	300
1	121	60	25	75	79	41
2	97	69	66	15	63	68
3	100	81	56	62	98	69
4	49	106	39	96	97	392
5	18	39	66	93	60	58
6	21	69	48	53		54
7	48	51	98	86		44
8	26	79	114	92		56
9	113	68	34	75		120
10	39	19		70		42
11	76	59		67		83
12	105	30		49		38
13	28	87		82		36
14	124	171		33		97
15	77	230		65		
16	40	310		55		
17	57	68		18		
18	61	83		148		
19		52		14		
Number of Plants	18	19	9	19	5	14
Mean length (mm)	67	91	61	66	79	86
St. Deviation	35.93	71.87	29.43	32.62	18.04	91.47

Table 8 *Sargassum muticum* recording, West Broad Ledge, St. Martin's

The total number of plants found within the bed was 84 with a mean length of 75mm and standard deviation of 56.23mm. This gives an average plant density of 84 plants in 360 square meters or 23.33 plants per 100 square meters. In four separate surveys during the 1996 expedition, the team recorded densities of 50, 52, 1.3 and 1.3 plants per 100 square meters and an average plant length of 3.0m, 4.1m, 1.7m and 2.2m respectively though from a different site (East Broad ledge, Tresco).

4 DISCUSSION AND FUTURE WORK

***Zostera marina* Survey**

The inclusion of the beds at Bar Point and St. Mary's and Rushy Bay, Bryher means that for the first time all the main *Zostera* beds within the Isles of Scilly archipelago have been surveyed. There may, however, be some small patches of *Zostera* at various sites around the islands, such as the one described in the channel to the east of Rushy Bay, that have not, as yet, been recorded. Expeditions in future years should endeavour to record these though surveying them would not be recommended due to the highly patchy nature of the plant distribution.

One of the most notable and worrying results of the 1999 survey was the reduction in the amount of *Zostera* recorded as Old Grimsby Harbour. The plants at this site have a history of high levels of epiphyte cover and although the levels of infection with the slime mould *Labyrinthula* are no higher than found at other sites, this bed must be regarded as the one being at most threat from extinction. The high level of epiphyte cover means that the rate at which the *Zostera* can grow is low as recorded by the maximum plant length of only 37.5mm. Whilst, however, this is greater than that recorded in 1998 (29mm) the low plant density must be indicative of a decreasing population. The high level of epiphyte cover and continued presence of *Labyrinthula* in the population means that the *Zostera* will remain under stress but perhaps no more than other at other sites. The one deciding factor that is experienced at Old Grimsby Harbour that is absent from other sites is the anthropogenic input by way of the mooring buoys and potential trampling by bathers.

Elsewhere in the islands, the overall level of both *Labyrinthula* infection and epiphytic cover follows similar patterns seen in earlier years and plant densities, although lower at Higher Town Bay, St. Martin's and at West Broad Ledge, St. Martin's, than previously recorded, remain constant. In order to gain a fuller picture of the amount of *Zostera* present, subsequent expeditions should aim to map fully the extent of the beds. A further long term aim should be the establishment of permanent monitoring sites throughout the island's *Zostera* beds to record the growth rates together with water sampling to record nutrient levels, turbidity rates and water temperature.

There now exists a large amount of data relating to the *Zostera* beds in the Isles of Scilly including time series dating back to the mid 1980s. Future analysis of this data to examine the possible relationship between variables may provide a better insight to some of the factors important in controlling *Zostera* growth.

This analysis may also shed light on the role of *Labyrinthula* infection on controlling *Zostera* population. As noted above, the leaves showing the characteristic signs of infection appear to be those on the outside of the plant whilst the smaller leaves in the middle of the plant, the newer growth, are mainly unaffected. It is possible that the presence of infection in the outer leaves does not affect the overall growth of the plant as these are shed and the newer growth, then exposed to the ambient light, take over the main photosynthetic role of the plant. Indeed, Short *et al.*, (1988) argue that disease in a plant should be assumed if the small newer leaves show evidence of infection. Their study showed that although infection is present throughout the whole year, its

expansion is slow during the winter months and expand rapidly in the summer. There remains net production of *Zostera* due to its also fast growth rate during the spring and early summer but that in late summer, as the available light levels are reduced, the metabolic stress of maintaining a large number of leaves makes the plant susceptible to disease. In order to test this theory in the Isles of Scilly, it establishment of a series of permanent monitoring sites is again recommended.

***Sargassum muticum* Survey**

Although the expedition was not able to record the occurrence of *Sargassum* in all the *Zostera* beds surveyed, the data recorded in 1999 showed that the *Sargassum* is well established within the Isles of Scilly. The actual affect the shading by *Sargassum* has on the *Zostera* and other species native to the Isles of Scilly is still not clear, though it is probably not as sever as was first suspected. Future surveys of the *Zostera* beds should seek to record all occurrences of *Sargassum* which will aid future understanding of the problem.

Summary of recommended work to be undertaken in 2000.

- 1 Map the full boundaries of the seven *Zostera* beds
- 2 Repeat the survey of the beds for *Labyrinthula* infection, epiphyte cover, plant density and maximum leaf length.
- 3 Record the occurrence of *Sargassum maticum* in the *Zostera* beds. This would best be achieved at the same time as the work listed in 2 above was carried out.
- 4 Establish one or a series of permanent monitoring sites in the *Zostera* beds.
- 5 Establish and examine the long term dataset of variables relating to *Zostera* in the Isles of Scilly.

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