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

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UNIQUE FEATURES OF THE AMAZON RIVER PLUME

1) The Amazon flows through the world’s largest and most densely populated forests, carrying with it massive amounts of sediments, nutrients and dissolved organic material.

2) Sediments and CDOM impart a greenish color to the water that can be visible several thousands of kilometers from the mouth from space.

3) As the river flows into the western tropical North Atlantic Ocean, a distinct gradient in environmental conditions develops along and across the axis of plume that has a profound impact on the pelagic ecosystem.
Cruise track and station locations of May-June 2010 Amazon plume cruise. Background color is satellite-based chlorophyll.
CHEMISTRY OF THE AMAZON RIVER PLUME

Salinity (PSU)

PO₄ (µM)

NO₃+NO₂ (µM)

SiO₃ (µM)

SiO₃ deficiency (µM)

N*
Distribution of diatoms along the cruise track
Distribution of Diatom-Diazotroph Association (DDAs) along the cruise track.
Distribution of *Trichodesmium* along the cruise track
Distribution of Green and Blue water Synechococcus along the cruise track
PCA shows that while river-sourced nutrients align opposite sea surface salinity (SSS), different phytoplankton groups vary independently of salinity, nutrients and $p\text{CO}_2$ along the river-ocean gradient.
Along-track variations in $pCO_2$, and Diatoms during May-June 2010
Amazon River Plume Cruise
Along-track variations in $pCO_2$, and DDAs during May-June 2010 Amazon River Plume Cruise
Along-track variations in $pCO_2$, and *Trichodesmium* during May-June 2010 Amazon River Plume Cruise
Distribution of major phytoplankton groups along the pCO2 gradient of the Amazon River Plume

Diatoms

Diatom-Diazotroph Associations

Trichodesmium spp
$p\text{CO}_2$ versus salinity (x-axis) and Chl a fluorescence (color scale, mV) in the Amazon plume (during May 2010) showing the range of $p\text{CO}_2$ observed. The line is a least square's fit, not a mixing line.
Cruise tracks of AN10, AN11 & AN12 and along-track distribution of salinity and $pCO_2$ in the Amazon River Plume
HYPOTHESES

1) Amazon river plume phytoplankton are typically exposed to a wider range of $pH$ than their truly oceanic counterparts but are as susceptible to ocean acidification as their oceanic counterparts.

2) Distribution of phytoplankton communities in the Amazon River plume is controlled by their sensitivity to the carbonic acid system.

3) The wide range of variability in carbonic acid system of the Amazon River Plume makes it a perfect natural laboratory to study the effects of ocean acidification on marine phytoplankton.
Phytoplankton biomass changes observed in shipboard $pCO_2$ manipulation experiments conducted with mesohaline waters of the Amazon River plume during cruise of 2011.
Phytoplankton biomass changes observed in shipboard $pCO_2$ manipulation experiments conducted with open ocean waters adjacent to the Amazon River plume.
Results from laboratory experiments showing the growth response of *Thalassiosira* sp. (Diatom) to varying concentrations of pCO$_2$. 
Results from laboratory experiments showing the growth response of *Trichodesmium* to varying concentrations of pCO$_2$. 

*Trichodesmium erythraeum*

- 150 ppm
- 400 ppm
- 800 ppm
Results from laboratory experiments showing the growth response of *Hemiaulus hauckii* (DDA) to varying concentrations of pCO$_2$. 

*Hemiaulus hauckii*
Confocal microscope changes in intracellular Richelia populations within Hemiaulus hauckii when exposed to different CO$_2$ levels
Seasonal shifts in the distribution of major phytoplankton groups in the Amazon River Plume
MODIS-Aqua $K_d490$ for the month of May showing Interannual variability of the size of the outflow of the Amazon River Plume
Can remote sensing data be utilized to study:

- the carbonic acid system and its impact on phytoplankton distribution in the Amazon River Plume?

- Inter-annual changes in the $p\text{CO}_2$ gradient and phytoplankton community structure across Amazon River plume due to changes in river discharge
Relationship of $pCO_2$ to remotely sensed proxies.
Shipboard $pCO_2$ versus satellite derived $pCO_2$
Comparisons of shipboard measured and modeled estimates of
A) near surface $pCO_2$ obtained as a function of SSS, SST and Chl $a$
B) DIC obtained as a function of SST and SSS and
C) TAlk obtained as a function of SSS and SST).
WORK IN PROGRESS

• Bio-optical data collected during cruises is being used to develop phytoplankton functional type and phytoplankton size class algorithms
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