The Bermuda Atlantic Time-series Study (BATS): A Time-series Window on Climate Forcing of Ocean Variability

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The Bermuda Atlantic Time-series Study (BATS) was started over 14 years ago as part of the Joint Global Ocean Flux Study. The BATS sampling region lies ~82km SE of Bermuda in >4600m of water near the Ocean Flux Program site and the Bermuda Testbed Mooring. Over this >14 year period, a suite of core measurements has been made monthly or bi-weekly during the winter/spring bloom period (January to April). These measurements cover a wide range of physical, chemical and biological stock measurements, as well as a number of core rate process measurements such as primary and bacterial production, and particle mass flux. Over the record of this program, numerous ancillary projects have greatly enhanced the context of these core measurements.

Biological variability in the ocean gyres is an important component of overall variability in the ocean carbon cycle, in particular the fate of carbon in the marine ecosystem. Seasonal and interannual variability in phytoplankton community structure, as determined through HPLC pigment analysis, has been found to relate to changes in the partitioning of primary production between seasonal DOC accumulation and POC flux (PANEL A), and the decreased shallow remineralization of sedimenting particles through the process of mineral ballasting (PANEL B).

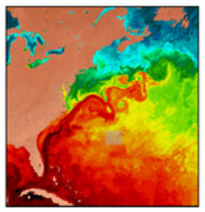
Over the 15-years of the BATS data record, there has been a change in partitioning of primary fixed carbon between the seasonal accumulation of DOC and the sediment flux of POC. Variability in the relative contribution of important phytoplankton groups, specifically haptophytes and prochlorophytes, is negatively related to DOC production. Interannual variability in the winter to spring haptophyte biomass is partially explained by changes in the NAO index.

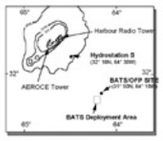
Diatoms and haptophytes, for example, are likely to be more important with regard to mineral ballasting given their silicious and calcareous frustules. Sediment traps at three depths allow calculation of shallow remineralization coefficients for the BATS region. Variability in integrated haptophyte and diatom biomass, but not cyanophytes and prochlorophytes, was significantly related to decreased shallow remineralization coefficients.

Lomas, M.W., & Bates, N.R. Potential controls on interannual paratitioning of organic carbon produced during the winter/spring phytoplankton bloom at BATS. Submitted to *Deep-Sea Research* I, May 2003.

Lomas, M.W. 2003. Shallow remineralization and phytoplankton community structure at the Bermuda Atantic Time-series Study. ASLO Aquatic Sciences Meeting, Salt Lake City.

Bermuda Atlantic Time-series Study (BATS)





★ Monthly sampling (bi-monthly during the bloom season) 16 core cruises (0 - 4200 m) and 2-3 validation cruises per year.
★ 24 Hydrostation 'S' cruises per year.

Core Measurements at BATS

Continuous (i.e., CTD)

Temperature	Salinity	PAR
Dissolved Oxygen	Fluorescence	Beam Attenuation

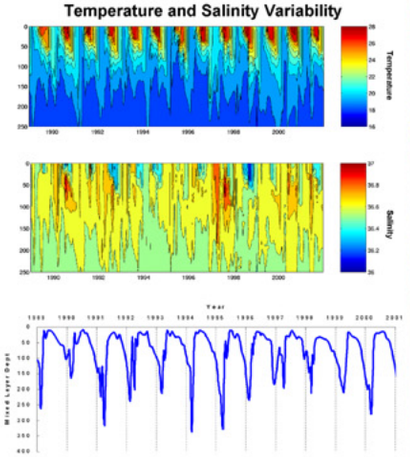
Discrete Measurements

Salinity	Nitrate/Phosphate
Silicate	POC/PON/DOC/DON
Oxygen	DIC (or TCO_2), TA
Pigments (HPLC)	Bacteria biomass
Part. Silicate	

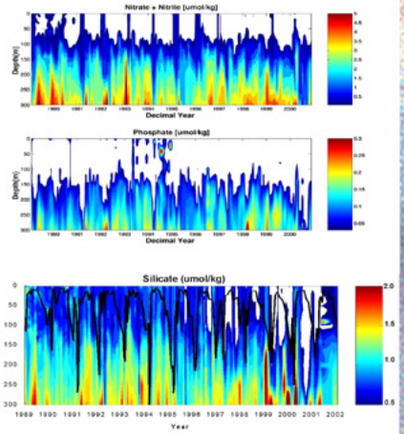
Rate Measurements

Primary Production Bacterial Production
Particle Flux

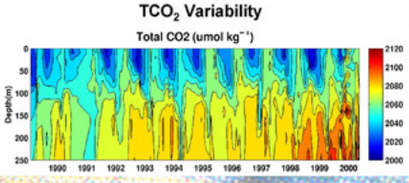
Temperature and Salinity Variability



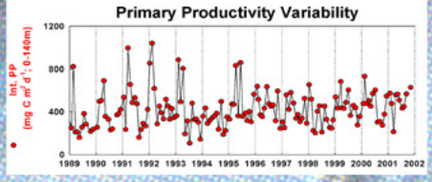
Nutrient Variability



TCO_2 Variability

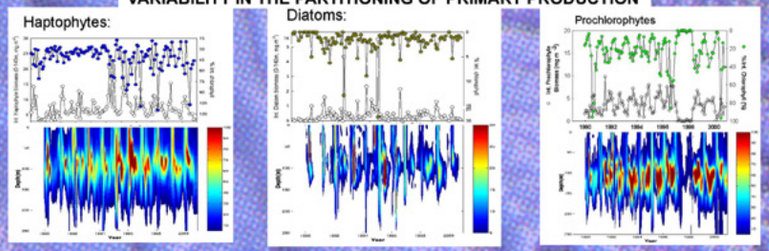


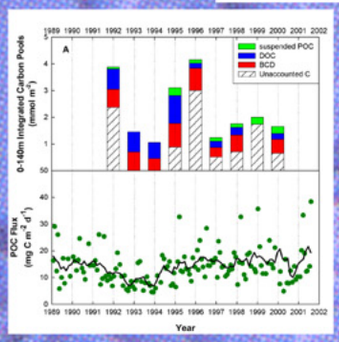
Primary Productivity Variability

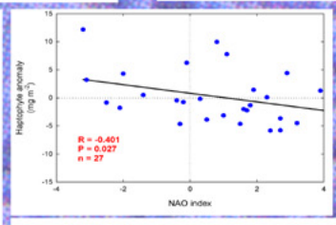


PANEL A

VARIABILITY IN THE PARTITIONING OF PRIMARY PRODUCTION







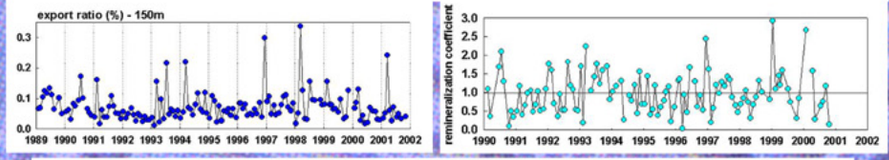
Carbon Partitioning – Correlation Table

	DOC	POC	DOC (%PP)	POC (%PP)
Dinoflagellates	-0.49	---[b]	-0.50	0.49
Cryptophytes	---	-0.25	---	**-0.74**
Diatoms	**0.80**[a]	0.35	0.30	-0.36
Haptophytes	0.29	---	0.25	**-0.75**
Prasinophytes	---	---	---	---
Cyanophytes	---	---	---	---
Prochlorophytes	0.29	0.53	-0.49	0.39
Hapto/Prochloros	**0.72**	**-0.72**	**0.84**	**-0.79**

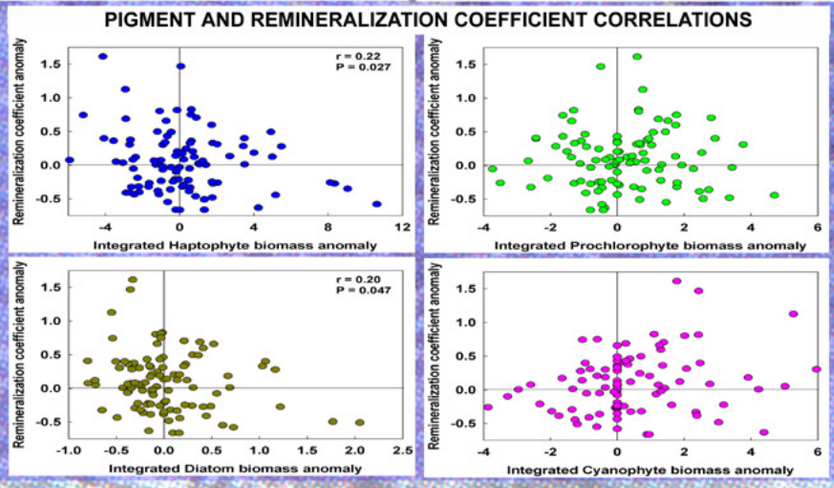
[a] Values in **bold** highlight significant correlations.
[b] Values below 0.20 are not reported.

PANEL B

PARTICLE FLUX AND REMINERALIZATION VARIABILITY



PIGMENT AND REMINERALIZATION COEFFICIENT CORRELATIONS



Hydrographic and Biogeochemical Anomalies over Time

-- A "mean" year for each parameter (e.g. primary production, mixed-layer depth) is calculated using BATS data from 1988 to 2000.

-- DIC is corrected for the long-term increase that is observed.

-- Each month of the data record is compared to the "mean month" and the anomaly calculated.

-- Cross-correlation coefficient analyses are used to examine statistical relationships between parameters.

✲ Upper-ocean temperatures are inversely correlated with parameters such as mixed-layer depth, rates of integrated net primary production (NPP) and DIC.

Temperature ↑ ↓ NPP ↓ DIC ↓ Mixed-layer

✲ Alkalinity anomalies appear to be correlated with salinity anomalies.

Salinity ↑ ↓ Alkalinity

Source: Bates, 2001

Finally…thanks to all who have worked on the BATS program

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