

## **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 (%)
<b>Silver sticks</b>					
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			
<b><i>Zostera</i> leaves</b>					
Fertilisation	3	0.05	2.7	0.059	2.28
Sedimentation	3	1.76	102.73	<b>0.001</b>	86.88
Fertilisation × sedimentation	9	0.04	0.72	0.684	1.82
Residual	32	0.18			
Total	47	2.03			
<b><i>Zostera</i> below ground</b>					
Fertilisation	3	0.07	1.13	0.343	5.54
Sedimentation	3	0.49	7.51	<b>0.002</b>	36.79
Fertilisation × sedimentation	9	0.07	0.37	0.94	5.46
Residual	32	0.69			
Total	47	1.33			
<b><i>Zostera</i> shoot density</b>					
Fertilisation	3	20	0.94	0.468	0.80
Sedimentation	3	2203	105.88	<b>0.001</b>	89.27
Fertilisation × sedimentation	9	23	0.37	0.933	0.94
Residual	32	222			
Total	47	2468			
<b>Abundance</b>					
Fertilisation	3	0.01	0.01	1	0.04
Sedimentation	3	15.65	12.01	<b>0.001</b>	47.53
Fertilisation × sedimentation	9	3.37	0.86	0.559	10.23
Residual	32	13.9			
Total	47	32.93			
<b>Richness</b>					
Fertilisation	3	0.16	1	0.393	2.45
Sedimentation	3	2.58	15.88	<b>0.001</b>	38.68
Fertilisation × sedimentation	9	2.19	4.5	<b>0.001</b>	32.89
Residual	32	1.73			
Total	47	6.66			
<b>Community structure</b>					
Fertilisation	3	3956	0.81	0.647	4.91
Sedimentation	3	11441	2.35	<b>0.005</b>	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 (%)
<b>Silver sticks</b>					
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			
<b>Zostera leaves</b>					
2HF	1	0.02	2.52	0.128	1.22
1HF	0	0	No test		0.00
Sedimentation	1	0.8	105.87	<b>0.001</b>	51.19
Elevation	1	0.01	0.98	0.328	0.47
Season	1	0.18	23.48	<b>0.001</b>	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	<b>0.001</b>	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	<b>0.001</b>	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	<b>0.046</b>	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	<b>0.025</b>	1.60
1HF	0	0	No test		0.00
Sedimentation	1	970.67	244.27	<b>0.001</b>	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	<b>0.049</b>	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	<b>0.001</b>	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	<b>0.001</b>	36.02
Elevation	1	0.74	1.27	0.245	0.57
Season	1	3.6	6.14	<b>0.013</b>	2.75
2HF × 1HF	1	0.06	0.09	0.762	0.04
2HF × sedimentation	1	2.33	3.98	<b>0.05</b>	1.79
2HF × elevation	1	5.85	9.99	<b>0.005</b>	4.48
2HF × season	1	2.16	3.69	0.053	1.65
1HF × sedimentation	1	7.9	13.48	<b>0.001</b>	6.04
1HF × elevation	1	8.05	13.74	<b>0.001</b>	6.16
1HF × season	1	1.17	2	0.161	0.90
Sedimentation × elevation	1	4.64	7.92	<b>0.007</b>	3.55
Sedimentation × season	1	3.15	5.37	<b>0.02</b>	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	<b>0.043</b>	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			
<b>Richness</b>					
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	<b>0.001</b>	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	<b>0.029</b>	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	<b>0.001</b>	9.06
1HF × season	1	0.47	4.35	<b>0.037</b>	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			
<b>Community structure</b>					
2HF	1	7515	7.43	<b>0.001</b>	4.82
1HF	1	7042	6.96	<b>0.001</b>	4.52
Sedimentation	1	20637	20.4	<b>0.001</b>	13.24
Elevation	1	2304	2.28	0.052	1.48
Season	1	7358	7.27	<b>0.001</b>	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	<b>0.002</b>	2.38
1HF × elevation	1	3597	3.56	<b>0.001</b>	2.31
1HF × season	1	1467	1.45	0.229	0.94
Sedimentation × elevation	1	3403	3.36	<b>0.01</b>	2.18
Sedimentation × season	1	3432	3.39	<b>0.005</b>	2.20
Elevation × season	1	3042	3.01	<b>0.019</b>	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	<b>0.007</b>	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	<b>0.02</b>	1.78
2HF × 1HF × sedimentation × elevation × season	1	2359	2.33	<b>0.044</b>	1.51
Residual	64	64744			
Total	95	155860			