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A PALAEOECOLOGICAL PERSPECTIVE ON THE ECOLOGICAL IMPLICATIONS OF SEAWALL REMOVAL AT GIBRALTAR POINT, UK

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Background and Rationale

Coastal salt marshes are increasingly threatened by sea level rise, reduced sediment availability and anthropogenic activity (e.g. embankments) threatening crucial ecosystem services (Schuerch *et al*., 2018, Schuerch *et al*., 2013). Human activities including the construction of sea defences can have unintended consequences on coastal salt marshes. Gibraltar Point, a UK National Nature Reserve site, is a highly dynamic sand spit enclosing coastal salt marsh that hosts a significant number of migrant and wintering birds, unique flora, and biodiversity (Williamson, 1967, Morgan, 1974). The site includes a sea defence (Bulldog bank), built in the mid-19th century, north of the (old) salt marsh (Figure 1).

This embankment was constructed to protect local pastureland from saline incursions, thereby creating its own unique freshwater marsh, rich in sward flora and aquatic fauna (Wilkinson *et al*., 2019). Breaches occurred on several occasions threatening the diverse freshwater wildlife by saltwater intrusion (Wilkinson *et al*., 2019). While the embankment has created a valuable freshwater marsh, seawalls such as this can have detrimental effects on the extent and carbon sequestration capacity of salt marshes (Kroeger *et al*., 2017). This project is exploring the environmental

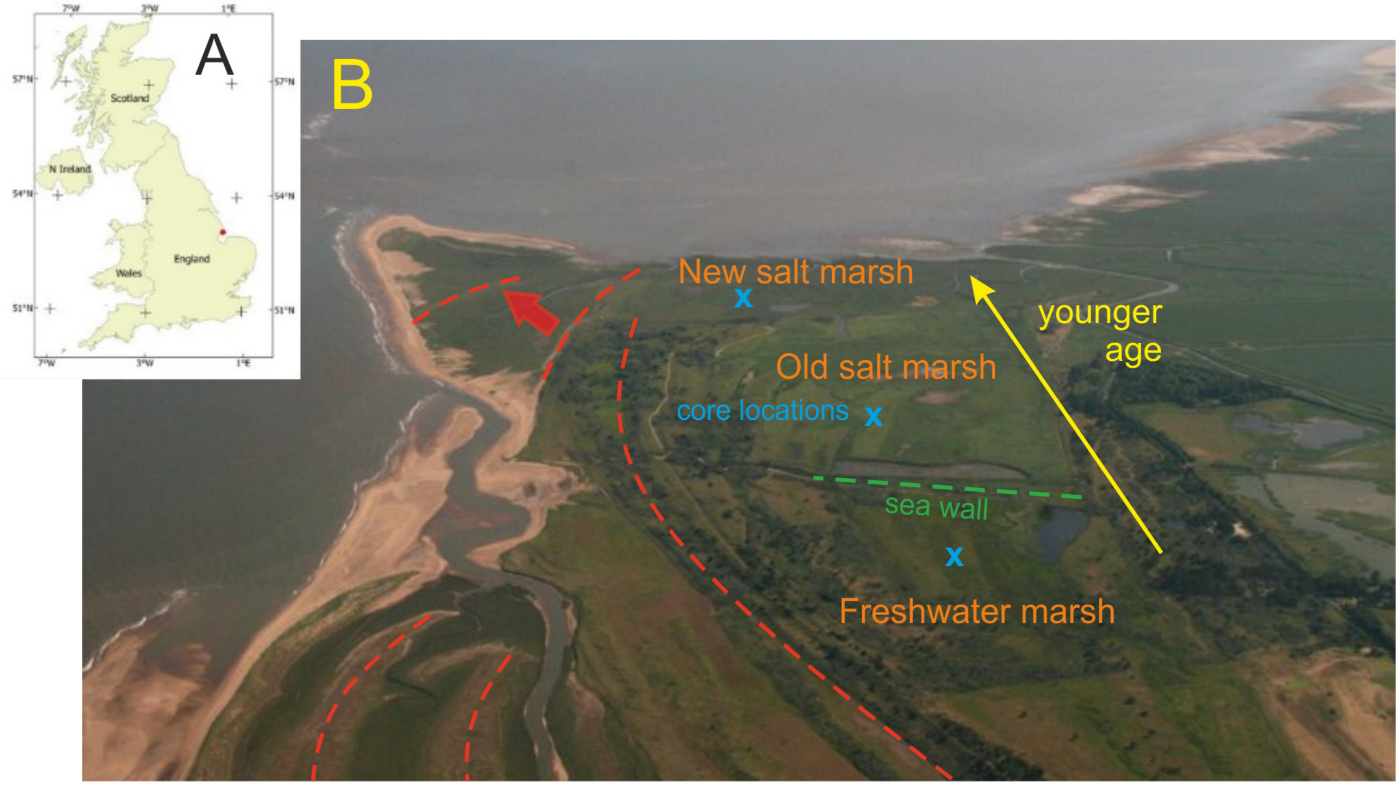

Figure 1. A) Location of Gibraltar Point, UK; B) the Gibraltar salt marsh system with recent over wash breaches, position of past sand barriers (red dashes lines), marsh ecological progressive units (in orange), Bulldog bank (dashed green line), and core locations (blue). Photo: https://www.geograph.org.uk/5837256

marsh history using a multiproxy palaeoecological approach to determine the past and future ecological trajectory of the marsh if the embankment is removed. The QRA provided the financial support for the lead-210 analysis to produce a chronology, key to determine the implications of the embankment on marsh development and if a possible removal is a viable restoration option.

Results

Lead-210 analysis was performed on the freshwater marsh core (GBHP0120 spanning 30 cm) and the old salt marsh core (GBHP0220 spanning 70 cm) using gamma spectroscopy (Table 1 & 2). Both Lead-210 profiles follow the expected exponential decline to a level comparable the Radium-226 values. Meanwhile Cs-137 shows distinct peaks for both profiles, likely

Table 1: Radiometric results for the old salt marsh core (GBHP0220).

Sample depth (cm)	Density (g/cm^3)	^{210}Pb (Bq/kg)	sd (^{210}Pb)	^{226}Ra (Bq/kg)	sd (^{226}Ra)	^{137}Cs (Bq/kg)	sd (^{137}Cs)
2-3 cm	0.6878	108.2	14.66	6.591	4.8995	5.946	1.916
6-7 cm	0.89208	90.44	18.05	19.84	5.914	26	2.619
8-9 cm	0.8492	69.37	13.84	15.655	5.2345	65.18	5.817
10-11 cm	0.89324	65.44	15.12	22.135	5.4575	51.55	4.378
12-13 cm	0.81552	42.26	15.46	18.395	5.408	31.59	3.197
14-15 cm	1.02348	41.99	11.51	26.445	5.612	16.56	2.149
16-17 cm	0.91956	26.78	12.5	25.57	4.4395	4.05	1.717
18-19 cm	0.85904	25.11	13.94	27.955	5.8685	3.917	1.393
20-21 cm	0.75804	29.45	14.31	29.65	6.733		
22-23 cm	0.8074	34.89	12.36	29.57	7.2675		
24-25 cm	0.86492	27.44	13.89	28.57	5.2855		
26-27 cm	0.88424	21.55	12.32	31.955	6.0645		
28-29 cm	0.82188	30.88	11.84	31.68	7.119		
30-31 cm	0.75112	25.5	13.36	18.575	6.284		
32-33 cm	0.84964	29.79	13.37	27.105	5.9885		
34-35 cm	1.05724	25.03	9.369	28.525	7.148		
36-37 cm	0.85332	27.66	12.7	21.975	6.009		
38-39 cm	0.8396	30.41	12.98	26.75	5.7915		
40-41 cm	0.90572	28.87	12.42	23.23	5.8245		
42-43 cm	0.9144	24.54	14.11	29.74	6.561		
44-45 cm	1.05988	22.59	9.682	32.54	6.0435		
46-47 cm	0.89552	35.77	12.48	26.52	5.785		
48-49 cm	1.14956	17.08	8.25	28.02	4.8355		
50-51 cm	1.12268	22.8	9.534	28.96	5.3265		
52-53 cm	1.30308	22.03	9.839	19.615	4.974		
64-65 cm	1.00168	31.12	11.73	32.14	7.54		
66-67 cm	1.1302	24.51	10.29	25.48	5.911		
69-70 cm	1.42828	14.6	8.794	16.815	2.73		

Table 2: Pb-210 results for the freshwater marsh core (GBHP0120).

Sample depth (cm)	Density (g/cm³)	²¹⁰Pb (Bq/kg)	sd (²¹⁰Pb)	²²⁶Ra (Bq/kg)	sd (²²⁶Ra)	¹³⁷Cs (Bq/kg)	sd (¹³⁷Cs)
1-2 cm	0.47316	179.3	30.37	11.59	7.02	13.69	2.792
2-3 cm	0.78396	122	18.2	12.965	5.795	28.12	3.389
3-4 cm	0.92048	111.8	16.54	9.0435	4.6305	36.68	3.423
4-5 cm	0.91512	80.28	16.12	10.4725	3.826	41.32	3.667
5-6 cm	1.162	58.24	11.89	10.725	3.6195	43.7	3.92
6-7 cm	1.21344	34.38	10.73	13.995	3.5735	22.07	2.071
7-8 cm	0.99344	18.99	11.56	13.61	4.5215	10.59	1.653
8-9 cm	1.20792	21.55	9.127	16.325	4.3265	6.816	6.816
9-10 cm	1.0664	17.08	11.07	10.97	4.05		
10-11 cm	1.17104	15.89	9.515	10.955	4.0805	1.602	0.8959
11-12 cm	1.08212	16.9	8.245	11.52	3.786		
13-14 cm	1.37832	16.18	8.328	16.35	4.3525		
14-15 cm	1.3314	16.14	8.328	14.145	4.0275		
16-17 cm	1.40996	16.41	9.243	15.545	3.842		
18-19 cm	1.28232	16.36	9.206	12.53	3.528		
20-21 cm	1.28536	17.03	8.489	12.745	3.9545		
22-23 cm	1.46376	13.9	8.904	11.65	3.049		
23-24 cm	1.41684	13.23	7.877	11.78	3.969		

originating from the nuclear accident in Chernobyl in 1986 (Callaway *et al*., 1996).

These results were used to create the age-depth models (Fig. 2 & 3) using the *plum* package v. 0.2.2 in *R* v. 4.0.4 which utilises Bayesian statistical modelling to accurately determine age-depths from raw (supported and unsupported) ^{210}Pb concentrations (Aquino-López, 2018). Both habitats show linear accumulation with unsupported ^{210}Pb reaching background at 18 cm in the old salt marsh (Fig. 2) and 12 cm in the freshwater marsh (Fig. 3). The mean accumulation rate of the salt marsh is 0.2 cm/yr (Fig. 2) and 0.1 cm/yr in the freshwater marsh (Fig. 3).

Significance

The chronology will be vital for understanding the implications of seawall removal on Gibraltar point's salt and freshwater marsh habitats. Analysis and interpretation are still underway, but preliminary results suggest changes in grainsize and organic matter accumulation following the construction of the Bulldog bank. Pollen analysis will further assist in these interpretations contributing to the understanding of the habitat development and impacts to vegetation with breaches of the seawall. The outcomes of this work will allow for recommendations to the Lincolnshire Wildlife Trust on the ecological impacts of the seawall and the potential removal.

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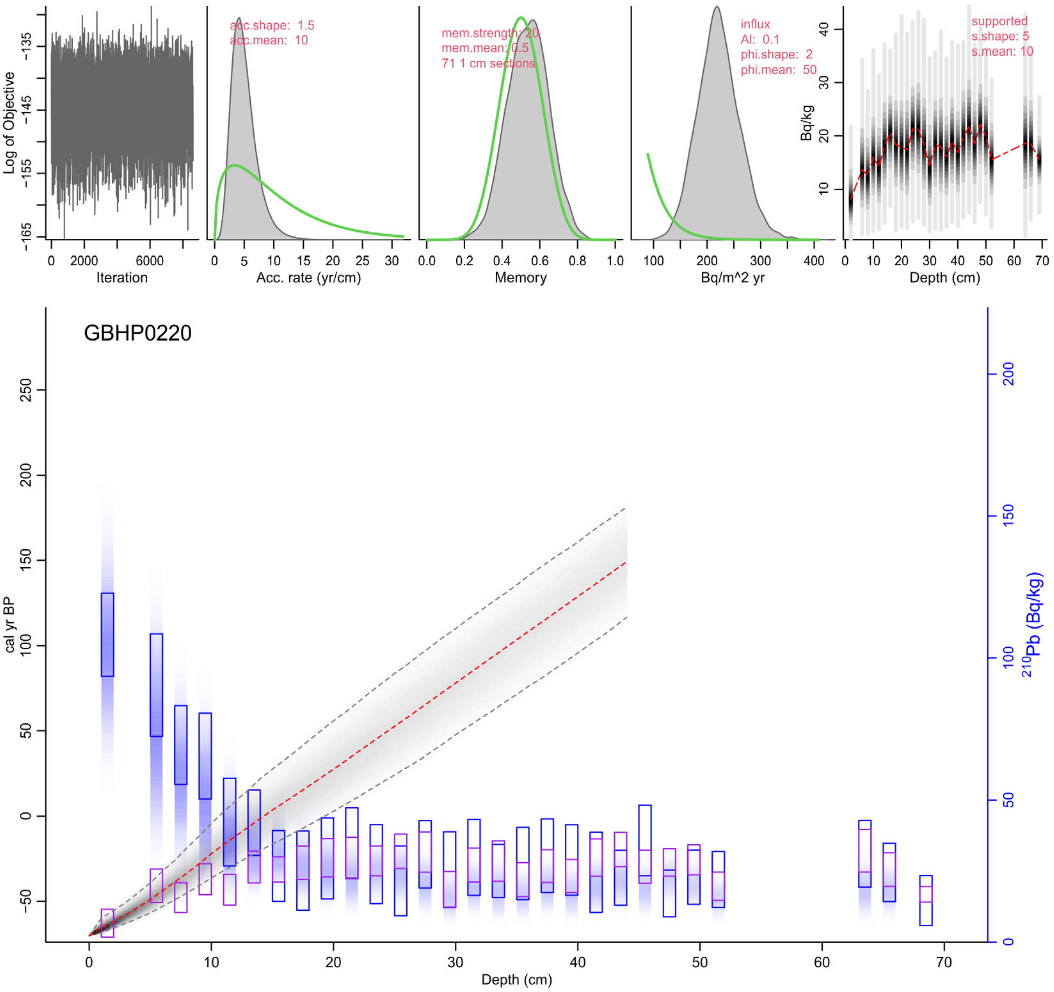

Figure 2. Age-depth model results for old salt marsh (core GBHP0220) performed using *plum* (Aquino-López, 2018) in *R*. Top panel from left to right: self adjusting Markov Chain Monte Carlo iterations, accumulation rates, age model memory, supply of ^{210}Pb, and supported ^{210}Pb by depth (cm). The bottom panel shows the results of the age-depth model with the blue squares indicating the trends in unsupported ^{210}Pb and the purple showing supported ^{210}Pb the black dashed lines show the bayesian iterations and the red dashed line the final age-depth model.

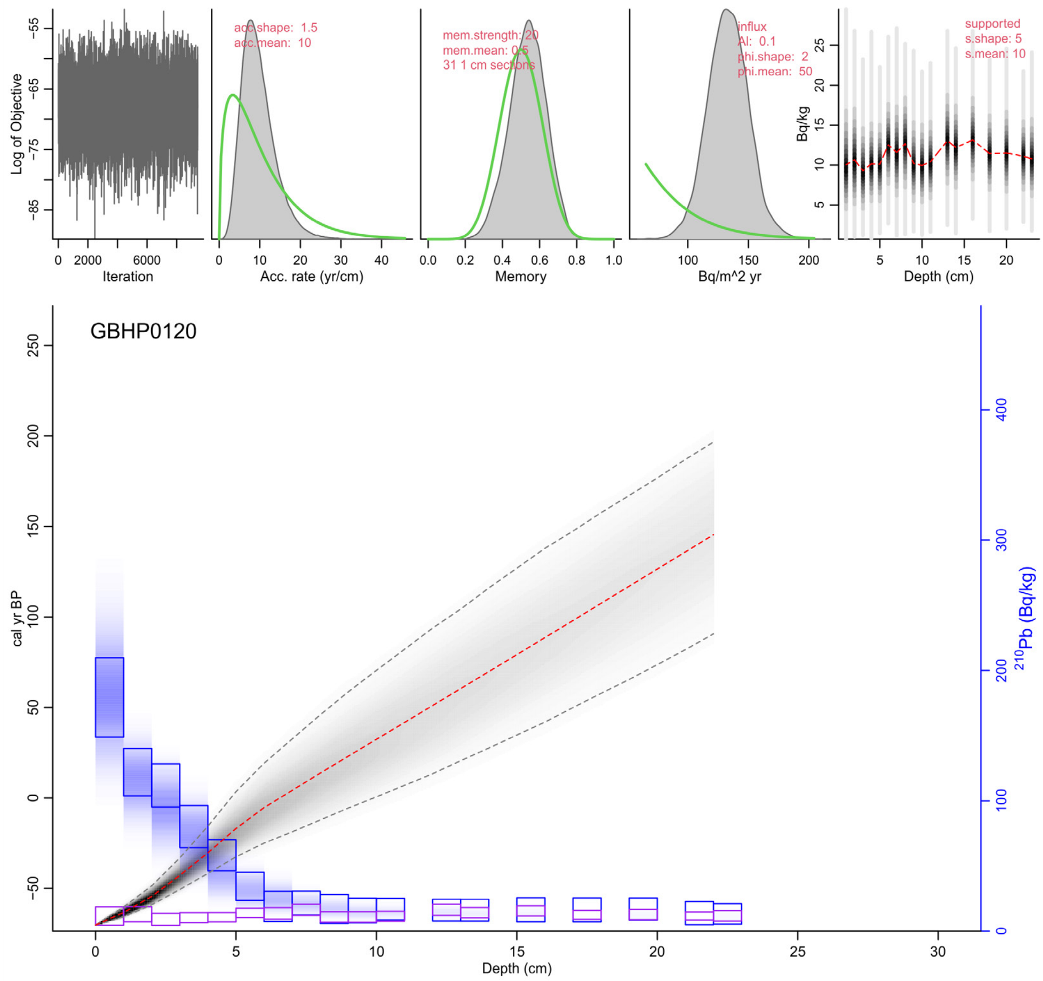

Figure 3. Age-depth model for the freshwater marsh (core GBHP0120) performed using *plum* (Aquino-López, 2018) in *R*. Top panel from left to right: self adjusting Markov Chain Monte Carlo iterations, accumulation rates, age model memory, supply of ^{210}Pb, and supported ^{210}Pb by depth (cm). The bottom panel shows the results of the age-depth model with the blue squares indicating the trends in unsupported ^{210}Pb and the purple showing supported ^{210}Pb the black dashed lines show the bayesian iterations and the red dashed line the final age-depth model.

References

Aquino-López, M. A. (2018). Plum for ^{210}Pb chronologies. *Plum for ^{210}Pb chronologies*. 0.1.0 ed.

Callaway, J., Delaune, R. & Patrick Jr, W. (1996). Chernobyl ^{137}Cs used to determine sediment accretion rates at selected northern European coastal wetlands. *Limnology and Oceanography,* 41, 444-450.

Kroeger, K. D., Crooks, S., Moseman-Valtierra, S. & Tang, J. (2017). Restoring tides to reduce methane emissions in impounded wetlands: A new and potent Blue Carbon climate change intervention. *Scientific reports*, 7, 11914.

Morgan, R. (1974). The Nest Record Scheme, 1968-72. *Bird Study*, 21, 159-164.

Schuerch, M., Dolch, M., Bisgwa, J. & Vafeidis, A. T. (2018). Changing Sediment Dynamics of a Mature Backbarrier Salt Marsh in Response to Sea-Level Rise and Storm Events. *Frontiers in Marine Science*, 5, Article 155.

Schuerch, M., Vafeidis, A., Slawig, T. & Temmerman, S. (2013). Modeling the influence of changing storm patterns on the ability of a salt marsh to keep pace with sea level rise. *Journal of Geophysical Research: Earth Surface*, 118, 84-96.

Wilkinson, B., Wilson, K. & Fraser, J. (2019). Gibraltar Point Freshwater Marsh. In: MANAGEMENT, C. (ed.). Lincolnshire, UK: Lincolnshire Wildlife Trust.

Williamson, K. (1967). A bird community of accreting sand dunes and salt marsh. *British Birds*, 60, 145-157.