



Supplement of

Towards circularity in shellfish aquaculture: stimulating mussel shell dissolution in marine sediments

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Figure S7. Pictures of shell-amended incubation chambers.

Table S1. Fluxes of oxygen, dissolved inorganic carbon, total alkalinity, nitrate, and ammonium

Table S2. Calcium carbonate dissolution fractions and rates.

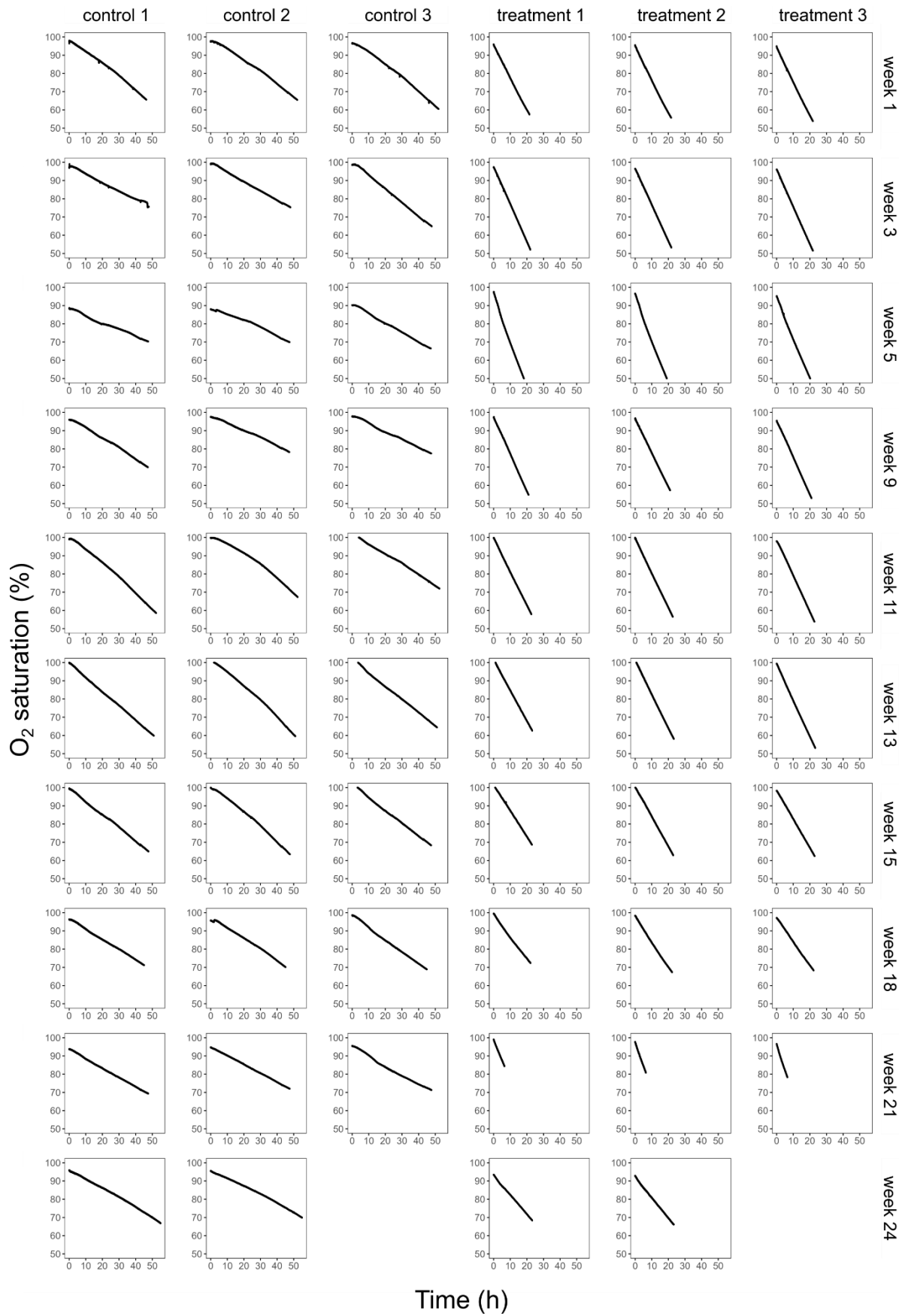


Figure S1: Oxygen (O_2) saturation changes versus incubation time, shown for each control and treatment chamber per week.

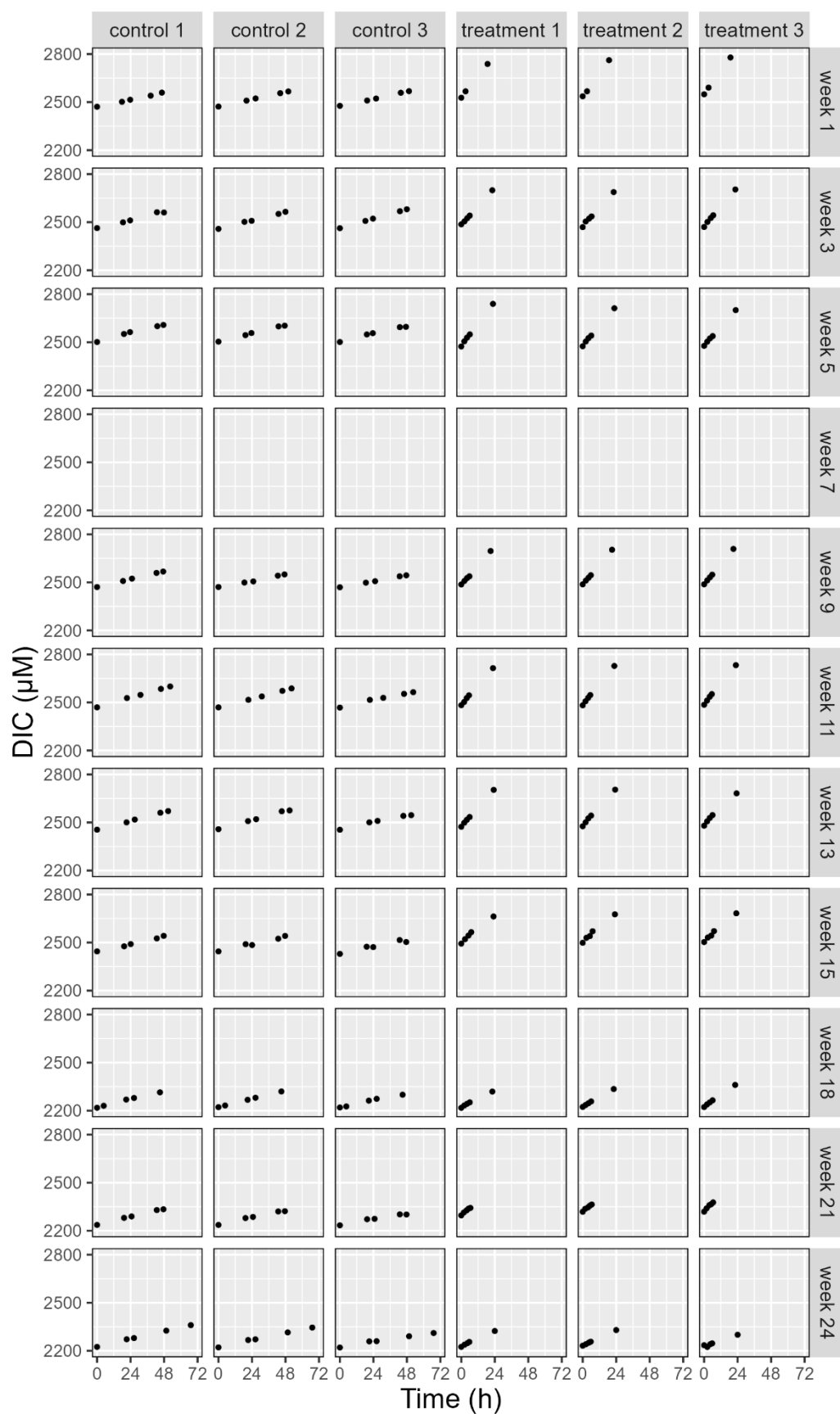


Figure S2: Dissolved inorganic carbon (DIC) concentration changes versus incubation time, shown for each control and treatment chamber per week.

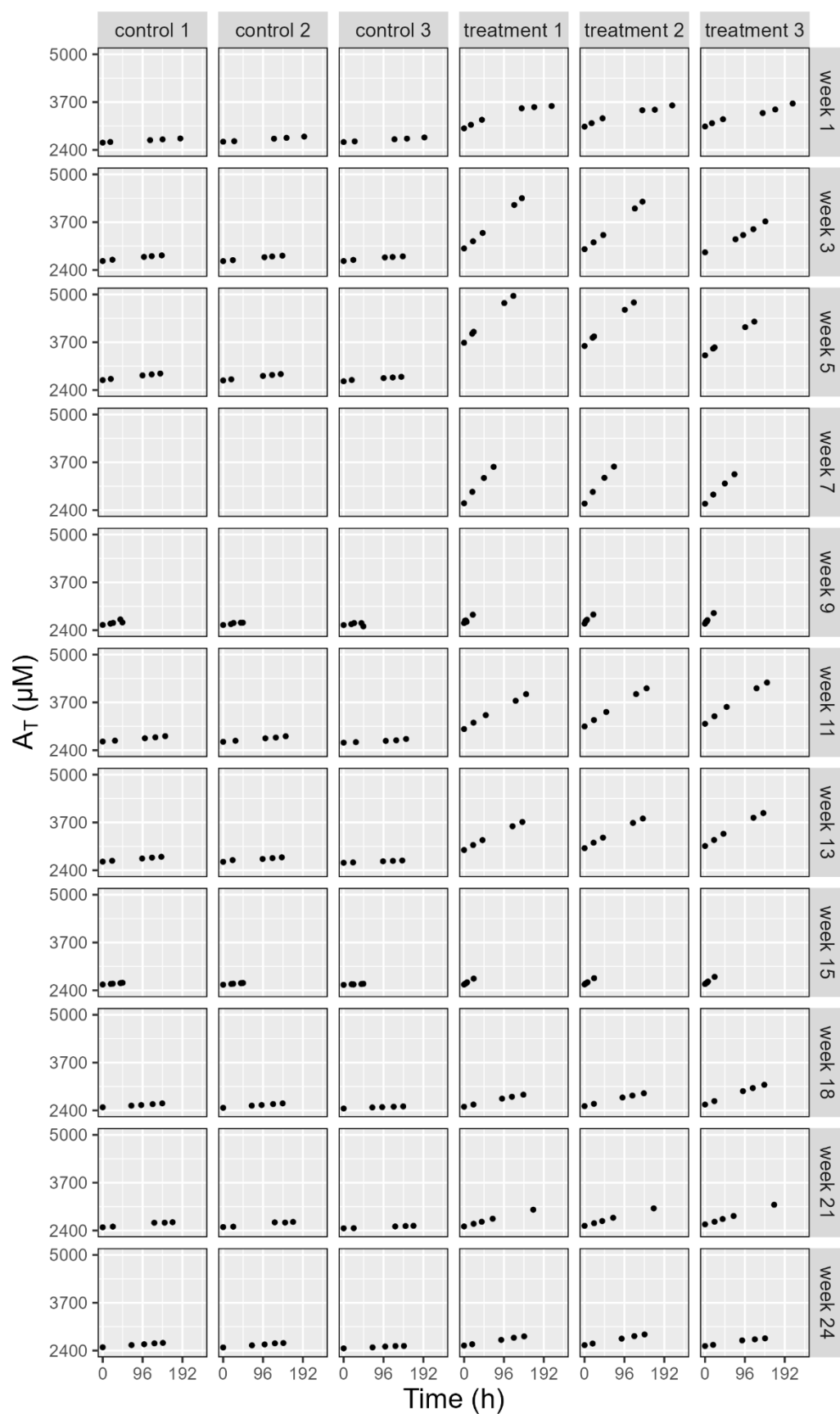


Figure S3: Total alkalinity (A_T) concentration changes versus incubation time, shown for each control and treatment chamber per week.

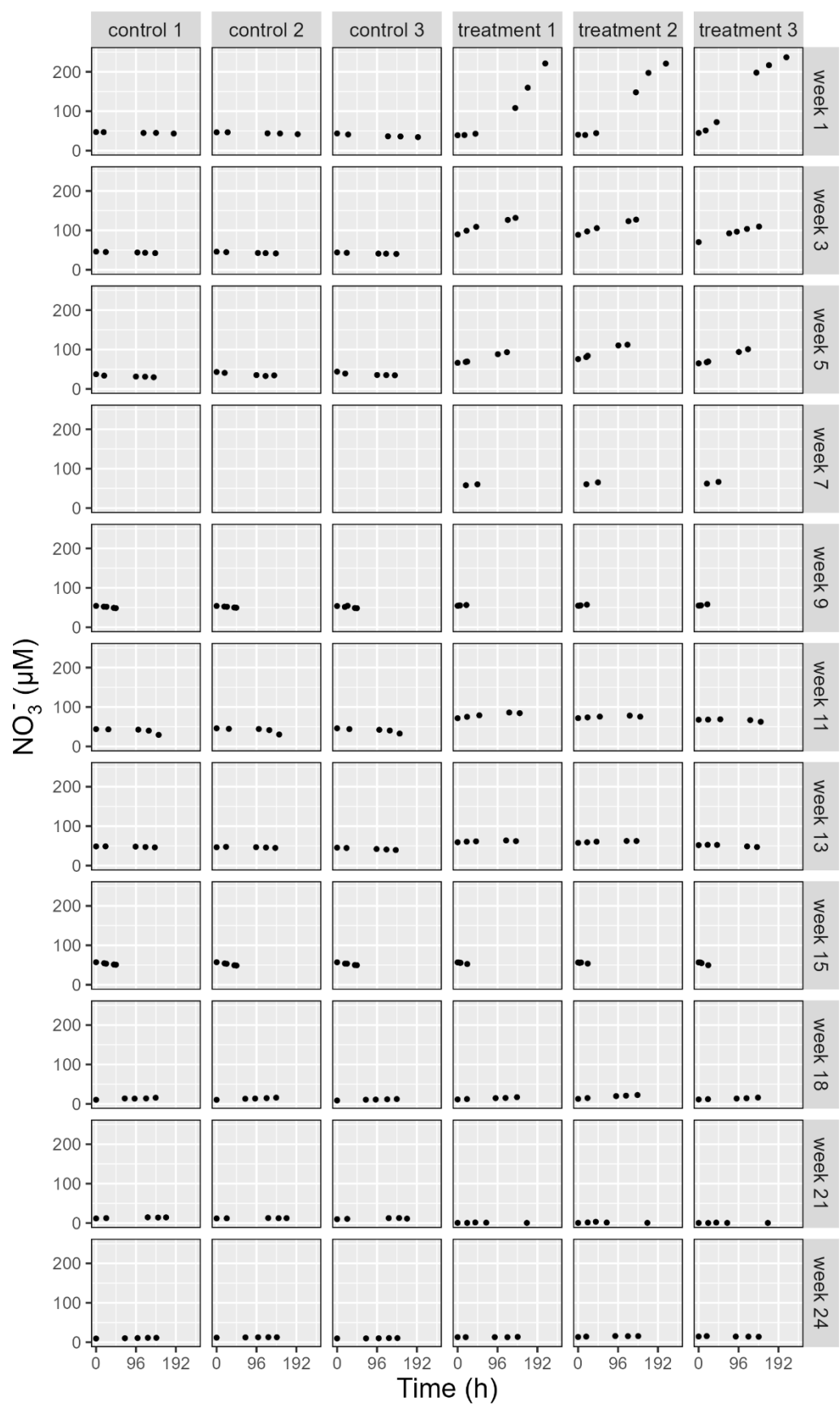


Figure S4: Nitrate (NO_3^-) concentration changes versus incubation time, shown for each control and treatment chamber per week.

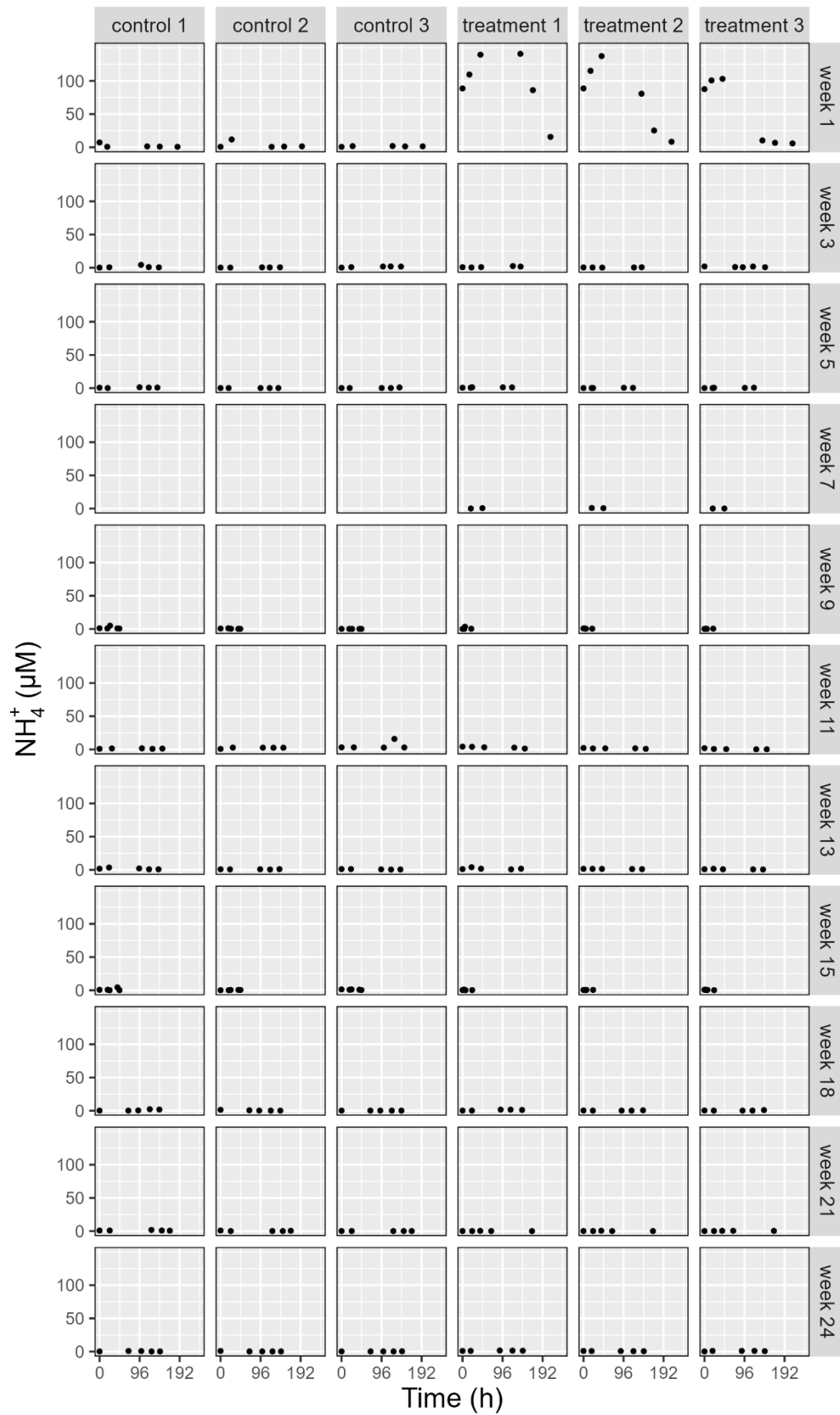


Figure S5: Ammonium (NH_4^+) concentration changes versus incubation time, shown for each control and treatment chamber per week.

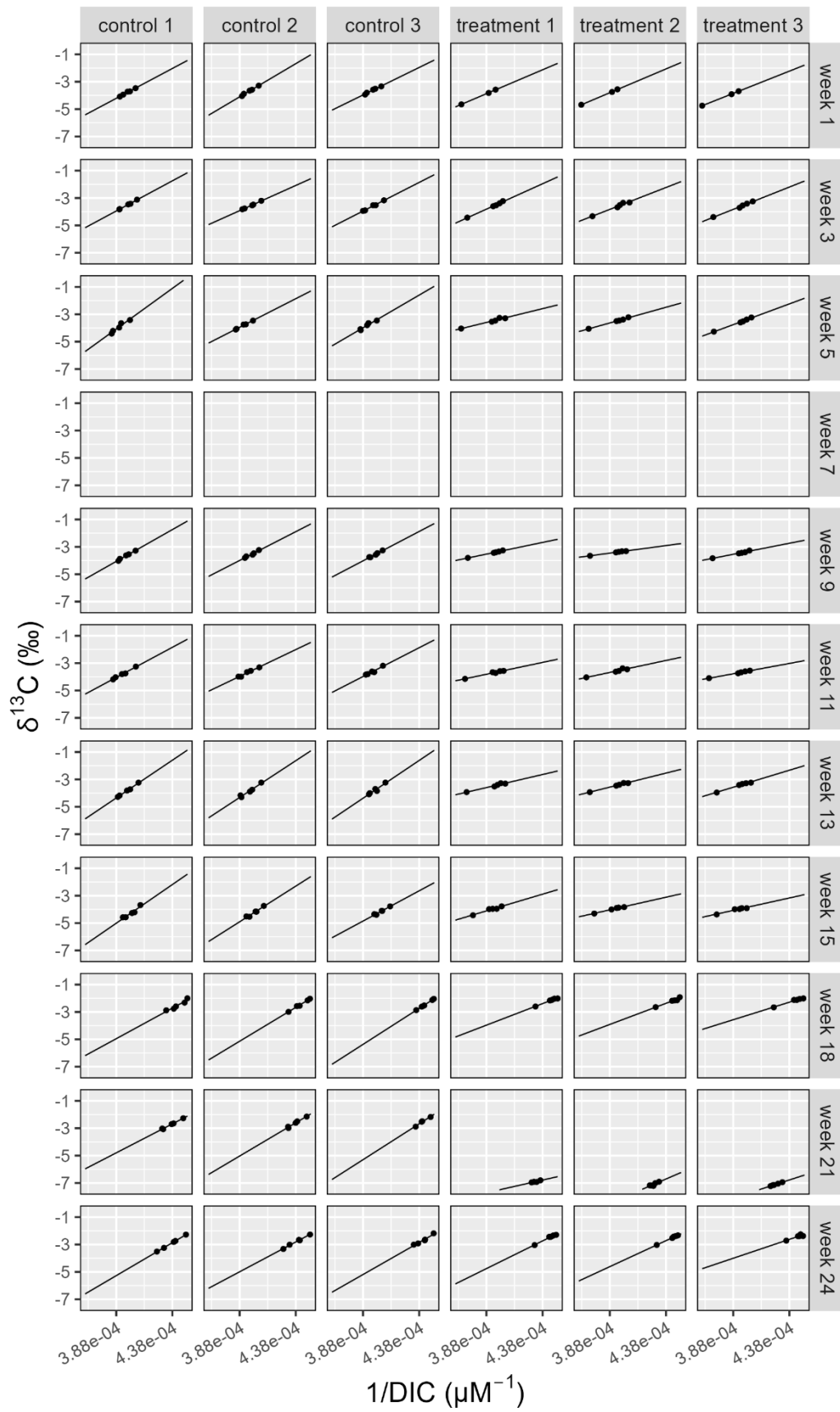


Figure S6: Linear regressions of $\delta^{13}\text{C}$ -DIC over $1/\text{DIC}$ for each control and treatment chamber per week.



Figure S7: Pictures of shell-amended incubation chambers per week. A buildup of anoxia in the shell layer was observed, followed by the slow reoxygenation of the sediment. A picture of a control chamber, taken at the end of the experiment, was added for comparison.

Week	Treatment	Chamber	FO ₂	p-value	Model	FDIC	p-value	Model	FA _T	p-value	Model	FNO ₃ ⁻	p-value	Model	FNH ₄ ⁺	p-value	Model
1	Control	C1	6.1	<2.2E-16	Lin	6.9	4.8E-05	Lin	2.2	6.5E-05	Lin	-0.1	4.3E-03	Lin	0.0	2.5E-01	Lin
1	Control	C2	6.3	<2.2E-16	Lin	7.0	7.6E-07	Lin	2.6	3.7E-05	Lin	-0.1	2.3E-03	Lin	0.0	4.4E-01	Lin
1	Control	C3	6.3	<2.2E-16	Lin	7.0	3.5E-05	Lin	2.3	3.2E-05	Lin	-0.2	2.4E-03	Lin	0.0	5.5E-01	Lin
1	Treatment	C4	16.2	<2.2E-16	Lin	41.5	1.7E-02	Lin	21.8	2.3E-04	Quad	6.6	NA	Quad	4.9	NA	Quad
1	Treatment	C5	17.1	<2.2E-16	Lin	44.4	1.7E-02	Lin	21.7	5.6E-03	Quad	4.7	6.5E-01	Quad	6.7	NA	Quad
1	Treatment	C6	16.7	<2.2E-16	Lin	43.4	7.2E-03	Lin	14.3	3.6E-01	Quad	6.0	5.9E-02	Quad	3.7	NA	Quad
3	Control	C1	4.2	<2.2E-16	Lin	8.0	6.8E-04	Lin	3.9	9.6E-05	Lin	-0.1	2.8E-03	Lin	0.0	6.3E-01	Lin
3	Control	C2	4.7	<2.2E-16	Lin	8.1	3.9E-05	Lin	3.8	9.3E-06	Lin	-0.1	2.5E-04	Lin	0.0	1.7E-02	Lin
3	Control	C3	7.2	<2.2E-16	Lin	9.2	5.2E-07	Lin	3.1	3.6E-04	Lin	-0.1	7.7E-04	Lin	0.0	2.4E-02	Lin
3	Treatment	C4	18.1	<2.2E-16	Lin	36.2	2.7E-06	Lin	35.8	9.0E-07	Lin	1.1	9.1E-04	Lin	0.0	8.5E-02	Lin
3	Treatment	C5	17.2	<2.2E-16	Lin	35.2	1.1E-04	Lin	33.9	5.4E-06	Lin	1.0	5.7E-04	Lin	0.0	3.7E-01	Lin
3	Treatment	C6	17.6	<2.2E-16	Lin	36.9	1.6E-05	Lin	19.6	4.7E-04	Lin	1.0	1.7E-04	Lin	0.0	2.8E-01	Lin
5	Control	C1	3.7	<2.2E-16	Lin	8.1	3.7E-04	Lin	4.6	1.9E-05	Lin	-0.2	1.5E-02	Lin	0.0	3.2E-01	Lin
5	Control	C2	3.7	<2.2E-16	Lin	7.9	7.4E-05	Lin	4.5	1.7E-05	Lin	-0.3	7.3E-03	Lin	0.0	NA	Lin
5	Control	C3	5.1	<2.2E-16	Lin	7.6	5.5E-04	Lin	3.0	1.1E-03	Lin	-0.2	2.1E-02	Lin	0.0	3.0E-01	Lin
5	Treatment	C4	27.0	<2.2E-16	Lin	43.5	9.2E-06	Lin	38.7	3.2E-05	Lin	0.9	2.0E-04	Lin	0.0	3.2E-01	Lin
5	Treatment	C5	24.6	<2.2E-16	Lin	38.1	1.7E-05	Lin	36.3	9.7E-06	Lin	1.2	8.0E-04	Lin	0.0	3.2E-02	Lin
5	Treatment	C6	22.1	<2.2E-16	Lin	35.6	8.6E-06	Lin	27.2	3.1E-05	Lin	1.2	2.1E-04	Lin	0.0	1.9E-01	Lin
7	Control	C1	NA	NA	Lin	NA	NA	Lin	NA	NA	Lin	NA	NA	Lin	NA	NA	Lin
7	Control	C2	NA	NA	Lin	NA	NA	Lin	NA	NA	Lin	NA	NA	Lin	NA	NA	Lin
7	Control	C3	NA	NA	Lin	NA	NA	Lin	NA	NA	Lin	NA	NA	Lin	NA	NA	Lin
7	Treatment	C4	NA	NA	Lin	NA	NA	Lin	51.6	7.3E-04	Lin	NA	NA	Lin	NA	NA	Lin
7	Treatment	C5	NA	NA	Lin	NA	NA	Lin	51.8	7.6E-04	Lin	NA	NA	Lin	NA	NA	Lin
7	Treatment	C6	NA	NA	Lin	NA	NA	Lin	40.7	5.1E-04	Lin	NA	NA	Lin	NA	NA	Lin
9	Control	C1	5.0	<2.2E-16	Lin	7.7	3.5E-06	Lin	5.4	4.8E-02	Lin	-0.4	1.7E-03	Lin	0.0	8.3E-01	Lin
9	Control	C2	3.6	<2.2E-16	Lin	6.2	2.9E-04	Lin	5.1	1.5E-02	Lin	-0.4	4.4E-04	Lin	-0.1	1.8E-01	Lin
9	Control	C3	4.1	<2.2E-16	Lin	5.9	1.5E-05	Lin	5.0	9.5E-02	Lin	-0.4	9.5E-02	Lin	0.0	5.6E-02	Lin
9	Treatment	C4	17.1	<2.2E-16	Lin	37.6	2.0E-05	Lin	38.4	1.2E-02	Lin	0.3	2.7E-02	Lin	0.0	9.8E-01	Lin
9	Treatment	C5	16.0	<2.2E-16	Lin	38.3	1.8E-06	Lin	40.8	3.1E-03	Lin	0.5	2.2E-03	Lin	0.0	3.2E-01	Lin
9	Treatment	C6	16.8	<2.2E-16	Lin	38.4	2.5E-07	Lin	49.7	1.9E-04	Lin	0.6	5.5E-04	Lin	0.0	1.3E-02	Lin
11	Control	C1	7.4	<2.2E-16	Lin	9.2	2.2E-05	Lin	3.5	1.7E-04	Lin	-0.1	1.4E-01	Lin	0.0	8.6E-01	Lin
11	Control	C2	5.9	<2.2E-16	Lin	8.4	3.0E-06	Lin	3.5	1.3E-04	Lin	-0.1	1.4E-01	Lin	0.0	2.6E-01	Lin
11	Control	C3	5.0	<2.2E-16	Lin	6.8	3.8E-04	Lin	2.2	6.1E-03	Lin	-0.1	5.6E-02	Lin	0.0	5.3E-01	Lin
11	Treatment	C4	16.3	<2.2E-16	Lin	38.4	1.4E-05	Lin	22.6	8.5E-05	Lin	0.4	8.2E-03	Lin	-0.1	1.4E-02	Lin
11	Treatment	C5	16.9	<2.2E-16	Lin	40.2	5.6E-06	Lin	25.1	1.1E-05	Lin	0.2	1.2E-01	Lin	0.0	1.5E-01	Lin
11	Treatment	C6	16.9	<2.2E-16	Lin	39.4	1.2E-05	Lin	26.7	8.1E-05	Lin	0.0	1.3E-01	Lin	0.0	1.0E-01	Lin
13	Control	C1	6.7	<2.2E-16	Lin	8.6	1.9E-05	Lin	3.3	4.2E-06	Lin	-0.1	3.7E-02	Lin	0.0	2.0E-01	Lin
13	Control	C2	7.3	<2.2E-16	Lin	8.7	9.1E-05	Lin	2.7	5.9E-03	Lin	-0.1	1.3E-01	Lin	0.0	8.7E-01	Lin

13	Control	C3	6.2	< 2.2E-16	Lin	6.8	5.7E-04	Lin	1.6	1.5E-05	Lin	-0.2	4.3E-04	Lin	0.0	1.0E-02	Lin
13	Treatment	C4	14.6	< 2.2E-16	Lin	37.0	2.9E-06	Lin	19.8	1.9E-05	Lin	0.1	8.2E-02	Lin	0.0	5.4E-01	Lin
13	Treatment	C5	16.1	< 2.2E-16	Lin	36.2	4.0E-05	Lin	20.8	3.2E-05	Lin	0.1	1.2E-02	Lin	0.0	1.5E-03	Lin
13	Treatment	C6	16.9	< 2.2E-16	Lin	30.9	2.3E-04	Lin	22.9	5.9E-05	Lin	-0.1	1.7E-02	Lin	0.0	1.8E-01	Lin
15	Control	C1	6.3	< 2.2E-16	Lin	7.4	2.8E-04	Lin	3.6	4.0E-04	Lin	-0.5	4.0E-04	Lin	0.0	5.6E-01	Lin
15	Control	C2	7.0	< 2.2E-16	Lin	7.1	1.5E-03	Lin	3.7	2.8E-04	Lin	-0.7	1.2E-04	Lin	0.0	9.0E-02	Lin
15	Control	C3	6.5	< 2.2E-16	Lin	6.4	7.3E-03	Lin	2.1	1.1E-02	Lin	-0.6	2.2E-04	Lin	-0.1	1.0E-01	Lin
15	Treatment	C4	12.6	< 2.2E-16	Lin	26.9	7.9E-04	Lin	26.5	1.3E-04	Lin	-0.7	5.2E-05	Lin	0.0	5.9E-01	Lin
15	Treatment	C5	14.2	< 2.2E-16	Lin	28.3	5.6E-04	Lin	27.7	4.2E-05	Lin	-0.4	2.5E-02	Lin	0.0	6.5E-01	Lin
15	Treatment	C6	13.6	< 2.2E-16	Lin	28.2	2.6E-04	Lin	31.9	3.9E-05	Lin	-1.2	6.2E-04	Lin	-0.1	1.3E-02	Lin
18	Control	C1	5.1	< 2.2E-16	Lin	8.0	1.7E-04	Lin	2.7	3.9E-04	Lin	0.1	1.4E-02	Lin	0.1	1.2E-01	Lin
18	Control	C2	5.4	< 2.2E-16	Lin	8.1	7.7E-07	Lin	3.1	5.3E-06	Lin	0.1	2.0E-04	Lin	0.0	1.4E-02	Lin
18	Control	C3	6.0	< 2.2E-16	Lin	7.0	6.5E-04	Lin	1.5	4.8E-06	Lin	0.1	2.6E-04	Lin	0.0	6.0E-02	Lin
18	Treatment	C4	11.7	< 2.2E-16	Lin	16.8	2.0E-04	Lin	8.5	1.8E-05	Lin	0.1	1.2E-03	Lin	0.0	7.1E-02	Lin
18	Treatment	C5	12.9	< 2.2E-16	Lin	18.7	2.0E-05	Lin	9.0	1.5E-05	Lin	0.3	2.5E-04	Lin	0.0	6.4E-01	Lin
18	Treatment	C6	11.4	< 2.2E-16	Lin	22.5	2.4E-05	Lin	13.5	2.8E-05	Lin	0.1	2.6E-03	Lin	0.0	4.6E-01	Lin
21	Control	C1	4.6	< 2.2E-16	Lin	7.7	7.3E-05	Lin	3.1	1.1E-03	Lin	0.1	1.4E-02	Lin	0.0	9.0E-01	Lin
21	Control	C2	4.2	< 2.2E-16	Lin	6.8	5.4E-04	Lin	3.2	2.4E-03	Lin	0.0	7.8E-02	Lin	0.0	4.5E-01	Lin
21	Control	C3	4.2	< 2.2E-16	Lin	5.5	1.8E-03	Lin	1.5	2.5E-04	Lin	0.1	1.2E-01	Lin	0.0	1.0E-02	Lin
21	Treatment	C4	20.0	< 2.2E-16	Lin	27.1	1.2E-03	Lin	10.0	5.3E-05	Lin	0.0	7.5E-01	Lin	0.0	5.7E-01	Lin
21	Treatment	C5	23.0	< 2.2E-16	Lin	25.6	1.1E-03	Lin	10.5	5.3E-05	Lin	0.0	7.0E-01	Lin	0.0	6.4E-01	Lin
21	Treatment	C6	24.5	< 2.2E-16	Lin	32.5	1.2E-03	Lin	11.1	6.2E-06	Lin	0.0	8.6E-01	Lin	0.0	3.1E-01	Lin
24	Control	C1	4.9	< 2.2E-16	Lin	7.4	1.9E-05	Lin	3.0	1.8E-05	Lin	0.1	1.8E-03	Lin	0.0	9.1E-01	Lin
24	Control	C2	4.4	< 2.2E-16	Lin	6.8	8.0E-05	Lin	3.1	1.8E-04	Lin	0.0	1.2E-02	Lin	0.0	5.7E-02	Lin
24	Control	C3	NA	NA	Lin	5.0	6.7E-04	Lin	1.7	1.3E-03	Lin	0.0	4.1E-02	Lin	0.0	3.2E-01	Lin
24	Treatment	C4	9.4	< 2.2E-16	Lin	15.1	2.0E-04	Lin	6.4	2.6E-06	Lin	0.0	3.4E-01	Lin	0.0	2.1E-01	Lin
24	Treatment	C5	9.9	< 2.2E-16	Lin	15.2	3.8E-06	Lin	7.4	4.7E-06	Lin	0.1	4.3E-02	Lin	0.0	5.2E-02	Lin
24	Treatment	C6	NA	NA	Lin	11.0	4.3E-03	Lin	5.3	4.7E-04	Lin	0.0	1.5E-01	Lin	0.0	5.5E-01	Lin

Table S1: Oxygen (O₂), dissolved inorganic carbon (DIC), alkalinity (A_T), nitrate (NO₃⁻), and ammonium (NH₄⁺) fluxes (F) calculated from the linear (lin) or quadratic (quad) regression of overlying water concentrations over time. All fluxes are expressed in mmol m⁻² d⁻¹, and corresponding p-values of the regression model are supplied. For quadratic models, the p-value of the quadratic term of the model is shown. Ammonium fluxes measured in the treatment chambers in week 1 are based on the first half of the incubation (anoxia), whereas nitrate fluxes are based on the second half of the incubation (reoxygenation).

Week	Treatment	Chamber	f carb	MCDE	Intercept	p value	R diss
1	Control	C1	13.3	26.6	-21.1	6.5E-04	0.9
1	Control	C2	3.4	6.8	-22.9	5.6E-04	0.2
1	Control	C3	16.4	32.8	-19.5	1.3E-03	1.1
1	Treatment	C4	22.9	45.8	-17.4	1.5E-02	9.5
1	Treatment	C5	20.9	41.8	-17.3	1.4E-02	9.3
1	Treatment	C6	23.5	47.0	-16.5	8.1E-03	10.2
3	Control	C1	13.6	27.2	-21.0	8.4E-05	1.1
3	Control	C2	23.9	47.8	-18.2	1.0E-04	1.9
3	Control	C3	13.8	27.6	-20.2	6.6E-04	1.3
3	Treatment	C4	19.4	38.8	-18.2	1.0E-04	7.0
3	Treatment	C5	25.9	51.8	-16.2	2.0E-03	9.1
3	Treatment	C6	23.4	46.8	-16.5	2.5E-04	8.6
5	Control	C1	-9.8	-19.6	-27.1	7.6E-03	NA
5	Control	C2	15.4	30.8	-20.1	6.4E-04	1.2
5	Control	C3	4.3	8.6	-22.5	6.4E-03	0.3
5	Treatment	C4	50.3	100.6	-11.4	2.6E-03	21.9
5	Treatment	C5	43.9	87.8	-12.5	1.8E-04	16.7
5	Treatment	C6	28.0	56.0	-15.5	1.4E-04	10.0
7	Control	C1	NA	NA	NA	NA	NA
7	Control	C2	NA	NA	NA	NA	NA
7	Control	C3	NA	NA	NA	NA	NA
7	Treatment	C4	NA	NA	NA	NA	NA
7	Treatment	C5	NA	NA	NA	NA	NA
7	Treatment	C6	NA	NA	NA	NA	NA
9	Control	C1	9.6	19.2	-22.1	8.1E-04	0.7
9	Control	C2	14.7	29.4	-20.3	3.8E-03	0.9
9	Control	C3	11.8	23.6	-20.7	1.4E-03	0.7
9	Treatment	C4	56.0	112.0	-10.2	1.4E-04	21.0
9	Treatment	C5	67.0	134.0	-7.7	2.2E-04	25.7
9	Treatment	C6	55.6	111.2	-9.8	8.7E-04	21.3
11	Control	C1	13.3	26.6	-21.1	7.0E-04	1.2
11	Control	C2	19.8	39.6	-19.2	2.4E-03	1.7
11	Control	C3	13.3	26.6	-20.3	4.6E-03	0.9
11	Treatment	C4	54.3	108.6	-10.5	1.8E-03	20.9
11	Treatment	C5	53.8	107.6	-10.5	5.2E-03	21.6
11	Treatment	C6	56.3	112.6	-9.6	1.8E-04	22.2
13	Control	C1	-4.6	-9.2	-25.7	1.8E-04	NA
13	Control	C2	-6.5	-13.0	-25.2	3.0E-03	NA
13	Control	C3	-9.1	-18.2	-25.8	8.0E-03	NA
13	Treatment	C4	52.1	104.2	-11.0	2.8E-03	19.3
13	Treatment	C5	48.7	97.4	-11.5	7.3E-04	17.6
13	Treatment	C6	39.2	78.4	-13.2	1.1E-03	12.1
15	Control	C1	-9.1	-18.2	-26.9	9.2E-03	NA
15	Control	C2	-6.2	-12.4	-25.1	4.1E-03	NA
15	Control	C3	6.4	12.8	-22.0	2.7E-03	0.4
15	Treatment	C4	40.3	80.6	-13.6	4.5E-03	10.8
15	Treatment	C5	50.2	100.4	-11.2	1.1E-03	14.2
15	Treatment	C6	49.3	98.6	-11.1	6.3E-03	13.9
18	Control	C1	8.9	17.8	-22.3	9.7E-03	0.7
18	Control	C2	-2.8	-5.6	-24.3	3.9E-04	NA
18	Control	C3	-9.1	-18.2	-25.8	2.8E-05	NA
18	Treatment	C4	28.6	57.2	-16.2	1.0E-03	4.8
18	Treatment	C5	27.6	55.2	-15.9	3.3E-03	5.2
18	Treatment	C6	37.7	75.4	-13.5	1.4E-03	8.5
21	Control	C1	13.0	26.0	-21.2	3.1E-04	1.0
21	Control	C2	-0.8	-1.6	-23.9	1.1E-03	NA
21	Control	C3	-8.5	-17.0	-25.6	1.3E-02	NA
21	Treatment	C4	34.3	68.6	-14.9	8.4E-02	9.3
21	Treatment	C5	-3.3	-6.6	-22.3	4.7E-02	NA
21	Treatment	C6	14.3	28.6	-18.4	3.1E-05	4.6

24	Control	C1	2.4	4.8	-23.9	1.2E-05	0.2
24	Control	C2	7.8	15.6	-21.9	2.6E-04	0.5
24	Control	C3	0.9	1.8	-23.3	3.4E-03	0.0
24	Treatment	C4	9.1	18.2	-20.5	8.3E-04	1.4
24	Treatment	C5	10.9	21.8	-19.3	1.5E-04	1.7
24	Treatment	C6	31.9	63.8	-14.7	2.5E-02	3.5

Table S2: Calcium carbonate (CaCO_3) dissolution fractions (f_{carb} , %), metabolic CaCO_3 dissolution efficiencies (MCDE, %) and CaCO_3 dissolution rates (R_{diss} , $\text{mmol m}^{-2} \text{d}^{-1}$), calculated using the Keeling plot approach. Intercepts and p-values of the linear regression models are supplied.