

Solent *Zostera marina* Health & Reproductive Surveys: June 2021



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In collaboration with

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Introduction

Over the last century it is estimated that up to 92% of UK seagrass meadows have been lost causing an urgent need to conserve and restore what little remains (Green et al. 2021). Seagrass restoration can involve the use of seeds or transplants of material, with both methods trialled in Wales since 2017. The use of seeds provides an attractive method for restoration as collection doesn't involve damaging the donor plant or population.

The eelgrass *Zostera marina* has a large over production of seeds relative to the requirements of meadow maintenance that is dominated by vegetative reproduction (extension of the rhizome). *Zostera* is estimated to contain up to 9000 seeds per m² with between 0-40% of germinated seeds reaching seedling stage in lab condition (Larkum et al. 2006) and less than 5% germinating in situ (Hosokawa et al. 2015). Many seeds in situ will naturally be lost due to high mortality when settlement is near the parent plant, settlement in inhabitable substrates and predation pressure. Therefore, a proportion of seeds can be removed from plants with negligible effect. Experience of long-term largescale removal of *Zostera* seeds in the US indicates that there is no negative impact upon donor populations and that the collection of these seeds can lead to the creation of successful restoration projects (Infantes & Moksnes 2018). Successive collections of seeds from donor meadows in North Wales also shows that meadows are not damaged by seed collections (Unsworth et al., *Unpub.*).

The Solent is a heavily used waterway, with many recreational and commercial vessels surrounded by industry and National Parks alike. It has many shallow bays providing sheltered areas for seagrass meadows (*Zostera marina* and *Zostera noltii*) along the Solent coastline. There is currently a great deal of focus on these, with multiple restoration efforts taking place and there exists an increasing need to understand the supply of available propagules to support the work, principally seed production. Seagrass meadow health and reproductive surveys were performed to identify sites that are suitable as seed donor beds. These surveys were designed to highlight sites which would be unlikely to be negatively impacted by the collection of the seeds, allowing further restoration and expansion of seagrass in the Solent.

Method

In June 2021 Swansea University and Project Seagrass worked in collaboration with Natural England, Ocean Conservation Trust and the Hampshire and Isle of Wight Wildlife Trust to perform 12 surveys within 8 seagrass meadows around the Solent (Fig. 1). Site selection was based on prior knowledge of seagrass meadow presence. Ryde was the only site where *Z. noltii* was observed.

Surveys were conducted by SCUBA using 0.25m² quadrats to determine percentage cover of seagrass and algae, and shoot density, following Natural England protocols (Cook 2002). For each survey 25 quadrat observations were taken at random within 30m of a fixed point. All seagrass in one quarter of the quadrat (0.0625 m²) was cut at the seabed for further assessments, including: maximum leaf length, maximum leaf width, and presence of eggs, wasting disease, and epiphytes.

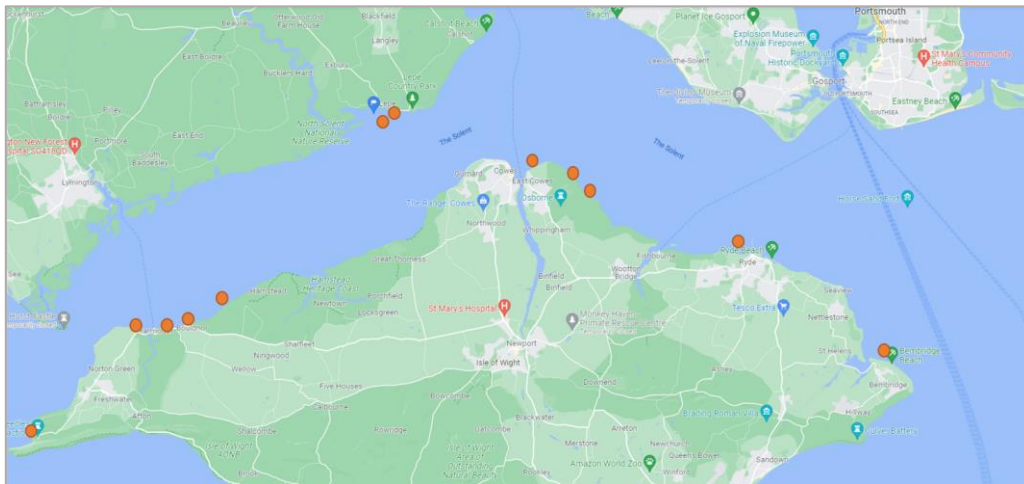


Fig. 1) Seagrass health survey sites conducted in June 2021. Sites from left to right: Totland, Yarmouth Harbour, Yarmouth 1, Bouldnor West, Bouldnor East, Beaulieu 1, Beaulieu 2, Cowes, Osborne 1, Osborne 2, Ryde and Bembridge.

Results

Seagrass cover:

Seagrass meadows around the Solent had an average cover of $45.66\% \pm 28.72$. Yarmouth 1 had the highest cover ($69.40\% \pm 26.43$), whilst Totland had the lowest ($12.80\% \pm 17.84$) (Table 1, Fig. 2). Totland had significantly lower cover than all other sites ($P < 0.001$).

Higher seagrass cover did reflect a statistically significant gradual increase in reproductive effort ($P < 0.001$), however the R^2 value was low (0.07) (Fig.3).

Shoot density:

The average shoot density per 0.25 m^2 in the Solent was 45.38 ± 30.79 . This reflected the seagrass percent cover, with Yarmouth 1 showing the highest density (85.64 ± 39.65), whilst Totland showed the lowest (19.64 ± 21.31) (Table1, Fig. 2).

Reproductive effort:

The proportion of shoots which were reproducing (showing flowers or seeds) averaged $7.47\% \pm 10.28$ across all sites. Bembridge had the highest reproductive output ($16.18\% \pm 10.75$), whilst Beaulieu had the lowest ($2.21\% \pm 4.98$) (Table 1, Fig. 2). Bembridge had an average density of 5.76 ± 3.85 reproductive shoots per 0.25 m^2 , at an average of 57 seeds per shoot. This equates to 14,888,965 seeds per hectare (Table 2, Fig. 4).

Hampshire & Isle of Wight Wildlife Trust (HIWWT) estimated 698 Ha of seagrass meadows around the Isle of Wight from surveys conducted between 2006- 2014 (Watson et al. 2020). Local observations suggest meadows have expanded, and many have not been sufficiently mapped. To improve this Ocean Infinity in collaboration with Project Seagrass have conducted multibeam and side scan surveys, repeatedly finding seagrass to be more extensive than the HIWWT surveys (Ocean Infinity, *Unpub.*). Using the conservative cover of 698 Ha, the seed abundance around the island would range between 1,022,067,328 (lowest seed density observed at Totland) to 10,392,497,877 seeds (highest seed density observed at Bembridge).

The removal of 1,000,000 seeds for restoration efforts would equate to 0.098% of the island's seeds. This figure is based on Totland with the lowest observed reproductive effort and underestimates the

number of seeds per reproductive shoot, the density of reproductive shoots and the extent of Solent seagrass meadows. Averaging the estimates of all Solent sites equates to the collection of 0.019% of seeds (Table 2).

Seed density estimates were based on 10 seeds per spathe, and an average of 5.69 spathes per shoot. Spathe average was calculated from counts performed on Bembridge, Bouldnor East, Bouldnor West, and Totland meadows, which ranged from 1- 16 spathes per reproductive shoot.

Algal cover:

The macroalgae cover around the Solent averaged 18.51% ± 20.71 within the seagrass meadows surveyed. The two surveys at Yarmouth, despite having the highest seagrass cover and shoot density, also had the highest cover of algae (Yarmouth 1: 48.32% ± 34.59, Yarmouth 2: 26.20% ± 20.98) (Table 1, Fig. 2). Cowes, the second sparsest meadow, had the lowest algal cover (4.17% ± 7.49).

Max leaf length:

Solent seagrass leaves averaged a maximum length of 521.68 mm ± 160.01. Cowes had the longest (702.22 ± 215.34), whilst Bembridge had the shortest (390.23 ± 93.70) (Table 1, Fig. 2).

Table 2) The average percent cover of seagrass, shoot density, percentage of shoots that are reproductive and percent cover of macrophytes with ± standard deviation, per survey site around the Solent in June 2021. The 'healthiest' site for each metric is highlighted in green, the worst in red.

Site	Seagrass cover (%)	Shoot density per 1m ²	Reproductive effort (%)	Algae cover (%)	Max leaf length (mm)
Beaulieu 1	38.64 ± 16.14	161.60 ± 70.17	10.32 ± 14.39	13.64 ± 9.54	623.81 ± 89.02
Beaulieu 2	40.40 ± 12.49	150.88 ± 58.24	2.21 ± 4.98	16.20 ± 8.20	527.08 ± 134.92
Bembridge	56.20 ± 32.68	161.44 ± 86.92	16.18 ± 10.75	13.52 ± 13.44	390.23 ± 93.70
Bouldnor East	48.96 ± 34.07	165.60 ± 69.12	9.21 ± 14.33	14.60 ± 20.17	411.06 ± 90.74
Bouldnor West	58.60 ± 29.76	195.68 ± 138.79	10.11 ± 11.65	25.32 ± 23.77	522.22 ± 146.64
Cowes	26.18 ± 32.70	59.24 ± 82.23	14.62 ± 19.95	4.17 ± 7.49	702.22 ± 215.34
Osborne 1	54.48 ± 26.31	260.16 ± 131.10	3.57 ± 6.06	17.40 ± 14.58	574.55 ± 113.17
Osborne 2	55.00 ± 21.26	249.60 ± 88.36	6.24 ± 5.76	17.80 ± 9.14	536.40 ± 109.15
Ryde	32.48 ± 19.50	134.24 ± 129.07	10.79 ± 7.04	10.08 ± 11.02	394.33 ± 77.13
Totland	12.80 ± 17.84	78.56 ± 85.25	3.27 ± 5.34	18.32 ± 19.97	512.55 ± 213.50
Yarmouth 1	48.40 ± 22.35	229.44 ± 105.01	3.66 ± 6.11	48.32 ± 34.59	466.67 ± 134.25
Yarmouth 2 (Harbour)	69.40 ± 26.43	342.56 ± 158.62	4.28 ± 5.71	26.20 ± 20.98	696.52 ± 131.07

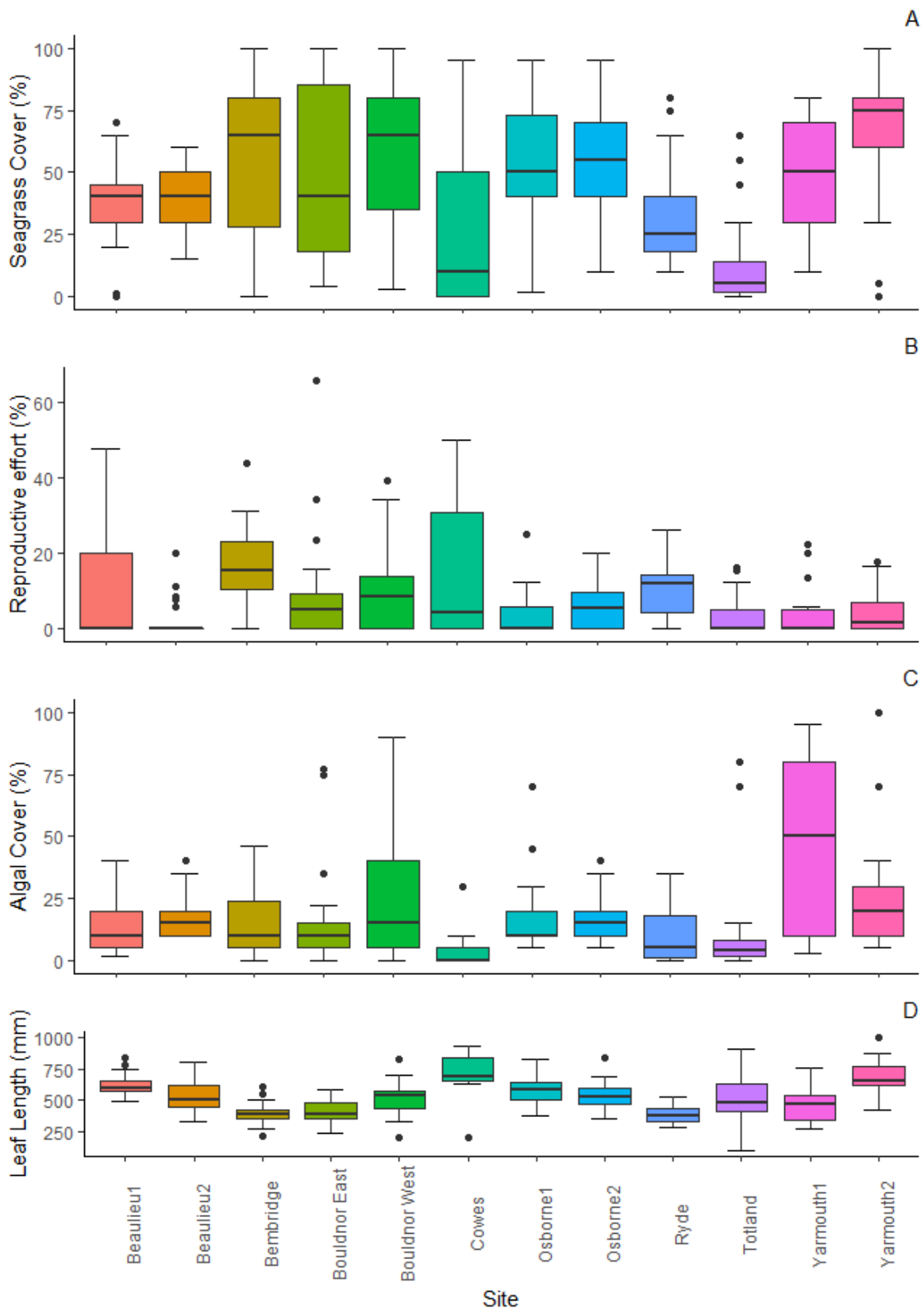


Fig. 2) Boxplots of seagrass surveys around the Solent in June 2021. This includes percentage cover of seagrass (A), percentage of shoots with reproductive spathes (flowers and seeds) (B), percentage cover of macrophytes (C) and the maximum leaf length (D).

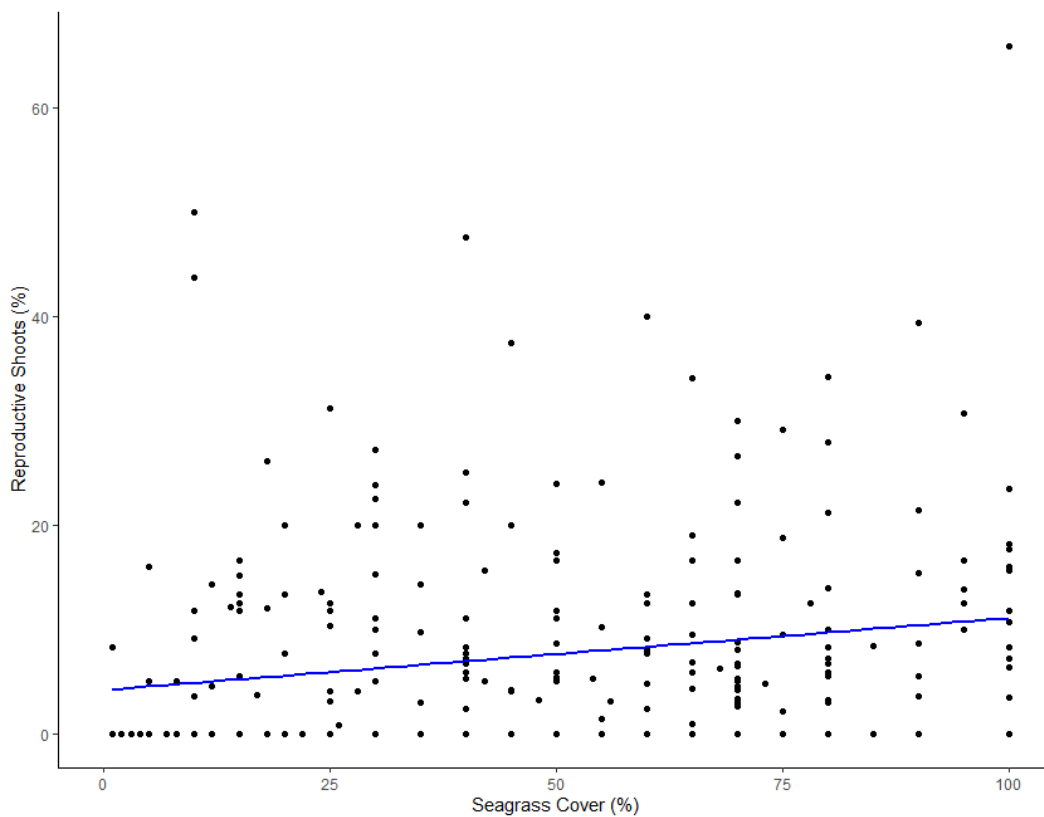


Fig. 3) The graph shows a weak (R^2 is 0.07) increase in reproductive effort (%) as seagrass cover (%) increased.

Table 2) Estimates of seagrass seed presence around the Solent based on an average of 57 seeds per reproductive shoot, and the presence of 698 Ha of seagrass meadow around the Isle of Wight. The percentage of seeds removed is based on a collection of 1,000,000 seeds. Yellow highlights data from outside of the Solent. Note that Sweden *Z. marina* has naturally lower densities.

Site	Shoot density per 0.25m ²	Reproductive effort (%)	Seeds per 1m ²	Seeds per 1 Ha	Seeds per 698Ha	Seeds removed (%)
Beaulieu 1	40.40	10.32	950.60	9505958	6635158963	0.015
Beaulieu 2	37.72	2.21	190.06	1900635	1326643481	0.075
Bembridge	40.36	16.18	1488.90	14888965	10392497877	0.010
Bouldnor East	41.40	9.21	869.35	8693503	6068065234	0.016
Bouldnor West	48.92	10.11	1127.65	11276451	7870963049	0.013
Cowes	14.81	14.62	493.67	4936706	3445820900	0.029
Osborne 1	65.04	3.57	529.40	5293996	3695209096	0.027
Osborne 2	62.40	6.24	887.78	8877773	6196685414	0.016
Ryde	33.56	10.79	825.62	8256163	5762801579	0.017
Totland	19.64	3.27	146.43	1464280	1022067328	0.098
Yarmouth 1	57.36	3.66	478.66	4786577	3341030941	0.030
Yarmouth 2 (Harbour)	85.64	4.28	835.71	8357094	5833251444	0.017

Average for the Solent	45.60	7.87	735.32	7353175	5132516276	0.019
Global max (Larkum et al., 2006)			9000	90000000	62820000000	0.001
Porthdinllaen			1536.59	15365955	10725436590	0.009
Wadden Sea, Netherlands			2250	22500000	15705000000	0.006

Table 3) Estimates of seed presence around the Solent based on 57 seeds per reproductive shoot, and meadows extents from surveys in 2008, the most recent surveys available (Collins, 2008). The percentage of seeds removed is based on a collection of 1,000,000 seeds from one site.

Site	Meadow extent (Ha)	Seed presence	Seeds removed (%)
Beaulieu 1	21.24	201906556	0.50
Beaulieu 2	21.24	40369495	2.48
Bembridge	2	29777931	3.36
Bouldnor East	31.52	274019221	0.36
Bouldnor West	31.52	355433747	0.28
Cowes	27.1	133784737	0.75
Osborne 1	117.56	622362151	0.16
Osborne 2	117.56	1043670970	0.10
Ryde	84.56	698141120	0.14
Totland	8.4	12299951	8.13

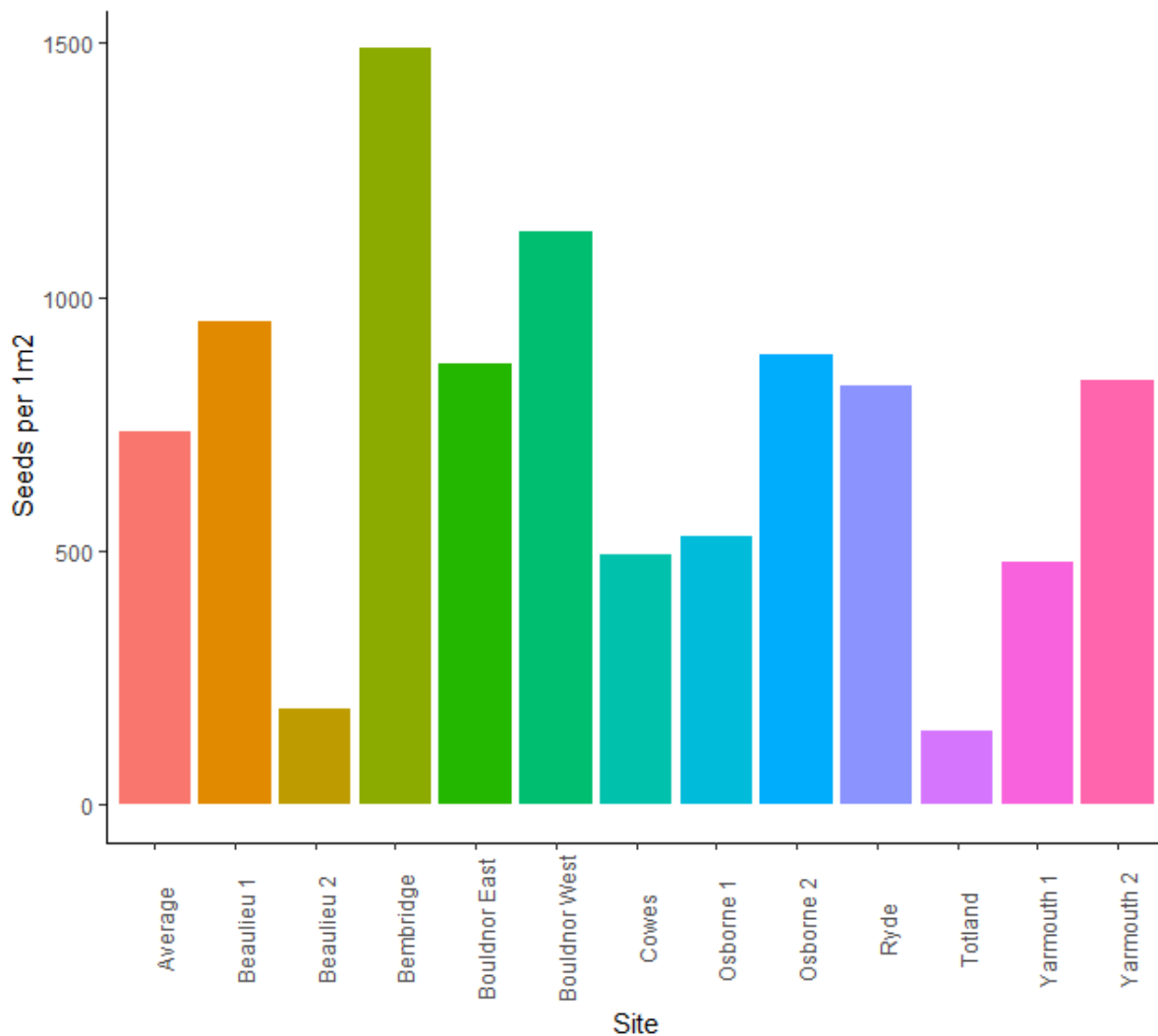


Fig. 4) The average number of seeds per 1m². Estimates are based on an average of 5.7 spathes per reproductive shoot and 10 seeds per spathe.

Discussion

Bembridge and Bouldnor West seagrass meadows both provide high density meadows (>50%) and a high proportion of reproductive shoots (>10%). The high seed production and healthy seagrass meadows provides an opportunity to collect seeds with negligible impact upon the total seed presence, whilst improving the story of Solent seagrass through the expansion of local meadows. Restoration efforts within the waterway would create a positive feedback loop by improving conditions for the donor meadows through increased water filtration and sediment stabilisation.

The low coverage of seagrass at Totland is likely due to high currents and exposure. Ryde and Cowes were the only other sites averaging below 40% seagrass cover. These sites are both largely intertidal in comparison to the others and are directly adjacent to larger settlements, reducing the water quality and explaining the lower seagrass density (Project Seagrass Report, In Prep). Although these three sites are in non-ideal conditions, and hence less productive, an excess of seeds was still observed. The collection of 1 million seeds if all meadows were in a similar state would still be less than 0.098% of Solent seagrass seeds. Regardless, these sites would be avoided for seed collection.

Taking an average across all the surveyed sites, using the conservative 57 seeds per reproductive shoot and the underestimate of 698 Ha of seagrass meadows around the Isle of Wight, then the collection of 1 million seeds equates to 0.019% of seeds available. This ensures negligible negative implications on donor meadow health and resilience, or on animals within.

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