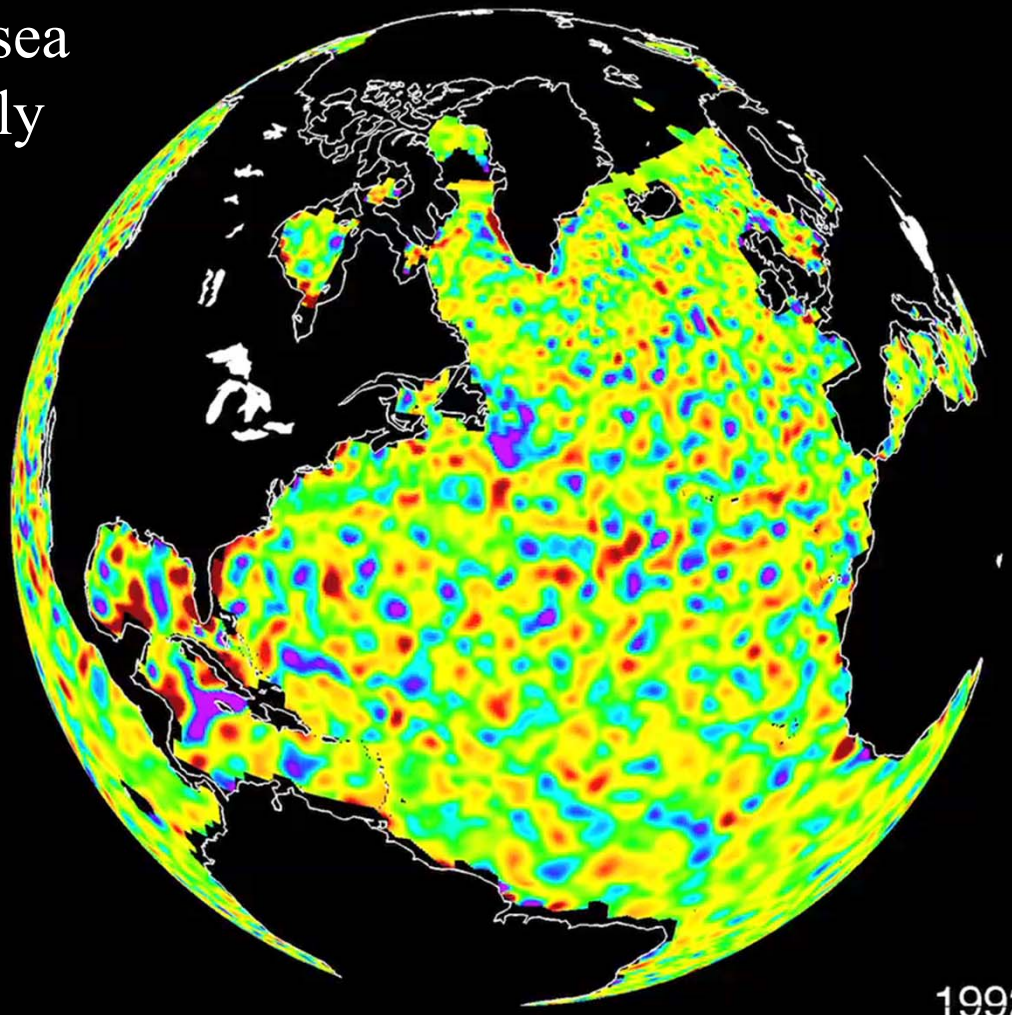
Mesoscale and submesoscale physical-biogeochemical interactions in the North Atlantic

Satellite altimetry: normalized sea level anomaly



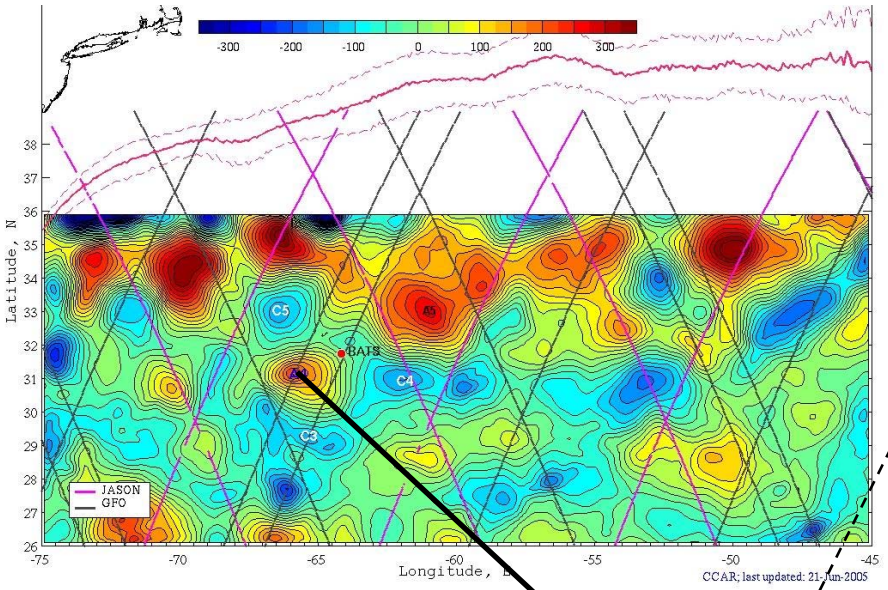
1992-10-14

Peter Gaube
pgaube@whoi.edu

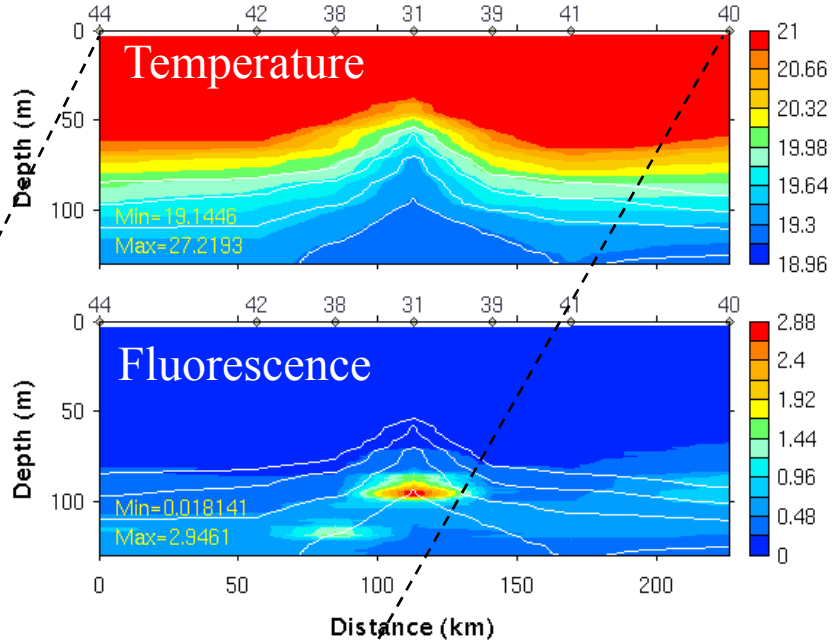
Eddy tracks: lifetimes > 11 weeks

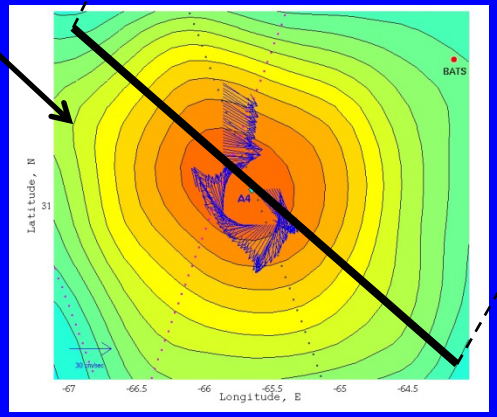
Adaptive sampling of eddy features in the Sargasso Sea using real-time satellite altimetry

Sea Level Anomaly



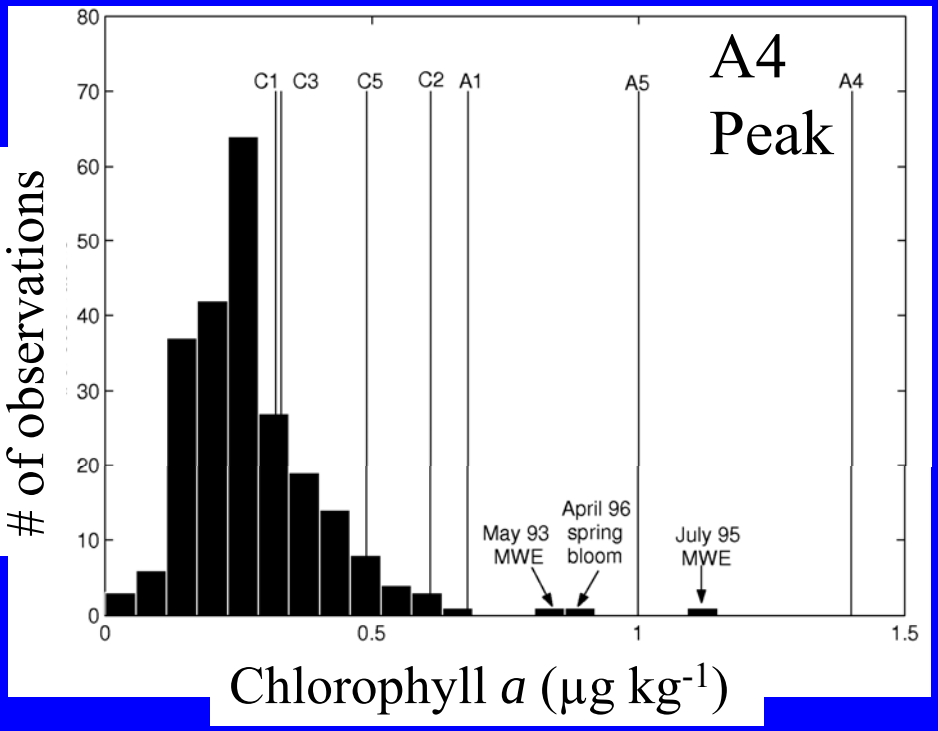
CTD Cross Section

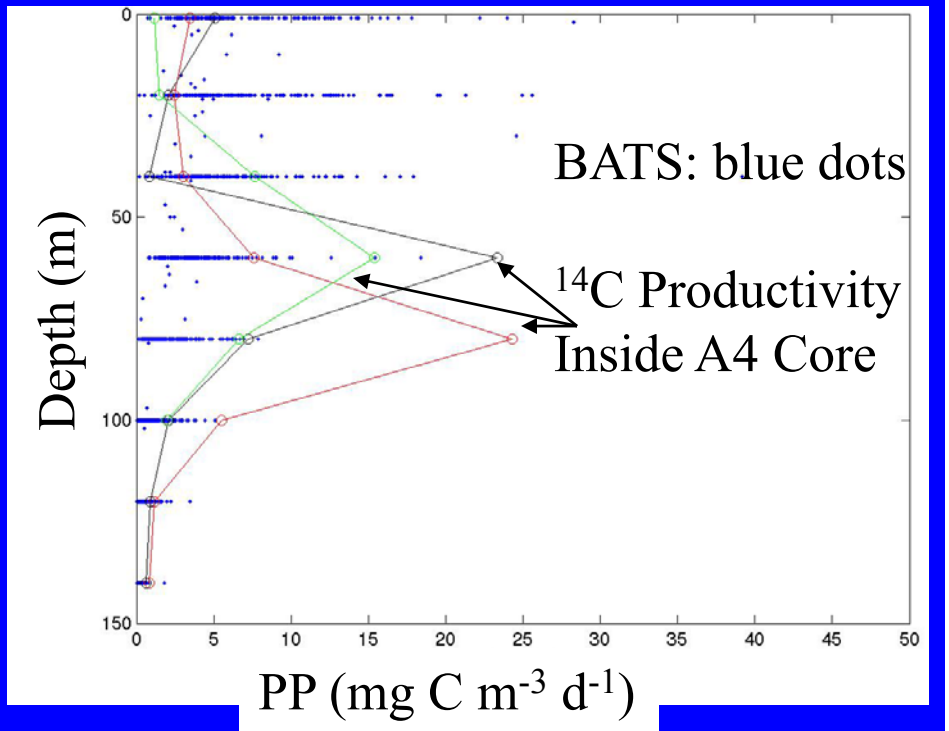




McG et al. 2007

BATS Chlorophyll *a* and ^{14}C Productivity 1988-2003





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

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

McG et al. 2007
Ledwell et al. 2008
Martin and Richards, 2001

Export flux in mode-water eddy A4

Particle export typical of BATS

Sediment Trap Flux
150m PITS
mg m^{-2} 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±39.0	27.2±8.0	4.3±1.5

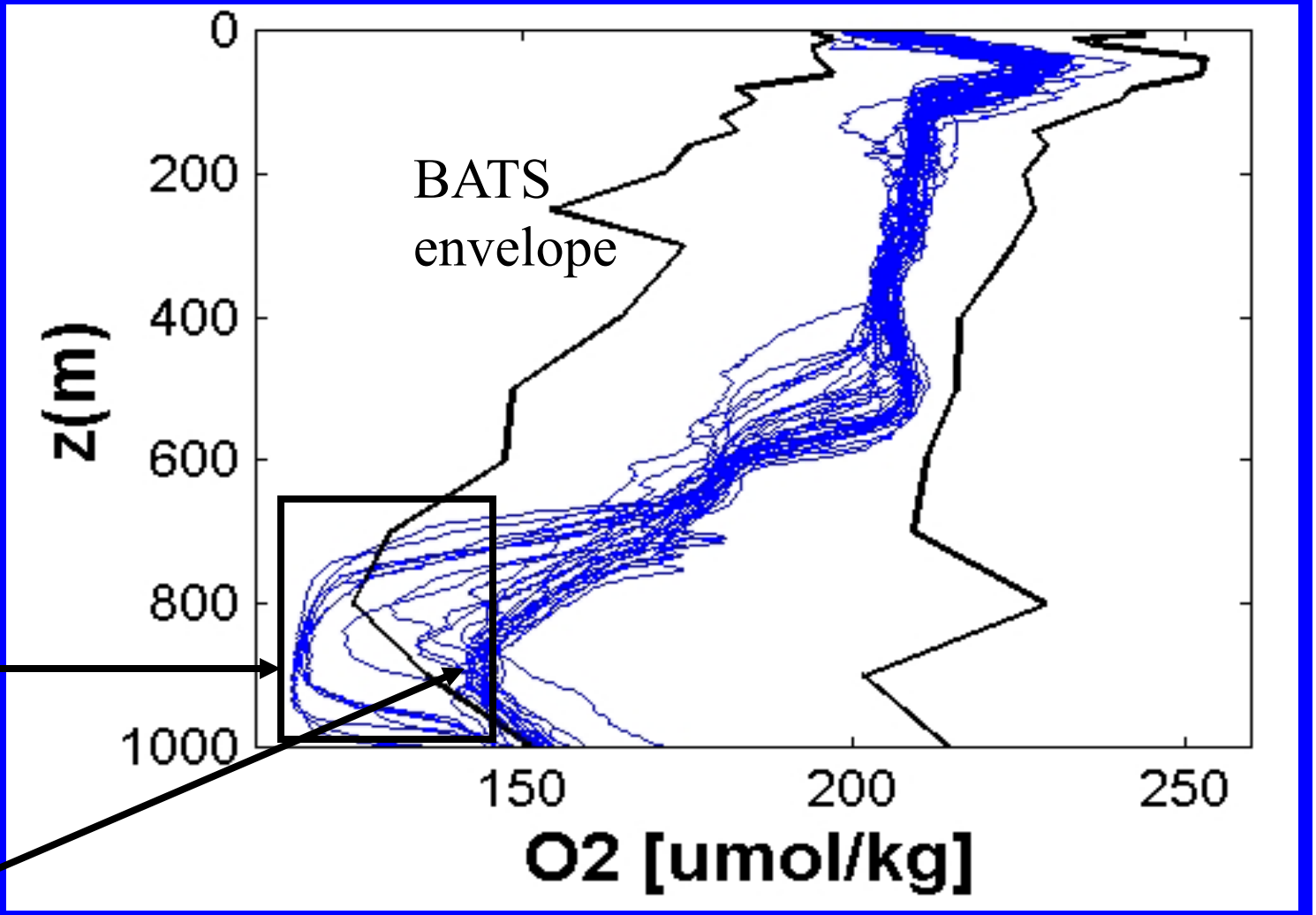
Rod Johnson, BBSR

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

	C
EDT3	15±5
EDT4	22±9

Buesseler et al. 2008

A4 Deep Oxygen Deficit

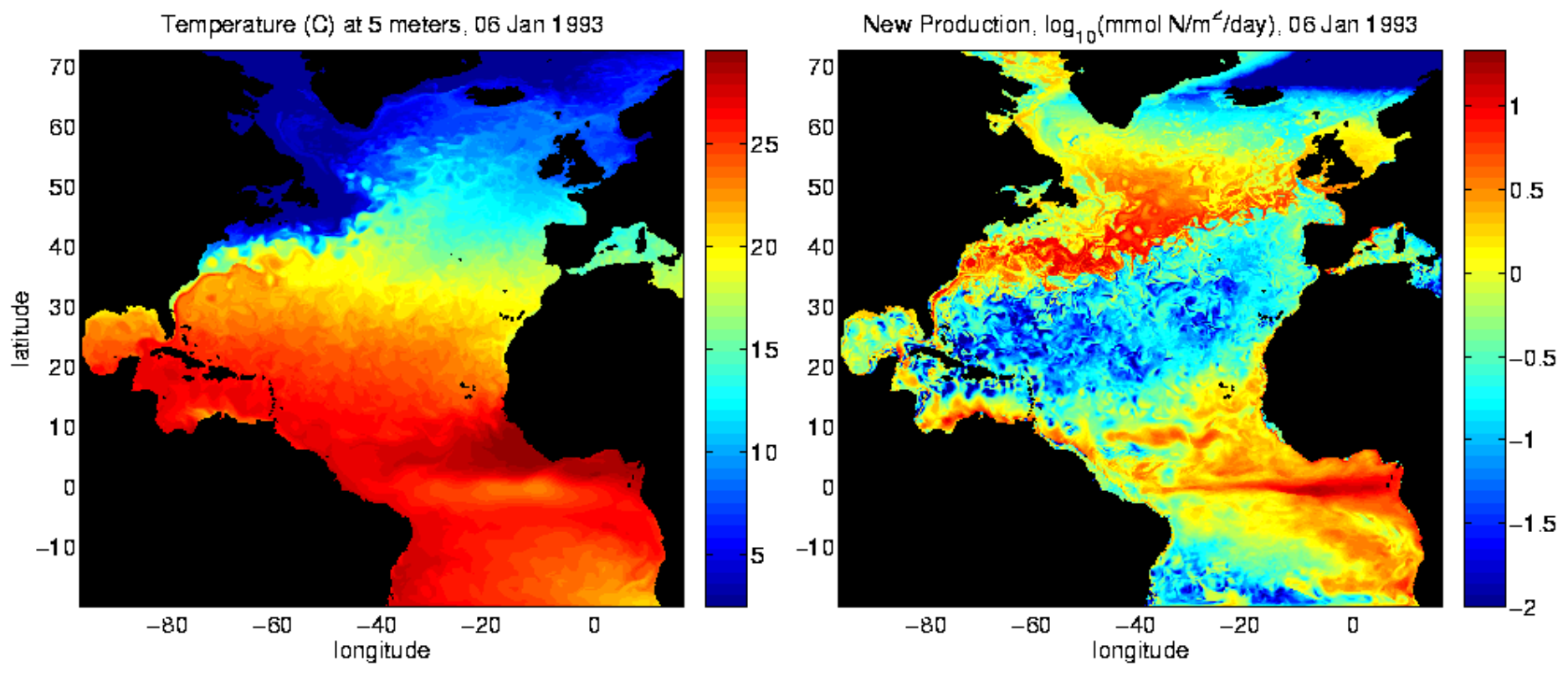


Inside A4

Outside A4

A4 oxygen deficit: 1.6 X annual new production

A 0.1° Resolution Model of the North Atlantic

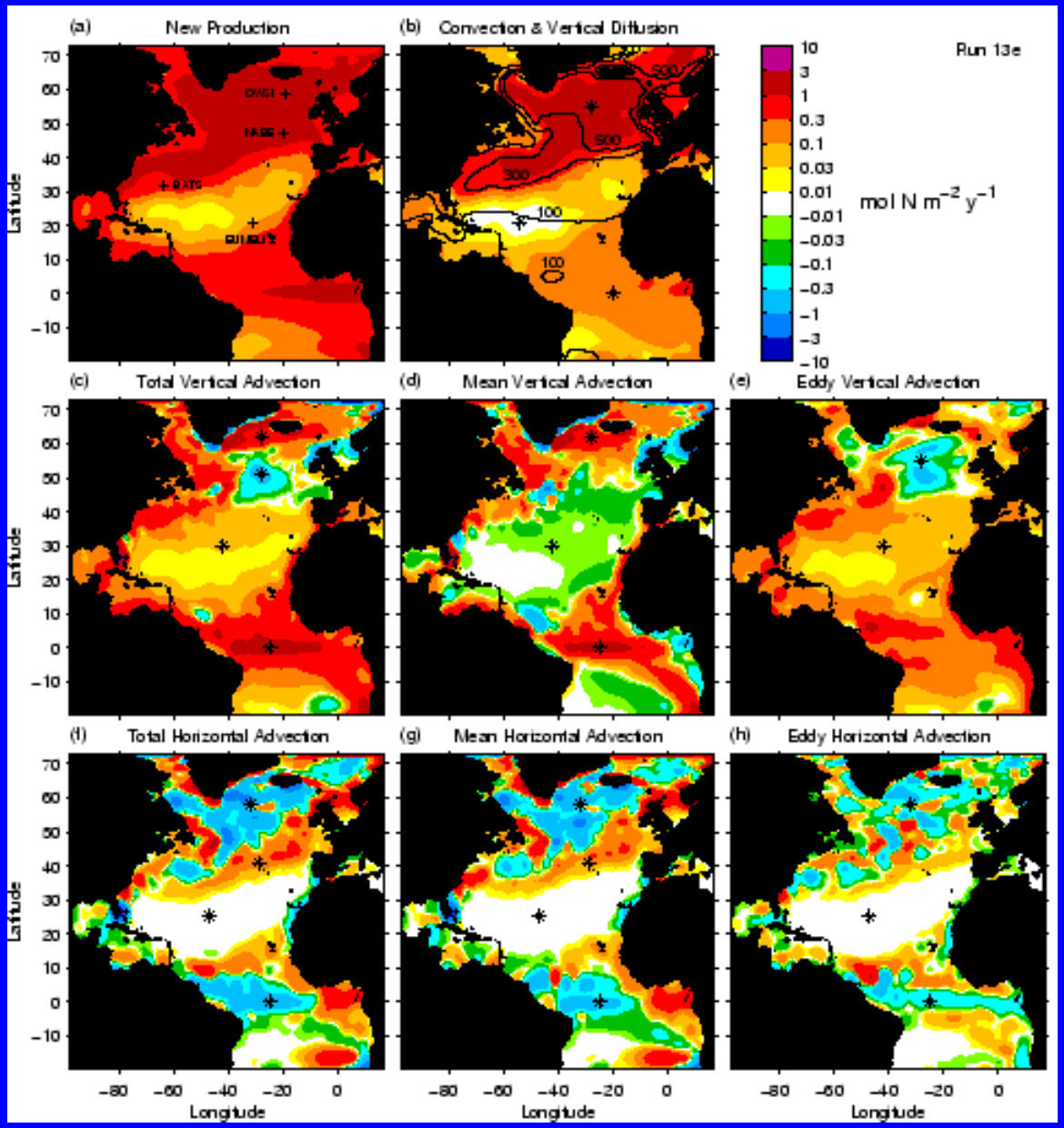


McG et al. 2003

Annual New Production and Nutrient Budgets

New Prod

Conv + Diff



Vertical advection

Horizontal advection

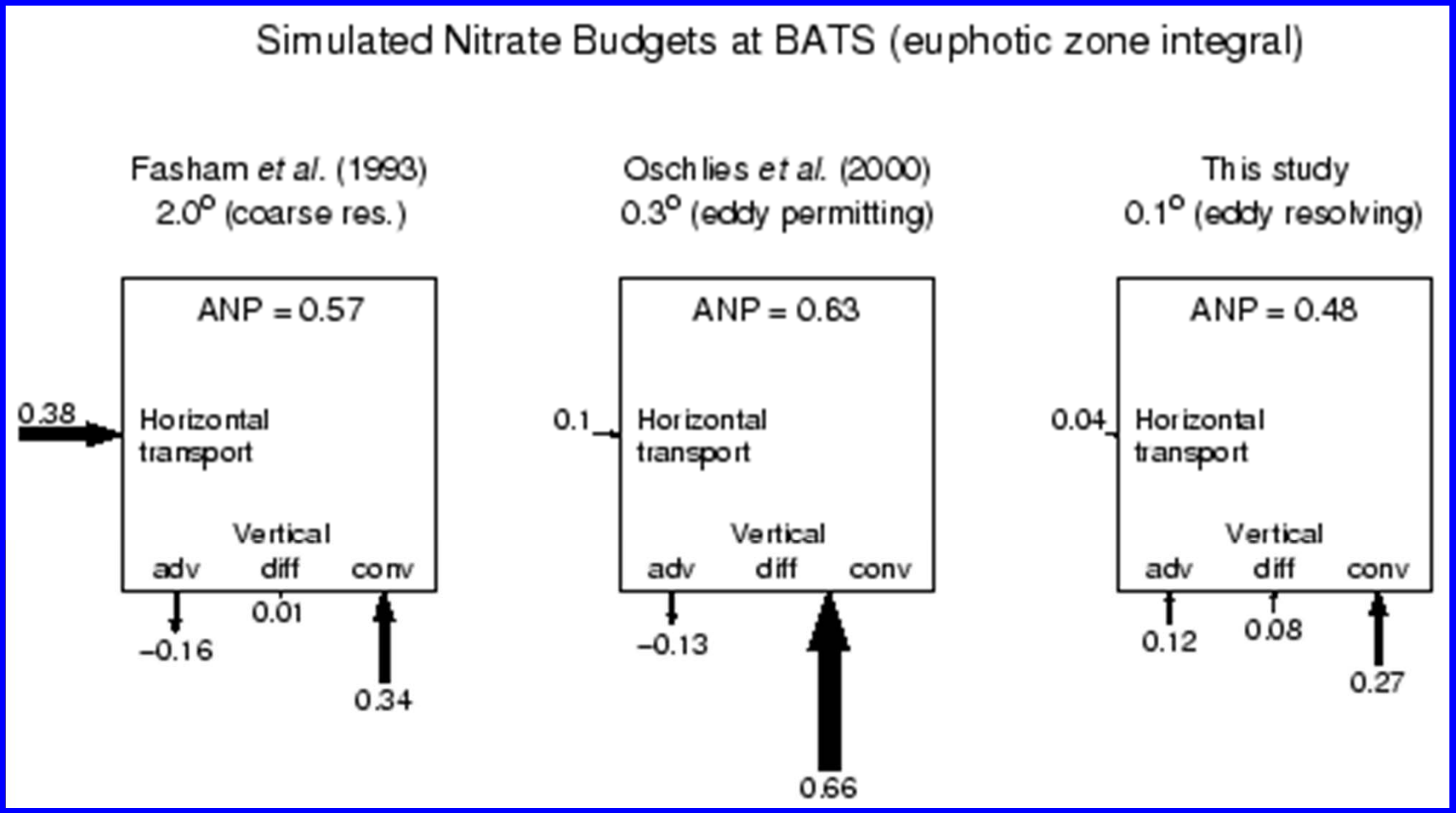
Total

Mean

Eddy

New Production at BATS:

Three Models, Three Different Nutrient Transport Pathways

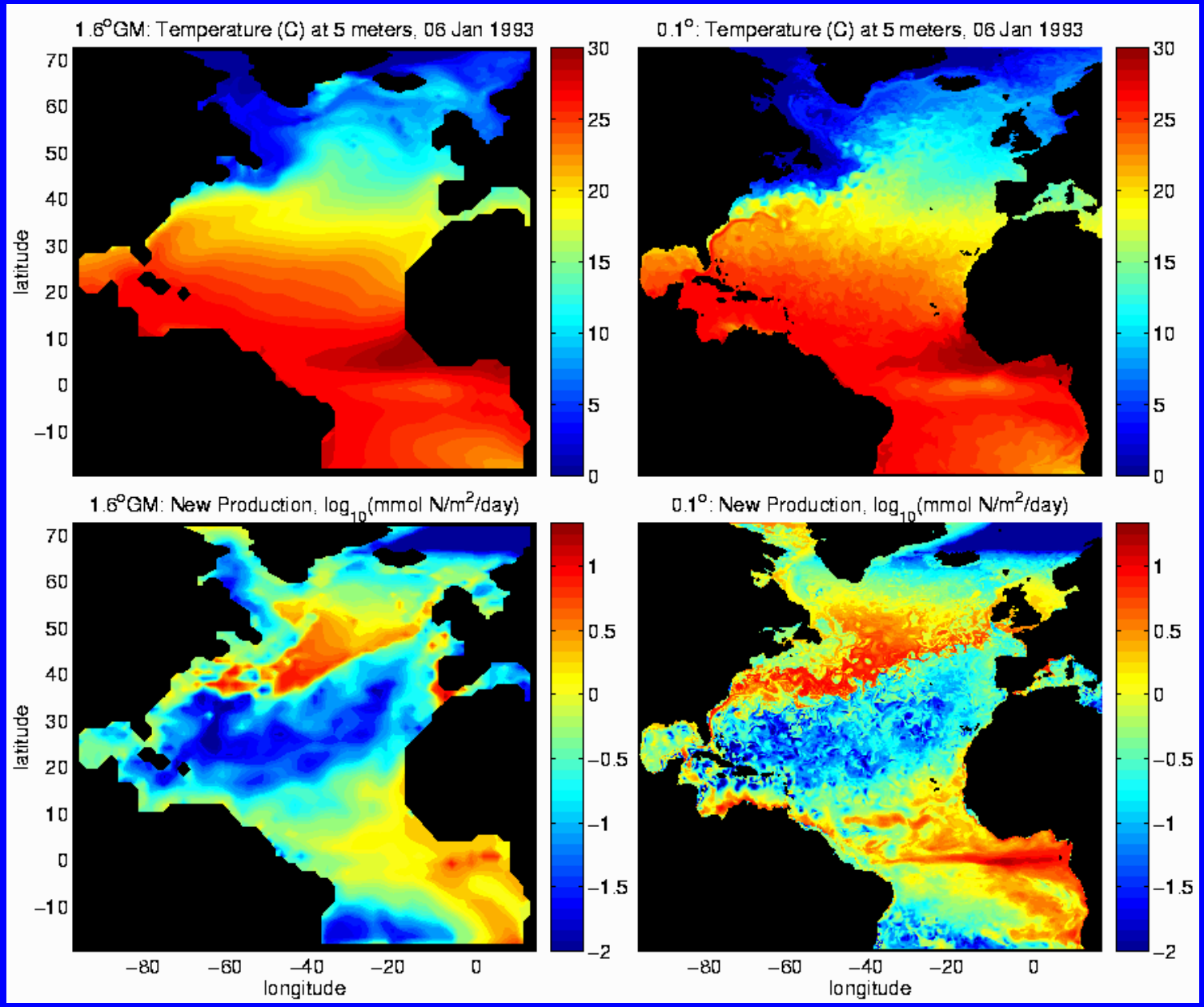


Observed Annual New Production = 0.5 mol N m^{-2} yr^{-1}

Coarse (1.6º) Eddy-resolving (0.1º)

Sea Surface Temperature

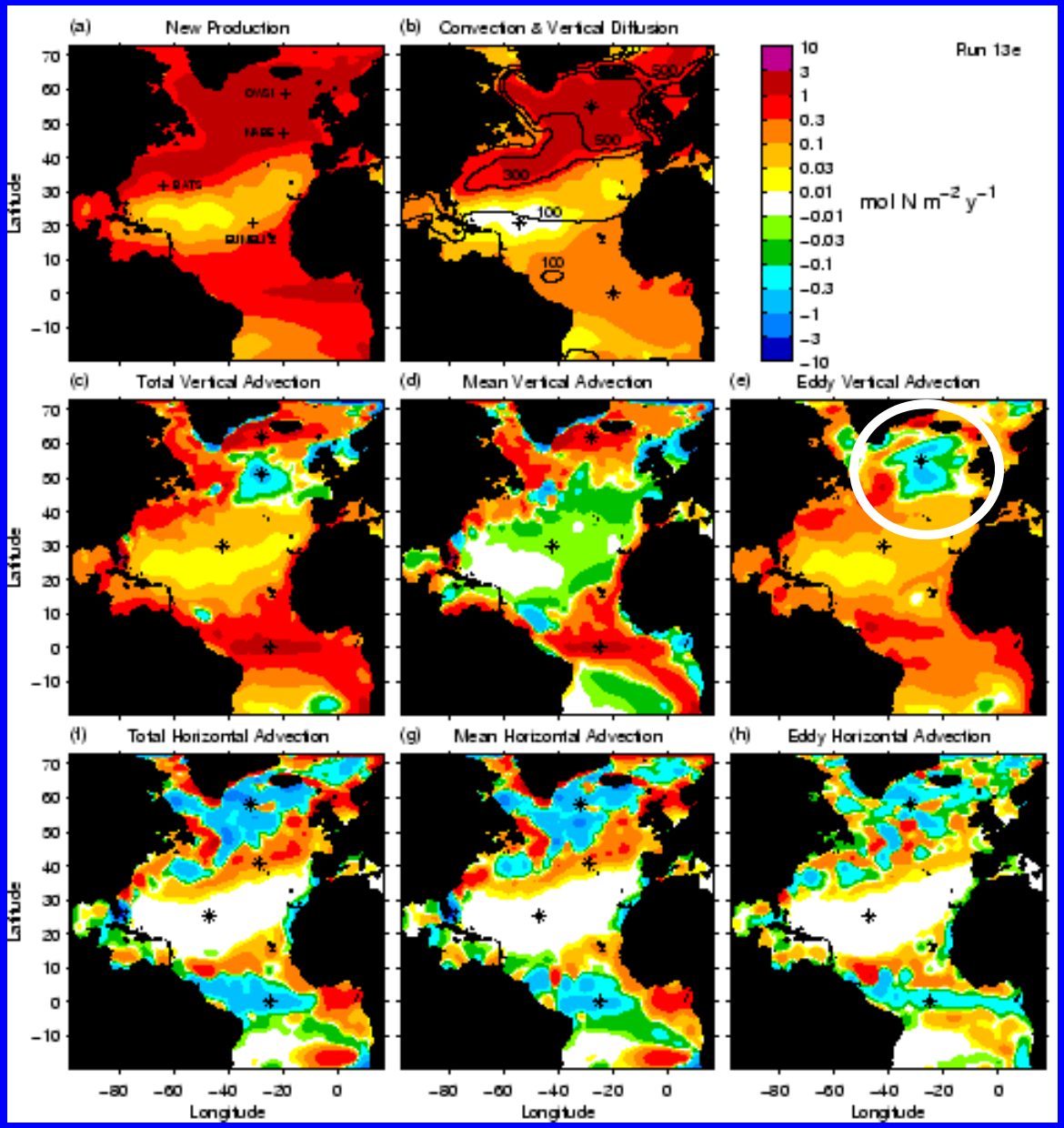
log (New Production)



Are eddies a sink of nutrients in the subpolar gyre?

New Prod

Conv + Diff



Vertical advection

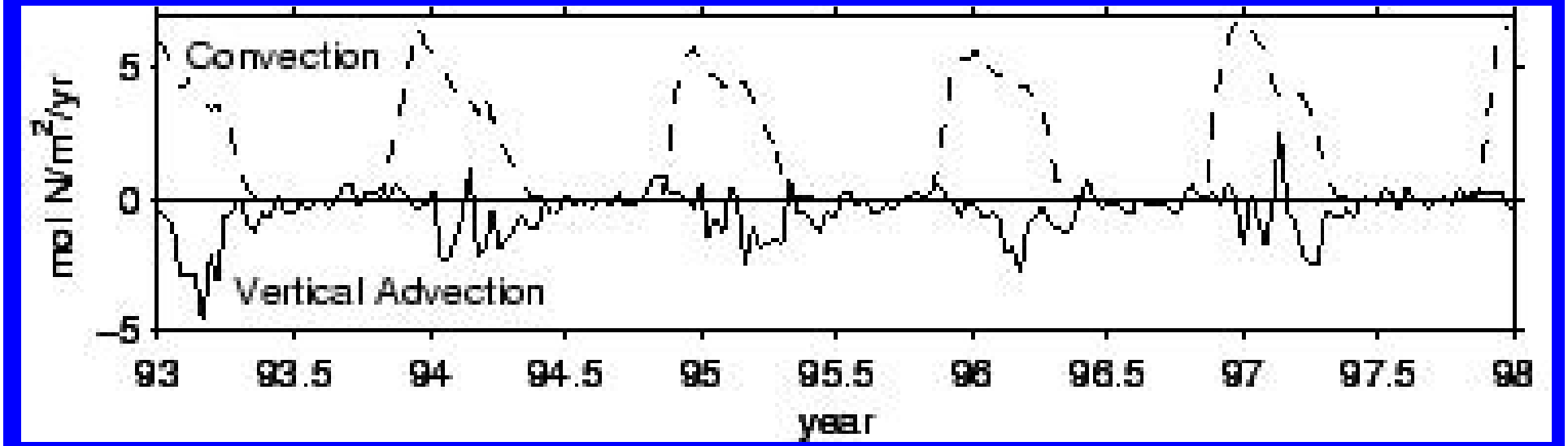
Horizontal advection

Total

Mean

Eddy

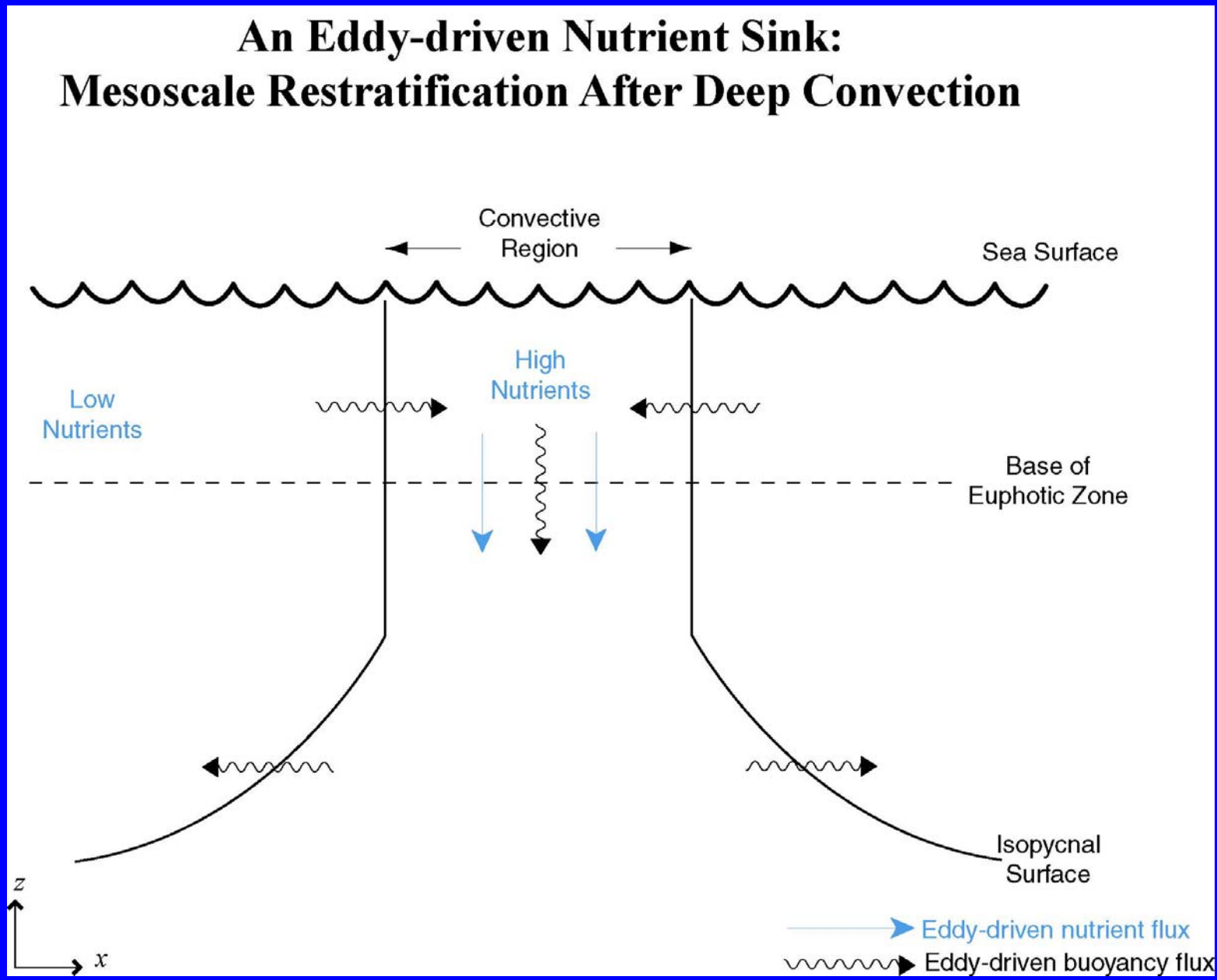
Time-series of terms in the blue spot
51N, 28W: 105m



Negative vertical advection of nitrate associated with post-convective adjustment

McG et al. 2003

An Eddy-driven Nutrient Sink: Mesoscale Restratification After Deep Convection

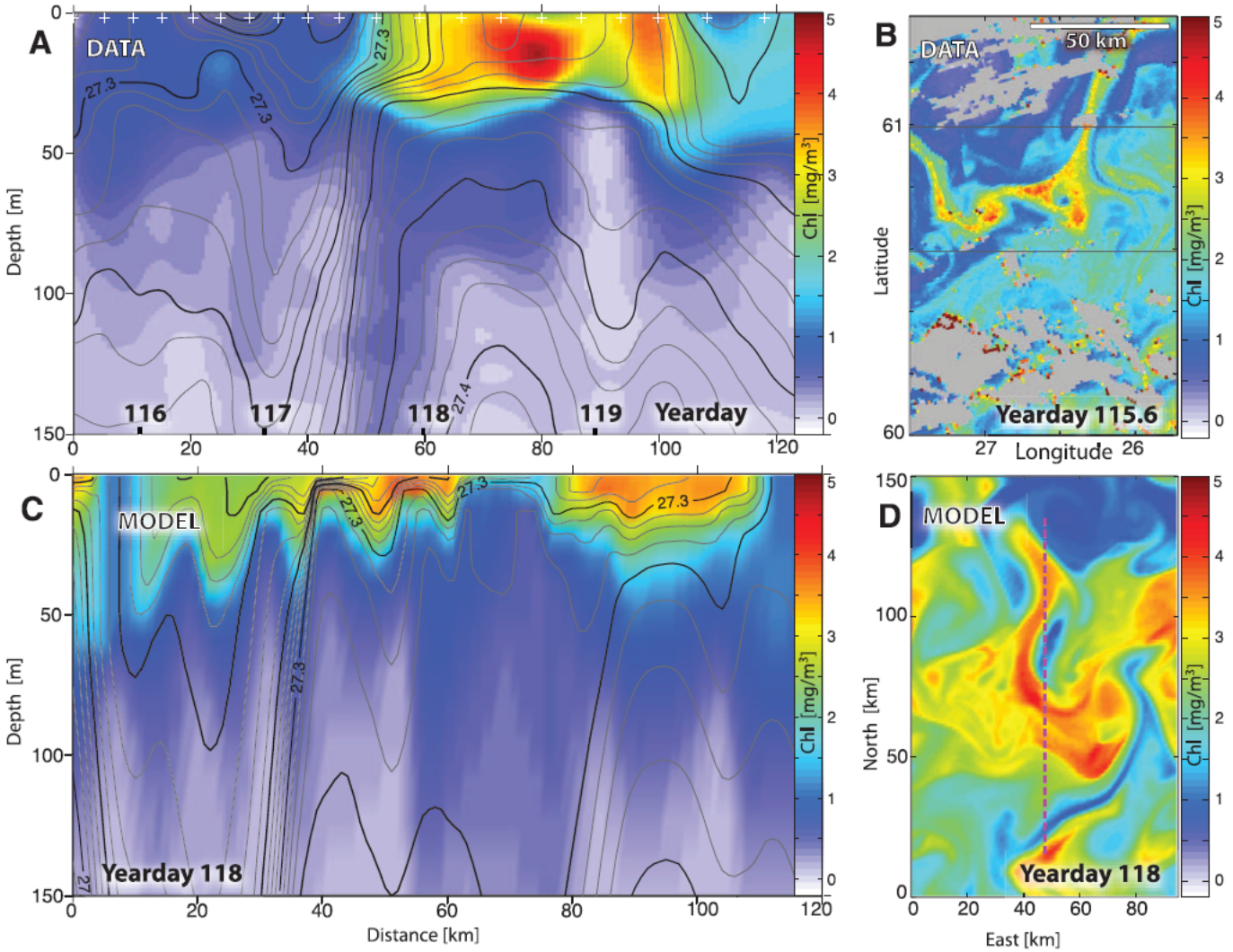


McG et al. 2003

SCIENCE VOL 337 6 JULY 2012

Eddy-Driven Stratification Initiates North Atlantic Spring Phytoplankton Blooms

Amala Mahadevan,[1] Eric D'Asaro,[2]* Craig Lee,[2] Mary Jane Perry[3]



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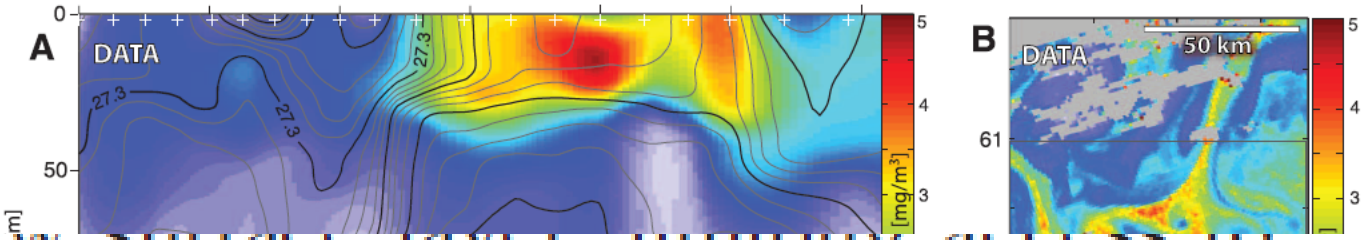
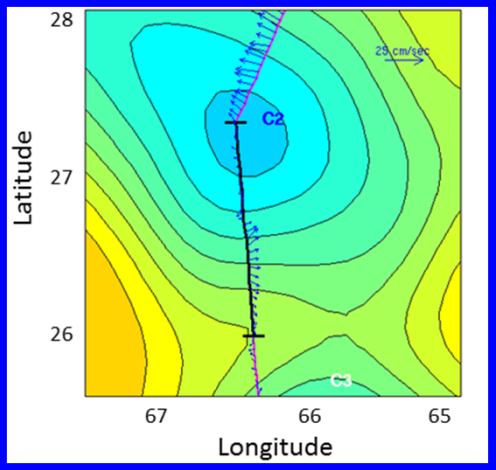


to the shallow surface layer, limiting access to and shading the nutrient-rich waters below. Thus although our simulations do not include nutrient effects, we anticipate that enhanced nutrient fluxes into surface waters due to ML eddies will lead to an overall increase in carbon fixation.

Eddy restratification is effective in this area of the Icelandic basin due to the existence of deep

Submesoscale hotspots in fluorescence and O_2

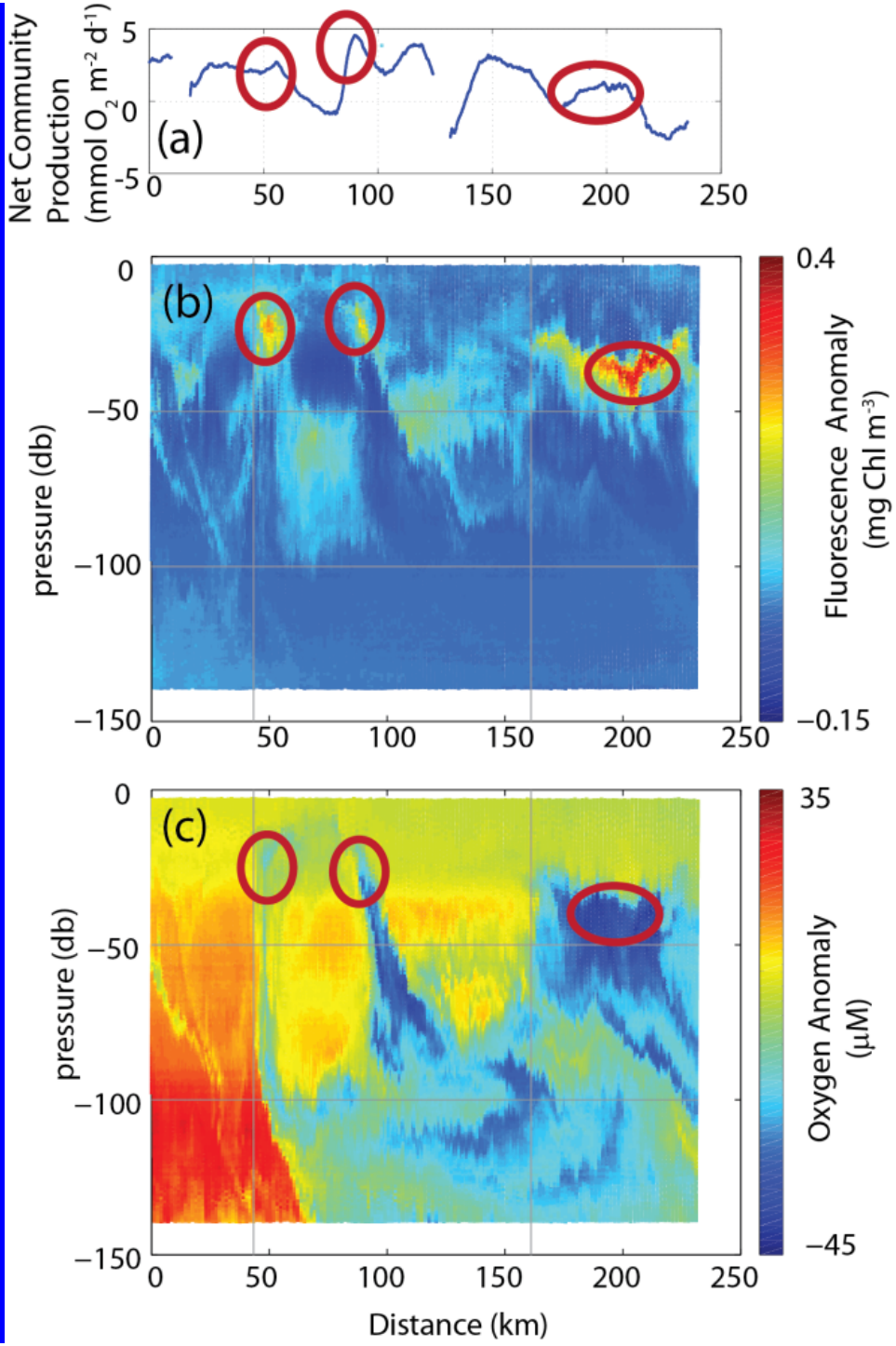


Video Plankton recorder (Davis et al., 2005)

NCP (EIMS O_2/Ar)

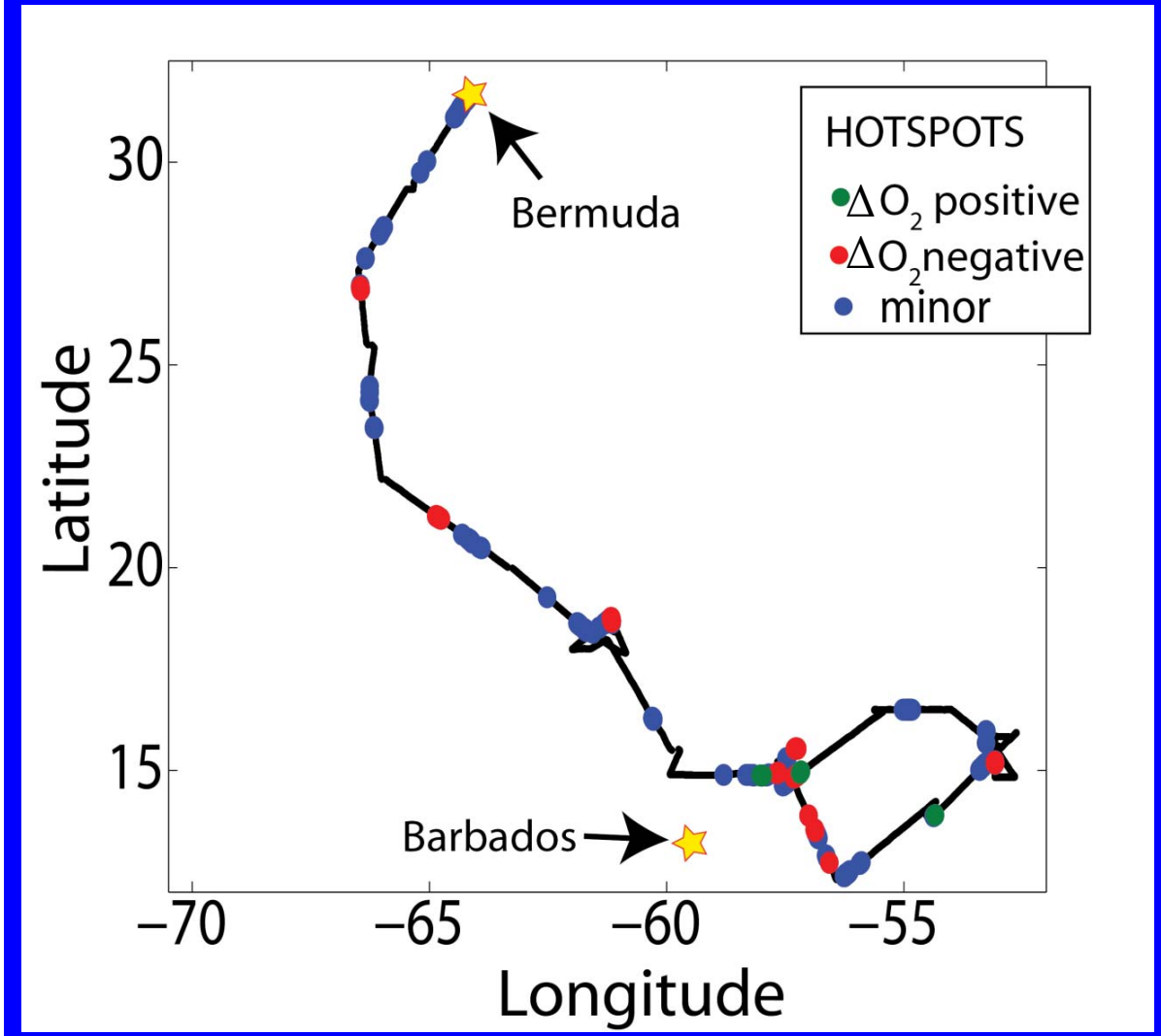
Fluorescence Anomaly

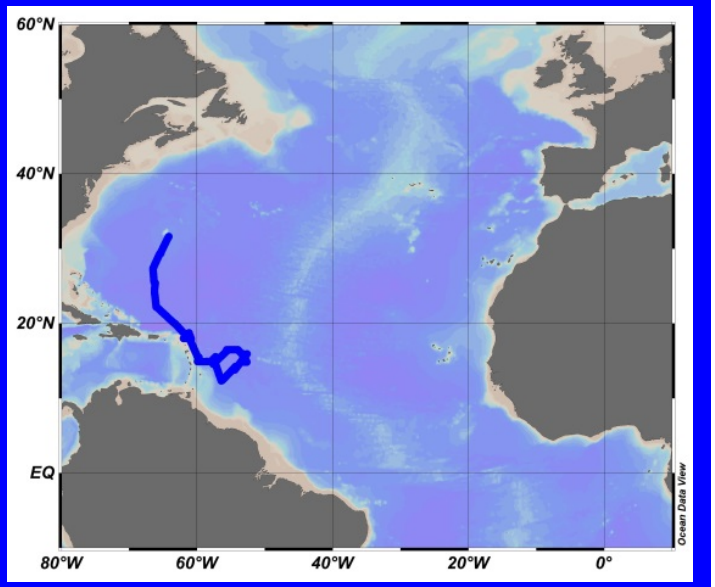
Oxygen Anomaly



Stanley and McG, in prep

Submesoscale hotspots ubiquitous in a survey of subtropical and tropical Atlantic

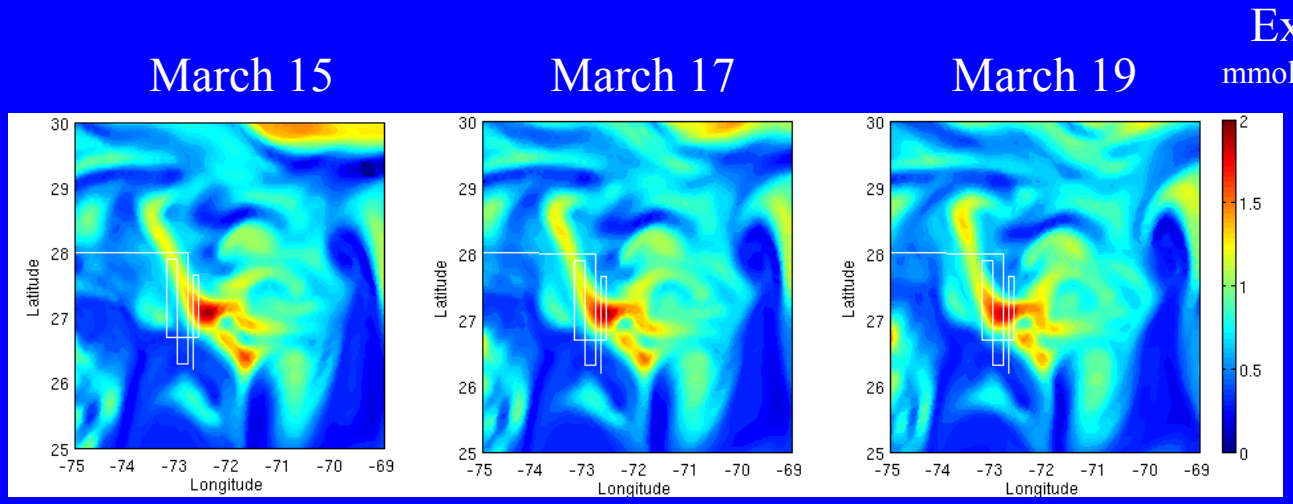




Stanley and McG, in prep

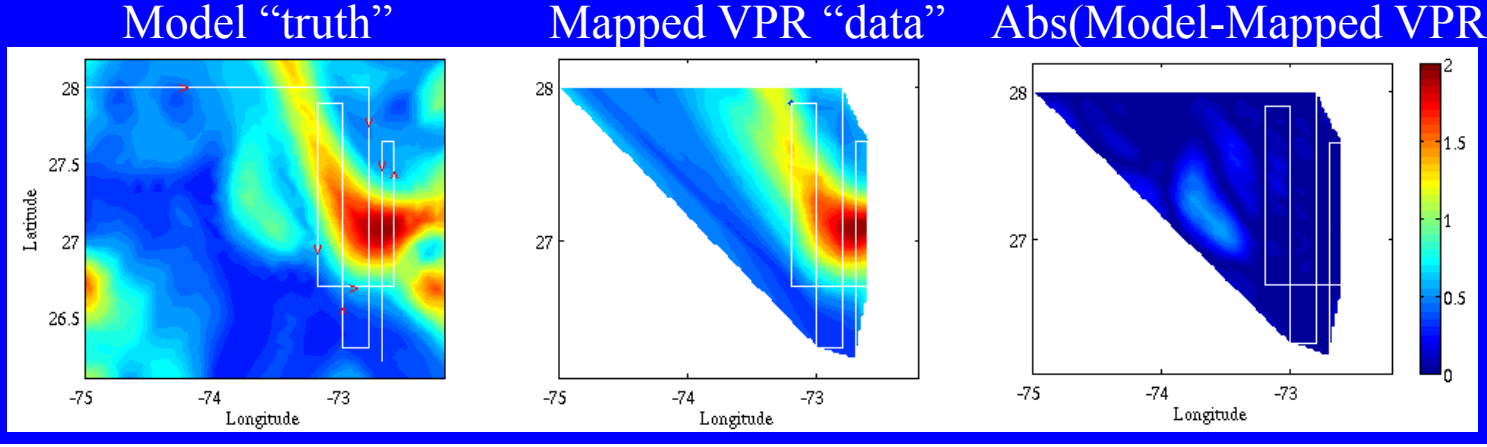
Can we resolve 3-D structure of such features with towed instrumentation?
An Observing System Simulation Experiment

1/54° model output
Courtesy of M.Levy
(Resplandy et al. 2012)



Simulated VPR survey:

1084 km
58 hours
10 knots



Summary

Mesoscale & submesoscale processes not only drive variability, but also impact mean bigeochemical fluxes

- Subtropics: nutrient source
- Subpolar: nutrient sink? source?

The enigma of export flux

- Aphotic zone O_2 anomalies: The Smoking Gun?
- Where /when does the export happen?

What processes determine ecosystem response to eddy-driven perturbations of the physical and chemical environment?

END