Plymouth Sound & Estuaries SAC
seagrass diving survey
15-17 July 2009

FINAL REPORT

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SUMMARY

This report details the findings of a diving survey undertaken in July 2009 investigating four seagrass *Zostera marina* beds within Plymouth Sound and Estuaries SAC. The main aim of the survey was to obtain reliable, quality data on the following attributes: plant density, mean longest leaf length, epiphyte cover, cover of macroalgae on the substratum and presence or absence of 'wasting disease'. As part of the overall assessment of the beds, their extent had already been determined by analysis of aerial photographs taken in 2006.

One requirement of the project was that the methodology employed had to be straightforward, cost-effective and repeatable, and follow certain requirements drawn up by Natural England in 2005. Three 50 m long transects were laid out within each of four eelgrass beds: Cawsand Bay and Drake's Island (both of which lie within Plymouth Sound); and Cellars Cove and Red Cove at the mouth of the River Yealm. A pair of divers then undertook recordings from twelve 0.5 m x 0.5 m quadrats placed at 4 m intervals along the transect (and a further six quadrats at 8 m intervals), with the following data being obtained *in situ* from the 18 quadrats:

- The no. of plants within the 0.5 m x 0.5 m quadrat;
- The length of the longest leaves of 3 randomly-chosen plants within the quadrat;
- The percentage cover of macroalgae (attached and/or loose) within the quadrat;
- The cutting of at least 20 randomly-chosen leaves (for later analysis of epiphytes);
- The taking of a representative photograph of all or part of the quadrat; and
- The depth of the seabed.

The results have provided a baseline on which future monitoring of these beds can be based. The greatest density of plants was found to be at Red Cove (142 plants/m^2, range: 4-496), although this figure should be viewed with some caution on account of the difficulty of recording from the quadrats at Red Cove owing to large amounts of drift algae obscuring the view of the diver. The mean density figure for Cawsand Bay was 78 plants/m^2 (range: 7-160); for Drake's Island 73 plants/m^2 (range: 12-156); and for Cellars Cove 90 plants/m^2 (range: 24-152). The mean lengths of the longest leaves were as follows: Cawsand Bay 40 cm; Drake's Island 68 cm; Cellars Cove 68 cm; and Red Cove 49 cm.

The epiphytic community present on the *Zostera marina* leaves was dominated by coralline algae (particularly *Hydrolithon* sp. and *Pneophyllum* sp.), non-calcareous algae (e.g. *Ceramium rubrum*, *Antithamnion plumula* and *Polysiphonia stricta*) and tubicolous amphipods. Other groups represented included hydroids and encrusting bryozoans. Characteristic macroalgal species recorded within quadrats included *Saccharina latissima*, *Calliblepharis ciliata*, *Polyides rotundus*, *Furcellaria lumbricoides* and *Nitophyllum punctatum*. Macrofauna recorded within quadrats included *Cerianthus lloydii*, *Lanice conchilega*, *Sabella pavonina*, *Chaetopterus variopedatus* and *Calliostoma zizyphinum*.

There were **no signs of nutrient enrichment** at any of the sites, as might be indicated by excessive attached macroalgae, particularly of the green alga *Enteromorpha* (*Ulva*) *lactuca*. However, at some locations, most noticeably at Red Cove South, there were large amounts of drift macroalgae smothering the seabed. Interestingly though, there were still healthy *Zostera marina* plants living underneath this covering showing no ill effects, implying that this smothering was likely only to be temporary. Additionally, there were **no *definite* signs of the wasting disease** caused by the slime mould/fungus *Labyrinthula macrocystis* being apparent in any of the leaves examined.

Frontispiece: Leaves of the seagrass *Zostera marina* (common name 'eelgrass') with obvious epiphytic growths, including hydroids and algae. Drake's Island, 16 July 2009.

Photo: JH-S.

CONTENTS

1. INTRODUCTION

On 8 July 2009, Sea-Scope, Marine Environmental Consultants, were commissioned by Natural England to undertake a diving survey of the eelgrass *Zostera marina* beds within Plymouth Sound and Estuaries SAC (Order No. 843676). This report sets out the findings of that diving survey[1].

The survey, and the subsequent analysis of the data the survey provided, was designed to initiate a repeatable (at least once every 6 years) monitoring programme, against which the condition of the site will be measured. The methodology has been described here in such a way as to allow a repeat of the survey to be undertaken without, it is hoped, little need for alteration to or adaptation of the methodology.

1.1 Background

Plymouth Sound and Estuaries Special Area of Conservation (SAC) (Fig. 1.1) has, as one of its Annex I features, "sandbanks which are slightly covered by sea water all the time" (as defined in the 1992 EC Habitats Directive). This Annex I feature is one of the main reasons why the site was designated as an SAC and, as part of the site's on-going management following English Nature's Regulation 33 advice for the site, there is a requirement for this feature's condition to be reported on at least once every six years.

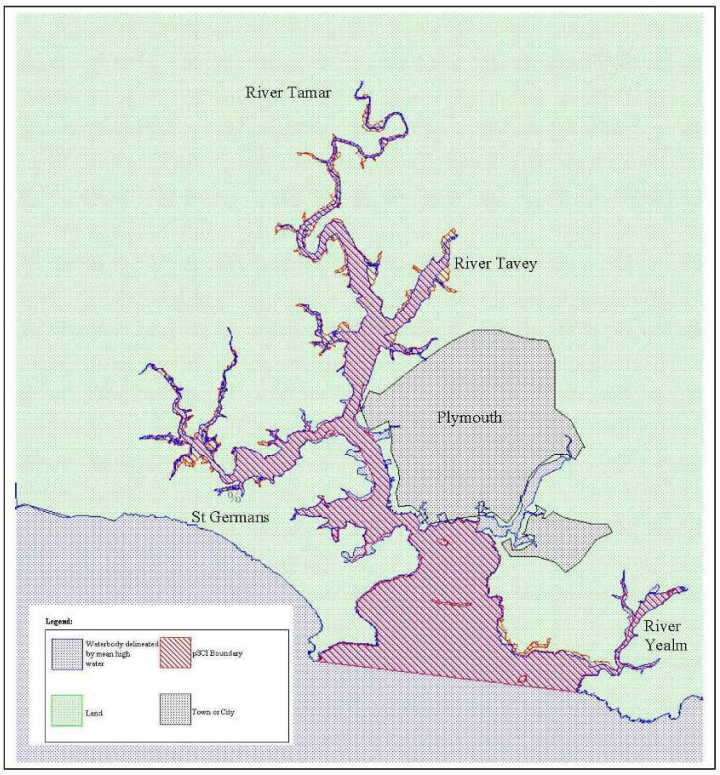


Fig. 1.1. Map showing the whole of the Plymouth Sound and Estuaries Special Area of Conservation (SAC). [Downloaded from JNCC website http://www. jncc.gov.uk/protectedsites/sacselection].

[1] Note that one printed report copy (as well as electronic copies of spreadsheets) containing all of the collected field data has also been submitted to Natural England (Exeter office).

Eelgrass *Zostera marina* bed communities[2] are one of three key sub-features of the 'shallow sandbanks' feature of the SAC. The main eelgrass beds occur at the mouth of the Yealm estuary (Cellars Cove); on the north and south shores of the lower Yealm (Red Cove); to the north of Drake's Island; and in Cawsand Bay on the west side of Plymouth Sound. Smaller, sparser beds are also present in Jennycliff Bay on the east side of Plymouth Sound[3].

As part of the condition assessment, Natural England[4] embarked on a monitoring programme in 2006 which was divided into two phases. Phase 1 provided baseline data on the **extent**, **distribution** and **spatial configuration** of the beds using the analysis of aerial photography (Irving *et al.*, 2007). Phase 2 (of which the present study is the main component) provides baseline data on the remaining attributes, namely **mean density** and maximum **leaf length**, **characteristic species / epiphytic community**, the presence / absence of the **wasting disease** *Labyrinthula* sp., and the **nutrient status** of the beds.

1.2 Objectives

The present study had the following Objectives (as set out in the contract terms):

1. The quantitative survey and analysis of data of [selected] *Zostera marina* beds in Plymouth Sound of the four attributes listed in Table 3.1 (p. 3). These are:

   Mean density and **leaf length**;

   Characteristic species / **epiphytic community**;

   Wasting disease (*Labyrinthula* sp., leaf infection scores); and

   Nutrient status / green algal mat.

2. For each site, to compare these data with any historical or recent data available to identify and quantify any temporal changes in the attributes for the *Zostera* beds.

1.3 Fieldwork

Diving fieldwork within Plymouth Sound and the Yealm Estuary was carried out over three days from 15th to 17th July 2009. A separate short report summarising the fieldwork was presented to the Project Officer, Gavin Black, on 21 July 2009.

[2] Intertidal dwarf eelgrass *Zostera noltii* is also present within the Plymouth Sound and Estuaries SAC, but this species has not been considered within the scope of this report.

[3] A 'new' eelgrass bed has recently been discovered (2009) between Wembury and the mouth of the Yealm. It lies outside the Yealm sandbar under a place on the cliff called 'the Tomb'. The bed is estimated to be at least 100 m in length (Gavin Black, *pers. comm*.).

[4] Natural England came into being in October 2006 as the result of the merger of English Nature, the Countryside Agency and the Rural Development Service.

The following individuals made up the diving team and the support staff:

Personnel	Position/Company	Role
Robert Irving	Principal Consultant, Sea-Scope	Project Manager / Scientific Diver / Dive Supervisor
Dr Jason Hall-Spencer	Royal Society Fellow, University of Plymouth	Scientific Diver
Sean Lindsley-Leake	Independent	Scientific Diver / Dive Supervisor
Dominic Flint	Independent	Scientific Diver
Katrina Brown	Independent	Scientific Diver
Gavin Black	Natural England	Scientific Diver / Dive Supervisor
Kevan Cooke	Natural England	Scientific Diver
Chris Pirie	Natural England	Scientific Diver
Pete Hambly	Eddystone Dive Charters	Skipper, Dive support vessel *Furious*

All divers were qualified to HSE Part IV level (or equivalent) and were all experienced scientific survey divers.

2. PREVIOUS STUDIES

There have been a number of studies of the *Zostera marina* beds within Plymouth Sound and the Yealm Estuary, which have looked at a variety of different parameters. Those relevant to the current study of which the author is aware are listed in Table 2.1 and their findings are discussed in greater detail in section 5. Full references are given in section 7.

Table 2.1. List of references featuring studies undertaken on the *Zostera marina* beds within Plymouth Sound and the Yealm Estuary.

Author(s)	Date	Main area of interest	Sites included within study		
Attrill, M. J. *et al*.	2000	Macroinvertebrate communities and eelgrass structural complexity	Cellars Cove	Published paper	*
Black, G. & Kochanowska, D.	2004	Inventory of eelgrass beds in Devon & Dorset		Report for English Nature & the Environment Agency	
Bugg, A.	2004	Extent, density & mean leaf length.	Jennycliff Bay	Seasearch report	
Downey, K.	2006	'Health' of eelgrass & biodiversity of associated megafaunal community.	Drake's Island	Unpublished B.Sc. dissertation, University of Plymouth	*
Irving, R.A. *et al*.	2007	Extent, distribution and spatial configuration, based on aerial photographs taken in 2006	Cawsand Bay Drake's Island Cellars Cove Red Cove	Contractor's Report to Natural England (Exeter).	
Luhde-Thompson, S.	1999	Extent, involving analysis of aerial photographs	Cellars Cove	Unpublished B.Sc. dissertation, University of Plymouth	
Mortimer, N.	2005	Plant density and macrofauna	Red Cove	Summary report for English Nature	*
Saunders, J.E. *et al.*	2003	Epiphytic algal assemblages	Cawsand Bay Drake's Island Cellars Cove	Published paper	*
Sharrock, S.	2005	Partial extent	Cawsand Bay	Short (1.5 pages) Seasearch report	
Webster, P. *et al*.	1998	Shoot density and the infaunal macro-invertebrate community.	Cellars Cove	Published paper	*

Reference to certain of these reports (as indicated by an asterisk in the right-hand column) is made in section 5, where comparisons are given for certain of the attributes for which historical data exist.

3. METHODOLOGY

3.1 Introduction

The suggested methods by which the main attributes for the eelgrass beds were to be assessed were set out by Jackson (2005) (see Table 3.1. below), who had been commissioned by English Nature to draw up monitoring guidelines. As part of Sea-Scope's tender submission for the present study, a sampling methodology was proposed and this was largely adhered to in the field, with only a few modifications.

Table 3.1. Attributes to be monitored within each *Zostera marina* bed community. Taken from Jackson (2005) and adapted from Favourable Condition Tables (within Regulation 33 documents*) for SAC sites.

	Attribute	Output	Suggested methods
1	Mean density and leaf length	Mean density and leaf length, measured during peak growth season.	Data should be collated by depth stratified random sampling used to identify mean density across the depth range of the meadow. Standardised distances from the edge should be used. 3 transects per site. 12 quadrats (0.5 x 0.5 m) per transect. Subtidally a total shoot count should be made. All quadrats should be photographed and the longest leaf of 3 shoots measured.
2	Characteristic species – epiphytic community	Identification of epiphyte functional groups with estimates of cover / abundance.	Diver sampling. 3 transects per site. 6 quadrats (0.25 x 0.25 m) per transect. Identification of functional groups in laboratory for area up to 10 cm from leaf apex.
3	Wasting disease (*Labyrinthula* sp. / leaf infection scores).	Measure mean leaf infection scores (or Wasting Disease index) as detailed in WFD toolkit.	Diver sampling. 3 transects per site. 6 quadrats (0.25 x 0.25 m) per transect. Leaf infection scores (or Wasting Disease index) identified for sampled *Zostera* material in lab. Can be done using image analysis.
4	Nutrient status – green algal mat.	Mean estimated percentage cover of ephemeral algae.	Use photographs or *in situ* diver observations to estimate percentage cover.

* Natural England's advice given under the Regulation 33 (2) of the Conservation (Natural Habitats &c.) Regulations 1994. This can be downloaded from Natural England's website: www.naturalengland.org.uk.

3.2 Pre-survey preparation

The following were undertaken prior to the commencement of the survey:

- Preparation of a full Risk Assessment and a Diving Project Plan (submitted to the Project Officer, Gavin Black, and to NE's Diving Officer, Eleanor Hill, prior to mobilisation);
- Liaison with the boat skipper re. on-board requirements, site locations etc.;
- A list of tide times for all sites (currents were found to be minimal at most sites throughout the tidal cycle as the survey was planned to coincide with neap tides);
- Preparation of waterproof recording sheets for use under water (see Appendix 2), to be kept as raw data sheets;
- Field survey equipment including 4x 15 m shot lines, 2x 50 m sinking lines marked every 2 m, weights and buoys; 4x 0.5 m x 0.5 m quadrats; scissors; underwater collecting bags; underwater cameras.

3.3 Diving practices

All diving operations were carried out under Health and Safety Diving at Work Regulations 1997, using the Scientific and Archaeological Diving Projects Approved Code Of Practice (ACOP). Robert Irving of Sea-Scope Marine Environmental Consultants was the designated Diving Contractor for the project. A 'rolling' system of diving supervision was undertaken whereby the Dive Supervisor's responsibilities could be shared by one or more of the dive team for set periods of time throughout a 24 hour period. The Dive Supervisor's Log Sheets (which record dive times, depths etc.) are included as Appendix 3.

3.4 The selection of sites

Eight *Zostera marina* beds have been described within Plymouth Sound and the mouth of the Yealm: Cawsand Bay; Firestone Bay; Drake's Island; Jennycliff Bay (N & S); Cellars Cove and Red Cove (N & S). All of these beds were included in the aerial photography coverage taken in 2006 (Irving *et al*., 2007) and a summary of the subsequent digital GIS analysis of these photographs is given in Table 3.2 below.

Table 3.2. Summary of the digital GIS analysis of aerial photographs (taken in 2006) of *Zostera marina* beds within Plymouth Sound and Estuaries SAC, taken from Irving *et al*., 2007.

Name of bed (largest bed first)	**Total Area ('dense' and 'moderately dense' categories[1] only)**	**Core Area[2]**	**Confidence level[3]**	**Overall accuracy[4]**
Cellars Cove	2.3156 ha	0.20 ha	High	95%
Cawsand Bay	2.3141 ha	0.007 ha	Medium-Low	84%
Drake's Island	2.1627 ha	0.49 ha	High-Medium	69%
Red Cove North	0.7621 ha	0.01 ha	Medium	78%
Red Cove South	0.4589 ha	0.035 ha	Medium	78%
Jennycliff North	0.4551 ha	0.0 ha	Low	79%
Jennycliff South	0.2193 ha	0.0 ha	Low	84%
Firestone Bay	Unmeasureable	-	-	-

[1] The density of eelgrass for each bed was divided into four categories: 'very sparse', 'sparse', 'moderately dense' and 'dense'.

[2] The Core Area is the area of each patch deemed to be unaffected by the edges of the patch (where disturbance may be greater). A high Core Area value indicates a fairly large continuous bed with a low perimeter to area ratio. A low Core Area value is indicative of fragmentation.

[3] The assessment of confidence here is loosely based on the results of the supervised classification.

[4] The figures for overall accuracy relate to the GIS analysis of the images, which take into account the quality of the original photograph.

The *Z. marina* plants making up the bed at Firestone Bay are now thought to be so sparse as not to constitute a bed at all (Irving *et al.*, 2007), so this location was discounted prior to the start of the present survey. There are also 'entity issues' with the beds at Jennycliff Bay (Jennycliff North and Jennycliff South), both of which have few areas which can be described as 'dense' and for which it would be difficult to obtain data from 12 consecutive stations along a 50 m transect line. Consequently, these two sites were also not included for monitoring purposes. The bed at Red Cove North was known to be narrow in its width (i.e. only 40 m or so wide at its widest), but it was decided that at least one transect should be undertaken here, with a further two transects being undertaken at the slightly wider bed of Red Cove South. Prior to the commencement of fieldwork, it was thus agreed with the Project Officer that the following beds (**Cawsand Bay**, **Drake's Island**, **Cellars Cove** and **Red Cove North** and **South**) were of a size and overall density to merit repeat monitoring to be undertaken (Fig. 3.1).

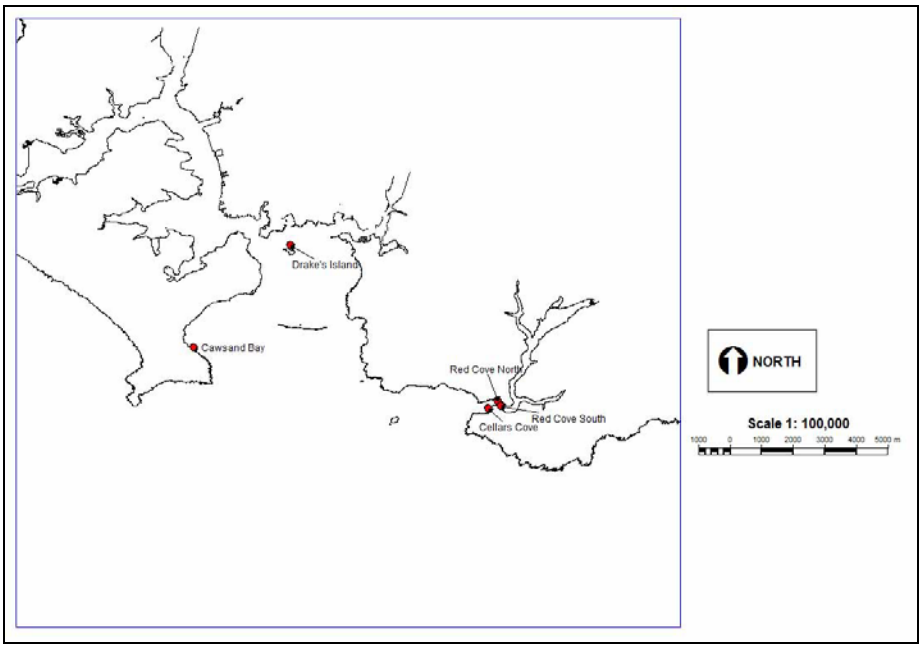


Fig. 3.1. The location of the main *Zostera marina* beds within Plymouth Sound and the Yealm Estuary which were the subject of the present study.

3.5 Survey methodology

3.5.1 Site location and the setting of transects

At each site, three[5] 50 m long transects were laid across the beds. The location of each transect was determined by assessing aerial photos of the sites in question (as presented in the report by Irving *et al*., 2007). At each site, an attempt was made to spread out the distribution of the three transects so that they coincided with the greatest apparent density of eelgrass plants (Plate 2)[6]. The inner end of each transect line was selected using suitable coastal features such as jetties, rocks or headlands.

Plate 1. The dive charter vessel MV *Furious*. Photo by Chris Pirie.

Plate 2. Planning the optimum location for deploying the 3 transect lines off Drake's Island. Photo by Jason Hall-Spencer.

Each transect comprised a 50 m long sinking line which, prior to deployment, was laid out on the deck in a zig-zag manner so as to avoid snagging (Plate 3). Once the boat was in position, a shot weight was lowered over the stern of the vessel attached to which were a line (with surface marker buoy), together with one end of the 50 m sinking line. The boat then proceeded on a pre-determined bearing (typically perpendicular to the shoreline) at a very slow speed, with the transect line being paid out from the stern. The outer end of the line had a second shot weight attached to it, together with a line and surface marker buoy. These were held taut prior to release in order to straighten the transect line as much as possible (Plate 4). The dGPS positions of the start and end points of each transect (as indicated by the shot surface marker buoys) were recorded once the divers had started their surveying tasks.

[5] The width of the bed on the north side of Red Cove (Red Cove North) was known to be less than 50 m wide, so in agreement with the Project Officer, only one transect was undertaken here.

[6] At Cawsand Bay, owing to the sparse nature of the bed, a snorkel dive was carried out prior to diving commencing, so as to confirm the presence of eelgrass.

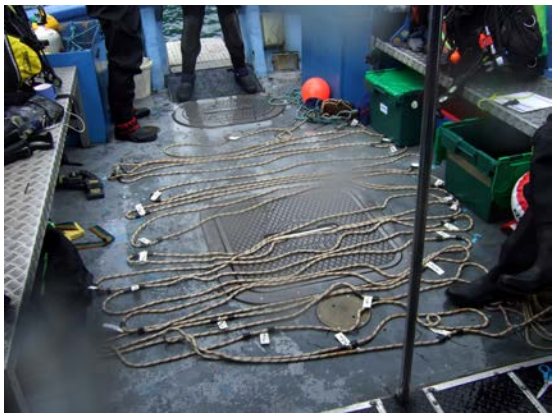


Plate 3. 50 m sinking line on the aft deck, with marker tags at 2 m intervals. Photo by Chris Pirie.

Plate 4. DF & GB about to deploy the end of the transect line and shot buoy. Photo by Chris Pirie.

3.5.2 Diver recording

The two survey divers were allocated different tasks, as set out in Table 3.3.

Table 3.3. Survey diver equipment and tasks.

Diver 1:	*Equipment:*	1x 0.5 m x 0.5 m steel quadrat; recording slate with recording proforma; measuring tape; depth gauge (typically a decompression computer).
	Tasks:	• Placement of quadrat within 0.5-1.0 m of RH side of transect line at predetermined distances (0 m, 4 m, 8 m etc.) along line. This to be repeated 12 times unless no bed present. • Noting the depth of the seabed at each station. • Taking representative photograph of quadrat and/or a section of the whole quadrat. • Counting total number of plants within the whole quadrat. • Measurement of the longest leaves of the 3 plants closest to any 3 corners of the quadrat.
Diver 2:	*Equipment:*	1x 0.5 m x 0.5 m steel quadrat, sub-divided by strings into four 0.25 m x 0.25 m squares; recording slate with recording proforma; scissors; 6 + 1 (spare) pre-labelled polythene collecting bags; string bag for holding full collecting bags.
	Tasks:	• Placement of quadrat within 0.5-1.0 m of LH side of transect line at predetermined distances (0 m, 8 m etc.) along line. This to be repeated 6 times unless no bed is present. • Noting cover of attached macrophytes, and any other relevant observations. • Using scissors, cutting the leaves of all plants (to at least 20 cm from the tip) within a 25 cm x 25 cm quartile of the whole quadrat and containing them with a numbered polythene collecting bag. • Placement of the full collecting bag within a string bag.

Each diver was instructed on the surface of their respective tasks when under water prior to the commencement of the dive. Once in the water, divers descended to the seabed adjacent to the surface marker buoy marking the inner end of the transect line.

Once on the seabed, the divers were required to find the inner edge of the eelgrass bed. This was done by clipping a tape measure to the shot and swimming towards the shore in line with the transect line itself (following a back-bearing). Once found, the first station was

taken as being 2 m in from the inner edge of the bed. Diver 1's quadrats were placed every 4 m along the transect line (on the right-hand side); Diver 2's were placed every 8 m (on the left-hand side). In this way, the divers kept as close to each other as could be expected.

Diver 1 was required to extricate all of the leaves which were caught underneath the quadrat prior to the commencement of counting plants or measuring leaves. Whilst each diver developed his/her own method for counting plants, it was found to be best to count from one corner or side towards the opposite corner or side, and to 'flatten' counted plants under one forearm (and thus keep their leaves out of the way). It was decided that the best way to select three plants in a random manner prior to measuring their longest leaves was by selecting single plants growing closest to three of the four corners of the quadrat.

Operating on the other side of the transect line, Diver 2 had similarly to extricate all of the leaves caught underneath the quadrat prior to making an assessment of the percentage cover of attached macroalgae within the quadrat. On several occasions, there was considerable drift algae within the quadrat too and this had to be moved out of the way in order to see how many attached plants were present. Once that task was completed, all of the leaves were cut (using scissors) to a length of at least 20 cm and were then pushed into a numbered polythene bag. There was quite a skill to this, the preferred method being to wrap the leaves tightly around one's hand, place the whole hand within the bag, release the leaves and then withdraw the hand slowly whilst keeping the opening of the bag held tightly around the withdrawing hand. Once the bag was sealed (similar difficulties were encountered with the tips of leaves preventing a true seal), it was transferred to a string bag which was closed with a drawstring.

Photographs of quadrats (for illustrative purposes only, as the poor underwater visibility prevented this being done for every quadrat systematically), together with overall views of the eelgrass, were taken wherever possible.

3.5.3 Post-fieldwork analysis

Leaf samples were analysed in the laboratory at the end of each diving day. Bench space, sorting trays and light microscopes were kindly provided free of charge by the University of Plymouth for the duration of the survey. The terminal 10 cm of each of 20 randomly-selected leaves (per quadrat) was analysed by eye for epiphyte cover and also for the degree of 'browning' of each leaf. Scores for both epiphyte cover and the degree of 'browning' (see section 4.2 for an explanation of these scores) were written on accompanying recording sheets.

Plate 5. 20 randomly-selected leaves from Quadrat 1, Red Cove South, prior to analysis. Photo by Dominic Flint.

Plate 6. Working up leaf epiphyte and leaf browning data in the laboratory at Plymouth University. Photo by Robert Irving.

4. RESULTS

The results of the survey are presented here by site and subsequently by transect. The data from each transect have been summarised onto a single A4 page. Electronic copies of spreadsheets with all of the data have been submitted separately to the Project Officer at Natural England's Exeter office.

4.1 Site locations and depths of transects

Essential metadata for each transect are presented in Table 4.1 below.

Table 4.1. Data relating to each site and to each transect.

Site	Transect	Inner position *[1] (Start)	Outer position *[1] (End)	Depth range *[2] (bcd)	Surveyors
Cawsand Bay	A	50° 19.682' N 04° 11.847' W	50° 19.704' N 04° 11.798' W	1.4 – 4.1 m	JHS/SLL
Cawsand Bay	B	50° 19.668' N 04° 11.800' W	50° 19.686' N 04° 11.780' W	1.3 – 3.8 m	GB/KC
Cawsand Bay	C	50° 19.656' N 04° 11.787' W	50° 19.676' N 04° 11.755' W	2.3 – 3.7 m	RI/KB
Drake's Island	A	50° 21.393' N 04° 09.190' W	50° 21.410' N 04° 09.168' W	1.2 – 1.6 m	JHS/SLL
Drake's Island	B	50° 21.400' N 04° 09.219' W	50° 21.429' N 04° 09.177' W	1.5 – 2.1 m	JHS/SLL
Drake's Island	C	50° 21.404' N 04° 09.279' W	50° 21.431' N 04° 09.259' W	0.7 – 2.1 m	CP/KC
Cellars Cove	A	50° 18.570' N 04° 03.957' W	50° 18.587' N 04° 03.990' W	0.5 – 2.0 m	CP/KC
Cellars Cove	B	50° 18.627' N 04° 03.883' W	50° 18.639' N 04° 03.920' W	1.2 – 2.4 m	RI/DF
Cellars Cove	C	50° 18.668' N 04° 03.859' W	50° 18.679' N 04° 03.891' W	1.8 – 2.9 m	JHS/SLL
Red Cove North	A	50° 18.777' N 04° 03.648' W	50° 18.746' N 04° 03.665' W	+0.1 – 2.2 m	CP/SLL
Red Cove South	B	50° 18.670' N 04° 03.557' W	50° 18.694' N 04° 03.542' W	+0.2 – 2.5 m	GB/DF
Red Cove South	C	50° 18.706' N 04° 03.603' W	50° 18.732' N 04° 03.584' W	0.3 – 2.6 m	RI/JHS

*[1] Differential GPS positions were taken using the boat's GPS, the aerial of which may have been up to 3 m from the marker buoy. Also note that the actual start of the 50 m transect may well have been landward of these positions, as would have been the case if the shot did not land at the edge of the bed itself.

*[2] Note that depths were taken from individuals' diving computers, which can vary up to +/- 0.2 m.

4.2 Scoring system

A 'Wasting Disease Index' was presented by Burdick *et al.* (1993) for assessing the level of infection of the disease caused by the slime mould/fungus *Labyrinthula macrocystis* in

Zostera leaves. This has since been incorporated into the Environment Agency's 'Angiosperm Tool Kit' (Foden 2005). Essentially, six categories are used to denote the percentage blackening caused by the disease in any one leaf (Table 4.2).

This scoring system was modified for the purposes of this survey to indicate 'browning' of the terminal 10 cm[7] of leaves[8], which is likely to be caused by cell breakdown, but may possibly also indicate the presence of the slime mould/fungus *Labyrinthula macrocystis*. See also section 5.3.

The same scoring system categories were used to assess the cover of epiphytic growths on the terminal 10 cm of the leaf as well.

Table 4.2. Scoring protocol for assessing 'browning' and also epiphytic[9] growths.

Percentage cover of 'browning' or epiphytic growth	**0%**	**1-9%**	**10-19%**	**20-39%**	**40-79%**	**80-100%+**
'Score'	**0**	**1**	**2**	**3**	**4**	**5**

Median scores for both 'browning' and epiphytic growth for *each transect* are presented on the summary pages which follow. Median scores for *each site* are presented in section 5.

4.3 Species associated with *Zostera marina*

All attached macroalgal species (i.e. those with holdfasts attached to the seabed substratum), together with a selection of macrofaunal species, which occurred within quadrats were noted and are presented in Table 4.3. Note, however, that these lists do not represent a comprehensive range of the species present within each bed, but merely those species recorded within each 0.5 m x 0.5 m quadrat.

Table 4.3. Attached macroalgae and macrofaunal species recorded within quadrats.

Site	Macroalgae	Macrofauna[10]
Cawsand Bay Range of percentage cover of attached macroalgae within (6 x 3) 18 quadrats: **0 – 5%**	*Ulva lactuca* *Calliblepharis ciliata* *Ceramium rubrum* ?*Dictyosiphon* *Furcellaria lumbricoides/* *Polyides rotundus* *Nitophyllum punctatum* *Palmaria palmata*	*Cerianthus lloydii* Sagartiid anemone indet. *Chaetopterus variopedatus* *Lanice conchilega* *Sabella pavonina* *Calliostoma zizyphinum* *Hinia reticulata* *Maja squinado* Goby sp. indet.

[7] The length of 10 cm follows the stipulation in Table 3.1, attribute no. 2 (from Jackson, 2005).

[8] Note that the term 'leaf' or 'leaves' used here is synonymous with 'blade' or 'blades' used by some workers, and also that 'plant' or 'plants' is synonymous with 'shoot' or 'shoots'.

[9] 'Epiphyte' – defined as literally "upon plants". Describes an organism, either plant or animal, which lives attached to plants. (after Hayward, 1988).

[10] The recording of macrofauna within quadrats was not a requirement of the project brief and so species were not recorded from all sites.

Site	Macroalgae		Macrofauna
Drake's Island Range of percentage cover of attached macroalgae within (6 x 3) 18 quadrats: **0 – 20%**	*Sacchoriza polyschides* *Laminaria hyperborea* *Saccharina latissima* *Sargassum muticum* *Fucus serratus* *Enteromorpha* (*Ulva*) *lactuca*	*Ceramium* sp.	*Hinia reticulata* *Chaetopterus variopedatus*
Cellar's Cove Range of percentage cover of attached macroalgae within (6 x 3) 18 quadrats: **0 – 70%**	*Enteromorpha* (*Ulva*) *lactuca* *Chorda filum* *Dictyota dichotoma* *Saccharina latissima* *Sargassum muticum* *Ahnfeltia plicata* *Ceramium* sp. *Calliblepharis ciliata* *Cryptopleura ramosa* *Dilsea carnosa* *Gelidium latifolium* *Gracillaria verrucosa*	*Hidenbrandia rubrum* *Hypoglossum hypoglossoides* *Jania rubens* *Lithophyllum* sp. *Lomentaria articulata* *Mastocarpus stellata* *Nitophyllum punctatum* *Peysonnelia* ? *Polyides rotundus* *Polysiphonia* sp. *Sphacelaria* sp.	Not recorded
Red Cove North Range of percentage cover of attached macroalgae within (6 x 3) 18 quadrats: **20 – 100%**	*Enteromorpha* (*Ulva*) *lactuca* *Saccharina latissima* *Sargassum muticum*		Not recorded (apart from noting cuttlefish eggs as being present).
Red Cove South Range of percentage cover of attached macroalgae within (6 x 3) 18 quadrats: **5 – 94%**	*Enteromorpha* (*Ulva*) *lactuca* *Dictyota dichotoma* *Saccharina latissima* *Sargassum muticum* *Ahnfeltia plicata* *Antithamnion* sp. *Asparagopsis armata* *Ceramium* sp. *Chondrus crispus* *Corallina officinalis*	*Cryptopleura ramosa* *Delesseria sanguinea* *Drachiella spectabilis* *Hildenbrandia rubrum* *Jania rubens* *Lithophyllum* sp. *Mastocarpus stellatus* *Nitophyllum punctatum* *Phycodrys rubens* *Polysiphonia* sp.	Not recorded

Those species recorded as growing epiphytically on the terminal 10 cm of leaves are presented in Table 4.4. The total cover provided by these organisms was recorded using the same scoring scale as for the leaf 'browning', as set out in Table 4.2.

Table 4.4. Epiphytic species recorded on leaves (analysed in the laboratory).

Algae	Non-algal
Calcareous species	Hydrozoa indet. (small feathers)
Hydrolithon sp.	*Agloaphenia plumosa*
Pneophyllum sp.	*Obelia* sp.
	Obelia geniculata
Non-calcareous species	*Kirchenpaueria pinnata*
Ceramium rubrum	*Clytia hemisphaerica*

Polyneura sp.	*Caprella* sp.
Polysiphonia sp.	Gastropod eggs
Antithamnion plumula	Nudibranch eggs
Polysiphonia stricta	*Patina pellucida*
Ectocarpaceae	*Membranipora membranacea*
	Electra pilosa
	Bryozoa indet. (encrusting)
	Botryllus schlosseri

Plate 7. Hydroids and gastropod eggs attached to the terminal end of a leaf. Cellars Cove, 16 July 2009. Photo by Dominic Flint.

Plate 8. Stalked jellyfish, probably *Haliclystus auricula*, with swollen gonads. Cellars Cove, 16 July 2009. Photo by Dominic Flint.

4.4 Transect summary data sheets

The results from each quadrat station from each transect from each site are presented as summary data sheets on the following pages.

4.4.1 Cawsand Bay

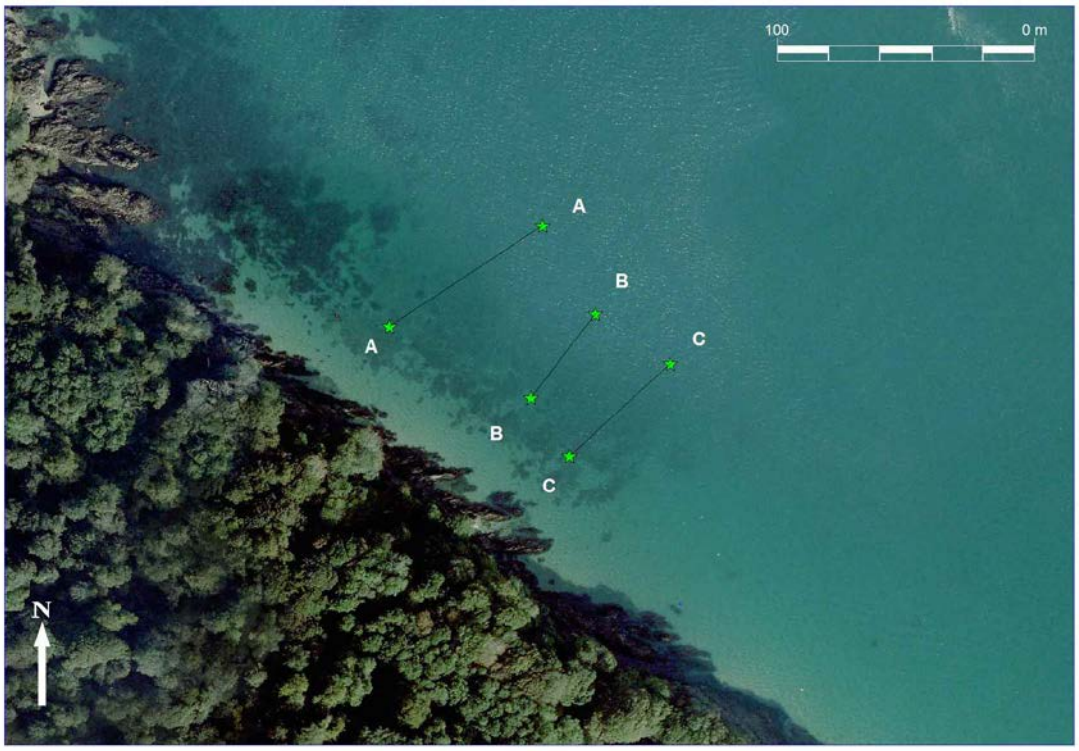


Fig. 4.1. The location of the three transects at Cawsand Bay. (Note that the stars at each end of the transects mark the position of the marker buoys on the surface and not the actual start/end of each transect. Transect B appears shorter than the other two as the edge of the bed lay further inshore than the position of the marker buoy).

General description of site

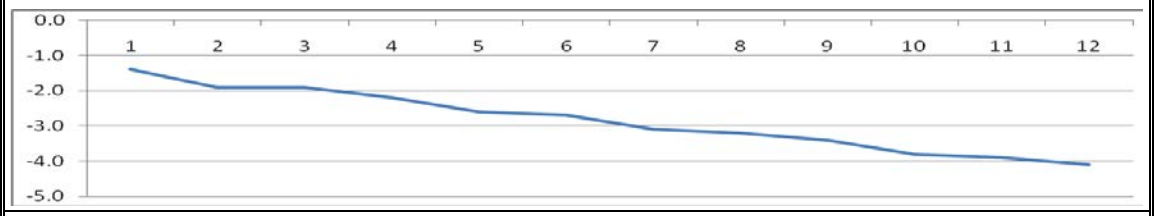
The *Zostera marina* bed lies off the southern end of Cawsand Beach, just offshore from Penlee Cottages. The sea bed here appears to be mostly of silty fine sand with occasional pebbles and/or bivalve shells. The bed has been described in the past as "patchy at the outer edges of the bed", with a greater density of plants in the core, shallower areas (Sharrock, 2005). Irving *et al.* (2007) gave an overall figure of the **extent of the bed as being 2.3 ha**. Measurements taken from maps included in Irving *et al*. (2007) give a maximum bed length of approximately 170 m along a NW/SE axis and a maximum bed width of approximately 100 m along a SW/NE axis.

In 2006, the deepest point at which *Zostera marina* was recorded at Cawsand Bay (as taken from the boat echo-sounder used by Irving *et al*., 2007) was 5.5 m (bcd), with the shallowest point at which *Zostera marina* was recorded as being 0.4 m. The present study measured the **deepest and shallowest points as being 4.1 m and 1.4 m** respectively. Whilst there appears to be considerable variation in these parameters, it should be noted that neither study set out to measure the maximum and minimum depths of the bed accurately, and so this kind of discrepancy should not be considered unexpected.

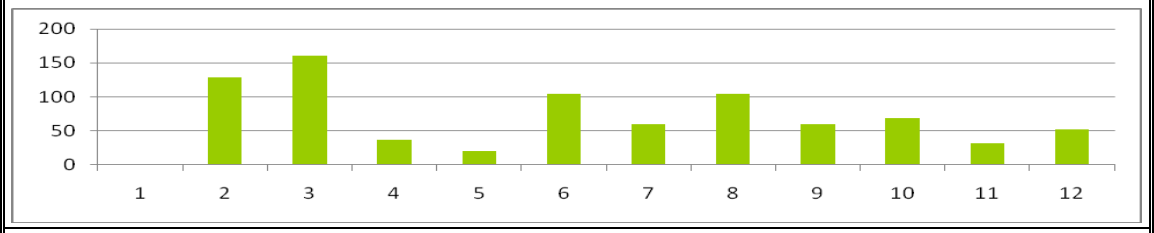
Very little **attached macroalgae** was recorded at Cawsand Bay: just 2% cover from a single quadrat on Transect A; the presence of a *Saccharina latissima* plant from a single quadrat on Transect B; and a cover of between 1 – 5% from all six quadrats on Transect C.

Site: **Cawsand Bay**	Transect No. **A**	Date: 15 July 2009
Time of survey: 11:09 – 12:00	Estimated u/w visibility: 0.5 m	
Position: Inner: 50° 19.682' N 04° 11.847' W	Outer: 50° 19.704' N 04° 11.798' W	

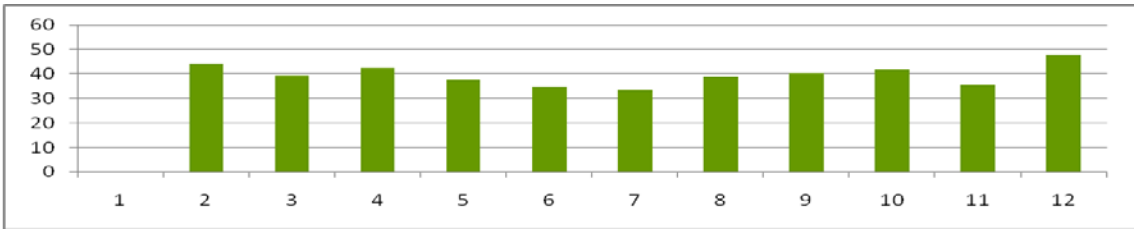
Depth profile (metres below chart datum): Max./min. depths (bcd): 1.4 – 4.1 m



Density of plants (/ m^2)



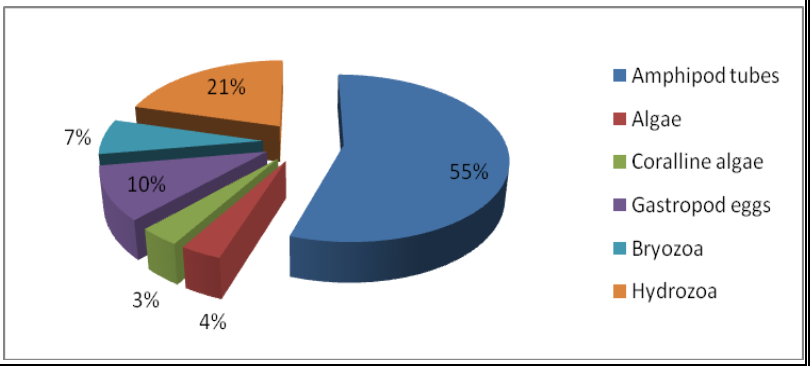
Mean longest leaf length (cm)



Median **'browning' score** (percentage cover) (range: 0% - 80%+). n = 50. **0%**

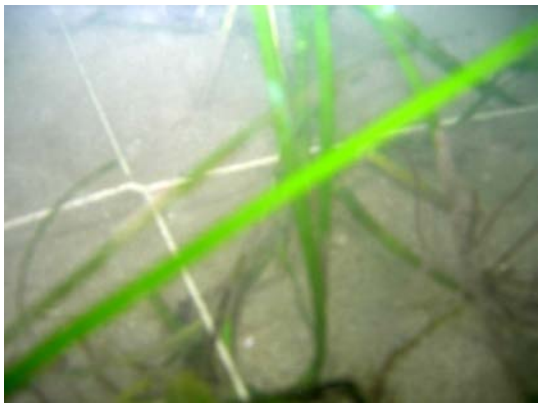
Median **epiphyte cover score** (percentage cover) (range: 0% - 80%+). n = 50. **5%**

Proportion of **main epiphytic groups** (flora & fauna).



Selected photographs Photographer: SLL

(Photo ref. DSCN3827)

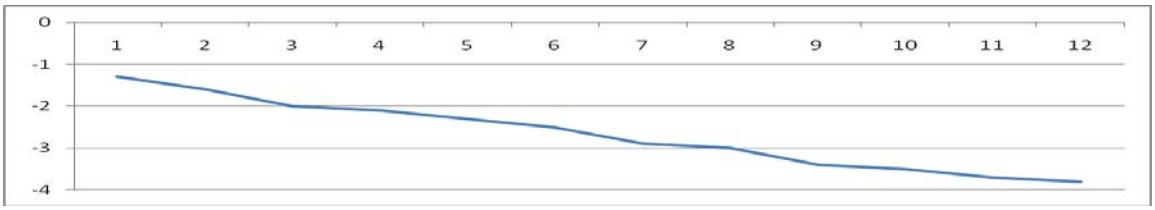


(Photo ref. DSCN3833)

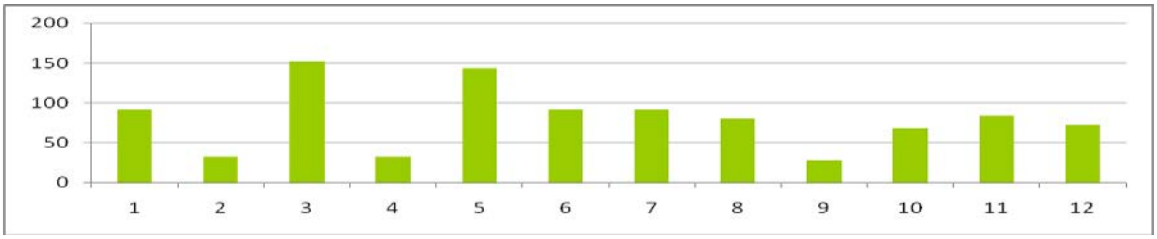
Comment: the blurry images are due to poor visibility preventing the camera auto-focussing.

Site: **Cawsand Bay**	Transect No. **B**	Date: 15 July 2009
Time of survey: 11:17 – 12:40	Estimated u/w visibility: ~ 0.5 m	
Position: Inner: 50° 19.668' N 04° 11.800' W	Outer: 50° 19.686' N 04° 11.780' W	

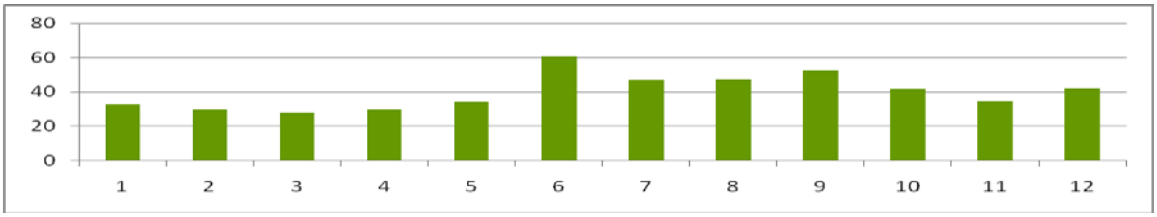
Depth profile (metres below chart datum): Max./min. depths (bcd): 1.3 – 3.8 m



Density of plants (/ m^2)



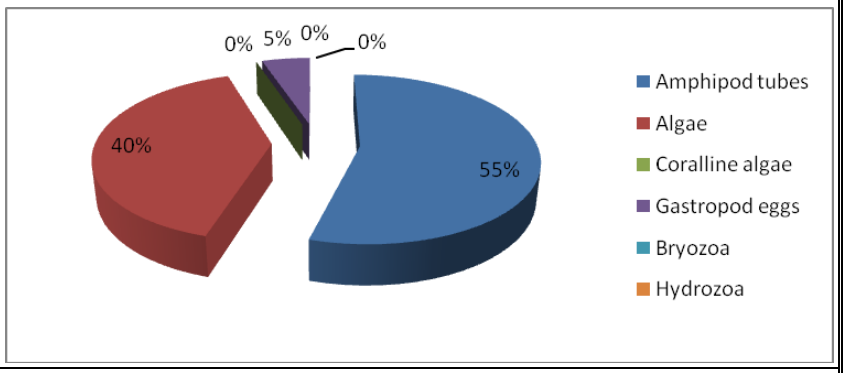
Mean longest leaf length (cm)



Median **'browning' score** (percentage cover) **0%**
(range: 0% - 20%).
n = 50.

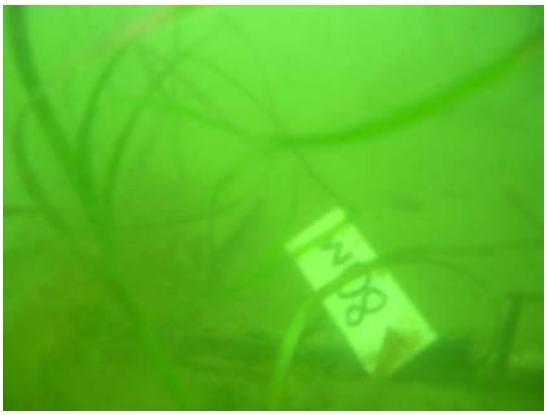
Median **epiphyte cover score** (percentage cover) **20%**
(range: 0% - 80%).
n = 50.

Proportion of **main epiphytic groups** (flora & fauna).



Selected photographs Photographer: KC

(Photo ref. DSCN3840)

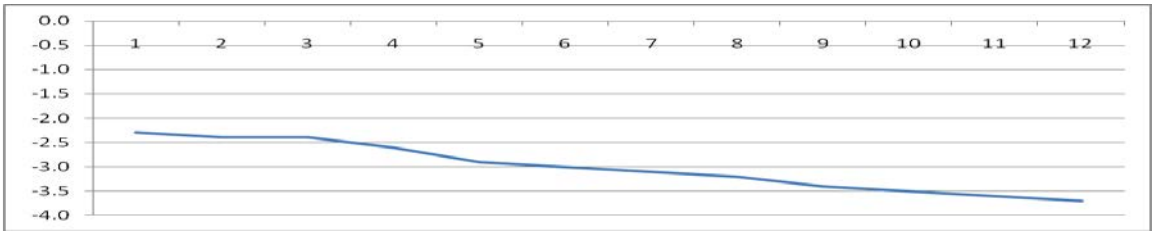


(Photo ref. DSCN3846)

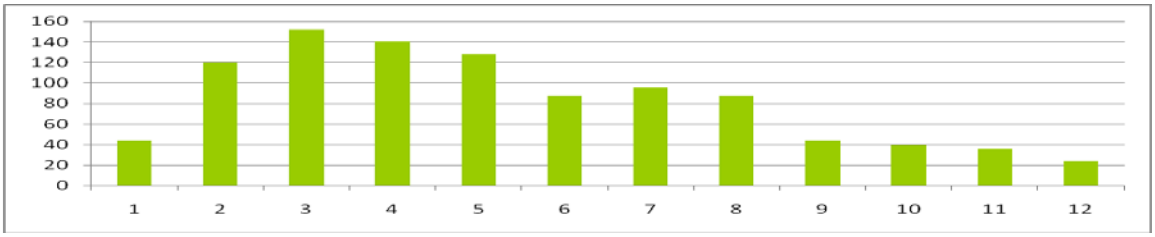
Comment: the blurry images are due to poor visibility preventing the camera auto-focussing.

Site: **Cawsand Bay**	Transect No. **C**	Date: 15 July 2009
Time of survey: 13:12 – 14:32		Estimated u/w visibility: < 0.5 m
Position:	Inner: 50° 19.656' N 04° 11.787' W	Outer: 50° 19.676' N 04° 11.755' W

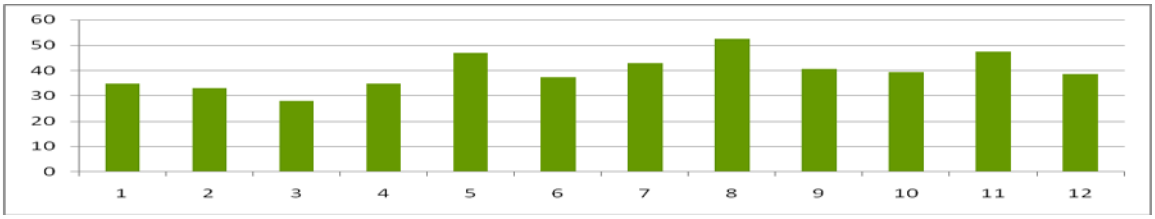
Depth profile (metres below chart datum): Max./min. depths (bcd): 2.3 – 3.7 m



Density of plants (/ m^2)



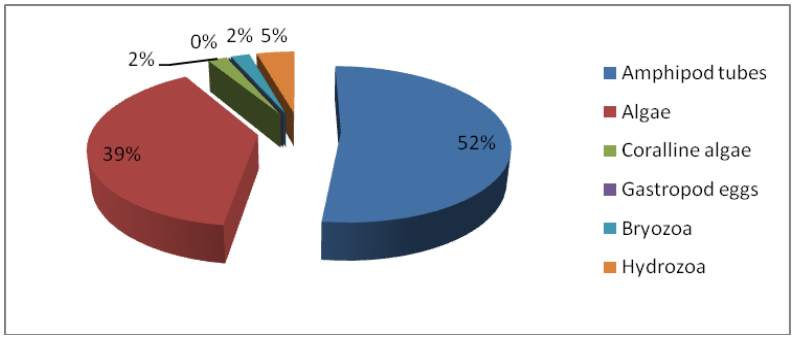
Mean longest leaf length (cm)



Median **'browning' score** (percentage cover) (range: 0% - 40%). n = 50. **0%**

Median **epiphyte cover score** (percentage cover) (range: 0% - 80%). n = 50. **20%**

Proportion of **main epiphytic groups** (flora & fauna).



Selected photographs Photographer: RI

(Photo ref. DSCN3837)

(Photo ref. DSCN3839)

Comment: the blurry images are due to poor visibility preventing the camera auto-focussing.

4.4.2 Drake's Island

Fig. 4.2. The location of the three transects at Drake's Island. (Note that the stars at each end of the transects mark the position of the marker buoys on the surface. Transect A appears shorter than the other two as the actual edge of the bed was further to the SW).

General description of site

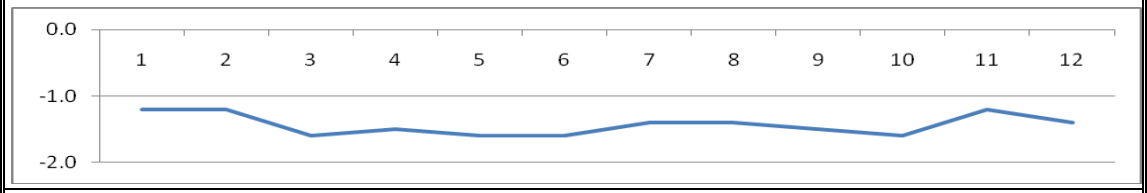
The Drake's Island *Zostera marina* bed lies off the northern shore of the island. The sea bed is mostly of fine silty sand with occasional pebbles and small rocky outcrops. Irving *et al.* (2007) gave an overall figure of the **extent of the bed as being 2.16 ha**. The bed extends approximately 200 m to the north of the island (a maximum bed width of approximately 150 m along a NE/SW axis), and its western and eastern edges are almost in line with the island (maximum bed length of approximately 300 m along a NW/SE axis).

In 2006, the deepest point at which *Zostera marina* was recorded at Drake's Island (as taken from the boat echo-sounder used by Irving *et al*., 2007) was 6.6 m (bcd), with the shallowest point at which *Zostera marina* was recorded as being 2.1 m. The present study measured the **deepest and shallowest points as being 2.1 m and 0.7 m** respectively. Whilst there appears to be considerable variation in these parameters, it should be noted that neither study set out to measure the maximum and minimum depths of the bed accurately, and so this kind of discrepancy should not be considered unexpected.

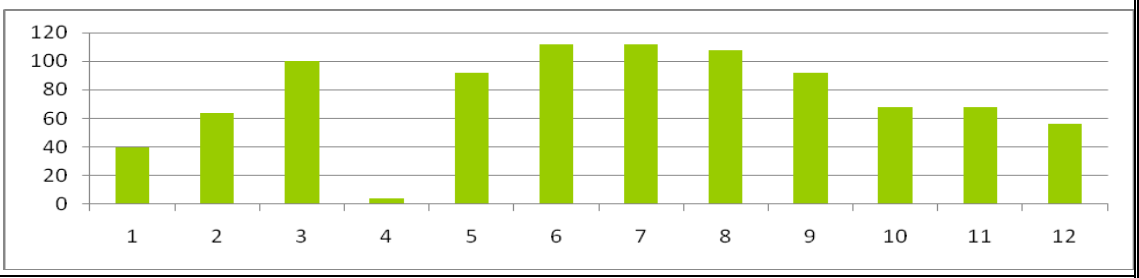
The cover provided by **attached macroalgae** at Drake's Island varied between 0 – 20% (Transect A) – though with large amounts of drift algae; 1% attached (including *Enteromorpha* (*Ulva*) *lactuca*) and up to 100% drift algae (Transect B); and 0% attached but up to 40% drift algae (Transect C). The attached algal species included *Saccorhiza polyschides*, *Saccharina latissima*, *Ceramium* sp. and *Enteromorpha* (*Ulva*) *lactuca*.

Site: **Drake's Island**	Transect No. **A**	Date: 15 July 2009
Time of survey: 15:19 – 16:14	Estimated u/w visibility: ~ 1.5 m	
Position: Inner: 50° 21.393' N 04° 09.190' W	Outer: 50° 21.410' N 04° 09.168' W	

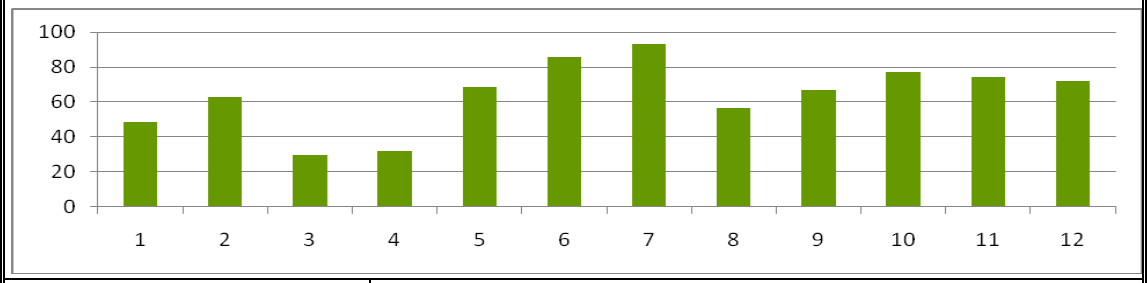
Depth profile (metres below chart datum): Max./min. depths (bcd): 1.2 – 1.6 m



Density of plants (/ m^2)



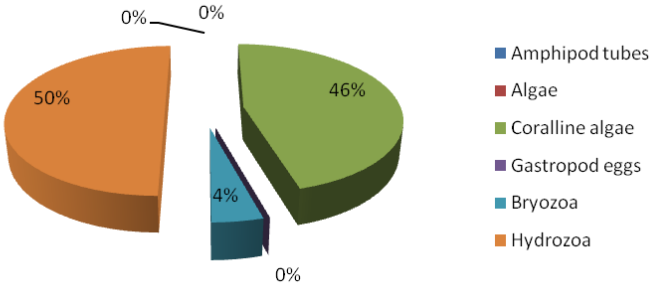
Mean longest leaf length (cm) Overall mean for transect: 65.4 cm Range: 30 – 93 cm



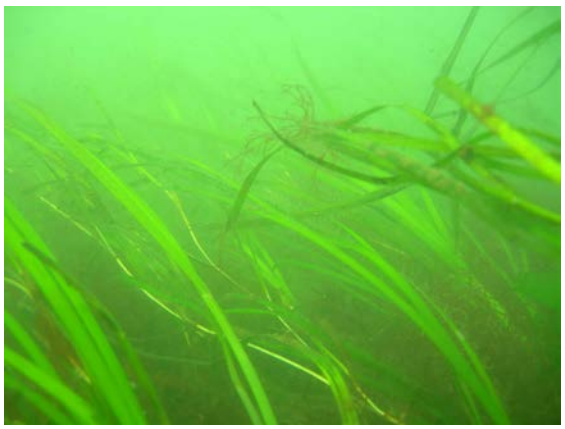
Median **'browning' score** (percentage cover) (range: 0% - 80%+). n = 50. **10%**

Median **epiphyte cover score** (percentage cover) (range: 0% - 80%+). n = 50. **20%**

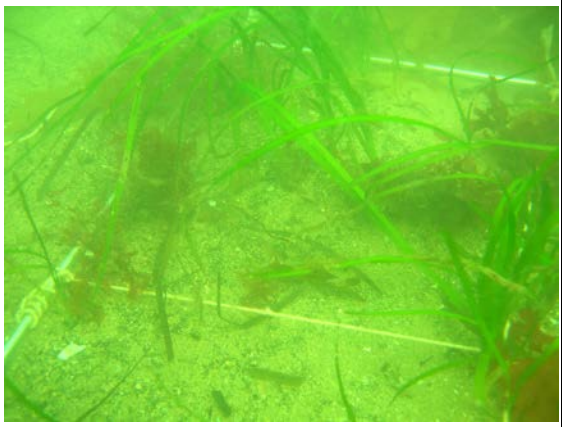
Proportion of **main epiphytic groups** (flora & fauna).



Selected photographs Photographer: SLL



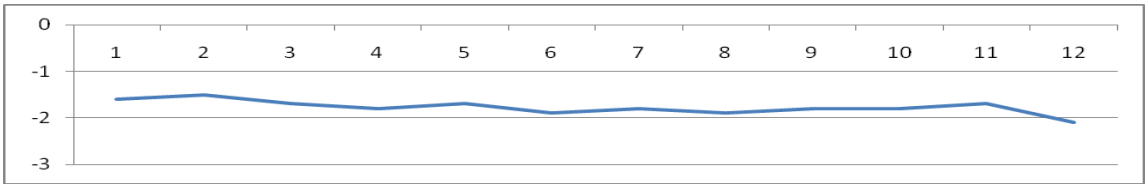
(Photo ref. DSCN5853)



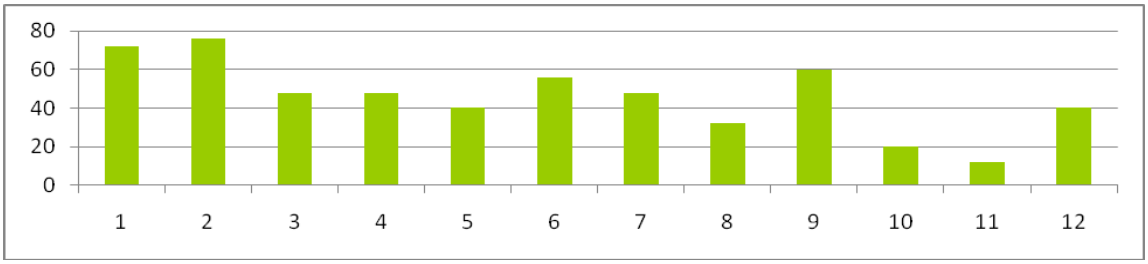
(Photo ref. DSCN5854)

Site: **Drake's Island**	Transect No. **B**	Date: 16 July 2009
Time of survey: 09:58 – 10:39	Estimated u/w visibility: ~ 1.5 m	
Position: Inner: 50° 21.400' N 04° 09.219' W	Outer: 50° 21.429' N 04° 09.177' W	

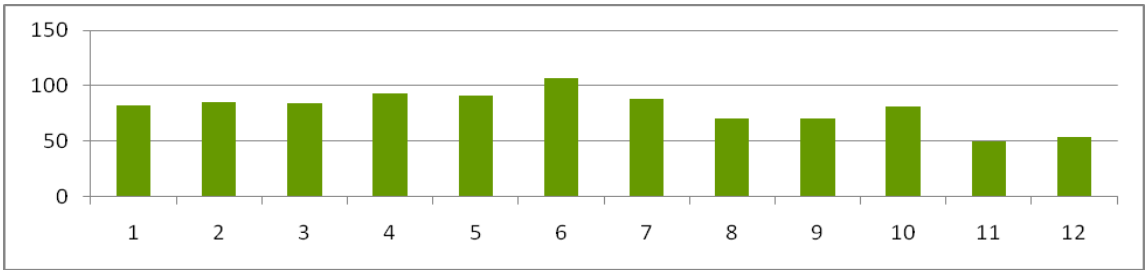
Depth profile (metres below chart datum): Max./min. depths (bcd): 1.5 – 2.1 m



Density of plants (/ m^2)



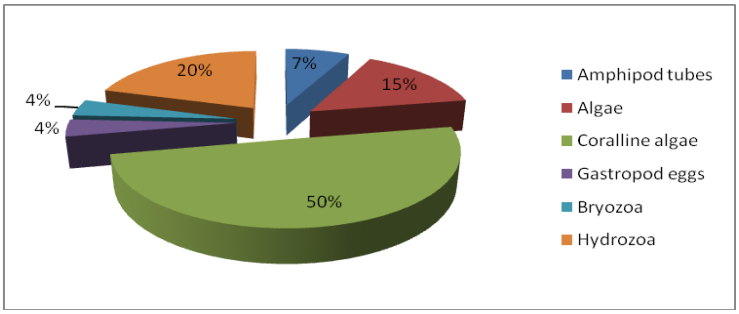
Mean longest leaf length (cm)



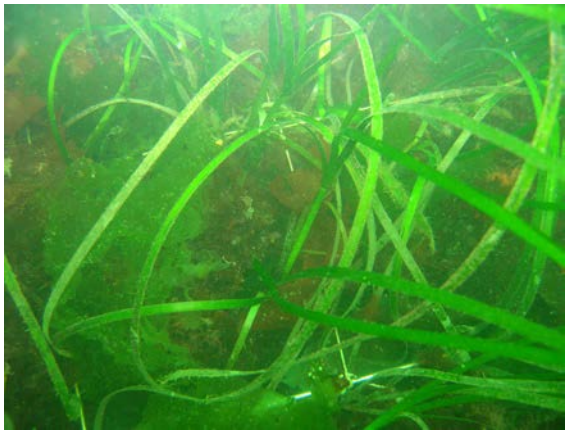
Median **'browning' score** (percentage cover) (range: 0% - 80%). n = 100. **10%**

Median **epiphyte cover score** (percentage cover) (range: 0% - 80%+). n = 100. **10%**

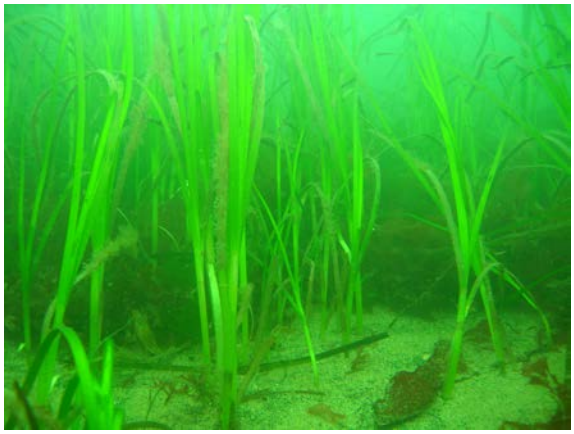
Proportion of **main epiphytic groups** (flora & fauna).



Selected photographs Photographer: SLL



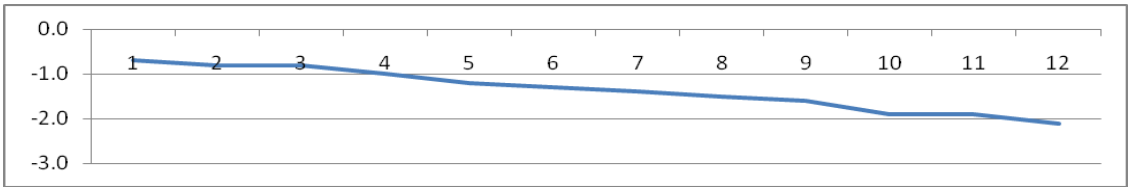
(Photo ref. DSCN3874)



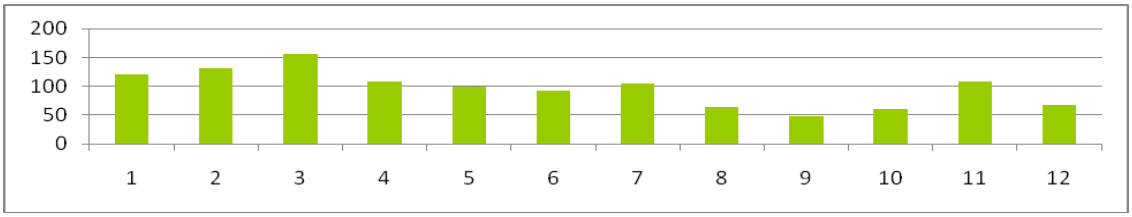
(Photo ref. DSCN3880)

Site: **Drake's Island**	Transect No. **C**	Date: 16 July 2009
Time of survey: 15:28 – 16:27	Estimated u/w visibility: ~ 5.0 m	
Position: Inner: 50° 21.404' N 04° 09.279' W	Outer: 50° 21.431' N 04° 09.259' W	

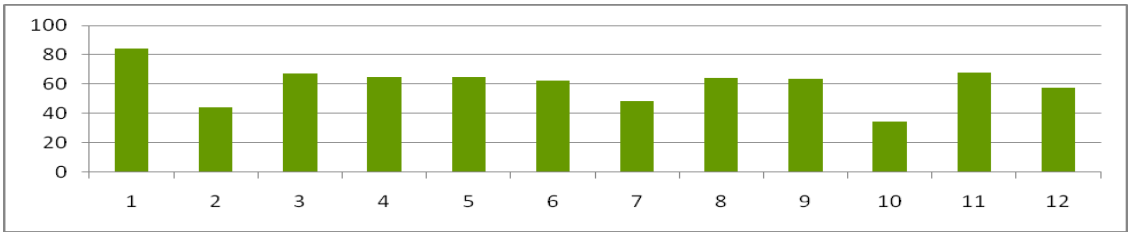
Depth profile (metres below chart datum): Max./min. depths (bcd): 0.7 – 2.1 m



Density of plants (/ m^2)



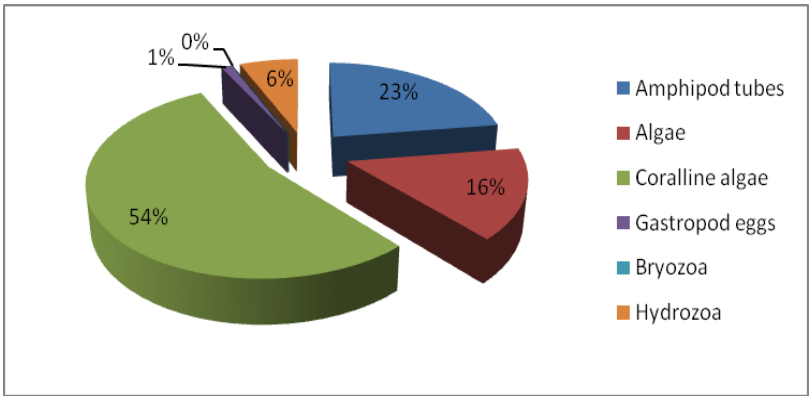
Mean longest leaf length (cm)



Median **'browning' score** (percentage cover) **10%**
(range: 0% - 80%).
n = 110.

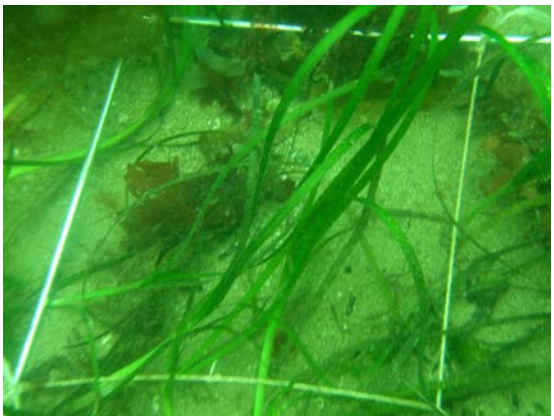
Median **epiphyte cover score** (percentage cover) **40%**
(range: 0% - 80%+).
n = 110.

Proportion of **main epiphytic groups** (flora & fauna).



Selected photographs Photographer: CP

(Photo ref. 0716/052)



(Photo ref. 0716/064)

4.4.3 Cellars Cove

Fig. 4.3. The location of the three transects at Cellars Cove at the mouth of the Yealm.

General description of site

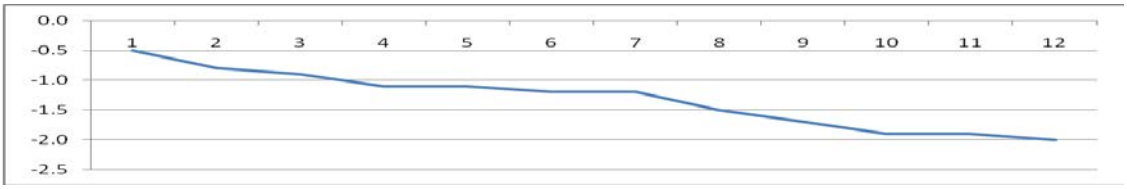
Cellars Cove is a small sheltered embayment on the southern side of the mouth of the River Yealm where it flows into Plymouth Sound. The sea bed is largely composed of medium to fine sand. The site is affected by weak to moderate tidal streams. Irving *et al.* (2007) gave an overall figure of the **extent of the bed as being 2.3 ha**. Measurements taken from maps included in Irving *et al*. (2007) give a maximum bed length of approximately 630 m along a SW/NE axis and a maximum bed width of approximately 170 m along a SE/NW axis.

In 2006, the deepest point at which *Zostera marina* was recorded at Cellars Cove (as taken from the boat echo-sounder used by Irving *et al*., 2007) was 3.5 m (bcd), with the shallowest point at which *Zostera marina* was recorded as being 0.8 m. The present study measured the **deepest and shallowest points as being 2.9 m and 0.5 m** respectively. Whilst there appears to be some variation in these parameters, it should be noted that neither study set out to measure the maximum and minimum depths of the bed accurately, and so this kind of discrepancy should not be considered unexpected.

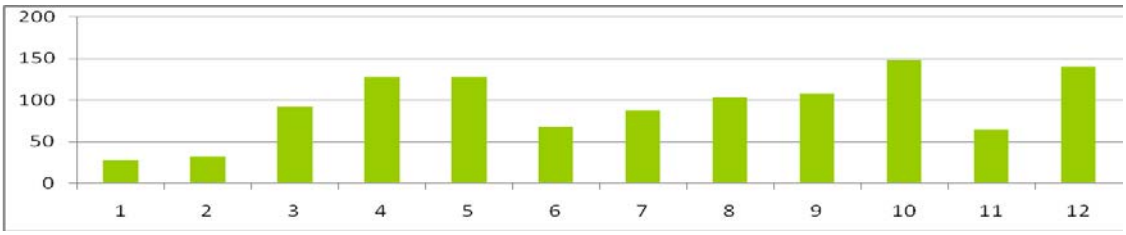
The amount of **attached macroalgae** recorded at Cellars Cove varied from 0% to 25% within quadrats. Species included *Laminaria hyperborea*, *Fucus* sp. and *Enteromorpha* (*Ulva*) *lactuca*. The amount of unattached (drift) algae varied from 10% - 40% and included species such as Laminaria hyperborea and *Saccharina latissima*.

Site: **Cellars Cove**	Transect No. **A**	Date: 16 July 2009
Time of survey: 11:35 – 12:41	Estimated u/w visibility: ~ 2 m	
Position: Inner: 50° 18.570' N 04° 03.957' W	Outer: 50° 18.587' N 04° 03.990' W	

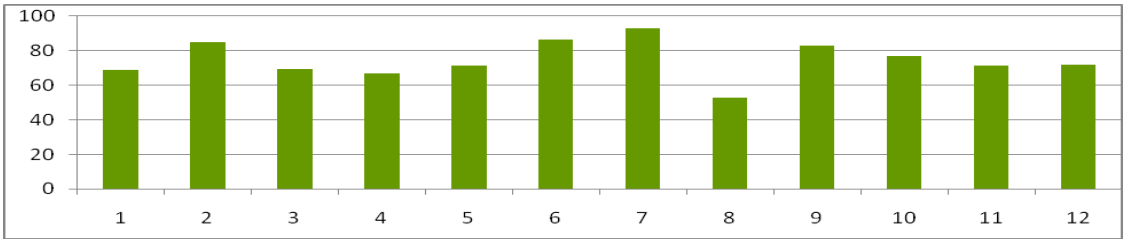
Depth profile (metres below chart datum): Max./min. depths (bcd): 0.5 – 2.0 m



Density of plants (/ m^2)



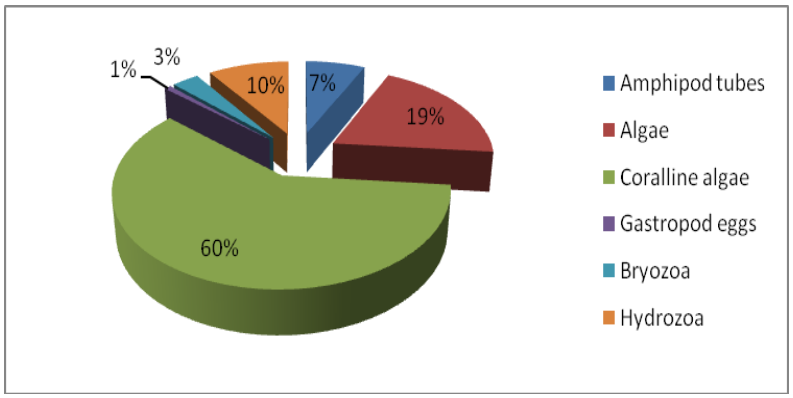
Mean longest leaf length (cm)



Median **'browning' score** (percentage cover) (range: 0% - 80%). n =100. **0%**

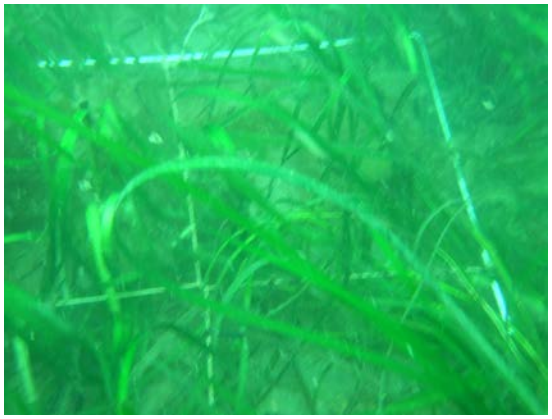
Median **epiphyte cover score** (percentage cover) (range: 0% - 80%+). n = 100. **20%**

Proportion of main epiphytic groups (flora & fauna).



Selected photographs Photographer: CP

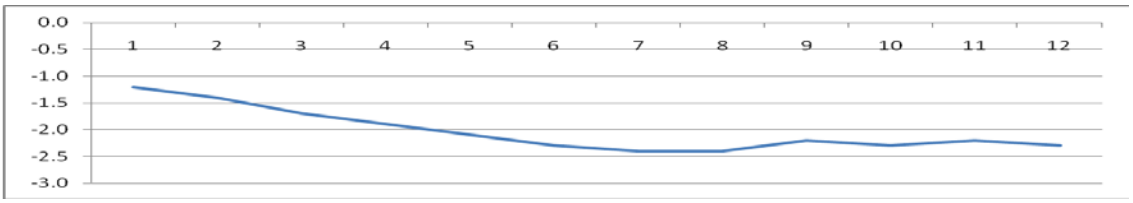
(Photo ref. 0716/016)



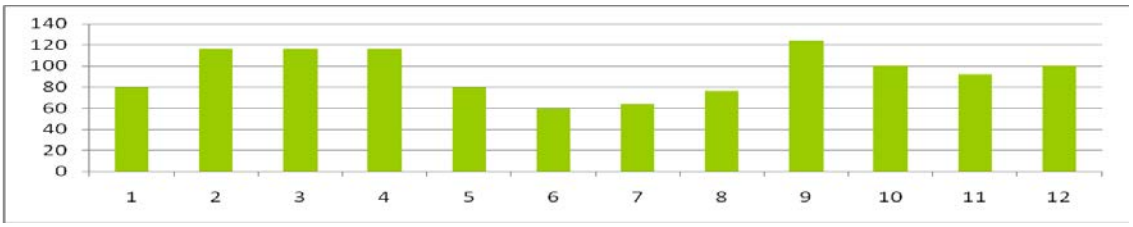
(Photo ref. 0716/017)

Site: **Cellars Cove**	Transect No. **B**	Date: 16 July 2009
Time of survey: 11:56 – 13:06	Estimated u/w visibility:	
Position: Inner: 50° 18.627' N 04° 03.883' W	Outer: 50° 18.639' N 04° 03.920' W	

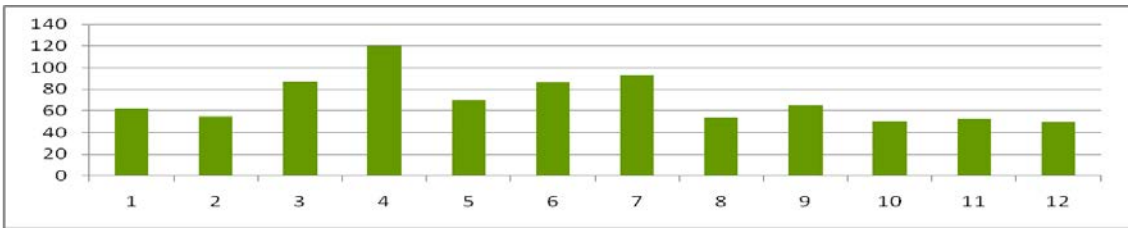
Depth profile (metres below chart datum): Max./min. depths (bcd): 1.2 – 2.4 m



Density of plants (/ m^2)



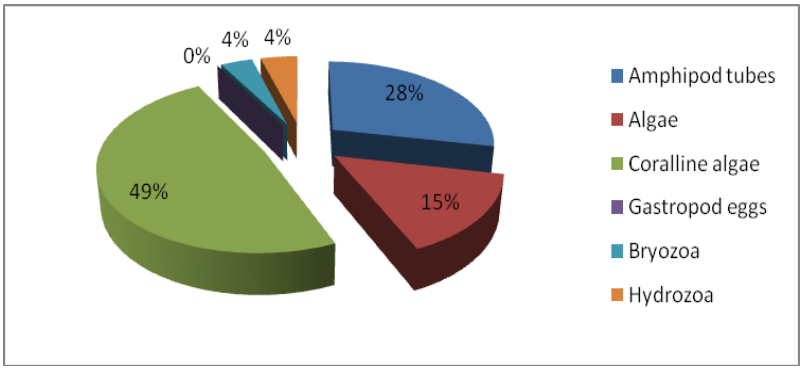
Mean longest leaf length (cm)



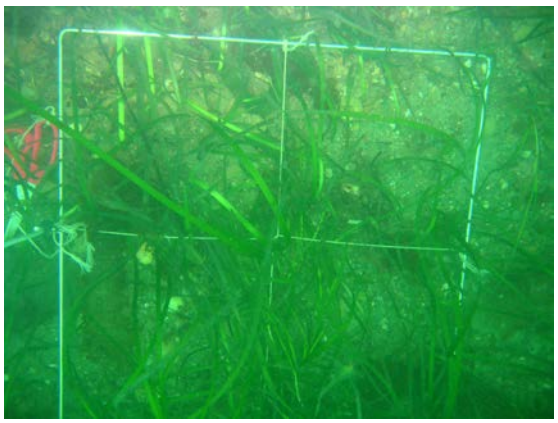
Median **'browning' score** (percentage cover) (range: 0% - 80%+). n = 112. **10%**

Median **epiphyte cover score** (percentage cover) (range: 0% - 80%+). n = 112. **20%**

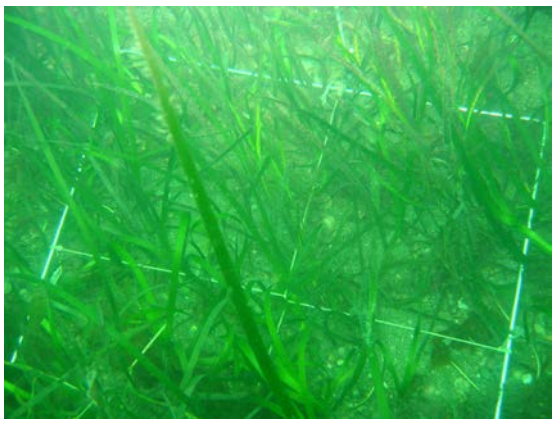
Proportion of **main epiphytic groups** (flora & fauna).



Selected photographs Photographer: RI



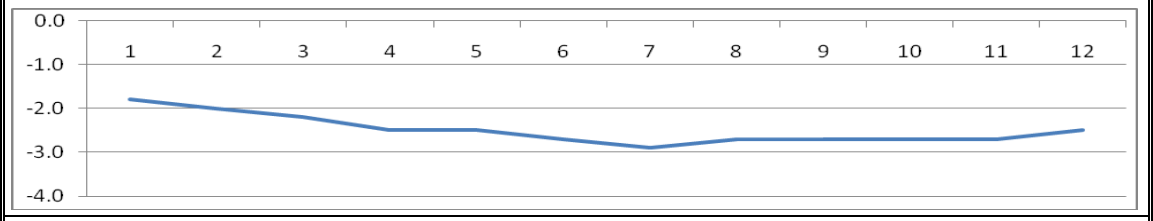
(Photo ref. DSCN3894)



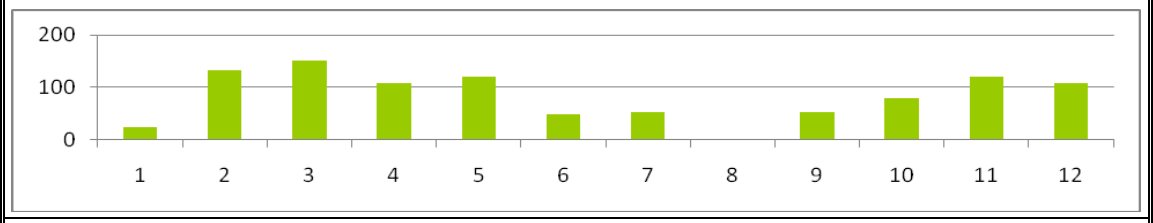
(Photo ref. DSCN3897)

Site: **Cellars Cove**	Transect No. **C**	Date: 16 July 2009
Time of survey: 13:50 – 14:37	Estimated u/w visibility:	
Position: Inner: 50° 18.668' N 04° 03.859' W	Outer: 50° 18.679' N 04° 03.891' W	

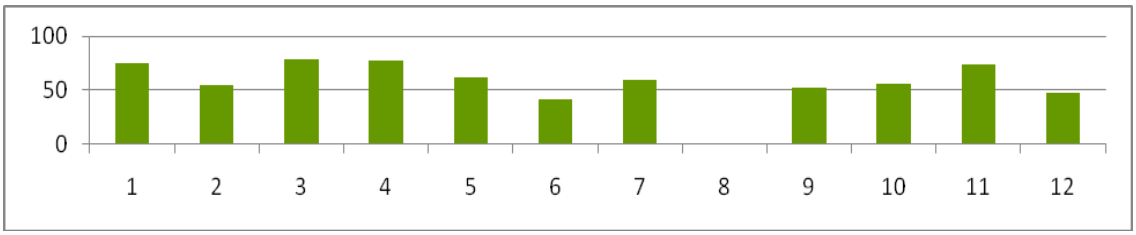
Depth profile (metres below chart datum): Max./min. depths (bcd): 1.8 – 2.9 m



Density of plants (/ m^2)



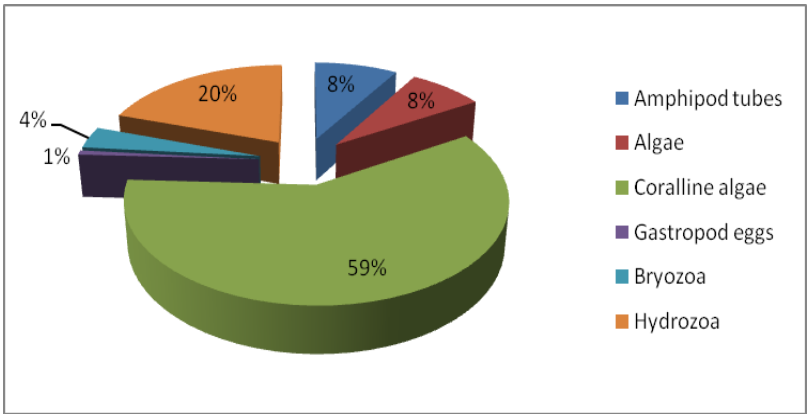
Mean longest leaf length (cm)



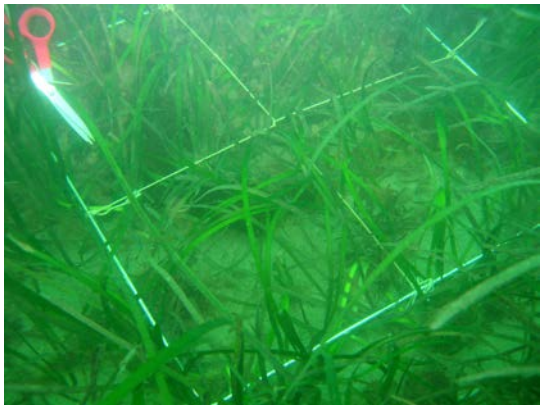
Median **'browning' score** (percentage cover) (range: 0% - 80%+). n = 96. **0%**

Median **epiphyte cover score** (percentage cover) (range: 0% - 80%+). n = 96. **40%**

Proportion of **main epiphytic groups** (flora & fauna).



Selected photographs Photographer: JHS



(Photo ref. DSCN3902)

(Photo ref. DSCN3905)

4.4.4 Red Cove

Fig. 4.4. The location of the three transects at Red Cove at the mouth of the Yealm.

General description of site

Red Cove lies a little further upstream from Cellars Cove, close to the mouth of the River Yealm. The site is divided between the two sides of the river here, with the *Zostera marina* bed appearing to straddle the two (that is, Red Cove North and Red Cove South). The seabed appears coarser than at the other sites, with coarse sand, gravel, pebbles and shells. Many of the larger pebbles were found to have pink calcareous algae growing on them. There are a number of permanent (block and chain) moorings along this stretch which will affect the seagrass in their immediate vicinities. The transects were positioned to miss any such moorings. The site is likely to be affected by moderate tidal streams.

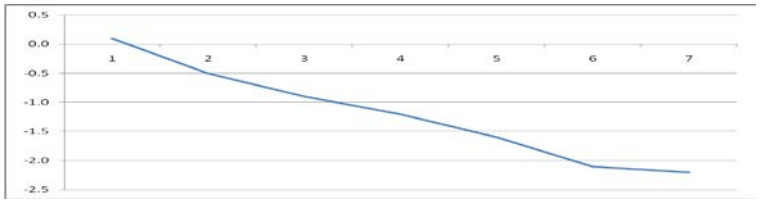
	Red Cove North		Red Cove South	
	Present study	**Irving *et al*. (2007)**	**Present study**	**Irving *et al*. (2007)**
Extent	-	0.76 ha	-	0.46 ha
Max. bed length	-	250 m + (SE/NW)	-	240 m
Max. bed width	-	40-50 m (SW/NE)	-	50 m
Max. depth of *Z.m* *	2.2 m	3.9 m	3.0 m	2.4 m
Min. depth of *Z.m* *	+ 0.1 m	1.1 m	+ 0.2 m	0.7 m

* Whilst there appears to be some variation in these recorded depths, it should be noted that neither study set out to measure the maximum and minimum depths of the bed accurately, and so this kind of discrepancy should not be considered unexpected.

The amount of **attached macroalgae** recorded at both sites ranged from 20% to 100% within quadrats. Species included *Laminaria hyperborea*, Saccharina latissima and *Sargassum muticum*. Of particular note was the amount of **unattached (drift) algae** which, at Red Cove South, was 0.5 m thick in places.

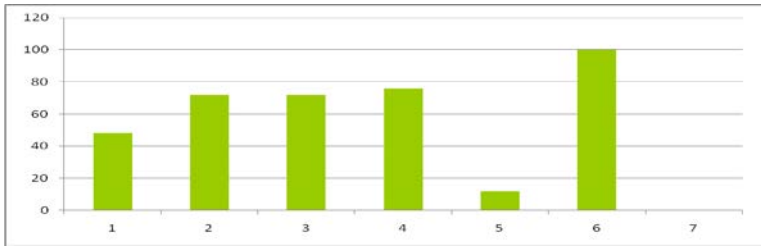
Site: **Red Cove North**	Transect No. **A**	Date: 17 July 2009
Time of survey: 11:16 – 11:55	Estimated u/w visibility: ~ 4 m	
Position: Inner: 50° 18.777' N 04° 03.648' W	Outer: 50° 18.746' N 04° 03.665' W	

Depth profile (metres below chart datum): Max./min. depths (bcd): +0.1 – 2.2 m



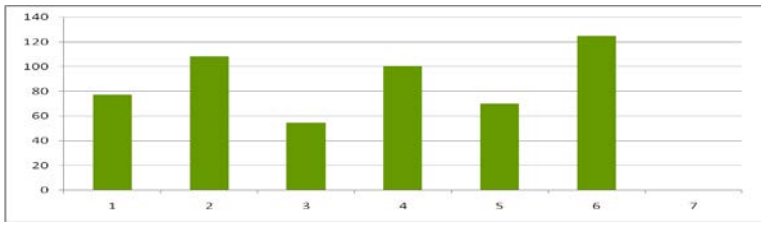
Depth only measured at quadrat 7 position.

Density of plants (/ m^2)



Eelgrass present only in first 6 quadrats.

Mean longest leaf length (cm)

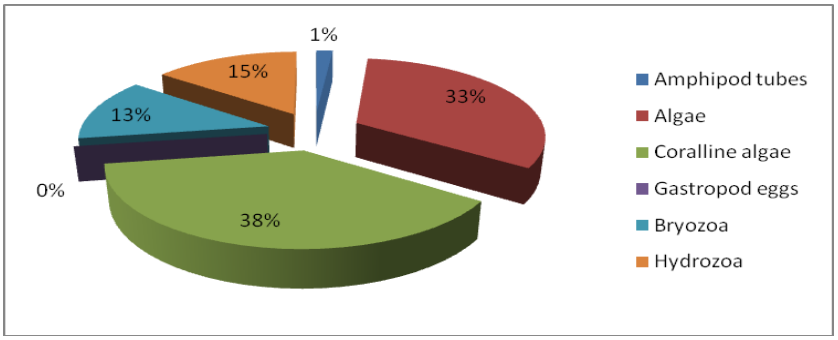


Eelgrass present only in first 6 quadrats.

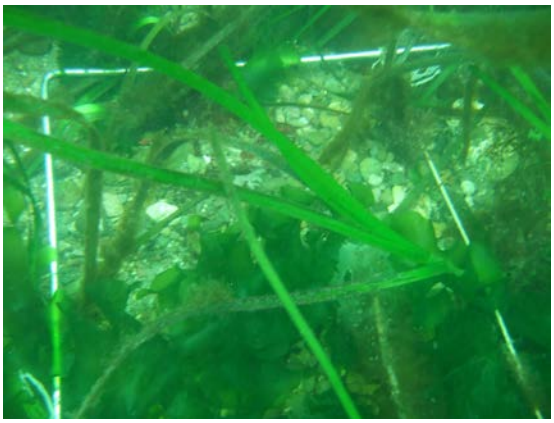
Median **'browning' score** (percentage cover) **0%**
(range: 0% - 80%).
n = 52.

Median **epiphyte cover score** (percentage cover) **80%**
(range: 0% - 80%+).
n = 52.

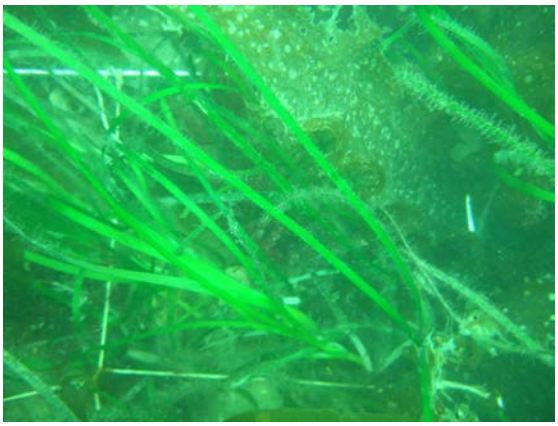
Proportion of **main epiphytic groups** (flora & fauna).



Selected photographs Photographer: CP



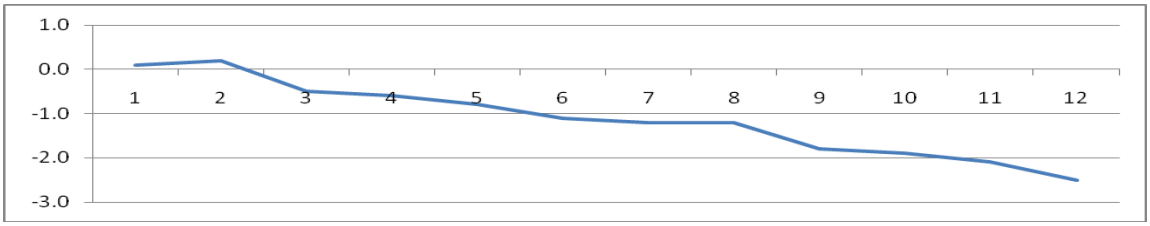
(Photo ref. 0717/010)



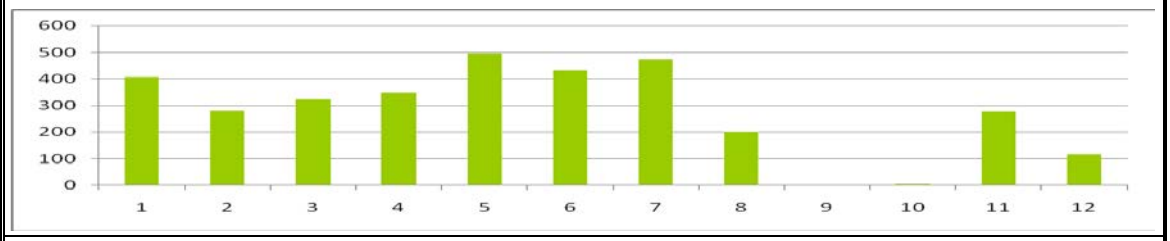
(Photo ref. 0717/022)

Site: **Red Cove South**	Transect No. **B**	Date: 17 July 2009
Time of survey: 11:41 – 12:54	Estimated u/w visibility: ~ 5 m	
Position: Inner: 50° 18.670' N 04° 03.557' W	Outer: 50° 18.694' N 04° 03.542' W	

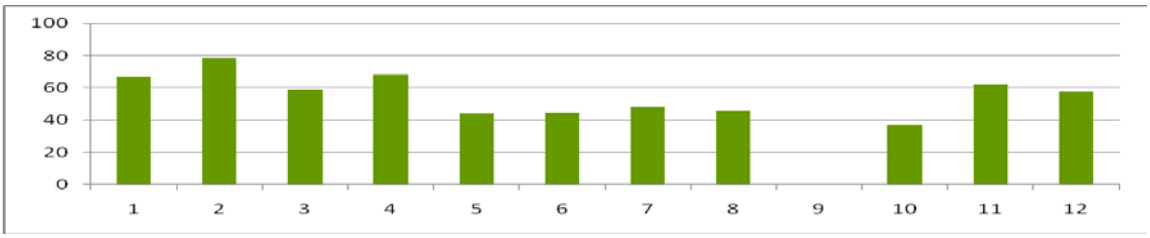
Depth profile (metres below chart datum): Max./min. depths (bcd): +0.2 – 2.5 m



Density of plants (/ m^2)



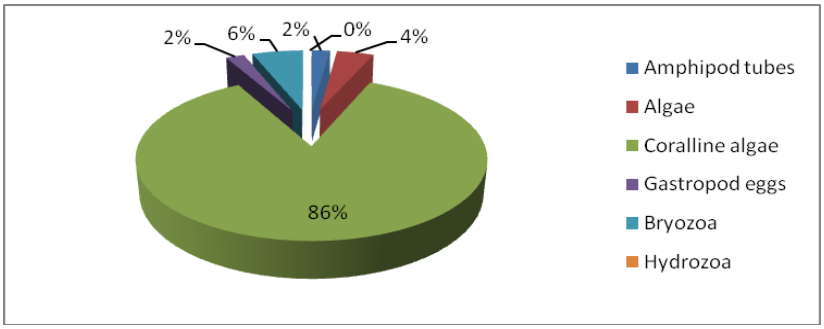
Mean longest leaf length (cm)



Median **'browning' score** (percentage cover) (range: 0% - 80%). n = 95. **0%**

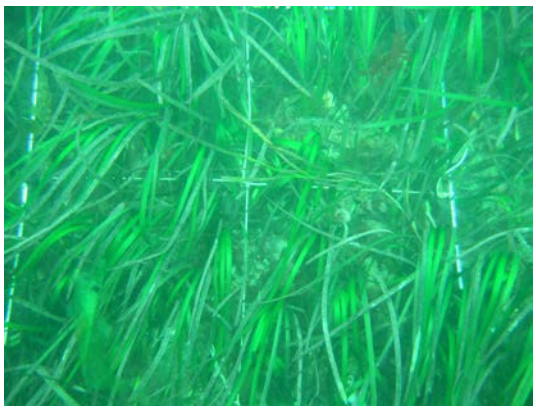
Median **epiphyte cover score** (percentage cover) (range: 0% - 80%+). n = 95. **80%**

Proportion of **main epiphytic groups** (flora & fauna).



Selected photographs Photographer: DF

(Photo ref. RCS/Q1)

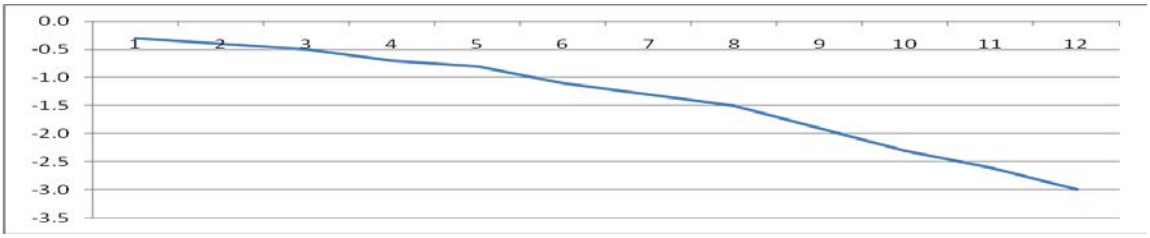


(Photo ref. RCS/Q4)

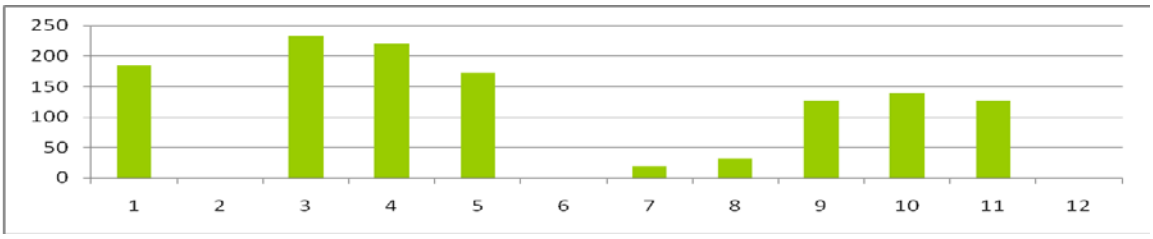
Comments: A thick (~0.5 m) layer of drift, unattached algae covered the first 4 quadrats.

Site: **Red Cove South**	Transect No. **C**	Date: 17 July 2009
Time of survey: 12:23 – 13:26	Estimated u/w visibility: ~ 5 m	
Position: Inner: 50° 18.706' N 04° 03.603' W	Outer: 50° 18.732' N 04° 03.584' W	

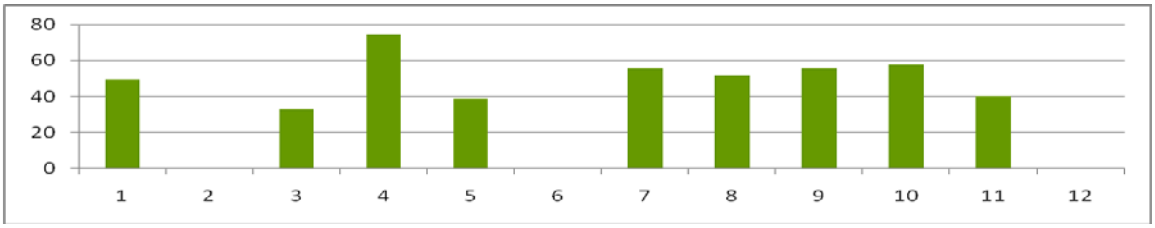
Depth profile (metres below chart datum): Max./min. depths (bcd): 0.3 – 2.6 m



Density of plants (/ m^2)



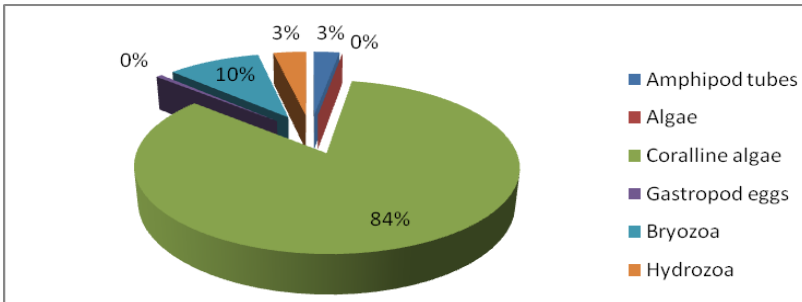
Mean longest leaf length (cm)



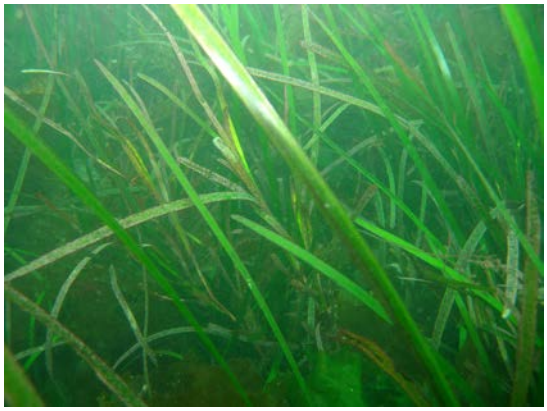
Median **'browning' score** (percentage cover) **0%**
(range: 0% - 80%).
n = 120.

Median **epiphyte cover score** (percentage cover) **80%**
(range: 0% - 80%+).
n = 120.

Proportion of **main epiphytic groups** (flora & fauna).



Selected photographs Photographer: JHS



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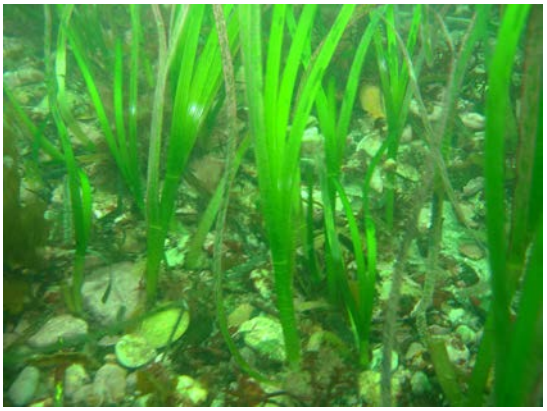

(Photo ref. DSCN3918)

Table 4.5. Summary of recorded data for all four sites.

Site:	Cawsand Bay				Drake's Island				Cellars Cove				Red Cove			
Transect:	**A**	**B**	**C**	**Mean**	**A**	**B**	**C**	**Mean**	**A**	**B**	**C**	**Mean**	**A**	**B**	**C**	**Mean**
Density of plants (no./m^2)	68.7	80.7	83.3	**77.6**	76.3	46.0	96.7	**73.0**	94.0	93.7	83.0	**90.2**	31.7	279.7	114.2	**141.9**
Mean longest leaf length (cm)	39.6	40.6	40.2	**40.1**	65.4	79.5	58.1	**67.7**	79.3	71.1	54.7	**68.4**	48.7	55.5	41.5	**48.6**
Median 'browning' % score	0%	0%	0%	-	10%	10%	10%	-	0%	10%	0%	-	0%	0%	0%	-
Median epiphyte cover % score	5%	20%	20%	-	20%	10%	10%	-	20%	20%	40%	-	80%	80%	80%	-
% Epiphyte cover (by group):																
Amphipod tubes	55	55	52	**54**	0	7	23	**10**	7	28	9	**15**	2	2	3	**2**
Non-calcareous algae	3	40	39	**27**	0	15	16	**10**	19	15	8	**14**	33	4	0	**12**
Coralline algae	3	0	2	**2**	46	50	54	**50**	60	48	59	**56**	38	86	84	**69**
Gastropod eggs	10	5	0	**5**	0	4	1	**2**	1	0	1	**1**	0	2	1	**1**
Bryozoa	7	0	2	**3**	4	4	0	**3**	3	4	4	**4**	13	6	10	**10**
Hydrozoa	21	0	4	**8**	50	20	6	**25**	10	4	20	**11**	15	0	3	**6**
no. of leaf samples (n)	50	50	50	-	50	100	120	-	100	112	96	-	52	94	120	-
No. of flowers/seeds stalks*	3	0	0	-	0	1	0	-	1	0	3	-	0	0	3	-

* During the laboratory analysis of 'browning' and epiphyte cover, the presence of flower or seed stalks within leaf samples was also noted.

5. DISCUSSION

5.1 Density of plants

The overall densities of *Zostera marina* plants at each site are presented in Fig. 5.1 and Fig. 5.2. These show that, whilst the beds at Cawsand Bay, Drake's Island and Cellars Cove

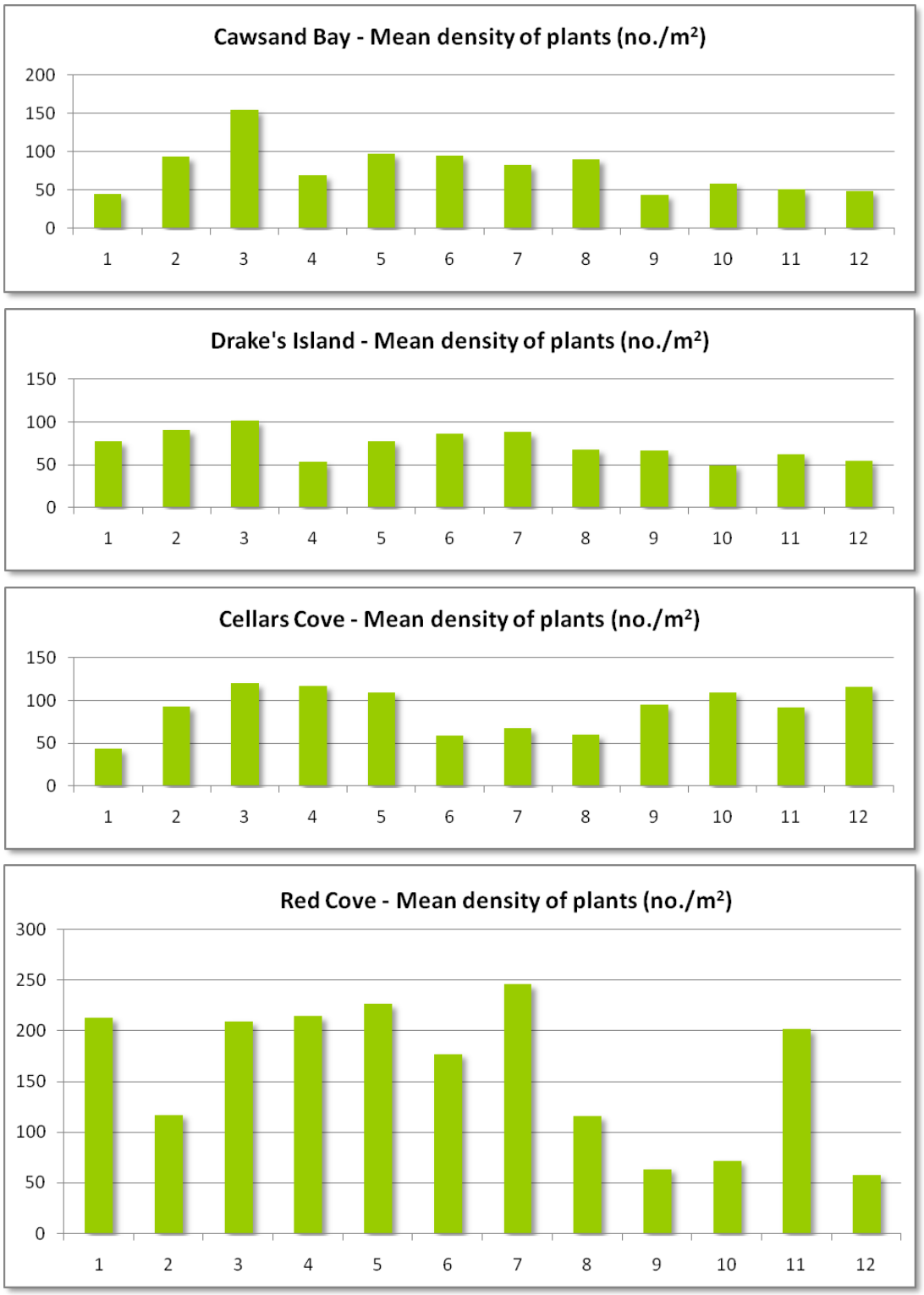

Fig. 5.1 Mean density of plants along each of three transects, by site.

have fairly similar densities of plants (at 77.6/m^2, 73.0/m^2 and 90.2/m^2 respectively), the density of plants at the Red Cove bed(s) is considerably higher (at 141.9/m^2). Indeed, the greatest density recorded was at Quadrat #5, Transect B, Red Cove South where the figure of 496 plants/m^2 was measured. This could be considered to be 'extremely dense'. However, it is by no means the densest figure that has been recorded for *Zostera marina* – Jacobs (1980) (as reported in Webster *et al*., 1998), for instance, reported densities of 500 – 800 shoots/m^2 from Roscoff on the NW coast of France.

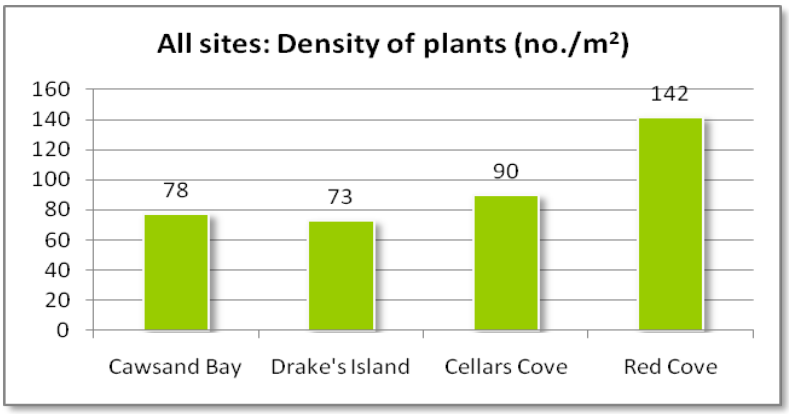

Fig. 5.2. Mean densities of *Zostera marina* plants (no. per m^2) along the lengths of the three transects at each site.

It is not clear why the density of plants at Red Cove should be so much higher than the densities of plants at the other sites, though it may well reflect the greater shelter that this site on the southern shore of the Yealm experiences from the prevailing winds (which are from the west/south-west). However, this is not reflected in a greater overall leaf length at this site when compared to the other sites (see Figs. 5.3 and 5.4 in section 5.2 below). Saunders *et al*. (2003) also found that the epiphytic communities present within the Cellars Cove bed did not differ significantly from those within 'another site' [not specified] within Plymouth Sound, indicating that environmental conditions affecting both sites were largely similar.

The large amount of drift macroalgae present at Red Cove may also have had a bearing on the counts of *Zostera marina* plants within quadrats at this site. For some quadrats, there was 100% cover of a thick blanket of drift weed, up to 0.5 m thick, which made undertaking the counts very difficult and time consuming (Plates 9 & 10). As a consequence, there may be a higher degree of error in the diver counts for some of the Red Cove quadrats.

Plate 9. Dense cover of drift macroalgae covering *Zostera marina* plants at Red Cove South (Transect B). Photo ref. RCS/Q1. Photo: DF

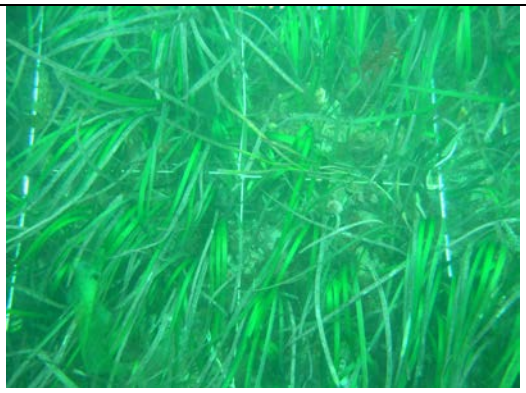

Plate 10. Dense *Zostera marina* plants revealed under the drift macroalgae blanket at Red Cove South (Transect B). Photo ref. RCS/Q1. Photo: DF

Of the beds surveyed within Plymouth Sound and at the mouth of the Yealm, historical records of plant density data exist for Drake's Island, Cellars Cove and Red Cove (Table 5.1).

Table 5.1. Historical records of the density of *Zostera marina* plants from Drake's Island, Cellars Cove and Red Cove.

Site	Year of survey	Reference	Plant density (no./m^2) (& range)	Notes
Drake's Island	Sept., 2000	Saunders *et al*., 2003	**85**	Figure quoted by Downey (2006) but not mentioned in Saunders' (2003) paper.
	2005	Downey, K., 2006	**125** (0-384)	Text comments that this is the highest density recorded for this bed.
	2009	Present study	**73** (12-156)	Mean from 36 quadrats taken across the bed.
Cellars Cove	July, 1996	Webster *et al*. 1998	**81** (12-144)	22(?) sites x 3 quadrats/site = 66(?) samples
	July, 1996	Attrill *et al*., 2000	(42-160)	No mean given. Range from 27 samples.
	2009	Present study	**90** (24-152)	Mean from 36 quadrats taken across the bed.
Red Cove	2005	Mortimer 2005	**98** (40-200)	Mean from 66 quadrats.
	2009	Present study	**142** (4-496)	Mean from 30 quadrats taken across the bed.

Mean density figures of *Zostera marina* from beds in the Isles of Scilly (monitored on an annual basis since 1993) are included here for comparative purposes (data kindly supplied by Kevan Cook, Natural England, Truro). These show considerable variation over time (Fig. 5.3). For instance, densities from Higher Town Bay, St Martin's range from 255 plants/m^2 (in 1996) to 115 plants/m^2 (in 2002). Details of the methodology and of the number of quadrats used to arrive at these figures are not known by the author, so some caution needs to be exercised in making direct comparisons. However, what is strikingly clear is how densities from the same bed are shown to vary over time. This is particularly relevant when considering data taken as part of a long-term monitoring programme based on a single visit every 6 years, as is being proposed by Natural England.

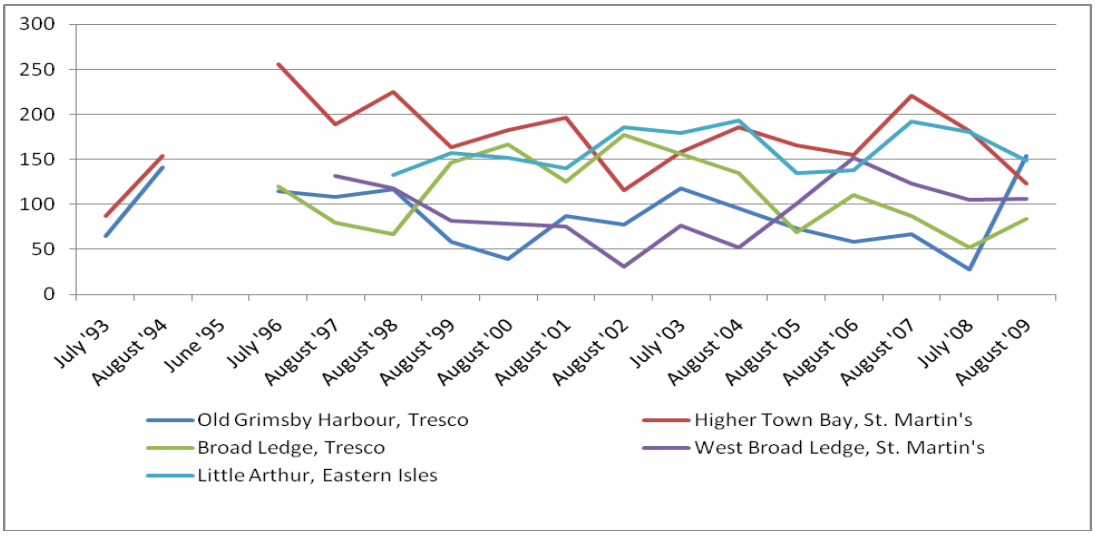

Fig. 5.3 Mean density figures of *Zostera marina* from five beds in the Isles of Scilly. Data kindly supplied by Kevan Cook, Natural England, Truro.

5.2 Mean length of longest leaves

The mean lengths of the longest leaves from all four sites are presented in Fig. 5.3 (composite of all three transects per site) and Fig. 5.4 (site by site comparisons).

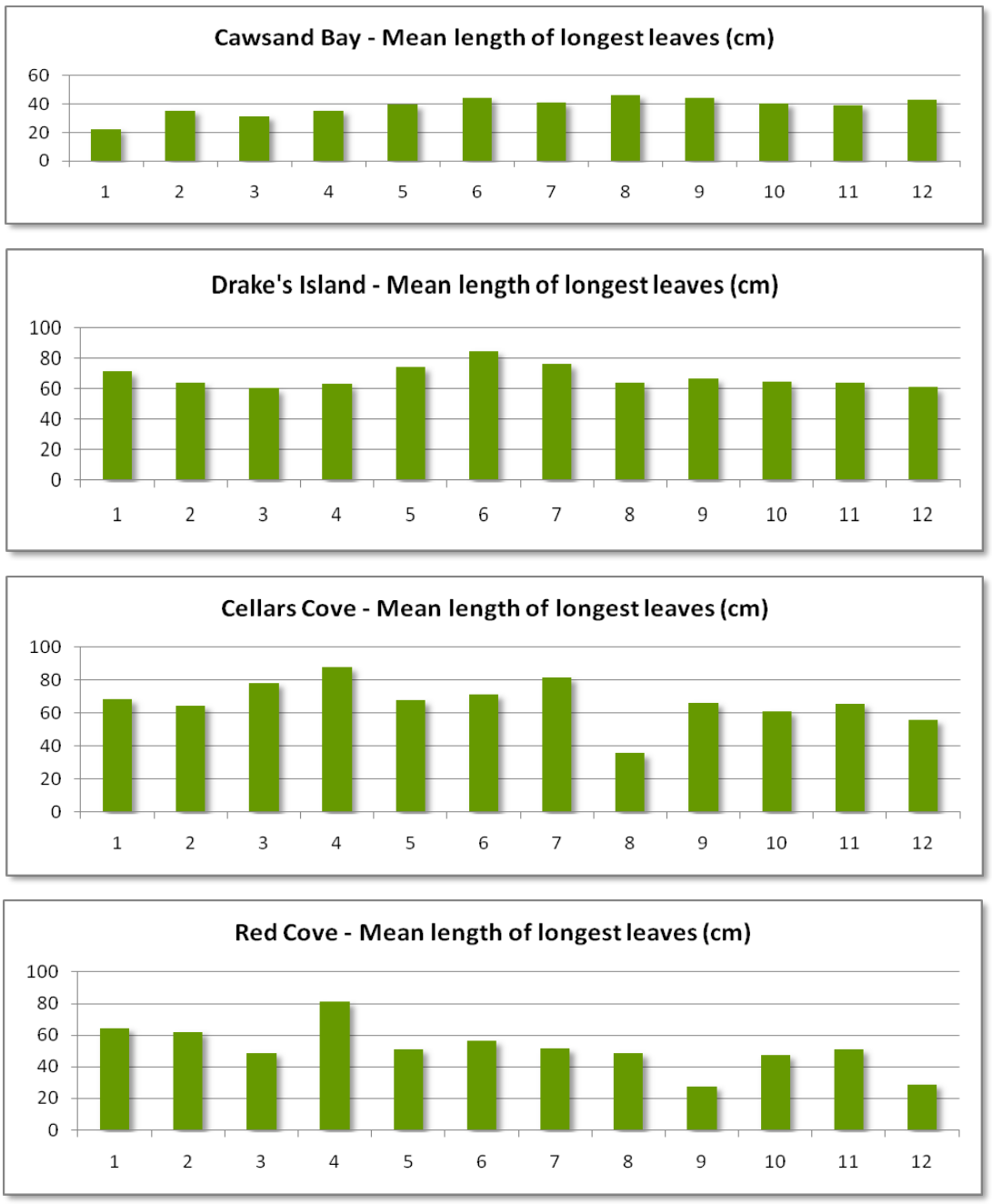

Fig. 5.3. Mean length of the longest leaves of randomly-selected plants along each of three transects, by site.

When mean data from all four sites are compared, plants from Drake's Island and Cellars Cove are shown to have longer mean longest leaf length than at the other two sites (Fig. 5.4). There appears to be no correlation however between plant density (densest at Red Cove) and maximum leaf length.

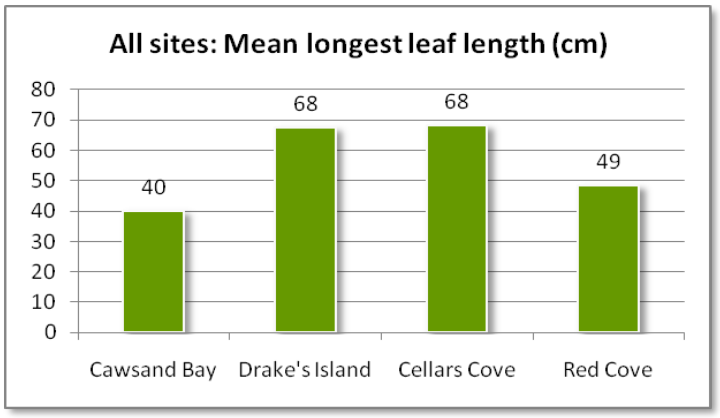

Fig. 5.4. Mean longest leaf length of *Zostera marina* plants from all quadrat measurements taken at each site.

Of the beds surveyed within Plymouth Sound and at the mouth of the Yealm, historical records of mean longest leaf length data exist for Drake's Island, Cellars Cove and Red Cove (Table 5.2).

Table 5.2. Historical records of the mean longest leaf length plants from Drake's Island and Cellars Cove.

Site	Year of survey	Reference	Longest leaf length and range (cm)	Notes
Drake's Island	2005	Downey, K., 2006	**75** (5 – 128)	Mean from 38 quadrats, 5 leaves measured/quadrat.
	2009	Present study	**68** (21 – 110)	Mean from 36 quadrats taken across the bed, 3 leaves/quadrat.
Cellars Cove	1996	Attrill *et al*. 2000	20 - 58	Range of leaf lengths extrapolated from graph.
	2009	Present study	**68** (33 – 122)	Mean from 36 quadrats taken across the bed, 3 leaves/quadrat.

Note that whilst Saunders *et al*. (2003) measured both eelgrass *leaf length* and *leaf width* from Cawsand Bay, Drake's Island and Cellars Cove, they only presented the resultant *leaf area* in their paper, with no separate mention of leaf lengths. Similarly, Attrill *et al*. (2000) gave no separate mention of leaf length measurements, simply plotting leaf length values against shoot densities.

Little can be said about comparing the mean longest leaf lengths with historical figures, other than to point out that they are within "the same ballpark".

5.3 *Zostera marina* associated community

Of the species of attached macroalgae and macrofauna recorded from within the quadrats, there were no rarities or particularly unusual species recorded.

The presence of *Enteromorpha* (*Ulva*) *lactuca* would have been expected within the macroalgal community, and its abundance of 'rare' to 'occasional' indicates that overall nutrient concentrations within the water column are low. There was certainly nothing resembling a 'green algal mat' (see section 1.2). The non-native 'wireweed' *Sargassum muticum* was also only present in small amounts.

Similarly, the macrofauna recorded at Cawsand Bay and Drake's Island (the only two sites where records were made of the macrofauna) are all species one might expect to find within a *Zostera marina* bed in south-west Britain.

5.4 Leaf 'browning'

Whilst the measurement of 'leaf infection scores' (or 'wasting disease index') was stipulated by Jackson (2005) as being an appropriate method for monitoring the 'health' of the *Zostera marina* leaves (see Table 3.1), accurate identification of the presence of the wasting disease slime mould/fungus *Labyrinthula* sp. is almost impossible without the aid of an electron microscope (*pers. comm*., E. Jackson). The symptoms of wasting disease are the appearance of rounded, dark brown spots on the leaves, which coalesce until the leaf is completely blackened. However, these can be hard to differentiate from natural cell deterioration of the leaf, which also causes brown patches. The disease will cause the leaves to die and detach from the main plant, the regenerative shoots decay and after two or three seasons of this defoliation, the rhizomes discolour and die. The final stages of this disease can be devastating, with up to 90% of the plants being lost and the bed being laid bare. It is likely that *Labyrinthula* persists at low, harmless levels within *Z. marina* populations between epidemics (Davison & Hughes, 1998). The reasons for the disease outbreaks are not fully understood, but it is possible that *Zostera* plants only succumb when stressed by certain environmental factors such as increased water temperature or pollution (Short *et al*., 1988).

As a result of the difficulty in positively identifying the presence of *Labyrinthula macrocystis*, it was decided that it would be best to note a 'browning' score for the terminal 10 cm of each leaf assessed. This would cover both cell breakdown (typically accompanied by the ingress of water and a consequent browning/blackening of sections of the leaf), as well as any possible *Labyrinthula* infection.

No *definite* signs of the wasting disease were apparent in any of the leaves examined (certainly no rounded, dark brown spots were seen), though we are unable to be 100% certain of this. It should be possible to obtain confirmation of the presence or absence of *Labyrinthula* infection utilising the scanning electron microscope (SEM) facilities at the University of Plymouth, but there would be cost implications associated with this. However, it is important that this is undertaken (if possible) at some stage in the *near* future as, should the presence of *Labyrinthula* be confirmed, it would have major implications for the overall health of the beds within Plymouth Sound and the Yealm.

The degree of 'browning' affecting the *Zostera marina* leaves from each of the sites/transects is set out in Table 5.3. Even though a few individual leaves had a high degree of 'browning' (i.e. from 41% to 80% [score 4], or from 81% to 100% [score 5]), the vast majority had none [score 0] or less than 10% [score 1]. Consequently the medians for all sites are low (0% or 10%).

Table 5.3. Median 'browning' scores (with range) expressed as percentage cover, as recorded from the terminal 10 cm of *Zostera marina* leaves from all sites.

Site:	Cawsand Bay	n	Drake's Island	n	Cellars Cove	n	Red Cove	n
Transect A	**0%** (0-80+%)	50	**10%** (0-80+%)	50	**0%** (0-80%)	100	**0%** (0-80%)	52
Transect B	**0%** (0-20%)	50	**10%** (0-80%)	100	**10%** (0-80+%)	112	**0%** (0-80%)	95
Transect C	**0%** (0-40%)	50	**10%** (0-80%)	110	**0%** (0-80+%)	96	**0%** (0-80%)	120

5.5 Epiphyte cover

The cover provided by epiphytes growing on the ends of the *Zostera marina* leaves was measured using the same scoring system as for the degree of 'browning' (see section 4.2 and Table 4.2). The medians of the epiphyte cover scores for each transect at each site are set out in Table 5.4. It is clear that the degree of cover is considerably higher than for the degree of 'browning' on the same leaves (Table 5.3). The most noticeable difference between the sites is that the medians for epiphyte cover on leaves from the Red Cove transects are considerably higher (at 80% or score 4) than those for the other three sites. Epiphytic cover on leaves at Red Cove, particularly of calcareous algae, was noticeable even *in situ*. It is not apparent why this should be so, although it is worth pointing out that the Red Cove sites also had the highest incidence of drift macroalgae (see also section 5.6.5).

Table 5.4. Median epiphyte cover scores (with range) expressed as percentage cover, as recorded from the terminal 10 cm of *Zostera marina* leaves from all sites.

Site:	Cawsand Bay	n	Drake's Island	n	Cellars Cove	n	Red Cove	n
Transect A	**5%** (0-80%+)	50	**20%** (0-80%+)	50	**20%** (0-80%+)	100	**80%** (0-80%+)	52
Transect B	**20%** (0-80%+)	50	**10%** (0-80%+)	100	**20%** (0-80%+)	112	**80%** (0-80%+)	95
Transect C	**20%** (0-80%+)	50	**40%** (0-80%+)	110	**40%** (0-80%+)	96	**80%** (0-80%+)	120

The proportion of the main epiphytic groups by site is set out in Fig. 5.4. Whilst there were only six dominant groups of epiphytes, the proportion of these varied from site to site. Most noticeable were the dominance of amphipod tubes and the near absence of coralline algae on *Zostera* leaves at Cawsand Bay, and the reverse situation at Red Cove, namely the dominance of coralline algae and the near absence of amphipod tubes.

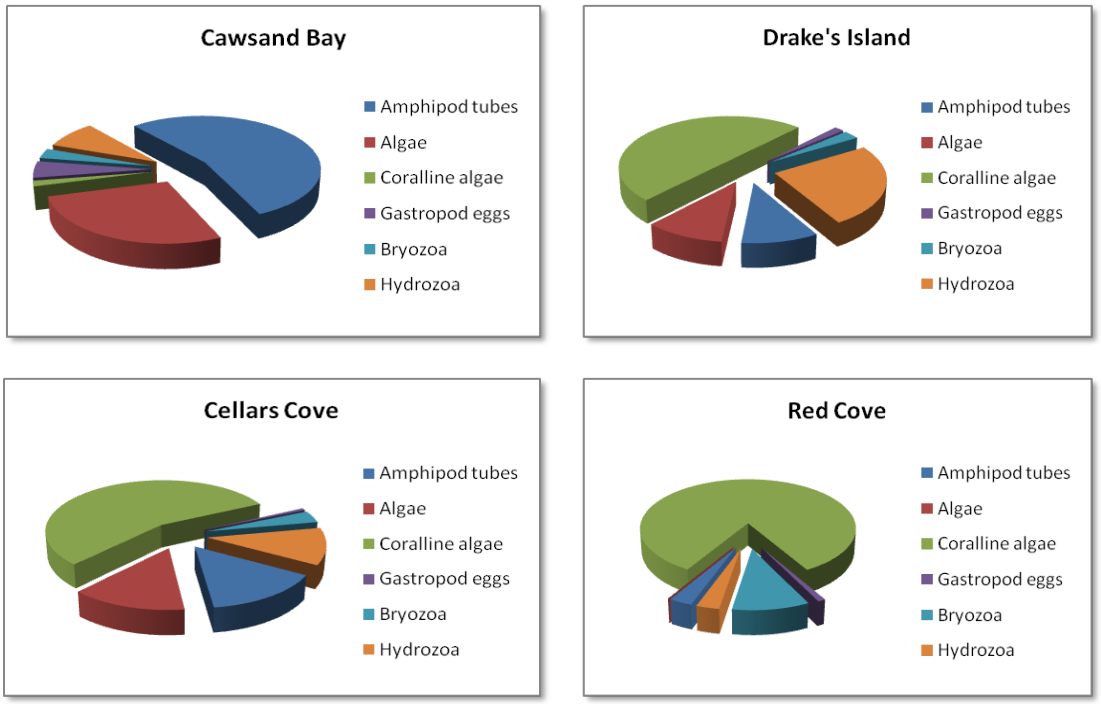

Fig. 5.4. Pie charts showing the relative proportions of the main epiphytic groups growing on *Zostera marina* leaves at all four sites.

Saunders *et al*. (2003) reported considerable variation in the epiphytic cover of *Zostera marina* leaves from Cawsand Bay, Drake's Island and Cellars Cove. They found that filamentous algae were the most abundant epiphytic group present (at 2.03 individuals per cm of leaf length), followed by encrusting coralline algae at 1.44 ind. cm^{-1}. Cawsand Bay had the lowest overall abundance of epiphytic algae (1.21 ind. cm^{-1}), and Cellars Cove had the highest (7.96 ind. cm^{-1}). Unfortunately, as a result of the different methodology and presentation of results by Saunders *et al*. (2003), from samples taken in September 2000, it is not possible to make direct comparisons with the data collected during the present study.

Saunders *et al*. (2003) also found amphipods as having a 'structural significance' to the eelgrass community at these sites, but found that both Drake's Island and Cellar's Cove had considerably higher numbers of amphipods present on the leaves than at Cawsand Bay. By contrast, as stated above, the present study found that epiphytic amphipods were considerably *more numerous* at the Cawsand Bay site than at either Drake's Island or Cellar's Cove (see Fig. 5.4 above).

5.6 Comments by site

5.6.1 Cawsand Bay

The bed at Cawsand Bay is not particularly well defined, though there does appear to be a moderately dense and dense area representing the 'core' of the bed (Fig. 5.8). Yachts and other pleasure craft are known to anchor in this locality, which may well lead to scouring of the seabed in certain areas.

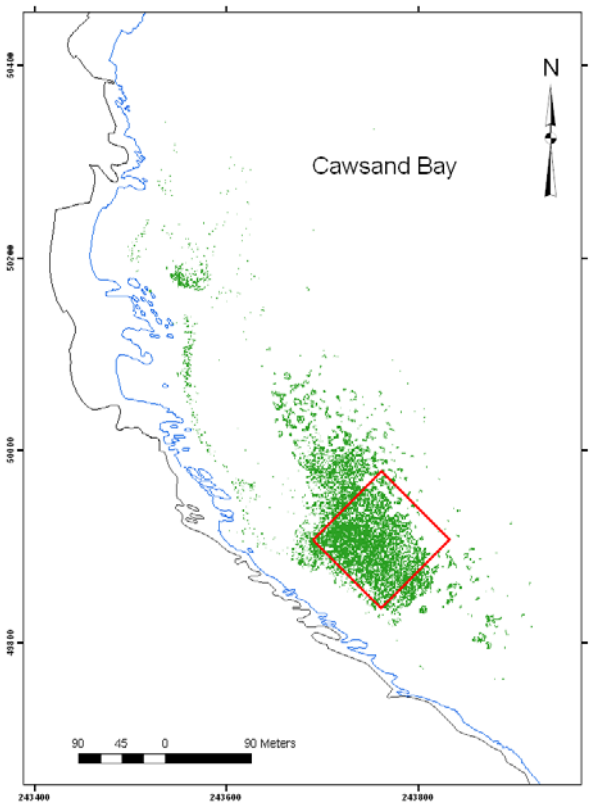

Fig. 5.8. The extent of the seagrass bed at Cawsand Bay, as indicated by the knowledge edited seagrass landscape, showing 'dense' and 'moderately dense' areas of seagrass only. The red square is 100 m x 100 m and encloses the densest area of the bed. Taken from Irving *et al*. 2007.

5.6.2 Drake's Island

The Drake's Island bed (also known by its location at Asia Shoals) also has a core area of greatest plant density (Fig. 5.9), though it is also likely to have suffered in the past from anchor damage and possibly propellor 'wash' as it lies adjacent to a busy shipping channel.

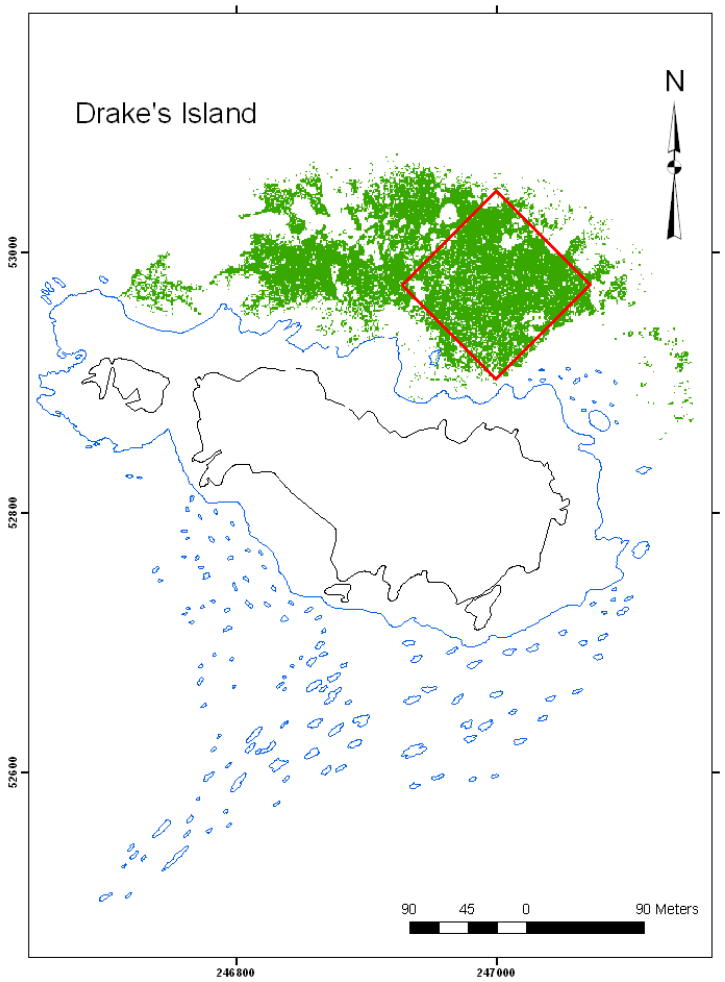

Fig. 5.9. The extent of the seagrass bed at Drake's Island, as indicated by the knowledge edited seagrass landscape, showing 'dense' and 'moderately dense' areas of seagrass only. The red square is 100 m x 100 m and encloses the densest area of the bed. Taken from Irving *et al*. 2007.

5.6.3 Cellars Cove

The Cellars Cove bed appears to have extended in size in a north-westerly direction since aerial photographs taken in 1991 were analysed by Ludhe-Thompson in 1999 (as reported in Irving *et al*., 2007). There is less variation in the distribution of moderately dense and very dense density categories, with fewer sparse patches apparent. The site also had the appearance of being 'cleaner' than either the Cawsand Bay or Drake's Island beds, with less silt settling on the leaves. This is probably a reflection of the greater water flow over the bed.

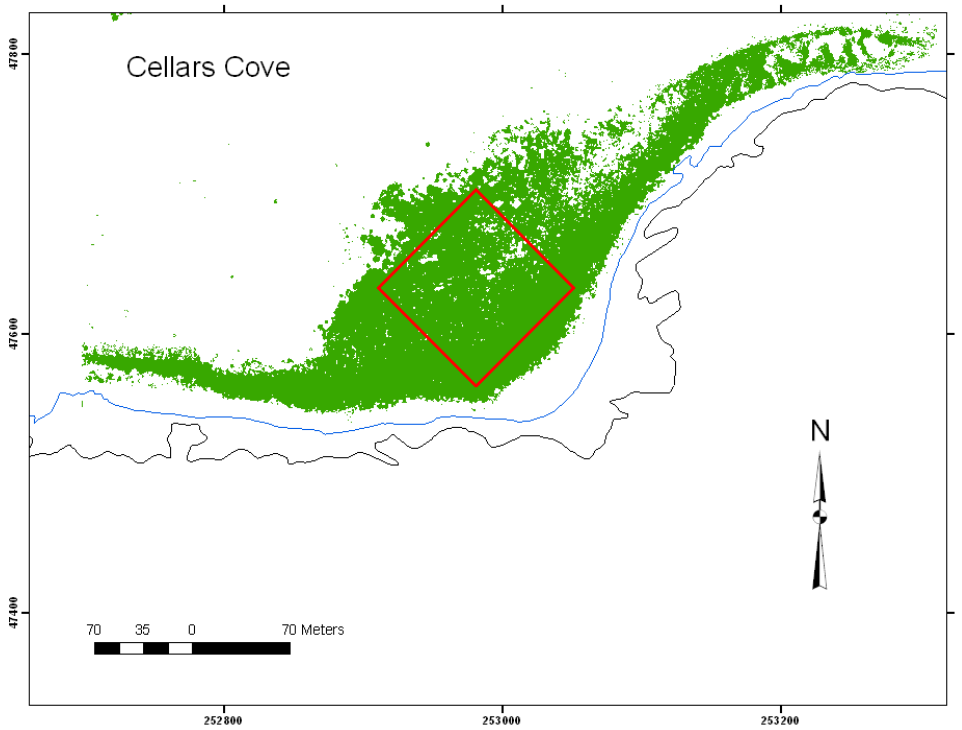

Fig. 5.10. The extent of the seagrass bed at Cellars Cove, as indicated by the knowledge edited seagrass landscape, showing 'dense' and 'moderately dense' areas of seagrass only. The red square is 100 m x 100 m and encloses the densest area of the bed. Taken from Irving *et al*. 2007.

5.6.4 Red Cove North

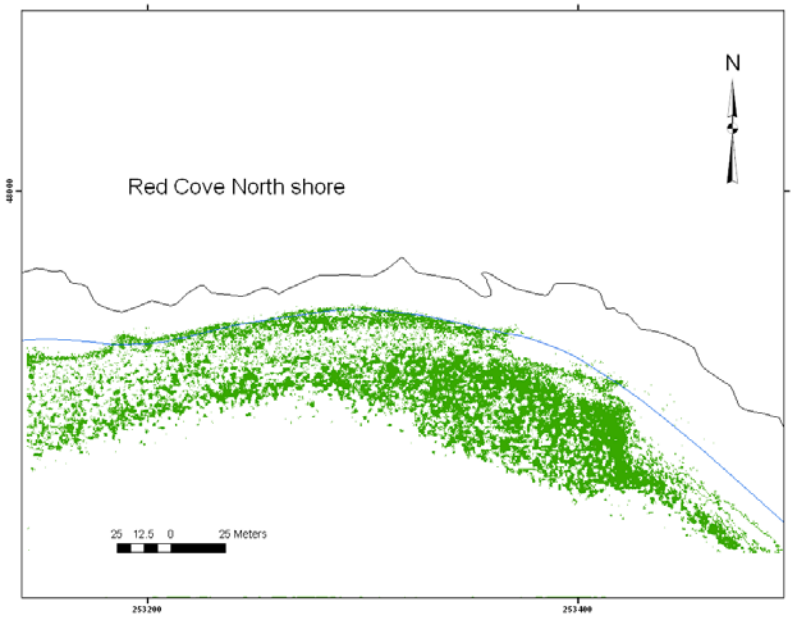

Fig. 5.11. The extent of the seagrass bed at Red Cove North, as indicated by the knowledge edited seagrass landscape, showing 'dense' and 'moderately dense' areas of seagrass only. Taken from Irving *et al*. 2007.

5.6.5 Red Cove South

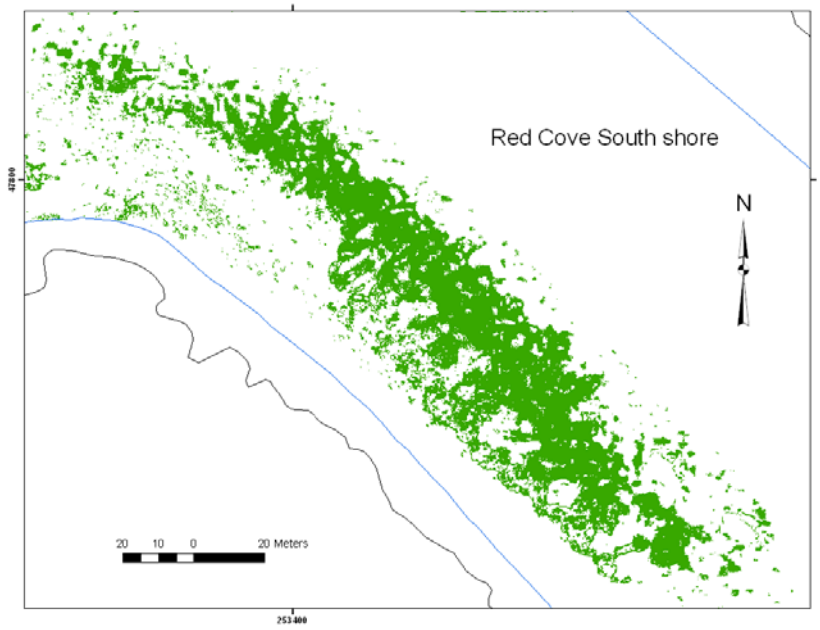

Fig. 5.12. The extent of the seagrass bed at Red Cove South, as indicated by the knowledge edited seagrass landscape, showing 'dense' and 'moderately dense' areas of seagrass only. Taken from Irving *et al*. 2007.

At Red Cove South, there were large amounts of drift macroalgae smothering the seabed at the near-shore stations on transects B & C. Here the amount of drift weed was surprisingly large – up to half a metre thick – making it difficult to record from the quadrat on the seabed below. However, there were still healthy *Zostera marina* plants living underneath this covering showing no apparent ill effects of being in the dark. This would imply that the collection of drift weed was only temporary, though it is not know how long it was present for, both before and after the survey event.

At one station within the bed where no *Zostera marina* plants were present within the randomly-placed quadrat, the recorder noted that this absence of eelgrass might have been due to the scouring action of a near-by mooring or anchor chain, as the seabed was depressed (i.e. scoured away) too.

Of all the sites, the two at Red Cove (i.e. Red Cove North and Red Cove South) may well warrant some further investigative survey work. If further transects were to be laid across the river/ria in this area, they would help confirm the extent of the overall bed, and also of the very high densities of plants which the present survey recorded from here. It may be possible for such a project to utilise the assistance of volunteer sports divers.

6. CONCLUSIONS AND RECOMMENDATIONS

1. Of the four *Zostera marina* beds within Plymouth Sound and Estuaries SAC surveyed in July 2009, namely Cawsand Bay, Drake's Island, Cellars Cove and Red Cove (north & south), all were found to be in a healthy condition. There was no sign of the wasting disease caused by the slime mould/fungus *Labyrinthula macrocystis*, and there were no areas encountered where there were noticeably increased abundances of macroalgae, such as *Enteromorpha* (*Ulva*) *lactuca* forming green mats, which might have indicated enriched nutrient levels affecting the beds.
2. The methodology used should allow a repeat survey to be undertaken at some time in the future (possibly in 2015?), with the minimum of alteration or adaptation.
3. The density of *Zostera marina* plants within each bed varied considerably, reflecting the randomly distributed quadrats falling either on patches where eelgrass was absent altogether, or on sparse, moderately dense or very dense patches. To eliminate this variation being a possible artefact of the survey methodology, a much larger number of quadrats would need to be assessed at each site. However, this would probably not be cost effective given the constraints and expense of diving time. The current level of sampling still provides a relevant overall mean density figure for each bed.
4. The densities derived from the present survey appear to be 'in the same ballpark' as from previous studies of the beds. It is not possible to say if overall densities have increased or declined – the survey methodology is not that accurate. Whilst overall mean density figures have been extrapolated for each bed as a whole, it should be remembered that the range of densities for each quadrat should be taken into consideration when analysing the figures.
5. As this survey presents baseline data, there has been little scope for detailed statistical analysis of the results. Second and subsequent visits to the sites in future should allow more comprehensive analysis to be undertaken.
6. The degree of epiphyte cover varied from sample to sample. The most noticeable difference was in the overall epiphyte cover at Red Cove (in the region of 80%) which was considerably higher than for the other three sites (5% - 40%).
7. As a result of the noticeably higher overall density of *Zostera marina* plants at the two Red Cove locations (north and south) when compared to the other locations, it is recommended that this site is re-surveyed in the near future to confirm these results. A re-survey could also be undertaken at a different time of year (perhaps during May) to see if there is less detached algae in early summer.
8. Some caution should be used when analysing the data presented here (and in the accompanying raw data spreadsheet files). There are likely to be one or two 'built-in' inaccuracies which may not be apparent at first glance – such as depths being measured by more than one depth computer. To eliminate such variability in future, it is recommended that all depth gauges used are calibrated prior to the start of recording.
9. It is recommended that a recording *proforma* be drawn up for the post-survey laboratory analysis of the *Zostera marina* leaves, in order to streamline the process of recording epiphyte cover and 'browning'.

Table 6.1 Summary of attributes and their condition (as at 2009) for the *Zostera marina* beds within Plymouth Sound and Estuaries SAC (after G. Black, pers. comm.).

	Attribute	Baseline & Historical studies	2009 study results	Assessment of attribute	Confidence in assessment
1a	Mean leaf length		Cawsand Bay **40cm (33-90)**	Mean leaf length has reduced at **Drake's Island** by ca. 10% since 2006. This variation may be due to possible natural fluctuation and/or different recording methodology. However other factors could have impacted the bed here. No data are available for comparisons at other sites. **Considered favourable due to other attributes being favourable and no anthropogenic impacts known to be occurring?**	Low
		Drake's Island - Downey,K. 2006 **75cm (5-128)**	Drake's Island **68cm (21-110)**		
		Cellars Cove - Attrill *et al.* 2000 **20-58cm**	Cellar's Cove **68cm (33-122)**		
			Red Cove **49cm (22-77)**		
1b	Mean shoot density	Drake's Island – Saunders *et al*. 2003 **85 shoots/m^2** Drake's Island - Downey,K. 2006 **125 shoots/m^2 (0-384)** Cellar's Cove – Webster *et al*. 1998 **81 shoots/m^2 (12-144)** Red Cove – Mortimer 2005 **98 shoots/m^2 (40-200)**	Cawsand Bay **78 shoots/m^2 (range?)** Drake's Island **73 shoots/m^2 (range: 12-156)** Cellar's Cove **90 shoots/m^2 (range: 24-152)** Red Cove **142 shoots/m^2 (range: 4-496)**	Mean density has reduced at **Drake's Island** from 85 shoots/m^2 in 2000 to 78 in 2009 (ca. 10%). However, comparisons with 2006 data, give a reduction of almost 40%. At **Cellar's Cove** and **Red Cove,** shoot density has increased since baseline. These variations may be due to possible natural fluctuation and/or different recording methodology. However other factors could have impacted the bed here. Caution should be used in using data from Red Cove as some numbers appear very high. **Considered favourable due to other attributes being favourable and no anthropogenic impacts known to be occurring?**	Low

	Attribute	Baseline & Historical studies	2009 study results	Assessment of attribute	Confidence in assessment
2	Characteristic species – epiphytic community	No suitable baseline available.	Cawsand Bay **15% (0-80%)**	The degree of epiphyte cover varied from sample to sample. The most noticeable difference was in the overall epiphyte cover at Red Cove (in the region of 80%) which was considerably higher than for the other three sites (5% - 40%). Characteristic/ dominating species varied from site to site. At **Drake's Island**, **Red Cove** and **Cellar's Cove** coralline algae made up most of the epiphytic species whilst at Cawsand amphipod tubes were dominant. Changes have occurred in make-up of epiphytic communities. Unknown if % cover has changed.	Low
			Drake's Island **23% (0-80%)**	**Attribute not assessed.**	
			Cellar's Cove **27% (0-80%)**		
			Red Cove **80% (0-80%)**		
3	Wasting disease (*Labyrinthula* sp. / leaf infection scores).	No suitable baseline available.	Cawsand Bay **0% (0-80%)**	No *definite* signs of the wasting disease were apparent in any of the leaves examined in 2009 (certainly no rounded, dark brown spots were seen), though we are unable to be 100% certain of this. **Favourable conservation status**	Moderate
			Drake's Island **10% (0-80%)**		
			Cellar's Cove **3% (0-80%)**		
			Red Cove **0% (0-80%)**		

	Attribute	Baseline & Historical studies	2009 study results	Assessment of attribute	Confidence in assessment
4	Nutrient status – green algal mat.	None available?	Cawsand Bay X**% cover (green algae)**	The presence of *Enteromorpha* (*Ulva*) *lactuca* would have been expected within the macroalgal community, and its abundance of 'rare' to 'occasional' indicates that overall nutrient concentrations within the water column are low. There was certainly nothing resembling a 'green algal mat'. The non-native 'wireweed' *Sargassum muticum* was also only present in small amounts. **Favourable conservation status**	Moderate
			Drake's Island X**% cover (green algae)**		
			Cellar's Cove X**% cover (green algae)**		
			Red Cove **X% cover (green algae)**		

7. REFERENCES

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APPENDICES

Appendices

APPENDIX 1

DAILY LOG

Daily Log

RI	Robert Irving	Survey leader	GB	Gavin Black	Project Officer
JHS	Jason Hall-Spencer	Scientific diver	KC	Kevan Cook	NE Scientific diver
SLL	Sean Lindsley-Leake	Scientific diver	CP	Chris Pirie	NE Scientific diver
DF	Dominic Flint	Scientific diver			
KB	Kat Brown	Scientific diver	PH	Pete Hambly	Skipper, Furious

Time	*Activity*
Tuesday 14 July	
	RI departs from Bampton, Devon and arrives at o/n accommodation (70 Alma Road, Plymouth) at 23:20. Remainder of contractors are Plymouth-based, although the NE personnel are arriving from Exeter, Truro and Southampton.
Wednesday 15 July	
Weather, wind & sea state:	Clear skies and sunshine all day. Fresh breeze (SW, 4-5). Sea state calm ((in lee).
Tide times:	(Devonport) LW: 05:09 (1.7m) HW: 11:06 (4.6m) LW: 17:27 (1.9m)
07:50	RI departs accommodation and drives the 4 miles through Plymouth to Mount Batten quay.
08:15-08:30	Meet with others in team (GB, KC, SLL, JHS, KB) in car park. Start to load gear on board *Furious*, which has pulled alongside the passenger ferry berth. Individuals put their own diving kit together.
09:15	RI runs through the Project Plan and Risk Assessment with everyone.
09:45	*Furious* departs Mount Batten and heads over to Cawsand Bay.
10:00	Arrive Cawsand Bay. The bay is sheltered from the SW wind, which has proved quite choppy on the way across the Sound. Prepare 50m transect lines with 'riser' buoys at each end.
10:30	JHS snorkels to see if seagrass present at transect location. Requires diving cylinder to reach the bottom (at 7m) in order to investigate properly. Confirms presence of seagrass but visibility is very poor (~ 0.5m!).
10:40	Lay first 50m transect line (A) from the boat, starting close to the shore and proceeding out on a bearing of 50°.
10:50	Lay second transect line (B), approx. 50m to the south of the first and running parallel with the first line.
11:09-12:00	First pair of divers (JHS & SLL) dive. One (SLL – Diver 1) is tasked with undertaking counts of *Zostera* plants within a 0.5m x 0.5m quadrat. 12 such counts are required every 4m, starting 2m in from the edge of the bed. The other diver (JHS – Diver 2) is tasked with cutting leaf samples from a quarter (i.e. 0.25m x 0.25m) quadrat, and taking some illustrative photos of the quadrats. These cuttings need to be done from 6 quadrats, so are done at every other station along the line. Diver 2 also notes down macroalgal cover on seabed within the quadrat. All tasks successfully completed.
11:17-12:40	Second pair of divers (GB & KC) dive on Transect B. Successfully complete the same tasks as above.
12:25	Lift first transect line and re-position it (as Transect C) 50m south of Transect B.
13:12-14:32	Third pair of divers (RI & KB) dive on Transect C. Successfully complete the same tasks as above.
14:35	Lift both transect lines (B & C). Depart site and head back to Drake's Island.
14:55	Lay out Transect A at Drake's Island, extending from the NW corner of the jetty on a bearing of approx. 50°.
15:19-16:14	First pair of divers (JHS & SLL) dive again. They report the u/w visibility to be much better (at least 2m) than at Cawsand Bay (where it was less than 0.5m).
16:20	Lift transect line and depart Drake's Island. Head back to Mount Batten
16:40	Offload gear at Mount Batten passenger ferry jetty. Take empty cylinders round to *In Deep* at the Mount Batten (Activity) Centre and arrange to collect them tomorrow morning at 08:45.
17:20	Head off to the Plymouth University School of Ocean Sciences (Drake's Circus) to inspect the leaf samples. JHS has kindly arranged for us to use one of the laboratories for this purpose. Coinciding with this, JHS has also agreed to give an interview to a Saudi Arabian film crew working for the international charity Save our Seas. They are keen to get shots of seagrass being inspected, so welcome the opportunity to film us all!
18:50	Depart laboratory and disperse to various accommodations.

Thursday 16 July	
Weather, wind & sea state:	Overcast, with showers. Wind: SW – SE, f2-3. Sea state: calm.
Tide times:	(Devonport) LW: 05:57 (1.9m) HW: 11:55 (4.5m) LW: 18:22 (2.0m) (Yealm) LW: 06:00 (1.8m) HW: 12:03 (4.5m) LW: 18:25 (2.0m)
08:45	Team meets at *In Deep*. Collect filled tanks and take them to the jetty, ready for loading onto *Furious*.
09:00	*Furious* (Pete Hambly) comes alongside the pontoon at the Mount Batten Centre and tanks are loaded on. Individuals take their cars round to the public car park beside the Mount Batten Hotel and walk back.
09:30	Depart Mount Batten and head to Drake's Island. Upon informing Long Room of our intentions for the morning (i.e. remaining on site until 12:00 hrs at least), we are told we will have to have divers out of the water by 11:00 hrs. This is to allow for the passage of a warship out of the dockyard area. We therefore only have time to complete one transect here.
09:50	Lay one transect line (Transect B) from the NE corner of the jetty on a bearing of approx. ?330°.
09:58-10:39	First pair of divers (JHS & SLL) dive, having been given the same tasks as yesterday. Successfully complete these same tasks.
10:45	Lift transect line and move on to the mouth of the Yealm.
11:15	Arrive at Cellars Cove on the southern side of the mouth of the Yealm. Deploy two transect lines approx. 50 m apart. Transect A is set along an approx. bearing of 320°, and Transect B 300°.
11:35-12:41	Second pair of divers (KC & CP) dive. Diving on Transect A, they share the same tasks as set out above which they duly complete.
11:56-13:06	Third pair of divers (RI & DF) dive. Diving on Transect B, they share the same tasks as set out above which they duly complete.
13:20	The first transect line is lifted and re-laid, following a bearing of approx. 295°.
13:50-14:37	The first pair of divers (JHS & SLL) dive on Transect C. They share the same tasks as set out above which they duly complete.
14:45	Both transect lines are lifted and brought on board. *Furious* departs for Drake's Island.
15:15	Arrive Drake's Island and lay out one transect line (Transect C).
15:28-16:27	Second pair of divers (KC & CP) dive on Transect C. They share the same tasks as set out above which they duly complete.
16:30	Lift transect line and head back to Mount Batten.
16:45	Offload gear at Mount Batten passenger ferry jetty and carry it back to the various cars parked in the public car park.
17:30	Take empty tanks round to *In Deep* by car and deposit ready for collection in the morning. The team then move on to the laboratory to inspect the sample bags.
18:00-19:30	Inspection of *Zostera* leaf samples for 'browning' and epiphytic cover at Plymouth University School of Ocean Sciences' laboratory at Drake's Circus.
19:30	Team disperses to various accommodations.

Friday 17 July	
Weather, wind & sea state:	Overcast with showers. Wind: NW f4-5 (with f8 gale warning for 20:00 hrs!). Sea state: calm in lee.
Tide times:	(Yealm) LW: 07:02 (2.0m) HW: 13:15 (4.5m) LW: 19:37 (2.1m)
09:45	Team meets at *In Deep*. Collect filled tanks and take them to the jetty, ready for loading onto *Furious*.
10:00	*Furious* (Pete Hambly) comes alongside the pontoon at the Mount Batten Centre and tanks are loaded on. Individuals take their cars round to the public car park beside the Mount Batten Hotel and walk back.
10:30	Depart Mount Batten and head to the mouth of the Yealm.
10:55	Arrive at Red Cove, a little further upstream from Cellars Cove at the mouth of the Yealm. There are *Zostera* beds associated with both the north and the south shore here. After inspecting an aerial photograph taken in 2006 (as part of the remote survey of the extent of the beds), RI decides to lay one transect (A) from the north shore and two (B & C) from the south shore.
11:16-11:55	First pair of divers (CP & SLL) dive on Transect A. Successfully complete their tasks (as set out in Wednesday's log entry).
11:25	Second transect (B) is laid from the southern shore.
11:41-12:54	Second pair of divers ((GB & DF) dive. They only manage to complete half of transect before needing to surface in order to remain within their stipulated estimated dive duration of 70 mins. They find that for the shoreward end of the transect, there is approx. 0.5m thickness of drift algae obscuring the seabed (and also the *Zostera* plants). The required removal of this drift algae adds considerably to the time taken to record from the quadrats.
12:05	First transect is lifted and re-laid as transect C from the southern shore.
12:23-13:26	Third pair of divers (RI & JHS) dive. This pair also has the difficulty of coping with vast amounts of drift algae overlying the *Zostera*.
14:08-14:53	The second pair of divers (GB & DF) dive again to complete transect B.
13:45	Third transect is lifted, dismantled and stowed.

15:00	Second transect is lifted, dismantled and stowed.
15:05	Depart site and head back to Mount Batten. Just as we are about to depart, the Yealm Harbour Master comes alongside and points out that we should have sought his permission first before diving within his harbour limits. We apologise, adding that we hadn't realised this area was separate from the jurisdiction of 'Long Room'. Our passage back to Mount Batten against the f5 wind/sea proves quite wet!
15:40	Arrive back at Mount Batten passenger ferry berth and offload all gear. Carry gear back to parked cars. Set off for the Plymouth University laboratory at Drake's Circus.
17:00	Start analysing the samples collected from today's three transects.
18:15	Completion of sample analysis. Team disperses in various directions.

APPENDIX 2

SAMPLE RECORDING FORM

Site:			Date:			
Transect No.	Start position:	End position				
Direction of transect:			From 0m or from 50m end of transect?			
Diver pair:			U/w vis. (m):			
Quadrat No.	**Distance along 50m transect (m)**	**Depth (m) (bsl)**	**Depth (m) (bcd)**	**No. of plants within 0.5m x 0.5m quadrat**	**Lengths of longest leaves of 3 random plants within quadrat**	**Notes (incl. % macrophyte cover on seabed within quadrat; attached algal spp.)**
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

APPENDIX 3

DIVE SUPERVISOR'S LOG SHEETS

DIVING OPERATIONS DAILY LOG SHEET

Sea-Scope
Marine Environmental Consultants

Project: Plymouth Sound seagrass diving survey, July 2009 | **Job No.** SS-0907-050 | **Date:** 15 JULY 2009

Name	Site Name	Pre-dive checks: Tanks (wp/wc)	% O_2	Pre-Dive Check	Estimated duration	Available gas (min.)	Air: In (Bar)	Air: Out (Bar)	Duration: Leave Surface	Duration: Arrive Surface	Duration: Total Time	Depth: Max. Depth (m)	Decompression: For time: mins	Decompression: At depth: m	Decompression: S or R	Decompression: De-sat. time	Supervisor's Initials
JASON	CAWSAND A	12/232 3/232	AIR	✓	90		200 60	130 40	11:09	12:00	52	7.8	-	-		00:40	RI
SEAN	CAWSAND A	12/232 3/232	AIR	✓	90		230 220	140 210	11:09	12:00	52	7.9	-	-		00:40	RI
GAVIN	CAWSAND B	15/232 3/232	AIR	✓	90		235 180	100 170	11:17	12:40	82	7.7	-	-		22:49	RI
KEVAN	CAWSAND B	7/300 7/300	AIR	✓	90		290 300	150 180	11:17	12:40	82	7.7	-	-		22:49	RI
ROBERT	CAWSAND C	7/232 7/232	AIR	✓	90		230 230	110 110	13:12 13:21	13:19 14:32	71	6.9	-	-		01:40	GB
KAT	CAWSAND C	12/232 3/232	AIR	✓	90		210 210	100 200	13:12 13:21	13:19 14:32	71	6.9	-	-		01:40	GB
JASON	DRAKE A ISLAND	15/232 3/232	AIR	✓	110		240 30	190 30	15:19	16:14	55	3.6	-	-			GB
SEAN	DRAKE A ISLAND	12/232 0/232	AIR	✓	110		230 210	150 200	15:19	16:14	55	3.6	-	-			GB

Supervisors (sign/date): 15/7/09. 15/7/09.

DIVING OPERATIONS DAILY LOG SHEET

Sea-Scope
Marine Environmental Consultants

Project: Plymouth Sound seagrass diving survey, July 2009 | **Job No.** SS-0907-050 | **Date:** 16 JULY 2009

Name	Site Name	Pre-dive checks: Tanks (wp/wc)	Pre-dive checks: % O_2	Pre-dive checks: Pre-Dive Check	Pre-dive checks: Estimated duration	Pre-dive checks: Available gas (min.)	Air: In (Bar)	Air: Out (Bar)	Duration: Leave Surface	Duration: Arrive Surface	Duration: Total Time	Depth: Max. Depth (m)	Decompression: For time: mins	Decompression: At depth: m	Decompression: S or R	Decompression: De-sat. time	Supervisor's Initials
SEAN	Drakes Is B	12/232 3/232	AIR	✓	65		230 200	160 200	09:58	10:39	40	5.6m				20:20	RI
JASON	Drakes Is B	15/232 3/232	AIR	✓	65		180 190	140 180	09:58	10:39	41	5.6m				20:18	RI
KEVAN	Cellars Cove A	7/300 7/300	AIR	✓	90		300 300	120 300	11:35	12:41	64	5.7				00:53	SL
CHRIS	Cellars Cove A	15/232 3/232	AIR	✓	90		215 220	130 210	11:35	12:41	66	5.7				00:53	SL
ROBERT	Cellars Cove B	7/~~200~~ 253 7/~~300~~	AIR	✓	90		220 220	140 220	11:56	13:06	69	6.1				~~00:53~~	SL
DOMINIC	Cellars Cove B	12/232 3/232	AIR	✓	90		200 200	80 200	11:56	13:06	69	5.8				~~00:53~~ 22:06	SL
SEAN	Cellars Cove C	12/232 3/232	AIR	✓	90		160 200	100 200	13:50	14:37	47	6.0				04:55	RI
JASON	Cellars Cove C	15/232 3/232	AIR	✓	90		140 180	80 170	13:50	14:37	47	5.9				04:~~55~~	RI
KEVAN	DRAKE'S IS. C	7/300 7/300	AIR	✓	90		130 280	130 140	15:28	16:27	58	4.3				06:50	RI
CHRIS	DRAKE'S IS. C	15/232 3/232	AIR	✓	90		120 220	50 220	15:28	16:27	58	4.2				06:49	RI
ROBERT																	
DOMINIC																	

Supervisors (sign/date): R Alp 16/7/09

SS/October 2003

DIVING OPERATIONS DAILY LOG SHEET

Sea-Scope
Marine Environmental Consultants

Project: Plymouth Sound seagrass diving survey, July 2009 | **Job No.** SS-0907-050 | **Date:** 17 JULY 2009

	Name	Site Name	Pre-dive checks: Tanks (vp/wc)	Pre-dive checks: % O_2	Pre-Dive Check	Pre-dive checks: Estimated duration	Pre-dive checks: Available gas (min.)	Air: In (Bar)	Air: Out (Bar)	Duration: Leave Surface	Duration: Arrive Surface	Duration: Total Time	Depth: Max. Depth (m)	Decompression: For (time: mins)	Decompression: At (depth: m)	Decompression: S or R	Decompression: De-sat. time	Supervisor's Initials
Camera	CHRIS	RCN A	12/232 3/232	AIR	✓	70		215 220	150 220	11:16	11:55	38	6.5					RI
	SEAN	RCN A	12/232 3/232	AIR	✓	70		240 190	170 190	11:16	11:55	38	6.5				20:23	RI
	GAVIN	RCS B	12/232 3/232	AIR	✓	70		200 170	70 170	11:41	12:54	78	6.2				00:12	RI/S
Camera	DOMINIC	RCS B	10/232 3/232	AIR	✓	70		230 200	60 200	11:41	12:54	78	6.2				18:51	RI/S
	ROBERT	RCS C	7/232 7/232	AIR	✓	70		220 220	150 150	12:23	13:26	61	6.3				21:36	SL
Camera	JASON	RCS C	12/232 3/232	AIR	✓	70		170 180	100 180	12:23	13:26	61	6.5				01:00	SL
	ROBERT	RCS B	7/232 7/232	AIR				150 150										
	JASON	RCS B	12/232 3/232	AIR				100 180										
	GAVIN	RCS B	12/232 3/232	AIR	✓	70		208 170	127 170	14:08	14:53	43	5.9					S
Camera	DOMINIC	RCS B	12/232 3/232	AIR	✓	70		215 220	120 200	14:08	14:53	43	5.9					S

Supervisors (sign/date): 17/7/09 17-7-09

SS/October 2003

Further information

Natural England evidence can be downloaded from our **Access to Evidence Catalogue**. For more information about Natural England and our work see **Gov.UK**. For any queries contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk**.

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