Natural England Commissioned Report NECR294

Seagrass condition monitoring in Plymouth Sound and Estuaries SAC 2018

First published May 2020

www.gov.uk/natural-england

NATURAL ENGLAND

Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

Plymouth Sound and Estuaries Special Area of Conservation (SAC) is an inshore site which was designated in 2005 for a range of features including subtidal seagrass beds. This report was commissioned to provide a report on condition monitoring of subtidal seagrass within the site undertaken by Natural England and the Environment Agency in 2018. It will be used in the condition assessment for the site and to support management measures as necessary.

This report should be cited as: BUNKER, F. St. P. D. and GREEN, B. 2019. *Seagrass condition monitoring in Plymouth Sound and Estuaries SAC 2018*. Natural England Commissioned Reports, Number294.

.

Natural England Project Manager – Angela Gall, Lead Marine Advisor, angela.gall@naturalengland.org.uk

Contractor – Francis Bunker

Keywords – Marine, Seagrass, Condition, Diving, Drop down video.

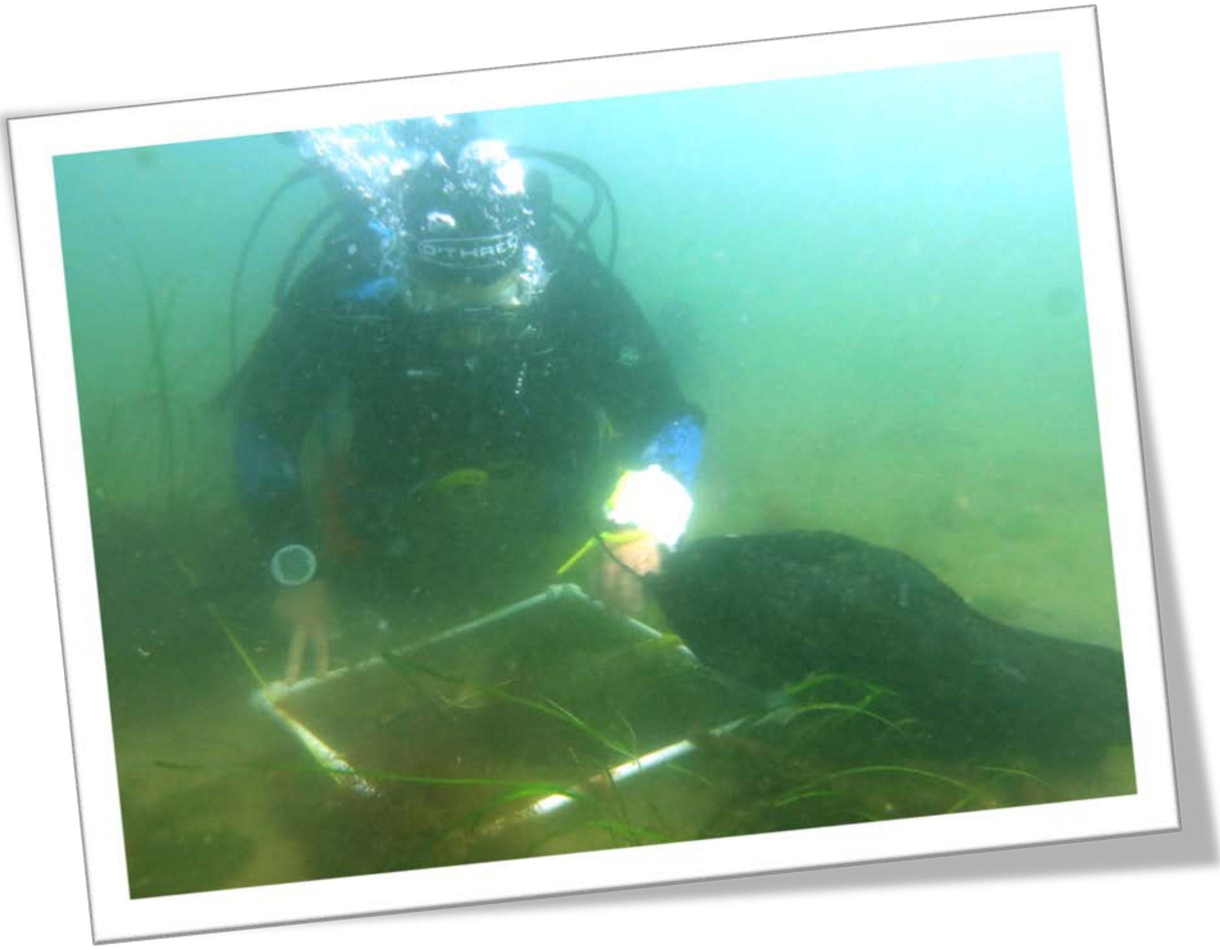
Further information
This report can be downloaded from the Natural England Access to Evidence Catalogue: **http://publications.naturalengland.org.uk/** . For information on Natural England publications contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk**.

ISBN 978-1-78354-620-6

Seagrass condition monitoring in Plymouth Sound and Estuaries SAC 2018

A report to Natural England by Menia Ltd.

Author: Francis Bunker & Benjamin Green
Client: Angela Gall, Natural England



Bunker, F. St. P. D. and Green, B. 2019. Seagrass condition monitoring in Plymouth Sound and Estuaries SAC. A report to Natural England from Menia Ltd.

Table of contents

Synopsis

A survey was convened in by Natural England (NE) in 2018 to assess the condition of the seagrass *Zostera marina* in Plymouth Sound and Estuaries Special Area of Conservation (SAC). This survey used a combination of Drop Down Video (DDV) techniques as well as *in situ* studies by divers.

The 2018 survey followed up on a baseline survey undertaken in 2012 (Curtis, 2012).

The DDV survey measured the extent and abundance of seagrass at Cawsand Bay, Drake's Island, Cellar's Cove, Red Cove, Tomb Rock, Jennycliff North, Jennycliff South and Firestone Bay. The diver survey studied density and collected seagrass samples for further analysis in four of these beds; Cawsand Bay, Drake's Island, Cellar's Cove and Red Cove.

The results of the DDV survey indicated that the extent and abundance of all the seagrass beds studied in Plymouth Sound and Estuaries SAC in 2018 has shown a decrease compared to 2012 apart from Cawsand Bay where there has been an increase. Confidence in the comparison between years is low due to changes in methodologies between years and the poor sea conditions and equipment failures encountered in 2012 (Curtis, 2012).

The results of *in situ* studies by divers showed that Cawsand Bay had the lowest densities of the four study beds but that it appears to have more than doubled in 2018 whereas the density of the Drake's Island bed appears to have fallen. These changes in Cawsand Bay and Drake's Island follow the same trend as shown by the DDV studies.

Infection by the 'wasting disease' causing fungus *Labyrinthula zosterae* is present in all four seagrass beds where samples were taken but no great increases were in the incidence and severity of *L. zosterae* were found in the current survey. Despite this, the continued monitoring of *L. zosterae* is useful in case of changes of condition that could result in this currently benign pathogen becoming virulent.

None of the seagrass beds studied in 2018 were so festooned by epiphytes (including micro and macro algae) that they could be considered to be having a deleterious effect on seagrass health.

The survey methodologies currently employed together with ideas for improving them going forward are presented in section 4.1. In particular, a revision of the diving methodology, changing from transect based surveys to one of stratified random sampling within the seagrass beds would provide results on density with more statistical power.

1 Introduction

The Habitats Directive (European Commision, 1994) establishes that the management of Special Areas of Conservation (SACs) should aim to achieve the *favourable conservation status* of habitat and species features. In the case of SACs, the features are the habitats and/or species listed in Annex I and Annex II of the Habitats Directive for which the individual site has been selected.

Plymouth Sound and Estuaries Special Area of Conservation (SAC), on the south-west coast of England includes the following Annex 1 habitats (European Commision, 1994) that are a primary reason for selection of this site:

- Sandbanks which are slightly covered by seawater all the time.
- Estuaries
- Large shallow inlets and bays
- Reefs
- Atlantic salt meadows (Glauco-Puccinellietalia maritimae)

Plymouth Sound and Estuaries SAC has extensive areas of sublittoral sandbanks, which consist of a range of sandy sediments within the inlet and on the open coast. These sediments include tide-swept sandy banks in estuarine habitats, sandy muds north of the Breakwater, muddy sands in Jennycliff Bay, fine sands with eelgrass *Zostera marina* and a rich associated flora and fauna in the Yealm entrance, as well as tide-swept sandy sediments with associated hard substrates colonised by distinctive communities of algae and invertebrates.

Sub-tidal *Zostera marina* is known to occur at the mouth of the River Yealm (Cellars Cove and Red Cove, and to a lesser extent, off Tomb Rock). In Plymouth Sound itself, the main beds are at Cawsand Bay and Drake's Island with smaller beds off Firestone Bay and Jennycliff Bay (Curtis, 2012). *Zostera noltei* is known from the intertidal but this is not part of the Annex 1 Sandbanks habitat. A map showing the positions of known *Zostera marina* beds in Plymouth Sound and Estuaries SAC is given in Figure 1.

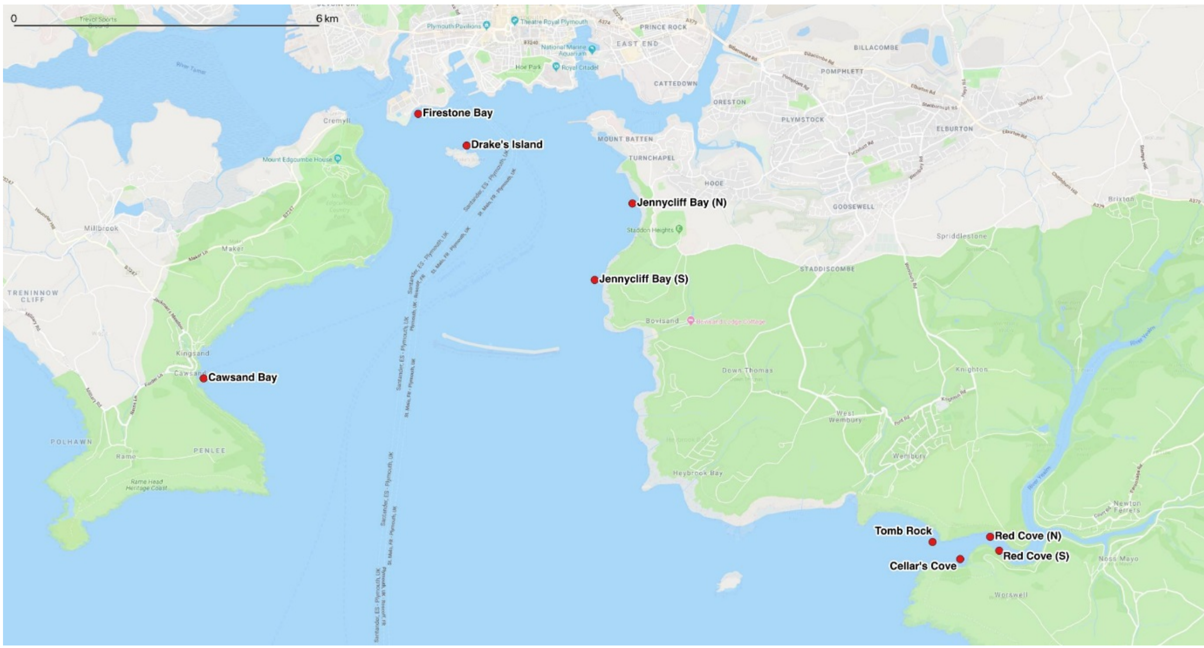


Figure 1 Map showing the location of known seagrass beds in Plymouth Sound and Estuaries SAC

Natural England (NE) has a statutory duty to produce advice under Regulation 35 of The Conservation of Habitats and Species Regulations 2010, which is the foundation for *feature condition monitoring*, which is required in order for NE to fulfil its function of reporting on whether features are in favourable conservation status.

This survey was convened to gather evidence from which NE can assess the condition of the seagrass *Zostera marina* in Plymouth Sound and Estuaries Special Area of Conservation (SAC).

1.1 Aims and objectives

There were aims and objectives of the 2019 survey work were as follows:

Aim 1
To check the extent and health of the seagrass against baseline of surveys which were undertaken in 2012 (Curtis, 2012).

Objective 1
To carry out drop-down video surveys on the known seagrass beds of Plymouth Sound and Estuaries SAC in order to map the extent and density of seagrass.

Objective 2
To undertake *in situ* surveys by divers to obtain data along a series of 50 m transects on the following:

- Density determination
- Presence of macro algae
- Collection of samples of seagrass plants for measurement of length, infection by the fungus *Labyrinthula zosterae*, colonisation by epiphytes, presence of eggs on leaves and incidence of flowering plants.

Aim 2
To provide baseline data on the area of moorings in Cawsand Bay that overlaps with seagrass beds. This is to provide site specific evidence of mooring damage and to act as a baseline when Advanced Mooring Systems are put in under a new project that is planned for that bay.

Objective 1
To undertake *in situ* surveys by divers based on the methodology of Unsworth et al. (2017) to examine effects of moorings on seagrass.

1.2 Historical data

The most recent condition monitoring of seagrass in Plymouth Sound and Estuaries SAC was given by (Curtis, 2012). This report contains the results of the 2012 survey and provides a useful summary of previous seagrass surveys in the area by Bugg (2004), Irving et al. (2007) and Irving (2010).

The 2012 survey described by Curtis (2012) used new methodologies which made quantitative comparisons with previous work impossible but NE decided to use these new methodologies going forward and treat the 2012 survey as baseline. The Curtis (2012) report considered the condition of the seagrass beds of the SAC to be ‘favourable’.

In 2016 NE revised the way in which the condition of Marine Protected Areas is assessed. In the current condition assessment for Plymouth Sound and Estuaries (https://designatedsites.naturalengland.org.uk/Marine/MarineFeatureCondition.aspx?SiteCo de=UK0013111&SiteName=plymouth sound&SiteNameDisplay=Plymouth+Sound+and+Estuaries+SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=) subtidal seagrass is assessed as in 'unfavourable condition' owing to pressures caused by mooring and anchoring. This is based on evidence from recent studies (Griffiths et al., 2017, Unsworth et al., 2017) which have examined the impact of mooring and anchoring in seagrass beds. Within Plymouth Sound and Estuaries SAC levels of these activities are known to be high and to occur within known areas of subtidal seagrass (particularly Cawsand Bay and Cellar's Cove).

The following are extracts from a report from Angela Gall (Lead Advisor Devon, Cornwall and Isles of Scilly Area Team) to the Tamar Estuaries Consultative Forum and Yealm Estuary Management Forum in April 2018:

"Unsworth et al. (2017) studied a range of sites in England where mooring occurs on seagrass *(Zostera marina*) and quantified the area of damage to seagrass caused by chain scour from swinging moorings. The authors found that the average area affected was 122 m^2 per individual swinging mooring. This study has also shown that loss of UK seagrass beds from boat moorings is 'small but significant at a local scale' and that this loss fragments existing meadows, 'ultimately reducing their resilience to other stressors'. Other stressors that may be impacting this feature; namely sediment surface contaminants, aqueous contaminants and invasive, non-native species, as well as significant disturbance from anchoring."

"Griffiths et al. (2017) identified Plymouth Sound and Estuaries SAC as one of the SACs most at risk from anchoring and mooring pressures. They ranked the site 9th out of 173 for exposure to anchoring. The site was considered to be at risk, with designated habitats (namely seagrass beds) considered 'at high risk based on the worst-case abrasion/disturbance pressure'."

"In summary, the condition of subtidal seagrass beds within the site is now considered to be 'unfavourable' and therefore a conservation objective of 'restore to favourable condition' should be applied. **This instigates the requirement for management, and we will be working with the relevant authorities to address what measures might be put in place to allow recovery of this feature.** It may also be necessary to subsequently revisit the condition assessments for the supporting habitat features."

In order to provide site specific evidence to support the condition assessment this current study was designed to include an element of surveying seagrass beds in the vicinity of moorings.

2 Methods

Methods for each of different elements of the survey are described below.

2.1 Environment Agency (EA) drop down video (DDV)

The following data files accompany this part of the work and are held by Natural England:

- Plymouth_PhotoLog_20180716.xlsx
- Zostera data from DDV.xlsx

The EA's Estuarine and Coastal Monitoring and Assessment Service (ECMAS) are currently undertaking drop down camera surveys to specifically monitor subtidal seagrass (*Zostera marina*) beds, both for Natural England and eventually to form part of a Water Framework Directive (WFD) subtidal seagrass programme.

These surveys collect hundreds of still images that will require interpretation in order to create habitat maps and undertake condition assessments. The aim is for this to be a quick process that requires as little post-processing as possible.

The surveys use a GoPro camera system attached to a 1 m^2 photo-quadrat. At each station, the quadrat is dropped and a still image is captured. Stations are normally on a grid, around 20 - 50 m apart.

All the photos should be placed in a PowerPoint photo album and each photo is a separate PowerPoint slide. Each photo has its own unique ID code (normally GOPR xxxx). This code matches to the correct row in **Column C** on the accompanying survey image analysis spreadsheet (Plymouth_PhotoLog_20180716.xlsx), where all the details of the image assessment are logged.

Each column in yellow in the spreadsheet is a different piece of information to be filled in:

- Visibility
- Seagrass percentage cover
- Kelp percentage cover
- Macroalgae percentage cover
- *Sargassum muticum* percentage cover
- Substrate type
- Litter
- Additional information

2.1.1 Quality Assurance

The methods followed for seagrass assessment following the recommendations of the North East Atlantic Marine Biological Analytical Quality Control Scheme (NMBAQC). Following completion of the analysis, 10% of the images (randomly selected) will be reassessed for consistency and the results compared.

Examples of how the photographs are analysed with examples are given in the 2018 report by the Environment Agency (Environment Agency, 2018).

2.1.2 Data analysis

The DDV data was analysed using tools in Excel and is contained in the file:

- Zostera data from DDV.xlsx

Contour maps showing the distribution and abundance of seagrass at each study site were created using QGIS 3.4.5. The GIS data files have been presented to NE as ArcGIS shape files.

2.2 Diver transect methodology

Data files with the results from the diver transect work and leaf analysis data are contained in the following file held by NE:

- MASTER Seagrass data Plymouth 2018.xlsx

The NE dive team carried out their survey of the SAC seagrass beds between 23rd and 26th July 2018 and study transects were undertaken on these seagrass beds (see Figure 1):

- Cawsand Bay (July 23rd)
- Drake's Island (July 26th)
- Cellar's Cove (July 24th)
- Red Cove South (July 24th)

The diving was carried out in accordance with the Diving at Work Regulations, 1997; Scientific and archaeological diving projects Approved Code of Practice (HSE, 2014) and the Countryside Agency Diving Rules (Holt, 2015). The divers used air with standard SCUBA equipment. Divers worked in pairs with one diver having a permanently inflated surface marker buoy (SMB) and each diver carrying a delayed surface marker buoy (DSMB) for use in case of separation. Each diver also carried a communications unit allowing for voice communication from the surface and signalling to the surface from the divers.

The Category 2 MCA registered charter boat *Venture* skippered by Pete Fergus (and based in Sutton Harbour) transported the divers and acted as the cover vessel.

The following permissions to dive were obtained:

- Permit from the Queen's Harbour Master Plymouth to carry out the survey.
- Permission to dive were secured daily by the skipper from Queen's Harbour Master Plymouth and from the Yealm Harbour Authorities for sites in the Yealm estuary.

The NE dive team was as follows:

Diving Project Manager:	Laura Gannon, Natural England
Dive Supervisors:	Angela Gall (AG), Gavin Black (GB) and Chris Pirie (CP) (all NE staff)
Divers / standby divers:	Angela Gall (AG), Gavin Black (GB), Rebecca Korda (RK), Jenny Murray (JM), Chris Pirie (CP), Carolyn Waddell (CW), Georgina Wright (GW) (all NE staff)
	Contractors: Francis Bunker (FB; Marine Seen) and Mark Parry (MP; National Marine Aquarium)

The methodology used was based on the diver surveys employed in 2012 and described by Curtis (2012). A series of 50 m long transect were studied within each seagrass bed.

Unfortunately, the results of the DDV survey were not available to the dive team. Because of this, the positioning of the survey transects is not always logical when viewed with the DDV maps presented in this report (see sections 3.1 and 3.2). Also, there were many factors influencing where transects were deployed including currents, position of other divers, avoiding the channel, boating traffic etc.

The transect study method is illustrated in Figure 2. A shot marker was deployed at each transect location and divers then deployed transect tapes on pre-determined compass bearings. Each diver carried a quadrat and worked together either side of the transect tape taking readings from within the quadrats every 5 m along the transect. The quadrats were placed adjacent to each other either side of the tape with the lower corner (right on the left side and left on the right) positioned on the appropriate tape mark.

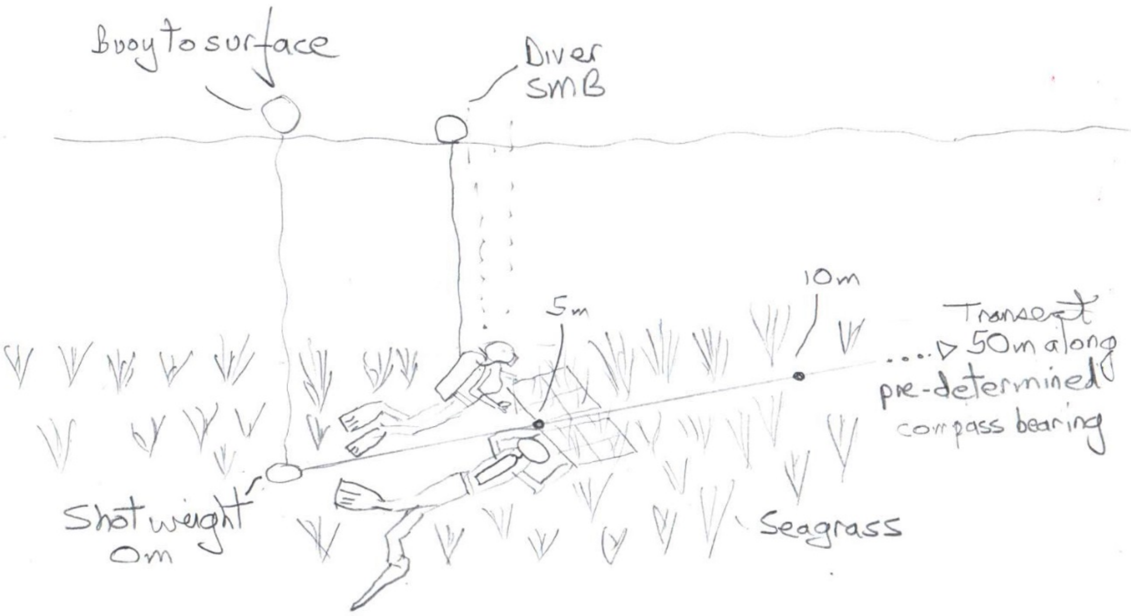


Figure 2 An illustration to show the transect study method carried out by divers

The following were recorded in each quadrat every 5 m (and a copy of the dive transect recording pro-forma is given in Appendix 1 - Dive transect recording proforma):

- Cover of *Zostera marina* using the following scale:

Table 1 Zostera marina abundance categories recorded in situ during the dive survey

Zostera abundance	**% cover category**
0 - No *Zostera* Present	0%
1 - Minimal *Zostera* Present	1-4%
2 - Up to a quarter of Quadrat contains *Zostera*	5-25%
3 - Up to half the Quadrat contains *Zostera*	26-50%
4 - Over half the Quadrat contains *Zostera*	51-75%
5 - Almost all the Quadrat contains *Zostera*	76-100%

- Sediment type based on the following categories:

Table 2 Sediment categories recorded during the dive survey

Sediment Type	Code
Sand	S
Shingle / Shells	H

Rock	R
Mixed	M
Macro Algae	A

2.2.1 Quality Assurance
Prior to diving, the team were properly briefed one how to carry out the surveys and pairs of surveyors were issued with recording pro-formas (see Appendix 1 - Dive transect recording proforma). Divers also studied ‘Percentage Cover Standards’ based on photographs available from Seagrass_Watch (2018).

2.2.2 Data analysis
Analysis of the 2018 data followed Curtis (2012) in order to provide a comparison to 2012. Curtis (2012) demonstrated (statistically) how the different transects were significantly different from each other. This was because some were at the edges of the beds, others were in dense areas and others differed for other reasons e.g. moorings were present. Because of this it was concluded that quadrats between diver transects could not considered to be replicates of the same population. In order to make a statement of densities about each *Zostera* bed, a mean of means for all transects was calculated for each bed. This allowed for some comparison between the different beds.

Curtis (2012) expressed densities in term of number per m^2. As plants were counted in 0.0625 m2 in the field (in both 2012 and 2016) results were multiplied by 16 to give a density per m^2.

The range of values for the different attributes (e.g. high and low densities) were taken from the raw data at each site.

Where proportions (i.e. percentages) have been calculated, the data was arcsine transformed prior to calculation[1] (Fowler et al., 1998). The proportion data is also presented as untransformed percentages.

2.2.3 Plant collection and data recording
At 5 stations along the transect, all the *Zostera* shoots in a quarter of the quadrat (0.0625 m^2) were collected and placed in labelled bags. Whole shoots were collected by snipping them off at the base i.e. just above where they arise from the rhizome. It was important to keep enough of the plant below where the leaves emanated so the leaves remained on the plant.

Collecting and bagging *Zostera* shoots underwater can be tricky and bag management practices were carefully thought out prior to diving. Bags had to be big enough to contain folded plants up to 1 m long. The labelled bags were ‘nested’ in the correct order, with the outer one being the first one to use and so on. ‘Zip’ fastened bags were used to prevent the plants from escaping but care had to be taken not to cut the plants when closing zips. Once safely bagged, the full bags were transferred to a mesh bag for safe transporting.

Back at the survey base, the samples were processed by the team with the following being recorded:

- Presence of flowers / seeds

[1] Data suitable for calculating means and standard deviations should be normally distributed. In distributions which are proportions the left and right hand tails are truncated because all values must lie on a scale with absolute limits of 0 and 1. Arcsine transformation of the data ensures that these statistical methods can be validly applied.

- Eggs present on leaves
- Maximum length of leaves in a plant
- Infection in individual leaves by *Labyrinthula zosterae* and cover of individual leaves by epiphytes measured on the following scale:

Table 3 Scale used for recording infection of *Zostera marina leaves by Labyrinthula zosterae* and cover of leaves by epiphytes (hydroids, bryozoans, algal crusts etc.)

0 - Uninfected	0%
1 - Minimal infection apparent	0-2%
2 - Up to a quarter of leaf infected	3-25%
3 - Up to half the leaf infected	26-50%
4 - Over half all of leaf infected	51-75%
5 - Almost all of leaf inftected	76-100%

A leaf infected by *Labyrinthula zosterae* and colonised by epiphytes is shown in Figure 3.

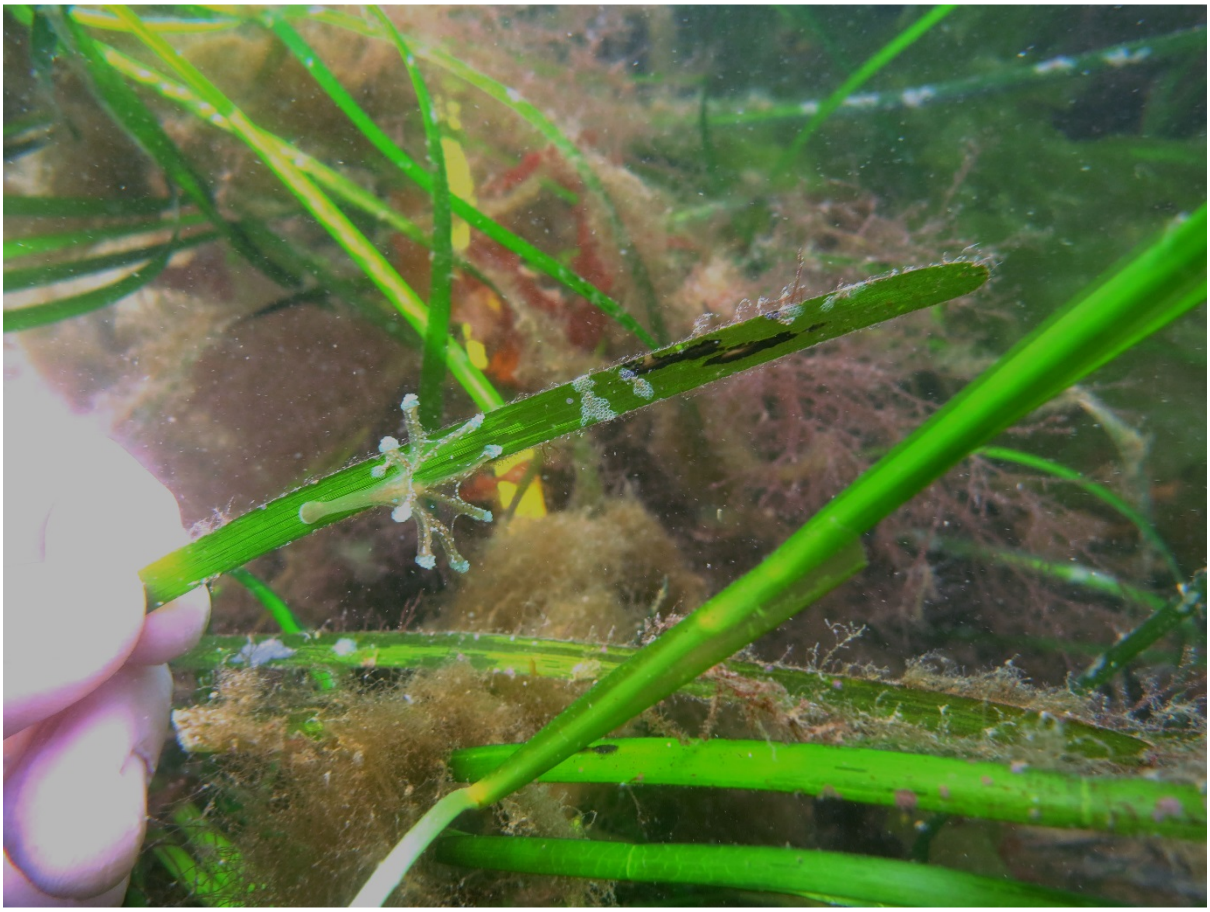


Figure 3 Zostera marina leaf showing both infection by Labyrinthula zosterae (black) and epiphytes (including a stalked jellyfish).

2.2.4 Data analysis

The data from the dive survey was analysed using tools in Excel and is contained in the file:

- MASTER Seagrass data Plymouth 2018.xlsx

2.3 Cawsand Bay mooring studies by divers

Data files with the results from the Cawsand moorings studies are contained in the following file held by NE:

- MASTER Seagrass data Plymouth 2018.xlsx

The methodology for studying possible impacts of moorings in Cawsand Bay was taken from (Unsworth et al., 2017), the difference being that divers were deployed to make *in situ* measurements rather than using a remotely deployed camera.

Boat moorings were used as central positions on the seabed and from there divers deployed a 20 m transect marked at 2 m intervals first to the north and then in turn to the other points of the compass (i.e. N, S, E and W). This gave a sampling pattern similar to Unsworth et al. (2017) as depicted in Figure 4.

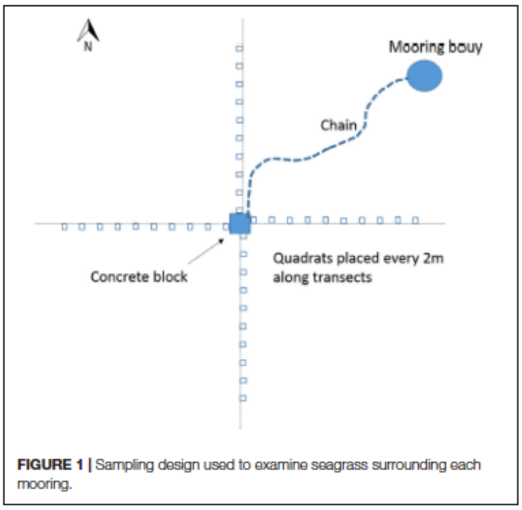


Figure 4 Sampling pattern after Unsworth et al. (2017). The difference being that divers placed quadrats at 2 m intervals either side of the transect rather than one side as shown in the diagram.

At each compass point, a diver pair swam along the transect and placed a 0.25 m^2 quadrat on either side of the transect at the mooring and then at each 2 m mark and estimated percentage cover. The results were recorded on the proforma shown in Appendix 3 – Mooring recording proforma.

Analysis of the results broadly followed the method used by Unsworth et al. (2017). The results were analysed using the analytical tools in Excel and can be seen in the file:

- MASTER Seagrass data Plymouth 2018.xlsx

3 Results

The results for each of the areas studied are now considered in turn.

3.1 Drop down video (DDV)

The results of the drop-down video studies are presented below, together with comparison with those obtained in 2012.

3.1.1 Drake's Island

A contour map showing the distribution of the density categories of *Zostera marina* in Drake's Island is shown in Figure 5.

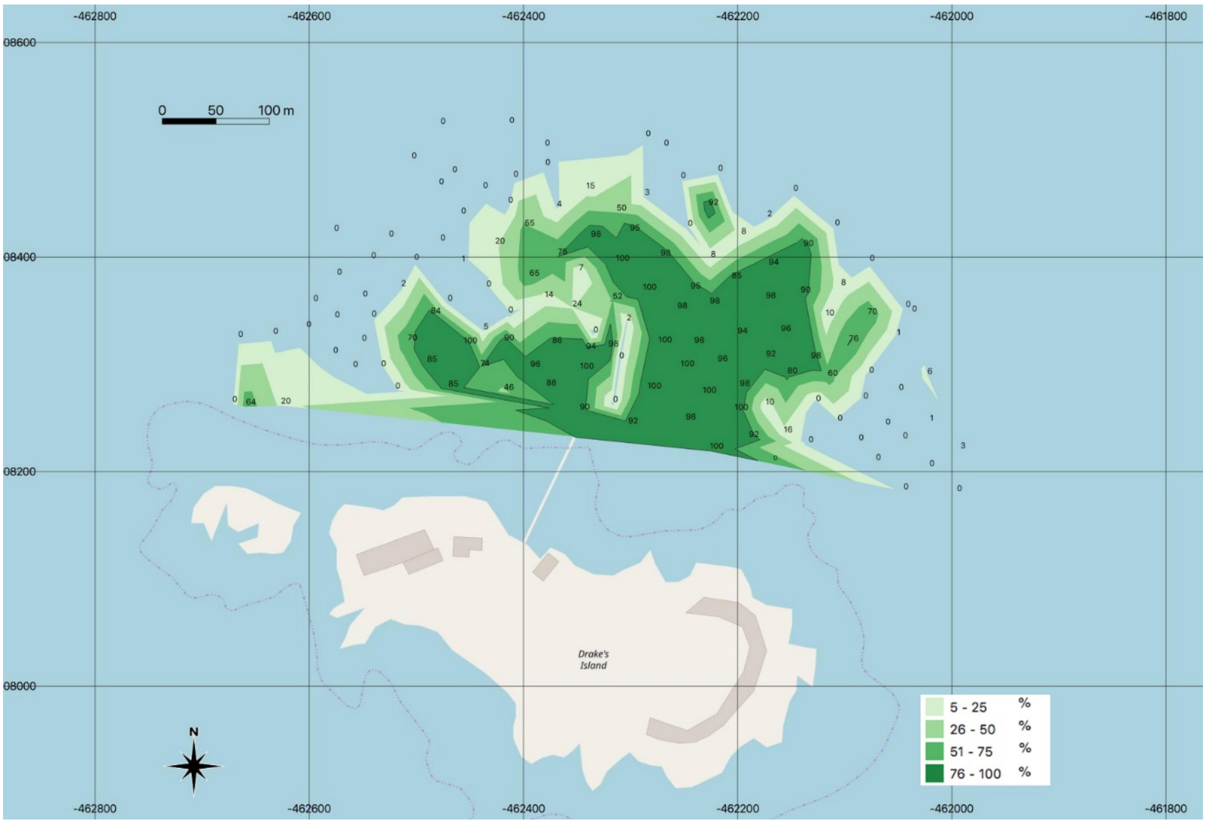


Figure 5 Contour map showing the density of Zostera marina in Drake's Island in July 2018, based on the results of drop-down video. Numbers are actual percentages recorded, colours represent percentage categories (see key on map).

The *Zostera* bed off Drake's Island is approximately 400 m long and 175 m wide (at the widest and longest points). A summary of the analyses of the DDV data is shown in Table 4 and Table 5.

Table 4 Mean percentage cover of Zostera marina in Drake's Island in 2012 and 2018 based on the results of drop-down video surveys

	Drake's Island	
	2012	**2018**
mean % cover of *Zostera marina*	72	66

Table 5 A summary of results from DDV surveys of Drake's Island in 2012 and 2018 together with the percentage change in Zostera between these years.

	Drake's Island			
	2012		2018	
Category	Area (m^2)	% of area	Area (m2)	% of area
5-25% (Very Sparse)	11,206	25.3	9,256	22.7
26-50% (Sparse)	8,713	19.7	8,732	21.4
51-75% (Moderate)	11,785	26.7	7,977	19.6
76-100% (Dense)	12,503	28.3	14,769	36.3
Total (5-100 %)	**44,207**	**100.0**	**40,734**	**100.0**
Change in area with *Zostera marina* > 5% cover			**- 8%**	

A comparison of the data between 2012 and 2018 shows a decrease in the area of *Zostera* bed of 8% (see Table 5 and Figure 6).

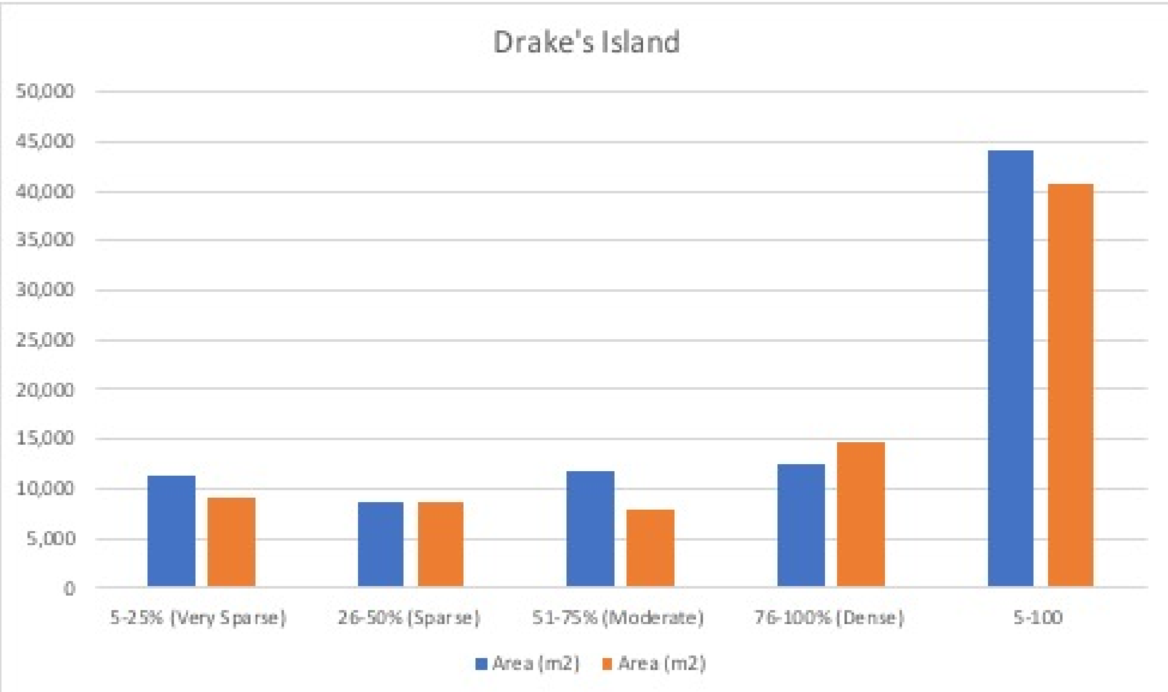


Figure 6 Graph to show changes in density of seagrass off Drake's Island between 2012 and 2018 based on the results of DDV surveys

3.1.2 Cawsand Bay

A contour map showing the distribution of the density categories of *Zostera marina* in Cawsand Bay are shown in Figure 7.

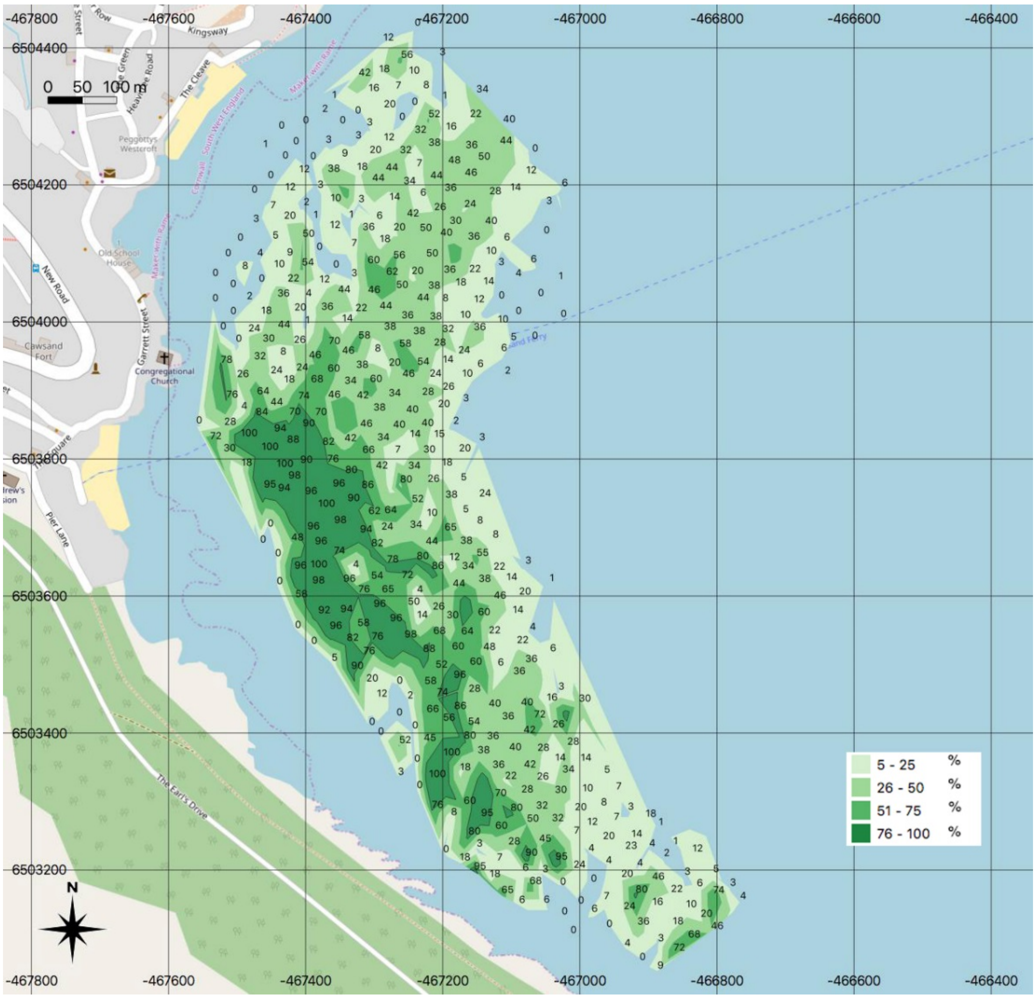


Figure 7 Contour map showing the density of Zostera marina in Cawsand Bay in July 2018, based on the results of drop down video. Numbers are actual percentages recorded, colours represent percentage categories (see key on map).

The *Zostera* bed in Cawsand Bay is approximately 900 m long and 300 m wide (at the widest point). The densest area of the bed is on the western side in shallow water and it becomes less dense to the east (and deeper water). A summary of the analyses of the DDV data is shown in Table 6 and Table 7.

Table 6 Mean percentage cover of Zostera marina in Cawsand Bay in 2012 and 2018 based on the results of drop-down video surveys.

	Cawsand Bay	
	2012	**2018**
mean % cover of *Zostera marina*	30	59

Table 7 A summary of results from DDV surveys of Cawsand Bay in 2012 and 2018 together with the percentage change in Zostera between these years.

	Cawsand Bay			
	2012		2018	
Category	**Area (m^2)**	**% of area**	**Area (m^2)**	**% of area**
5-25% (Very Sparse)	72,541	60.6	77,622	41.7
26-50% (Sparse)	29,560	24.7	63,097	33.9
51-75% (Moderate)	17,141	14.3	26,129	14.0
76-100% (Dense)	497	0.4	19,366	10.4
Total (5-100 %)	**119,739**	**100.0**	**186,214**	**100.0**
Change in area with *Zostera marina* > 5% cover			**+ 56%**	

A comparison of the data between 2012 and 2018 shows an increase area of *Zostera* bed of 56%, with an increase cover of all higher percentage categories (Table 7 and Figure 8).

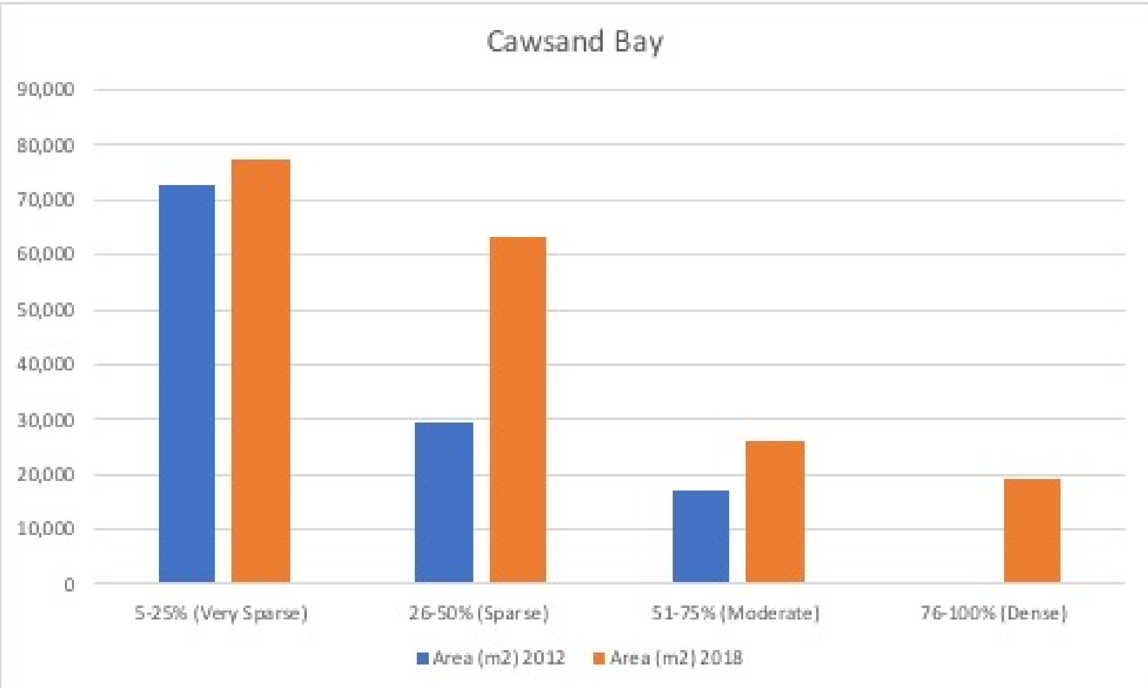


Figure 8 Graph to show changes in density of seagrass in Cawsand Bay between 2012 and 2018 based on the results of DDV surveys

3.1.3 Cellar's Cove

A contour map showing the distribution of the density categories of *Zostera marina* in Cellar's Cove is shown in Figure 9.

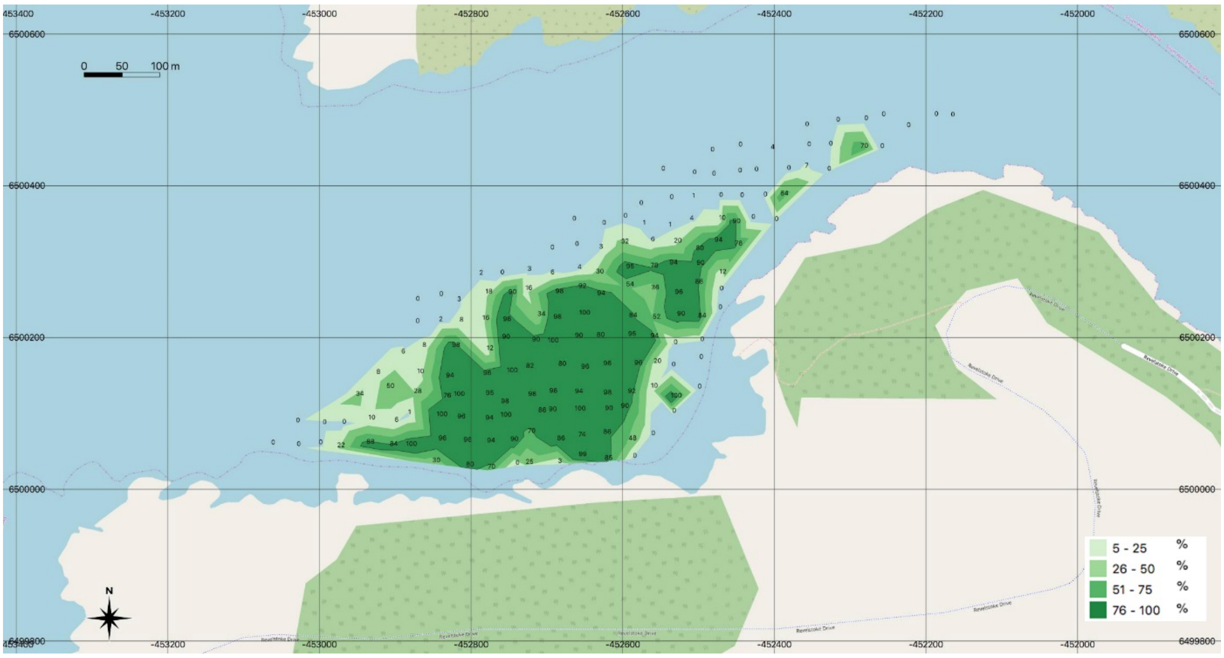


Figure 9 Contour map showing the density of Zostera marina off Cellar's Cove in July 2018, based on the results of drop-down video. Numbers are actual percentages recorded, colours represent percentage categories (see key on map).

The *Zostera* bed in Cellar's Cove is approximately 440 m long and 200 m wide (at the widest point). A summary of the analyses of the DDV data is shown in Table 8 and Table 9.

Table 8 Mean percentage cover of Zostera marina in Cellar's Cove in 2012 and 2018 based on the results of drop-down video surveys.

	Cellar's Cove	
	2012	**2018**
mean % cover of *Zostera marina*	74	69

Table 9 A summary of results from DDV surveys of Cellar's Cove in 2012 and 2018 together with the percentage change in Zostera between these years.

	Cellar's Cove			
	2012		2018	
Category	Area (m^2)	% of area	Area (m^2)	% of area
5-25% (Very Sparse)	7,673	13.5	9,921	21.0
26-50% (Sparse)	6,585	11.6	7,940	16.8
51-75% (Moderate)	12,936	22.7	7,898	16.7
76-100% (Dense)	29,815	52.3	21,587	45.6
Total (5-100 %)	**57,009**	**100.0**	**47,346**	**100.0**
Change in area with *Zostera marina* > 5% cover			**- 17%**	

A comparison of the data between 2012 and 2018 shows a decrease in area of *Zostera* bed of 17%, with a decrease in the proportion of higher percentage categories (Table 9 and Figure 10).

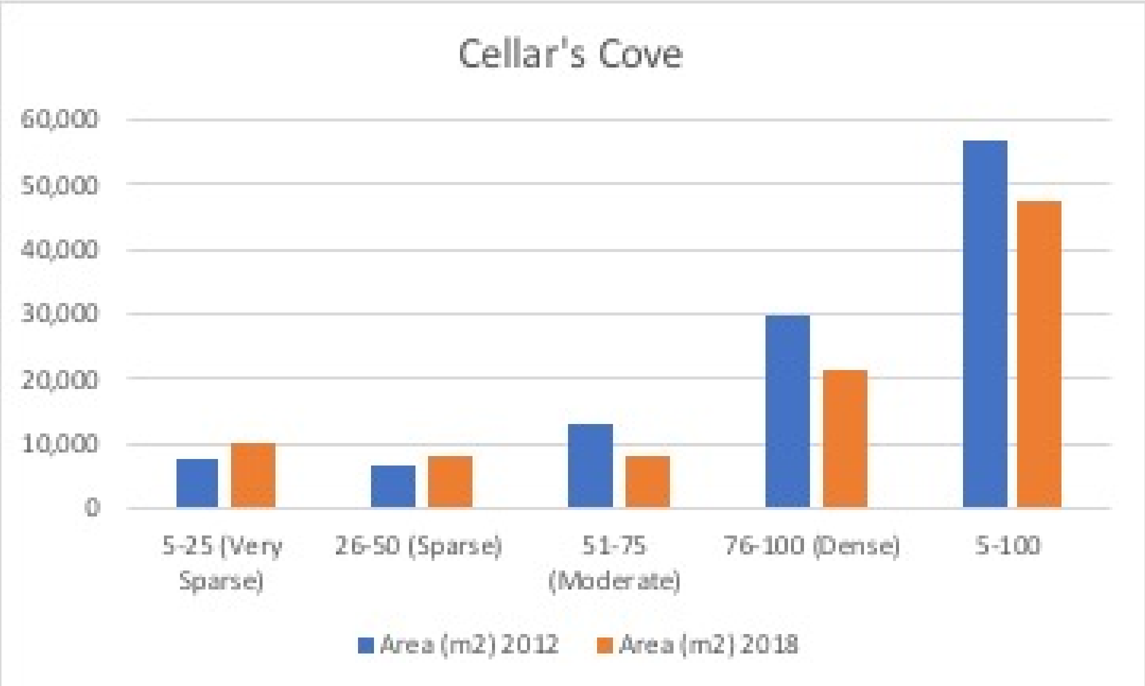


Figure 10 Graph to show changes in density of seagrass in Cellar's Cove between 2012 and 2018 based on the results of DDV surveys

3.1.4 Red Cove

The 2012 DDV survey separated Red Cove into north and south areas and provided different maps and statistics for each. In 2018, Red Cove south was surveyed but only the eastern part of Red Cove north.

A map showing the results of the 2018 survey is given in Figure 11.

Figure 11 Contour map showing the density of Zostera marina off Red Cove in July 2018, based on the results of drop-down video. Numbers are actual percentages recorded, colours represent percentage categories (see key on map).

Figures for the cover and densities of *Zostera* recorded in 2012 and 2018 are given in Table 10 and Table 11.

Table 10 Mean percentage cover of Zostera marina off Red Cove in 2012 and 2018 based on the results of drop-down video surveys.

	Red Cove South		Red Cove North	Red Cove North (eastern part only)
	2012	2018	2012	2018
mean % cover of *Zostera marina*	80	55	77	46

The area of seagrass bed at Red Cove South is virtually unchanged in area since 2012 (with an increase of 1%) but the mean percentage cover shows a decline. The areas of seagrass bed for Red Cove North cannot be directly compared as different regions were surveyed, however, the results show a decline of mean cover between 2012 and 2018.

Table 11 A summary of results from DDV surveys of Red Cove in 2012 and 2018. Due to the low number of records of 'Moderate' Zostera cover in 2018 and their scattered distribution, the GIS would not draw polygons for this category from which area could be calculated. For this reason, the Moderate and Dense categories have been combined in 2018.

	Red Cove North				Red Cove South			
	North 2012 (whole)		North 2018 (eastern part only)		South - 2012		South - 2018	
Category	Area (m²)	% of area	Area (m²)	% of area	Area (m²)	% of area	Area (m²)	% of area
5-25% (Very Sparse)	6,050	23.1	3,154	49	2,920	25.5	2,585	22.3
26-50% (Sparse)	5,470	20.9	1,841	29	2,823	24.7	2,624	22.7
51-75% (Moderate)	5,874	22.4	1,259	20	5,704	49.8	6,363	55.0
76-100% (Dense)	8,794	33.6	147	2				
Total (5-100 %)	**26,188**	**100.0**	**6,401**	**100.0**	**11,447**	**100.0**	**11,572**	**100.0**
Change in area with *Zostera marina* > 5% cover	**Unknown**				**+1%**			

3.1.5 Tomb Rock

A map showing the results of the 2018 survey is given in Figure 12.

Figure 12 Contour map showing the density of Zostera marina off Tomb Rock in July 2018, based on the results of a drop-down video survey. Numbers are actual percentages recorded, colours represent percentage categories (see key on map).

Figures for the cover and densities of *Zostera* recorded in 2012 and 2018 are given in Table 12 and Table 13.

Table 12 Mean percentage cover of Zostera marina off Tomb Rock in 2012 and 2018 based on the results of drop-down video surveys.

	Tomb Rock	
	2012	2018
mean % cover of *Zostera marina*	19	11

Table 13 A summary of results from DDV surveys of Tomb Rock in 2012 and 2018.

	Tomb Rock			
	2012		2018	
Category	**Area (m²)**	**% of area**	**Area (m²)**	**% of area**
5-25% (Very Sparse)	55,423	84	13,776	100
26-50% (Sparse)	10,083	15	4	0
51-75% (Moderate)	815	1	0	0
76-100% (Dense)	0	0	0	0
Total (5-100 %)	**66,321**	**100**	**13,780**	**100**
Change in area with *Zostera marina* > 5% cover			**Unknown**	

A comparison of areas between 2012 and 2018 is not possible as the 2018 did not study the whole extent of the Zostera bed. The density results do show a decrease in cover between the years (Table 12 and Table 13).

3.1.6 Jennycliff North

A map showing the results of the 2018 survey is given in Figure 13.

Figure 13 Contour map showing the density of Zostera marina off Jennycliff North in July 2018, based on the results of a drop-down video survey. Numbers are actual percentages recorded, colours represent percentage categories (see key on map).

Figures for the cover and densities of *Zostera* recorded in 2012 and 2018 are given in Table 14, although the figures for each of these years are based on a single record in this area. The record from 2018 is of a much lower density than that recorded in 2012.

Table 14 Mean percentage cover of Zostera marina off Jennycliff North in 2012 and 2018 based on the results of drop-down video surveys.

	Jennycliff North	
	2012	**2018**
mean % cover of *Zostera marina*	70	6

3.1.7 Jennycliff South

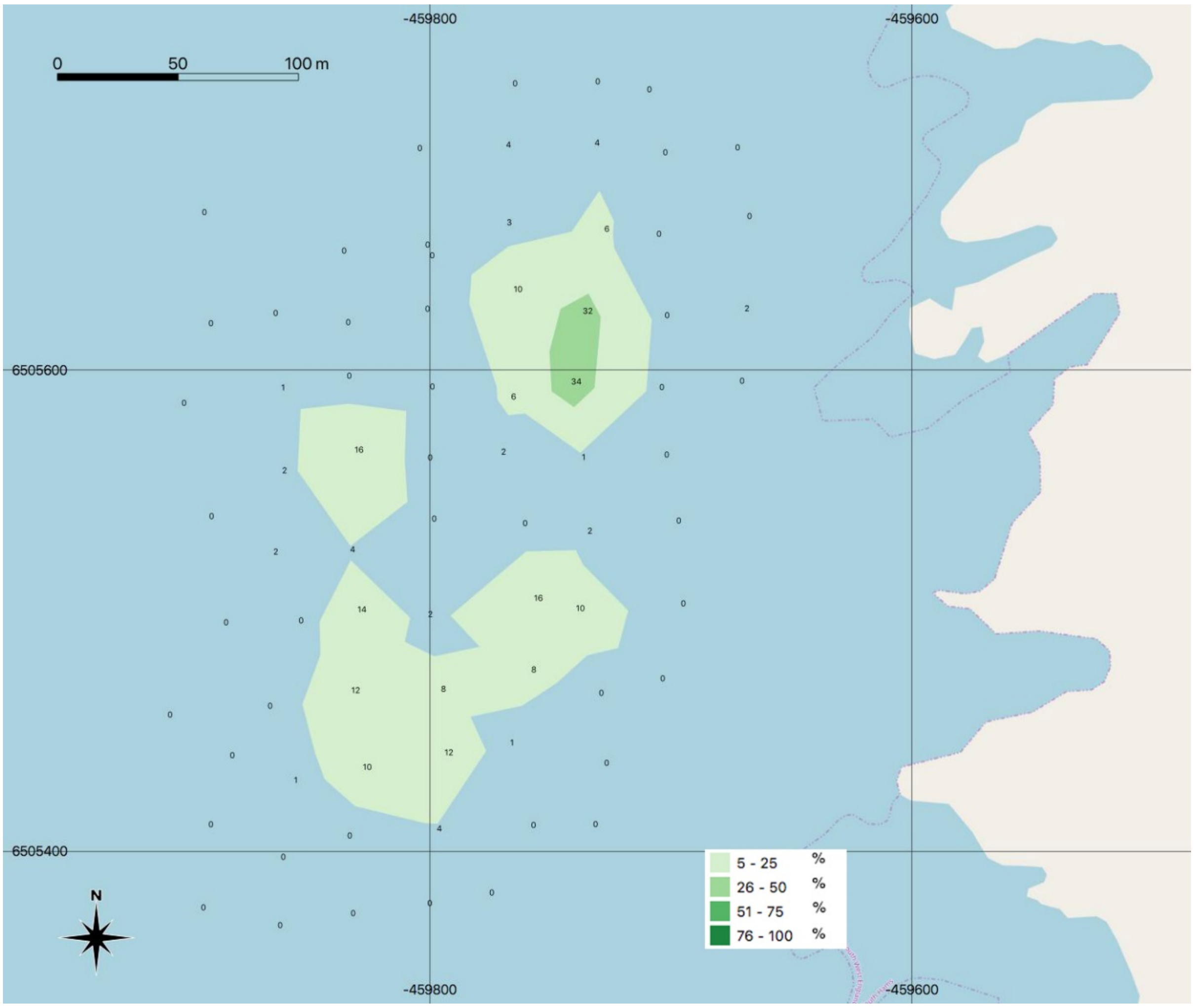


Figure 14 Contour map showing the density of Zostera marina off Jennycliff South in July 2018, based on the results of a drop down video survey. Numbers are actual percentages recorded, colours represent percentage categories (see key on map).

Figures for the cover and densities of *Zostera* recorded in 2012 and 2018 are given in Table 15 and Table 16.

Table 15 Mean percentage cover of Zostera marina off Jennycliff South in 2012 and 2018 based on the results of drop down video surveys.

	Jennycliff South	
	2012	**2018**
mean % cover of *Zostera marina*	21	14

Table 16 A summary of results from DDV surveys of Jennycliff South in 2012 and 2018 together with the percentage change in Zostera between these years.

Jennycliff South				
	2012		2018	
Category	Area (m^2)	% of area	Area (m^2)	% of area
5-25% (Very Sparse)	13,554	94.3	6,028	95.3
26-50% (Sparse)	768	5.3	299	4.7
51-75% (Moderate)	56	0.4	0	0.0
76-100% (Dense)	0	0.0	0	0.0
Total (5-100 %)	**14,378**	**100.0**	**6,327**	**100.0**
Change in area with *Zostera marina* > 5% cover			**- 56 %**	

A comparison of the data between 2012 and 2018 shows a decrease in area of *Zostera* of 56 % in this sparse bed, with a slight decrease in all percentage categories (Table 15, Table 16 and Figure 15).

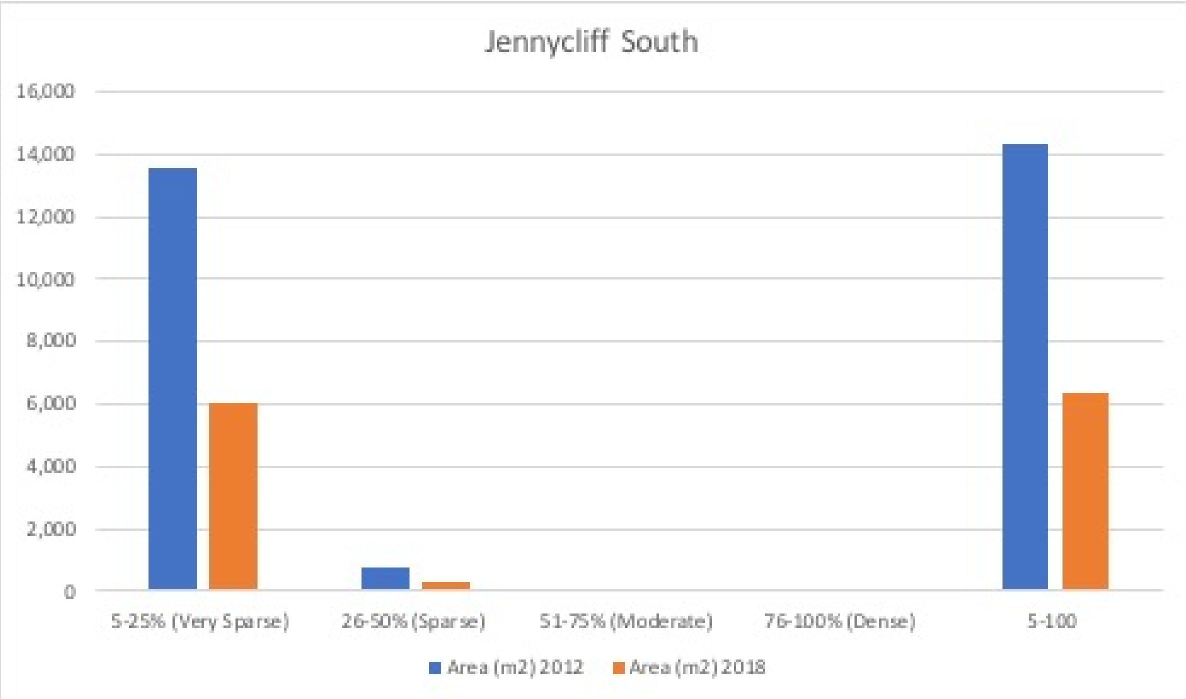


Figure 15 Graph to show changes in density of seagrass of Jennycliff South between 2012 and 2018 based on the results of DDV surveys

3.1.8 Firestone Bay

Figure 16 Contour map showing the density of Zostera marina off Firestone Bay in July 2018, based on the results of drop-down video. Numbers are actual percentages recorded, colours represent percentage categories (see key on map).

Figures for the cover and densities of *Zostera* recorded in 2012 and 2018 are given in Table 17 and Table 18.

Table 17 Mean percentage cover of Zostera marina off Firestone Bay in 2012 and 2018 based on the results of drop-down video surveys.

	Firestone Bay	
	2012	**2018**
mean % cover of *Zostera marina*	21	17

Table 18 A summary of results from DDV surveys of Firestone Bay in 2012 and 2018 together with the percentage change in Zostera between these years.

	Firestone Bay			
	2012		2018	
Category	**Area (m^2)**	**% of area**	**Area (m^2)**	**% of area**
5-25% (Very Sparse)	5,691	74.8	3,144	99.8
26-50% (Sparse)	1,901	25.0	5	0.2
51-75% (Moderate)	15	0.2	0	0.0
76-100% (Dense)	0	0.0	0	0.0
Total (5-100 %)	**7,607**	**100.0**	**3,149**	**100.0**
Change in area with *Zostera marina* > 5% cover			**- 59 %**	

A comparison of the data between 2012 and 2018 shows a decrease in area of *Zostera* of 59% with a decrease in the denser categories and an increase in the proportion of very sparse seagrass categories (Table 17, Table 18 and Figure 17).

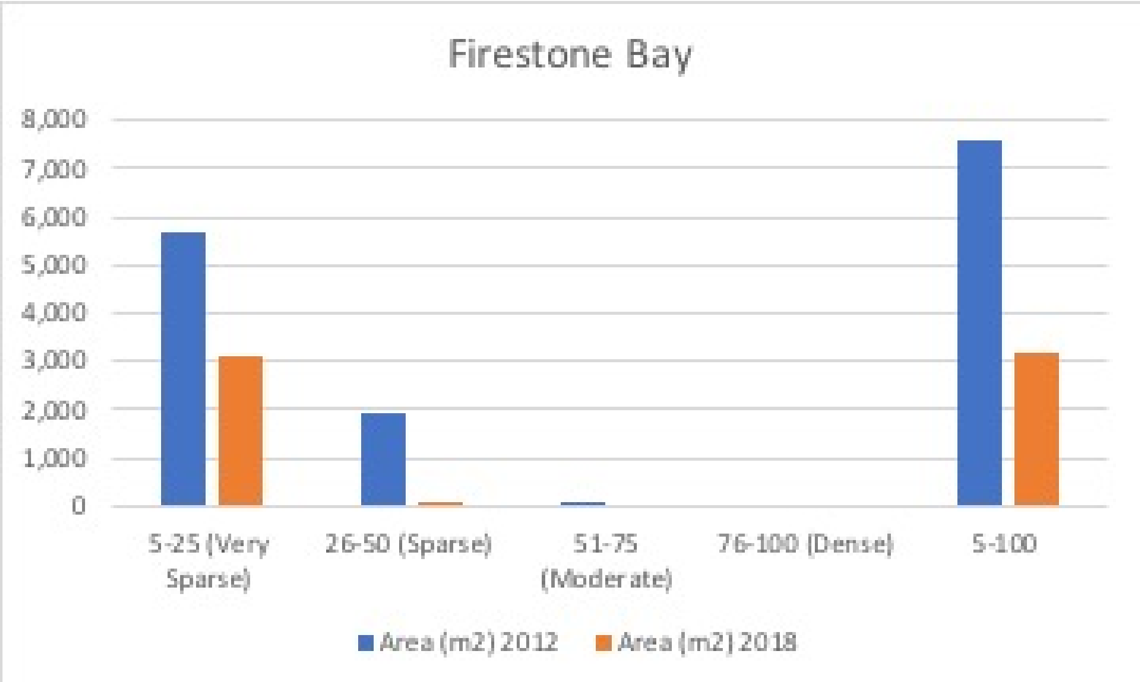


Figure 17 Graph to show changes in density of seagrass of Firestone Bay between 2012 and 2018 based on the results of DDV surveys

3.1.9 Summary of losses and gains

A summary of losses and gains in seagrass in the different beds studied is given in Table 19. The results for Red Cove North and Tomb Rock are not included as the areas studied in 2012 and 2018 were different. Jennycliff North is not included are not included as seagrass was only recorded from a single drop and it does not constitute a bed (by the >5% cover definition).

Table 19 A summary table giving the areas of seagrass bed mapped by DDV in 2012 and 2018 together with the percentage change in area between years

	Drake Island		Cawsand Bay		Cellar's Cove		Red Cove South		Jennycliff South		Firestone Bay	
	2012	2018	2012	2018	2012	2018	2012	2018	2012	2018	2012	2018
Area m2	44,207	40,734	119,739	186,214	57,009	47,346	11,447	11,572	14,378	6,327	7,607	3,149
% change in area	-8		56		-17		1		-56		-59	

3.2 Studies carried out by diving

Transects studies were undertaken by divers At Drake's Island, Cawsand Bay, Cellar's Cove and Red Cove South. Maps showing the location of these transects are shown in Figure 18, Figure 19, Figure 20 and Figure 21 and data on these transects is given in Appendix 4 – Dive transect information.

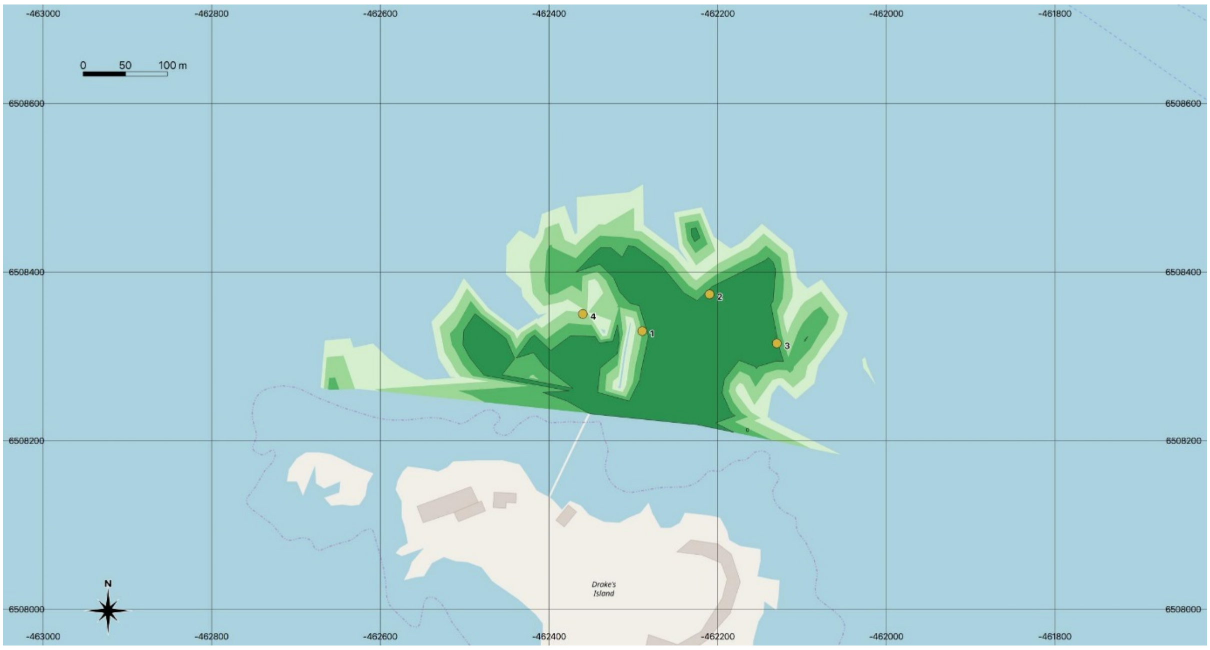


Figure 18 Map showing positions of transects surveyed by divers in the Drake's Island Zostera bed

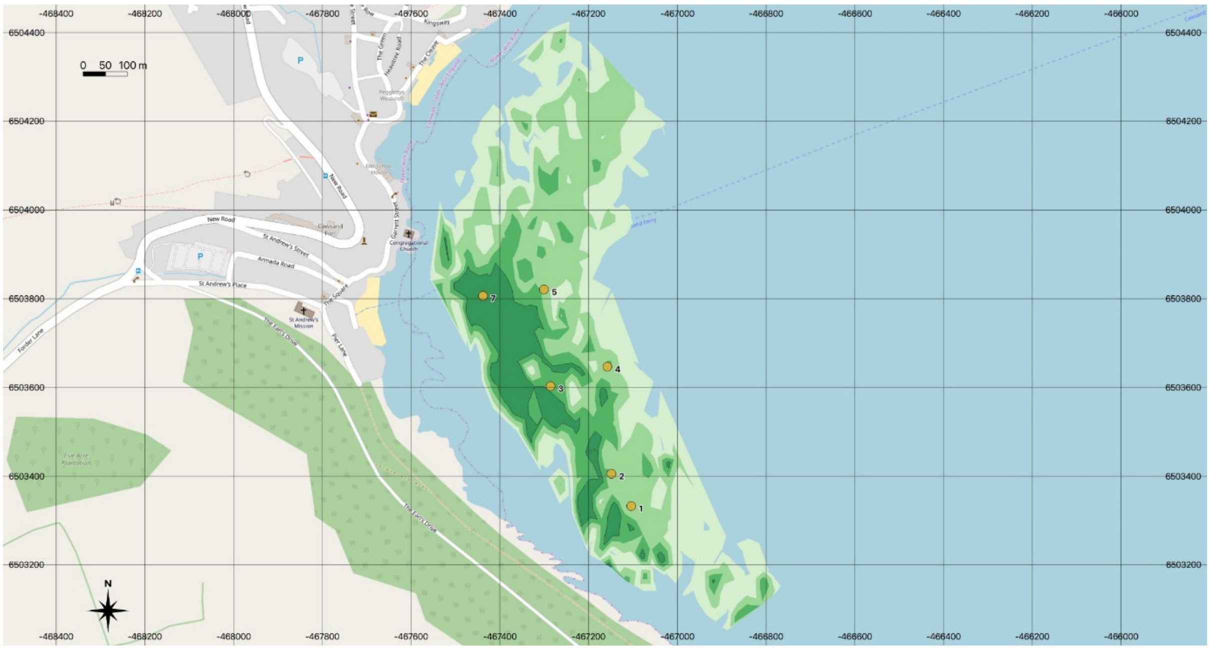


Figure 19 Map showing positions of transects surveyed by divers in the Cawsand Zostera bed

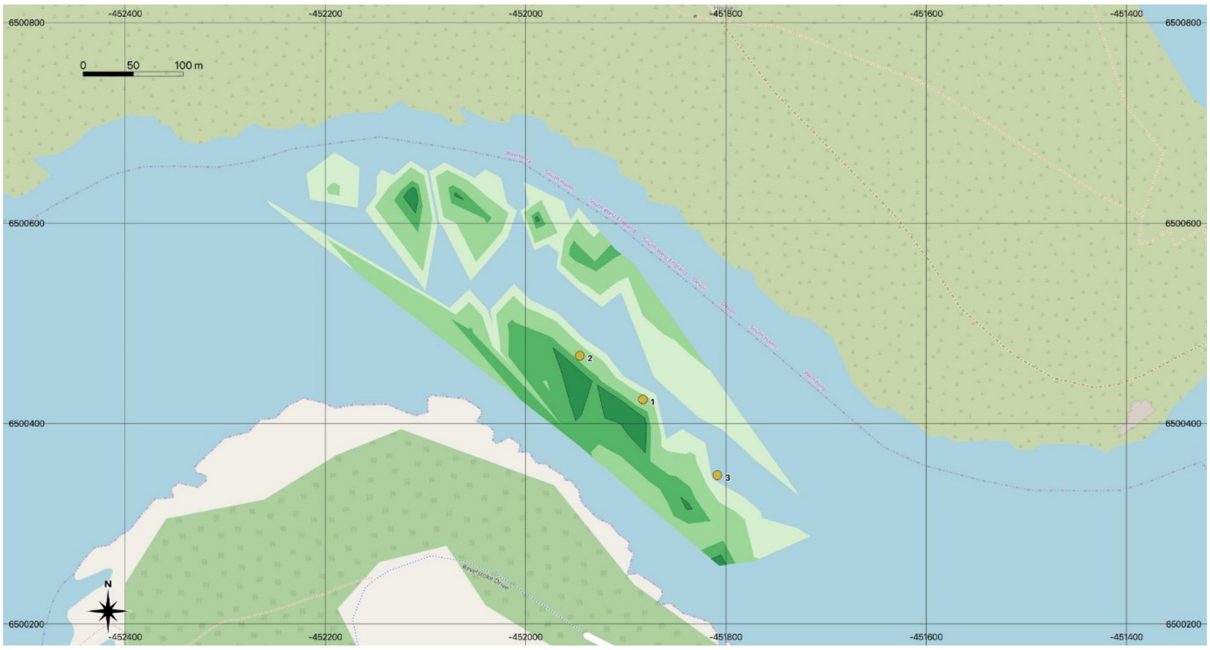


Figure 20 Map showing positions of transects surveyed by divers in the Red Cove Zostera bed

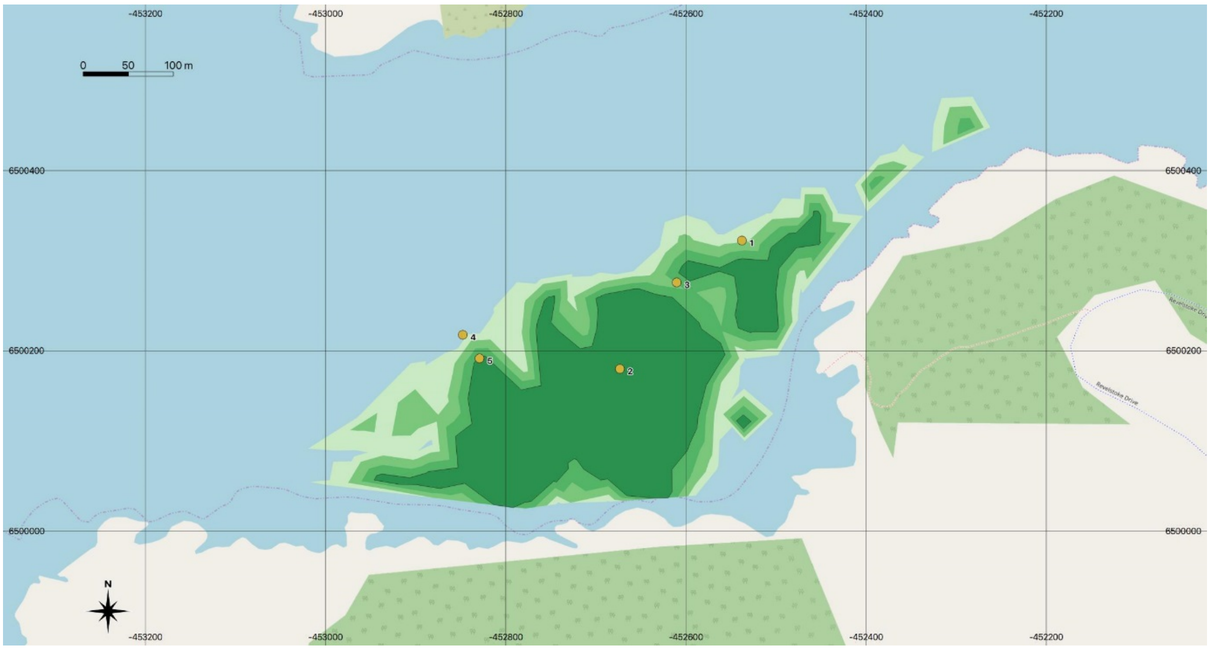


Figure 21 Map showing positions of transects surveyed by divers in the Cellar's Cove Zostera bed

3.2.1 Densities and lengths of plants

The mean number of plants per square metre was estimated at each site by averaging the mean density calculated for each transect and these are presented in Table 21 and Figure 22. A comparison between the data from 2012 and 2018 shows, the *Zostera* beds of the Yealm (Cellar's Cove and Red Cove) to have highest densities in both years. In 2012, Cawsand Bay had the lowest densities of the four study beds but it appears to have more than doubled in 2018 whereas the density of the Drake's Island bed appears to have fallen.

Table 20 Calculations of densities and plant lengths at sites studied by divers.

Site	mean no plants per m^2 (mean of means for all transects). Range for all transects in brackets		mean maximum, plant length (mm)	
	2012	2018	2012	2018
Drake's Island	97 (0-256)	64 (0-176)	54 (11-114)	80 (13-144)
Cawsand Bay	34 (0-144)	86 (0-208)	34 (9-62)	54 (7-114)
Cellar's Cove	122 (16-336)	112 (0-288)	63 (9-156)	52 (7-134)
Red Cove South	134 (0-240)	119 (0-240)	50 (9-78)	56 (15-125)

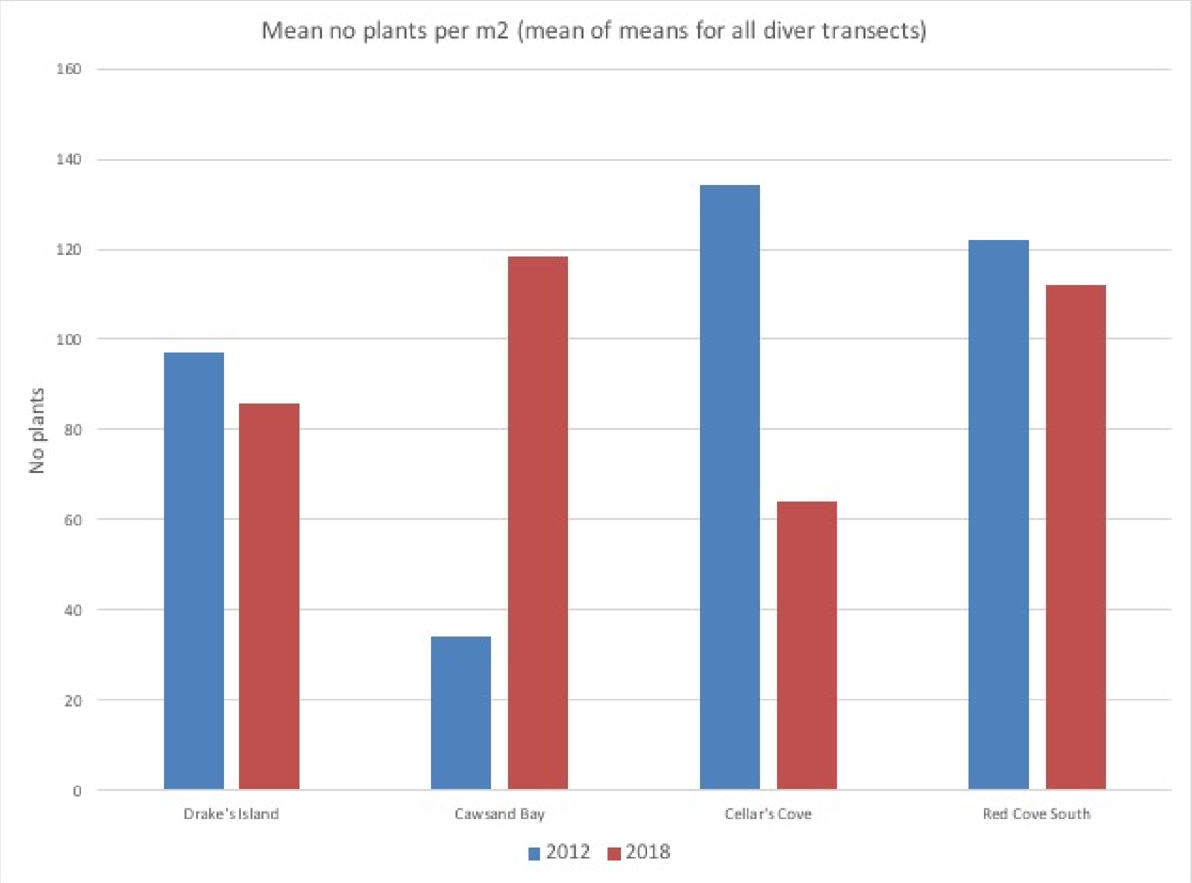


Figure 22 The mean number of plants per m² calculated for each of the sites studied by divers in 2012 and 2018

The maximum leaf length was measured for each of the plants collected along the dive transects and a mean length calculated. The plant length data for 2012 and 2018 is presented in Table 21 and Figure 23. In 2018, the average maximum leaf length was greatest in the Drake's Island *Zostera* bed and they were longer than those measured in 2012. The average leaf maximum leaf length of plants collected in Cawsand Bay in 2018 were greater than in 2012. The results from Red Cove South and Cellar's Cove were similar.

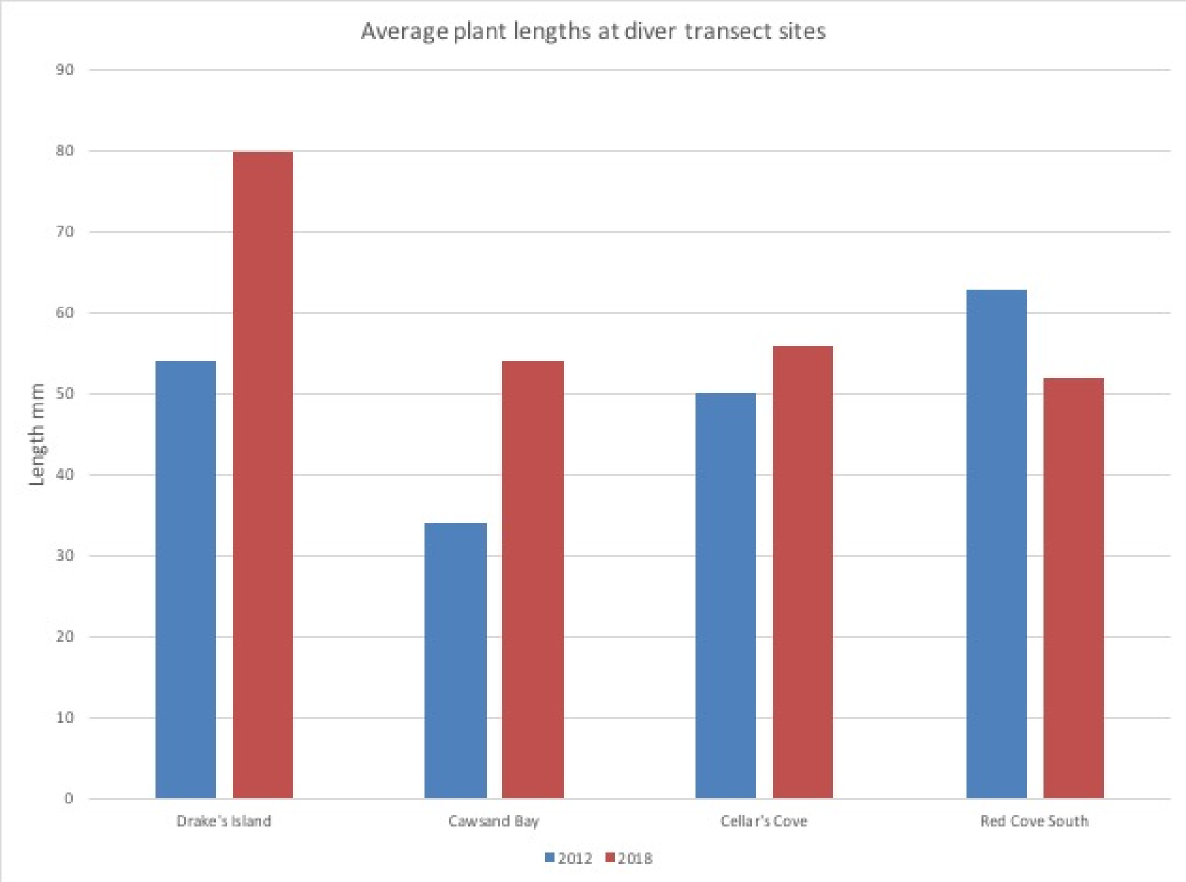


Figure 23 Average length of Zostera plants recorded at sites studied by divers

3.2.2 Incidence of plant flowering

Zostera marina plants with flowers and / or seeds were found at all study sites, with the incidence of flowering being approximately 5% at all sites studied. A summary of the 2018 data collected is shown in Table 22 and Figure 23. A low incidence of flowering was recorded in 2012 but the results were not recorded in the same systematic way as in 2018 and so valid comparisons cannot be made.

Table 21 Incidence of Zostera marina flowering at sites studied by divers

Site	No. plants examined	No. plants with flowers	mean % plants with flowers	mean arcsin of % plants with flowers
Drake's Island	189	9	5.0	12.4
Cawsand Bay	390	20	4.9	11.4
Cellar's Cove	302	14	4.9	13.9
Red Cove South	226	14	4.8	10.4

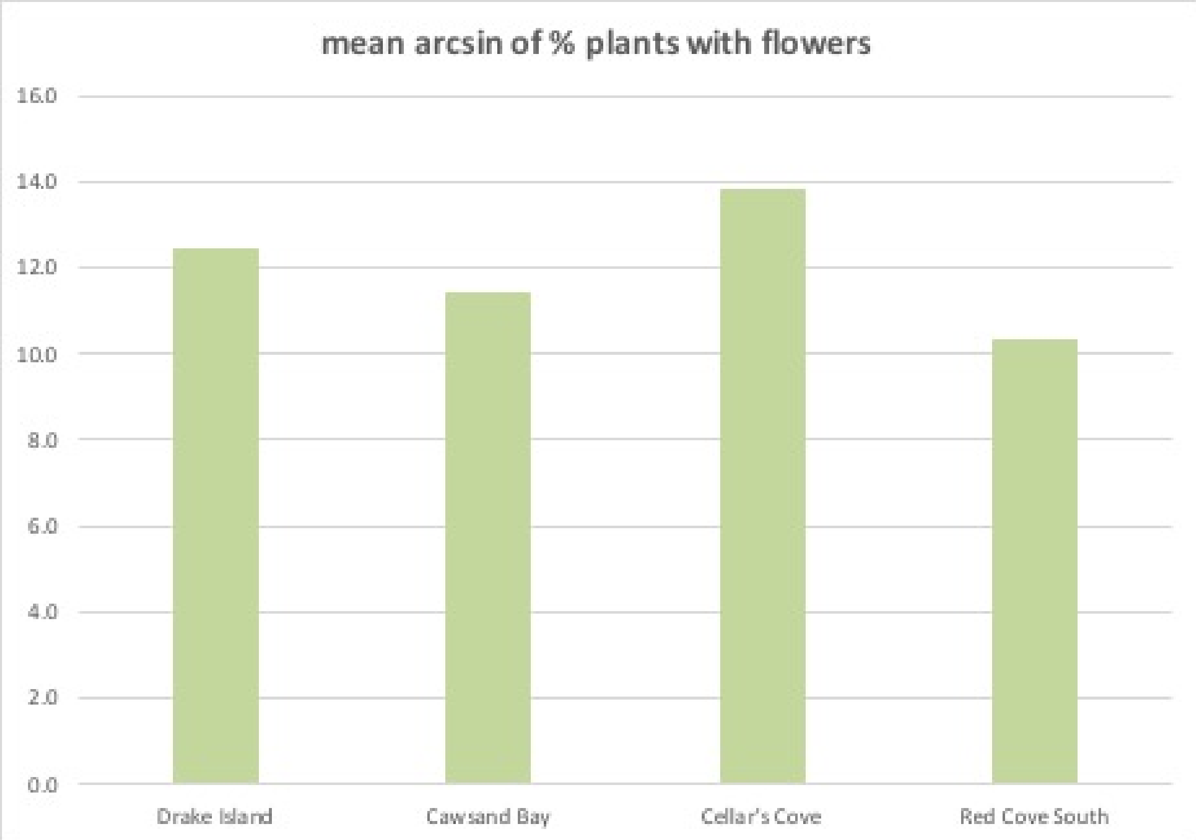


Figure 24 Bar graphs to show the % of plants with flowers at each of the sites studied by divers. The % data has been arcsin transformed.

3.2.3 Infection by *Labyrinthula zosterae*

The leaves collected by divers at each site were examined for infection by the fungus *Labyrinthula zosterae*. The percentage of the leaves infected was calculated and the degree of infection estimated on the following scale:

Score	Description	% Infection
0	Uninfected/uncovered leaf	0
1	Minimal infection/cover apparent	0 - 2
2	Up to a quarter of leaf infected/covered	3 - 25
3	Up to half the leaf infected/covered	26 - 50
4	Over half all of leaf infected/covered	51 - 75
5	Almost all of leaf infected/covered	76 - 100

The data collected is presented in Table 23, Figure 25 and Figure 26. There was little variation in the percentage of leaves infected between the study sites and between years except at Red Cove where there was a noticeably low incidence of infection in 2018. The infection scores did vary both between sites and years. There were noticeably lower infections scores at Drake’s Island and Red Cove in 2018 compared with 2012 and less in Cawsand Bay.

Table 22 Infection by Labyrinthula zosterae of leaves collected by divers at each of the study sites.

Site	Percentage leaves infected (mean of means for all transects) and range		Infection score mean of means for all transects and range	
	2012	2018	2012	2018
Drake's Island	55 (30-77)	53 (50 - 55)	0.9 (0.5-1.8)	0.4 (0.36 - 0.42)
Cawsand Bay	42 (0-75)	41 (20 - 89)	0.6 (0-1.2)	1.1 (0.61 - 1.89)
Cellar's Cove	50 (25-78)	53 (45 - 63)	0.8 (0.3-1.6)	0.7 (0.61 - 0.73)
Red Cove	56 (33 - 80)	29 (15 - 36)	0.9 (0 - 5)	0.4 (0.23 - 0.61)

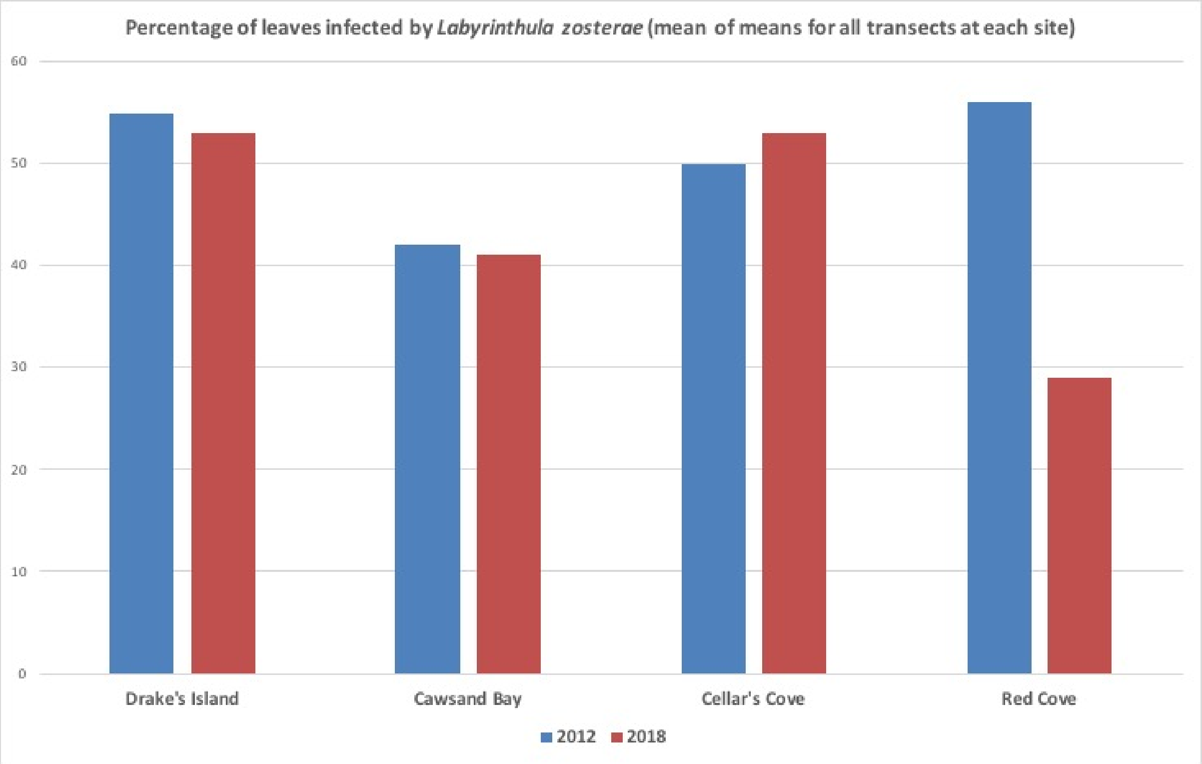


Figure 25 Percentage of leaves infected by Labyrinthula zosterae at each of beds studied by divers in 2012 and 2018. The graph represents mean of the mean percentage infection from all transects

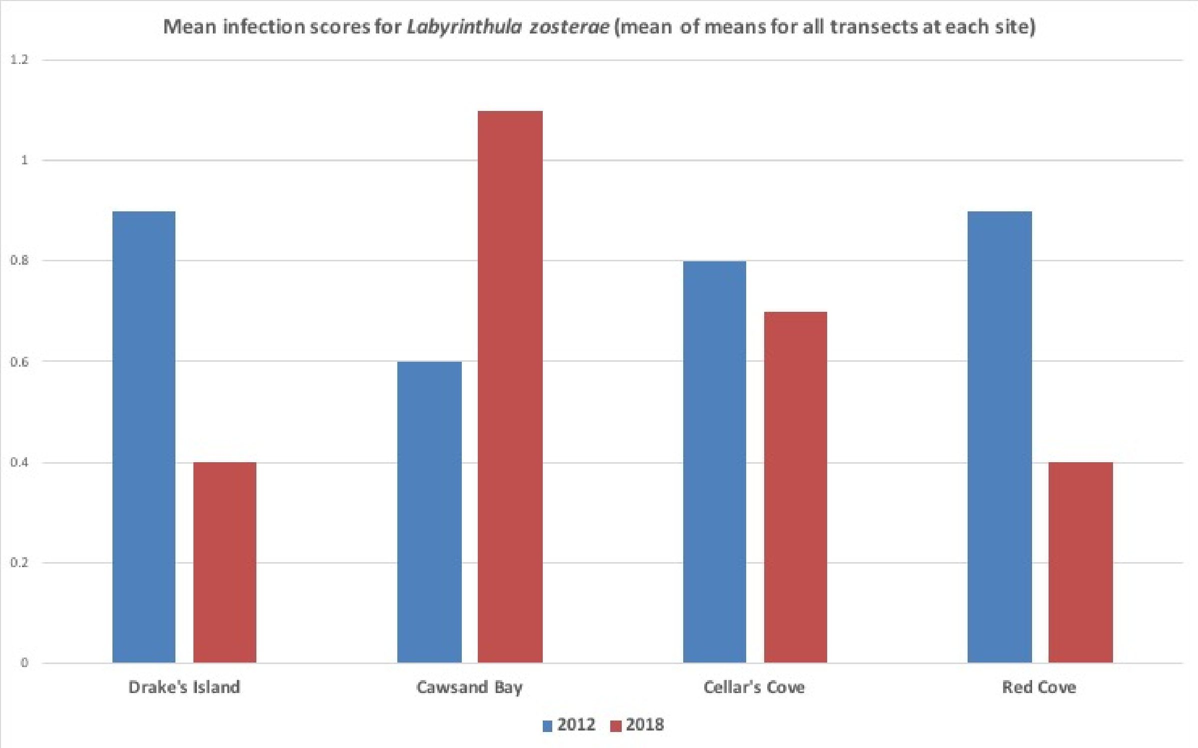


Figure 26 Scores for infection of Zostera marina leaves the fungus Labyrinthula zosterae in each of the beds studied by divers in 2012 and 2018. The graphs represent mean of means for all transects.

3.2.4 Cover of leaves by epiphytes

Conspicuous epiphytes on *Zostera* included filamentous red and brown seaweeds, encrusting red seaweeds, hydroids, bryozoans and ascidians. The cover by epiphytes of the leaves collected and examined was scored on the same scale as that used for *Labyrinthula zosterae* infection (see section 3.2.3 above).

The highest percentage of epiphytised leaves was found at Drake's Island and the least at Cawsand Bay. Cover by epiphytes was similar at all sites except Cawsand Bay where it was lower. Summary data on epiphytisation is given in Table 24 and Figure 27.

Table 23 Epiphytisation of Zostera leaves collected by divers at each of the study sites.

Site	Percentage leaves with epiphytes (mean of means for all transects) and range		Epiphyte Score mean of means for all transects and range	
	2012	2018	2012	2018
Drake's Island	?	100 (0 - 100)	2.4 (1.8-3.3)	2.1 (1.89 - 2.33)
Cawsand Bay	?	73 (41 - 87)	1.8 (0.4-2.9)	1.3 (1.04 - 1.57)
Cellar's Cove	?	93 (90 - 98)	2.3 (0.9-3.8)	2.2 (2.14 - 2.33)
Red Cove	?	83 (17 - 96)	1.8 (0.8.7 - 2)	2.2 (1.54 - 3.08)

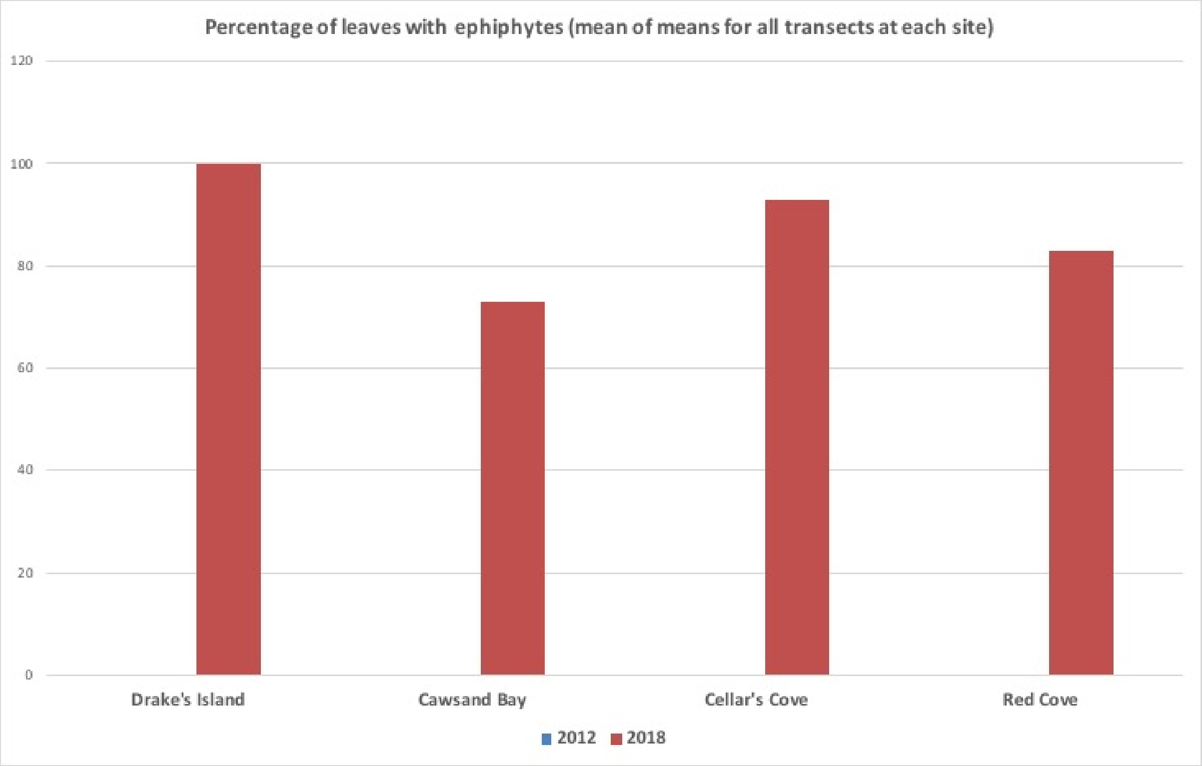


Figure 27 Percentage of leaves with epiphytes at each of beds studied by divers in 2018 (no data was available for 2012). The graph represents mean of the mean percentage infection from all transects at each site.

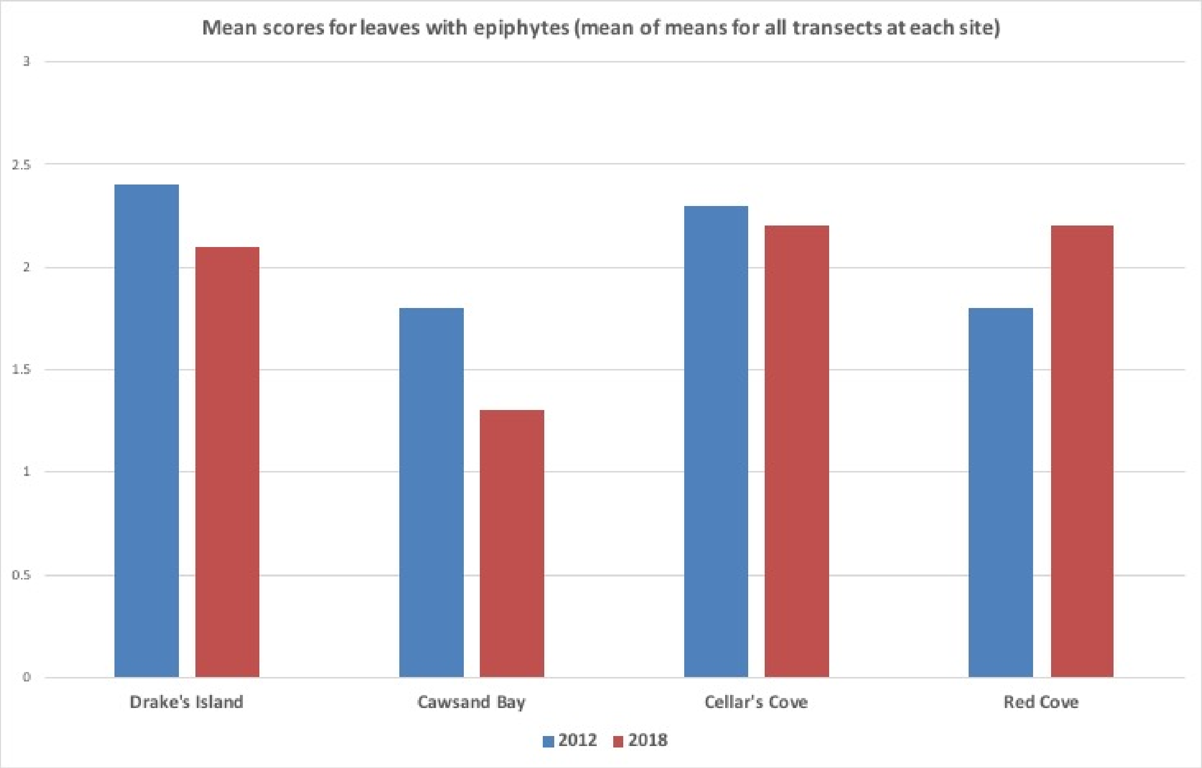


Figure 28 Scores for epiphytisation of Zostera marina leaves at four study sites in 2012 and 2018. The graphs represent mean of means for all transects at each site.

3.3 Moorings in Cawsand Bay

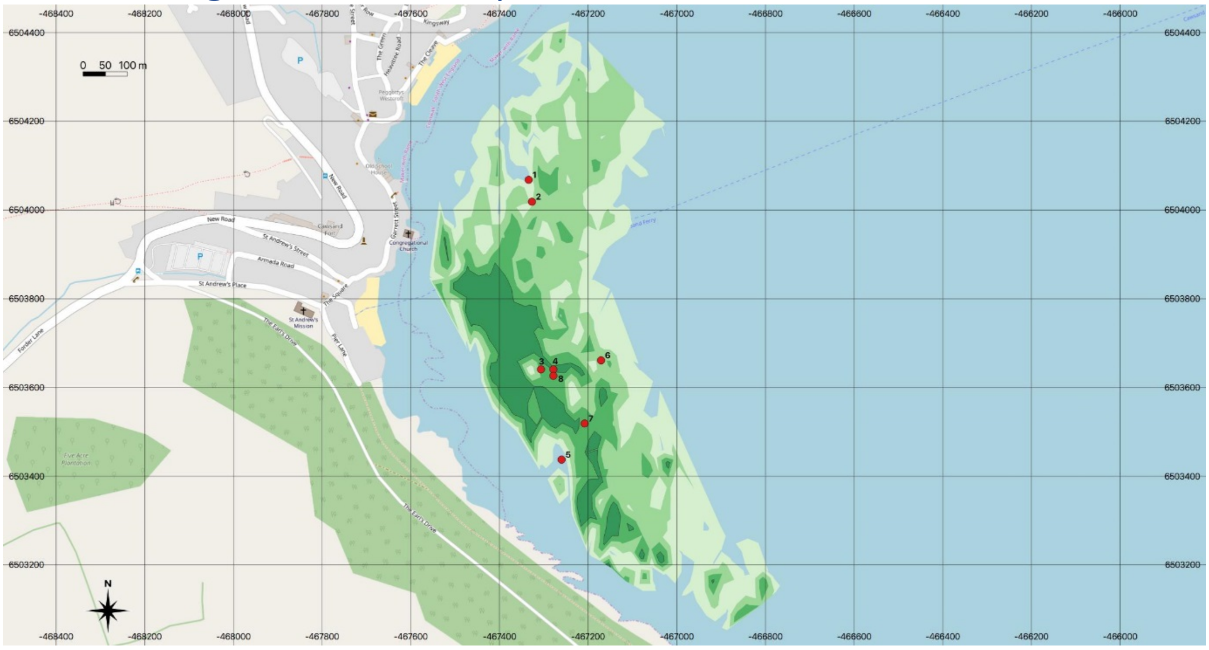


Figure 29 Map to show location of sites where moorings were studied on July 24th 2019

A total of eight moorings were studied in Cawsand Bay in an attempt to determine any effects and the extent of effects that the presence of hardware on the seabed (blocks, anchors, chains etc.) might be having on the *Zostera* bed. The location of these mooring study sites is shown in Figure 29. Parameters measured included % cover of *Zostera marina* and canopy height. A summary of the data collected is presented in Table 25, Figure 30 and Figure 31.

The results show a significant decrease both in cover of *Zostera* and average canopy height in a 4 m to 6 m radius around mooring blocks.

Table 24 Mean percentage cover and mean canopy height of Zostera marina at increasing distances from mooring blocks (from 0m to 20 m along the seabed).

Distance from mooring (m)	mean % cover	arcsin transformed mean % cover	95% confidence limits of the mean (arcsined)	mean maximum canopy height (cm)
0	9.1	11.7	3.58	19
2	10.6	14.9	3.18	27
4	12.0	16.5	3.22	35
6	14.7	19.1	3.32	41
8	19.7	23.1	3.67	45
10	21.6	25.1	3.40	51
12	23.0	26.4	3.21	53
14	22.3	25.4	3.62	50
16	20.5	23.9	3.63	48
18	19.7	23.6	3.36	49
20	21.3	24.4	3.57	50

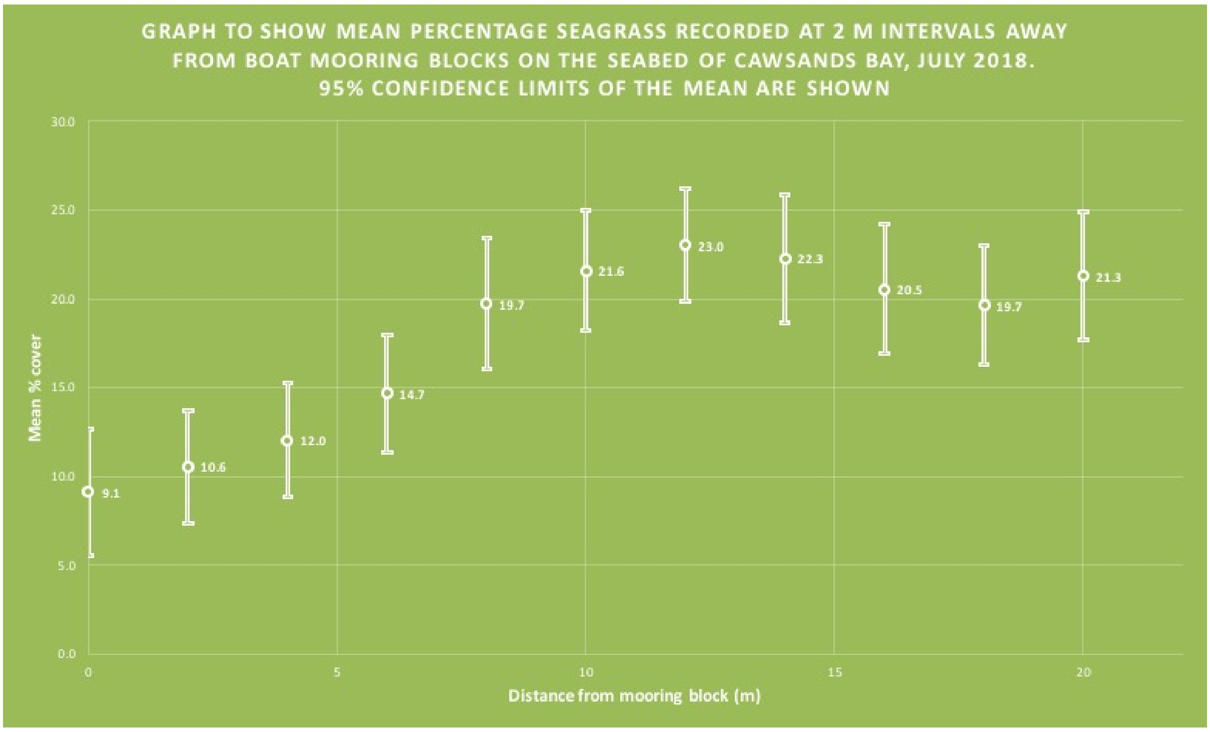


Figure 30 Graph to show mean percentage of seagrass recorded at 2 m intervals in four directions (N, S, E and W) from a series of 8 mooring blocks in Cawsands Bay. The percentage data has been arcsine transformed and 95% confidence limits of the mean are shown.

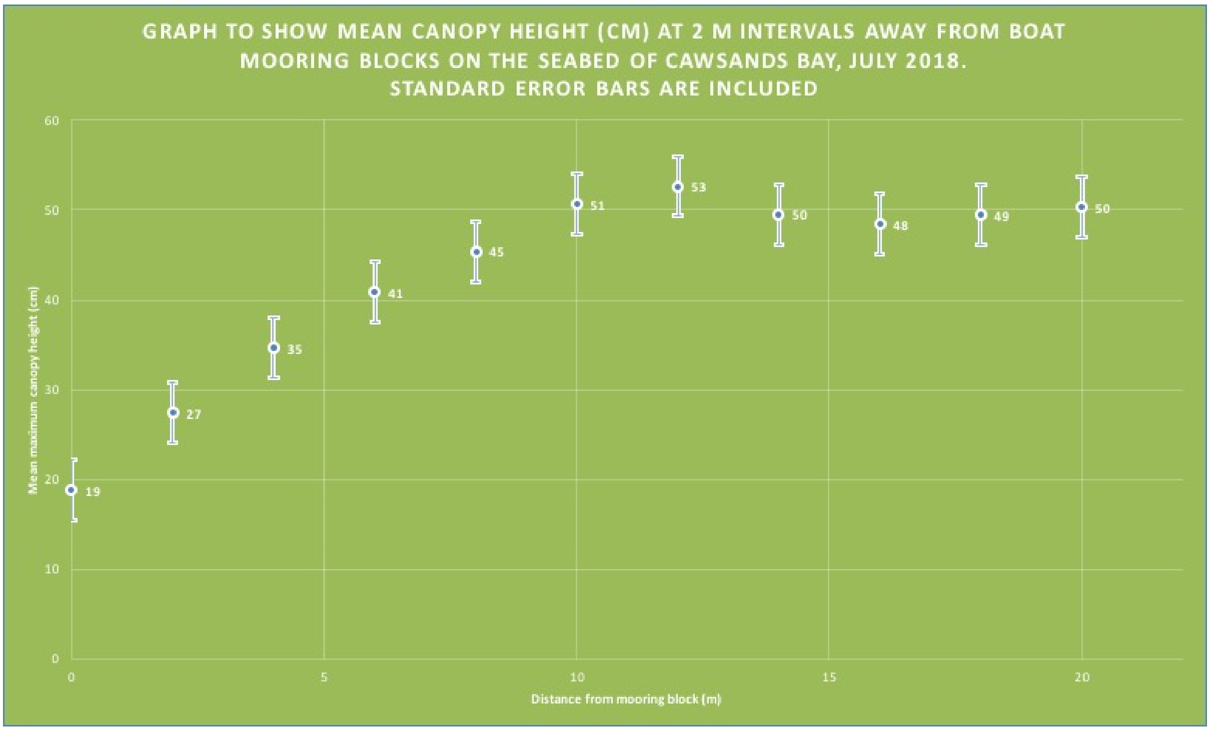


Figure 31 Graph to show mean canopy height of seagrass recorded at 2 m intervals in four directions (N, S, E and W) from a series of 8 mooring blocks in Cawsands Bay. The percentage data has been arcsine transformed and 95% confidence limits of the mean are shown.

4 Discussion

To appreciate long term trends in marine habitats and populations requires several years of data. The present methods have only two points on the monitoring time-line, 2012 and 2018. This means that little can be drawn in terms of concrete conclusions as to changes that have taken place. Below is what is hoped by the authors to be a useful discussion of the methods used and the results obtained.

4.1 Appraisal of methods

Attempts to monitor for change is the seagrass beds in Plymouth Sound and Estuaries SAC employ two main approaches, DDV, *in situ* observation by divers and the laboratory analysis of samples collected by divers. There are both advantages and drawbacks with each method when it comes to obtaining data that can be compared between sampling events. Obtaining quantitative data on the distribution and abundance of subtidal *Zostera marina* is difficult due to the vagaries of underwater visibility and sea conditions which affect both DDV and divers. It is far easier to work in good weather with good visibility than in bad weather with bad visibility and prevailing conditions, which will doubtless affect the results obtained.

Both the DDV and diver surveys are based on estimation of percentage cover of seagrass in quadrats. When considering the results, limitations of surveyor's abilities to accurately estimate percentage cover of seagrass should be recognised and this is particularly true of *in situ* observations by divers. Inconsistency with respect to how different surveyors estimate percentage cover of organisms is well known (Baker and Little, 1989, Moore et al., 2015). As well as inter-surveyor variability, the way seagrass is arranged in a quadrat may also affect how individuals record e.g. whether the current is running and streaming seagrass is in or out of the quadrat will affect perception of cover. Patchiness can make estimations problematical. In order to help compensate for this, both the DDV team and the divers used reference photographs when doing estimates (Environment Agency, 2018).

Curtis (2012) commented on problems with visibility during the 2012 DDV survey whereas in 2018 conditions were good. The equipment used in 2012 (Curtis, 2012) was different to that deployed in 2018 (Environment Agency, 2018) and both these factors will have an impact on the results obtained. The 2018 survey did not study the whole area of the *Zostera* beds in either Red Cove North nor Tomb Rock and so comparisons of change in area were not possible. It is important that in future standard areas are studied to allow for area change to be detected.

The Skomer Highly Protected Marine Conservation Zone (Skomer MCZ) have traditionally mapped the North Haven bed of Zostera marina using volunteer divers. Between 2013 and 2018 the Natural Recourses Wales (NRW) Fisheries Assessment Team trialled a Biosonics DT-X split beam echo sounder to survey the estimated area of the seagrass bed for the Skomer MCZ team (Burton et al., 2019). The method was judged to work well and was found to closely match the *in situ* diver survey results. This Biosonics acoustic survey method provides the Skomer MCZ team with quick and practical way to get an annual estimate of area of extent. This method is something that could be considered to add to future surveys of the Plymouth Sounds and Estuaries SAC seagrass beds.

Abundance of seagrass in the transects was recorded on an abundance scale (see Table 1). Scales of abundance are not ideal when collecting monitoring data as the results cannot readily be analysed statistically. It would be better to record estimates of percentage cover underwater and later convert to abundances if thought necessary.

Curtis (2012) highlighted the problem of calculating statistics for each seagrass bed using the data from all transects. This was because each transect differed significantly from the others. This is hardly surprising as the depths of the 2018 transects (see Appendix 4 – Dive transect information) shows they vary between 1.2 m to 5.1 m below chart datum.

Ideally the positioning of diver transects should be the same between years at each site in order to more satisfactorily compare data sets (as is the case in Milford Haven (RPS, 2012)). When transects are not put in the same place each time then comparison between data sets is problematical. In 2018, the positioning of transects attempted to cover the known extent of the beds but was influenced by a number of factors including shipping movements on the day, tides, prevailing weather and the ability to deploy and recover divers safely in shallow waters. In future surveys it would be useful to have set positions for the transects in order to improve chances of comparison.

Another diver-lead sampling regime would be to follow the one proposed by Unsworth et al. (2014) where the seagrass status is assessed within randomly assigned quadrats radiating out from pre-determined seagrass sampling points spread in a stratified fashion throughout the whole seagrass meadow. If such a regime were followed the problem of calculating statistics from independent transects could be solved.

Proper quality control of the data recorded by field surveyors during the diver surveys was not possible during the dive survey, largely due to the volume of work generated in the field. In the evenings the time was spent transcribing data to spreadsheets and dealing with the leaf samples. The appointing of a Data Manager whose sole job is to collate and QA the data would be a valuable asset to future surveys.

It is important to ensure consistency in the way attributes are recorded between years. It was noted in section 3.2.2 how records of plants bearing flowers were not made in a systematic way in 2012 making comparison with 2018 impossible. Also, information on the % cover of leaves by epiphytes was not available from the 2012 survey.

4.2 Comparison with previous data

The 2012 survey (Curtis, 2012) provided a new baseline for seagrass surveys in Plymouth Sound with new improved methodologies which have been repeated in 2018.

4.2.1 Extent and abundance of *Zostera marina*

The DDV survey measured the extent and abundance of *Zostera marina* in the different subtidal seagrass beds of Plymouth Sound.

Apart from Cawsand Bay, which shows an apparent increase in the area of the bed and its abundance, *Zostera* appears to have declined in extent and abundance at all the other sites since 2012 (see Table 19). This is particularly marked in Jennycliff South and Firestone Bay where there was a decrease in area of over 50% in each case.

The *in situ* studies by divers showed the *Zostera* beds of the Yealm (Cellar's Cove and Red Cove) to have highest densities in both 2012 and 2018. In 2012, Cawsand Bay had the lowest densities of the four study beds but it appears to have more than doubled in 2018 which agrees with the trend noticed in the DDV survey.

Reasons for this apparent decline in *Zostera* everywhere apart from Cawsand Bay are unclear. Certainly, factors such as the severe storms during the winter of 2013 to 2014 are likely to have had an impact but whether this effect would extend to the summer of 2018 is open to question. The changes in methodology used in the DDV survey were discussed in section 4.1 and because of this the significance of the apparent changes should be viewed with caution. To date there are only two points of reference on the monitoring timeline and natural variation in the extent and abundance of *Zostera* is not fully understood in Plymouth

Sound and Estuaries SAC. Despite this a close watch should be kept on the extent and abundance of the beds in case of continued decline.

4.2.2 Shoot density measurements

Curtis (2012) commented on an apparent change between 2009 and 2012 in the number of plants per m2 at Cawsand Bay and Cellars Cove, where numbers of plants appear to have decreased and increased respectively. Due to data limitations, with changes in methodology between 2009 (Irving, 2010) and 2012 (Curtis, 2012) the apparent changes in shoot density were deemed inconclusive.

The results of the current survey show a rise in shoot density measured in Cawsand Bay and a fall in the Drake's Island bed compared to the 2012 data (see section 3.2.1). We can be more confident in this change as the same methodologies were used in 2012 and 2018, but its significance remains obscure as there are only two points on the timeline. Also, there is no systematic recording of environmental parameters in Plymouth Sound and Estuaries SAC that can be related to change in the seagrass beds (anthropogenic or otherwise).

Skomer MCZ has the benefit of having a team of permanent staff on site who record some of the more important environmental variables and can relate changes to those noted in the North Haven *Zostera* bed (Burton et al., 2019). These include the following:

- Light availability via turbidity measurements taken using a Secchi disk.
- Photosynthetic Active Radiation (PAR) measurements. A PAR sensor has recorded light levels through the water column over the seagrass bed.
- Net radiation and sunshine hours estimated from a local weather station 1 km away.
- Physical damage. Skomer MCZ provide moorings for yachts outside the seagrass bed and boat traffic and anchoring is closely monitored.
- Water quality and health of seagrass. Taking seagrass samples to examine C:N:P ratios.

Natural England does not have the staff nor resources to monitor the seagrass beds in Plymouth Sound and Estuaries SAC in the same way as Skomer MCZ but important lessons can be learned from Skomer. Taking tissue samples for examination of C:N:P ratios would be a good addition to the SAC seagrass monitoring. In a mesocosm experiment, Burkholder et al. (1992) showed how in low water exchange (simulating quiet embayments), eelgrass growth and survival significantly decreased at all enrichment levels, with most rapid decline at the highest nitrate loadings. Jones et al. (2018) suggest using the 15N isotope to separate out nitrogen from human and agricultural origins. Comparing the C:N:P ratios from the different beds could give clues as to whether they are being adversely affected by eutrophication.

4.2.3 Incidence of flowering

Despite a lack of data from 2012, the conclusion can be drawn that at the times of the surveys, there has been a low incidence in the occurrence of flowering plants in both surveys. Philips et al. (1983) studied *Zostera marina* populations from the Pacific coast of North America and found that in subtidal areas where salinity fluctuation is minimal, dense stands of perennial plants reproduced vegetatively. This contrasted with intertidal areas where seasonally low salinities enhanced seed germination, where there was a higher incidence of flowering. A recent study in temperate China by Xu et al. (2018) examined the contribution of sexual reproduction to population recruitment. At a site protected from strong currents and waves, sexual reproduction in *Zostera marina* populations was more important than in an open coast situation. It was postulated that temperature regime may induce shifts in sexual recruitment strategies in *Zostera marina*. Blok et al. (2018) suggested that global warming will result in an increased capacity for sexual reproduction at northern latitudes.

The importance of collecting data on sexual reproduction in the Plymouth Sound and Estuaries SAC populations is underlined by the above studies relating to climate change.

4.2.4 Infection by Labyrinthula zosterae

Muehlstein et al. (1991) identified the fungus *Labyrinthula zosterae* as the pathogen associated with wasting disease in *Zostera marina* which allegedly devastated seagrass beds in the 1930's. A recent study by Brakel et al. (2014) found little evidence that *L. zosterae* negatively impacted *Zostera* plants. On the contrary, infected plants showed enhanced leave growth and kept infection to a low level and genetic studies indicated that *Zostera marina* was probably able to control host infection. The conclusion was that in their study area (the Wadden Sea and the Baltic), *L. zosterae* was not associated with substantial virulence under non-stress conditions.

No great increases were seen in the incidence and severity of *L. zosterae* were found in the current survey. Despite this, the continued monitoring of *L. zosterae* is useful in case of changes of condition that could result in this currently benign pathogen becoming virulent.

4.2.5 Cover of leaves by ephiphytes

Plant and animal epiphytes are a characteristic and diverse component of the seagrass community. Some species are endemic to seagrasses, such as the red encrusting seaweed *Rhodophysema georgii* (Irvine, 1983) and the hydroid *Laomedea angulata* (Cornelius, 1995). Others are common species which are small enough to live on or feed on the seagrass community. A study of seaweed epiphytes found in seagrass beds in Wales was carried out by Edwards et al. (2003).

A review of epiphyte-seagrass relationships with an emphasis on the role of micrograzing was undertaken by Orth and Montfrans (1984). The authors describe how the pioneer pennate diatom *Cocconeis scutellum* colonise *Zostera marina* leaves forming a mat which is in-turn colonised by a variety of micro-organisms, mainly bacteria, which are incorporated into a mucous matrix. It is thought that dissolved organic carbon released by the seagrass blades may enhance the growth of bacteria. Detritus becomes incorporated into the periphyton and a thick crust develops with algal growth on seagrass blades benefiting from nutrients released by seagrasses e.g. phosphates.

The epiphyte crust acts as a barrier to photosynthesis. Borum and Wium-Andersen (1980) demonstrated that less than 10% of incoming light was transmitted through a thick old crust at leaf tips whereas greater than 90% of ambient light was available for photosynthesis to lightly epiphytised (younger) basal portions of the blades. Grazing by molluscs, polychaetes and crustacea help keep fouling in check as well as rapid growth of new leaves and the shedding of old leaves. A study in France, (Jacobs and Noten, 1980 cited Orth and Montfrans, 1984) found new leaves grew every 13 days in May and 28 days in December.

Orth and Montfrans (1984) state that the diatom and bacteria component of the periphyton is responsible for a considerable percentage of production of seagrass bed ecosystems. On a per unit area basis, epiphytes contribute an average between 18% and 50% of the combined *Z. marina* leaf production. This production is available for consumption by the numerous grazers found in seagrass habitats, including molluscs, polychaetes and crustacea. The grazing is beneficial to the seagrass, as it helps remove the periphyton crust. Ruesink (2016) pointed out that epiphyte load was only of concern when it slows seagrass growth either as a result of lack of 'top-down' and / or 'bottom up' control shifts the relationship to a point where seagrass can no longer out-grow its competitors. The development of an epiphyte indicator of nutrient enrichment and finding threshold values for seagrass epiphyte load was advocated by Nelson (2017). He considers epiphyte load on submerged aquatic vegetation to be a useful biological indicator of water quality conditions with respect to nutrients.

Nelson (2018), in a study evaluating factors controlling the abundance of epiphytes on *Z. marina* considered that both seagrass and seagrass epiphytes my become increasingly light limited in the upper estuary and so epiphyte loads may have proportionally more impact in estuarine regions. In eutrophic conditions, macroalgae epiphytic on the seagrass *Posidonia australis* were found to impede its growth and has been known to cause disappearance of seagrass beds in polluted areas (Larkum, 1976 cited Orth and Montfrans, 1984). Prado (2018) found how epiphyte patterns clearly matched in situ measures of nutrient availability and were consistent with decreased shoot densities in discharge sites.

In this study, the highest percentage of epiphytised leaves was found at Drake's Island and the least at Cawsand Bay (see section 3.2.43.2.3 above). The Zostera bed at Cawsand Bay is the one furthest from estuarine water courses and so sources of nutrients and this may account for the lower epiphyte scores. None of the beds studied in 2018 were so festooned by epiphytes (including micro and macro algae) that they could be considered to be having a deleterious effect on seagrass health.

The types of epiphytes that occur on seagrasses are thought to be an indicator of climate change. Brodie et al. (2014) predict than with an increase in CO_2 in the oceans, seagrasses will proliferate, and associated epiphytes switch from calcified algae to diatoms and filamentous species. It would be useful to devise a way of cataloguing the species occurring in the epibiota to see if this changes over time. Certainly the epiphytes are known to vary from bed to bed in Plymouth Sound (Saunders et al., 2003).

4.3 Moorings in Cawsand Bay

The effects of moorings study in Cawsand Bay presented in section 3.3, were in line with the findings of Unsworth et al. (2017) and showed a significant decrease both in cover of *Zostera* and average canopy height in a 4 m to 6 m radius around mooring blocks.

The development of Advanced Mooring Systems that can be deployed in seagrass beds and minimise damage to the communities is encouraging and a trial using one of these moorings in Cawsand Bay in 2018 has proved successful. The replacement of conventional moorings with Advanced Mooring Systems on the seagrass beds in Plymouth Sound and Estuaries SAC is desirable.

This survey did not study the effects of anchoring in the seagrass beds of the SAC. Although anchoring doubtless has an impact, it would require a targeted study to quantify the effect.

4.4 The condition of subtidal seagrass beds in Plymouth Sound

The importance and benefits of seagrass beds to marine ecosystems is well known and documented and have a long history of study. Recent summaries regarding conservation of seagrasses and their importance are given in Unsworth et al. (2018) and (Nordlund et al., 2018). Globally, seagrass beds are under threat with an estimated 29% of the known areal extent has disappeared since seagrass areas were initially recorded in 1879, making them amongst the most threatened habitats on earth along with mangroves, coral reefs, and tropical rainforests (Waycott et al., 2009).

Natural fluctuations in the areal extent and density are to be expected and this requires separating these from actual decline and degradation. It is only by long term monitoring and investigating the environmental parameters that impinge on the health of seagrass communities that they can be effectively conserved.

The extent of the different seagrass beds in the SAC have all been calculated to have changed between 2012 and 2018 (Table 19). Of these beds, most have decreased in extent apart from Red Cove South which has stayed almost the same and Cawsand Bay which has increased.

Based on the results of this study and comparisons to the 2012 survey, it can be concluded that extent and density (or biomass), which are primary attributes of the seagrass beds have declined in some areas of the SAC.

This apparent decrease in extent together with decline in density at some sites when compared with 2012 (see section 3.1) is of concern and should be closely monitored. The calculated changes should be viewed with caution due to poor conditions encountered during the 2012 survey and the change in method used to map the beds between years.

Other indices studied e.g. plant length, infection by *Labyrinthula zosterae* and epiphytism indicate that the seagrass is generally healthy.

4.5 Summary and conclusions

- The extent and abundance of all the seagrass beds studied in Plymouth Sound and Estuaries SAC in 2018 has shown a decrease compared to 2012 apart from Cawsand Bay where there has been an increase. Confidence in the comparison between years is low due to changes in methodologies between years and the poor sea conditions and equipment failures encountered in 2012 (Curtis, 2012).

- The results of *in situ* studies by divers showed that Cawsand Bay had the lowest densities of the four study beds but that it appears to have more than doubled in 2018 whereas the density of the Drake's Island bed appears to have fallen. These changes in Cawsand Bay and Drake's Island follow the same trend as shown by the DDV studies.

- Infection by the 'wasting disease' causing fungus *Labyrinthula zosterae* is present in all four seagrass beds where samples were taken but no great increases were in the incidence and severity of *L. zosterae* were found in the current survey. Despite this, the continued monitoring of *L. zosterae* is useful in case of changes of condition that could result in this currently benign pathogen becoming virulent.

- None of the seagrass beds studied in 2018 were so festooned by epiphytes (including micro and macro algae) that they could be considered to be having a deleterious effect on seagrass health. In future studies it would be useful to devise a way of cataloguing the species occurring in the epibiota to see if this changes over time.

- Monitoring the effects of anthropogenic impacts, including the measurement of C:N:P ratios in plants would be a useful addition to the current suite of monitoring tools (see section 4.2.2).

- The survey methodologies currently employed together with ideas for improving them going forward are presented in section 4.1). In particular, a revision of the diving methodology, changing from transect based surveys to one of stratified random sampling within the seagrass beds would provide results on density with more statistical power.

5 References

Baker, J.M. and Little, A. 1989. Worker variability in biological recording *In* J. McManus and M. Elliott eds. *Developments in Estuarine and Coastal Study Techniques.* . EBSA 17 Symposium, Dundee 1987, Olsen & Olsen. pp. 29-34.

Blok, S.E., Olesen, B. and Krause-Jensen, D. 2018. Life history events of eelgrass *Zostera marina* L. populations across gradients of latitude and temperature. *Mar Ecol Prog Ser* 590 79- 93.

Borum, J. and Wium-Andersen, S. 1980. Biomass and production of epiphytes on eelgrass (*Zostera marina* L.) in the Oresund, Denmark. *Ophelia* nr. suppl. 1 57-64.

Brakel, J. et al. 2014. Current European Labyrinthula zosterae Are Not Virulent and Modulate Seagrass (Zostera marina) Defense Gene Expression. *PLoS One* 9(4) e92448.

Brodie, J. et al. 2014. The future of the northeast Atlantic benthic flora in a high CO2 world. *Ecology and Evolution* 4(13) 2787-2798.

Bugg, A. 2004. Survey of Zostera marina bed at Jennycliff Bay, Plymouth. A Seasearch report to Natural England by the MCS Plymouth Local Group.

Burkholder, J.M., Mason, K.M. and Glasgo, J., H.B. 1992. Water column nitrate enrichment promotes decline of *Zostera marina*: evidence from seasonal mesocosm experiments. *Mar Ecol Prog Ser* 81 163 – 178.

Burton, M. et al. 2019. Skomer Marine Conservation Zone Distribution & Abundance of Zostera marina in North Haven 2018. *NRW Evidence Report*. 44.

Cornelius, P.F.S. 1995. North-West European Thecate Hydroids and their Medusae. *In* R. S. K. Barnes and J. H. Crothers eds. *Synopses of the British Fauna (New Series)*. The Linnean Society, London, Field Studies Council.

Curtis, L.A. 2012. Plymouth Sound and Estuaries SAC Seagrass Condition Assessment 2012. Ecospan.

Edwards, M., Bunker, F., Maggs, C.A. and Johnson, M.P. 2003. Biodiversity within eelgrass (Zostera marina) beds on the Welsh Coast: analysis of epiflora and recommendations for conservation. Grant aided by the Countryside Council for Wales Species Challenge Fund .

Environment Agency 2018. Subtidal Seagrass Image Analysis Version 3, September 2018. Environment Agency.

European Commision 1994. The Conservation (Natural Habitats, &c.) Regulations 1994 (Statutory Instrument 1994 No. 2716). *Official Journal of the European Communities*.

Fowler, J., Cohen, L. and Jarvis, P. 1998. *Practical Statistics for Field Biology*. Second ed. Chichester, New York, Weinheim, Brisbane, Singapore and Toronto: John Wiley & Sons.

Griffiths, C.A., Langmead, O.A., Readman, J.A.J. and Tillin, H.M. 2017. Anchoring and Mooring Impacts in English and Welsh Marine Protected Areas: Reviewing sensitivity, activity, risk and management, Defra (final draft submitted but not published). DEFRA.

Holt, R.H.F. 2015. Rules and guidance for scientific diving in the country agencies. Version: December 2015. Natural Resources Wales.

HSE 1997. *Diving at Work Regulations 1997*: Health and Safety Executive.

HSE 2014. Scientific and archaeological diving projects. Diving at Work Regulations 1997. Approved code of practice. 36.

Irvine, L.M. 1983. *Seaweeds of the British Isles. A collaborative project of the British Phycological Society and the Natural History Museum. Volume 1 Rhodophyta. Part 2A Cryptonemiales (senu stricto), Palmariales, Rhodymeniales.* London: HMSO.

Irving, R.A. 2010. Plymouth Sound and Estuaries SAC seagrass diving survey, 15-17 July 2009. A Seascope report to Natural England.

Irving, R.A., Jackson, E.L. and Cole, H. 2007. Mapping eelgrass Zostera marina beds within Plymouth Sound and Estuaries SAC. A Seascope report to Natural England.

Jacobs, R.P.W.M. and Noten, T.M.P.A. 1980. The annual pattern of the diatoms in the epiphyton of eelgrass (Zostera marina L.) at Roscoff, France. *Aquatic Botany* 8 355-370.

Jones, B.L., Cullen-Unsworth, L.C. and Unsworth, R.K.F. 2018. Tracking Nitrogen Source Using $\delta^{15}N$ Reveals Human and Agricultural Drivers of Seagrass Degradation across the British Isles. *Frontiers in Plant Science* 9(133).

Larkum, A. 1976. Ecology of Botany Bay. I. Growth of <I>Posidonia australis</I> (Brown) Hook. f. in Botany Bay and other bays of the Sydney basin. *Marine and Freshwater Research* 27(1) 117-127.

Moore, J., Bunker, F.S.D., Rein, H.v. and Jones, J. 2015. Methodological trials: Recording subtidal epibiota in-situ and in photographs, Portrush August 2013 and Sound of Mull August 2014. JNCC Peterborough. Report No. 561.

Muehlstein, L.K., Porter, D. and Short, F.T. 1991. Labyrinthula zosterae sp. nov., the Causative Agent of Wasting Disease of Eelgrass, Zostera marina. *Mycologia* 83(2) 180-191.

Nelson, W.G. 2017. Development of an epiphyte indicator of nutrient enrichment: Threshold values for seagrass epiphyte load. *Ecological Indicators* 74 343-356.

Nelson, W.G. 2018. An evaluation of factors controlling the abundance of epiphytes on Zostera marina along an estuarine gradient in Yaquina Bay, Oregon, USA. *Aquatic Botany* 148 53-63.

Nordlund, L.M., Unsworth, R.K.F., Gullström, M. and Cullen-Unsworth, L.C. 2018. Global significance of seagrass fishery activity. *Fish and Fisheries* 19(3) 399-412.

Orth, R.J. and Montfrans, J.V. 1984. Epiphyte-seagrass relationships with an emphasis on the role of micrograzing: A review. *Aquatic Botany* 18(1-2) 43-69.

Philips, R.C., Grant, W.S. and McRoy, C.P. 1983. Reproductive strategies of Eelgrass (*Zostera marina* L.). *Aquatic Botany* 16 1-20.

Prado, P. 2018. Seagrass epiphytic assemblages are strong indicators of agricultural discharge but weak indicators of host features. *Estuarine, Coastal and Shelf Science* 204 140-148.

RPS 2012. A report on behalf of South Hook LNG Terminal Company Ltd. A Post-Operational Monitoring Survey of Common Eelgrass *Zostera marina* in Milford Haven Waterway. RPS (Rural Planning, Transport and Environment).

Ruesink, J.L. 2016. Epiphyte load and seagrass performance are decoupled in an estuary with low eutrophication risk. *Journal of Experimental Marine Biology and Ecology* 481 1-8.

Saunders, J.E., Attrill, M.J., Shaw, S.M. and Rowden, A.A. 2003. Spatial variability in the epiphytic algal assemblages of *Zostera marina* seagrass beds. *Mar Ecol Prog Ser* 249 107-115.

Seagrass_Watch. 2018. *SW_Field_booklet_Cooktown* [*online*]. http://www.seagrasswatch.org.

Unsworth, R.K.F., Bertelli, C.M. and Bull, J.C. 2014. Options for long-term seagrass monitoring at Porthdinllaen, Wales. *Seagrass Ecosystem Research Group at Swansea University*. A report prepared for Gwynedd Council, Natural Resources Wales and the Pen Llŷn a'r Sarnau SAC.

Unsworth, R.K.F. et al. 2018. Global challenges for seagrass conservation. *Ambio*.

Unsworth, R.K.F., Williams, B., Jones, B.L. and Cullen-Unsworth, L.C. 2017. Rocking the Boat: Damage to Eelgrass by Swinging Boat Moorings. *Frontiers in Plant Science* 8(1309).

Waycott, M. et al. 2009. Accelerating loss of seagrasses across the globe threatens coastal ecosystems. *Proceedings of the National Academy of Sciences* 106(30) 12377-12381.

Xu, S. et al. 2018. New Insights into Different Reproductive Effort and Sexual Recruitment Contribution between Two Geographic Zostera marina L. Populations in Temperate China. *Frontiers in Plant Science* 9(15).

6 Acknowledgements

The authors thank Mark Burton (NRW) for assistance with this report and sharing the results and experiences of the Skomer MCZ monitoring. Thank you also to Richard Unsworth (Swansea University) for comments on the results of the Cawsand moorings studies.

Thanks also goes to those who have read and commented on this report including Angela Gall and Anne Bunker. Thank you to James Perrins for help and advice with the GIS.

Appendix 1 - Dive transect recording proforma

Zostera Transect Recording

Site Name		Date	
Transect Number		Recorders	
Transect Direction			

Score and description	% Cover	Sed. Type	Code
0 - No Zostera Present	0%	Sand	S
1 - Minimal Zostera Present	1-4%	Shingle / Shells	H
2 - Up to a quarter of Quadrat contains Zostera	5-25%	Rock	R
3 - Up to half the Quadrat contains Zostera	26-50%	Mixed	M
4 - Over half the Quadrat contains Zostera	51-75%	Macro Algae	A
5 - Almost all the Quadrat contains Zostera	76-100%		

Dist	Zostera	Sediment	Num Plants	Dist	Zostera	Sediment	Num Plants
Start				26			
1				27			
2				28			
3				29			
4				30			
5				31			
6				32			
7				33			
8				34			
9				35			
10				36			
11				37			
12				38			
13				39			
14				40			
15				41			
16				42			
17				43			
18				44			
19				45			
20				46			
21				47			
22				48			
23				49			
24				End			
25							

Appendix 2 – Leaf data recording sheet

SEA GRASS SURVEY RECORD SHEET

Site:			Leaf Infection / Epiphyte Cover Score											Flowering plant?	Eggs present on leaves?
	Bearing and Distance	Longest leaf length (cm)	0 - Uninfected 0% 1 - Minimal infection apparent 0-2% 2 - Up to a quarter of leaf infected 3-25% 3 - Up to half the leaf infected 26-50 4 - Over half all of leaf infected 51-75 5 - Almost all of leaf inftected 76-100%												
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															
31															
32															
33															
34															
35															
36															
37															
38															
39															
40															
41															
42															
43															
44															
45															
46															
47															
48															
49															

Appendix 3 – Mooring recording proforma

Seagrass Mooring Damage Recording Proforma

Mooring No: ....Surveyor:................ L/R.........Date:.......... Conditions?...........

Dist.	Bearing	Time	Depth	% cover
0	N			
2	N			
4	N			
6	N			
8	N			
10	N			
12	N			
14	N			
16	N			
18	N			
20	N			
0	E			
2	E			
4	E			
6	E			
8	E			
10	E			
12	E			
14	E			
16	E			
18	E			
20	E			
0	S			
2	S			
4	S			
6	S			
8	S			
10	S			
12	S			
14	S			
16	S			
18	S			
20	S			
0	W			
2	W			
4	W			
6	W			
8	W			
10	W			
12	W			
14	W			
16	W			
18	W			
20	W			

Dist.	Bearing	Time	Depth	% cover
0	N			
2	N			
4	N			
6	N			
8	N			
10	N			
12	N			
14	N			
16	N			
18	N			
20	N			
0	E			
2	E			
4	E			
6	E			
8	E			
10	E			
12	E			
14	E			
16	E			
18	E			
20	E			
0	S			
2	S			
4	S			
6	S			
8	S			
10	S			
12	S			
14	S			
16	S			
18	S			
20	S			
0	W			
2	W			
4	W			
6	W			
8	W			
10	W			
12	W			
14	W			
16	W			
18	W			
20	W			

FDB 12/07/18

Appendix 4 – Dive transect information

Drake Island							
Description	Moderately dense seagrass on sand						
Date	26.07.18						
Transect number	Northing	Easting	Direction	Surveyors	Depth	Depth Below CD	Time
1	50 21.419	-004 09.169	N	GW and JM	3.7	1.2	09:42
2	50 21.434	-004 09.126	N	FB and MP	4.4	2.2	10:00
3	50 21.414	-004 09.083	N	CW and RK	4.6	2.5	10:08
4	50 21.426	-004 09.207	N	FB and CP	4.2	2.7	11:23
Cawsand Bay							
Description	Moderately dense seagrass on sand						
Date	23.07.18						
Transect number	Northing	Easting	Direction	Surveyors	Depth	Depth Below CD	Time
1	50 19.700	-004 11.764	SE	GW and CP	7.5	4.8	11:06
2	50 19.725	-004 11.788	SSW	CW and RK	7	4.2	11:12
3	50 19.793	-004 11.862	SW	FB and MP	8	4.1	12:58
4	50 19.808	-004 11.793	SW	JM and AG	9	5.1	13:00
5	50 19.868	-004 11.870	S	GW and CP	8.8	4.4	14:35
6	50 19.863	-004 11.944	S	CW and RK	7.2	2.8	14:25
7	50 19.863	-004 11.944	S	FB and MP	8	3.4	15:34
Cellars Cove							
Description	Moderately dense seagrass on sand						
Date	25.7.18						
Transect number	Northing	Easting	Direction	Surveyors	Depth	Depth Below CD	Time
1	50 18.664	-004 03.913	SW	JM and AG	5.4	3.2	12:45
2	50 18.615	-004 03.986	SW	FB and MP	5.8	2.1	14:30
3	50 18.648	-004 03.952	S	GW and CP	6.3	2.9	14:07
4	50 18.628	-004 04.080	East	CW and RK	6.0	1.5	15:52
5	50 18.619	-004 04.070	East	JM and AG	6.0	1.4	16:07
Red Cove							
Description	Dense seagrass on sand and gravel						
Date	25.7.18						
Transect number	Northing	Easting	Direction	Surveyors	Depth	Depth Below CD	Time
1	50 18.699	-004 03.560	East	GW and CP	4	2.3	10:15
2	50 18.714	-004 03.594	SE	FB and MP	3.8	2.1	10:25
3	50 18.673	-004 03.520	SE	CW and RK	3.8	2.3	11:21