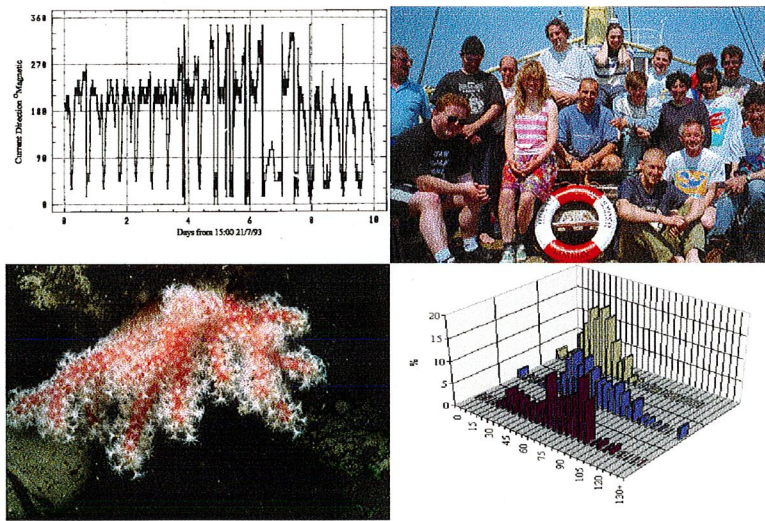


Coral Cay Conservation Sub-Aqua Club

Isles of Scilly 1993

Expedition Report



Prepared

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1. Abstract

In July 1993 a team of volunteer divers from the Coral Cay Conservation branch of the British Sub-Aqua Club (CCCSAC) undertook a two week (14 day) programme of marine surveys on behalf of the Isles of Scilly Marine Park Management Committee. This expedition followed an earlier expedition August 1992 when a similar team from the CCCSAC undertook two coastal marine survey projects on behalf of the Isles of Scilly Environmental Trust.

Following the successful completion of the surveys in 1992 the Isles of Scilly Environmental Trust invited the CCCSAC to undertake further work in 1993. CCCSAC submitted a proposal to undertake a similar programme of surveys on behalf of the Isles of Scilly Marine Park Management Committee. The proposal was provisionally accepted for funding under the English Nature Voluntary Marine Nature Reserves Grants Scheme. The proposed surveys included:

- i) Study of *Zostera* beds
- ii) Habitat survey
- iii) Water quality survey
- iv) General surveys of habitats in the eastern isles

The expedition successfully completed all of the projects and the data collected has been analysed. The following report details the background to the expedition and gives a brief summary of the survey work undertaken.

2. Introduction

Lying 40 km 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 physical environment and climate have dictated the very individual composition of the natural history of the Islands. Rare indigenous plants, as well as exotics characteristic of sub-tropical climates thrive on the Islands. The almost complete absence of traffic and plentiful wind-break 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 plant and animals that make up some of the most important marine communities to be found in Britain.

So unique 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'. Although battered by the full force of the Atlantic, delicate sea fans and various species of coral thrive in this harsh environment, at threat only from human interference. In contrast, on the more protected eastern seaboard, sheltered, deep-water habitats are home to colonies of various species with 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 which require clear waters through which adequate sunlight can pass for photosynthesis. These clear waters encourage the growth of extensive beds of Eel-grass (*Zostera marina*) and the fast-growing kelp forests, 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 visitors include the Great 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 europaeus*), Trigger-Fish (*Ballistes capriscus*), Blue Marlin (*Makaira nigricans*) and various species of turtle. Not all such vagrants are welcome: the Japanese weed (*Sargassum muticum*) has now taken a firm hold in Scilly and may out-compete indigenous species for available space and sunlight for photosynthesis.

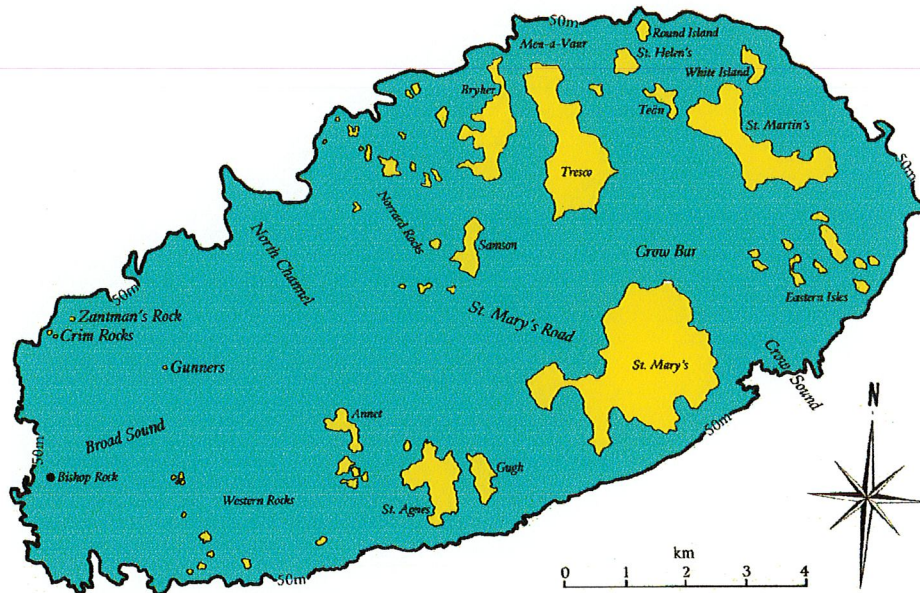


Figure 2.1 - Isles of Scilly Marine Park

2.1 The Isles of Scilly Environmental Trust¹

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 2.1). 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 IOS 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”.

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

¹ Source: “The Isles of Scilly: A Precious Heritage” - an Isles of Scilly Environmental Trust publication.

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.

2.2 Coral Cay Conservation

Coral Cay is a UK-Based, non-profit organisation established in 1986. It has undertaken a series of surveys of the unique coastal marine resource associated with the Great Atlantic Barrier Reef of Belize¹, under a Memorandum of Understanding with the Belizian Government. The Reef has come under pressure with the increase of tourism and fishing in Belize.

In order to assist the Government of Belize with initiatives to protect its coastal resources, Coral Cay Conservation recruits teams of over 350 volunteer scientists and divers each year to participate in a systematic survey of the Reef. These volunteers are mainly from the UK and many of them have joined forces under the umbrella of the Coral Cay Conservation Sub-Aqua Club (a branch of the British Sub-Aqua Club) to continue to apply their underwater skill to conservation projects in Britain.

3. The Expedition

Following the successful completion of the 1992 expedition and submission of the report to the Isles of Scilly Environmental Trust, the CCCSAC was invited to return the following year to undertake further survey work. A project proposal was submitted by Brian Cleator the expedition science officer and duly accepted by both The Isles of Scilly Environmental Trust, and by English Nature for grant support under the Voluntary Marine Nature Reserves Grants Scheme.

3.1 Expedition Team

Many of the team members have been volunteer divers sent out by Coral Cay Conservation to Belize in Central America. There they have received training in underwater survey techniques and marine identification while surveying the Barrier Reef. These divers along with other members of the team all volunteered to give up one or two weeks of their time and finance themselves to take part in this expedition.

The Expedition Team was as follows: Brian Cleator (Science Officer), Cath Downie, Carolyn Tripp, Debbie Moore, Geoff Shaxton, Gordon Mackenzie, Laura Sandford-Johnson, Mark Evans (Diving Officer), Pete Raines (Expedition Leader), Mary Hamilton, Tess Clements, Helen Harris. The Expedition was financed in part with funds raised by fixed contributions from the participating volunteers in addition to a grant from English Nature. All aspects of expedition planning were co-ordinated by CCCSAC volunteer divers.

Items of food were kindly donated by Kellogg's Company of Great Britain Limited. The Isles of Scilly Steamship Company generously supported the Expedition by arranging subsidised transportation for equipment and personnel, and accommodation in Scilly was provided by the Board of St. Mary's School. English Nature provided the expedition with the use of an additional boat. The Duchy of Cornwall provided mooring in St. Mary's harbour and storage facilities on St. Mary's dock.

The expedition accomplished its survey objectives to schedule and within the allocated budget and each member of the expedition carried out their tasks with enthusiasm and professionalism. Except for minor damage to one of the dive boats, all items of expedition equipment functioned faultlessly.

The success of the expedition was largely due to the help and support generously offered by the Duchy of Cornwall's office, Isles of Scilly Environmental Trust and English Nature, to whom we are extremely grateful. We are also indebted to the inhabitants of St. Mary's for their support, encouragement and patience, and for allowing us to share with them the natural beauty of their Isles.

It is hoped that the work presented in this report will contribute towards the continued collaboration between Coral Cay Conservation and the Isles of Scilly Environmental Trust.

¹ Coral Cay Conservation is also participating in a number of projects in Southeast Asia.

4. Studies on *Zostera*

4.1 Introduction

The programme of study was designed to continue the investigations carried out by CCCSAC during 1992 concerned with the status of the *Zostera marina* beds.

Previous work undertaken by English Nature indicated that the health of the *Zostera marina* beds had deteriorated between 1988 and 1991, apparently due to a parasitic slime mould of the genus *Labyrinthula* sp. (Fowler 1992). Results from the 1992 study indicated that a very high proportion of the plants (over 90% at all sites examined) were apparently infected. *Labyrinthula* infection had been implicated in the outbreak of the seagrass wasting disease that decimated seagrass beds during the 1930's and 40's (Den Hartog 1987). No definite causative agent has been implemented in the outbreak although pollution and adverse climatic conditions have been suggested as possible causes.

A slightly different approach to field sampling was adopted in comparison with the 1992 survey by retrieving the plants and analysing them on the surface instead of the submerged counting technique previously adopted. The study program had two broad aims:

- To establish the extent of *Labyrinthula* infection amongst seagrass and any relationship with the size and density of the plants.
- To compare the size structure of the populations at each location.



Figure 4.1 - Position of sample stations

4.2 Methods

4.2.1 Survey Locations

Two of the seagrass beds sampled in 1992, at English Island (East Highertown Bay) and Old Grimsby Harbour were re-sampled. A third site at Chimney Rocks was also surveyed and it was here that most of the work was undertaken.

4.2.2 Assessment of Seagrass Condition

The position of each quadrat within the seagrass bed was determined by randomly generated distances and bearings from a shot-line located at a central datum point. A 0.25m² quadrat was then placed on the seabed and the *Zostera marina* plants falling within it harvested and placed in labelled plastic bags to be returned to the surface.

A number of determinants were then measured: the length of the longest leaf, the number of infected and uninfected leaves and the extent of infection (measured as 0 - 4 infectivity score with 0 being uninfected and 4 being heavily infected) illustrated in Figure 4.2.



Figure 4.2 - *Labyrinthula* Infection Scale

4.2.3 Data Analysis

The data was entered onto Excel for Windows spread sheet and analysis carried out as follows: The level of infectivity (i.e. the proportion of infected leaves) was expressed as a percentage of the total number of leaves per plant and the mean infectivity score for each plant. The density of the plants per 0.25m² was also calculated. The following statistical analyses were then undertaken.

- i) One-way ANOVA on the percentage of infected leaves per plant and the length of the longest leaf to determine whether a significant difference exists between sites.
- ii) Correlation matrix of plant density, mean longest leaf length, and the mean infectivity score, to identify any relationship between: occurrence and extent of infection; the mean density of the plants and mean longest leaf length. The percentage of leaves infected and the infectivity score were also correlated to ascertain the extent of the agreement between the two methods of assessing the level of infection.
- iii) Frequency histograms of longest leaf length to investigate the population structure at the three sites.

In addition the means of all variables were then calculated for each quadrat and for each site.

4.3 Results

The sampling program was carried out between 21 and 29 of July 1993. In total 839 plants were sampled from the three sites surveyed. Ten quadrats were sampled each from East Higher Town Bay and Old Grimsby Harbour, and twenty two from Chimney Rocks. The overall appearance of the seagrass did not suggest an obvious deterioration from the previous year.

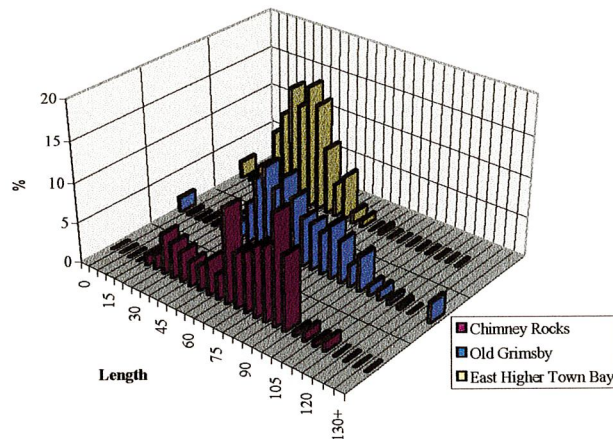


Figure 4.3 - Size Distribution of Longest Leaf

4.3.1 Size Distribution and Plant Density

The size frequency distributions for the three sites are illustrated in Figure 4.3 and together with the plant densities, summarised in Table 4.1. The summary data from each quadrat is detailed in the appendices.

	Chimney Rocks	East Higher Town Bay	Old Grimsby Harbour
Mean Length (and range) of Longest Leaf per Quadrat (cm)	66.7 (54.55 - 120.05)	48.8 (41.73 - 53.5)	69.40 (29.6 - 80.53)
Mean Density (and range) of Plants (per 0.25m ²)	22.1 (3 - 34)	21.8 (3 - 35)	16.2 (7 - 25)

Table 4.1 - Summary of Mean Longest Leaf Length and Mean Density per Site

The size distribution of plants (as represented by the longest leaf length) is markedly different for each site. East Higher Town Bay appears to have a normal distribution (Figure 4.3) with a mean of 48.8 and is therefore smaller than Chimney Rocks and Old Grimsby that have means of 69.4 and 66.7 respectively. The latter two sites have apparently non-normal distributions (Figure 4.3). Old Grimsby is skewed to the smaller leaf sizes and Chimney Rocks has a bimodal distribution, the larger peak of which (representing the distribution of the larger plants) is truncated.

The results of the one-way ANOVAR (Table 4.2) indicate that the Null Hypothesis: 'no significant difference existed between the leaf lengths at different sites' is not supported.

	SS	df	MS	F	P-value	F-Crit
Between Groups	748556.2807	2	374278.1404	346.2689	4.472	3.0018
Within Groups	1598634.322	1479	1080.8886			
Total	2354369.2	1481				

Table 4.2 - Results of One-Way ANOVAR of Length of the Longest Leaf Between Sites

The mean density of the plants is similar for Chimney Rocks and East Higher Town Bay but differs from Old Grimsby where the plants grow less densely. Results of the correlation analysis for the length of the longest leaf against plant density indicate that at Old Grimsby Harbour, there is a negative relationship (correlation co-efficient -0.51794) between these two determinants (Table 4.3).

4.3.2 Infectivity

The correlation analysis summarised in Table 4.3 indicates that there is no apparent relationship between the length of the longest leaf and the mean infectivity score. For East Higher Town Bay and Old Grimsby Harbour there is a significant positive correlation between the mean infectivity and the plant density.

The level of infectivity was measured by the mean leaf infectivity score for each plant and the percentage of each plant's leaves that were infected. The results of a correlation of these two determinants (Table 4.4) indicate that they are positively correlated for Old Grimsby and Chimney Rocks. The mean leaf infectivity and mean percentage infected leaves are also very similar between these two sites at 0.97 and 58.83 for Chimney Rocks and 0.95 and 58.26 for Old Grimsby.

The plants at East Higher Town Bay appear to be more infected with mean values of 64.24 and 1.23. These differences are apparent in the results of the ANOVAR that tests the Null Hypothesis that: 'no significant difference occurs between the level of leaf infectivity between sites' (Table 4.5). The calculated F-value indicates that the Null Hypothesis has to be rejected.

Determinant	Density	Mean Leaf Length	Mean Infectivity Score
East Higher Town Bay			
Density	1.0		
Mean Leaf Length	0.1040	1.0	
Mean Infectivity	0.7048	0.07135	1.0
Old Grimsby Harbour			
Density	1.0		
Mean Leaf Length	-0.51794	1.0	
Mean Infectivity	0.6806	-0.4263	1.0
Chimney Rocks			
Density	1.0		
Mean Leaf Length	-0.0894	1.0	
Mean Infectivity	-0.211	0.199	1.0



Significant Positive Correlation
Significant Negative Correlation

±0.5 - significance level

Table 4.3 - Results of Correlation Analysis

	Chimney Rocks	East Higher Town Bay	Old Grimsby Harbour
Mean Leaf Infectivity Score (0-4)	0.97	1.23	0.95
Mean % Leaves Infected	58.83	64.24	58.86
Correlation Analysis of Mean Leaf Infectivity and Mean % Leaves Infected	0.579	0.0387	0.6256

Table 4.4 - Results of One-Way ANOVAR of % Leaves Infected Between Sites

	SS	df	MS	F	P-value	F-Crit
Between Groups	749138.93	2	345.81452	345.8152	5.55E	3.0017
Within Groups	1605230.3	1482	1083.1514			
Total	2354369.2	1482				

Table 4.5 - Summary of Mean Leaf Infectivity Score and Mean % Leaves Infected

4.4 Discussion

4.4.1 Population Size Structure

The longest leaf data (Figure 4.3) suggests that plant populations from separate seagrass beds from similar locations, may have a different size structure. The results from East Higher Town Bay, which appear to be normally distributed, have the shortest leaves and the smallest range.

At Old Grimsby the skew to the smaller end of the distribution, and absence of the very smallest size range, may indicate a population in which no recruitment has recently occurred from seed set and

rhizomes. At this site the mean longest leaf length is intermediate between the East Higher Town Bay and Chimney Rocks.

The skew in favour of the larger leaf sizes from the Chimney Rocks site indicates that this may be the most mature of the populations studied. The abrupt truncation in the distribution of the larger size classes at this site may be a consequence of senescence in the larger plants or indicative of the maximum leaf length possible under local conditions. In comparison with the East Higher Town Bay, the smaller sized plants are proportionally more significant suggesting that some recruitment has taken place.

The penetration of light through the canopy of the seagrass bed will depend initially on the separation of the plants, but as they mature, also on the length of the leaves. Competition for light, limiting the growth of smaller plants, and a reduction in recruitment from rhizomes and seed set (although the latter is not thought to be important in *Zostera marina* (Tutin 1942)) is likely to result from excessive shading. Therefore with shading at a maximum it would be expected that the plant density would be lowest.

This is supported by the results, particularly from Old Grimsby Harbour where a significant negative correlation exists between plant density and leaf length possibly indicating that competition for light is at a maximum, smaller understory plants being shaded out. However, as the longer leaves senescence and die back the decreased shading could result in recruitment to the smaller size classes, mainly from rhizomes. At Higher Town Bay and Chimney Rocks the presence of smaller size classes suggests that competition for light is not limiting for the less mature plants from these populations at the time of the survey.

4.4.2 Infectivity

No significant relationship was found between the length of the longest leaf and the mean infectivity score. Thus it can be concluded that the cause of lesions is not related to leaf size and therefore age of the plant.

The level of infection, as measured by the two methods used, was lower than that recorded during the previous study in 1992 (Coral Cay 1992). This may be due to the different methodologies used in the two studies. It may suggest however a residual level of infection is present in seagrass populations the extent of which may fluctuate with time, according to influence of a causative factor. Thus in years when the plants are exposed to excessive stress, the level of infection is correspondingly high.

The original hypothesis regarding possible causes for the apparent increase in the occurrence of the wasting disease symptoms (Coral Cay 1992) suggested that abnormal temperature conditions were most likely to be responsible as there are no known alternative causes of stress in the Isles of Scilly. A discussion of the factors controlling variations in sea water temperature are covered in the 3rd report from the 1993 expedition.

The positive correlation at two sites of the two methods for assessing the degree of infection as measured by the percentage of leaves infected and the mean infectivity score indicates that they are likely to generate similar results and so in future only one method should be used.

4.5 Further Work

It is suggested that the following subject areas should be investigated:

- More detailed work on individual plants undertaken *in situ*, measuring the development of each leaf and the progress of any wasting disease lesions over a number of months.
- The population size structure of an individual seagrass bed should be followed for a number of years and the fluctuations in the extent of wasting disease assessed in relation to the water temperature and irradiance conditions.
- The spatial dynamics of the beds in the study area should be assessed using aerial photography or possibly a RoxAnn acoustic signal processor. Such work would require accurate position fixing to enable the results to be georeferenced.

5. Habitat Surveys

5.1 Introduction

The waters surrounding the Isles of Scilly are recognised as being of significant marine conservation importance. The Islands are noted for the diversity of habitat types and the significance of a number of the assemblages found.

The sublittoral communities of the islands were studied in detail by Hiscock in 1983 and 27 community types identified. Although the 1983 surveys were detailed and extensive, a number of locations were identified as requiring further or initial investigation. These included sites on the east facing coasts, particularly at Menawethan and St Martin's. In addition, other areas, similar to those on the east coast of St Mary's have been identified as likely to support important and diverse communities.

The identification of sites with rare southern species, occupying very stable habitats, is of particular interest. These sites are important as they are sensitive to environmental disturbance and may be of use in establishing natural patterns of long term change in benthic communities.

English Nature also requested that a general survey for sites that may be of biological or aesthetic value should be undertaken to establish locations which may be used as long term monitoring and in the enhancement of public understanding of the marine environment.

Thus the objectives of the following survey were to:

- 1) Undertake initial investigations in areas previously unsurveyed.
- 2) Identify sites which may be of conservation significance and therefore used for the monitoring stable habitat communities.
- 3) Identify sites which may be suitable for the establishment of marine nature trails.

5.2 Methods

The survey was undertaken during July and August 1993 using SCUBA apparatus from the English Nature survey vessel Melza and Coral Cay's RIB.

Twenty five dives were carried out in total at 10 sites as illustrated in Table 5.1. The volunteer divers were briefed before diving on the nature of the communities and species present in the Isles of Scilly, and the Sea Search Phase One Habitat Survey methods. In particular, attention was drawn to conspicuous, rare species of conservation significance, for example: *Eunicella verrucosa*, *Balanophylla regia*, *Leptopsammia pruvoti* *Parazoanthus axinellae* and *Alcyonium glomeratum*.

Each pair of divers was dropped at a site and descended to the seabed. They then ascended to the surface taking notes on the habitat types and species encountered to give a vertical profile. These notes were transcribed on the surface. All depths have been converted relative to LAT.

5.3 Results

The divers notes have been transcribed and are listed in full in the appendices. The results are summarised in Table 5.1.

5.3.1 Performance of the Volunteer Divers

The divers commonly noted large conspicuous species which were comparatively easy to identify. The diversity of more cryptic assemblages, for example macroalga or faunal turf communities, was frequently unsurveyed. The divers consistently made good notes on the underwater topography and the overall appeal of the site although the standard of recording was variable. Unfortunately no experienced UK diving biologists were present during the study, however a degree of confidence can be had in the identification of species such as *Eunicella verrucosa* and *Alcyonium glomeratum*. The erect, branching Axinellid sponges were also frequently noted. In general the most diverse sites where

identified as the most interesting. The notes taken, whilst lacking detail, are sufficient to assign the sites visited to the community types suggested by Hiscock 1983. Interestingly, the lack of species recorded at the Gap Point site contrasts sharply with the overall impression of diversity which is known to be high.

5.3.2 Community Types Encountered

The species reported did not change dramatically between stations, and some were reported from almost every location visited. Broadly the sites can be divided up into two types, stations exposed to higher tidal current velocities, i.e. Gilstone, Hard Lewis Ledges, Gap Point, St Martin's Head and Menpingrin were typified by a diverse communities including species with a more southerly distribution and the sites in more sheltered locations, mainly in the Eastern Isles.

In more detail, the community types encountered could be interpreted in terms of the descriptions given by Hiscock 1983. Two sites were similar to the 'circalittoral bedrock and boulders on eastern coasts' community type, Gilstone and Hard Lewis Ledges. These sites were typified by high faunal diversity and the species *E. verrucosa*, *A. gomeratum* and yellow branching Axinellid sponges. Such sites are similar to the Gap Point location which is known to have rare southern species such as *L. pruvoti* and *B. regia*. The Gilstone is topographically very diverse with a variety of different habitat types in a very small area.

Two sites, The Moulds and St Martins Head, appeared similar to the 'Circalittoral bedrock and boulders on northern coasts' community description. The sites were notably less diverse than other deeper sites recorded. Interestingly Hiscock (1983) regards this habitat type as being of regional importance. Menpingrin in the Western Rocks near Annet, was suggested by local divers as being aesthetically interesting. The habitat was typical of the west facing coasts of rocks to the West of the archipelago.

Three sites in areas effected by low tidal currents, namely Neck of Menawethan, South Little Innisvoul and Great Arthur, in the Eastern Isles, were similar to the 'lower infralittoral/upper circalittoral mixed substrata including boulders, pebbles, gravel and sand in channels between islands' habitat type. The site at Neck of Menawethan was reported as having a diverse algal community. The site at Porth Hellick was disappointing, with low biological diversity resembling the description of the 'shallow infralittoral bedrock and large boulders on sand in sheltered areas from wave and tidal streams' community.

5.4 Discussion

The use of taxonomically inexperienced volunteers to undertake habitat survey work of this nature has several inherent problems. Although instruction, taxonomic literature and initial guidance were provided, it is expected that several different kinds of errors are likely to have occurred as follows:

- mis-identification of common species for rare;
- overlooking small or cryptic species;
- focusing on large easily identifiable species which are familiar;
- interest in a particular site based on aesthetic evaluation rather than biological;
- diversity.

The latter three problems are likely to have been more prevalent than the first in this survey as virtually none of the species recorded were uncommon except for *E. verrucosa* which, however, is reasonably easy to identify.

The results from Gap Point are interesting as, although this site is known as being diverse the number of species recorded were conspicuously low. The volunteers did, however, record the site as being of great interest. Other aspects of conservation assessment require a detailed knowledge of the biogeography of the survey area so that communities can be viewed in a broader context. For example, the sites at St Martin's Head and The Moulds were not considered to be of great interest by

the volunteers due to their lack of diversity, although they appear to be of a regionally important community type classified as such because it is restricted to the Isles of Scilly.

The assessment of and evaluation of algal communities and faunal turf communities by volunteers is more difficult than for large conspicuous fauna due to the cryptic nature of many of the species. Therefore, whilst it is possible to identify sites as being especially interesting using volunteers it is not possible to categorically state that a site does not have significance. Despite the above, the information provided is sufficient to determine the habitat types. One advantage of using semi-trained and inexperienced volunteers is that they are likely to give a reliable impression of the intrinsic appeal a site would have for members of the public.

Of particular interest are the sites at the Gilstone and Hard Lewis Ledges which appear to be similar to the communities at Gap point. These two sites are worthy of more detailed survey as they had a diverse number of habitat types including gullies, overhangs, sheltered and non sheltered aspects which were reflected in different communities.

The species indicative of sites exposed to higher tidal velocities are noted in similar habitats elsewhere in south west Britain. *E. verrucosa* and *A. glomeratum* are of particular conservation significance. *A. glomeratum* is confined to the extreme south west of the British Isles and was frequently encountered during the survey of the sites exposed to moderately currents. The presence of yellow, branching sponges is also of interest. The taxonomy of this group is very difficult however and there are a number of relatively common yellow branching sponge species found in the Islands.

The Neck of Menawethan provided some very scenic diving and is reported as having a diverse algal community. Isolated algae were reported growing amongst the coarse sand between 24-27m. The other sites did not appear to have any special value or interest however, this may have been due to the depth zone which in most cases was the lower infralittoral.

It is important to note that the most diverse areas were often confined to the aspect most exposed to current velocity. Therefore the survey method could be improved by surveying lateral as well as horizontal transects. Further improvements to the quality of the data could be made by: increased training of the volunteers, greater involvement of specialist and experienced taxonomist, standardisation of survey and recording techniques, greater use of photography. An important step in achieving this would be to lay out an underwater trail, supported by photographs and an underwater guide so that volunteer surveyors can learn taxonomy and survey techniques *in situ*. Such a trail would have to be located in a site that is regularly diveable, diverse in terms of both habitats and species, without being particularly fragile. In this context the Gilstone and Hard Lewis Ledges sites may be suitable although current velocities rendered the site undiveable for a significant proportion of the tidal cycle. In addition, some of the species present may be fragile and so subject to damage by divers. These sites should certainly be surveyed more fully and may be a suitable site for long term study of community change against fluctuations in the physical environment.

Whilst divers are an efficient method of preliminary surveying vertical rock areas they are limited when considering broader scale studies defining the distribution of community and habitat types. A greater area of the archipelago could be covered by the use of RoxAnn and subsequent ground truthing by divers, particularly in the shallower intertidal areas between the islands.

5.5 Conclusions

Coral Cay Conservation Volunteers surveyed ten sites within the Eastern Isles and the east coast of St Mary's. The information gained was sufficient to assign the sites into two broad types. Further division into community types outlined by Hiscock in 1983 were tentatively made. The results indicated that two sites in particular were considered to be of interest due to their diversity and intrinsic appeal. The site surveys identified the Gilstone and Hard Lewis Ledges as areas that are worthy of further study and that may be suitable for a marine nature trail. This was regarded as an important first step in furthering volunteer studies in the Isles of Scilly. In addition it is recommended that the projects utilise other broader volunteer survey initiatives such as the sea search survey program or by using the MNCR biotope survey forms. With a more co-ordinated approach, increased training and some involvement of more experienced marine biologists the utility of the information provided could be greatly improved.

Site	Location	Typical Species	Habitat Type	Hiscock's Community Type	Comments
Gilstone	St Mary's East Coast	Infralittoral: <i>Laminaria hyperborea</i> , <i>Palmaria palmata</i> , <i>Dicyota dichotoma</i> Circalittoral: Axinellid sponges, <i>Ciona celata</i> , <i>Myxilla</i> sp.? <i>Corynactis viridis</i> , <i>Metridium senile</i> , <i>Caryophyllia smithii</i> , <i>Actinothoe sphyrrodetta</i> , <i>Sagartia elegans</i> , <i>Tubularia</i> sp., <i>Nemerites antennina</i> , <i>Alcyonium digitatum</i> , <i>A. glomeratum</i> , <i>Pentapora foliacea</i> , <i>Luidia ciliaris</i> , <i>Henricia oculata</i> , <i>Marthasterias glacialis</i> , <i>Holothuria forskali</i> , Squat lobsters <i>Labrus mixtus</i> , <i>Labrus bergylta</i> , <i>Seyllorhinus canicula</i> .	Steep cliff with boulders at bottom in 30m. Numerous ledges and crevices. Sheltered from strong wave action exposed to strong currents. Described as a very interesting and diverse site. No of dives = 3	Circalittoral bedrock and boulders on eastern coasts	Regarded as a very attractive site with a diverse fauna. During 1990 <i>Eunicella verrucosa</i> and <i>Epizoanthus couchii</i> have been observed here.
Hard Lewis Ledges	Eastern Isles	Infralittoral: <i>L. hyperborea</i> , <i>Saccorhiza polyschides</i> Circalittoral: Very diverse faunal turf, yellow encrusting sponges, <i>Myxilla</i> sp.? branched red sponge branched yellow sponges, <i>C. celata</i> , <i>Eunicella verrucosa</i> , <i>Caryophyllia smithii</i> , <i>C. viridis</i> , <i>Sagartia</i> sp. <i>M. senile</i> , <i>N. antennina</i> , <i>A. digitatum</i> , <i>A. glomeratum</i> , <i>P. foliacea</i> , <i>H. forskali</i> , <i>L. ciliaris</i> , <i>E. esculentus</i> , <i>Homerus gammarus</i> , <i>S. canicula</i> , <i>L. mixtus</i> , <i>L. bergylta</i> , <i>Ctenolabrus rupestris</i> , <i>Pollachius virens</i> .	Large consolidated boulders, abutting against a steep rock cliff at 25m. Exposed to strong tidal currents but sheltered from server wave action. Record of <i>Eunicella verrucosa</i> and general description indicates that this habitat is similar to the Gilstone and other more sheltered sites on the east coast of St Mary's. Described as very interesting and attractive. No. of dives =3	Circalittoral bedrock and boulders on eastern coasts	Most of the divers recorded this as being an impressive and attractive site both from the point of its topography and, in some cases, the biology. The presence of <i>E. verrucosa</i> is of significance.
Neck of Menawethan	Eastern Isles	Infralittoral: <i>L. hyperborea</i> , Coralline algae, faunal turf, <i>Suberites carnosus</i> , <i>Grantia compressa</i> , <i>S. ciliata</i> <i>C. viridis</i> , <i>Sagartia elegans</i> , <i>A. digitatum</i> , <i>C. smithii</i> , <i>Nemerites</i> sp., <i>E. esculentus</i> , <i>L. ciliaris</i> , <i>M. glacialis</i> , <i>A. rubens</i> , <i>H. forskali</i> , <i>C. pagurus</i> , spider crab, squat lobsters.	This site was almost entirely in the infralittoral zone and was dominated by kelp. Weak to moderate tidal currents, sheltered from wave action. The substrate consisted of very large granite blocks on sand in 20m. It was reported that there was a good variety of algal species. No. of dives = 2.	Lower infralittoral/ upper circalittoral mixed substrata including boulders, pebbles, gravel and sand in channels between islands	May be of interest for the algae species particularly in the deep sandy areas although the topography was considered the most attractive feature.
Gap Point	East Coast of St Mary's	Circalittoral: Faunal turf, Axinellid sponges indet. <i>Suberites carnosus</i> , <i>Axinella polypoides</i> , <i>Axinella infundibuliformis</i> , <i>E. verrucosa</i> <i>A. glomeratum</i> , <i>C. viridis</i> , <i>C. smithii</i> , <i>E. esculentus</i> , <i>H. forskali</i> .	Very sheltered, stable site with sandy silt at 33m. rock cliff reached 20m. very diverse with a number of Mediterranean species present. Very popular site. No of dives = 2	Circalittoral bedrock and boulders on eastern coasts	Noted as a very good dive with a tremendous amount of sea life, however species list not as long as at other sites.
St Martin's Head	St Martin's	Infralittoral/Circalittoral: <i>L. hyperborea</i> , <i>Lithothamnium</i> , Axinellid sponges, <i>C. Smithii</i> , <i>C. viridis</i> , <i>A. digitatum</i> , <i>A. glomeratum</i> , <i>P. foliacea</i> , <i>E. esculentus</i> , <i>M. glacialis</i> <i>C. pagurus</i> , <i>Galathea strigosa</i> , <i>Liocarcinus</i> sp. <i>L. mixtus</i> , <i>L. bergylta</i> , <i>Ctenolabrus rupestris</i> , <i>Pollachius virens</i>	Substrate in 19m, just below the lower infralittoral, was sandy with some silt and boulders. Further out towards the western rock there more gullies and overhangs reported but otherwise a relatively flat site with moderate tidal currents. Described as a bit barren. No of dives =3.	Circalittoral bedrock and boulders on northern coasts	Not regarded as being of special interest by the volunteers but recorded by Hiscock as being of regional importance

Site	Location	Typical Species	Habitat Type	Hiscock's Community Type	Comments
Great Arthur	Eastern Isles	Circalittoral: <i>L. hyperborea</i> , red encrusting algae on rocks, faunal turf, sponges indet., <i>S. elegans</i> , <i>C. smithii</i> , <i>Sagartiogeton laceratus</i> , <i>E. esculentus</i> , <i>M. glacialis</i> , <i>H. forskali</i> , <i>Ascidella aspersa</i> , <i>C. pagurus</i> , squat lobster, spider crab.	Flat sandy seabed with some bedforms near the start of a boulder are at 22m. Sheltered from wave and strong tidal currents. In shallower areas the boulders were approximately 1m in diameter. Kelp coverage was extensive by 20m. It was noted that crustacean fauna appeared to be well developed. No. of dives = 2	Lower infralittoral/upper circalittoral mixed substrata including boulder, gravel and sand in channels between islands.	Described by Hiscock as of Regional importance
Menpingrin	Western rocks Isles	Infralittoral/Circalittoral: <i>L. hyperborea</i> purple sponge, yellow sponge indet. <i>S. ciliata</i> , <i>C. viridis</i> , <i>M. senile</i> , <i>C. smithii</i> , <i>A. glomeratum</i> , <i>Calliostoma zizyphinum</i> , <i>E. esculentus</i> , <i>H. forskali</i> , <i>M. glacialis</i> , <i>Asterias rubens</i> , <i>L. ciliaris</i> , <i>L. bergylta</i> ,... <i>S. canicula</i>	Broken rock wall down from 26m, gullies at 30m very exposed. No if dives = 3	West facing coasts of rocks to the west of the archipelago	Described by Hiscock as of Regional importance
Porth Helick Point	East Coast of St Mary's	Infralittoral/Circalittoral <i>L. hyperborea</i> , sponge indet <i>Anemonia viridis</i> , <i>C. smithii</i> , <i>C. viridis</i> , <i>Pomatoceros sp.</i> , <i>M. glacialis</i> , <i>H. forskali</i> , <i>E. esculentus</i> , <i>L. bergylta</i> .	Generally sheltered, boulders in infralittoral, circalittoral at around 20m, below which there are sand/rock gullies. No of dives = 3	Shallow infralittoral bedrock and large boulders on sand in sheltered areas from wave and tidal streams	Low biological diversity
S. Little Innisvoulis	Eastern Isles	Infralittoral/Circalittoral <i>Laminaria saccharina</i> , <i>L. digitata</i> , <i>L. hyperborea</i> , <i>Ulva sp.</i> , Faunal turf, <i>Cerianthus lloydii</i> , <i>C. smithii</i> , <i>C. viridis</i> (sparse), <i>Pomatoceros sp. E. esculentus</i> (sparse), <i>L. bergylta</i> .	Kelp covered boulders extending down to 17.4m. at extreme end of transect mostly fine sand and isolated kelp covered boulders. Generally little life. No. of dives = 2	Lower infralittoral/upper circalittoral mixed substrata including boulder, gravel and sand in channels between islands.	Described by Hiscock as of Regional importance
The Moulds	Eastern Isles	Infralittoral <i>L. hyperborea</i> , <i>C. smithii</i> , <i>C. viridis</i> , <i>H. forskali</i> , <i>M. glacialis</i> , <i>P. virens</i> , <i>C. rupestris</i> .	Shelving rock with numerous gullies with fine sediment at base of gullies. Silt on rocks and kelp. Less diversity than other sites. No. of dives = 1	Circalittoral bedrock and boulders on northern coasts	Biologically interesting but not as diverse as the deeper sites surveyed.

Table 5.1 - Summary of Habitat Survey Results

6. Assessment of Wine Cove refuse disposal site

6.1 Introduction

The cost of domestic refuse disposal is high in terms of land, money and other resources. These costs are increased in island situations where transport by boat is the only practicable means of moving bulk materials. The island of St Martins had, until recently, adopted a policy of disposing certain elements of domestic refuse, mainly drinks cans and other non-organic materials, over a low cliff into the intertidal area of Wine Cove. This material has built up over the years to form a large and conspicuous disposal site.

The continued use of this site was viewed undesirable for the following reasons:

- compliance with UK waste disposal legislation principally the Environmental Protection Act 1990, the Food and Environmental Protection Act 1985;
- impairment of visual amenity;
- pollution of waters and sediments by heavy metals and other materials in the refuse;
- danger of injury from material washed onto nearby Great Bay beach.

A programme of study was undertaken between 20 and 27 August 1993 to establish the extent and nature of contamination in adjacent sublittoral and intertidal areas.



Plate 6.1 - The Disposal Area Wine Bay St Martins

6.2 Methods

6.2.1 Intertidal Survey

Shore surveys were carried out at the foot of the refuse pile and on the adjacent beach. A transect (0) was established approximately at the centre of the refuse pile and continued normal to the shore to the lower intertidal. A tape measure was run down the transect and used as a datum for the survey.

A 0.25m² quadrat was placed at 10m intervals along the tape from low water to the foot of the refuse pile. The amount and type of refuse, the nature of the substrate and the flora and fauna were noted in each quadrat. In addition, a general description was made for each 10m band on the shore.

A sediment sample was obtained for heavy metal analysis by removing the surface 3-5cm of sediment with a plastic spatula and transferring to a plastic bag. The samples were analysed by Microwave Acid Digestion/FAAS at the Forth River Purification Board.

6.2.2 Subtidal Survey

Nine transects were arranged normal to the shore. Five at 50m intervals to the west (W_1 , W_2 , W_3 , W_4 , W_5) and three at the same intervals to the east (E_1 , E_2 , E_3). The 0 transect was extended a further 100m offshore.

A team of two divers was deployed at the shore end of each transect where they fixed a 100m tape with a grapnel. The divers swam away from the shore along the transect bearing, noting the conspicuous species, habitat type and items of refuse at 10m intervals. The position of any refuse was noted.

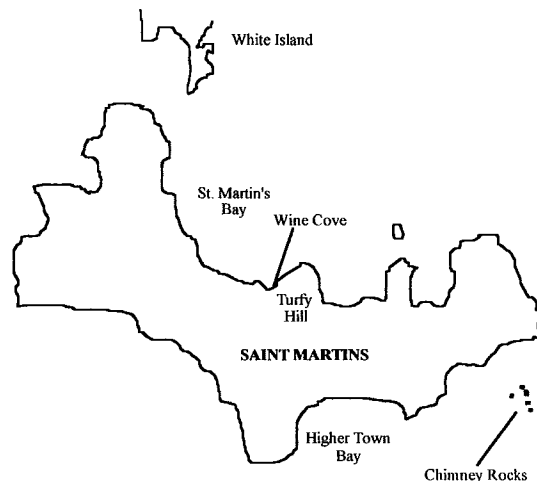


Figure 6.1 - Position of Wine Cove

6.3 Results

6.3.1 Site Description

Wine cove is small embayment on the northern shore of St Martins exposed to the north east. (Figure 6.1). The shoreline consists of a bedrock and ram cliff, approximately 15m high, at the foot of which are small boulders and cobbles (Plate 6.1). Further down the shore the boulders and exposed bedrock become interspersed with coarse sand. The subtidal area shelves gradually with bedrock, boulders and cobbles and small areas of poorly sorted coarse sand and gravel. Some static nets were noticed across the cove during the survey. To the south west, the cliffs give way to a sandy beach, Great Bay (Plate 6.2), which is of high amenity and conservation value.

6.3.2 Nature of Refuse

No quantitative study of the refuse was carried out, however, the area of deposition was studied qualitatively. The majority of the freshly deposited refuse consisted of drinks cans and bottles (Plate 6.3). Little or no organic material was noticed amongst the refuse and most of the larger metal items were badly corroded and appeared to have been present for some time although a few domestic appliances were less badly corroded and may have been deposited more recently.

6.3.3 Intertidal Survey

The results of the intertidal survey are summarised in Table 6.1. Most of the very large items of refuse were confined to the uppermost areas of the shore. These included batteries, axles, washing machines and engine blocks. Some fridge components and car batteries were also noted at 20m. Further down the shore, the occurrence of large items decreased. Significant amounts of glass fragments

(45/0.25m²) where recorded in the sediment between the boulders at 10m. This increased to 198/0.25m² at 20m, then decreased to 88/0.25m² and 71/0.25m² at 30m and 40m respectively. Contamination from iron was evident over much of the areas of soft sediment which was predominantly coarse sand (Plate 6.4). At the bottom of the shore the Redox Potential Depletion (RPD) Layer (the depth in the sediment where the deoxygenation occurs) was very close to the surface (within 1cm) although it attained greater depth with shore height. During the survey, a number of drinks can tops were noticed washed up on the western most end of Great Bay beach.



Plate 6.2 - Great Bay with the Wine Cove Disposal Site in the middle distance



Plate 6.3 - Close-up of refuse site

The results of analyses for heavy metals are detailed in Table 6.2. Figures for heavy metal analysis from MAFF surveys of disposal sites (90-500um fraction) are included to provide a comparison. It is clear from these results that levels of cadmium copper zinc and lead are elevated and comparable to those concentrations from contaminated disposal site samples.

The hard substrate communities were typical of similar habitats around the Isles of Scilly and can be compared to shore type 5a and 5b of Hiscock (1983). They were not considered to be of any conservation significance.



Plate 6.4 - Coarse sand further down the beach at Wine Cove, note brown discolouration.



Plate 6.5 - Refuse in a sublittoral area off the disposal site, note contamination of the sediment.

Distance (From HWS)	Quadrat Counts Figures per 0.25m ²	Sediment	Fauna	Debris	General Remarks
40m	71 Glass Fragments 1 Nail	Gravel (poorly sorted), pebbles and cobbles	(<i>Enteromorpha sp./Fucus serratus</i>)	Tins, glass, flat pieces of metal, bits of drain pipes	RDP layer is very close to surface
30m	88 Glass Fragments 1 Tin Can 2 Sheets of sharp metal	As for 40m	(<i>Patella vulgata</i> , <i>F. serratus</i> , <i>Littorina obtusata</i> , hydroid indet, <i>Lithothamnion sp.</i> , <i>Gibbula sp.</i> , <i>Actinea equina</i>)	Glass, tin and flat metal	RDP layer at greater depth
20m	198 Glass Fragments 1 Electric wire	Coarse Sand (poorly sorted) to 10m then boulders <1m in diameter	(<i>Enteromorpha sp.</i> , <i>F. vesiculosus</i> , <i>P. vulgata</i>)	Car batteries, fridge parts	Cast Algae
10-0m	45 Glass Fragments 2 Cans 3 Metal Fragments (stuck between cobbles)	Large boulders and coarse sand between	(<i>Enteromorpha sp.</i> , <i>F. vesiculosus</i> , <i>F. spiralis</i> , <i>P. vulgata</i>)	Mainly large items. Car chassis, engines etc. Large pieces of glass	Debris spreads laterally throughout bay especially in gullies

Table 6.1 - Wine Cove Intertidal Survey Transect Descriptions

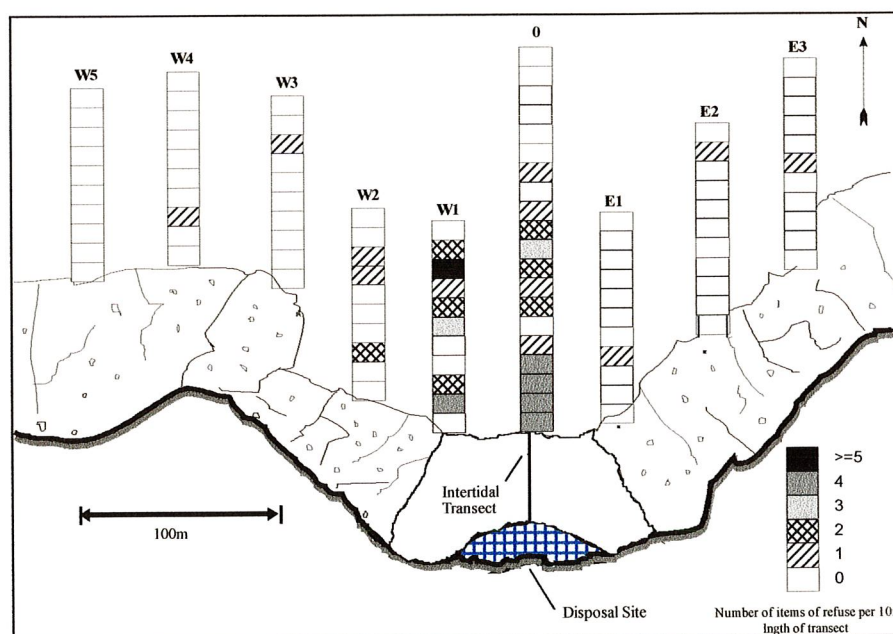


Figure 6.2 - Distribution of refuse in sublittoral area of Wine Cove Disposal site

Sample	Cd	Cr	Cu	Ni	Pb	Zn
0m	0.61	8.3	12	4.8	100	190
10m	0.42	4.2	9.2	4.2	63	85
40m	0.81	7.5	32	8.4	180	83
Bristol ¹ Channel	<0.2	2-15	2-19	6-47	<10-80	15-130
Plymouth ¹	0.5-2.2	8-20	4-270	10-30	12-350	20-220
Humber ¹	ND	4-20	3-28	<5-25	<10-80	20-140

Table 6.2 - Wine Cove Intertidal Survey, Sediment Heavy Metal Results mg/kg

6.4 Sub Tidal Survey Results

The sublittoral communities were dominated by thong weed (*Himanthalia elongata*) with kelp (*Laminaria hypoborea*) and sugar kelp (*Saccorhiza polyschides*). The understory consisted predominantly of encrusting red algae and *Mastocarpus stellatus* in the shallower areas.

The results from the transect swims are summarised in the appendices and Table 6.1. The majority of the debris observed occurred along the 0 and W₁ transect. Heavier objects were concentrated along the 0 transect within 50m of low water. Most of the material distributed further away consisted of drinks can fragments. These were observed up to 100m offshore on the W₁ transect.

In some locations the sediment had a brown discolouration which may have been iron contamination (Plate 6.5).

¹ MAFF data from disposal sites. 90-50um fraction trace metals using nitric/perchloric digestion; All sites encompass clean areas and dump localities; Plymouth is very polluted due to presence of dockyards dump (MOD); High cadmium at Plymouth found only in the coarse fraction and correlates well with loss on ignition and shell content.

6.5 Discussion

6.5.1 Physical Dispersion of Material

There are four potential mechanisms whereby waste can be modified and transported from the site by marine processes.

- i) *Transport of large dense items ALONGSHORE from the tip face by wave action.* Waves breaking on a shoreline impose a natural selection and transportation system. Particles coarser than about 0.2mm (and of quartz density) remain trapped inside the breaker line under this system, due to the net onshore movement of bottom waters in this zone, but can be subject to longshore drift.
- ii) *Dispersion OFFSHORE of particles capable of being maintained in suspension.* Slowly settling particle (e.g. mineral fragments finer than 0.2mm, or because of the settling properties imposed by their plate-like nature, e.g. aluminium tin tops) can move seaward, through the turbulent breaker zone, in suspension.
- iii) *Attrition and abrasion of waste materials under wave action, reducing the effective size of the material and hence its potential mobility.*
- iv) *Solution of soluble components of the waste, with either dilution and dispersion, into ocean waters or re-disposition in a different solid form.* Re-disposition may occur as a result of biological uptake, or as a result of changed chemical environment, commonly found within the interstitial waters of sediment deposits.

In addition to marine processes, percolating rainwater may dissolve elements of the waste. This leachate probably emerges as seepage in the intertidal area along the foot of the tip.

Active erosion of the tip face is most likely during winter periods of large ground seas (swells) which effectively penetrate the archipelago. In terms of local storms, winds from a northerly aspect are liable to have the most effect. With the complex configuration of the offshore bathymetry, and the alignment of the local shoreline, wave refraction is liable to produce shore normal wave approach at most times, thus not forming a persistent longshore drift. This is consistent with confinement of most coarse waste close to the tip site.

6.5.2 Trace Metals in Sediments

Trace metal concentrations in the intertidal area close to the tip are shown in Table 6.2. The sediments sampled are essentially sand with effectively zero fines content. The sands are suspected to be comprised largely of quartz and feldspar mineral from the deposition of granite, together with shell fragments. Much of the sands contains an iron oxide coating.

The level of contamination of these sediments can be identified through comparison with other UK sites of known cleanliness and contamination. The Ministry of Agriculture Fisheries and Food (MAFF) routinely examines the trace metal content of sands (0.1-0.5mm) in the vicinity of offshore waste disposal sites. The range of concentrations found at three UK sites are also shown in Table 6.2. The ranges represent the extremes of natural and worst contamination values for each site.

Given that the extraction techniques used by MAFF is probably a little more vigorous than that used for this survey, it is clear that the beach sediments below St Martin's disposal site are significantly contaminated with cadmium, copper zinc and lead. It is conceivable but unlikely that these high levels may be naturally occurring mineralisation of the local rocks. Further control samples would need to be taken to confirm this point.

The absence of decreased metal concentrations away from the tip face and the noted iron coatings on the sand grains suggests that re-disposition from solution may largely account for this contamination. This process is most likely to occur within the interstitial environmental of the beach sands, with occasional episodes of disruption and physical dispersion of the coated sands by wave action. The percolation of leachate waters is liable to play a major role in this contamination process.

6.5.3 Environmental Impacts

Although contamination of other areas by transported sediments and bioaccumulation of metals by flora and fauna, local to the disposal site, is a possibility, it is difficult to assess the local environmental impact on the marine habitats without further study concerning the partitioning and therefore transport of the metals in Wine Cove.

The disposal site is visible from the beach at Great Bay (Plate 6.2) and may be observed by walkers following the cliff top path around St Martins. It therefore has significant impact on the landscape and also represents a hazard to public health in its present state.

6.5.4 Remediation

There are currently two options being considered for remediation of this site:

- 1) Build a retaining wall around the base of the disposal site and cover the refuse with a concrete or earth skin.
- 2) Remove the refuse and segregate prior to disposal on the main land.

An additional option may be to remove a proportion of the easily accessible refuse and enclose the remaining material.

The first option may prove problematical as the works would not prevent the escape of leachate from the base of the site. In addition, the seawall and covering would require careful landscaping and design to blend in with the surrounding scenery and prevent alterations to patterns of wave energy in the area. If however, the contamination within the sediment is due to particles of metal rather than leachate from the tip, then there would be no advantage in removing the material in order to reduce heavy metal contamination of the foreshore and coastal waters. It may be appropriate to undertake a Best Practicable Environmental Option (BPEO) Study which would consider cost, environmental and practical acceptability of the project. A BPEO study is a prerequisite for some coastal works undertaken requiring a licence under the Food and Environmental Protection Act 1985.

As part of this study further investigations should include studies on the contamination of the sediments and flora and fauna of the immediate area, estimates of the nature and extent of the material deposited and detailed costings for the remedial works.

7. Physical Environment of Chimney Rocks

7.1 Introduction

In order to further understand the ecology of the Isles of Scilly seagrass beds, a programme of study was undertaken concerning the physical environment. This study was driven by two considerations resulting from the work undertaken in the previous year's Coral Cay Conservation Programme (Coral Cay 1993) on the Isles of Scilly as follows:

- One factor which may contribute to the occurrence of the wasting disease caused by *Labyrinthula* sp. would be an unfavourable combination of light and water temperature, reducing photosynthesis and increasing respiration and thus stressing the *Z. marina* plants.
- Individual seagrass beds are known to move, with a receding and advancing (Fowler 1992) it is possible that this movement is caused by erosion and deposition of sediment.

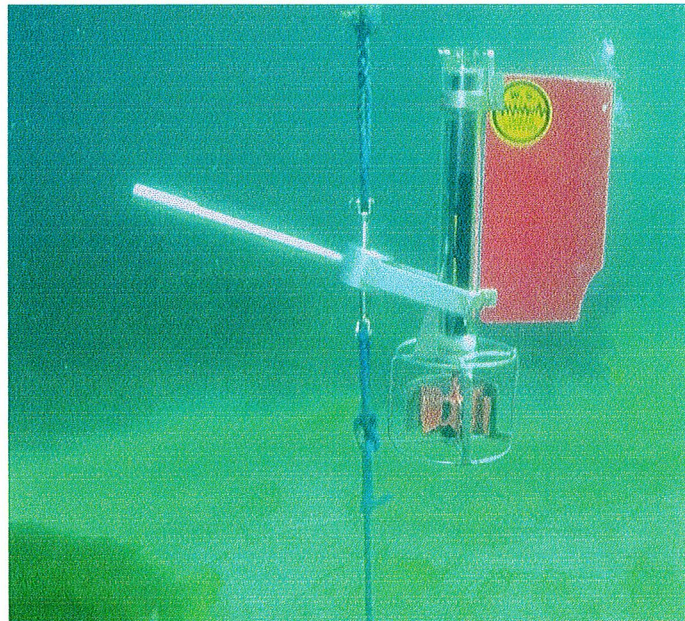


Plate 7.1 - Current Meter Set-up

No information is available on the hydrography of seagrass beds in Scilly, therefore a programme of study was planned to investigate aspects of the physical environment at a site near Chimney Rocks (see Figure 6.1 on page 15), i.e. the thermal regime, turbidity, strength and direction of currents.

7.2 Methods

7.2.1 Current Velocity, Direction and Automated Temperature Measurement

A recording current meter was deployed as illustrated in Plate 7.1, 1m above the sea bed in a sand patch amongst the seagrass bed at Chimney Rocks. The meter was programmed to record current direction (m/sec) direction (°magnetic) and water temperature (°C) at 8 minute intervals from the 21/07/95 to 28/07/95. The meter was checked daily to clear any debris collected in the rotor.

7.2.2 Turbidity

A Secchi disk was used to estimate the turbidity by lowering over the side of the survey vessel and recording the depth at which the black and white quarters could no longer be differentiated. Surface glare was eliminated using a glass bottomed box.

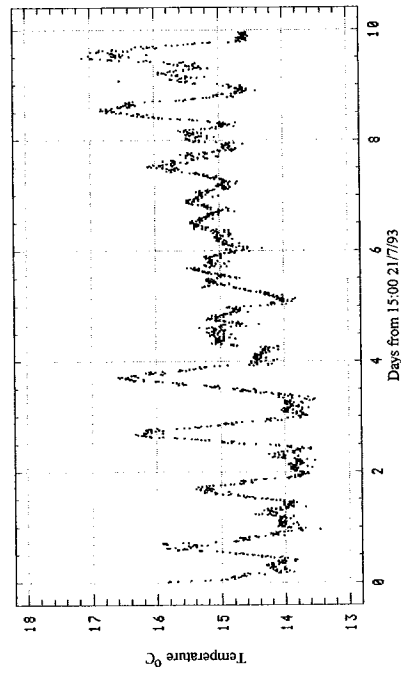


Figure 7.1 - Temperature Plot

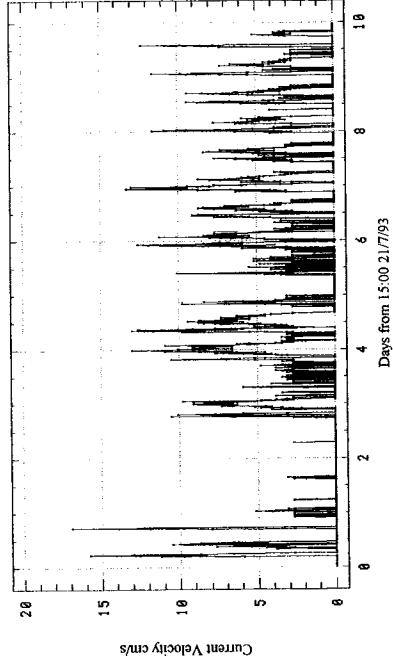


Figure 7.3 - Current Velocity

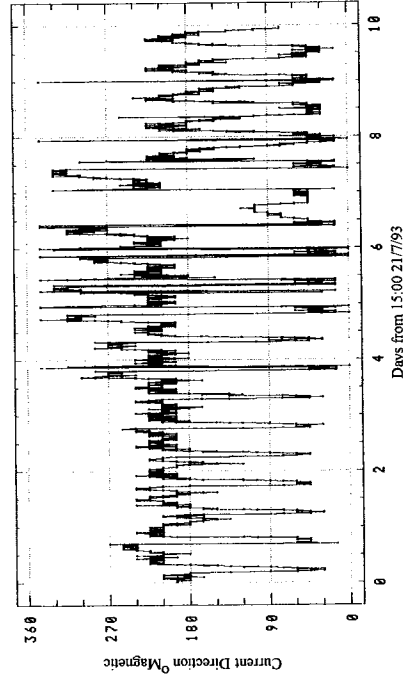


Figure 7.2 - Current Direction

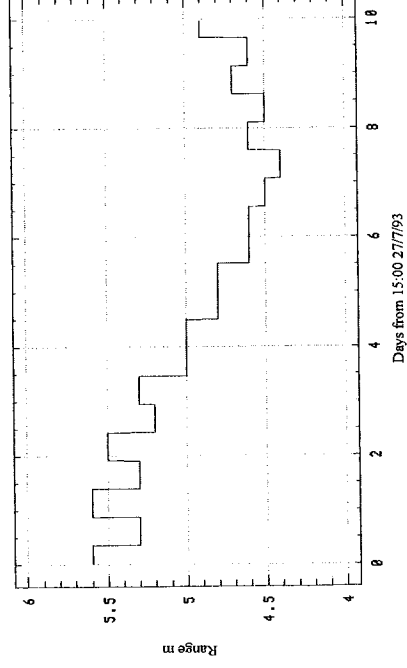


Figure 7.4 - Tidal Range at Devonport

7.2.3 Data Analysis

The data obtained from the current meter was subject to analysis using Statgraphics and Excel computer software. Scatter plots were produced of the temperature, current velocity and direction against time. Velocity against direction was also plotted in the same way. The tidal range was obtained from admiralty charts for Devonport and the maximum and minimum air temperature and insolation were obtained for the study period from the Meteorological Office. Correlation analysis was undertaken comparing: the tidal range with daily minimum water temperature and maximum water temperature with insolation and daily maximum air temperature.

7.3 Results

7.3.1 Turbidity

The Secchi disk 'depth' was at, or deeper than, the sea bed on every occasion a reading was taken.

7.3.2 Water Temperature

The highest daily maximum was recorded on the 31 July at 17.1°C and the lowest daily minimum of 13.4°C on 21 July.

Figure 7. illustrates the fluctuation in water temperature values during the study period. These data illustrate a diurnal variation superimposed upon an underlying longer term trend. The diurnal variation in temperature fluctuated in magnitude during the study period. This fluctuation was greater during the initial four and final two days. It is also evident that the daily maximum and minimum values followed different trends. However the underlying pattern over the study period indicates a general increase in temperature.

The minimum water temperature data were correlated against the tidal range and the maximum water temperature against insolation (hours of sunshine, St Mary's) and maximum daily air temperature. The data is summarised in Table 7.1 and the results are in Table 7.2. It is indicated that the daily minimum has a significant negative correlation with the tidal range. No other significant correlations were noted but the plot of daily maximum water temperature and daily maximum air temperature (Figure 7.5) indicated that the these determinants followed similar trends with time.

7.3.3 Current Velocity and Direction

The current direction, velocity and tidal range are illustrated in Figure 7.2, Figure 7.3, and Figure 7.4 respectively for the study period. Figure 7.6 and Figure 7.7 show the current data with successive tidal cycles superimposed, showing the variability of the conditions through a 12.5 hour period. Figure 7.8 illustrates the relationship between velocity and direction. All these data indicate that the currents are very slow in this area during the study period, varying between 0cm/s and 18cm/s (1m above the seabed) with a flood flow to 60° and the ebb to 220°. Because of the gentleness of the flow, current directions are not very constant with spring-neaps variability in flow patterns and periods of meandering currents perhaps due to wind effects.

Peak flows were recorded the during the ebb tide on a bearing of 045°. On the flood tide the highest velocity recorded was 13cm/s flowing between 210° and 240°, that is approximately parallel to the shore. Highest tidal velocities coincided with the highest tidal range and therefore spring tides.

7.4 Discussion

7.4.1 Sediment Transport

The tidal currents within the seagrass bed during the study period were not competent to mobilise medium sand. It is unlikely therefore that transport of sediment occurs due to tidal currents. Furthermore, the seagrass itself will attenuate current velocity underneath the canopy of leaves and bind the sediment with its rhizomes so reducing the tendency for erosion and encouraging deposition and sediment stability. Erosion due to storm wave induced currents is possible especially along the

exposed aspect of a bed and therefore the occurrence of a storm condition may be regarded as potentially damaging to the seagrass.

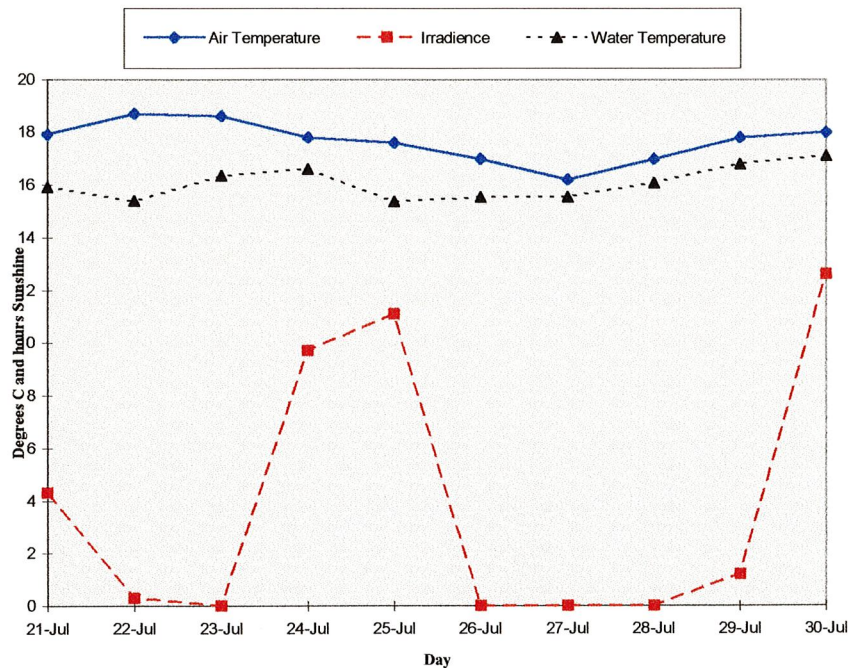


Figure 7.5 - Plot of Irradiance, Air Temperature and Water Temperature

Date	Max Air Temp	Max Water Temp	Min Temp	Irradiance hrs sunshine St Mary's	Tidal range
21 Jul	17.9	15.9	13.6	4.3	5.6
22 Jul	18.7	15.4	13.6	0.3	5.6
23 Jul	18.6	16.3	13.6	0	5.5
24 Jul	17.8	16.6	13.6	9.7	5.3
25 Jul	17.6	15.4	14.1	11.1	5.0
26 Jul	17.0	15.6	13.8	0	4.8
27 Jul	16.2	15.6	14.4	0	4.6
28 Jul	17.0	16.1	14.7	0	4.5
29 Jul	17.8	16.8	14.7	1.2	4.7
30 Jul	18.0	17.1	14.6	12.6	4.9

Table 7.1 - Summary of Results - Water Temperature, Air Temperature, Irradiance and Tidal Range

	Max Air Temperature	Irradiance	Max Water Temperature
Max Air Temperature	1		
Irradiance	0.183	1	
Max Water Temperature	0.276	0.359	1
	Tidal Range	Min Water Temperature	
Tidal Range	1		
Min Water Temperature	-0.854	1	

±0.5 = significance level

Table 7.2 - Results of Correlation Analysis

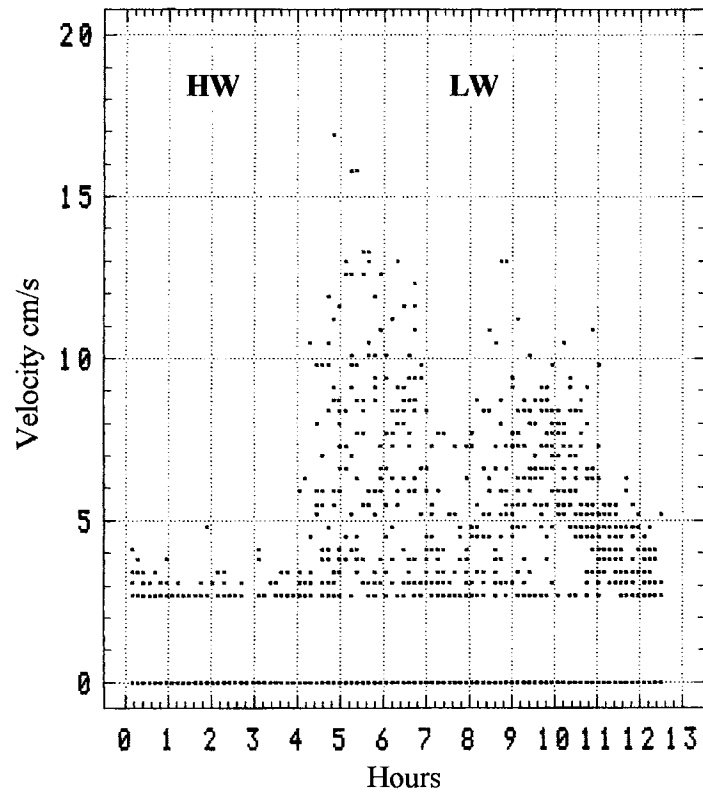


Figure 7.6 - Tidal Cycle Overlays: Current Velocities

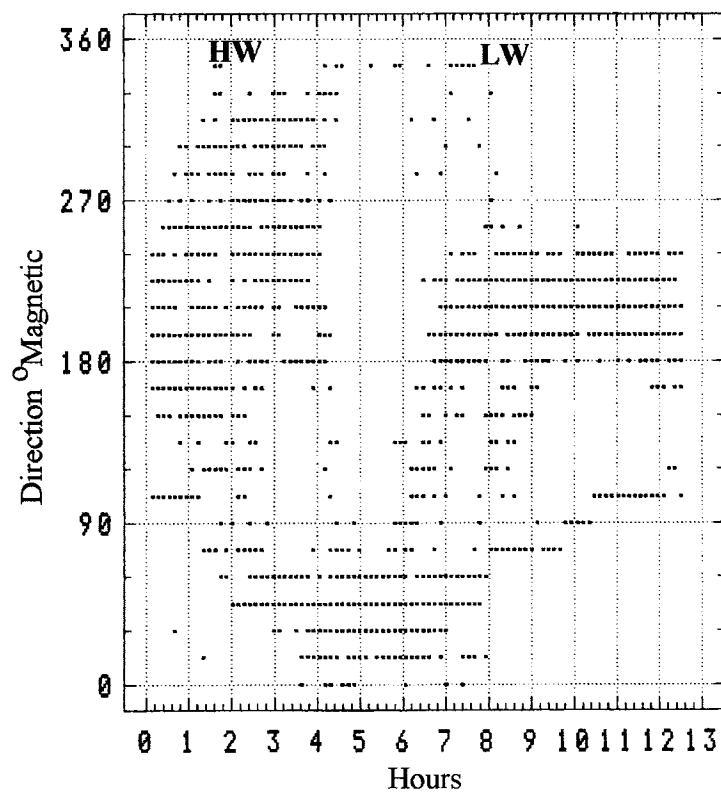


Figure 7.7 - Tidal Cycle Overlays: Direction Plot

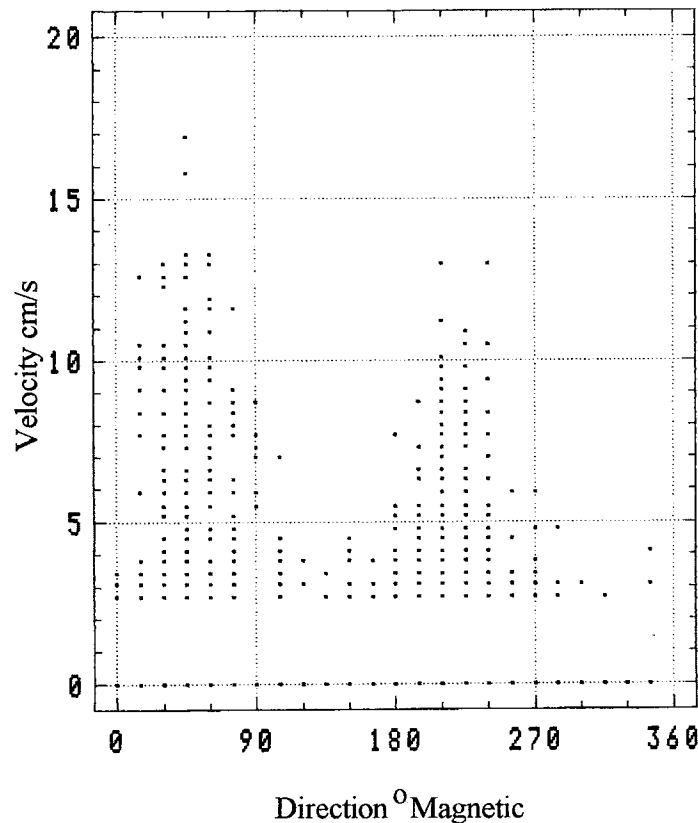


Figure 7.8 - Velocity/Direction Plot

7.4.2 Water Temperature and Turbidity

A simple model for the control of water temperature over the seagrass bed is suggested from the results. The minimum temperature appears to be controlled by the mixing of water from the inter island basin with cooler oceanic water from outside the islands. This mixing will be greater during spring tides and least during neaps suggesting a reason for the apparent relationship between tidal range and minimum temperature. Figure 7.9 illustrates the correlation between tidal range and minimum temperature with the equation constant modified to minimum rather than mean temperatures. This closely reproduces the night time water temperatures that were recorded during the period (Figure 7.10). If this interpretation of the data proves valid it may provide the basis of a method for modelling long term temperature variability over seagrass beds on Scilly.

The mechanism controlling maximum temperature is likely to be more complex. However, it is suggested that air temperature and insolation are the primary factors. It would be expected therefore that conditions that would encourage the *Labyrinthula* infection would arise in years when oceanic water temperatures are elevated during the initial part of the year, followed by a period of dull but warm weather in late summer and autumn. These conditions would be exacerbated during neap tides.

Due to water clarity over the seagrass bed observed during the survey period it is not anticipated that the light is likely to be limited due to turbidity.

7.5 Further Work

Long term monitoring of the temperature and current conditions within a sea grass bed could, if related to indicators of seagrass health and the movement of the bed, provide valuable information on the effects of these two parameters on the ecology of the species.

Validation of the model for predicting minimum water temperature could be accomplished by extending the study over a longer time period. In addition, other meteorological characteristics such as wind speed and direction should be taken into account in order to investigate the factors which control

maximum water temperatures. It is anticipated that this could be most efficiently achieved by deploying recording temperature meters and initiating a program of hourly weather recording on St Martin's.

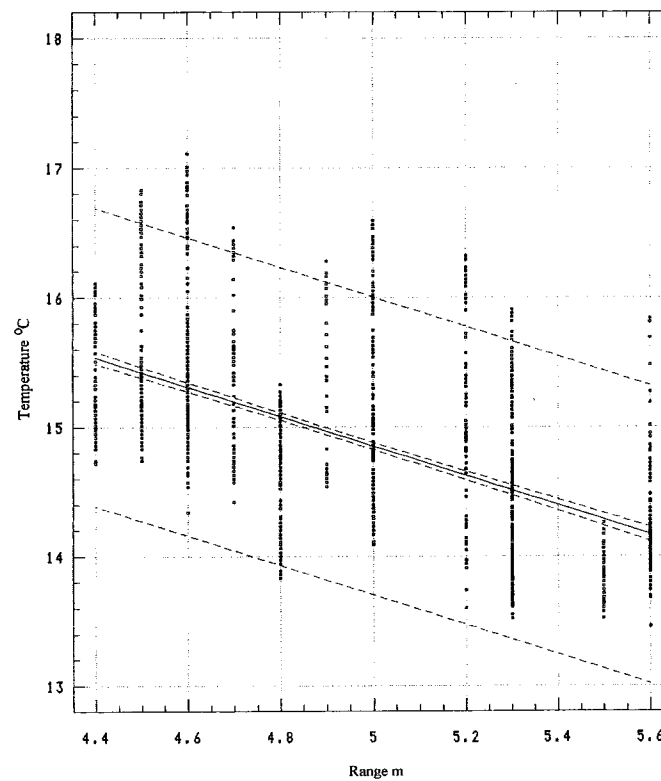


Figure 7.9 - Correlation of Temperature to Range

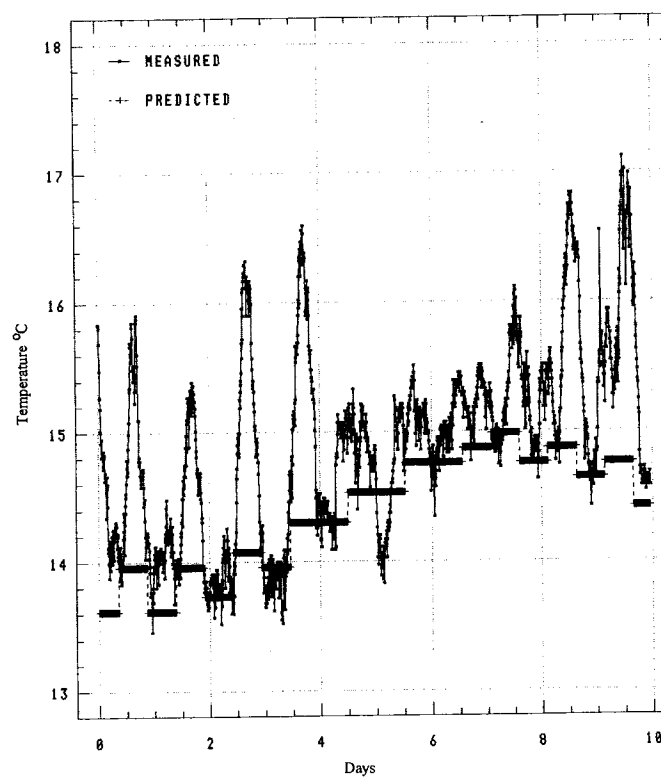


Figure 7.10 - Temperature to Range, Fitted Model

8. Appendices

8.1 Budget

The following summarises the expenditure of the expedition.

Food	292.12
Fuel	387.23
Air	305.20
Chandlery	152.36
Ferry	460.00
Towing & Parking	170.98
Accommodation	615.20
Postage & Stationary	47.74
Scientific	282.79
Miscellaneous	94.87
Total	2,808.49

8.2 Divers Field Notes

Note that no attempt has been made to edit these notes or to change the interpretation of the volunteers.

Date: 30/7/93 **Divers:** Kathy, Louise and Deborah
Place: Gilstone Rock **Depth:** 27m
Time: 12:00 BST

Dropped onto south side of rock into strong current. Visibility was 5-8m, managed to get beneath kelp line but had difficulty surveying area as currents so strong. Most aesthetic area was below 22m.

30m - Vertical wall covered in *Corynactis* of very many different colours. Also huge areas of yellow (brilliant) boring sponge - *Cliona celata*? Also bright orange encrusting sponge, *Caryophyllia smithii*, spiny starfish, sea urchins, *Alcyonium digitatum*, red branching and sheet like algae, *Holothuria forskali*. ballan wrasse (*Labrus bergylta*). Above this was thick kelp over large boulders making up 'steps' of rock. This was not surveyed in any more detail as current was strong.

Would be an excellent dive in slack water - particularly from 27m+.

Date: 20/7/93 **Divers:** Geoff Shaxton & Cath Downie
Place: Gilstone Rock **Depth:** 21m
Time: 09:45 © = common, ® = rare

18-21m - Walls densely covered in anemones - jewel and plumose. Sand gullies with finer sediment. Isolated massive sponges © on sand. Branching sponges ® on rocks. Large boulders on sand. Unidentified species resembling marram grass growing on rock surface whitish-green colour around 10cm high. Individual 'blades' from single base, around 3mm wide. Only one colony observed (*Nemertesia*?).

14-18m - Kelp. Walls densely covered in jewel anemones © and cup corals ®, variety of colours. Also green plumose anemones, ballan wrasse ©, pollack ©, goldsinny ©, cotton spinners ©, dead-man fingers ®, red fingers ®, 7 arm starfish ®, rose coral ©, red and brown algae - various species ©.

11-14m - 3m wall down to next 'step' covered in animal turf and densely covered in plumose anemones © - orange and white individuals with white dominating. Yellow encrusting sponges © in places, particularly in crevices. Spiny starfish ®, sea fir ®.

7-11m - Rock continued down in steps, dense kelp on surface. Some sea urchins ©, pollack ©, and ballan wrasse ©.

1-7m - Rock formed large steps with a level surface covered in kelp. Gullies with coarse sand and shell fragments. Numerous juvenile fish (Pollack?) ©.

Overall Impression - spectacular site, both in terms of rock formation with a series of steps and walls, and for life with great diversity and brilliant colours. Numerous crevices.

Date: 30/7/93 **Divers:** Helen Harris, Gordon Mackenzie
Place: Gilstone Rock **Depth:** 28m
Time: 11:00

Strong current led to difficult diving conditions and the most diverse and scenic part of the site was not surveyed.

28m - Managed to find 28m depth and worked up in an approximate north direction. Rock face rose in steps with vertical wall of 3-5m and flat ledges with some coarse sand and pebbles.

Rock faces carpeted with jewel anemones with some encrusting and branching sponges. Occasional cup coral, rose coral, starfish and sea urchin. Some red and brown algae which became denser at 23m.

23m - Cotton spinner observed at this depth as were a few red fingers.

22m - More brown algae with some kelp in places. Deep canyon in rock face.

17m - Brown algae became dominant at 17m where kelp line started. Kelp became dominant at 14m. Other species observed, *Polymastia boletiforme*, *Metridium senile*, *Actinothoe sphyrodeta*.

12m - Sheer faces 3-4m high, covered with jewel anemones, common anemones and dead mans fingers. Some sponge, spiny starfish.

9m - More red algae interspersed with the kelp.

6m - Rocky crevices with anemones and sponge within.

3m - Top of kelp.

Date: 29/7/93 **Divers:** Pete, Louise
Place: Gilstone Rocks **Depth:** 29m
Time: 16:15

Site Description - Dive from 29m depth to surface up southern face of Gilstone rocks.

29-13m - Encrusted animal turf on rock face. Jewel anemones and plumose anemones predominate.

Invertebrates:

Sponges -	<i>Myxilla sp.</i> (very common, large colonies) <i>Axinella sp.</i> (common) <i>Suberites sp.</i> <i>Polymastia sp.</i> (some large colonies)
Bryozoans -	<i>Pentapora foliacea</i> - very common (some large colonies amongst crevices)
Cnidaria -	<i>Caryophyllia sp.</i> - very numerous <i>Alcyonium digitatum/glomeratum</i> - common <i>Corynactis viridis</i> - abundant <i>Metridium senile</i> - abundant <i>Actinothoe sp.</i> - common <i>Sagartia elegans</i> - common <i>Tubularia sp.</i> - thick turf at depth <i>Nemertesia sp.</i> - abundant at depth
Echinoderms -	<i>Echinus esculentus</i> - common <i>Holothuria forskali</i> - a few observed <i>Marthasterias glacialis</i> - present
Algae -	<i>Laminaria digitata</i> - a few plants on ledges <i>Dictyota dichotoma</i> - common

13m - surface - Thick kelp forest under storey of red algae

Invertebrates

Sponges -	<i>Myxilla sp.</i>
Bryozoans -	<i>Pentapora sp.</i> - small colonies
Cnidaria -	As for lower habitat except general reduction in density. Very few devonshire cups seen.
Echinoderms -	<i>Echinus sp.</i> - common <i>Marthasterias sp.</i> - present <i>Henricia oculata</i> <i>Luidia ciliaris</i>
Algae -	<i>Laminaria hyperborea</i> - dominant <i>Laminaria digitata</i> - present <i>Palmaria palmata</i> - common <i>Dictyota dichotoma</i> - common
Fish -	<i>Scyliorhinus canicula</i> (one) <i>Labrus bergylta</i> - adult and juvenile <i>Labrus mixtus</i> Goby

General Remarks - Very beautiful site, as all of it was teeming with life. Extremely dramatic because of the steep cliff face and its gullies - definitely worth diving again.

Date:	30/7/93	Divers:	James Taylor, Tess Clements
Place:	Gilstone Rock	Depth:	29m
Time:	10:20		

28m -

Sand and boulders
Ballan and cuckoo wrasse common to 15m
Urchins
Cotton spinner
Top knot flat fish
Crabs and squat lobster seen amongst boulders
Polychaete cast

Fissured wall with small cracks to surface.
Wide variety of sponges (Elephants ear sponge) and plumose inhabited these
Red algae
Yellow sponge fingers - *Axinella polypoides* ?
Nemertesia antennina also on top
Walls covered at all levels with multi-coloured jewel anemones.
Some areas dominant with rose coral and surrounded by plumose anemones
Large yellow sponges seen at all levels.

11m - Kelp Also topshell seen in fissures, 2 pollacks at 11m.

Date:	29/7/93	Divers:	Geoff, Mark, Cath Downie
Place:	Hard Lewis Rock	Time:	10:20
Depth:	28m		

Dropped in off Melza near rocks in about 6m water in dense kelp beds which thinned out at about 9m, sloped down to 19m and dropped off steeply to 28m. Lots of massive bounders square and rounded with sanded pockets/gullies in between. Strong current about 1 knot, had to curtail dive after 19 minutes. Also poor visibility approximately 8m.

19-28m - Lots of cotton spinners, common sea urchins. One large encrusting sponge and small yellow branching sponge. Dead men's fingers white (lots) and a few red, some algae on boulders (sparse).

Fish female cuckoo wrasse at approximately 23m, Goldsinny wrasse. In kelp ballan wrasse.

Overall impression substrate impressive, but limited biological diversity.

Date:	29/7/94	Divers:	Laura, Gordon
Place:	Hard Lewis Rock	Time:	09:11
Depth:	32m		

32m - Large angular boulders covered in minuscule anemones of many colours. Rocks mixed with metal plates/guides also covered in life. Rock faces covered with turf and bryozoa and large clump of red dead men's fingers. Occasional single red and brown algae patches.

28m - As for 34m but with a much thicker coverage of algae. Starfish (approx. 1cm sq.) and urchins on rock sides.

26m - White fingers mostly on wreckage along with starfish, algae and small areas of sponge.

22m - Algae coverage increased considerably and the odd strand of kelp mixed in. Turf covered all wreckage with widespread coverage of small anemones 7 armed and spiny starfish on wreckage. Several cucumbers in wreck.

18m - Kelp becoming abundant and massive boulders (2-3m faces). Large patch of jewel anemones on sheer rock face coloured yellow, orange and purple. Devonshire cup corals occasional on wreckage.

17m - Large boulders with kelp - quite a lot of which were covered in bryozoa.

13m - As for 19m with occasional white fingers and jewel anemones.

Note that both a cuckoo wrasse and dogfish followed as we surveyed this site.

Date:	29/7/93	Divers:	Kathy Rikhardts and Tess
Place:	Hard Lewis Rock	Time:	10:30
Depth:	27m		

Dive in western side of Hard Lewis rocks. Swam west down boulder cliff covered in thick kelp. At 17m, flattened out to sandy bottom with some large and small boulders. Turned south west, gentle slope down to 27m and substrate was sandy with rocks and boulders. Visibility was 6-8m.

17-27m - Very aesthetic, diverse fauna, i.e. boulder walls covered in *Corynactis sp.*, *Caryophyllia sp.* and *Sargartia sp.* Jewel anemones only covered some walls and other anemones less abundant and found on other walls. *Alcyonium digitatum* and *Alcyonium glomeratum*. Large colonies of *Pentapora foliacea*. Large areas covered in a brilliant yellow (encrusting?) sponge - *Cliona celata*?

Sea fans - *Eunicella verrucosa*, Cotton spinners, Sea urchins, seven armed starfish, ballan wrasse.

17m - Boulders with encrusting pink calcareous algae, *Nemertesia sp.*, algae and orange sponges, Devonshire cup corals, white worm cases, some urchins.

Above 17m - Thick dense covering of kelp, sea urchins lurking in kelp. *Ulva*, red algae, *Fucus sp.* Some spiny starfish. Large (20") Lesser spotted dogfish, saithe.

Date:	29/7/93	Divers:	Helen and James
Place:	Hard Lewis Rock	Time:	08:50
Depth:	24m		

Site Description - Dropped off on east side of Hard Lewis. Descended and then moved to rocks a 10m hit top of rock reef. Covered in kelp. A lot of decaying white planks. Water cloudy with plankton. Mostly turf covered bedrock. Descended down slope.

Vertical face - 6m in length, many jewel anemones - purple, yellow, white and orange also colonies of plumose anemones usually on underside - yellow and orange. Few Devonshire cups around. Large colonies of yellow sponge (60cm across) mollusc, branched red sponge (*Axinella sp.*) and rose coral (40cm) at bottom of wall boulders and bedrock continued below.

Amongst boulders:

Covered with red algae
 7 arm starfish
 Evidence of wreck
 Not many urchins or starfish or cotton spinners but were present.
 Saw pollack out from rock
 Ballan and cuckoo wrasse amongst boulders, goldsinny around.

Verdict - Great site to dive. Visibility improves as depth increases (less suspension). Great vertical faces. Wreck debris around. Lots of colour and life.

Date:	29/7/93	Divers:	Pete, Louise
Place:	Hard Lewis Rock	Time:	08:30
Depth:	33m		

Site Description - Dive on eastern side of Hard Lewis's Rocks, navigating west towards the rocks from a depth of 33m up to surface adjacent to rocks. Visibility at 33m was between 8-13m, decreasing with decreasing depth. Large consolidated boulders at 23m abutting against a steep rock cliff. Rocks heavily encrusted with highly diverse animals turf. Kelp dive at 15m.

Aesthetics - Very attractive and interesting site.

18m

Inverts:- Jewel anemones - very dense carpets through zone.
Nemertesia sp. very abundant and well developed in deeper zone.
Sagartia sp. - abundant in sheltered gullies. Various colour morphs but commonly yellow body with white tentacles (possible *Actinothoe* sp.?) *Metridium* sp. - white and reds (?) most common. Abundant in upper half of zone, particularly shelved gullies.
Alcyonium digitatum and *A. glomeratum* - common throughout zone.
Pentapora foliacea - common throughout zone. Very well developed at depth (colonies over 30cm long)
Axinella sp. - yellow branching sponge - common
Myxilla sp. - large, yellow encrusting sponge. Common with some colonies over 30 cm long.
Homarus gammarus - medium size
Echinus esculentus - common

Algae:-

Predominantly reds (*Membranipora* sp.), coral weed

Fish:-

Dogfish (s), pollack - common (juvenile), cuckoo wrasse - common, ballan wrasse - common (some large individuals), goldsinny - a few seen., wrasse.

8m - Kelp zone:- Mixture of kelps (*Laminaria digitata* and *Sacchoriza polyschides* sp), red algae (*Kallymenia/Delesseria?* sp) and numerous plumose anemones. Also some spiny starfish (*Echinus esculentus* - common).

Above 8m - Thick kelp zone, *Sacchoriza polyschides* and *Laminaria hyperborea*.

Very beautiful site.

Date:	29/7/93	Divers:	Pete, Cath
Place:	St Martins Head	Time:	09:00
Depth:	16-20m		© = common, ® = rare

Substrate - Coarse sand with shell fragments and boulders. Appeared to be on edge of kelp line. Uniform flat platform - surveyed 20m - 16m. Westerly current (<0.5 knots). Surveyed on SW bearing - boulders became more massive. Headed towards Outer Rock. Many narrow gullies, some overlays. Animal turf well developed on boulders.

Fish - Numerous wrasse - cuckoo, ballan, goldsinny, juvenile pollack

Crustaceans - Spiny squat lobster, 2 swimming crabs, 1 edible crab

Invertebrates - Sea cucumber ©, starfish (spiny) ©, common sea urchins ©, Dead man's fingers ©, red fingers ©, rose coral ©, formerly dense mats over most rock surfaces. Jewel anemones ©, Devonshire cup corals ©, encrusting red algae ©, encrusting sponges ®, red algae - *Delesseria* sp ©, brown algae - seaweed ©, small kelp plants ©, *Halidrys* - like sp. ©.

Aesthetics - Poor

Date:	28/7/93	Divers:	Helen Harris, Gordon Mackenzie
Place:	St Martins Head	Time:	08:25
Depth:	8m		

Dropped in about 6m and swam west - strong (1 knot ?) current running approximately north made progress difficult. Kelp patch on rocky substrate went down to 8m and levelled out. Some small sand patches but little else in the kelp patch.

Date:	28/7/93	Divers:	Kathy Rickards, Deborah Moore
Place:	St Martins Head	Time:	09:50
Depth:	16-19m		

Substrate was sandy, some silt with small boulders and large lumps of rock. No zonation - all area was similar apart from at most south westerly point where some kelp was noted - start of lower infralittoral?

Species Notes: Kelp - didn't look as healthy as in shallower sites, i.e. dull brown, ragged browns, covered in epiphytes/encrusting sp. Large white patches - *Membranipora membranacea*, only present at <16m.

22-20m

On large boulders:

Alcyonium digitatum
Caryophyllia smithi
Echinus esculentus
Marthasterias glacialis
Silt covered pink encrusting calcareous algae

16m

On large boulders:	Same as above, except no <i>Alcyonium glomeratum</i>
On bedrock:	Flat sheet like red algae, no prominent animal or plant communities - general turf over small boulders
On surface:	<i>Cyanea lamarckii</i> - jellyfish

General Remarks - Pleasant enough, quite a lot to see, picturesque though in places a bit barren. Good visibility

Date:	30/7/93	Divers:	Cath Downie, Geoff Shaxton
Place:	The Moulds	Time:	15:45
Depth:	13m		

Substrate - Rock shelving down, covered in boulders with numerous gullies. Fine sediment at bottom of gullies - fine sand with some organic particles. Boulders covered in kelp and a feathery brown algae. Fine covering of silt on kelp leaves.

13-8m - Did not reach start of kelp at 13m. Numerous pollack at all depths, and juveniles amongst kelp. Goldsinny wrasse at 8-13m. Some ballan wrasse including juveniles. Numerous cotton spinners at 10-13m. *Pomatoceros* sp in sand gullies at 13m. Walls covered in animal turf with some jewel anemones and cup corals.

8m - A few spiny starfish at all depths. Various red algae around 7m. Small top-shells on kelp at 1-7m.

Overall impression - An attractive site, particularly with the numerous gullies and overlays to explore. Biologically interesting, although at the depth we did (13m) less variety than some other sites. Numerous seals at surface.

Date:	28/7/93	Divers:	Deborah, Kathy
Place:	South of Little Innisvoul	Time:	15:15
Depth:	13m		

13m - Sandy bottom with stray fronds of sugar kelp and *Ulva sp.* An anthozoa - photo by Deborah - possible *Cerianthus lloydii*. Sand covered with turf and silt, little life. Shoals' of gobies.

11-12m - Large boulders with pink encrusting coralline algae and orange encrusting sponge. White, hard worm cases - *Pomatoceros sp?* *C. lloydii* between boulders, Devonshire cup coral - boulders were covered in a turf and silt. No sign of common sea urchins or starfish.

8m - Very thick covering of kelp, probably on rocky substrate difficult to see. Health looking, presence of large patches of bryozoan - *Membranipora membranacea*. Many fronds covered in red, turf like, algae, very fine, small with crinkly edges. Some urchins (relatively few), some fish - wrasse (juvenile), crab (velvet swimming crab?). Area wasn't cliff but was made up of large, rocky outcrops interspersed with narrow sandy gullies.

Date:	28/7/93	Divers:	Pete, Cath
Place:	Little Innisvoul (South)	Time:	15:30
Depth:	13m		

Site Description - Kelp covered boulders descending from surface to 13m depth. Transect swam in a due 5 direction. Southern - most extreme of transect mostly fine sand and kelp - covered isolated boulders.

Aesthetics - Poor (although numerous seals observed from surface)

Species

Fish:	Numerous ballan wrasse
Mammals:	Seals
Algae:	<i>Delesseria sp.</i> - dense growth <i>Laminaria hyperborea</i> - dense bryozoan <i>Laminaria saccharina</i> - sparse epiphytic species <i>Laminaria digitata</i> - common
Inverts:	<i>Echinus esculentus</i> - very common <i>Corynactis viridis</i> - sparse

Date:	29/7/93	Divers:	Laura, Gordon
Place:	Menpingrin	Time:	15:43
Depth:	26m		

26m - Bottom of gully - sandy bottom/coarse gully formed by massive rocks. Some red/brown algae. Scattered urchin. Some dead man's fingers on rocks. Spiny and common starfish. Some ballan wrasse observed.

22m - Some kelp and more brown/red algae. Some yellow encrusting sponge, 7-armed starfish. Occasional devonshire cup coral.

19m - More brown algae. Cotton spinner. Jewel anemone on rock face and yellow encrusting sponge. Dead man's fingers under overhanging rock.

17m - Kelp predominant (bryozoa covered) with red algae.

16m - Purple sponge on boulder with dead man's fingers. Filamentous algae- possible dead or encrusting, some cobbles. Frequent cotton spinners, urchins and yellow sponge.

Date: 29/7/93 **Divers:** James and Helen
Place: Menpingrin
Depth: 17m - limited depth due to previous dive

Top of wall m covered in kelp. Wall from m down to 21m. Wall broken up with vertical fissures and horizontal ledges. Ledges covered with *Drachiella spectabilis*?. Most of dive spent along wall between 17m and 9m. Seen on wall - clumps of white dead man's fingers.

13m - Some slopes - anemones jewel and beadlet - scattered along wall, the largest one being 80mm in diameter. A purple printed top shell seen at 18m attached to bedrock and one seen attached to kelp. Dogfish seen amongst the kelp. Crabs seen in the fissures. Kelp showed heavy growth of tunicates - hydroids. Some starfish.

Date: 29/7/93 **Divers:** Mark Evans, Cath Downie
Place: Porth Hellick Point **Time:** 16:50
Lady Charlotte wreck
Depth: 15m

15m - End of sand/rock gullies, beginning of kelp line. Large boulders, much of which covered in a fine silt due to little tidal effect in the bay area.

12m - On some vertical exposed faces of the rocks in areas of little kelp a number of Devonshire cup corals could be seen with some small jewel anemones.

8m - On the vertical walls of the ship boilers much encrusting sponge and spiny starfish were there. There was very little other life, no help except on the top. Occasional sea urchins amongst the boulders. Much small/juvenile fish life. Adult ballan wrasse also present at most depths.

7-1m - Very dense kelp all over large boulders much coarser substrate present with shell fragments between the boulders. Fish life as before.

1m - Large snakelock anemones growing on the kelp

Overall Impression - An attractive site with many parts of the wreck visible although not at all intact. Reasonable diversity of life but not the best site in the area.

Date: 29/7/93 **Divers:** Kathy and Tess
Place: Lady Charlotte wreck **Time:** 16:00
Depth: 8m

Whole area was dense kelp covering an area of boulders and sandy gullies. Large snakelocks on kelp and topshells. Bits of wreck (that we saw) lay in ~8-5m of water encrusted with pink coralline algae, red feather-like algae and other encrusting animals and plants. Boulders of orange sponge, pink coralline algae, keel worm and Devonshire cup corals. Some urchins, spiny starfish, wrasse, ballan wrasse.

General Remarks - A nice dive in a sheltered site with the added advantage of the presence of the wreck.

Date: 29/7/93 **Divers:** Deborah Moore, Geoff Shaxton
Place: Porth Hellick Pt **Time:** 16:25
Lady Charlotte wreck
Depth: 10m

10m - Parts of wreck Lady Charlotte, some Devonshire cup coral was seen with some jewel anemones, cotton spinners, sea urchins, starfish and one large ballan wrasse. Towards end of dive encountered some rock faces 2m high.

9m - Red large algae and branching red algae were seen.

9-7m - kelp began to thin out and gullies between boulders were filled with sand.

4m - Dense kelp with lots of brown filamentous algae grown on kelp also browsing snails. Lots of boulders with kelp on gullies in between filled with small pebbles encrusted with red algae. Silt on kelp leaves

Impression - Interesting dive with lots of boulders, gullies and some rock faces with bits of wreck amongst rock. Not very much biological diversity however and mainly kelp forest.

Date: 27/7/93
Site: Gap Point

Divers: Mark Evans, Laura Sandford-Johnson

34m? - Sea Bed. Flat featureless coarse sand and silt, occasional anemone, common starfish. Some flat metal plates (shipwreck?) in a small group.

32m? - Start of Cliff face. Very large granite like square-ish boulders some up to 2/3m tall. All covered in 'animal turf'. Some red dead man's fingers, common sea urchins.

30m? - Cliff face. Similar species to the 32m description

25m? - Cliff face. Same as 32m and sea cucumber

24m? - Cliff face. Start of algal layer

20m? - Top of ridge on cliff face, appeared to descend back down to sandy type gully.

Date: 27/7/93
Place: Gap Point
Depth: 31m

Divers: Louise Lowans, Pete Raines
Time: 09:30

At base of rocks the sea bed was sandy/silt. Rocks ended at 18 metres. Marine life found from base of rocks - at 31m to the top of the rocks 18 metres. The following marine life was found, it was abundantly covered and no damage was seen.

Suberites carnosus
Axinella infundibuliformis
Axinella polypoides
Alcyonium glomeratum
Eunicella verrucosa
Caryophyllia smithii
Sea urchins
Holothuria forskali
Red and green seaweed - sparse

All of the rocks had a fine covering of algae, they were also covered in silt/sand. Visually this was a very good dive, with a tremendous amount of marine life to see, definitely a site worth doing again.

Date: 30/7/93
Site: Gilstone
Depth: 28m

Divers: Laura Sandford-Johnson, Mark Evans
Time: 09:43

28m - Massive boulders all with sheer faces reaching up to about 3m in height. Rock faces covered with a fine layer of bryozoa with the occasional thickening patches of jewel and other anemones along with red and white fingers covered most of the faces. Occasional common urchins and small 7-armed starfish. Several crevices ran in the rock face from fist size to body size.

23m - Reached a flat ledge (top of rock) 2-3m² in size. Surface covered with bryozoa and anemones with small patches of red and white fingers. One or two strands of kelp present. Some other cotton spinners present wedged in vertical crevices or on horizontal crevice floors. Small patches of ross coral.

21m - Reached a level where majority tops of rocks all with patches of brown algae. Scattering of Devonshire cup corals and fairly large patches of yellow encrusting sponge. Odd spiny starfish and

velvet crabs hiding in crevices. Occasional cotton spinners. Occasional patches of porifera and plumose anemones.

16m - As for 25m but a wider covering of kelp.

8m - Thick kelp with brown and red algae covering rocks. Fissure plentiful with common anemones, plumose, bryozoa and red and white fingers.

5m - Large patch of red branching algae mostly covered by a white substance but not calcified. Kelp had bryozoa growing over some strands.

0m - Top of kelp

Date:	28/7/93	Divers:	Laura Sandford-Johnson, Mark Evans
Site:	Midway between Ragged Rock and Great Arthur Island		
Depth:	24m	Time:	10:32

24m - Flat sandy bed with shells, fairly silty, becoming ripples nearer to start of boulders (some ripples quite indented, almost like a ploughed field). Several edible crabs in hollows, some anemones.

18m - Boulders started, some quite large (1m). Red and brown algae covering on boulders. Several urchins mostly on underside of boulders, mainly commons and one cucumber. Small coarse sandy patches between rocks. Most boulders had a fine covering of animal turf.

16m - Marked increase in brown algal covering ranging from fine filamentous to foliose, mixed with kelp. Some urchins on sides of boulders. Kelp coverage extensive.

14-4m - Kelp covered majority of rocks with small amount of red and brown algae present. Some small patches of encrusting sponge occurring on sides of boulders amongst kelp. Occasional starfish on sides of rocks. Boulders increased in size and kelp coverage up to approximately 8m.

Date:	28/7/93	Divers:	Tess, Louise, James
Site:	Neck of Menawethan	Time:	16:30
Depth:	15m		

Site Description - Maximum depth of 15m, sandy bottom with a large rocky outcrop ascending to 14m which were densely covered with kelp and encrusting red algae and green algae. A fair amount of the kelp stipes were damaged. The following were seen:

Suberites carnosus
Grantia compressa
Caryophyllia smithii
Corynactis viridis on underside of rocks
Sagartia elegans var miniata
Alcyonium digitatum
Nemertesia sp.
Compass jellyfish
Spider crab,
Cancer pagurus
Prawn
Barnacles
Holothuria forskali
Echinus esculentus
Luidia sp
Marthasterias glacialis
Asterias rubens
Snails on kelp
Arenicola marina
Shoal of juvenile fish
Gobies
Laminaria hyperborea

Corallina sp

General Remarks - Sand, then kelp, kelp and more kelp. Loads of seals in this area (saw them on surface) but we saw more underwater. Would be an excellent place to see them and a good dive if you like kelp and a good variety of algal species. Interesting topography, decent shallowish dive as 18m max. for as far as we swam.

Date:	28/7/93	Divers:	Laura Sandford-Johnson
Place:	Neck of Menawethan		Mark Evans
Depth:	27m	Time:	16:23

27m - Sloping sandy bed going gradually up. Some anemones, shells and broken shells and occasional live scallops and some pebbles. Sand coarse with small isolated algae.

24m - Boulders started - some massive. Some edible crabs hiding underneath and odd common urchins on sides. Some algae and smattering of tiny sponges, minuscule anemones and fine animal turf.

22m - As above with some kelp patches, small common and spiny starfish quite often with some cucumbers on sides and rock tops. Algae mixed in with kelp on tops of boulders. Bright red ¼" sea scorpion!

18m - Top of one huge block and looked as though it was going to slope back down to sandy bed on other side and all around.

Lots of squat lobsters in crevices at 21m

Date:	28/7/93	Divers:	Tess, James, Louise
Place:	South of Great Arthur	Depth:	26.7 - m
Visibility:	6 - 8m	Time:	10:47

Site Description - Bottom sandy/silt with some shell debris. Bivalve remnants. Scant red and green algae. Between 16-17m the boulders were replaced with rocks. At 17-18m a fine kelp level was found, with abundant brown algae. Red encrusting algae was on all the rocks. The following was seen at the site:

Labrus mixtus
Labrus bergylta
Sagartiogeton laceratus
Corallina sp
Ctenolabrus rupestris
Spiny squat lobster
Shrimp
Prawn
Spider crab
Sea urchins (abundant)
Holothuria forskali
Marthasterius glacialis
Caryophyllia Smithii
Sagartia elegans
Tunicate - possible *Ascidella aspersa*

General - Boulders were interesting as much life was hiding in rock crevices. Initial part of dive boring - more crustaceans on site than any other. No evidence was seen of over grazing from sea urchins

8.3 Zostera Quadrat Summaries

8.3.1 Old Grimsby Harbour

Quadrat	No. Leaves	No. plants/0.25m	No. Infected	No. Uninfected	% Infected	Total Length	Mean Leaf Infection Scores
A	4.29	24	2.5	1.79	58.19	65.38	1.08
B	4.85	13	3.15	1.69	64.87	80.31	0.84
C	4.04	25	2.36	1.6	58.53	29.6	1.36
D	4.53	17	2.71	1.76	59.41	58.76	0.89
E	5.71	14	3.36	2.36	60.24	80.21	1.11
F	4.63	16	3.06	1.56	66.34	80.38	1.16
G	3.95	19	2.21	1.74	57.02	80.53	0.77
H	4.44	16	2.31	2.13	55.07	74.5	0.82
I	4.18	11	2.64	1.55	61.21	79.64	0.92
J	4.43	7	2	2.43	41.67	63.14	0.58
Grand Mean	4.51	16.2	2.63	1.86	58.26	69.25	0.95

8.3.2 East Higher Town Bay

Quadrat	No. Leaves	No. Plants/0.25m	No. Infected	No. Uninfected	% Infected	Total Length	Mean Leaf Infection Scores
A	4.65	23	2.7	1.96	59.11	42.3	1.33
B	4.33	21	2.76	1.57	64.13	65.71	1.38
C	3.97	35	2.69	1.29	68.57	43.2	1.51
D	4.22	27	2.41	1.81	58.57	45.93	1.33
E	4.54	35	3.03	1.51	67.87	49.4	1.53
F	3.88	25	2.56	1.32	65.4	45.56	1.43
G	4.33	3	3.33	1	76.67	43.33	1.1
H	4.27	10	2.69	1.58	63.94	48.68	0.93
I	3.85	20	2.5	1.35	62.58	53.5	0.91
J	3.89	19	2.47	1.42	64.65	47.95	0.84
Grand Mean	4.19	21.8	2.71	1.48	65.15	48.56	1.23

8.3.3 Chimney Rocks

Quadrat	No. Leaves	No. Plants /0.25m	No. Infected	No. Uninfected	% Infected	Total Length	Mean Leaf Infection Scores
A	3.55	11	2	1.55	57.12	54.55	0.49
B	3.73	34	2.21	1.48	60.81	75.61	0.82
C	4.54	13	2.69	1.85	58.97	92.31	1.13
D	3.55	9	2	1.55	57.12	54.55	0.49
E	4.5	24	2.5	2	55.47	63.88	1.04
F	4.31	26	2.58	1.73	59.76	48.69	1.19
G	4.38	21	2.38	1.81	55.63	45.38	0.96
H	4.31	13	3.38	1.15	79.87	81.54	1.43
K	4.63	32	2.75	1.81	59.38	61.22	1.15
L	4.76	25	2.84	1.92	59.4	60	0.76
M	4.12	26	2.36	1.72	58.67	101.64	1.15
N	4.72	25	2.16	2.56	46.25	78.2	0.96
O	4.64	25	2.48	2.16	52.95	61.6	0.62
P	4.46	28	2.46	2	56.55	50.57	0.75
Q	4.19	26	2.08	2.12	49.94	54.73	0.71
R	4.58	31	1.97	2.61	43.12	53.1	0.53
S	4.36	22	2.73	1.64	62.05	94.05	1.06
T	4.82	22	2.59	2.23	53.92	120.05	0.86
U	3.62	21	2.81	0.76	79.44	79.14	1.09
V	5.38	17	3	2.38	56.53	86.31	0.96
W	3.25	12	2.67	0.42	81.94	59.42	1.99
X	4.48	23	2.17	2.3	49.42	57.57	1.1
Grand Mean	4.31	22.09	2.49	1.81	58.83	69.73	0.97

8.4 Wine Cove Transect Results

Date	Site	Distance	Remarks
24/7/93	E3	100-90m	Boulders, cobbles (30cm). Red algal turf on boulders with some fine sand. Also encrusting reds, Kelp (<i>Laminaria hyperborea</i>) forest.
		90-80m	As above, some pebbles in gaps.
		80-70m	More sediment between rocks. Sugar kelp (<i>Saccorhiza polyschides</i>). Quite a lot of gravel at 70m. RPD layer >5cm down. Sediment poorly sorted with some fines.
		70-60m	More pebbles than above.
		60-50m	Tin can at 50m, otherwise as above.
		50-40m	Encrusting reds increase in diversity, kelp replaced by Thong weed (<i>Himanthalia elongata</i>) at 41m. Sediment as above.
		40-30m	Red alga turf on stable poorly sorted gravel.
		30-20m	More cobbles and some large boulders.
		20-10m	Sediment as above.
		10-0m	Dense thong weed.
21/7/93	E2	100-80m	Kelp on rock. Some sand/pebbles.
		70m	Whole new drink can.
		50-30m	Some thong weed.
21/7/93	E1	100-90m	Coarse gravel and shell/finer underneath (loosely packed). Pebbles 5cm angular (occasional). Flat bottom lots of loose seaweed debris.
		90-80m	Large rock 6-7m with kelp growing. Red filamentous algae floating around, red branching algae growing in sand (rare).
		80-70m	Kelp on rocks.
		60-50m	Odd kelp covered boulder scattered around, mostly flat gravel beds with weed debris. Small angular pebbles.
		50-40m	Lots of pebbles and red calc algae. Sheet metal (15 x 30cm) well rusted. Kelp and boulder wall running east/west. Small rocks start
		40-30m	Snakelocks anemones, massive rocks and kelp, lots more pebbles. Pocket of coarse sand.
		30-20m	Lots of rock, no sand, kelp, red and green calc algae. Snakelocks anemones (<i>Anemonia viridis</i>), Thong weed and Cans (aluminium).
		20-10m	Rocks, some kelp.
		10-0m	Rocky boulder covered in kelp, little gravel.
		100-90m	Boulder and kelp with some sand/pebble gravel. 60cm piece of rubbish at 91m. 20cm piece of metal at 93m. 2cm piece of tin at 96m.
20/7/93	Origin Transect	90-80m	Boulder and kelp, some clean sand. Some pebbles, can bottom at 80m, metal fragment at 84m.
		80-70m	Can bottom at 71m, can top at 78m.
		70-60m	No gravel, cleaner sand. Boulder and kelp - small amount of kelp debris. Little rubbish.
		60-50m	Small pebbles, kelp, one small old tin.
		50-40m	Boulders with less sand and some gravel, kelp and debris. Small bits of old glass and cans. 10cm tin plate at 44m, large piece of corrugated iron

Date	Site	Distance	Remarks
24/7/93	Origin Transect Extended		at 46m, some plastic.
		40-30m	Pebble and gravel, kelp and kelp debris black sediment. Little rubbish, one hot water bottle found. Large/small bits of metal, some plastic.
		30-20m	Kelp and kelp debris (lots of it). Black sandy sediment. Whole can, metal, wood, some fragments of dinner plate, glass fragments.
		20-10m	Large pieces of metal. Some glass and one dry cell battery. Gravel and pebble with some sand.
		10-0m	Gravel and pebble with some sand. Small pieces of metal and glass. New and old debris.
		100m	Substrate coarse sand and some shell with worm holes, some loose seaweed.
		90m-100m	Sand slightly coarse, some Sea lettuce (<i>Ulva</i> sp.) on small pebbles. Occasional snakelocks anemones.
		80m-90m	Sand slightly coarse, some sea lettuce on small pebbles.
		70m-80m	As above
		60m-70m	Pebbles with kelp attached.
		50m-60m	Sea lettuce and red branching algae. Sand decreasing into pockets between rocks.
		40m-50m	Kelp on large rocks, 1cm fragment of metal aluminium can.
		30m-40m	Dense kelp with some small pebbles
		20m-30m	Glass bottom top, jagged edges
		10m-20m	Large boulders with kelp and starfish
27/7/93	W1	0m-10m	Tin top and plastic bottle top.
		100m-90m	Large boulders/stable bedrock with pockets of coarse sand. Weathered drink can top 1 observed, weathered tin can bodies 1 observed.
		90-80m	Stable bedrock with coarse sand pockets. Kelp covered. Drink cans (tops/bottoms) - 2 observed, weathered tin can bodies - 1 observed, 30 x 30cm metal sheet - 1 observed 88m.
		80-75m	Stable bedrock with coarse sand pockets, kelp covered. Numerous tops/bottoms of drinks cans (7), appeared to be weather beaten. Pieces of thin, weather beaten tin cans - 2 observed.
		75-60m	Boulders and kelp. 1 can base found
		60-50m	No big kelp, kelp present was loose. Linoleum found (20 x 30cm ²). Shoe (size 10) found.
		50-40m	One can base, big brass can (10cm diameter), old can base - very thin. Thin kelp
		40-30m	Some gravel, granite boulders. Thickening kelp.
		30-20m	Big boulder at 28m (2m across), dense kelp. Can bases observed, big boulder at 21m.
		20-10m	Gravel gullies and large craggy boulders, kelp and thong weed, very dense. Two can bases, metal refrigerator tubing (15x10cm) tarnished black.
20/7/93	W2	10-0m	Gravel and boulders - loose floating kelp. Patchy areas.
		90m-100m	Clean Sand, boulder and kelp
		80m-90m	Some gravel
		70m-80m	Coarse sand, some kelp debris, some floating polythene.

Date	Site	Distance	Remarks
21/7/93		60m-70m	Coarse sand, few boulders and kelp. can, 1 old saucepan.
		50m-60m	Rock and kelp with some pebbles
		40m-50m	Kelp on boulders, some sand, some kelp debris
		30m-40m	Coarse clean sand. Some kelp debris
		20m-30m	Rock and kelp with black sediment, glass fragments
		10m-20m	Rock and kelp with black sediment, no rubbish
		0m-10m	Rock and kelp with black sediment, no rubbish.
		100-90m	Kelp on boulders and pebbles. Some sand.
		80m-90m	Thong weed on rock and kelp.
		70m-80m	Mostly thong weed, 1cm fragment of tin.
21/7/93	W3	60m-70m	Some coarse sand with a little black sediment.
		30-60m	Thong weed, boulders, some sand with black debris. A little sand.
		20m-30m	Thong weed, some pebbles/sand with black debris.
		0-20m	Boulders.
		100m-90m	Kelp on rocks, coarse sand in pockets, red algae.
		80m-90m	Small pebbles 4cm, angular. Large kelp, thong weed.
		70m-80m	Thong weed, 20cm pebbles, small pebbles 4cm.
		60m-70m	Rock substrate, kelp on rock substrate, no sand, thing weed.
		50m-60m	Angular rock with small pockets of sand (loose).
		40m-50m	Snakelocks, pebbles 10cm. Sea lettuce and thong weed.
21/7/93	W4	30m-40m	Flat rocky substrate, small pebbles, bladder wrack.
		20m-30m	Small pebbles 2cm angular, bladder rock, lots of red algae on rocks. Flat rocky substrate. Kelp patches. Silver foil.
		10m-20m	Rocky substrate, limpets on rocks, red calc algae and bladder wrack.
		0m-10m	Granite boulders coloured pink. Gravel in gullies.
		80m-90m	Coarse sand, kelp on boulders. Some kelp debris.
		70m-80m	Kelp on boulders.
		50m-70m	Some sandy patches.
		40m-50m	Thong weed and kelp on boulders.
		30m-40m	Some sandy patches.
		20m-30m	Mainly thong weed.
21/7/93	W5	0-10m	Kelp and thong weed. Some black sediment.

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