

The following supplement accompanies the article

Factors controlling the seasonal distribution of pelagic *Sargassum*

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Biogeochemical model equations

The biogeochemical model uses ten state variables to track the flow of nitrogen and phosphorus. This model operates in nitrogen units, with a basic structure adapted from Fennel et al. (2006) with additional light and grazer parameterizations adapted from Hood et al. (2001) and Stukel et al. (2014), respectively. Phytoplankton (P) biomass is a function of growth rate (μ_P), grazing rate (g_P), mortality rate (m_P), and aggregation into detrital particles (τ)

$$\frac{dP}{dt} = \mu_P P - g_P Z - m_P P - \tau(Ds + P)P, \quad (\text{Eqn S.1})$$

where growth is a function of maximum growth rate (μ_{maxP}), nutrient limitation (L_{Ntot}, L_{DIP}), and light ($f(I)$).

$$\mu_P = \mu_{maxP} \cdot \min(L_{Ntot}, L_{DIP}) \cdot f(I). \quad (\text{Eqn S.2})$$

Nitrogen and phosphorus limitation are given by

$$L_{Ntot} = L_P^N + L_P^A \quad (\text{Eqn S.3})$$

where

$$L_P^N = \frac{NO_3}{k_{NO_3+NO_3}} \cdot \frac{1}{1 + \frac{NH_4}{k_{NH_4}}}, \quad L_P^A = \frac{NH_4}{k_{NH_4+NH_4}}, \quad (\text{Eqns S.4, S.5})$$

and

$$L_P^P = \frac{DIP}{k_{PDIP+DIP}}, \quad (\text{Eqn S.6})$$

while light (I) dependence is determined via light saturation tolerance (I_P) and photoinhibition irradiance level ($I_{\beta P}$) by

$$f(I) = (1 - e^{-I/I_P})(e^{-I/I_{\beta P}}) \quad (\text{Eqn S.7})$$

after Hood et al. (2001).

Zooplankton grazing is density-dependent, with

$$g_P = g_{max} \frac{P^2}{k_P + P^2}, \quad (\text{Eqn S.8})$$

where g_{max} is zooplankton maximum grazing rate and k_P is the half-saturation constant for zooplankton grazing.

The modeled diazotroph, T is parameterized after *Trichodesmium*. It has similar growth rate (μ_T) and mortality (m_T) formulations as the other phytoplankton, although it is not limited by nitrogen availability. It also has a higher rate of self-aggregation (τ_T) and experiences a small leakage to the ammonium pool (α),

$$\frac{dT}{dt} = \mu_T T - m_T T - \tau_T T^2 - \alpha T . \quad (\text{Eqn S.9})$$

$$\mu_T = \mu_{maxT} \cdot L_{TDIP} \cdot f_T(I) . \quad (\text{Eqn S.10})$$

with phosphorus limitation only,

$$L_T^P = \frac{DIP}{k_{TDIP} + DIP}, \quad (\text{Eqn S.11})$$

and no photoinhibition,

$$f_T(I) = (1 - e^{-I/I_T}) . \quad (\text{Eqn S.12})$$

The rate of change of zooplankton is dependent on grazing (g_P), with assimilation efficiency (β), basal metabolism (l_{BM}), assimilation-dependent excretion, and density-dependent mortality with maximum rate m_Z (Fennel et al. 2006).

$$\frac{dZ}{dt} = g_P \beta Z - l_{BM} Z - l_E \frac{P^2}{k_P + P^2} \beta Z - m_Z Z^2 . \quad (\text{Eqn S.13})$$

Model nitrate is dependent on phytoplankton uptake and nitrification (n)

$$\frac{dN}{dt} = -\mu max_P f_P(I) L_P^N P + nA , \quad (\text{Eqn S.14})$$

while change in ammonium concentration is dependent on phytoplankton uptake, nitrification, zooplankton metabolism and assimilation, remineralization from small and large detrital pools, and losses from the *Trichodesmium* pool.

$$\frac{dA}{dt} = -\mu max_P f_P(I) L_P^A P - nA + l_{BM} Z + l_E \frac{P^2}{k_P + P^2} \beta Z + r_{DSN} D_S^N + r_{DLN} D_L^N + \alpha T \quad (\text{Eqn S.15})$$

Dissolved inorganic phosphorus is depleted via phytoplankton and *Trichodesmium* uptake, and replenished via zooplankton excretion and remineralization of detritus

$$\begin{aligned} \frac{dDIP}{dt} = & -\mu max_P f_P(I) L_P^P P - \mu max_T f_T(I) L_T^P T + l_{BM} Z + l_E \frac{P^2}{k_P + P^2} \beta Z \\ & + r_{DSP} D_S^P + r_{DLP} D_L^P . \end{aligned} \quad (\text{Eqn S.16})$$

Detritus is tracked as four different pools to allow for differential remineralization (r) of nitrogen and phosphorus, and of different size classes. The rates of change of these pools are given by

$$\frac{dD_S^N}{dt} = m_P P + m_T T + m_Z Z^2 - \tau(D_S^N + P) D_S^N - r_{DSN} D_S^N \quad (\text{Eqn S.17})$$

$$\frac{dD_S^P}{dt} = m_P P + m_T T + m_Z Z^2 - \tau(D_S^N + P) D_S^N - r_{DSP} D_S^P \quad (\text{Eqn S.18})$$

$$\frac{dD_L^N}{dt} = \tau(D_S + P)^2 + \tau_T T^2 - r_{DLN} D_L^N \quad (\text{Eqn S.19})$$

$$\frac{dD_L^P}{dt} = \tau(D_S + P)^2 + \tau_T T^2 - r_{DLP} D_L^P , \quad (\text{Eqn S.20})$$

with the small pools gaining contributions from the living compartments via mortality, and the large pools growing via aggregation, and all detrital pools diminished via remineralization.

Supplemental References

- Fennel, K., J. Wilkin, J. Levin, J. Moisan, J. O'Reilly, and D. Haidvogel. 2006. Nitrogen cycling in the Middle Atlantic Bight: Results from a three-dimensional model and implications for the North Atlantic nitrogen budget. *Global Biogeochem. Cycles* **20**: GB3007. doi:10.1029/2005GB002456
- Hood, R. R., N. R. Bates, D. G. Capone, and D. B. Olson. 2001. Modeling the Effect of Nitrogen Fixation on Carbon and Nitrogen Fluxes at BATS. *Deep. Res.* 1–53.
- Stukel, M. R., V. J. Coles, M. T. Brooks, and R. R. Hood. 2014. Top-down , bottom-up and physical controls on diatom-diazotroph assemblage growth in the Amazon River plume. *Biogeosciences* **1**: 3259–3278. doi:10.5194/bg-11-3259-2014

Table S.1 Biogeochemical Model Parameters

Symbol	Parameter	Value	Units
μ_{max_P}	Phytoplankton maximum growth rate	2.0	d^{-1}
μ_{max_T}	<i>Trichodesmium</i> maximum growth rate	0.15	d^{-1}
k_{NO3}	Phytoplankton NO ₃ uptake half saturation	0.5	$mmol\ N\ m^{-3}$
k_{NH4}	Phytoplankton NH ₄ uptake half saturation	0.5	$mmol\ N\ m^{-3}$
k_{PDIP}	Phytoplankton DIP uptake half saturation	0.0125	$mmol\ P\ m^{-3}$
k_{TDIP}	<i>Trichodesmium</i> DIP uptake half saturation	0.0125	$mmol\ P\ m^{-3}$
I_P	Phytoplankton light saturation	20.0	$W\ m^{-2}$
$I_{\beta P}$	Phytoplankton photoinhibition	400.0	$W\ m^{-2}$
I_T	<i>Trichodesmium</i> light saturation	70.0	$W\ m^{-2}$
τ	Phytoplankton and detritus aggregation parameter	0.005	$(mmol\ N\ m^{-3})^{-1}\ d^{-1}$
τ_T	<i>Trichodesmium</i> aggregation parameter	0.001	$(mmol\ N\ m^{-3})^{-1}\ d^{-1}$
α	<i>Trichodesmium</i> leakage to the NH ₄ pool	0.01	d^{-1}
m_P	Phytoplankton mortality	0.15	d^{-1}
m_T	<i>Trichodesmium</i> mortality	0.02	d^{-1}
m_Z	Zooplankton mortality	0.015	d^{-1}
g_{max}	Zooplankton maximum grazing rate	0.6	$(mmol\ N\ m^{-3})^{-1}\ d^{-1}$
k_P	Half saturation of phytoplankton ingestion	2.0	$(mmol\ N\ m^{-3})^2$
β	Zooplankton assimilation efficiency	0.75	dimensionless
l_{BM}	Zooplankton basal metabolism-based excretion rate	0.1	d^{-1}
l_E	Zooplankton assimilation-related excretion	0.1	d^{-1}
n	maximum nitrification rate	0.05	d^{-1}
r_{DSN}	Remineralization of nitrogen in small detritus	0.03	d^{-1}
r_{DLN}	Remineralization of nitrogen in large detritus	0.01	d^{-1}
r_{DSP}	Remineralization of phosphorus in small detritus	0.2	d^{-1}
r_{DLP}	Remineralization of phosphorus in large detritus	0.2	d^{-1}