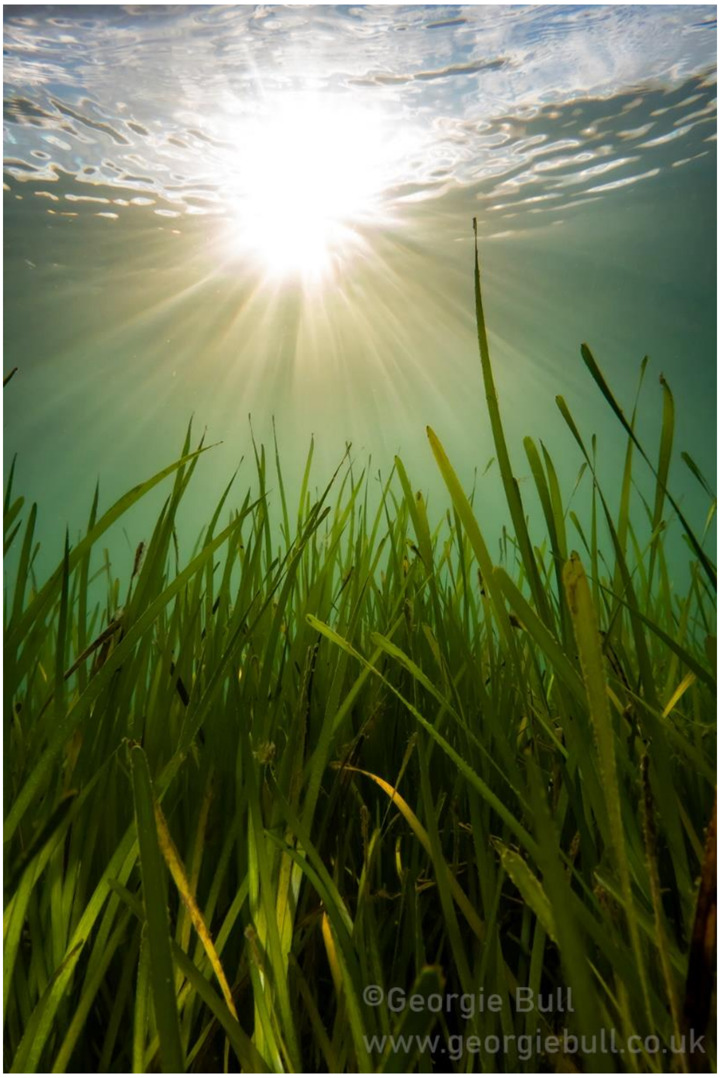
Cawsand Advanced Mooring Systems interim project results



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A project carried out in collaboration with the Ocean Conservation Trust, and supported by Princess Yachts:

Introduction:
The climate crisis has resulted in a greater understanding of what enhanced ocean ecosystems can do to draw down CO_2. Seagrass beds around the world are declining at an annual rate of about 5 to 7% and yet they store vast amounts of carbon in their deep root systems under the seabed[1]. They act as nursery areas for many juvenile fish[2]. Eggs are laid in and around the fronds by small sharks and cuttlefish, and iconic species such as bass and seahorses use them to shelter, breed and feed. They are one of the important coastal ecosystems for buffering the destructive power of the sea including kelps, coral reefs, mangroves and saltmarsh[3]. As a result of their deep, solid root systems, they lock together the sandy seabed, reducing coastal erosion and the impact of waves.

Being in such shallow, and generally sheltered inshore areas in many natural harbours, seagrass beds have been vulnerable to human derived pollution, development and boating activity. Pollution from rivers, increased sediment disturbance and physical structures and reclaimed land in ports has led to declines in English seas of up to 90% since the 1930s[4]. Subsequent increases in recreational boating, and associated infrastructure (such as moorings, pontoons, anchoring) has also continued to pressure the beds. A solution to the recreational boating issue is to make current and new moorings 'rise above' the seabed: Chains that drag on the seafloor can be raised above the seabed with relatively simple technology[5].

Although the modification of traditional moorings to 'Advanced Mooring Systems' (AMS) is novel, it is proven in both an engineering[6] and ecological sense. Seaflex[7] 'bungy-style' systems using a heavy elastic rode have been successfully used in ports and harbours in Scandanavia, USA and Australia for moored vessels. A similar system was used in the Helford in Falmouth to mark seagrass beds, but not as a mooring device. A more recent development has been to use a chain rode lifted above the seabed using smaller floats attached to 1-2m lengths of the chain initially developed by the Ocean Conservation Trust, and studied for its environmental impact by University of Plymouth[8]. A useful guide to environmentally sensitive mooring and anchoring has been published by the Green Blue – an initiative of the Royal Yachting Association[9].

Since 2020, our study has been subsumed into a wider project - 'ReMEDIES[10]' – an EU 'LIFE' funded multi-partner project that is attempting to reduce the impact of recreational activities (largely boating) on the seabed in 5 south coast Marine Protected Areas. The Isles of Scilly, Falmouth Bay, Plymouth, The Solent and in the estuaries of Essex. The project has funds to support delivery and exchange of up to 79 traditional swing moorings with Advanced Mooring Systems[11] between 2019 and 2024.

[1] https://www.frontiersin.org/articles/10.3389/fmars.2020.00001/full
[2] https://linkinghub.elsevier.com/retrieve/pii/S235198941400050X
[3] https://journals.sagepub.com/doi/10.1177/1759313115623163
[4] https://www.frontiersin.org/articles/10.3389/fpls.2021.629962/full
[5] https://www.nature.com/articles/s41598-019-55425-y
[6] https://www.morek.co.uk/case-study/advanced-mooring-system-numerical-analysis
[7] https://www.seaflex.com/about-us/why-seaflex/
[8] Luff et al (2019) A simple mooring modification reduces impacts on seagrass meadows. *Scientific reports* 9 https://www.nature.com/articles/s41598-019-55425-y
[9] https://thegreenblue.org.uk/wp-content/uploads/2021/01/The-Green-Guide-to-Anchoring-Moorings.pdf
[10] https://saveourseabed.co.uk/
[11] https://www.rya.org.uk/e-news/inbrief/advanced-mooring-systems

This study is based on carrying out ecological sampling of the change in seagrass cover around 5 AMS locations in Cawsand where we installed Stirling Advanced Mooring Systems[12] in May 2019. The work was carried out in collaboration with divers and project staff from the Ocean Conservation Trust. The OCT contracted divers to deploy the moorings and identify volunteers from the local Cawsand boat club who were willing to trial these mooring designs to replace their traditional block and chain 'swing' moorings.

Advanced Mooring System (AMS) 'Stirling' Design:

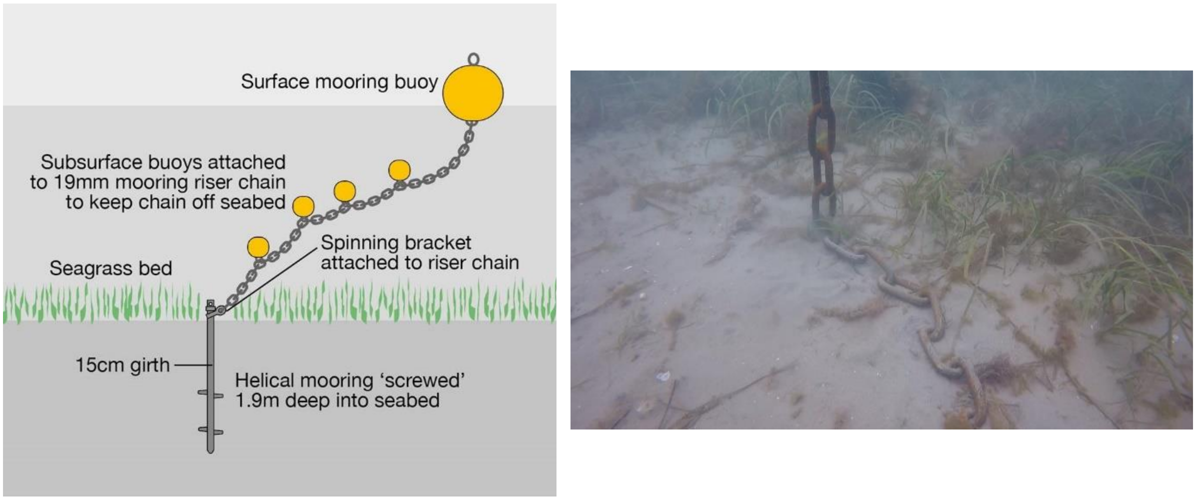

Figure 1: *Diagram of the design of the Stirling 'Advanced Mooring System'. (Source: Yachting Monthly) (Left). Picture (right) of 'traditional swing mooring' chain abrasion of the seabed at Cawsand (source: Ocean Conservation Trust).*

Aims:
Initial proposed aims of the project (as funded by Princess Yachts) were to install 15 such Advanced Mooring Systems in Cawand Bay Plymouth Sound between 2019 and 2021. The moorings themselves are owned by private year-round residents of Cawsand. A variety of small vessels are attached to the moorings during spring and summer months, from a small crab 'pot' fishing vessel, to yacht cruisers, generally between 5 and 9m in length.

The initial aims of the project were:

1. To install Advanced Mooring Systems in Cawsand Bay Plymouth.
2. To raise awareness of the technology, and monitor the results on seagrass regeneration around the base of the new moorings relative to traditional moorings.
3. Publicise the results with partners to inspire other recreational boat users and harbour masters.

[12] https://oceanconservationtrust.org/project/seagrass-moorings/

Project Objectives:

1. Install 15 Advanced Mooring Systems with consent of boat users and local regulators in 3 years (2019-2021).
2. Demonstrate recovery / change of seagrass habitat (density and shoot height) around moorings.
3. Demonstrate mechanical safety of Advanced Mooring Systems.
4. Foster greater co-ordinated working between regulators, harbour authorities, boat users and NGOs.

Developing the project:
Initial discussions took place between Mr Mark Parry of the Ocean Conservation Trust and Peter Scott of the Rame Head boat club in late 2017. Mr Scott, a resident of Cawsand, helped Mark Parry to identify 5 volunteers willing to switch moorings. Locations of the mooring are all inside the seagrass bed (Fig 2).

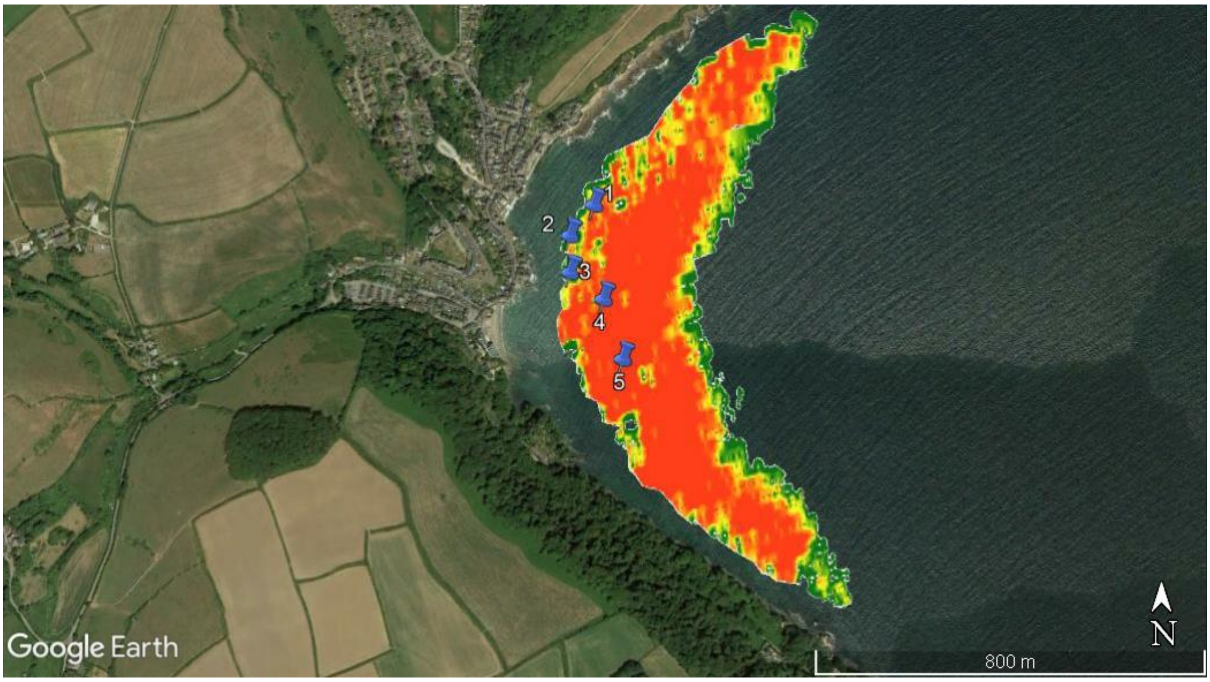

Figure 2: Location of the 5 original AMS installed in May 2019 monitored between May 2019 and November 2021. The background red/orange/green area is seagrass density as mapped by Cornwall Inshore Fisheries and Conservation Authority in August 2021 (from red – high, to green – low density).

Stakeholder meetings were had early in the project (2018) (note their roles):

i. Queens Harbour Master (responsible for shipping safety and port operations, particularly with regard to military) within Plymouth Sound.
ii. Plymouth City Council (involved in statutory decision making, licensing of harbour authority consents).
iii. Tamar Estuaries Consultative Forum (responsible for information exchange for the Plymouth Sound and Estuaries Special Area of Consultation). In effect, the forum acts as a management committee for the MPA.
iv. Rame Head Boat Club (responsible for moorings and maintenance of moorings within Cawsand).
v. Natural England (responsible for providing conservation advice on activities particularly in relation to vulnerable habitats of the MPA).

vi. Marine Conservation Society (coordination of the project, funding, communication and supporting ecological monitoring)
vii. Ocean Conservation Trust (collaborated with MCS to install the moorings by identifying a subcontractor to install the moorings).

Project timeline (2018-2021):

1. Initial discussions between MCS and OCT: December 2017
2. Initial funding support from Princess Yachts (£20,000): secured March 2018
3. Discussions with volunteers and relevant authorities (see above): Spring/Summer 2018
4. Equipment procurement: Autumn 2018
5. Initial unsuccessful jack up barge installation from surface vessel: October 2018
6. Successful instalment of 5 moorings using local commercial divers using underwater hydraulic wrench to screw in piles: May 2019.
7. Initial dive survey to monitor seagrass growth around AMS: May 2019.
8. 5 further dive survey events (June 2019 – November 2021).
9. Installation of further 10 AMS in Cawsand under the wider ReMEDIES project[13] (Summer-Autumn 2021).
10. Collaboration with NE/ReMEDIES on further installations (including 2 funded by 'NatureSave[14]') using 'Seaflex' technology attached to a helical screw (Autumn 2021).

Elements of the project were curtailed by the COVID-19 pandemic, particularly throughout the whole of 2020 – other than one dive carried out by a student dive team. This disrupted field work to monitor the original 5 moorings, and subsequent placement of further moorings.

Method of monitoring seagrass response to moorings:

Dives were carried out on 6 occasions from May 2019 to November 2021 to monitor the recovery of seagrass densities and shoot lengths around moorings.

Divers laid out a 9m transect tape in 4 compass directions away from the centre of the mooring. Initially they swam in a northwesterly direction, stopping at 9m to set down a 0.25m^2 quadrat. Within this quadrat they recorded the numbers of shoots (not individual blades, but the shoots that came from the substrate). They then recorded the 10 longest blade lengths from within the quadrat. They then moved to 5m away from the mooring (as indicated on the transect line), then 0.5m from the pin, and repeated the counts. They then swam in a perpendicular direction (southeast), and repeated the process for 3 more data points. They then laid out the line in a northeast to southwest direction to gather a further 6 data points (Fig. 3). As traditional moorings at these depths are considered to have a 'zone of influence' of the ground chain related to the tidal range of the sites they are deployed, we estimated that the zone of influence to be within 5m radius of the central mooring point. As such, the 9m quadrats we considered to be 'controls' outside the zone of influence of the moorings.

Data analysis:

We used ANOVA (in excel) to compare the change in seagrass shoot density from between 0.5m, 5m and 9m distances from the central mooring point for the 5 moorings. We did this comparing the data between 2019 (data from within 1 month of when we established the AMS), and 2020 (data from either June or August depending on if it was available). By comparing these dates, we are within similar seasons (summer) for analysing any change in seagrass.

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[13] https://saveourseabed.co.uk/

[14] https://www.naturesave.co.uk/

We also plotted seagrass shoot count over time for the 5 moorings for the 3 radial distances for each moorings. We then combined an average shoot count for the 5 moorings.

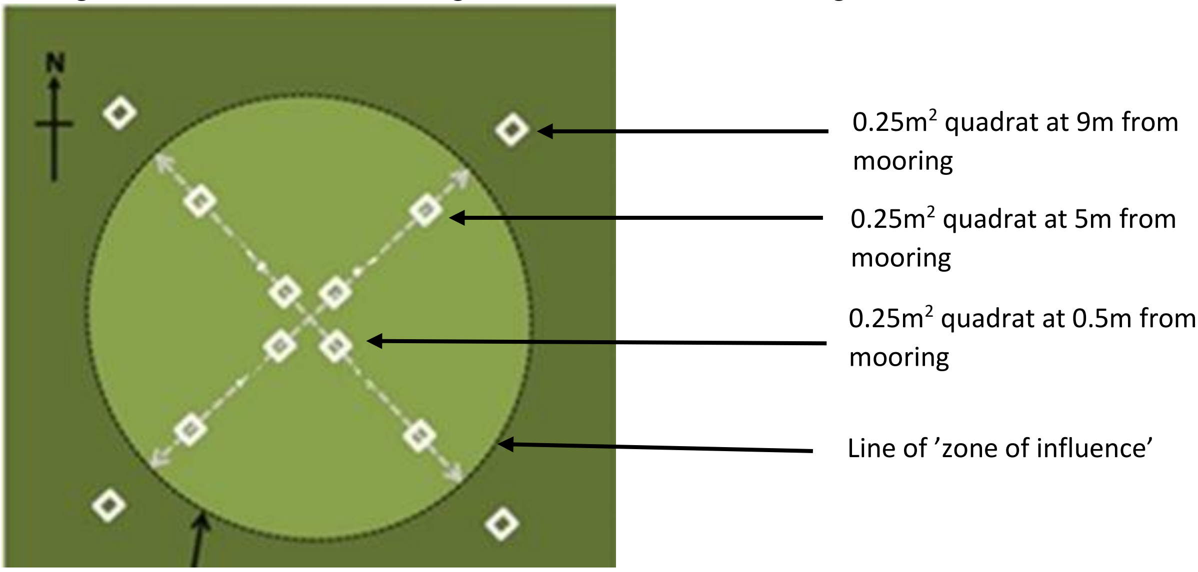

Figure 3. schematic showing the survey design.

Sampling issues:
COVID curtailed sampling throughout the summer of 2020. A University of Plymouth team followed COVID protocols to carry out a dive in November 2020 to record the seagrass density & shoot growth that was not coordinated by either MCS or Ocean Conservation Trust staff. Other issues related to the qualifications and abilities of volunteer divers to undertake the tasks. Such tasks involved using a quadrat, transect tape, tape measure and slate and pencil between each dive pair. As this is a skilled task, some volunteers were only able to record a subset of data points because of running low on air or other technical issues. Although the difference between 'shoots' and 'blades' were described by Mr Parry prior to dives, we were relying on (at times) inexperienced divers to record the difference between these parameters that may have resulted in over-counts at some times.

Results:

There was no clear pattern of results between the moorings. It appears that there was a slight positive change in seagrass density for moorings to the north/central part of the bay (moorings #1 and #2) (Fig 4). Moorings #3 and #4 showed considerable decrease in seagrass density, particularly within 5m radius of the mooring point. Mooring #5 showed significant increase in seagrass density in the control (9m) compared to little change in the 5m and 0.5m radius samples.

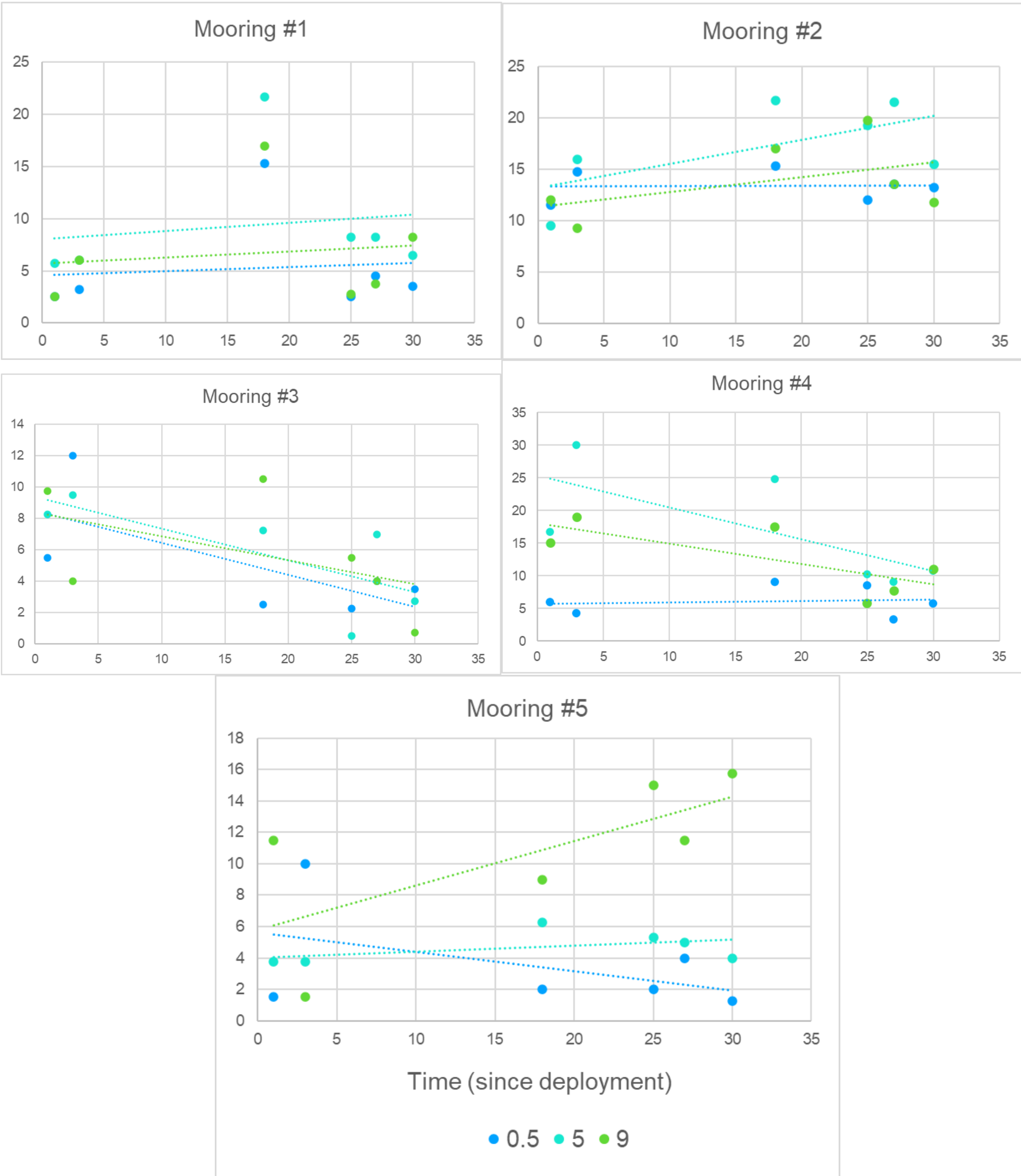

Figure 4. *Mean net change in seagrass shoot count per 0.25m² quadrat from 3 distances (0.5m; 5m; 9m) from the 5 moorings installed in May 2019. Data are mean shoots per 0.25m² + SD. Time is recorded in months since deployment in May 2019.*

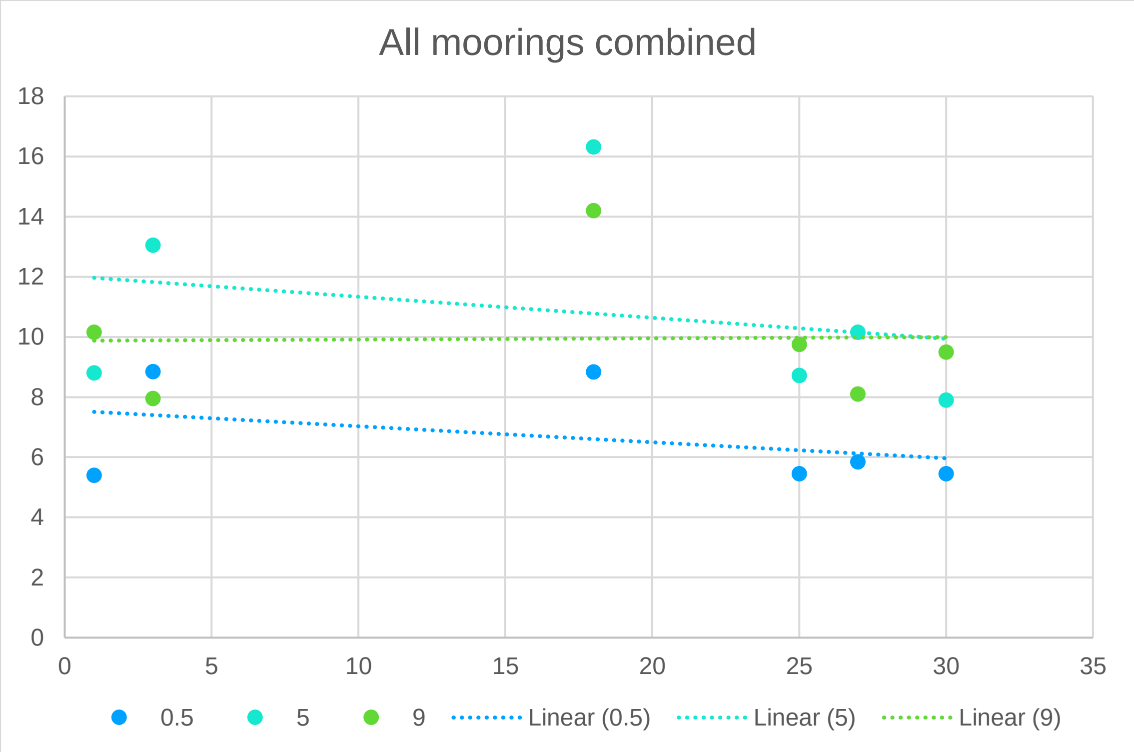

Figure 5. Combined data from the 5 moorings. There is a slight change in seagrass density within the 0.5m and 5m radii (decline), whilst the controls – showed almost no change.

Evidence suggests that there is very little net change in overall density of seagrass over the initial 2.5 year timeframe of the monitoring. Mooring #1 showed a very slight increase in density of shoots over the project period at all distances (0.5, 5 and 9m from the mooring). Mooring #2 displayed a slight fall in the density of shoots around the 0.5m radius near to the pin, with an increase at 5m and at the 'control' distance of 9m. Mooring #3 showed a sharp decline in all stations (0.5, 5 and 9m). Mooring #4 showed a great decline in seagrass around the base of the screwpile mooring (at 0.5m) with little change at 5m; there was also a decline at 9m distance from the screwpile. Mooring #5 showed a decline at 0.5m from the mooring, a small increase at 5m, and a considerable increase in density of shoots at 9m.

Figure 6: *Location o the Advanced Moorings Systems studied in this project.*

Discussion:
Cawsand is one of the busiest areas of the Plymouth Sound SAC, particularly with tourism and small boat use, and particularly over holiday periods (May bank holiday, Easter, Summer holidays until early September. We've identified a number of activities that may have affected the results of seagrass density around the moorings:

i. Anchoring and propellor damage

Cawsand Bay (much like Studland Bay is very popular with recreational users). Yachts, power boats, paddleboarders and swimmers all access the waters of the seagrass beds (or over them) with their craft.

Mooring #3 & #4 are very much in line with the entry of the Cawsand Ferry to the beach (Fig. 6). As they are also in line with the beach where tenders make for shore from yachts, they are popular with recreational boating (Fig. 7). This may be affecting the ability of seagrass to re-establish around the new moorings that we have put in. At lowest low water, these moorings are in 2-3m of water, making any disturbance at the surface from propellers significant.

Figure 7: Paddleboards at Mooring #3 (marked on the buoy as '24') during the June 2021 survey.

ii. anchoring

The author was actually hit by an anchor during the June 2021 survey. Fortunately, the anchor only passed by, without attaching to dive kit (hoses in particular), but it also passed very close to the mooring itself. This was fortuitous as the anchor actually made a course very close to one of the AMS screwpile moorings, that increases the likelihood of snagging against the top of the screwpile, and thereby damaging the seagrass within the vicinity of the mooring.

Figure 8: *June 2021 survey. Locals reported heavy boat use in summer holiday months, with up to 120 vessels counted using the sheltered seagrass-rich area for anchoring (photo by JL Solandt during June 2021 dive monitoring survey trip).*

iii. Water quality

Another environmental factor affecting the density of the beds is likely to be poor water quality. On some dives, the health of the beds appeared to be affected by heavy colonisation of epiphytes. Red algae was particularly abundant around the blades of mooring #1 in June 2021 (Fig 9). This was at a time of very heavy boat use within the sheltered bay.

We note that the quality of the blades is 'cleaner' in the winter survey (November 2021 in particular), with little fouling of blades.

Figure 9: *Image taken in June 2020 showing heavy sediment in the water column, and some epiphytisation of the seagrass blades.*

Recent research by the MCS has highlighted the number of times that numerous Combined Sewage Overflows (CSOs) spilt into Plymouth Sound (Fig. 10&11). Four CSOs in the area of Cawsand itself discharged directly into Cawsand Bay over 60 times during 2021 alone. This data discounts the potential impact of the 90+ CSOs that are consistently discharging into the wider site.

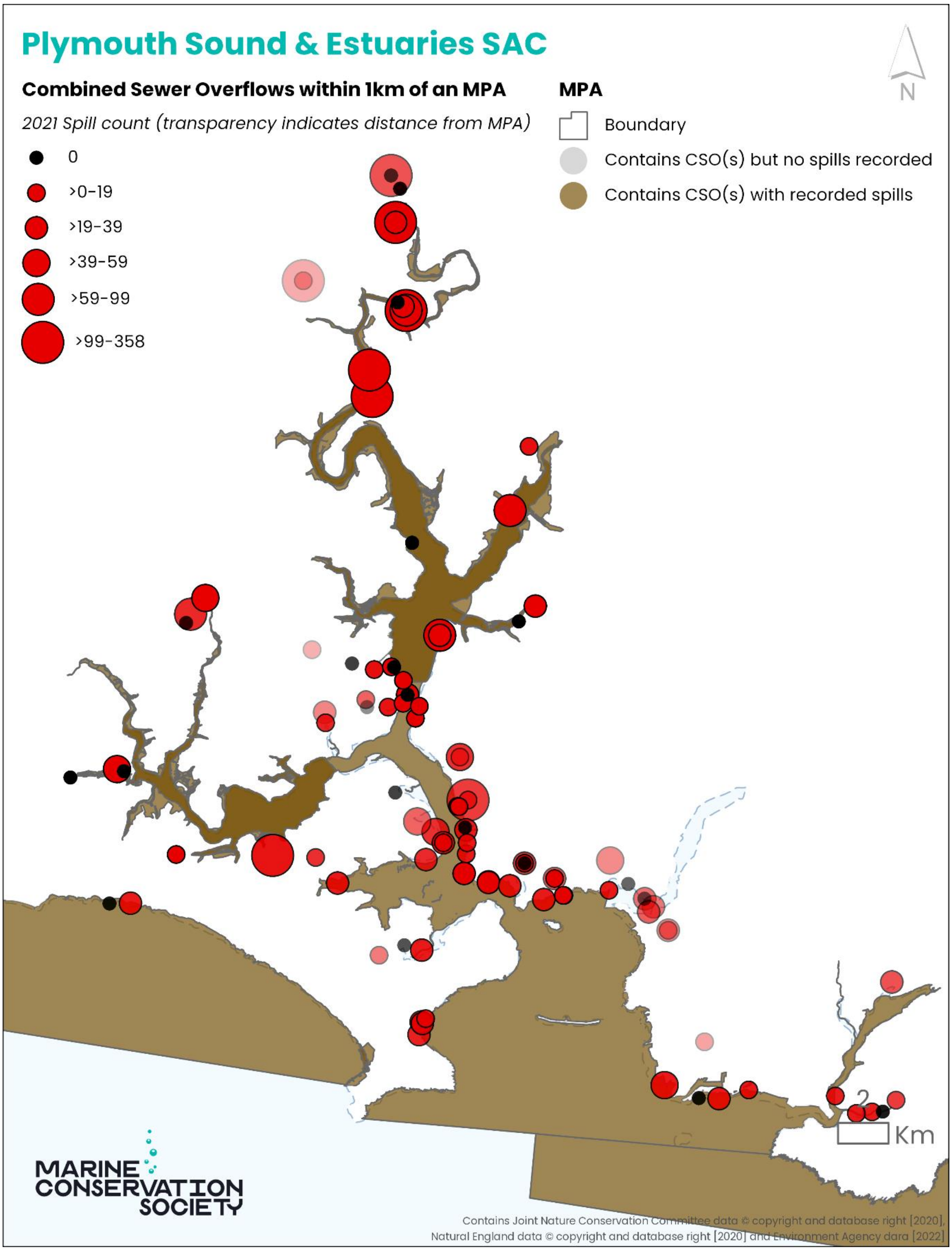

Figure 10. CSO discharges into Plymouth Sound and estuaries in 2021. The MPA is in brown.

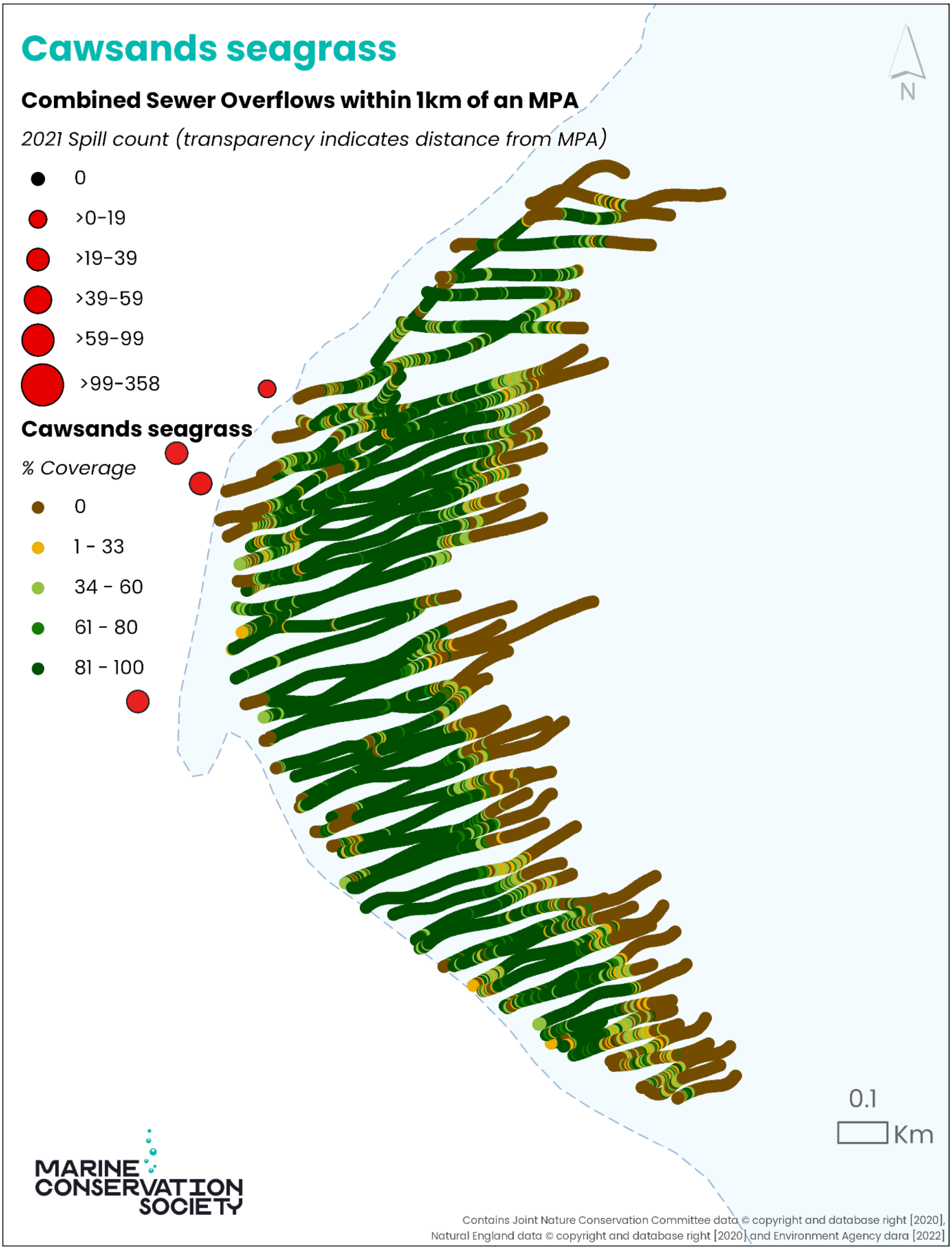

Figure 11. CSO discharges into Cawsand in 2021. (Colour is related to transects carried out by Cornwall Inshore Fisheries and Conservation Authority in summer 2021, and relative density of seagrass).

iv. Long-term damage of rhizome bed before AMS installation

A significant problem at this site could be long-term rhizome matt damage preceding the installation of the Advanced Mooring Systems. Scaring is caused by the chains that continuously erode the seabed over years. When combined with annual inspection of moorings that involves raising and lowering the mooring block in a slightly different location, we believe that the top layer of the rhizome matt may not be able to regenerate seagrass blades[15]. This is significant and may need remedial work. An example is being trialled by 'Project Seagrass' who are re-seeding the 'halos' around the base of moorings with seagrass seed bags to attempt to regenerate damaged areas.

Evans (2020) during a talk at a ReMEDIES Advanced Mooring Systems conference in Plymouth stated that scars / halos / depressions from traditional moorings can take over 5 years to 'repair' or recover after installation of AMS in Massachusetts coastal waters[16]. As such, the period of monitoring during this study at 30 months may well be too short for re-growth to be achieved. As such, it's important that the site is revisited at least once in 2023.

[15] https://www.frontiersin.org/articles/10.3389/fpls.2017.01309/full

[16] https://defra.sharepoint.com/:p:/r/sites/WorkDelivery1390/ECE/AMS_workshops/2020/Evans_AMSworkshop.audio..pptx?d=wfd59417dcf184eccb9cc6578065c0381&csf=1&web=1&e=T3aNZz

Figure 12: Moorings riser buoys in situ in June 2021.

A**wareness raising:**
As the partners involved in the project Ocean Conservation Trust and Marine Conservation Society with funds from Princess Yachts, we wanted to illustrate the feeling of the local boating community to seagrass conservation more generally, and whether they were happy with their moorings. As such a film was made with partners (funders, volunteer boat owners, MCS and Ocean Conservation Trust)[17].

Conclusions:
Whilst the results from these initial trial surveys are disappointing in terms of recovery of seagrass shoots, we have seen success in the following aspects of our initiative:

v. The engineering strength of the devices has been proven over 30 months of use (moorings were only used in Spring and Summer months, with vessels taken out of the water in Autumn).
vi. The devices are effective at lifting the chain rode off the seabed.
vii. The monitoring technique we used is effective at understanding impact.
viii. The buy-in of the sector was good over this and the wider project.

It is heartening that the community remains supportive (summer 2022) of the devices. We may have to undertake some remedial restoration work in the footprint of the moorings to promote recolonisation and recovery of the wider seagrass bed in the footprint of these AMS.

Recommendations

i. Include assessment of size of mooring scar over time.
ii. Include monitoring of mooring condition, and necessary repairs.
iii. Combine with assessment of anchoring levels in the area.
iv. Undertake biological monitoring in the site (with Seasearch methods).
v. Monitor seagrass density and shoot length for at least 10 years, with (perhaps) monitoring every 2 years after year 2.
vi. Undertake stakeholder study to understand social value of project.

Acknowledgments:
We'd like to acknowledge the hard work of Mark Parry at the OCT and his dedication to seagrass. We would like to thank the Cornwall Inshore Fisheries and Conservation Authority for the use of their maps of seagrass density in the Cawsand area. We thank Frith Dunkley of MCS for mapping CSO discharge rate in 2021. Most of all, we want to thank our supporters, Princess Yachts of Plymouth who have been supportive of this initiative since 2018. This work was (in part) funded by the Recreational ReMEDIES project.

[17] https://www.youtube.com/watch?v=IzI-I6OvxM8

LIFE Recreation ReMEDIES (LIFE18 NAT/UK/000039)
Reducing and Mitigating Erosion and Disturbance Impacts affEcting the Seabed
www.gov.uk/government/publications/life-recreation-remedies-project

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