Assessing the Impacts of Ocean Acidification on Phytoplankton Functional Types – A Case Study for the Amazon River Plume

Joaquim Goes¹, Helga do R Gomes¹, Kali McKee¹, Tegan Galina², Therese Chen³, M. Diaz Turkowsky⁴, Patricia Yager⁵

¹Lamont Doherty Earth Observatory, Columbia University, Palisades, New York, USA
²New York University, NY, USA
³UCLA Fielding School of Public Health, CA, USA
⁴Lund University, Sweden
⁵Department of Marine Sciences, University of Georgia

As human activities continue to raise the levels of atmospheric and oceanic CO₂, we require a clearer understanding of the responses of plankton to these increases and better ways to detect the global impacts of anthropogenic change on marine ecosystems. The Amazon River plume, which contains the surface ocean’s largest environmental gradient of pCO₂ (~100 ppm and ~1300 µmol C kg⁻¹), provides the perfect natural laboratory for making critical progress on these challenges. Our recent ship-based bio-optical measurements along the plume’s gradient of salinity, CDOM, nutrients, and pCO₂, together with on-deck and laboratory -CO₂ manipulation experiments, suggest that phytoplankton community structure and metabolic activity may be in large part controlled by DIC concentrations and to a lesser degree by dissolved inorganic phosphate and nitrate availability. These observations allow us to postulate that 1) coastal-estuarine phytoplankton, which are typically exposed to a wider range of pH than their truly oceanic counterparts, are as susceptible to ocean acidification as their oceanic counterparts and 2) changes in the carbonic acid system will fundamentally alter the community structure and function of tropical marine primary producers. We also discuss our findings in the context of their potential application to ocean acidification studies using satellite data.

Cruise track and station locations of May-June 2010 cruise in the Amazon plume. Background is satellite Chlorophyll a

Chi a fluorescence (color scale, mV) plotted on pCO₂ vs salinity (x-axis) in the Amazon plume (May 2010). Range of pCO₂, on y axis can be observed. The line denotes the least squares fit, not a mixing line.

During the May-June of 2010 cruise, we utilized an Advanced Laser Fluorometer (ALF) and microscopy to map the distribution of phytoplankton communities in the Amazon River Plume. When examined in the context of the physical and chemical environment of the plume, these high resolution measurements of phytoplankton revealed that the interaction of freshwater from the Amazon River Plume with high salinity waters of the Western North Atlantic Ocean, creates extreme variability in hydrographic conditions and a complex mosaic of habitats that have a huge bearing on the spatial patterns of phytoplankton communities in the plume. Results from ship-based bio-optical measurements along the plume’s gradient of salinity, CDOM, nutrients and pCO₂, together with on-deck CO₂ manipulation experiments, suggest that the phytoplankton community structure and metabolic activity may be in large part controlled by pCO₂ concentrations and to a lesser degree by dissolved inorganic phosphate and nitrate availability. These data along with results from recent laboratory experiments confirm the notion that the inorganic carbonate system of the Amazon River Plume has a huge bearing on the distribution of phytoplankton functional types.

Along-track variations in A) salinity, B) pCO₂, and phytoplankton abundance: C) asymbiotic diatoms, D) Trichodesmium, and E) Diatom-Diazotroph Associations (DDAs) during May-June 2010 Amazon plume expedition. F) PCA showing the affinity of Diatoms and Cryptophytes for low pCO₂ waters, DDAs (including its endosymbiont Richelia intracellularis) for intermediate pCO₂ waters and Trichodesmium spp. for high pCO₂ waters.

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