Supplementary material to Löscher et al. 'No nitrogen fixation in the Bay of Bengal?'

Model experiment

The model framework is the modified version of Canfield's 5-box model (Canfield 2006) as presented in Boyle et al. (2013), using the available measurements for the BoB (Tab. M1, the complete code will be released on Pangaea). It is based on identification of the limiting nutrient for euphotic primary production under Redfield conditions. Primary production provides the basis for determination of export fluxes under consideration of respiration first using oxygen, followed by nitrate and sulfate according to the following stoichiometry:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

$$C_6H_{12}O_6 + 12NO_3^- \rightarrow 6N_2 + 15CO_2 + 12OH^- + 9H_2O$$

$$CH_3COO^- + SO_4^{2-} + H_2O \rightarrow H_2S + 2HCO_3^- + OH^-$$

Export production is estimated as the sum of organic carbon respiration (R) of the three above mentioned processes:

$$EP = R_{aerobic} + R_{denitrification} + R_{sulfate\_reduction}$$

For nitrate-based primary production, i.e. if nitrate is available above Redfield conditions, primary and export production directly depend on upwelling of bioavailable nitrogen. Surface N_2 fixation is based on Redfield stoichiometry and on Fe availability (Fe > 0). If

$$N_{ox} - r_{N:P}\, P < 0$$

is true, export production is proportional to phosphate upwelling to the euphotic zone.

The model was further modified to explore OMZ N_2 fixation, which we suggest adding a source of reduced N (N_R) to the OMZ. This pool of N_R would upon mixing or upwelling to the oxic surface promote nitrification and primary production.

OMZ N_2 fixation has been shown not to be limited by Redfield constraints Redfield stoichiometry as suggested by Bombar, Paerl, and Riemann (2016). This leads to a modification of the previous OMZ model (Boyle et al, 2013) with the Redfield control of N_2 fixation being replaced by a phosphorous only control with P > 0 constantly allowing for N_2 fixation and export production scaling with phosphate and $N_{ox} + N_R$ upwelling.

Tables

Tab M1: Concentrations used in the model experiment, data taken from Bristow et al. (2017), Grand et al. (2015) and (Chinni et al. 2019)

Parameter	Description	Concentration [µM]	Reference
O_{2U}	Oxygen concentration in surface waters	220	Bristow et al., 2017
O_{2I}	Oxygen concentration in intermediate waters	0.05	Bristow et al., 2017
O_{2D}	Oxygen concentration in deep sea	50	Bristow et al., 2017
P_U	Phosphate concentration in surface	0	Bristow et al., 2017
P_I	Phosphate concentration in intermediate water depth	2.7	Bristow et al., 2017
P_D	Phosphate concentration in deep waters	2.5	Bristow et al., 2017
N_{oxU}	Nitrate concentration in surfcae	0	Bristow et al., 2017
N_{oxI}	Nitrate concentration in intermediate water depth	38	Bristow et al., 2017
N_{oxD}	Nitrate concentration in intermediate water depth	35	Bristow et al., 2017
N_{RU}	Ammonia concentration in surface	0	Bristow et al., 2017
N_{RI}	Ammonia concentration in intermediate water depth	0	Bristow et al., 2017
N_{RD}	Ammonia concentration in deep sea	0	Bristow et al., 2017
Fe_{RU}	Dissolved iron concentration in surface waters	0.0004	Chinni et al., 2019
Fe_{RI}	Dissolved iron concentration in intermediate waters	0.015	Grand et al., 2015
Fe_{RD}	Dissolved iron concentration in deep sea	0.01	Grand et al., 2015

Table S1: CO_2 and N_2 fixation rates based on triplicate measurements at stations 1 (17.9970°N, 88.9968°E), 4 (16.9828°N, 89.2063°E) and 5 (17.2075°N, 89.4282°E). N_2 fixation was only measurable in two individual samples, but only in one out of three technical replicates.

station #	Incubation depth	CO_2 fixation [nmol L^{-1} d^{-1}]	SD	N_2 fixation [nmol L^{-1} d^{-1}]	SD
1	67	460.1	14.0	0.0	0.0
1	106	186.2	174.7	0.0	0.0
1	112	0.0	0.0	0.0	0.0
1	128	8.8	2.6	17.4	8.2
1	169	4.8	0.2	0.0	0.0
1	253	2.0	2.9	0.0	0.0
4	60	286.1	270.2	0.0	0.0
4	112	50.6	4.1	0.0	0.0
4	145	0.0	0.0	0.0	0.0
4	176	2.4	2.4	0.0	0.0
4	213	3.2	2.2	1.0	0.5
4	265	10.2	2.9	0.0	0.0
5	60	1855.0	157.6	0.0	0.0
5	111	109.3	5.8	0.0	0.0
5	122	41.7	1.2	0.0	0.0
5	157	37.8	3.8	0.0	0.0
5	195	37.7	4.5	0.0	0.0
5	280	56.1	12.4	0.0	0.0

Table S2: OTU counts of primary producers from a metagenome from station #4, 84m.

Class	%of OTUs in metagenome	Order	% of OTUs in class
Cyanobacteria	3,25%	Chroococcales	48%
		Prochlorales	41%
		Nostocales	5%
		Oscillatoriales	5%
		unclassified cyanobacteria	1%
Chlorophyta	0,33%	Mamiellales	75%
		Chlamydomonadales	21%
		Chlorellales	2%
		Ulvophyceae	0.4%
		unclassified chlorophta	1.6%

Table S3: POC and PON distribution at stations 1 (17.9970°N, 88.9968°E), 4 (16.9828°N, 89.2063°E) and 5 (17.2075°N, 89.4282°E).

station #	Incubation depth	POC [µmol L^{-1}]	SD	PON [µmol L^{-1}]	SD	POC:PON
1	67	4.956	0.195	0.531	0.027	9.331
1	106	11.057	5.038	1.411	0.773	7.838
1	112	6.730	2.493	0.700	0.182	9.613
1	128	6.709	1.015	0.818	0.048	8.198
1	169	5.946	0.830	0.586	0.125	10.151
1	253	4.720	1.774	0.262	0.105	17.998
4	60	5.854	0.734	0.688	0.051	8.505
4	112	3.833	0.336	0.395	0.030	9.714
4	145	6.674	2.634	1.022	0.645	6.527
4	176	7.884	1.713	1.247	0.255	6.321
4	213	4.858	0.112	0.676	0.048	7.186
4	265	4.166	0.667	0.475	0.074	8.773
5	60	7.844	1.094	1.253	0.256	6.259
5	111	6.461	1.462	1.013	0.080	6.376
5	122	8.783	1.263	1.488	0.143	5.902
5	157	7.409	0.241	1.325	0.067	5.590
5	195	9.337	0.404	1.433	0.203	6.514
5	280	5.232	0.659	0.674	0.017	7.766

Table S4: *nifH* qPCR quantification [copies L^{-1}], clusters which did were detectable by PCR but not quantifiable (below the detection limit of 4 copies L^{-1}) are not shown.

			nifH [copies L^{-1}]					
station	depth [m]	filtration volume [L]	filamentous	SD	Gamma-PO	SD	Green sulfur	SD
1	10	10.2	8.2E+08	4.6E+03	1.5E+03	5.6E+02	6.4E+03	2.6E+03
1	68	10.3	1.4E+11	2.2E+06	1.2E+03	1.6E+02	1.1E+04	1.2E+03
1	80	16.2	2.4E+11	6.1E+10	5.4E+02	0.0E+00	1.8E+03	2.0E+03
1	115	12.7	0.0E+00	0.0E+00	2.2E+03	3.8E+02	3.0E+03	1.5E+03
1	130	14	0.0E+00	0.0E+00	4.3E+03	9.0E+02	1.6E+03	5.0E+02
1	140	20	0.0E+00	0.0E+00	1.7E+11	3.9E+10	4.5E+02	2.3E+02
1	160	20.2	0.0E+00	0.0E+00	5.1E+02	6.9E+01	3.4E+03	1.1E+03
1	256	21.5	0.0E+00	0.0E+00	1.7E+03	1.7E+02	3.8E+03	5.5E+02
1	500	16.3	0.0E+00	0.0E+00	7.5E+02	3.3E+01	1.6E+03	1.4E+02
2	61	14	6.7E+03	8.5E+03	1.7E+03	2.6E+02	1.9E+03	7.4E+02
2	120	10.7	8.3E+05	3.7E+05	0.0E+00	0.0E+00	1.5E+03	1.2E+03
4	60	8	0.0E+00	0.0E+00	5.1E+02	7.3E+01	1.7E+03	3.4E+01
4	84	7.6	0.0E+00	0.0E+00	4.4E+02	6.1E+01	1.6E+03	1.4E+02
4	112	9.2	0.0E+00	0.0E+00	1.0E+12	1.3E+12	2.9E+03	3.4E+02
4	154	11.7	0.0E+00	0.0E+00	1.6E+02	2.0E+01	1.5E+04	2.1E+03
4	179	19.1	0.0E+00	0.0E+00	1.8E+02	4.1E+01	3.9E+03	1.0E+03
4	211	20.1	0.0E+00	0.0E+00	1.1E+02	1.8E+01	7.7E+02	2.8E+02
4	265	22.9	5.4E+04	7.0E+04	4.7E+02	0.0E+00	2.0E+03	1.3E+03
4	321	23.2	3.0E+03	3.2E+03	0.0E+00	0.0E+00	7.3E+02	1.7E+02
5	60	7.6	5.8E+02	5.1E+02	7.5E+02	2.3E+02	1.8E+03	5.8E+02
5	80	12.6	8.9E+02	4.4E+02	0.0E+00	0.0E+00	8.1E+02	1.8E+02
5	127	14.3	0.0E+00	0.0E+00	2.4E+03	7.9E+02	2.5E+04	8.8E+03
5	156	6.4	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.8E+02	1.5E+02
5	560	15.4	8.2E+08	4.6E+03	1.5E+03	5.6E+02	6.4E+03	2.6E+03

Figures

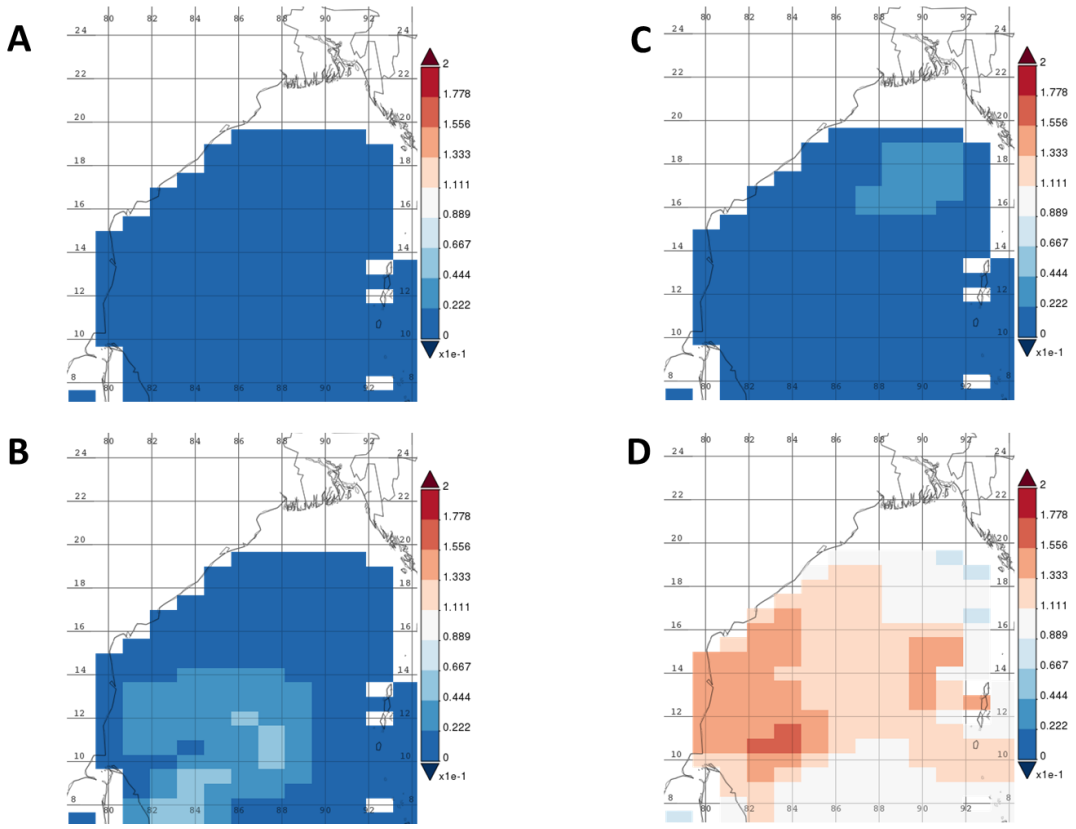

Figure S1: (A) OTU quantification from a metagenome obtained from the depth with high carbon fixation (#4, 84m) compared to satellite derived phytoplankton distribution in the BoB during the time of the cruise: (B) diatoms, (C) chlorophytes, (D) coccolithophores, and (A) cyanobacteria in mg m^{-3}.

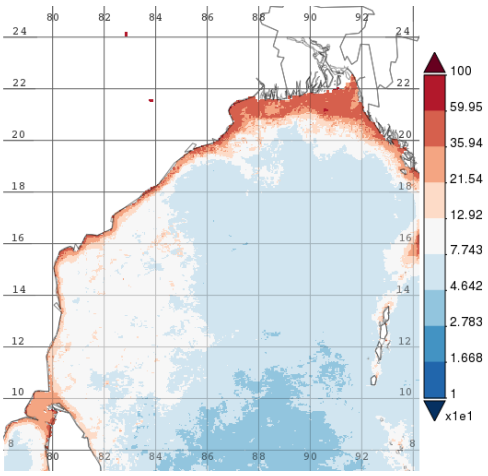

Figure S2: Time averaged POC distribution as monitored via MODIS-Aqua on an 8-daily basis, with a 4km resolution, POC concentrations in mg m^{-3}, concentrations in the cruise area were between 7.7 and 12.9 mg m^{-3} and are consistent with our in-situ measurements.

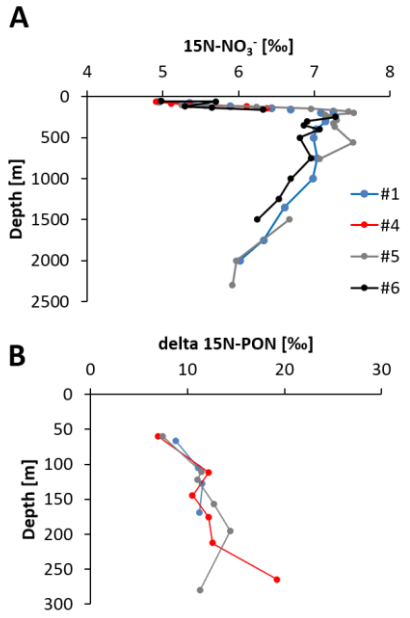

Fig. S3: Both, (A) $^{15}N\text{-}NO_3^-$ (data from Bristow et al., 2017) and (B) delta ^{15}N-PON show slightly lighter isotope signatures in the upper 100 m of the water column, however, this signal does not clearly indicate N_2 fixation.

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