Introduction

The "Supplementary Material" includes a total of six tables (Tables S1–S6) and two figures (Figures S1–S2). Table S1 complements Table 4 of the manuscript by showing absolute values of the carbon budget terms (rather than deviations from the Control experiment). Table S2 and Figures S1–S2 provide a model-data comparison for the key variables of the model. Tables S3–S6 document the biogeochemical module used in the study. Table S3 lists the prognostic equation in the water column for each state variable. Table S4 lists the sources and sinks at the surface and bottom boundaries of the ocean model. Table S5 lists the functions used in the prognostic equations. Table S6 lists the biogeochemical parameters used in the numerical simulations.

Table S1

Table S1: Absolute values of the carbon budget[a] for the six numerical experiments (see Methods)

	Ctrl.exp.	1900_{CO2}	1900_{T}	1900_{N}	1900_{C}	1900_{all}
River DIC	1169	1169	1169	1169	850	850
Export DIC	935	884	948	966	635	630
Riv−Exp.DIC	234	285	221	203	215	220
Net air-sea	34	−20	57	−36	76	−8
∂DIC/∂t	9	6	6	9	4	4
Production	4748	4747	4496	4256	4746	4025
Respiration	4489	4489	4224	4098	4459	3816
NEP	259	258	272	158	287	209
River TOC	507	507	507	507	451	451
Export TOC	545	545	549	499	524	483
Riv−Exp.TOC	−38	−38	−42	+8	−73	−32
Burial	221	221	230	166	216	177
∂TOC/∂t	−1	−1	−1	1	−1	0

[a]Units: Gg-C yr^{-1}. The values are averaged over the period of the simulation and rounded to the nearest integer.

Table S2 and Figures S1–S2

Table S2: Evaluation of the Control experiment (years 2000–2014) using data collected during the same period by the Water Quality Monitoring Program of Chesapeake Bay (*USEPA*, 2012). The evaluation is repeated for depths above and below 10 m (approximately the position of the pycnocline along the Bay's main stem). NO3 is nitrate, POC is Particulate Organic Carbon, STD is STandard Deviation, RMSD is Root Mean Squared Deviation, and N_{obs} is the number of measurements for each variable. The model bias is computed as $\text{Mean}_{mod} - \text{Mean}_{obs}$. The unbiased RMSD is computed as $\sqrt{N^{-1}\sum\left[(Mod - \text{Mean}_{mod}) - (Obs - \text{Mean}_{obs})\right]^2}$ (*Jolliff et al.*, 2009).

Variable (units)	Mean ± STD model	Mean ± STD observations	Bias	Unbiased RMSD	N_{obs}
Temp. above 10 m (°C)	18.4 ± 8.2	17.7 ± 8.1	0.7	1.3	68717
Temp. below 10 m (°C)	17.5 ± 7.8	16.4 ± 7.9	1.1	1.2	21094
Salin. above 10 m (psu)	17.4 ± 6.5	15.7 ± 6.8	1.6	2.1	68715
Salin. below 10 m (psu)	20.9 ± 3.4	18.8 ± 3.8	2.2	1.9	21116
O_2 above 10 m (mg L^{-1})	8.3 ± 2.6	8.4 ± 2.5	−0.1	1.6	68595
O_2 below 10 m (mg L^{-1})	5.3 ± 3.2	5.3 ± 3.7	0.1	1.7	21087
NO3 above 10 m (mg L^{-1})	0.15 ± 0.27	0.17 ± 0.30	−0.02	0.16	16831
NO3 below 10 m (mg L^{-1})	0.10 ± 0.11	0.06 ± 0.09	0.04	0.09	2790
POC above 10 m (mg L^{-1})	1.51 ± 0.66	1.17 ± 0.72	0.34	0.79	16694
POC below 10 m (mg L^{-1})	1.18 ± 0.53	0.85 ± 0.60	0.33	0.58	2787

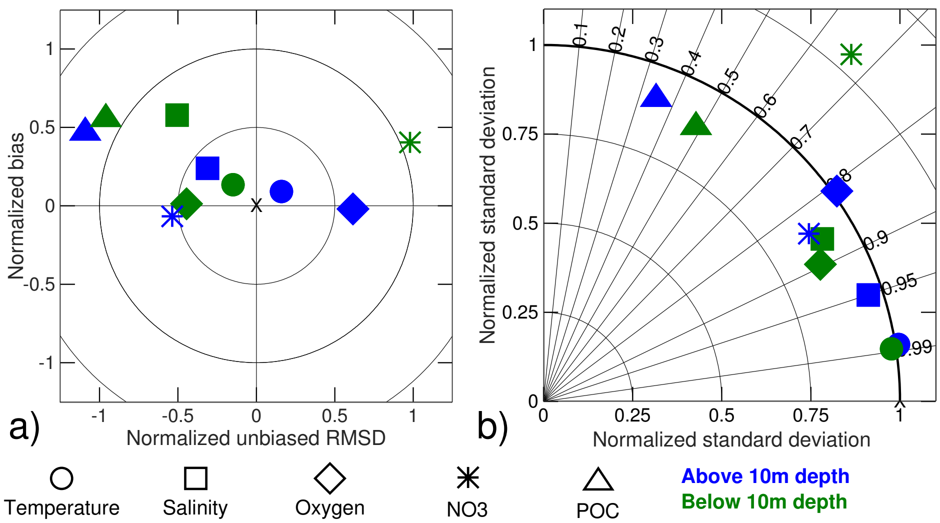

Figure S1: Evaluation of the Control experiment (years 2000–2014) based on (a) Target and (b) Taylor diagrams (see *Jolliff et al.*, 2009, for their interpretation). The evaluation is repeated for depths above and below 10 m (approximately the position of the pycnocline along the Bay's main stem). All the data were collected during 2000–2014 by the Water Quality Monitoring Program of Chesapeake Bay (*USEPA*, 2012) and are further described in Table S2 and Figure S2.

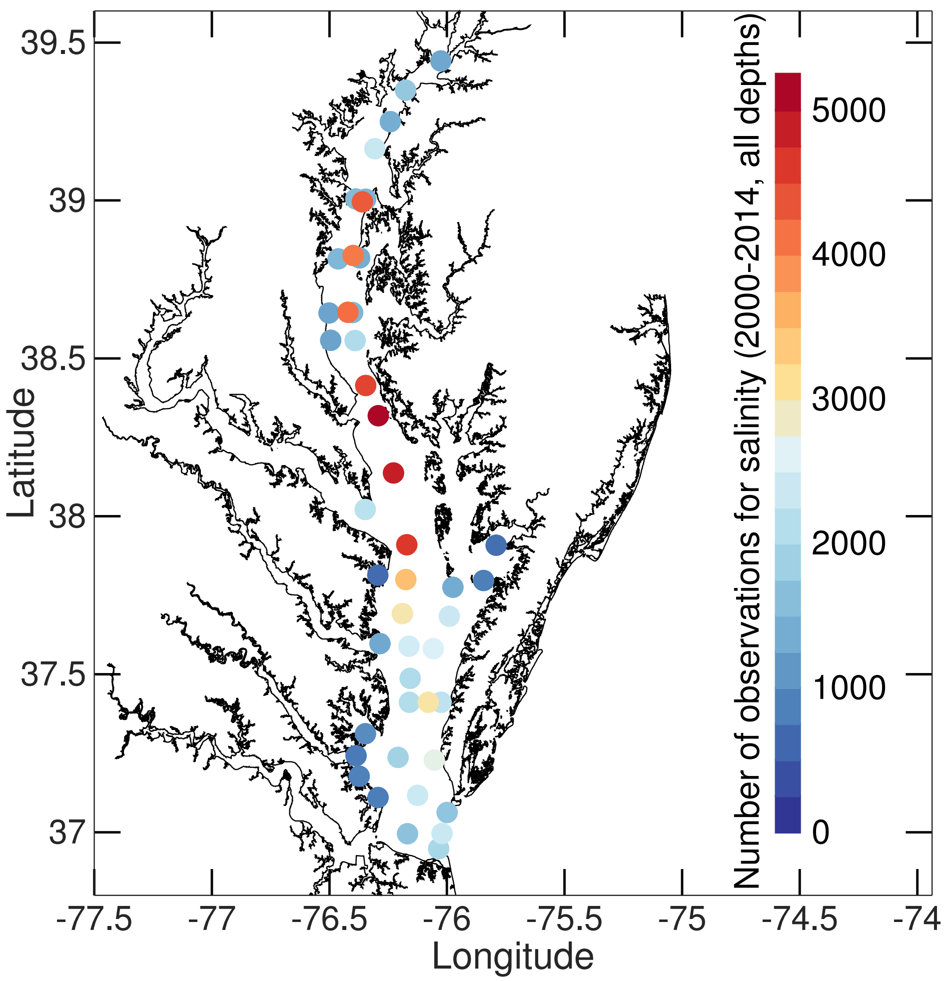

Figure S2: Location of the monitoring stations (circles) used in the evaluation of the Control experiment (years 2000–2014). The circles are colored according to the number of salinity data points available for each station (total: 89831). Other variables have a similar spatial distribution.

Table S3

Table S3: State variable equations for the water column of the biogeochemical module. Advective and diffusive terms are omitted for simplicity. Refractory variables are conservative by definition and also omitted. The surface/bottom boundary conditions are listed in Table S4. The functions and parameters used in the table equations are further detailed in Tables S5 and S6 (respectively). Arrows indicate fluxes between variables. Nitrogen variables have units of mmol-N m^{-3}, carbon variables are in mmol-C m^{-3}, total alkalinity is in meq m^{-3}, oxygen is in mmol-O2 m^{-3}, chlorophyll-a is in mg m^{-3}, and t is in days.

Var. (Symbol)	Term	Equation
Nitrate	Rate of change =	$\partial NO3/\partial t =$
($NO3$)	− Phyto uptake ($\rightarrow P$)	$-\mu\, L_I\, L_{NO3}\, P$
	+ Nitrification ($\leftarrow NH4$)	$+n\, f_{NTR}\, NH4$
	− water column denitrif. ($\rightarrow N_2$)	$-\eta_{DNF}\, f_{DNF}\, \exp(\psi_{resp}T)$
		$\times[\,(1-\delta_N)\,(r_{SD}\, SD + r_{LD}\, LD)$
		$+r_{DON}\, DON_{SL}]$
Ammonium	Rate of change =	$\partial NH4/\partial t =$
($NH4$)	− Phyto uptake ($\rightarrow P$)	$-\mu\, L_I\, L_{NH4}\, P$
	+ Exudation ($\leftarrow P$)	$+\omega\, (f_{NTR} + f_{DNF})\, \mu\, L_I\, (L_{NO3} + L_{NH4})\, P$
	− Nitrification ($\rightarrow NO3$)	$-n\, f_{NTR}\, NH4$
	+ Sloppy feeding ($\leftarrow P$)	$+(1-\beta)\,\lambda\,(1-\delta_N)\, g\, Z$
	+ Excretion ($\leftarrow Z$)	$+l_E\, \beta\, P^2\, (K + P^2)^{-1}\, Z$
	+ Basal metabolism ($\leftarrow Z$)	$+l_{BM}\, Z$
	+ Remineral. ($\leftarrow SD + LD + DON_{SL}$)	$+(f_{NTR} + f_{DNF})\, \exp(\psi_{resp}T)$
		$\times[\,(1-\delta_N)\,(r_{SD}\, SD + r_{LD}\, LD)$
		$+r_{DON}\, DON_{SL}\,]$
Phytoplankton	Rate of change =	$\partial P/\partial t =$
(P)	+ Phyto uptake ($\leftarrow NH4 + NO3$)	$+\mu L_I (L_{NO3} + L_{NH4}) P$
	− Exudation ($\rightarrow DON_{SL} + NH4$)	$-\mu\, L_I\, (L_{NO3} + L_{NH4})\, P$
		$\times[\,\gamma_P + \omega\, (f_{NTR} + f_{DNF})\,]$
	− Grazing assimilation ($\rightarrow Z$)	$-\beta\, g\, Z$
	− Fecal pellet from grazing($\rightarrow LD$)	$-(1-\beta)\,(1-\lambda)\, g\, Z$
	− Sloppy feeding ($\rightarrow DON_{SL}$)	$-(1-\beta)\,\lambda\,\delta_N\, g\, Z$
	− Sloppy feeding ($\rightarrow NH4$)	$-(1-\beta)\,\lambda\,(1-\delta_N)\, g\, Z$
	− Mortality ($\rightarrow SD$)	$-m_P\, P$
	− Aggregation ($\rightarrow LD$)	$-\tau\,(SD + P)\, P$
	− Sinking ($\rightarrow$ sediment)	$-w_P\, \partial P/\partial z$
Zooplankton	Rate of change =	$\partial Z/\partial t =$
(Z)	+ Grazing assimilation ($\leftarrow P$)	$+\beta g Z$
	− Excretion ($\rightarrow NH4$)	$-l_E\, \beta\, P^2 (K + P^2)^{-1}\, Z$
	− Mortality ($\rightarrow SD$)	$-m_Z\, Z^2$
	− Basal Metabolism ($\rightarrow NH4$)	$-l_{BM}\, Z$
Small	Rate of change =	$\partial SD/\partial t =$
Detrital	+ Mortality ($\leftarrow P$)	$+m_P\, P$
nitrogen	+ Mortality ($\leftarrow Z$)	$+m_Z\, Z^2$
(SD)	− Aggregation ($\rightarrow LD$)	$-\tau\,(SD + P)\, SD$
	− Solubilization ($\rightarrow DON_{SL}$)	$-\delta_N\, r_{SD}\, \exp(\psi_{resp}T)\, SD$
	− Remineralization ($\rightarrow NH4$)	$-(1-\delta_N)\,(f_{NTR} + f_{DNF})\, r_{SD}\, \exp(\psi_{resp}T)\, SD$
	− Sinking ($\rightarrow$ sediment)	$-w_{SD}\, \partial SD/\partial z$
Large	Rate of change =	$\partial LD/\partial t =$
Detrital	+ Fecal pellets production ($\leftarrow P$)	$+(1-\beta)\,(1-\lambda)\, g\, Z$
nitrogen	+ Aggregation ($\leftarrow SD + P$)	$+\tau\,(SD + P)^2$
(LD)	− Solubilization ($\rightarrow DON_{SL}$)	$-\delta_N\, r_{LD}\, \exp(\psi_{resp}T)\, LD$

	− Remineralization (→ $NH4$)	$-(1-\delta_N)\,(f_{NTR}+f_{DNF})\,r_{LD}\,\exp(\psi_{resp}T)\,LD$
	− Sinking (→ sediment)	$-w_{LD}\,\partial LD/\partial z$
Semilabile Dissolved Organic Nitrogen (DON_{SL})	Rate of change =	$\partial DON_{SL}/\partial t =$
	+ Exudation (← P)	$+\gamma_P \mu L_I (L_{NO3}+L_{NH4})P$
	+ Sloppy feeding (← P)	$+(1-\beta)\lambda\,\delta_N\,g\,Z$
	+ Solubilization (← $SD+LD$)	$+\delta_N\,\exp(\psi_{resp}T)(r_{SD}SD+r_{LD}LD)$
	− Remineralization (→ $NH4$)	$-(f_{NTR}+f_{DNF})r_{DON}\,\exp(\psi_{resp}T)DON_{SL}$
Dissolved Inorganic Carbon (DIC)	Rate of change =	$\partial DIC/\partial t =$
	− Phyto uptake (→ P)	$-\eta^P_{C:N}\,\mu\,L_I\,(L_{NO3}+L_{NH4})\,P$
	− Carbon excess uptake (→ DOC_{SL})	$-\sigma^C_P\,\gamma^C_P\,\eta^P_{C:N}\,\mu\,L_I\,(1-L_{NO3}-L_{NH4})\,P$
	+ Exudation of 'labile DOC' (← P)	$+\eta^P_{C:N}\,\omega\,\mu\,L_I\,(L_{NO3}+L_{NH4})\,P$
	+ Sloppy feeding (← P)	$+\eta^P_{C:N}\;(1-\beta)\;\lambda\;(1-\delta_C)\;g\,Z$
	+ C excess respiration by zoo (← Z)	$+\left(\eta^P_{C:N}-\eta^Z_{C:N}\right)\;\beta\,g\,Z$
	+ Basal metabolism (← Z)	$+\eta^Z_{C:N}\,l_{BM}\,Z$
	+ Excretion (← Z)	$+\eta^Z_{C:N}\,l_E\,\beta\,P^2\,(K+P^2)^{-1}\,Z$
	+ Remineralization (← DOC_{SL})	$+r_{DOC}\,\exp(\psi_{resp}T)\,DOC_{SL}$
	+ Remineralization (← $SDC+LDC$)	$+(1-\delta_C)\,\exp(\psi_{resp}T)\,(r_{SDC}SDC+r_{LDC}LDC)$
Small Detrital Carbon (SDC)	Rate of change =	$\partial SDC/\partial t =$
	+ Mortality (← P)	$+\eta^P_{C:N}\,m_P\,P$
	+ Mortality (← Z)	$+\eta^Z_{C:N}\,m_Z\,Z^2$
	− Aggregation (→ LDC)	$-\tau\,(SD+P)\,SDC$
	− Solubilization (→ DOC_{SL})	$-\delta_C\,r_{SDC}\,\exp(\psi_{resp}T)\,SDC$
	− Remineralization (→ DIC)	$-(1-\delta_C)\,r_{SDC}\,\exp(\psi_{resp}T)\,SDC$
	− Sinking (→ sediment)	$-w_{SD}\,\partial SDC/\partial z$
Large Detrital Carbon (LDC)	Rate of change =	$\partial LDC/\partial t =$
	+ Fecal pellets production (← P)	$+\eta^P_{C:N}\,(1-\beta)\,(1-\lambda)\,g\,Z$
	+ Aggregation (← $SDC+P$)	$+\tau\,(SD+P)\,\left(SDC+\eta^P_{C:N}\right)$
	− Solubilization (→ DOC_{SL})	$-\delta_C\,r_{LDC}\,\exp(\psi_{resp}T)\,LDC$
	− Remineralization (→ DIC)	$-(1-\delta_C)\,r_{LDC}\,\exp(\psi_{resp}T)\,LDC$
	− Sinking (→ sediment)	$-w_{LD}\,\partial LDC/\partial z$
Semilabile Dissolved Organic Carbon (DOC_{SL})	Rate of change =	$\partial DOC_{SL}/\partial t =$
	+ Carbon excess uptake (← DIC)	$+\sigma^C_P\,\gamma^C_P\,\eta^P_{C:N}\,\mu\,L_I\,(1-L_{NO3}-L_{NH4})\,P$
	+ Exudation (← P)	$+\gamma_P\,\eta^P_{C:N}\,\mu\,L_I\,(L_{NO3}+L_{NH4})\,P$
	+ Sloppy feeding (← P)	$+\eta^P_{C:N}\,(1-\beta)\,\lambda\,\delta_C\,g\,Z$
	+ Solubilization (← $SDC+LDC$)	$+\delta_C\,\exp(\psi_{resp}T)\,(r_{SDC}SDC+r_{LDC}LDC)$
	− Remineralization (→ DIC)	$-r_{DOC}\,\exp(\psi_{resp}T)\,DOC_{SL}$
Total Alkalinity (TA)	Rate of change =	$\partial TA/\partial t =$
	+ NO3 uptake	$+\mu\,L_I\,L_{NO3}\,P$
	− Nitrification	$-n\,f_{NTR}\,NH4$
Oxygen ($O2$)	Rate of change =	$\partial O2/\partial t =$
	+ Production	$+\mu\,L_I\,\left(\eta_{O2:NO3}\,L_{NO3}+\eta_{O2:NH4}\,L_{NH4}\right)\,P$
	− Exudation	$-\omega\,f_{NTR}\,\eta_{O2:NH4}\,\mu\,L_I\,\left(L_{NO3}+L_{NH4}\right)\,P$
	+ Synthesis of carbohydrates	$+\gamma^C_P\,\eta^P_{C:N}\,\mu\,L_I\,(1-L_{NO3}-L_{NH4})\,P$
	− Nitrification	$-2\,n\,f_{NTR}\,NH4$
	− Sloppy feeding	$-\eta_{O2:NH4}\,(1-\beta)\,\lambda\,(1-\delta_N)\,g\,Z$
	− Basal metabolism	$-\eta_{O2:NH4}\,l_{BM}\,Z$
	− Excretion	$-\eta_{O2:NH4}\,l_E\,\beta\,P^2\,(K+P^2)^{-1}\,Z$
	− Remineralization	$-\eta_{O2:NH4}\,f_{NTR}\,\exp(\psi_{resp}T)$
		$\times\left[\,r_{DON}\,DON_{SL}+(1-\delta_N)\;(r_{SD}\,SD+r_{LD}\,LD)\,\right]$
Chlorophyll-a ($Chla$)	Rate of change =	$\partial Chla/\partial t =$
	+ Phyto uptake	$+\rho\,\mu\,L_I\,(L_{NO3}+L_{NH4})\,Chla$
	− Exudation	$-\rho\,\mu\,L_I\,(L_{NO3}+L_{NH4})\,Chla$
		$\times\left[\gamma_P+\omega\;(f_{NTR}+f_{DNF})\right]$
	− Grazing	$-g\,Z\,(P)^{-1}\,Chla$
	− Mortality	$-m_P\,Chla$
	− Aggregation	$-\tau\,(SD+P)\,Chla$

− Sinking	$-w_P \, \partial Chla/\partial z$

Table S4

Table S 4: Biogeochemical sources/sinks in the model's surface/bottom vertical level. The units are the same as in Table S3. Particulate organic nitrogen that reaches the seabed is either re-suspended (and re-directed to small detrital nitrogen), buried, or instantly undergoes coupled nitrification/denitrification (the product of which is re-directed to semilabile DON, ammonium and N_2). The same goes on for carbon except that the non-resuspended/non-buried fraction is redirected to semilabile DOC and DIC.

Var. (Symbol)	Process	Source / Sink
Ammonium ($NH4$)	Bottom nitrification/denitrif. (source)	$\eta_{NF/DNF}\,(1-\phi_1)\,(\Delta z)^{-1}$ $\times[\,w_P\,P\,\left(1-\phi_2^P\right)$ $+w_{SD}\,SD\left(1-\phi_2^{SD}\right)$ $+w_{LD}\,LD\left(1-\phi_2^{LD}\right)]$ $\times(1+3L_{BO2})$
Phytoplankon (P)	Burial (sink)	$(1-\phi_1)\,\phi_2^P\,(\Delta z)^{-1}\,w_P\,P$
Small Detrital nitrogen (SD)	Burial (sink)	$(1-\phi_1)\,\phi_2^{SD}\,(\Delta z)^{-1}\,w_{SD}\,SD$
Small Detrital nitrogen (SD)	Bottom resusp. (source)	$\phi_1(\Delta z)^{-1}\,F_{TON}$
Large Detrital nitrogen (LD)	Burial (sink)	$(1-\phi_1)\,\phi_2^{LD}\,(\Delta z)^{-1}\,w_{LD}\,LD$
Semilabile DON (DON_{SL})	Bottom nitrification/denitrif. (source)	$\gamma_{DON}\,(1-\phi_1)\,(\Delta z)^{-1}$ $\times[\,w_P\,P\,\left(1-\phi_2^P\right)$ $+w_{SD}\,SD\left(1-\phi_2^{SD}\right)$ $+w_{LD}\,LD\left(1-\phi_2^{LD}\right)]$ $\times(1+3L_{BO2})$
N_2	Bottom denitrification (source)	$[1-(\eta_{NF/DNF}+\gamma_{DON})\,(1+3L_{BO2})]$ $\times(1-\phi_1)\,(\Delta z)^{-1}$ $\times[\,w_P\,P\,\left(1-\phi_2^P\right)$ $+w_{SD}\,SD\left(1-\phi_2^{SD}\right)$ $+w_{LD}\,LD\left(1-\phi_2^{LD}\right)]$
Dissolved Inorganic Carbon (DIC)	Surface CO_2 exchange (sink/source)	$0.31 \div 100 \times 24 \times (\Delta z)^{-1}$ $\times V_{wind}^2\sqrt{660/\mathrm{Sc}_{CO2}}$ $\times\alpha_{sol}\,(p\mathrm{CO}_{2\mathrm{a}}-p\mathrm{CO}_{2\mathrm{w}})$
Dissolved Inorganic Carbon (DIC)	Bottom remineral. (source)	$(1-\gamma_{DON})\,(1-\phi_1)\,(\Delta z)^{-1}$ $\times[\,w_P\,P\,\left(1-\phi_2^P\right)\,\eta_{C:N}^P$ $+w_{SD}\,SDC\left(1-\phi_2^{SDC}\right)$ $+w_{LD}\,LDC\left(1-\phi_2^{LDC}\right)]$
Phytoplankon (P)	Burial (carbon; sink)	$(1-\phi_1)\,\phi_2^P\,(\Delta z)^{-1}\,w_P\,P\,\eta_{C:N}^P$
Small Detrital Carbon (SDC)	Burial (sink)	$(1-\phi_1)\,\phi_2^{SDC}\,(\Delta z)^{-1}\,w_{SD}\,SDC$
Small Detrital Carbon (SDC)	Bottom resusp. (source)	$\phi_1\,(\Delta z)^{-1}\,F_{TOC}$
Large Detrital Carbon (LDC)	Burial (sink)	$(1-\phi_1)\,\phi_2^{LDC}\,(\Delta z)^{-1}\,w_{LD}\,LDC$
Semilabile DOC (DOC_{SL})	Bottom remineral. (source)	$\gamma_{DON}\,(1-\phi_1)\,(\Delta z)^{-1}$ $\times[\,w_P\,P\left(1-\phi_2^P\right)\,\eta_{C:N}^P$ $+w_{SD}\,SDC\left(1-\phi_2^{SDC}\right)$ $+w_{LD}\,LDC\left(1-\phi_2^{LDC}\right)]$
Oxygen (O2)	Surface O2 exchange (sink/source)	$0.31 \div 100 \times 24 \times (\Delta z)^{-1}$ $\times V_{wind}^2\sqrt{660/\mathrm{Sc}_{O2}}$ $\times(O2_{sat}-O2)$
Oxygen (O2)	Bottom nitr./denitr. (sink)	$-(115/16)\,(1-\phi_1)\,(\Delta z)^{-1}$ $\times(1-L_{BO2})$ $\times[\,w_P\,P\,\left(1-\phi_2^P\right)$ $+w_{SD}\,SD\,\left(1-\phi_2^{SD}\right)$

		$+w_{LD}\, LD\, \left(1-\phi_2^{LD}\right) \,]$
Chlorophyll-*a* ($Chla$)	Burial (sink)	$(\Delta z)^{-1}\, w_P\, Chla$

Table S5

Table S5: Definition of functions used in state variable equations. Note that burial efficiency (ϕ_2) varies among phytoplankton and detrital compartments.

Symbol	Description	Equation	Units
α_{sol}	Solubility of CO2	See *Weiss* (1974)	mol (kg atm)$^{-1}$
Δz	Thickness of vertical level	from physical model	m
θ	Chlorophyll to carbon ratio	$\min\left[\theta_{max}, Chla\, \left(12\, \eta^P_{C:N}\, P\right)^{-1}\right]$	mg-Chla mg-C^{-1}
λ	Ratio grazing : max.grazing	$0.71\, P^2\, \left(K+P^2\right)^{-1}$	dimensionless
μ	Maximum phyto specific growth rate	$0.6\exp(\psi_{pmax}T)$ (if $T>20°$C), 2.15 (if $T<20°$C)	day^{-1}
ρ	Fraction of phyt. growth devoted to chl	$\theta_{max}\, \mu\, L_I\, \left(L_{NO3}+L_{NH4}\right)(\alpha\, I\, \theta)^{-1}$	dimensionless
τ_b	Bottom stress	from physical model	Pa
ϕ_1	Resuspension fraction (see *Peterson*, 1999)	$\min\left[1, \tau_b \,/\, 0.01\,\mathrm{Pa}\right]$	dimensionless
ϕ_2	Burial efficiency (see *Henrichs and Reeburgh*, 1987)	$\min\left[0.75,\, 0.023\, F^{0.5797}\right]$	dimensionless
f_{NTR}	Oxygen limitation for nitrification	$O2\,(O2+K_{NTR})^{-1}$	dimensionless
f_{DNF}	Oxygen limitation for denitrification	$K_{DNF}\,(O2+K_{DNF})^{-1}$	dimensionless
F_P	Phyto unresuspended carbon flux	$12\times 0.365\, (1-\phi_1)\, \eta^P_{C:N}\, w_P\, P$	g-C m^{-2} yr^{-1}
F_{SD}	Detrital unresuspended carbon flux	$12\times 0.365\, (1-\phi_1)\times 9.3\, w_{SD}\, SD$	g-C m^{-2} yr^{-1}
F_{LD}	Detrital unresuspended carbon flux	$12\times 0.365\, (1-\phi_1)\times 9.3\, w_{LD}\, LD$	g-C m^{-2} yr^{-1}
F_{SDC}	Detrital unresuspended carbon flux	$12\times 0.365\, (1-\phi_1)\, w_{SD}\, SDC$	g-C m^{-2} yr^{-1}
F_{LDC}	Detrital unresuspended carbon flux	$12\times 0.365\, (1-\phi_1)\, w_{LD}\, LDC$	g-C m^{-2} yr^{-1}
F_{TON}	Total organic nitrogen flux at seabed	$w_P\, P + w_{SD}\, SD + w_{LD}\, LD$	mmol-N m^{-2} day^{-1}
F_{TOC}	Total organic carbon flux at seabed	$\eta^P_{C:N}\, w_P\, P$ $+w_{SD}\, SDC + w_{LD}\, LDC$	mmol-C m^{-2} day^{-1}
g	Zooplankton grazing rate	$g_{max}\, \exp(\psi_{resp}T)\, P^2\, (K+P^2)^{-1}$	day^{-1}
ISS	Inorganic suspended solids	from physical model	g m^{-3}
I	Photosynthetically active rad.	$\partial I/\partial z = -k_d\, I$ with $I(z=0)=\mathrm{PARfrac}\, SW$	W m^{-2}
k_d	Diffuse attenuation coefficient	$\max[\,0.6,$ $1.4+0.063(ISS+OSS)-0.057S\,]$	m^{-1}
L_{BO2}	Bottom oxygen limitation factor	$K_{BO2}\,(O2_{sat}-O2)\, O2_{sat}^{-1}\, (O2+K_{BO2})^{-1}$	dimensionless
L_I	Light limitation for phyto. growth	$\alpha\, I\, \left(\sqrt{\mu^2+\alpha^2 I^2}\right)^{-1}$	dimensionless
L_{NO3}	Nitrate uptake limitation for phyto	$NO3\,(K_{NO3}+NO3)^{-1}$ $\times(1+NH4/K_{NH4})^{-1}$	dimensionless
L_{NH4}	Ammonium uptake limitation for phyto	$NH4\,(K_{NH4}+NH4)^{-1}$	dimensionless
n	Nitrification rate	$n_{max}(1-\max[\,0,$ $(I-I_{NTR})\,(K_I+I-2I_{NTR})^{-1}\,])$	day^{-1}
OSS	Organic suspended solids	$\left(\eta^P_{C:N}\, P + \eta^Z_{C:N}\, Z + SDC + LDC\right)$ $\times 12 \div 1000 \times 2.9$	g m^{-3}
$O2_{sat}$	O2 saturation in seawater	See *Garcia and Gordon* (1992)	mmol-O2 m^{-3}
$p\mathrm{CO}_{2\mathrm{a}}$	CO2 partial pressure in the air	See Methods	ppm by volume
$p\mathrm{CO}_{2\mathrm{w}}$	Partial pressure of CO2 in seawater	See *Fennel et al.* (2008)	ppm by volume
Sc_{O2}	Schmidt number for O2 in seawater	See *Wanninkhof* (1992)	dimensionless
Sc_{CO2}	Schmidt number for CO2 in seawater	See *Wanninkhof* (1992)	dimensionless
S	Water salinity	from physical model	psu
SW	Net surface shortwave radiation	from physical model	W m^{-2}
T	Water temperature	from physical model	°C

T_{K}	Water temperature	from physical model	K
V_{wind}	Wind speed	from physical model	m s^{-1}

Table S6

Table S6: Definition of biogeochemical parameters used in state variable equations.

Symbol	Description (Name in Fortran code)	Value	Units
α	Initial slope of Photosynthesis-Irradiance curve (PhyIS)	0.04	(W m^{-2} day$)^{-1}$
β	Zooplankton nitrogen assimilation efficiency (ZooAE_N)	0.75	dimensionless
γ_P	Phytoplankton exudation of semilabile DON (EsDON)	0.04	dimensionless
γ_P^C	Phytoplankton C excess-based DOC exudation (gammaC)	0.2	dimensionless
γ_{DON}	Fraction of semilabile DON produced in coupled nitr./denitr.	0.01	dimensionless
δ_N	Semilabile fraction of N in detritus (deltN)	0.15	dimensionless
δ_C	Semilabile fraction of C in detritus (deltC)	0.275	dimensionless
$\eta_{C:N}^P$	Phytoplankton C:N ratio (PhyCN)	106/16	mol-C mol-N^{-1}
$\eta_{C:N}^Z$	Zooplankton C:N ratio (ZooCN)	106/16	mol-C mol-N^{-1}
η_{DNF}	Stoichiometry for remineralization via denitrification	84.8/16	dimensionless
$\eta_{NF/DNF}$	Stoichiometry for remineralization via coupled nitr./denitr	4/16	dimensionless
$\eta_{O2:NO3}$	Moles of O2 produced when consuming 1 mole of NO3	138/16	mol-O2 mol-N^{-1}
$\eta_{O2:NH4}$	Moles of O2 produced when consuming 1 mole of NH4	106/16	mol-O2 mol-N^{-1}
θ_{max}	Maximum chlorophyll to carbon ratio (Chl2C_m)	0.02675	mg-Chla mg-C^{-1}
σ_P^C	Fraction of DOC_{SL} in carbon excess based exudation (slCexc)	0.45	dimensionless
τ	Aggregation rate of small detritus and phyto (CoagR)	0.008	mmol-N^{-1} m^3 day^{-1}
ψ_{pmax}	Temperature-dependence for max.photosynthetic rate	0.0780	$°C^{-1}$
ψ_{resp}	Temperature-dependence for community respiration rate	0.0742	$°C^{-1}$
ω	Phytoplankton exudation of labile DON (ElDON)	0.03	dimensionless
g_{max}	Maximum grazing rate at 0°C (ZooGR)	0.05	day^{-1}
I_{NTR}	Radiation threshold for nitrification inhibition (I_thNH4)	0.0095	W m^{-2}
K	Half-saturation constant for phyto ingestion (K_Phy)	2	$(\text{mmol m}^{-3})^2$
K_{BO2}	Half-saturation constant for bottom denitrification switch	26.5	mmol-O2 m^{-3}
K_I	Half-saturation for nitrification inhibition (D_p5NH4)	0.1	W m^{-2}
K_{NO3}	Half-saturation for nitrate uptake (1/K_NO3)	0.5	mmol-N m^{-3}
K_{NH4}	Half-saturation for ammonium uptake (1/K_NH4)	0.5	mmol-N m^{-3}
K_{NTR}	Half-saturation for water-column nitrification	1	mmol-O2 m^{-3}
K_{DNF}	Half-saturation for water-column denitrification	1	mmol-O2 m^{-3}
l_{BM}	Zooplankton basal metabolism (ZooBM)	0.1	day^{-1}
l_E	Zooplankton specific excretion rate (ZooER)	0.1	day^{-1}
m_P	Phytoplankton mortality rate (PhyMR)	0.05	day^{-1}
m_Z	Zooplankton mortality rate (ZooMR)	0.025	mmol-N^{-1} m^3 day^{-1}
n_{max}	Nitrification rate (NitriR)	0.05	day^{-1}
PARfrac	Photosynthetically active fraction of shortwave rad.	0.43	dimensionless
r_{SD}	Detritus solubilization rate at 0°C (SDeNSR)	0.05	day^{-1}
r_{LD}	Detritus solubilization rate at 0°C (LDeNSR)	0.05	day^{-1}
r_{SDC}	Detritus solubilization rate at 0°C for C (SDeCSR)	0.04	day^{-1}
r_{LDC}	Detritus solubilization rate at 0°C for C (LDeCSR)	0.04	day^{-1}
r_{DON}	Remineralization rate of DON at 0°C (a0N)	0.00765	day^{-1}
r_{DOC}	Remineralization rate of DOC at 0°C (a0C)	0.012	day^{-1}
w_P	Sinking velocity of phytoplankton (wPhy)	0.1	m day^{-1}
w_{SD}	Sinking velocity of small detritus (wSDet)	0.1	m day^{-1}
w_{LD}	Sinking velocity of large detritus (wLDet)	5	m day^{-1}

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