

Table S1: Ambient site conditions at the oyster farm during sampling events. Temperature and dissolved oxygen (DO) values are from a HOBO data logger deployed adjacent to the oyster farm and set to log every 15 minutes. The mean daily low and high DO values incorporate every day the logger was deployed, and not just days sediment flux incubations were conducted. Salinity measurements are from a handheld probe and were made during sediment incubations. Values presented are means, followed by the standard deviation.

Sample Month	Mean Water Temp. (° C)	Salinity	Mean Daily Low DO ($\mu\text{mol L}^{-1}$)	Mean Daily High DO ($\mu\text{mol L}^{-1}$)
July 2014	24.6 ± 1.9	31.1 ^a	178 ± 63	425 ± 9
August 2014	23.9 ± 1.5	--	178 ± 44	453 ± 6
July 2015	24.8 ± 2.7	30.6 ± 0.8	125 ± 63	447 ± 19
August 2015	26.2 ± 2.4	30.7 ± 0.3	122 ± 84	469 ± 125
September 2015	22.4 ± 2.5	29.4 ± 0.5	69 ± 19	447 ± 31

^a Only one salinity measurement was collected in July 2014

Table S2: Best models to describe sediment nitrogen and oxygen fluxes and pore water ammonium (NH_4^+) concentration in the presence and absence of culture, and based on the length of time aquaculture gear had been in place. Only the pore water $[\text{NH}_4^+]$ model included a random effect (“Ring”).

Flux	Distribution	Fixed Effects
$\text{N}_2\text{-N}$	Gamma	Aquaculture Presence Aquaculture Age
N_2O	Normal (after square root transformation)	Aquaculture Presence Aquaculture Age
NH_4^+	Normal	Aquaculture Presence Aquaculture Age + Month
NO_x	Normal	Aquaculture Presence Aquaculture Age
ΣN	Gamma	Aquaculture Presence Aquaculture Age
O_2	Lognormal	Aquaculture Presence + Month Aquaculture Age + Month
PO_4^{3-}	Lognormal	Aquaculture Presence Aquaculture Age
Pore water $[\text{NH}_4^+]$	Gamma	Aquaculture Presence + Temperature + Month + Ring Aquaculture Age + Temperature + Month

Table S3: AIC scores for mixed models generated for N₂-N, N₂O, NH₄⁺, NO_x, O₂, and PO₄³⁻ fluxes from sediment and porewater [NH₄⁺] beneath oyster aquaculture and a control site. In all cases the presence or absence of oyster aquaculture was used as a fixed effect. Temperature, salinity, and sampling month were considered as fixed effects, and incubation chamber ID was a random effect. An “N” below the variable name means it was not used in the model, while a “Y” indicates it was. The bolded AIC value indicates the best model for each flux type following model selection. AIC scores marked with -- indicate models that failed to converge.

Temp.	Model Variables			Model AIC Score							
	Salinity	Month	Incubation Chamber ID	N ₂ -N	N ₂ O	NH ₄ ⁺	NO _x	O ₂	ΣN	PO ₄ ³⁻	Pore water [NH ₄ ⁺]
N	N	N	N	824.38	376.99	782.64	367.34	29.96	761.55	43.38	222.66
Y	N	N	N	826.13	378.06	786.33	368.92	28.22	763.50	45.38	224.34
Y	Y	N	N	827.36	380.05	785.80	370.47	30.22	765.44	47.36	223.94
Y	N	N	Y	--	380.06	786.33	370.92	30.22	767.50	47.22	223.66
N	Y	N	N	825.63	378.97	784.16	368.84	31.95	763.50	45.36	224.28
N	Y	N	Y	--	380.97	786.16	370.84	33.95	767.50	47.18	224.74
N	N	N	Y	--	378.99	784.64	369.34	31.96	765.55	45.22	222.85
Y	Y	N	Y	831.35	382.05	787.80	372.47	32.22	769.44	49.18	220.57
N	N	Y	N	827.66	377.94	776.77	372.52	16.32	766.03	47.40	224.19
Y	N	Y	N	829.66	378.94	778.76	373.98	15.91	768.02	49.01	220.01
Y	Y	Y	N	831.61	380.81	780.16	375.64	16.62	769.41	51.00	221.86
Y	N	Y	Y	833.66	380.90	780.56	375.98	17.91	--	50.72	215.45
N	Y	Y	N	829.61	379.91	778.20	374.00	17.64	767.41	49.40	226.19
N	Y	Y	Y	833.61	381.91	780.12	376.00	19.64	--	51.09	--
N	N	Y	Y	831.66	379.94	778.59	374.52	18.32	770.02	49.09	224.77
Y	Y	Y	Y	835.61	382.76	782.03	377.64	18.62	773.41	52.70	--

TableS 4: AIC scores for mixed models generated for N₂-N, N₂O, NH₄⁺, NO_x, O₂, and PO₄³⁻ fluxes from sediment and porewater [NH₄⁺] beneath various ages of oyster aquaculture and a control site. In all cases the length of time oyster aquaculture was in place used as a fixed effect. Temperature and salinity were considered as fixed effects, and incubation chamber ID was a random effect. An “N” below the variable name means it was not used in the model, while a “Y” indicates it was. The bolded AIC value indicates the best model for each flux type following model selection. AIC scores marked with -- indicate models that failed to converge.

Model Variables				Model AIC Score							
Temp.	Salinity	Month	Incubation Chamber ID	N ₂ -N	N ₂ O	NH ₄ ⁺	NO _x	O ₂	ΣN	PO ₄ ³⁻	Pore water [NH ₄ ⁺]
N	N	N	N	828.67	384.76	770.53	372.88	16.75	765.39	44.00	218.27
Y	N	N	N	832.67	385.38	772.05	374.60	10.69	767.34	45.98	219.49
Y	Y	N	N	831.43	387.11	767.34	375.71	7.74	769.25	47.86	212.95
Y	N	N	Y	834.63	387.38	774.05	376.60	12.69	771.34	47.94	--
N	Y	N	N	829.50	386.58	766.28	373.92	15.28	767.32	45.89	219.55
N	Y	N	Y	--	388.58	768.28	375.92	17.28	771.32	47.87	223.02
N	N	N	Y	832.67	386.76	772.53	374.88	18.75	769.39	45.97	221.41
Y	Y	N	Y	835.43	389.11	769.34	377.71	9.74	773.25	49.83	--
N	N	Y	N	832.08	384.81	758.79	377.69	6.64	770.26	49.37	220.09
Y	N	Y	N	834.05	383.66	759.50	378.36	8.64	772.26	51.37	211.61
Y	Y	Y	N	836.02	380.25	761.46	379.43	9.48	773.99	53.37	212.82
Y	N	Y	Y	--	385.66	761.50	380.36	10.64	776.26	53.34	213.12
N	Y	Y	N	834.04	385.68	760.25	377.73	7.68	772.08	51.37	220.63
N	Y	Y	Y	--	387.68	762.25	379.73	9.68	776.08	53.34	224.44
N	N	Y	Y	835.25	386.81	760.79	379.69	8.64	774.26	51.34	223.31
Y	Y	Y	Y	--	382.25	763.46	381.43	11.48	777.99	55.34	214.98

Table S5: P-value estimates of pairwise comparisons of sediment N₂-N, N₂O, NH₄⁺, NO_x, O₂, and the sum of the absolute value of all N fluxes derived from least-square means tests of mixed models of various ages of oyster culture.

Aquaculture Ages	N ₂ -N	N ₂ O	NH ₄ ⁺	NO _x	O ₂	ΣN	PO ₄ ³⁻	Pore water [NH ₄ ⁺]
0-2	0.002	0.999	1.000	0.999	1.000	0.001	0.995	--
0-3	0.463	1.000	1.000	0.984	1.000	0.104	0.996	0.001
0-4	0.678	0.997	< 0.001	0.977	0.114	< 0.001	0.794	--
0-5	0.931	0.999	0.993	0.999	0.900	0.597	0.999	< 0.001
0-6	0.133	0.991	0.983	0.999	0.232	0.440	1.00	--
0-7	0.855	1.000	0.999	0.866	0.983	0.173	0.732	< 0.001
2-3	0.381	1.000	1.000	0.885	1.000	0.813	0.900	--
2-4	0.503	0.969	< 0.001	0.999	0.077	0.993	0.989	--
2-5	0.318	0.989	0.998	1.000	0.832	0.662	0.954	--
2-6	0.986	0.945	0.970	1.000	0.173	0.643	0.992	--
2-7	0.150	1.000	0.997	0.994	0.998	0.541	0.390	--
3-4	1.000	0.986	0.003	0.749	0.126	0.354	0.520	--
3-5	0.999	0.996	1.000	0.952	0.930	0.999	1.000	0.003
3-6	0.954	0.969	0.941	0.934	0.267	0.999	1.000	--
3-7	0.998	1.000	1.000	0.475	0.957	0.999	0.989	0.03
4-5	0.999	1.000	0.043	0.999	0.702	0.268	0.691	--
4-6	0.965	1.000	< 0.001	0.999	1.000	0.234	0.828	--
4-7	0.999	0.999	0.002	1.000	0.018	0.135	0.109	--
5-6	0.867	0.999	0.873	1.000	0.864	1.000	1.000	--
5-7	1.000	0.998	1.000	0.998	0.456	1.000	0.996	0.696
6-7	0.775	0.976	0.770	0.997	0.054	1.000	0.943	--

Table S6: Dissolved nutrient concentrations at the start of incubations. Values are mean concentration (μM) \pm standard error. Samples collected on 7/22/15 and 7/31/15 were not measured as they were thawed for a week.

Incubation Date	[NH₄⁺]	[NO_x]	[PO₄³⁻]
6/30/2014	2.29 \pm 1.25	0.15 \pm 0.12	0.33 \pm 0.45
7/1/2014	3.26 \pm 0.67	0.06 \pm 0.00	0.47 \pm 0.06
7/2/2014	2.69 \pm 0.84	0.10 \pm 0.02	0.30 \pm 0.05
7/7/2014	1.89 \pm 0.56	0.10 \pm 0.02	0.46 \pm 0.02
8/11/2014	1.10 \pm 0.57	0.11 \pm 0.04	0.17 \pm 0.07
8/12/2014	1.53 \pm 0.36	0.27 \pm 0.17	0.17 \pm 0.03
8/14/2014	1.18 \pm 0.56	0.11 \pm 0.01	0.13 \pm 0.00
8/15/2014	0.21 \pm 0.21	0.02 \pm 0.02	0.15 \pm 0.01
6/29/2015	1.42 \pm 0.07	0.16 \pm 0.03	0.35 \pm 0.00
6/30/2015	1.65 \pm 0.25	0.12 \pm 0.01	0.44 \pm 0.07
7/22/2015	n.m.	n.m.	n.m.
7/23/2015	1.39 \pm 0.28	0.11 \pm 0.03	0.41 \pm 0.02
7/31/2015	n.m.	n.m.	n.m.
8/18/2015	2.10 \pm 0.82	0.07 \pm 0.05	0.32 \pm 0.04
8/19/2015	0.76 \pm 0.20	0.09 \pm 0.04	0.42 \pm 0.06
8/20/2015	0.56 \pm 0.15	0.07 \pm 0.00	0.19 \pm 0.03
8/27/2015	1.23 \pm 0.10	0.06 \pm 0.01	0.17 \pm 0.03
9/14/2015	0.75 \pm 0.11	0.03 \pm 0.00	0.15 \pm 0.05
9/15/2015	0.95 \pm 0.04	0.10 \pm 0.04	0.15 \pm 0.03
9/16/2015	0.46 \pm 0.14	0.19 \pm 0.08	0.18 \pm 0.10
9/17/2015	2.70 \pm 0.06	0.11 \pm 0.02	0.20 \pm 0.03

Table S7: Relationships between sediment nitrogen fluxes and sediment properties estimated using Pearson correlations. Statistically significant ($p < 0.05$) relationships are bolded.

	C:N	% Organic Matter	Porosity	Density	Pore water [NH ₄ ⁺]
N ₂ -N	p = 0.015 r = 0.52	p = 0.154 r = -0.32	p = 0.071 r = -0.39	p = 0.045 r = 0.43	p = 0.975 r = 0.01
N ₂ O	p = 0.272 r = -0.25	p = 0.022 r = -0.50	p = 0.142 r = -0.32	p = 0.701 r = 0.09	p = 0.459 r = -0.17
NH ₄ ⁺	p = 0.953 r = -0.01	p = 0.845 r = -0.05	p = 0.166 r = 0.31	p = 0.269 r = -0.05	p = 0.221 r = 0.27
NO _x	p = 0.003 r = -0.61	p = 0.208 r = -0.29	p = 0.714 r = -0.08	p = 0.851 r = 0.04	p = 0.264 r = -0.25
ΣN	p = 0.054 r = 0.43	p = 0.123 r = -0.35	p = 0.600 r = -0.12	p = 0.382 r = 0.20	p = 0.373 r = 0.20
PO ₄ ³⁻	p = 0.645 r = -0.11	p = 0.745 r = -0.08	p = 0.975 r = -0.01	p = 0.453 r = 0.17	p = 0.577 r = -0.13

Table S8: Sample variance (σ^2) for sediment fluxes under various ages of oyster aquaculture. The “Aqua” row pools fluxes from all ages (2-7 yrs) of sediment beneath oyster aquaculture gear.

Group	ΣN	N_2-N	N_2O	O_2	NH_4^+	NO_x	PO_4^{3-}
0 yr (Bare)	46653	37064	290655	137585574	3435	56	1070
2 yr	1780999	2459410	40409	106820728	383325	0	602
3 yr	146443	105447	132221	100118451	218105	240	0
4 yr	1303893	326020	344489	335007204	927228	20	3050
5 yr	66984	58893	132974	3348675063	43859	0	0
6 yr	233463	260458	167524	87437398	348782	0	21
7 yr	244702	173731	77147	29088917	36026	198	6
Aqua	688289	568343	131284	757410429	428157	91	645