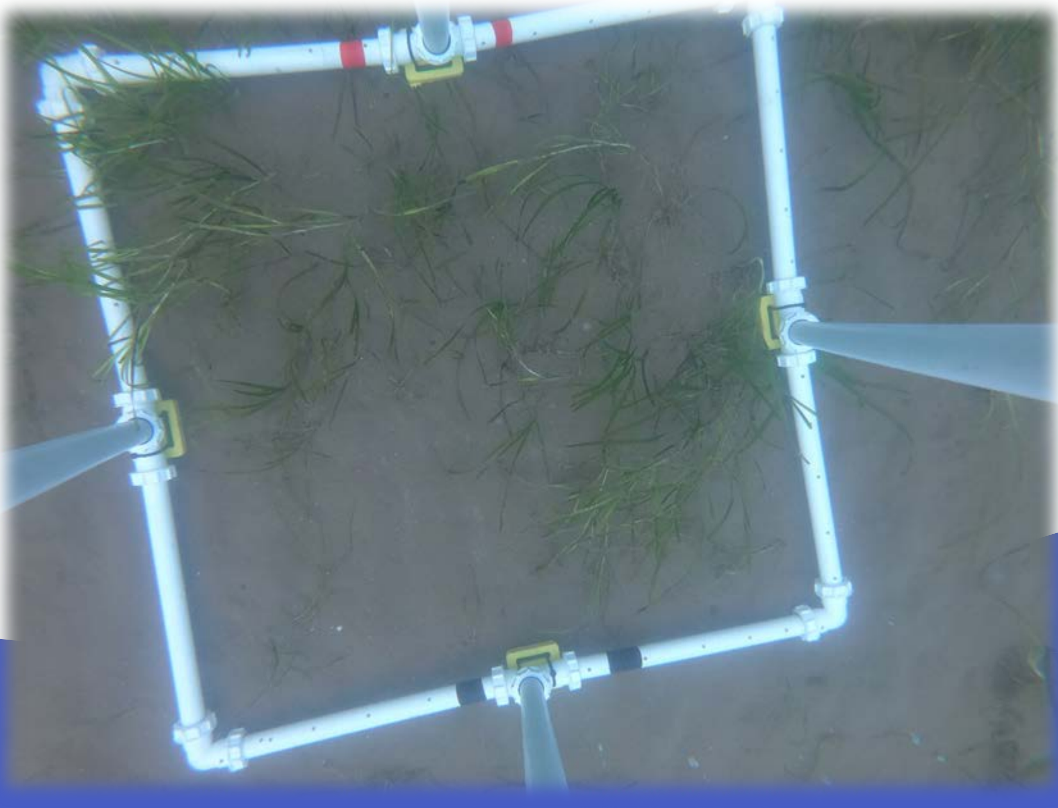
Natural England Commissioned Report NECR293

Torbay MCZ Seagrass Baseline Monitoring: 2019



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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

Torbay Marine Conservation Zone (MCZ) is an inshore site which was designated in 2013 for a range of features including subtidal seagrass beds. This report was commissioned to provide a baseline for subtidal seagrass within the site. It will be used in the condition assessment for the site and to support management measures as necessary.

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Natural England Project Manager – Trudy Russell, Marine Ecology Specialist trudy.russell@naturalengland.org.uk

Contractor – Ecospan Environmental info@ecospan.co.uk

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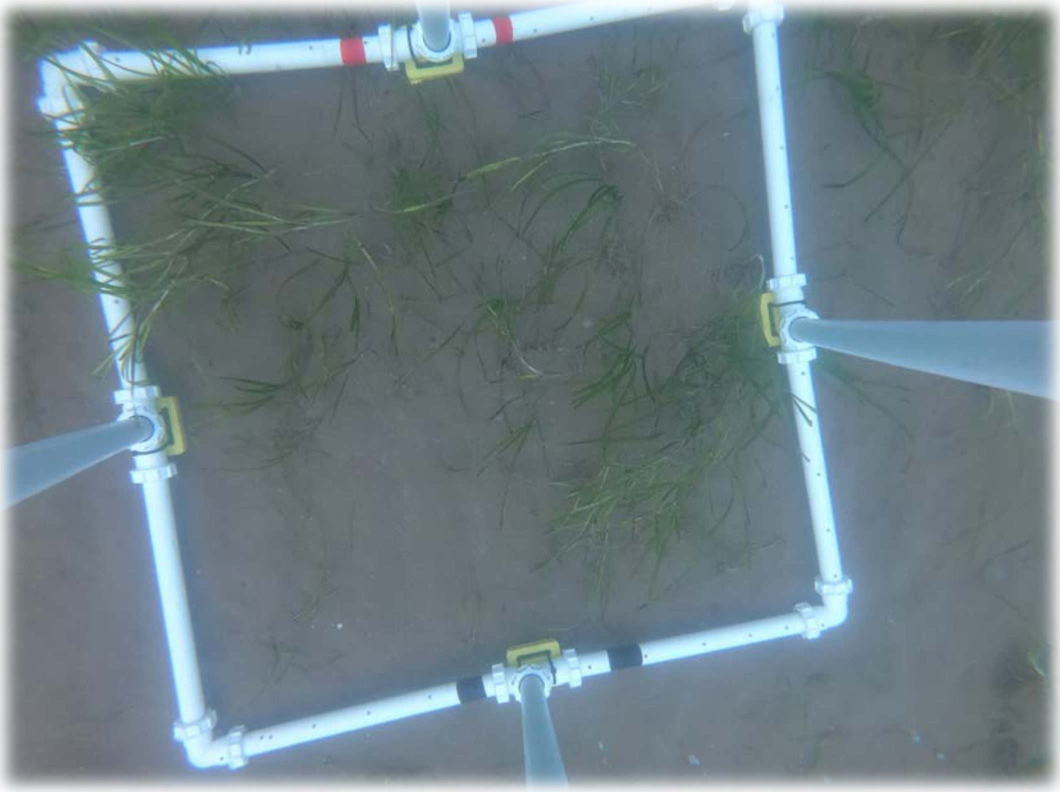

Performing Company:

Ecospan Environmental Ltd.
Unit 8 Strashleigh View
Lee Mill Industrial Estate
Plymouth
Devon
PL21 9GS

Tel: 01752 897198
Email: info@ecospan.co.uk
www.ecospan.co.uk

Sponsor: Natural England

Ecospan Project No.19-573

Ecospan Environmental Ltd. is registered in England No. 5831900

Author(s):	M D R Field
Approved By	M J Hutchings
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1. Trudy Russell — Natural England
2. Mike Field — Ecospan Environmental Ltd

Contents

1 EXECUTIVE SUMMARY

Surveys of the seagrass beds within the Torbay Marine Conservation Zone (MCZ) were undertaken by the Environment Agency (E.A.) and Natural England during the summer and early autumn of 2019. The drop-down video (DDV) survey was undertaken by the EA from 09th to the 13th July 2019. Seagrass beds were surveyed at all the known locations within the MCZ (8 beds in total) from Hope Cove to Breakwater beach. The results of the DDV survey were then used to determine suitable dive site locations for the diving survey which was carried out by Natural England from the 24th to 27th September at five of the known beds.

The results of the 2019 DDV survey were compared to that from previous surveys undertaken by the Devon and Severn Inshore Fisheries and Conservation Authority (IFCA). To do this contour plots of the 2019 data were made at each location and the area of seagrass within the pre-determined categories calculated. This was then compared to the seagrass bed areas published by the IFCA. Since the methodology was very different between the IFCA surveys and the current survey, the areas calculated are not directly comparable between the two. However, the extent from the last IFCA survey (2017) has then been super-imposed on the 2019 contour plots. The match between the two sets of data increases the understanding of any differences between seagrass at each point and therefore (in some cases) the confidence in the conclusions drawn.

The diving surveys examined the % cover, shoot density, infection and epiphyte loading as well as the presence of invasive non-native species (INNS), litter and anchor scars. No baseline diving surveys had been carried out at these sites previously and therefore no temporal comparisons could be made.

Due to the lack of baseline data and substantial differences between methodology where previous data existed, an assessment could only be made of two of the seagrass attributes. It is considered that all of the seagrass beds met the target for INNS and pathogens as infection scores were very low at every site and very few INNS were observed during the course of both the diving and DDV surveys.

It has been concluded that the extent and distribution of the seagrass beds has been maintained at Thatchers Point and Fishcombe. The other beds have all decreased to some extent, for seagrass beds at Hope Cove, Millstones, Elberry Cove and Breakwater Beach, the confidence in this conclusion is low due to inconsistencies in the data and the quality of the baseline data. However, at Livermead there appears to have been a substantial reduction in both the area and extent metrics and at Roundham Point no seagrass was observed in 2019. Therefore, the confidence at these two beds is moderate to high. Since the target is to recover the total extent and spatial distribution of seagrass, it can be concluded that the target has not been reached for the Torbay MCZ as a whole.

There is some suggestion from the data that the more exposed beds/areas of seagrass beds have declined the most. If this is the case, it is probable that natural variations in weather patterns are responsible and therefore that it may be worthwhile to monitor trends in these as well as the seagrass beds in future.

The design and power of the survey methods has been reviewed and suggestions made of how these could be improved in future made. The two principle weaknesses have been identified as too large a grid size (for the DDV survey) and too little replication for the diving surveys.

2 INTRODUCTION

Torbay Marine Conservation Zone (MCZ) is an inshore site covering an area of coastline in South Devon between Oddicombe Beach and Sharkham Point which was designated in 2013 [1]. From the shoreline, the site boundary extends to a depth of 30m encompassing Hope's Nose near Torquay and Berry Head near Brixham. The site includes a range of habitats exposed to different environmental conditions. This variation creates an area that is capable of supporting a rich array of marine wildlife and it has been described as 'the jewel in South Devon's crown' for marine wildlife. The site is designated for a number of intertidal and subtidal habitat features including sediments, rock and seagrass beds.

Seagrass beds are known to be present at a number of sites within the MCZ and have been monitored periodically by the Devon and Severn Inshore Fisheries and Conservation Authority (IFCA) since 2012 [2, 3, 4]. The seagrass beds have been assigned a 50 m buffer by the IFCA and lie within an area closed to the use of mobile fishing gear. A chart showing their distribution (taken from the 2017 IFCA report [4]) is shown in Fig. 1.

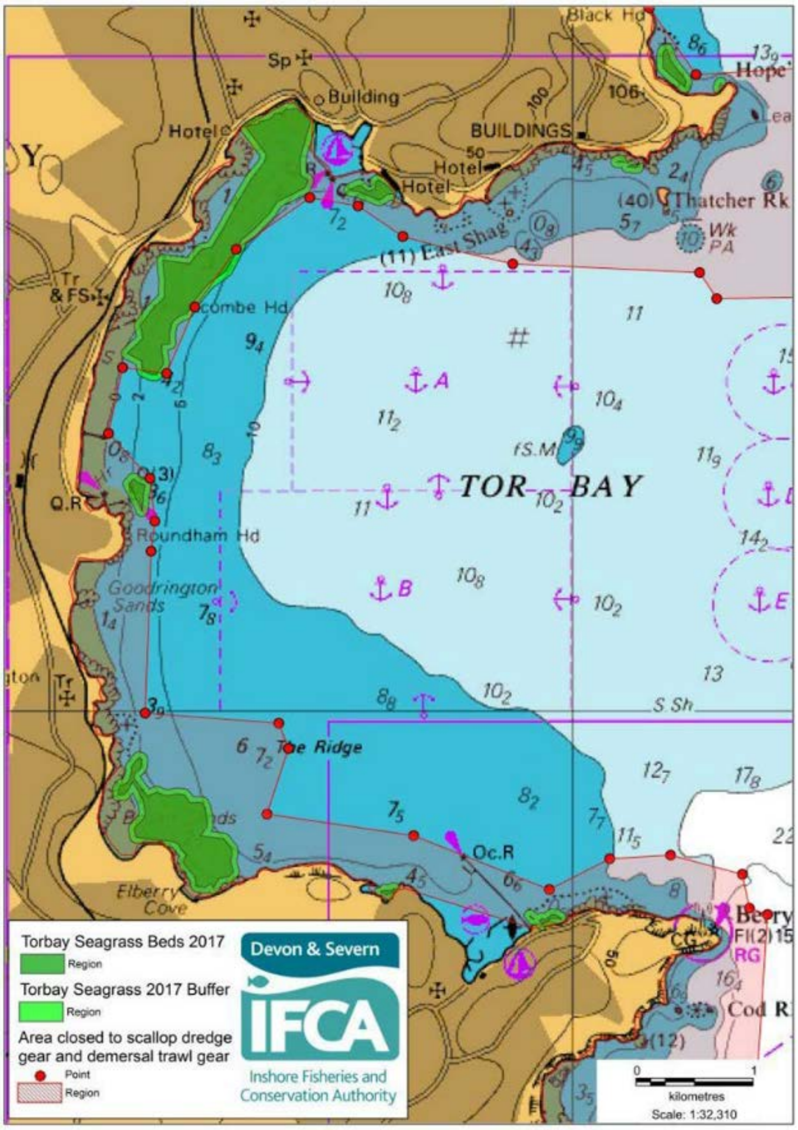


Fig. 1. Chart of the Torbay MCZ showing the location of the seagrass beds and the buffers assigned by the IFCA. NOT TO BE USED FOR NAVIGATION

As a designated feature of the MCZ, seagrass beds have a number of attributes each of which has a target set for it. These can broadly be split into two groups: those that relate to the seagrass beds themselves (e.g. distribution and extent) and those that relate to supporting processes (e.g. light levels, water quality, sedimentation rates etc). These are shown in Tables 1 and 2.

Table 1. Attributes and targets for the seagrass beds themselves.

Attribute	Target
Distribution: presence and spatial distribution of biological communities	Recover the presence and spatial distribution of intertidal seagrass bed communities.
Extent and distribution	Recover the total extent and spatial distribution of seagrass beds.
Extent of supporting habitat	Maintain the area of habitat that is likely to support the subfeature.
Structure and function: presence and abundance of key structural and influential species	[Maintain/Recover/Restore] the abundance of listed typical species, to enable each of them to be a viable component of the habitat.
Structure: biomass	Recover the leaf / shoot density, length, percentage cover, and rhizome mat across the feature at natural levels (as far as possible), to ensure a healthy, resilient habitat.
Structure: non-native species and pathogens	Restrict the introduction and spread of non-native species and pathogens, and their impacts.
Structure: rhizome structure and reproduction	Recover the extent and structure of the rhizome mats across the site, and conditions to allow for regeneration of seagrass beds.
Structure: sediment composition and distribution	Maintain the distribution of sediment composition types across the feature.
Structure: species composition of component communities	Recover the species composition of component communities.

Table 2. Targets for the supporting processes.

Supporting Process	Target
Energy / exposure	Maintain the natural physical energy resulting from waves, tides and other water flows, so that the exposure does not cause alteration to the biotopes, and stability, across the habitat.
Light levels	Maintain the natural light availability to the seagrass bed.
Morphology	Maintain the natural physical form and coastal processes that shape the seagrass bed.
Physico-chemical properties	Maintain the natural physico-chemical properties of the water.
Sediment contaminants	Restrict surface sediment contaminant levels to concentrations where they are not adversely impacting the infauna of the feature.
Sedimentation rate	Maintain the natural rate of sediment deposition.
Water quality - contaminants	Restrict aqueous contaminants to levels equating to High Status according to Annex VIII and Good Status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels.
Water quality - dissolved oxygen	Maintain the dissolved oxygen (DO) concentration at levels equating to High Ecological Status (specifically ≥ 5.7 mg per litre (at 35 salinity) for 95 % of the year), avoiding deterioration from existing levels.
Water quality - nutrients	Maintain water quality and specifically mean winter dissolved inorganic nitrogen (DIN) at a concentration equating to High Ecological Status (specifically mean winter DIN is < 12 µM for coastal waters), avoiding deterioration from existing levels.
Water quality - turbidity	Maintain natural levels of turbidity (e.g. concentrations of suspended sediment, plankton and other material) across the habitat.

In 2019 surveys were undertaken by the Environment Agency and Natural England to assess the seagrass beds against the relevant targets. Following a successful tender for the work, Ecospan Environmental Ltd. was commissioned to review the proposed diving methodology, and to report the results from the surveys. The diving methods were reviewed after the drop-down video (DDV) survey had taken place, but before the diving began and are reported separately [5].

3 AIMS

The aims of the surveys were to monitor the following attributes of the seagrass beds:

- Extent and distribution
- Distribution: presence and spatial distribution of biological communities
- Structure: biomass
- Structure: non-native species and pathogens

4 METHODS

4.1 Drop-down video

A DDV survey of seven of the areas of seagrass shown in Fig. 1 was carried out by the Environment Agency (EA) from 09th to the 13th July 2019 following the EA's operational instructions [6]. Seagrass beds at Hope Cove, Thatchers Point, Millstones, Livermead, Roundham Head, Elberry Cove, Fishcombe Cove and Breakwater Beach were assessed. Surveys were undertaken from the EA's MCA Cat 3 coded 6.2 m catamaran *Three Rivers*.

Sampling aimed to take place 2 hours either side of low water to ensure the seagrass canopy was at a constant height to enable a consistent estimation of seagrass cover. Some sampling took place outside this window, but this was targeted to stations that were considered to have a low chance of seagrass being present.

Based on the results of the previous IFCA surveys, sample points were assigned using a 50 m triangular grid over the survey area. In a few areas, extra points were added to increase the resolution. In order to define the boundary of the bed, this included areas thought to be outside the potential extent. Where seagrass was observed outside of the gridded area, further points were added to determine the full extent of the bed

At each point a 1 m^2 photo quadrat was taken using a 12-megapixel Go-Pro HERO7 Black camera in in an underwater Supersuit housing. The location of each station was recorded using a Garmin dGPS positioned on the davit. Lighting was provided by a 2000 lumen, 160 white LED light. The quadrat frame was constructed from plastic piping and weighted with lead. (Fig. 2). A live feed from the camera was fed back to a tablet computer on the vessel, allowing the surveyor to observe when the frame was on the seabed.

At each point the following information was recorded:

- % cover of seagrass
- Depth
- Exact sampling position
- Substrate type
- % cover of *Sargassum muticum,* green algae, red algae and kelp

- Any unusual observations (e.g. moorings, kelp, pot lines, litter and anchor scars)

Fig. 2. DDV camera and quadrat frame being deployed from the side of the survey vessel.

4.2 Diving

Diving surveys of the seagrass beds were undertaken by Natural England at Hope Cove, Millstones, Livermead, Elberry Cove and Fishcombe Cove from 24th to 27th September 2019. All diving took place from the dive charter boat Falcon II following the HSE's approved code of practice [7]. One station was assessed in each bed except for Livermead where three stations were surveyed. The exact position of the centre of each dive station (i.e. the shot line) was recorded using dGPS. These are shown in Table A1 of the Appendix.

4.2.1 Quadrat placement

Twenty-five (0.25 m^2) quadrats were sampled at each site. Stations were pre-determined using pairs of randomly generated rectangular ('x' and 'y') coordinates which were then translated into polar coordinates ('distance' and 'bearing'). Any polar coordinates with distance components greater than 30m were discarded. This process continued until 25 sets of polar coordinates within the maximum survey radius of 30m were assigned to each survey site. This method ensures a more even sampling of a circular survey area than if random polar coordinates had been generated (as this tends to oversample close to the centre).

The following information was recorded from each quadrat:

- Seagrass % cover
- The number of shoots present
- Algal % cover
- Sediment type
- Depth (subsequently converted relative to Chart Datum (CD).

Additionally, the occurrence of Invasive Non-Native Species (INNS) and evidence of anthropogenic impact, anchor scars, litter etc were recorded for each area.

4.2.2 Shoot leaf data

All the *Zostera* shoots in a quarter of the quadrat (0.0625 m^2) were collected and placed in labelled bags. Seagrass shoots were cut above the rhizome but below the point at which the stem bifurcates into leaves to ensure that the rhizome integrity was maintained before being placed in pre-labelled sample bags. The collected shoots were analysed on shore with the following data being recorded:

- Presence of flowers / seeds
- Eggs present on leaves
- Maximum length of leaves in a shoot
- Presumed infection in individual leaves by *Labyrinthula zosterae*
- Cover of individual leaves by epiphytes

The presumptive rates of infection by *Labyrinthula* and the epiphyte cover were scored as shown in Table 3.

Table 3. Scale used for recording infection of seagrass leaves by *Labyrinthula zosterae* and the cover of leaves by epiphytes.

Score	Description	% infected
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

5 RESULTS

5.1 Extent and distribution of seagrass

The first two aims of this assessment (to monitor the extent and distribution and to monitor the distribution: presence and spatial distribution of biological communities) were determined using the DDV data. All the raw data has been provided electronically along with this report.

A grid (using the Kriging method) was made of the % cover of seagrass from each quadrat using the contouring and 3 D surface mapping software SURFER 10. A boundary file was then created and used to create a contour map of the seagrass cover. These contour maps have been super-imposed over the chart for each area. This technique was also used on the recorded depths (converted relative to CD).

The contour map of seagrass cover at each of the 7 sites surveyed together with the positions of each of the sampling stations is shown in Figs. 3 - 9. For seagrass beds that were also assessed by divers, the positions of the dive station(s) have also been marked. No seagrass was observed at Roundham Point in 2019. Seagrass was only observed at two stations at Breakwater Beach (one at the west end and one at the east end of the survey area), consequently the confidence in this plot is low (% cover at each station is therefore included on this plot).

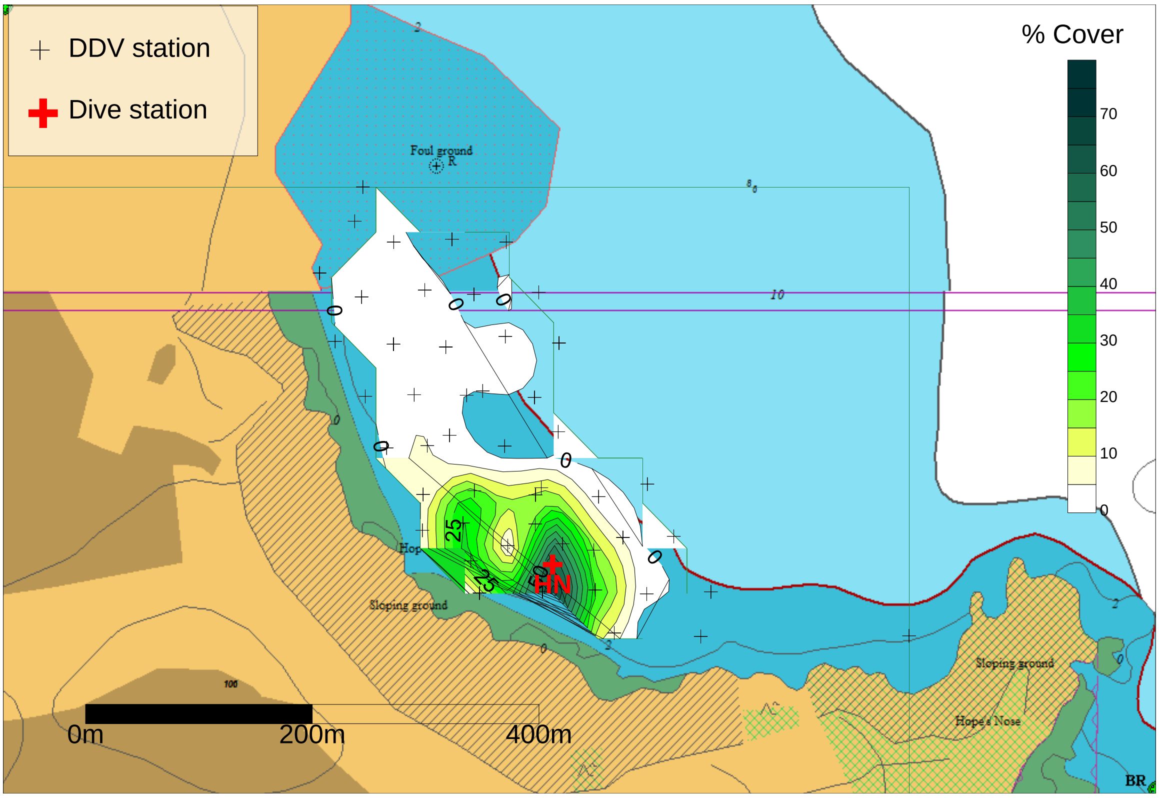


Fig. 3. Contour plot of seagrass cover (%) at Hope Cove.

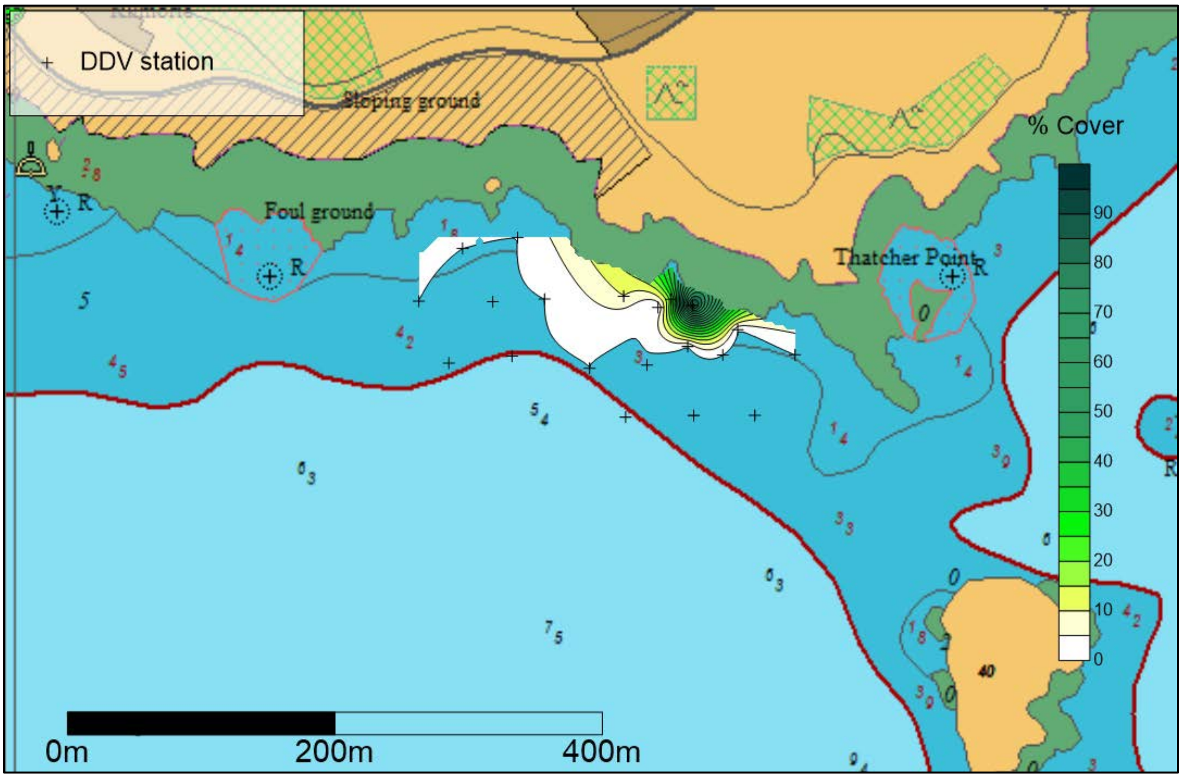


Fig. 4. Contour plot of seagrass cover (%) at Thatcher Point

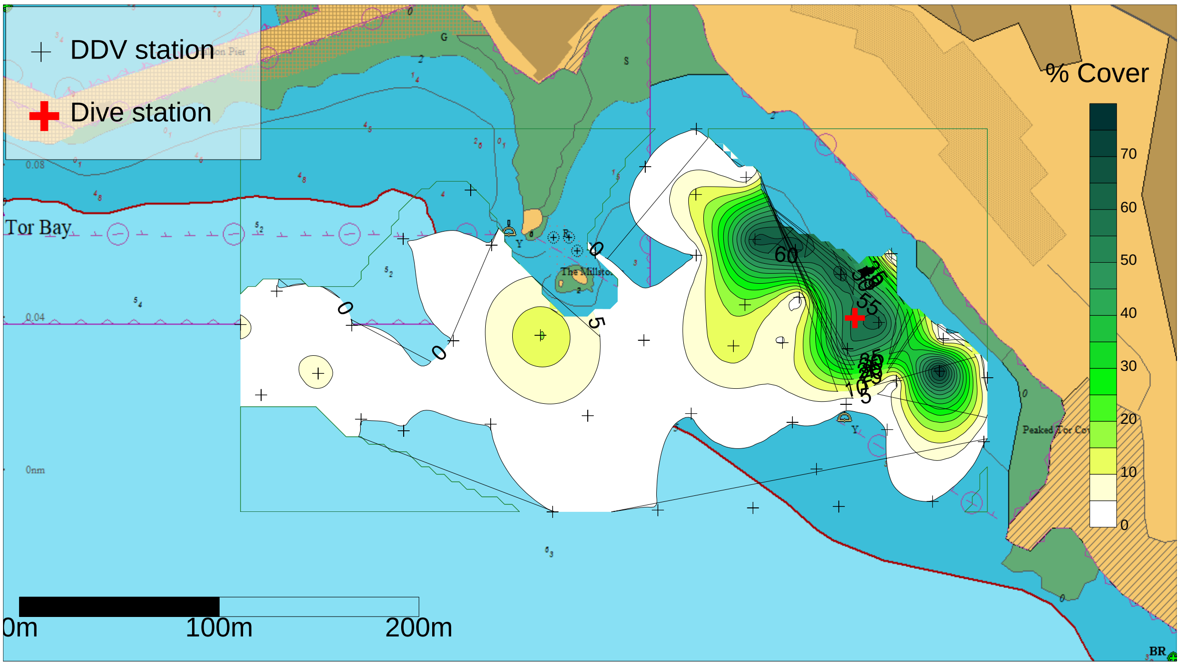


Fig. 5. Contour plot of seagrass cover (%) at Millstones

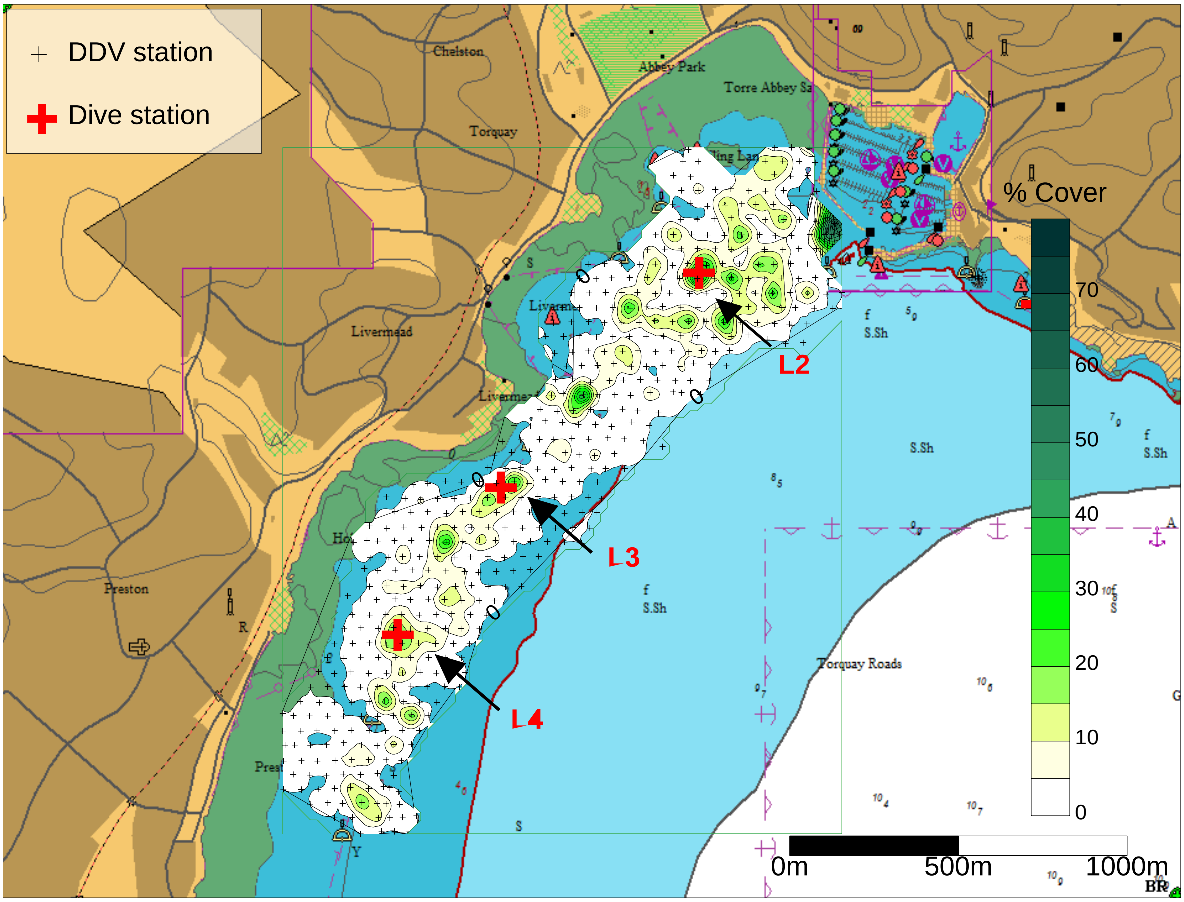


Fig. 6. Contour plot of seagrass cover (%) at Livermead

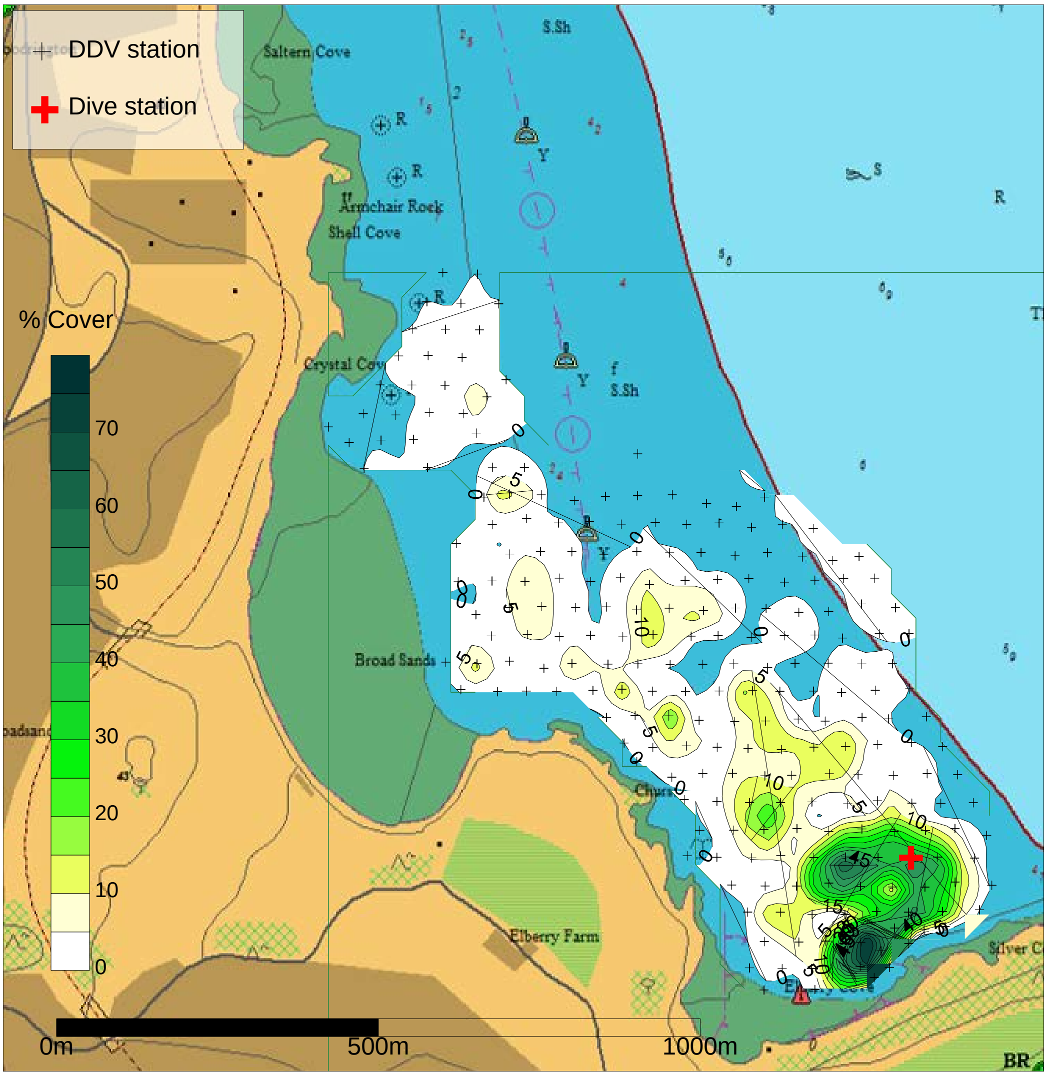


Fig. 7. Contour plot of seagrass cover (%) at Elberry Cove

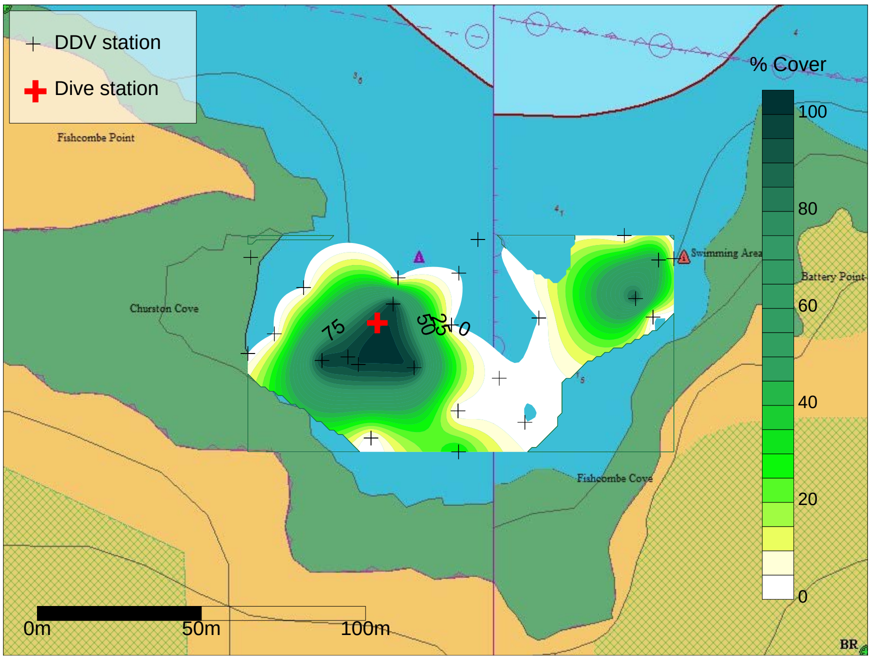


Fig. 8. Contour plot of seagrass cover (%) at Fishcombe Cove

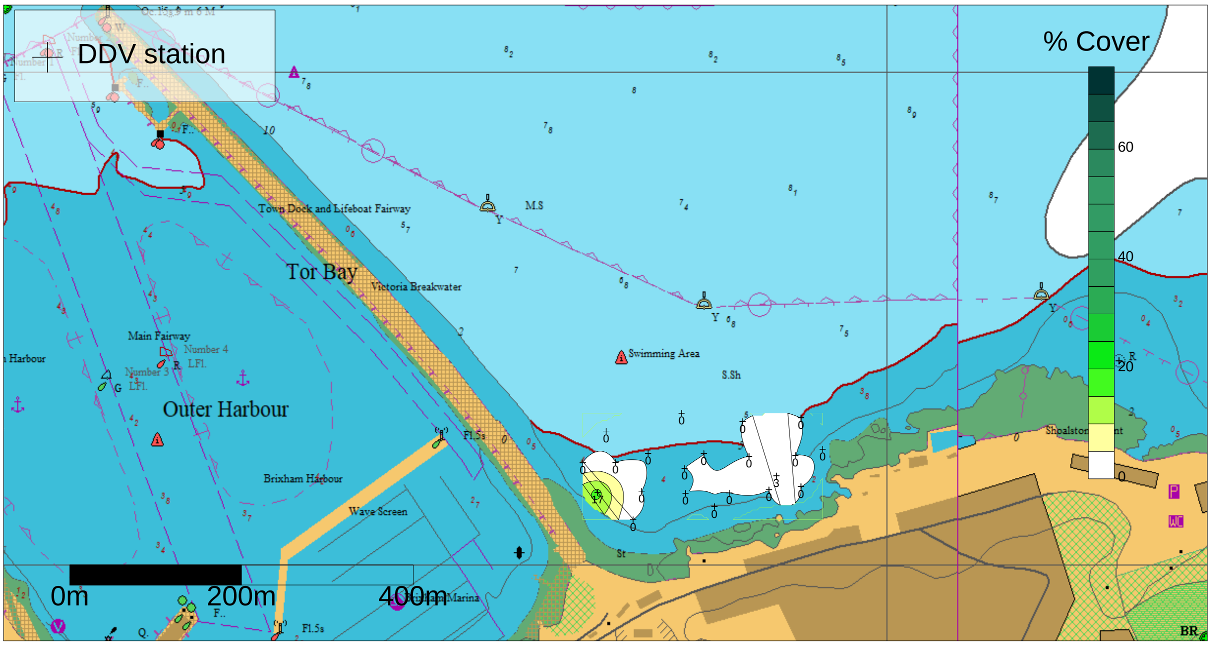


Fig. 9. Contour plot of seagrass cover (%) at Breakwater Beach.

It is evident from these plots that the seagrass tends to be densest in areas that are the most protected from the prevailing south westerly winds (with the exception of Breakwater Beach which is sheltered from south westerlies, but very exposed to north or north easterly winds). This includes the small area at Thatcher Point which is afforded some degree of shelter by the rocks extending from the shore towards Thatcher Rock. However, this does not explain the variation seen at Fishcombe Cove which is very sheltered.

It is well documented that both the depth of water and the substrate are key environmental factors that determine the distribution of seagrass [8]. Therefore, both the depth and substrate type at each point have been investigated to determine the potential effect of these variables. The influence of depth is shown in Fig. 10.

It can be seen from the plots that in most areas there was no correlation between the depth of the station and the cover of seagrass. If stations that did not contain seagrass are excluded, there is a slight but significant ($P<0.05$) correlation between these two factors at Millstones.

The substrate data recorded during the DDV survey shows that seagrass was present primarily on muddy sand (which also comprised the vast majority of the substrate), but was also growing on sand and gravel in some areas. Unsurprisingly, it was not present on rock.

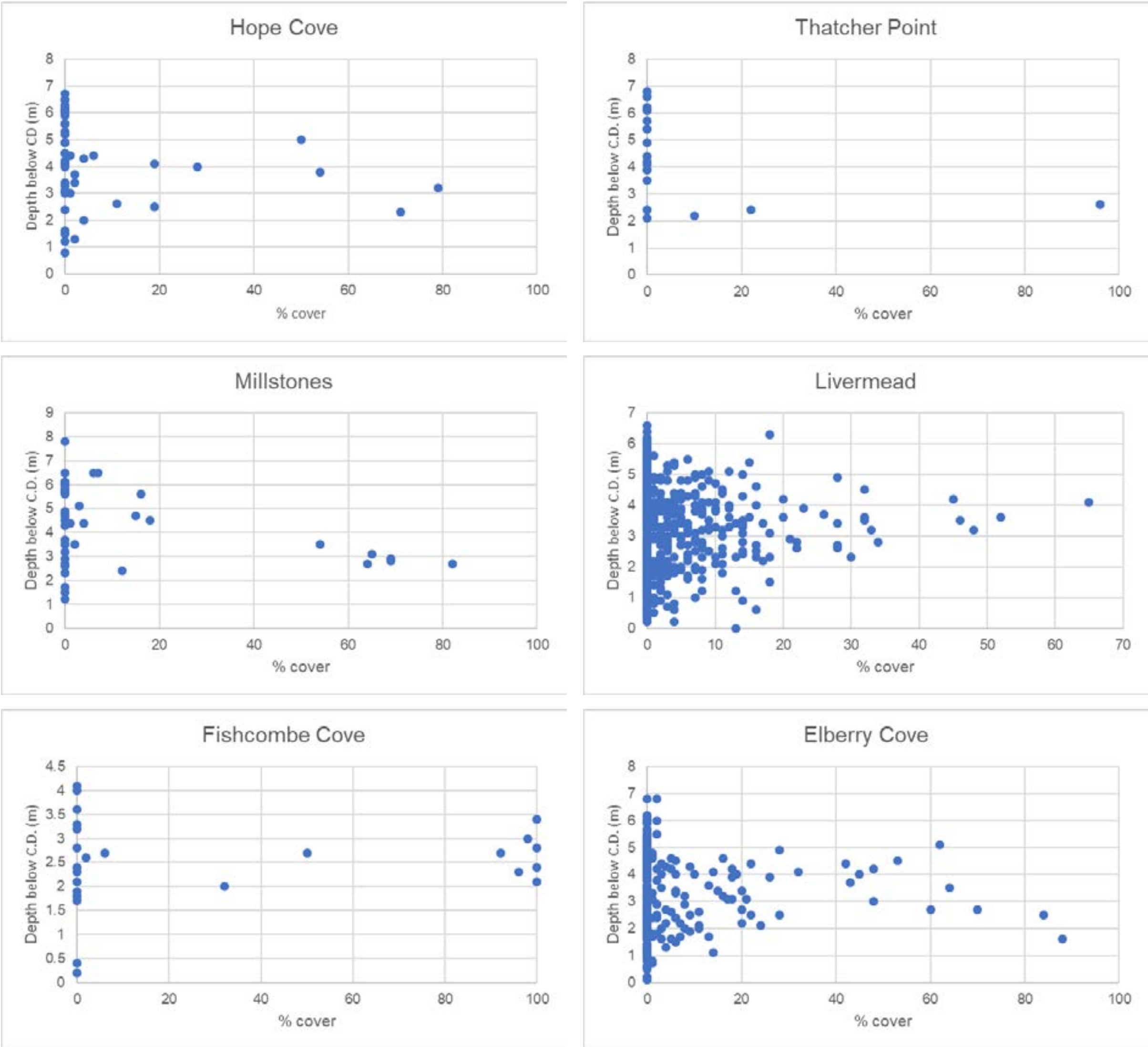


Fig. 10. Relationship between depth and seagrass cover within each bed.

5.1.1 Area of each seagrass density category

Historically [e.g. 9, 10] the seagrass cover has been separated into 4 categories ranging from very sparse (5 - 25%) to dense (76 - 100%). The area covered by each of these categories is shown in Fig. 11 with the exact areas being shown in Table A2 of the Appendix.

It can be seen from both the contour plots (Figs 3 – 9) and Fig. 11 that the seagrass was generally very sparse in most areas. Excluding the data from Breakwater Beach, where only two quadrats had seagrass within them), the proportion within this category varied from 97% at Livermead to 40% at the densest bed which was in Fishcombe Cove (Table A2 of the Appendix). Only the beds at Fishcombe Cove and Thatcher Point had any dense seagrass (17% and 3% of the total area within each bed respectively) although over 10% of the area of seagrass at Millstones was classified as moderate (51 -75% cover).

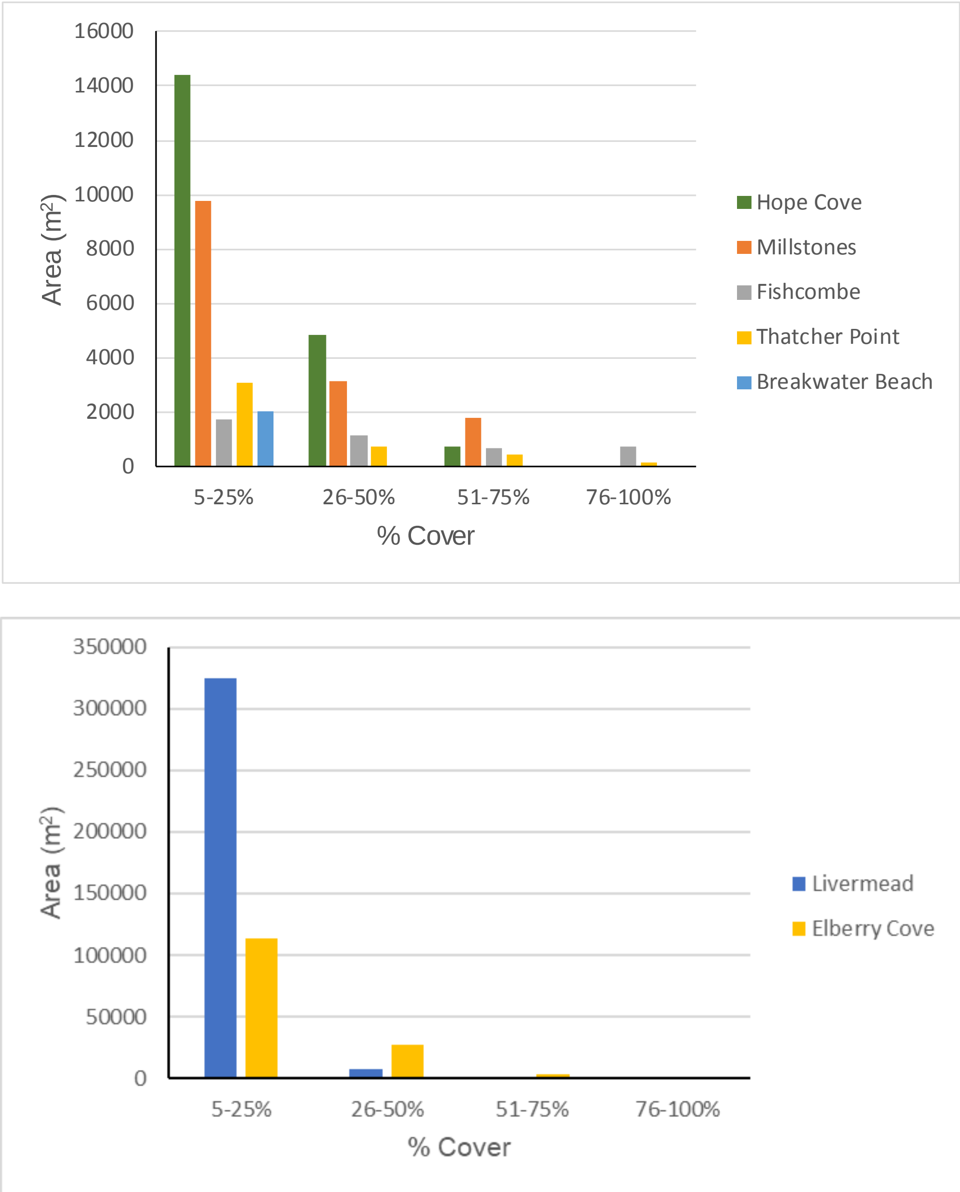
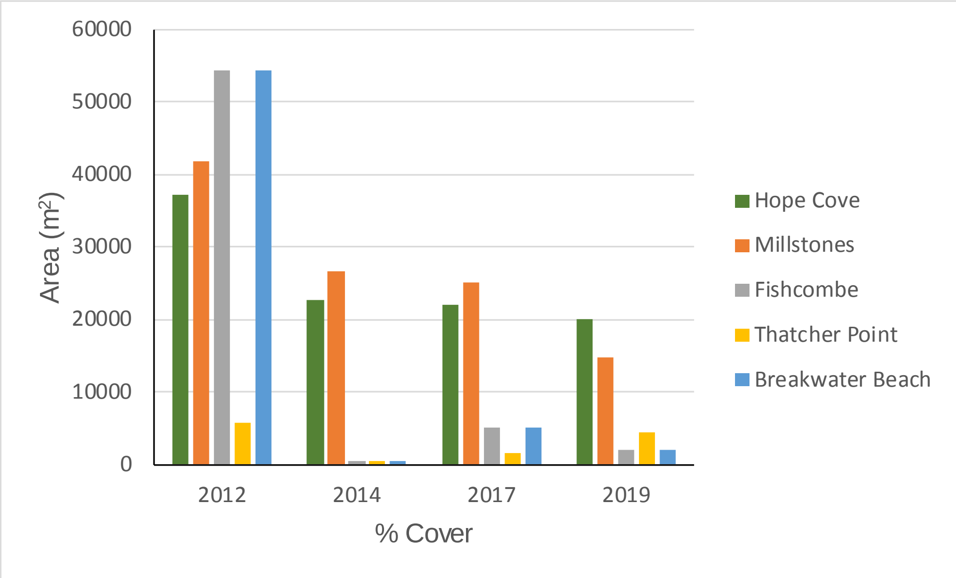


Fig. 11. Area of seagrass in each of the 4 categories of % cover.

5.1.2 Temporal variation

Although this was the first year that monitoring has been carried out using the current methodology, it is possible to make some comparisons with the results of the previous surveys undertaken by the IFCA from 2012 to 2017 [2, 3, 4]. The change in the area of seagrass beds from 2012 to 2019 is shown in Fig. 12. The bed at Roundham Point as it has only been monitored twice: once in 2017 where it covered 16,570 m^2 and once in 2019 when no seagrass was observed, consequently this is not shown in Fig. 12..

Great caution should be taken in interpreting the above data as the methodology between the IFCA surveys and the current survey is extremely different. The IFCA surveys were designed to delineate the seagrass bed extent and enable them to be protected from mobile fishing gear. Five categories of seagrass were used (absent, sparse, patchy, medium and dense), but these were not defined. It is also not clear how the areas were determined, but it appears that best judgement was used around the data from the DDV. It is also very likely that the areas of seagrass are over-estimated in the IFCA studies as a 5% threshold (to determine what constituted a bed) was not used. It should also be noted that the transits undertaken by the IFCA were not the same each year and relied on the direction of the drift of the boat. This therefore adds considerably to variability between years.



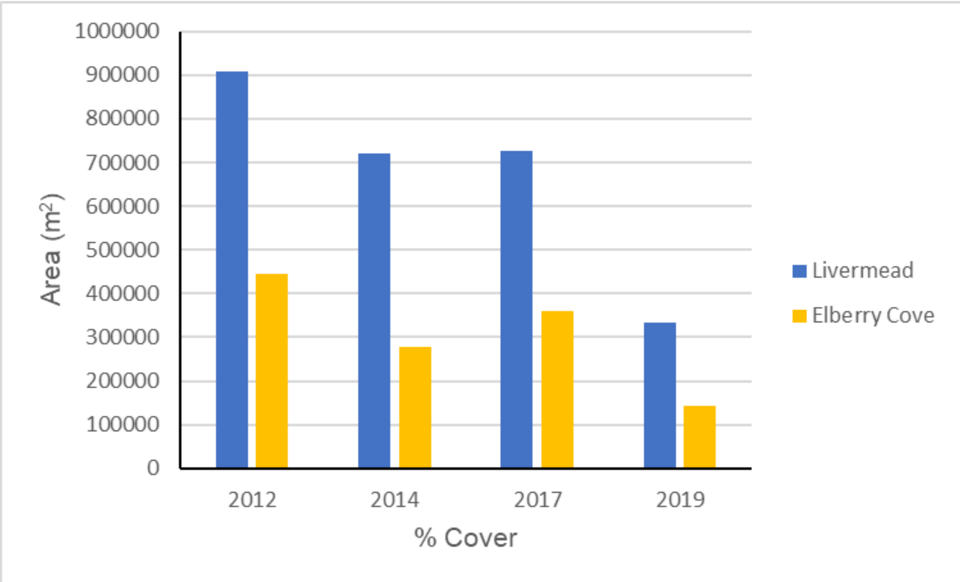


Fig. 12. Change in the area of seagrass beds from 2012 to 2019.

Although the data suggests that all beds have declined in area from 2012, it appears likely (since the data pre 2019 was probably an overestimate) that the seagrass beds at Fishcombe and Thatchers Point have increased moderately since 2014. From the area data, it also seems that the bed at Hope Cove has not reduced in area within the same time period (as values are within approximately 10% of each other). The data from Millstones and Breakwater Beach are less clear (given the uncertainties discussed above), but it appears that there may have been a substantial reduction in coverage at Livermead, Elberry Cove and Roundham Point (where no seagrass was observed in 2019).

To enable greater confidence in these conclusions, the IFCA data from 2017 has been super-imposed on the contour plots from 2019 (Figs 13 – 20).

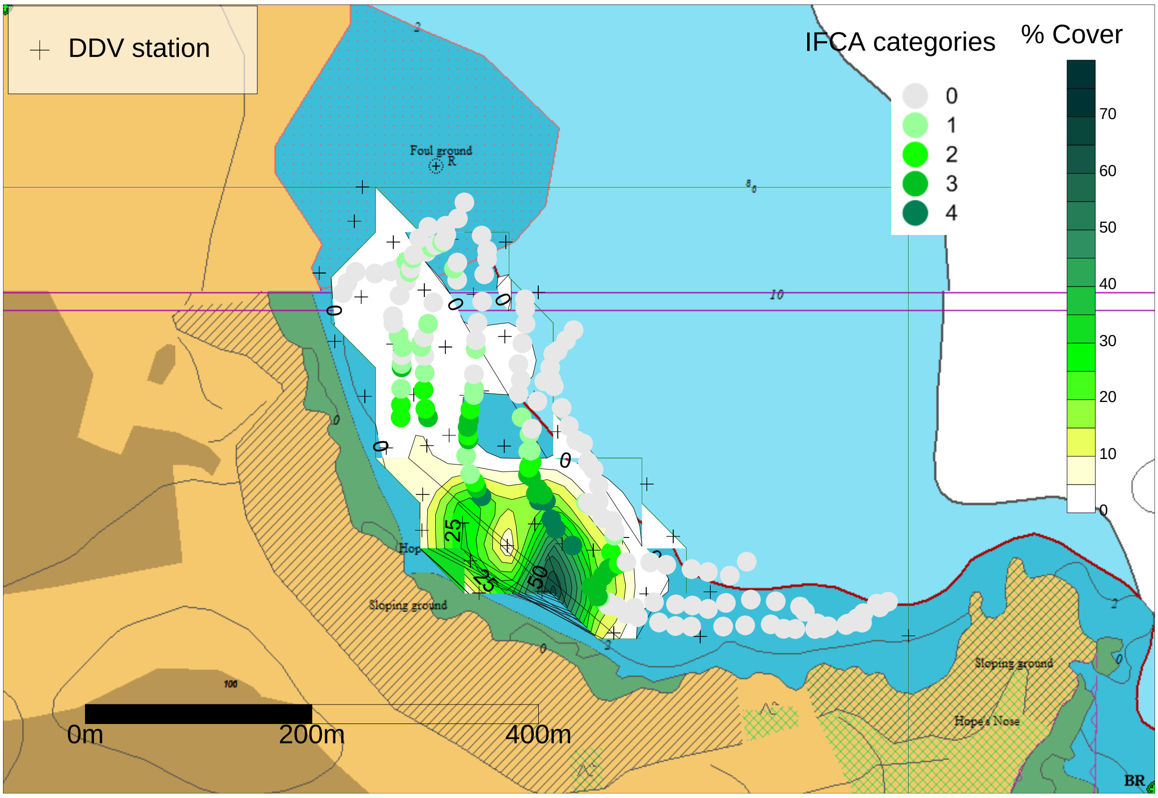


Fig. 13. Contour plot of the 2019 seagrass cover at Hope Cove with the 2017 IFCA results super-imposed.

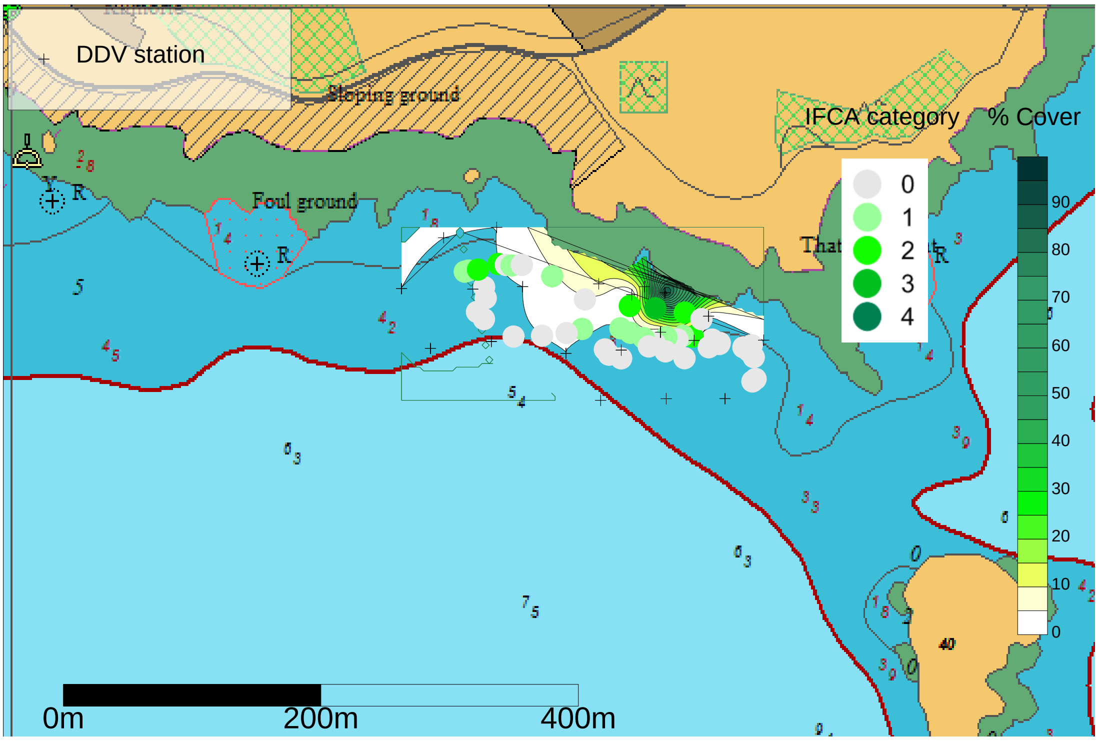


Fig. 14. Contour plot of the 2019 seagrass cover at Thatcher Point with the 2017 IFCA results super-imposed.

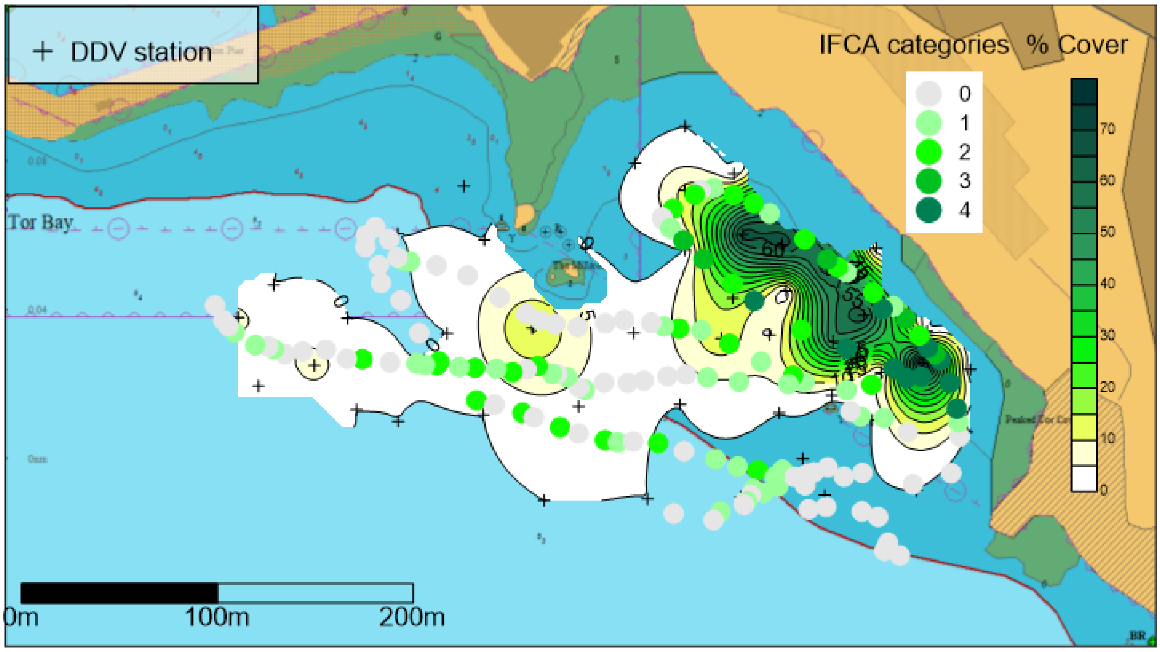


Fig. 15. Contour plot of the 2019 seagrass cover at Millstones with the 2017 IFCA results super-imposed.

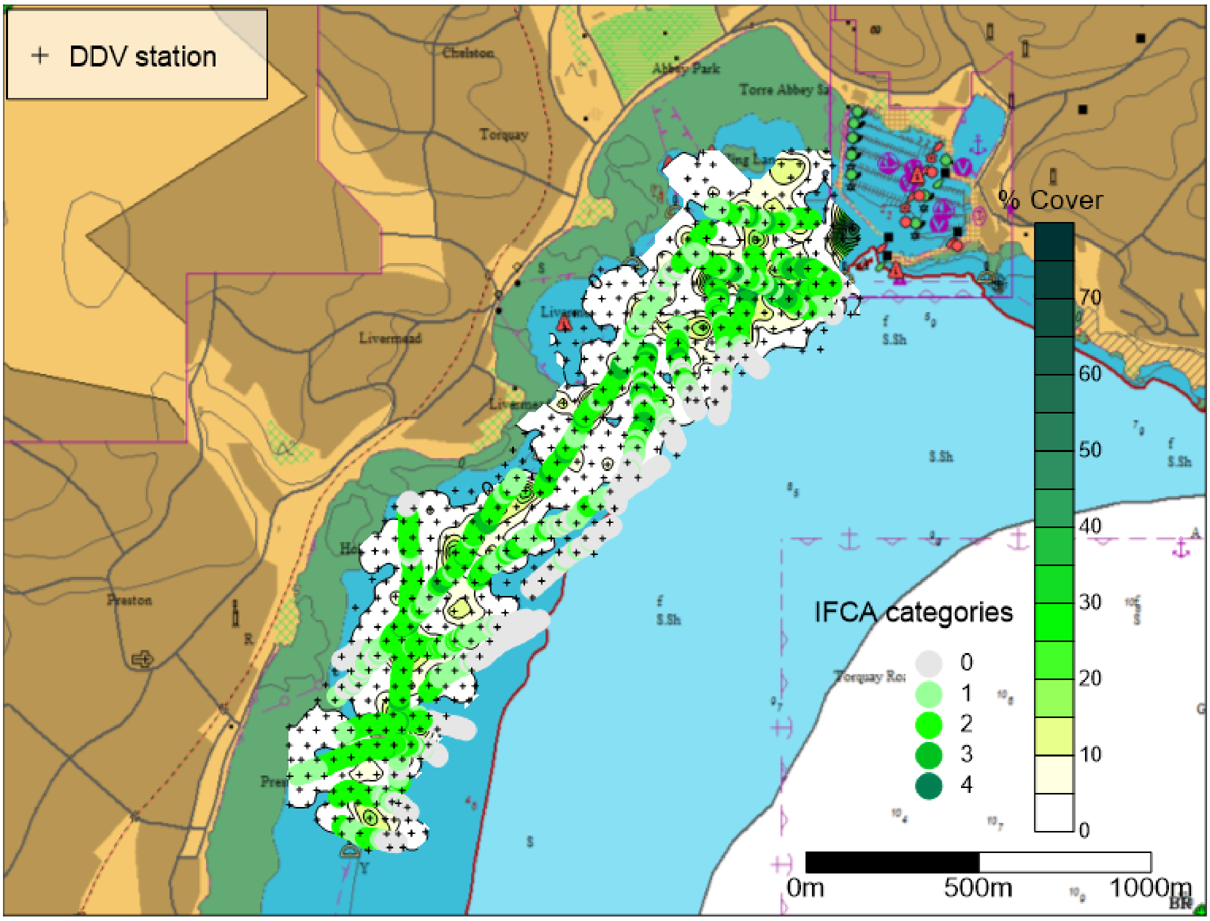


Fig. 16. Contour plot of the 2019 seagrass cover at Livermead with the 2017 IFCA results super-imposed.

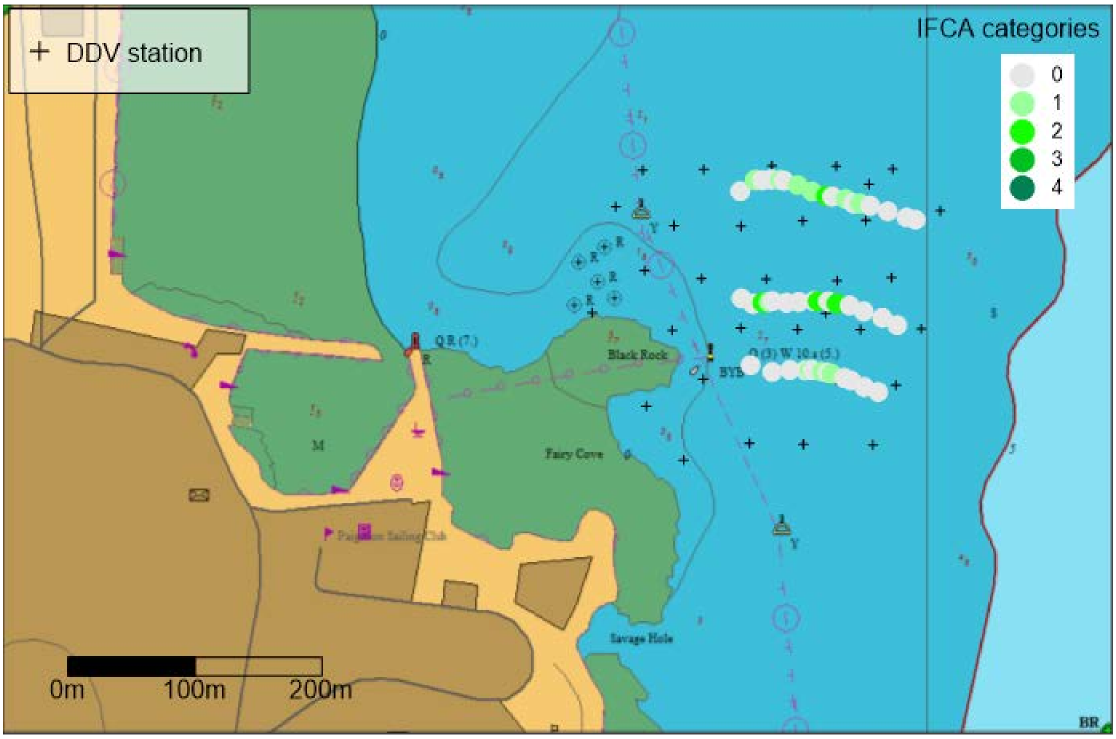


Fig. 17. Contour plot of the 2019 seagrass cover at Roundham Point with the 2017 IFCA results super-imposed.

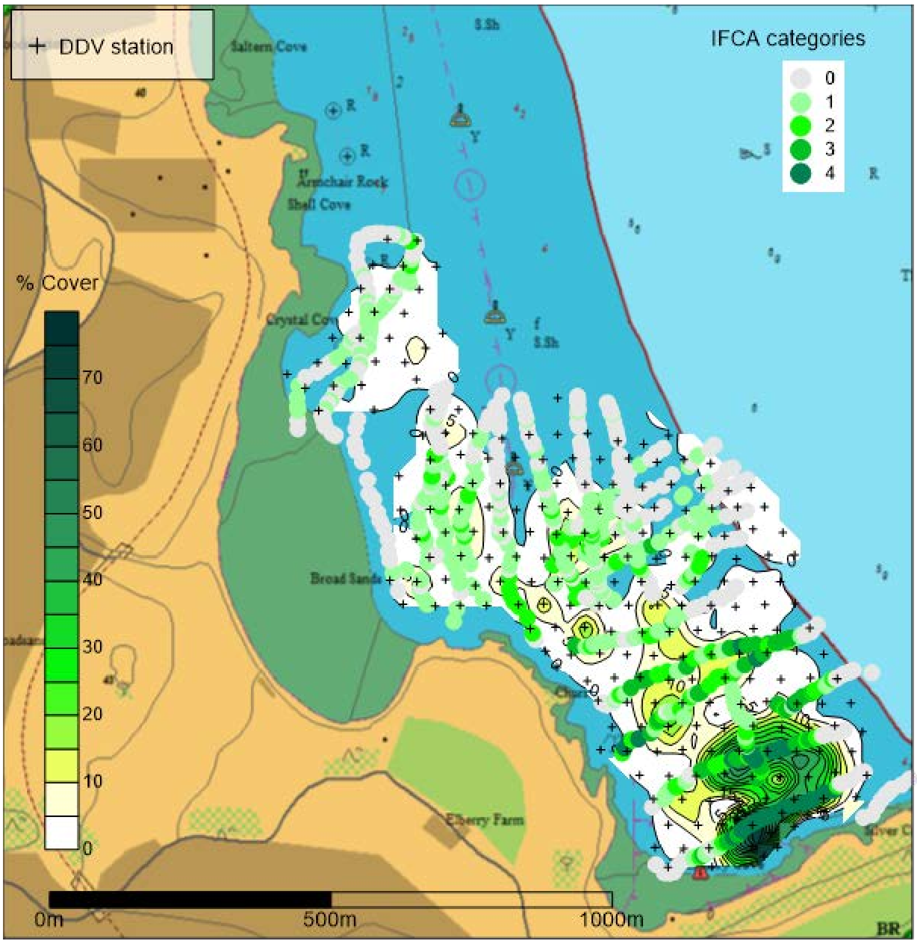


Fig. 18. Contour plot of the 2019 seagrass cover at Elberry Cove with the 2017 IFCA results super-imposed.

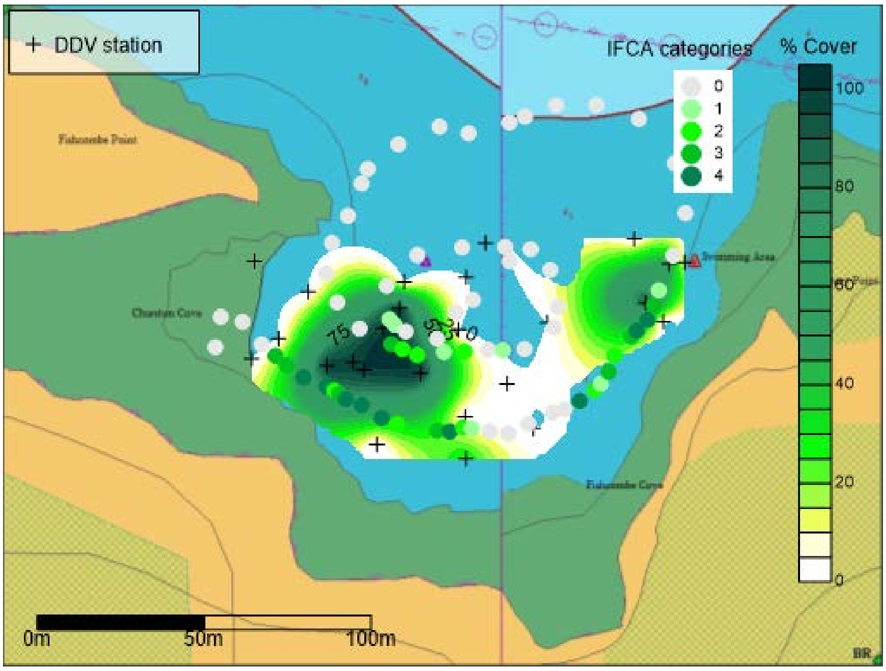


Fig. 19. Contour plot of the 2019 seagrass cover at Fishcombe Cove with the 2017 IFCA results super-imposed.

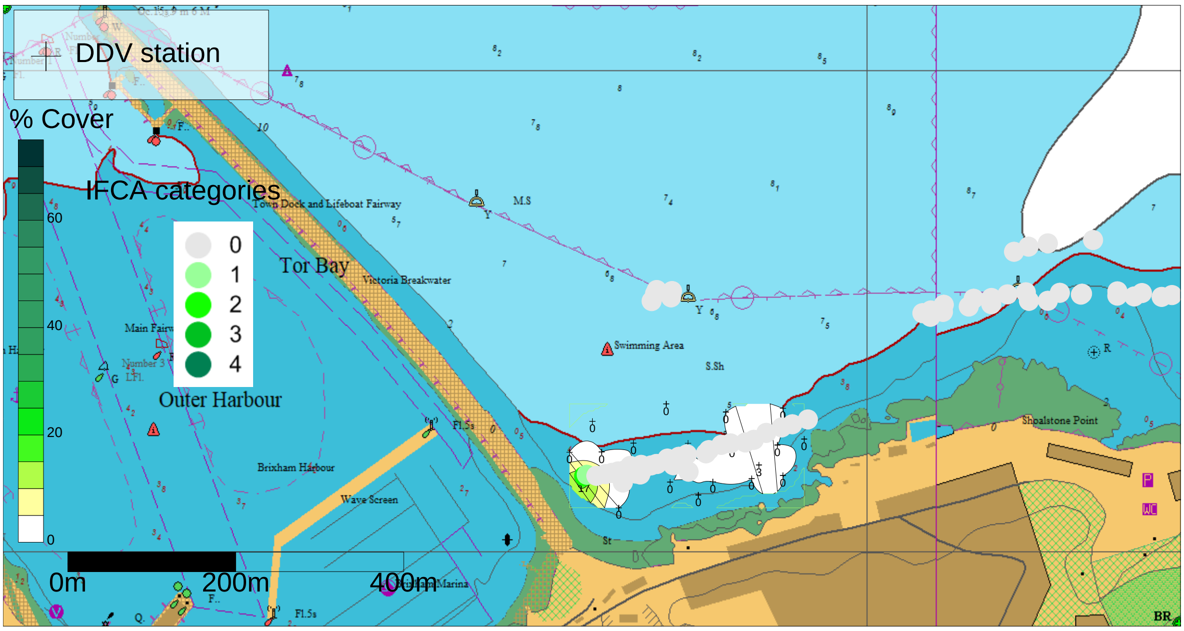


Fig. 20. Contour plot of the 2019 seagrass cover at Breakwater Beach with the 2017 IFCA results super-imposed.

In spite of the very different methodologies, in agreement with the area data discussed above, these plots suggest that the seagrass beds at Fishcombe may have increased slightly. Although the area data (Fig. 12) suggest that the bed at Thatchers Point may have increased in extent, it can be seen from Fig. 14, that it has remained more or less the same as have those at Millstones and Elberry Cove. However, it is concluded that the bed at Hope Cove which appeared to have increased in size from the area data may well have lost some of its extent (particularly on its northern extremity) since 2017. As was seen from the area data, considerable reduction is visible at Livermead and at Roundham Point (where no seagrass was observed in 2019). It is very difficult to draw any conclusions from the data from

Breakwater Beach, as the extent was poorly differentiated in 2017. It is only clear that one of the two stations that had seagrass present in 2019 also had a similar density of seagrass in 2017.

There is some suggestion from the data that the more exposed beds/areas of seagrass beds have declined the most. If this is the case, it is probable that natural variations in weather patterns are responsible (since vessels tend to anchor in the most sheltered regions of a bay and fishing activity is banned from these areas).

It is also apparent from these plots that the 50 m grid employed by the EA during the DDV survey is too large to give a good degree of confidence in the conclusions above. This is particularly true in the smaller beds. Since the method does not involve towing the camera, and only one quadrat ($1m^2$) is recorded rather than an average of several square metres in reasonable visibility when recorded live, it is concluded that the method may not give sufficient resolution particularly on small or patchy beds. This may potentially lead to large temporal variations in extent and perhaps should be reviewed before the next survey.

5.2 Seagrass bed structure (diving surveys).

The central position for each of the dive sites surveyed is shown in the contour plots of seagrass density (Figs.3 - 9). The data for shoot counts from each quadrat was multiplied by 4 to give the number of plants per square meter prior to subsequent analysis.

The mean summary seagrass data for the% cover, density (No. shoots m^2), % cover of macroalgae and depth below C.D. is shown for all the sites dived in Fig 21. The numbers are shown in Table A4 of the Appendix together with the number of quadrats which had no seagrass cover. The number of quadrats with no seagrass present varied between 0% (at Millstones) and 68% at Fishcombe Cove, but was between 8 and 20% at all other stations. It is immediately evident from this plot that there was (unsurprisingly) a strong correlation between the seagrass cover (%) and the shoot density. This varied from an R^2 of 0.64 at Hopes Nose (R^2 of 0.74 if one outlier is excluded) to 0.99 at Fishcombe with most sites being above 0.70. Overall the mean data from each site gives a correlation of 0.88.

As would be expected given the differing nature of the sites (in terms of shelter and seagrass cover) there was no overall correlation (R^2 of 0.24) between the mean % cover at each site and the depth.

Algal coverage was much higher at Fishcombe Cove which is the most sheltered site where it averaged approximately 13% cover. This may have implications for surveys of extent using acoustic techniques as these can be poor at differentiating between marine algal species and seagrass.

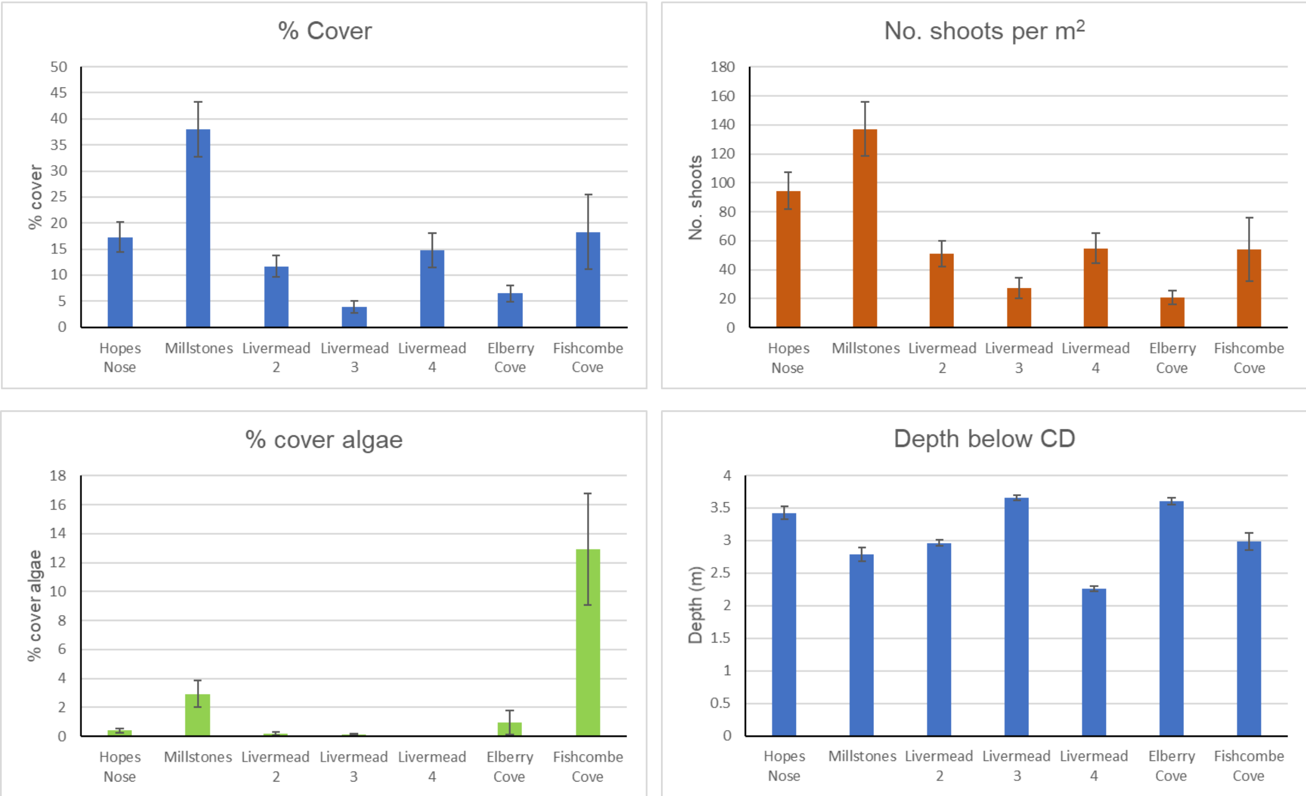


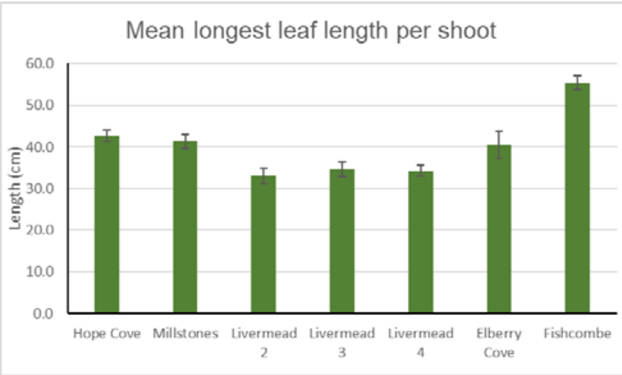
Fig. 21. Mean seagrass cover, density, macroalgal cover and depth for each seagrass station surveyed. Error bars represent the Standard Error (S.E.).

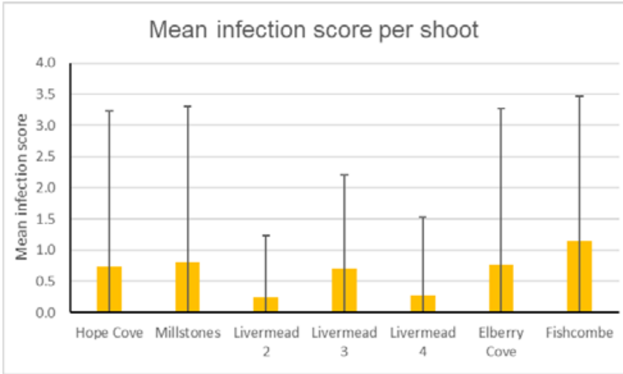
As this is baseline data there is no previous data with which to compare the results from the current survey, if this survey is repeated in future (i.e. exactly the same sites) comparisons will be able to be made. It should be noted that the replication within each seabed is extremely low (n=1 for all beds except Livermead where n=3). Since it can be seen from the contour plots that there is considerable variation over most of the beds, extrapolating any data from these individual sites to the whole bed will not be valid.

5.2.1 Leaf length and health

To facilitate a determination of the health of the seagrass plants, the leaves were measured and the epiphytes and putative degree of infection with *Labyrinthula zosterae* were recorded. These metrics are summarised in Fig. 22 for each site. The error bars are SE for the leaf length and ranges for the epiphyte and infection scores.

It can be seen from Fig. 22 that the longest leaf lengths were found in the most sheltered location (Fishcombe) with the shortest being found at Livermead which is probably the most exposed location. Both the mean infection and mean epiphyte scores were low and similar for all sites





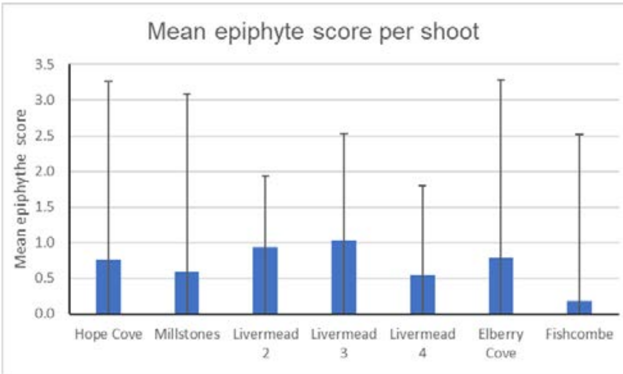


Fig. 22. Mean leaf length, epiphyte scores and infection scores for each dive site.

5.2.2 Flowering plants

Although it is known that *Zostera marina* flowers and produces seeds from the early summer until autumn [11, 12], only three flowers were observed over the course of this survey. Two of these were at Millstones and one at Livermead. This is a low proportion compared to the results from other studies in the region (e.g. the seagrass monitoring within Plymouth Sound and Estuaries [10] where the incidence of flowering was approximately 5%). However, the current study was undertaken at the very end of September which is the end of the season, whereas those in Plymouth have been undertaken in mid-summer which may account for the differences observed.

5.2.3 Non-Native Species

There was a very low incidence of INNS recorded during the survey, with only one species being observed during the diving survey (the slipper limpet *Crepidula fornicata*). This was found in one quadrat at Hope Cove. Notes taken during the DDV survey show that only 9 of the 934 stations contained *Sargassum muticum.* No other INNS were recorded during the DDV survey.

5.2.4 Anthropogenic influences

No anchor scars or litter were recorded during either the DDV or dive surveys. A pot line was recorded at one station at Livermead. It has been suggested (e.g. from studies at Studland Bay [13]) that anchor scars are a relatively persistent phenomenon. The data from this survey therefore indicates that neither fishing or anchoring are substantial pressures on the seagrass beds of Torbay (given the protection already afforded to them). However, it is probable that the current DDV methodology (i.e. not towing the video from one point to the next) reduces the likelihood of detecting these.

6 STATISTICAL POWER

It is important to understand that it is likely that the many of the metrics used for seagrass surveys will differ significantly from year to year due to natural factors such as weather, visibility etc. Therefore, although the power to statistically detect change from year to year is important, it is the ability to detect directional change over time that is more important. It may therefore not be necessary to have a statistically powerful survey methodology if the survey is repeated at regular intervals with multiple stations (enabling trends across all stations to be seen at one time point). This is of particular relevance for seagrass diving surveys as the cost of each sample is high due to the limited number of dives that can be undertaken per day and the fact that a minimum dive team of 4, a boat and a skipper are required for each day.

6.1 DDV survey

The primary aim of this survey is to delineate the extent and the seagrass cover within each bed. The area of each bed and for each of the density categories is therefore a single figure with no replication. Consequently, it is not possible to calculate the power of the survey to detect change for these metrics. However, it is possible to state that the more widely spaced the grid the less accurate and therefore more variable the results will be. Inevitably, there is only a limited budget available for every survey, but it is thought that that the current grid size is too large, particularly in the small beds.

It is possible to determine the power of the DDV survey to detect a change in the % cover at each station, but since the number of stations in which seagrass is found and the number of stations surveyed may alter from year to year, some caution would be required reaching any conclusions. The data could be presented as the mean % cover at those stations at which seagrass was present, but how useful that statistic is would depend on what differed between years. Obviously, greater power would be achieved in those beds with a large number of quadrats containing seagrass with the smallest power being in small beds with a lower proportion of quadrats containing seagrass. This is another reason why increasing the resolution (i.e. decreasing the grid size) is desirable for smaller beds. To illustrate the power of this survey at Livermead (a large but sparse bed), when all stations are included, the data shows that a 1.4-point difference in the mean % cover of seagrass (i.e. the mean value +/- 1.4) could be detected 80% of the time at a significance level of 5%. Due to the low mean % cover of seagrass, this equates to a 32% change. If only stations with seagrass present are used a 2.3-point difference can be detected which equates to approximately a 25 % difference in the mean value.

6.2 Diving survey

The replication within each bed was lower than initially anticipated (due to the weather experienced and other operational difficulties) and was originally rather low. This is, to some extent, inevitable given the restrictions on the amount of data that can be gained within a day and the cost of each days diving. Suggestions of how the amount of data gathered per diver day could be increased have already been provided to Natural England [5].

Although it was originally expected that the basic design of the diving survey should have given a robust analysis at each sentinel station when compared with subsequent years, the patchy nature of the seagrass beds has resulted in great variation between quadrats at each site and therefore much lower confidence in the results from each year and a lower power to detect change.

The detectable change (at a significance level of 5%, 80% of the time) using the current design at each site has been calculated for the shoot density (as this is the least subjective measure). The results are shown in Table 4. It can be seen from this Table that, with the current magnitude and variability in the % cover at quadrats within each site, the power is very low. The highest power is achieved at the Millstones where a 54 % change in the mean can be detected and worst at Livermead 3 when only a 107 % change can be detected.

Table 4. Detectable changes for the mean shoot count at each dive site (based on the 2019 diving data).

Site	Mean shoot count (per m^2)	Detectable change	% of mean
Hope Cove	94.6	76	80.4
Millstones	137.1	75	54.7
Livermead 2	51.2	36	70.3
Livermead 3	27.0	29	107.2
Livermead 4	54.7	42	76.8
Elberry Cove	20.8	18	86.5
Fishcombe	53.9	88	163.2

The power achieved is lower than would be expected given that 25 quadrats were surveyed at each site and is a reflection of the low mean count and the variability between quadrats. For these seagrass beds, it is concluded that the number of quadrats at each dive site needs to be increased if at all possible, within the budget available for the condition assessment. The power desired would need to be balanced against the effort and therefore the cost of achieving it, but it will have to be accepted that it will not be possible to achieve a high degree of statistical power and more emphasis will need to be placed on the temporal and spatial trend data. The number of quadrats that would be required for each site to detect a 20% change is shown in Table 5.

Table 5. No. quadrats required to detect a 20% change in the shoot count per quadrat at a 5% significance level per site.

Site	No. quadrats required per site
Hope Cove	175
Millstones	186
Livermead 2	296
Livermead 3	674
Livermead 4	354
Elberry Cove	469
Fishcombe	1604

The low power of the design also underlines the importance of having multiple dive stations within each bed as more confidence can be assigned to data (even if it the means are not significantly different) if the trend is replicated across several sites. Having only one dive site in the majority of beds also makes it difficult/impossible to extrapolate the data to draw conclusions for the whole bed particularly where the power of the design is low and the bed is heterogenous in nature.

7 DISCUSSION AND CONCLUSIONS

7.1 Survey design

Inevitably, with any survey, there is a balance between the cost of undertaking the assessment and the quality of the results. Given the relatively high cost of these surveys (particularly with respect to the diving), it is concluded that the current design provides a reasonable understanding of the state of the seagrass beds within the Torbay MCZ and, if repeated, will provide a moderate (though increasing with repeated surveys) confidence in the assessment of the attributes/supporting processes against their targets. However, it is thought that the design could be improved.

7.1.1 DDV survey

The current EA operating instructions [6], are focussed on increasing the precision of the survey (by using 1m^2 photo quadrats which are analysed after the survey and by only using a portion of the tide to undertake the survey). It is known that the % cover of seagrass within a quadrat can vary from operator to operator, but this can be minimised using photographic guides and an experienced operator. A proportion of the data (if recorded) can also be quality assured after the survey. Similarly, it is not known how much the current actually effects the surveyor's ability to determine the % cover, but it is likely that it may not have a large effect. Further studies would be required to examine this.

The operating instructions for the analysis of the photo-quadrats [14] also state that *Percentage cover should assess the base of the seagrass shoots, rather than how far the blades are spreading across the quadrat, as this simply reflects how long the blades are.* Although it is true that % cover assesses the area covered by the blades, this is entirely consistent with other macroalgae surveys (e.g. for kelps or opportunistic macroalagae) and assessing the area of the seagrass shoots is also impossible to achieve. This is because it is not possible to determine the area covered by the base of the seagrass shoots if this area is obscured by the area covered by the blades (which inevitably will happen in quadrats with moderate to high seagrass densities). It is also extremely unlikely that a quadrat would have a very high % cover of seagrass using this technique due to the relatively small footprint of each shoot. From the data received for this survey, it is concluded that the EA have not followed this part of the guidance as some quadrats have greater than 95% cover.

The increase in precision of the survey is at the expense of the accuracy of the survey. Observations (using photographic % cover guides) made in the field using a towed or drop-down video will effectively increase the area of each of the observations made and thereby probably increase the accuracy of the assessment. Evidently, a smaller grid will also improve the resolution. The use of fixed-point quadrats at widely spaced intervals also considerably reduces the likelihood of detecting anthropogenic impacts such as anchor scars.

It is considered that by changing the way the data is collected (i.e. by using *in situ* observations from a towed video), using a 25 m grid for smaller beds and by using the whole of the tide available rather than a window 2 hrs either side of high water, the accuracy and resolution of the survey could be increased without substantially altering the costs.

7.1.2 Diving survey

The fundamental weakness of the current design is that only 7 stations were surveyed in total. These sampled only 5 of the eight beds giving a very low level of replication (n=1 in 4 beds and n=3 at Livermead). The low statistical power observed at each sentinel station (dive site) in this survey also emphasises the importance of having multiple sites within each bed. Although the sentinel stations can be directly compared from year to year, it will not be possible, for the majority of beds, to determine whether these changes are representative of any other areas of the bed.

As discussed during the pre-survey review of methods [5], it is recommended that the number of dive sites is increased as much as possible. This will give a higher degree of confidence in the data for each seagrass bed and for the seagrass within Torbay as a whole. In order to achieve this, potential ways of increasing the number of dive sites assessed per day need to be considered. Ways in which this could be achieved have been discussed in the review, but it is likely that a more rapid method of assigning quadrats would be beneficial. There is no good reason why this could not be as simple as using linear transects. It is also recommended that advice is sought from an ecological statistician to optimise the experimental design, as it is probable that a design that could utilise a paired t-test or similar (this should be possible using a linear transect) would have a much greater statistical power to detect change. The compromise between replication and time/cost is commonly encountered in marine surveys but is particularly acute in diving surveys where the costs are high and the number of dives possible in a day are limited. This often leads to inappropriate statistical analysis due to pseudo-replication which historically has occurred in the analysis of seagrass surveys.

The strength of the diving survey relies very much on the comparison of sentinel stations from year to year. It is therefore key that Natural England has an understanding of how reliable this is (either from this survey or other surveys). The best way to determine this would be to completely re-survey one station on a different day giving each pair different sectors (or preferably using different surveyors) to previously and not re-using the same shot line. It is important that the surveyors do not collude and remain as ignorant as practical of the results from the previous survey of the site.

7.2 Assessment of the seagrass beds against their targets

Vulnerability assessment work undertaken by Natural England prior to the designation of the Torbay MCZ indicated that bottom trawling (specifically from cuttlefish fishing and scalloping) and recreational anchoring occurred within the site and could damage the seagrass beds. Consequently, the General Management Approach for this feature was set as 'recover'. On 1st January 2014, Devon and Severn IFCA introduced a byelaw stopping the use of mobile gear within or close to the seagrass beds. However, recreational anchoring may still be occurring and resulting in damage. It was concluded that this could cause fragmentation of the habitat and consequently, a recover target was deemed appropriate for most of the attributes that relate to this.

No evidence of anchoring was noted during the 2019 survey and therefore if this activity is taking place it is probably at a fairly low intensity and not damaging the bed. However, it should be noted that the current methods used for the DDV survey are not well suited to detecting anchor scars and most of the beds were sparse making these harder to determine. Consequently, confidence in this conclusion is fairly low.

The data also suggests that one of the main factors that might influence the extent and density of the seagrass beds is the degree of exposure of the bed and the weather experienced. For future monitoring it is recommended that nearby weather data is gathered (hopefully from existing sources such as the EA, or possibly the harbour authority). Over time it should then be possible to determine the magnitude (if any) of the effect caused by the weather.

As this was the first study using the current methodology, no assessment can be made for some attributes and supporting processes as there is no baseline. For others, there is some data, but the confidence is often low due to the differing methodologies. The condition of each attribute that was the focus of this survey against its targets is shown in Table 6.

It can be seen that for two of these (distribution: presence and spatial distribution of biological communities, and structure/biomass) no assessment could be made. For the presence and spatial distribution of biological communities there was no baseline data and no sampling of the communities within the seagrass beds was undertaken in 2019. No assessment of the structure/biomass could be made.

It is considered that all of the seagrass beds met the target for INNS and pathogens as infection scores were very low at every site and very few INNS were observed during the course of both the diving and DDV surveys.

It is concluded that the extent and distribution of the seagrass beds has been maintained at Thatchers Point and Fishcombe. However due to very large differences in the methods, the confidence is moderate for Fishcombe (where both the area and extent data indicate and increase) but low for Thatchers point where the area data suggest an increase but the extent looks rather similar. The other beds have all decreased to some extent, for seagrass beds at Hope Cove, Millstones, Elberry Cove and Breakwater Beach, the confidence in this conclusion is low due to inconsistencies in the data and the quality of the baseline data. However, at Livermead there appears to have been a substantial reduction in both the area and extent metrics and at Roundham Point no seagrass was observed in 2019. Therefore, the confidence at these two beds is moderate to high. Since the target is to recover the total extent and spatial distribution of seagrass, it can be concluded that the target has not been reached for the Torbay MCZ as a whole.

Although the target for all of these attributes is to recover, for many e.g. the extent the aim is to recover to known historical levels. Which historical level the data should be assessed against is not determined (and hence in this assessment the available historical data has been used). In the feature target Natural England refer to the extent reported before the large-scale die-offs from wasting disease in the 1920s and 1990s, but no data could be found for the extent at Torbay. It would be useful (if the data exists) to know the extent on the seagrass beds before the wasting disease epidemic.

Table 6. Review of the attributes that were the aims of this assessment.

Attribute	Target	Area	Comments
Distribution: presence and spatial distribution of biological communities	Recover the presence and spatial distribution of intertidal seagrass bed communities.	Hope Cove	Insufficient data since there was no baseline and, other than the seagrass itself, no sampling of the communities that the seagrass beds support was undertaken.
		Thatchers Point	
		Millstones	
		Livermead	
		Roundham Point	
		Elberry Cove	
		Fishcombe Cove	
		Breakwater Beach	
		Overall	
Extent and distribution	Recover the total extent and spatial distribution of seagrass beds.	Hope Cove	The extent data suggests a reduction in the nothern part of the bed
		Thatchers Point	Area data suggests an increase but the extent appears similar.
		Millstones	The area data suggests a decrease, but the extent appears very similar.
		Livermead	Both the area data and the extent show a considerable decline
		Roundham Point	No seagrass observed in 2019
		Elberry Cove	Area data suggest a decline, but the extent appears very similar to 2017.
		Fishcombe Cove	Both metrics apear to have increased since 2017 at this site.
		Breakwater Beach	The data are poor for this bed, but the area data suggest a large decline since 2012
		Overall	
Structure: biomass	Recover the leaf / shoot density, length, percentage cover, and rhizome mat across the feature at natural levels (as far as possible), to ensure a healthy, resilient habitat.	Hope Cove	No baseline data available
		Thatchers Point	
		Millstones	
		Livermead	
		Roundham Point	
		Elberry Cove	
		Fishcombe Cove	
		Breakwater Beach	
		Overall	
Structure: non-native species and pathogens	Restrict the introduction and spread of non-native species and pathogens, and their impacts.	Hope Cove	Incidence of INNS and the infection scores were extremely low throughout the survey area
		Thatchers Point	
		Millstones	
		Livermead	
		Roundham Point	
		Elberry Cove	
		Fishcombe Cove	
		Breakwater Beach	
		Overall	

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9 APPENDIX

Table A1. Diving station locations: 2019.

Dive site	Position (WGS 84)	
	Latitude	Longitude
Hope's Nose	50° 27.850'	-3° 29.249'
Millstones	50° 27.373'	-3° 31.335'
Livermead bed 2	50° 27.415'	-3° 32.184'
Livermead bed 3	50° 27.062'	-3° 32.669'
Livermead bed 4	50° 26.823'	-3° 32.920'
Elberry Cove West	50° 24.291'	-3° 32.485'
Fishcombe Cove	50° 24.174'	-3° 31.347'

Table A2. Area of seagrass in each of the 4 categories of % cover: 2019

Site	Area (m^2)				
	Total (≥ 5%)	5-25%	26-50%	51-75%	76-100%
Hope Cove	20017	14406	4864	747	0
Thatcher Point	4380	3089	716	434	141
Millstones	14710	9772	3142	1796	0
Livermead	334010	324960	7683	1367	0
Elberry Cove	142874	113228	26551	3095	0
Fishcombe	4304	1713	1151	711	729
Breakwater Bea	2008	2008	0	0	0

Table A3. Proportion of the total area of seabed within each seagrass bed by % cover category.

Site	% of total area in each category			
	5-25%	26-50%	51-75%	76-100%
Hope Cove	72.0	24.3	3.7	0.0
Thatcher Point	70.5	16.3	9.9	3.2
Millstones	66.4	21.4	12.2	0.0
Livermead	97.3	2.3	0.4	0.0
Elberry Cove	79.3	18.6	2.2	0.0
Fishcombe	39.8	26.7	16.5	16.9
Breakwater Bea	100.0	0.0	0.0	0.0

Table A4. Mean seagrass statistics for each dive site.

Site	% cover seagrass	Shoot count	% cover algae	Depth (m BSL)	Depth (m BCD)	No. quadrats with no seagrass	% quadrats with no seagrass
Hopes Nose	17.3	94.6	0.4	6.9	3.4	2	8
Millstones	38.0	137.1	2.9	6.0	2.8	0	0
Livermead 2	11.7	51.2	0.2	7.0	3.0	3	12
Livermead 3	3.9	27.0	0.1	5.3	3.7	3	12
Livermead 4	14.8	54.7	0.0	5.1	2.3	4	16
Elberry Cove	6.5	20.8	1.0	5.2	3.6	5	20
Fishcombe Cove	18.3	53.9	12.9	4.6	3.0	17	68