The Sea Floor as a Sediment Trap:

Contributions to JGOFS from Benthic Flux Studies

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- **Milestones and Acknowledgements**
- **Why Benthic Fluxes are Useful**
- **Global Distribution of Sea Floor Flux**
- **Opal as Ballast for POC Flux**

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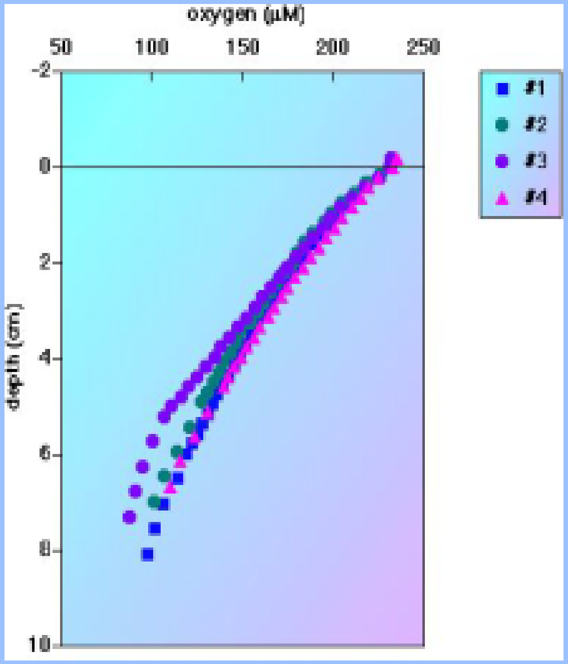
Major Highlights in the Development of Deep Sea Benthic Flux Studies

- **Ken Smith** (SIO) begins frequent benthic oxygen fluxes measurements in the deep sea with the free vehicle grab respirometer
- **Clare Reimers** (OSU) introduces microelectrode oxygen pore water measurements



Major Highlights in the Development of Deep Sea Benthic Flux Studies

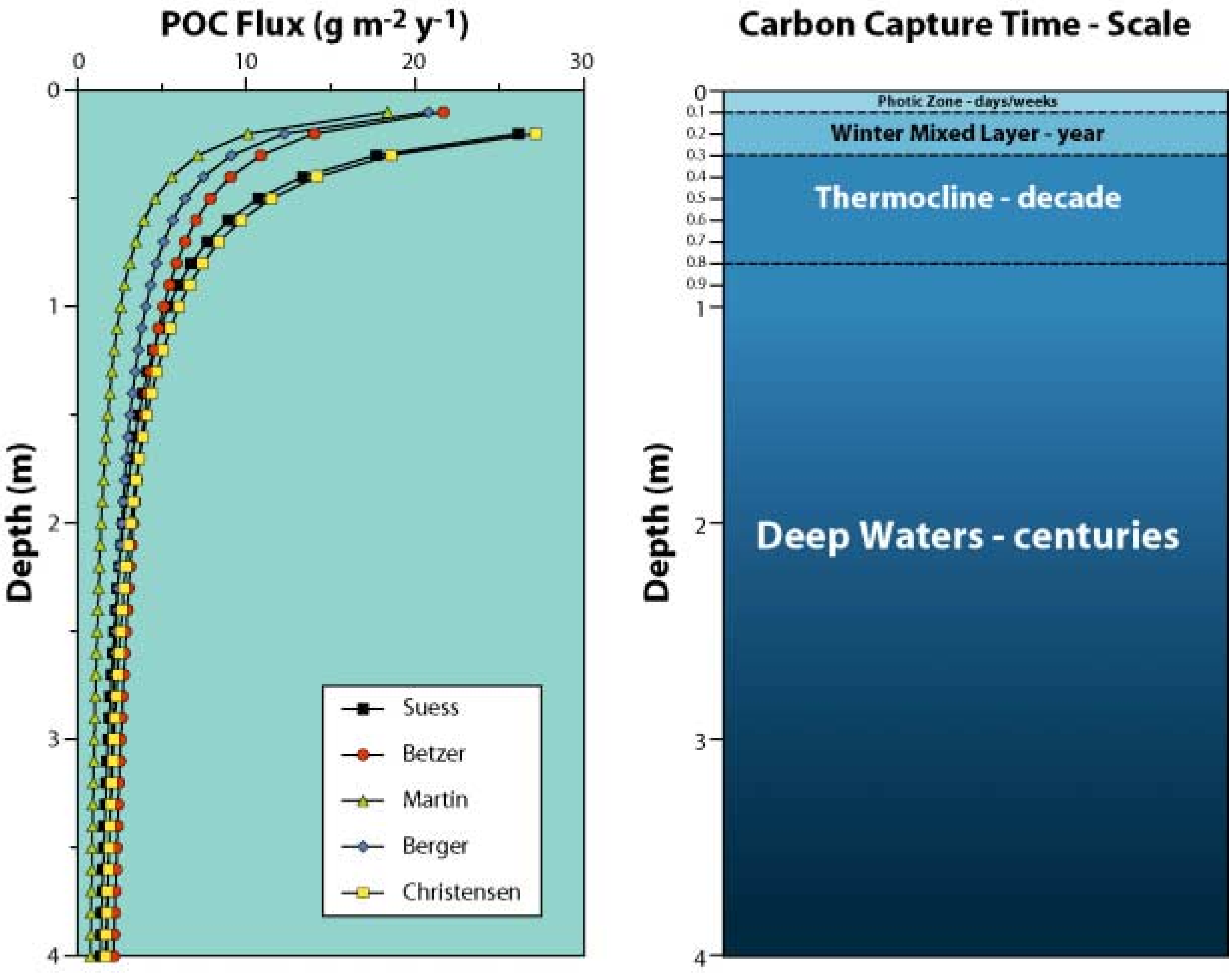
- **Fred Sayles** begins in situ benthic flux time-series measurements off Bermuda

- **Ken Smith** deploys ROVER for long time-series, benthic flux measurements

- >20 groups world-wide

What makes benthic flux measurements useful to JGOFS?

- Ultimate Sediment Trap
- Represents deep, climate time-scale fluxes
- Solute fluxes supported by remineralization - a destructive process
- Dampen input variability - facilitating estimate of mean fluxes
- Physical boundary, multiple approaches for assessing accuracy
- Links modern processes to the sediment record
- Provides a approach


POC Flux (g m-2 y-1)
0
10
20
30
Depth (m)
0
1
2
3
4
Suess
Betzer
Martin
Berger
Christensen
Carbon Capture Time - Scale
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
2
3
4
Depth (m)
Photic Zone - days/weeks
Winter Mixed Layer - year
Thermocline - decade
Deep Waters - centuries

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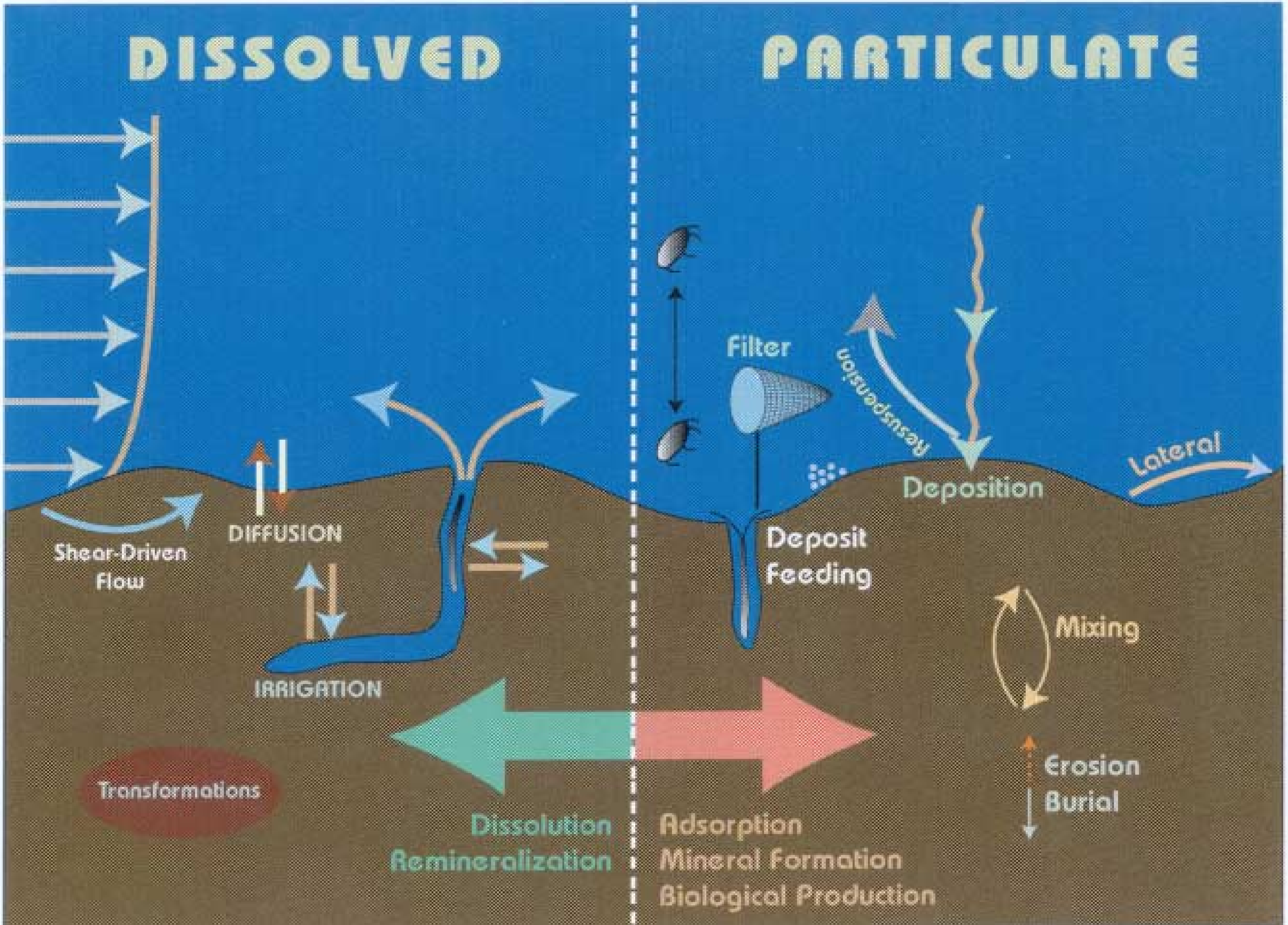
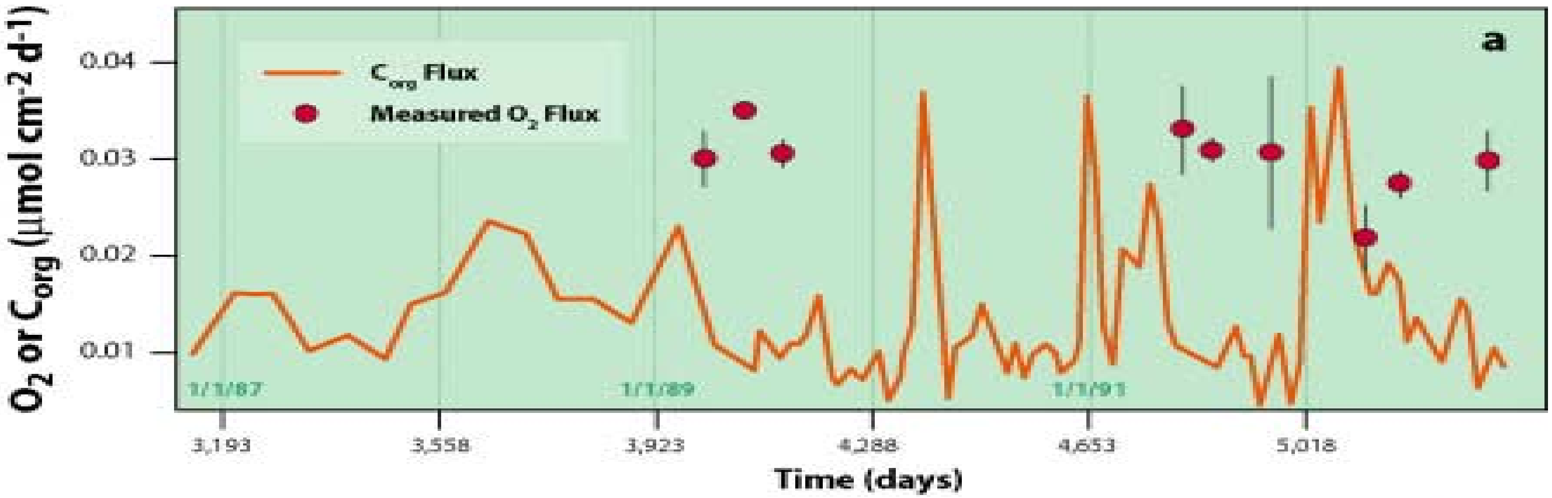
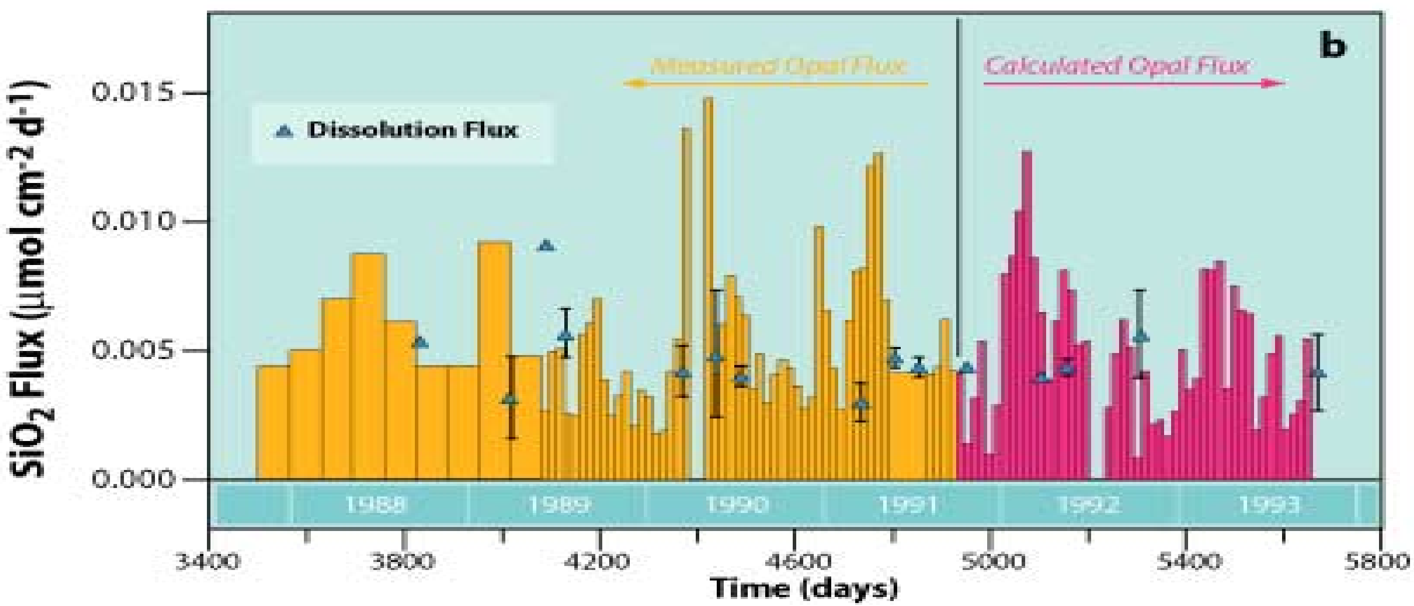
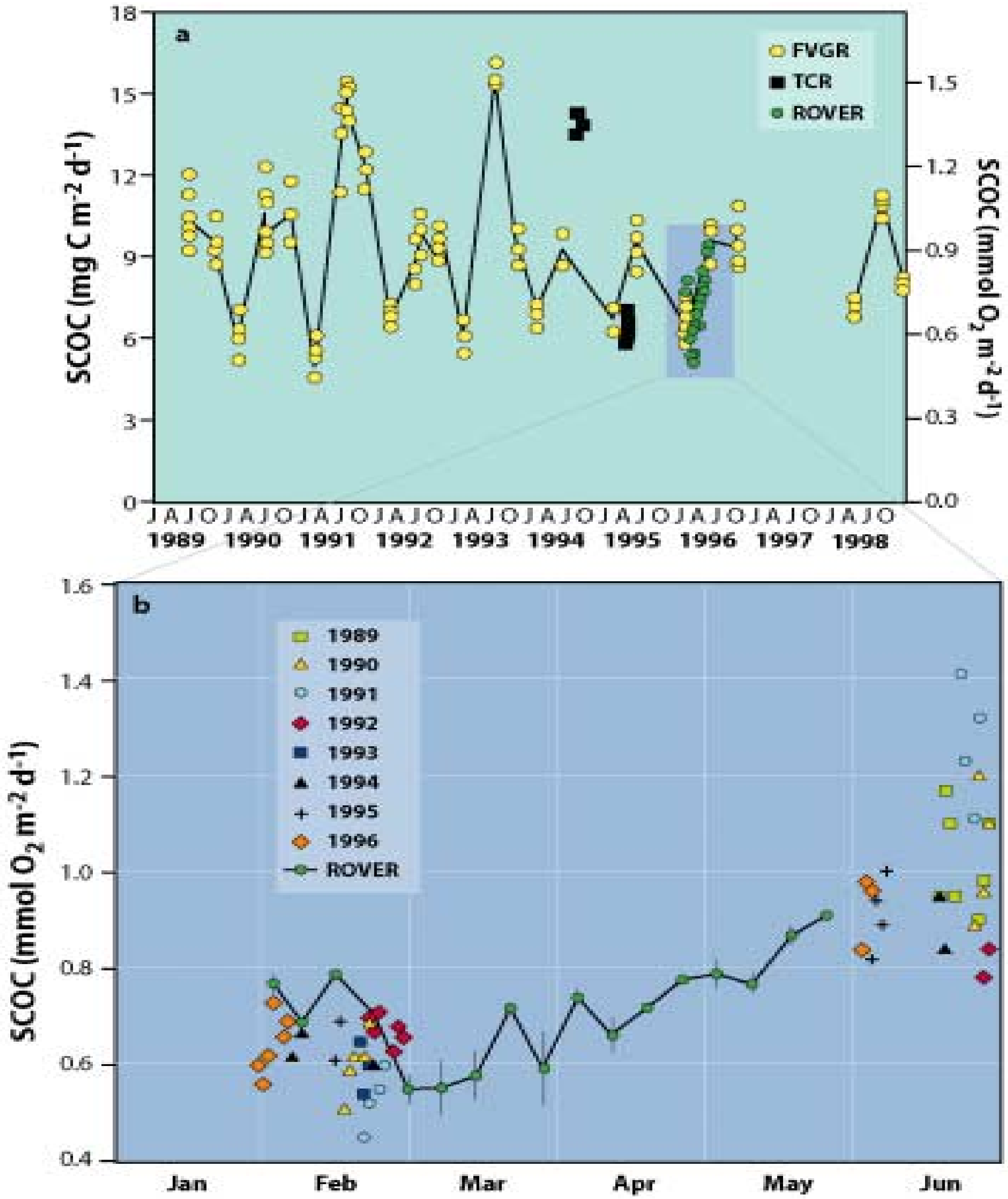

DISSOLVED
PARTICULATE
Filter
Resuspension
Lateral
Deposition
DIFFUSION
Shear-Driven
Flow
Deposit
Feeding
Mixing
IRRIGATION
Transformations
Erosion
Burial
Dissolution
Remineralization
Adsorption
Mineral Formation
Biological Production

Benthic O_2 and Si Fluxes (Sayles) & POC and PSi Fluxes (Deuser)







Smith Time-series

Northeastern

Pacific

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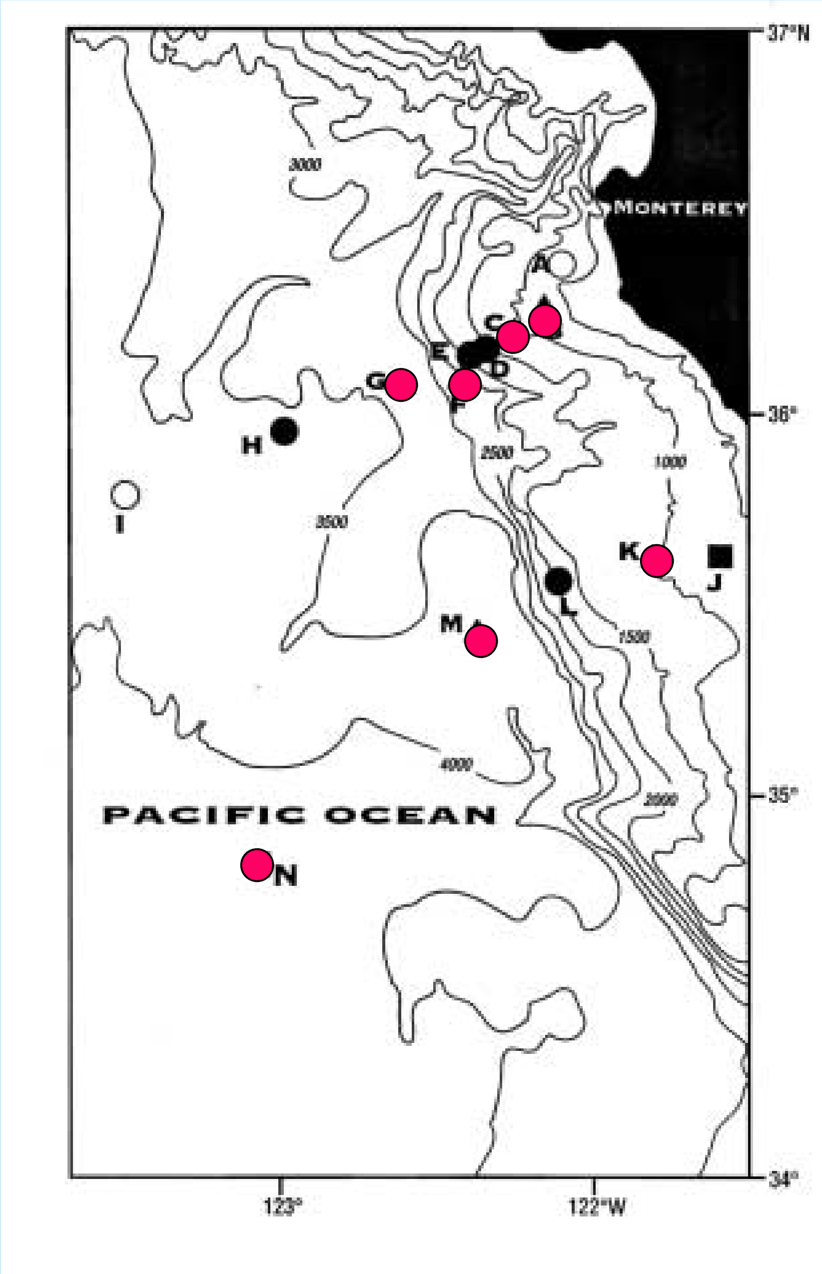

Flux Comparison

Average Microelectrode Flux

45±22 μmol O_2 cm^{-2} yr^{-1}

Average Chamber Flux

44±11 μmol O_2 cm^{-2} yr^{-1}

Reimers et al.1992

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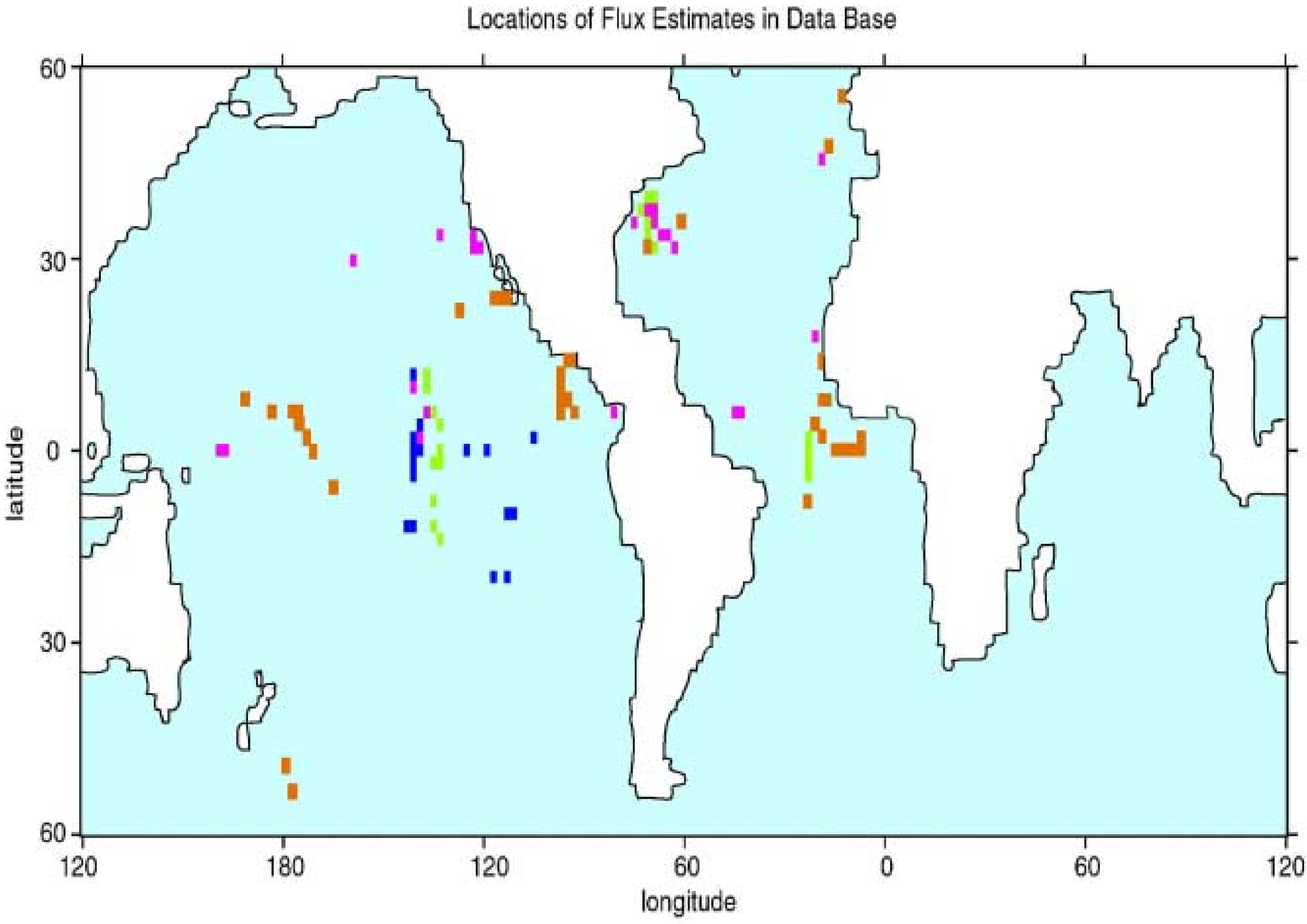
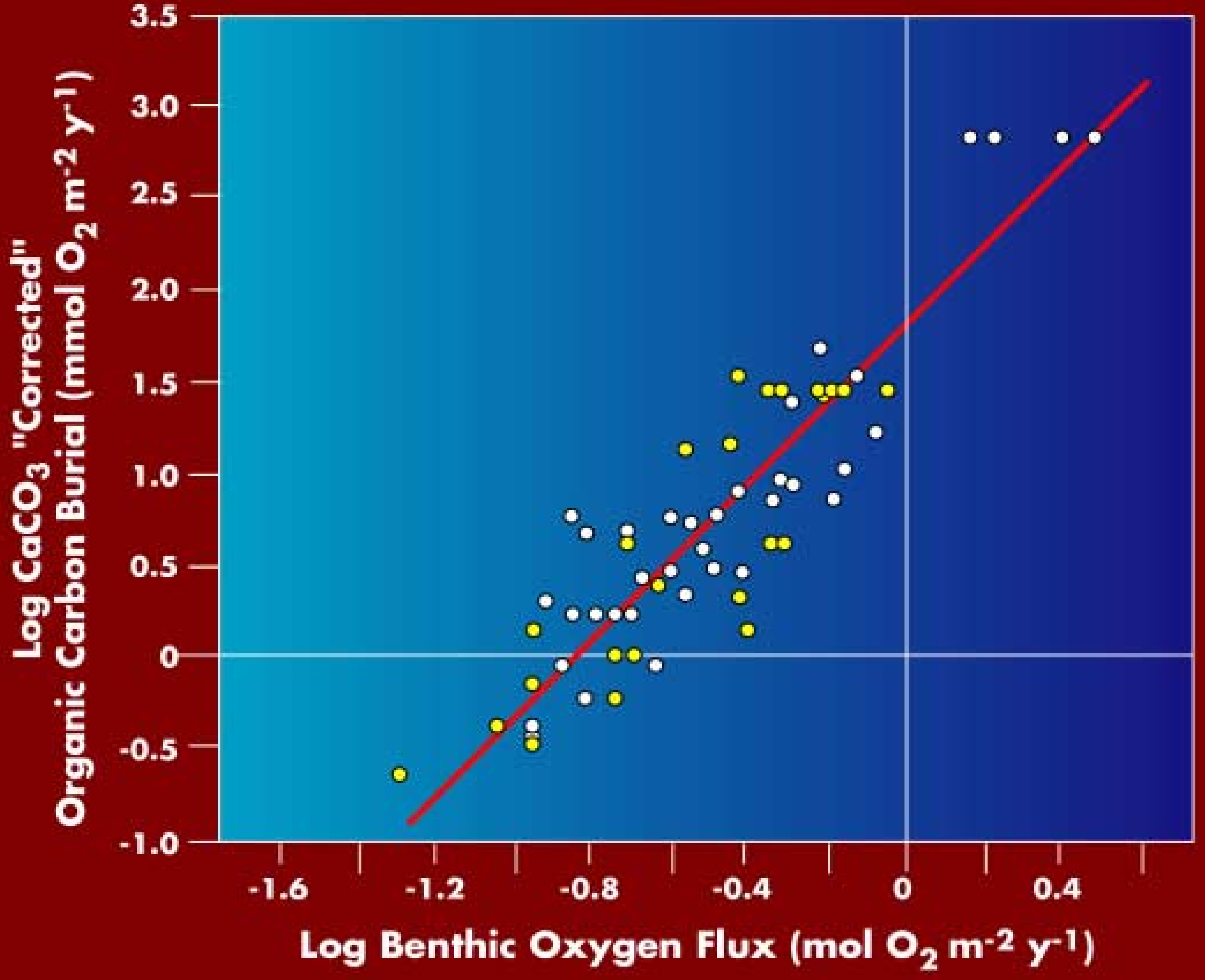
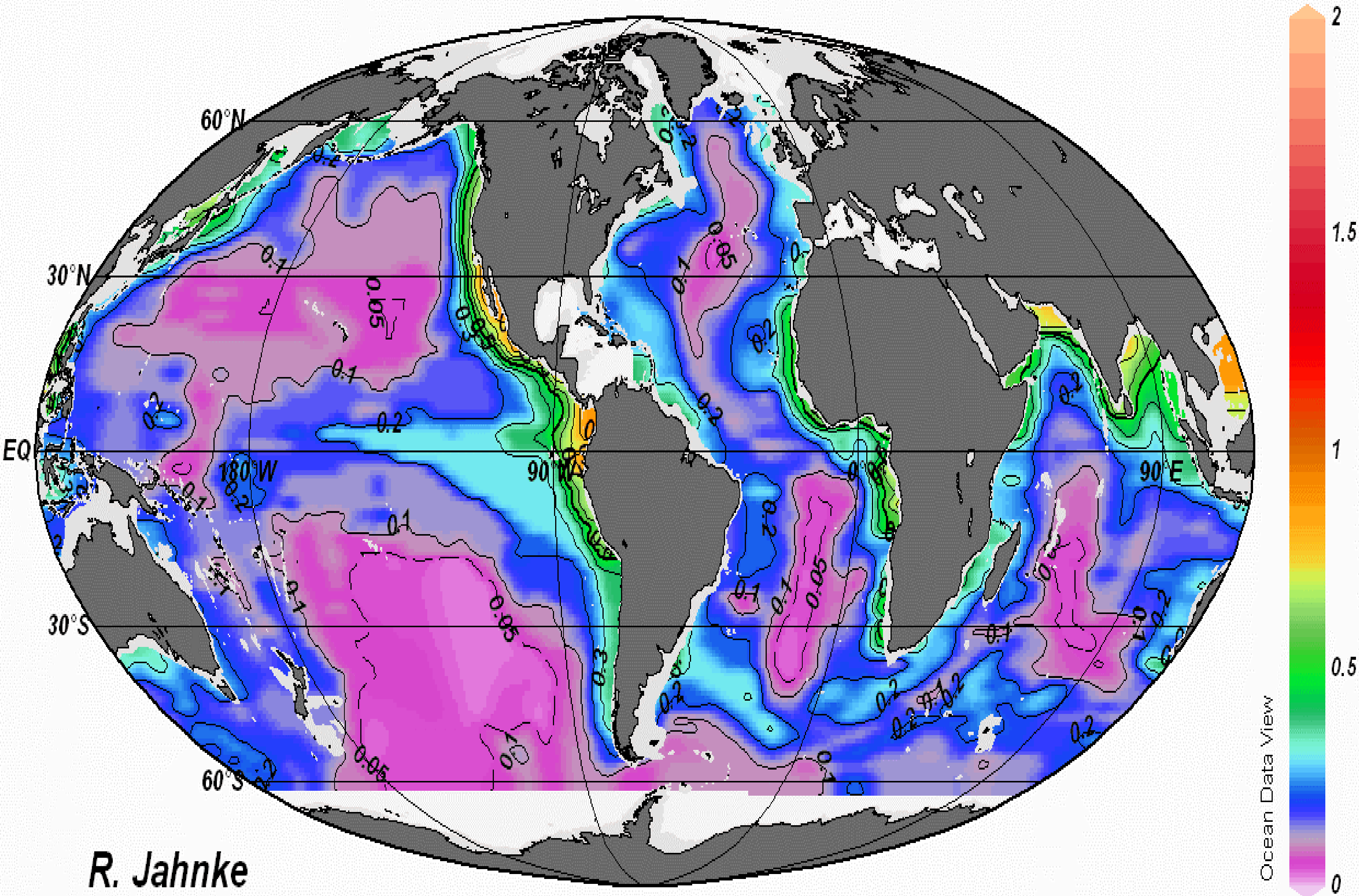
- Links modern processes to the sediment record
- Provides an alternative perspective on deep fluxes



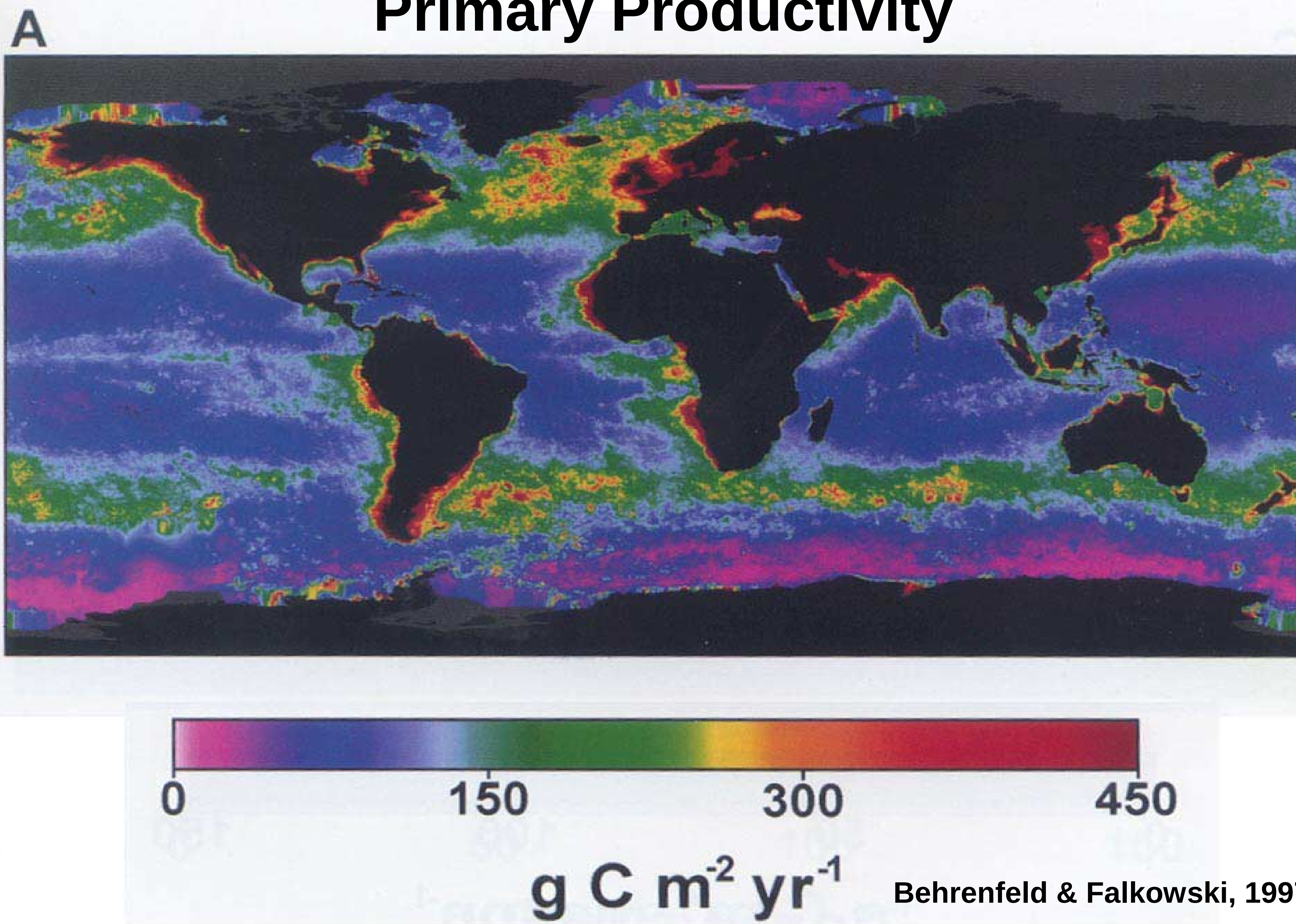
Locations of Flux Estimates in Data Base
60
30
0
30
60
latitude
120
180
120
60
0
60
120
longitude


3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-0.5
-1.0
Log CaCO3 "Corrected"
Organic Carbon Burial (mmol O2 m-2 y-1)
-1.6
-1.2
-0.8
-0.4
0
0.4
Log Benthic Oxygen Flux (mol O2 m-2 y-1)

benthic O_2 Flux [mol O_2 m^{-2} yr^{-1}]



Primary Productivity

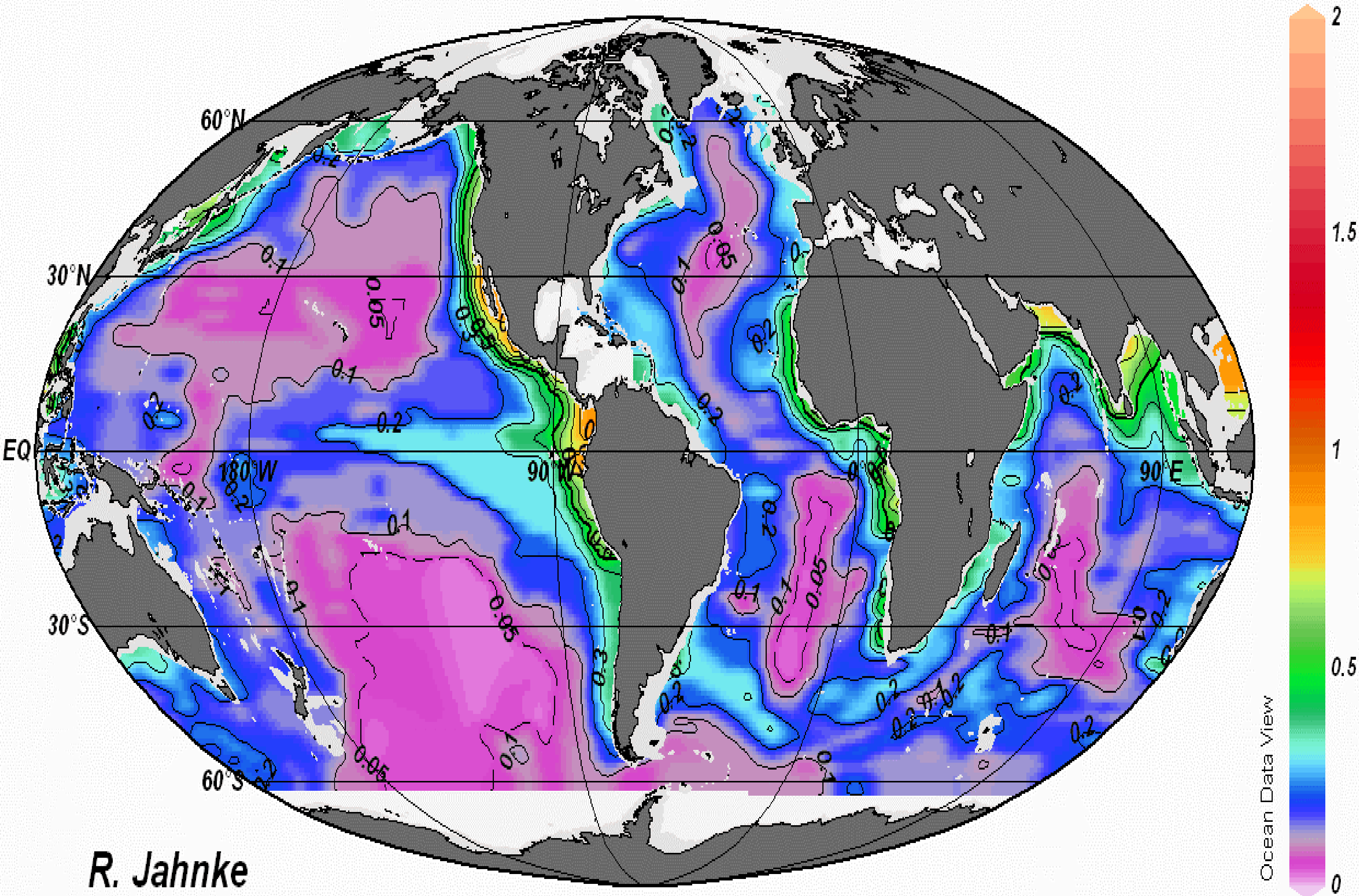


Behrenfeld & Falkowski, 1997

Sea Floor Flux Summaries (10^{12} mol O_2 yr^{-1})

	Slope	Rise	Equator	Gyre	Total
Atlantic	3.4 (23)	3.5 (24)	0.53 (3)	7.4 (50)	14.8
Pacific	4.8 (20)	4.2 (17)	3.1 (13)	12 (50)	24.1
Indian	4.3 (28)	3.9 (25)	0.9 (6)	6.3 (41)	15.4
Ocean	12.5 (23)	11.6 (21)	4.5 (8)	25.7 (47)	54.3

benthic O_2 Flux [mol O_2 m^{-2} yr^{-1}]



R. Jahnke

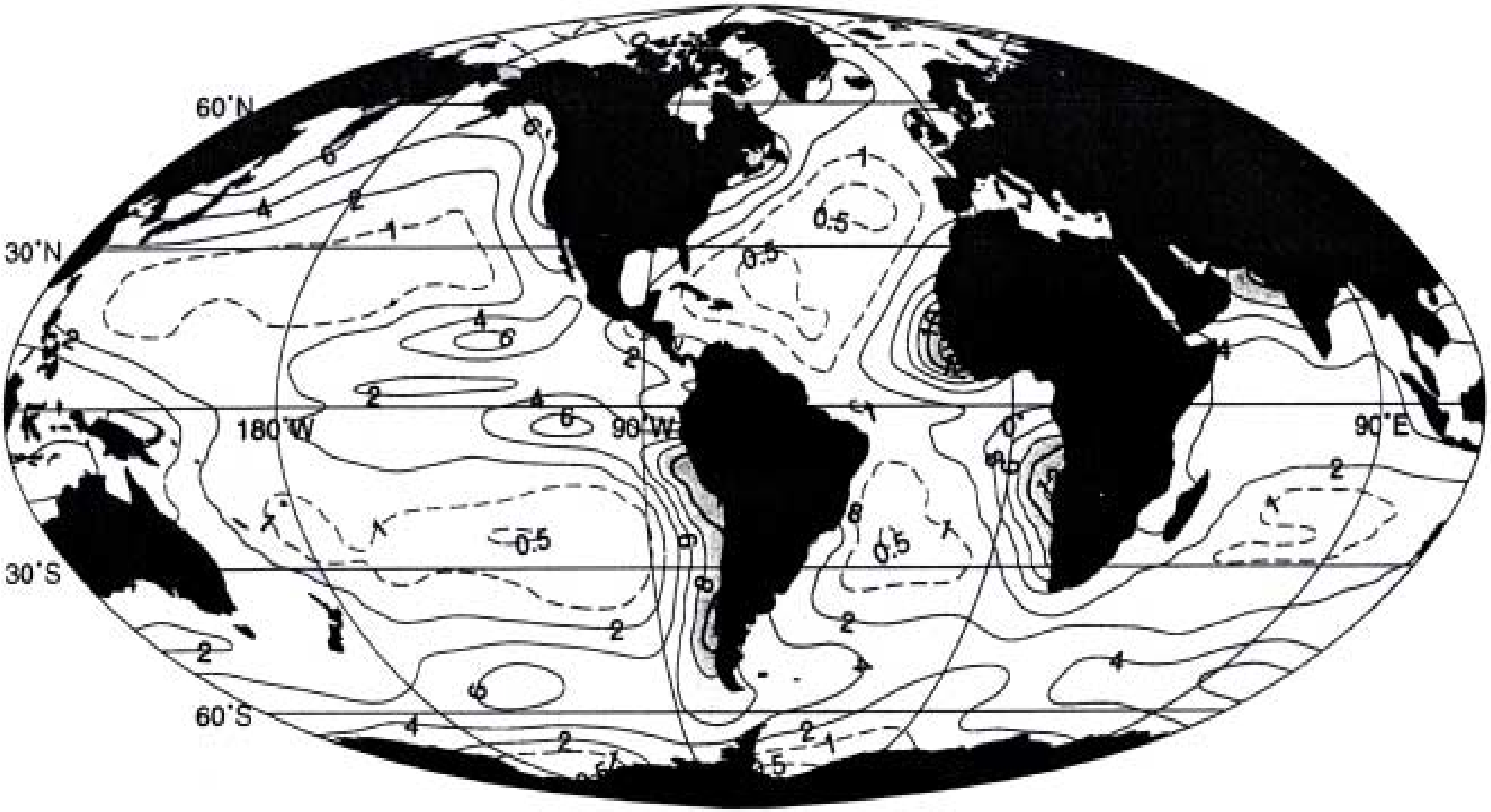
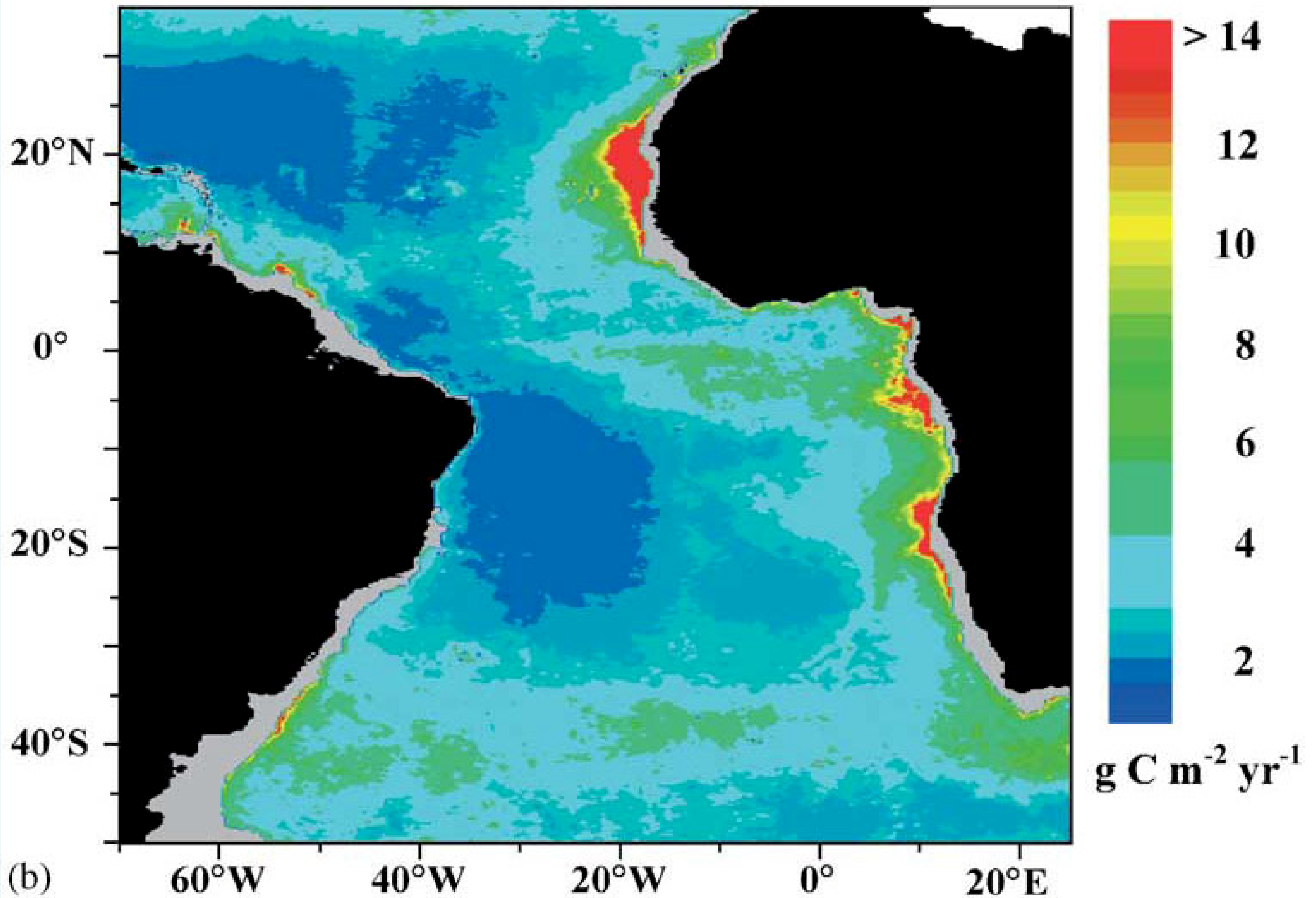


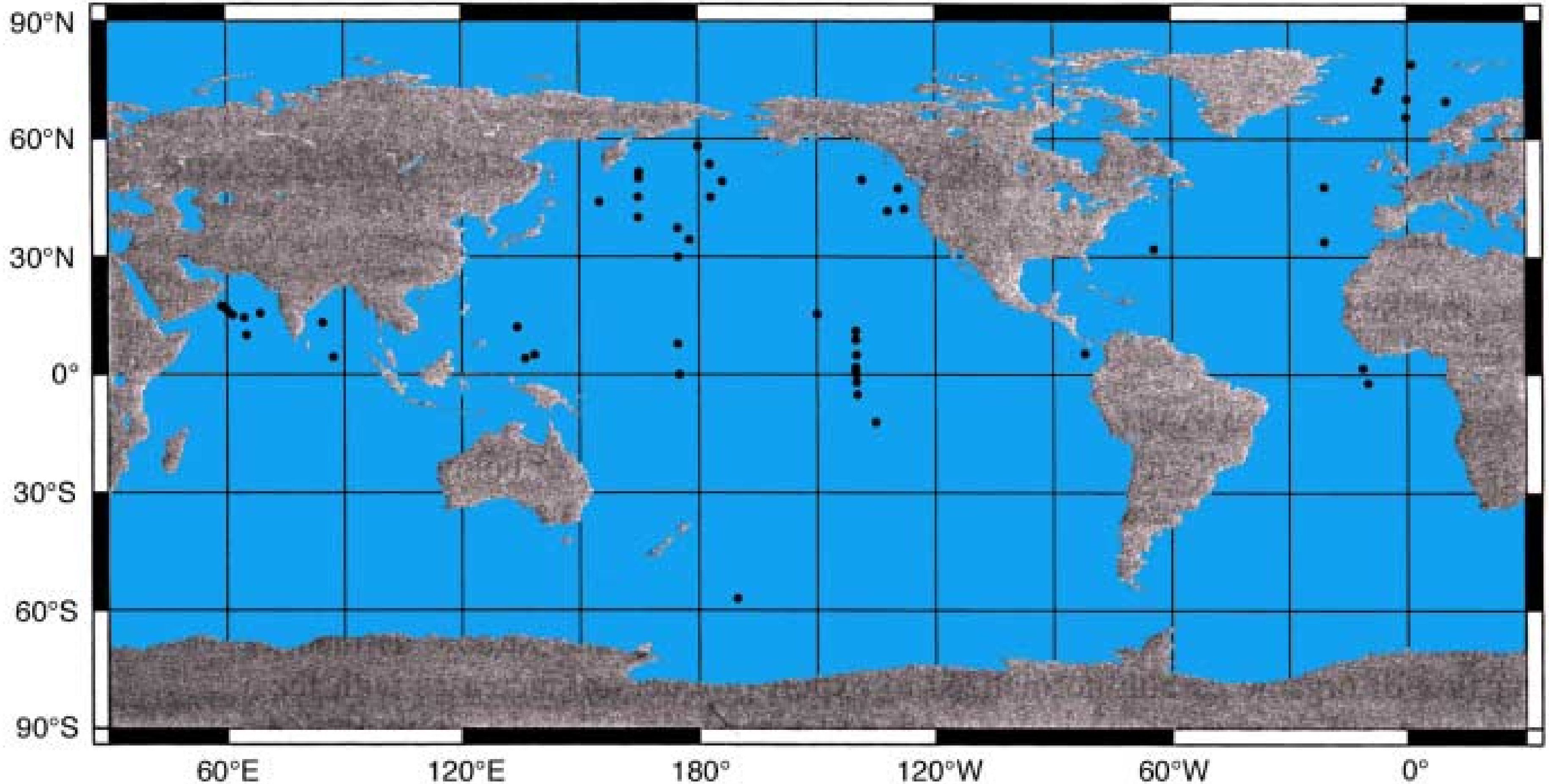
Figure 9. Export production of particulate organic matter (POM) [mol C m^{-2} yr^{-1}] for the global model.

R. Schlitzer

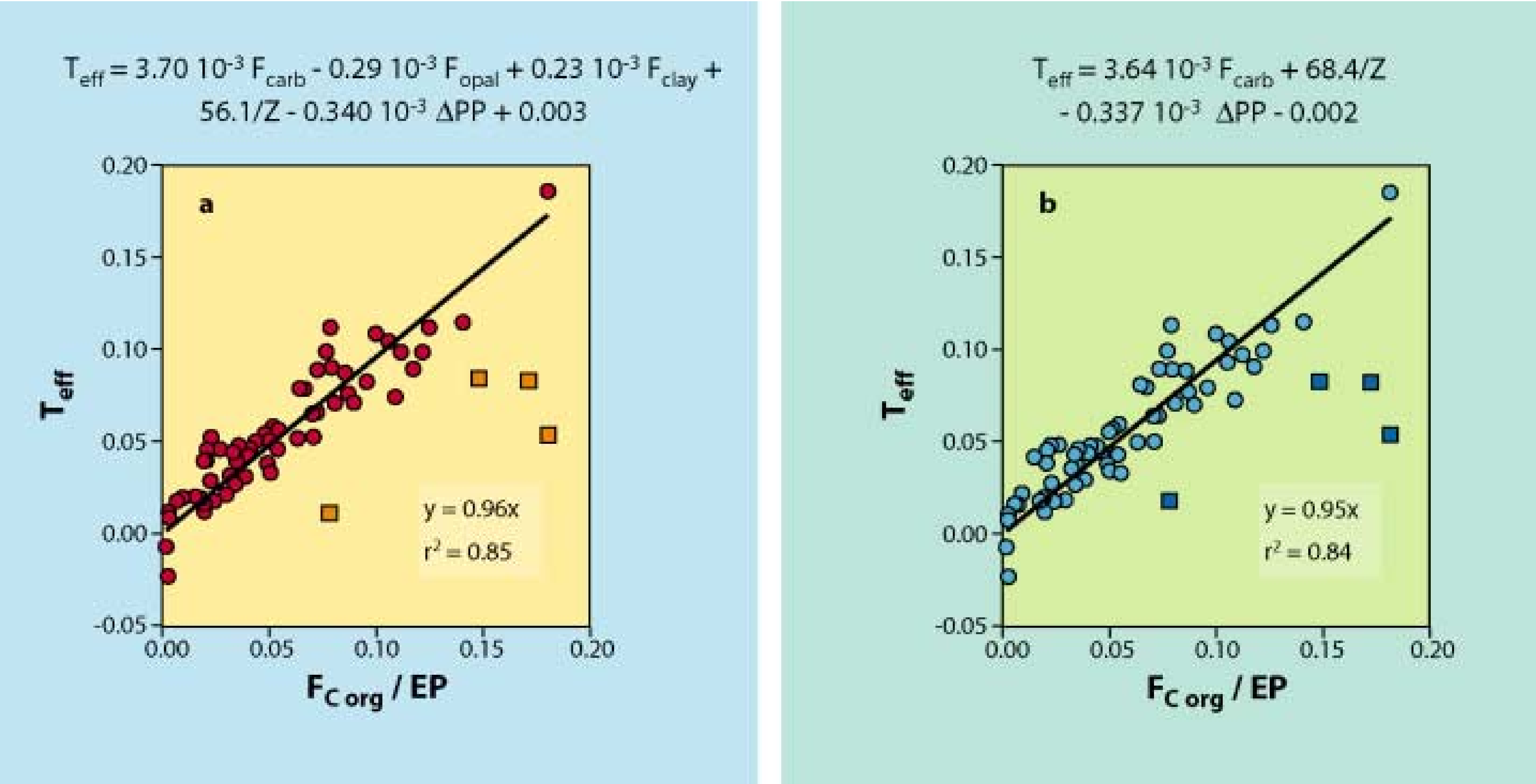
Wenzhofer & Glud (2002) Total Benthic Oxygen Uptake



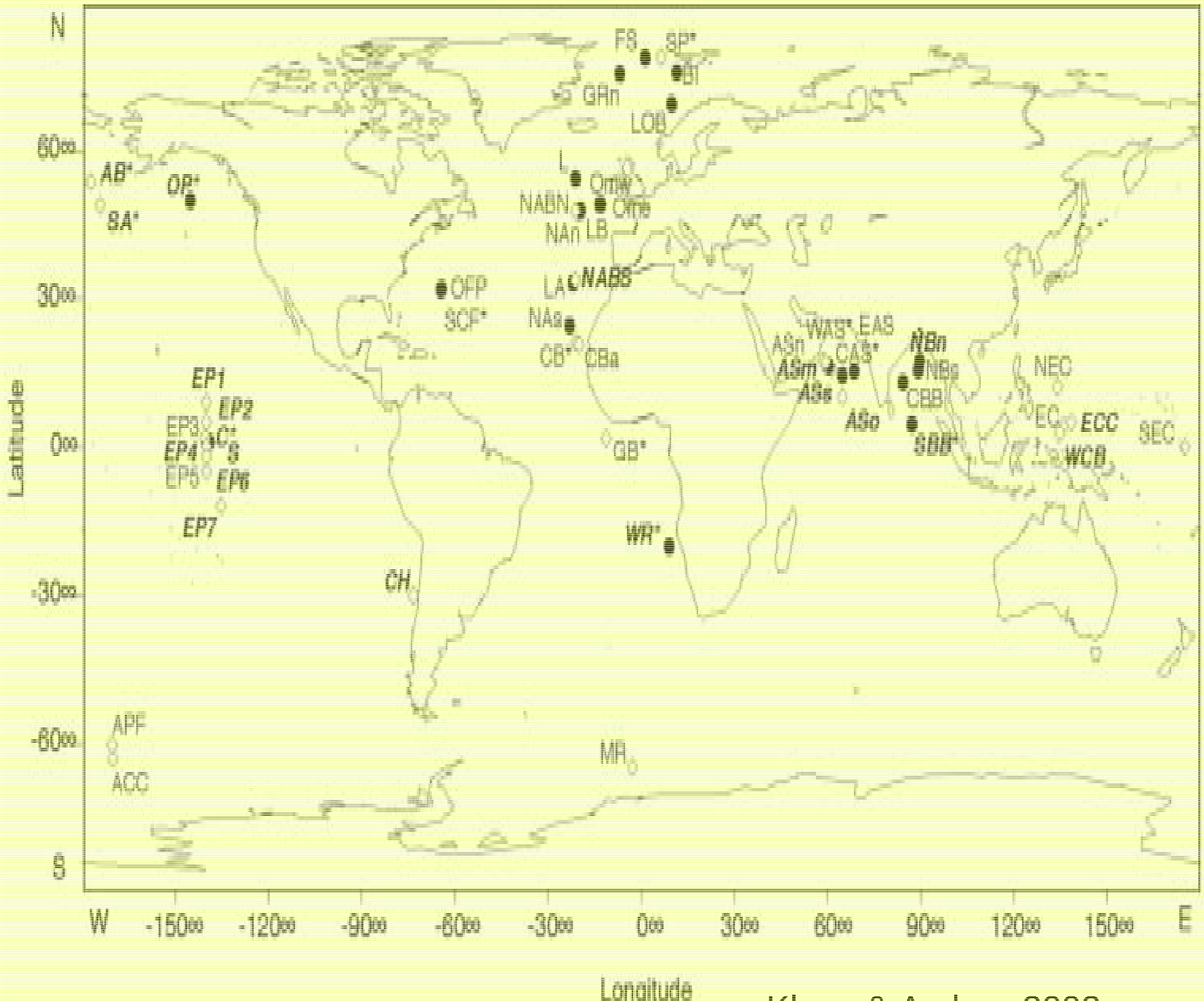
Francois et al. 2002 - Sediment Trap Locations



Trap POC Flux - Ballast Flux Correlations



Francois et al. 2002



Klaas & Archer, 2002

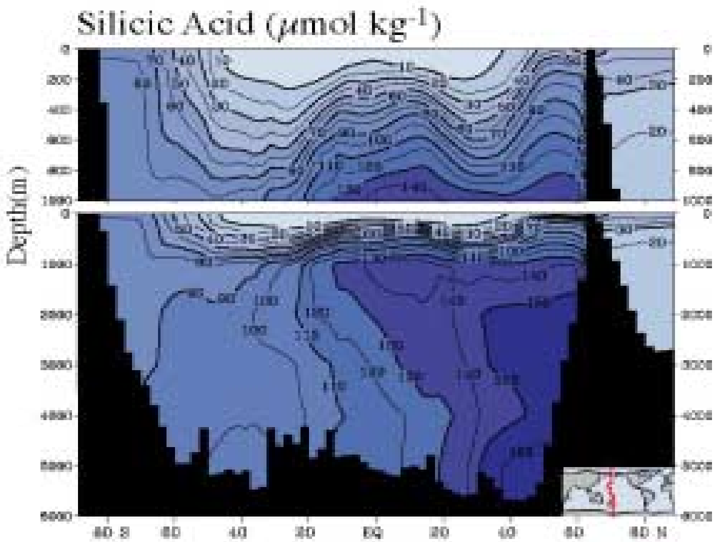
Benthic Fluxes Predicted from Sediment Trap Regressions and Benthic POC Flux Estimate

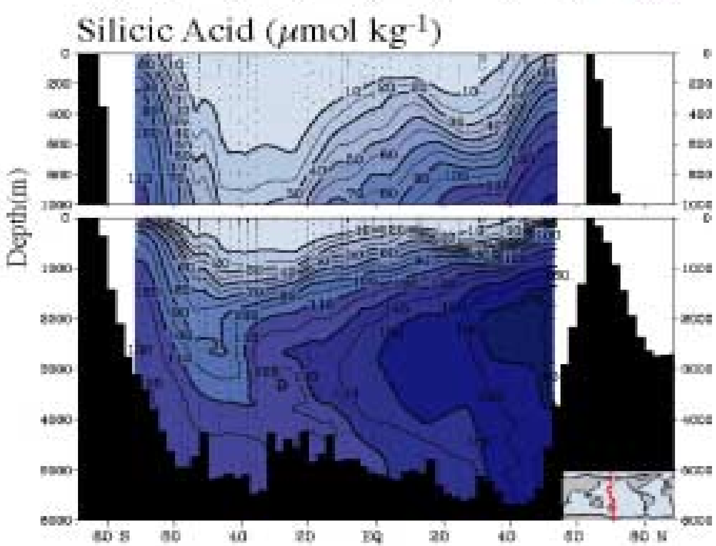
Carrying Phase	POC Flux (10^{12} g/yr)	% of Total
$CaCO_3$	521 - 617	80 - 83
SiO_2	84 - 95	11 - 15
Clay	39 - 41	5 - 6

Klaas & Archer, 2002

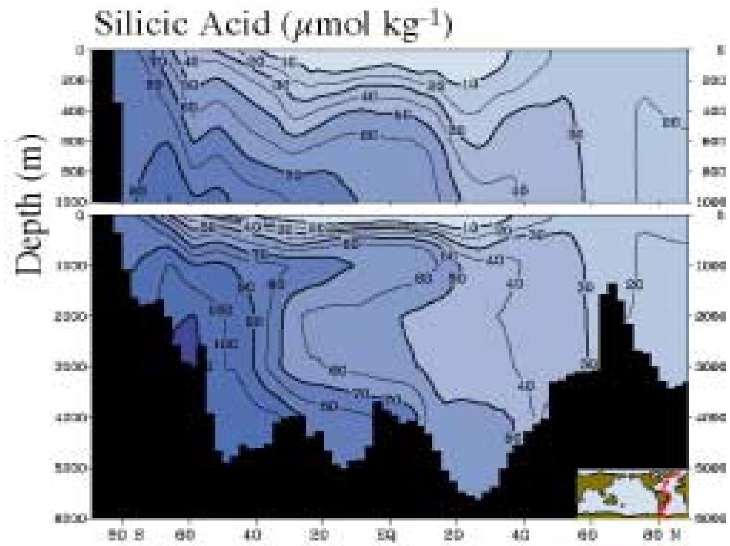
Heinze, et al. In press (GBC) HAMOCC model & Biogeochemical Si Cycle

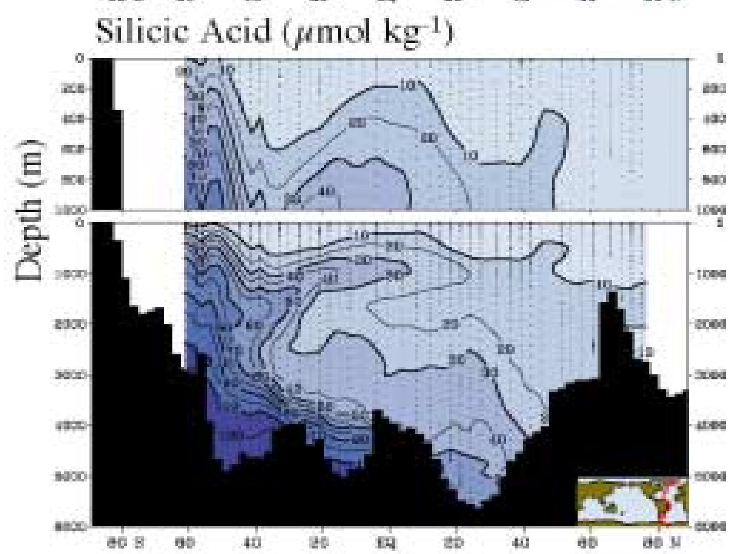
Pacific N-S Section



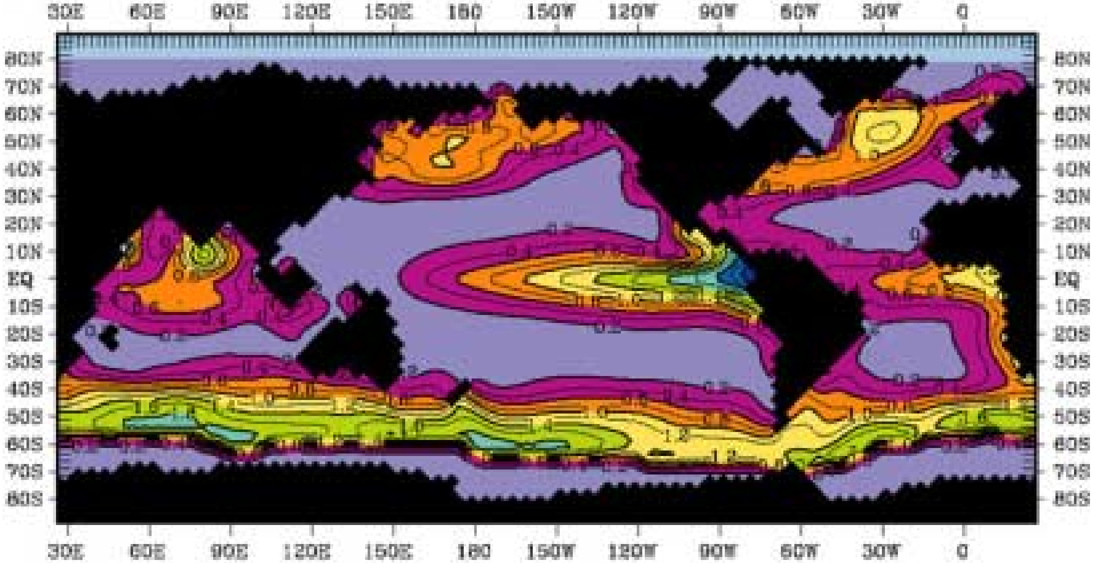


Atlantic N-S Section

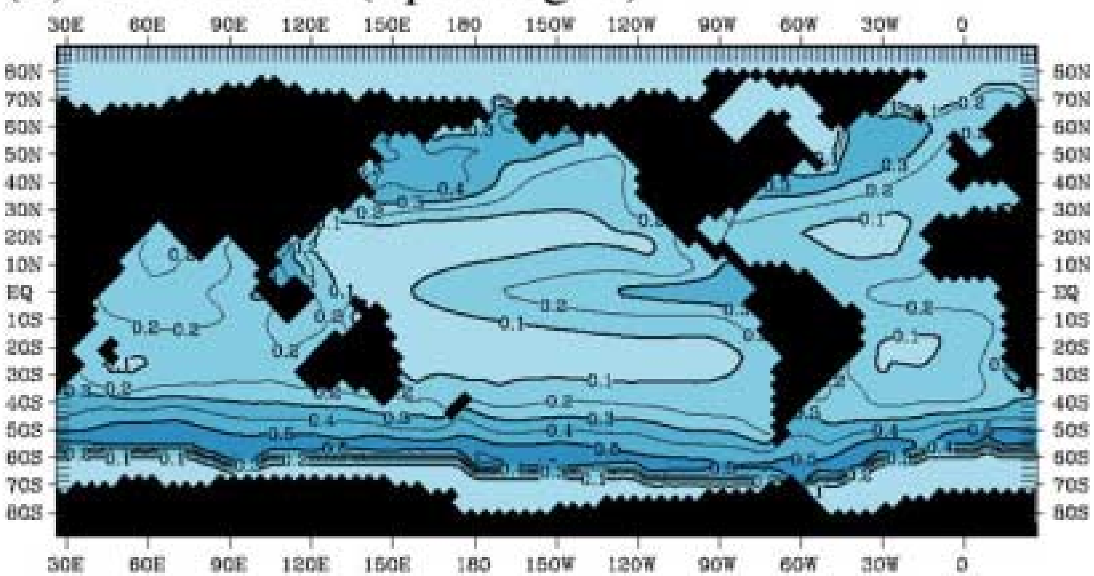




(a) Opal Export Production (mol m^{-2} y^{-1})

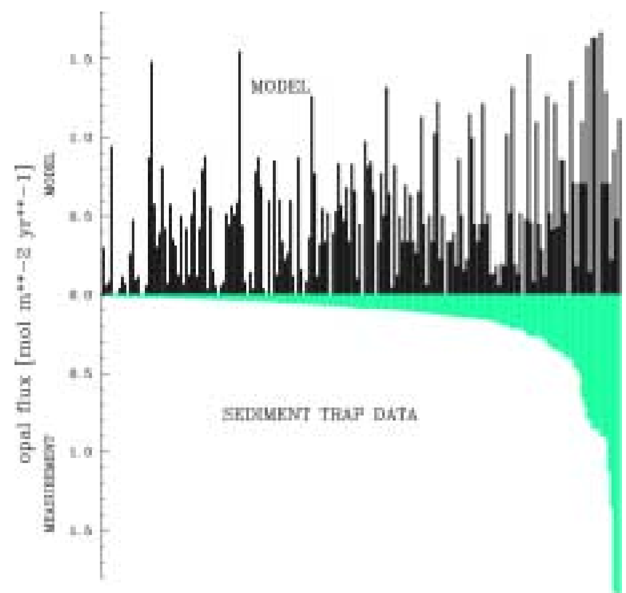


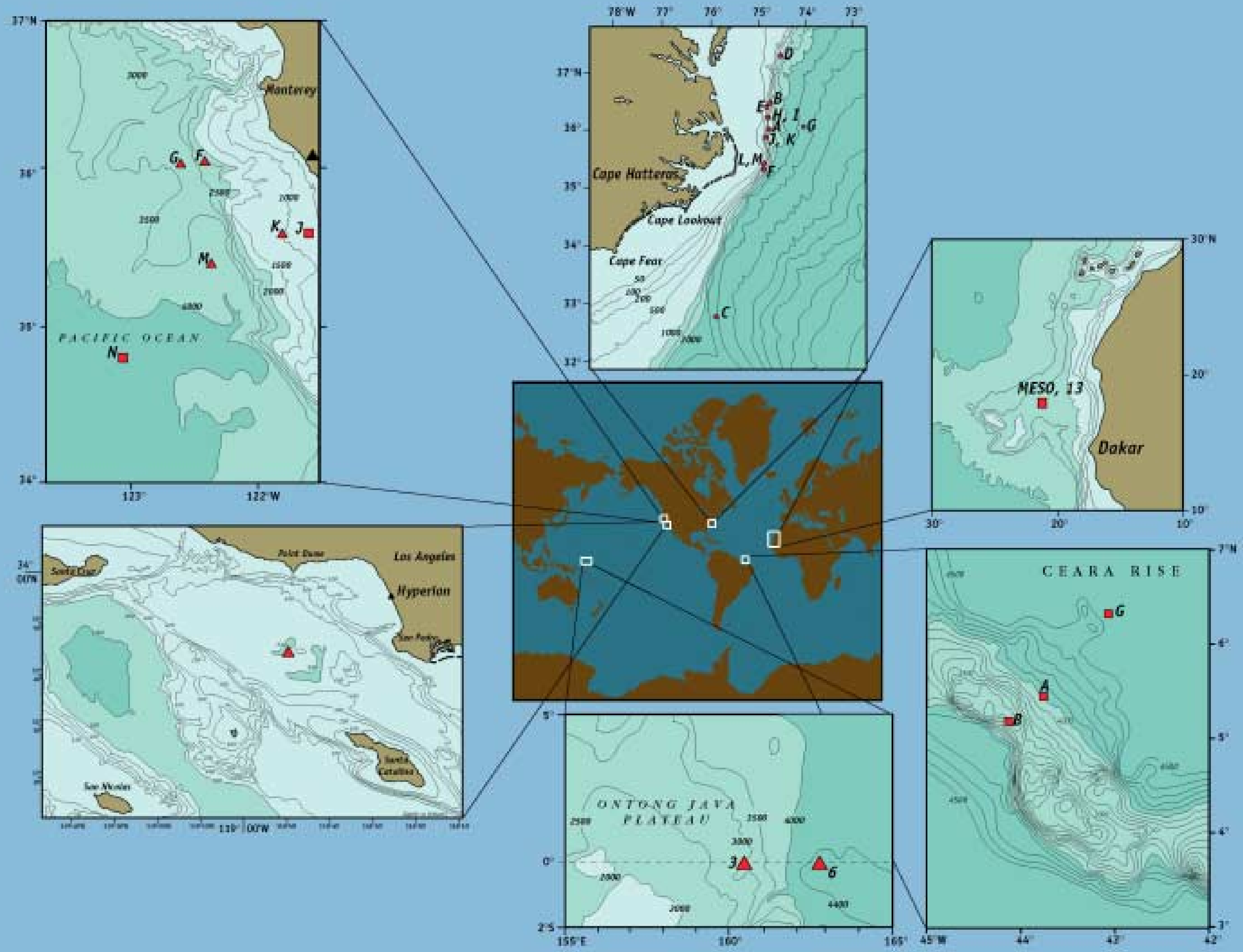
(b) Rain Ratio (opal/org C)



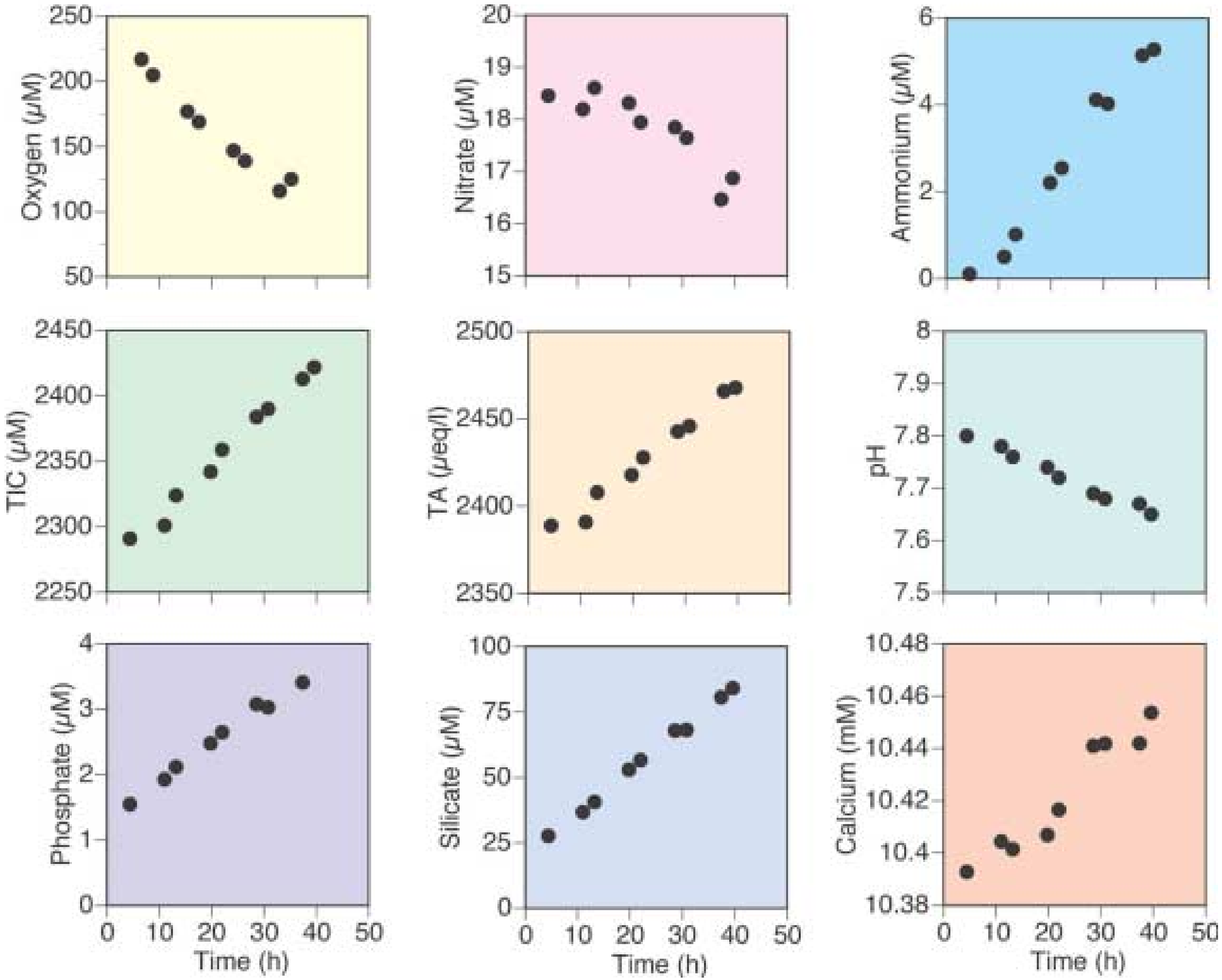
Heinze, et al. In press (GBC)

HAMOCC model & Biogeochemical Si Cycle

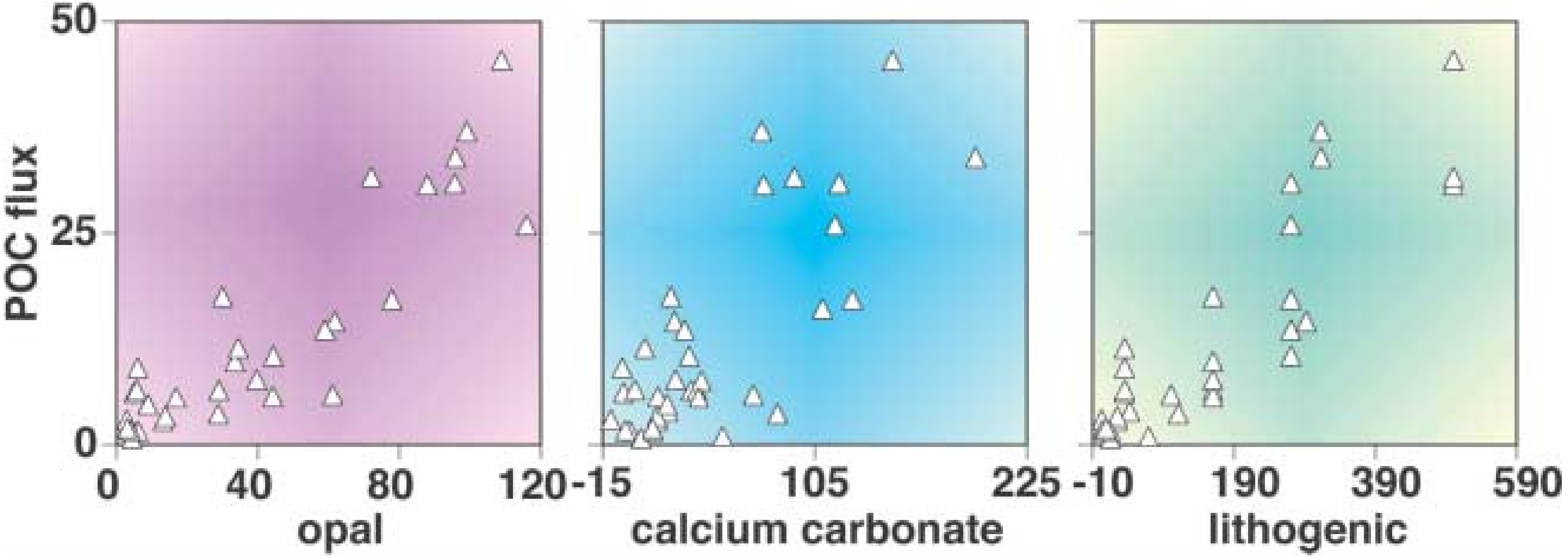



Monterey
PACIFIC OCEAN
Cape Hatteras
Cape Lookout
Cape Fear
MESO, 13
Dakar
CEARA RISE
Los Angeles
Point Dume
Hyperion
Santa Cruz
Santa Catalina
San Nicolas
ONTONG JAVA PLATEAU

Free Vehicle Chamber - North Carolina Slope

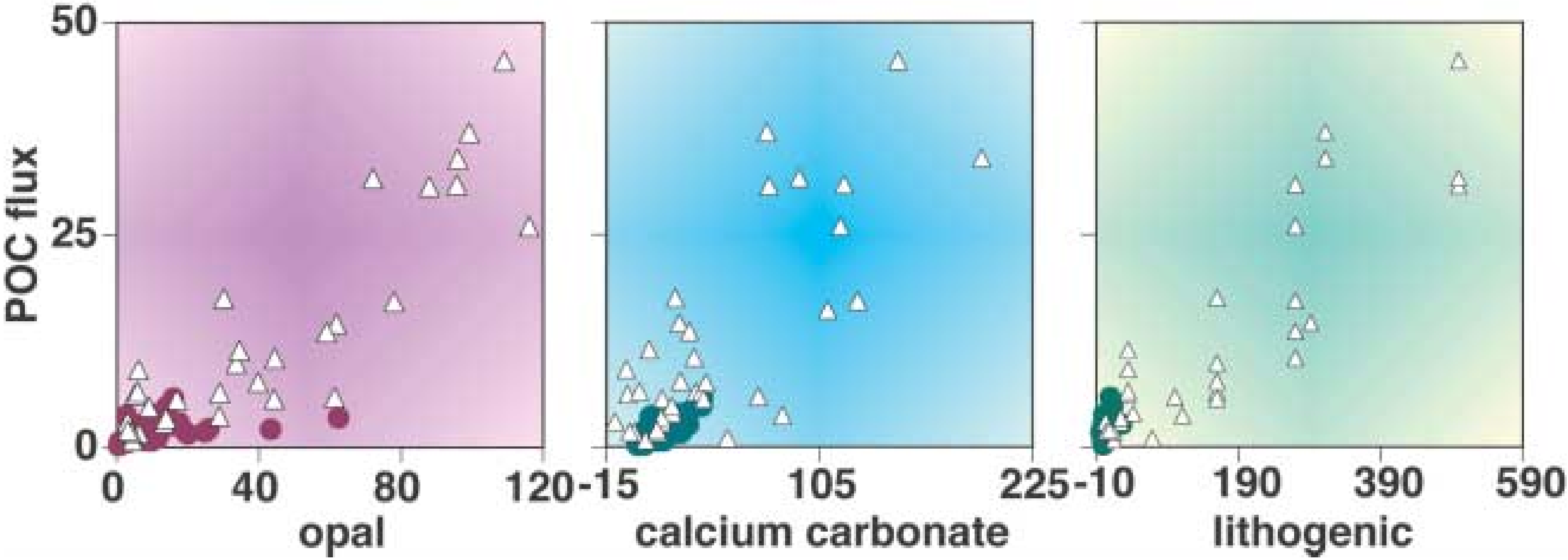


Benthic Flux Chamber Results



Values in g m^{-2} y^{-1}

Trap - Chamber Comparison



values in g m^{-2} y^{-1}

Conclusions

- Sea floor is the ultimate sediment trap
- Benthic flux distributions provide a unique perspective of global particulate fluxes
- Variations in benthic fluxes imply large differences in POC transfer efficiency to the deep ocean
- Fluxes of mineral components imply significant variations in the role of individual ballasting materials.
- Future flux studies may need to expand to additional ecosystem types to achieve global closure of the biological carbon pump.

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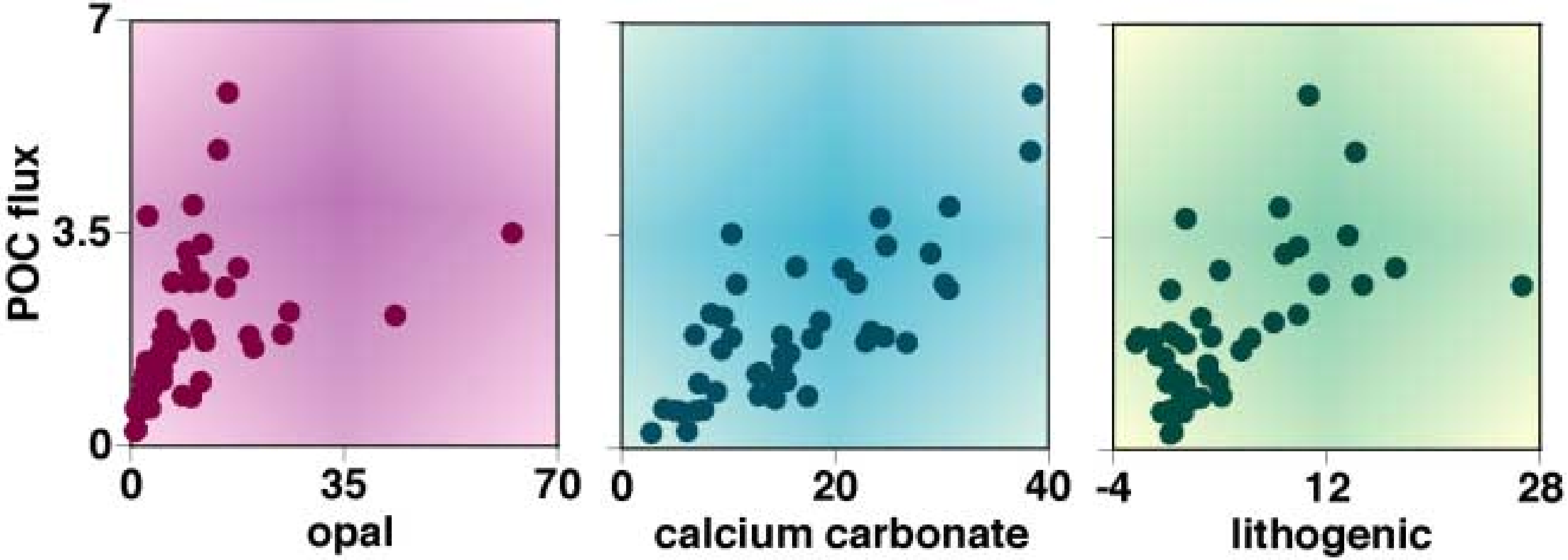
Klaas & Archer, 2002

Annual Sediment Trap Fluxes



All values in g m^{-2} d^{-1}