# Technical report on seagrass restoration in Dale, Pembrokeshire

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PROJECT SEAGRASS

# Contents

# 1 Executive summary

In 2019, WWF and the Sky Ocean Rescue programme provided funding to Swansea University, Project Seagrass and Pembrokeshire Coastal Forum to undertake a pilot to expand seagrass restoration to a project scale of 2 hectares. Such a pilot would be the UKs first major seagrass restoration project and require the collection and planting of over 1 million seagrass seeds of the species *Zostera marina*. Dale Bay in Pembrokeshire was the proposed site of this pilot and was built on many years of experimentation into seagrass planting methods and the assessment of sites suitable for restoration to take place. Here we describe the ecological aspects of the pilot in Dale that has been named Seagrass Ocean Rescue to plant 2 hectares of seagrass and the resultant monitoring of the project in 2020 and 2021.

Seagrass shoot density in this restoration area in Dale remains low and is not at the levels that the project had hoped to achieve by this point, but the evidence is clear that plants have developed into mature clumps, that have expanded in density and length over time. We conclude that the Seagrass Ocean Rescue project is now ecologically on a strong footing as seagrass in Dale is increasing in density and now exists throughout the restoration area. We anticipate that over the coming years density will increase and continued monitoring is required to assess this.

With continued stakeholder engagement, improved signage, and further moorings we expect the conditions to be right for seagrass. This report describes a pilot project for seagrass restoration in the UK that is providing a beacon of hope to the recovery of our UK coastal seas. It provides evidence of extensive lessons learned throughout the project that have and are continuing to improve our means of undertaking seagrass restoration. It will be many years until we understand the true impact of this project, this will require further work to assess the seagrass and to begin to assess its role in supporting biodiversity. It is vital that continued marine conservation activities exist in Dale that build on the close support of the community in helping shape this project.

# 2 Introduction

Seagrass loss in the UK has been extensive and recovery mostly poor. Although some localised recovery of intertidal *Zostera noltii* meadows has occurred [1], recovery of the intertidal and subtidal *Zostera marina* meadows has been limited. Historical distributions and observations of seagrass throughout the UK are more extensive than those known to currently exist [2-4]. A recent examination of historical distributions of seagrass together with the use of modelling indicates seagrass loss may be as great as 92% over the last 100 years [4,5]. There are now many areas devoid of seagrass totally and many areas containing only fragments of their distribution.

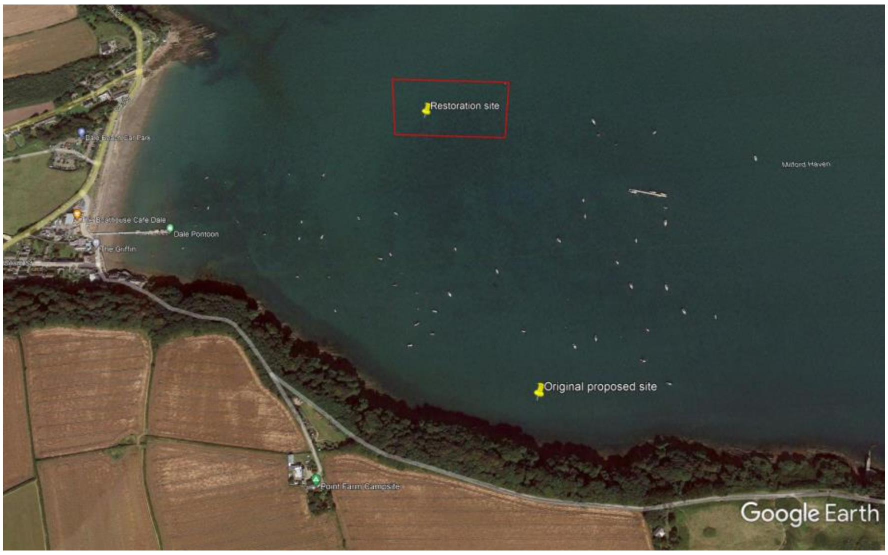
Around the Welsh coastline, habitat suitability modelling together with sporadic historic and anecdotal records indicates that seagrass was probably far more extensive than it is now [5,6]. A mix of land reclamation associated to port and urban development, a deep history of metal mining and associated coastal contamination, and the often hidden problems of elevated water nutrients are probably some of the reasons for this loss. Many other areas of the UK have also suffered large scale loss, possibly associated to poor water quality, urban sprawl and historic industrial and port activities. Recent surveys on seagrass throughout the British Isles confirm that this loss and degradation is continuing, with the environmental state (high turbidity and elevated nutrients) of many seagrass meadows placing them in a perilous state [7]. This is often as a result of the effluent of a human or animal origin [8]. For example, seagrasses in Littlewick Bay in West Wales have significantly declined in health since the 1980s [9].

Seagrasses matter because the habitat they provide creates extensive ecosystem services in support of human well-being, particularly with respect to fisheries support, biodiversity, nutrient cycling and sediment stabilisation [10]. UK studies have revealed that seagrass harbours 4.6 times the abundance of fish of unvegetated habitat at a density of 6000 fish per hectare [11], resulting in UK seagrasses currently supporting approximately 50 million fish, many of commercial importance (e.g. juvenile whiting, cod, plaice and pollack). Increasingly seagrasses are being applauded for their role in supporting carbon sequestration due to their rapid ability to lock away carbon into marine sediments [12]. This rate is thought to be many times that of the soils within tropical rainforests [13]. Based on average figures for carbon storage seagrass in the UK the estimated total carbon stored in the top 100cm of recently mapped seagrasses of the UK is ~1.2 megatonnes [5]. The loss of up to 92% of the UKs seagrass has clearly had a major impact upon the UKs natural capital provision.

Seagrass restoration provides a means of bringing this back, but water quality is the biggest hurdle to making this happen. Although many waterways around the UK coast remain impacted by the problems of eutrophication and other pollutants there has been evidence of long-term improvement in water quality, with concentrations of nitrate and phosphate declining since 1992 (EEA). This results in the opportunity for environmental renewal to begin. Since 2013, Project Seagrass and Swansea University have been expanding their work into seagrass restoration resulting in a series of publications that document refinements and improvements in restoration methodology [14-17]. A particular methodology was developed to enable the expanded use of hessian bags for planting of seagrass seeds along lines, enabling large scale deployment from a boat [15].

In 2019, WWF and the Sky Ocean Rescue programme provided funding to Swansea University, Project Seagrass and Pembrokeshire Coastal Forum to undertake a pilot to expand seagrass restoration to a project scale of 2 hectares. Such a pilot would be the UKs first major seagrass restoration project and require the collection and planting of over 1 million seagrass seeds of the species Zostera marina. Dale Bay in Pembrokeshire was the proposed site of this pilot and was built on many years of experimentation into seagrass planting methods and the assessment of sites suitable for restoration to take place.

Here we describe the ecological aspects of the pilot in Dale that has been name Seagrass Ocean Rescue to plant 2 hectares of seagrass and the resultant monitoring of the project in 2020 and 2021.




**Map1.** Location of the 2 hectare seagrass restoration project within Dale Bay.

# 3 Methods

## 3.1 Restoration site

Very small experimental seagrass restoration trials have been conducted in Dale Bay since 2017 and led to the refinement of a range of key methods appropriate for use in the UK. These trials were conducted within the Frenchman's area of the bay near to the southern shore. The successful use of the BOSSLines method led to its proposed use in further restoration within Dale Bay and the proposal to plant 2 hectares of seagrass in collaboration with WWF and Sky Ocean Rescue.

Following an initial proposal to plant this seagrass within the Frenchman's Bay area and the successful application to obtain a Band 1 marine license from Natural Resources Wales there was concern from key stakeholders within the local village of Dale. Following extensive stakeholder engagement with local communities [18] a Band 2 Natural Resources Wales marine licence (CML1944) was obtained to conduct the restoration work in a slightly revised location within the middle of the bay (see map 1). This licence will last 5 years from February 2020. In addition, a lease was secured for the use of the seabed from the Crown Estate for a similar 5-year period. The lease is registered under the name of Dr Richard Unsworth at Swansea University.

## 3.2 Seed collection

Seeds were collected by hand between July to September in 2019 and 2020. This was done around the whole UK coast and occurred in correspondence to peak seed production and the timing of seed maturity. Although flowering in *Zostera marina* is well established to be controlled by temperature [19], there exists little available data on what determines the point at which seeds start to become mature [20,21].

Seed collection followed methods described by authors such as Marion et al 2010 and |Infantes *et al* 2018 [21,22]. The majority of our seed material collections took place at Porthdinllaen on the Llŷn Peninsula in North Wales. This was during August 2019 and 2020. Collections were also conducted in Falmouth, Weymouth, Torbay, the Isles of Scilly, Penzance, Littlewick, Skomer, Inland Sea (Anglesey), Isle of Man, Guernsey, and Lindisfarne. SCUBA was used as the primary method of hand collection, however at sites where seagrass was exposed for short periods at low tide targeted walking collections were also conducted. In addition, snorkel collections were widely conducted in order to incorporate staff and volunteers unable to SCUBA dive to HSE standard.

As the primary location for seed collection was in Porthdinllaen (North Wales), the project also collected background data from that site to help demonstrate the negligible impact of seagrass seed collection on local seagrass. During each seed collection year, density of seeding seagrass shoots was quantified at Porthdinllaen using SCUBA divers counting shoot densities within 0.25m$^2$ quadrats. In 2019 and 2020 these were haphazardly spread throughout the middle of the meadow. In 2021 they were conducted along set transects as part of a marine licence application for an additional experimental seagrass trial.

## 3.3 Seed processing and storage

All seeding seagrass material collected was transported using fresh cool seawater to the laboratory at Swansea University where it was processed for separation into seeds for restoration use. Seeds were stored within Swansea University within a temperature controlled refrigerator set to 1 degree C. Normally seagrass seeds would not have been stored for long durations, however due to time constraints on the project seeds were stored until late February. To reduce chance of seeds rotting they were placed within high salinity seawater containing copper sulphate. Previous studies have used the method as a means of reducing fungal rotting of seeds and to reduce incidences of potato blight [23]. After storage from October 2019 until February 2020 many seeds were in a poor condition and although viability was found to be over 60%, mould had built up on seeds and some seeds were observed to have discoloured due to the use of copper.

In total, during summer 2019 we estimate that 750000 seeds were collected and processed for planting. In summer 2020 we estimate that a further 450000 seeds were collected and processed for planting. Seeds collected in summer 2020 weren't stored for extended periods and were planted in the autumn.

## 3.4 Seed bag preparation

During 2019 and early 2020 the team at Swansea University, WWF, PCF and Project Seagrass worked with volunteer groups throughout the UK to pack approximately 20000 hessian bags with sand and tie them to lines in readiness for filling with seagrass seeds just before planting. This activity served a dual purpose of engaging communities and groups about seagrass and empowering them to get involved with nature restoration activities.

## 3.5 Seed planting

In February 2020, approximately 15000 hessian bags measuring 12cm in length were planted into a 2 hectare area in Dale Bay. These were strung along 100m lines spread 1 bag every metre over the seabed. They were deployed using a Rigid Hard Inflatable boat (RHIB). The lines were comprised of hessian rope of a 10mm thickness and were weighted to the seabed using large sandbags at each end and at a central point along the lines. The lines were all laid perpendicular to the beach in an East to West direction. They were laid in broadly parallel lines, however in reality we anticipated that some cross over would occur due to difficulties of achieving accuracy whilst using GPS and in windy conditions. In November 2020 following further seed collections a further 5000 bags and 450000 seeds were planted in areas that had not been covered by existing planting.

## 3.6 Experimental seed planting

As a result of concerns about the effectiveness of planting seed bags on long lines (from year one results) and the reduced capacity of these seed bags to end up buried into the seabed (as had been observed with previous smaller trials) a range of further experimental trials were created. These trials aimed to improve our understanding of the most effective means of seagrass seed planting in shallow subtidal waters. All of this planting was conducted using SCUBA divers.

The aims of this experiment were to determine the effectiveness of burying the hessian bags directly into the sediment vs placement on top of the sediment. This was to be done relative to assessments of direct seed deployment through hand raking them directly into the sediment. All bags were anchored into the sediment using additional wooden stakes placed through the hessian bag to reduce movement.

A grid of nine 10 x 10 $m^2$ squares (Total area 30m x 30m) was set up on the southerly edge of the restoration plot in Dale to trial three different seed planting methods. This area was picked following initial diving assessments in September 2020 as having no seagrass present. Divers found no prior evidence of  of seagrass, seeds lines, or seed bags was recorded within this area

Three squares were planted with buried bags, three squares were planted with bags on the sediment surface and the final three squares were planted with seeds buried into the sediment using hand rakes. The nice squares were stratified with respect to their treatment and surface markers were used to delineate them. Each square, irrespective of treatment was planted with 15000 seeds.

Within the squares a set planting method was used to equally spread the bags and seeds irrespective of treatment. This was achieved by splitting the squares into quarters using surface markers, and divers following set distance along compass bearings around a central point.

To plant seeds directly into the sediment, SCUBA divers with a small hand-rake, a 50 x 50 cm quadrat, and small plastic tubes of seagrass seeds (approx. 416 seeds in each, measured by volume (8.3 ml) followed a similar planting pattern as the staked bag deployment. The sediment in quadrats was raked to create 2 cm deep furrows into which seeds were poured, the furrows were then covered over by sediment by hand.

**Plate 1.** *Assessments of seedling emergence were conducted in June 2020, following the BOSSLines (Photos: Blaise Bullimore).*

## 3.7 Site assessments

To assess the broader effectiveness of the seagrass restoration project, SCUBA surveys were conducted, twice during 2020 (June and September) and once during 2021 (September). Initial assessments in June 2020 were done by SCUBA divers following individual hessian seed bags lines and counting the presence of shoots. Following a summer of activity at the site and the cutting and breakdown of lines this method was no longer effective by September 2020 as the rope lines were no longer clear and so a longer term monitoring plan was required that could be repeated annually. We created a method of laying ten parallel 100m x 5m underwater belt transects (measured using a 100 m ground line) to assess the emergence of young seagrass shoots. Belt transects were evenly placed to broadly cover the whole area. The 100m belt transects were laid using weighted ground lines from the boat and marked with short lines to the surface.

As an additional detailed survey, a series of Seagrass Watch transects were established at the site for repeating over time following an established method. The method of Seagrass Watch sampling using small quadrats meant that the approach was largely ineffective initially in Dale due to low overall shoot density, but by establishing the sites for later repeat, detailed assessments can be undertaken over time.

To undertake assessment of the experimental seagrass sites, each plot was surveyed using assessment of the seabed within quadrats. SCUBA divers used random sampling to place these quadrats (following a range of distances and compass bearings from a central point) throughout the area. Within the quadrats, the following data was recorded: diver-assessed shoot count, maximum leaf length and % macro algae.

## 3.8 Statistical analysis

To analyse experimental planting data to determine whether statistical differences existed between treatments and between years a method called the General Linear Model was used. This utilised a piece of software called Jamovi using 'R' code from the package GAMLj. This analysis used a 2-factor analysis (treatment, block and their interaction term) on BoxCox transformed data of shoot numbers. BoxCox was conducted due to non-normality of data and heterogeneity of variance. 'Block' refers to the position in the block relative to the shore and treatment refers to one of three seed planting treatments (bags unburied, bags buried, or raked seeds). Pairwise comparisons with respect to treatment were conducted using bonferonni pairwise tests.

# 4 Results

## 4.1 Seagrass donor site seed assessment

Seagrass seed densities at the primary donor site were assessed using SCUBA divers observing quadrats within the subtidal areas of the seagrass meadow at Porthdinllaen. This data was collected in order to provide an assessment of the levels of seed collection relative to the seed production. Seed production was estimated to range from 1291 to 1977 seeds per $m^2$. This created a significant resource across a meadow estimated to cover at least 28 hectares (see Table 1). Our collections of seeds from the site we estimate to have been less than 0. 2% of the production.

**Table 1.** *Assessment of seagrass reproductive stems and associated estimates of seagrass seed density at Porthdinllaen from 2019 to 2021*

| Year | No of reproductive shoots per m2 | No of spathes per m2 | No of seeds per m2 | No of seeds per hectare | No of seeds at Porthdinllaen | Seeds collected |
|---|---|---|---|---|---|---|
| 2019 | 24 ± 9.4 | 131 | 1977 | 19,779,775 | 553,833,708 | 750000 |
| 2020 | 16.3 ± 14.5 | 89 | 1340 | 13,406,292 | 375,376,180 | 450000 |
| 2021 | 15.7 ± 11.2 | 86 | 1291 | 12,911,798 | 361,530,337 | 60000 |

## 4.2 Seed lines

In June 2020, SCUBA diving surveys along restoration BOSSLines quantified the number of shoots observed in 626 bags (see Plate 2). Poor visibility restricted the extent of these assessments, however 140 of them (22%) were found to contain seedlings. Where seedlings were observed they were at a density of 2.27 ± 1.58 shoots perbag. Extrapolating this initial result to the wider planting indicated that initial shoot density in June 2020 at the site was 0.37 ± 0.26 shoots per square metre. This equated to an initial seed emergence rate (not germination rate) of 0.01%. The average length of these emerging shoots was 131.0 ± 74.9 mm. The lines were described to be mostly intact, and most bags were still visible and in a sound state with limited degradation. Lines were beginning to show signs of colonisation by Sugar Kelp (*Saccharina latissima*). Prior to June 2020 (since planting) almost no boating activity had taken place due to the Covid19 lockdown that prohibited any recreational boating in Milford Haven Waterway.

**Plate 2.** *Initial pictures taken of emerging seagrass seedlings in Dale Bay in June 2020 (Photos: Sam Rees).*

## 4.3 Long-term transects

Shoot density within belt transect surveys conducted in September 2020 recorded a shoot density that ranged from 3 to 127 per 600m$^2$, this equates to an average density of 0.06 ± 0.07 shoots per square metre. This is an 83% reduction relative to initial assessments in June 2020 and finds that some areas were almost completely devoid of seagrass in contrast to initial seed bag assessments in June 2020. By September 2021 this density had increased to 0.28 ± 0.22 shoots.m$^2$, a 79% increase on 2020. In September 2021, maximum shoot length was an average of 304 ± 119mm, this was a 38% increase on the maximum shoot length recorded in September 2020. The number of individual shoots per clump of seagrass (small group of plants) was recorded in 2020 to be 3.0 ± 1.8 shoots per clump, by September 2021 this had increased 32% to 4.4 ± 3.2 shoots perclump.

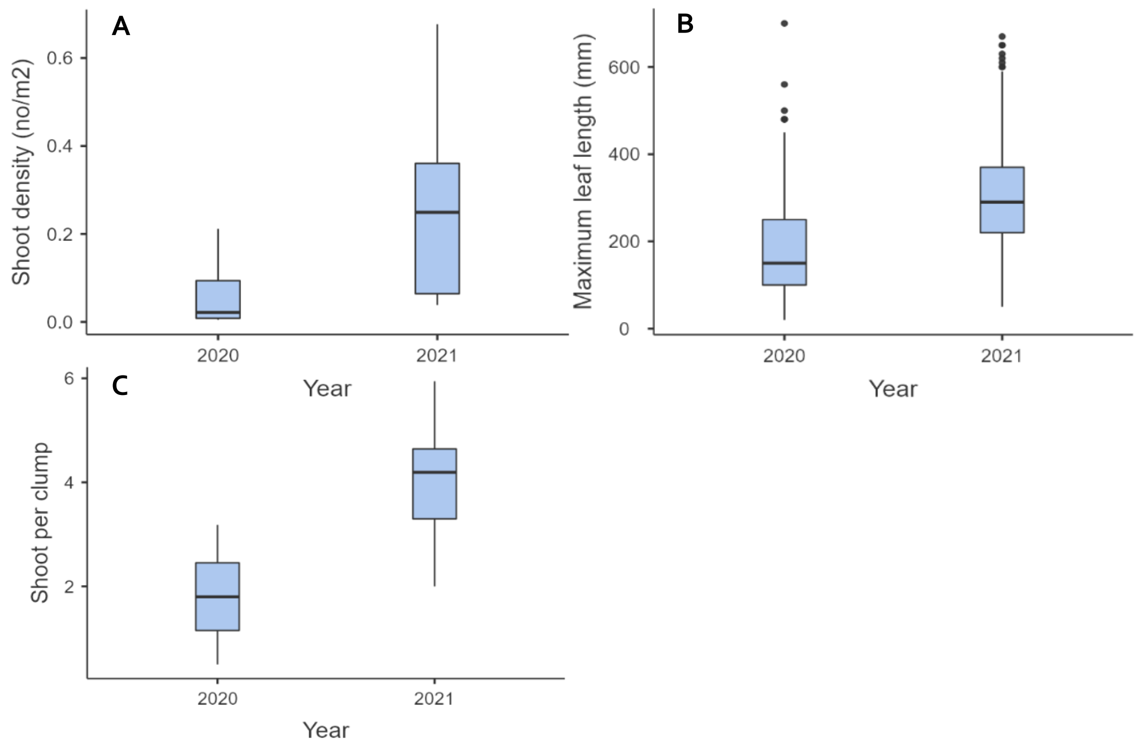



**Figure 1.** *Boxplots showing the range of seagrass density (A), maximum shoot length (B), and numbers of shoots per clump (C) recorded within the seagrass restoration plot in Dale in September 2020 and 2021. Background image was of a clump of seagrass observed in September 2021.*

During dives in September 2020 there was significant evidence that many lines (and thousands of bags) has been caught up and entangled into bunches. In the area of the southern eastern corner where the lines were entangled, no seagrass was recorded. The lack of extreme weather events during the period of June to September 2020 indicates that it's unlikely to have been a weather-related impact. Anecdotal observations from members of the Dale community indicates that anchoring activity during that period was the likely cause of this entanglement. None of these entangled masses of bags contained seagrass and were removed from the site by divers.

By September 2021, there was no evidence within the survey area of remaining ropes or bags, however some anecdotal observations of remaining fragments of these have been recorded on the beach in Dale. Unfortunately, the area now contained extensive coverage of drift Sugar Kelp

(*Saccharina latissima*), it is hoped that winter storms will lead to the movement of this material away from the restoration area. During the dive surveys, significant observations were made of the biodiversity present, however this has yet to be conducted in a quantitative manner. Of particular note was the high abundance of juvenile Pollack.

The transect surveys were only restricted to the 2 hectare restoration area, significant anecdotal observations indicate the possible spread of seeds beyond this with small seagrass patches observed throughout the intertidal area in Dale.

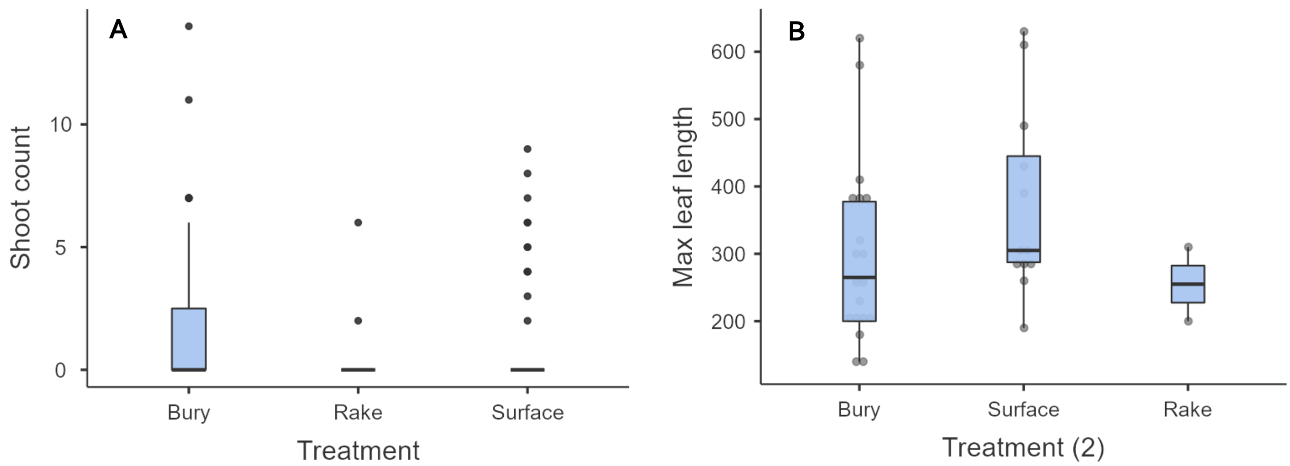
## 4.4 Experimental seed planting

Within the experimental seagrass restoration plots that were planted in November 2020 and then assessed in September 2021 average seagrass density was recorded to be 3.91 ± 9.48 shoots.m². On average the maximum shoot length was 323 ± 137mm. The densities recorded within this area are an order of magnitude higher than those across the broader restoration area and represent a seedling emergence rate of 0.026%, approximately three times that recorded in the initial Dale seagrass planting.

The three treatments significantly affected the density of seagrass shoots ($P<0.001$) and pairwise tests found this difference was only present between the bags relative to the raking. Anecdotal observations on raking indicated the high abundance of crabs ready to feed on the seeds. Shoot density was found to be the highest within plots where seeds were placed in bags that were buried with a density of 6.92 ± 1.6 shoots.m². In bags placed on the surface this density was on average 4.2 ± 1.16 shoots.m². In areas where seagrass seeds were raked into the sediment density was on approximately 10 times less than is the bags with density recorded as being 0.52 ± 0.40 shoots.m². Within the experimental plots, those containing raked seeds had seagrass in only 3% of quadrats, this compared to 20% of quadrats from surface bags and 32% of quadrats from plots containing buried bags, indicating a higher likelihood of observing seagrass when the bags were buried.

Although no significant difference exists between the surface to buried treatments there is far less variability within the buried bags relative to highly variable results for the seed bags placed on the surface. No significant difference exists with respect to shoot lengths between the treatments, however it is important to note the reduced level of variability and reduced maximum shoot length within the raked seeds relative to the bags (see Figure 2).

**Figure 2.** *Box plots of (A) seagrass shoot density (shoots per square metre) and (B) maximum leaf length for experimental plots planted with seagrass seeds by three different methods (seeds in surface bags, seeds in buried bags, seeds hand raked into sediment).*



Macroalgae was a significant component of the sites used within the experimental planting trial (See Plate 2). This was mostly present as thick mats of drift algae that had arrived in Dale in winter 2020/21 and had floated around the bay ever since (anecdotal observations). A significant negative correlation was recorded between the percent cover of the algae and the seagrass shoot density, however this explained only 18% of the variance within the data. Mostly seagrass was only recorded where macroalgae was lower than 20% cover. In all plots where it was above 45% no seagrass was present (see Figure 3). There was no significant difference in the density of macroalgae between treatments and is therefore not considered to be a major driver between the plots.

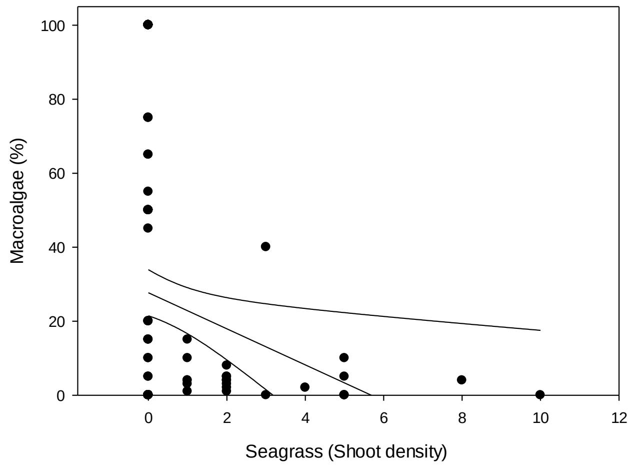



**Figure 3.** *Relationship between seagrass shoot density and the presence of macroalgae across experimental seed planting plots in Dale Bay. Plot shows the negative Pearson's correlation (± 95% CI) between the two variables that was recorded to be significant (P<0.01) and explain 18% of the variance in the data.*

## 4.5 Overall area summary in 2021

By September 2021 the seagrass in the wider area of the restoration plot (20000m²) was on average at a density of 0.22 shoots.m², however within the experimental area (900m²) this density was recorded to be much higher at a density of 3.91 shoots.m². Based on these assessments we estimate that the whole area contains between 5,600 and 9,119 mature seagrass shoots. This estimate does not include numbers of shoots that have developed beyond the restoration area, for which we know has occurred but has not been quantified.

# 5 Discussion

Seagrass restoration remains in its infancy, but the findings of the UK's first pilot scale restoration project provide reasons for optimism as to the potential future recovery of the UKs seagrass meadows. The present report documents that in an area in Dale Bay surveyed in 2019 to be devoid of seagrass there now contains an abundance of seagrass throughout a 2-hectare area. Seagrass shoot density in this restoration area in Dale remains low and is not at the levels that the project had hoped to achieve by this point, but the evidence is clear that plants have developed into mature clumps, that have expanded in density and length over time. Broadly the initial assessment of the restored seagrass indicates the seagrass is on a firm footing going forward in order to ultimately develop into a thick flourishing meadow.

The present project documents that through the use of a large team of volunteers it is possible to collect high densities of seagrass seeds and process these in an effective manner for the restoration of seagrass at the scale of hectares. Whilst there were many successes in this pilot project, there were also a range of lessons learnt. Many of the lessons were also investigated experimentally by undertaking aligned research to understand the cause of the lessons learned.

**Plate 3.** *Seagrass at Dale observed in September 2021 in excellent survey conditions of high light and high-water clarity. Images show the healthy status (long green leaves with low levels of attached algal epiphytes) of the seagrass now growing in Dale, but also reveals the relative low density of shoots at the site. The images also show evidence of the abundance of macroalgae at the site and its interaction with the seagrass seedlings.*

Seagrass seedling emergence in Dale after the initial planting was recorded to be very low, even relative to established low levels within the literature [24]. What the exact cause for this was remains unclear however we suspect the necessity to undertake a rapidly constructed seed storage facility due to extended stakeholder engagement meant that conditions were not ideal. Since undertaking the initial storage, trials are beginning to reveal that our storage was not as suitable as initially thought. Our laboratory results indicate that low temperature and high salinity are most effective and that copper has a negative effect, and that storing seeds in very thin layers (one or two seeds deep) rather than in deep tubs reduces fungal growth.

Whilst initial seedling emergence during summer 2020 was low, levels of shoot density recorded in September 2020 were even lower (an 83% reduction). Circumstantial evidence indicates that this reduction was caused by the impacts of anchoring during the intense boating summer of 2020 following the lockdown boating hiatus. We also speculate the exposure of the site in the centre of the bay may also have exacerbated seedling failures. The reason that the anchoring was so problematic for the seedlings was not necessarily that anchor was particularly intense, but that the breakdown of the hessian rope was insufficient before the summer period, leaving long lines able to be readily snagged. Following the creation of visitor boat moorings in winter 2021, clearance of large amounts of rope in September 2020, and the planting of further bags (in autumn rather than in February) using much thinner line, there was rapid breakdown of the hessian and similar problems were not encountered. The use of the relatively thick hessian rope was also problematic at is created ready structures for the floating seaweed washed into Dale to anchor upon, exacerbating its already high abundance. Although the seaweed (Sugar Kelp) in Dale is drift algae, we do believe that it has been problematic in small areas, as stayed in the same location for long periods due to the relative shelter of the bay. Macroalgae is commonly found to be problematic for seagrass, commonly leading to suffocation of the plants through lack of light [25], it is therefore unsurprising to find that within our experimental plots planted in late 2020 we recorded a negative effect of macroalgae.

Further planting in 2020 learning from initial planting in February 2020 appears to have improved the emergence rate and overall success of the project. The use of the thinner BOSSline, the presence of visitor moorings to discourage anchoring, the lack of ineffective seed storage due to early planting, and a large area experimentally planted by divers improved overall levels of success. The experimental hand planting enabled the demonstration of two key processes, the effectiveness of enclosing seeds within bags and the improved success rate of seeds when the bags become fully buried into the sediment. Both processes point to the importance of considering positive and negative feedbacks in seagrass systems [26]. The enclosed seeds are likely protected from the presence of high crab densities, whilst the burial of seeds possibly improves their exposure to sulphide, a known trigger of germination [27,28].

# 6 Conclusions

We conclude that the Seagrass Ocean Rescue project is now ecologically on a strong footing as seagrass in Dale is increasing in density and now exists throughout the restoration area. We anticipate that over the coming years density will increase and continued monitoring is required to assess this. With continued stakeholder engagement, improved signage and further moorings we expect the conditions to be right for seagrass. This report describes a pilot project for seagrass restoration in the UK that is providing a beacon of hope to the recovery of our UK coastal seas. It provides evidence of extensive lessons learned throughout the project that have and are continuing to improve our means of undertaking seagrass restoration. It will be many years until we understand the true impact of this project, this will require further work to assess the seagrass and to begin to assess its role in supporting biodiversity. It is vital that continued marine conservation activities exist in Dale that build on the close support of the community in helping shape this project.

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