

Effects of local anthropogenic stressors on a habitat cascade in an estuarine seagrass system

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Supplementary material

Table S1. Field experiment 1, testing for the effects of eutrophication and sedimentation on oxidation of silver sticks, seagrass leaves and below-ground biomass, shoot density, and invertebrate abundances, richness and community

Analysis conducted with permutation-based factorial analysis of variance (PERMANOVA) in Primer (ver. 6). All factors were considered as fixed. Data were square-root transformed before analysis.

Source	d.f.	SS	Pseudo- <i>F</i>	<i>P</i> (perm)	Contribution (%)
Silver sticks					
Fertilisation	3	600.8	0.82	0.508	6.70
Sedimentation	3	307.23	0.42	0.761	3.43
Fertilisation × sedimentation	9	688.21	0.31	0.983	7.68
Residual	30	7366.3			
Total	45	8962.5			
<i>Zostera</i> leaves					
Fertilisation	3	0.05	2.7	0.059	2.28
Sedimentation	3	1.76	102.73	0.001	86.88
Fertilisation × sedimentation	9	0.04	0.72	0.684	1.82
Residual	32	0.18			
Total	47	2.03			
<i>Zostera</i> below ground					
Fertilisation	3	0.07	1.13	0.343	5.54
Sedimentation	3	0.49	7.51	0.002	36.79
Fertilisation × sedimentation	9	0.07	0.37	0.94	5.46
Residual	32	0.69			
Total	47	1.33			
<i>Zostera</i> shoot density					
Fertilisation	3	20	0.94	0.468	0.80
Sedimentation	3	2203	105.88	0.001	89.27
Fertilisation × sedimentation	9	23	0.37	0.933	0.94
Residual	32	222			
Total	47	2468			
Abundance					
Fertilisation	3	0.01	0.01	1	0.04
Sedimentation	3	15.65	12.01	0.001	47.53
Fertilisation × sedimentation	9	3.37	0.86	0.559	10.23
Residual	32	13.9			
Total	47	32.93			
Richness					
Fertilisation	3	0.16	1	0.393	2.45
Sedimentation	3	2.58	15.88	0.001	38.68
Fertilisation × sedimentation	9	2.19	4.5	0.001	32.89
Residual	32	1.73			
Total	47	6.66			
Community structure					
Fertilisation	3	3956	0.81	0.647	4.91
Sedimentation	3	11441	2.35	0.005	14.19
Fertilisation × sedimentation	9	13238	0.91	0.639	16.42
Residual	32	51975			
Total	47	80610			

Table S2. Field experiment 2, testing for effects of sedimentation, drift alga, seagrass, elevation level and season on oxidation of silver sticks, seagrass leaves and below ground biomass, shoot density, and invertebrates abundances, richness and community

Analysis conducted with Permutation based factorial analysis of variance (PERMANOVA) in Primer (ver. 6). All factors were considered as fixed. Data were square-root transformed before analysis

Source	d.f.	SS	Pseudo- <i>F</i>	<i>P</i> (perm)	Contribution (%)
Silver sticks					
2HF	1	24.72	0.13	0.728	0.23
1HF	1	25.63	0.14	0.718	0.24
Sedimentation	1	395.7	2.14	0.154	3.71
Elevation	1	223.31	1.21	0.266	2.09
Season	1	20.89	0.11	0.743	0.20
2HF × 1HF	1	197.32	1.07	0.305	1.85
2HF × sedimentation	1	286.36	1.55	0.246	2.68
2HF × elevation	1	158.24	0.86	0.353	1.48
2HF × season	1	92.42	0.5	0.501	0.87
1HF × sedimentation	1	17.56	0.09	0.754	0.16
1HF × elevation	1	1.65	0.01	0.917	0.02
1HF × season	1	218.74	1.18	0.286	2.05
Sedimentation × elevation	1	8.09	0.04	0.835	0.08
Sedimentation × season	1	167.27	0.9	0.369	1.57
Elevation × season	1	80.86	0.44	0.509	0.76
2HF × 1HF × sedimentation	1	59.47	0.32	0.58	0.56
2HF × 1HF × elevation	1	521.65	2.82	0.099	4.89
2HF × 1HF × season	1	145.12	0.78	0.362	1.36
2HF × sedimentation × elevation	1	144.94	0.78	0.36	1.36
2HF × sedimentation × season	1	50.44	0.27	0.618	0.47
2HF × elevation × season	1	2.93	0.02	0.888	0.03
1HF × sedimentation × elevation	1	76	0.41	0.547	0.71
1HF × sedimentation × season	1	1.39	0.01	0.936	0.01
1HF × elevation × season	1	5.3	0.03	0.879	0.05
Sedimentation × elevation × season	1	160.57	0.87	0.373	1.50
2HF × 1HF × sedimentation × elevation	1	226.06	1.22	0.246	2.12
2HF × 1HF × sedimentation × season	1	0.36	0	0.967	0.00
2HF × 1HF × elevation × season	1	143.17	0.77	0.381	1.34
2HF × sedimentation × elevation × season	1	6.69	0.04	0.828	0.06
1HF × sedimentation × elevation × season	0	0	No test		0.00
2HF × 1HF × sedimentation × elevation × season	0	0	No test		0.00
Residual	39	7212.6			
Total	68	10675			
Zostera leaves					
2HF	1	0.02	2.52	0.128	1.22
1HF	0	0	No test		0.00
Sedimentation	1	0.8	105.87	0.001	51.19
Elevation	1	0.01	0.98	0.328	0.47
Season	1	0.18	23.48	0.001	11.35
2HF × 1HF	0	0	No test		0.00
2HF × sedimentation	1	0.02	2.38	0.118	1.15
2HF × elevation	1	0.01	1.33	0.271	0.64
2HF × season	1	0	0.33	0.559	0.16
1HF × sedimentation	0	0	No test		0.00
1HF × elevation	0	0	No test		0.00
1HF × season	0	0	No test		0.00
Sedimentation × elevation	1	0.01	1.44	0.233	0.70
Sedimentation × season	1	0.25	33.41	0.001	16.16

Source	d.f.	SS	Pseudo- <i>F</i>	<i>P</i> (perm)	Contribution (%)
Elevation × season	1	0	0.01	0.902	0.01
2HF × 1HF × sedimentation	0	0	No test		0.00
2HF × 1HF × elevation	0	0	No test		0.00
2HF × 1HF × season	0	0	No test		0.00
2HF × sedimentation × elevation	1	0	0.18	0.695	0.09
2HF × sedimentation × season	1	0	0.08	0.785	0.04
2HF × elevation × season	1	0	0.12	0.737	0.06
1HF × sedimentation × elevation	0	0	No test		0.00
1HF × sedimentation × season	0	0	No test		0.00
1HF × elevation × season	0	0	No test		0.00
Sedimentation × elevation × season	1	0.02	2.1	0.155	1.02
2HF × 1HF × sedimentation × elevation	0	0	No test		0.00
2HF × 1HF × sedimentation × season	0	0	No test		0.00
2HF × 1HF × elevation × season	0	0	No test		0.00
2HF × sedimentation × elevation × season	1	0	0.56	0.449	0.27
1HF × sedimentation × elevation × season	0	0	No test		0.00
2HF × 1HF × sedimentation × elevation × season	0	0	No test		0.00
Residual	32	0.24			
Total	47	1.57			
<i>Zostera</i> below ground					
2HF	1	0.04	1.26	0.274	1.72
1HF	0	0	No test		0.00
Sedimentation	1	0	0.01	0.908	0.02
Elevation	1	0.05	1.68	0.189	2.29
Season	1	0.89	31.15	0.001	42.57
2HF × 1HF	0	0	No test		0.00
2HF × sedimentation	1	0.04	1.46	0.242	2.00
2HF × elevation	1	0	0.14	0.7	0.20
2HF × season	1	0	0	0.993	0.00
1HF × sedimentation	0	0	No test		0.00
1HF × elevation	0	0	No test		0.00
1HF × season	0	0	No test		0.00
Sedimentation × elevation	1	0.01	0.25	0.63	0.34
Sedimentation × season	1	0	0.11	0.742	0.15
Elevation × season	1	0.02	0.76	0.395	1.03
2HF × 1HF × sedimentation	0	0	No test		0.00
2HF × 1HF × elevation	0	0	No test		0.00
2HF × 1HF × season	0	0	No test		0.00
2HF × sedimentation × elevation	1	0	0.07	0.784	0.10
2HF × sedimentation × season	1	0.12	4.09	0.046	5.60
2HF × elevation × season	1	0	0.04	0.835	0.05
1HF × sedimentation × elevation	0	0	No test		0.00
1HF × sedimentation × season	0	0	No test		0.00
1HF × elevation × season	0	0	No test		0.00
Sedimentation × elevation × season	1	0	0.05	0.826	0.07
2HF × 1HF × sedimentation × elevation	0	0	No test		0.00
2HF × 1HF × sedimentation × season	0	0	No test		0.00
2HF × 1HF × elevation × season	0	0	No test		0.00
2HF × sedimentation × elevation × season	1	0	0.09	0.795	0.12
1HF × sedimentation × elevation × season	0	0	No test		0.00
2HF × 1HF × sedimentation × elevation × season	0	0	No test		0.00
Residual	32	0.91			
Total	47	2.08			
<i>Zostera</i> shoot density					
2HF	1	23.88	6.01	0.025	1.60
1HF	0	0	No test		0.00
Sedimentation	1	970.67	244.27	0.001	65.11
Elevation	1	1.12	0.28	0.608	0.08
Season	1	5.18	1.3	0.249	0.35

Source	d.f.	SS	Pseudo- <i>F</i>	<i>P</i> (perm)	Contribution (%)
2HF × 1HF	0	0	No test		0.00
2HF × sedimentation	1	10.49	2.64	0.107	0.70
2HF × elevation	1	17.76	4.47	0.049	1.19
2HF × season	1	0.7	0.18	0.669	0.05
1HF × sedimentation	0	0	No test		0.00
1HF × elevation	0	0	No test		0.00
1HF × season	0	0	No test		0.00
Sedimentation × elevation	1	5.26	1.32	0.264	0.35
Sedimentation × season	1	314.75	79.21	0.001	21.11
Elevation × season	1	6.43	1.62	0.21	0.43
2HF × 1HF × sedimentation	0	0	No test		0.00
2HF × 1HF × elevation	0	0	No test		0.00
2HF × 1HF × season	0	0	No test		0.00
2HF × sedimentation × elevation	1	9.97	2.51	0.114	0.67
2HF × sedimentation × season	1	4.16	1.05	0.311	0.28
2HF × elevation × season	1	0.47	0.12	0.734	0.03
1HF × sedimentation × elevation	0	0	No test		0.00
1HF × sedimentation × season	0	0	No test		0.00
1HF × elevation × season	0	0	No test		0.00
Sedimentation × elevation × season	1	0.87	0.22	0.66	0.06
2HF × 1HF × sedimentation × elevation	0	0	No test		0.00
2HF × 1HF × sedimentation × season	0	0	No test		0.00
2HF × 1HF × elevation × season	0	0	No test		0.00
2HF × sedimentation × elevation × season	1	3.82	0.96	0.349	0.26
1HF × sedimentation × elevation × season	0	0	No test		0.00
2HF × 1HF × sedimentation × elevation × season	0	0	No test		0.00
Residual	29	115.24			
Total	44	1490.8			
Abundance					
2HF	1	0.96	1.64	0.201	0.73
1HF	1	0.21	0.36	0.547	0.16
Sedimentation	1	47.08	80.36	0.001	36.02
Elevation	1	0.74	1.27	0.245	0.57
Season	1	3.6	6.14	0.013	2.75
2HF × 1HF	1	0.06	0.09	0.762	0.04
2HF × sedimentation	1	2.33	3.98	0.05	1.79
2HF × elevation	1	5.85	9.99	0.005	4.48
2HF × season	1	2.16	3.69	0.053	1.65
1HF × sedimentation	1	7.9	13.48	0.001	6.04
1HF × elevation	1	8.05	13.74	0.001	6.16
1HF × season	1	1.17	2	0.161	0.90
Sedimentation × elevation	1	4.64	7.92	0.007	3.55
Sedimentation × season	1	3.15	5.37	0.02	2.41
Elevation × season	1	0.49	0.83	0.359	0.37
2HF × 1HF × sedimentation	1	0.01	0.02	0.888	0.01
2HF × 1HF × elevation	1	0.01	0.01	0.919	0.00
2HF × 1HF × season	1	0.38	0.65	0.414	0.29
2HF × sedimentation × elevation	1	0.12	0.2	0.668	0.09
2HF × sedimentation × season	1	0.48	0.81	0.369	0.36
2HF × elevation × season	1	0.03	0.05	0.823	0.02
1HF × sedimentation × elevation	1	0.47	0.8	0.365	0.36
1HF × sedimentation × season	1	0.29	0.49	0.463	0.22
1HF × elevation × season	1	0.37	0.63	0.437	0.28
Sedimentation × elevation × season	1	0	0	0.96	0.00
2HF × 1HF × sedimentation × elevation	1	2.37	4.04	0.043	1.81
2HF × 1HF × sedimentation × season	1	0	0	0.998	0.00
2HF × 1HF × elevation × season	1	0.01	0.02	0.894	0.01
2HF × sedimentation × elevation × season	1	0.14	0.24	0.657	0.11
1HF × sedimentation × elevation × season	1	0	0	0.992	0.00

Source	d.f.	SS	Pseudo- <i>F</i>	<i>P</i> (perm)	Contribution (%)
2HF × 1HF × sedimentation × elevation × season	1	0.14	0.24	0.612	0.11
Residual	64	37.49			
Total	95	130.68			
Richness					
2HF	1	0	0.02	0.899	0.01
1HF	1	0.04	0.38	0.539	0.19
Sedimentation	1	8.38	77.58	0.001	39.23
Elevation	1	0	0	0.972	0.00
Season	1	0.3	2.78	0.104	1.41
2HF × 1HF	1	0.05	0.5	0.497	0.25
2HF × sedimentation	1	0.01	0.07	0.771	0.04
2HF × elevation	1	0.58	5.39	0.029	2.73
2HF × season	1	0.1	0.97	0.335	0.49
1HF × sedimentation	1	0.37	3.43	0.063	1.73
1HF × elevation	1	1.94	17.93	0.001	9.06
1HF × season	1	0.47	4.35	0.037	2.20
Sedimentation × elevation	1	0.29	2.68	0.111	1.35
Sedimentation × season	1	0	0.02	0.889	0.01
Elevation × season	1	0.29	2.65	0.104	1.34
2HF × 1HF × sedimentation	1	0.09	0.85	0.375	0.43
2HF × 1HF × elevation	1	0.05	0.47	0.478	0.24
2HF × 1HF × season	1	0.07	0.62	0.413	0.31
2HF × sedimentation × elevation	1	0.1	0.91	0.349	0.46
2HF × sedimentation × season	1	0.25	2.27	0.142	1.15
2HF × elevation × season	1	0	0.05	0.841	0.02
1HF × sedimentation × elevation	1	0.03	0.29	0.597	0.14
1HF × sedimentation × season	1	0	0.04	0.825	0.02
1HF × elevation × season	1	0.41	3.8	0.058	1.92
Sedimentation × elevation × season	1	0	0	0.981	0.00
2HF × 1HF × sedimentation × elevation	1	0.03	0.27	0.637	0.13
2HF × 1HF × sedimentation × season	1	0.38	3.53	0.073	1.78
2HF × 1HF × elevation × season	1	0.08	0.75	0.409	0.38
2HF × sedimentation × elevation × season	1	0.08	0.71	0.394	0.36
1HF × sedimentation × elevation × season	1	0.05	0.49	0.541	0.25
2HF × 1HF × sedimentation × elevation × season	1	0	0	0.954	0.00
Residual	64	6.91			
Total	95	21.37			
Community structure					
2HF	1	7515	7.43	0.001	4.82
1HF	1	7042	6.96	0.001	4.52
Sedimentation	1	20637	20.4	0.001	13.24
Elevation	1	2304	2.28	0.052	1.48
Season	1	7358	7.27	0.001	4.72
2HF × 1HF	1	936	0.93	0.51	0.60
2HF × sedimentation	1	1853	1.83	0.118	1.19
2HF × elevation	1	1262	1.25	0.342	0.81
2HF × season	1	1913	1.89	0.091	1.23
1HF × sedimentation	1	3702	3.66	0.002	2.38
1HF × elevation	1	3597	3.56	0.001	2.31
1HF × season	1	1467	1.45	0.229	0.94
Sedimentation × elevation	1	3403	3.36	0.01	2.18
Sedimentation × season	1	3432	3.39	0.005	2.20
Elevation × season	1	3042	3.01	0.019	1.95
2HF × 1HF × sedimentation	1	518	0.51	0.746	0.33
2HF × 1HF × elevation	1	630	0.62	0.685	0.40
2HF × 1HF × season	1	904	0.89	0.506	0.58
2HF × sedimentation × elevation	1	1875	1.85	0.112	1.20
2HF × sedimentation × season	1	3234	3.2	0.007	2.07
2HF × elevation × season	1	1946	1.92	0.105	1.25

Source	d.f.	SS	Pseudo- <i>F</i>	<i>P</i> (perm)	Contribution (%)
1HF × sedimentation × elevation	1	601	0.59	0.687	0.39
1HF × sedimentation × season	1	342	0.34	0.842	0.22
1HF × elevation × season	1	1851	1.83	0.121	1.19
Sedimentation × elevation × season	1	1391	1.37	0.261	0.89
2HF × 1HF × sedimentation × elevation	1	708	0.7	0.634	0.45
2HF × 1HF × sedimentation × season	1	854	0.84	0.549	0.55
2HF × 1HF × elevation × season	1	464	0.46	0.782	0.30
2HF × sedimentation × elevation × season	1	1199	1.19	0.341	0.77
1HF × sedimentation × elevation × season	1	2774	2.74	0.02	1.78
2HF × 1HF × sedimentation × elevation × season	1	2359	2.33	0.044	1.51
Residual	64	64744			
Total	95	155860			