Supporting Materials:

Exploring Estuarine Nutrient Susceptibility

Text

Application of Bayesian Analysis

Comparison of Grazing and Sedimentation Rates

Figure captions:

Figure S1. Distribution of estuarine properties. Blocks from left to right are for Embayment, Fjords, Lagoons, and River Run estuaries.

Figure S2. Model results vs. observed mean values for Chl a. Symbols represent modeled-observed pairs. The dashed line is 1:1 and the solid line is the regression results. Horizontal error bars represent ±standard deviation of the observed 7-year summer

Figure S3. Sensitivity of the Chl *a* predictions to the prior distributions assigned to the parameters, (a) estimated Chl *a* using doubled variance, (b) estimated Chl *a* using halved variance; and (c) estimated α values when changing the other parameters' variances.

Figure S4. Relationship between nitrogen conversion efficiency (ε) and some additional estuarine physical characters.

Figure S5. Relationship between nitrogen conversion efficiency (ε) and the Q/V for four estuarine types.

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Table S1. Characters of the 75 estuaries included in the modeling analysis.

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Table S4. Primary production values from the literature used in Figure 1.

Table S5. Estimated parameter values with doubled and halved variance.

***Application of Bayesian Analysis* -** In Bayesian analysis, all unknown parameters are treated as random variables and their distributions are derived from known information *(1)*, thus providing a rigorous method for uncertainty analysis and presenting key information for management decision making *(2)*. Bayesian inference is based on Bayes' Theorem *(3)*:

$$p(\theta \mid y) = \frac{p(\theta)p(y \mid \theta)}{p(y)} = \frac{p(\theta)p(y \mid \theta)}{\int_{\theta} p(\theta)p(y \mid \theta)d\theta} \propto p(\theta)p(y \mid \theta)$$

where $p(\theta \mid y)$ is the posterior probability of θ, which is the conditional distribution of the parameters after observation of the data; θ is the parameter to be estimated; $p(\theta)$ is the prior probability of θ (i.e., its assumed probability distribution before observation of data); $p\ (y \mid \theta)$ is the likelihood function, which represents the probability of the occurrence of the observations y given different realizations of the postulated mechanistic relationship between the response and predictor variables, i.e., equation 1.

The difficult in to obtaining the posterior distributions analytically generally limits application of the Bayesian approach. However, in recent decades, the Markov Chain Monte Carlo (MCMC) algorithm has been applied to obtain the numerical summarization of parameters *(4)*. MCMC is a method to draw samples from multidimensional distributions for numerical integration. The idea underlying the MCMC implementation in Bayesian inference is to construct a Markov process whose stationary distribution is the model posterior distribution, and then run the process long enough to produce an accurate approximation of this distribution *(5)*. Many methods (e.g., Gibbs sampler) have been proposed for obtaining sequences of realizations from the posterior model distributions *(6)*, but all of them are special cases of the general Metropolis-Hastings algorithm *(7,8)*. There are three steps in the Bayesian approach using Markov Chaing Monte Carlo

(MCMC) sampling *(5)*: identifying the prior probability distributions formulation, determining the likelihood function, and MCMC sampling. Starting values are provided for the model "burn-in" period, which aims to make the model reach convergence after a sufficient time. Then the samples after the "burn-in" period are saved for determining statistical inferences of the posterior distribution *(5).*

In our analyses, a lognormal model error was used to bound predictions of *B* at zero, and structured to accommodate autocorrelation in the error term, as suggested by *(9)*. The basic Bayesian model for the study is:

$$\log(B_i^o) \sim N\left[\log(B_i^m), \sigma^2\right]$$

where B_i^o (i=1,…, 75) is observed phytoplankton biomass for estuary *i*, converted from observed chlorophyll with a C:Chl ratio; B_i^m is the modeled phytoplankton biomass from equation (6); σ is the lognormal model error standard variance.

R^2 and *RMSE* are defined as:

$$R^2 = 1 - \frac{SS_E}{SS_T} = 1 - \frac{\sum_{i=1}^{n}(y_i - y_i')^2}{\sum_{i=1}^{n}(y_i - \overline{y_i})^2} \qquad RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_i - y_i')^2}{n}}$$

where, SS_E and SS_T are the sum of squared errors and total sum of squares, respectively; y_i and y_i' are the original data values and modeled values respectively; $\overline{y_i}$ is the mean of the observations y_i; n is the number of observations. Because *RMSE* is scale dependent, we used a scale-independent *RMSE* value to measure goodness-of-fit, *RMSE* divided by the mean of the observations. It should be noted though that the Bayesian approach generates a predictive distribution and not a single value for each variable ($y_i^{'}$), and thus the use of correlation coefficient, slope, R^2 and *RMSE* is essentially a non-Bayesian ("point") assessment of the model performance.

The prior distribution of σ is usually considered as non-informative or vague with a prior $\rho(\sigma^2) \propto 1/\sigma^2$, which assumes an improper uniform distribution on $(-\infty, +\infty)$ *(5).* Thus in this study, we used a uniform distribution for σ rather than the standard non-informative prior *(5)*. Then the MCMC sampling was carried out using four chains, each with 40,000 iterations (first 20,000 discarded after model convergence); and samples for each unknown quantity were taken from the next 20,000 iterations using a thin equal to 40 to reduce serial correlation. Statistical inference was based on the resulting 1,000 MCMC samples. A potential scale reduction factor, *Rhat*, was produced in package R2WinBUGS to determine the model convergence (at convergence, *Rhat*=1.0) *(10)*.

Comparison with Grazing and Sedimentation Rates **-** Calbet and Landry presented a meta-analysis of 788 observations across 66 marine systems, including 142 observations for coastal system and 136 for estuarine system *(11)*. They found grazing to consume 59.9±3.3% and 59.7±2.7% of phytoplankton production for coastal and estuarine systems, respectively. Mortazavi *(12)* reported 62% for the estuarine portion of the Mississippi River mouth in September, about 50% in Hudson River in fall, 23 - 52% in Long Island Bays during the spring and summer, 83% in Mobile Bay, more than 31% in the Chesapeake Bay during summer, and 80% in Apalachicola Bay on an annual basis. Landry and Hassett *(13)* reported 17-52% for coastal waters off Washington and McManus and Edering-Cantrell *(14)* reported 50-60% for the

Chesapeake Bay. Micro-zooplankton grazed between 46% and 60% of production in Mundaka Estuary, Spain *(15)* and 64% and 83% of production at offshore and bay stations in Mobile Bay *(16)*.

Sedimentation as a percentage of production in the Baltic proper (72%, 12%) *(17,18)*, a Baltic fjord (30-48%) *(19)*, the Mississippi River plume (27%)*(20*), Dona Paula Bay, India (39%) *(21*), Narragansett Bay mesocosms (47%) *(22*), including manipulations that were warm with zooplankton and mussels (29-43%) *(23*) and colder without mussels (73-82%), as well as a tropical shelf off Kingston, Jamaica (15%) *(24)*.

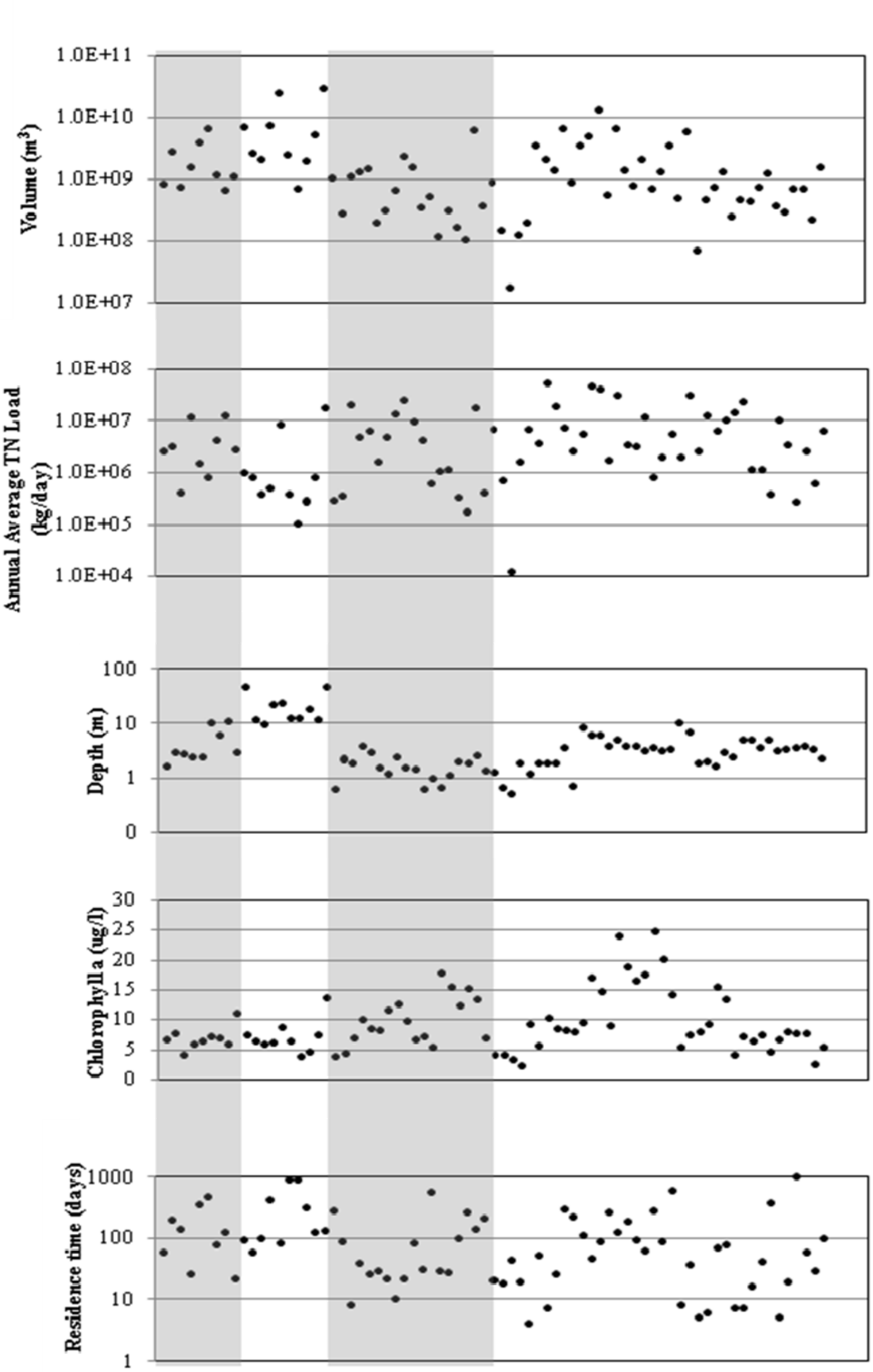


Figure S1. Distribution of estuarine properties. Blocks from left to right are for Embayments, Fjords, Lagoons, and River Run estuaries.

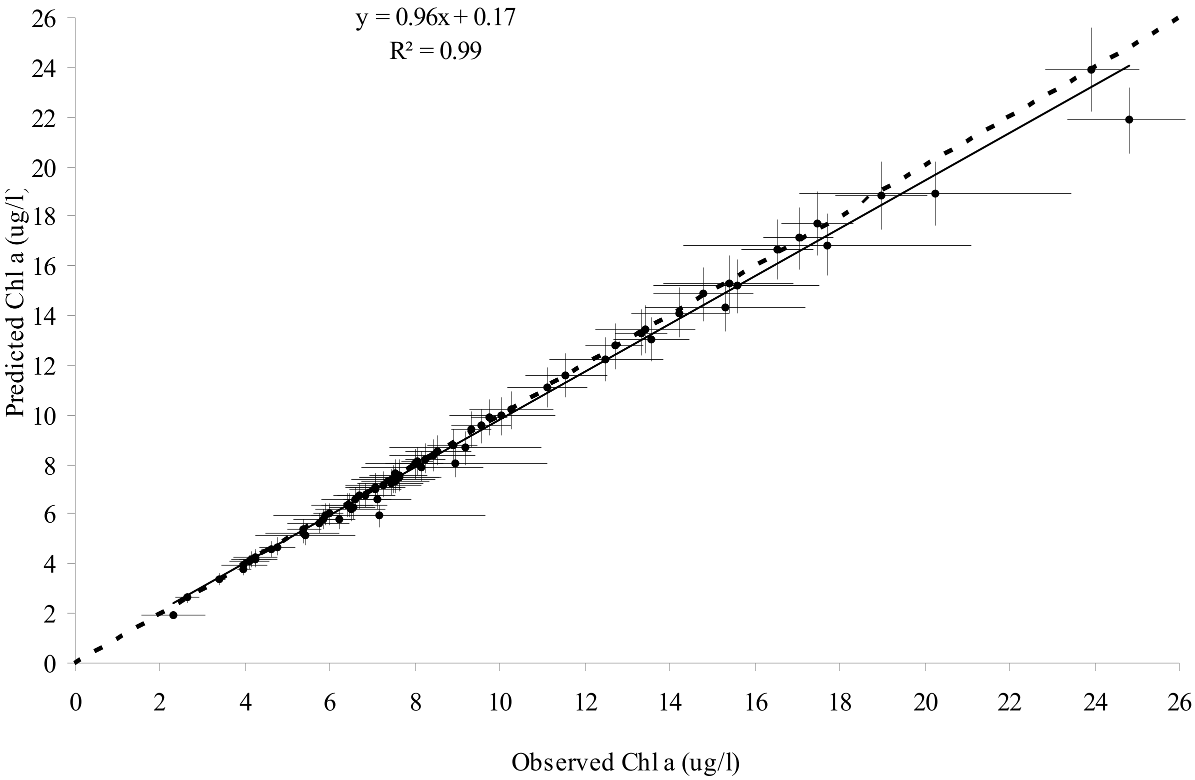
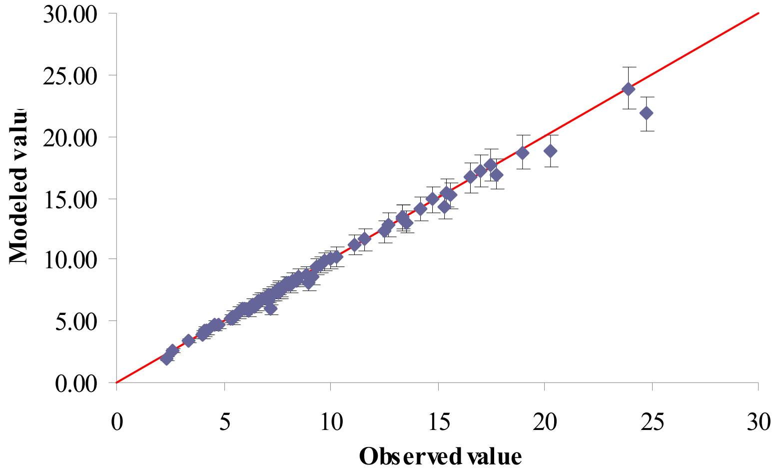
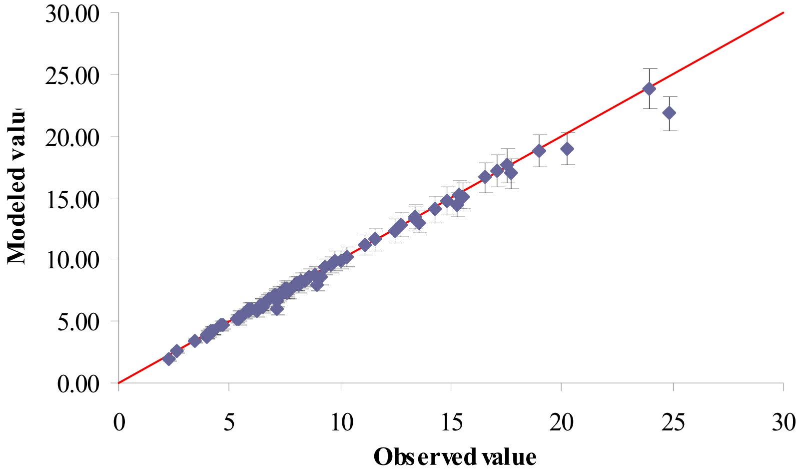


Figure S2. Model results vs. observed mean values for Chl *a*. Symbols represent modeled-observed pairs. The dashed line is 1:1 and the solid line is the regression results. Horizontal error bars represent ±standard deviation of the observed 7-year summer Chl *a*; and vertical error bars represent ± one standard deviation of the modeled values.


30.00
25.00
20.00
15.00
10.00
5.00
0.00
Modeled valu
0
5
10
15
20
25
30
Observed value

(a)


30.00
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0
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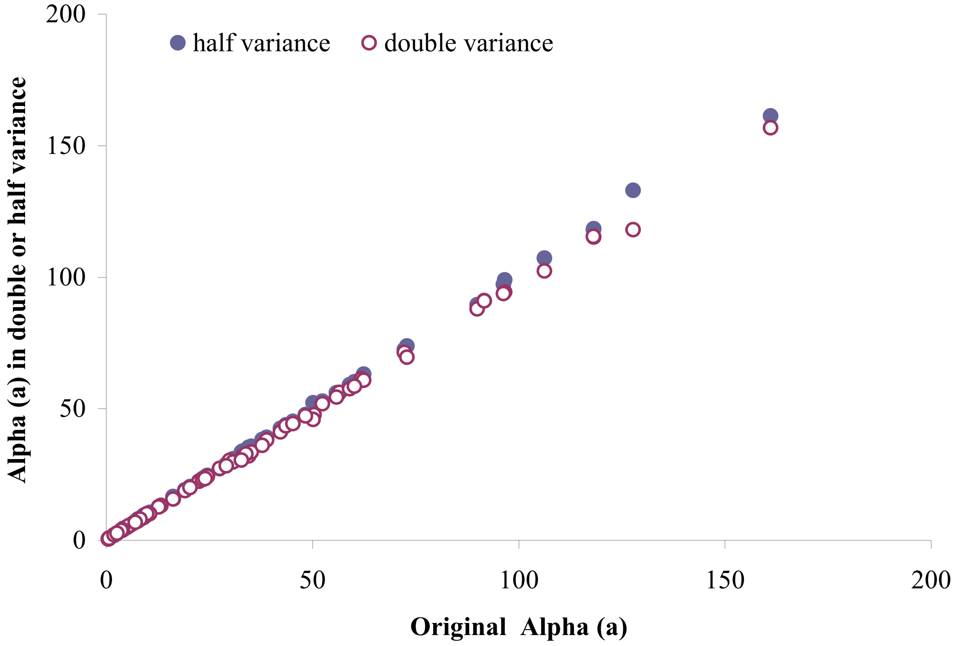
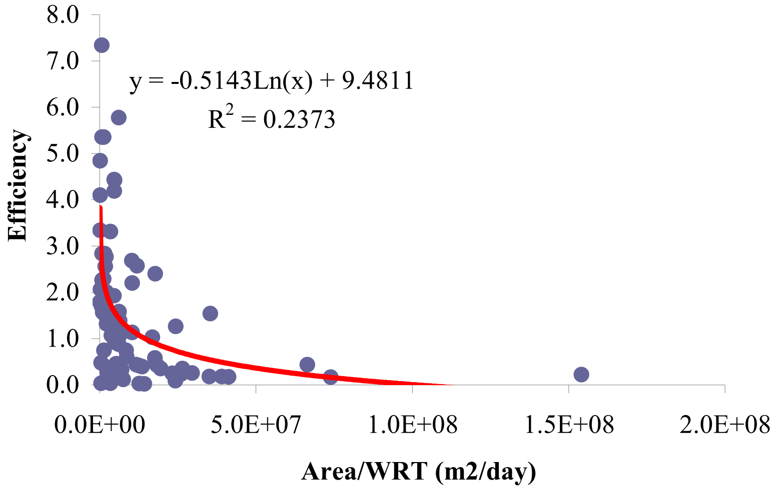
Observed value

(b)



(c)

Figure S3. Sensitivity of the Chl *a* predictions to the prior distributions assigned to the parameters, (a) estimated Chl *a* using double variance, (b) estimated Chl *a* using half variance; and (c) estimated α values when changing the other parameters' variances. Vertical error bars represent ± one standard deviation of the modeled values.



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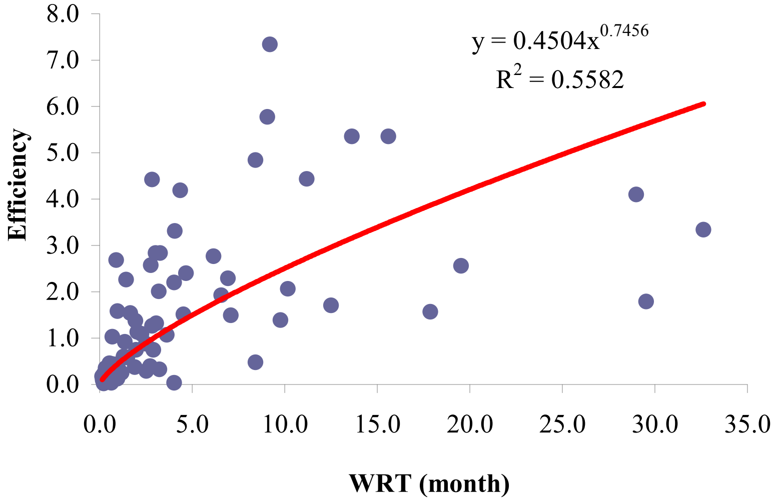
R2 = 0.2373
Efficiency
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
Area/WRT (m2/day)



y = 0.4504x0.7456
R2 = 0.5582
Efficiency
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7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
WRT (month)

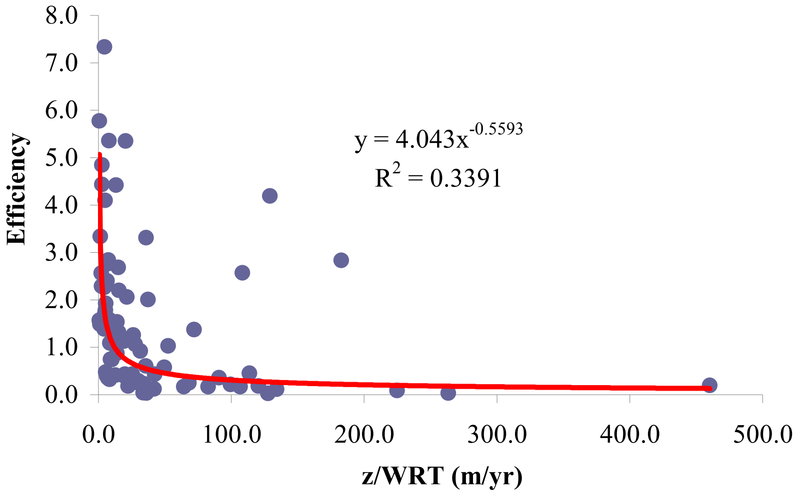
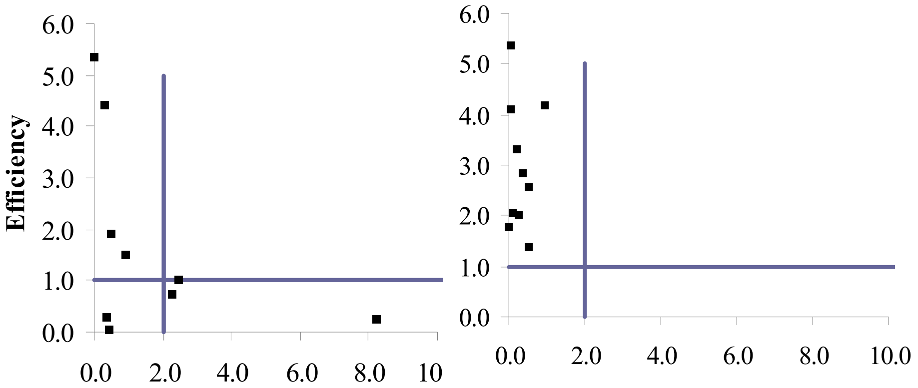
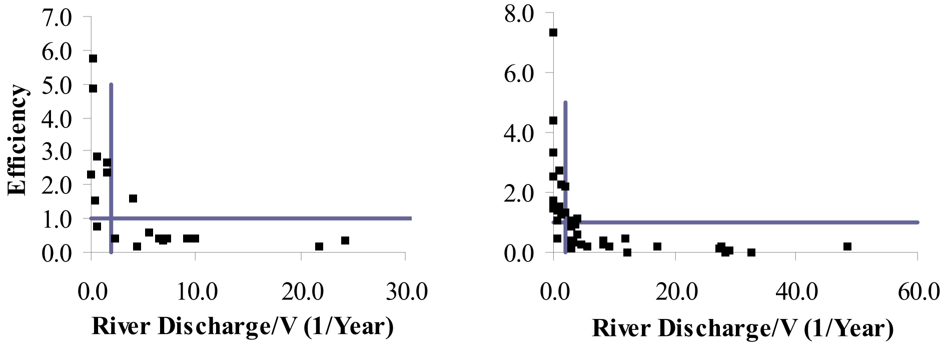


Figure S4 Relationship between nitrogen conversion efficiency (ε) and some estuarine physical characters



(a) Embayment

(b) Fjords



(c) Lagoons

(d) River Run estuaries

Figure S5. Relationship between nitrogen conversion efficiency (ε) and the Q/V for four estuarine types.

Table S1 Characters of the 75 estuaries included in the modeling analysis

NO	EDA	NAME	Sub-Name	Type	Volume (m^3)	Depth (m)	Area (m^2)	Res. Time (day)	TN load (kg/yr)	Discharge (m^3/day)	Ocean N flux(kg/yr)	Observed Chl a (µg/L)	Q/V (1/Year)
1	G010x	Florida Bay	Florida Bay EDA	Lagoons	1.03E+09	0.62	1.66E+09	272	2.8E+05	504000	1.3E+04	3.98	0.179
2	G020x	South Ten Thousand Islands	South Ten Thousand Islands EDA	River Dominated	1.44E+08	0.63	2.29E+08	18	7.1E+05	3250000	1.9E+04	4.23	8.238
3	G040x	Rookery Bay	Rookery Bay EDA	River Dominated	1.74E+07	0.50	3.48E+07	43	1.2E+04	58800	1.1E+03	3.41	1.233
4	G050a	Charlotte Harbor	Caloosahatchee River EDA	River Dominated	1.26E+08	1.88	6.70E+07	19	1.7E+06	4170000	6.3E+03	2.30	12.080
5	G050w	Charlotte Harbor	Charlotte Harbor EDA	Coastal Embayments	8.19E+08	1.63	5.02E+08	59	2.6E+06	5070000	2.5E+04	6.81	2.260
6	G060x	Sarasota Bay	Sarasota Bay EDA	Lagoons	2.72E+08	2.19	1.24E+08	87	3.6E+05	487000	5.4E+03	4.25	0.654
7	G070x	Tampa Bay	Tampa Bay EDA	Coastal Embayments	2.70E+09	3.00	9.00E+08	197	3.3E+06	3510000	2.1E+04	7.63	0.475
8	G080x	Suwannee River	Suwannee River EDA	River Dominated	1.93E+08	1.17	1.65E+08	4	6.6E+06	25700000	6.8E+04	9.17	48.604
9	G090x	Apalachee Bay	Apalachee Bay EDA	River Dominated	3.40E+09	1.92	1.77E+09	50	3.6E+06	9590000	2.1E+05	5.73	1.030
10	G100x	Apalachicola Bay	Apalachicola Bay EDA	Lagoons	1.07E+09	1.81	5.91E+08	8	2.0E+07	64000000	3.1E+05	7.07	21.832
11	G110x	St. Andrew Bay	St. Andrew Bay EDA	Coastal Embayments	7.14E+08	2.83	2.52E+08	136	4.0E+05	1750000	1.9E+04	4.23	0.895
12	G120x	Choctawhatchee Bay	Choctawhatchee Bay EDA	Lagoons	1.29E+09	3.80	3.39E+08	39	4.9E+06	19300000	1.0E+05	10.04	5.461
13	G130x	Pensacola Bay	Pensacola Bay EDA	Lagoons	1.44E+09	3.02	4.77E+08	26	6.4E+06	25800000	2.5E+05	8.41	6.540
14	G140x	Perdido Bay	Perdido Bay EDA	Lagoons	1.97E+08	1.53	1.29E+08	29	1.6E+06	3910000	2.3E+04	8.16	7.244
15	G150x	Mobile Bay	Mobile Bay EDA	River Dominated	2.06E+09	1.91	1.08E+09	7	5.3E+07	157000000	1.2E+06	10.26	27.818
16	G160x	East Mississippi Sound	East Mississippi Sound EDA	Coastal Embayments	1.53E+09	2.34	6.54E+08	25	1.2E+07	34400000	2.5E+05	5.83	8.207
17	G170a	West Mississippi Sound	Lake Borgne EDA	River Dominated	1.34E+09	1.81	7.40E+08	25	1.9E+07	30600000	2.1E+05	8.54	8.335
18	G170b	West Mississippi Sound	Lake Pontchartrain EDA	River Dominated	6.57E+09	3.50	1.88E+09	293	7.4E+06	11500000	7.6E+04	8.24	0.639
19	G170w	West Mississippi Sound	West Mississippi Sound EDA	Coastal Embayments	3.84E+09	2.43	1.58E+09	336	1.5E+06	3100000	5.2E+04	6.53	0.295

20	G210x	Terrebonne/Timbalier Bays	Terrebonne/Timbalier Bays EDA	River Dominated	8.54E+08	0.68	1.26E+09	213	2.6E+06	64900	1.3E+04	8.05	0.028
21	G240x	Calcasieu Lake	Calcasieu Lake EDA	Lagoons	3.11E+08	1.20	2.59E+08	22	4.8E+06	8390000	2.0E+04	11.56	9.847
22	G250x	Sabine Lake	Sabine Lake EDA	Lagoons	6.61E+08	2.49	2.65E+08	10	1.4E+07	44100000	7.7E+04	12.70	24.352
23	G260x	Galveston Bay	Galveston Bay EDA	Lagoons	2.25E+09	1.54	1.46E+09	22	2.5E+07	56300000	9.4E+04	9.75	9.133
24	G280x	Matagorda Bay	Matagorda Bay EDA	Lagoons	1.57E+09	1.41	1.11E+09	82	9.5E+06	9930000	6.3E+03	6.61	2.309
25	G290x	San Antonio Bay	San Antonio Bay EDA	Lagoons	3.47E+08	0.59	5.88E+08	30	4.2E+06	6590000	3.0E+03	7.25	6.932
26	G300x	Aransas Bay	Aransas Bay EDA	Lagoons	5.15E+08	0.98	5.26E+08	536	6.3E+05	587000	2.9E+02	5.36	0.416
27	M010x	Buzzards Bay	Buzzards Bay EDA	Coastal Embayments	6.42E+09	10.05	6.39E+08	468	8.4E+05	420000	1.8E+05	7.13	0.024
28	M020x	Narragansett Bay	Narragansett Bay EDA	River Dominated	3.46E+09	8.31	4.16E+08	109	5.5E+06	4920000	3.5E+05	9.55	0.519
29	M060x	Hudson River/Raritan Bay	Hudson River/Raritan Bay EDA	River Dominated	4.90E+09	6.13	7.99E+08	45	4.8E+07	51400000	4.9E+05	17.04	3.829
30	M070x	Barnegat Bay	Barnegat Bay EDA	Lagoons	1.18E+08	0.65	1.82E+08	29	1.1E+06	1320000	1.8E+04	17.72	4.083
31	M080x	New Jersey Inland Bays	New Jersey Inland Bays EDA	Lagoons	3.10E+08	1.11	2.79E+08	27	1.2E+06	1330000	6.9E+04	15.57	1.566
32	M090x	Delaware Bay	Delaware Bay EDA	River Dominated	1.27E+10	6.12	2.08E+09	85	4.2E+07	41400000	6.5E+05	14.80	1.190
33	M100x	Delaware Inland Bays	Delaware Inland Bays EDA	Lagoons	1.60E+08	2.00	8.00E+07	98	3.4E+05	237000	4.2E+03	12.50	0.541
34	M110x	Maryland Inland Bays	Maryland Inland Bays EDA	Lagoons	1.04E+08	1.92	5.42E+07	253	1.7E+05	48800	1.8E+03	15.31	0.171
35	M130a	Chesapeake Bay	Patuxent River EDA	River Dominated	5.37E+08	3.78	1.42E+08	253	1.7E+06	1170000	4.6E+03	8.96	0.795
36	M130b	Chesapeake Bay	Potomac River EDA	River Dominated	6.47E+09	5.13	1.26E+09	121	3.1E+07	34100000	1.1E+05	23.95	1.924
37	M130c	Chesapeake Bay	Rappahannock River EDA	River Dominated	1.41E+09	3.75	3.76E+08	185	3.5E+06	4380000	4.8E+04	18.98	1.134
38	M130d	Chesapeake Bay	York River EDA	River Dominated	7.86E+08	3.82	2.06E+08	92	3.3E+06	4030000	2.5E+04	16.54	1.871
39	M130e	Chesapeake Bay	James River EDA	River Dominated	2.06E+09	3.22	6.40E+08	61	1.2E+07	21600000	6.4E+04	17.49	3.827
40	M130f	Chesapeake Bay	Chester River EDA	River Dominated	6.81E+08	3.47	1.96E+08	276	8.3E+05	118000	1.2E+04	24.81	0.063
41	M130g	Chesapeake Bay	Choptank River EDA	River Dominated	1.27E+09	3.09	4.11E+08	85	2.0E+06	568000	8.2E+04	20.26	0.163
42	M130h	Chesapeake Bay	Tangier/Pocomoke	River Dominated	3.48E+09	3.29	1.06E+09	586	5.5E+06	857000	2.4E+04	14.24	0.090

43	N010x	Passamaquoddy Bay	Passamaquoddy Bay EDA	Fjords	6.74E+09	45.57	1.48E+08	91	9.7E+05	6460000	1.3E+06	7.42	0.350
44	N020x	Englishman/Machias Bay	Englishman/Machias Bay EDA	Fjords	2.57E+09	11.44	2.25E+08	58	8.3E+05	3540000	8.0E+05	6.40	0.503
45	N030x	Narraguagus Bay	Narraguagus Bay EDA	Fjords	2.03E+09	9.85	2.06E+08	96	3.9E+05	1560000	3.8E+05	5.97	0.280
46	N040x	Blue Hill Bay	Blue Hill Bay EDA	Fjords	7.25E+09	22.87	3.17E+08	409	5.0E+05	1120000	3.3E+05	6.21	0.056
47	N050x	Penobscot Bay	Penobscot Bay EDA	Fjords	2.44E+10	24.64	9.90E+08	83	8.3E+06	35800000	5.3E+06	8.88	0.536
48	N060x	Muscongus Bay	Muscongus Bay EDA	Fjords	2.47E+09	12.28	2.01E+08	870	3.9E+05	343000	4.4E+04	6.49	0.051
49	N070x	Damariscotta River	Damariscotta River EDA	Fjords	6.79E+08	12.82	5.30E+07	886	1.1E+05	1930	1.4E+04	3.98	0.001
50	N080x	Sheepscot Bay	Sheepscot Bay EDA	Fjords	1.92E+09	17.94	1.07E+08	305	2.8E+05	613000	1.1E+05	4.74	0.117
51	N100x	Casco Bay	Casco Bay EDA	Fjords	5.14E+09	12.04	4.27E+08	122	8.2E+05	3210000	8.2E+05	7.55	0.228
52	N110x	Saco Bay	Saco Bay EDA	River Dominated	4.94E+08	10.09	4.90E+07	8	2.0E+06	7370000	1.2E+06	5.39	5.445
53	N170a	Massachusetts Bay	Boston Harbor EDA	Coastal Embayments	1.16E+09	6.25	1.86E+08	76	4.3E+06	1130000	2.4E+05	7.07	0.356
54	P050w	San Pedro Bay	San Pedro Bay EDA	Coastal Embayments	6.35E+08	11.15	5.70E+07	121	1.3E+07	771000	7.0E+03	5.90	0.443
55	P090a	San Francisco Bay	Central San Francisco/San Pablo/Suisun Bays EDA	River Dominated	5.62E+09	6.72	8.36E+08	36	3.0E+07	72300000	9.2E+05	7.53	4.696
56	P240x	Tillamook Bay	Tillamook Bay EDA	River Dominated	6.99E+07	1.84	3.80E+07	5	2.6E+06	5270000	8.7E+04	8.01	27.519
57	P270x	Willapa Bay	Willapa Bay EDA	Coastal Embayments	1.07E+09	3.02	3.54E+08	21	2.9E+06	7260000	5.0E+05	11.12	2.477
58	P280x	Grays Harbor	Grays Harbor EDA	River Dominated	4.65E+08	1.98	2.35E+08	6	1.3E+07	22000000	6.4E+05	9.33	17.269
59	P290b	Puget Sound	Skagit Bay/Whidbey Basin EDA	Fjords	2.88E+10	46.37	6.21E+08	131	1.8E+07	74400000	1.7E+06	13.56	0.943
60	S010x	Albemarle Sound	Albemarle Sound EDA	Lagoons	6.25E+09	2.50	2.50E+09	140	1.8E+07	27400000	6.5E+04	13.34	1.600
61	S020a	Pamlico Sound	Pamlico/Pungo Rivers EDA	River Dominated	7.34E+08	1.62	4.53E+08	68	6.5E+06	6000000	1.6E+04	15.38	2.984
62	S020b	Pamlico Sound	Neuse River EDA	River Dominated	1.31E+09	2.86	4.58E+08	75	1.0E+07	10200000	2.3E+04	13.41	2.842
63	S030x	Bogue Sound	Bogue Sound EDA	Lagoons	3.63E+08	1.32	2.75E+08	208	4.2E+05	45500	3.9E+03	7.06	0.046
64	S050x	Cape Fear River	Cape Fear River EDA	River Dominated	2.45E+08	2.45	1.00E+08	7	1.5E+07	19100000	3.9E+04	4.09	28.455

65	S060x	Winyah Bay	Winyah Bay EDA	River Dominated	4.49E+08	5.05	8.89E+07	7	2.4E+07	40200000	4.3E+04	7.15	32.679
66	S080x	Charleston Harbor	Charleston Harbor EDA	River Dominated	4.24E+08	4.99	8.50E+07	16	1.2E+06	13700000	2.1E+04	6.46	11.794
67	S100x	St. Helena Sound	St. Helena Sound EDA	River Dominated	7.20E+08	3.55	2.03E+08	41	1.1E+06	7380000	1.6E+04	7.49	3.741
68	S110x	Broad River	Broad River EDA	River Dominated	1.22E+09	5.03	2.43E+08	375	3.8E+05	452000	3.9E+03	4.60	0.135
69	S120x	Savannah River	Savannah River EDA	River Dominated	3.73E+08	3.08	1.21E+08	5	1.0E+07	29700000	6.9E+04	6.69	29.063
70	S130x	Ossabaw Sound	Ossabaw Sound EDA	River Dominated	2.94E+08	3.35	8.78E+07	19	3.3E+06	7470000	1.2E+04	7.99	9.274
71	S140x	St. Catherines/Sapelo Sounds	St. Catherines/Sapelo Sounds EDA	River Dominated	6.83E+08	3.63	1.88E+08	979	2.7E+05	69200	5.9E+02	7.65	0.037
72	S160x	St. Andrew/St. Simons Sounds	St. Andrew/St. Simons Sounds EDA	River Dominated	6.82E+08	3.87	1.76E+08	57	2.6E+06	5640000	9.4E+03	7.61	3.018
73	S170x	St. Marys River/Cumberland Sound	St. Marys River/Cumberland Sound EDA	River Dominated	2.14E+08	3.34	6.41E+07	29	6.1E+05	1700000	9.2E+03	2.64	2.900
74	S180x	St. Johns River	St. Johns River EDA	River Dominated	1.51E+09	2.21	6.83E+08	97	6.3E+06	13100000	2.7E+03	5.42	3.167
75	S200x	Biscayne Bay	Biscayne Bay EDA	Lagoons	8.64E+08	1.23	7.02E+08	20	6.7E+06	10500000	1.3E+05	4.13	4.436

Note: Observed Chl a (µg/L) means the mean observed Summer Chl a of 7 years (µg/L).

Table S2 Characteristics of the 24 estuaries not included

REASON	EDA	NAME	Sub-Name	Type	Volume (m^3)	Discharge (m^3/day)	Depth (m)	Area (m^2)	Res. Time (day)	TN load (kg/yr)	Observed Chl a (µg/L)
M	G180x	Breton/Chandeleur Sound	Breton/Chandeleur Sound EDA	Coastal Embayments	1.18E+10	238000	3.1	3.81E+09	504	1.3E+04	7.85
P	N180x	Cape Cod Bay	Cape Cod Bay EDA	Coastal Embayments	3.25E+10	147000	22.56	1.44E+09	1294	1.8E+04	4.23
M	M120x	Chincoteague Bay	Chincoteague Bay EDA	Lagoons	6.48E+08	52900	1.94	3.34E+08	183	6.7E+04	18.80
M	S020w	Pamlico Sound	Pamlico Sound EDA	Lagoons	1.37E+10	303000	3.1	4.42E+09	959	1.9E+04	6.46
P	P080w	Monterey Bay	Monterey Bay EDA	Coastal Embayments	4.56E+10	1950000	83.75	5.44E+08	3249	2.5E+06	10.12
M	M030x	Gardiners Bay	Gardiners Bay EDA	Coastal Embayments	3.27E+09	90100	6.39	5.12E+08	389	1.9E+05	7.47
P	N170w	Massachusetts Bay	Massachusetts Bay EDA	Coastal Embayments	2.23E+10	179000	29.09	7.67E+08	1320	2.3E+05	4.55
M	P290c	Puget Sound	South Puget Sound EDA	Fjords	1.76E+10	5280000	39.30	4.48E+08	313	2.3E+06	9.45
P	P290w	Puget Sound	Puget Sound EDA	Fjords	9.85E+10	14000000	91.16	1.08E+09	500	8.3E+06	10.13
M	M050x	Great South Bay	Great South Bay EDA	Lagoons	4.20E+08	471000	1.10	3.82E+08	199	7.0E+05	25.21
M	S190x	Indian River	Indian River EDA	Lagoons	6.69E+08	2980000	0.77	8.69E+08	36	8.2E+04	6.09
M	M040w	Long Island Sound	Long Island Sound EDA	Coastal Embayments	6.35E+10	15500000	19.47	3.26E+09	425	1.1E+07	11.81
M	P290d	Puget Sound	Port Orchard Sound EDA	Fjords	1.41E+09	165000	15.33	9.20E+07	183	5.6E+04	8.73
M	G030x	North Ten Thousand Islands	North Ten Thousand Islands EDA	River Dominated	2.84E+08	4200000	0.73	3.89E+08	16	7.8E+04	5.71
P	G200x	Barataria Bay	Barataria Bay EDA	River Dominated	3.62E+08	598000	0.42	8.62E+08	114	7.2E+05	14.21
P	P290a	Puget Sound	Hood Canal EDA	Fjords	2.69E+10	7450000	67.96	3.96E+08	470	1.5E+07	7.34
P	G310x	Corpus Christi Bay	Corpus Christi Bay EDA	Lagoons	1.54E+09	492000	2.69	5.72E+08	1320	9.5E+05	4.61
P	P020x	San Diego Bay	San Diego Bay EDA	Lagoons	1.04E+08	62500	2.37	4.39E+07	1384	9.6E+05	4.62
P	G220x	Atchafalaya/Vermilion Bays	Atchafalaya/Vermilion Bays EDA	River Dominated	2.67E+09	716000000	1.20	2.23E+09	3	3.7E+08	11.45
P	M130t	Chesapeake Bay	Chesapeake Bay Mainstem EDA	River Dominated	5.11E+10	105000000	28.00	1.83E+09	232	5.9E+07	15.36

P	P090w	San Francisco Bay	San Francisco Bay EDA	River Dominated	2.14E+09	692000	4.38	4.88E+08	1782	4.2E+06	6.90
P	P260x	Columbia River	Columbia River EDA	River Dominated	2.85E+09	595000000	4.63	6.16E+08	4	1.2E+08	12.81
P	G230x	Mermentau River	Mermentau River EDA	River Dominated	2.25E+07	7890000	0.05	4.50E+08	3	7.3E+06	12.07
P	G190x	Mississippi River	Mississippi River EDA	River Dominated	6.88E+09		7.01	9.81E+08	3	1.1E+09	9.34

Note: Dropped Reasons: P- extreme physical characteristics (marked red); M- outlier results from early attempts with our model resulting in very high converting efficiencies (all>17 and some larger than 90.

P :
N180x : long residence time as 1294 days;
P080w: too deep as 83.75 m;
N170w : long residence time as 1320 days;
P290w : too deep as 91.16 m;
G200x : too shallow as 0.42m;
P290a : too deep as 67.96 m
G310x : long residence time as 1320 days;
P020x long residence time as 1384 days;
G220x : extreme load as 3.7E+08 kg/day;
M130t : complex estuarine characters;
P090w : long residence time as 1782 days;
P260x : extreme load as 1.2E+08 kg/day;
G230x : too shallow as 0.05m;
G190x: extreme load as 1.1E+09 kg/day.

M: Very high efficiencies

EDA	Q/V(1/year)	Efficiency
G180x	0.0074	123
M120x	0.0298	98
S020w	0.0081	91
M030x	0.0101	77
P290c	0.1095	72
M050x	0.4093	43
S190x	1.6259	22
M040w	0.0891	19
P290d	0.0427	19
G030x	5.3979	18

Table S3 The model results:

(a) Modeled Chl *a* and Alpha (α) values

NO	EDA	Modeled Chl a (μg/L)	Chla-s.d.	Chla-2.5%	Chla-25%	Chla-50%	Chla-75%	Chla-97.5%	Alpha (α)	alpha-s.d.	alpha-2.5%	alpha-25%	alpha-50%	alpha-75%	alpha-97.5%	efficiency (ε)
1	G010x	3.79	0.27	3.28	3.62	3.78	3.96	4.31	125.57	24.11	81.91	109.00	124.20	140.35	175.30	6.69
2	G020x	4.23	0.31	3.66	4.02	4.21	4.42	4.86	8.99	1.61	6.10	7.85	8.87	9.96	12.40	0.47
3	G040x	3.41	0.25	2.97	3.24	3.39	3.58	3.93	49.21	10.25	31.50	41.67	48.49	55.70	70.79	2.70
4	G050a	1.96	0.15	1.69	1.86	1.96	2.05	2.24	0.69	0.11	0.51	0.61	0.68	0.76	0.93	0.03
5	G050w	6.79	0.49	5.88	6.44	6.78	7.11	7.77	16.15	2.71	11.52	14.35	15.96	17.69	22.17	0.77
6	G060x	4.24	0.31	3.66	4.03	4.23	4.43	4.89	16.19	2.67	11.61	14.31	16.07	17.90	21.71	0.78
7	G070x	7.50	0.54	6.54	7.12	7.47	7.85	8.64	41.84	7.36	28.93	36.68	41.24	46.15	57.89	1.91
8	G080x	8.66	0.66	7.47	8.19	8.66	9.06	9.93	3.70	0.55	2.74	3.32	3.67	4.03	4.91	0.17
9	G090x	5.64	0.43	4.84	5.35	5.62	5.93	6.50	33.37	5.59	23.89	29.37	32.76	36.89	45.59	1.59
10	G100x	7.10	0.52	6.18	6.73	7.08	7.46	8.11	3.67	0.56	2.69	3.26	3.64	4.00	4.92	0.17
11	G110x	4.18	0.30	3.63	3.96	4.17	4.38	4.78	32.86	5.60	23.07	29.10	32.41	36.34	44.50	1.54
12	G120x	9.95	0.74	8.61	9.44	9.91	10.41	11.64	13.12	2.12	9.45	11.67	12.94	14.39	17.71	0.60
13	G130x	8.37	0.61	7.20	7.94	8.36	8.78	9.56	9.33	1.46	6.81	8.33	9.18	10.19	12.54	0.42
14	G140x	7.92	0.58	6.81	7.50	7.90	8.29	9.11	8.60	1.44	6.08	7.59	8.47	9.47	11.69	0.40
15	G150x	10.19	0.77	8.76	9.66	10.17	10.72	11.68	4.75	0.76	3.41	4.24	4.67	5.23	6.35	0.21
16	G160x	5.79	0.41	5.01	5.50	5.80	6.06	6.61	5.05	0.78	3.63	4.51	5.03	5.52	6.76	0.23
17	G170a	8.57	0.63	7.36	8.14	8.52	8.97	9.89	5.58	0.94	4.03	4.90	5.48	6.16	7.70	0.25
18	G170b	8.25	0.62	7.06	7.80	8.23	8.67	9.47	30.17	5.13	20.92	26.58	30.23	33.33	40.68	1.42
19	G170w	6.26	0.44	5.48	5.96	6.25	6.54	7.16	96.45	16.42	66.79	85.27	94.60	106.60	131.92	4.50
20	G210x	8.13	0.59	7.03	7.71	8.10	8.50	9.34	32.38	5.52	22.70	28.34	32.02	36.01	43.43	1.63
21	G240x	11.59	0.86	10.08	10.97	11.53	12.16	13.35	9.40	1.55	6.77	8.30	9.30	10.37	12.66	0.44
22	G250x	12.78	0.91	11.09	12.15	12.77	13.38	14.65	7.70	1.27	5.46	6.82	7.60	8.49	10.34	0.34
23	G260x	9.87	0.73	8.48	9.38	9.84	10.31	11.39	9.40	1.53	6.72	8.26	9.27	10.36	12.49	0.43
24	G280x	6.58	0.48	5.69	6.24	6.57	6.89	7.53	8.58	1.44	6.12	7.55	8.49	9.48	11.64	0.41
25	G290x	7.18	0.51	6.26	6.82	7.17	7.54	8.21	7.60	1.32	5.29	6.73	7.42	8.41	10.47	0.39

26	G300x	5.23	0.39	4.57	4.96	5.20	5.50	6.02	34.05	6.19	23.73	29.72	33.48	37.82	47.60	1.73
27	M010x	6.61	0.42	5.86	6.33	6.60	6.88	7.53	116.44	20.91	80.57	101.80	114.50	129.40	159.84	5.15
28	M020x	9.54	0.68	8.30	9.05	9.53	10.00	10.97	23.17	4.23	15.89	20.25	22.89	25.80	32.47	1.02
29	M060x	17.12	1.25	14.72	16.26	17.01	17.96	19.66	12.56	2.41	8.62	10.77	12.28	13.98	18.07	0.54
30	M070x	16.84	1.24	14.67	15.98	16.81	17.64	19.51	34.37	5.81	24.03	30.19	33.92	38.09	47.08	1.64
31	M080x	15.18	1.10	13.13	14.43	15.16	15.93	17.40	58.39	9.81	40.91	50.95	57.91	64.80	79.26	2.68
32	M090x	14.85	1.06	12.88	14.14	14.83	15.48	17.01	27.41	5.07	18.32	23.87	26.93	30.51	37.75	1.18
33	M100x	12.26	0.88	10.50	11.68	12.24	12.85	14.01	61.69	11.02	42.77	53.59	60.82	68.91	85.41	2.79
34	M110x	14.36	0.97	12.42	13.69	14.36	15.00	16.27	105.28	18.49	72.56	91.81	103.65	116.80	144.63	4.71
35	M130a	8.06	0.60	6.96	7.63	8.03	8.45	9.31	10.38	1.83	7.31	9.12	10.25	11.55	14.26	0.48
36	M130b	23.94	1.69	20.83	22.78	23.87	25.03	27.36	47.84	8.95	32.59	41.50	47.07	53.81	66.22	2.05
37	M130c	18.85	1.38	16.32	17.84	18.87	19.74	21.59	60.06	11.21	41.11	52.13	59.16	66.30	84.57	2.60
38	M130d	16.66	1.24	14.40	15.77	16.60	17.47	19.12	28.63	5.15	19.74	25.03	28.25	32.11	39.73	1.26
39	M130e	17.71	1.29	15.31	16.84	17.65	18.55	20.33	24.61	4.44	16.73	21.72	24.19	27.29	34.58	1.08
40	M130f	21.87	1.33	19.44	20.93	21.81	22.76	24.62	159.50	28.38	110.69	140.50	156.20	176.90	220.86	7.05
41	M130g	18.92	1.33	16.59	17.99	18.88	19.79	21.86	96.07	17.66	65.54	83.72	94.54	106.70	135.00	4.27
42	M130h	14.11	1.03	12.21	13.41	14.09	14.79	16.10	55.67	10.24	38.08	48.58	54.77	61.98	78.29	2.50
43	N010x	7.28	0.51	6.34	6.92	7.29	7.59	8.33	61.66	11.86	41.70	53.04	60.39	69.22	85.43	2.59
44	N020x	6.36	0.46	5.53	6.02	6.37	6.66	7.30	29.90	5.29	20.91	26.16	29.31	33.16	40.99	1.31
45	N030x	6.00	0.44	5.17	5.66	5.98	6.27	6.93	43.59	7.86	30.53	37.93	42.67	48.60	62.09	1.92
46	N040x	5.80	0.38	5.05	5.54	5.79	6.05	6.58	116.37	21.40	79.35	101.40	114.70	129.90	160.90	5.08
47	N050x	8.78	0.65	7.59	8.34	8.76	9.22	10.08	55.88	11.09	37.95	47.84	54.83	62.58	80.10	2.39
48	N060x	6.18	0.44	5.33	5.87	6.18	6.49	7.05	89.02	16.90	59.53	76.94	88.21	99.80	125.40	3.91
49	N070x	3.92	0.27	3.41	3.73	3.92	4.09	4.50	38.81	6.72	27.40	34.01	38.41	43.19	53.51	1.73
50	N080x	4.70	0.34	4.05	4.46	4.71	4.95	5.37	44.82	8.31	30.32	38.74	44.30	50.33	61.98	1.96
51	N100x	7.35	0.52	6.33	7.01	7.34	7.68	8.38	71.93	13.55	48.88	62.79	70.97	80.11	101.50	3.11
52	N110x	5.42	0.40	4.68	5.14	5.40	5.67	6.23	4.17	0.70	3.00	3.68	4.10	4.60	5.66	0.18
53	N170a	7.08	0.53	6.07	6.72	7.07	7.45	8.10	6.27	1.07	4.36	5.49	6.25	6.94	8.53	0.28
54	P050w	5.98	0.45	5.14	5.67	5.97	6.29	6.85	0.80	0.15	0.54	0.70	0.79	0.90	1.13	0.04
55	P090a	7.62	0.56	6.59	7.23	7.58	7.97	8.82	5.42	0.93	3.85	4.76	5.32	6.05	7.49	0.24

56	P240x	8.02	0.61	6.88	7.58	8.01	8.42	9.26	2.55	0.39	1.83	2.27	2.52	2.81	3.36	0.11
57	P270x	11.13	0.81	9.62	10.58	11.11	11.63	12.79	22.35	3.51	16.41	19.83	21.94	24.50	30.03	1.02
58	P280x	9.41	0.70	8.09	8.91	9.39	9.89	10.85	3.92	0.59	2.84	3.51	3.90	4.28	5.23	0.17
59	P290b	13.03	0.88	11.38	12.43	12.98	13.61	14.82	91.09	18.02	59.80	77.95	89.71	102.55	130.50	3.86
60	S010x	13.31	0.94	11.58	12.67	13.31	13.92	15.23	52.19	9.48	35.87	45.41	51.83	58.16	72.87	2.31
61	S020a	15.29	1.17	13.26	14.41	15.27	16.06	17.60	23.67	4.37	16.33	20.58	23.07	26.43	33.15	1.07
62	S020b	13.45	0.95	11.73	12.80	13.37	14.09	15.24	19.03	3.52	12.99	16.64	18.64	21.23	26.64	0.83
63	S030x	7.03	0.51	6.04	6.67	7.01	7.37	8.09	49.77	8.80	34.29	43.61	48.78	55.35	69.18	2.41
64	S050x	4.08	0.30	3.51	3.87	4.09	4.27	4.69	0.52	0.08	0.38	0.46	0.51	0.56	0.69	0.02
65	S060x	5.95	0.44	5.14	5.64	5.94	6.24	6.80	0.66	0.11	0.47	0.59	0.65	0.72	0.91	0.03
66	S080x	6.37	0.49	5.46	6.05	6.36	6.69	7.36	9.86	1.54	7.09	8.81	9.72	10.80	13.32	0.44
67	S100x	7.41	0.55	6.38	7.01	7.39	7.76	8.52	19.98	3.30	14.52	17.69	19.75	21.95	27.01	0.94
68	S110x	4.61	0.34	3.94	4.40	4.61	4.83	5.28	37.01	5.97	25.49	32.96	36.52	41.00	49.25	1.75
69	S120x	6.72	0.50	5.85	6.35	6.68	7.06	7.76	1.91	0.31	1.40	1.68	1.87	2.09	2.63	0.08
70	S130x	8.02	0.59	6.87	7.61	8.03	8.40	9.24	3.64	0.56	2.67	3.25	3.61	3.96	4.85	0.17
71	S140x	7.46	0.53	6.48	7.10	7.44	7.81	8.60	72.54	12.48	50.39	63.70	71.65	81.07	100.30	3.36
72	S160x	7.60	0.57	6.54	7.21	7.57	7.99	8.76	8.07	1.34	5.75	7.13	7.96	8.91	10.99	0.37
73	S170x	2.64	0.19	2.30	2.50	2.64	2.77	3.01	2.65	0.40	1.92	2.36	2.63	2.92	3.49	0.13
74	S180x	5.11	0.38	4.44	4.86	5.10	5.36	5.88	6.99	1.16	5.01	6.20	6.86	7.73	9.50	0.33
75	S200x	4.18	0.32	3.58	3.97	4.17	4.39	4.80	3.89	0.62	2.74	3.45	3.86	4.30	5.26	0.19

(b) Correlation matrix

	v_s	*C:CHL*	L	α
v_s	1.00			
C:CHL	-0.58	1.00		
L	0.57	-0.83	1.00	
ad	0.20	0.24	-0.03	1.00

Table S4 Primary production values from the literature used in Figure 1

M-H	S&H	Boynton	U&K
1.29	1.94	0.16	0.55
1.28	1.20	0.17	0.16
1.05	1.16	0.24	0.23
0.88	1.15	0.24	0.50
0.83	0.77	0.30	0.04
0.74	0.74	0.30	0.11
0.74	0.73	0.30	0.99
0.43	0.69	0.37	0.67
0.37	0.53	0.37	0.71
0.23	0.51	0.43	0.07
0.19	0.53	0.46	1.27
0.18	0.48	0.49	1.08
0.17	0.47	0.49	1.15
0.17	0.42	0.55	0.74
0.13	0.39	0.61	0.64
	0.35	0.67	0.29
	0.32	0.73	2.29
	0.31	0.89	0.96
	0.29	0.91	0.30
	0.20	0.97	0.57
	0.16	1.10	1.07
	0.07	1.22	0.40
		1.34	0.32
		1.58	1.60
		1.83	1.95
		0.07	0.45
		0.12	1.49
		0.17	1.87
		0.32	0.48
		0.32	0.59
		0.62	
		0.67	
		0.73	
		0.79	
		0.24	
		0.43	
		0.61	
		0.61	
		0.97	
		0.15	
		0.30	
		0.34	
		0.76	
		1.53	
		1.64	

Table S5 Estimated parameter values with doubled and halved variance

Variance		mean	s.d.	2.50%	25%	50%	75%	97.50%
Original Variance	**L**	0.66	0.23	0.26	0.49	0.64	0.81	1.16
	C:Chla	56.69	10.57	41.50	48.72	55.03	63.08	81.90
	vs	0.21	0.07	0.09	0.16	0.21	0.26	0.35
Half variance	**L**	0.77	0.17	0.45	0.64	0.76	0.88	1.08
	C:Chla	50.92	5.92	40.91	46.71	50.36	54.70	63.72
	vs	0.25	0.06	0.15	0.21	0.25	0.29	0.36
Double variance	**L**	0.57	0.33	0.10	0.31	0.50	0.79	1.29
	C:Chla	66.72	21.22	38.51	50.42	62.68	77.00	120.31
	vs	0.17	0.08	0.05	0.11	0.16	0.22	0.37

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