Nutrient Addition Effects on Phytoplankton Communities in the Amazon River Plume

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Introduction

The types and abundance of phytoplankton is largely controlled by availability of sunlight and bioavailable nutrients. Phytoplankton require essential nutrients including nitrate, phosphate, and silicate to grow, so understanding the role of these macronutrients in limiting the growth phytoplankton communities—and the way this may differ depending on community composition—is key to understanding the controls on phytoplankton biomass and community structure. We aimed to explore how the availability of these nutrients affects the health and composition of phytoplankton communities by conducting a series of nutrient amendment experiments (NAEs) with samples from the Western Tropical North Atlantic, which is heavily influenced by the nutrient-rich, low salinity waters of the Amazon River Plume. These experiments, conducted at five locations in and around the plume, provide greater resolution and further our understanding about the ways nutrients affect communities in dynamics costal regions.

Results

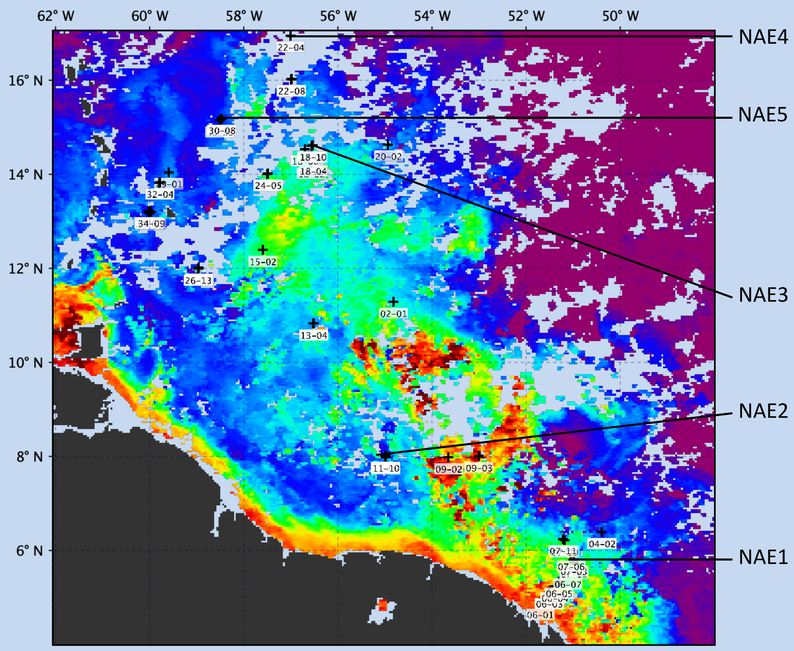


Figure 1. Sea surface chlorophyll map from the duration of the cruise with the sampling stations plotted atop.

Chlorophyll Fluorescence

Experiment	+Si	+P	+P, Si	+N	+N, Si	+N, P	+N, P, Si	Salinity (psu)	Mean PO_4^{3-} (µM)	Mean Si (µM)	Mean NO_3^- + NO_2 (µM)	Mean NO_2 (µM)
NAE1	0.9	0.8	1.6	1.9	3.7	25.0	26.8	19.1	1.51	52.32	0.00	0.00
NAE2	0.8	1.0	0.7	5.9	3.2	15.1	16.4	33.4	0.17	3.50	0.15	0.00
NAE3	1.7	0.4	1.0	2.8	3.2	57.2	53.5	30.4	0.39	10.20	0.05	0.03
NAE4	1.0	1.1	1.1	2.7	1.9	7.8	6.2	31.9	0.19	5.97	0.14	0.00
NAE5	0.8	0.9	1.0	1.4	1.8	9.1	8.5	33.4	0.34	3.97	0.40	0.00

Figure 2. Chlorophyll fluorescence measurements, shaded by the statistical significance of the difference between control and the treatment. The numbers show the ratio between treatment fluorescence and control fluorescence. The statistically significant values are shaded by the scale of this ratio.

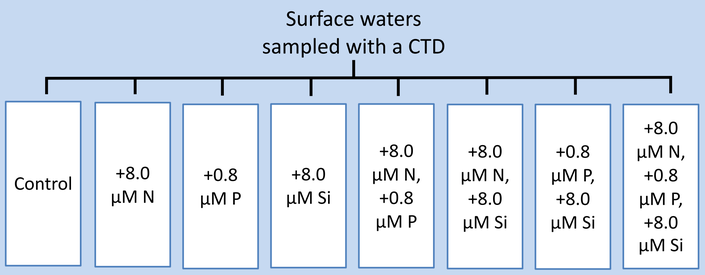
Phycoerythrin/Chlorophyll Fluorescence

Experiment	+Si	+P	+P, Si	+N	+N, Si	+N, P	+N, P, Si
NAE1	0.68	0.84	0.44	0.54	0.28	0.04	0.02
NAE2	1.09	0.80	1.27	1.62	2.22	0.80	0.79
NAE3	0.50	0.41	0.33	0.80	0.77	0.21	0.24
NAE4	1.31	1.39	0.87	0.83	1.35	0.79	0.55
NAE5	0.82	0.84	0.86	1.22	0.49	0.27	0.26

No statistically significant difference between control and treatment
Treatment significantly larger than control
Treatment significantly smaller than control

Figure 3. Measurements of phycoerythrin normalized to chlorophyll, shaded by the statistical significance of the difference between control and the treatment. The numbers show the ratio between treatment and control values. The statistically significant values are shaded by the scale of this ratio

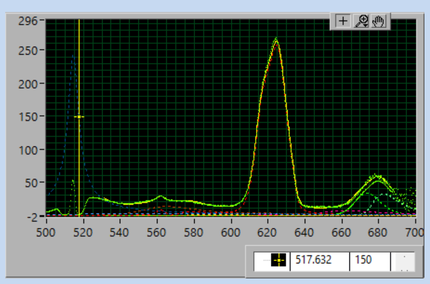
Methods



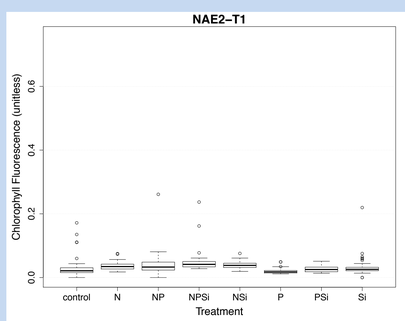
Nutrient Amendment Experiment (NAE) sampling scheme. Treatments were conducted in triplicate and incubated in 1L bottles for a total of 48 hours in on-deck incubators. Sub-sampling occurred after 0, 12, 24, and 48 hours. At each timepoint, the treatments were sampled for nutrient concentrations and chlorophyll and phycoerythrin fluorescence.

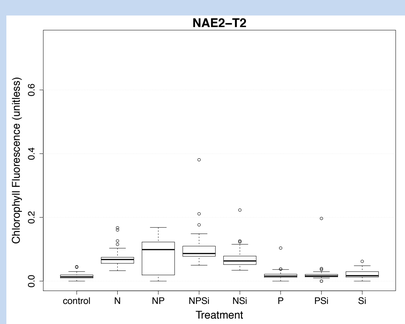
Chlorophyll and phycoerythrin fluorescence were measured using the CLASS, which uses dual-wavelength excitation at 405 and 532 nm to stimulate emission from photochemically active pigments: chlorophyll, which is present in all phytoplankton, and phycoerythrin, an accessory pigment found in red algae and cyanobacteria.

Chlorophyll and phycoerythrin measurements were compared to the control at each time point using an unpaired t-test.



Sample CLASS output showing the aggregate emission spectrum from one sample.





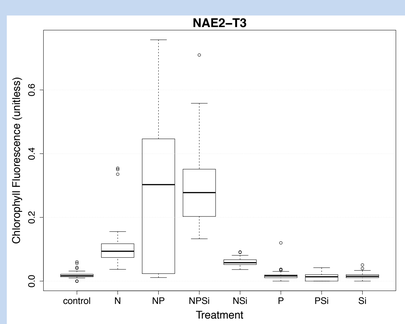


Figure 4. Comparison of chlorophyll fluorescence across three time points showing a significant increase between all treatments involving nitrogen at 24- and 48-hour timepoints. The difference between the control and nitrogen treatments is significant at both time points but a much larger magnitude at T3.

Conclusions

Experiments conducted on plume-dominated and non-plume-dominated waters of various salinities and initial biomasses show evidence of the communities being serially limited by nitrogen, then phosphorous. Cyanobacteria respond to the addition of nutrients, particularly nitrogen, but do not constitute an important response compared to other species, such as diatoms or Prochlorococcus.

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References

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