Auxiliary Material for

Do *Trichodesmium* spp. populations in the North Atlantic export most of the nitrogen they fix?

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This document provides supplementary information describing the model used in the main article, as well as comparisons with a prior solution described in Anderson et al. [2011].

Contents:

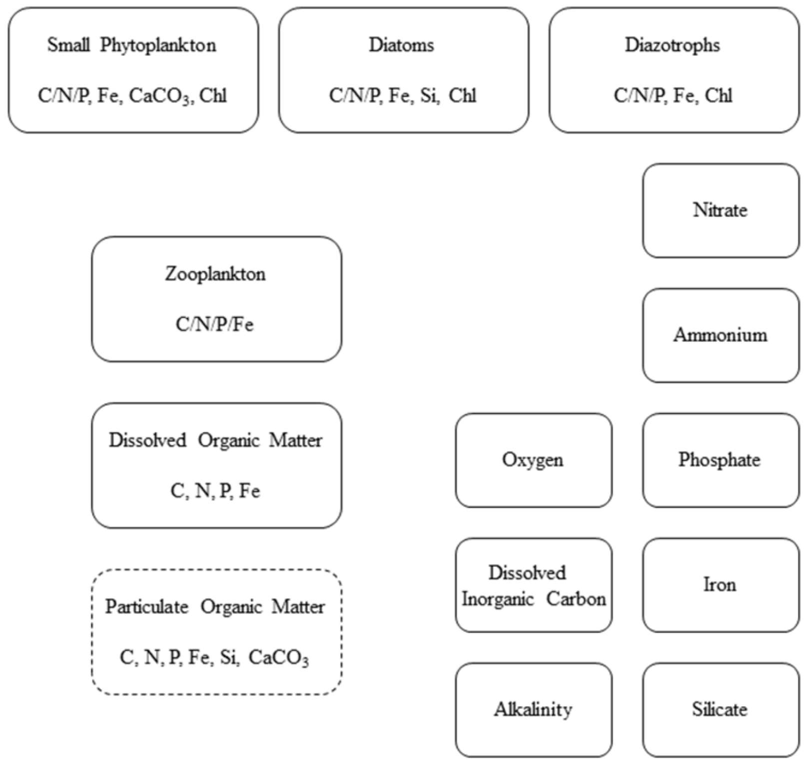

Figure S1. The BEC model as described by Moore and Doney [2007] and Moore et al. [2006]. The dashed box for particulate organic matter reflects the fact that it is not a true state variable, insofar as that material is assumed to sink and remineralize instantly.

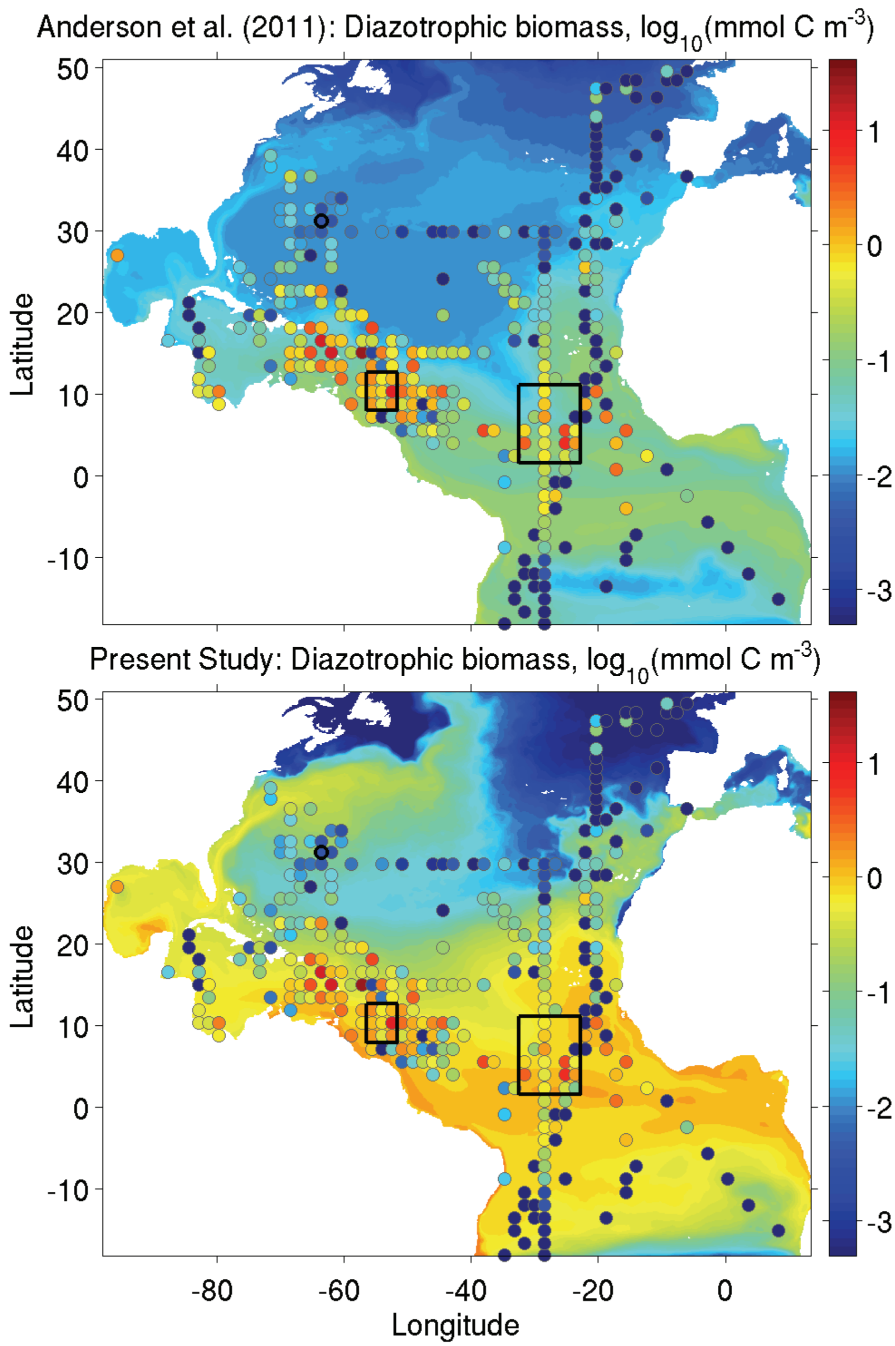

Figure S2. Near-surface (0-10 m) diazotrophic biomass for the Anderson et al. [2011] solution (top) and new biological model (bottom). Data from Luo et al. [2012], binned onto the 1.6° model grid, are shown as colored circles. Outlined in black are the locations of BATS (circle near 32°N 64°W), as well as Tropical West (rectangle centered at 10°N 54°W) and Tropical East (rectangle centered at 6°N 28°W) domains, for which detailed flux diagnosis is presented in Figure 6.

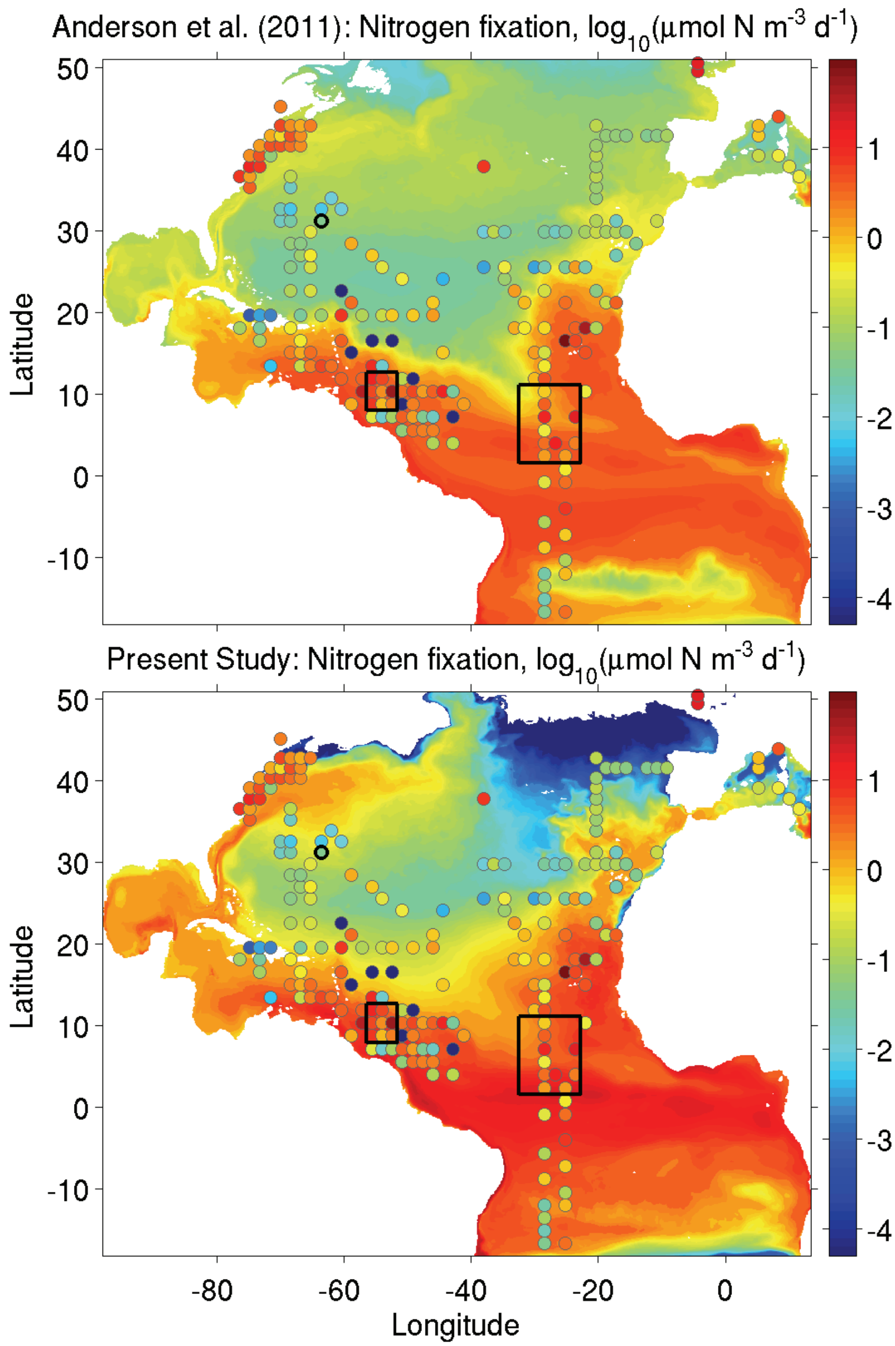

Figure S3. Near-surface (0-10 m) nitrogen fixation for the Anderson et al. [2011] solution (top) and new biological model (bottom). Data from Luo et al. [2012], binned onto the 1.6° model grid, are shown as colored circles. Outlined in black are the locations of BATS (circle near 32°N 64°W), as well as Tropical West (rectangle centered at 10°N 54°W) and Tropical East (rectangle centered at 6°N 28°W) domains, for which detailed flux diagnosis is presented in Figure 6.

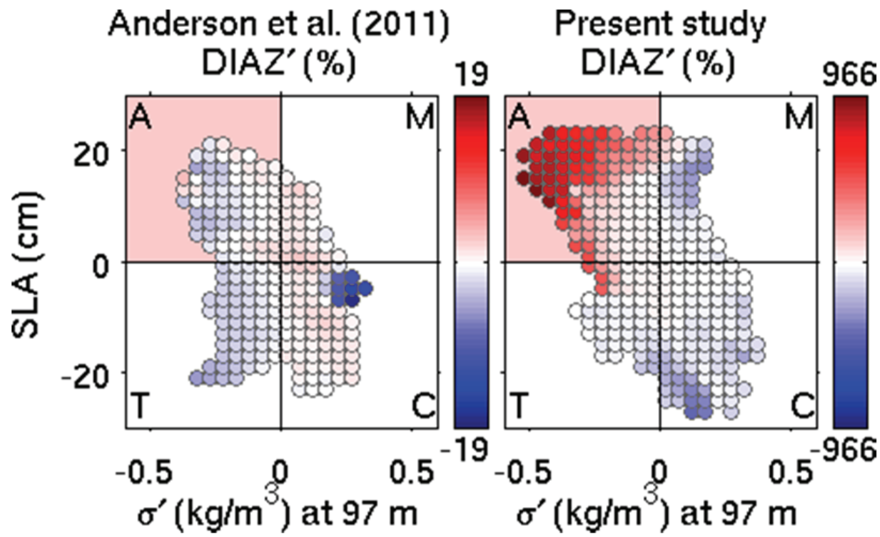

Figure S4. Vertically integrated (0–104 m) diazotrophic biomass anomalies (mg C m^{-2}), expressed as percent anomaly from the large-scale mean, binned according to SLA and *in situ* density anomaly at 97 m in the subdomain bordered by the white rectangle in Figure 8 (30-35°N, 30-48°W). The four quadrants correspond to anticyclones (A), mode-water eddies (M), thinnies (T) and cyclones (C). The background shading indicates the observed correlations in this region, which suggest enhancement of *Trichodesmium* spp. populations in anticyclones [*Davis and McGillicuddy*, 2006]. Left: the solution from Anderson et al. [2011]; right: the new model. For consistency with the observations, analysis of the model output is restricted to the August-September time frame.

Table S1: Selected parameters of the ecosystem model. Changes from the Anderson et al. [2011] model are highlighted in bold.

Parameter	Definition	Anderson et al. [2011] (Run 14)	This model (Run 63)
sp_kNO3	Half saturation constant for nitrate uptake by diazotrophs	0.5	0.5 μM N
diat_kNO3	″ nitrate uptake by diatoms	2.5	2.5 μM N
diaz_kNO3	″ nitrate uptake by diazotrophs	N/A	**1.0 μM N**
sp_kNH4	″ ammonium uptake by small phytoplankton	0.005	0.005 μM N
diat_kNH4	″ ammonium uptake by diatoms	0.08	0.08 μM N
diaz_kNH4	″ ammonium uptake by diazotrophs	N/A	**0.1 μM N**
sp_kPO4	″ phosphate uptake by small phytoplankton	0.005 μM P	0.005 μM P
diat_kPO4	″ phosphate uptake by diatoms	0.02 μM P	0.02 μM P
diaz_kPO4	″ phosphate uptake by diazotrophs	0.005 μM P	0.005 μM P
diat_kFe	″ iron uptake by diatoms	0.15 nM Fe	**0.08 nM Fe**
diaz_kFe	″ iron uptake by diazotrophs	0.1 nM Fe	**0.8 nM Fe**
fe_max_scale2	Iron scavenging coefficient	4286 (μM Fe yr)$^{-1}$	**20000 (μM Fe yr)$^{-1}$**
loss_thres_diaz	Threshold for diazotrophic loss terms	0.01 μM C	**0.001 μM C**
diaz_umax_0	Maximum growth rate of diazotrophs	1.2 d^{-1}	**0.1 d^{-1}**
diaz_mort	Coefficient of linear diazotrophic mortality	0.16 d^{-1}	**0.02 d^{-1}**
diaz_mort2	Coefficient of quadratic diazotrophic mortality	0	**0.0324 (μM C d)$^{-1}$**
r_Nfix_photo	Ratio of nitrogen fixation to assimilation	1.43	**1.0***
f_diaz_loss_poc	Fraction of linear diazotrophic mortality going to POCt	0	**1.0**
f_graze_diaz_poc	Fraction of diazotrophic grazing loss going to POCt	0	**0.275**
POCt_diss	Length scale for diazotroph POC remineralization	N/A	**300 m**

*The decrease in r_Nfix_photo from 1.43 to 1.0 was an attempt to alleviate the unrealistic buildup of nitrate by eliminating the excess amount of fixed N_2 excreted as DON, which is in turn remineralized to nitrate. This proved to have little impact on the solutions. Future versions of the model should include DON excretion by diazotrophs, as there is ample evidence that *Trichodesmium* spp. do just that [*Glibert and Bronk*, 1994; *Mulholland et al.*, 2004].

References

Anderson, L. A., D. J. McGillicuddy, M. E. Maltrud, I. D. Lima, and S. C. Doney (2011), Impact of eddy–wind interaction on eddy demographics and phytoplankton community structure in a model of the North Atlantic Ocean, *Dynamics of Atmospheres and Oceans*, *52*(1-2), 80-94, doi:10.1016/j.dynatmoce.2011.01.003.

Davis, C. S., and D. J. McGillicuddy (2006), Transatlantic Abundance of the N_2-Fixing Colonial Cyanobacterium *Trichodesmium*, *Science*, *312*, 1517-1520.

Glibert, P. M., and D. A. Bronk (1994), Release of dissolved organic nitrogen by marine diazotrophic cyanobacteria, *Trichodesmium* spp., *Applied Environmental Microbiology*, *60*, 3996-4000.

Luo, Y.-W., S. C. Doney, L. A. Anderson, M. Benavides, I. Berman-Frank, A. Bode, S. Bonnet, K. H. Boström, D. Böttjer, D. G. Capone, E. J. Carpenter, Y. L. Chen, M. J. Church, J. E. Dore, L. I. Falcón, A. Fernández, R. A. Foster, K. Furuya, F. Gómez, K. Gundersen, A. M. Hynes, D. M. Karl, S. Kitajima, R. J. Langlois, J. LaRoche, R. M. Letelier, E. Marañón, D. J. McGillicuddy, P. H. Moisander, C. M. Moore, B. Mouriño-Carballido, M. R. Mulholland, J. A. Needoba, K. M. Orcutt, A. J. Poulton, E. Rahav, P. Raimbault, A. P. Rees, L. Riemann, T. Shiozaki, A. Subramaniam, T. Tyrrell, K. A. Turk-Kubo, M. Varela, T. A. Villareal, E. A. Webb, A. E. White, J. Wu, and J. P. Zehr (2012), Database of diazotrophs in global ocean: abundance, biomass and nitrogen fixation rates, *Earth System Science Data*, *4*, 47–73, doi:doi:10.5194/essd-4-47-2012.

Moore, J. K., and S. C. Doney (2007), Iron availability limits the ocean nitrogen inventory stabilizing feedbacks between marine denitrification and nitrogen fixation, *Global Biogeochemical Cycles*, *21*(GB2001), doi:10.1029/2006GB002762,2007.

Moore, J. K., S. C. Doney, K. Lindsay, N. Mahowald, and A. F. Michaels (2006), Nitrogen fixation amplifies the ocean biogeochemical response to decadal timescale variations in mineral dust deposition, *Tellus*, *58B*, 560-572.

Mulholland, M. R., D. A. Bronk, and D. G. Capone (2004), Dinitrogen fixation and release of ammonium and dissolved organic nitrogen by Trichodesmium IMS101, *Aquatic Microbial Ecology*, *37*(1), 85-94, doi:10.3354/ame037085.