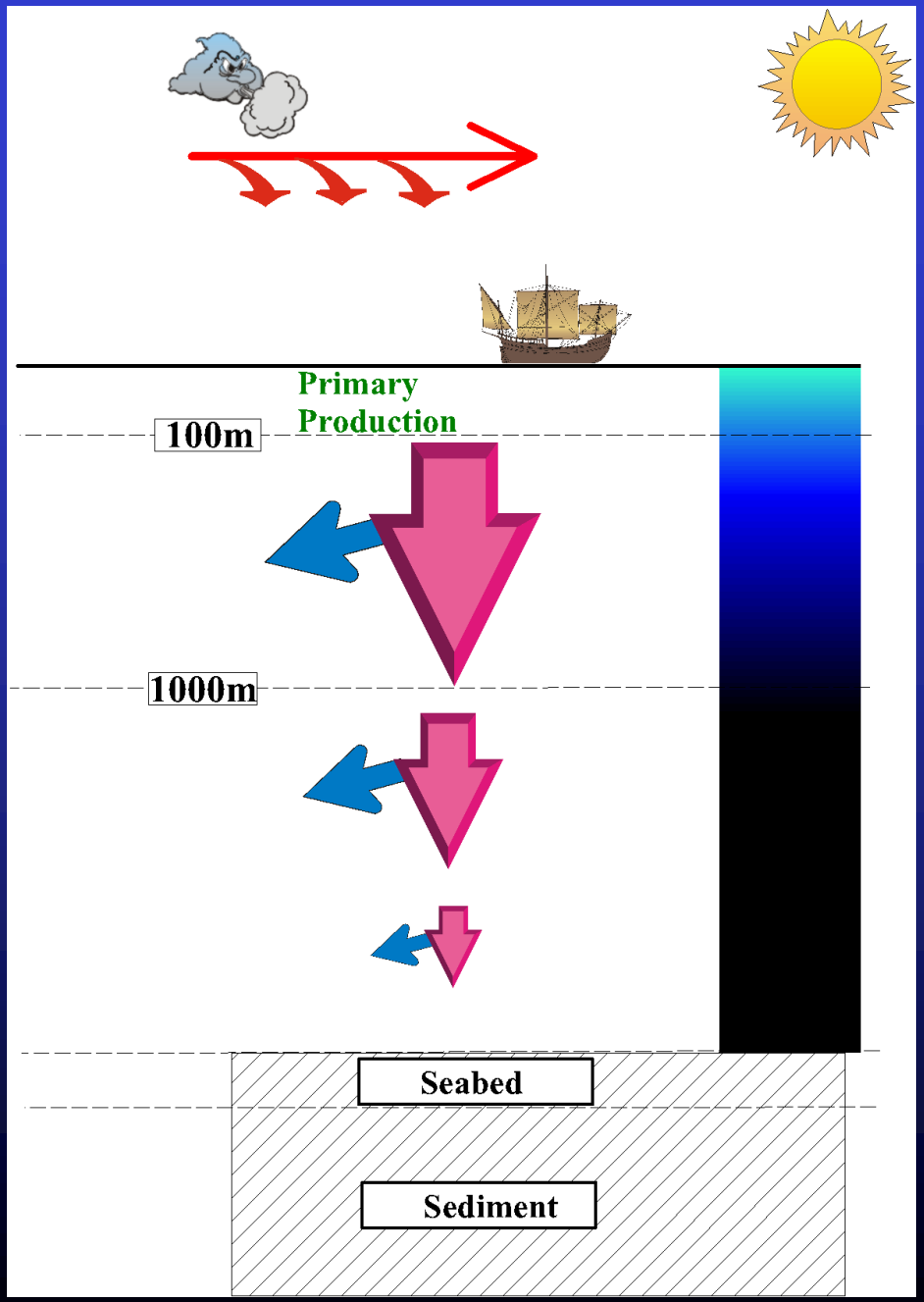
Climate change and the deep deep ocean: Links, effects and feedback.

Richard Lampitt

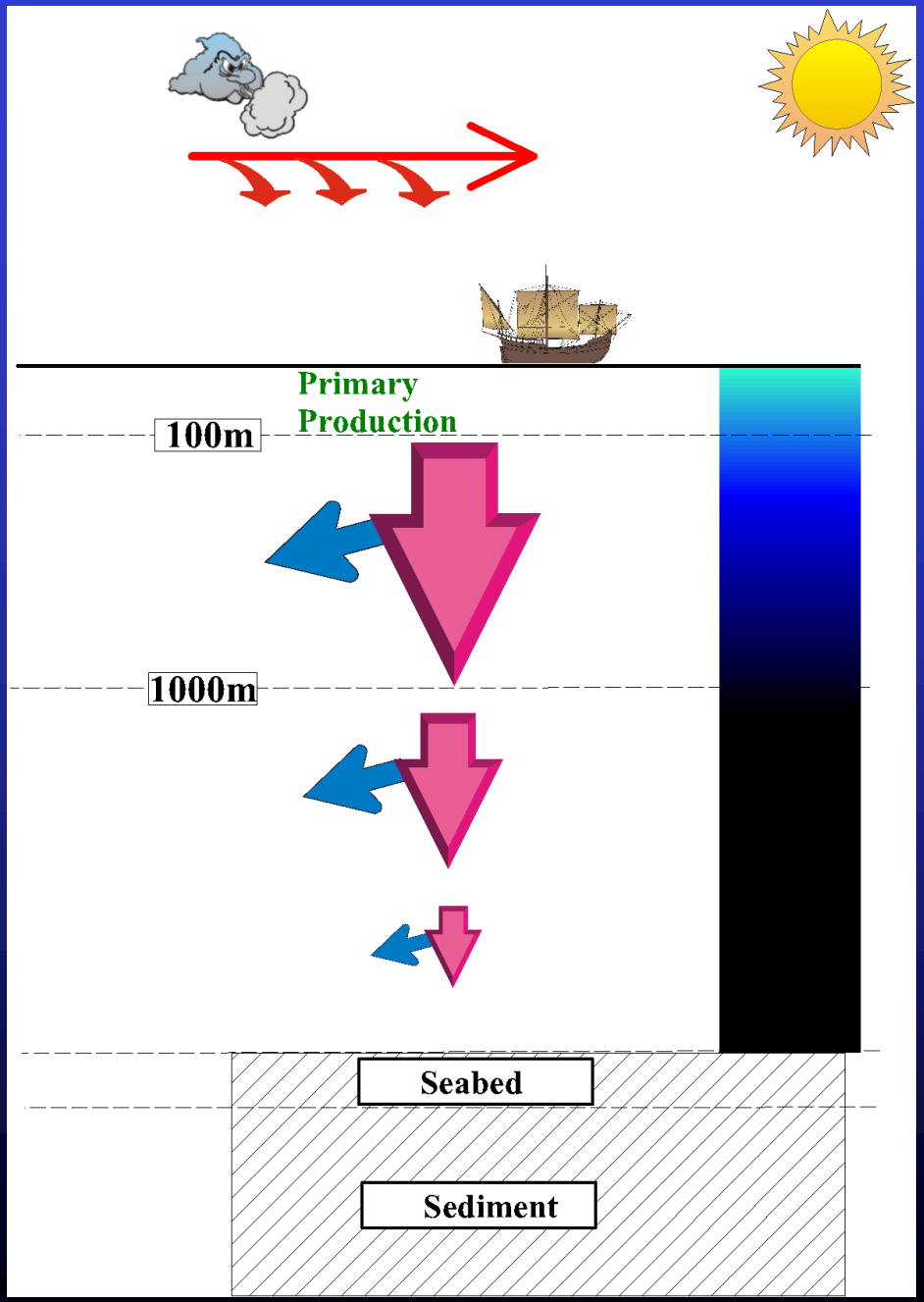
National Oceanography Centre

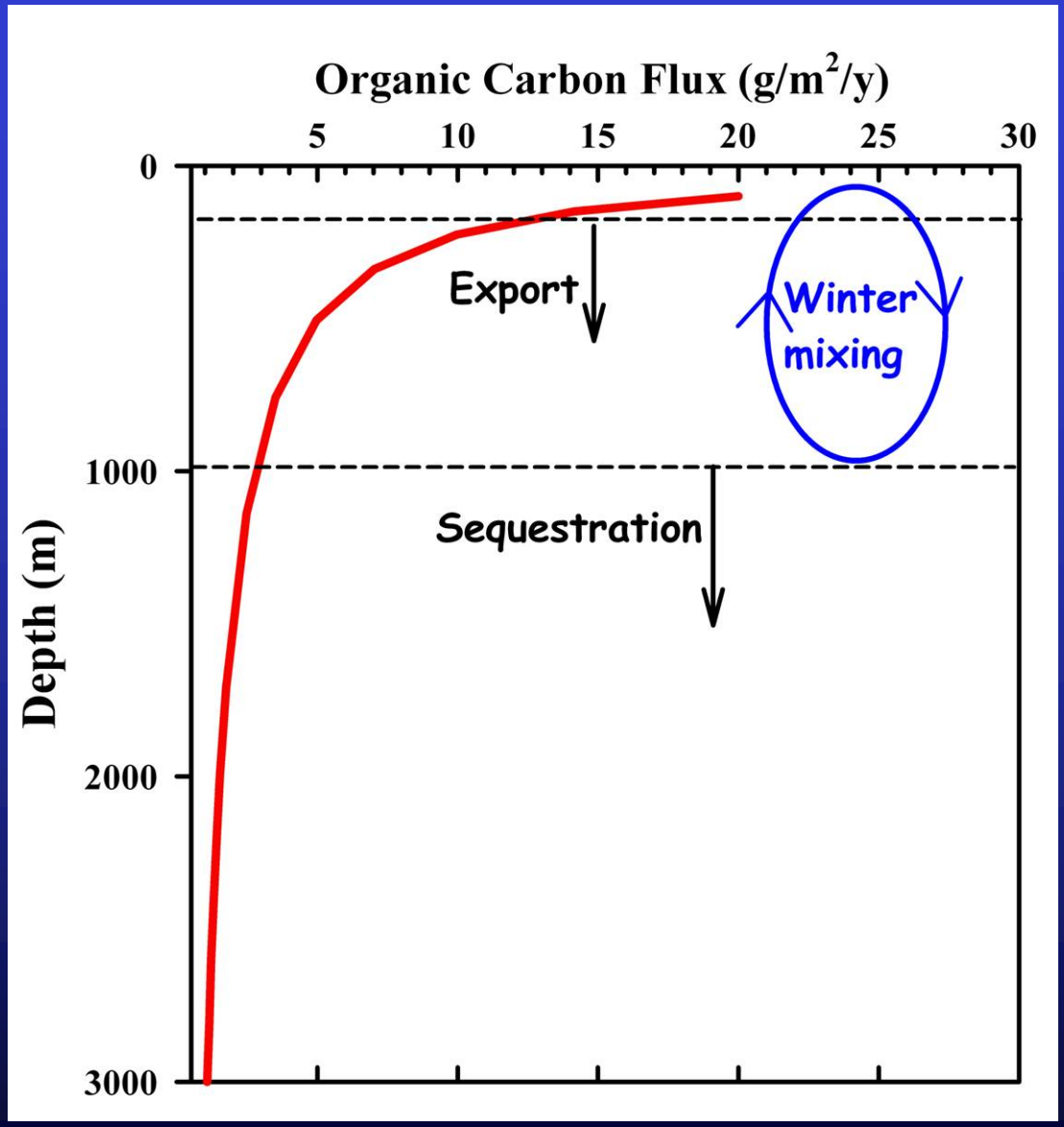
Southampton

UK


Primary
Production
100m
1000m
Seabed
Sediment

The Twilight Zone





Downward particulate flux as a function of depth

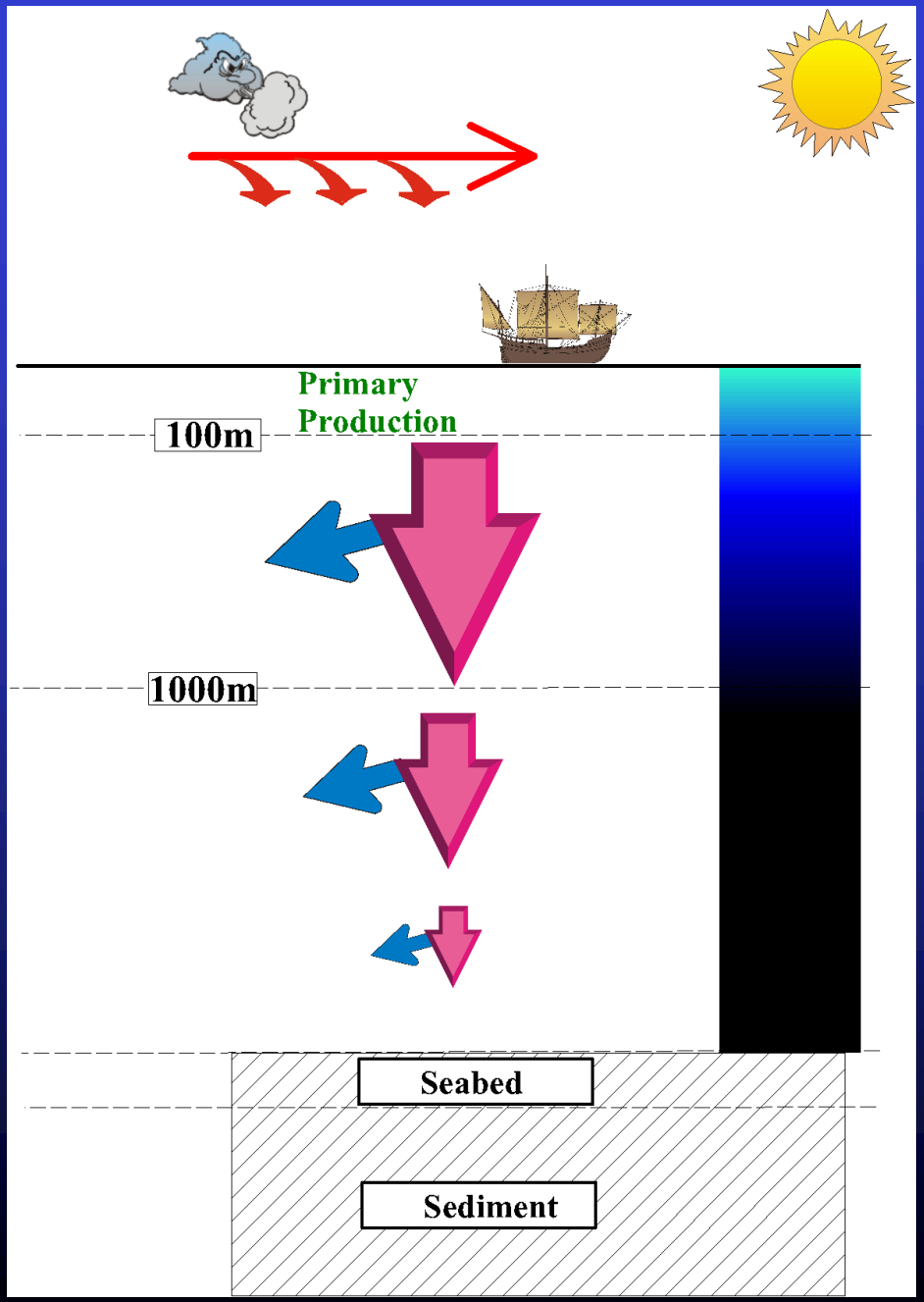
Epipelagic

Mesopelagic

Bathypelagic

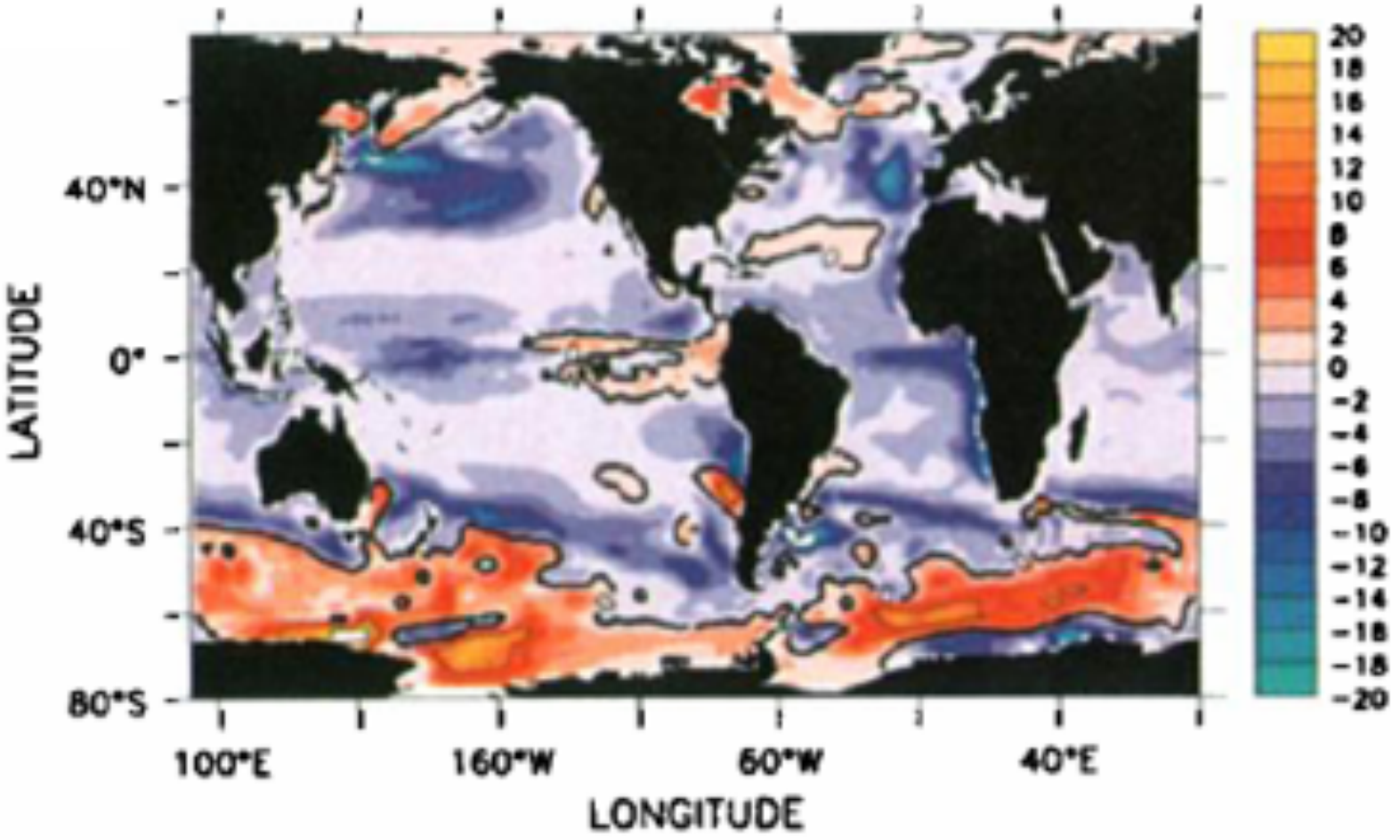
Benthopelagic

Benthos



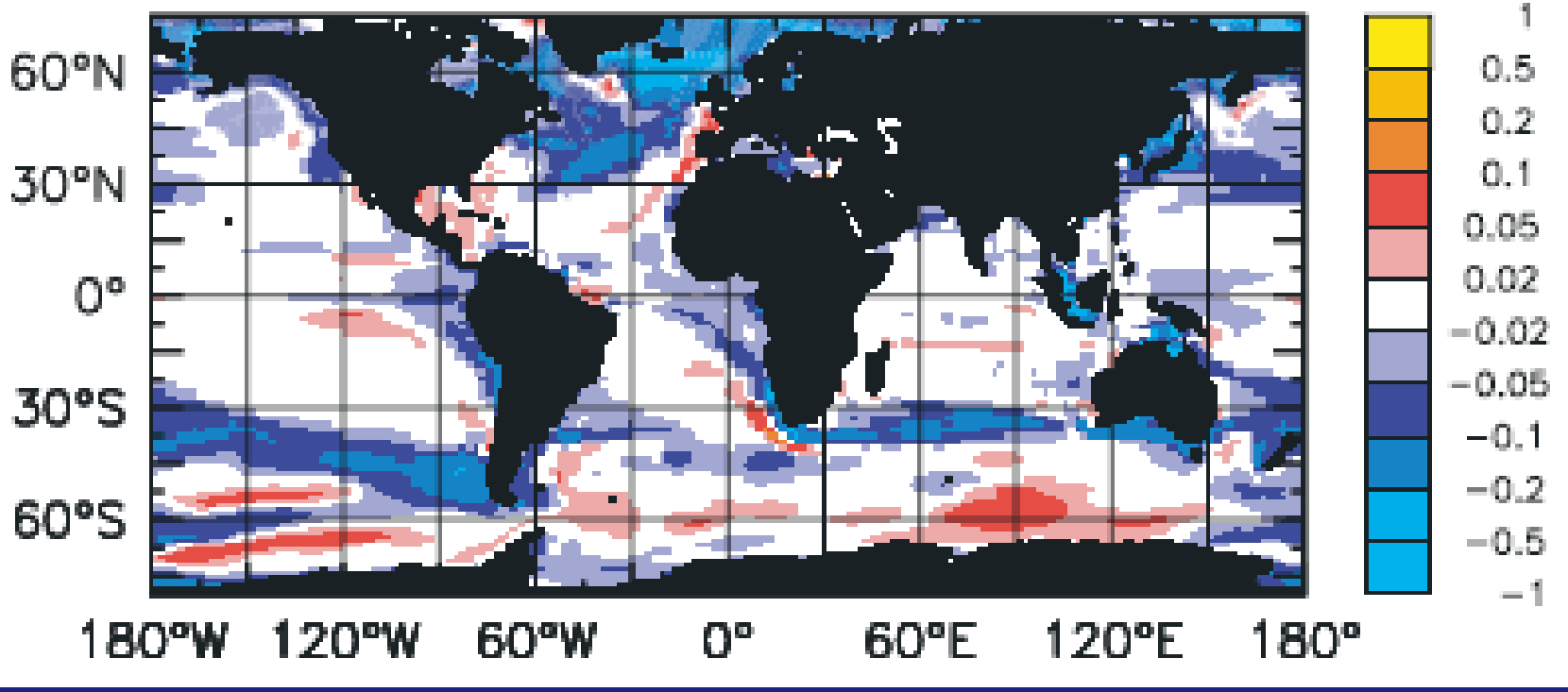
Surface ocean changes likely to affect the deep ocean:

1. Enhanced stratification
2. Increased SST
3. Decreased thermohaline circulation
4. Decreased pH
5. Decreased dust supply



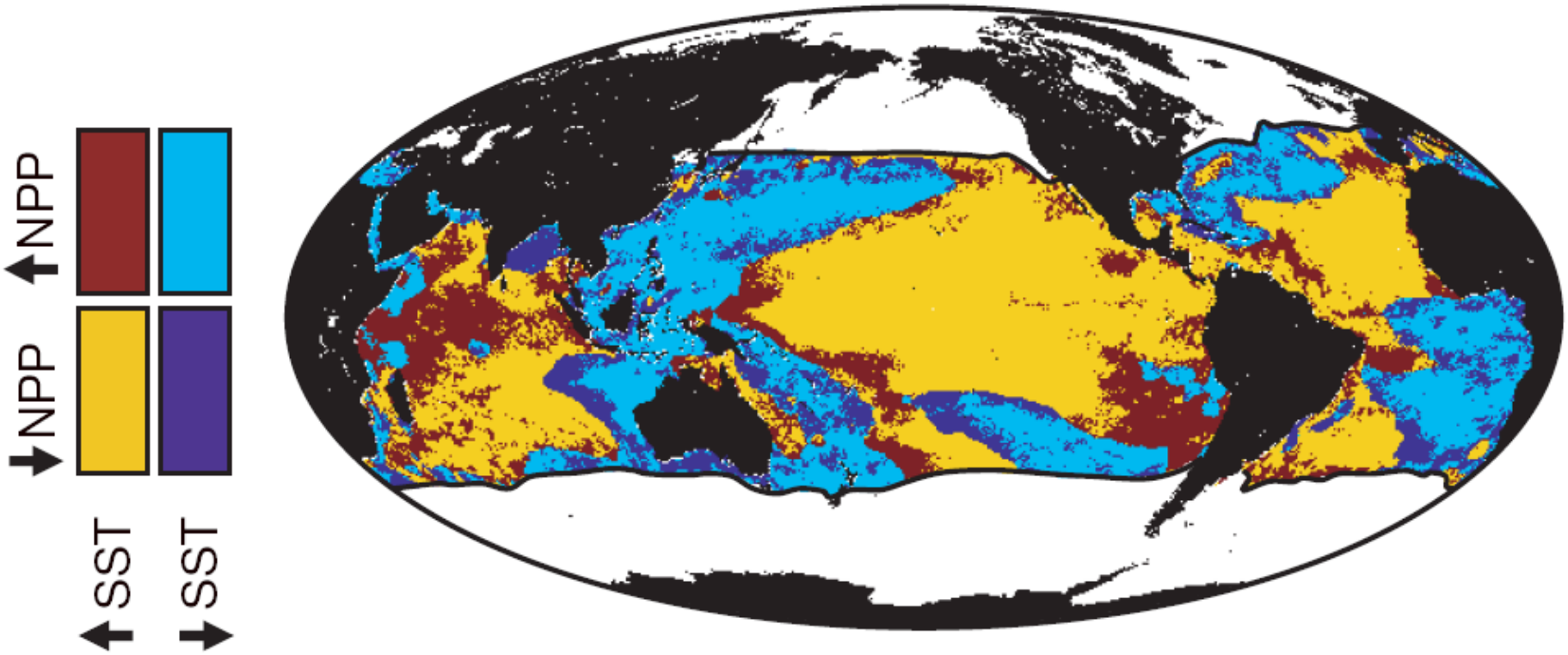
Change in export flux (100m) at twice current PCO_2

Bopp et al 2001

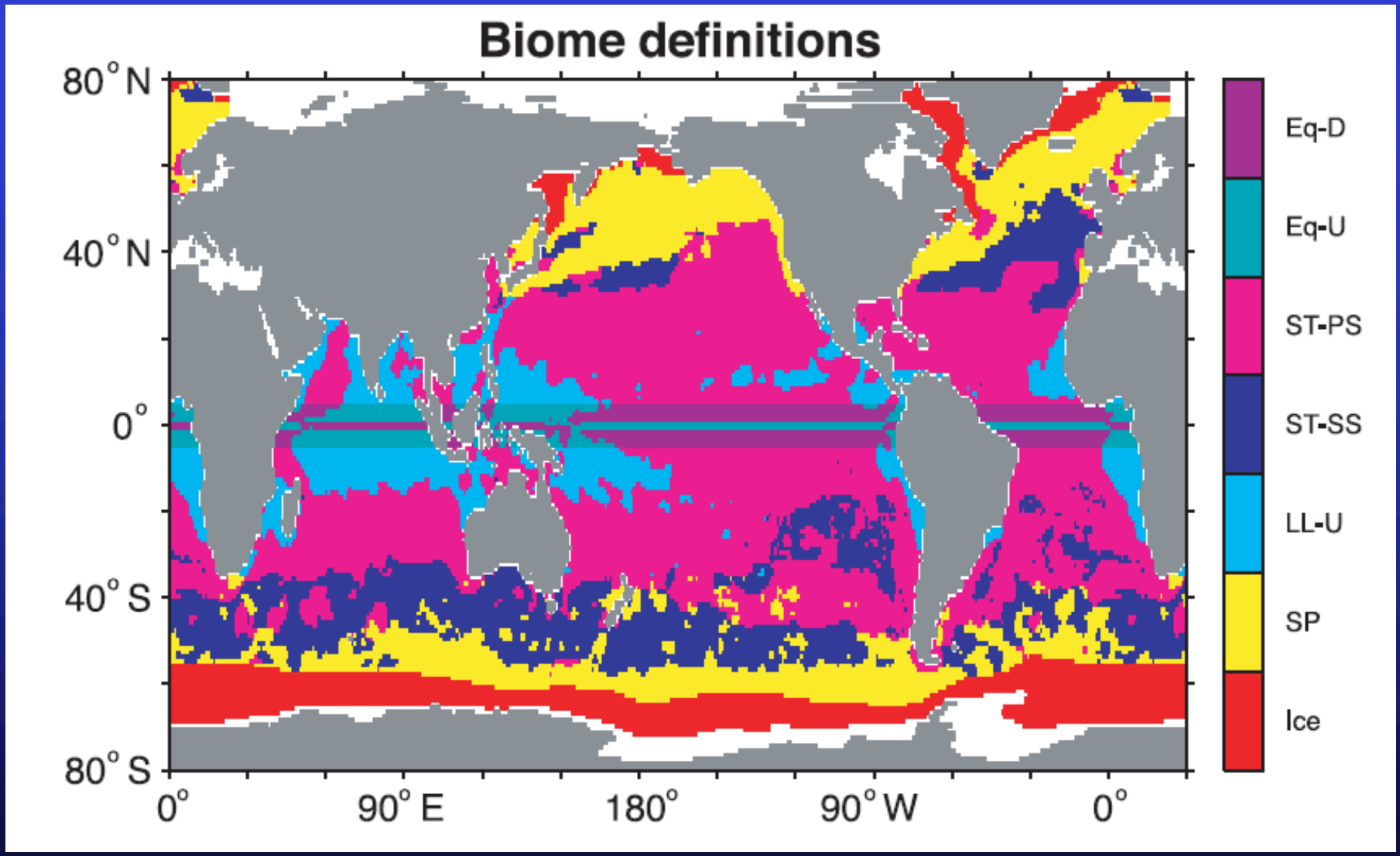


Change in diatom relative abundance in response to 4 times increase in CO2.

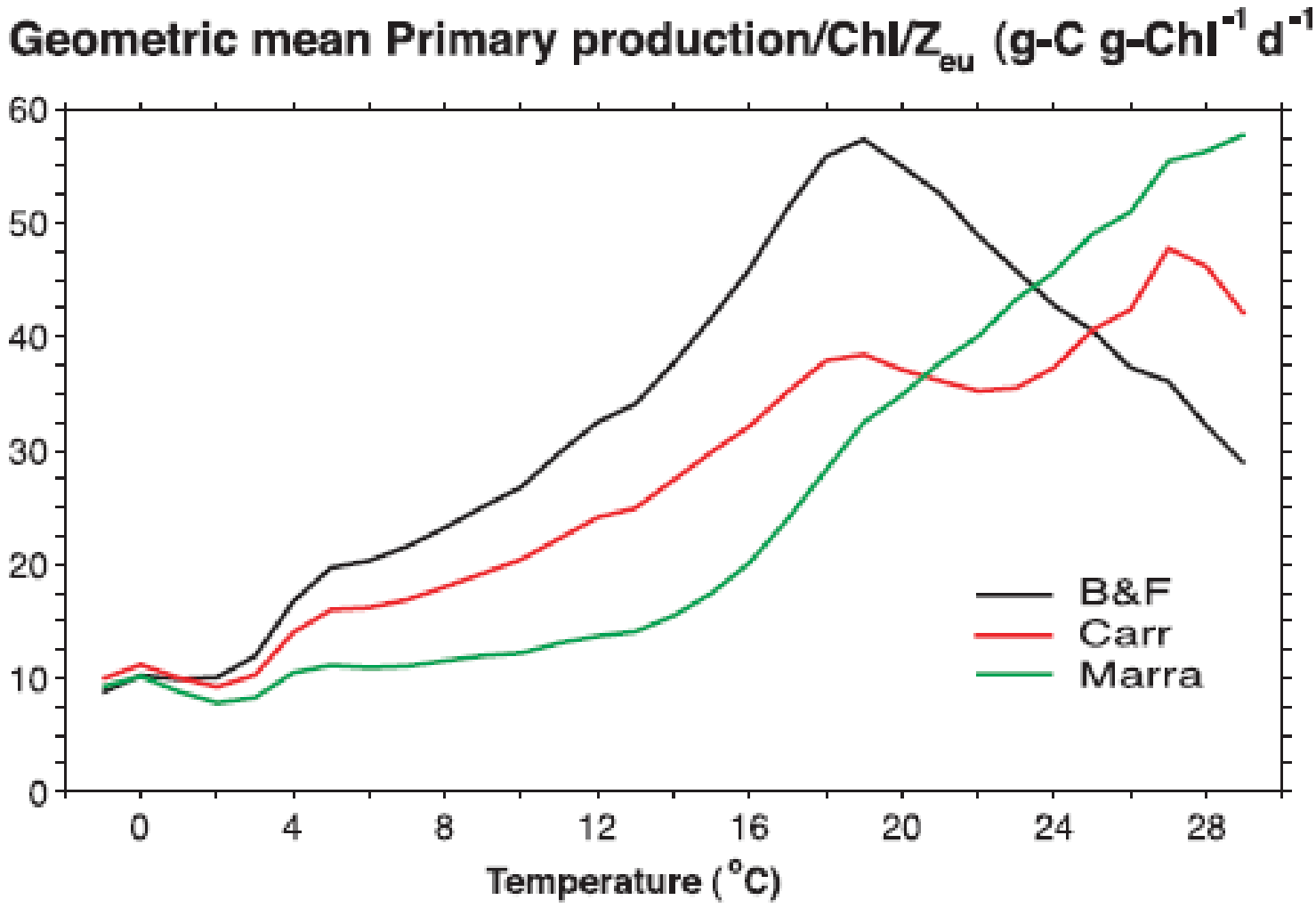
Bopp et al 2005



Behrenfeld et al 2006



Sarmiento et al 2004



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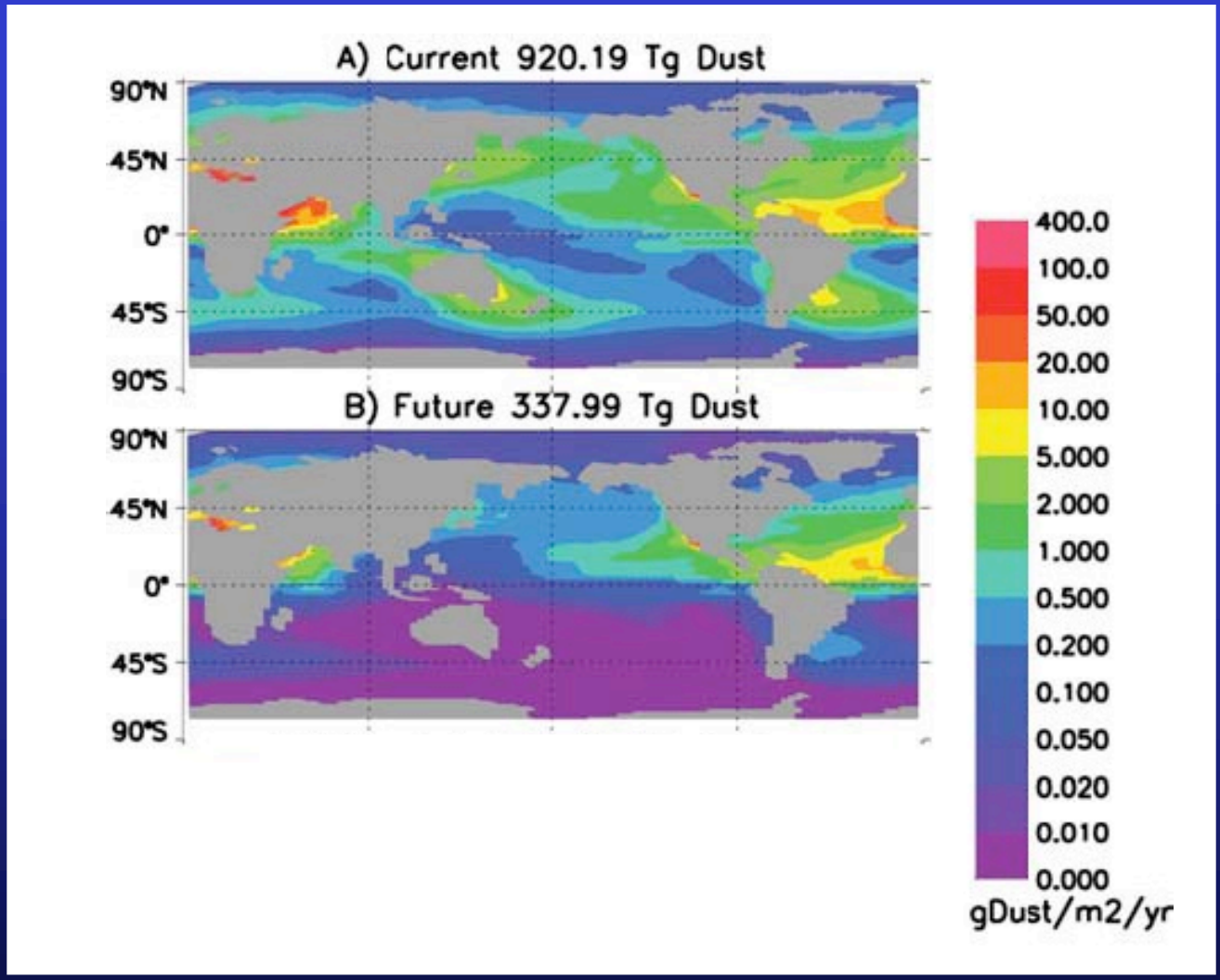
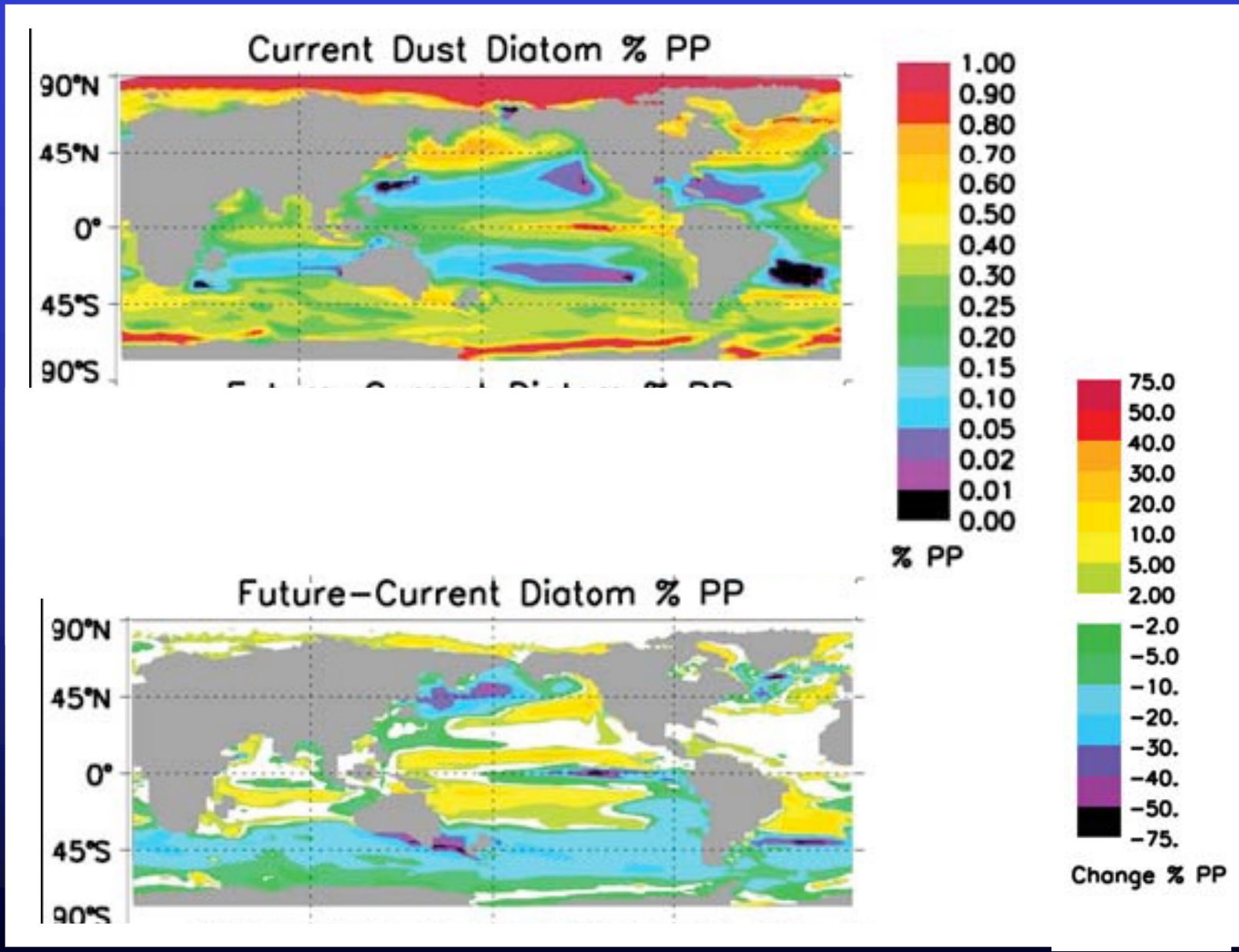


Moore et al 2006

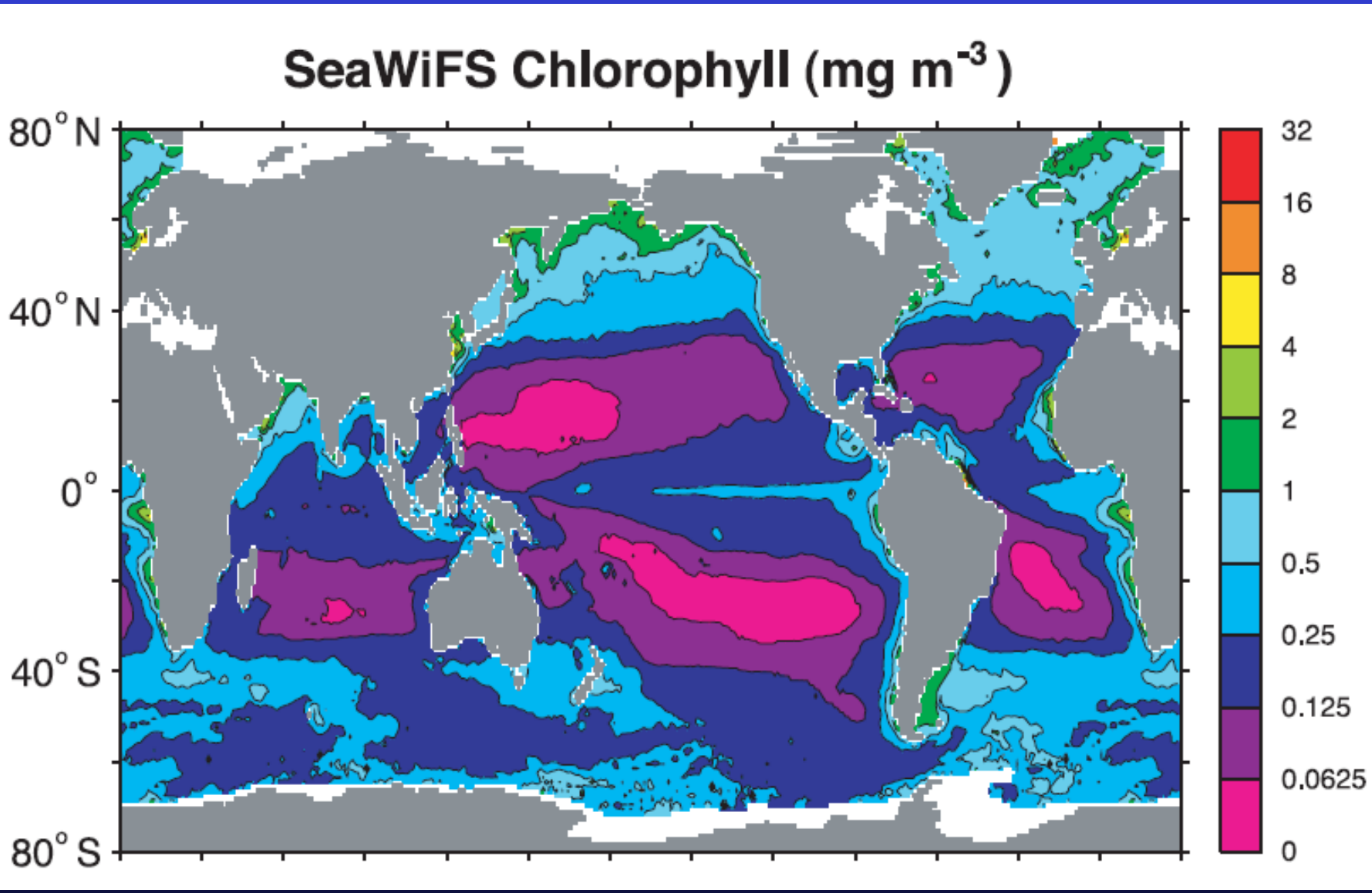


Moore et al 2006

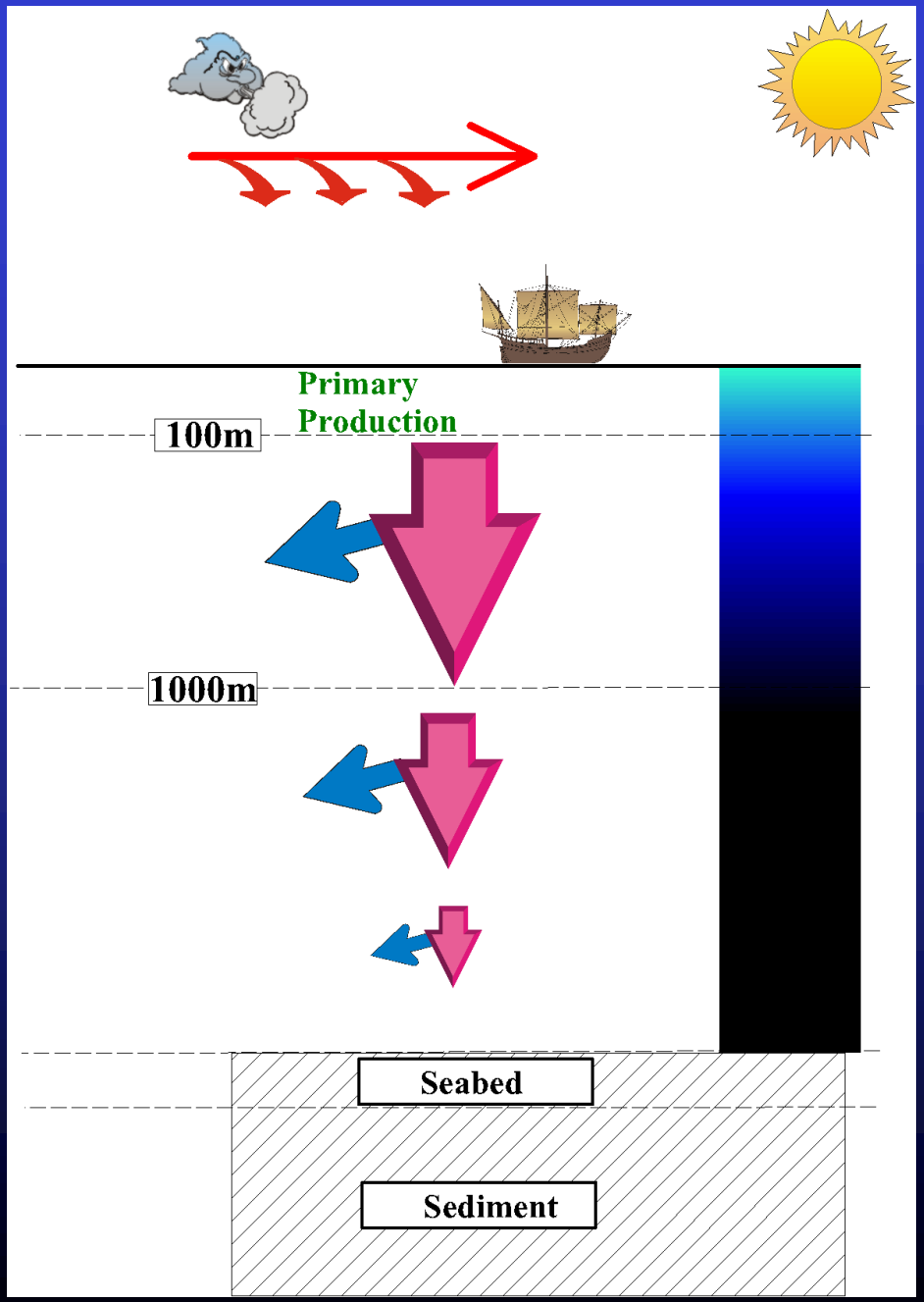
At high latitudes diatoms with high seasonality encourage high export efficiency and low transfer efficiency

At low latitudes calcifiers with low seasonality generate conditions of low export efficiency and high transfer efficiency.

Francois et al 2002



Sarmiento et al 2004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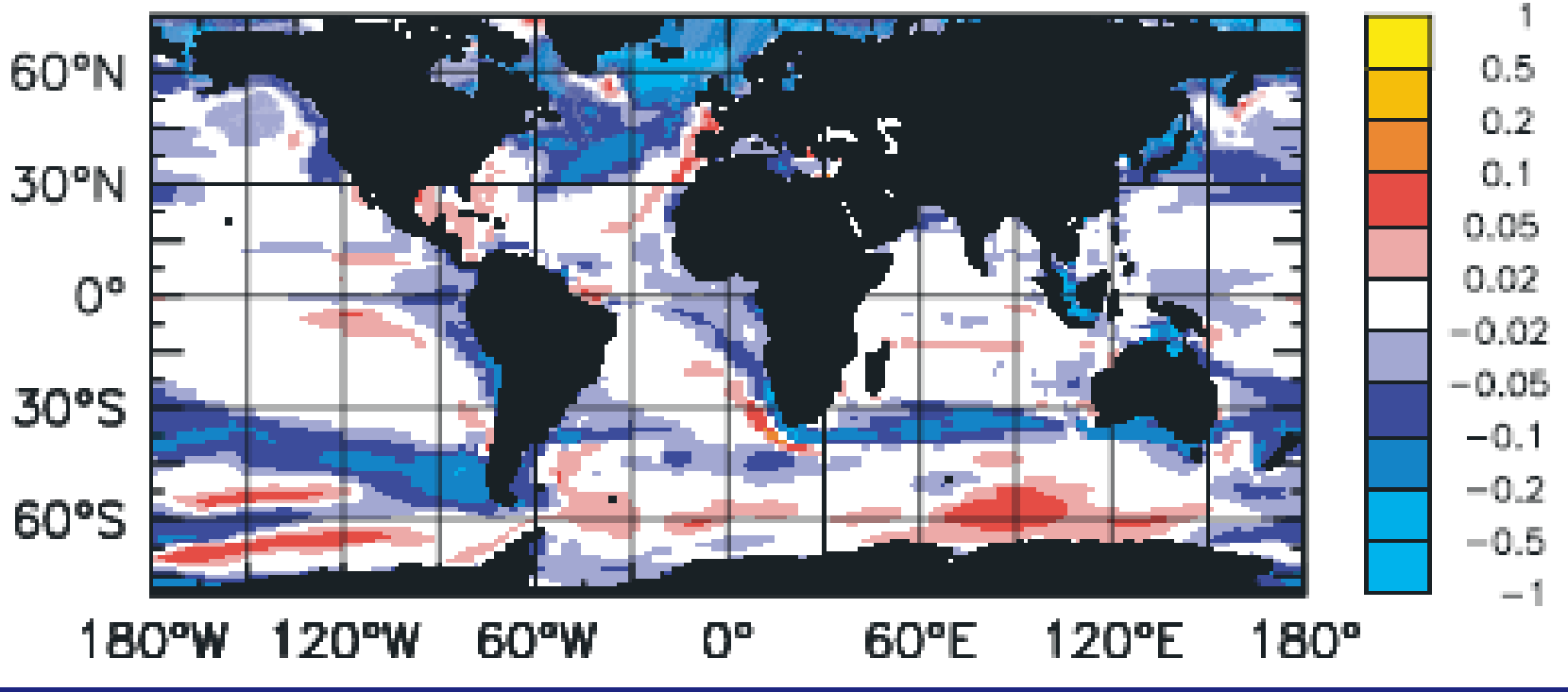

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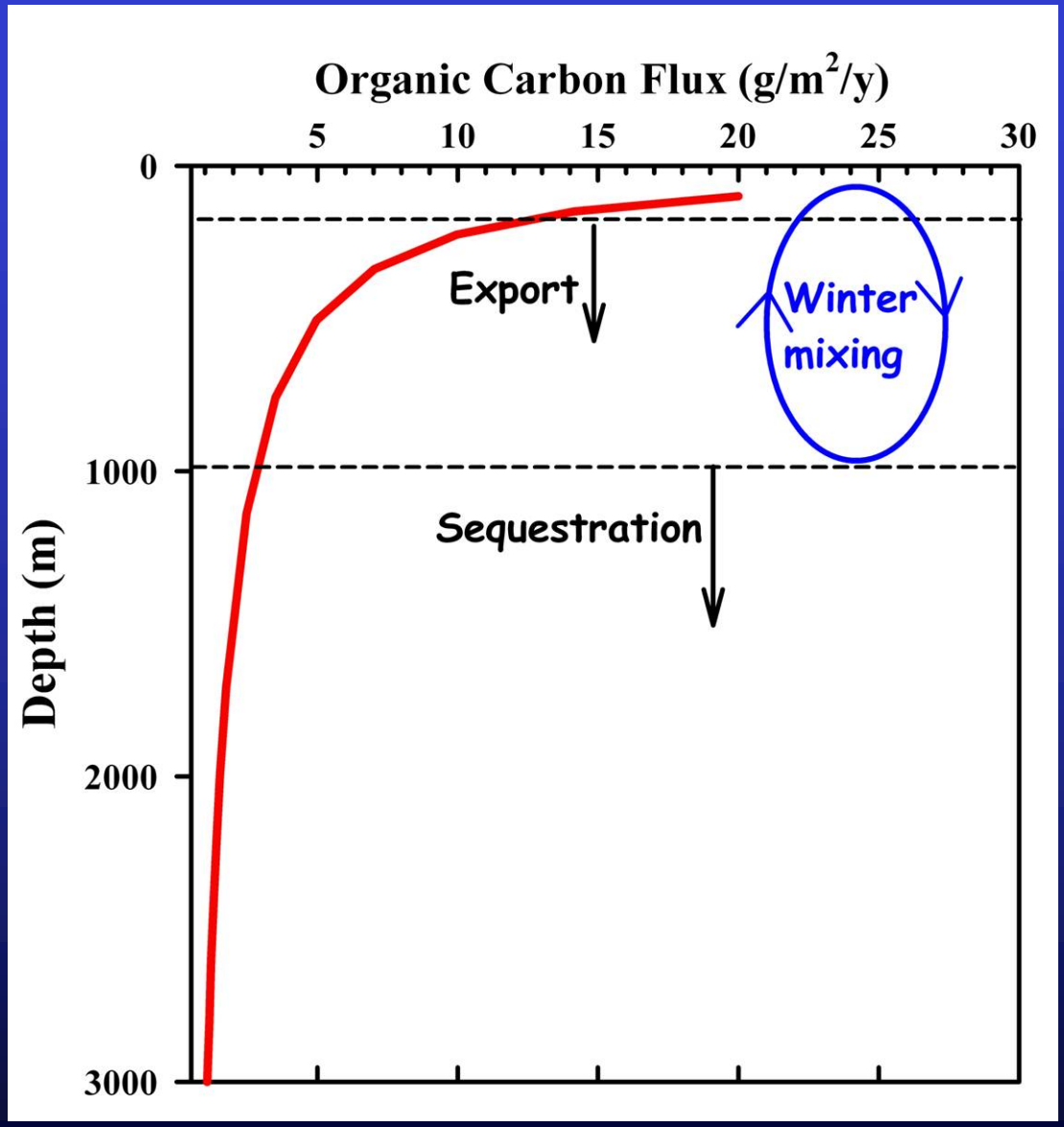

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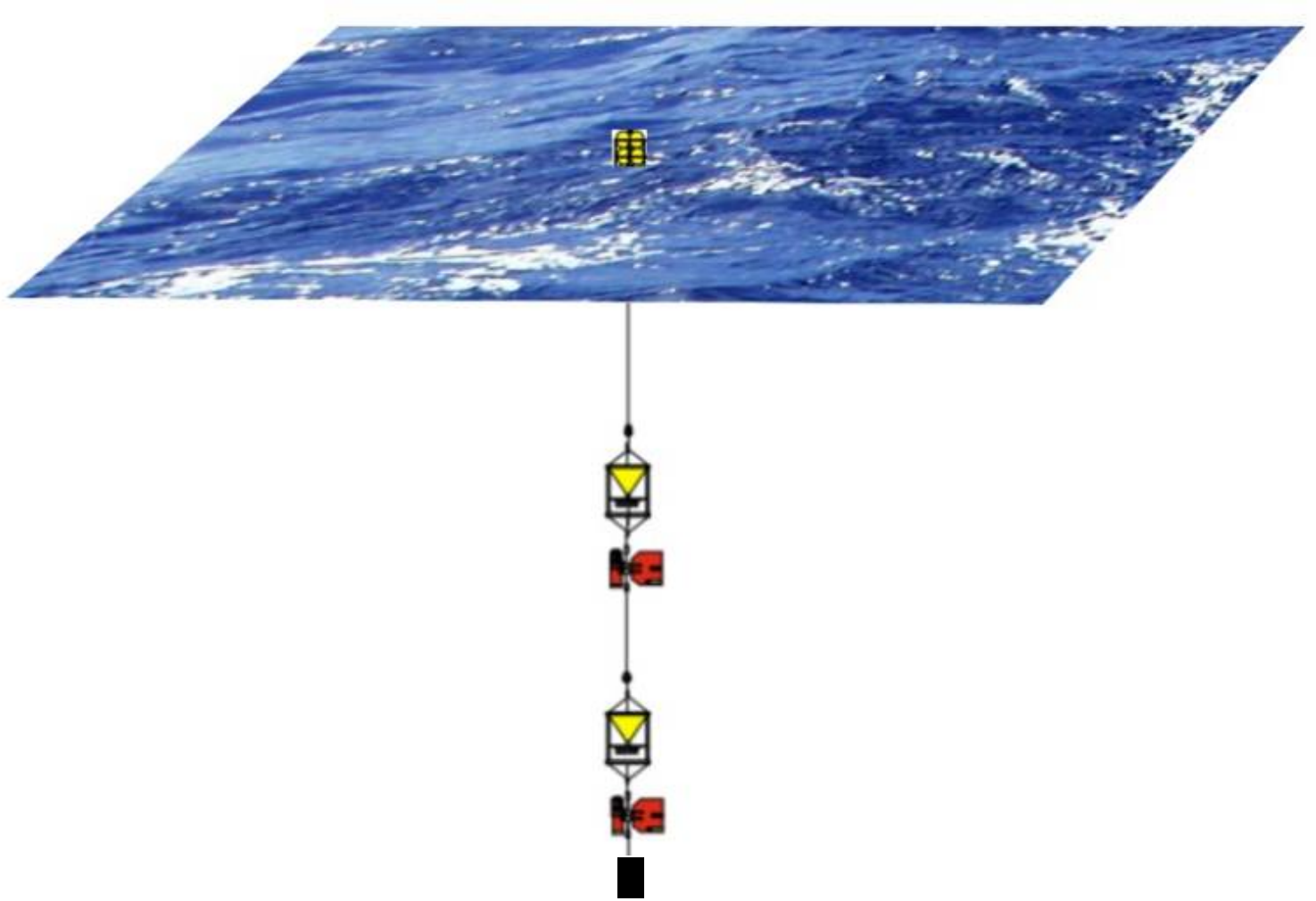
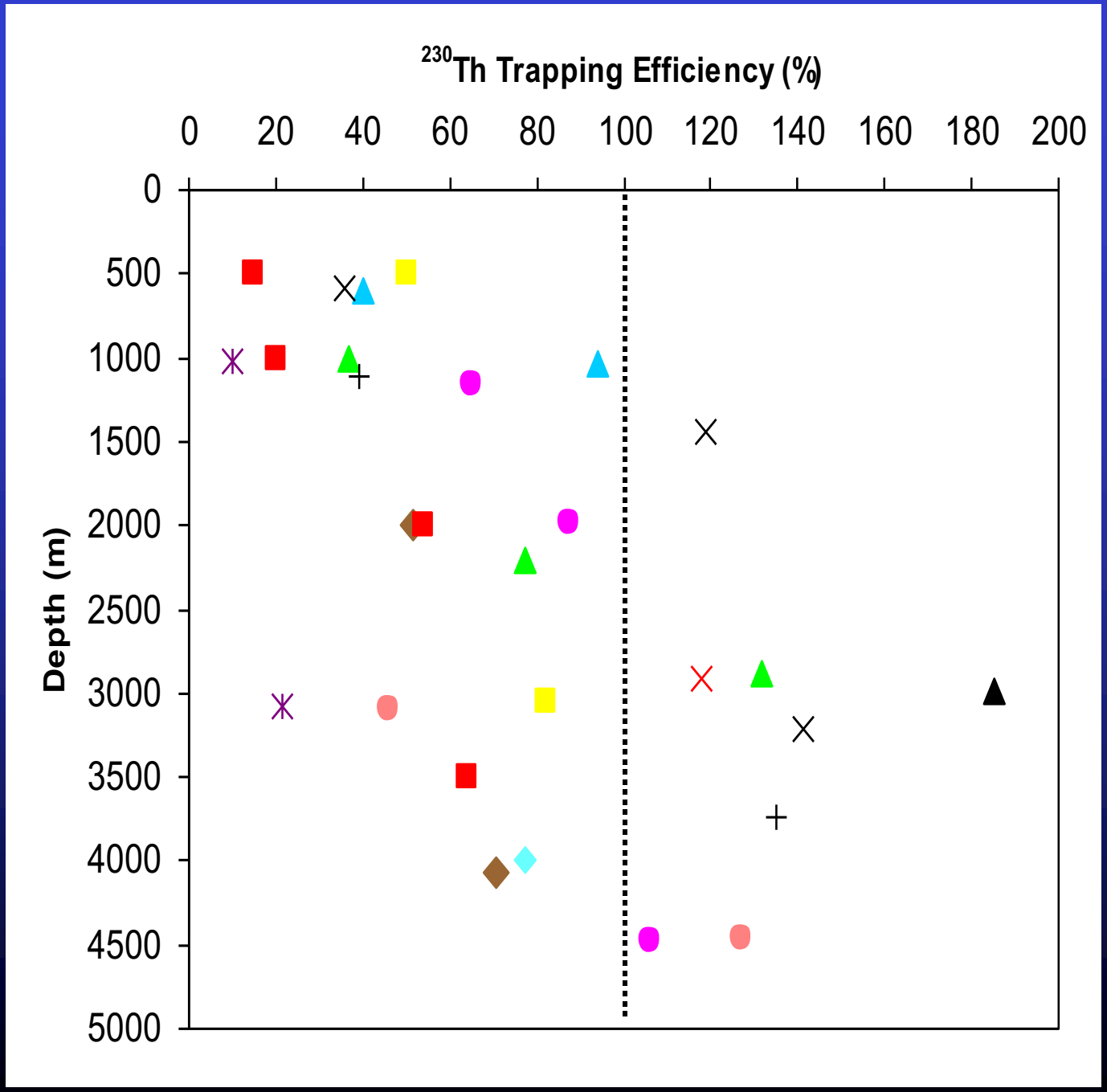
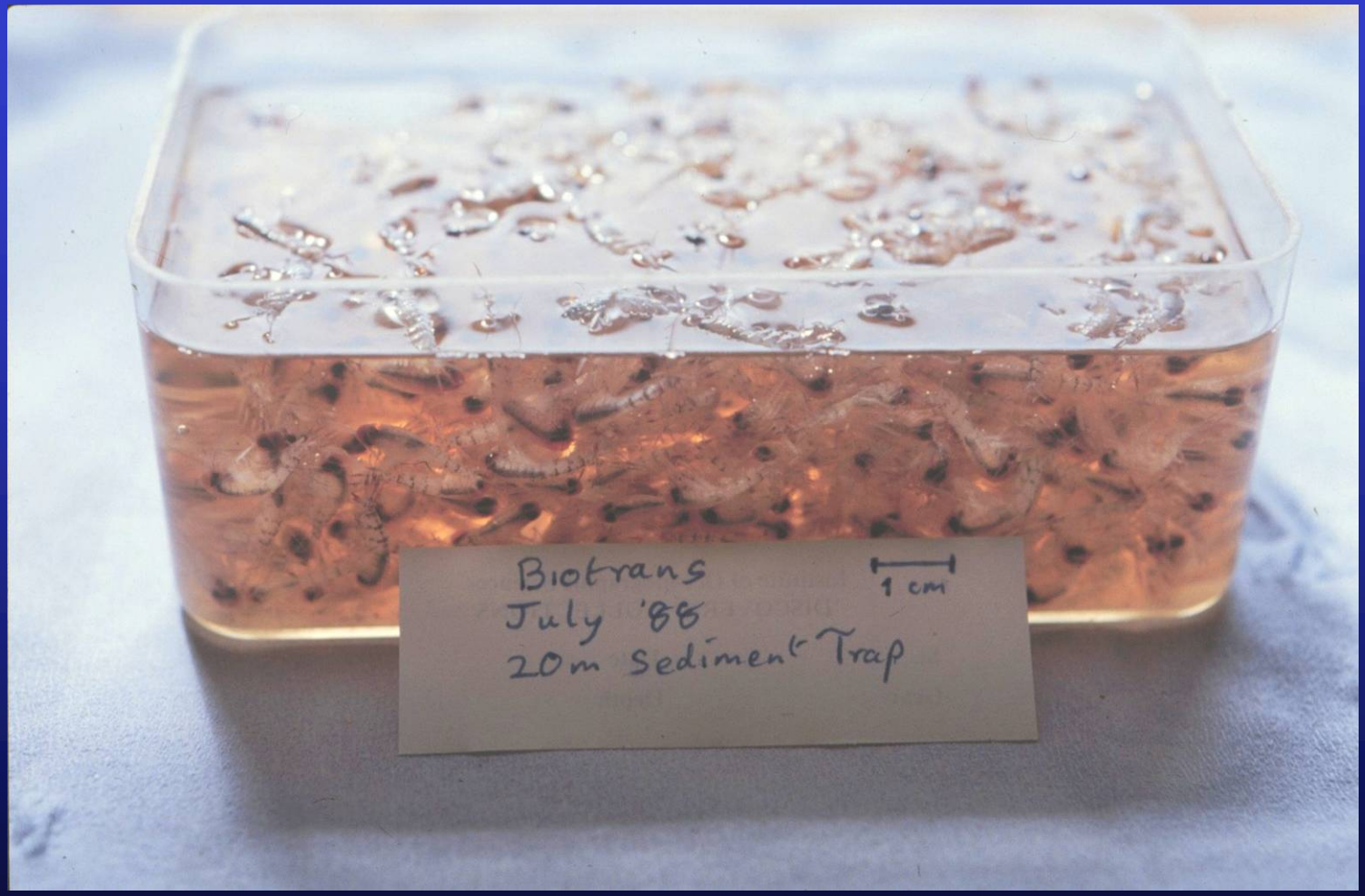




Scholten et al 2002



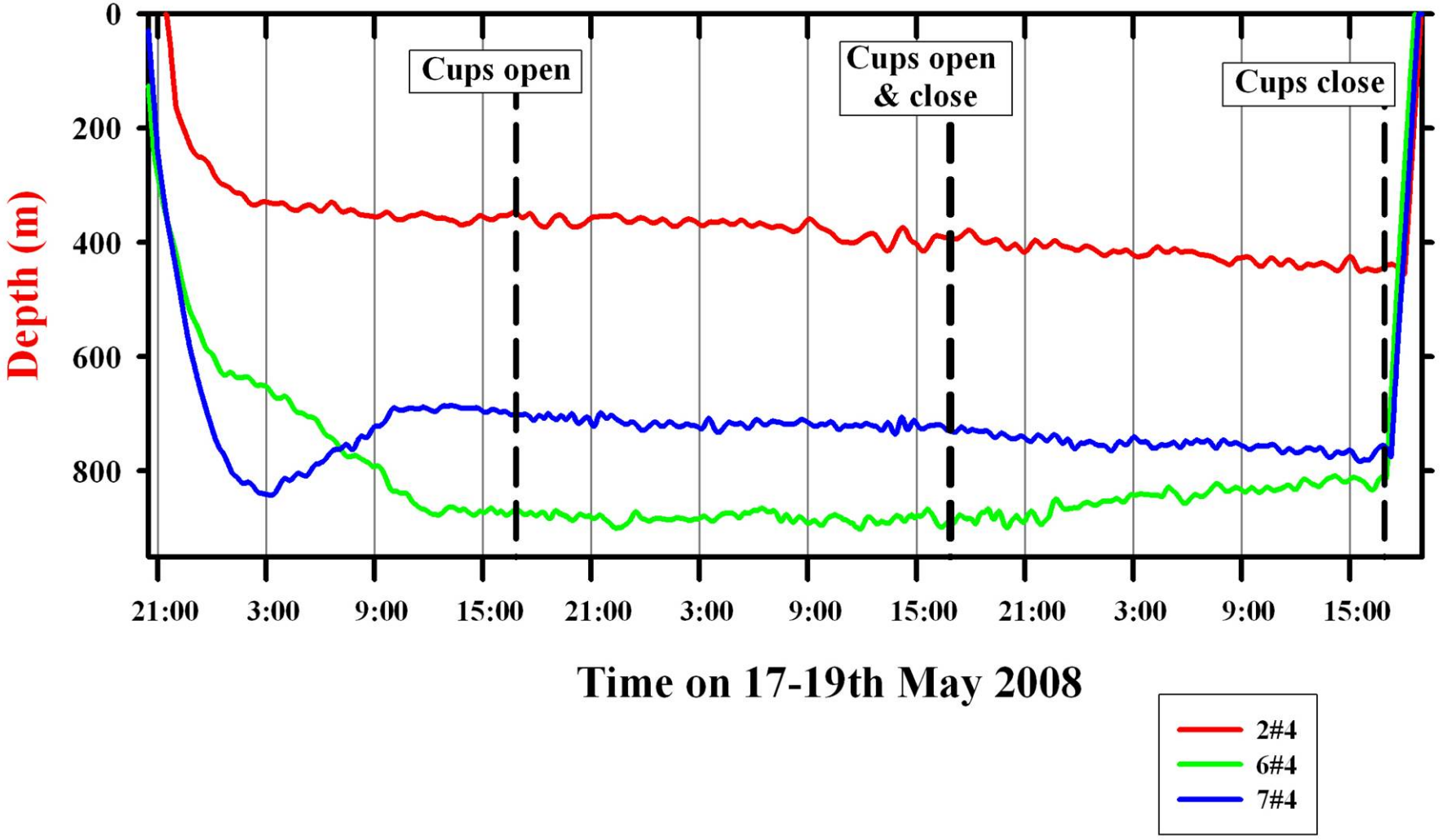
“Swimmers” from a drifting sediment trap.

The NBST

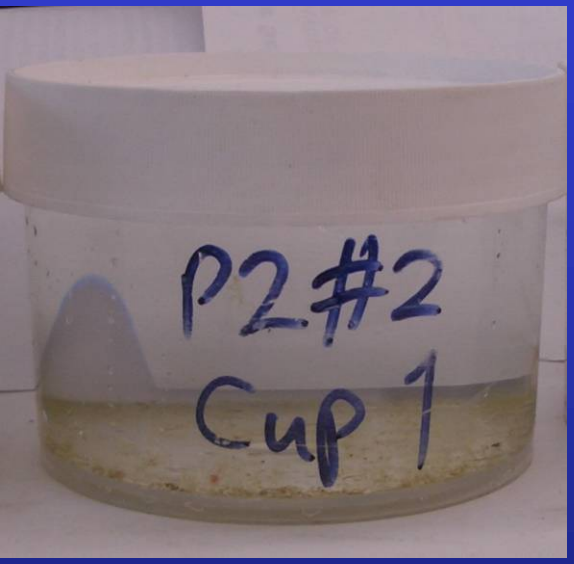
PELAGRA on board RV Knorr May 2008

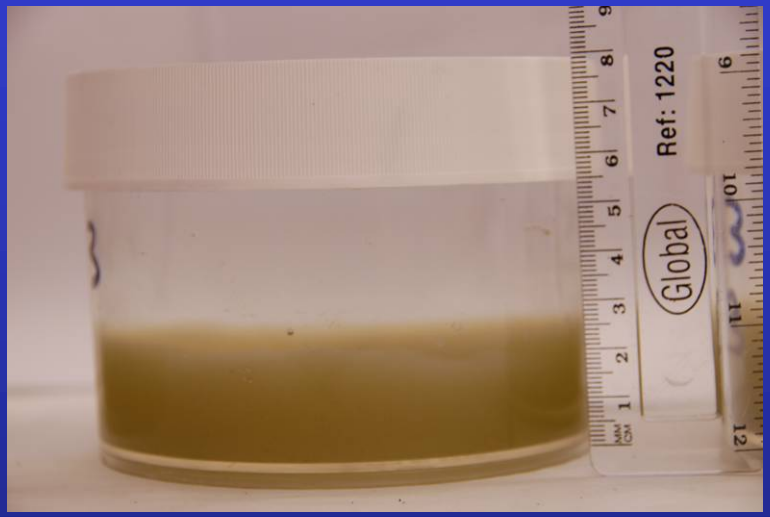
A shoal of PELAGRA traps

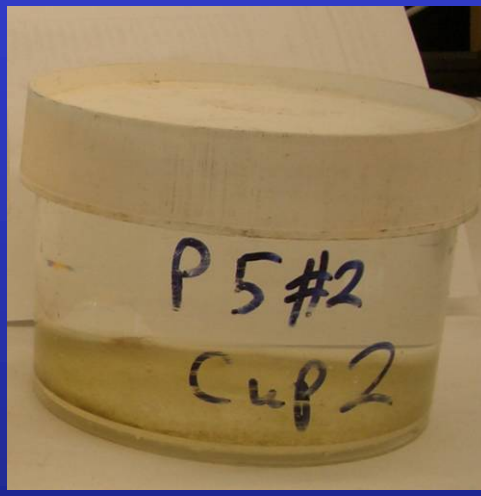
(May 2008 on board RV Knorr)



PELAGRA depth profiles
(6 hour time marks)







7-11th May

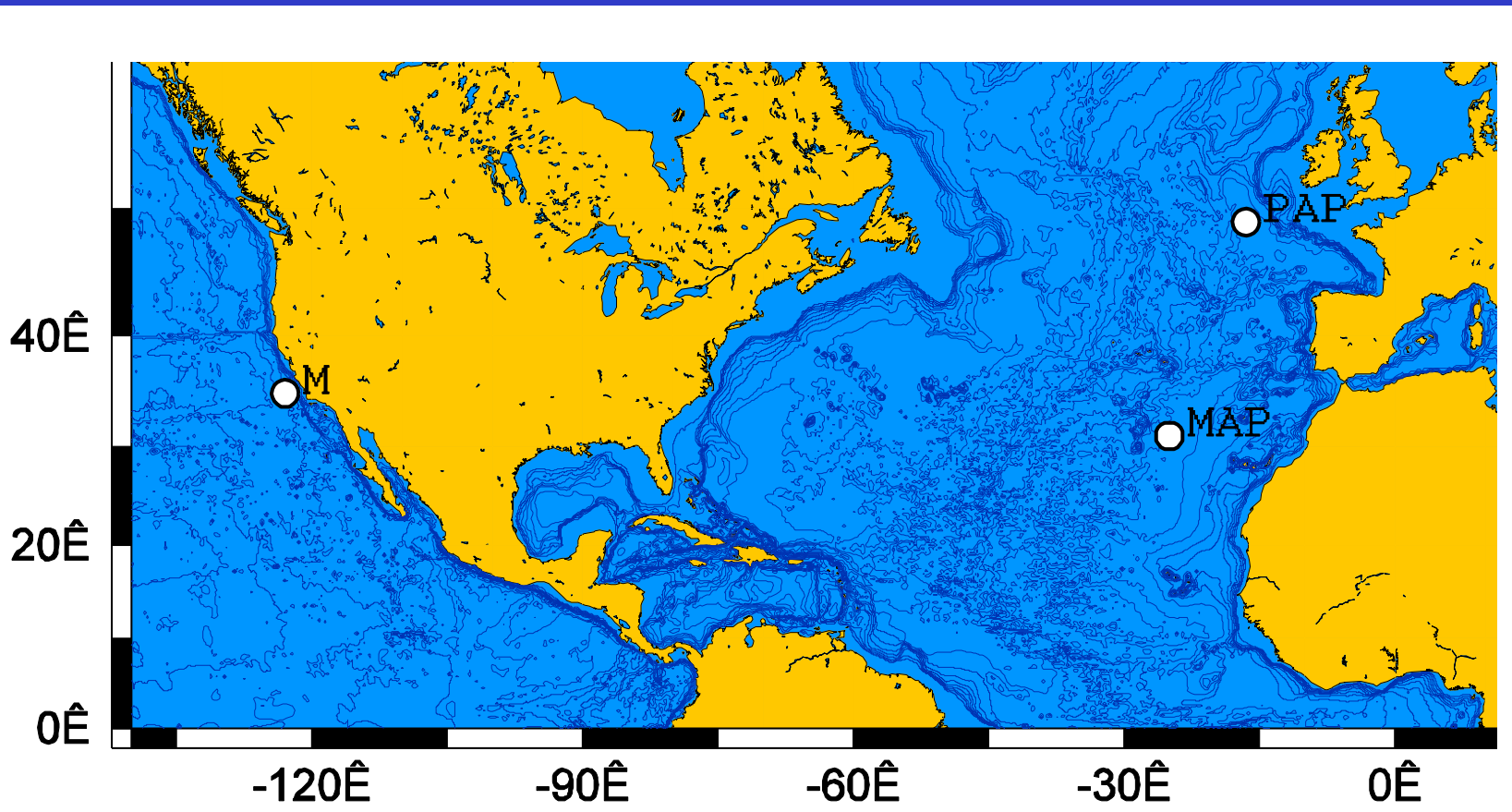
14th May

17th May

Relevant features of flux:

1. Annual supply of POC
2. Seasonal variability in supply
3. Interannual variability
4. Quality of organics
5. Sinking rate of particles
6. Regional variation
7. Match-Mismatch

Mesozooplankton: A copepod


PAP
M
MAP
40Ê
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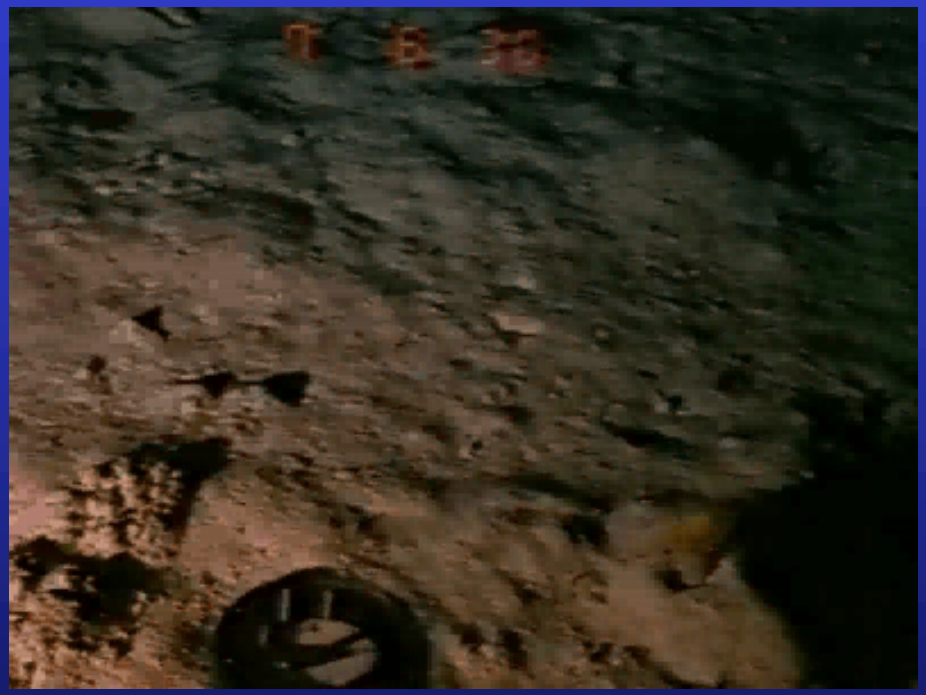
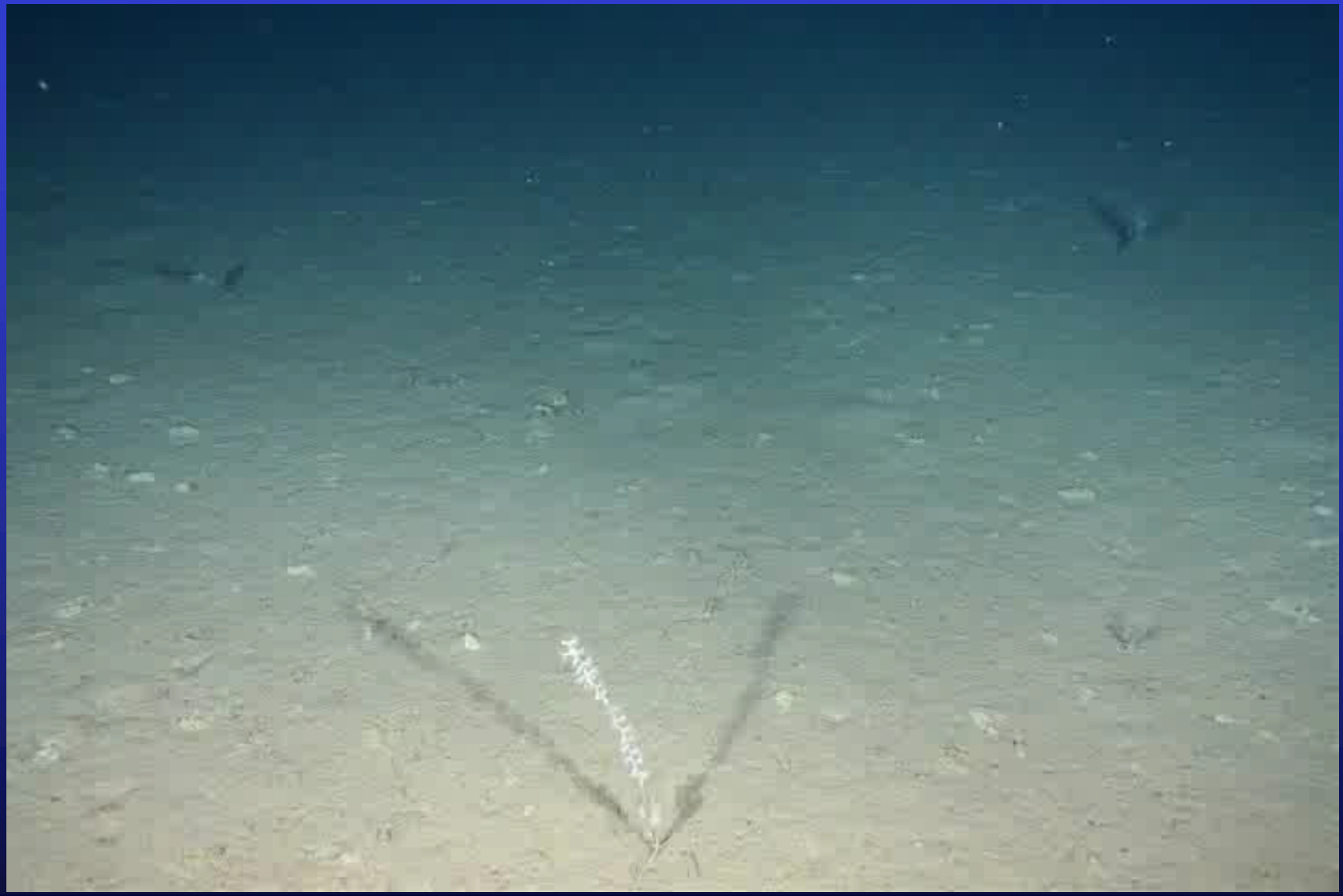
0Ê
-120Ê
-90Ê
-60Ê
-30Ê
0Ê



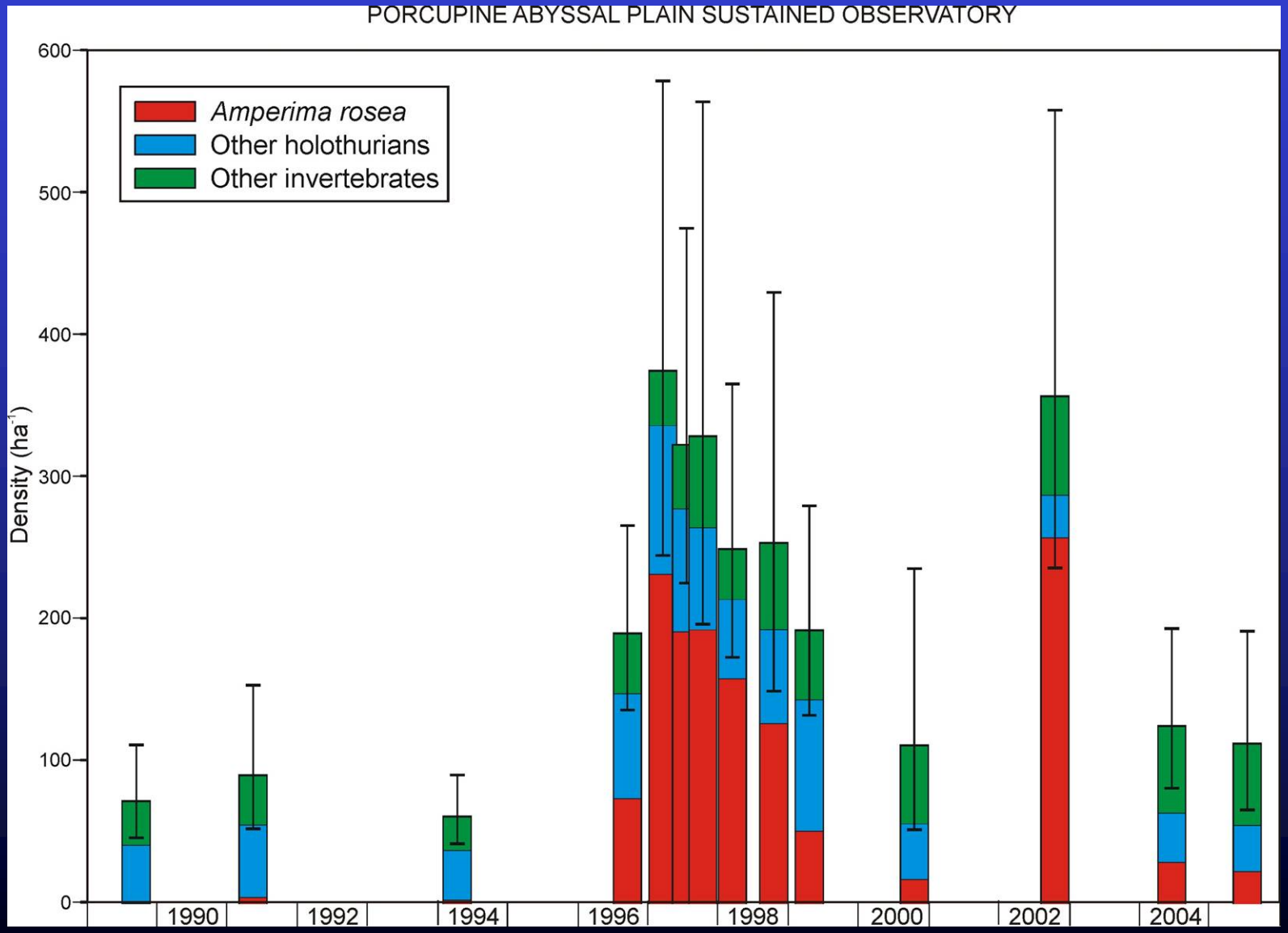
PAP

MAP



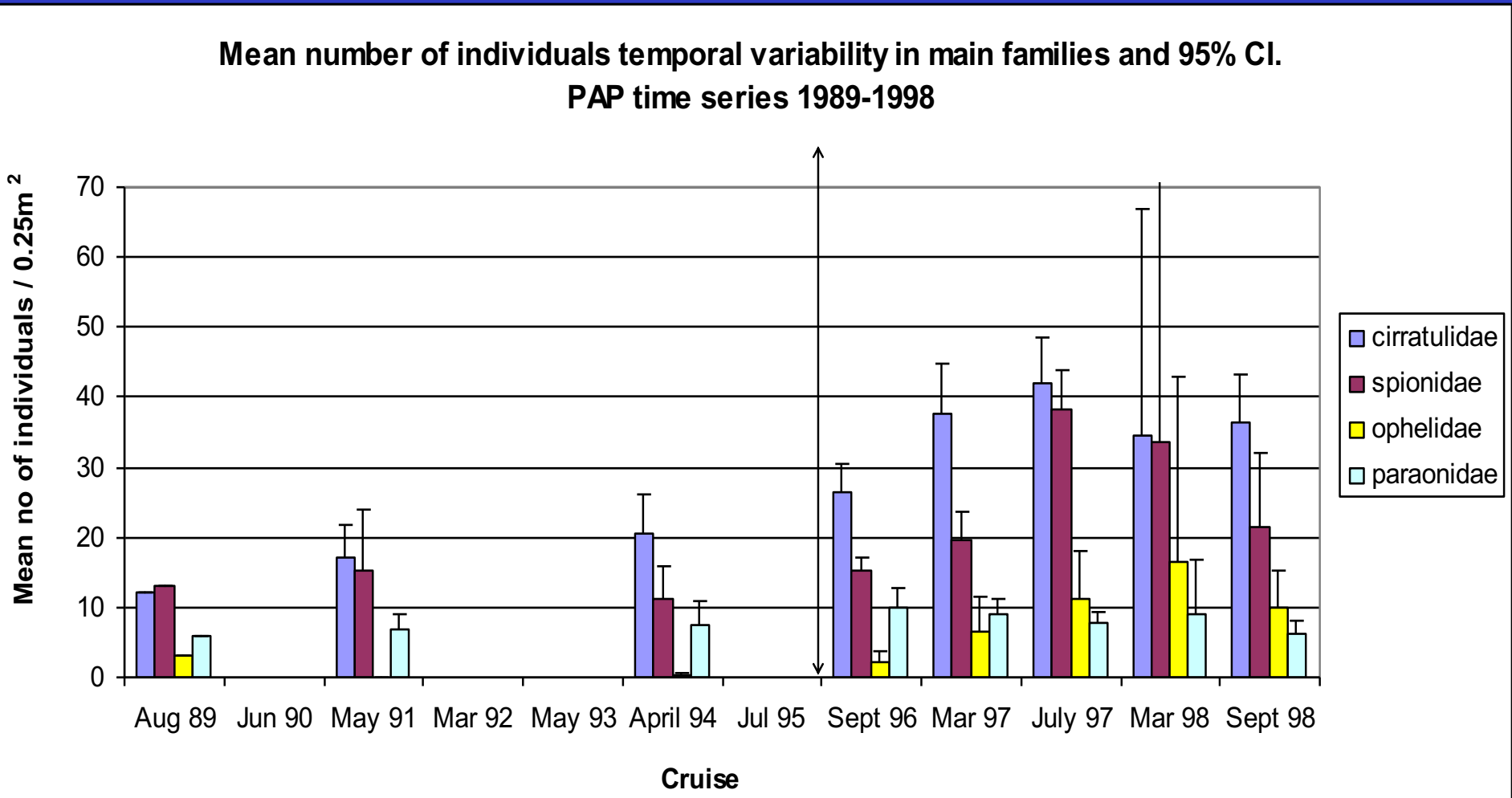
Ruhl et al

Long-term change in invertebrate megafauna at PAP



Billett et al (in review)

Polychaete main families



Soto et al (in review)

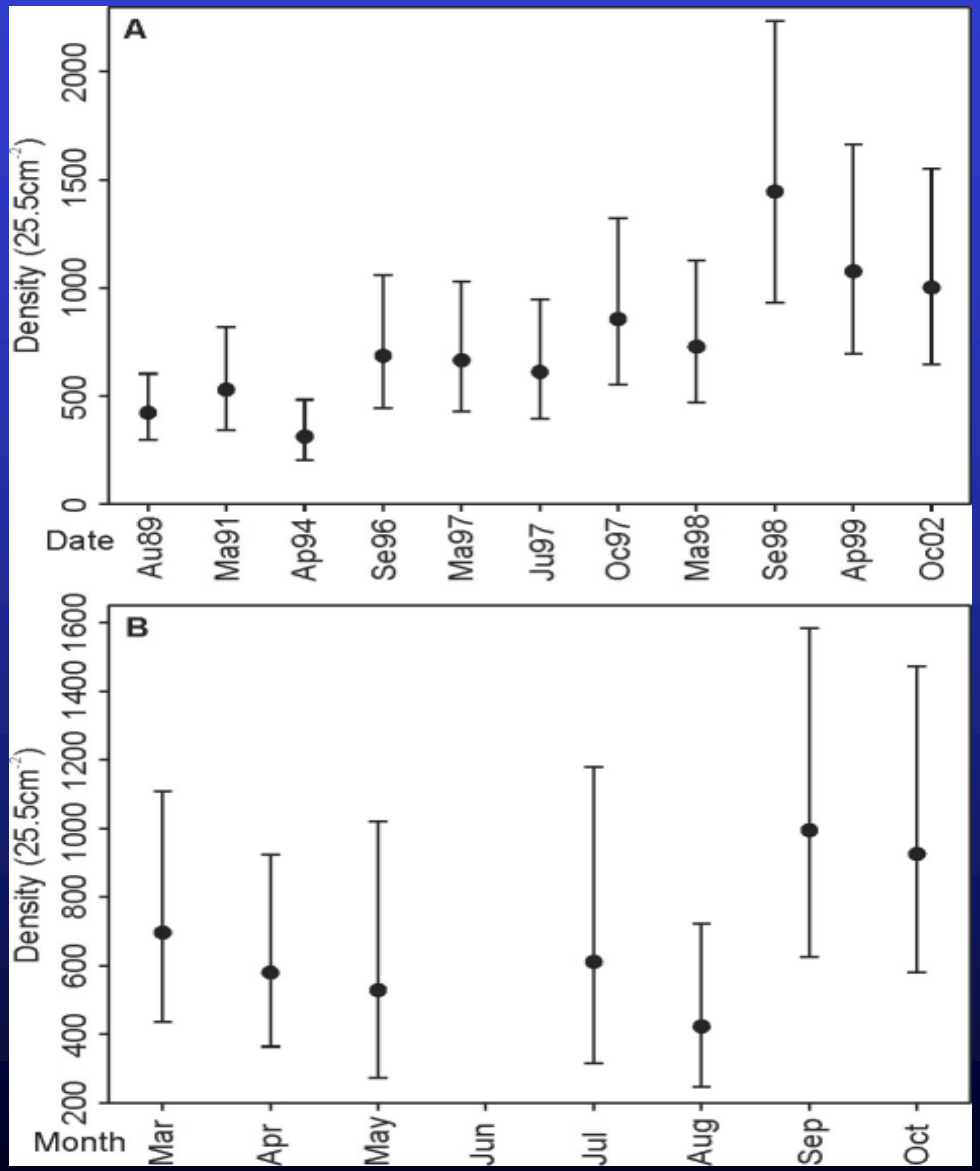
Abundance of 'live' (stained) Foraminifera

A) Abundance 1989-2002:

significant increase over time p <0.001

B) Abundance by month:

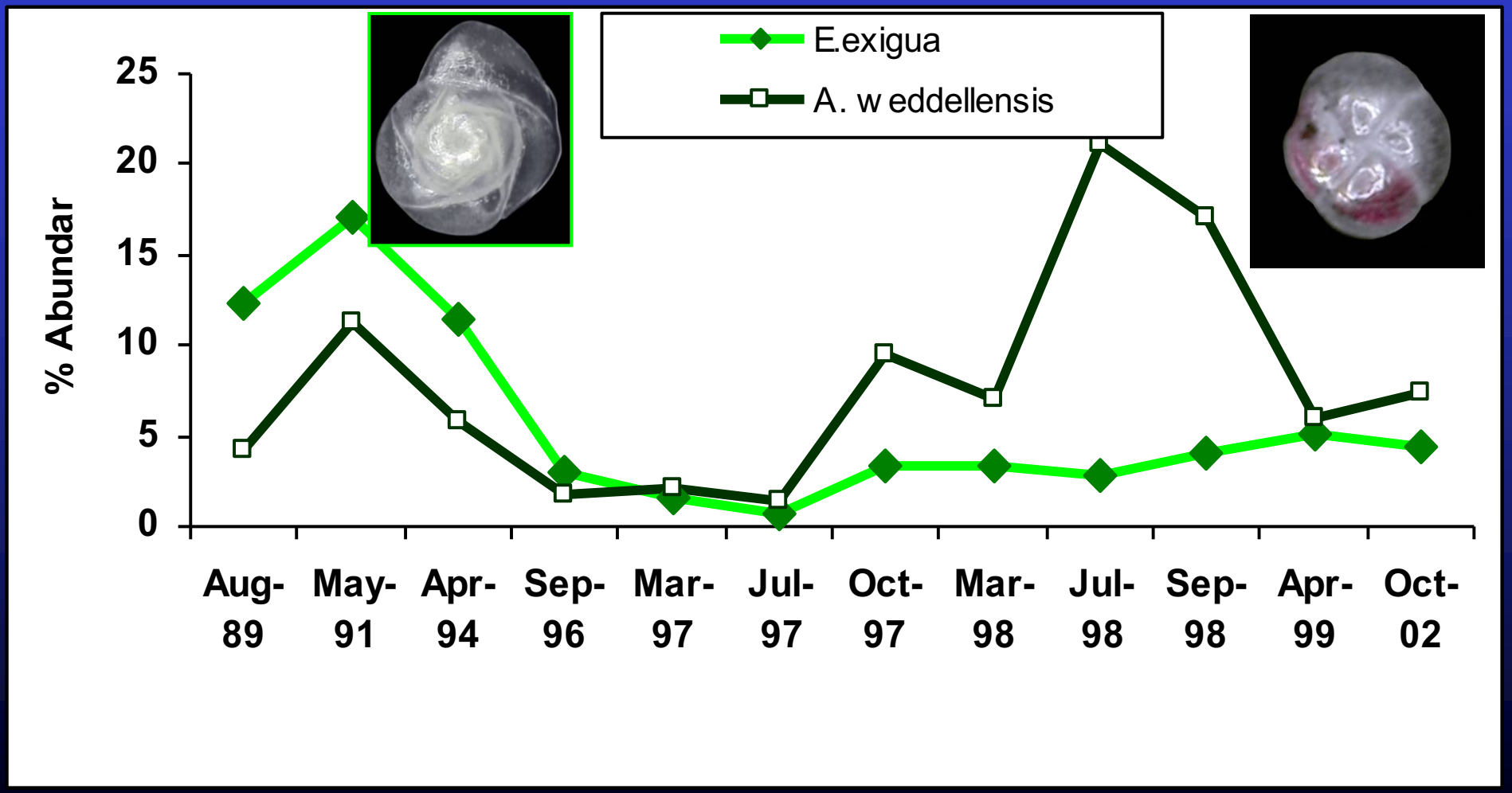
no significant differences between months



Gooday et al (in review)

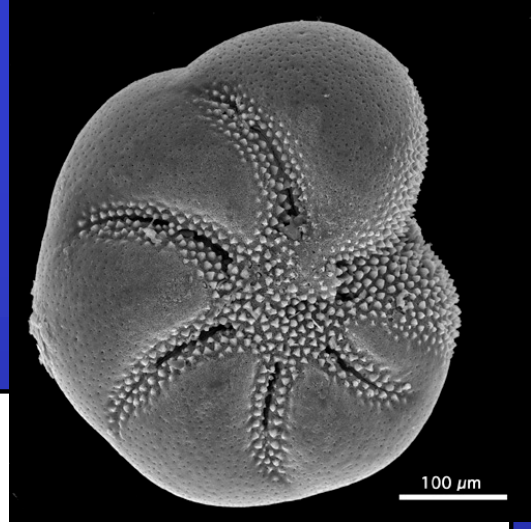
Change in dominance of Foraminifera

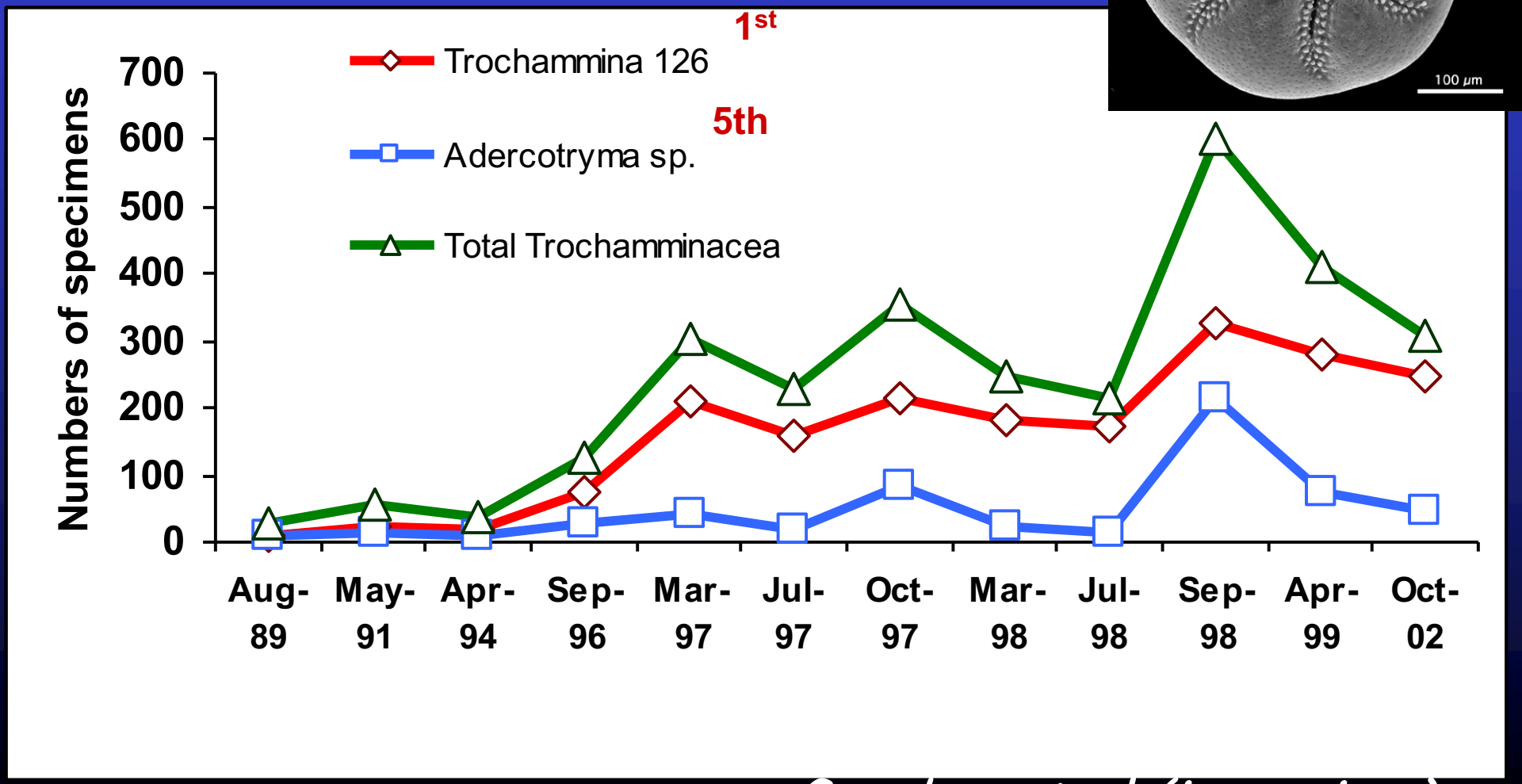
Epistominella exigua to *Alabaminella weddellensis*



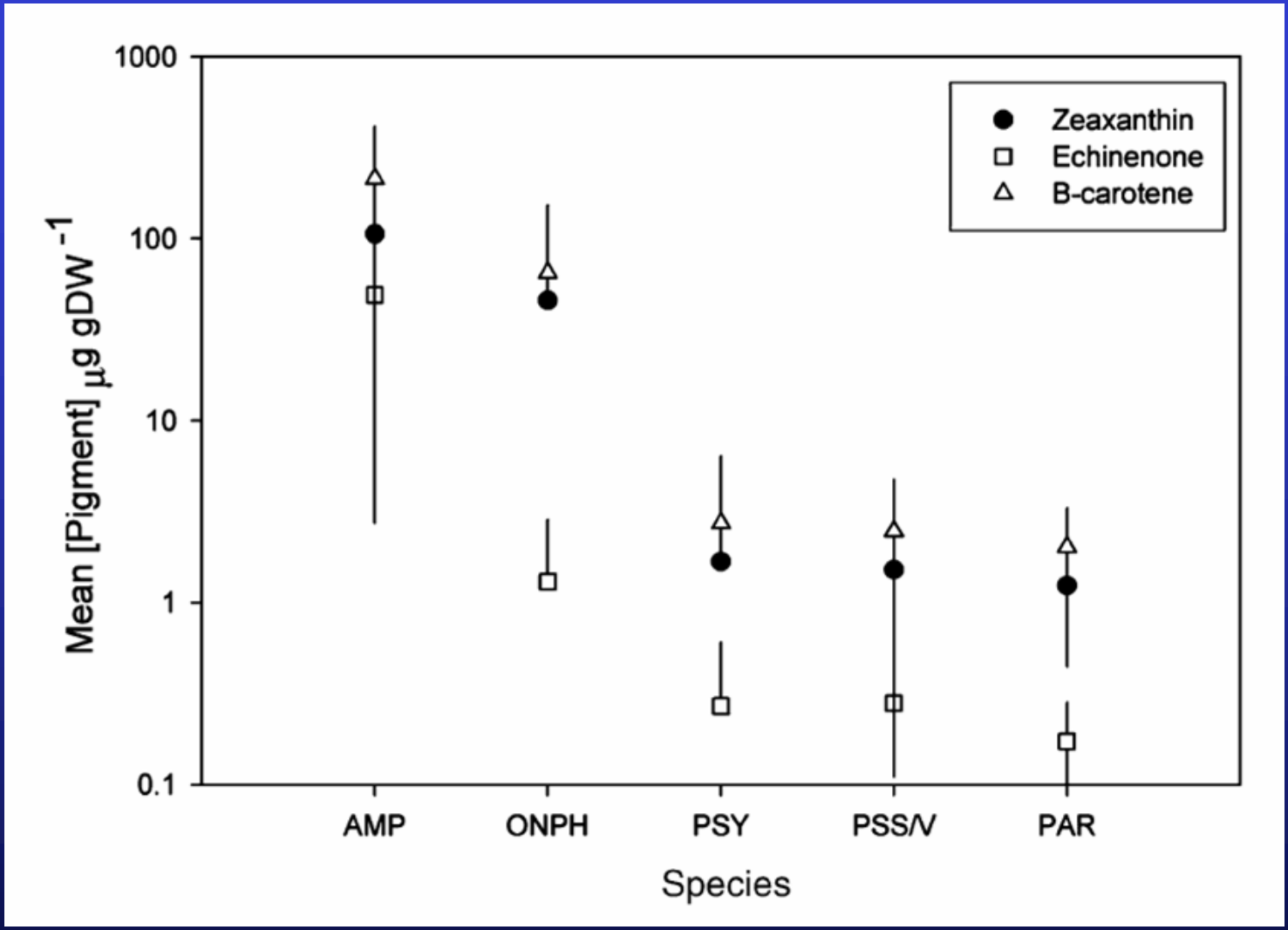
Gooday et al (in review)

Abundance -Trochamminacea



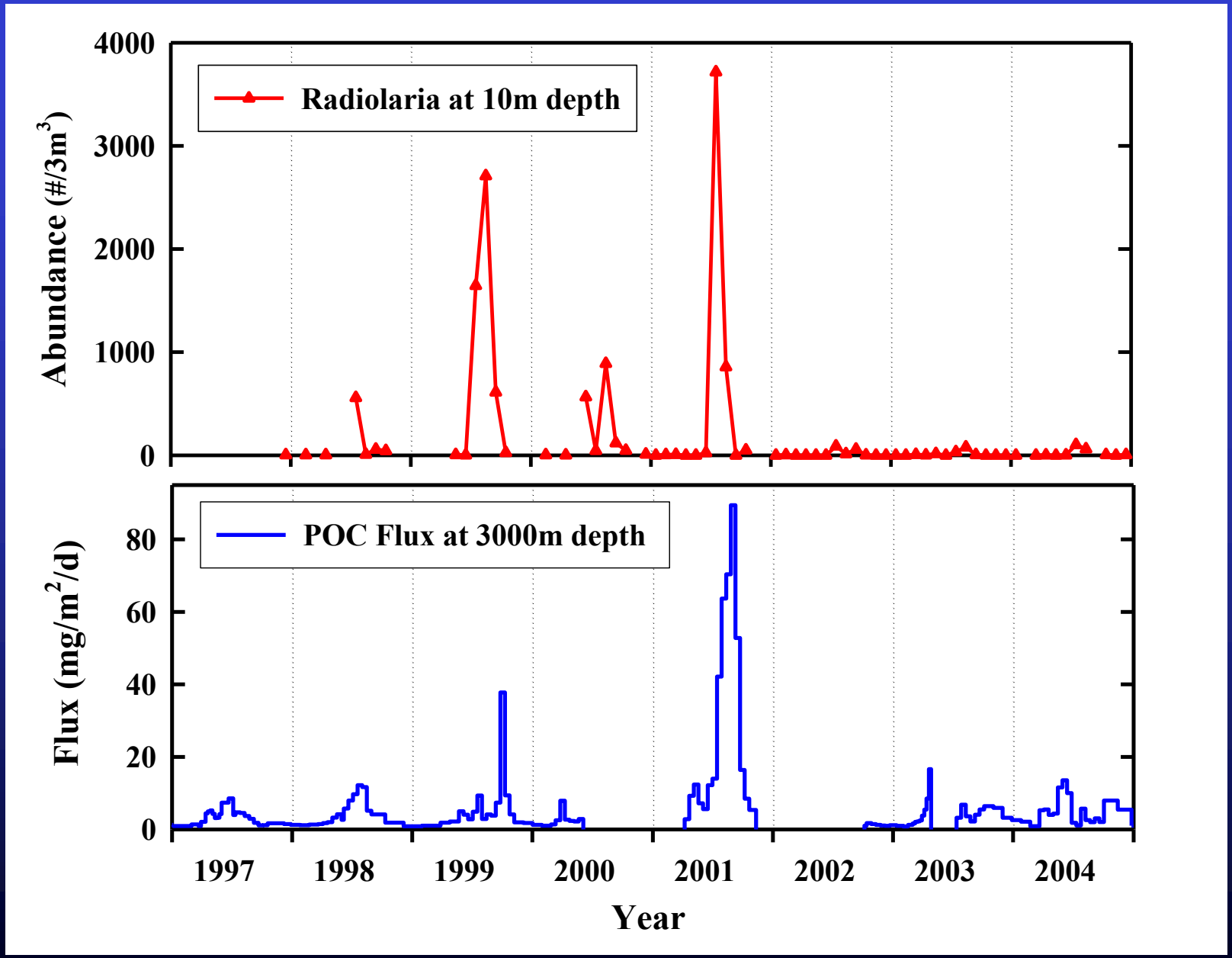


Gooday et al (in review)

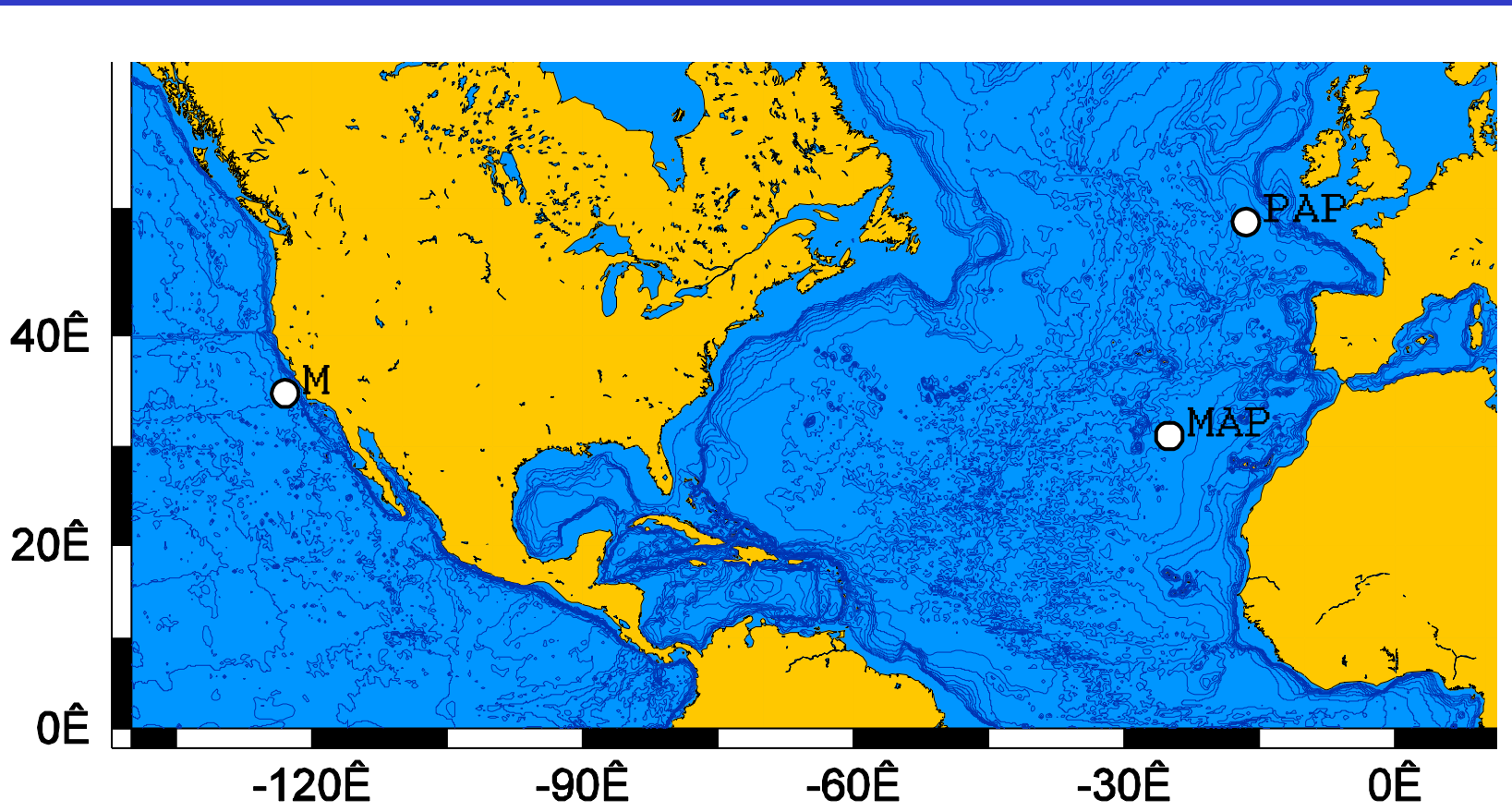


Phytoplankton pigments found in the ovaries of holothurians from 4800m

Wigham et al 2003



Lampitt et al GBC (in review)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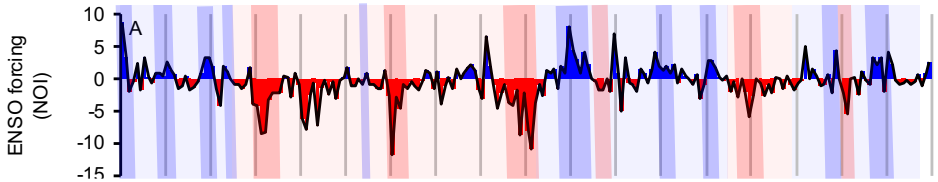
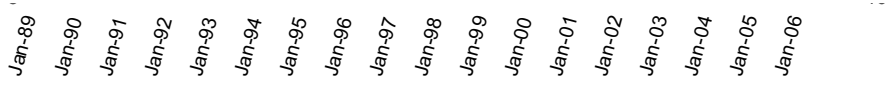


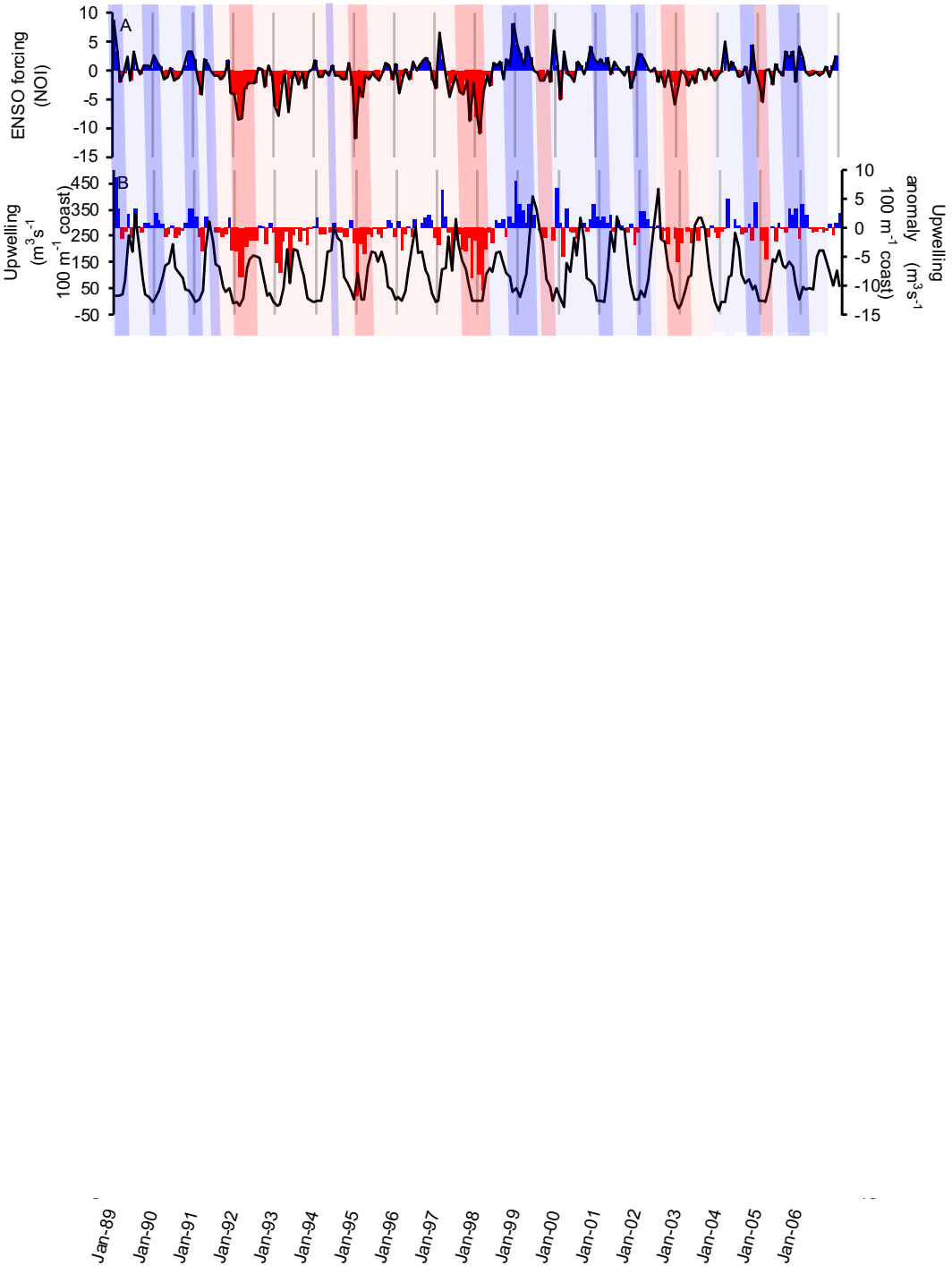
ENSO



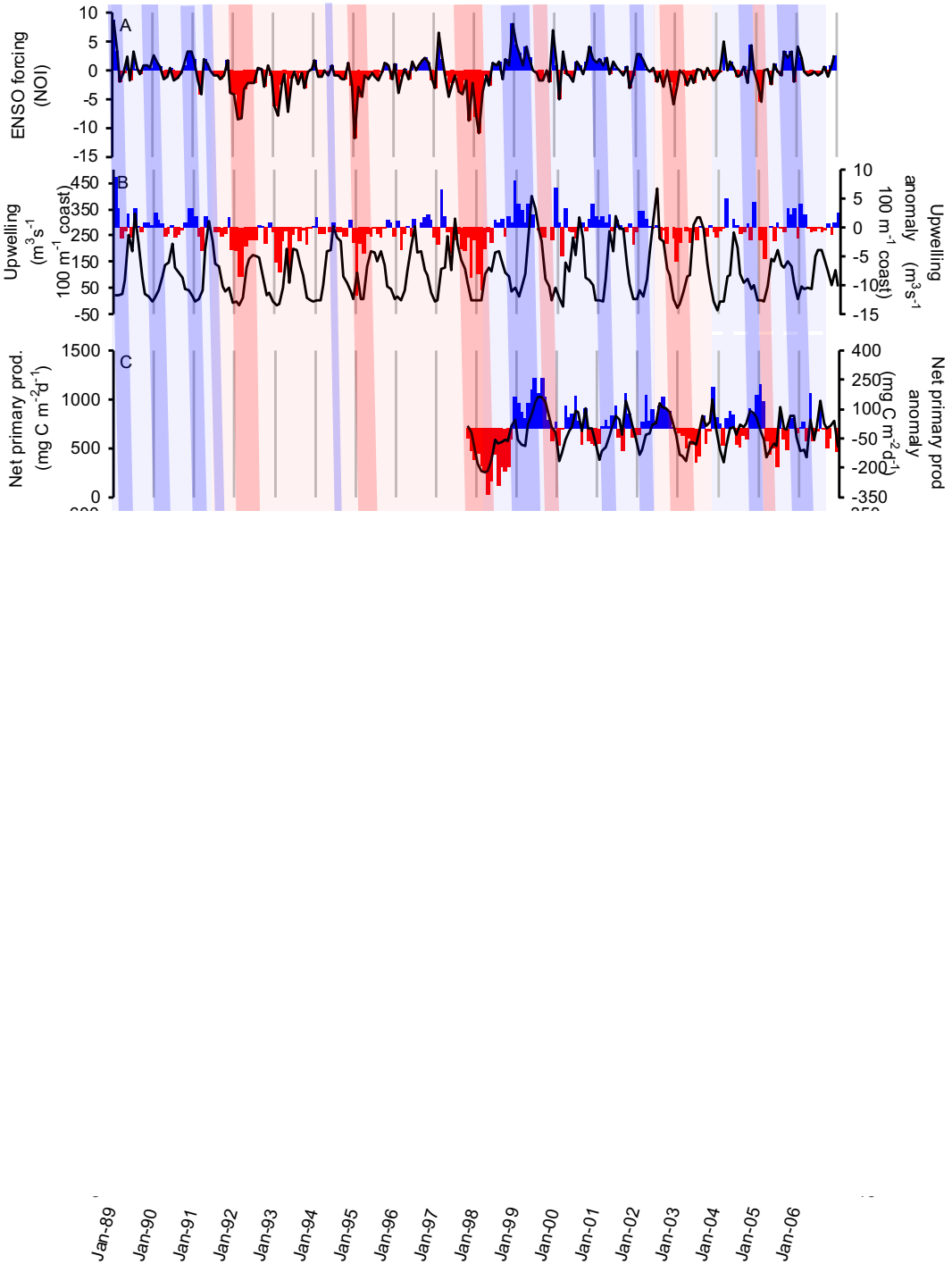
Henry Ruhl

ENSO

Upwelling



Henry Ruhl

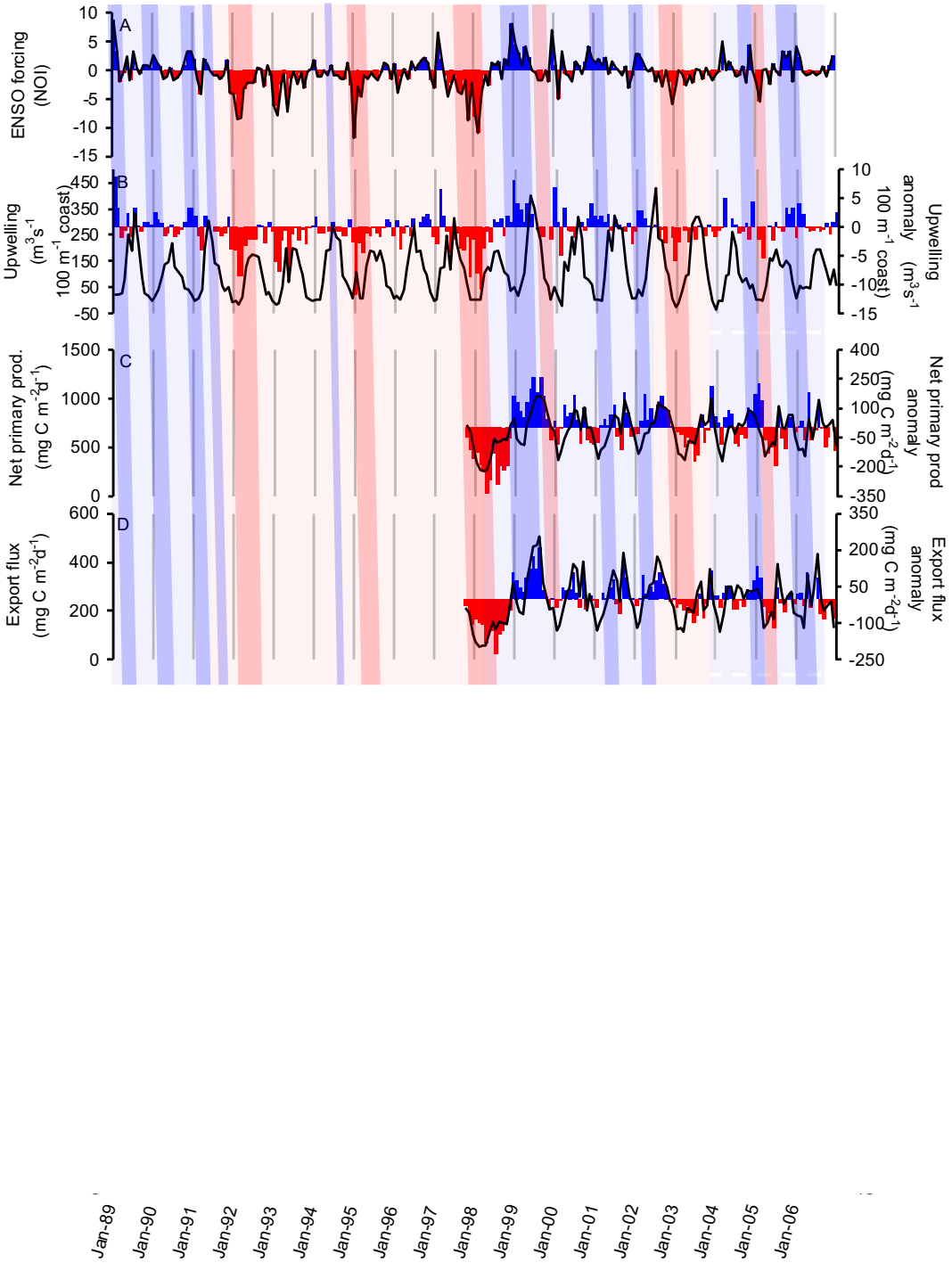


ENSO

Upwelling

Primary Production

Henry Ruhl



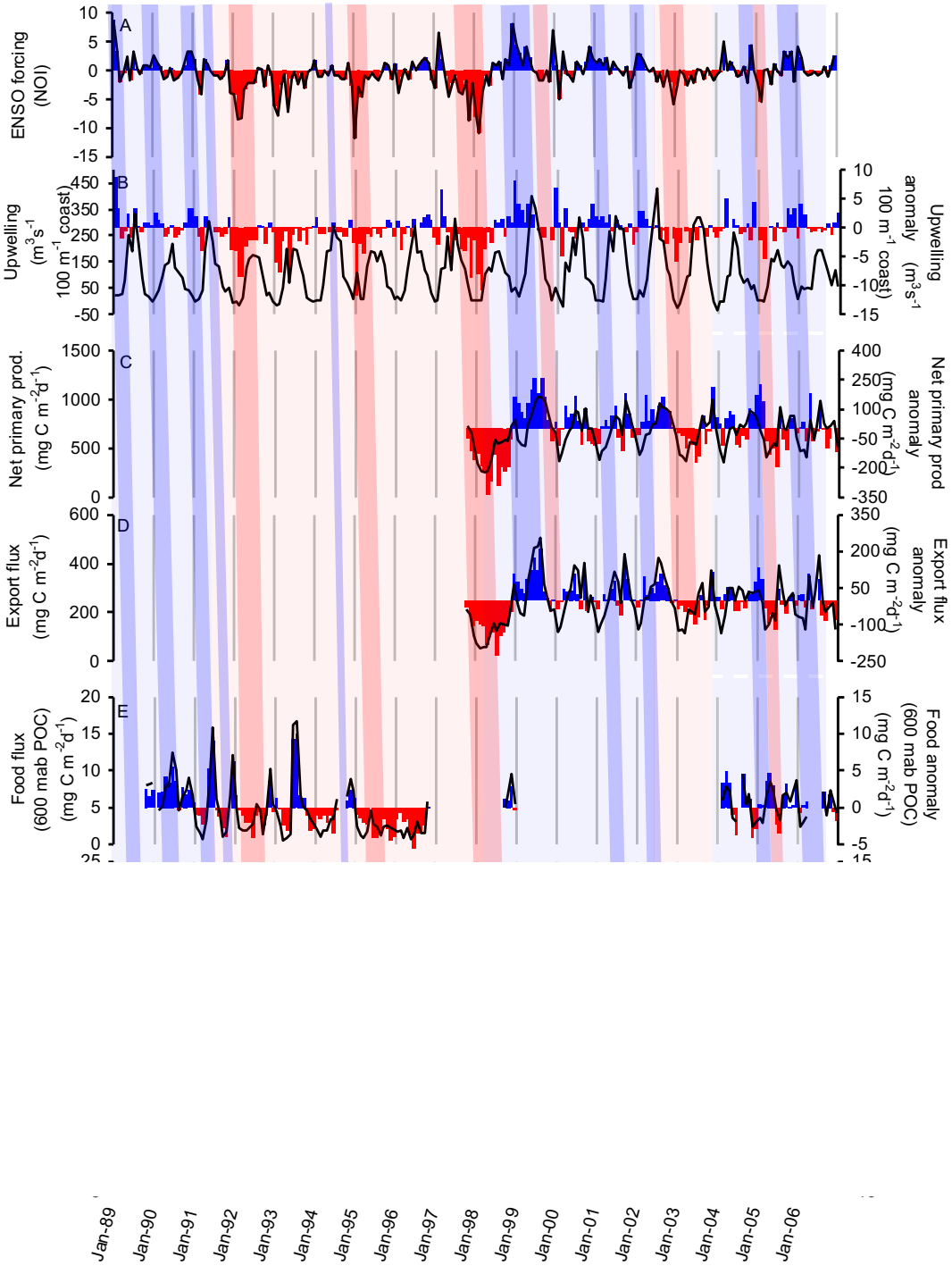
ENSO

Upwelling

Primary Production

Export flux

Henry Ruhl



ENSO

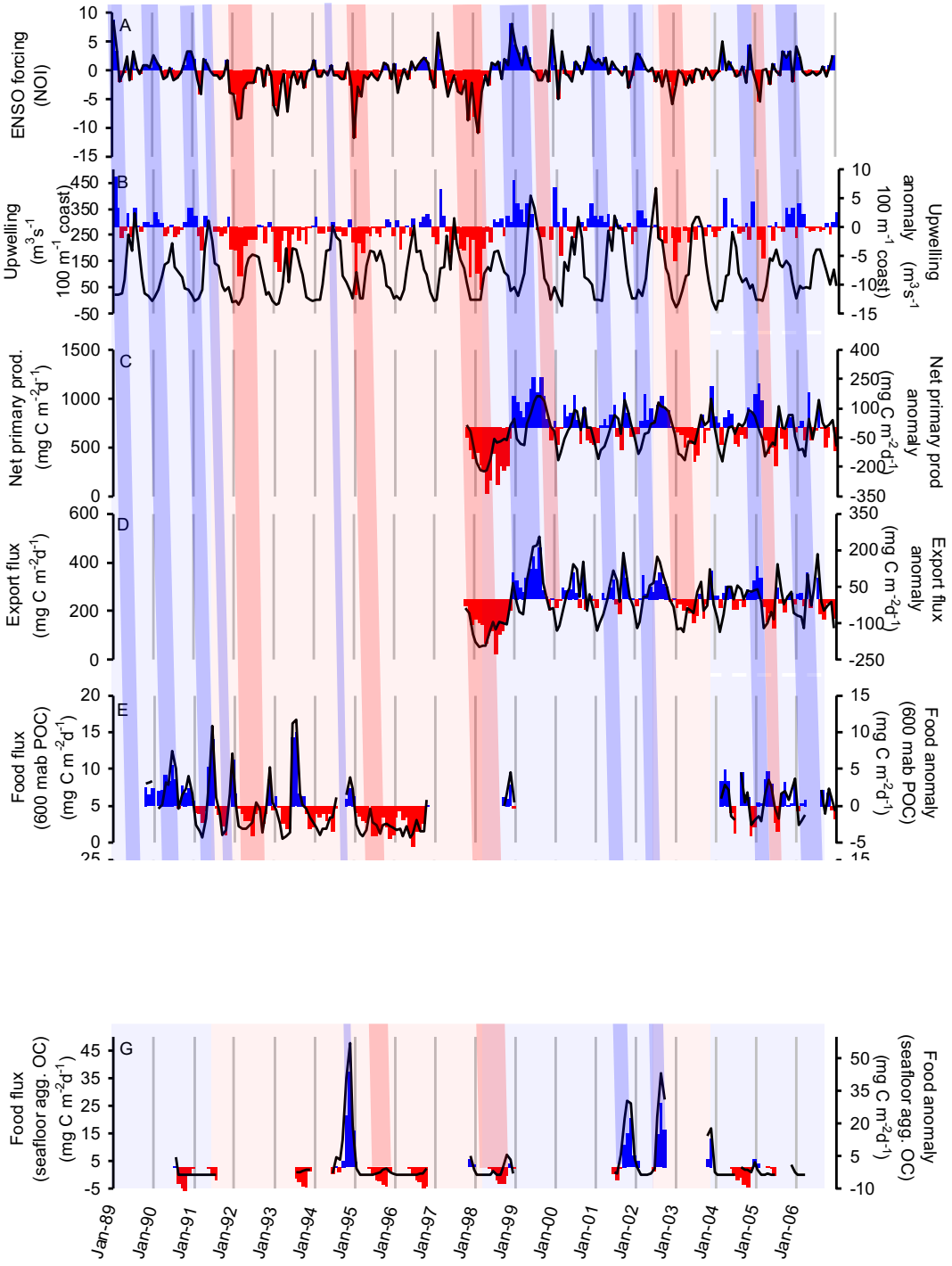
Upwelling

Primary Production

Export flux

Flux to seabed

Henry Ruhl



ENSO

Upwelling

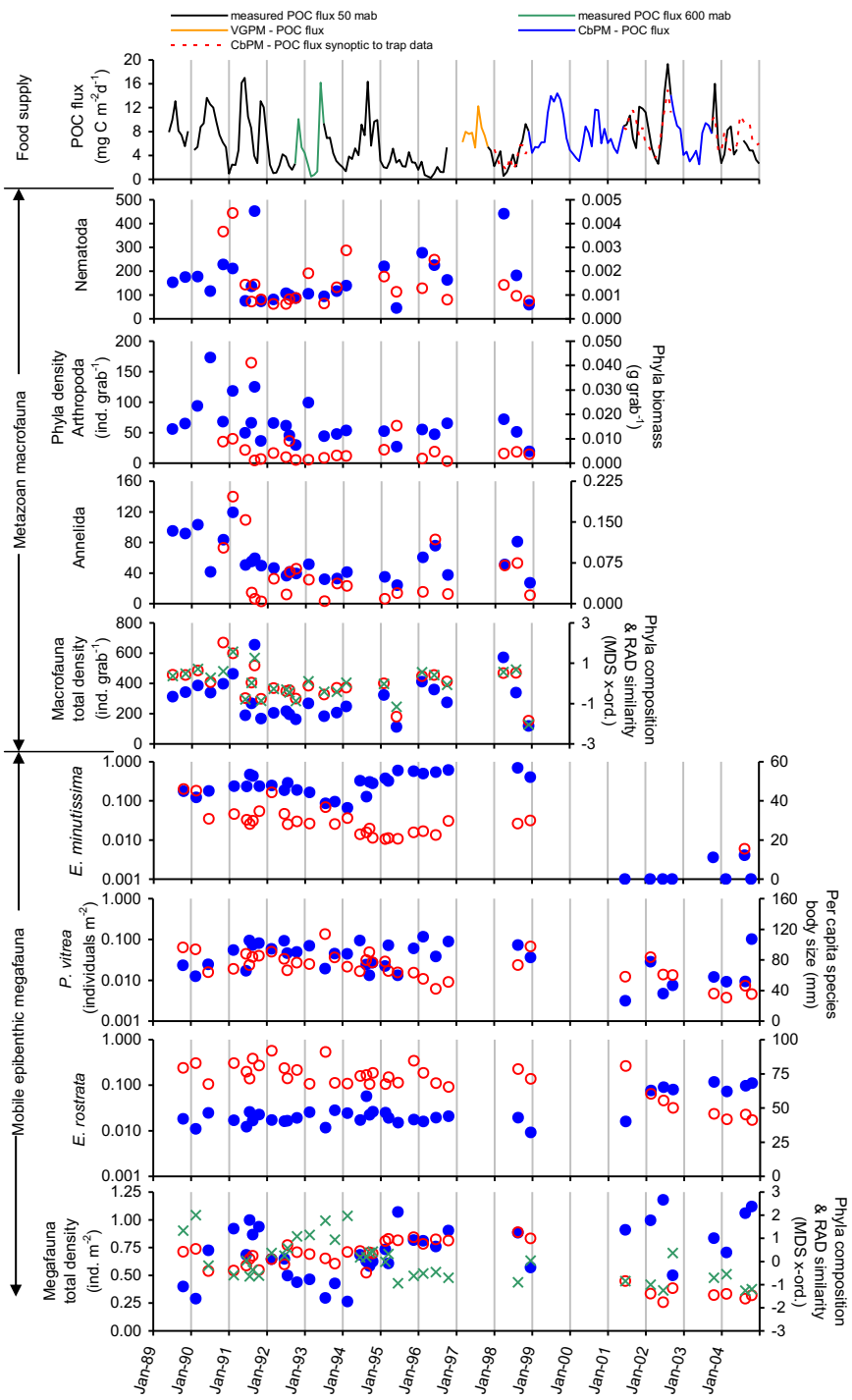
Primary Production

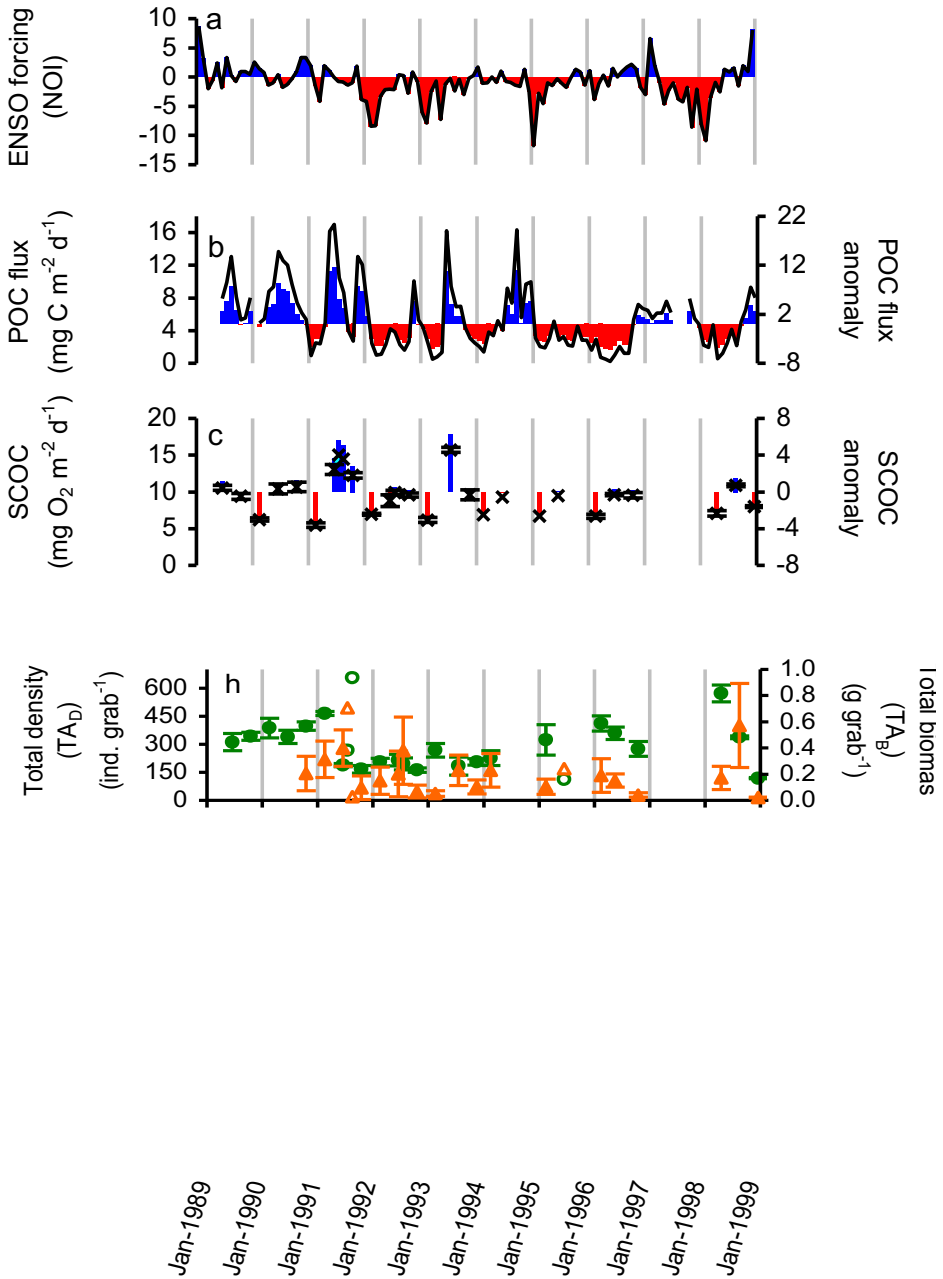
Export flux

Flux to seabed

Aggregate to seabed

Henry Ruhl


measured POC flux 50 mab
VGPM - POC flux
CbPM - POC flux synoptic to trap data
measured POC flux 600 mab
CbPM - POC flux
Food supply
POC flux (mg C m-2 d-1)
Metazoan macrofauna
Nematoda
Phyla density Arthropoda (ind. grab-1)
Phyla biomass (g grab-1)
Annelida
Macrofauna total density (ind. grab-1)
Phyla composition & RAD similarity (MDS x-ord.)
Mobile epibenthic megafauna
E. minutissima
P. vitrea (individuals m-2)
Per capita species body size (mm)
E. rostrata
Megafauna total density (ind. m-2)
Phyla composition & RAD similarity (MDS x-ord.)
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04


ENSO forcing (NOI)
a
10
5
0
-5
-10
-15
POC flux (mg C m-2 d-1)
b
16
12
8
4
0
22
12
2
-8
POC flux anomaly
SCOC (mg O2 m-2 d-1)
c
20
15
10
5
0
8
4
0
-4
-8
SCOC anomaly
Total density (TAD) (ind. grab-1)
h
600
450
300
150
0
1.0
0.8
0.6
0.4
0.2
0.0
Total biomas (TAB) (g grab-1)
Jan-1989
Jan-1990
Jan-1991
Jan-1992
Jan-1993
Jan-1994
Jan-1995
Jan-1996
Jan-1997
Jan-1998
Jan-1999

Henry Ruhl

Complexity but not impossibility

Developments in models, observational techniques, experiments etc

Models:

- Better parameterisation
- Novel models eg Finite element

Observational techniques:

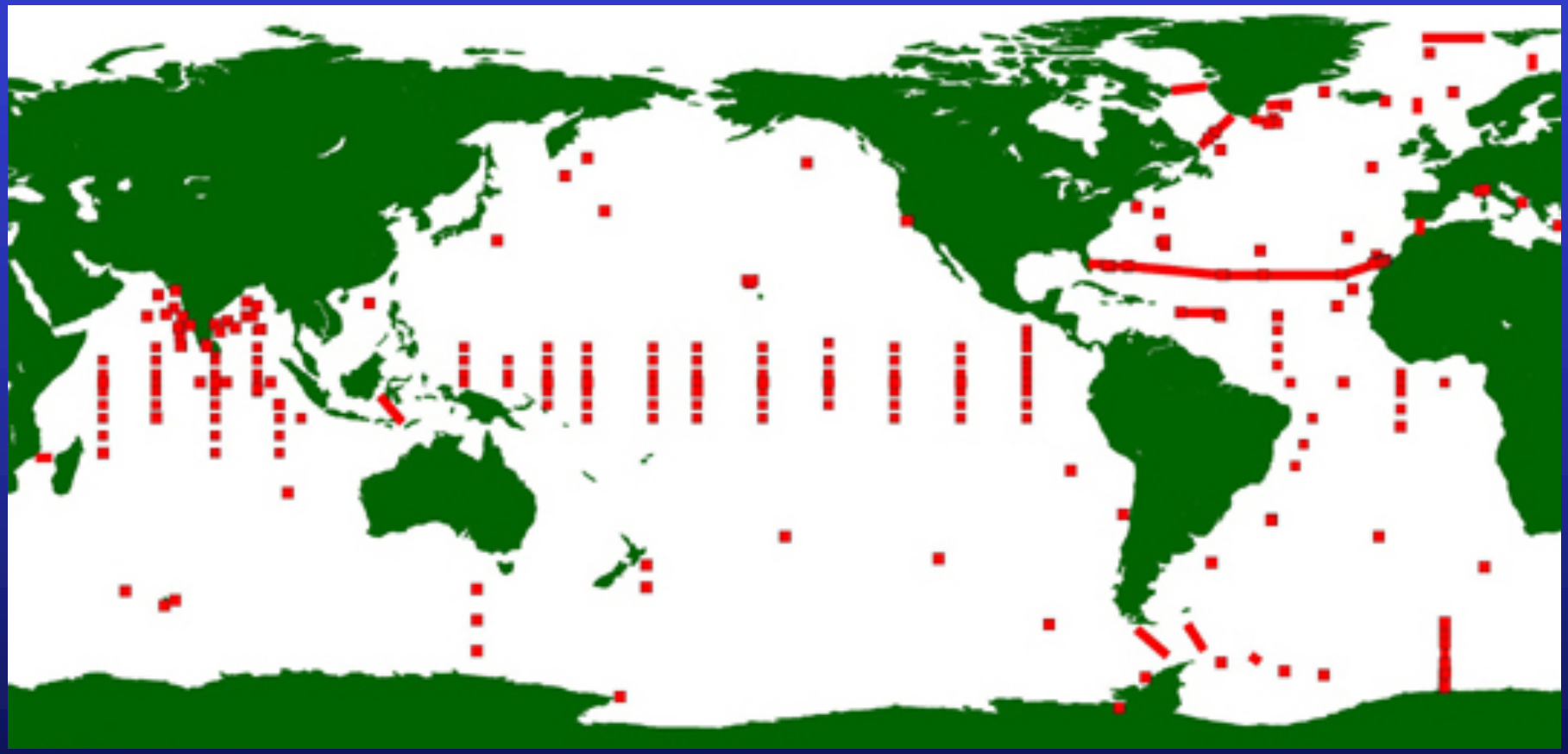
- Drifting sediment traps
- Instrumented buoys
- Eulerian observatory network
- Satellite remote sensing

Experimentation:

- Open ocean eg Iron fertilisation
- Mesocosm
- Laboratory

A shoal of PELAGRA traps

(May 2008 on board RV Knorr)



OceanSITES fixed point observatories

EuroSITES

An FP7 integrated European network of deep ocean multidisciplinary observatories

Coordinated by:
NOC
Richard Lampitt
Assistant coordinator: Dr Kate Larkin

Started April 1st 2008 for 3 years

www.EuroSIES.info

Relevant features of flux:

1. Annual supply of POC
2. Seasonal variability in supply
3. Interannual variability
4. Quality of organics
5. Sinking rate of particles
6. Regional variation
7. Match-Mismatch

The End