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Characterisation and quantification of organic carbon burial using a multiproxy approach in saltmarshes from Aotearoa New Zealand

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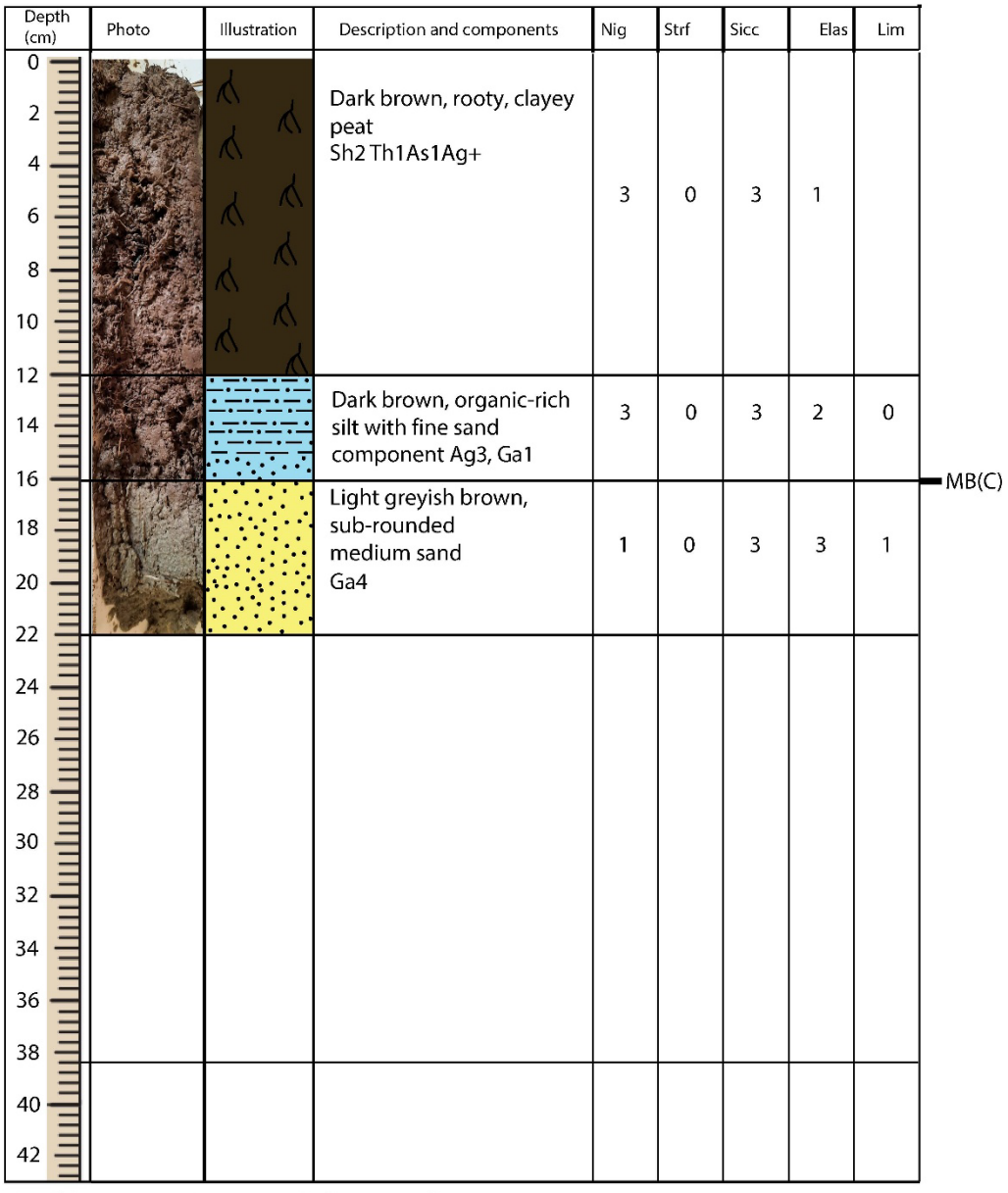
Table S1: Locations, the total number of cores collected across marsh zones (total depth in brackets), and the surrounding vegetation types for each study site.

Marsh Zone	Core	Location (WGS84)	Dominant Vegetation
Pāuatahanui Wildlife Reserve			
Low marsh	Pau-LM1 (18 cm) Pau-LM2 (30 cm) Pau-LM3 (15 cm) Pau-LM4 (28 cm)	-41.0996522, 174.9150162 -41.0983717, 174.9138370 -41.1006246, 174.9138819 -41.1035482, 174.9114934	*Juncus kraussii* with sparse *Kindberdia* spp. and *Polytrichum* spp.
Mid marsh	Pau-MM1 (20 cm) Pau-MM2 (16 cm) Pau-MM3 (15 cm) Pau-MM4 (44 cm)	-41.0991782, 174.9157722 -41.0973502, 174.9145763 -41.1022903, 174.9146370 -41.1039568, 174.9087110	*Apodasmia similis, Plagianthus divaricatus, Typha orientalis, Lolium arundinaceum, sparse Kindberdia* spp. *and Polytrichum* spp.
High marsh	Pau-HM1 (24 cm) Pau-HM2 (20 cm) Pau-HM3 (16 cm) Pau-HM4 (27 cm)	-41.0992224, 174.9170620 -41.0974905, 174.9166265 -41.1021537, 174.9157384 -41.1059960, 174.9133733	*Plagianthus divaricatus, Poa annua, Selliera radicans, Carex flagellifera, Lolium arundinaceum, Carex coriacea, Typha orientalis, Phormium tenax*
Robert Findlay Wildlife Reserve			
Low marsh	Puk-LM1 (5 cm) Puk-LM2 (10 cm) Puk-LM3 (5 cm)	-37.1829576, 175.3222302 -37.1822626, 175.3221232 -37.1793629, 175.3222583	*Samolus repens and Salicornia quinqueflora*
Mid marsh	Puk-MM1 (12 cm) Puk-MM2 (12 cm) Puk-MM3 (10 cm)	-37.1764619, 175.3204250 -37.1795753, 175.3227817 -37.1822105, 175.3214345	*Carex divisa, Selliera radicans, Isolepis cernua*
High marsh	Puk-HM1 (5 cm) Puk-HM2 (10 cm) Puk-HM3 (10 cm)	-37.1755747, 175.3205353 -37.1799204, 175.3229108 -37.1824418, 175.3212890	*Bromus catharticus, Polypogon viridis, Epilobium ciliatum, Carex divisa*
Omaia Island			
Low marsh	Oma-LM1 (20 cm) Oma-LM2 (34 cm) Oma-LM3 (30 cm)	-34.9844134, 173.2648659 -34.9960895, 173.2589576 -35.0009796, 173.2692111	*Pasture, Cotula coronopifolia*, *Lagurus ovatus*, *Polypogon monspeliensis* and *Lobelia anceps*
Mid marsh	Oma-MM1 (20 cm) Oma-MM2 (14 cm) Oma-MM3 (20 cm)	-34.9890245, 173.2640991 -34.9900862, 173.2639586 -34.9976081, 173.2615339	
High marsh	Oma-HM1 (29.5 cm) Oma-HM2 (20 cm) Oma-HM3 (22 cm)	-34.9951711, 173.2631915 -34.9953268, 173.2623952 -34.9980382, 173.2661889	
Okatakata Islands			
Low marsh	Oka-LM1 (47 cm) Oka-LM2 (30 cm) Oka-LM3 (30 cm)	-34.9920759, 173.2734023 -34.9879439, 173.2758958 -34.9840782, 173.2801531	*Juncus kraussii, Salicornia quinqueflora, sparse Kindberdia* spp. *and Polytrichum* spp.
Mid marsh	Oka-MM1 (30 cm) Oka-MM2 (20 cm) Oka-MM3 (30 cm)	-34.9830517, 173.2799168 -34.9874470, 173.2751894 -34.9918548, 173.2737624	*Apodasmia similis, Machaerina juncea, sparse Kindberdia* spp. *and Polytrichum* spp.
High marsh	Oka-HM1 (15 cm) Oka-HM2 (20 cm) Oka-HM3 (20 cm)	-34.9827858, 173.2796975 -34.9859390, 173.2754546 -34.9912065, 173.2742546	*Cyperus ustulatus, Ficinia nodosa, Austroderia splendens, Cortaderia jubata*
Awanui			
Low marsh	Awa-LM1 (6 cm) Awa-LM2 (5 cm) Awa-LM3 (30 cm)	-35.0049151, 173.2670039 -35.0049596, 173.2663042 -35.0050615, 173.2642325	*Salicornia quinqueflora and Juncus kraussii*
Mid marsh	Awa-MM1 (40 cm) Awa-MM2 (95 cm) Awa-MM3 (45 cm)	-35.0052644, 173.2634138 -35.0106002, 173.2612322 -35.0103981, 173.2614833	*Apodasmia similis, Machaerina juncea, sparse Kindberdia* spp. *and Polytrichum* spp.

Core Pau-HM3

Coordinates: -41.1021537, 174.9157834

Author: O. Albot



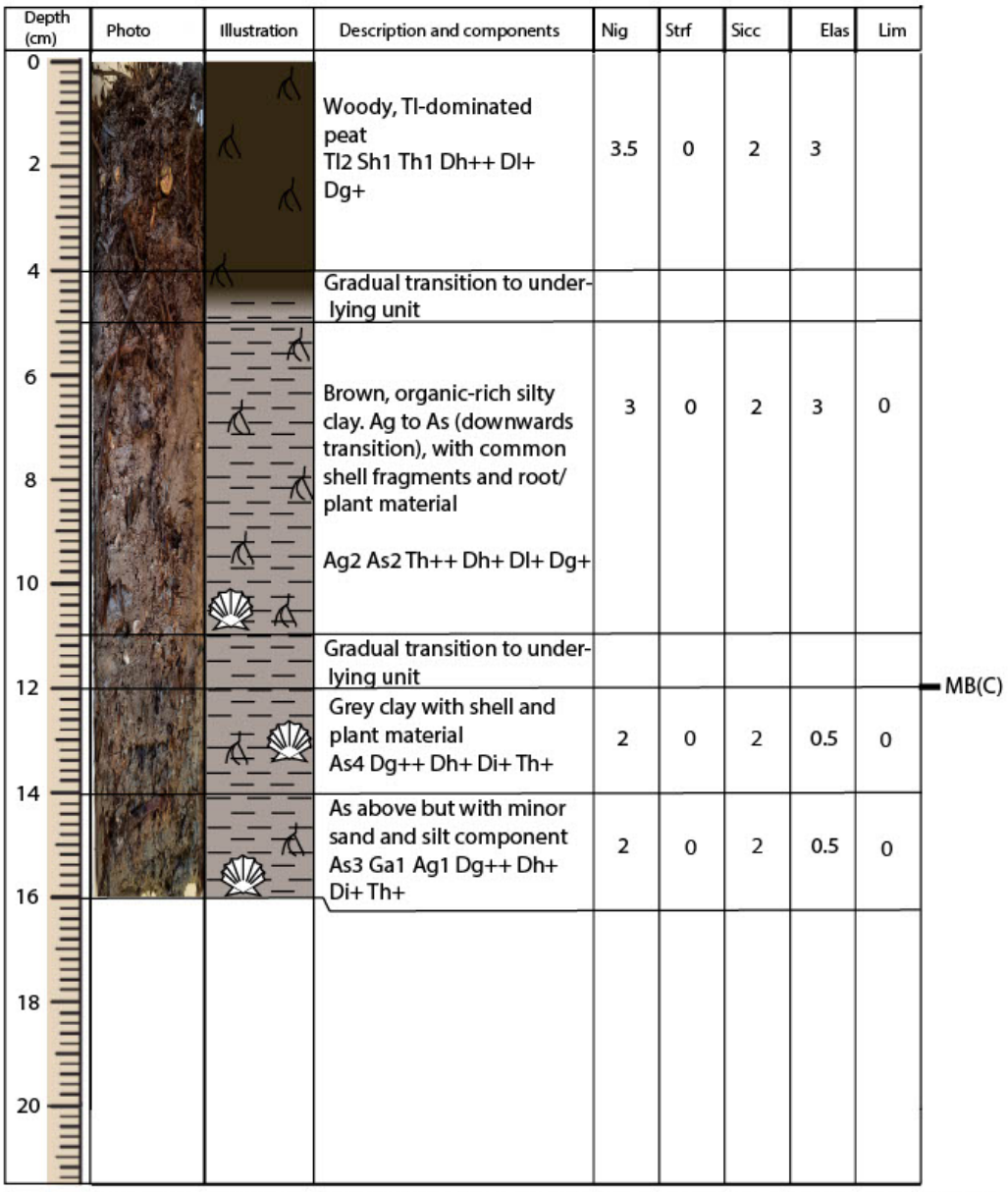
Overlying vegetation: 100% *Lolium arundinaceum*

Figure S1: Detailed stratigraphic log for core Pau-HM3 from Pāuatahanui following the Troels-Smith (1955) sediment classification system. MB (C) – marsh base via correlation with other cores.

Core Puk-MM1

Coordinates: -37.1764619, 175.3204250

Author: O. Albot



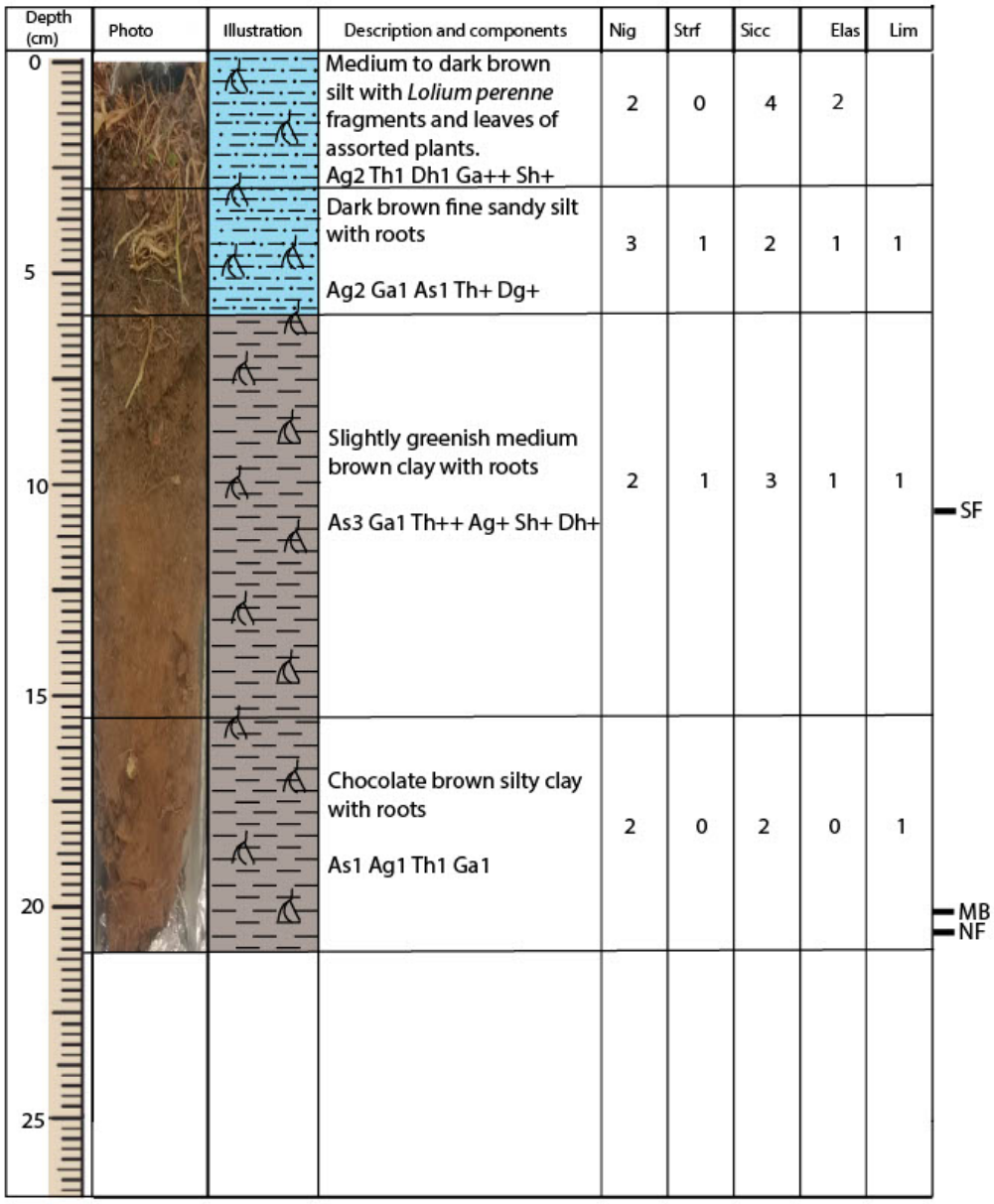
Overlying vegetation: 98% *Carex divisa*, 2% *Salicornia quinqueflora*. Trace: *Lolium arundinaceum, Foeniculum vulgare, Polypogon viridis*

Base of marsh based on correlation with Puk-LM3 & HM2.

Figure S2: Detailed stratigraphic log for core Puk-MM1 from Robert Findlay following the Troels-Smith (1955) sediment classification system. MB(C) = marsh base via correlation with other cores.

Core Oma-MM3

Coordinates: -34.9976081, 173.2615339
Author: D.J. King & O. Albot



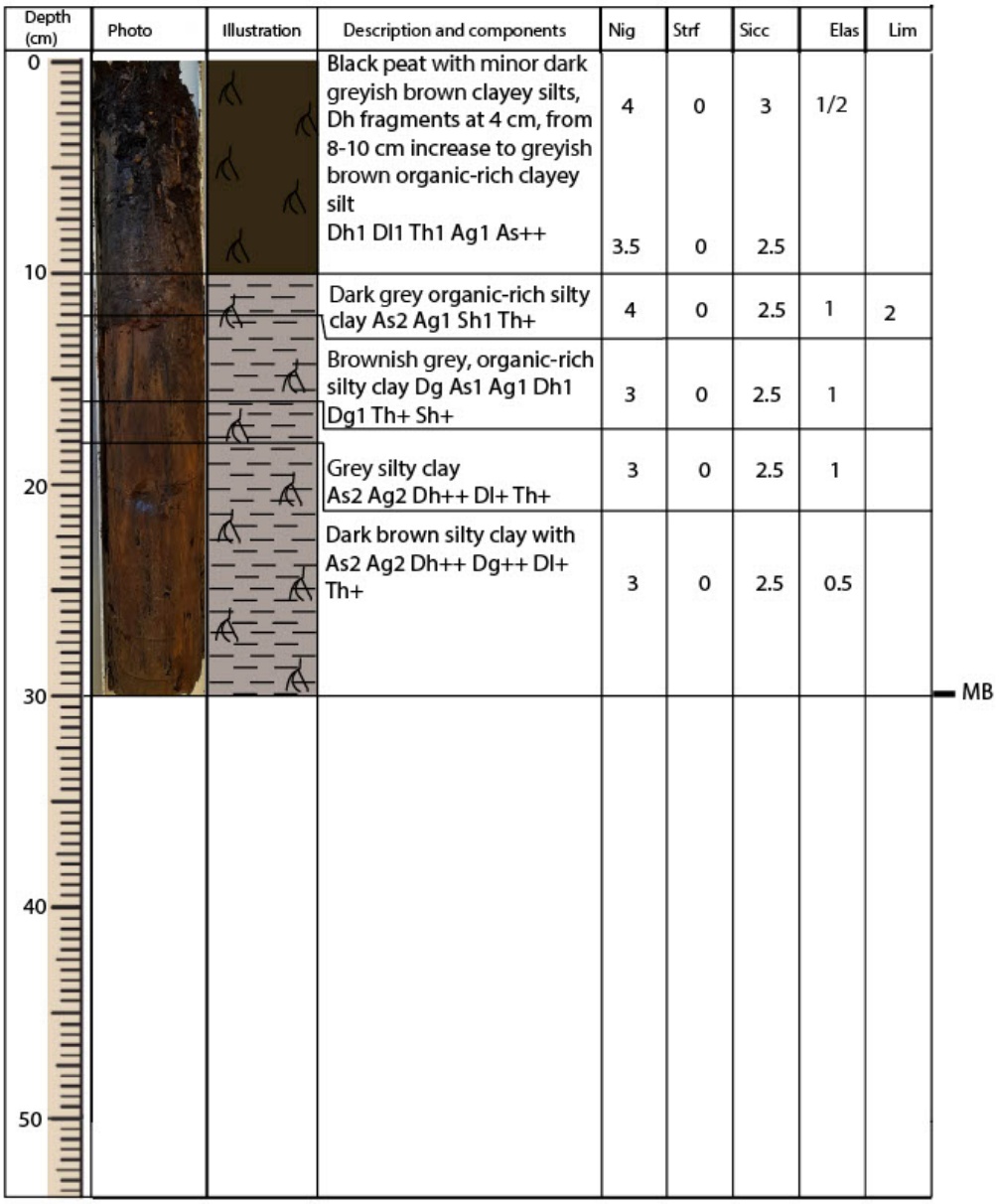
Overlying vegetation: See Table S4.1.
Duplicates of this core extend to 46 cm depth, getting sandier below 36.5 cm. Absence of foraminifera below ~20 cm indicates a potentially terrestrial (non-salt marsh) soil underlying the marsh in this core.

Figure S3: Detailed stratigraphic log for core Oma-MM3 from Omaia following the Troels-Smith (1955) sediment classification system. SF = saltmarsh foraminifera; MB = marsh base; NF = no foraminifera.

Core Oka-MM1

Coordinates: -34.9830517, 173.2799168

Author: O. Albot



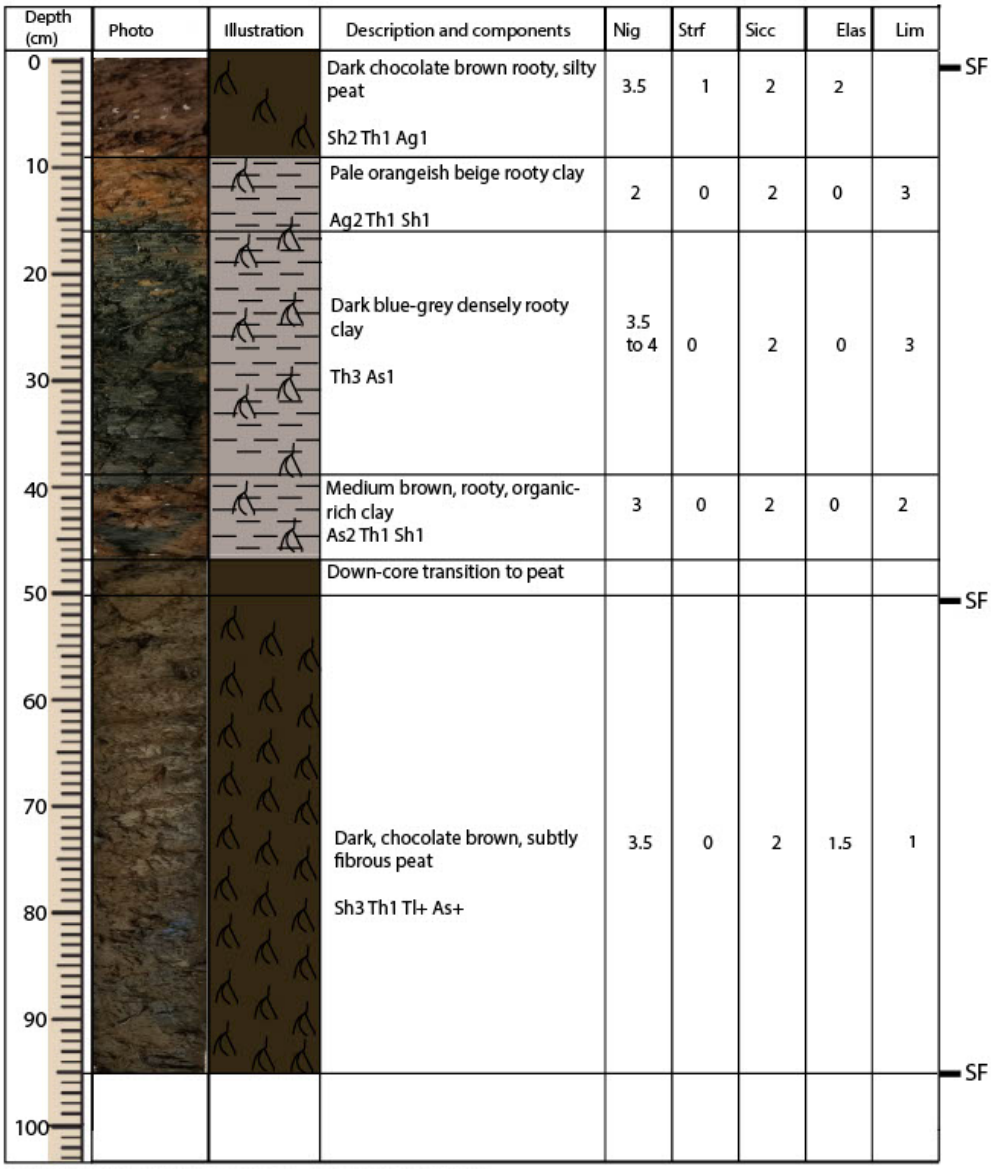
Overlying vegetation: 50% *Machaerina juncea*, 50% *Apodasmia similis*. Trace: *Austroderia splendens*.
Based on Oka-MM2, this core represents salt marsh all the way down to the base.

Figure S4: Detailed stratigraphic log for core Oka-MM1 from Okatakata following the Troels-Smith (1955) sediment classification system. MB = marsh base.

Core Awa-MM2

Coordinates: - 35.0106002, 173.2612322

Author: O. Albot & D.J. King



Overlying vegetation: 100% *Apodasmia similis*

On the basis of foraminifera (and sedimentology), this core is saltmarsh all the way to the base, and the underlying mud/sandflat was not reached

Figure S5: Detailed stratigraphic log for core Awa-MM2 from Awanui following the Troels-Smith (1955) sediment classification system. SF = saltmarsh foraminifera.

Table S2: The results of Levene's, Shapiro-Wilk's and Kruskal-Wallis tests for Total Organic Carbon (TOC; wt%), Total Nitrogen (TN; wt%), Carbon Density (CD; g cm^{-3}), and Dry Bulk Density (DBD; g cm^{-3}). For each test, the p-value is reported along with the test statistic and degrees of freedom (or sample size for Shapiro-Wilk's test) in brackets. Oka – Okatakata; Awa – Awanui; Oma – Omaia; Pau – Pāuatahanui; Puk – Robert Findlay.

Variable	Levene's p-Value Across Sites	Shapiro-Wilk's p-Value By Site	Kruskal-Wallis p-Value Across Sites	Kruskal-Wallis p-Value By Vegetation Zone
TOC (wt%)	1.31E-05 (F=7.27, df1=4, df2=309)	Pau: 3.96E-05 (W=0.93, n=97) Puk: 4.16E-02 (W=0.92, n=25) Oma: 1.30E-09 (W=0.71, n=61) Oka: 6.79E-14 (W=0.54, n=75) Awa: 4.57E-07 (W=0.81, n=56)	4.47E-16 (H=78.07, df=4)	Pau: 0.0262 (H=7.28, df=2) Puk: 0.6472 (0.87, df=2) Oma: 0.0019 (H=12.54, df=2) Oka: 0.0002 (H=17.51, df=2) Awa: 0.0027 (H=9.00, df=1)
TN (wt%)	3.08E-03 (F=4.08, df1=4, df=309)	Pau: 1.23E-03 (W=0.93, n=97) Puk: 7.27E-02 (W=0.94, n=25) Oma: 3.73E-10 (W=0.69, n=61) Oka: 1.39E-11 (W=0.68, n=75) Awa: 3.10E-03 (W=0.93, n=56)	9.44E-14 (H=67.07, df=4)	Pau: 0.006 (H=10.15, df=2) Puk: 0.0336 (H=2.18, df=2) Oma: 0.002 (H=12.73, df=2) Oka: 1.86E-04 (H=17.18, df=2) Awa: 0.0458 (H=3.99, df=1)
CD (g cm^{-3})	1.10E-04 (F=6.03, df1=4, df2=309)	Pau: 0.0159 (W=0.97, n=97) Puk: 0.0082 (W=0.88, n=25) Oma: 9.30E-08 (W=0.80, n=61) Oka: 1.35E-8 (W=0.84, n=75) Awa: 0.0005 (W=0.910, n=56)	8.19E-08 (H=38.66, df=4)	Pau: 0.3981 (H=1.84, df=2) Puk: 0.9557 (H=0.10, df=2) Oma: 0.00547 (H=15.43, df=2) Oka: 0.0057 (H=10.34, df=2) Awa: 0.00359 (H=8.48, df=1)
DBD (g cm^{-3})	1.08E-07 (F=10.10 df1=4, df=309)	Pau: 7.35E-08 (W=0.87, n=97) Puk: 0.0777 (W=0.93, n=25) Oma: 0.00025 (W=0.909, n=61) Oka: 0.0061 (W=0.95, n=75) Awa: 2.79E-07 (W=0.80, n=56)	2.2E-16 (H=106.06, df=4)	Pau: 0.0099 (H=9.24, df=2) Puk: 0.954 (H=0.10, df=2) Oma: 0.0058 (H=10.23, df=2) Oka: 0.04627 (H=6.15, df=2) Awa: 0.2075 (H=1.59, df=1)

Table S3: The results of the *post-hoc* Dunn tests for all sites: Oka – Okatakata; Awa – Awanui; Oma – Omaia; Pau – Pāuatahanui; Puk – Robert Findlay. The final p-value was obtained by applying the Benjamini-Hochberg correction.

Total Organic Carbon (wt%)				
	Oka	Oma	Pau	Puk
Awa	1.45E-02	2.83E-06	8.04E-02	1.28E-02
Oka	-	1.16E-02	2.94E-06	6.56E-06
Oma	-	-	1.16E-12	4.44E-10
Pau	-	-	-	1.45E-01
Total Nitrogen (wt%)				
	Oka	Oma	Pau	Puk
Awa	0.5370	0.0054	0.0027	0.0001
Oka	-	0.0166	6.8E-05	4E-06
Oma	-	-	3.69E-10	6.97E-10
Pau	-	-	-	0.0342
Carbon Density (g cm^{-3})				
	Oka	Oma	Pau	Puk
Awa	1.29E-02	1.88E-02	2.02E-01	1.61E-03
Oka	-	9.45E-01	1.35E01	1.73E-07
Oma	-	-	1.67E01	2.79E-07
Pau	-	-	-	1.06E05
Dry Bulk Density (g cm^{-3})				
	Oka	Oma	Pau	Puk
Awa	0.1491	3.11E-08	8.66E-04	6.44E-01
Oka	-	8.64E-06	8.16E-08	5.31E-01
Oma	-	-	3.49E-23	9.82E-05
Pau	-	-	-	2.83E-03

Table S4: The results of the *post-hoc* Dunn tests for Pāuatahanui. The final p-value was obtained by applying the Benjamini-Hochberg correction.

Total Organic Carbon (wt%)											
	Pau-HM2	Pau-HM3	Pau-HM4	Pau-LM1	Pau-LM2	Pau-LM3	Pau-LM4	Pau-MM1	Pau-MM2	Pau-MM3	Pau-MM4
Pau-HM1	0.6972	0.0620	0.9627	0.0474	0.0531	0.9330	0.6710	0.1429	0.0548	0.0397	0.0875
Pau-HM2	-	0.0365	0.7492	0.0466	0.0489	0.7020	0.4180	0.1083	0.0594	0.0288	0.0894
Pau-HM3	-	-	0.0520	0.7088	0.9321	0.1074	0.0473	0.6812	0.6859	0.5740	0.2021
Pau-HM4	-	-	-	0.0949	0.0902	0.9328	0.7173	0.2039	0.1064	0.0498	0.1948
Pau-LM1	-	-	-	-	0.8305	0.1988	0.0902	0.9183	0.9251	0.3311	0.4959
Pau-LM2	-	-	-	-	-	0.1658	0.0927	0.7490	0.7699	0.5279	0.3844
Pau-LM3	-	-	-	-	-	-	0.8726	0.3368	0.2182	0.0626	0.3803
Pau-LM4	-	-	-	-	-	-	-	0.2736	0.1090	0.0456	0.2024
Pau-MM1	-	-	-	-	-	-	-	-	0.9360	0.3239	0.7500
Pau-MM2	-	-	-	-	-	-	-	-	-	0.3136	0.5951
Pau-MM3	-	-	-	-	-	-	-	-	-	-	0.1058
Total Nitrogen (wt%)											
	Pau-HM2	Pau-HM3	Pau-HM4	Pau-LM1	Pau-LM2	Pau-LM3	Pau-LM4	Pau-MM1	Pau-MM2	Pau-MM3	Pau-MM4
Pau-HM1	0.9804	0.0462	1.0000	0.2034	0.1991	0.9817	0.9773	0.2429	0.0696	0.0510	0.0669
Pau-HM2	-	0.0654	1.0000	0.2630	0.2299	0.9718	0.9844	0.2778	0.1759	0.0700	0.1970
Pau-HM3	-	-	0.0668	0.3009	0.6147	0.0679	0.0537	0.5597	0.7096	0.7243	0.2982
Pau-HM4	-	-	-	0.2250	0.2207	0.9422	0.9818	0.2651	0.1356	0.0763	0.1746
Pau-LM1	-	-	-	-	0.9647	0.2558	0.1791	0.9949	0.7316	0.2410	0.9887
Pau-LM2	-	-	-	-	-	0.2371	0.1792	0.9568	0.9905	0.3333	1.0000
Pau-LM3	-	-	-	-	-	-	0.9979	0.2737	0.1855	0.0649	0.2045
Pau-LM4	-	-	-	-	-	-	-	0.2389	0.0690	0.0517	0.0639
Pau-MM1	-	-	-	-	-	-	-	-	0.9656	0.3094	0.9953
Pau-MM2	-	-	-	-	-	-	-	-	-	0.3873	0.8048
Pau-MM3	-	-	-	-	-	-	-	-	-	-	0.2464
Carbon Density (g cm^{-3})											
	Pau-HM2	Pau-HM3	Pau-HM4	Pau-LM1	Pau-LM2	Pau-LM3	Pau-LM4	Pau-MM1	Pau-MM2	Pau-MM3	Pau-MM4
Pau-HM1	0.1712	0.0197	0.3576	0.0623	0.8159	0.5971	0.5533	0.8690	0.1589	0.3859	0.4377
Pau-HM2	-	0.0021	0.6878	0.0072	0.3747	0.5515	0.0588	0.3660	0.0177	0.0622	0.0506
Pau-HM3	-	-	0.0044	0.5520	0.0385	0.0367	0.0464	0.0486	0.3929	0.4828	0.0479
Pau-HM4	-	-	-	0.0175	0.5406	0.7909	0.1496	0.5509	0.0445	0.1291	0.1008
Pau-LM1	-	-	-	-	0.0915	0.0812	0.1825	0.1347	0.7423	0.7622	0.1725
Pau-LM2	-	-	-	-	-	0.7616	0.5096	0.9599	0.1770	0.3605	0.4310
Pau-LM3	-	-	-	-	-	-	0.3725	0.2403	0.1504	0.2732	0.3653
Pau-LM4	-	-	-	-	-	-	-	0.2533	0.3838	0.5555	0.8876
Pau-MM1	-	-	-	-	-	-	-	-	0.2408	0.3758	0.5135
Pau-MM2	-	-	-	-	-	-	-	-	-	0.9464	0.3905
Pau-MM3	-	-	-	-	-	-	-	-	-	-	0.5881
Dry Bulk Density (g cm^{-3})											
	Pau-HM2	Pau-HM3	Pau-HM4	Pau-LM1	Pau-LM2	Pau-LM3	Pau-LM4	Pau-MM1	Pau-MM2	Pau-MM3	Pau-MM4
Pau-HM1	0.5893	0.0563	0.3135	0.0797	0.0064	0.5944	0.7363	0.0135	0.1261	0.0074	0.0190
Pau-HM2	-	0.4039	0.7932	0.4951	0.0978	0.9370	0.7469	0.1374	0.6197	0.0777	0.4259
Pau-HM3	-	-	0.5859	0.8303	0.2906	0.5113	0.1023	0.4861	0.7295	0.2051	0.8542
Pau-HM4	-	-	-	0.6961	0.1307	0.8227	0.5072	0.2031	0.8107	0.1179	0.6235
Pau-LM1	-	-	-	-	0.2027	0.5889	0.1350	0.3562	0.8146	0.1473	0.9646
Pau-LM2	-	-	-	-	-	0.1317	0.0073	0.8422	0.1373	0.7796	0.1520
Pau-LM3	-	-	-	-	-	-	0.7208	0.2024	0.7193	0.1122	0.5618
Pau-LM4	-	-	-	-	-	-	-	0.0269	0.2079	0.0103	0.0525
Pau-MM1	-	-	-	-	-	-	-	-	0.2569	0.6929	0.3111
Pau-MM2	-	-	-	-	-	-	-	-	-	0.1399	0.3905
Pau-MM3	-	-	-	-	-	-	-	-	-	-	0.5881

Table S5: The results of the *post-hoc* Dunn tests for Okatakata. The final p-value was obtained by applying the Benjamini-Hochberg correction.

Total Organic Carbon (wt%)								
	Oka-HM2	Oka-HM3	Oka-LM1	Oka-LM2	Oka-LM3	Oka-MM1	Oka-MM2	Oka-MM3
Oka-HM1	0.5183	0.7625	0.0774	0.0321	0.0837	0.1030	0.9004	0.7434
Oka-HM2	-	0.2029	0.1018	0.0444	0.1238	0.1982	0.5186	0.6922
Oka-HM3	-	-	0.0331	0.0164	0.0443	0.0358	0.6711	0.5149
Oka-LM1	-	-	-	0.2715	0.6844	0.8019	0.0750	0.0837
Oka-LM2	-	-	-	-	0.6727	0.2217	0.0347	0.0314
Oka-LM3	-	-	-	-	-	0.6363	0.0797	0.0910
Oka-MM1	-	-	-	-	-	-	0.0911	0.1241
Oka-MM2	-	-	-	-	-	-	-	0.7826
Total Nitrogen (wt%)								
	Oka-HM2	Oka-HM3	Oka-LM1	Oka-LM2	Oka-LM3	Oka-MM1	Oka-MM2	Oka-MM3
Oka-HM1	0.8123	0.8332	0.0916	0.0891	0.4521	0.0934	0.9058	0.8194
Oka-HM2	-	0.5565	0.0662	0.0991	0.5396	0.0950	0.8172	0.9466
Oka-HM3	-	-	0.0773	0.0674	0.2171	0.0708	0.8353	0.6214
Oka-LM1	-	-	-	0.8523	0.5111	0.8621	0.0961	0.0969
Oka-LM2	-	-	-	-	0.5093	0.8474	0.1012	0.1164
Oka-LM3	-	-	-	-	-	0.6004	0.4734	0.5527
Oka-MM1	-	-	-	-	-	-	0.0952	0.1149
Oka-MM2	-	-	-	-	-	-	-	0.8530
Carbon Density (g cm^{-3})								
	Oka-HM2	Oka-HM3	Oka-LM1	Oka-LM2	Oka-LM3	Oka-MM1	Oka-MM2	Oka-MM3
Oka-HM1	0.3405	0.9007	0.2957	0.0066	0.0080	0.6767	0.2572	0.3098
Oka-HM2	-	0.2068	0.9151	0.0121	0.0205	0.4450	0.6961	0.8273
Oka-HM3	-	-	0.1623	0.0021	0.0020	0.4320	0.1546	0.1743
Oka-LM1	-	-	-	0.0076	0.0122	0.3053	0.6882	0.8349
Oka-LM2	-	-	-	-	0.8864	0.0033	0.1560	0.0802
Oka-LM3	-	-	-	-	-	0.0026	0.1825	0.1140
Oka-MM1	-	-	-	-	-	-	0.2963	0.3572
Oka-MM2	-	-	-	-	-	-	-	0.8810
Dry Bulk Density (g cm^{-3})								
	Oka-HM2	Oka-HM3	Oka-LM1	Oka-LM2	Oka-LM3	Oka-MM1	Oka-MM2	Oka-MM3
Oka-HM1	0.9090	0.8645	0.0916	0.9356	0.9084	0.0848	0.8557	0.9115
Oka-HM2	-	0.3300	0.0356	0.3589	0.3495	0.0387	0.6961	0.3958
Oka-HM3	-	-	0.0043	1.0000	1.0000	0.0051	1.0000	1.0000
Oka-LM1	-	-	-	0.0196	0.0070	1.0000	0.0038	0.0035
Oka-LM2	-	-	-	-	0.9884	0.0102	0.9874	1.0000
Oka-LM3	-	-	-	-	-	0.0054	1.0000	0.9854
Oka-MM1	-	-	-	-	-	-	0.0042	0.0032
Oka-MM2	-	-	-	-	-	-	-	1.0000

Table S6: The results of the *post-hoc* Dunn tests for Omaia. The final p-value was obtained by applying the Benjamini-Hochberg correction.

Total Organic Carbon (wt%)								
	Oma-HM2	Oma-HM3	Oma-LM1	Oma-LM2	Oma-LM3	Oma-MM1	Oma-MM2	Oma-MM3
Oma-HM1	0.3860	0.0052	1.0000	0.0105	0.5169	0.9967	0.7376	0.9915
Oma-HM2	-	0.1728	0.3898	0.4573	0.8022	0.4097	0.5614	0.4439
Oma-HM3	-	-	0.0050	0.4740	0.0316	0.0053	0.0045	0.0045
Oma-LM1	-	-	-	0.0141	0.5017	1.0000	0.6971	0.9961
Oma-LM2	-	-	-	-	0.1803	0.0185	0.0227	0.0226
Oma-LM3	-	-	-	-	-	0.5366	0.7730	0.5568
Oma-MM1	-	-	-	-	-	-	0.7426	0.9633
Oma-MM2	-	-	-	-	-	-	-	0.7957
Total Nitrogen (wt%)								
	Oma-HM2	Oma-HM3	Oma-LM1	Oma-LM2	Oma-LM3	Oma-MM1	Oma-MM2	Oma-MM3
Oma-HM1	0.2299	0.0003	0.9799	0.0434	0.0785	0.8948	0.6333	0.7948
Oma-HM2	-	0.0720	0.2435	0.7413	0.7133	0.3235	0.5693	0.4765
Oma-HM3	-	-	0.0006	0.0396	0.1749	0.0008	0.0008	0.0023
Oma-LM1	-	-	-	0.0576	0.0782	0.9082	0.6297	0.8209
Oma-LM2	-	-	-	-	0.9053	0.0777	0.1180	0.1281
Oma-LM3	-	-	-	-	-	0.1155	0.1817	0.1751
Oma-MM1	-	-	-	-	-	-	0.7272	0.8952
Oma-MM2	-	-	-	-	-	-	-	0.9030
Carbon Density (g cm^{-3})								
	Oma-HM2	Oma-HM3	Oma-LM1	Oma-LM2	Oma-LM3	Oma-MM1	Oma-MM2	Oma-MM3
Oma-HM1	0.1588	0.0048	0.8422	0.2578	0.0559	0.8689	0.5831	0.7272
Oma-HM2	-	0.4342	0.1252	0.9370	0.7902	0.1317	0.3082	0.3049
Oma-HM3	-	-	0.0078	0.0168	0.5952	0.0034	0.0128	0.0300
Oma-LM1	-	-	-	0.1601	0.0469	0.9524	0.8429	0.5930
Oma-LM2	-	-	-	-	0.2629	0.2047	0.5783	0.5864
Oma-LM3	-	-	-	-	-	0.0493	0.1944	0.1727
Oma-MM1	-	-	-	-	-	-	0.5380	0.5980
Oma-MM2	-	-	-	-	-	-	-	0.9026
Dry Bulk Density (g cm^{-3})								
	Oma-HM2	Oma-HM3	Oma-LM1	Oma-LM2	Oma-LM3	Oma-MM1	Oma-MM2	Oma-MM3
Oma-HM1	0.5818	0.2822	0.9086	0.0042	0.2909	0.7622	0.9120	0.5765
Oma-HM2	-	0.0691	0.4999	0.0007	0.6362	0.4489	0.5218	0.9841
Oma-HM3	-	-	0.4609	0.0686	0.0049	0.5530	0.2849	0.0670
Oma-LM1	-	-	-	0.0223	0.2270	0.9017	0.9497	0.4937
Oma-LM2	-	-	-	-	0.0000	0.0452	0.0022	0.0005
Oma-LM3	-	-	-	-	-	0.1588	0.1782	0.6417
Oma-MM1	-	-	-	-	-	-	0.8492	0.4398
Oma-MM2	-	-	-	-	-	-	-	0.5156

Table S7: The results of the *post-hoc* Dunn tests for Awanui. The final p-value was obtained by applying the Benjamini-Hochberg correction.

Total Organic Carbon (wt%)					
	Awa-LM2	Awa-LM3	Awa-MM1	Awa-MM2	Awa-MM3
Awa-LM1	0.9154	0.2584	0.5262	0.0088	0.2413
Awa-LM2	-	0.4331	0.5720	0.1150	0.4246
Awa-LM3	-	-	0.5118	0.1978	0.9339
Awa-MM1	-	-	-	0.0075	0.4832
Awa-MM2	-	-	-	-	0.0939
Total Nitrogen (wt%)					
	Awa-LM2	Awa-LM3	Awa-MM1	Awa-MM2	Awa-MM3
Awa-LM1	0.9154	0.0679	0.3565	0.0142	0.1971
Awa-LM2	-	0.2681	0.5583	0.2459	0.4247
Awa-LM3	-	-	0.2383	0.7439	0.4951
Awa-MM1	-	-	-	0.0902	0.6024
Awa-MM2	-	-	-	-	0.2061
Carbon Density (g cm^{-3})					
	Awa-LM2	Awa-LM3	Awa-MM1	Awa-MM2	Awa-MM3
Awa-LM1	0.9610	0.8124	0.7948	0.0290	0.9158
Awa-LM2	-	0.7939	0.8462	0.0600	0.8713
Awa-LM3	-	-	0.7782	0.0199	0.7638
Awa-MM1	-	-	-	0.0001	0.8563
Awa-MM2	-	-	-	-	0.0004
Dry Bulk Density (g cm^{-3})					
	Awa-LM2	Awa-LM3	Awa-MM1	Awa-MM2	Awa-MM3
Awa-LM1	0.1893	0.0509	0.0164	0.0670	0.0113
Awa-LM2	-	0.9424	0.9425	0.7059	0.9673
Awa-LM3	-	-	0.7548	0.7700	0.8475
Awa-MM1	-	-	-	0.1602	0.9573
Awa-MM2	-	-	-	-	0.1963

Table S8: Mean (± standard error) values for Total Organic Carbon (TOC; wt%), Total Nitrogen (TN; wt%), Dry Bulk Density (DBD; g cm^{-3}), Carbon Density (CD; g cm^{-3}), and carbon stocks (Mg C ha^{-1}) for all study sites. The carbon stocks were calculated for the top 10 cm (standardised where required) and the total length of the marsh deposits at all sites.

Site	TOC (%, mean ± SE)	TN (%, mean ± SE)	DBD (g cm^{-3}, mean ± SE)	CD (g cm^{-3}, mean ± SE)	Carbon Stock (Mg C ha^{-1}; standardised to 10 cm ± SE)	Carbon Stock (Mg C ha^{-1}; mean to marsh base ± SE)	Dominant Vegetation
Pāuatahanui (site mean)	9.6 ± 0.7	0.60 ± 0.04	0.40 ± 0.03	0.03 ± 0.001	30.2 ± 3.3	51.4 ± 7.3	
Low marsh (n=4; 15, 18, 28 & 30 cm)	9.2 ± 1.2	0.49 ± 0.05	0.44 ± 0.06	0.03 ± 0.002	31.4 ± 4.8	51.3 ± 10.9	*Juncus kraussii*
Mid marsh (n=4; 15, 16, 20 & 44 cm)	11.7 ± 1.3	0.75 ± 0.06	0.33 ± 0.04	0.03 ± 0.001	30.0 ± 4.8	60.7 ± 16.1	*Apodasmia similis, Plagianthus divaricatus, Typha orientalis*
High marsh (n=4; 16, 20, 24 & 27 cm)	7.3 ± 1.3	0.51 ± 0.07	0.45 ± 0.03	0.02 ± 0.003	29.4 ± 8.3	42.3 ± 6.3	*Plagianthus divaricatus, Lolium arundinaceum, Poa annua, Bromus catharticus, Carex coriacea*
Robert Findlay (site mean)	10.0 ± 1.0	0.76 ± 0.07	0.64 ± 0.07	0.05 ± 0.006	40.0 ± 7.8	41.3 ± 9.4	
Low marsh (n=3; 10, 5 & 5 cm)	8.1± 1.1	0.61 ± 0.06	0.67 ± 0.11	0.05 ± 0.005	41.6 ± 7.6	30.0 ± 12.8	*Salicornia quinqueflora, Samolus repens*
Mid marsh (n=3; 12, 12 & 10 cm)	11.4 ± 1.9	0.74 ± 0.11	0.69 ± 0.16	0.06 ± 0.01	46.0 ± 24.2	50.0 ± 28.9	*Carex divisa, Selliera radicans, Isolepis cernua*
High marsh (n=3; 5, 10 & 10 cm)	9.9 ± 2.0	0.90 ± 0.15	0.56 ± 0.05	0.05 ± 0.01	58.0 ± 13.4	43.9 ± 1.7	*Polypogon viridis, Epilobium ciliatum, Bromus catharticus, Carex divisa,*
Omaia (site mean)	2.7 ± 0.4	0.247± 0.04	1.9 ± 0.07	0.03 ± 0.005	35.9 ± 7.4	62.9 ± 11.7	
Low marsh (n=3; 20, 30 & 34 cm)	2.2 ± 0.5	0.23 ± 0.05	1.5 ± 0.13	0.03 ± 0.004	40.6 ± 19.2	72.3 ± 22.6	Pasture grasses and legumes, *Cotula coronopifolia, Lagurus ovatus, Polypogon monspeliensis, Lobelia anceps, patchy Juncus kraussii and Salicornia quinqueflora*
Mid marsh (n=3; 14, 20 & 20 cm)	4.3 ± 0.9	0.44 ± 0.10	0.87 ± 0.05	0.04 ± 0.006	40.0 ± 6.9	60.8 ± 8.2	
High marsh (n=3; 20, 22 & 29.5 cm)	2.1 ± 0.5	0.21 ± 0.06	1.0 ± 0.06	0.02 ± 0.004	27.3 ± 13.2	55.1 ± 31.3	
Okatakata (site mean)	5.5 ± 0.9	0.38 ± 0.05	0.70 ± 0.04	0.02 ± 0.002	29.2 ± 5.3	54.2 ± 9.7	
Low marsh (n=3; 30, 30 & 47 cm)	2.1 ± 0.1	0.20 ± 0.02	0.78 ± 0.06	0.02 ± 0.002	15.8 ± 10.3	46.3 ± 28.2	*Juncus kraussii, Salicornia quinqueflora*
Mid marsh (n=3; 20, 20 & 30 cm)	8.3 ± 2.3	0.48 ± 0.10	0.74 ± 0.09	0.03 ± 0.004	37.6 ± 8.6	62.2 ± 18.5	*Apodasmia similis, Machaerina juncea*
High marsh (n=3; 15, 20 & 20 cm)	8.0 ± 2.0	0.61 ± 0.10	0.51 ± 0.06	0.03 ± 0.002	34.3 ± 5.4	54.0 ± 8.2	*Austroderia splendens, Ficinia nodosa, Cortaderia jubata*
Awanui (site mean)	6.9 ± 0.8	0.36 ± 0.03	0.61 ± 0.05	0.03 ± 0.003	30.6 ± 15.2	92.3 ± 66.2	
Low marsh (n=3; 5, 6, and 30 cm)	2.6 ± 0.8	0.22 ± 0.06	0.96 ± 0.24	0.01 ± 0.003	28.3 ± 12.0	19.7 ± 15.6	*Salicornia quinqueflora, Juncus kraussii (newly colonised low marsh and juvenile plants for 5 and 6 cm long cores)*
Mid marsh (n=3; 40, 45, 95 cm)	7.7 ± 0.9	0.38 ± 0.03	0.54 ± 0.03	0.04 ± 0.003	32.8 ± 20.7	165.0 ± 127.9	*Apodasmia similis (40 and 45 cm cores were retrieved from mid marsh zones with patchy vegetation)*

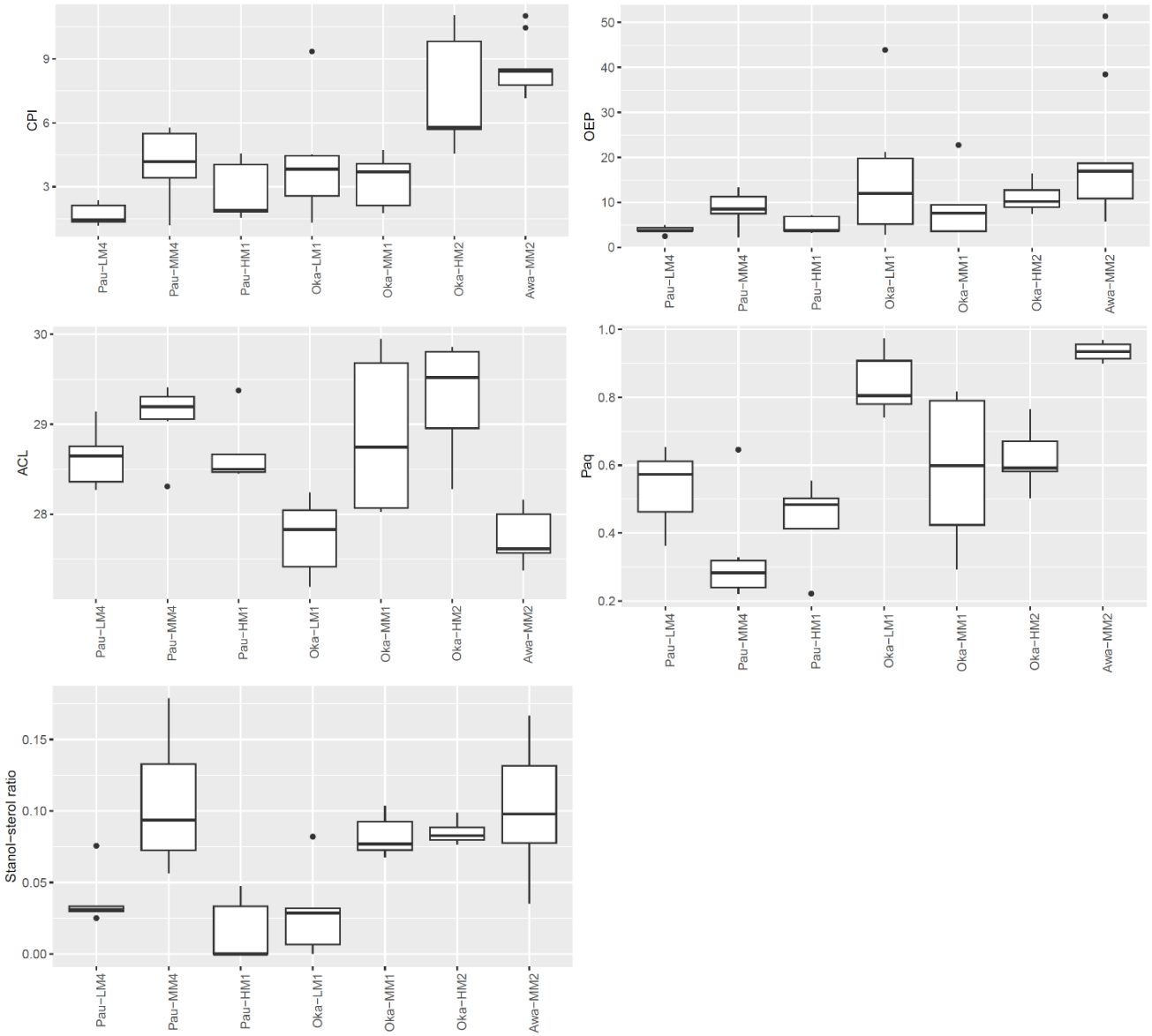


Figure S6: Boxplots showing the values of each biomarker index for all sampled cores at Pāuatahanui (Pau), Okatakata (Oka) and Awanui (Awa) for low marsh (LM), mid marsh (MM) and high marsh (HM). Topmost: P_{aq} (left) and ACL (right); middle: CPI (left) and OEP (right); bottom: stanol-sterol ratio.

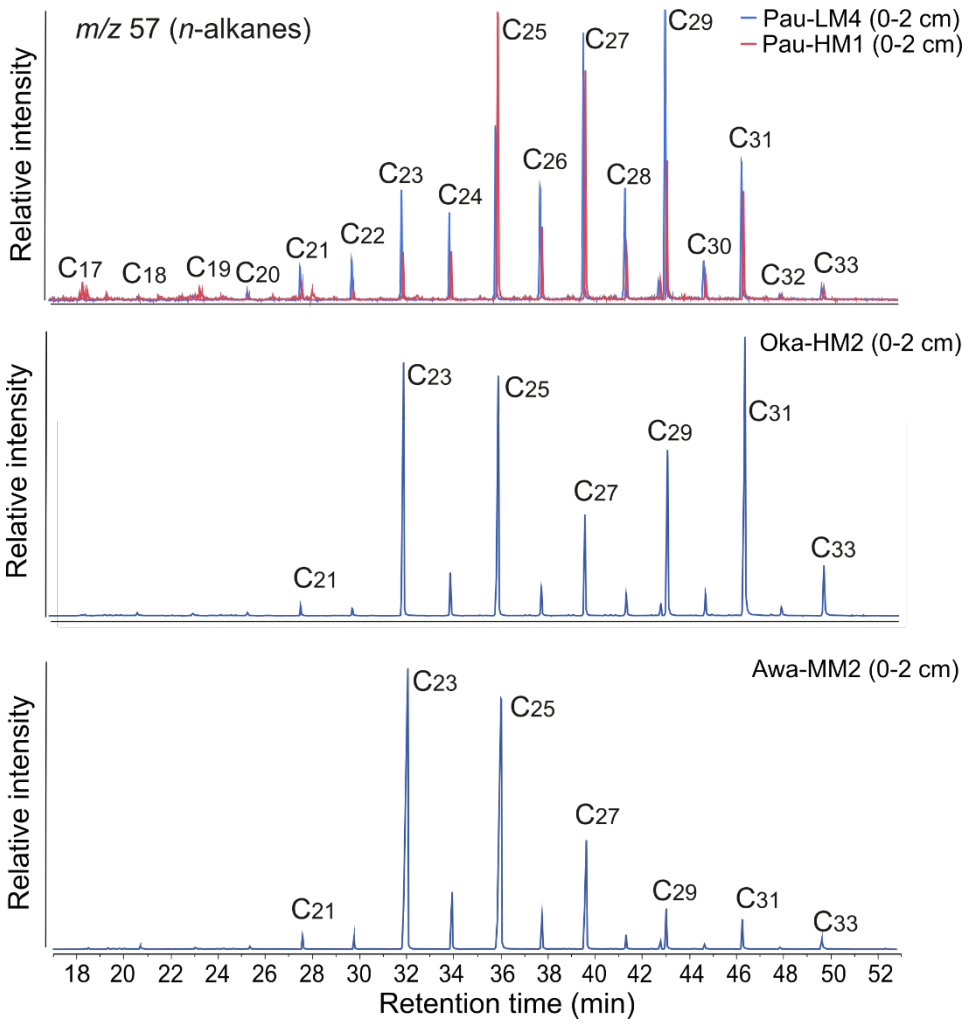


Figure S7: Example ion fragmentograms (m/z 57) for samples from Pāuatahanui (Pau), Okatakata (Oka) and Awanui (Awa) showing the *n*-alkane distributions present in the apolar fractions of the total lipid extracts (TLEs).

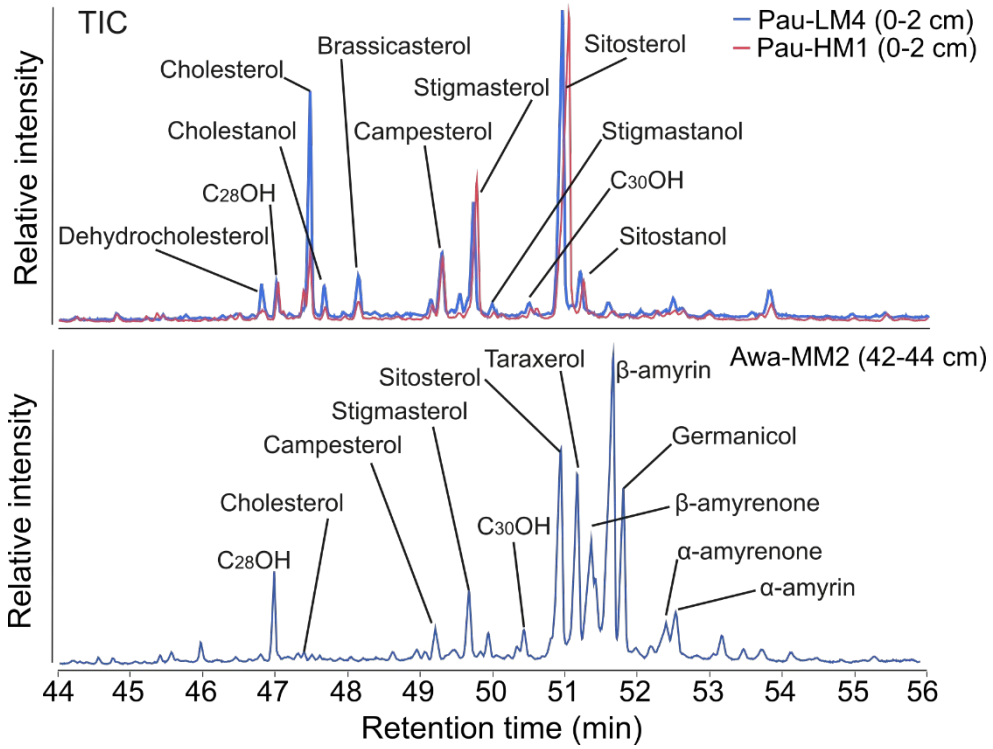


Figure S8: Example of Total Ion Current (TIC) signal for samples from Pāuatahanui (Pau) and Awanui (Awa) showing the distributions of sterols and their respective stanols, as well as plant terpenoids, present in the polar fractions of the total lipid extracts (TLEs).

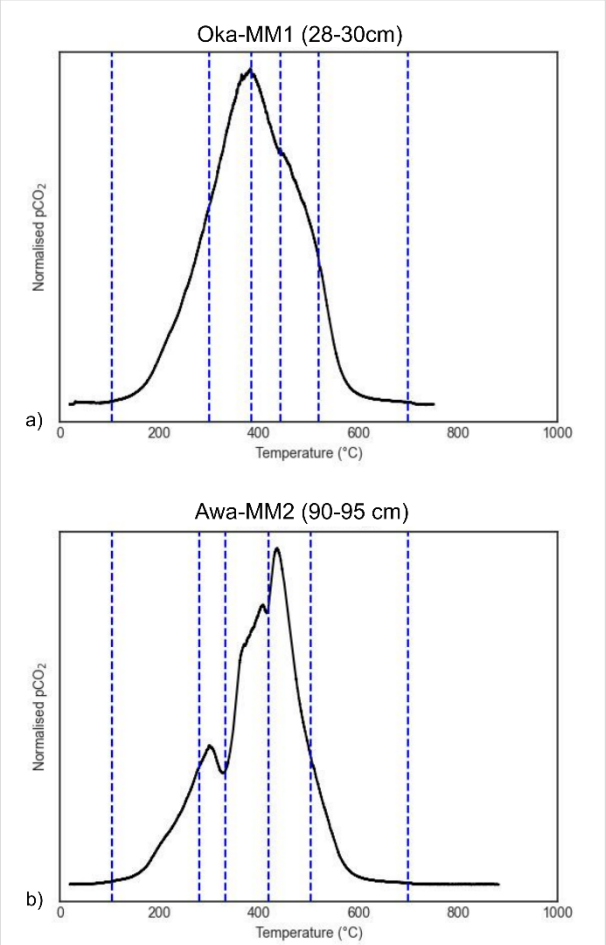


Figure S9: RPO-AMS thermographs for a) Okatakata sample Oka-MM1 (28-30 cm) and b) Awanui sample Awa-MM2 (90-95 cm). The x-axis is the temperature during ramped heating of the sample (°C), with the dotted blue lines representing the obtained pyrolytic splits. The y-axis is the CO_2 evolution normalised to account for sample size differences.

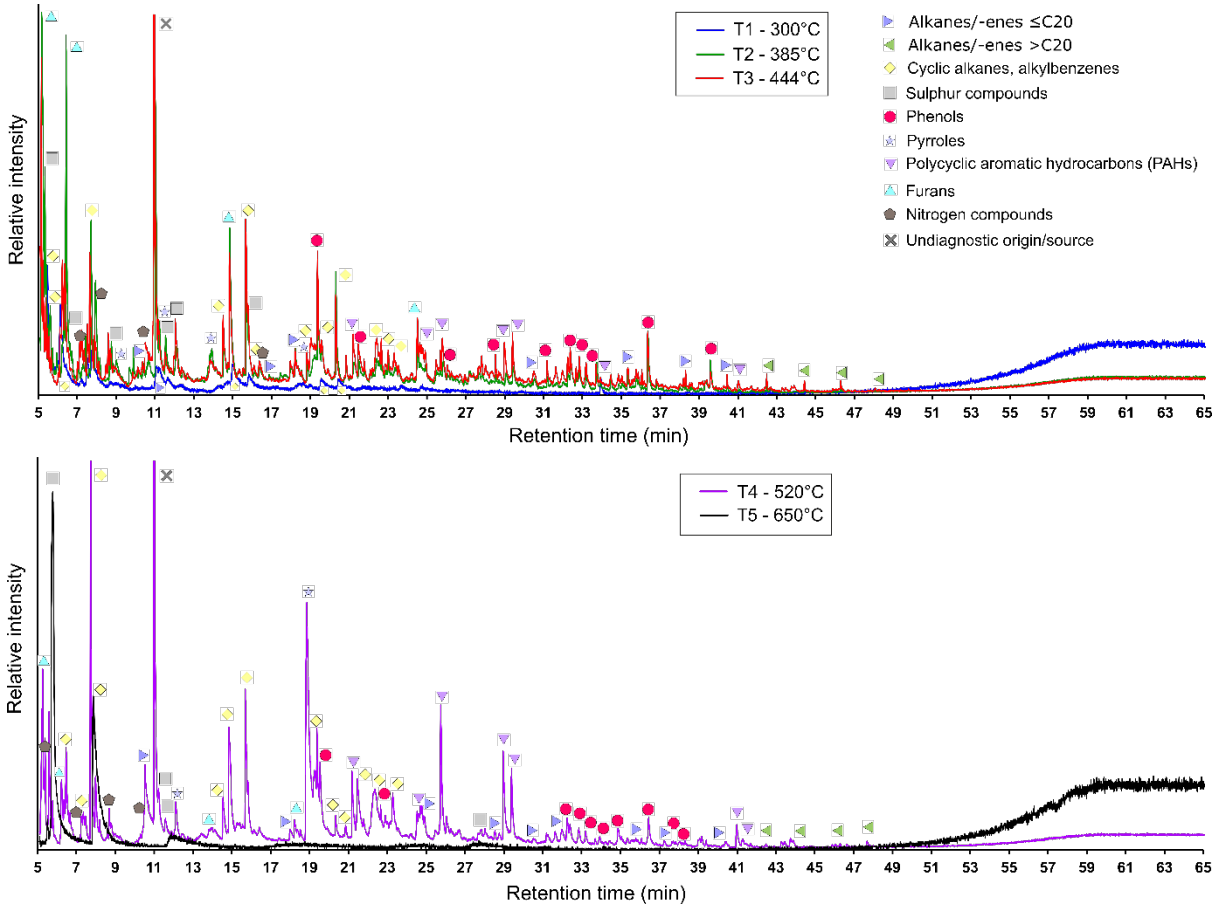


Figure S10: Example chromatograms of the different temperature splits obtained following ramped pyrolysis gas chromatography mass spectrometry (Py-GC-MS). The sample chromatogram is for one sample from Okatakata, Oka-MM2 (28-30 cm).

Table S9: Results of hierarchical cluster analysis for elemental, stable isotopes and XRF datasets for all samples. The matrix shows p-values for each variable in Clusters 1, 2, and 3, compared to the overall mean of that variable across the entire dataset.

Variable	Cluster 1	Cluster 2	Cluster 3
TOC	5.00E-20	1.40E-03	1.28E-02
TN	2.00E-20	2.20E-03	2.80E-03
CD	4.80E-08	1.16E-02	1.63E-01
DBD	3.90E-05	1.10E-04	5.61E-01
delta_13C	3.80E-07	2.28E-01	3.40E-03
C:N	2.70E-05	3.50E-04	8.66E-01
S	9.22E-01	6.74E-02	4.80E-03
Al	1.20E-05	8.24E-01	1.40E-04
Ti	2.30E-04	8.50E-03	1.70E-14
Si	2.70E-09	8.10E-07	8.39E-01
Fe	7.62E-02	7.80E-04	1.90E-11
Zr:Rb	8.50E-08	2.25E-02	1.33E-02

Table S10: Results of hierarchical cluster analysis for elemental, stable isotope, and XRF datasets for all samples. The matrix shows p-values for differences in each variable between Clusters 1, 2 and 3.

Variable	Cluster 1 vs Cluster 2	Cluster 1 vs Cluster 3	Cluster 2 vs Cluster 3
TOC	0.00E+00	0.00E+00	5.02E-05
TN	0.00E+00	0.00E+00	5.30E-01
CD	5.42E-18	6.62E-13	6.62E-03
DBD	1.43E-16	2.22E-17	2.12E-04
delta_13C	1.41E-12	0.00E+00	4.06E-03
C:N	1.00E-20	4.47E-05	1.48E-13
S	1.05E-08	1.14E-02	2.13E-06
Al	3.79E-05	0.00E+00	3.05E-14
Ti	5.17E-01	0.00E+00	0.00E+00
Si	0.00E+00	6.23E-14	3.00E-19
Fe	1.15E-06	0.00E+00	0.00E+00
Zr:Rb	1.00E-20	0.00E+00	8.48E-01

Table S11: Results of hierarchical cluster analysis for elemental, stable isotope, XRF and biomarker indices. The matrix shows p-values for each variable in Clusters 1, 2, and 3, compared to the overall mean of that variable across the entire dataset.

Variable	Cluster 1	Cluster 2	Cluster 3
TOC	0.0019	0.4831	0.1415
TN	0.0017	0.4638	0.1094
CD	0.0860	0.4959	0.5708
DBD	0.0344	0.7658	0.0498
delta_13C	0.2250	0.6268	0.0406
C:N	0.2288	0.7319	0.5429
Sr	0.6926	0.0146	0.0619
S	0.7416	0.5161	0.0542
Ti	0.2956	0.1610	0.0002
Si	0.0650	0.2506	0.6222
K	0.7243	0.0592	0.1238
Fe	0.6797	0.2409	0.0183
Zr:Rb	0.0526	0.2584	0.4379
CPI	0.5987	0.2296	0.3768
OEP	0.7049	0.4248	0.0208
ACL	0.1647	0.6536	0.0216
Paq	0.2584	0.3298	0.0077

Table S12: Results of hierarchical cluster analysis for elemental, stable isotopes, XRF and lipid biomarker datasets. The matrix shows p-values for differences in each variable between Clusters 1, 2, and 3.

Variable	Cluster 1 vs Cluster 2	Cluster 1 vs Cluster 3	Cluster 2 vs Cluster 3
TOC	0.0001	0.0001	0.8216
TN	1.1E-06	8.0E-07	0.9547
CD	0.0256	0.0568	0.1197
DBD	0.0028	6.2E-09	0.2986
delta_13C	0.5472	0.0041	0.0010
C:N	0.1616	0.1616	0.7599
Sr	1.2E-06	0.0927	3.8E-10
S	0.0282	0.0781	0.0245
Ti	0.0715	9.8E-08	7.4E-09
Si	0.0000	0.0015	0.0201
K	0.0013	0.2964	1.1E-12
Fe	0.0267	0.0082	0.0001
Zr:Rb	0.0030	0.0000	0.2942
CPI	0.0030	0.9902	0.0001
OEP	0.0024	0.0324	0.0024
ACL	0.3092	0.0008	0.0005
Paq	0.6345	0.0006	1.8E-06

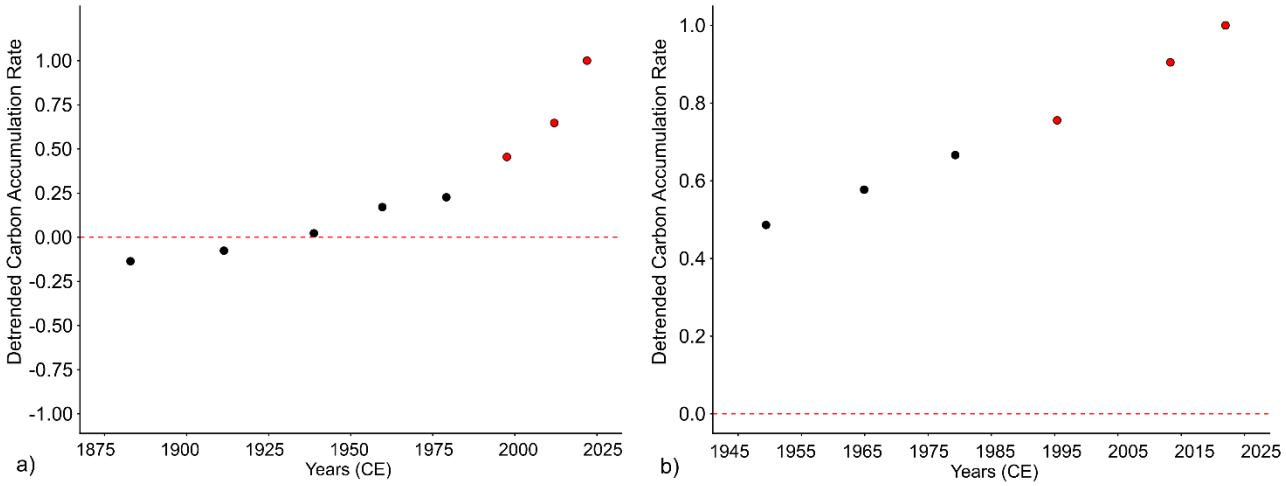


Figure S11: Detrended and normalised CARs (unitless) at a) Pāuatahanui core Pau-HM3 and b) Robert Findlay core Puk-MM1. Black circles represent pre-restoration rates, and red circles represent post-restoration rates. CARs were derived for each age-depth interval and detrended using the Okatakata age-depth model to remove natural near-surface increases. Rates were normalised to the maximum observed value within each core. Post-restoration mean normalised CARs were 0.70 at Pāuatahanui (after 1984) and 0.89 at Robert Findlay (after 1980), indicating substantial improvement in carbon accumulation relative to the restoration baseline.