

**Text S1.** Description of mussel aggregation patterns at various sites.

Capable of local movement, the mussels self-arranged to create beds that differ in spatial composition. The bed at Motuora appeared the most complex and varied in terms of arrangements seen, with large, densely packed sections and small to large clumps separated by sporadic areas with no mussels. A greater number of clumps and individual mussels appeared near the edges of the bed. In contrast, Motoketekete was the most patchy bed, with small clumps and individuals spread out over greater distances. This bed was largest in terms of physical distance, but population density was quite low (mussels predominately found in clumps of 5-10 individuals). No dense patches of mussels were observed at this site. Lagoon Bay was also characterized by many clumps, but these mussels congregated in larger assemblages (rather than the smaller clumps observed at Motoketekete) with many sizeable, densely-packed patches (>100 mussels) and some smaller aggregations (roughly 10-30 mussels per clump) as well. No mussels were seen living individually at this site. Like Lagoon Bay, no individuals were found at Pukapuka; uniformity was greatest at this long, narrow bed, with densely-packed mussels throughout. Some larger clumps (of around 50-75 congregated individuals) were also found at this site, but overall very few gaps were observed at the time of sampling.

**Table S1.** Summary of chamber contents and incubation times for all benthic chambers used in this experiment.

Site	Number of Mussels	Incubation Start Time	Incubation End Time	Total Incubation Time (min)
Pukapuka	0	10:40	13:45	185
	0	10:45	13:55	190
	0	10:52	14:07	195
	40	10:41	13:47	186
	40	10:46	13:57	191
	50	10:48	14:01	193
Lagoon Bay	0	11:32	14:32	180
	0	11:30	14:42	192
	0	11:34	14:46	192
	11	11:30	14:30	180
	11	11:43	14:40	177
	16	11:37	14:36	179
Motuora	0	10:53	13:53	180
	0	10:55	13:55	180
	3	11:01	14:01	180
	4	11:07	13:59	172
	6	10:57	13:57	180
	10	11:01	13:53	172
	12	11:03	14:03	180
	20	11:05	13:57	172
Motoketekete	0	10:49	14:13	204
	0	10:54	14:18	204
	0	10:55	14:19	204
	0	10:59	14:21	202
	4	10:53	14:17	204
	4	11:01	14:22	201
	5	10:48	14:12	204
	7	10:50	14:14	204
	9	10:52	14:16	204
	11	10:57	14:20	203
	13	10:51	14:15	204
	14	11:03	14:22	199

**Table S2.** Environmental characteristics measured at each site. PAR = photosynthetically active radiation. Where relevant, data represent the mean  $\pm$  SE.

Site	Salinity (ppt)	Temperature (°C)	Depth (m)	PAR (counts)	Ambient NO <sub>x</sub> ( $\mu\text{mol L}^{-1}$ )	Ambient NH <sub>4</sub> <sup>+</sup> ( $\mu\text{mol L}^{-1}$ )	Ambient O <sub>2</sub> ( $\mu\text{mol L}^{-1}$ )
Lagoon Bay	32.6	21	5.0	3135 $\pm$ 310	1.18 $\pm$ 0.12	10.33 $\pm$ 0.84	358.58 $\pm$ 4.34
Pukapuka	33.3	21	5.5	2169 $\pm$ 118	1.26 $\pm$ 0.59	7.46 $\pm$ 1.50	370.85 $\pm$ 7.13
Motuora	31.5	21	8.0	865 $\pm$ 52	1.12 $\pm$ 0.15	11.14 $\pm$ 1.10	393.84 $\pm$ 7.61
Motoketekete	32.8	21	8.5	2665 $\pm$ 165	1.56 $\pm$ 0.17	6.54 $\pm$ 0.82	399.07 $\pm$ 2.78

**Table S3.** Results of 2-way ANOVA showing the effects of site and chamber contents (presence or absence of mussels) on measured sediment characteristics and nutrient fluxes. Significant results ( $p \leq 0.05$ ) are indicated in **bold**.  $N_2$  and  $NH_4^+$  flux data were log-transformed prior to analysis. Site labels: Lagoon Bay = LB, Pukapuka = PP, Motuora = MR, and Motoketekete = MK. SOM = sediment organic matter.

Factor	df	SS	MS	F value	p-value
<b><math>N_2</math> flux</b>					
Site	3	0.030	0.010	10.232	<b>&lt;0.001</b>
Chamber contents	1	0.000	0.000	0.022	0.883
Site x chamber contents	3	0.000	0.000	0.167	0.918
Residuals	24	0.024	0.001		
Pairwise comparisons for sites (Tukey)		Diff in Means	Lower confidence interval	Upper confidence interval	Adjusted p-value
LB-MR		-0.078	-0.125	-0.032	<b>&lt;0.001</b>
PP-MR		-0.000	-0.047	0.047	0.999
MK-MR		0.001	-0.039	0.040	0.999
PP-LB		0.078	0.028	0.128	<b>0.001</b>
MK-LB		0.079	0.036	0.122	<b>&lt;0.001</b>
MK-PP		0.001	-0.043	0.044	0.999
Factor	df	SS	MS	F value	p-value
<b>% Mud</b>					
Site	3	2443.6	814.5	333.426	<b>&lt;0.001</b>
Chamber contents	1	5.4	5.4	2.215	0.150
Site x chamber contents	3	20.4	6.8	2.783	0.063
Residuals	24	58.6	2.4		
Pairwise comparisons for sites (Tukey)		Diff in Means	Lower confidence interval	Upper confidence interval	Adjusted p-value
LB-MR		15.045	12.716	17.374	<b>&lt;0.001</b>
PP-MR		16.802	14.473	19.130	<b>&lt;0.001</b>
MK-MR		-3.186	-5.154	-1.218	<b>&lt;0.001</b>

PP-LB		1.757	-0.733	4.246	0.236
MK-LB		-18.231	-20.387	-16.075	<b>&lt;0.001</b>
MK-PP		-19.987	-22.143	-17.832	<b>&lt;0.001</b>
<b>Factor</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F value</b>	<b>p-value</b>
<b>SOM</b>					
Site	3	4.921	1.640	8.045	<b>&lt;0.001</b>
Chamber contents	1	0.001	0.001	0.004	0.953
Site x chamber contents	3	0.580	0.193	0.949	0.433
Residuals	24	4.893	0.204		
Pairwise comparisons for sites (Tukey)		Diff in Means	Lower confidence interval	Upper confidence interval	Adjusted p-value
LB-MR		-0.985	-1.658	-0.313	<b>0.003</b>
PP-MR		0.037	-0.636	0.710	0.999
MK-MR		-0.591	-1.160	-0.023	<b>0.039</b>
PP-LB		1.022	0.303	1.742	<b>0.003</b>
MK-LB		0.394	-0.229	1.017	0.323
MK-PP		-0.628	-1.251	-0.005	<b>0.047</b>
<b>Factor</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F value</b>	<b>p-value</b>
<b>Chl <i>a</i></b>					
Site	3	45.320	15.105	5.310	<b>0.006</b>
Chamber contents	1	1.590	1.591	0.559	0.462
Site x chamber contents	3	17.490	5.828	2.049	0.134
Residuals	24	68.270	2.844		
Pairwise comparisons for sites (Tukey)		Diff in Means	Lower confidence interval	Upper confidence interval	Adjusted p-value
LB-MR		2.573	0.060	5.085	<b>0.043</b>
PP-MR		-0.510	-3.023	2.002	0.943
MK-MR		1.867	-0.256	3.991	0.099
PP-LB		-3.083	-5.769	-0.397	<b>0.020</b>

MK-LB		-0.705	-3.032	1.621	0.837
MK-PP		2.378	0.051	4.704	<b>0.044</b>
<b>Factor</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F value</b>	<b>p-value</b>
<b>Macrofaunal abundance</b>					
Site	3	27074	9025	8.350	<b>&lt;0.001</b>
Chamber contents	1	295	295	0.273	0.606
Site x chamber contents	3	3139	1046	0.968	0.424
Residuals	24	25940	1081		
Pairwise comparisons for sites (Tukey)					
		Diff in Means	Lower confidence interval	Upper confidence interval	Adjusted p-value
LB-MR		-69.500	-118.479	-20.521	<b>0.003</b>
PP-MR		-66.167	-115.146	-17.188	<b>0.005</b>
MK-MR		-15.000	-56.395	26.395	0.751
PP-LB		3.333	-49.027	55.694	0.998
MK-LB		54.500	9.154	99.846	<b>0.014</b>
MK-PP		51.167	5.821	96.512	<b>0.023</b>
<b>Factor</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F value</b>	<b>p-value</b>
<b>NO<sub>x</sub><sup>-</sup> flux</b>					
Site	3	14930	4977	1.283	0.303
Chamber contents	1	556	556	0.143	0.708
Site x chamber contents	3	26414	8805	2.269	0.106
Residuals	24	93118	3880		
<b>Factor</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F value</b>	<b>p-value</b>
<b>PO<sub>4</sub><sup>3-</sup> flux</b>					
Site	3	1166	388.6	1.339	0.285
Chamber contents	1	315	314.5	1.084	0.308
Site x chamber contents	3	2278	759.5	2.618	0.074
Residuals	24	6964	290.2		
<b>Factor</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F value</b>	<b>p-value</b>

<b>NH<sub>4</sub><sup>+</sup> flux</b>					
Site	3	0.918	0.306	0.840	0.486
Chamber contents	1	0.056	0.056	0.154	0.670
Site x chamber contents	3	5.267	1.756	4.816	<b>0.009†</b>
Residuals	24	8.750	0.365		
<b>Factor</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F value</b>	<b>p-value</b>
<b>O<sub>2</sub> flux</b>					
Site	3	16241621	5413874	1.883	0.159
Chamber contents	1	69036931	69036931	24.018	<b>&lt;0.001</b>
Site x chamber contents	3	300960	100320	0.035	0.991
Residuals	24	68985297	2874387		
Pairwise comparison for chamber contents (Tukey)		Diff in Means	Lower confidence interval	Upper confidence interval	Adjusted p-value
No mussels-Mussels		2965.770	1688.070	4243.480	<b>&lt;0.001</b>

† Pairwise comparisons for NH<sub>4</sub><sup>+</sup> fluxes (site x chamber contents interaction) not shown, as Tukey tests were insignificant for all pairs of means.

**Fig. S1.** Two-dimensional non-metric multidimensional scaling plot for visualisation of differences in macrofaunal community structure observed between sites. Plot overlaid with species that significantly contribute (Pearson correlation coefficient of  $> 0.6$ ) to the resulting ordination. Ordination created using PRIMER v. 7 (Clarke & Gorley 2015; available at <http://www.primer-e.com/>) on square root transformed data.

