Electronic Supplementary Material (ESI) for Environmental Science: Water Research & Technology.

Supporting Information

Labile Carbon Release from Oxic-Anoxic Cycling in Woodchip Bioreactors Enhances Nitrate Reduction without Increasing Nitrous Oxide Accumulation

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Number of Pages: 34

Number of Tables: 3

Number of Figures: 28

Summary

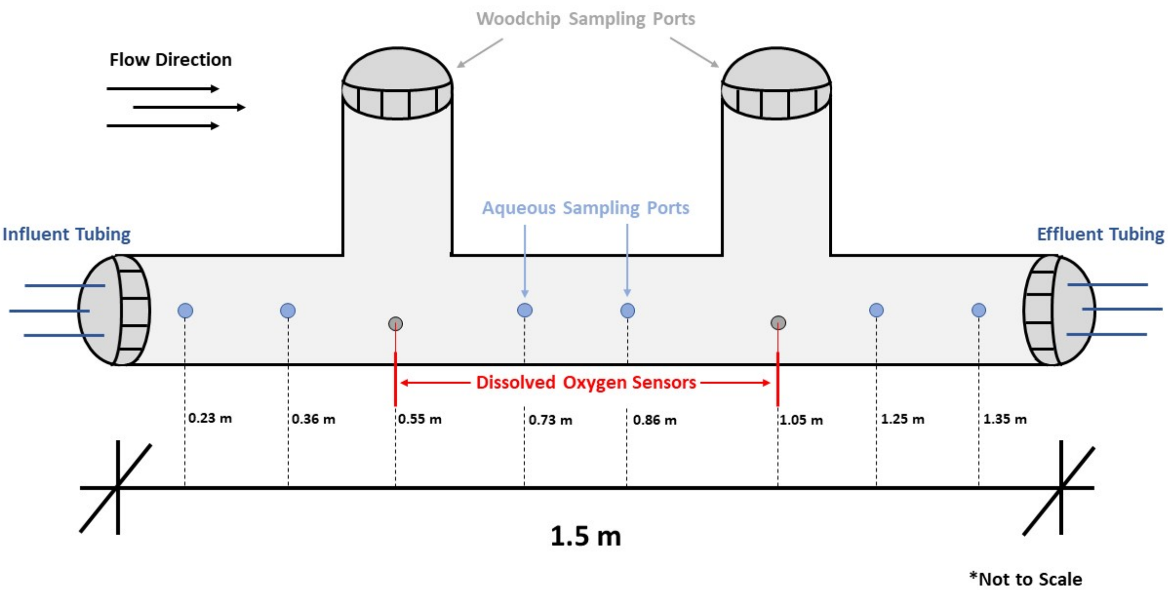


Figure S1: Schematic of a single flow-through reactor.

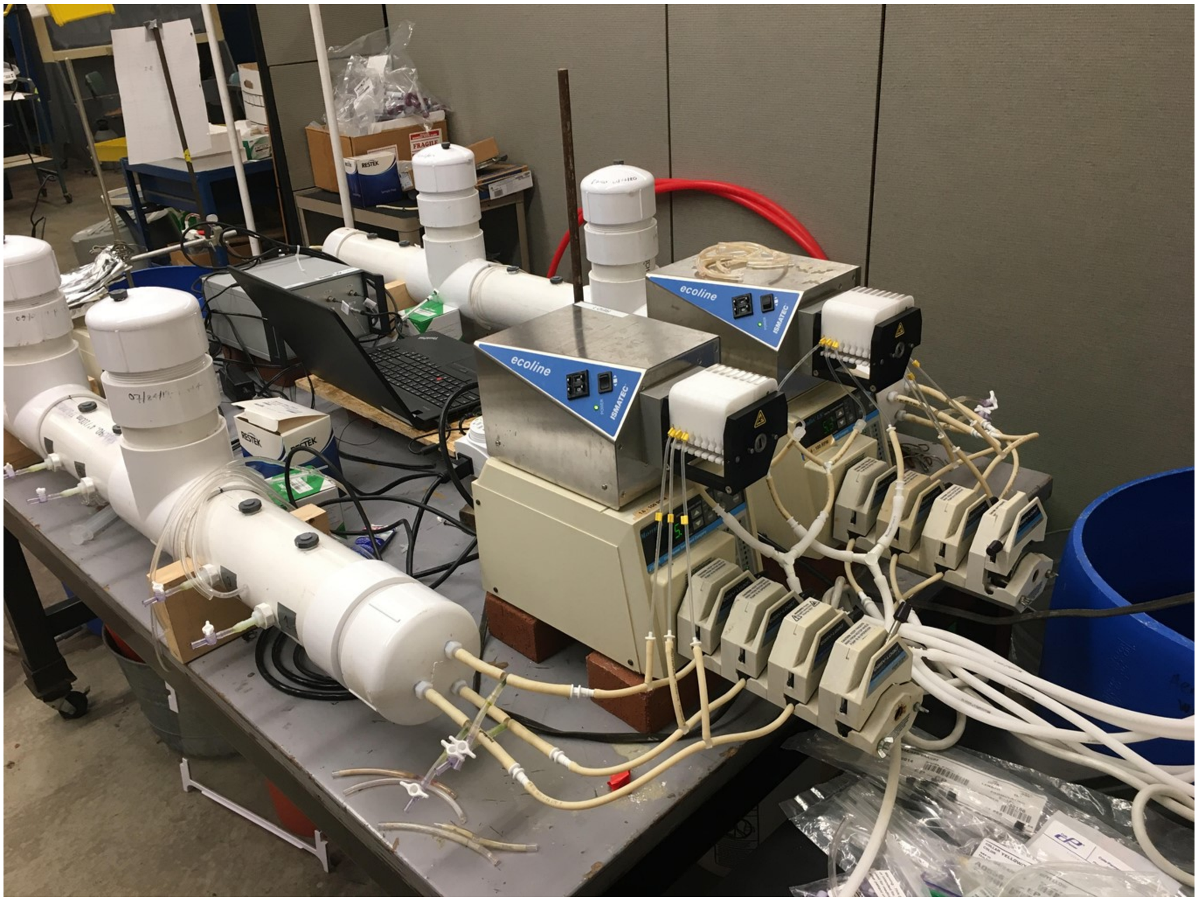


Figure S2: Image of laboratory flow-through reactor. Peristaltic pumps for flow control are seen in the foreground. Reactor sampling ports can be visualized on the left-side of the reactor seen in the left-hand side of the photograph. Dissolved oxygen probes are located at the junction of the reactor barrel and woodchip sampling ports. In this photograph, flow through the reactors proceeds from the lower right to the upper left.

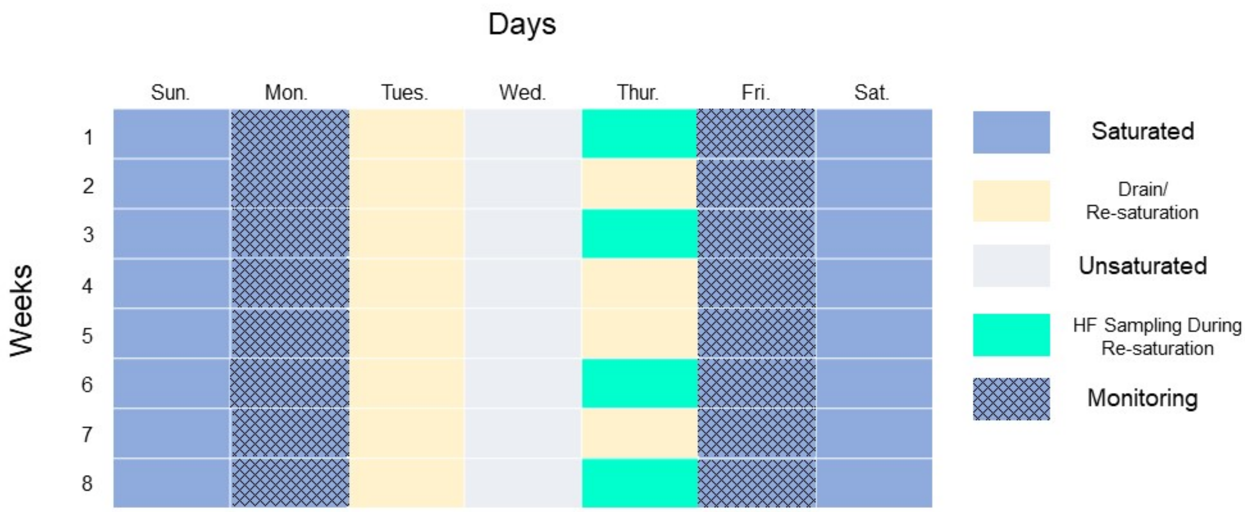


Figure S3: Schedule of reactor operation and sampling for drying-rewetting reactors. Reactors were drained weekly on Tuesday and re-saturated on Thursday. A similar porewater chemistry monitoring schedule was kept for the continuously saturated reactors. In Experiment 1, this schedule was truncated during Week 5.

Table S1: Trace Element Solution Composition

Solution	Chemical Reagents	1000X Stock Solution (g/L)
Trace Element Solution I (0.1 M H_2SO_4)	$NiCl_2{\bullet}6H_2O$	0.020
	$CoCl_2{\bullet}6H_2O$	0.010
	$ZnSO_4{\bullet}7H_2O$	0.100
	$MnSO_4{\bullet}7H_2O$	2.319
Trace Element Solution II (0.1 M NaOH)	H_3BO_3	0.300
	$NaMoO_4{\bullet}2H_2O$	0.030

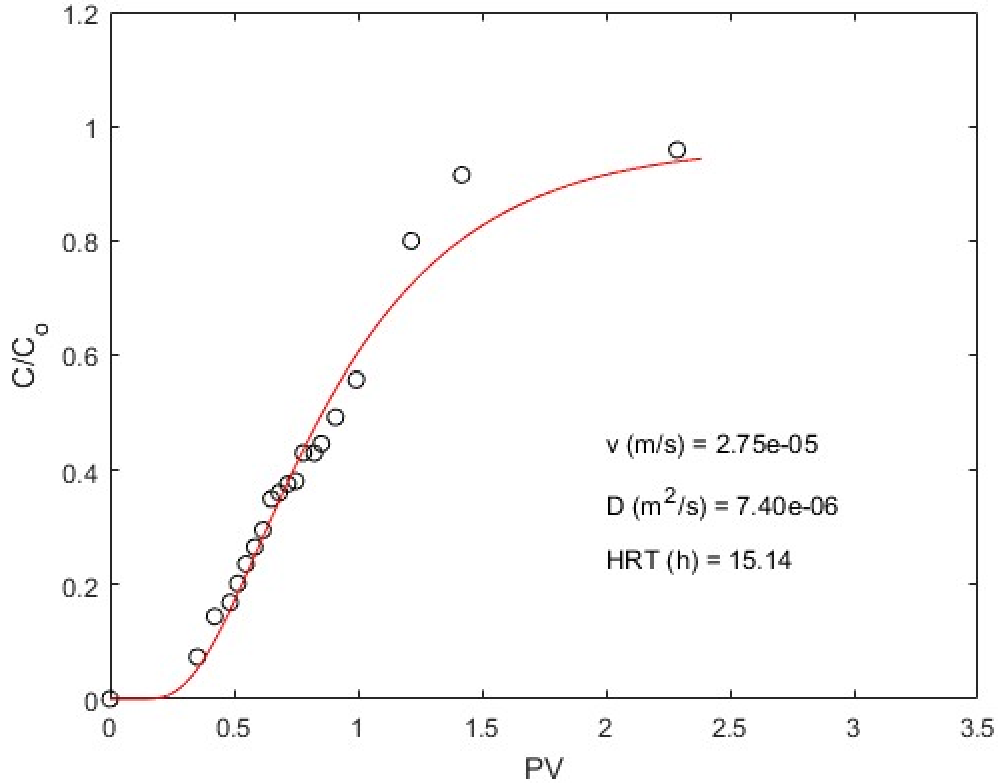


Figure S4: Bromide tracer test results from Experiment 1 continuously saturated reactor. Breakthrough curve was modeled using a 1-dimensional advection-dispersion equation implemented in MATLAB.

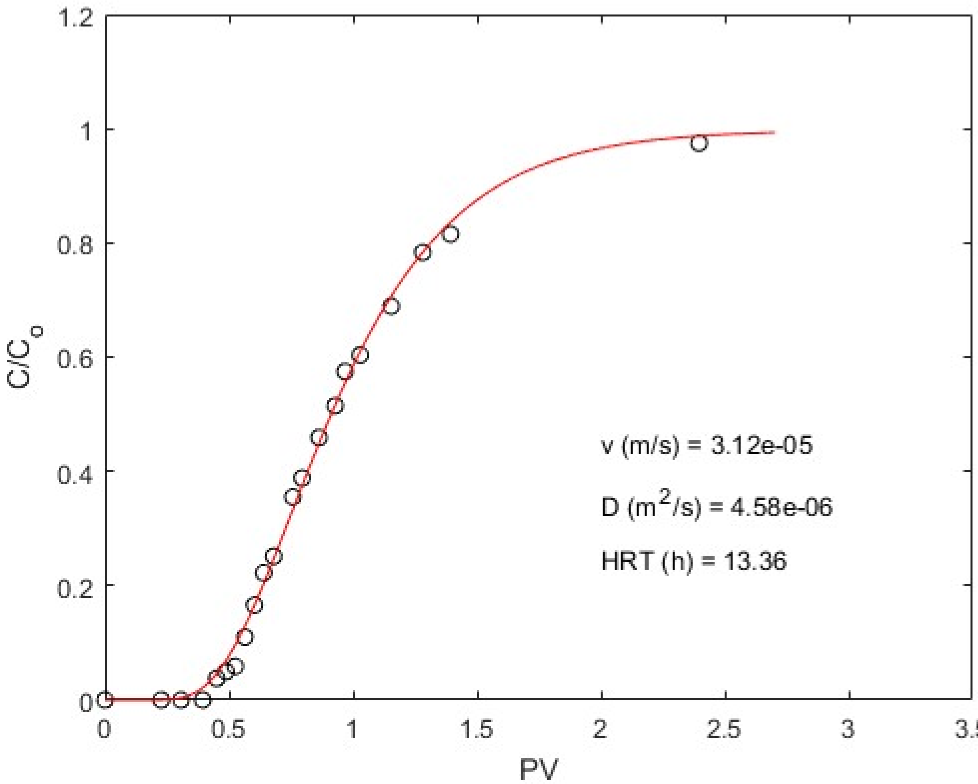


Figure S5: Bromide tracer test results from Experiment 1 drying-rewetting reactor. Breakthrough curve was modeled using a 1-dimensional advection-dispersion equation implemented in MATLAB.

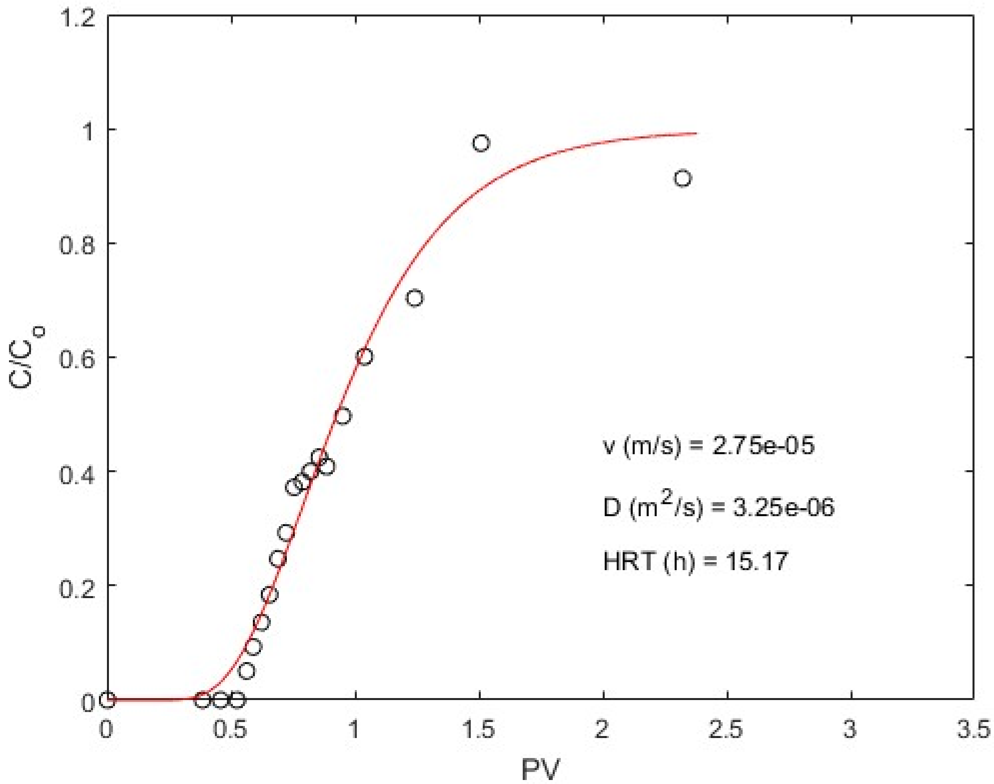


Figure S6: Bromide tracer test results from Experiment 2 continuously saturated reactor. Breakthrough curve was modeled using a 1-dimensional advection-dispersion equation implemented in MATLAB.

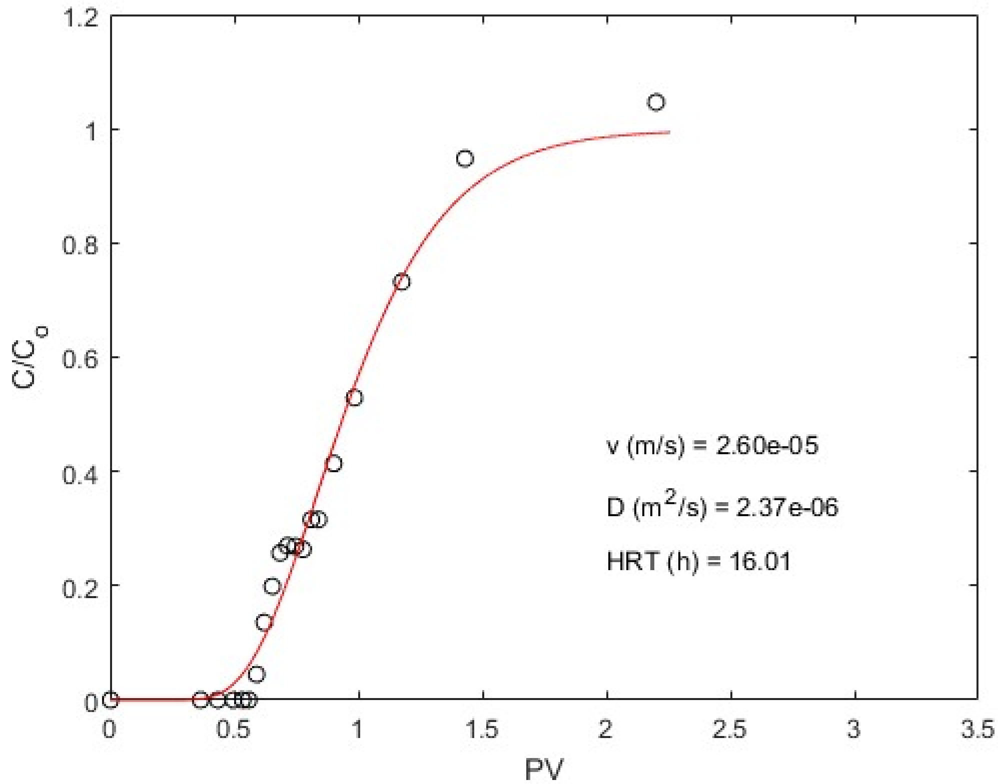


Figure S7: Bromide tracer test results from Experiment 2 drying-rewetting reactor. Breakthrough curve was modeled using a 1-dimensional advection-dispersion equation implemented in MATLAB.

Table S2: Compiled Hydraulic Parameters from Flowthrough Experiments

Experiment	Reactor Hydraulic Regime	MRT (h)	Porewater Velocity (m/s)	Dispersion (m^2/s)	Peclet Number
Experiment 1	Continuously Saturated (CS)	15.1	2.8×10^{-5}	7.4×10^{-6}	5.68
	Drying-Rewetting (DRW)	13.4	3.1×10^{-5}	4.58×10^{-6}	10.2
Experiment 2	Continuously Saturated (CS)	15.2	2.8×10^{-5}	3.25×10^{-6}	12.9
	Drying-Rewetting (DRW)	16.0	2.6×10^{-5}	2.37×10^{-6}	16.5

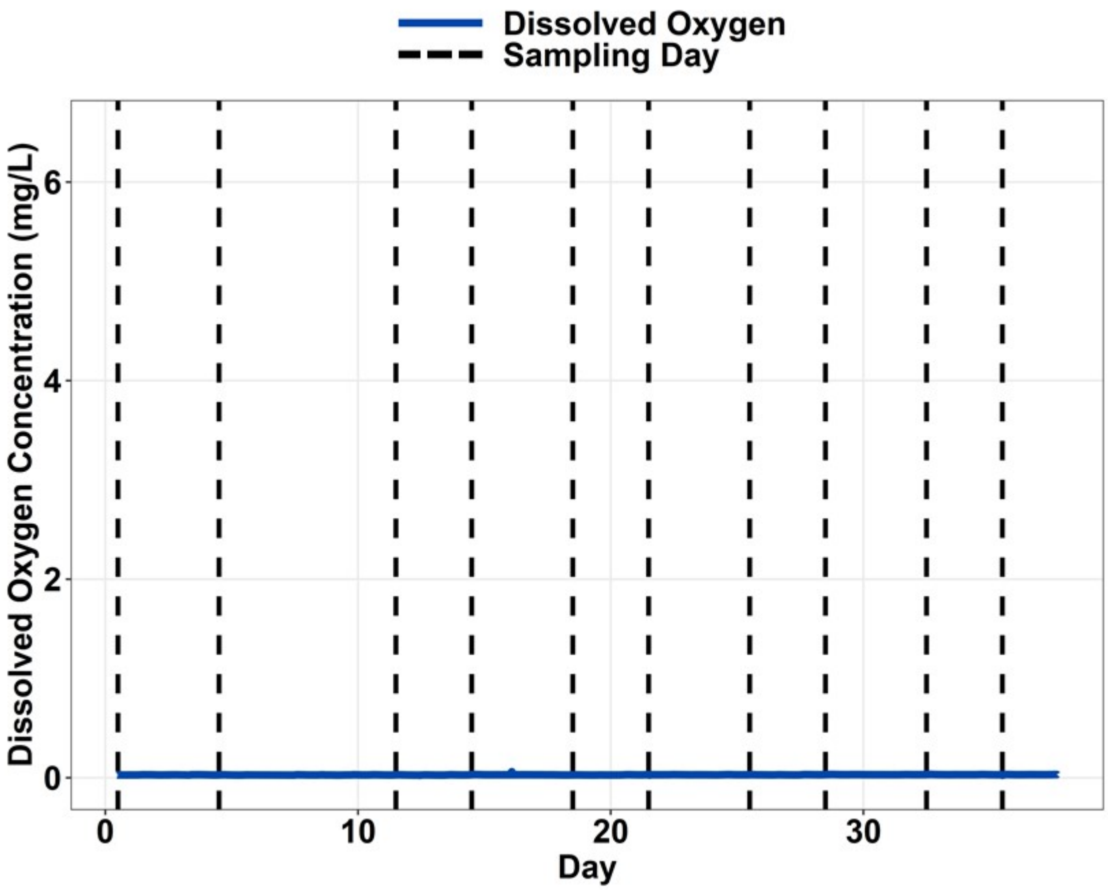


Figure S8: Dissolved oxygen concentrations from Experiment 1 at the upstream location of the continuously saturated reactor. Sampling days are indicated by vertical dashed lines.

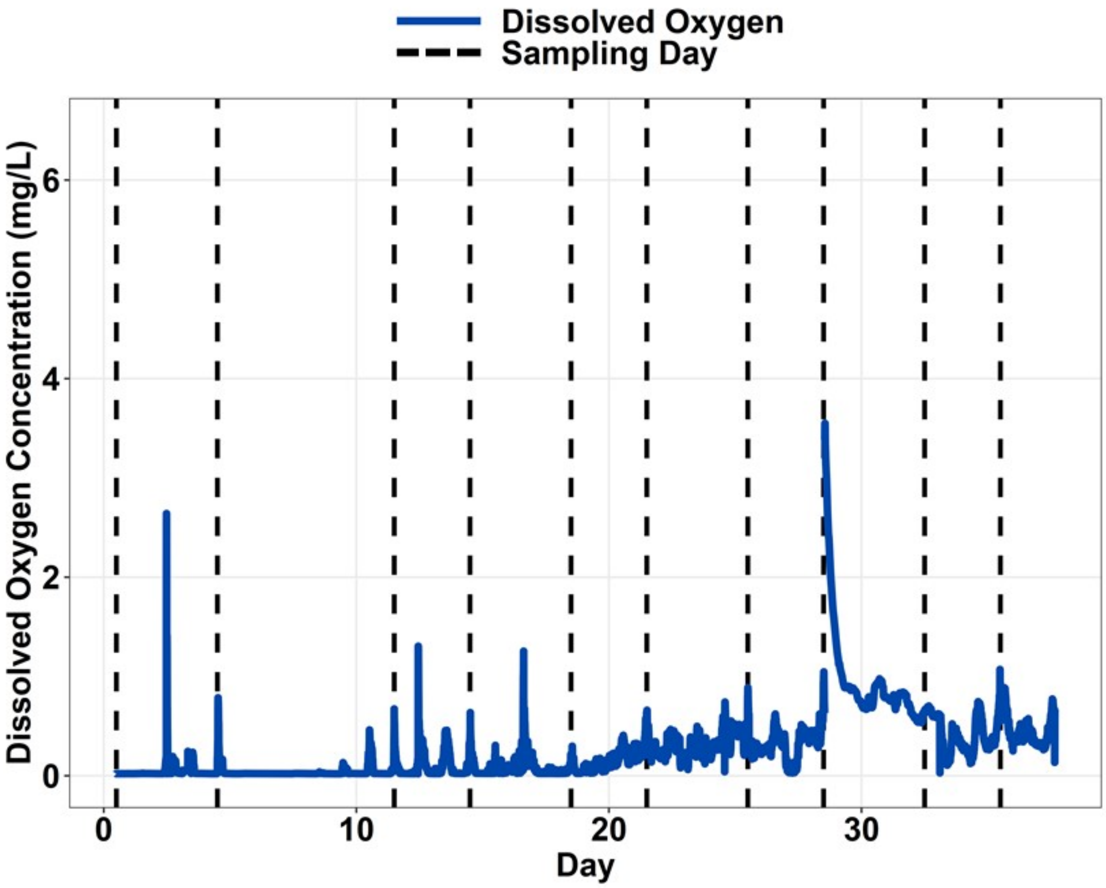


Figure S9: Dissolved oxygen concentrations from Experiment 1 at the downstream location of the continuously saturated reactor. Sampling days are indicated by vertical dashed lines.

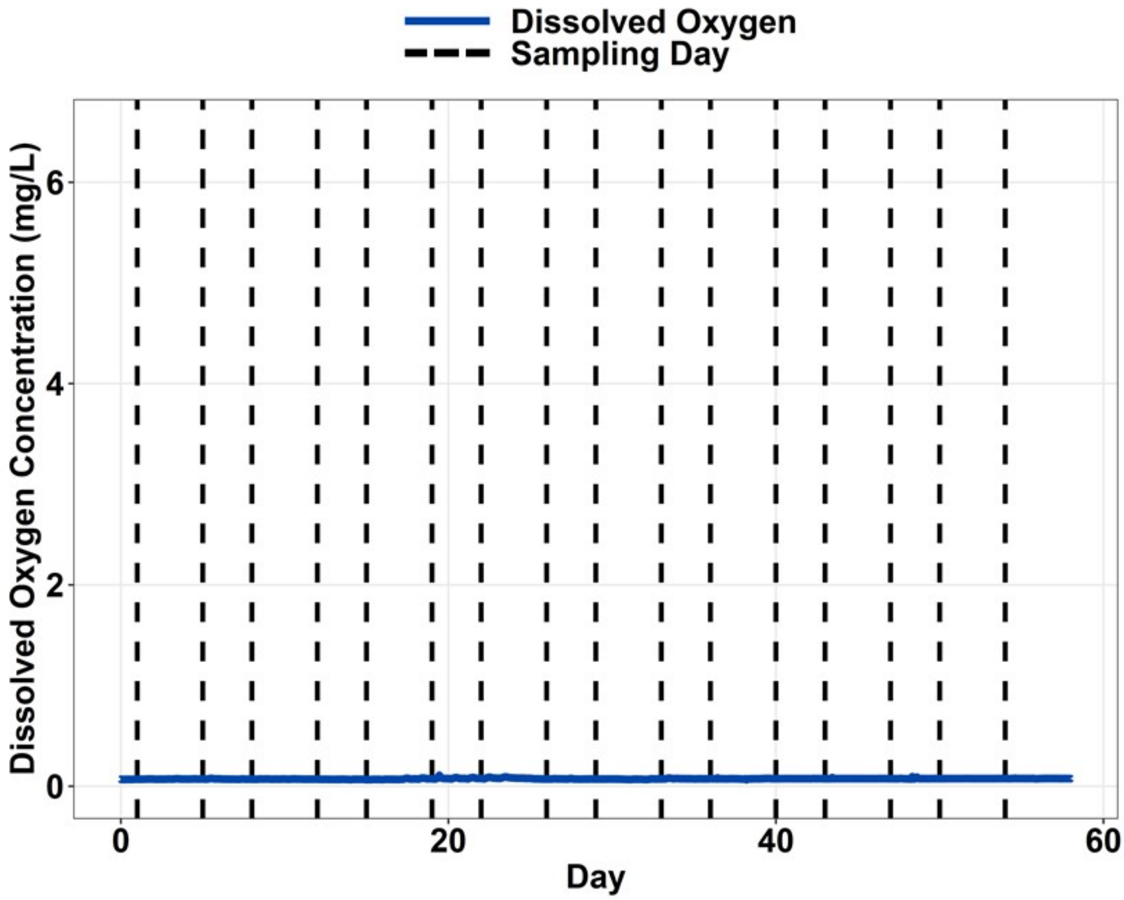


Figure S10: Dissolved oxygen concentrations from Experiment 2 at the upstream location of the continuously saturated reactor. Sampling days are indicated by vertical dashed lines.

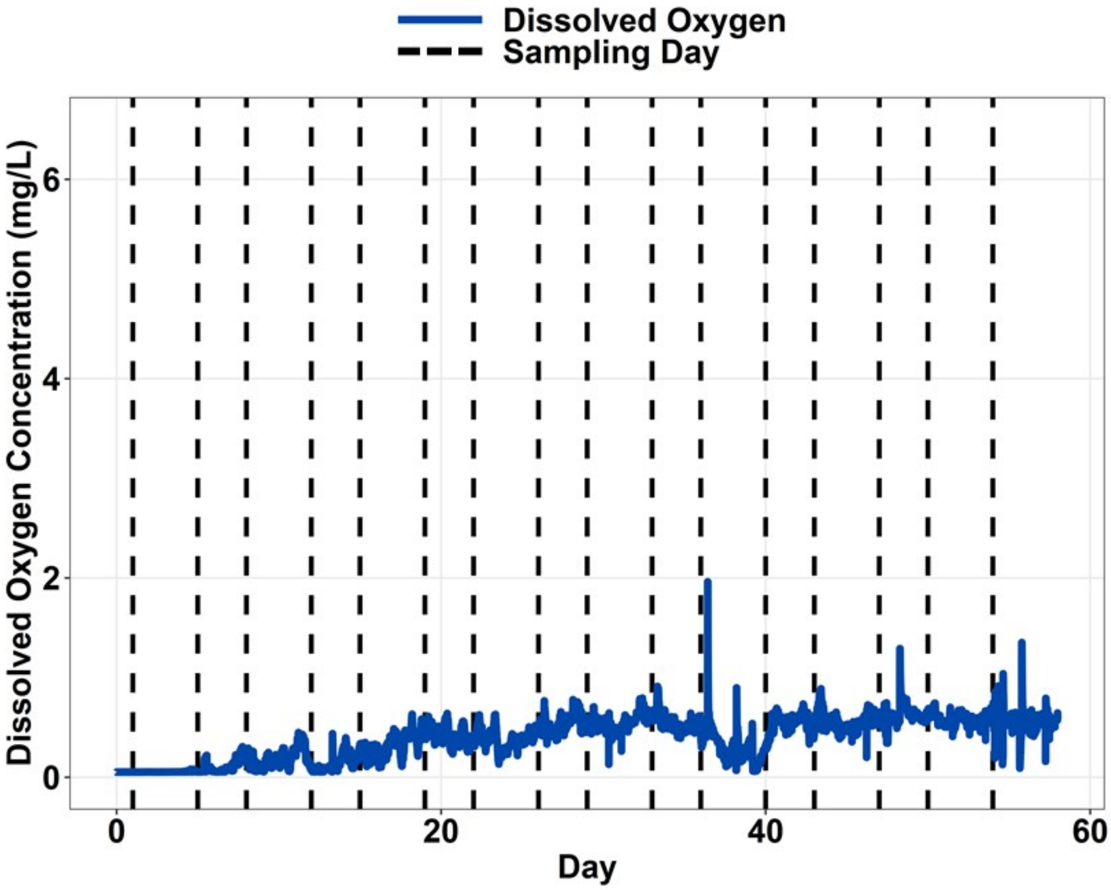
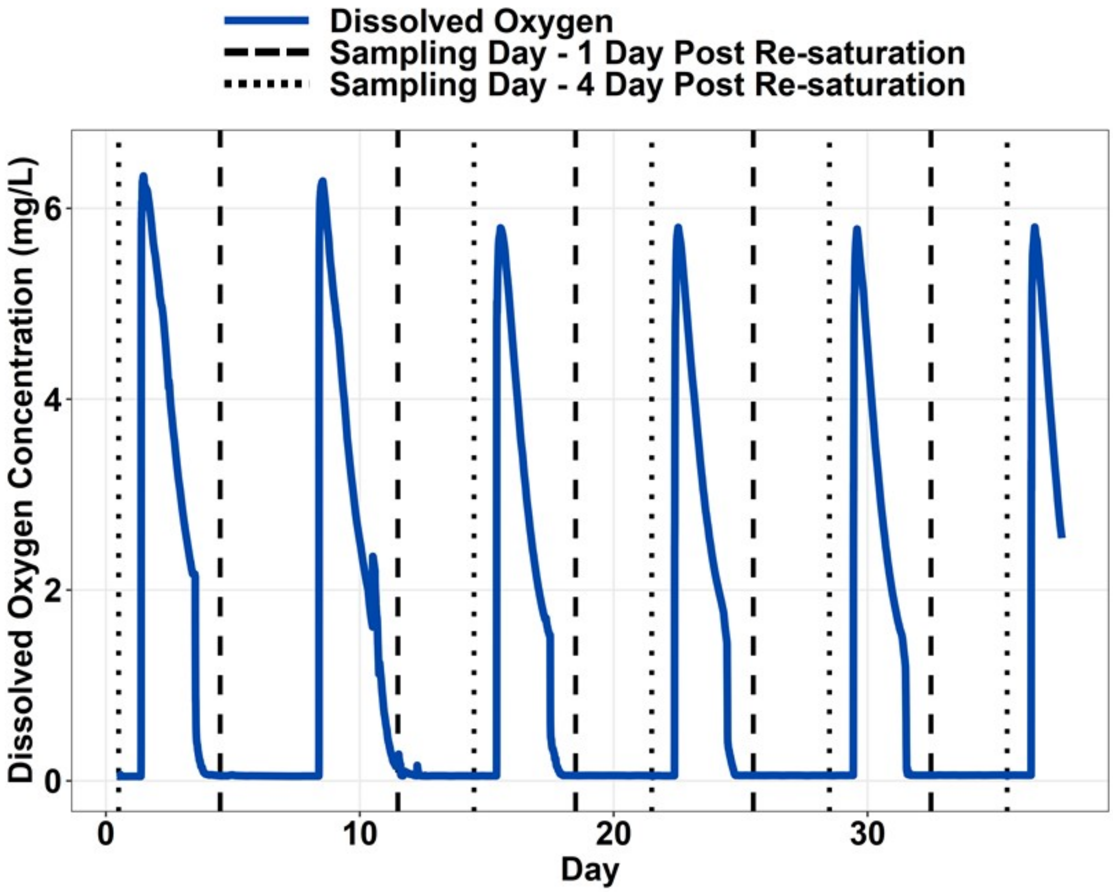
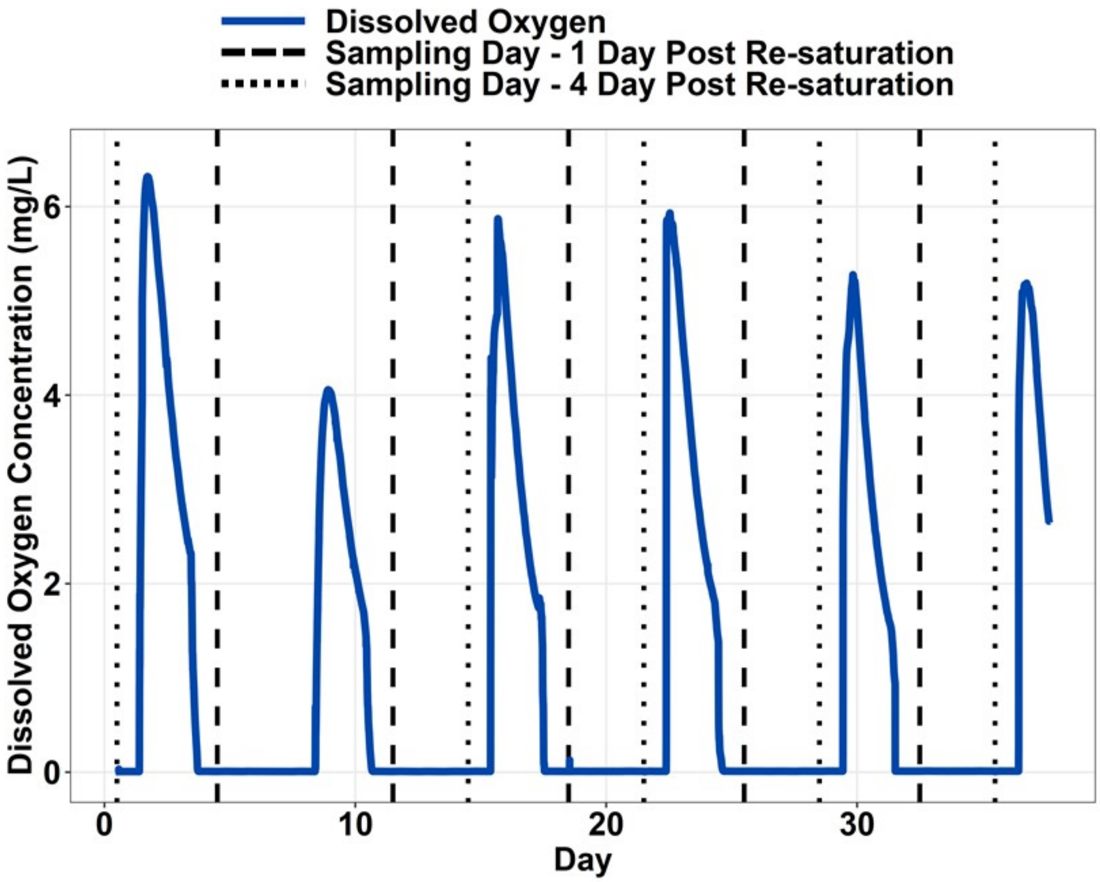


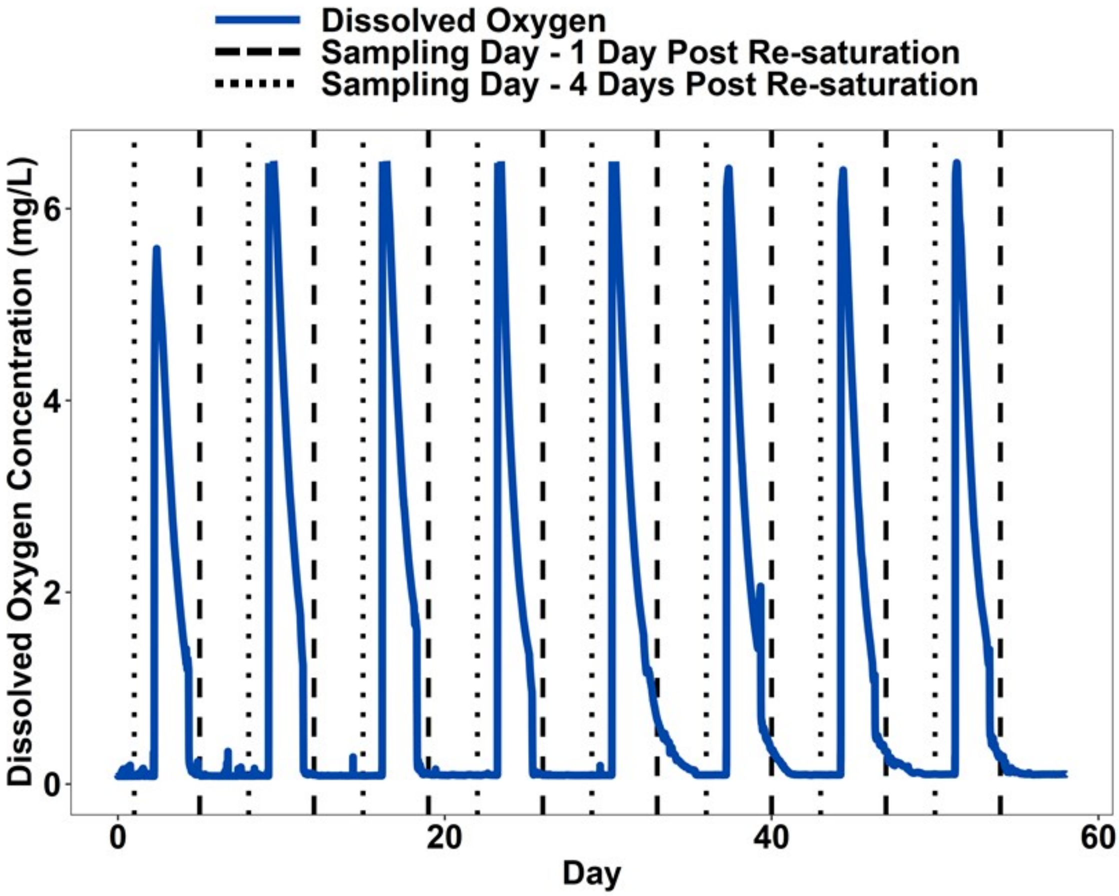
Figure S11: Dissolved oxygen concentrations from Experiment 2 at the downstream location of the continuously saturated reactor. Sampling days are indicated by vertical dashed lines.



S12: Dissolved oxygen concentrations from Experiment 1 at the upstream location of the drying-rewetting reactor. Sampling days are indicated by vertical dashed or dotted lines.



S13: Dissolved oxygen concentrations from Experiment 1 at the downstream location of the drying-rewetting reactor. Sampling days are indicated by vertical dashed or dotted lines.



S14: Dissolved oxygen concentrations from Experiment 2 at the upstream location of the drying-rewetting reactor. Sampling days are indicated by vertical dashed or dotted lines.

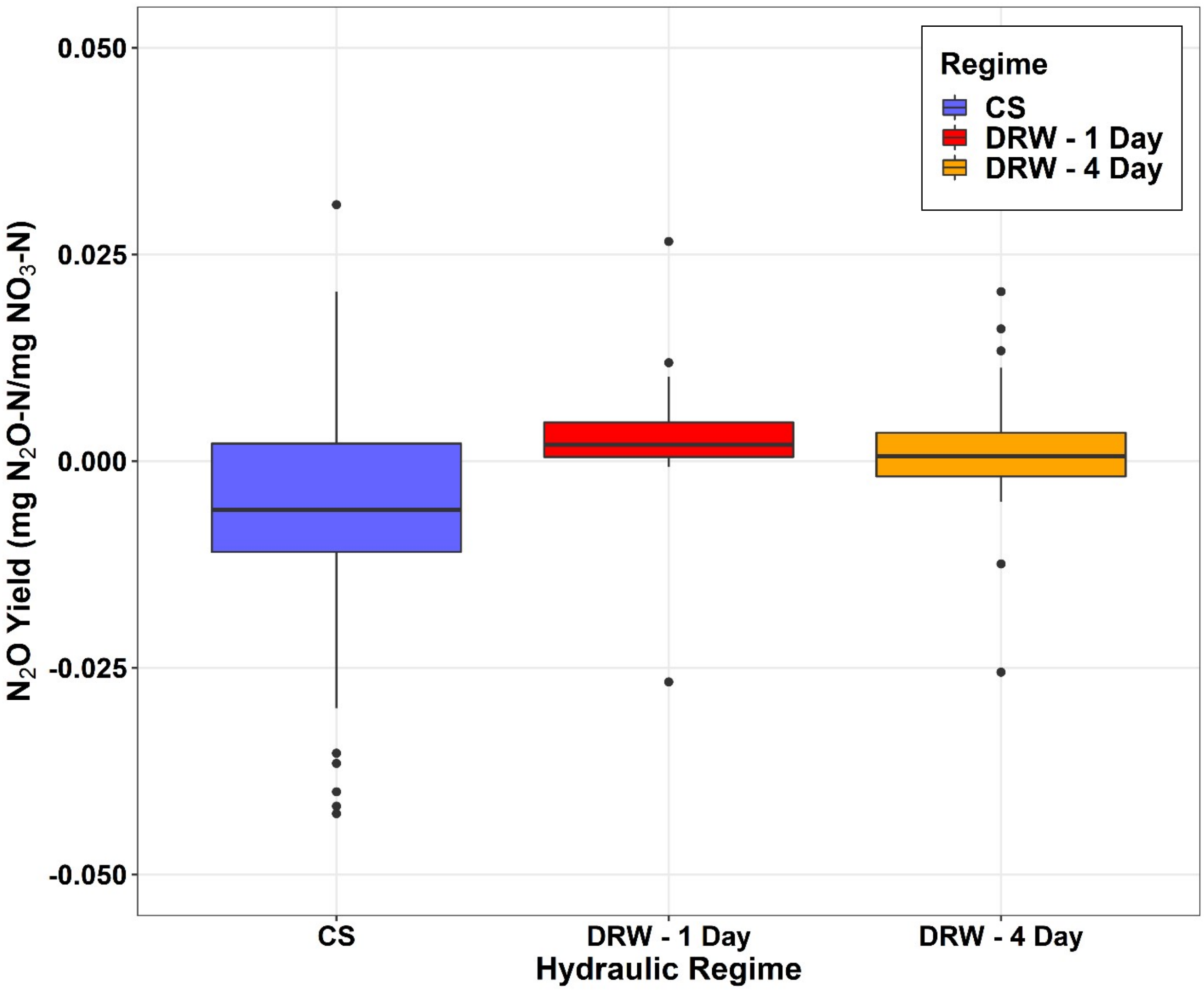


Figure S15: Effective N_2O yields from Experiment 2 in upstream sampling ports (ports located at 0.23, 0.36, and 0.55 m), as defined in Eq. 3. 15 datapoints are not shown for exceeding the y-axis limits.

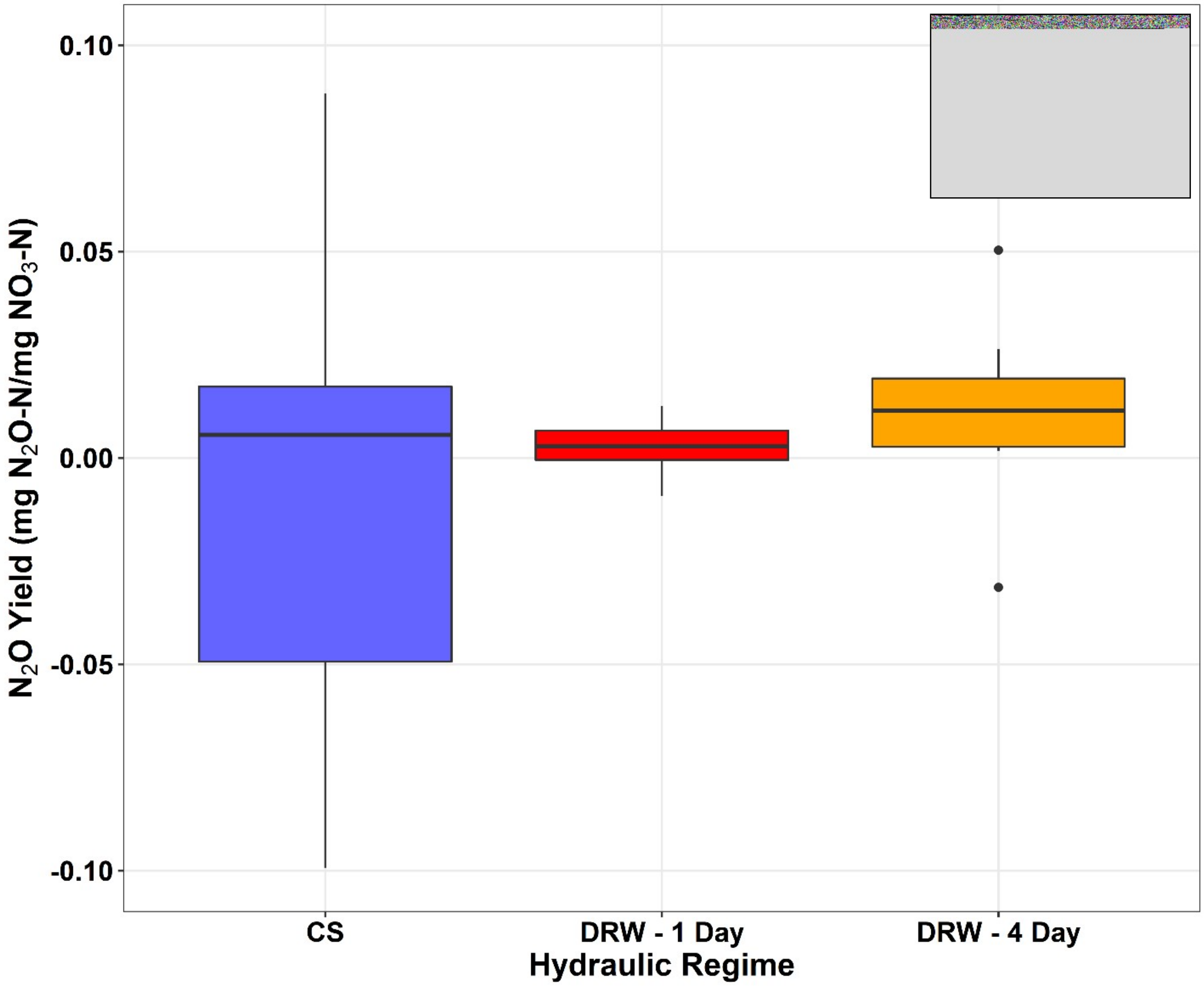


Figure S16: Effective N_2O yields from Experiment 1 in upstream sampling ports (ports located at 0.23, 0.36, and 0.55 m), as defined in Eq. 3. 9 datapoints are not shown for exceeding the y-axis limits.

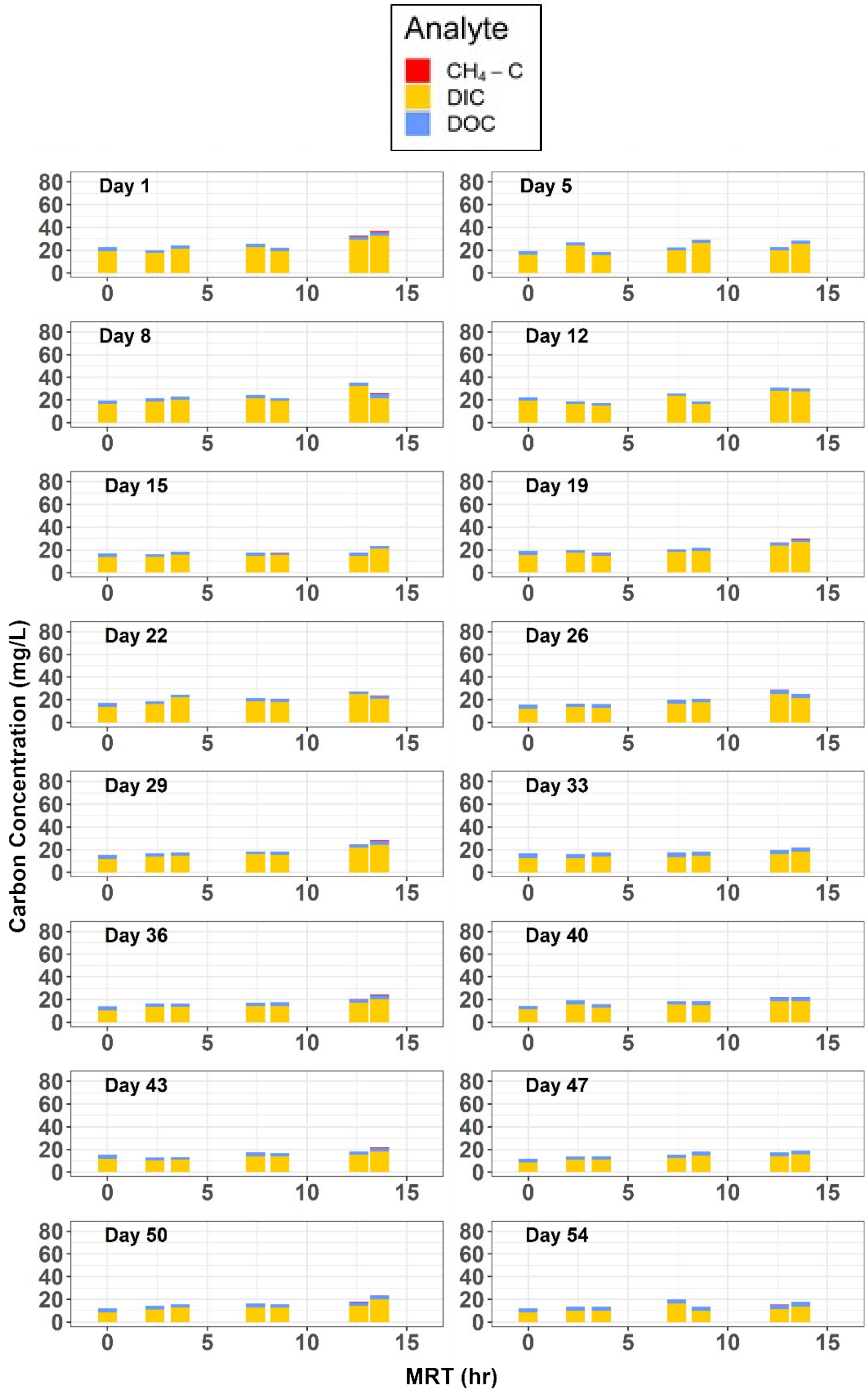


Figure S17: Profiles of methane (CH_4-C), dissolved inorganic carbon (DIC), and dissolved organic carbon (DOC) in continuously saturated (CS) reactor from Experiment 2. Each bar represents a discrete water sampling port, with mean residence time (MRT) determined as length along the reactor/porewater velocity.

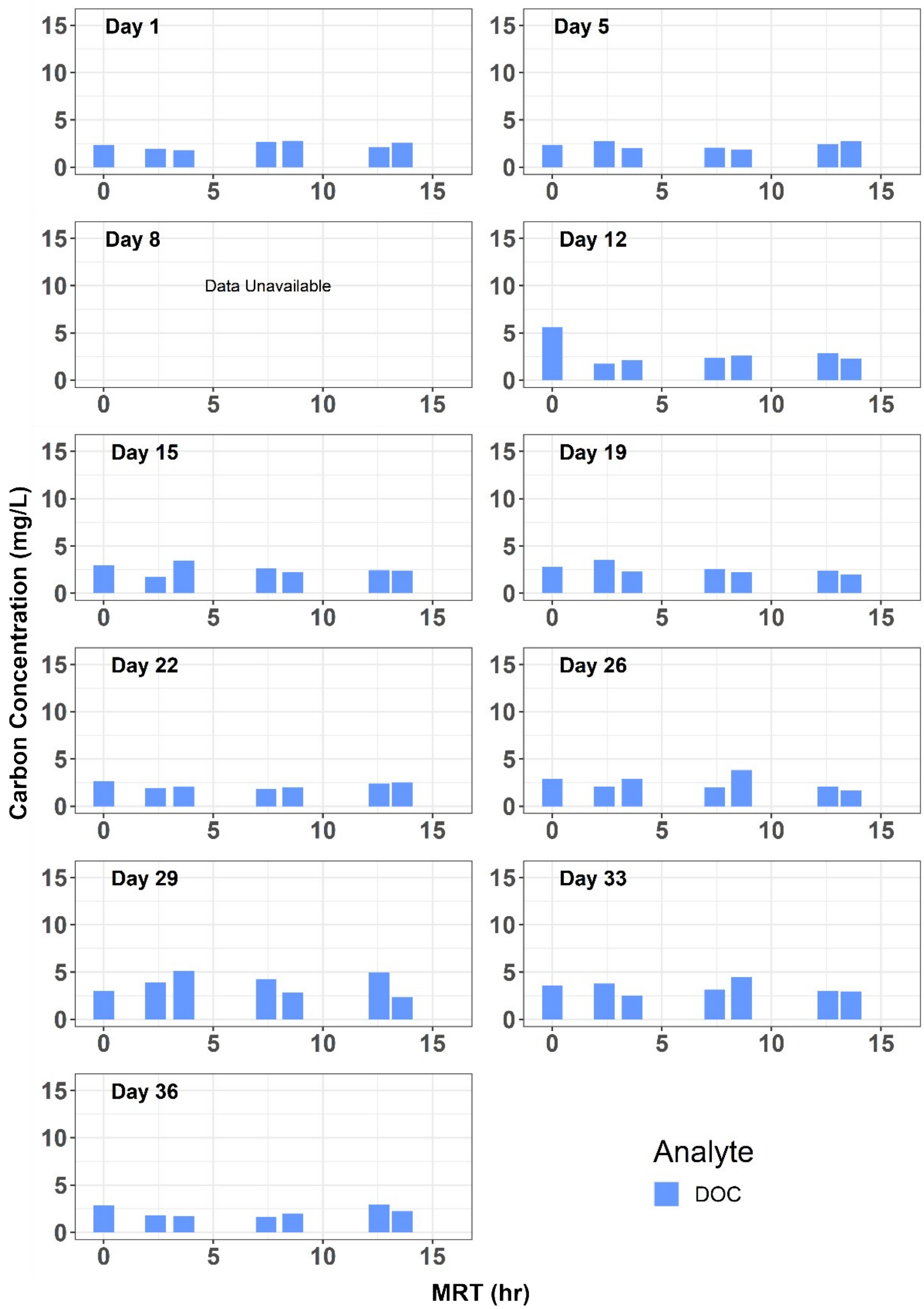


Figure S18: Profiles of dissolved organic carbon (DOC) in continuously saturated (CS) reactor from Experiment 1. Each bar represents a discrete water sampling port, with mean residence time (MRT) determined as length along the reactor/porewater velocity. Methane and dissolved inorganic carbon data were not available.

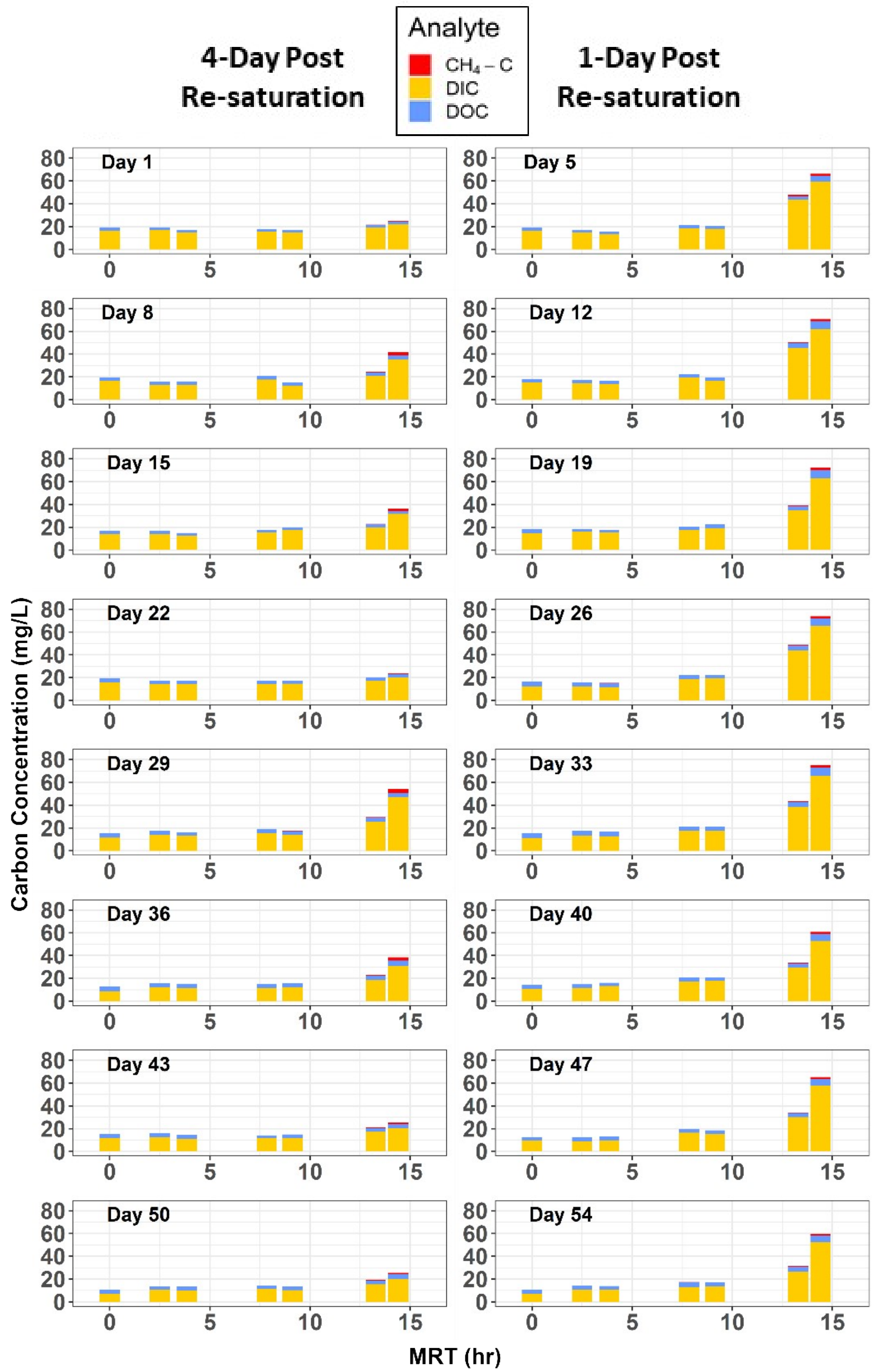


Figure S19: Profiles of methane (CH_4-C), dissolved inorganic carbon (DIC), and dissolved organic carbon (DOC) in drying-rewetting (DRW) reactor from Experiment 2. Each bar represents a discrete water sampling port, with hydraulic residence time (HRT) determined as length along the reactor/porewater velocity. The left hand column represents 4 days post re-saturation and the right hand column represents 1 day post re-saturation.

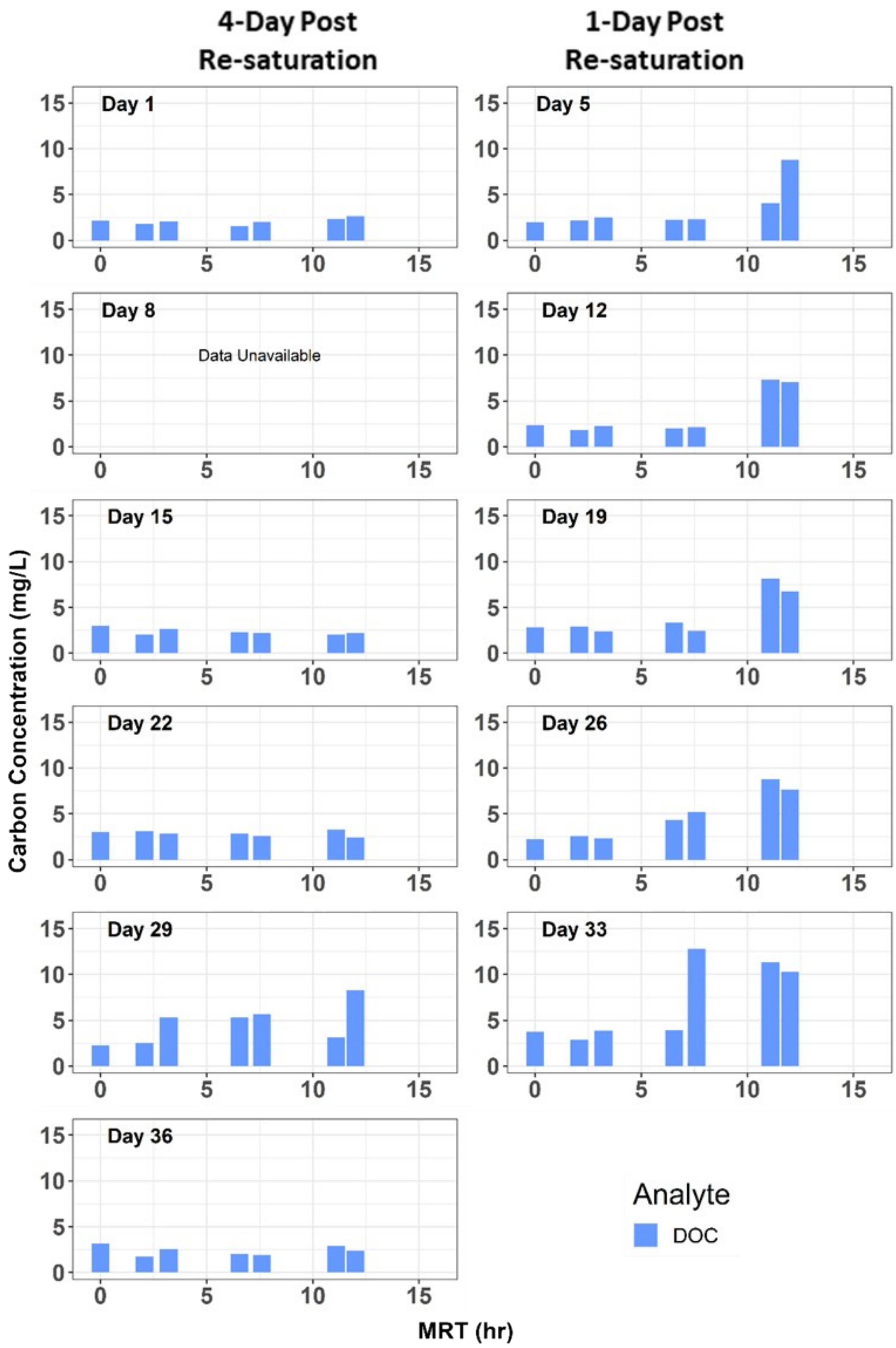


Figure S20: Profiles of dissolved organic carbon (DOC) in drying-rewetting (DRW) reactor from Experiment 1. Each bar represents a discrete water sampling port, with mean residence time (MRT) determined as length along the reactor/porewater velocity. Methane and dissolved inorganic carbon data were not available. The left hand column represents 4 days post re-saturation and the right hand column represents 1 day post re-saturation.

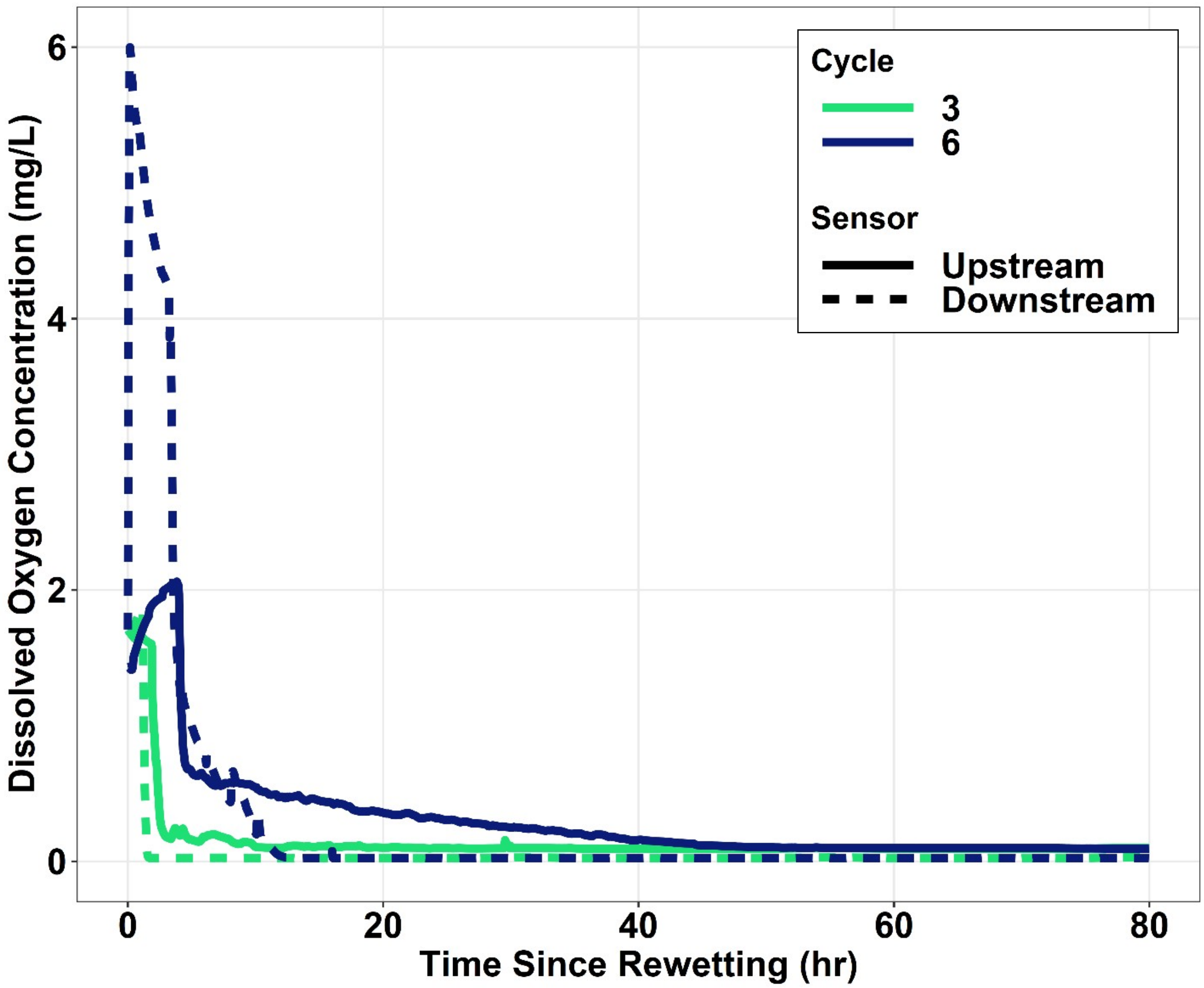


Figure S21: Extended duration dissolved oxygen concentrations of porewater immediately following rewetting during drying-rewetting Cycles 3 and 6.

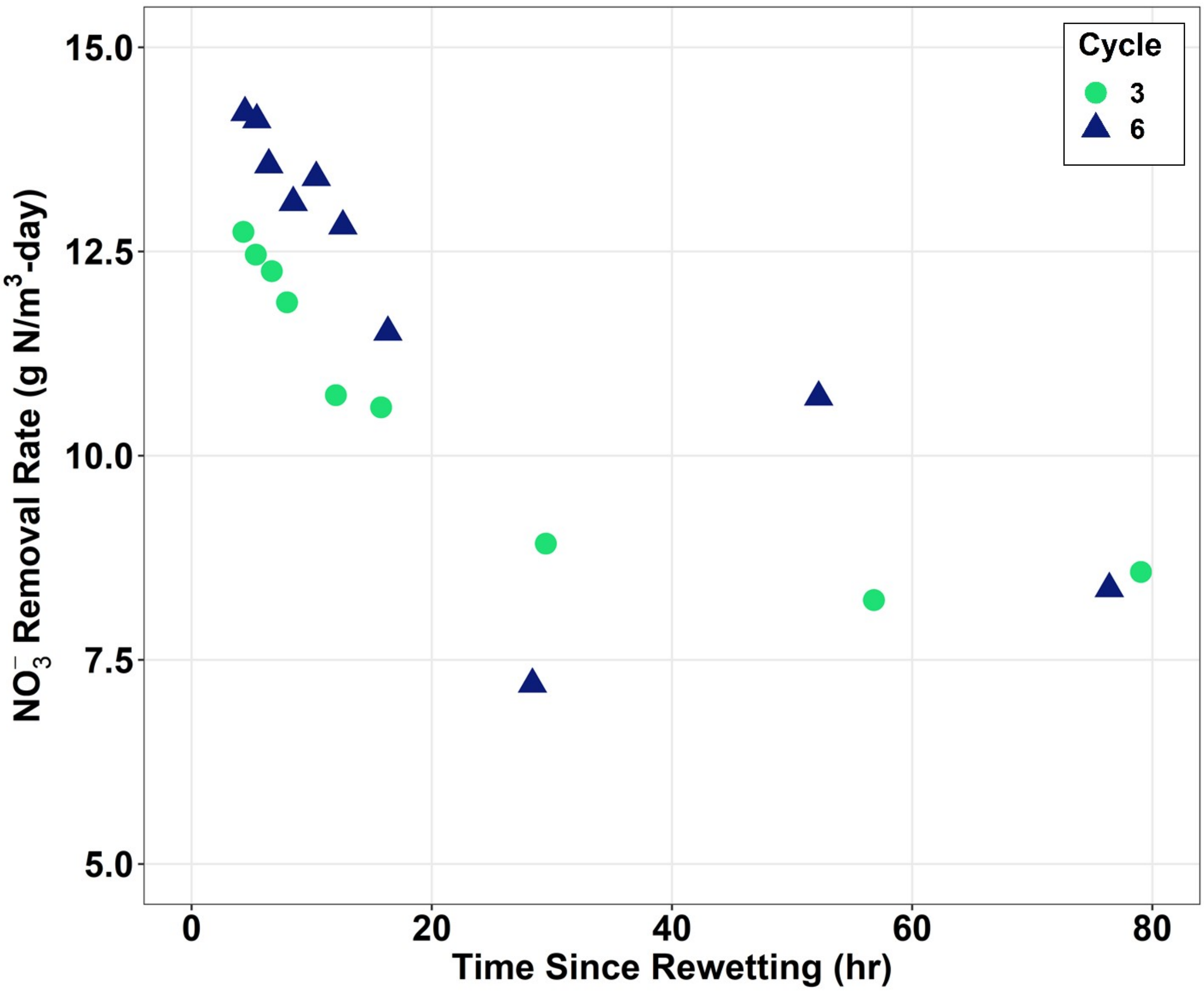


Figure S22: Extended duration nitrate removal rates in porewater immediately following rewetting during drying-rewetting Cycles 3 and 6.

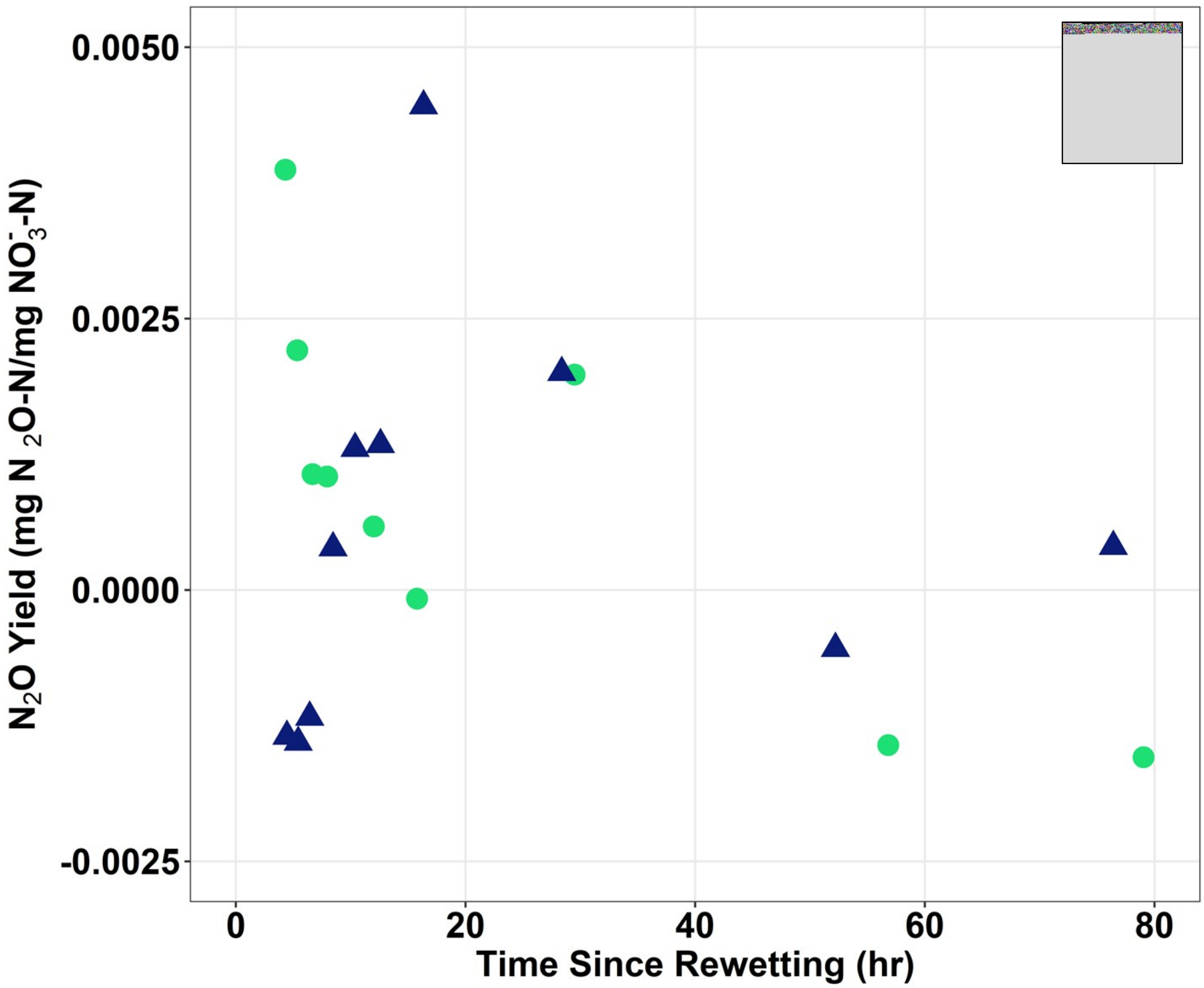


Figure S23: Extended duration nitrous oxide yields in porewater immediately following rewetting during drying-rewetting Cycles 3 and 6.

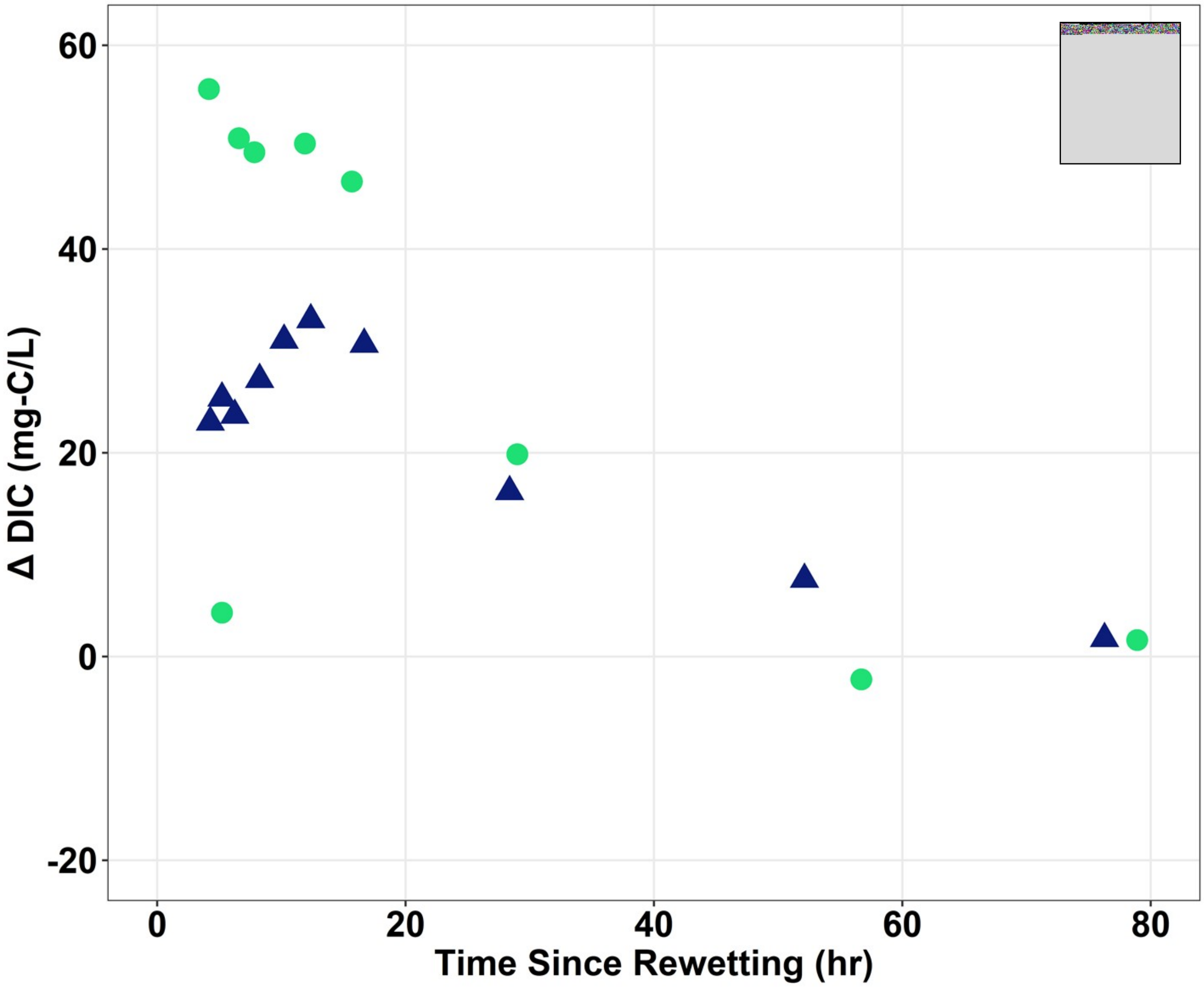


Figure S24: Extended duration of shifts in porewater dissolved inorganic carbon immediately following rewetting during drying-rewetting Cycles 3 and 6.

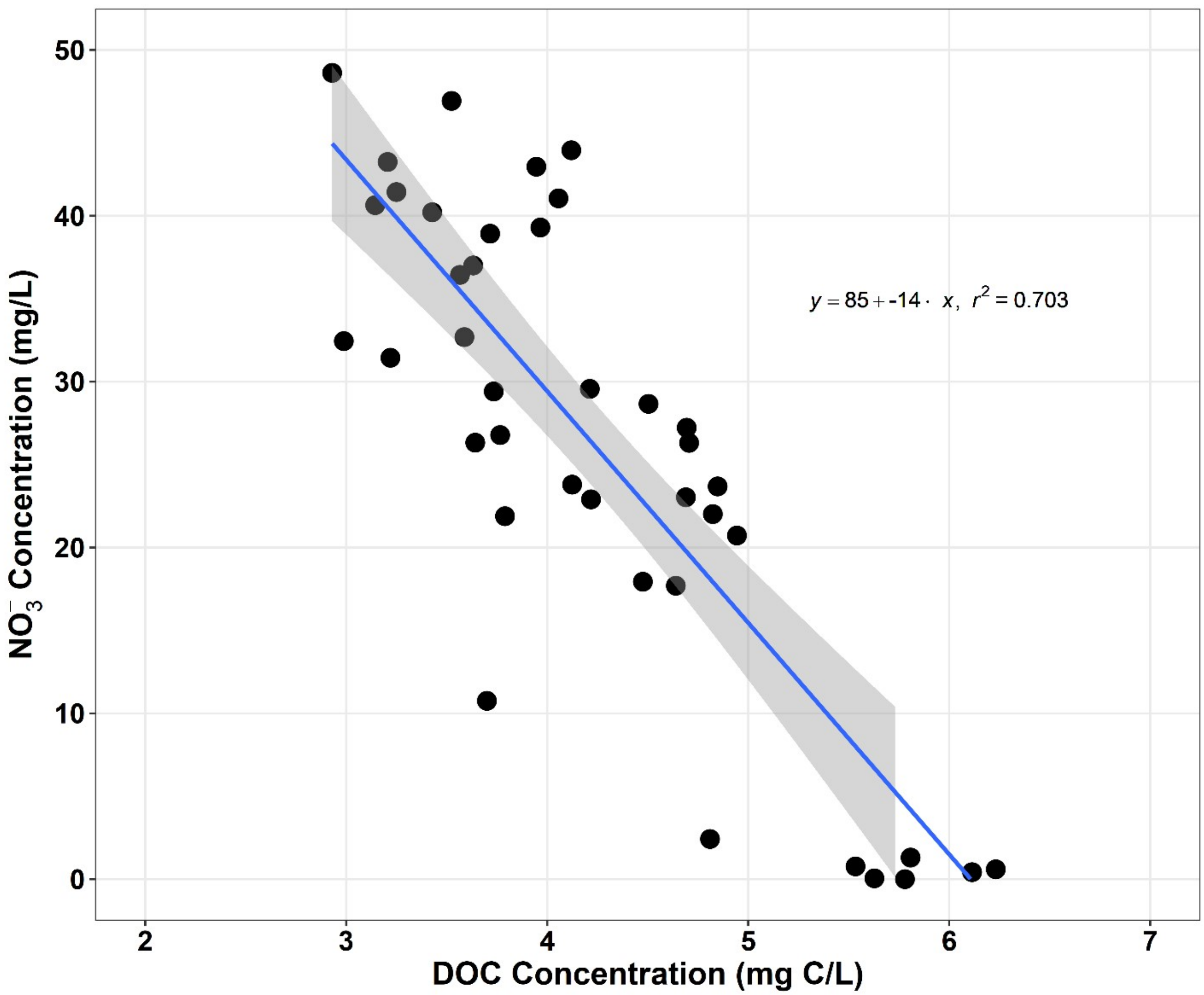


Figure S25: Correlation between nitrate (NO_3^-) and dissolved organic carbon (DOC) porewater concentrations from high frequency sampling during Cycle 6 of Experiment 2. Trendline was generated using a linear model. The grey area represents the 95% confidence interval of the linear model.

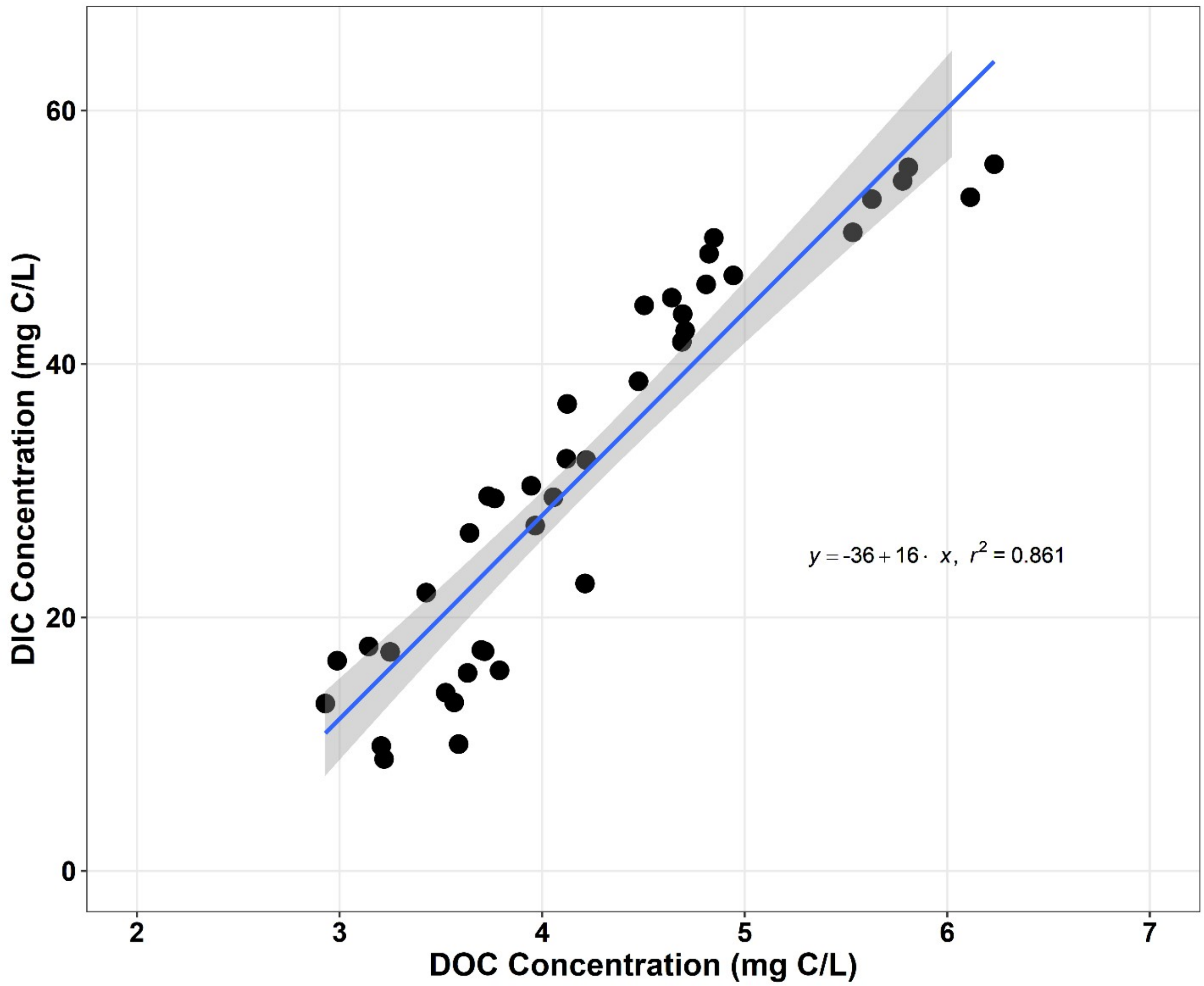


Figure S26: Correlation between dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC) porewater concentrations from high frequency sampling during Cycle 6 of Experiment 2. Trendline was generated using a linear model. The grey area represents the 95% confidence interval of the linear model.

High Frequency Carbon Chemistry Statistical Analysis

ANOVA assumptions of homogeneity of variance and normality were assessed via Levene's Test and Shapiro-Wilk Test, respectively. Analysis of both the DOC and ΔDIC data determined that the assumption of homogeneity of variances was not violated, however the assumption of normality was violated, and a Kruskal-Wallis rank sum test was implemented. Results suggested a significant difference between the average DOC concentrations for the high frequency cycles ($p < 0.001$), but not between the average ΔDIC concentrations for the high frequency cycles ($p = 0.064$). A post hoc Wilcoxon rank sum test was utilized for pairwise-comparisons of the average DOC by high frequency cycle. Data visualizations are available as Figures S31 and S32. A summary of resulting p-values is available as Table S2.

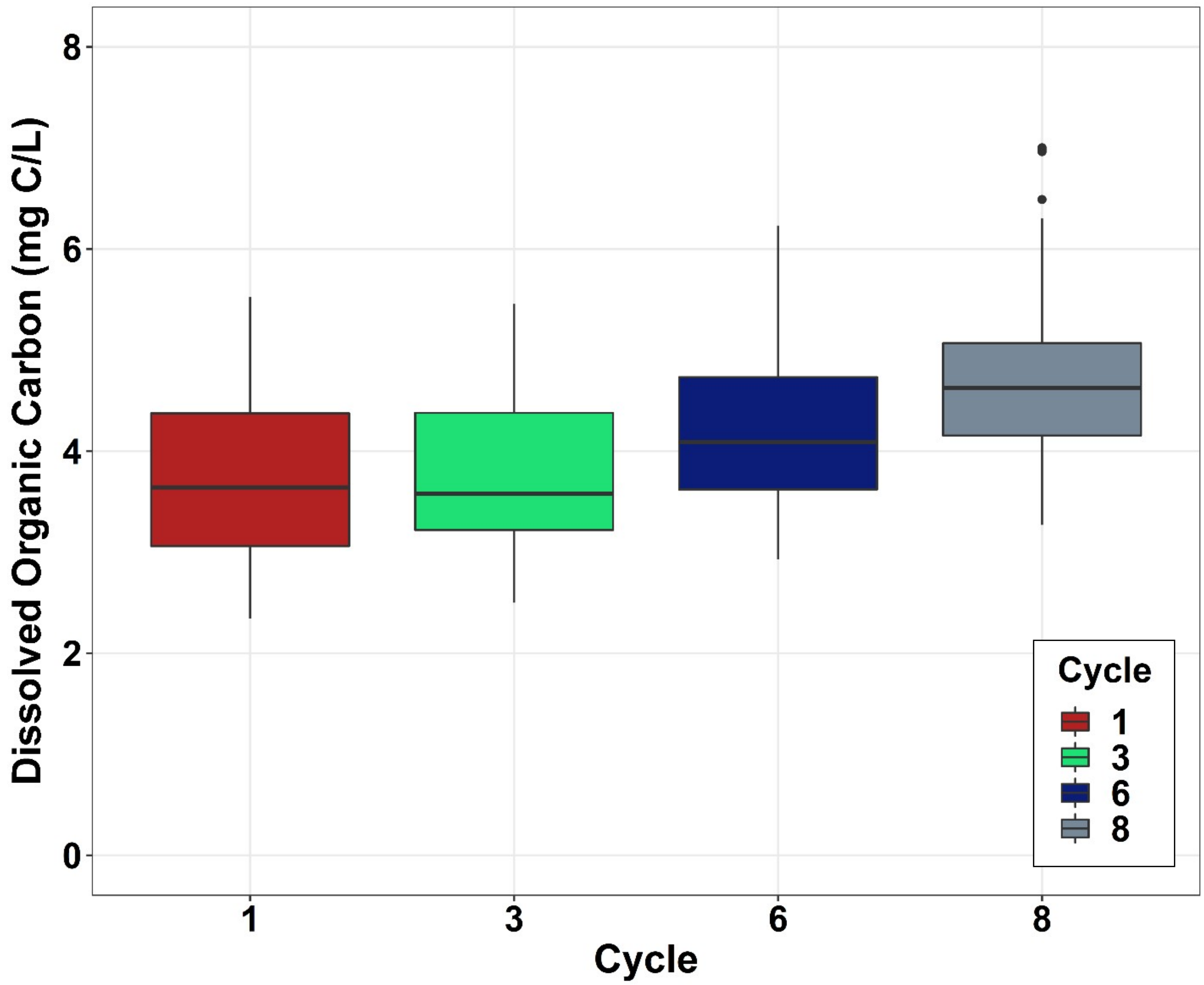


Figure S27: Dissolved organic carbon porewater concentrations during high frequency sampling events in Experiment 2.

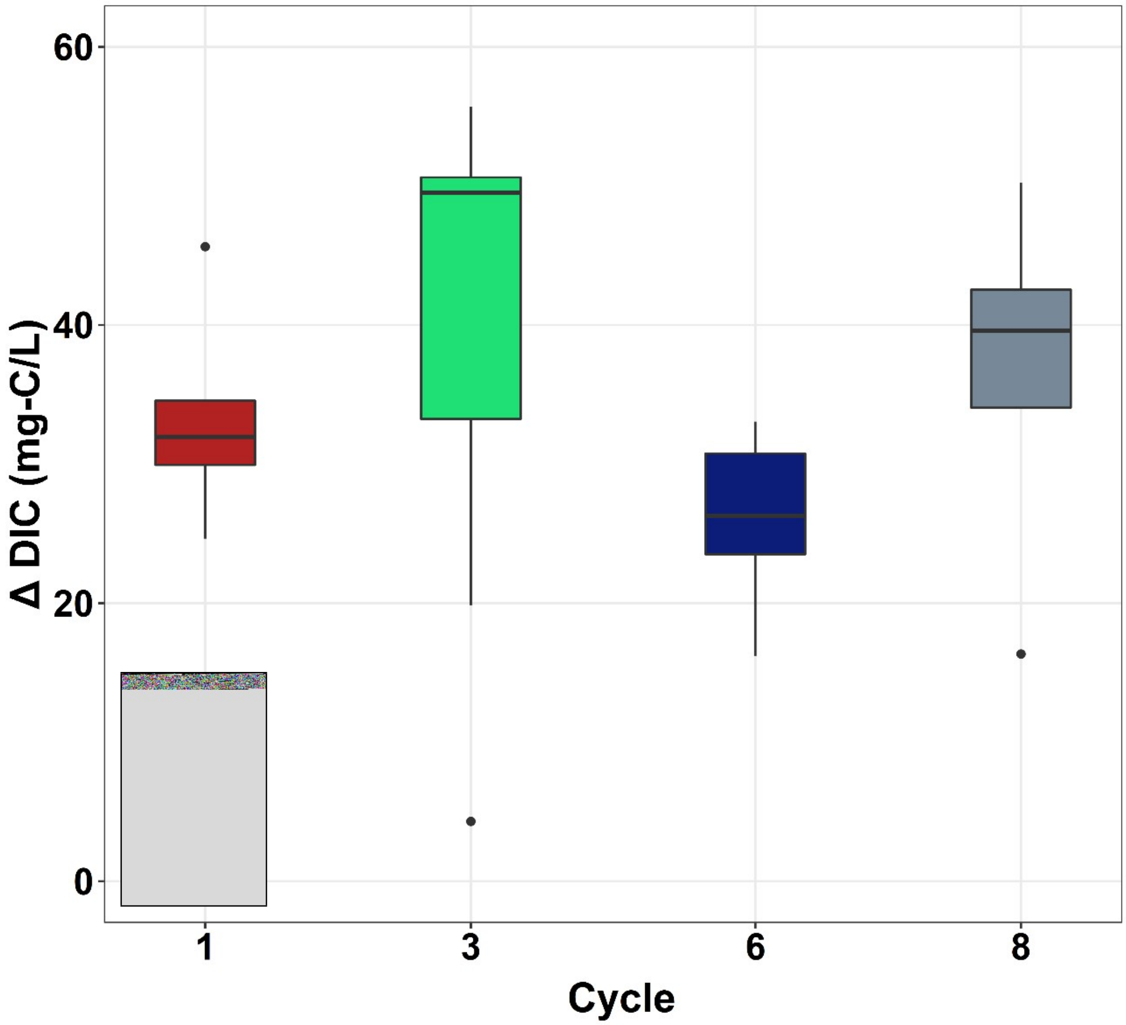


Figure S28: Shifts in dissolved inorganic carbon porewater concentrations during high frequency sampling events in Experiment 2.

Table S3: High Frequency Carbon Chemistry Statistical Analysis – Reported p-values

Cycle Comparison	Examined Metric
	DOC
1-3	0.792
1-6	*0.039*
1-8	*<0.001*
3-6	0.057
3-8	*<0.001*
6-8	*0.031*