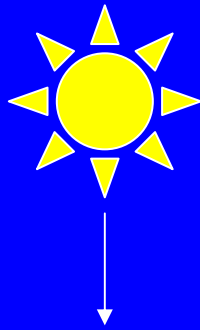


What are some of the big
questions in ocean
biogeochemistry?

How are nutrients supplied to
fuel the biological pump?

Where does the ocean export
organic matter?



Plankton Production in the Open Ocean

Sea Surface

Phytoplankton



$$0.5 \text{ mol N m}^{-2} \text{ yr}^{-1}$$

100m

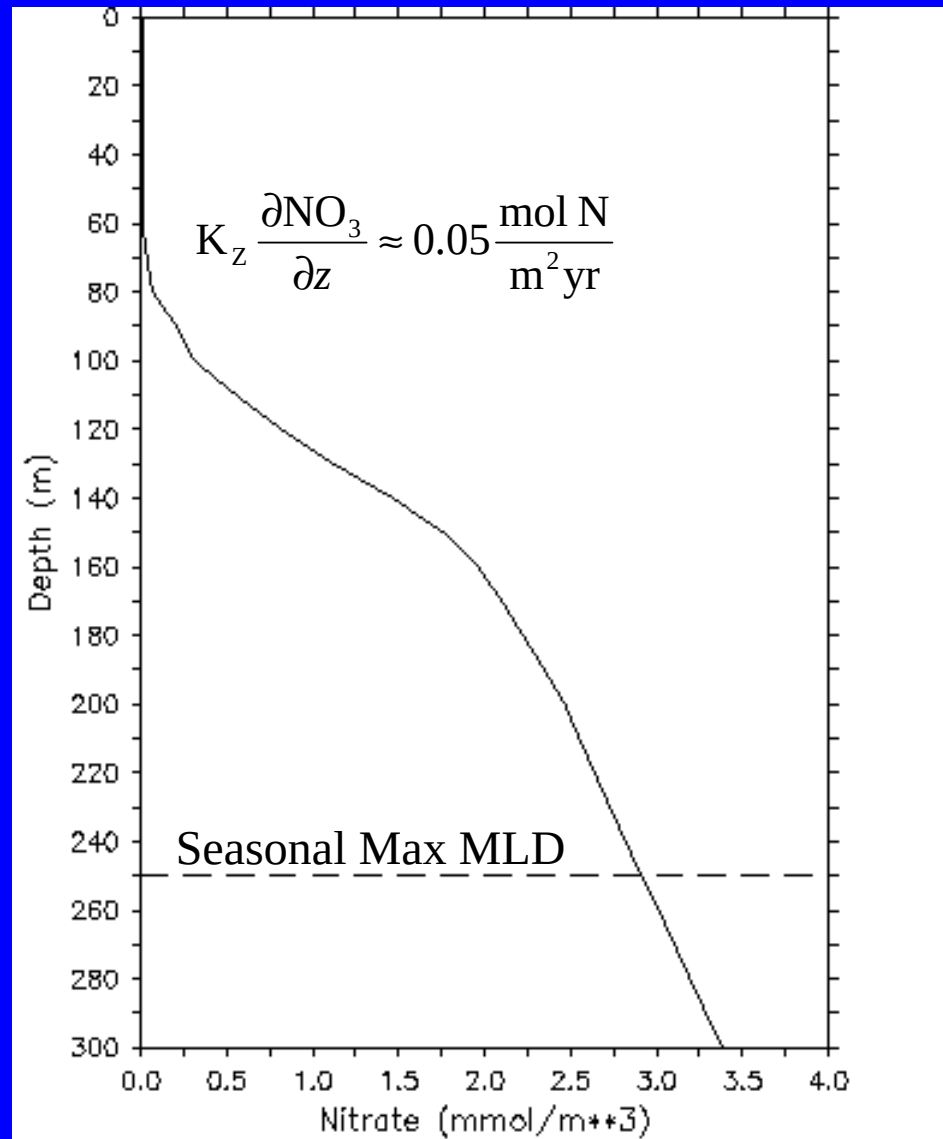


Shulenberger and Reid, 1981
Jenkins and Goldman, 1985

Nutrients



Where do the nutrients come from?



Bats Average Summertime Nitrate Profile

Demand:

New Prod. 0.5

Supply:

Wintertime
convection 0.15

Diapycnal
diffusion 0.05

Ekman
transport 0.05

“Missing
nutrient” 0.25

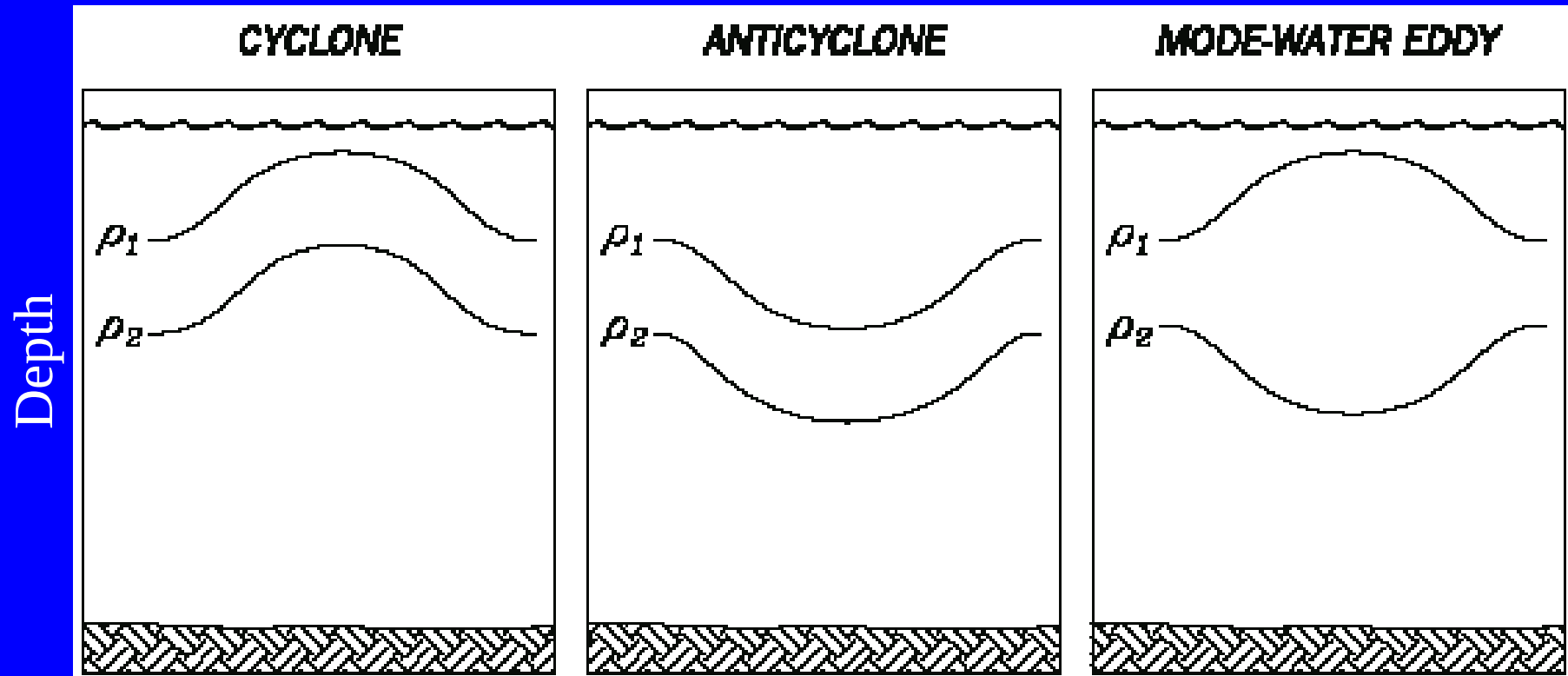
Impacts of Eddies and Mixing on Plankton Community Structure and Biogeochemical Cycling in the Sargasso Sea

McGillicuddy
Ledwell
Jenkins
Buesseler
Davis
Falkowski
Hansell
Siegel
Carlson
Bates
Johnson
Steinberg



http://science.whoi.edu/users/mcgillic/eddies/Eddies_Project.html

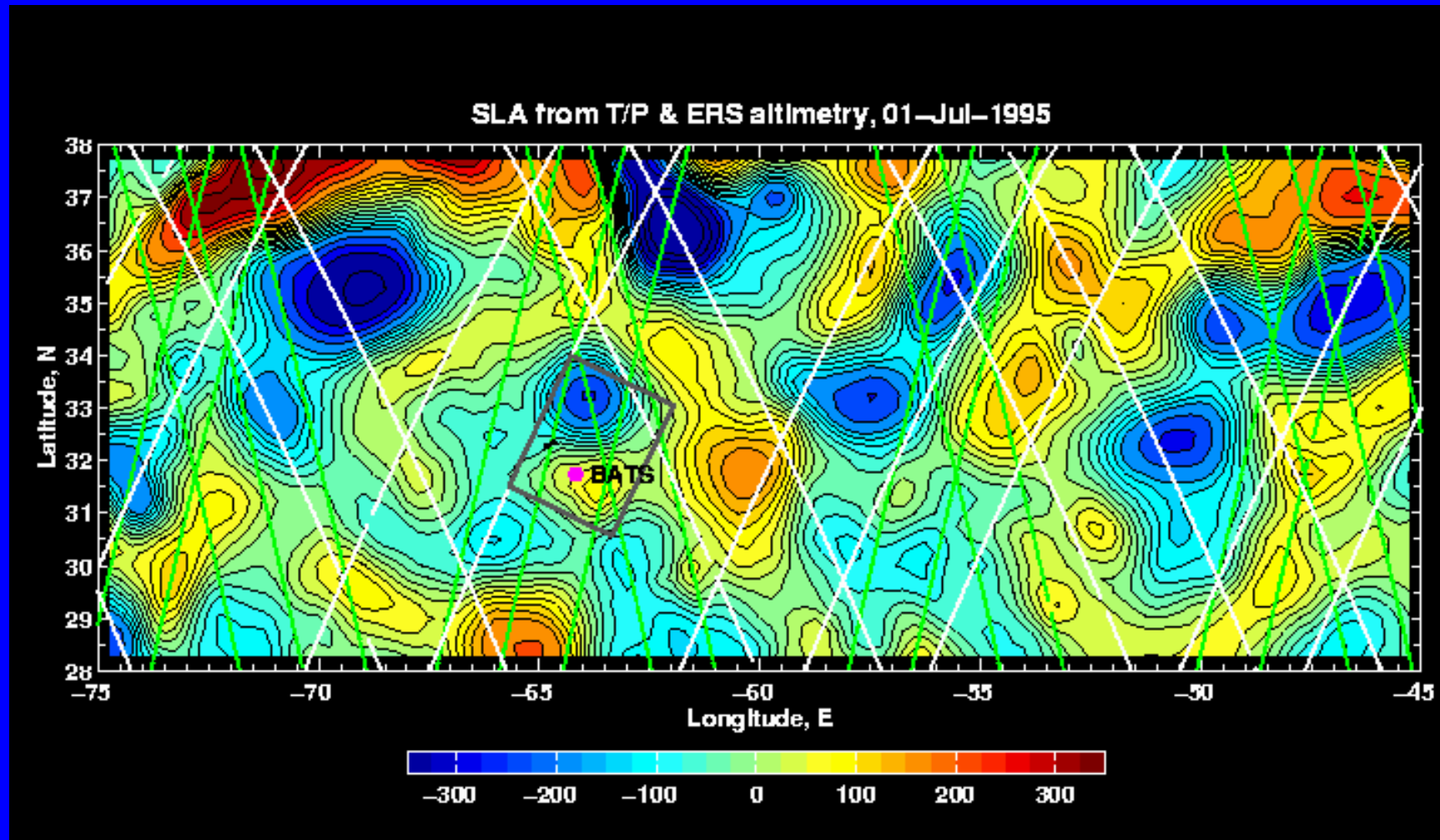
Three types of eddies in the Sargasso Sea



Conceptual model:

Cyclones and Mode-Water Eddies will cause plankton blooms as they form and intensify.

Objectively Mapped Sea Level Anomaly



Real time data feed: Bob Leben, CCAR

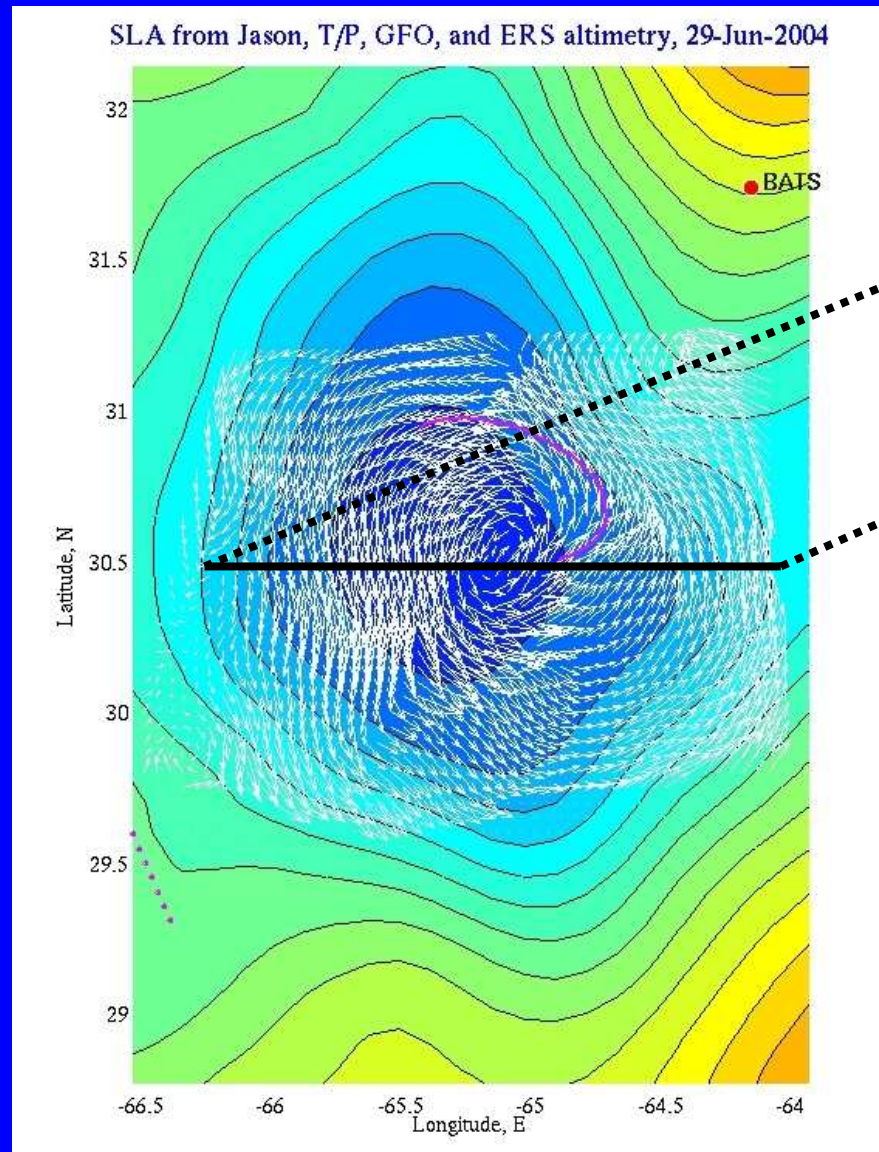
http://www-ccar.colorado.edu/realtime/nwatlanticreal-time_ssh).

2004/2005 EDDIES Cruises

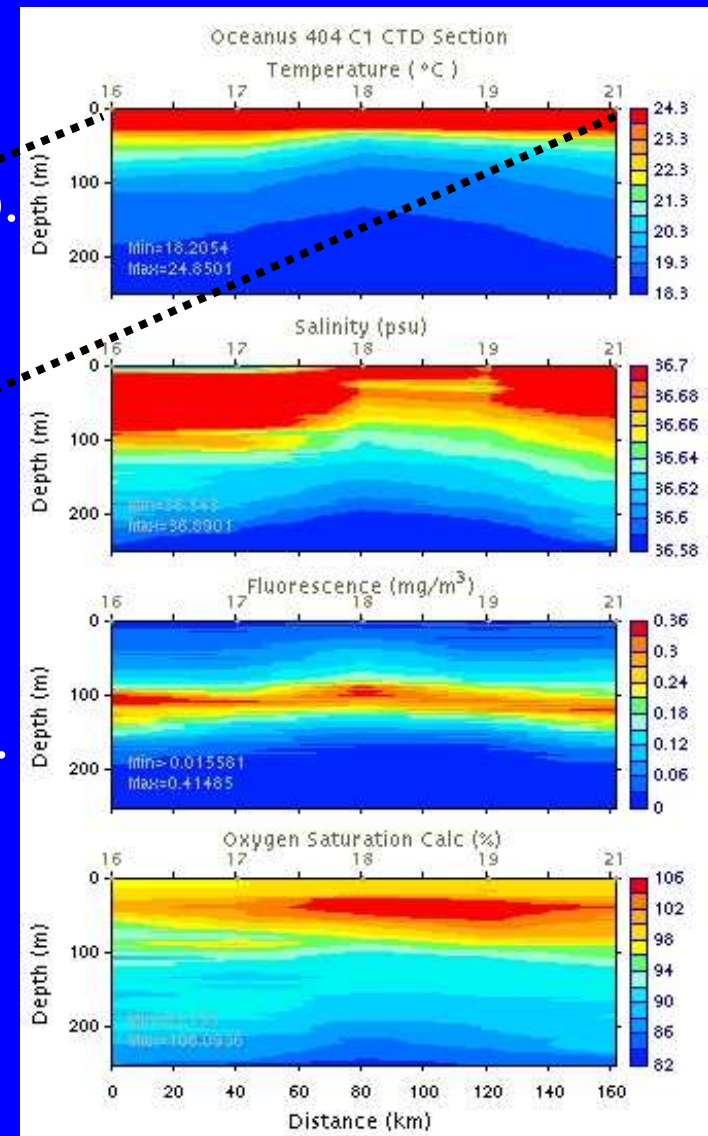
Ten different eddies sampled, five more than once

Cyclones	Occupations
C1 – OC404-1 (3), OC404-4 (1)	4
C2 – OC404-1, OC404-4	2
Cold-core GS Ring	1
C3 – OC415-1	1
C5 – OC415-1 (2)	2
Anticyclones	
<i>“Regular”</i>	
A2 – OC404-1 (XBT/ADCP/VPR only)	1
A3 – OC404-1 (XBT/ADCP/VPR only)	1
<i>18° Mode-water eddy</i>	
A4 – OC415-1 (2), OC415-2, OC415-3 (2), OC415-4	6
<i>16° Mode-water eddies</i>	
A1 – OC404-1	1
A5 – OC415-1, OC415-3	2

Cyclone C1

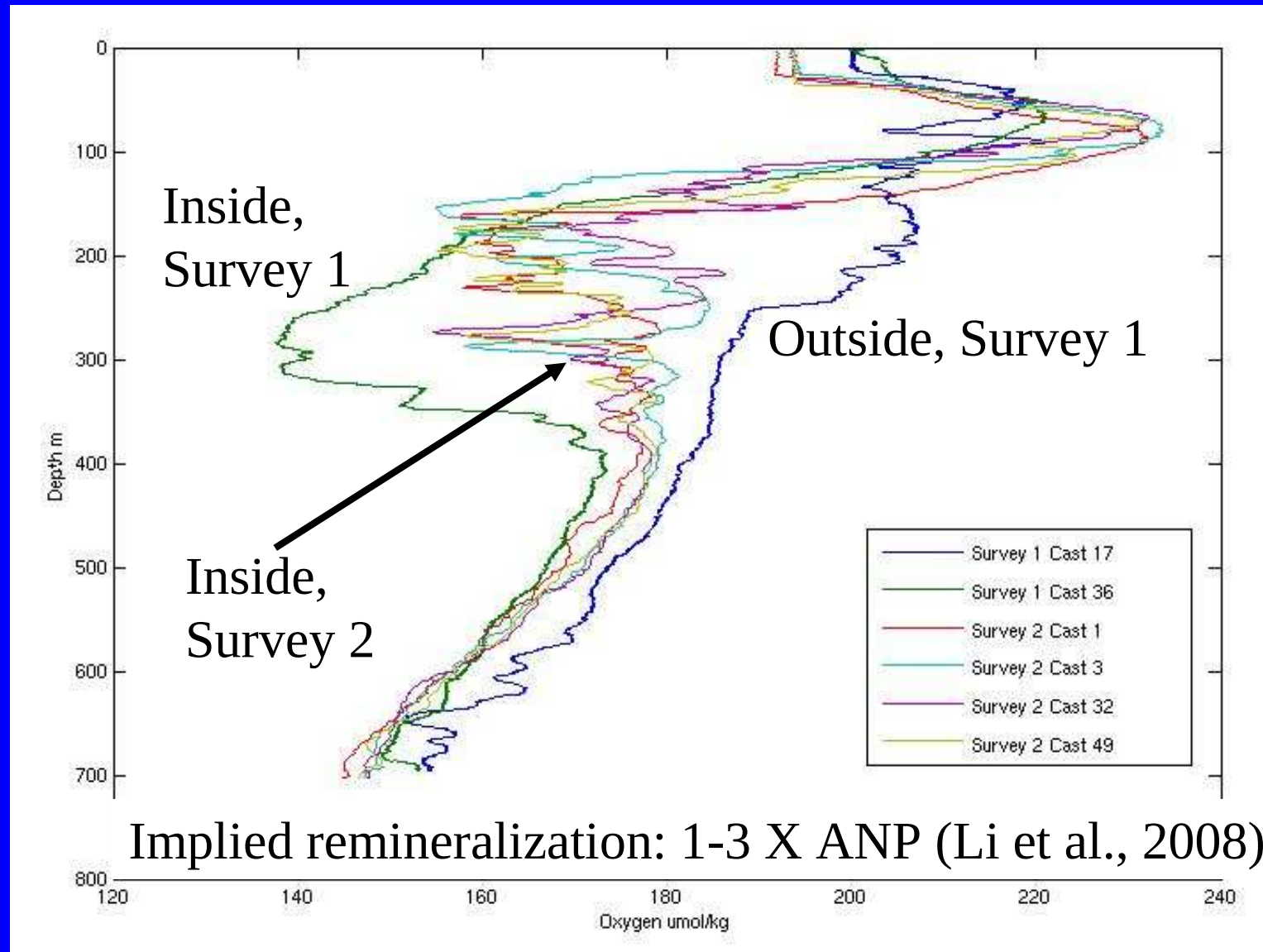


SLA and shipboard ADCP



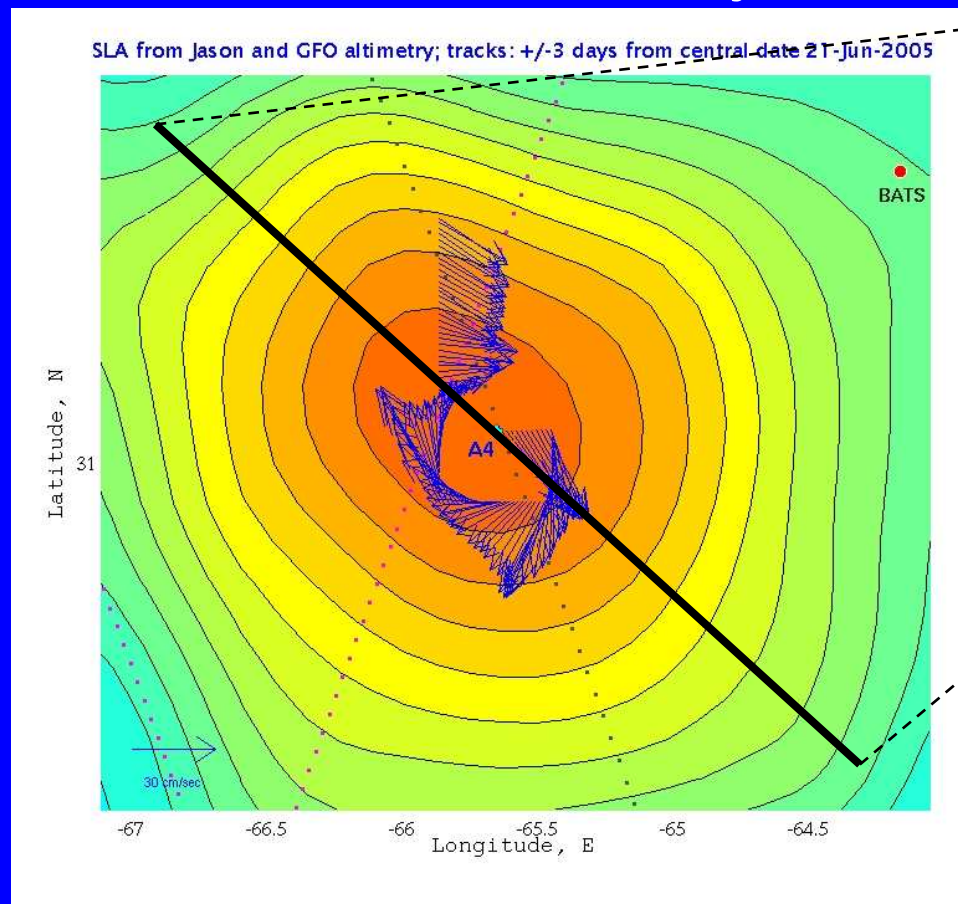
Hydro Section: 0-250m

Cyclone C1 oxygen profiles

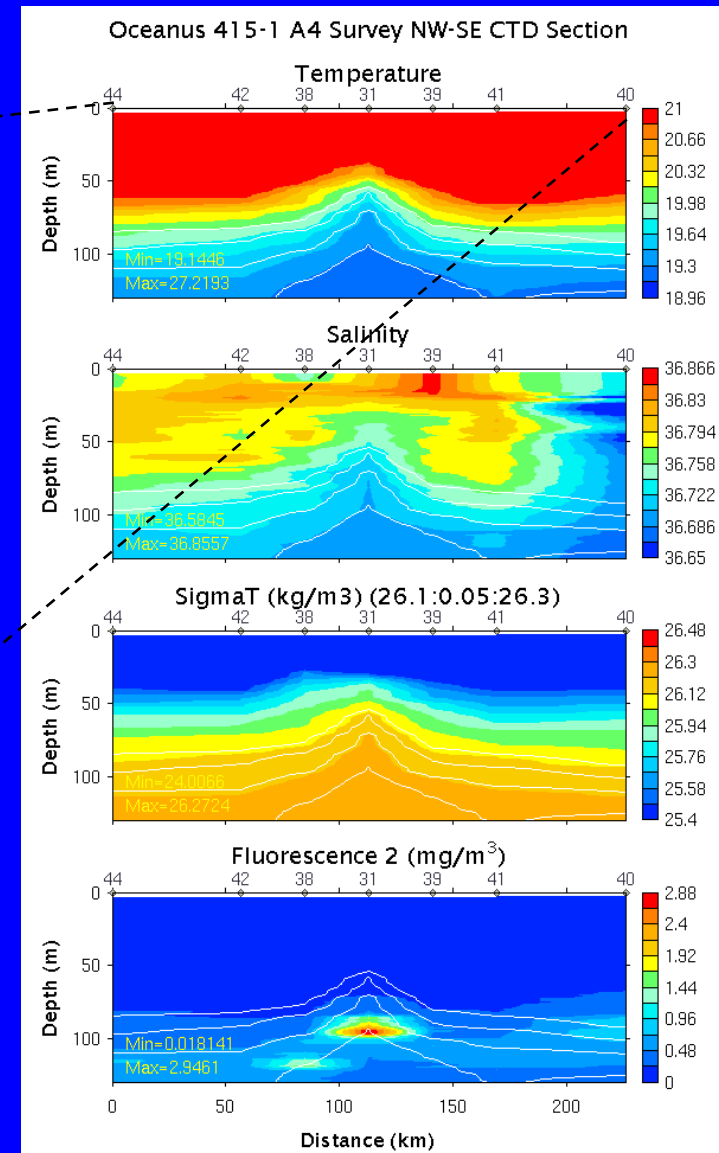


Target Feature A4

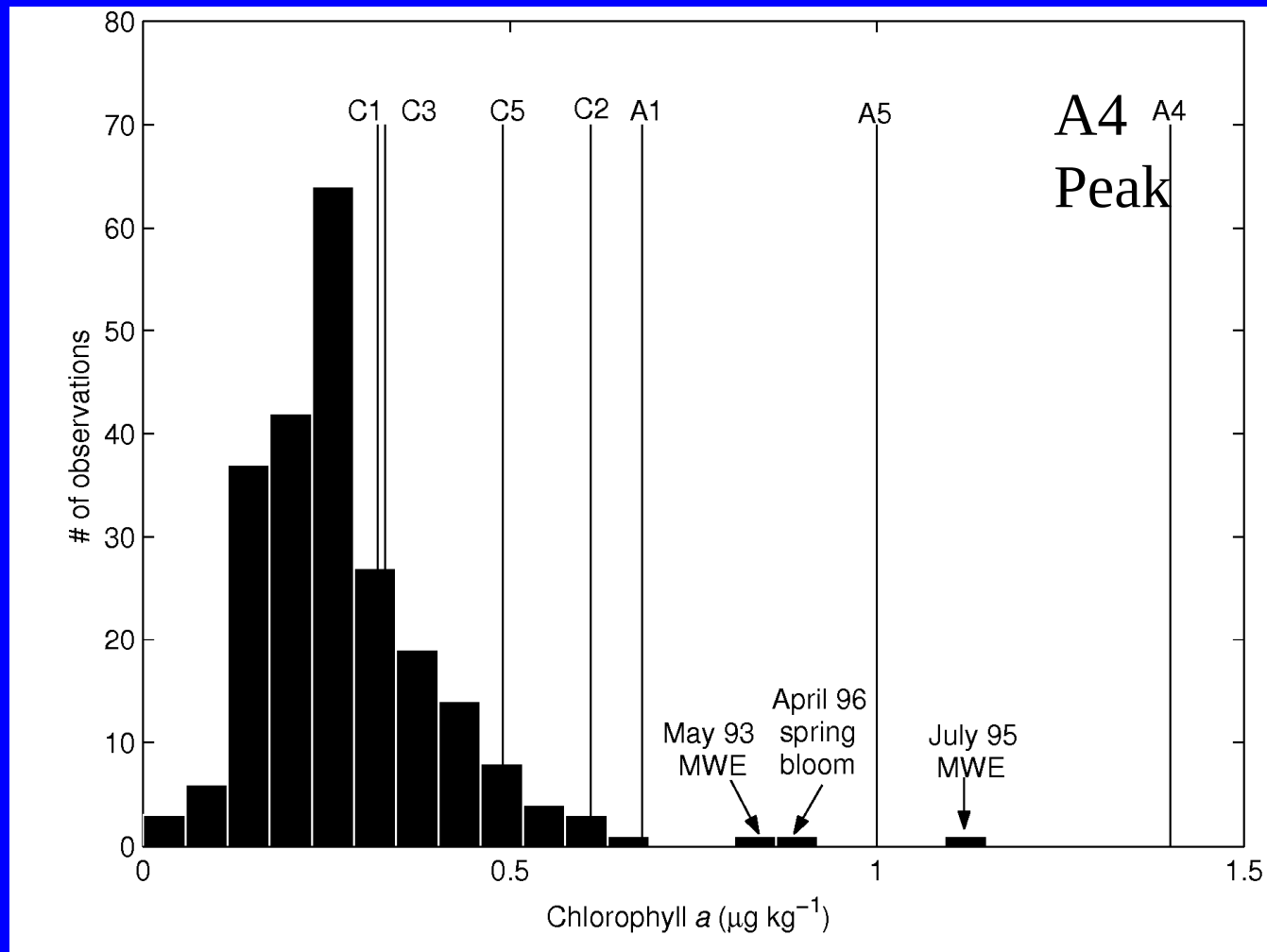
Sea Level Anomaly



Cross Section



BATS Chlorophyll *a* 1988-2003

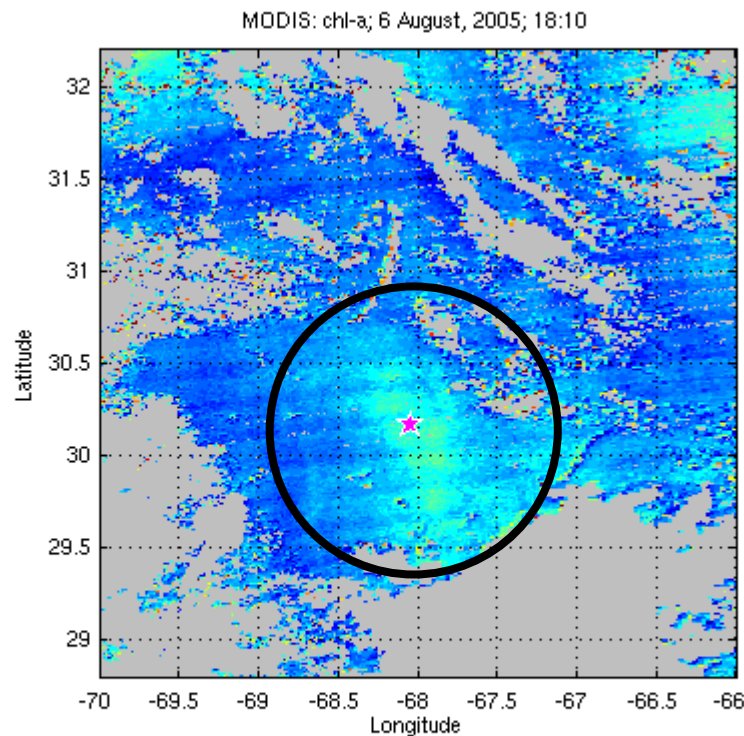


BATS: mean=.28; std=0.14; max=1.15

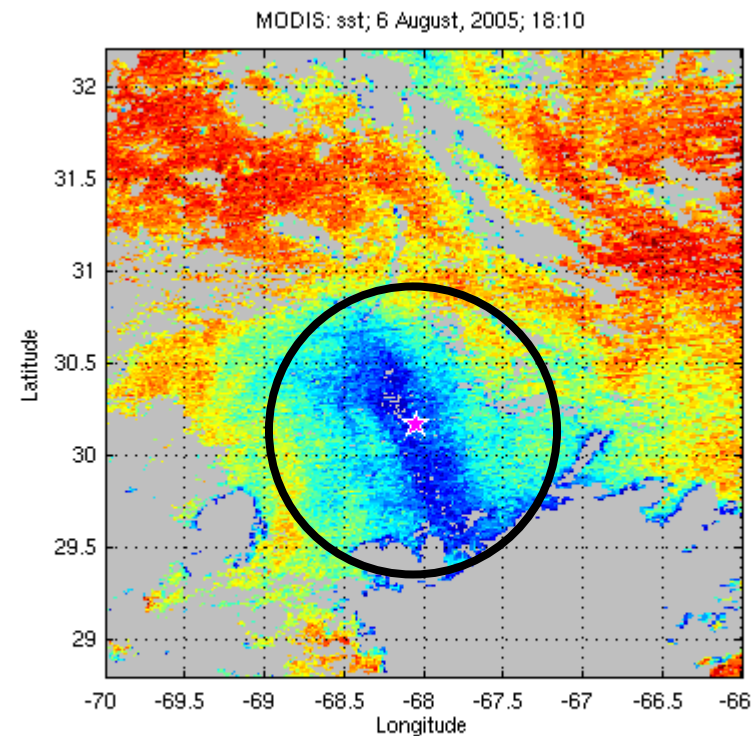
$$\overline{Max(Chl(z)_{A4})} = \overline{Max(Chl(z)_{BATS})} + 8\sigma$$

MODIS Image of A4

August 6, 2005

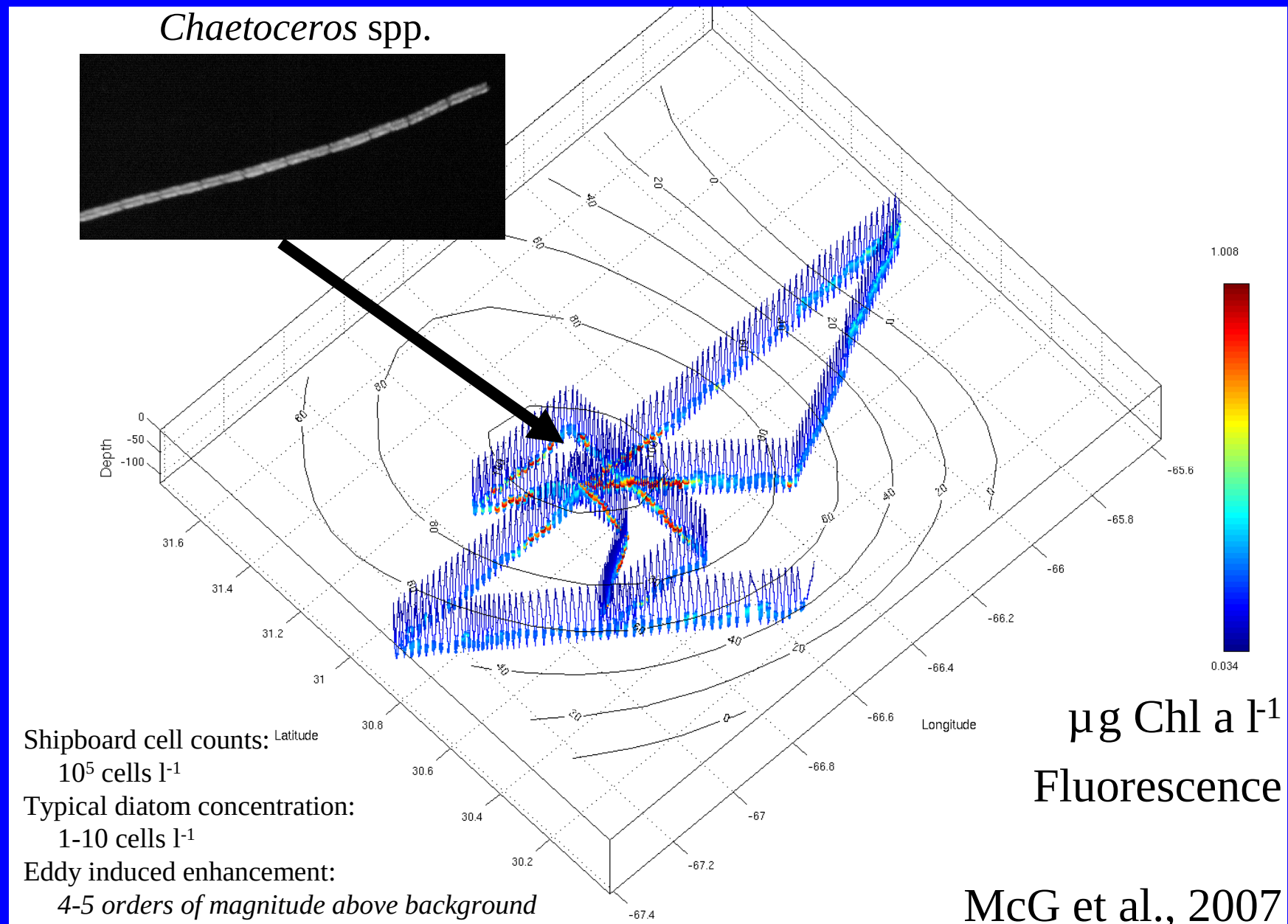


Chlorophyll

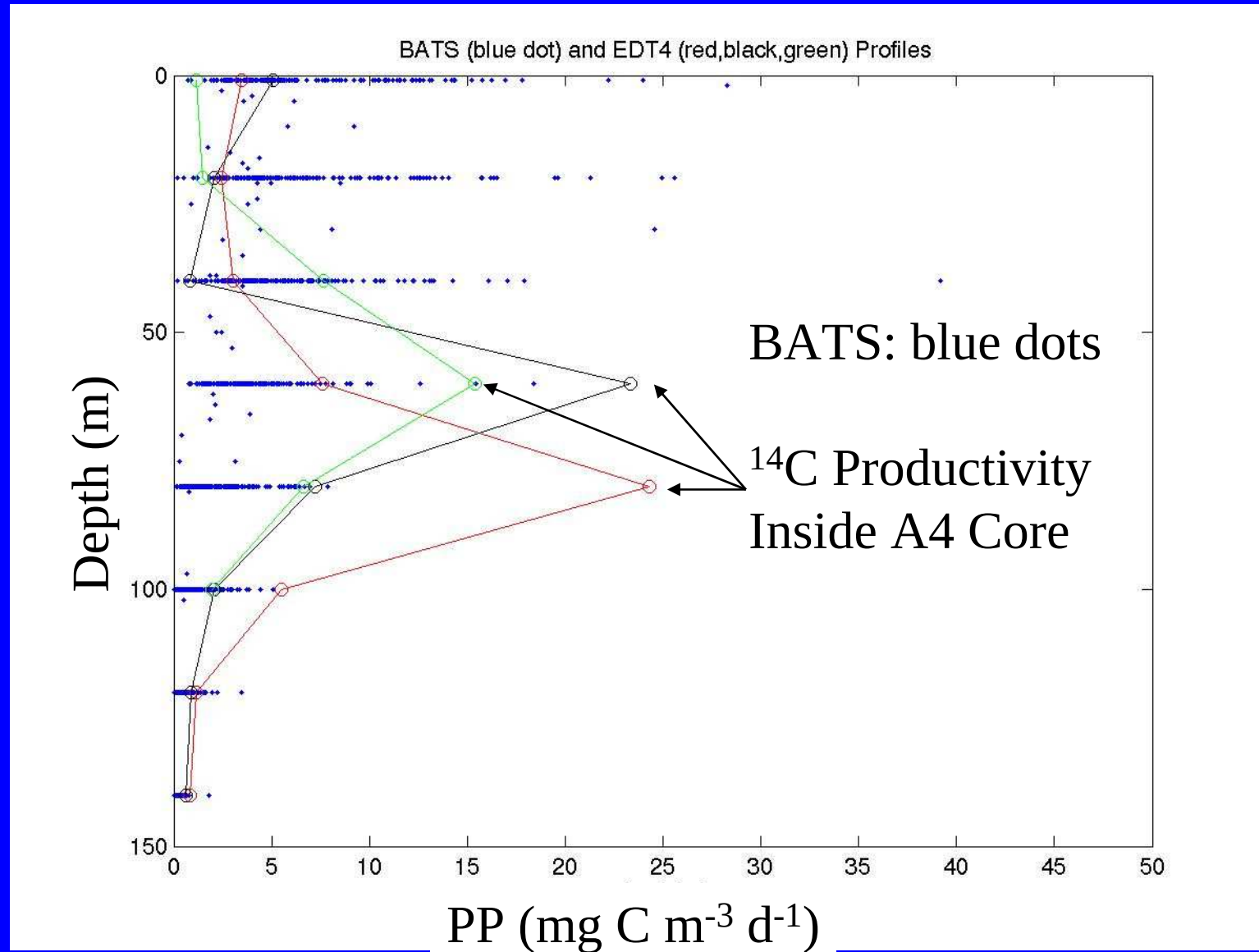


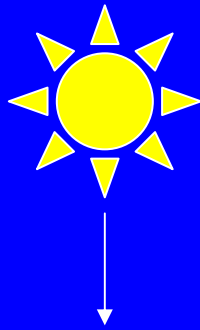
SST

Video Plankton Recorder Survey of A4: Fluorescence



A4 Productivity vs. BATS 1988-2003





Plankton Production in the Open Ocean

Sea Surface

Phytoplankton



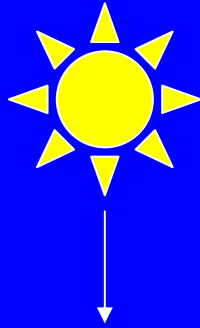
100m



Nutrients

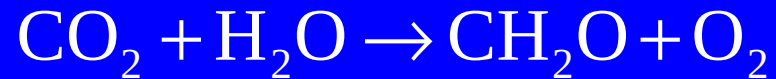


The biological pump

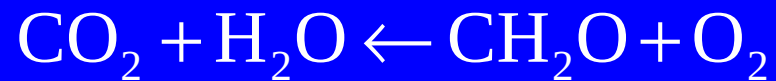


Sea Surface

Photosynthesis



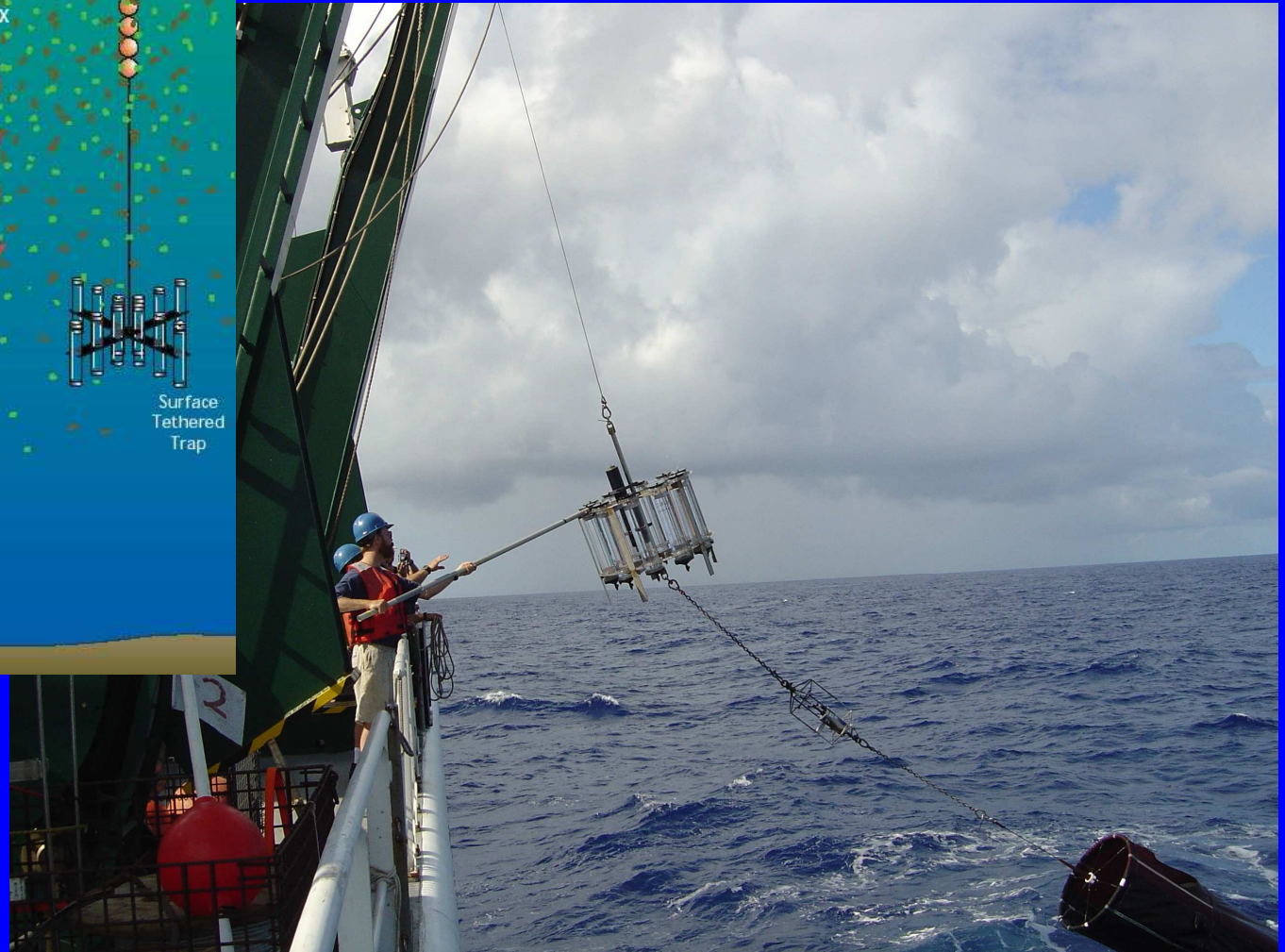
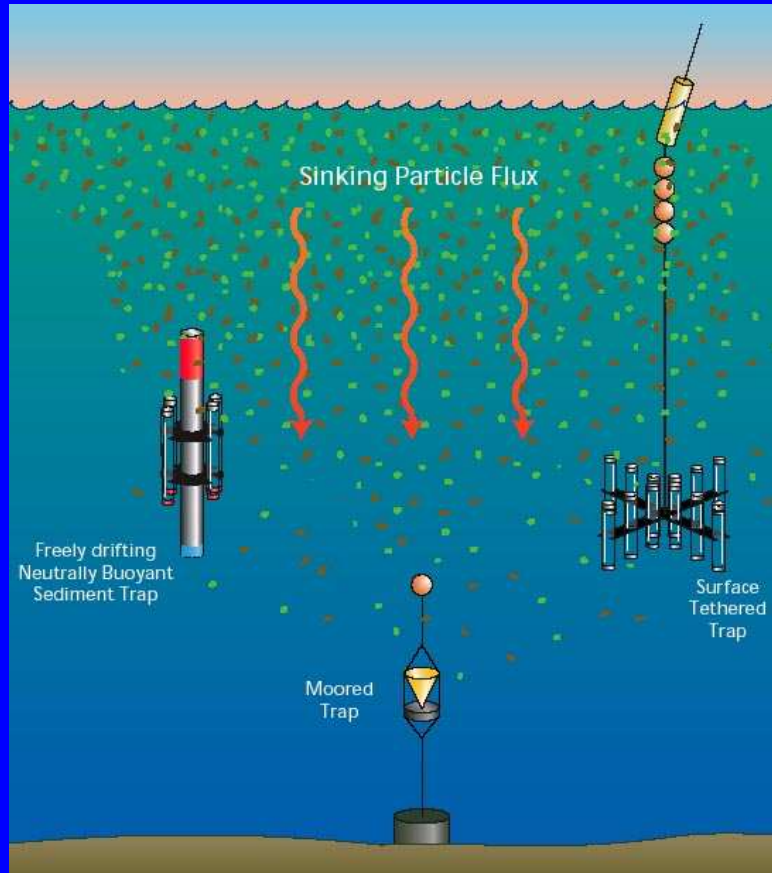
100m



Respiration



Measuring export: Sediment traps



Ken Buesseler

Export flux in mode-water eddy A4

Particle export typical of BATS

Sediment Trap Flux 150m PITS $\text{mg m}^{-2} \text{ day}^{-1}$

	Mass	C	N
EDT3 - Array A	81.2	17.2	2.6
EDT3 - Array B	61.0	14.6	2.2
EDT4 - Array A	68.0	12.5	2.2
EDT4 - Array B	59.0	12.3	2.0
BATS Climatology (summer 1988-2003)			
	107.8 $\pm$ 39.0	27.2 $\pm$ 8.0	4.3 $\pm$ 1.5

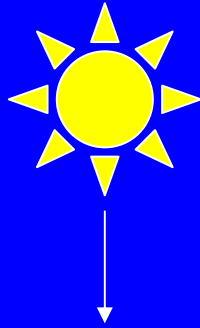
Rod Johnson, BBSR

²³⁴Thorium-based Carbon Flux $\text{mg C m}^{-2} \text{ day}^{-1}$

	C
EDT3	15 $\pm$ 5
EDT4	22 $\pm$ 9

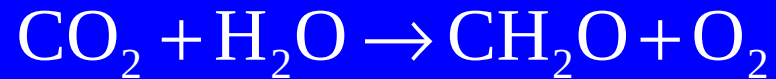
Ken Buesseler

The biological pump

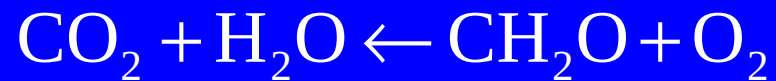
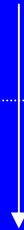


Sea Surface

Photosynthesis



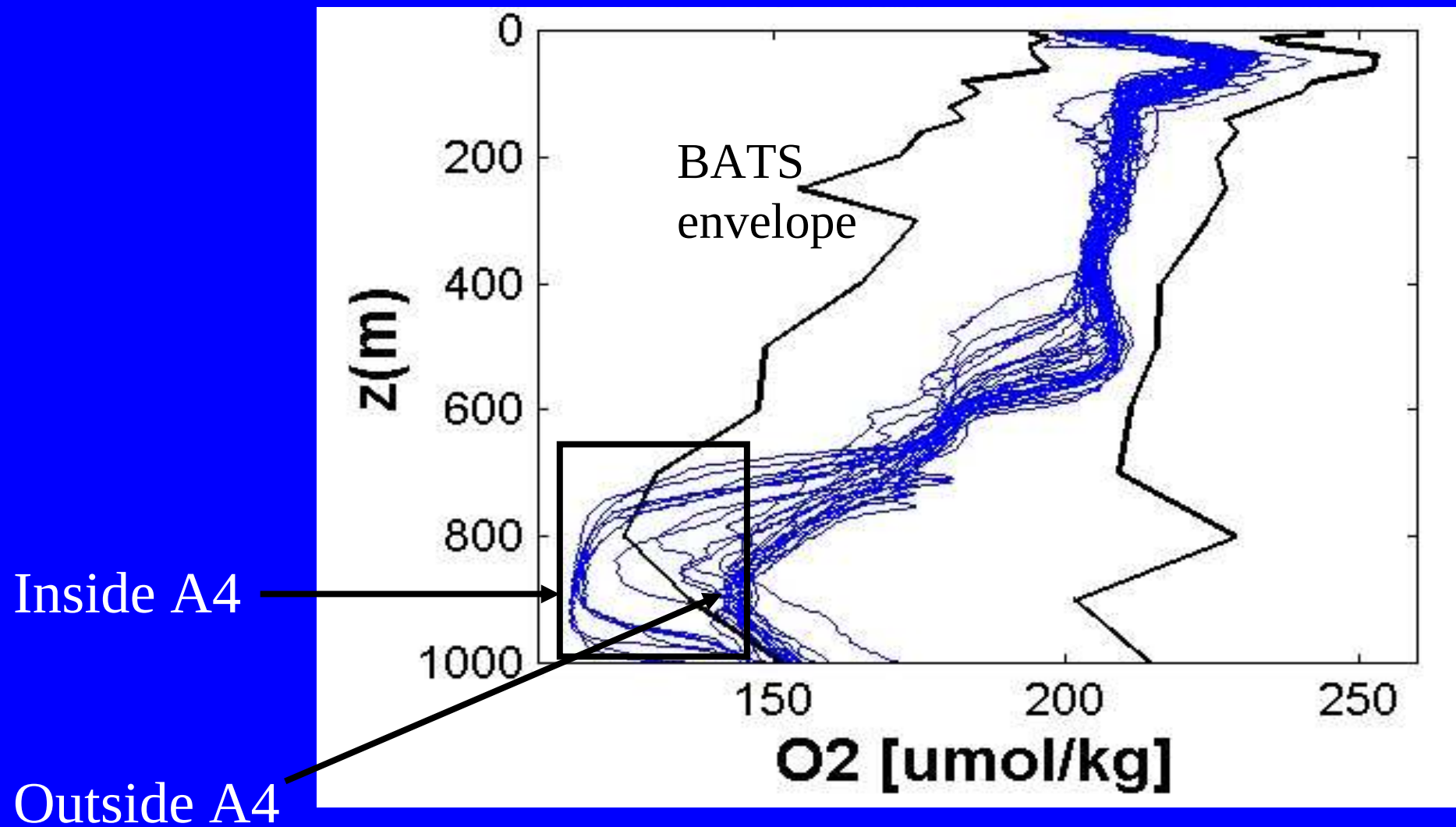
100m



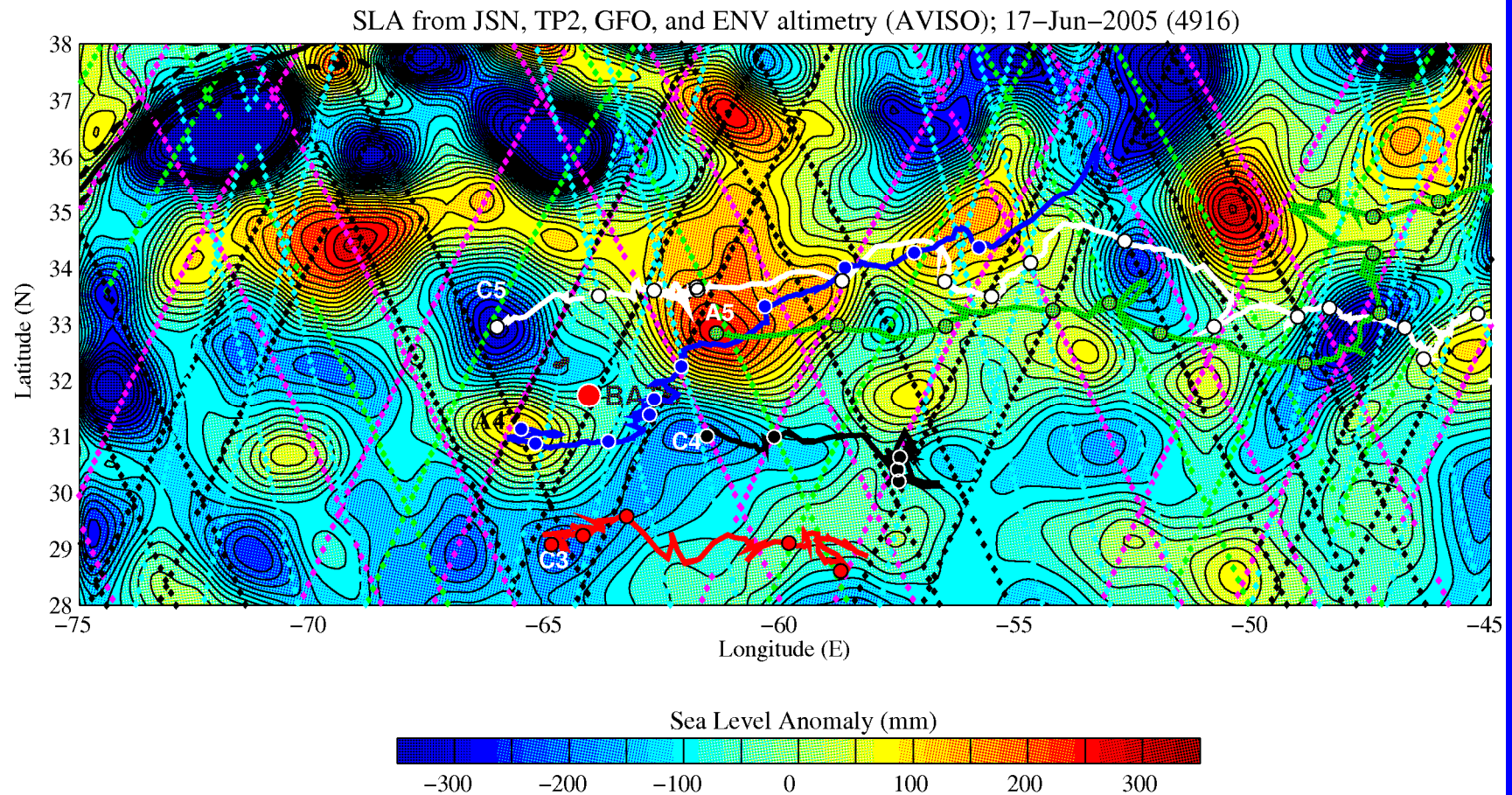
Respiration



A4 Deep Oxygen Deficit



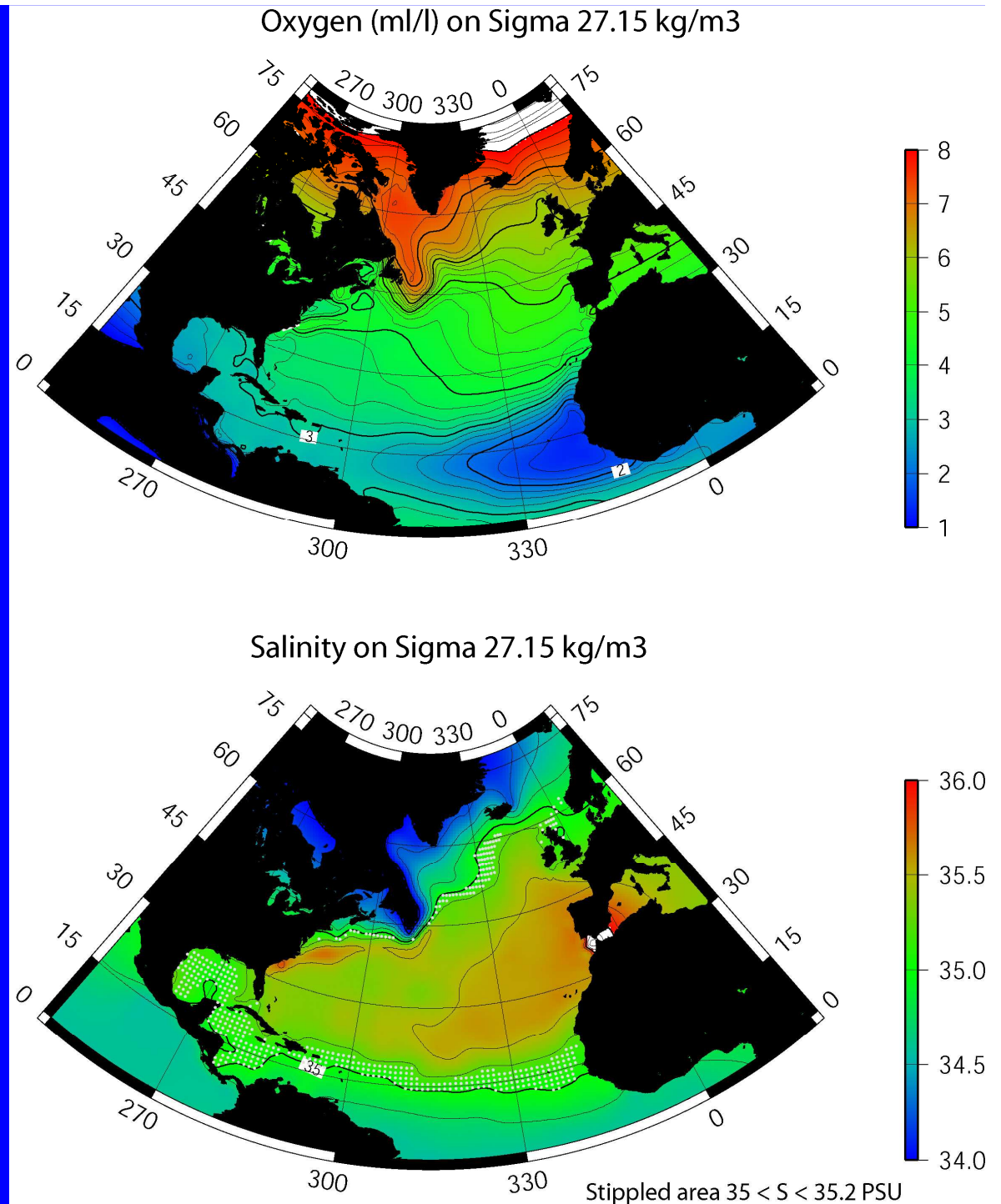
Eddy trajectories - 2005



A4 possible origins

- Levitus Atlas
- Salinity on 27.15 isopycnal
- What were the oxygen “initial conditions”?

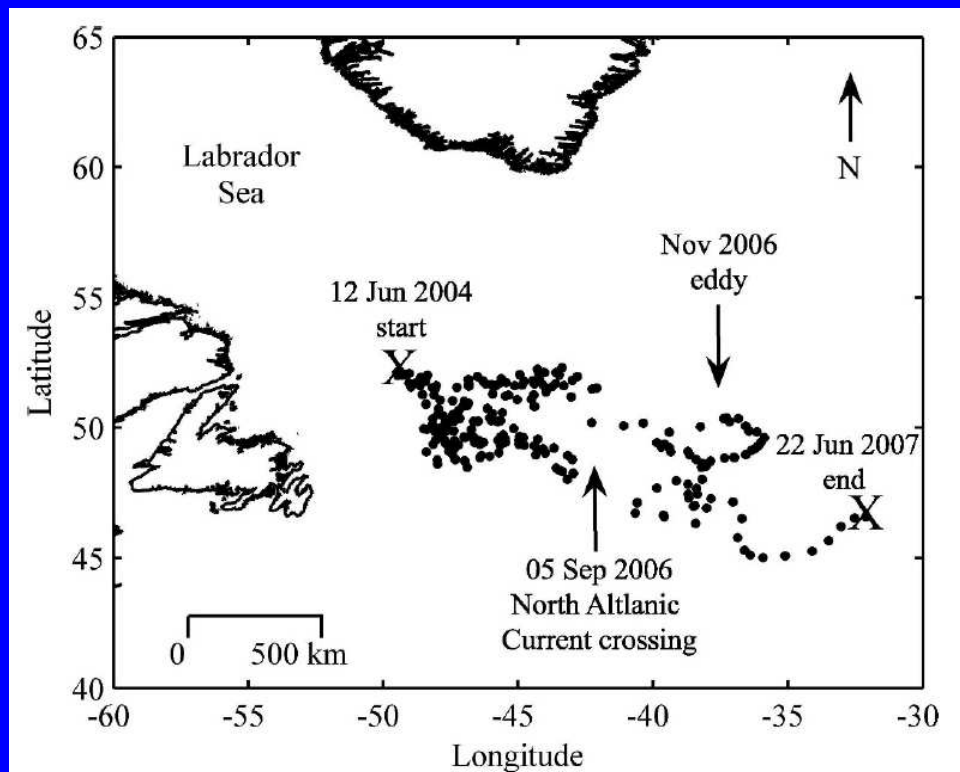
Maps courtesy of Bill Jenkins



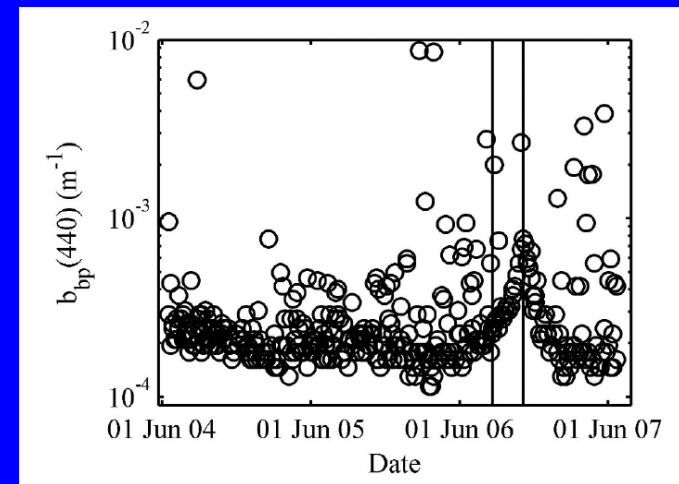
An eddy-induced particle export event?

Boss et al. (2008)

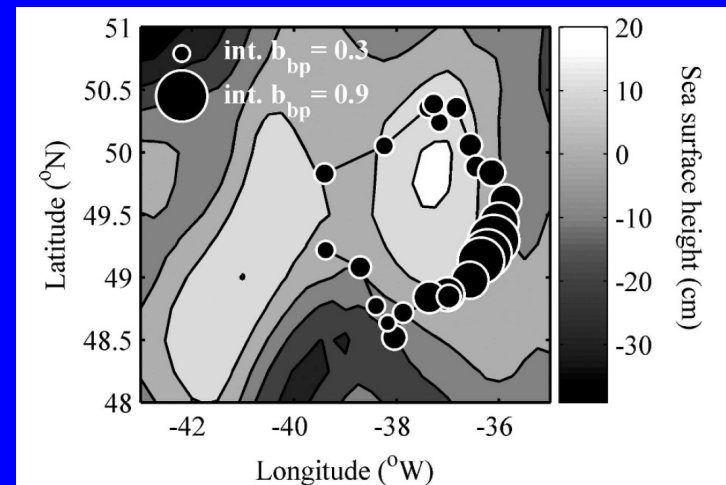
Profiling float with optical measurements: a 3-year record



Backscatter ($z > 970\text{m}$)



Depth-integrated backscatter



Where does the ocean export?

The enigma of export flux

Mesoscale O₂ anomalies in the aphotic zone suggest export events of 1-3X annual new production:
The Smoking Gun?

Where /when does the export happen in the ocean?

Why autonomous platforms with biogeochemical sensors could help

Potential bias in prior shipboard sampling?

Looking for a collection of needles in a sea of haystacks

Systematic sampling at mesoscale resolution over basin scales

End