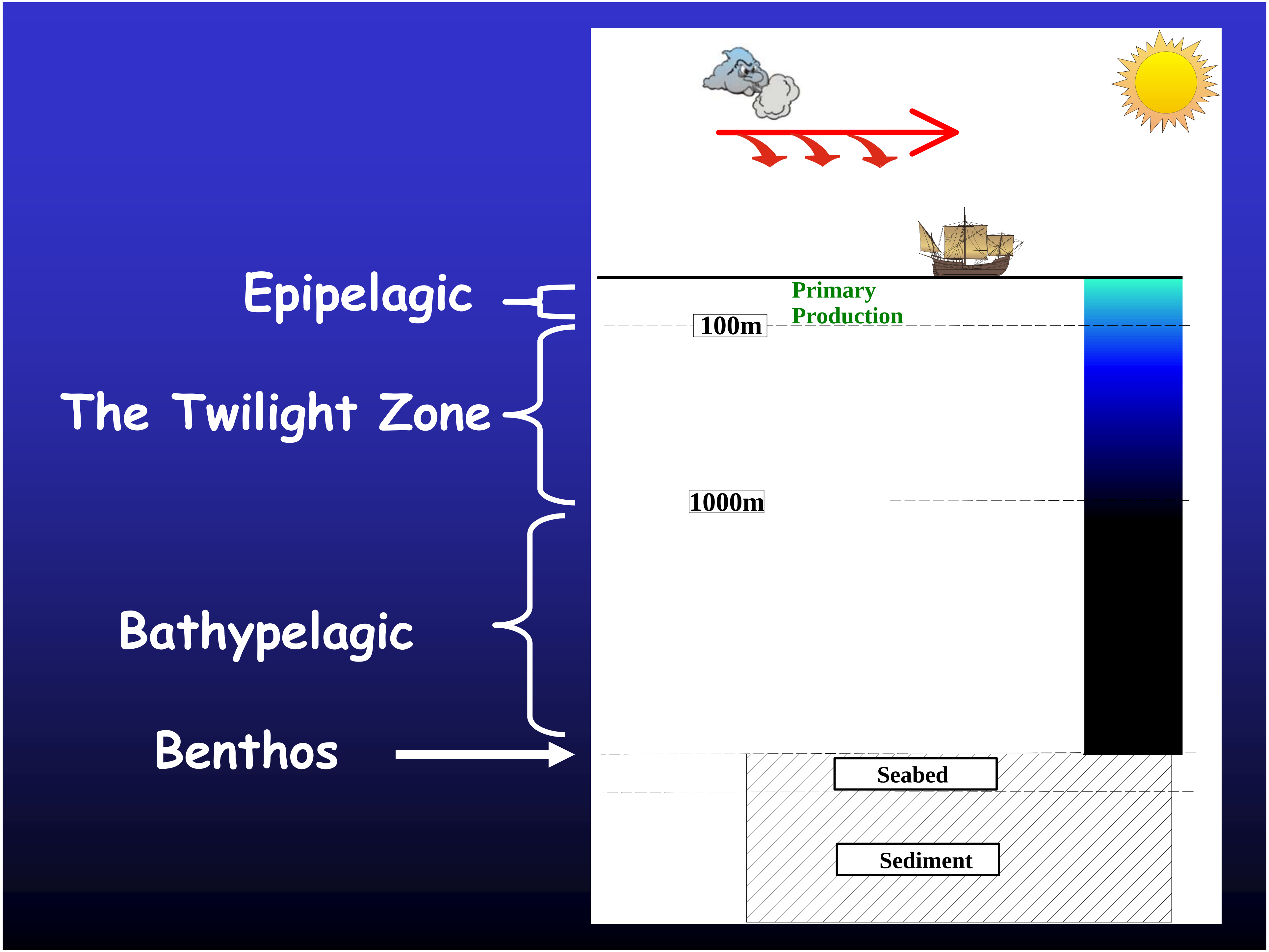
Biogeochemical and ecological coupling between the epipelagic and the deep sea: regional to global implications

Richard Lampitt

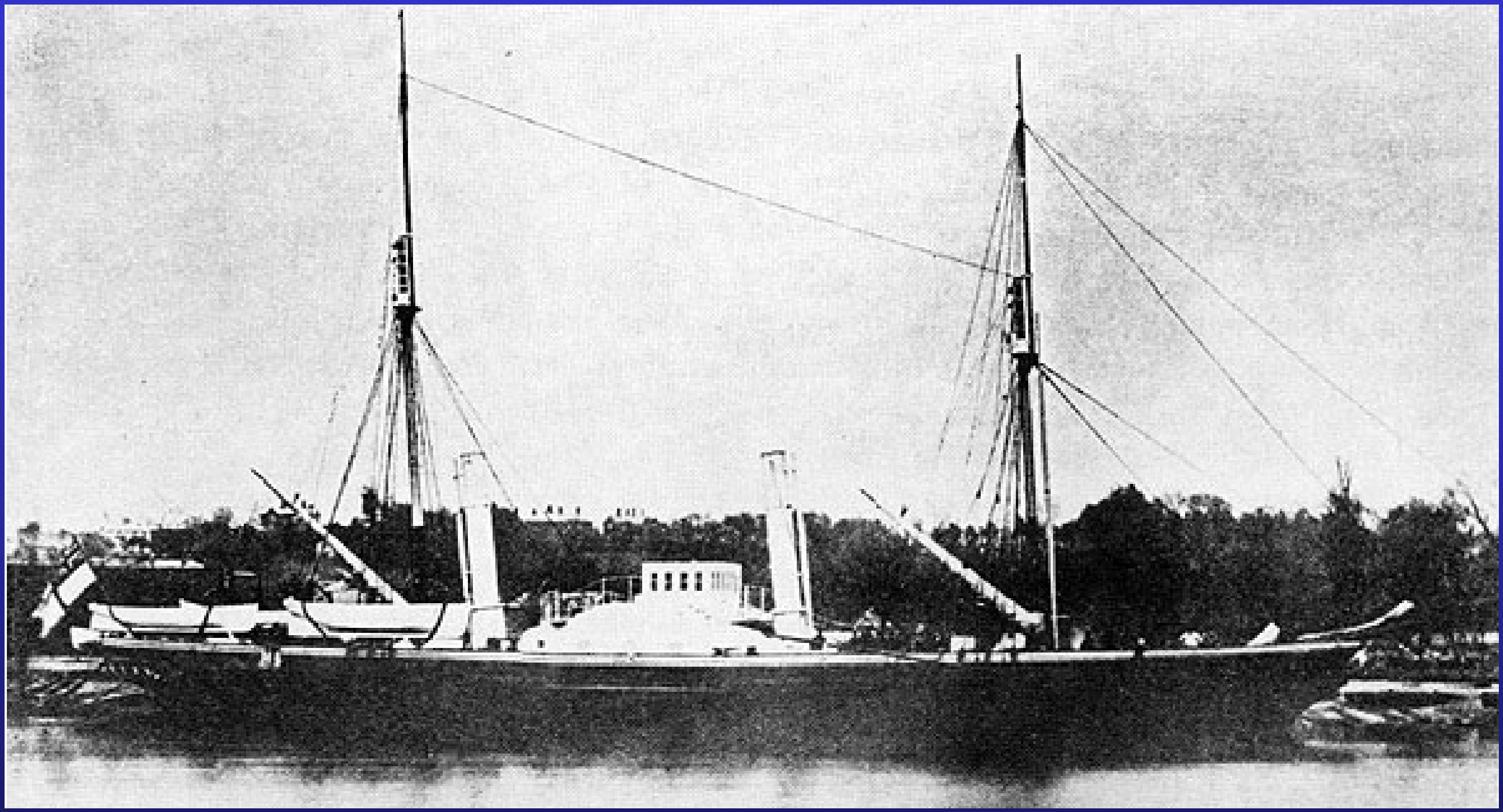
NOC

UK

OCB Hawaii September 22nd 2010

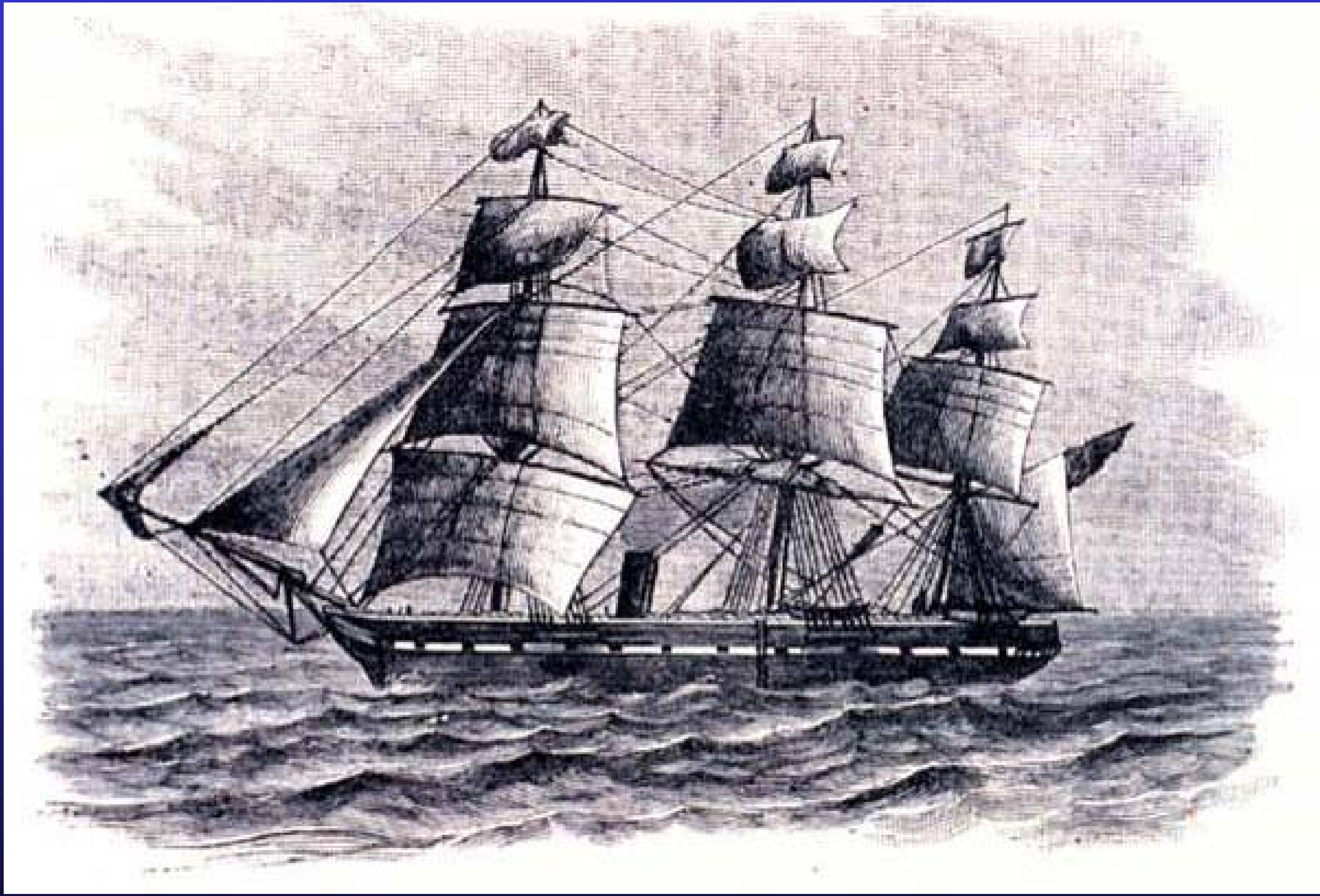

Epipelagic
The Twilight Zone
Bathypelagic
Benthos
Primary Production
100m
1000m
Seabed
Sediment

In order to monitor and understand the marine system we need to make sustained multidisciplinary observations at appropriate temporal resolution.

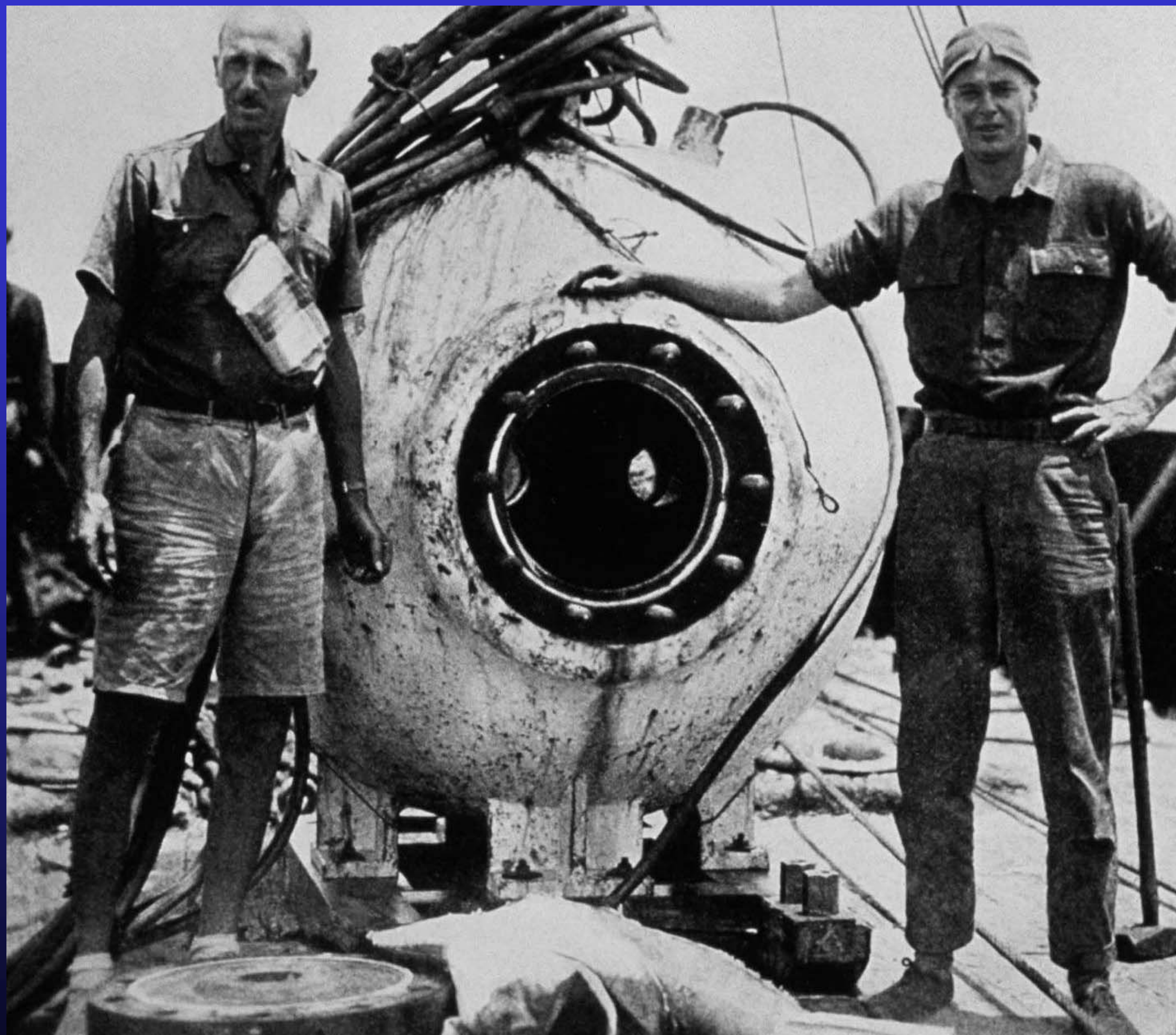


HMS Porcupine

N.E. Atlantic and Mediterranean 1869 and 1870.



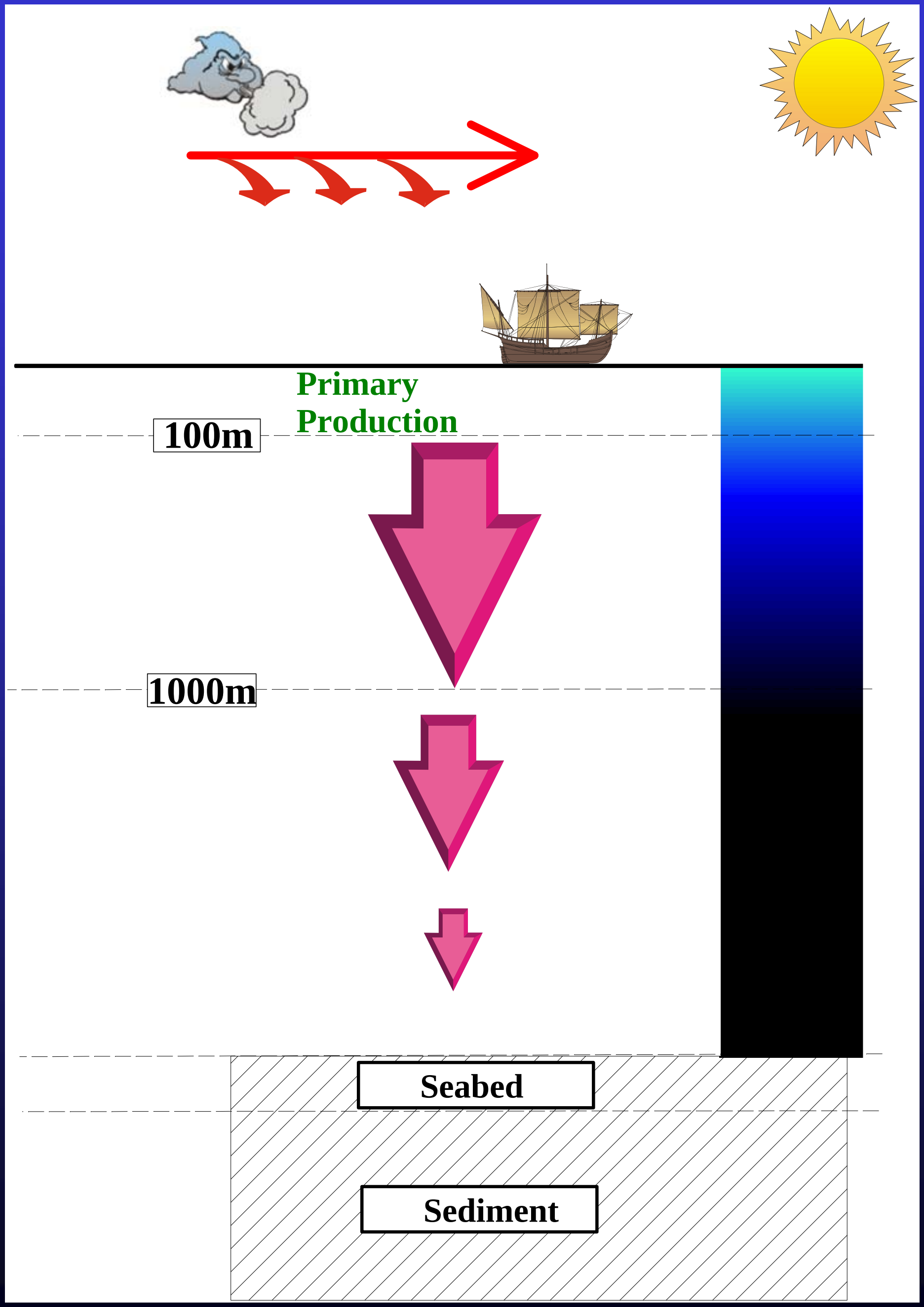
HMS Challenger, 1872-1876

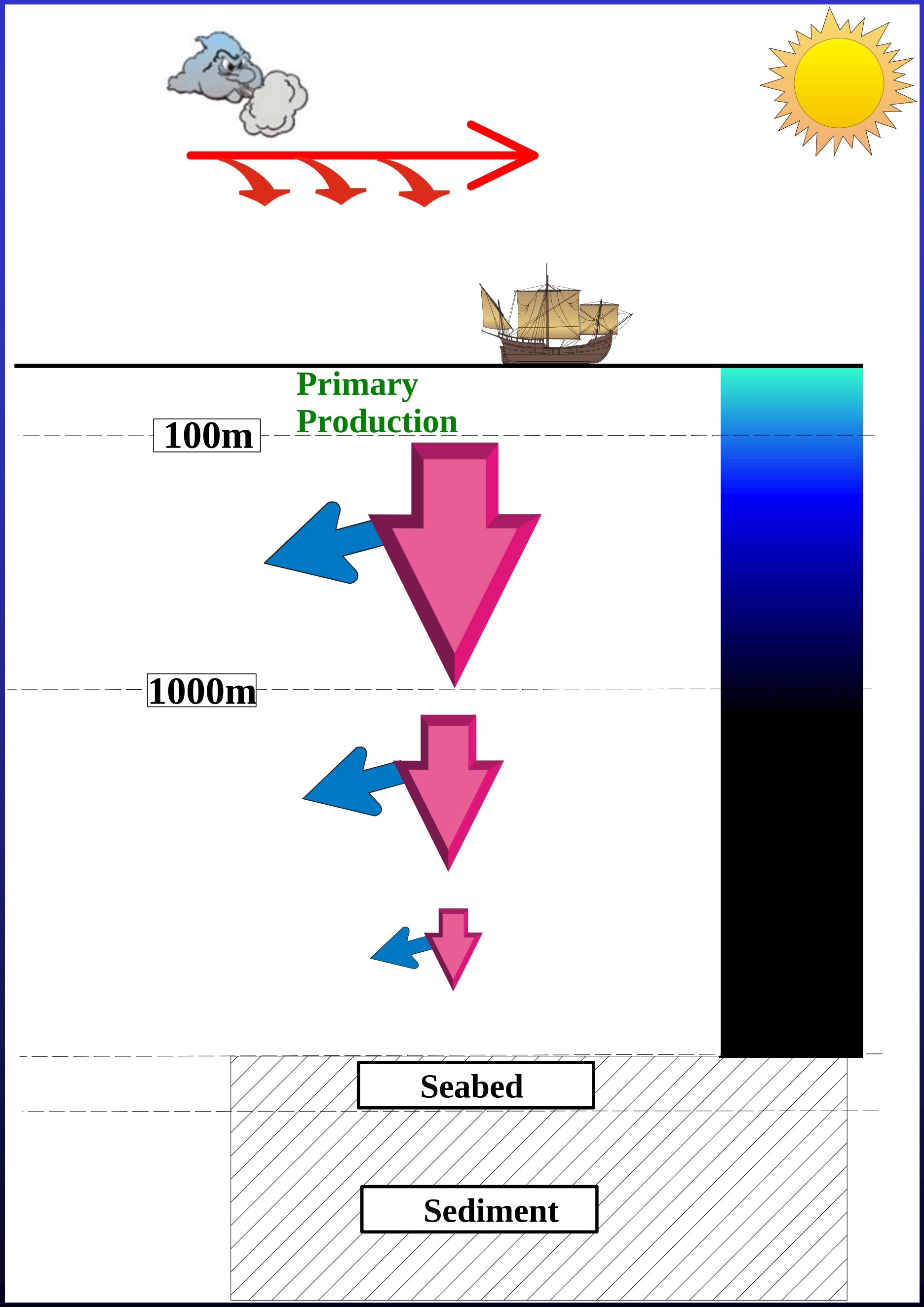


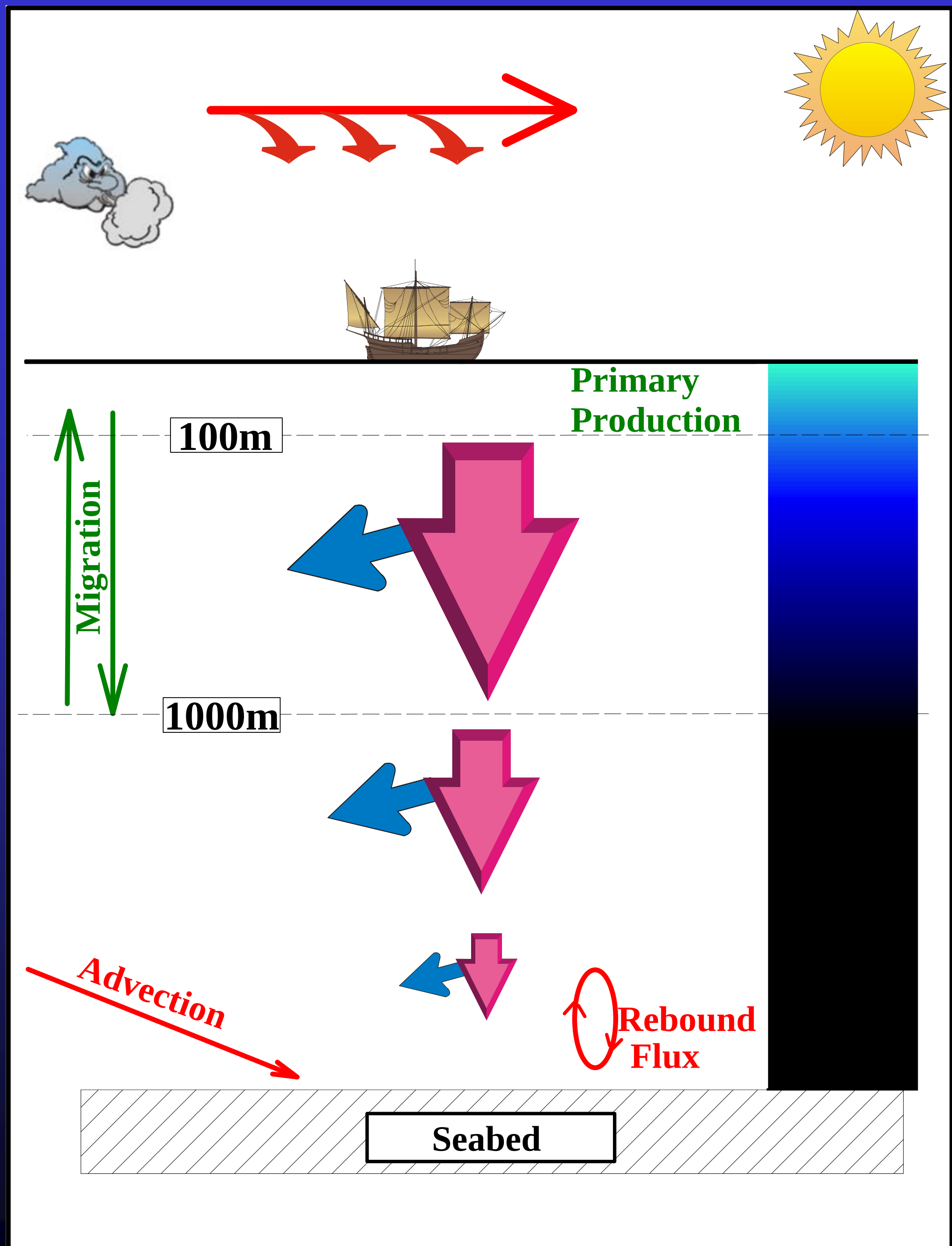
William Beebe and Otis Barton in 1932

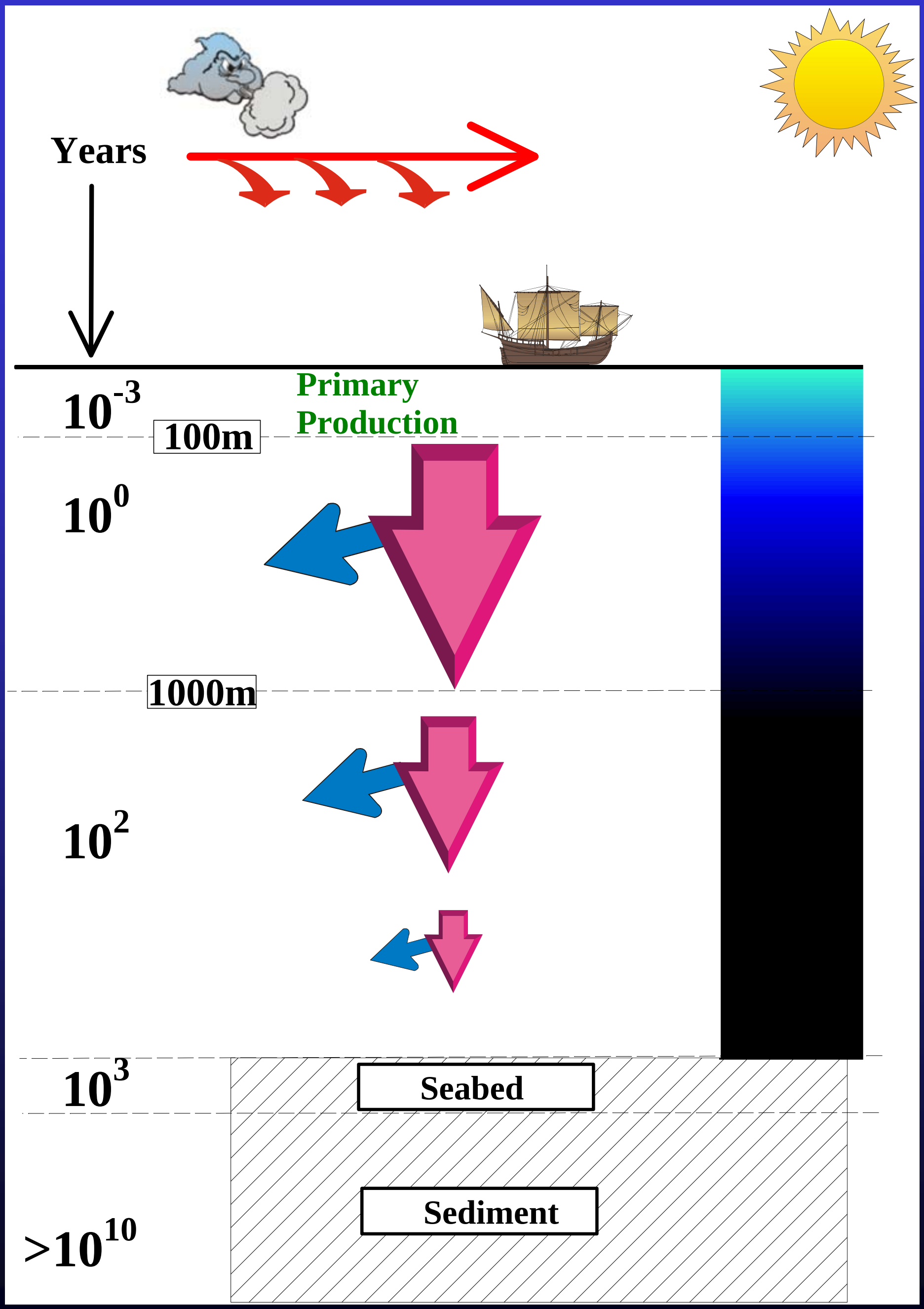
1. The twilight zone (Mesopelagic)
2. Bathypelagic
3. Benthos

All in the context of time series

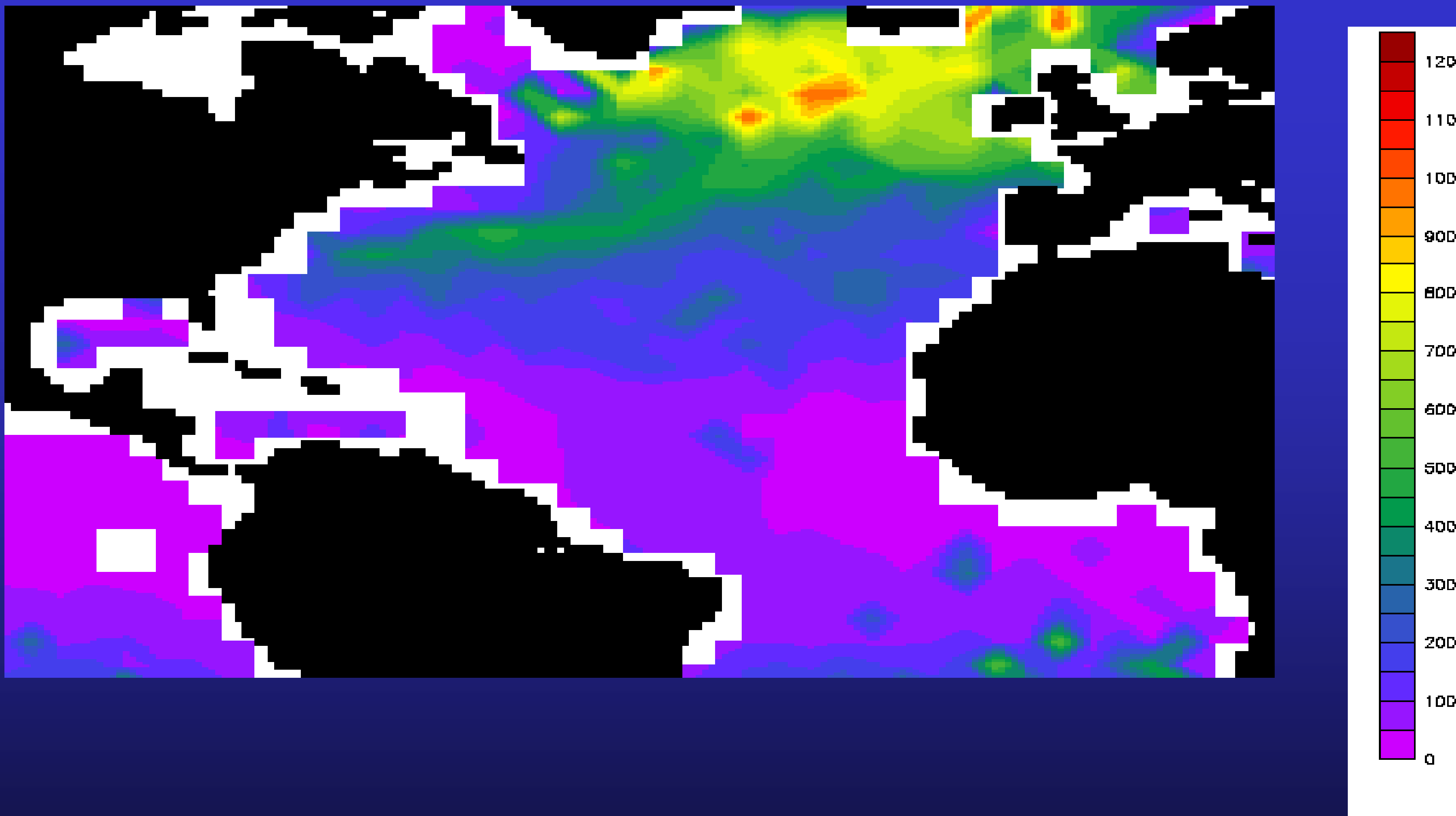

Primary
Production
100m
1000m
Seabed
Sediment


Primary
Production
100m
1000m
Seabed
Sediment


Primary
Production
100m
Migration
1000m
Advection
Rebound
Flux
Seabed



Years
Primary Production
10^{-3}
100m
10^{0}
1000m
10^{2}
10^{3}
Seabed
Sediment
$>10^{10}$



Maximum monthly mean mixed layer depth, 1980-2001 (m)

(MLD = 0.125 kg/l from surface)

Corinne Lequere (pers comm)

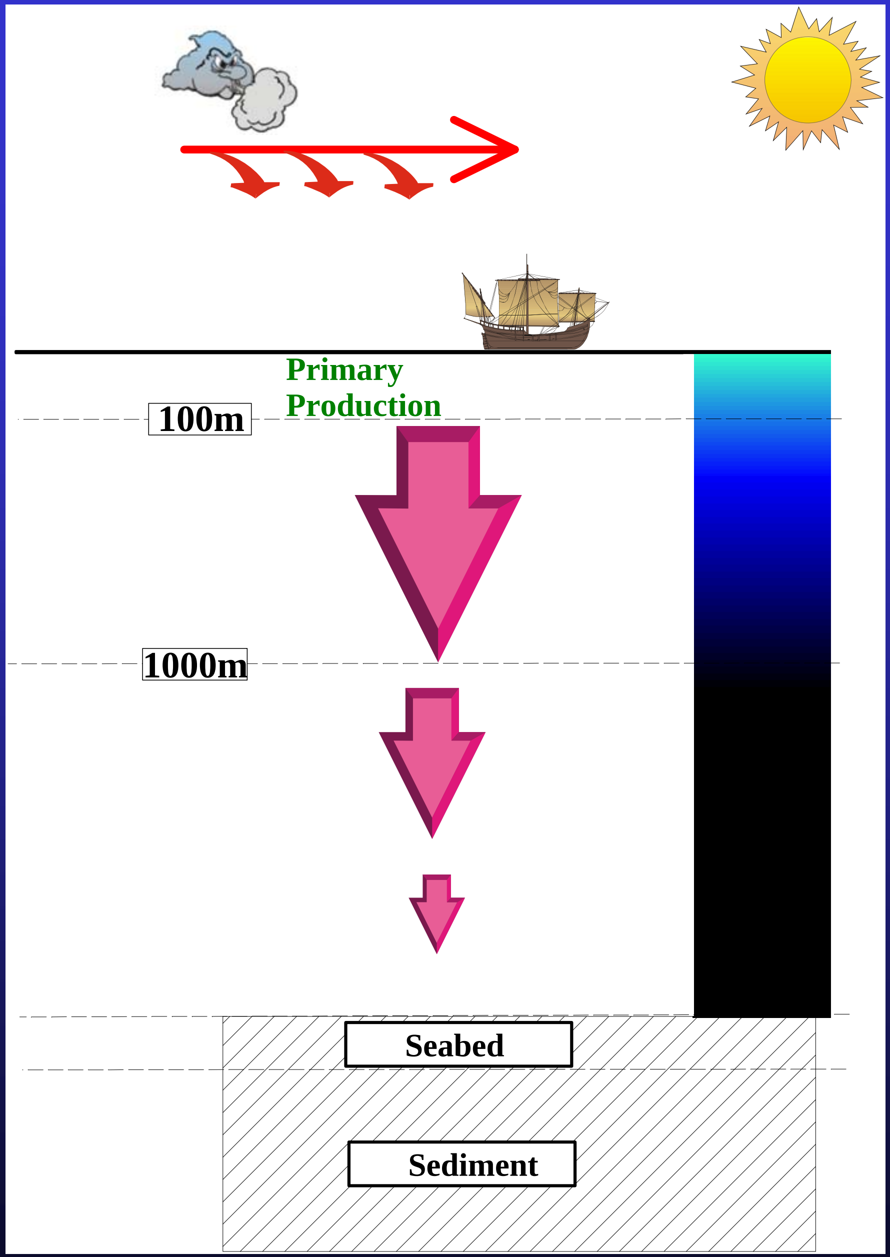
Who cares about the Mesopelagic?

Why we care:

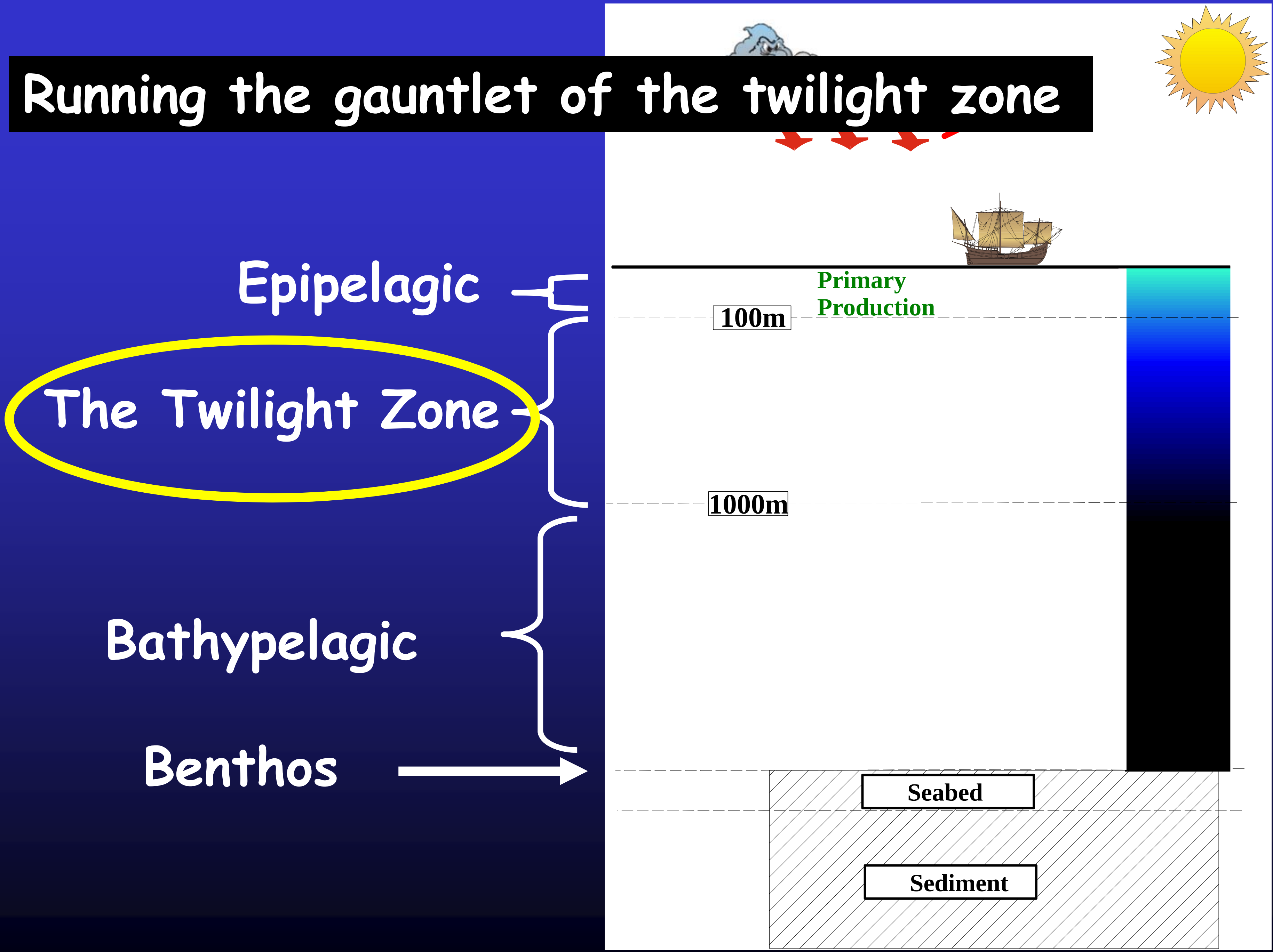
Reflux

Carbon sequestration

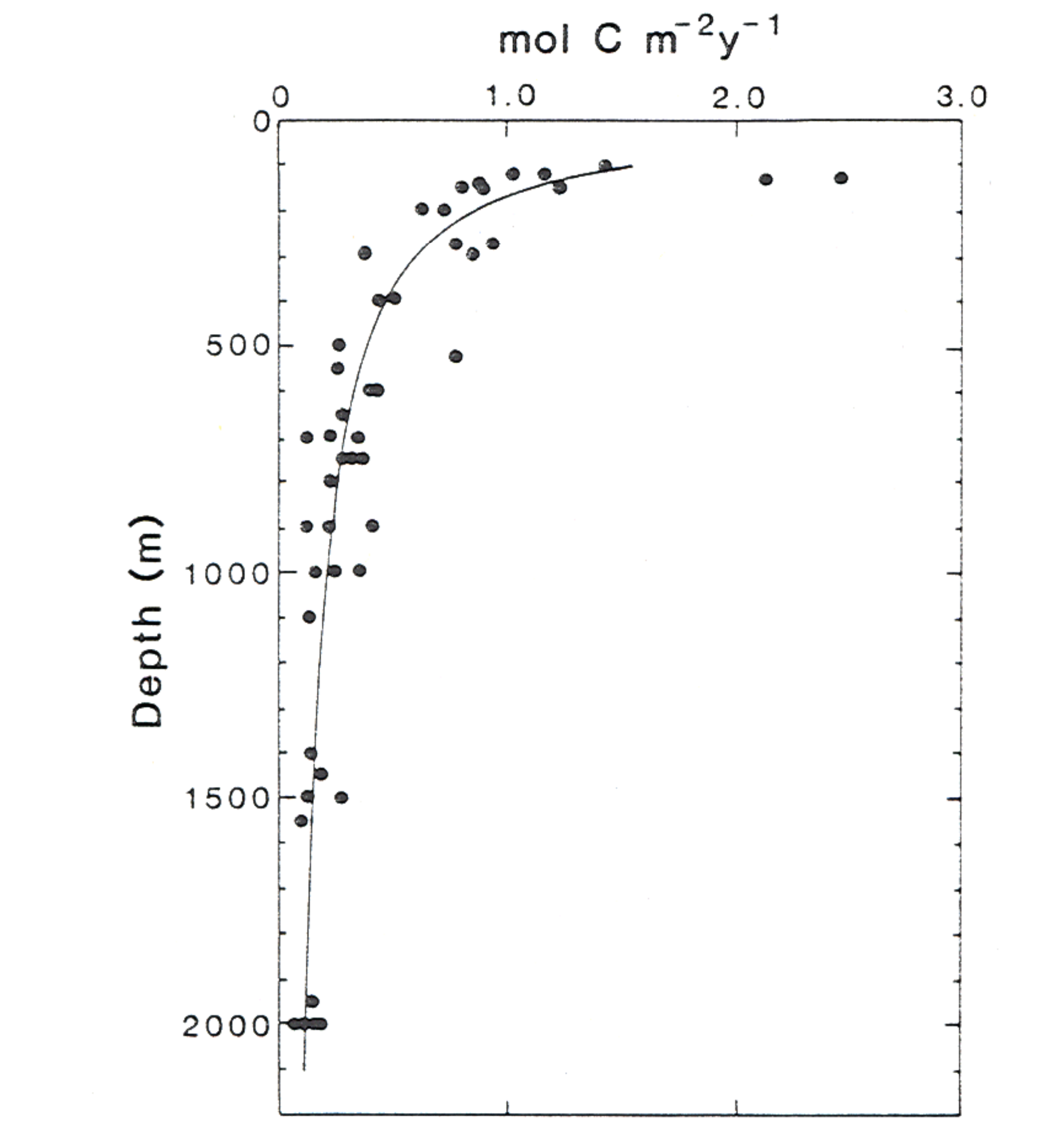
Supply to bathypelagic and benthos



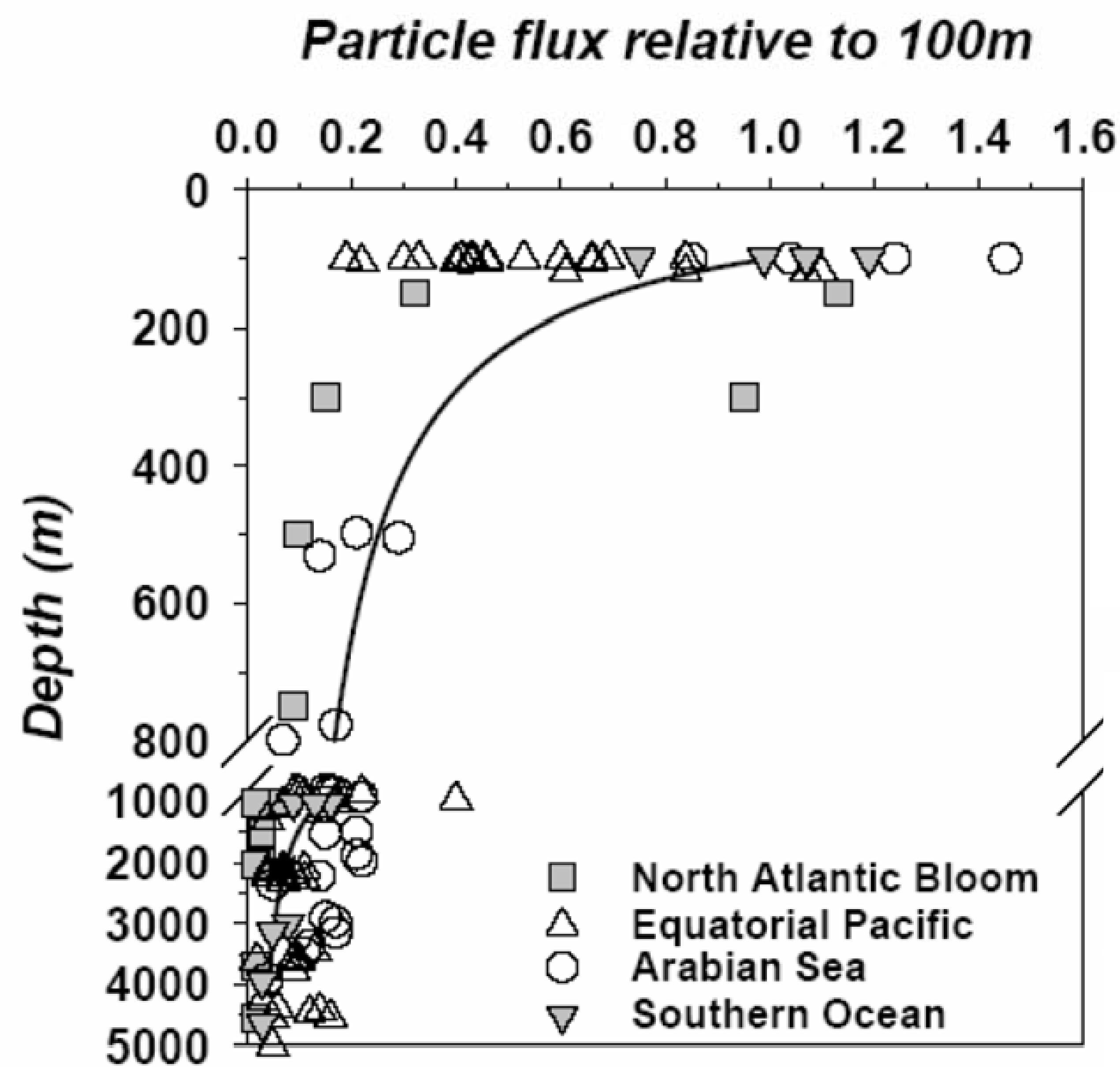
Running the gauntlet of the twilight zone



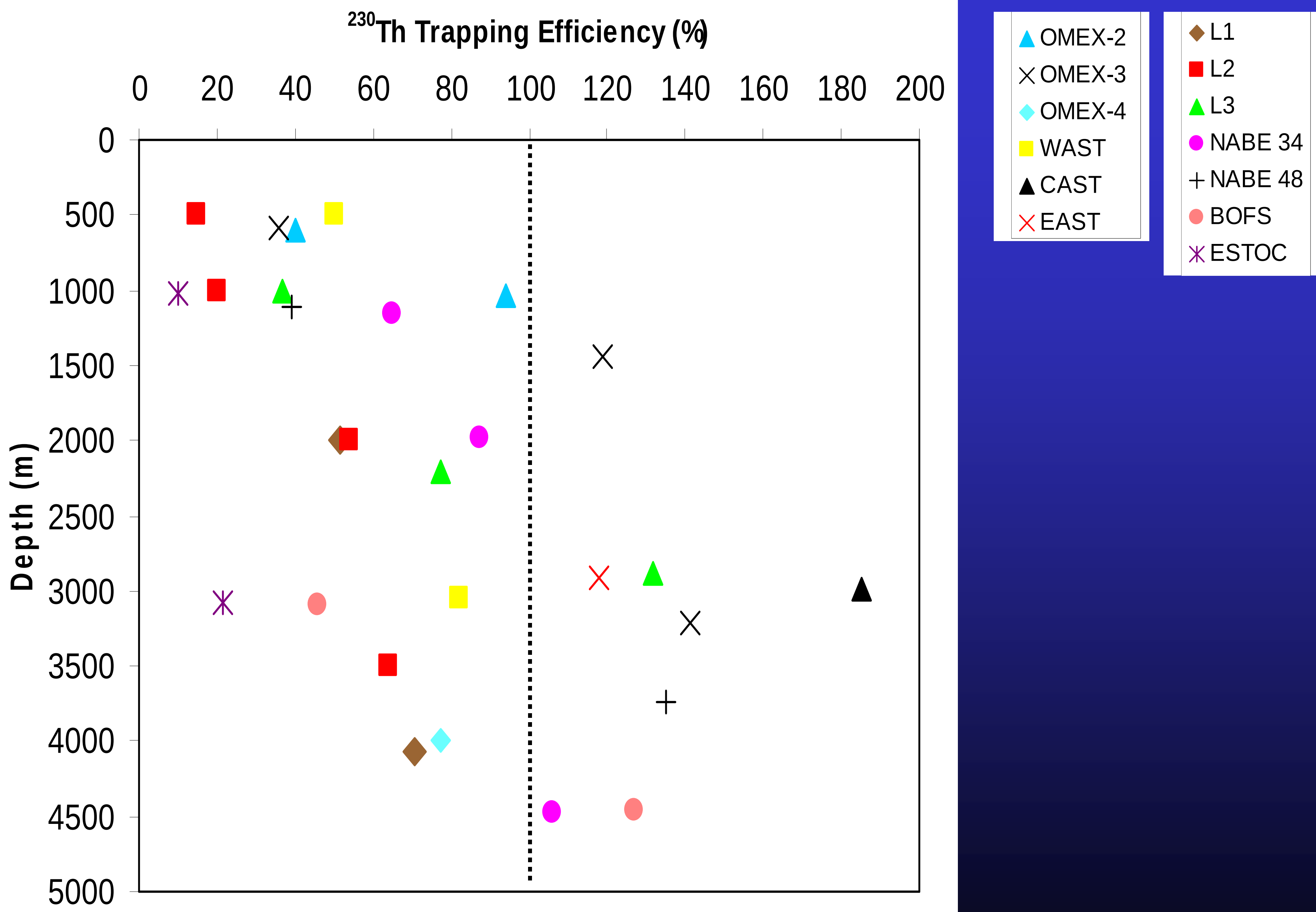
Open Ocean Composite Curve



Martin et al 1987



Carl Lamborg (2006)



Scholten et al 2002

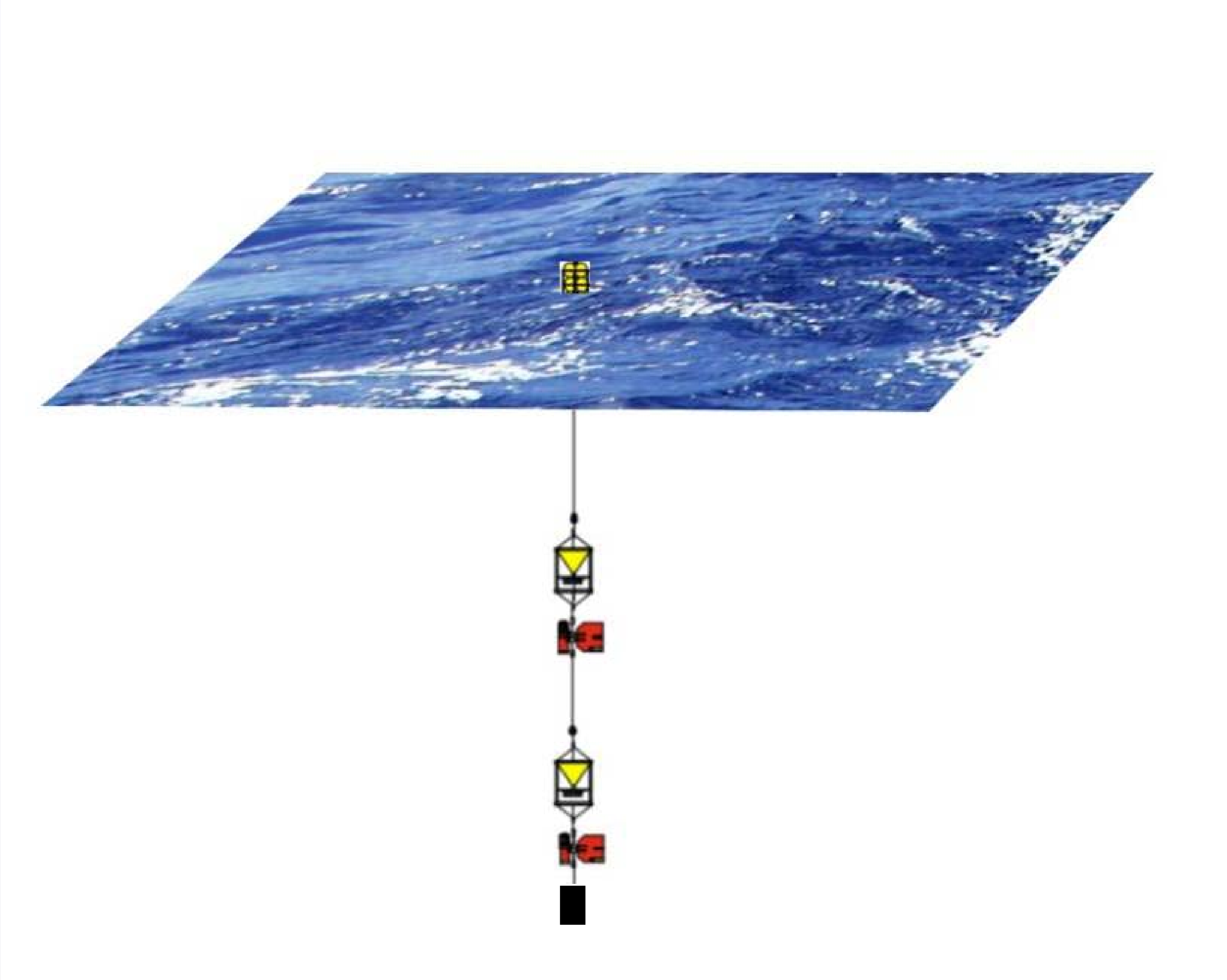
From data and models we know that there is considerable variability in the distribution of flux with depth.

This will be affected by:

1: Characteristics of the source material

2: The nature of midwater processing

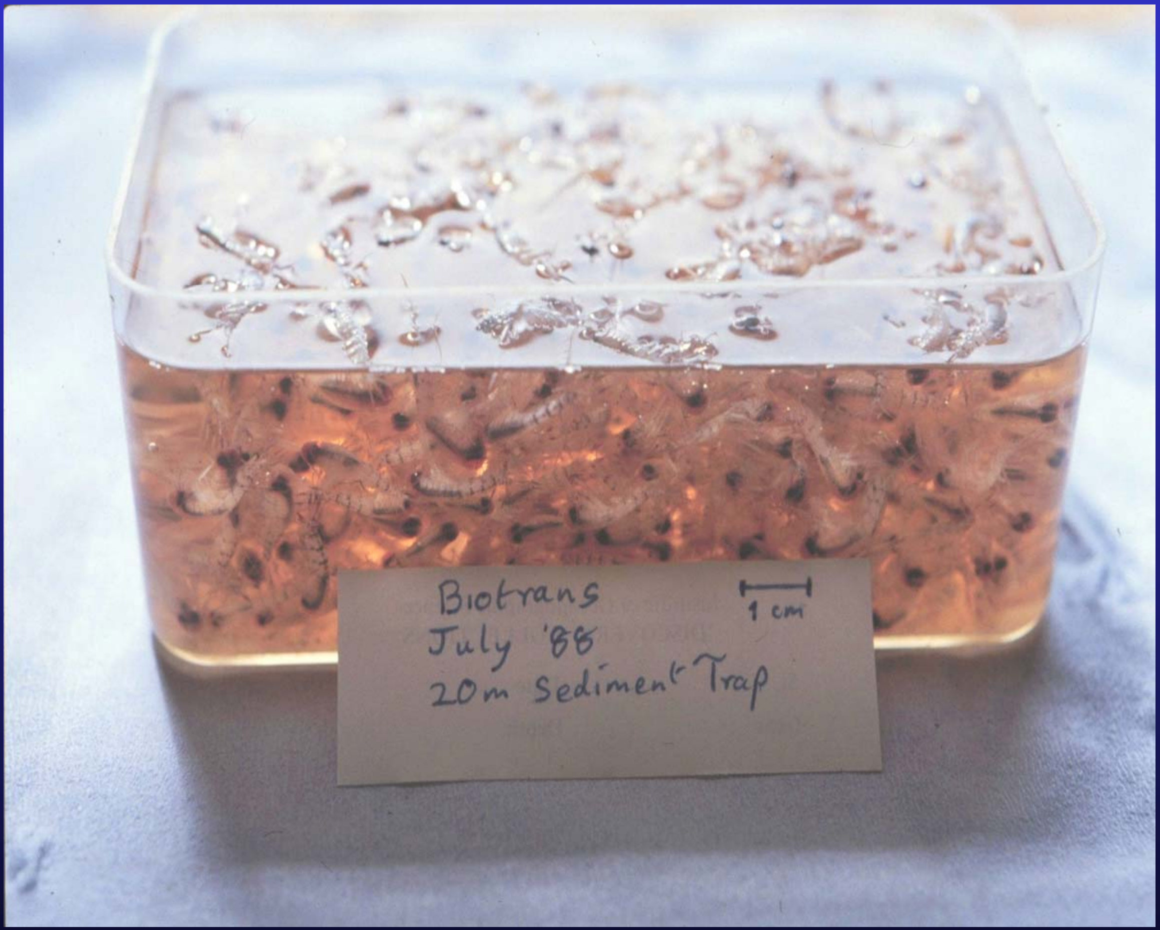
Can we measure this downward flux?



A frequent method of measuring downward flux in upper ocean

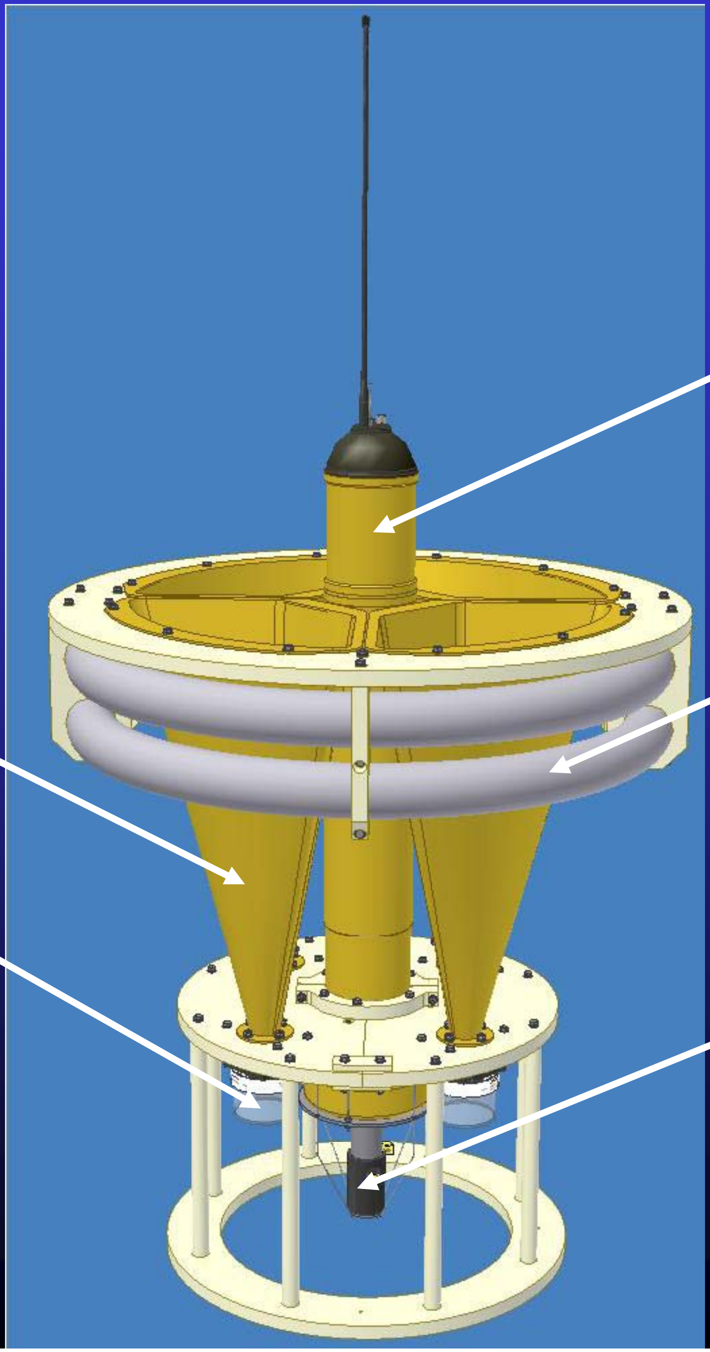
Problems with surface tethered traps

- Hydrodynamic shear
- Swimmer contamination

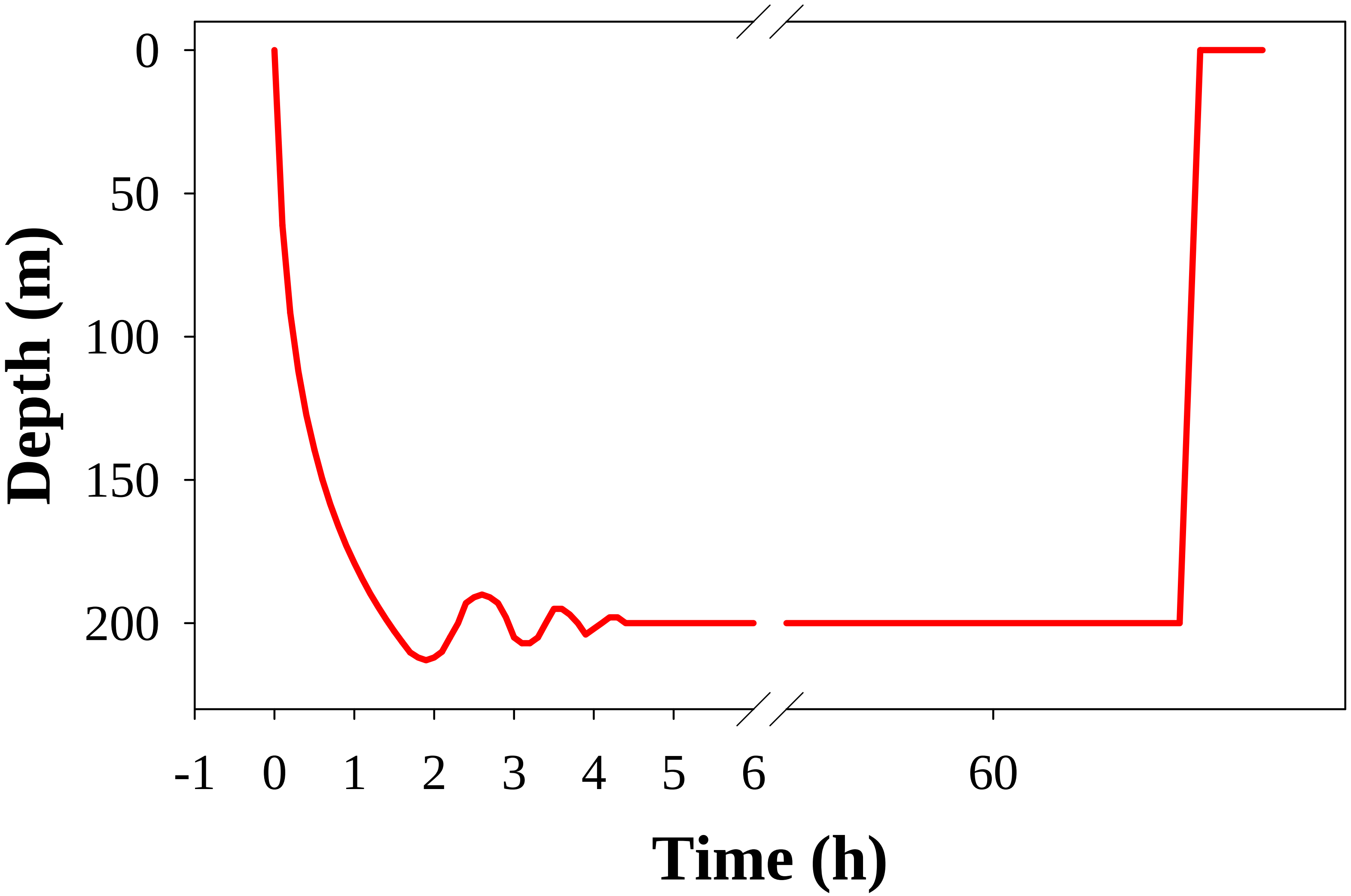


The NBST

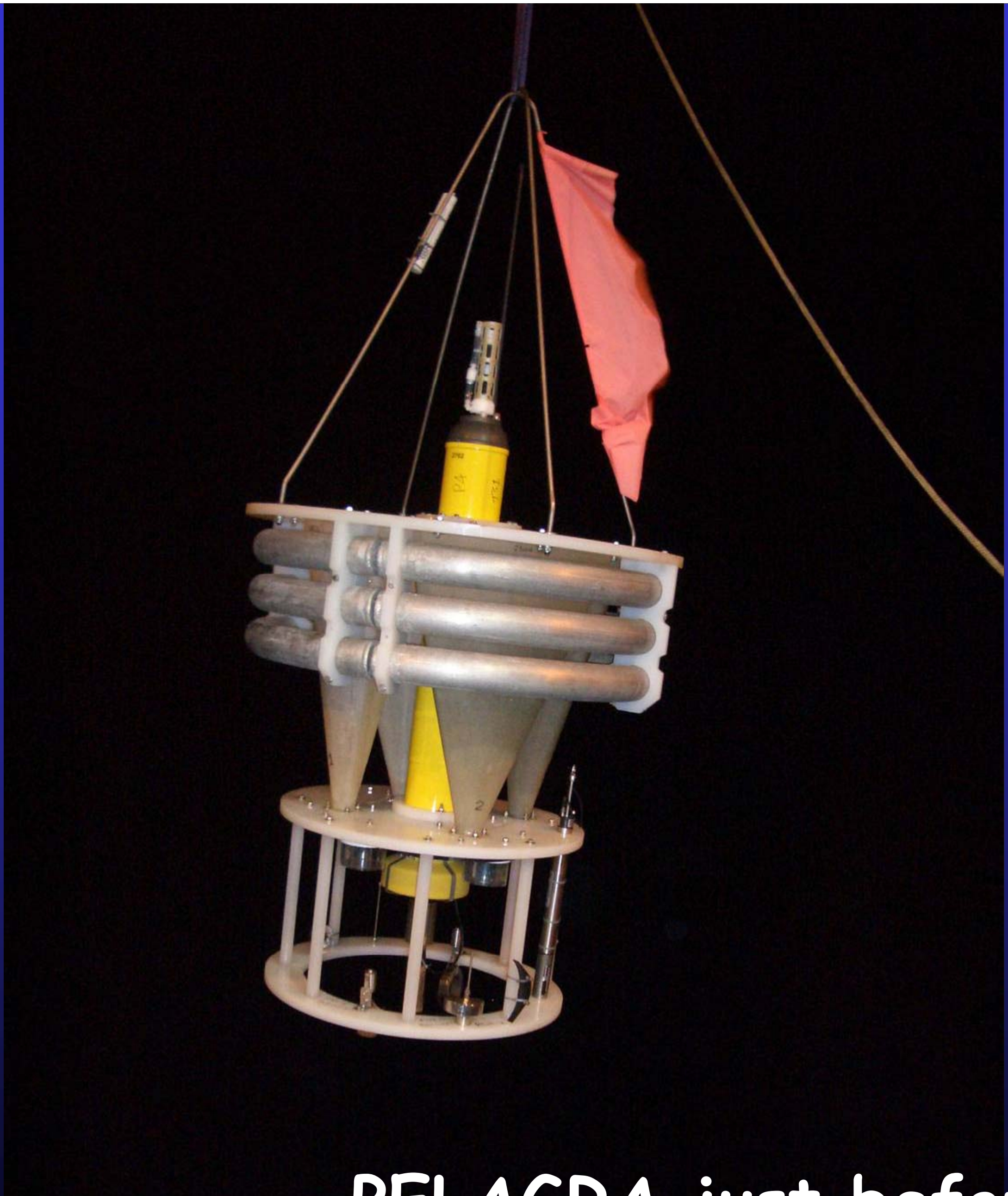
PELAGRA



Kev Saw



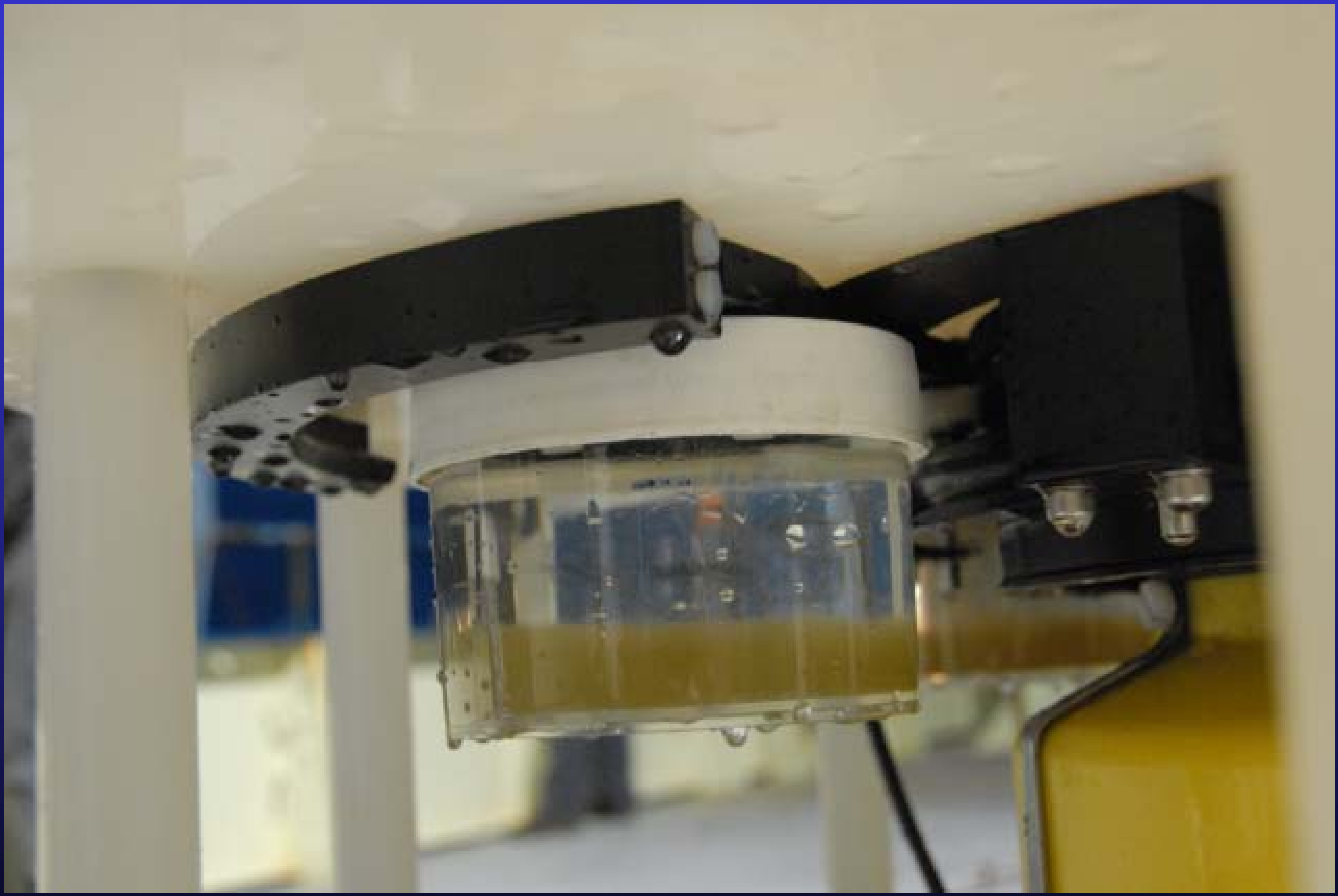
Depth (m)
0
50
100
150
200
-1
0
1
2
3
4
5
6
60
Time (h)

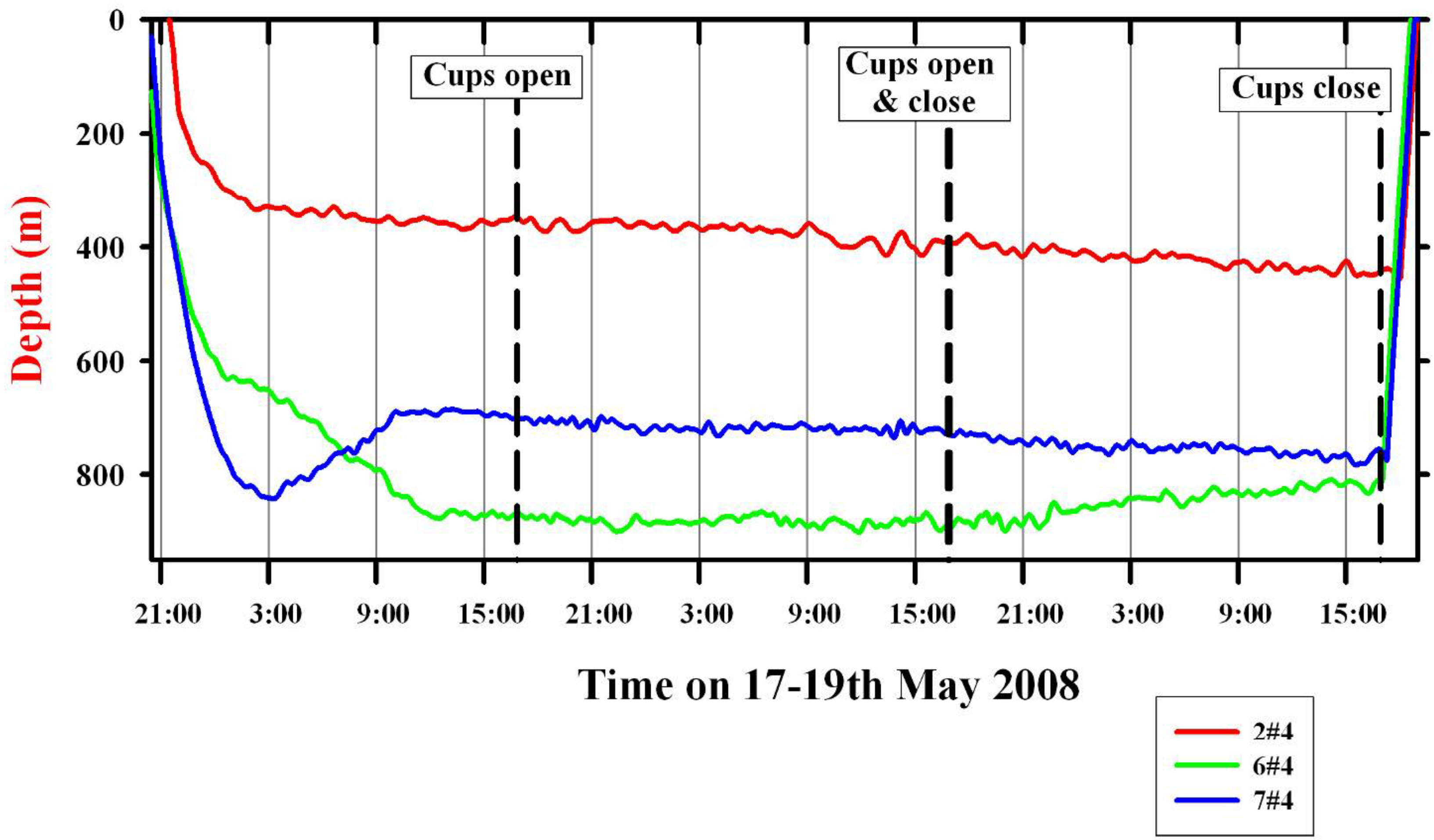


PELAGRA just before deployment July 2006 off RRS Discovery.

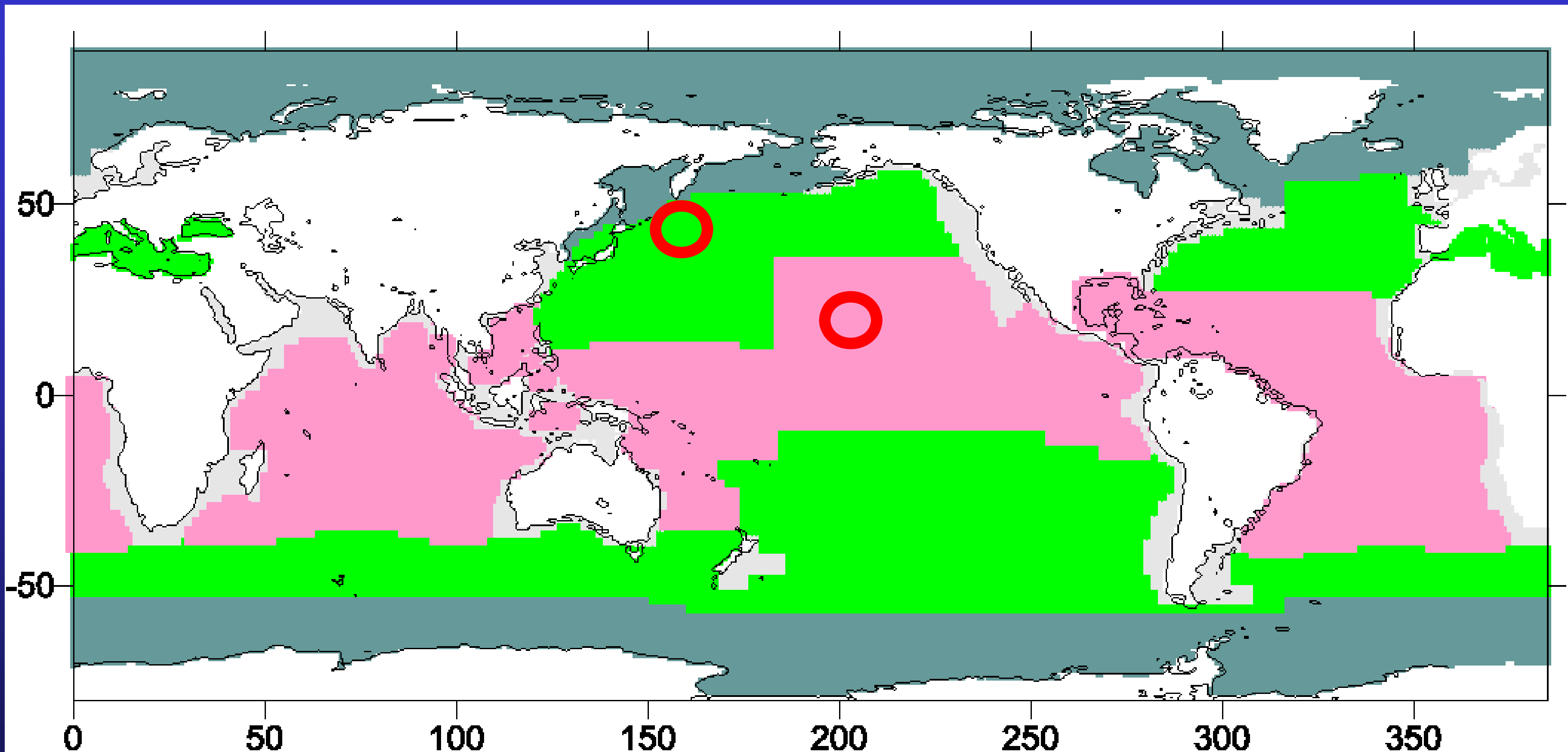
A shoal of PELAGRA traps

(May 2008 on board RV Knorr)





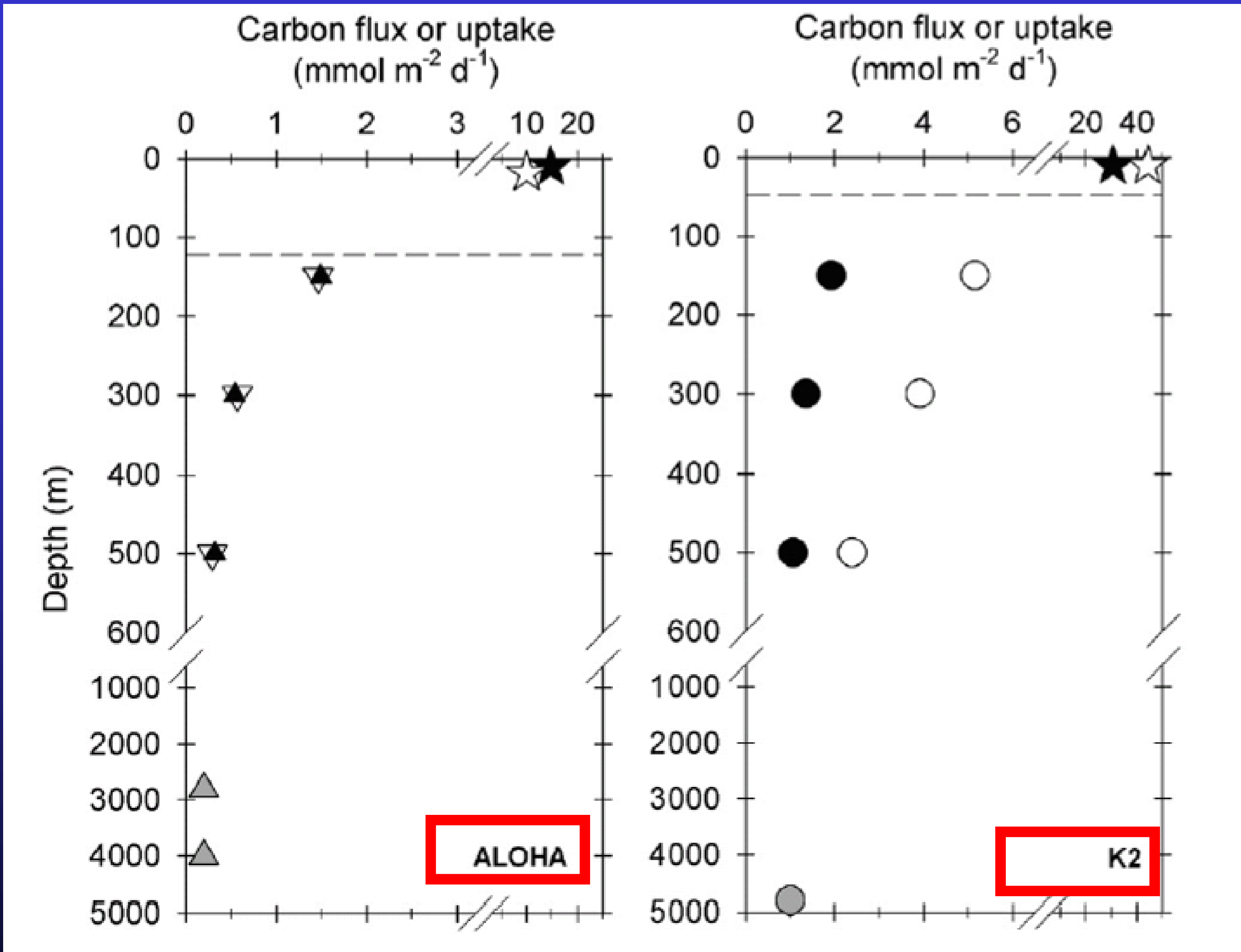
Depth (m)
0
200
400
600
800
Cups open
Cups open
& close
Cups close
21:00
3:00
9:00
15:00
21:00
3:00
9:00
15:00
21:00
3:00
9:00
15:00
Time on 17-19th May 2008
2#4
6#4
7#4



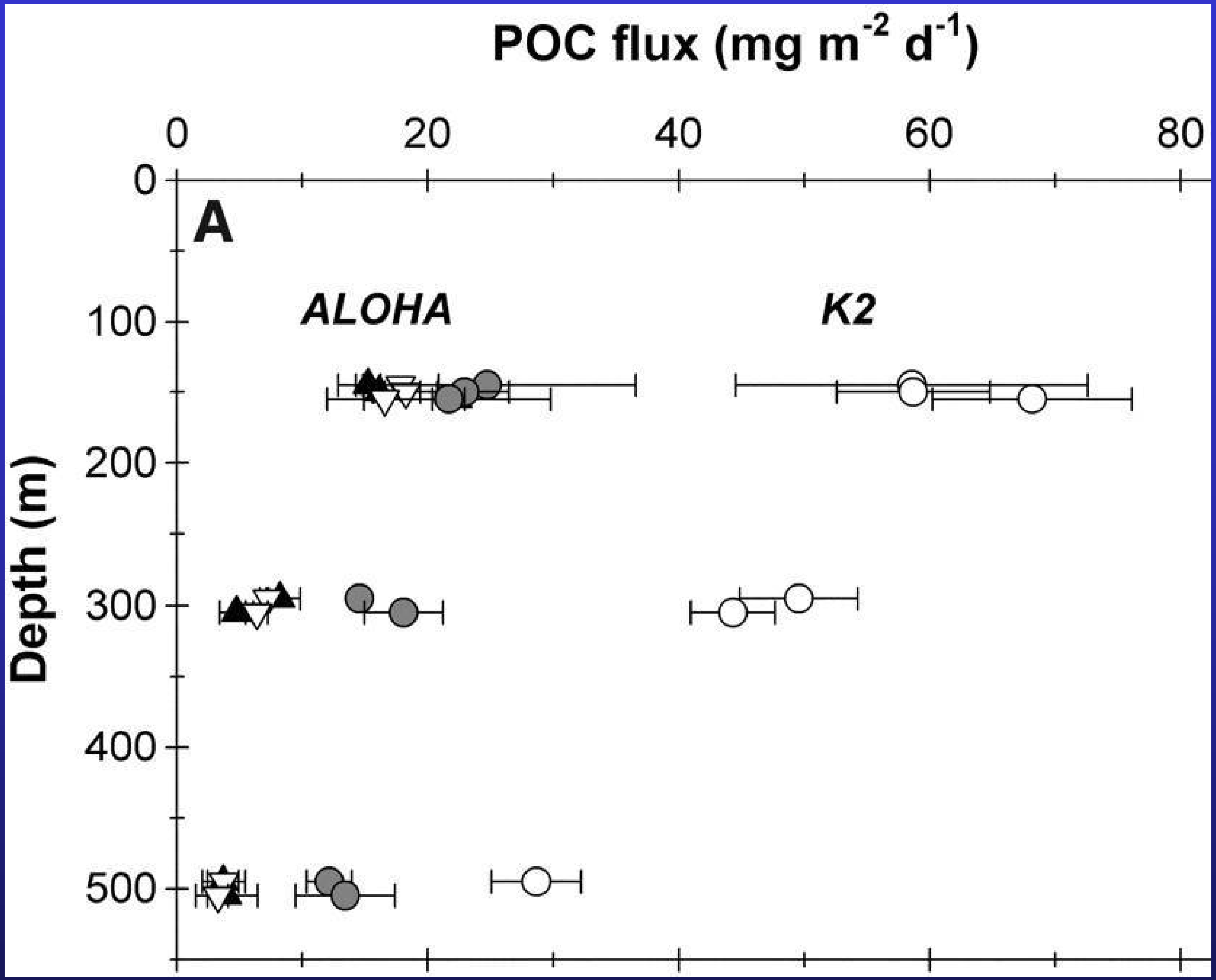
Upper ocean domains (from Longhurst 1995)

VERTIGO

1. ALOHA and K2 during 3-week in 2004 and 2005

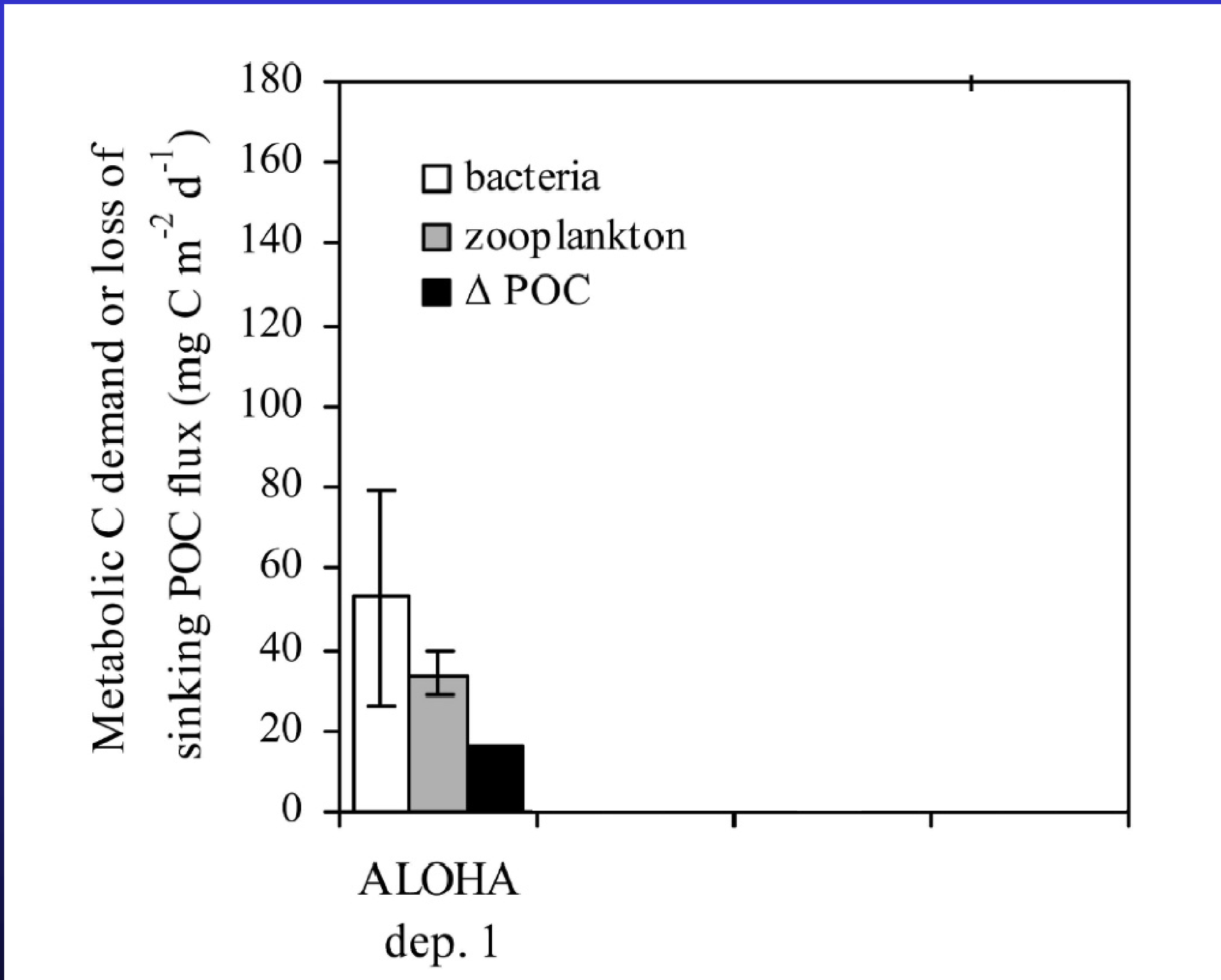


Buesseler et al., (2008)



POC flux versus depth
ALOHA (triangles) (oligotrophic) and K2 (circles) (mesotrophic)

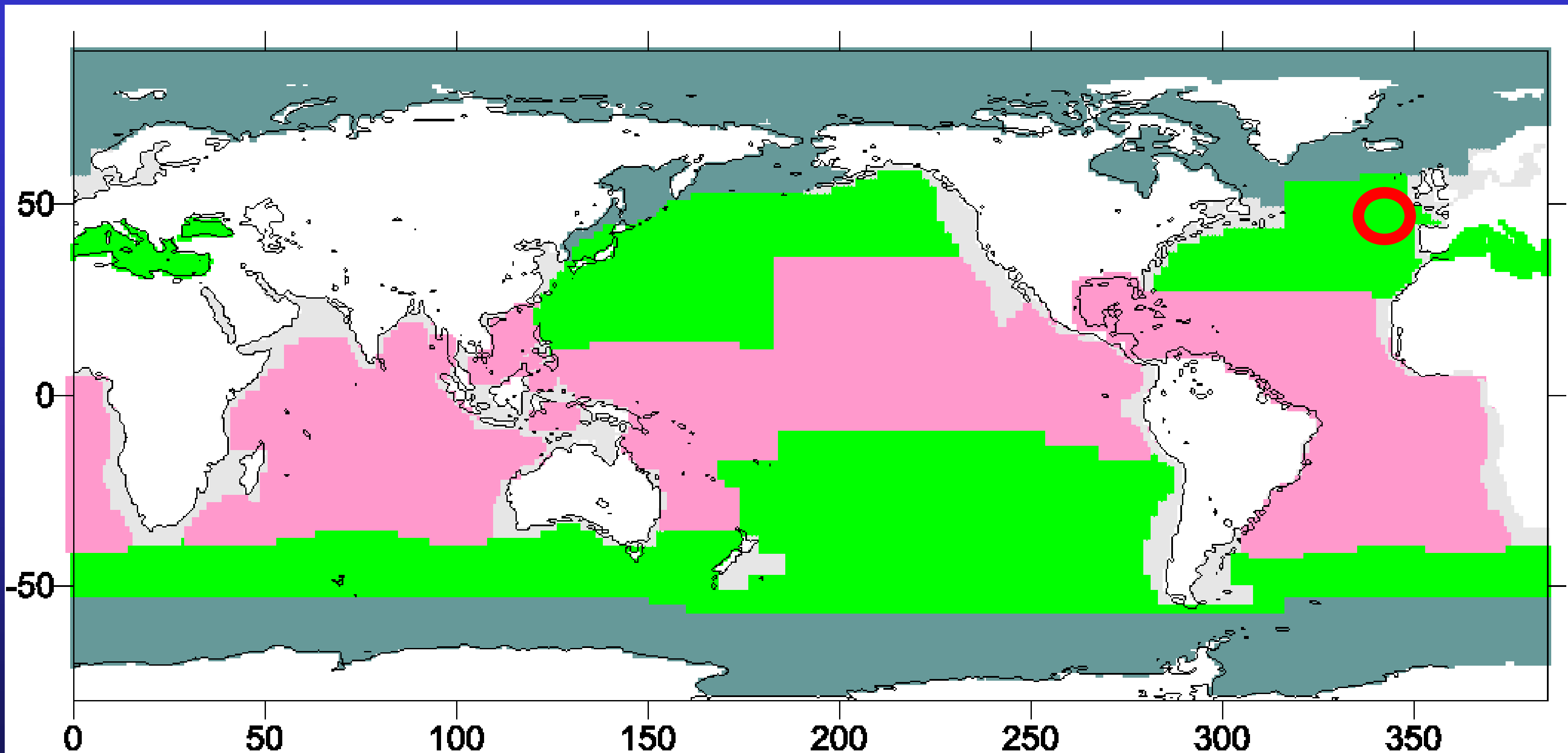
Buesseler et al., (2007)



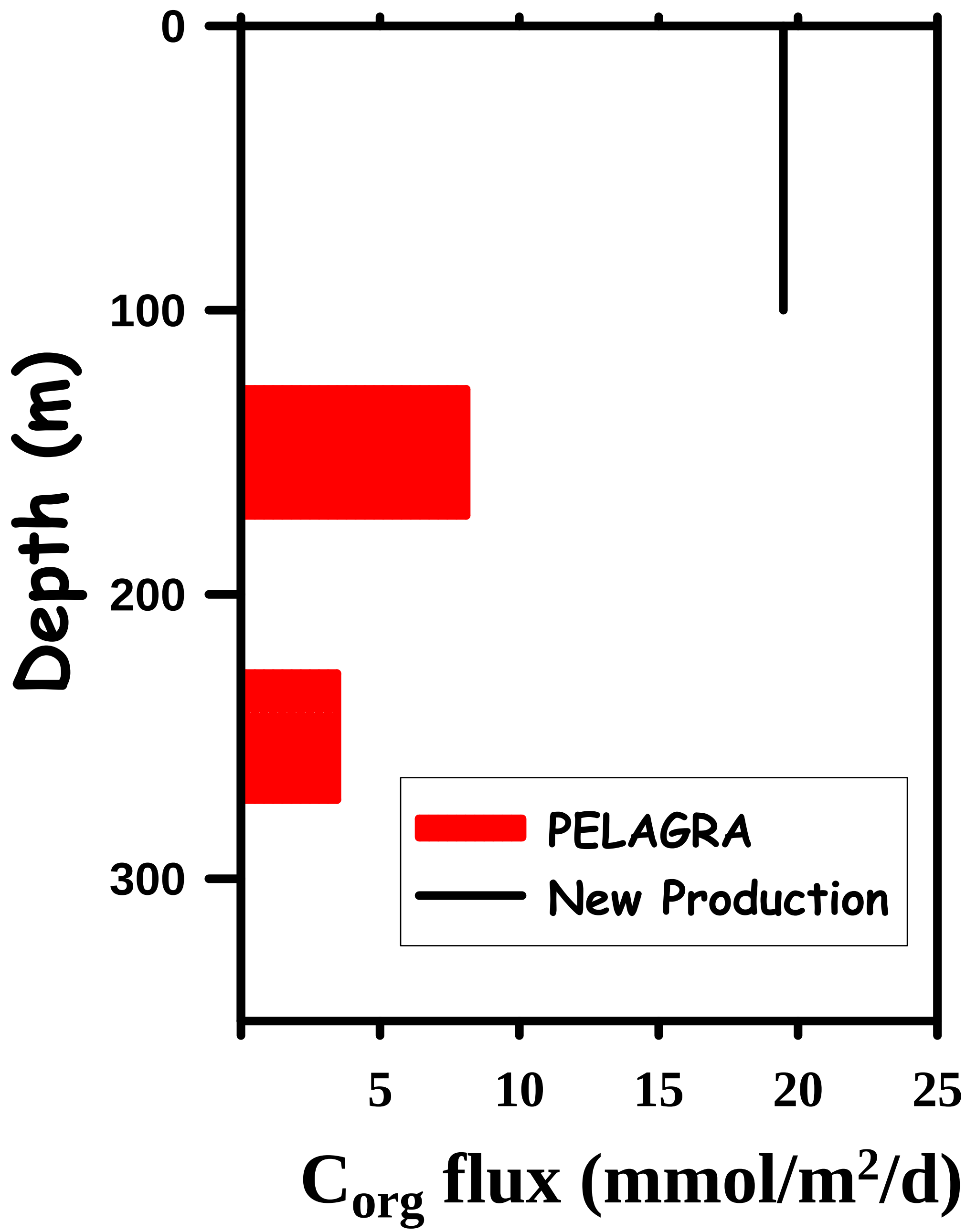
Steinberg et al. (2008)

VERTIGO

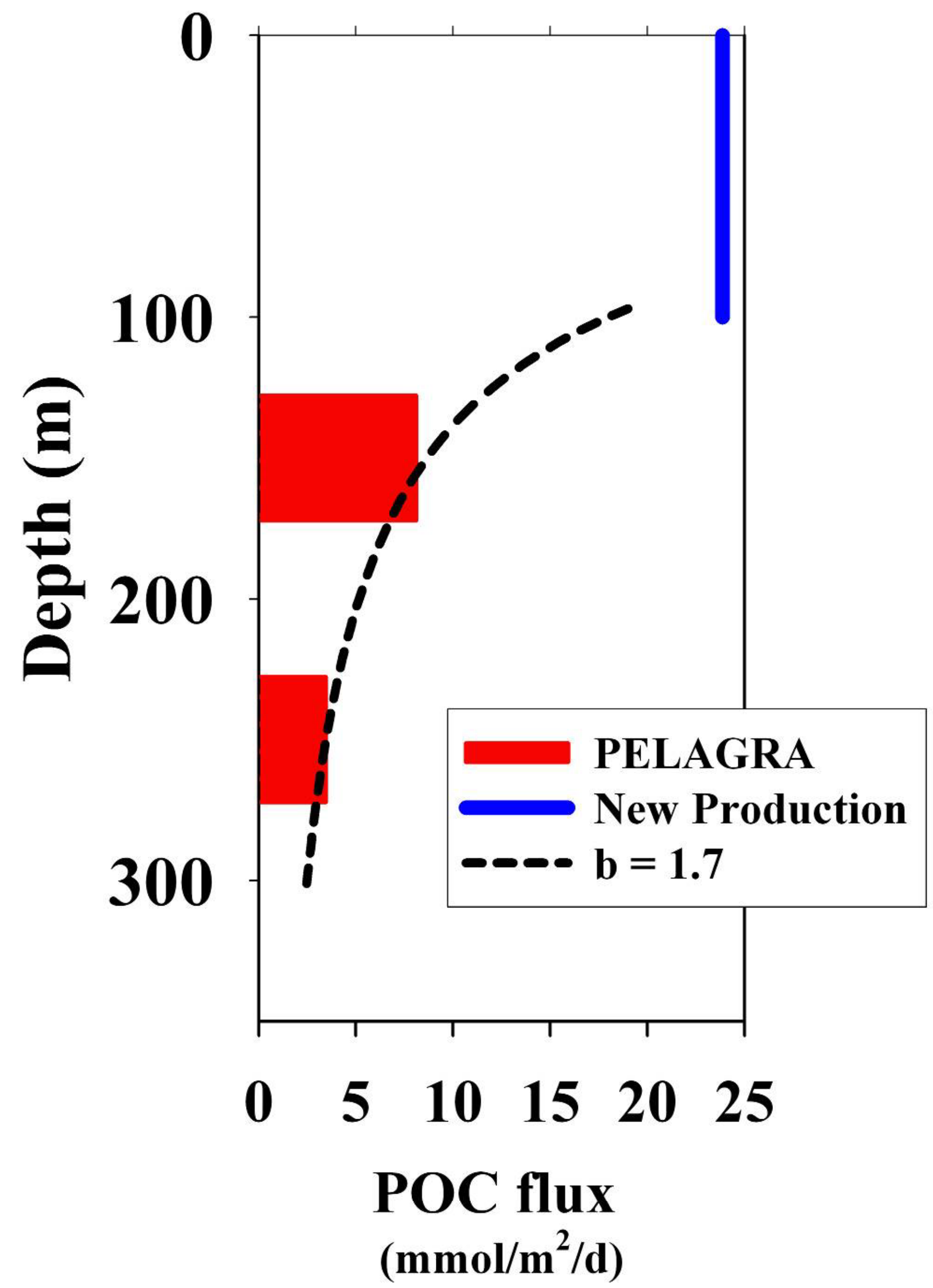
1. ALOHA and K2 during 3-week in 2004 and 2005
2. Diatom dominated K2 with silica-rich particles dominate flux at end of a diatom bloom
3. Zooplankton and their pellets larger @ K2.
4. Export ratios (POC flux/primary production) higher @ K2
5. Transfer efficiency higher @ K2 (50%) than @ ALOHA (20%).
6. Three processes : heterotrophic degradation of sinking particles, zooplankton surface feeding & migration and particle advection.



Upper ocean domains (from Longhurst 1995)

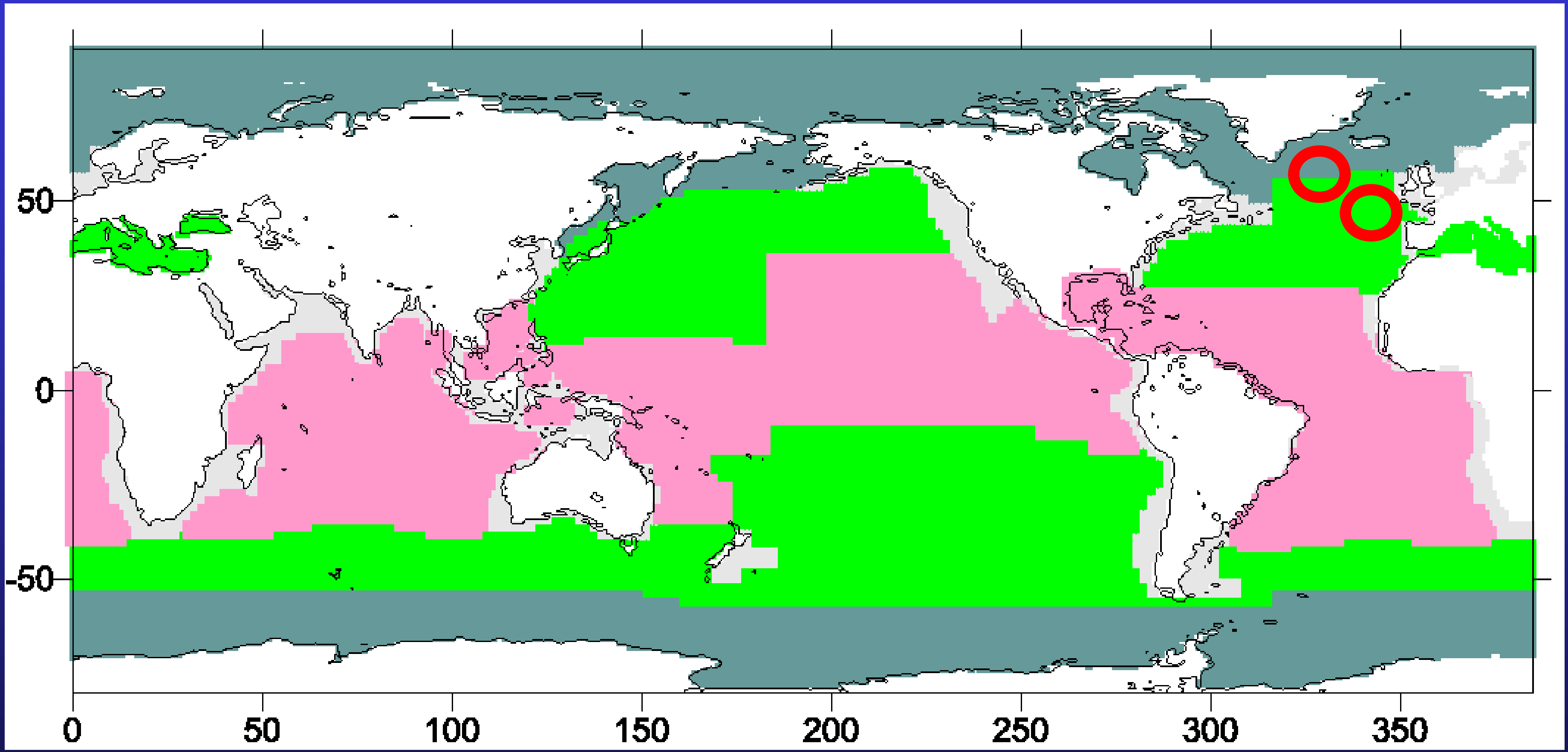


Downward flux at PAP, July 2006

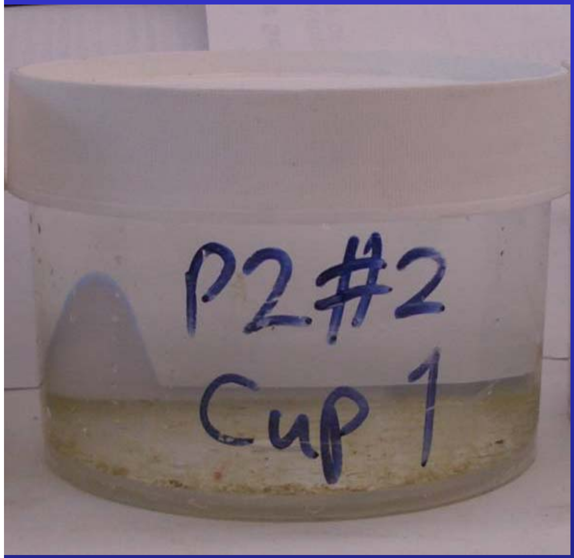


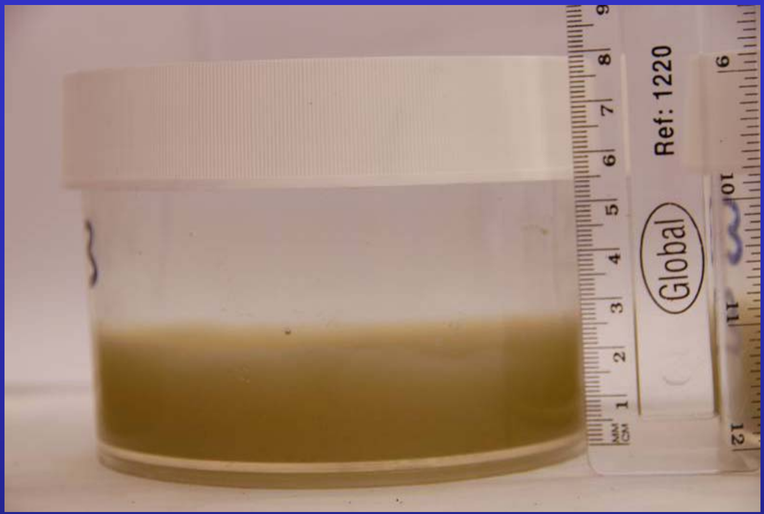
Downward flux at PAP, July 2006

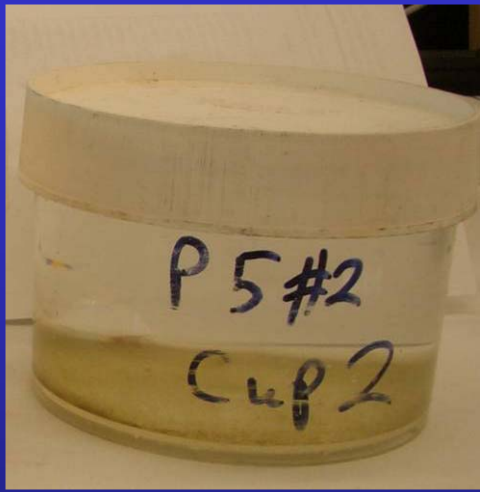
Lampitt et al 2008



Upper ocean domains (from Longhurst 1995)





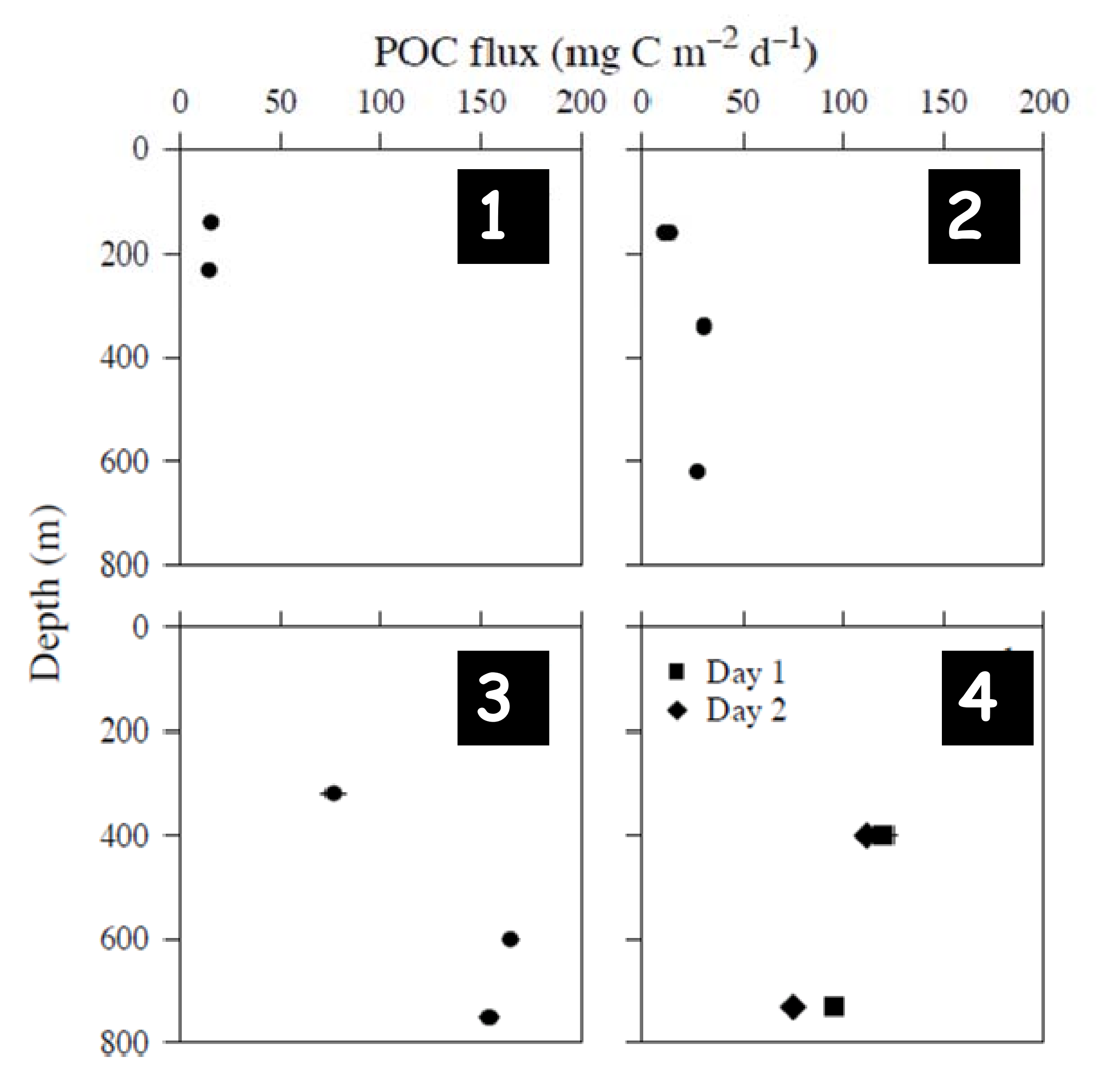


7-11th May

14th May

17th May

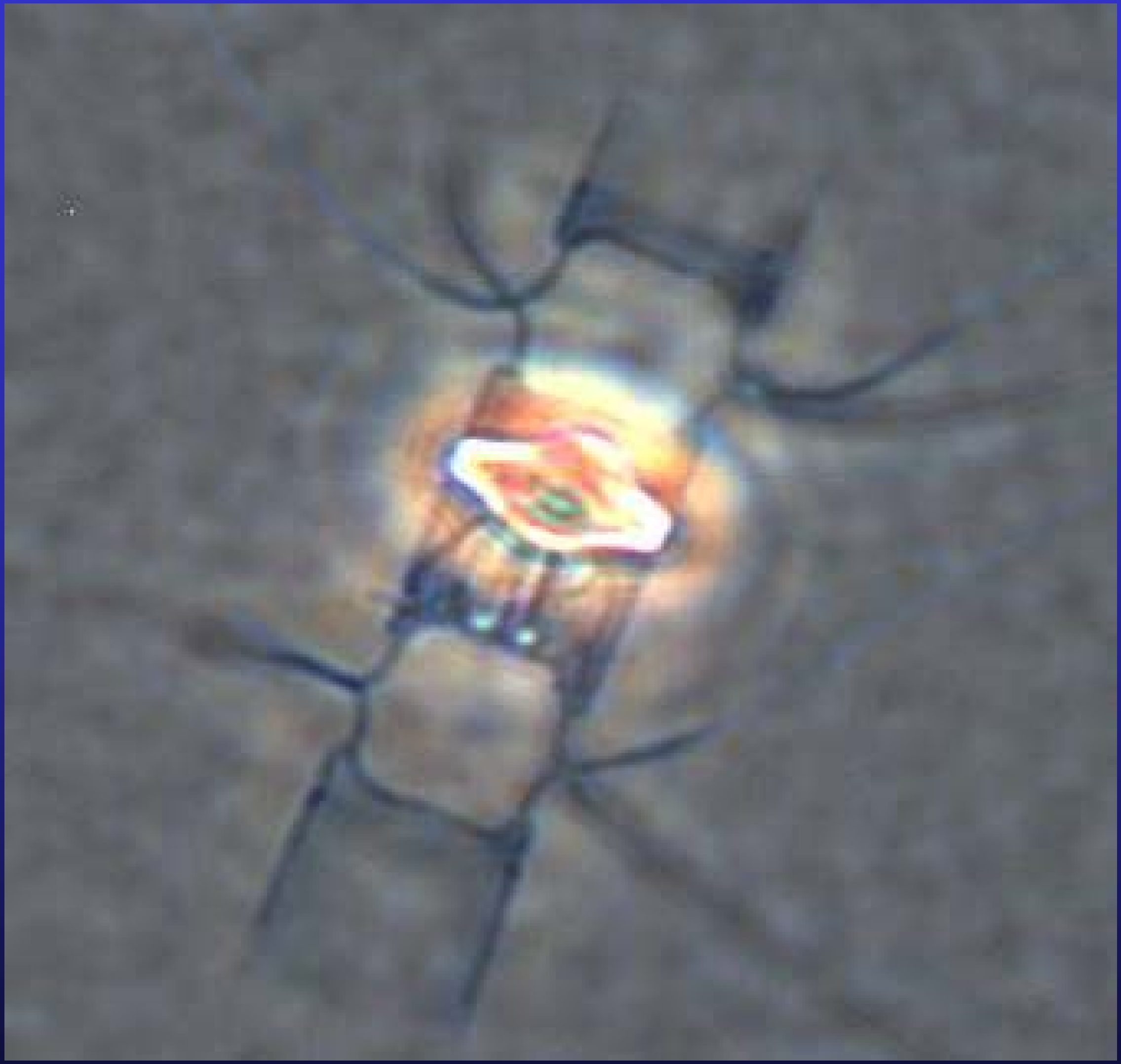
Northern North Atlantic in 2008 at 600m depth



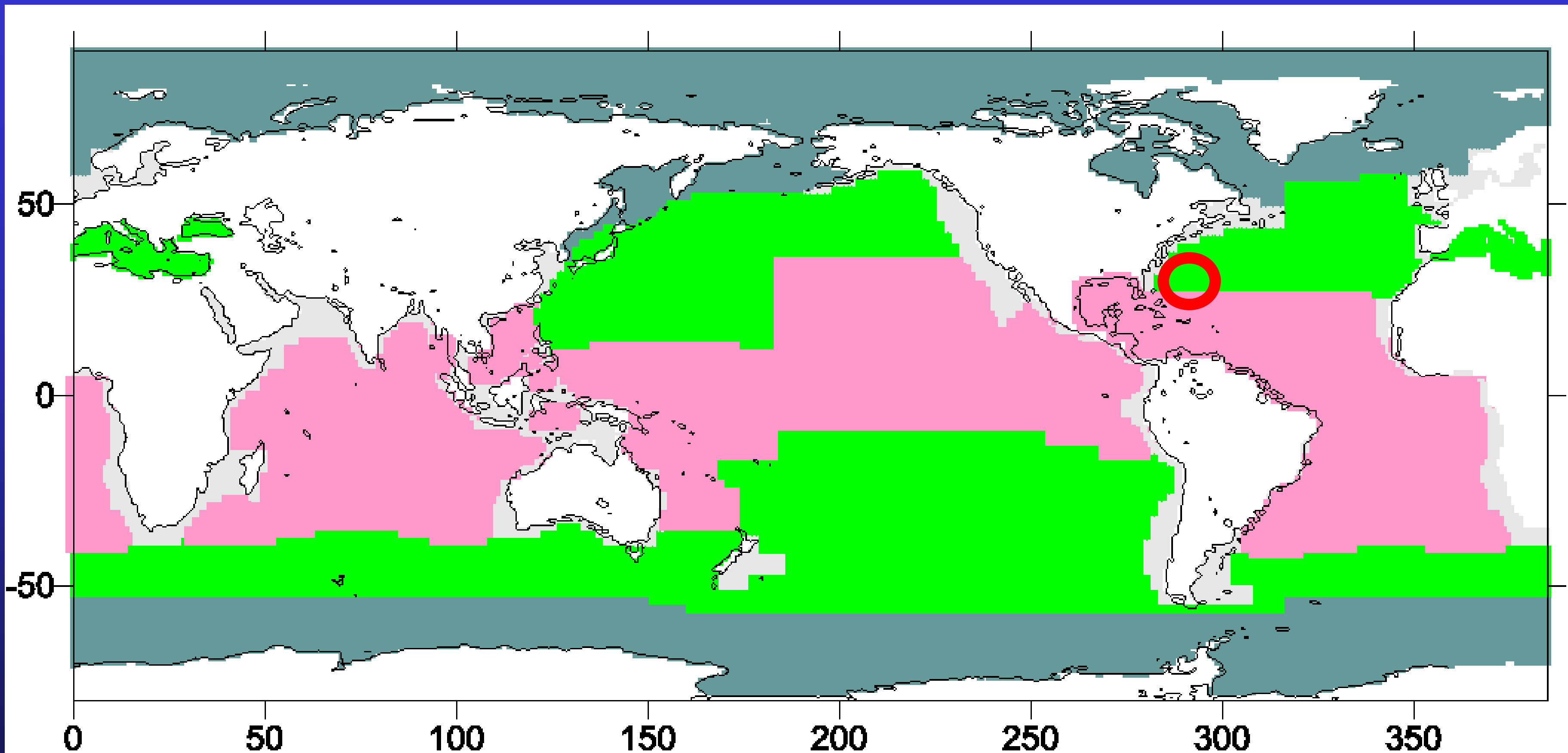
NABE 2008

4 consecutive deployments, May

Martin et al (submitted)

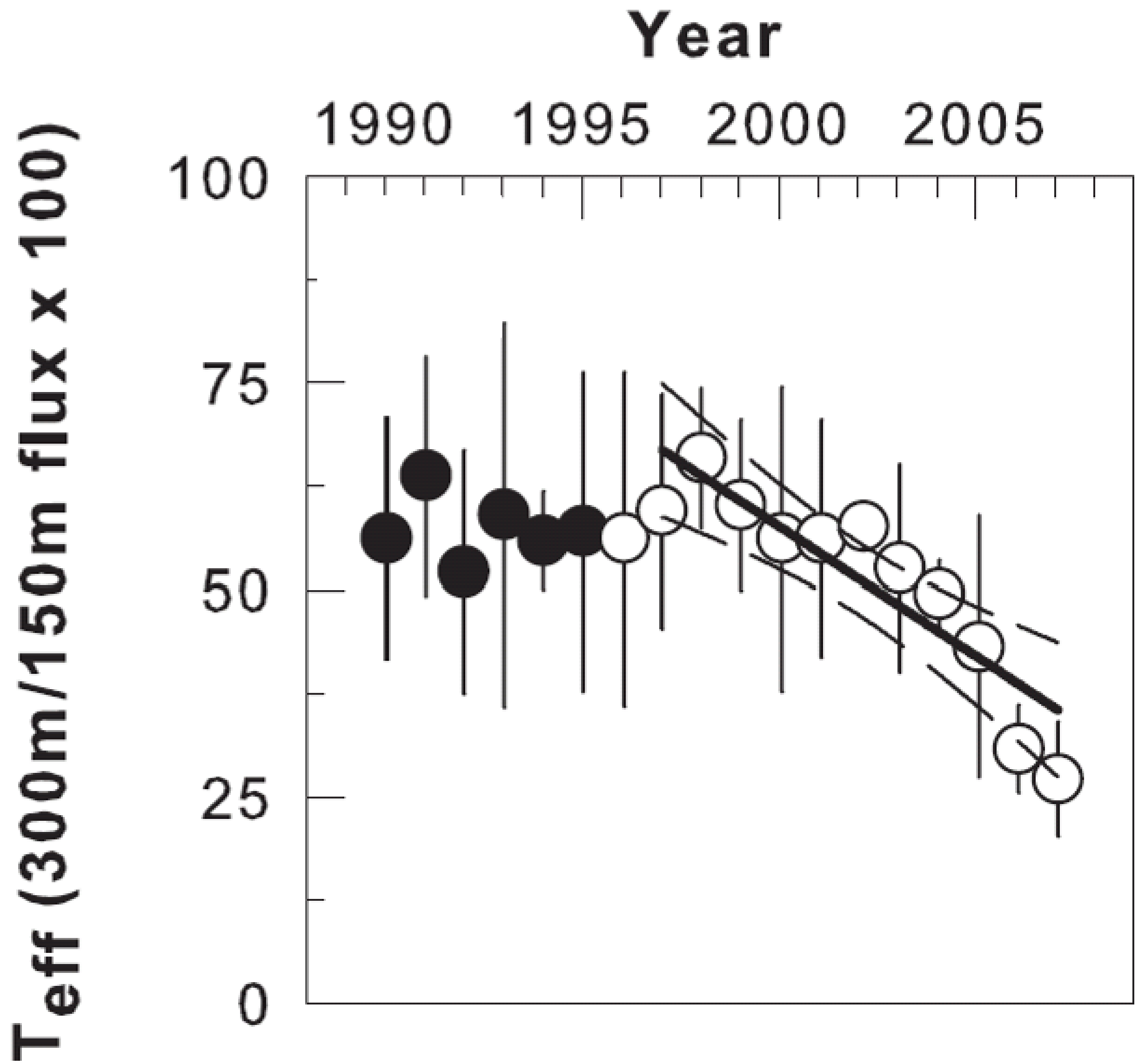


Rynearson (pers. comm.)



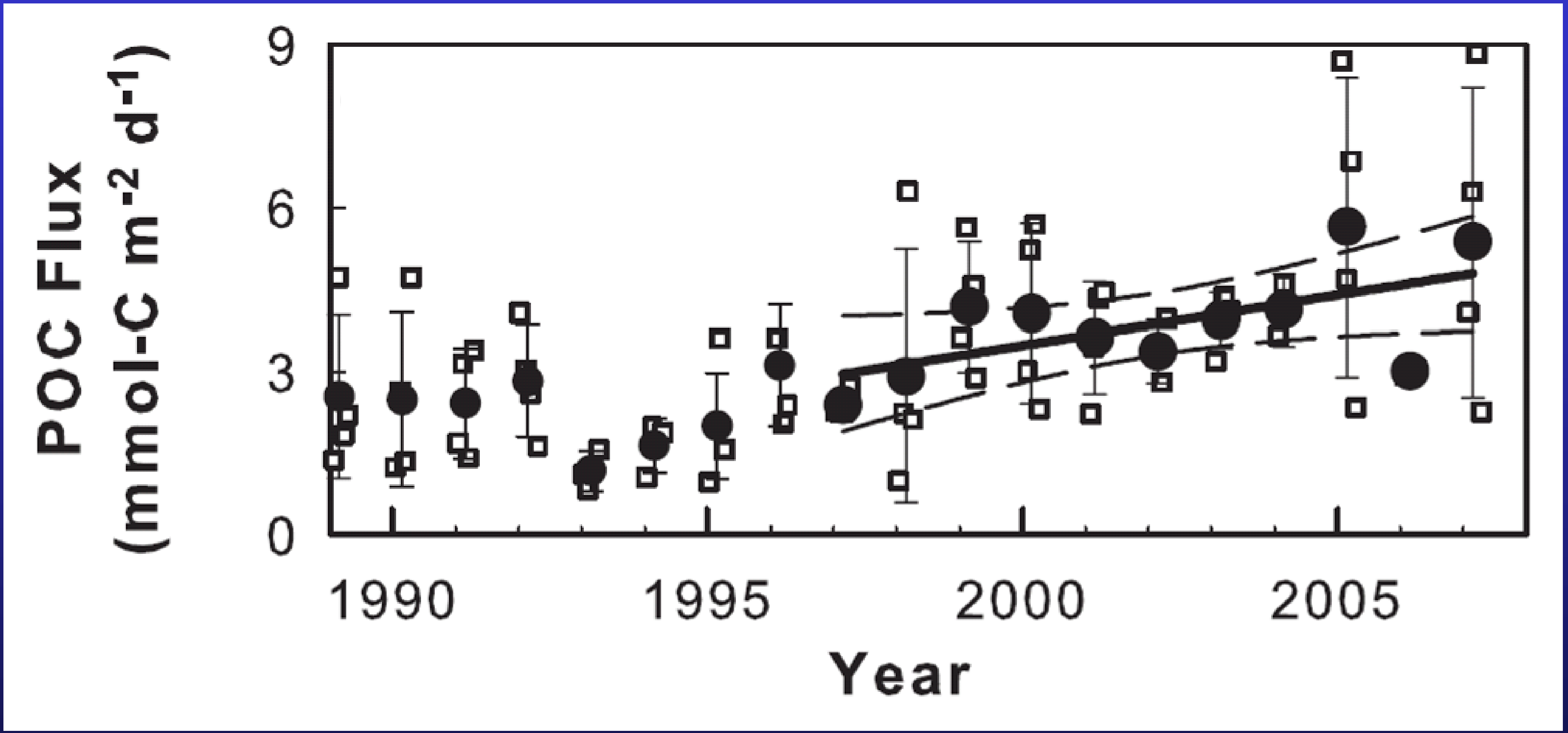
Upper ocean domains (from Longhurst 1995)

BATS: Transfer efficiency



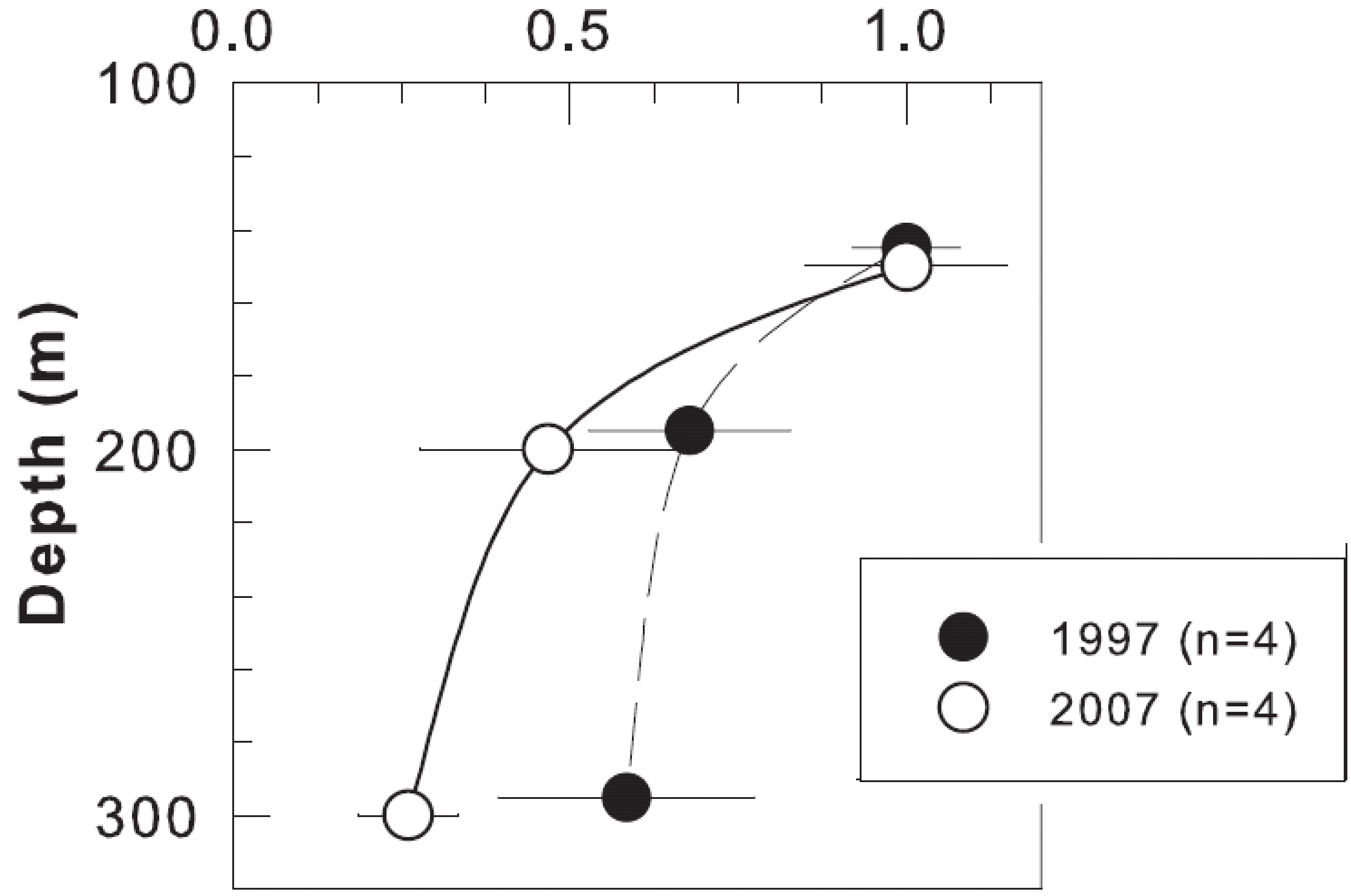
Lomas et al 2010

BATS: Export at 150m

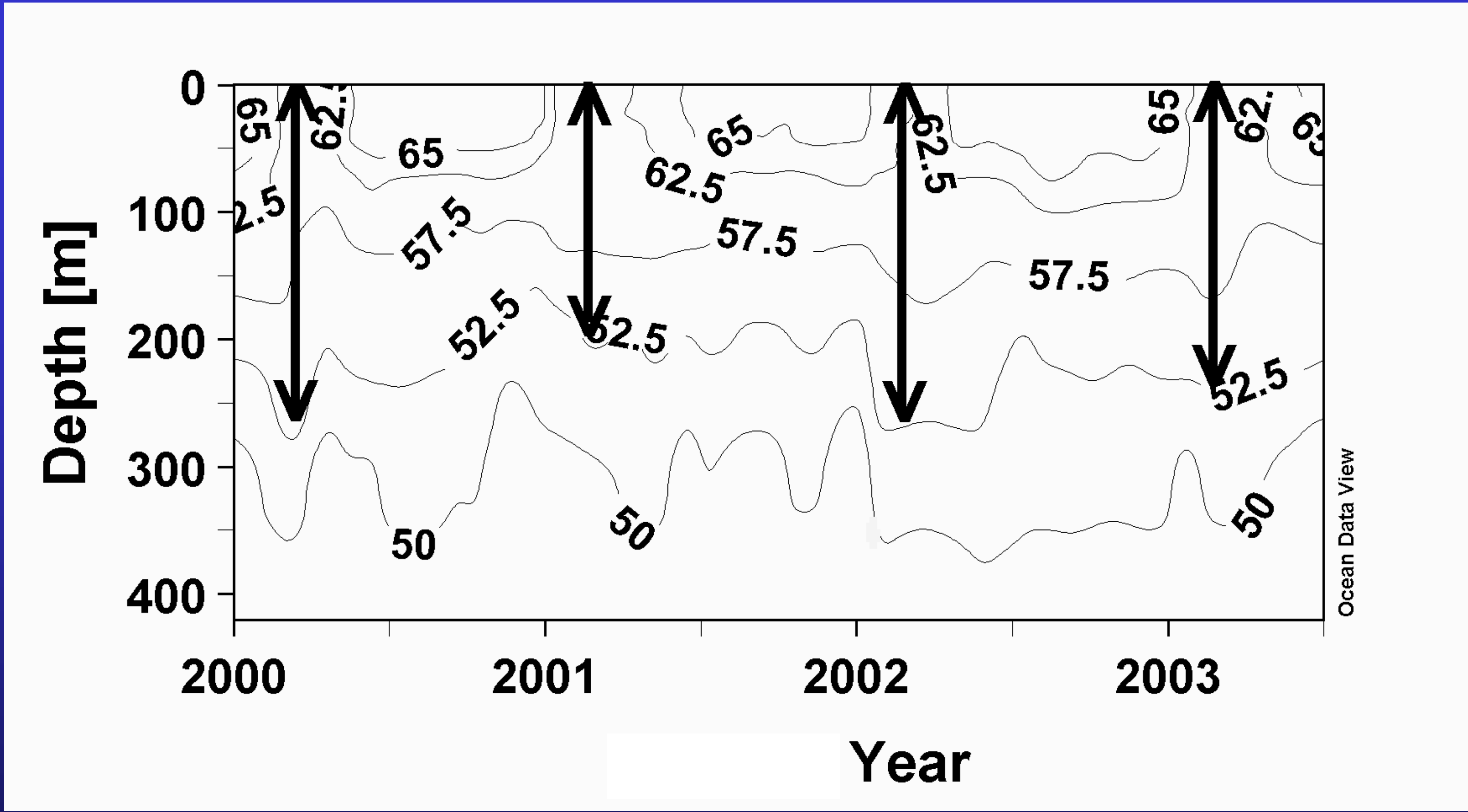


Lomas et al 2010

BATS: POC flux



Lomas et al 2010



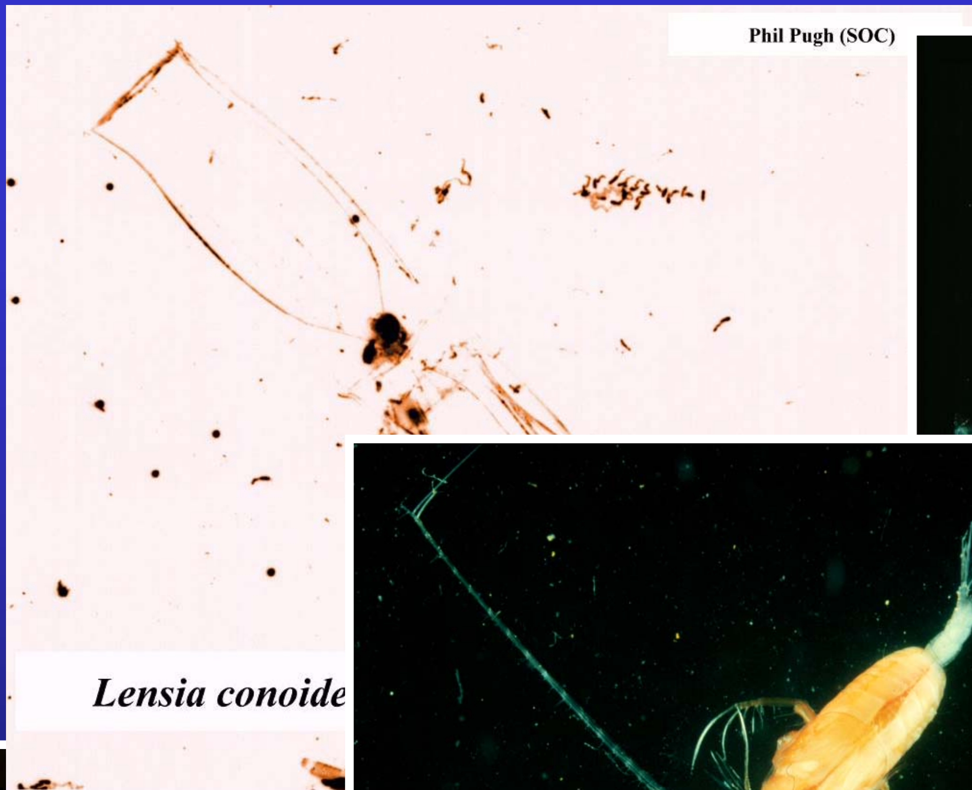
DOC concentrations at BATS:

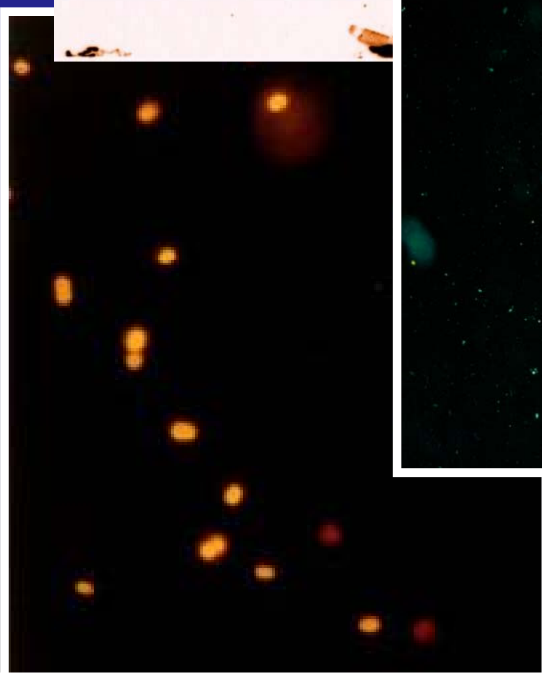
Interannual variability in export.

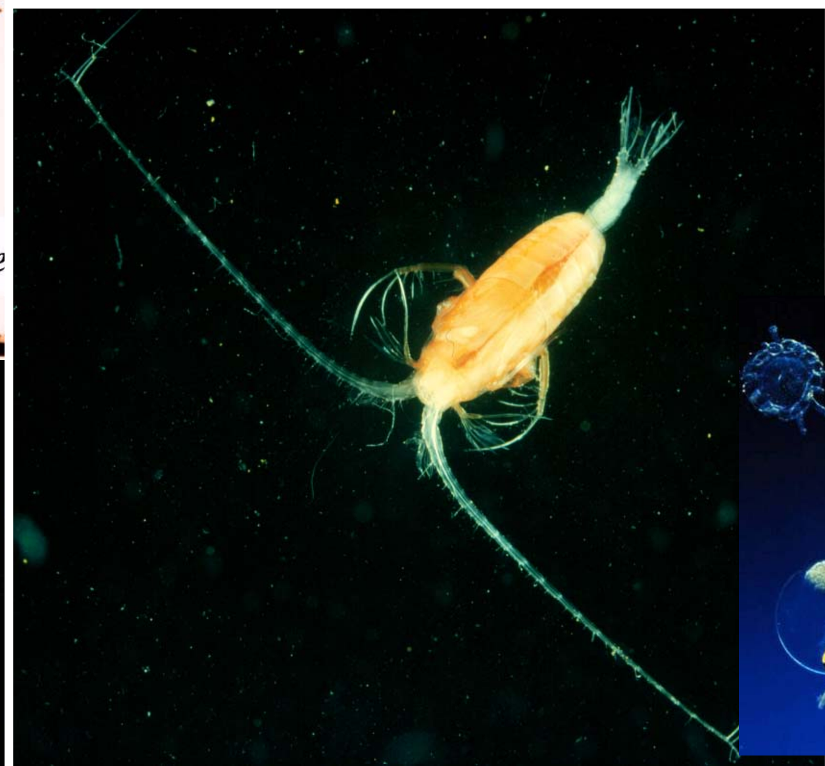
Arrows: winter-time downward mixing of DOC.

Burd et al 2010

Who is degrading the supply of organic carbon?

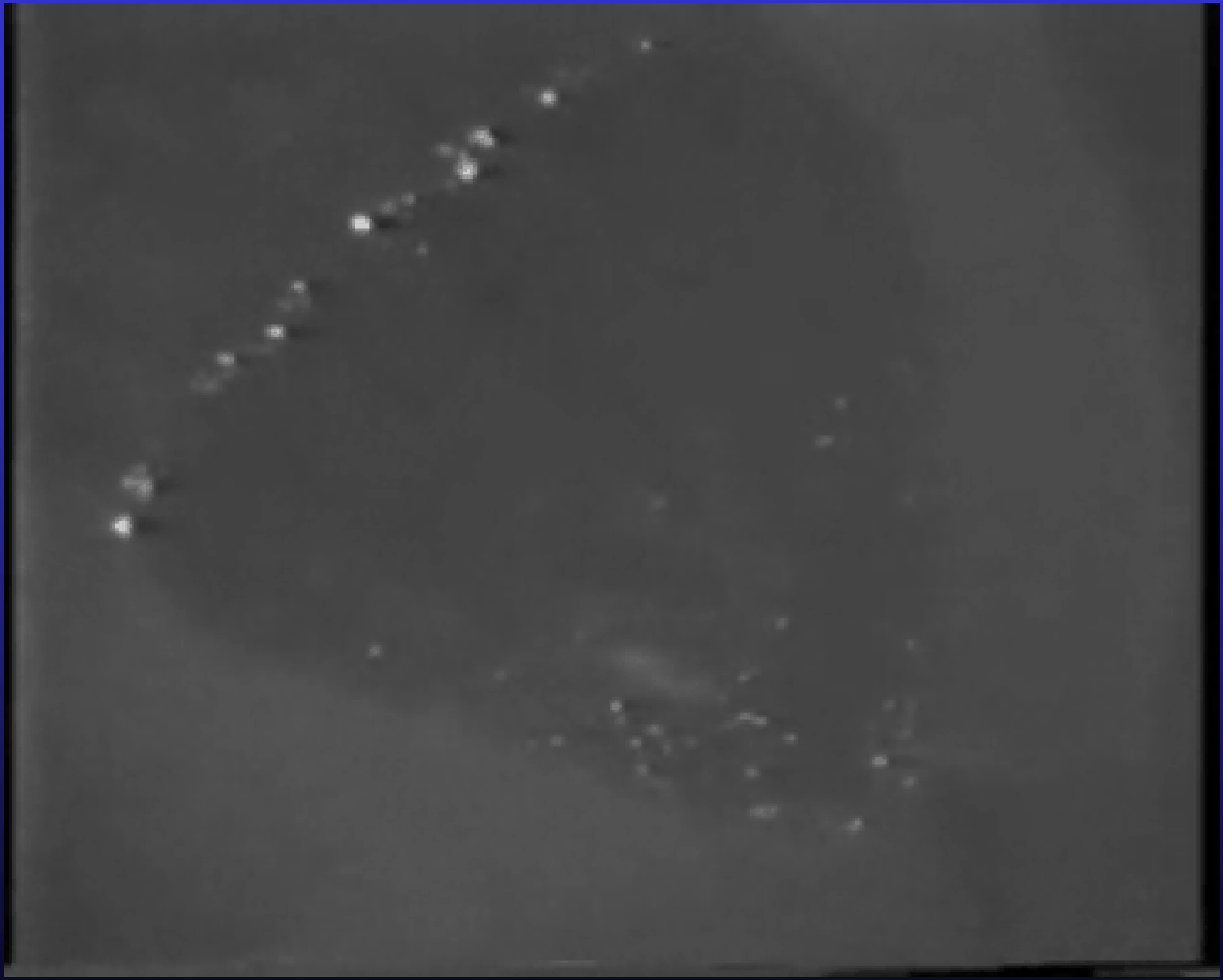

Phil Pugh (SOC)
Lensia conoide





Twilight zone fauna

P. Herring **Malacosteus niger**

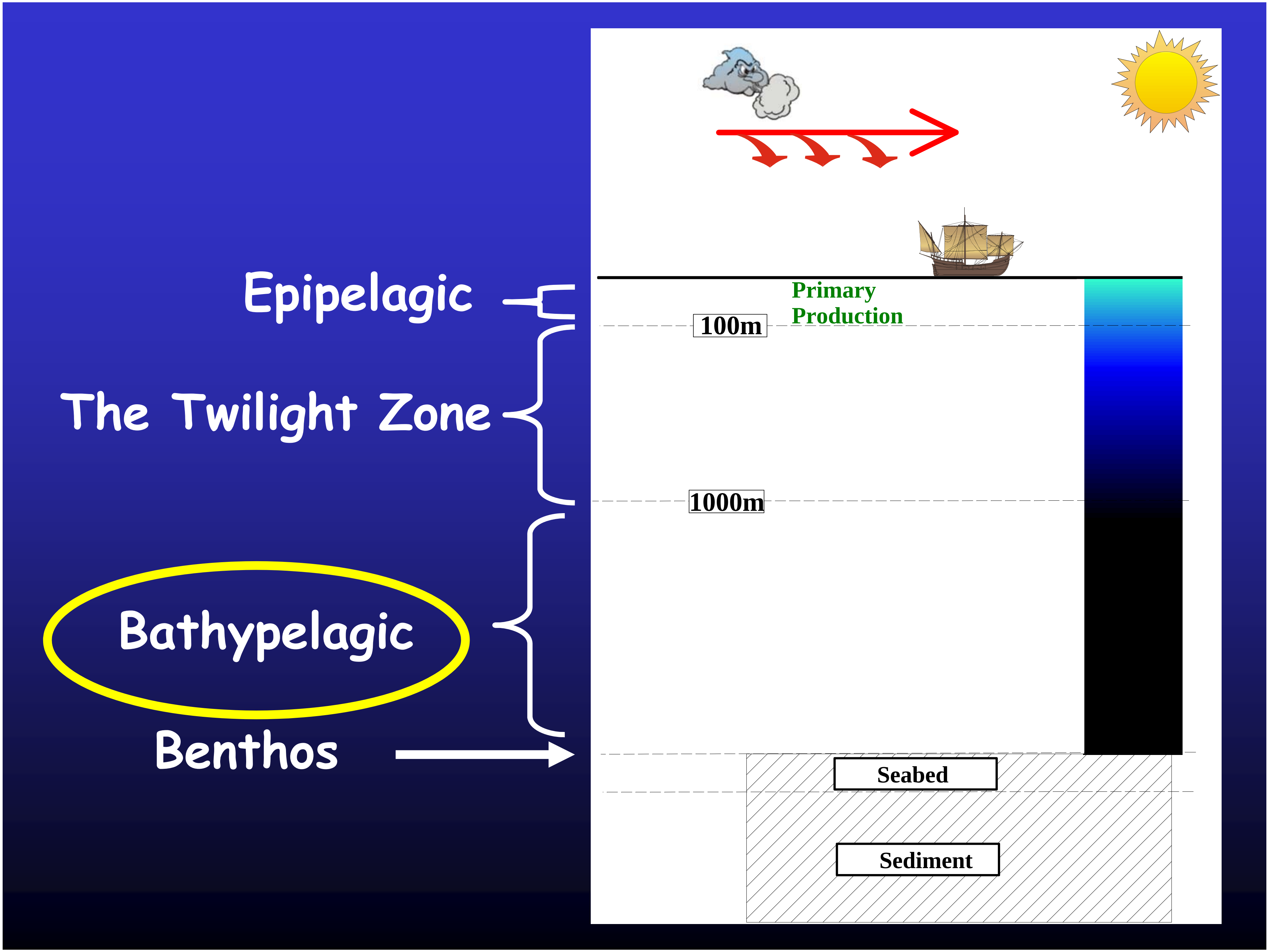


P.Herring **Periphylla periphylla**

A hatchet fish: Master of camouflage.

Can we collect them effectively?

The RMT system in 1973


Epipelagic
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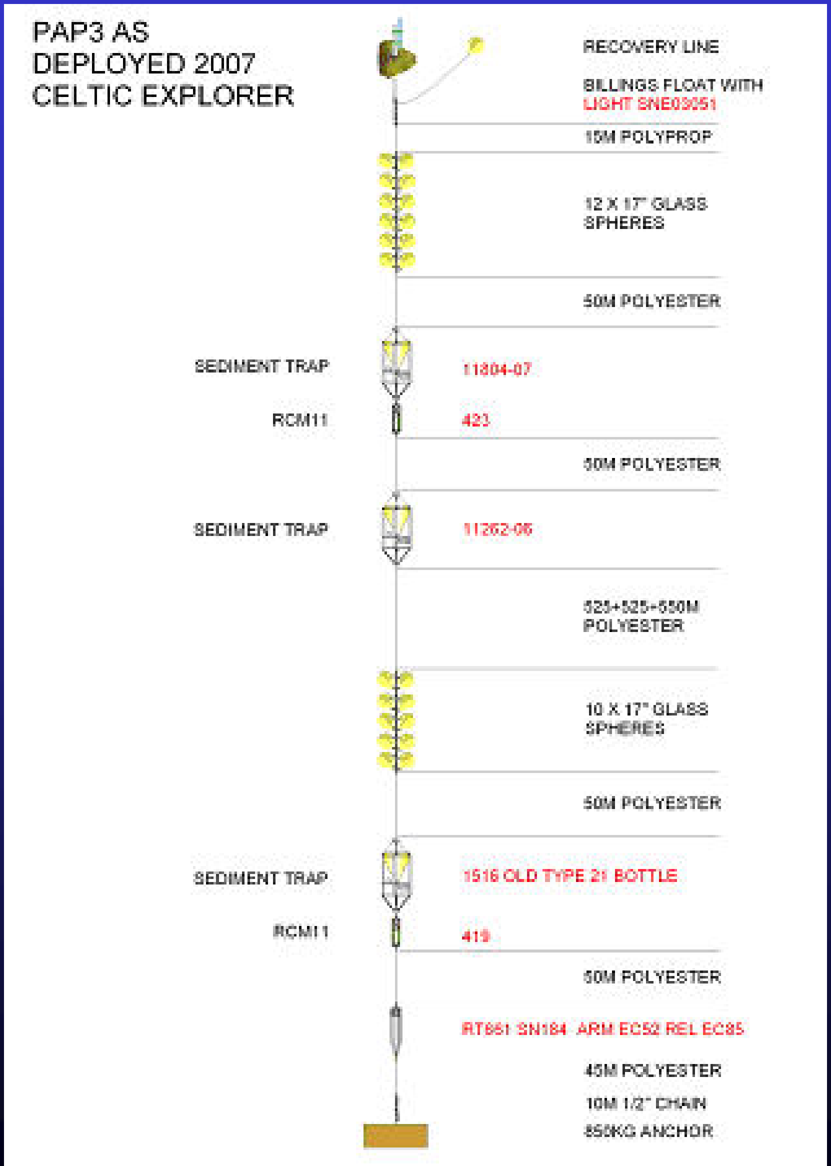
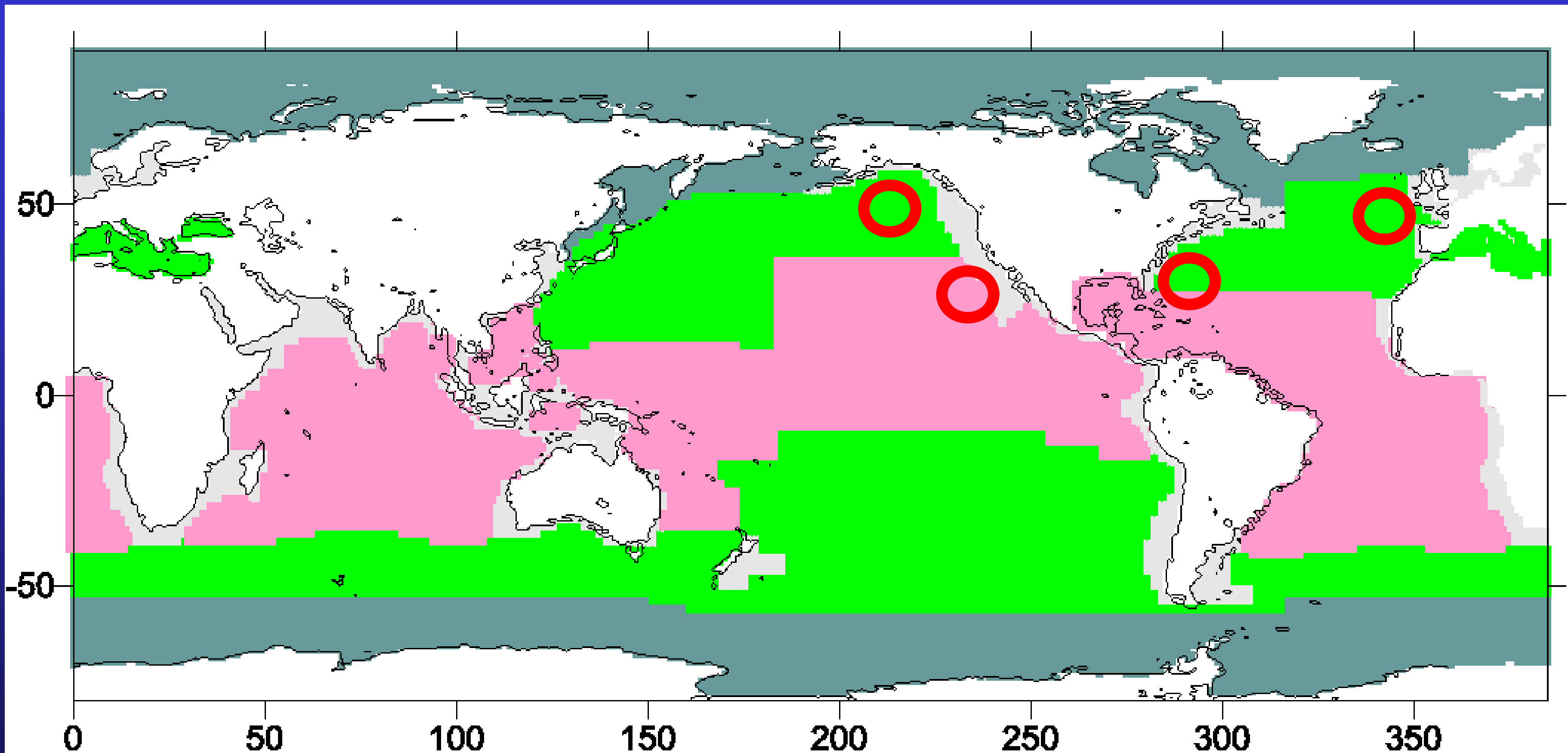
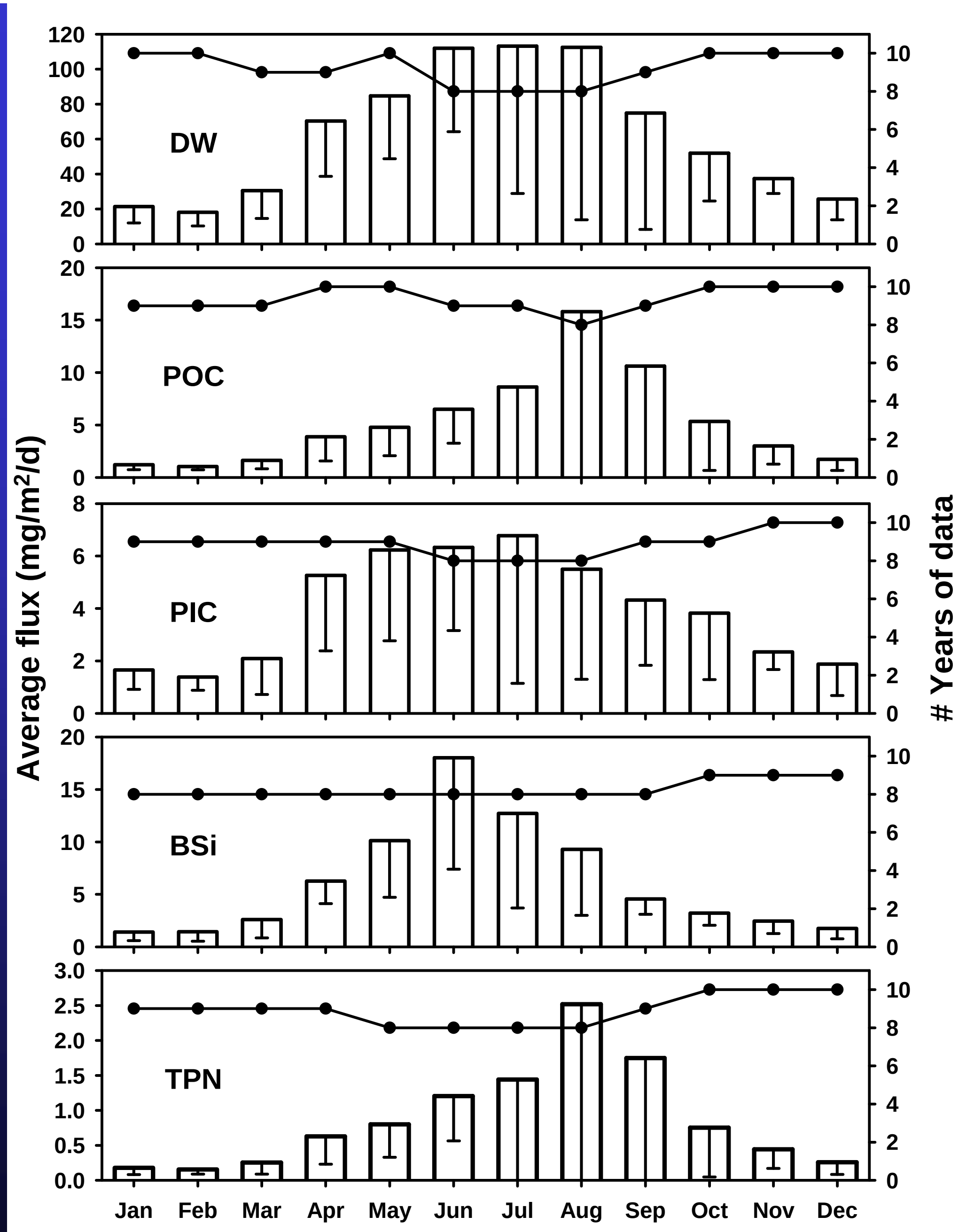
Downward flux: From ocean interior to seafloor
Sediment Trap mooring



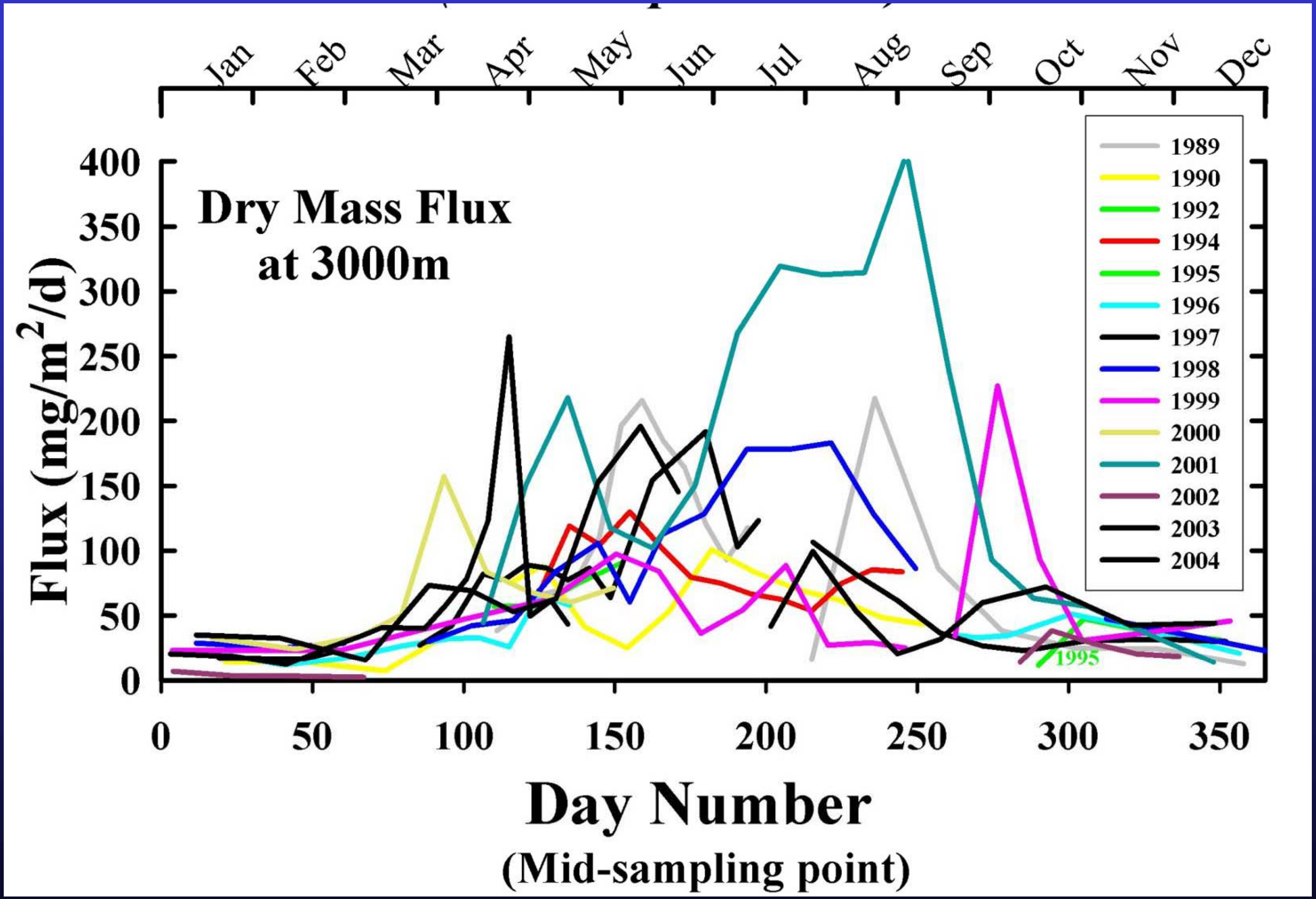


Upper ocean domains (from Longhurst 1995)

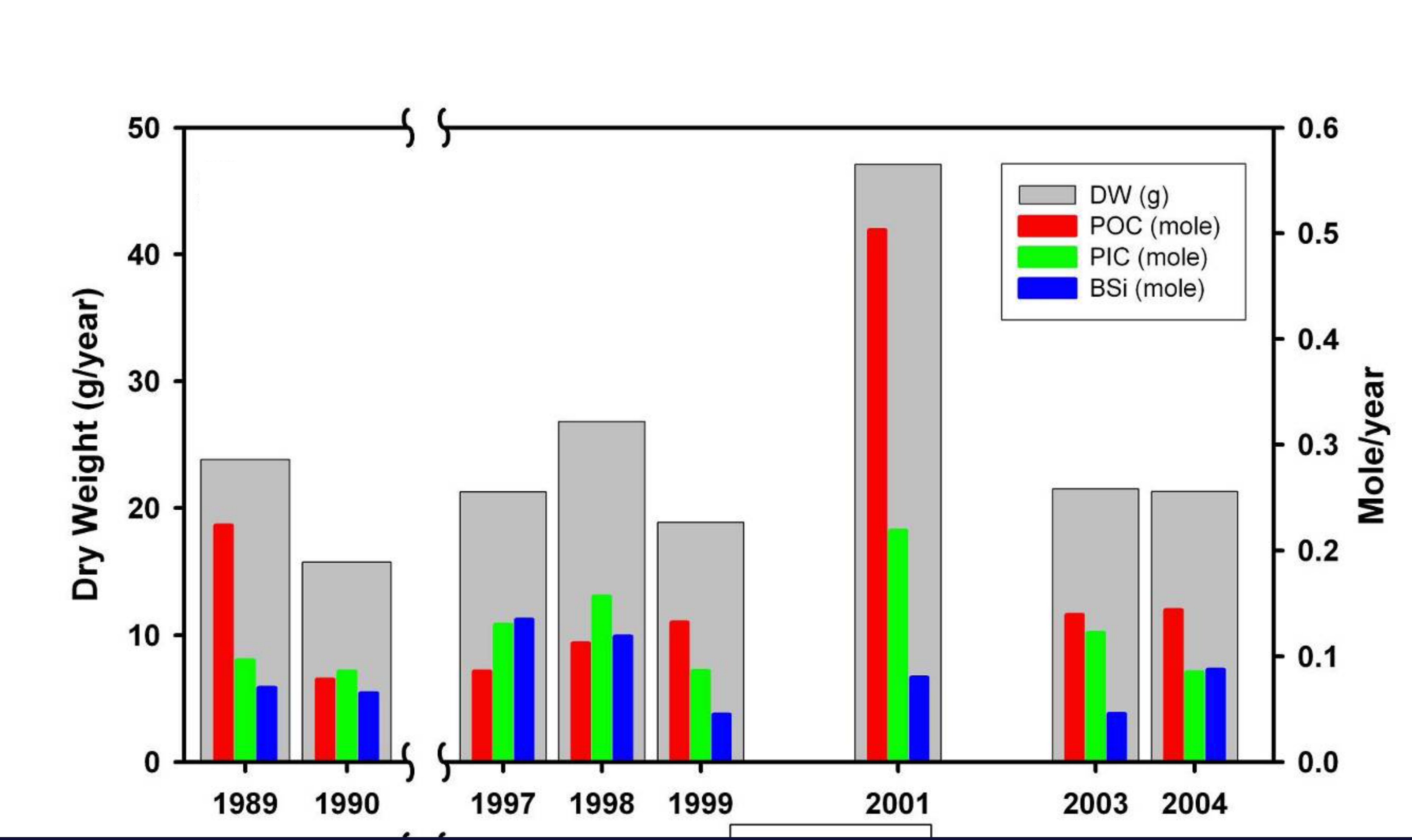


Lampitt et al 2010

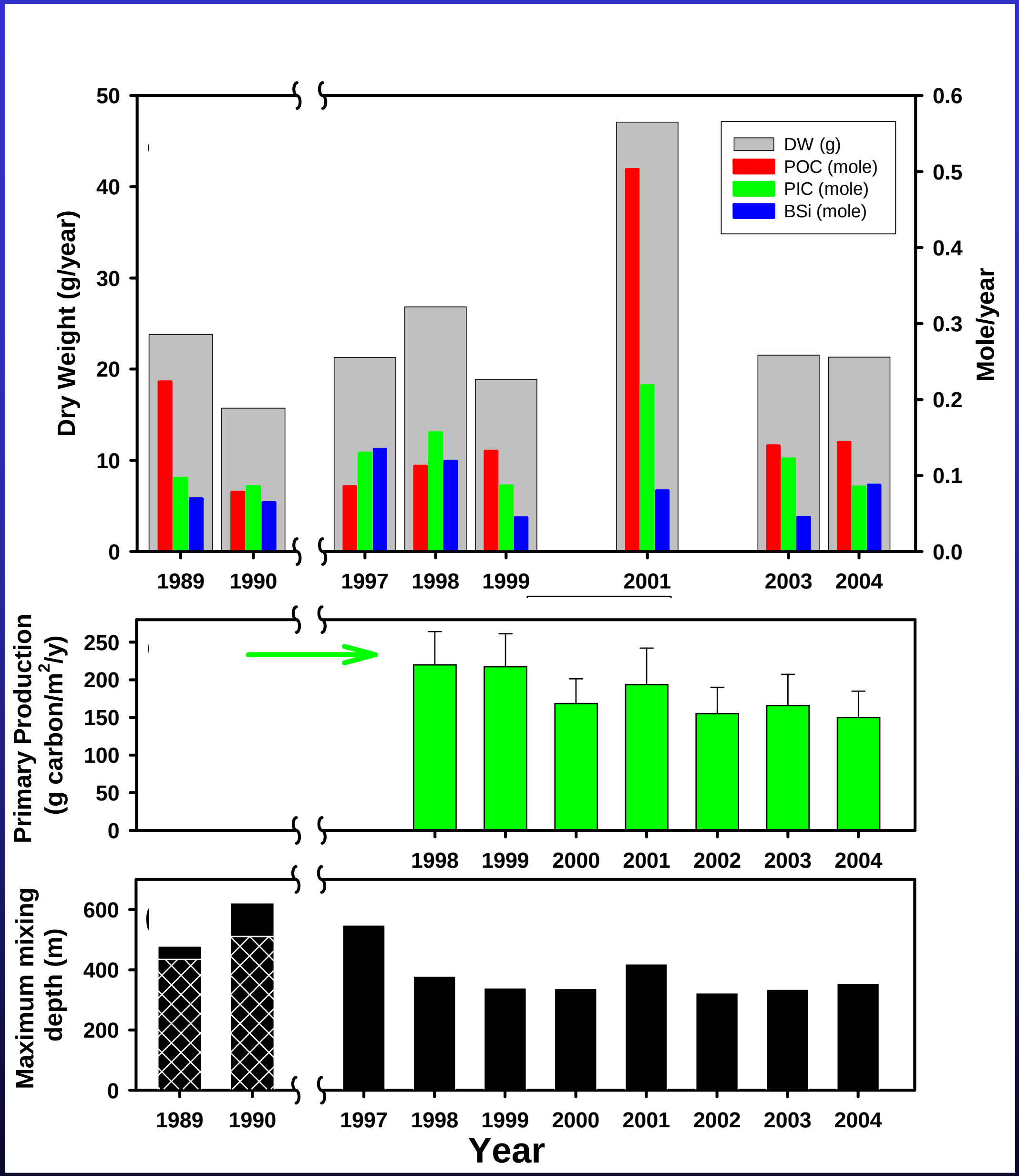
Downward particle flux at PAP at 3000m depth



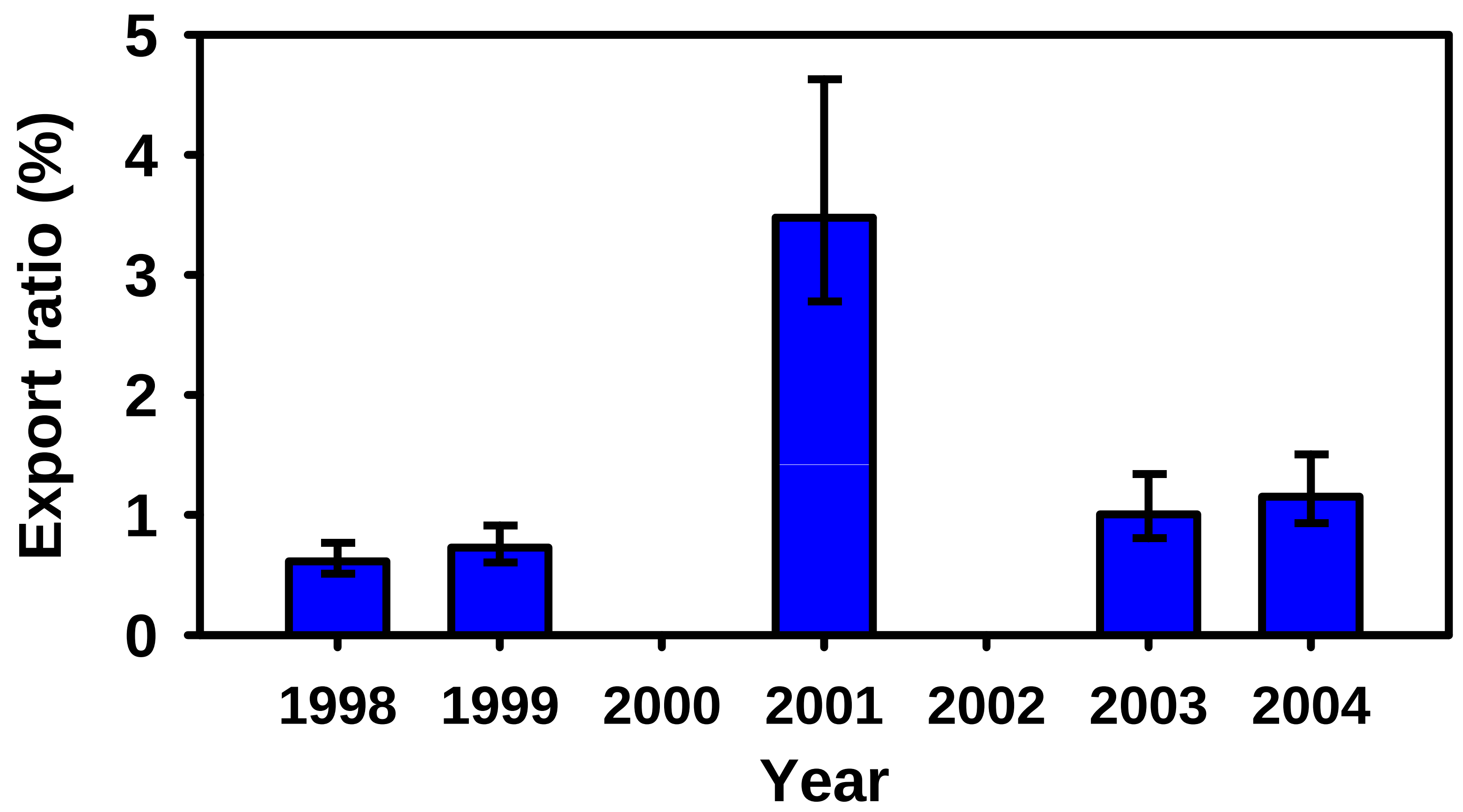
Downward particle flux at 3000m depth



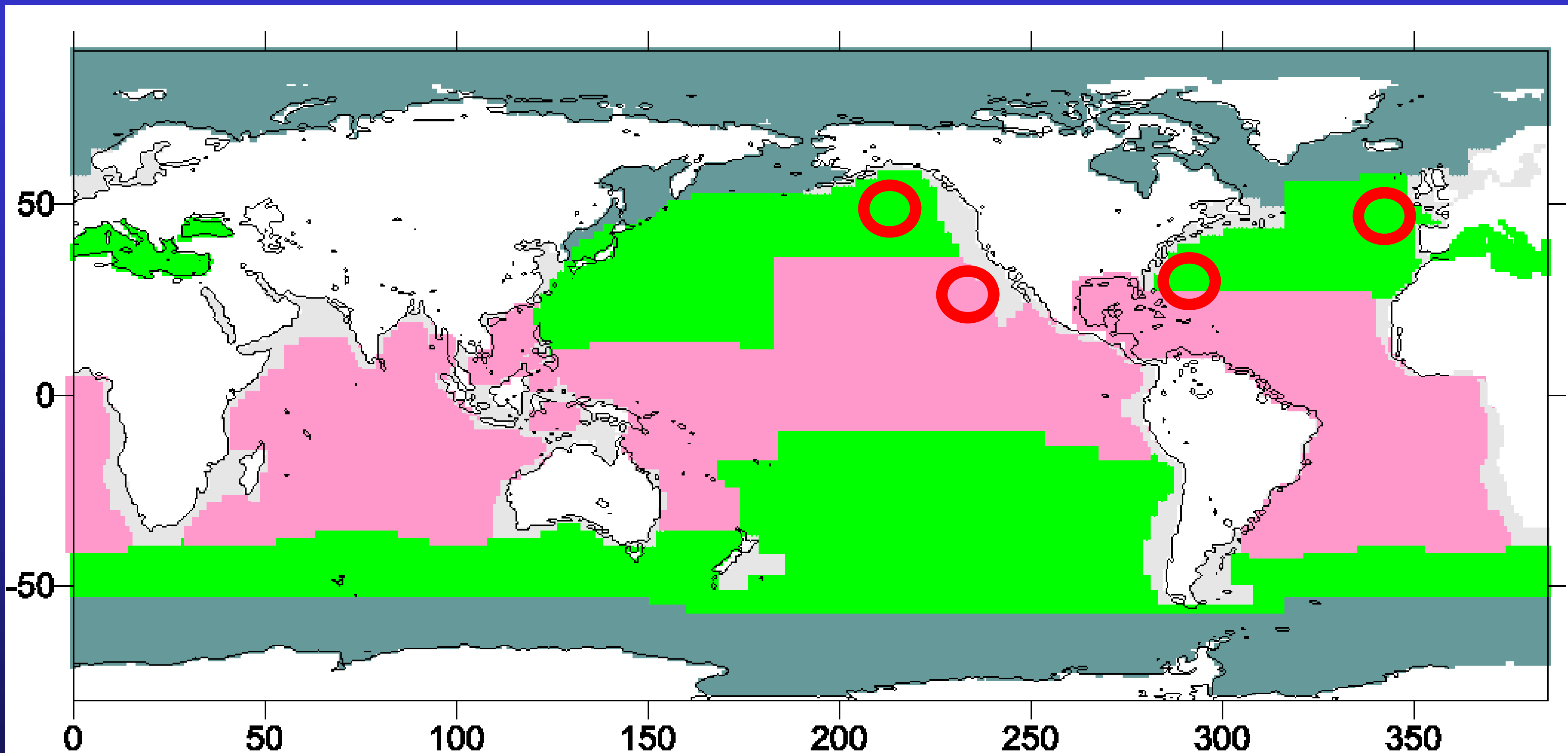
Lampitt et al 2010



Lampitt et al 2010



Lampitt et al 2010



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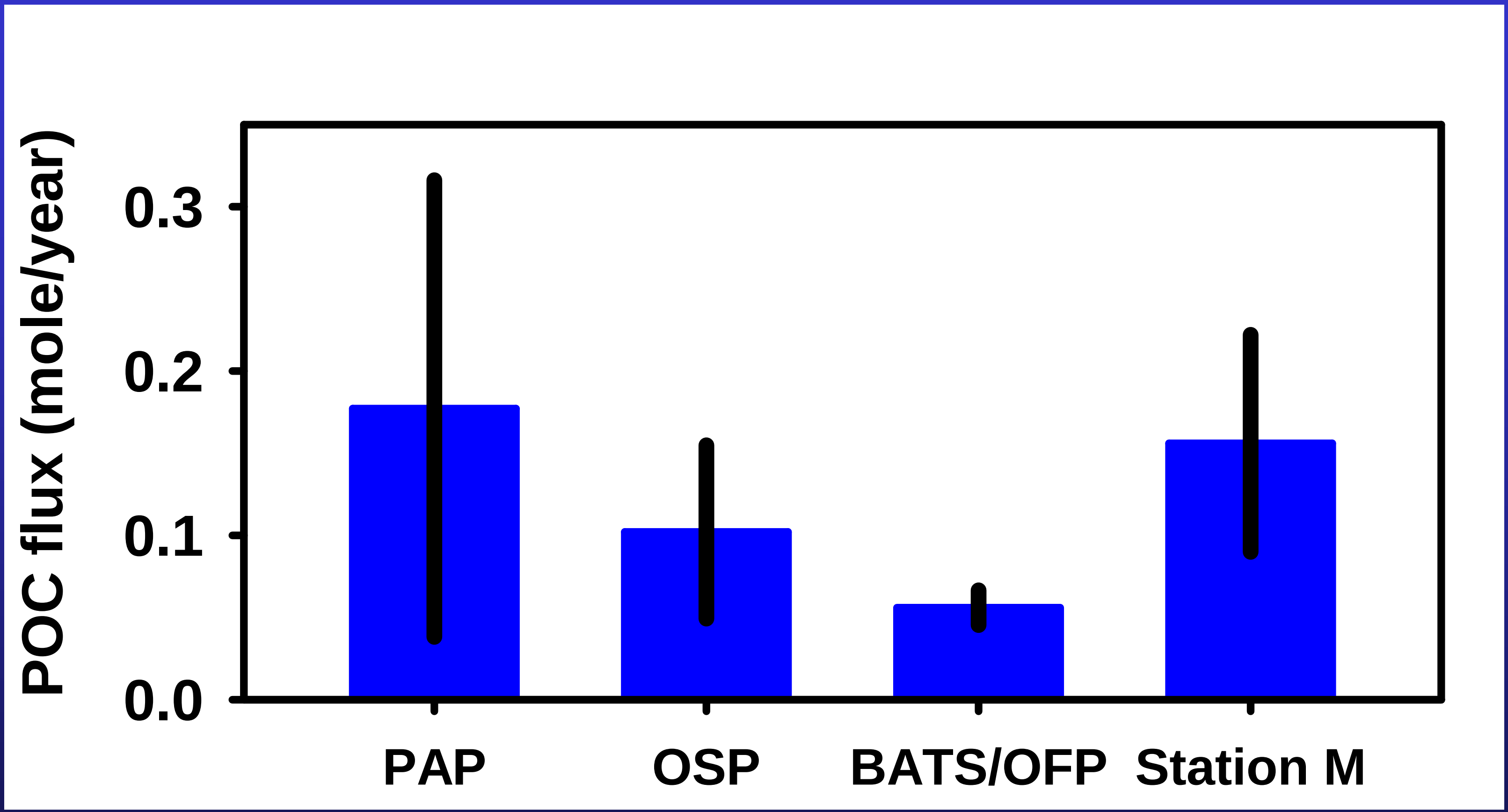
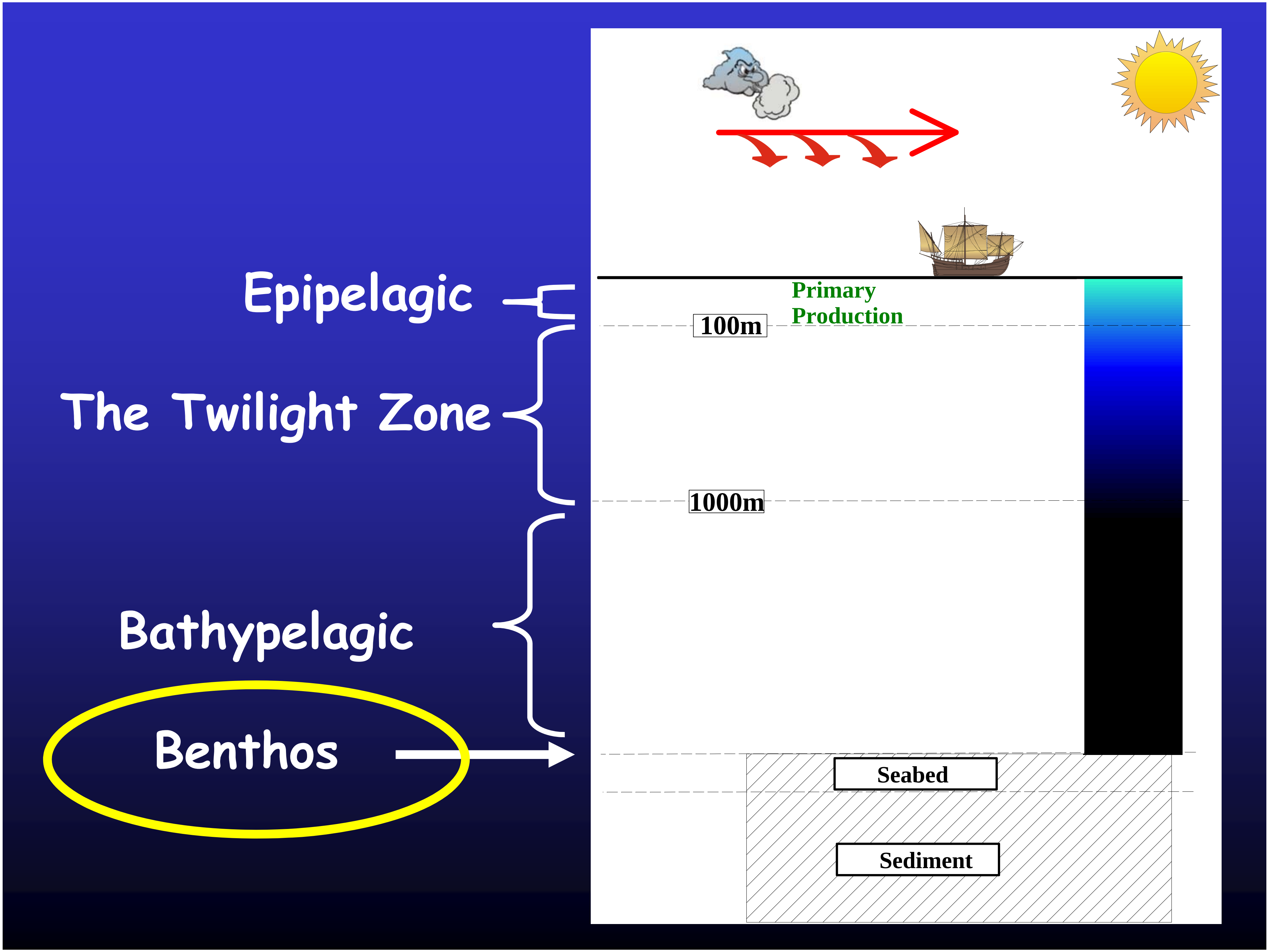


Lampitt et al 2010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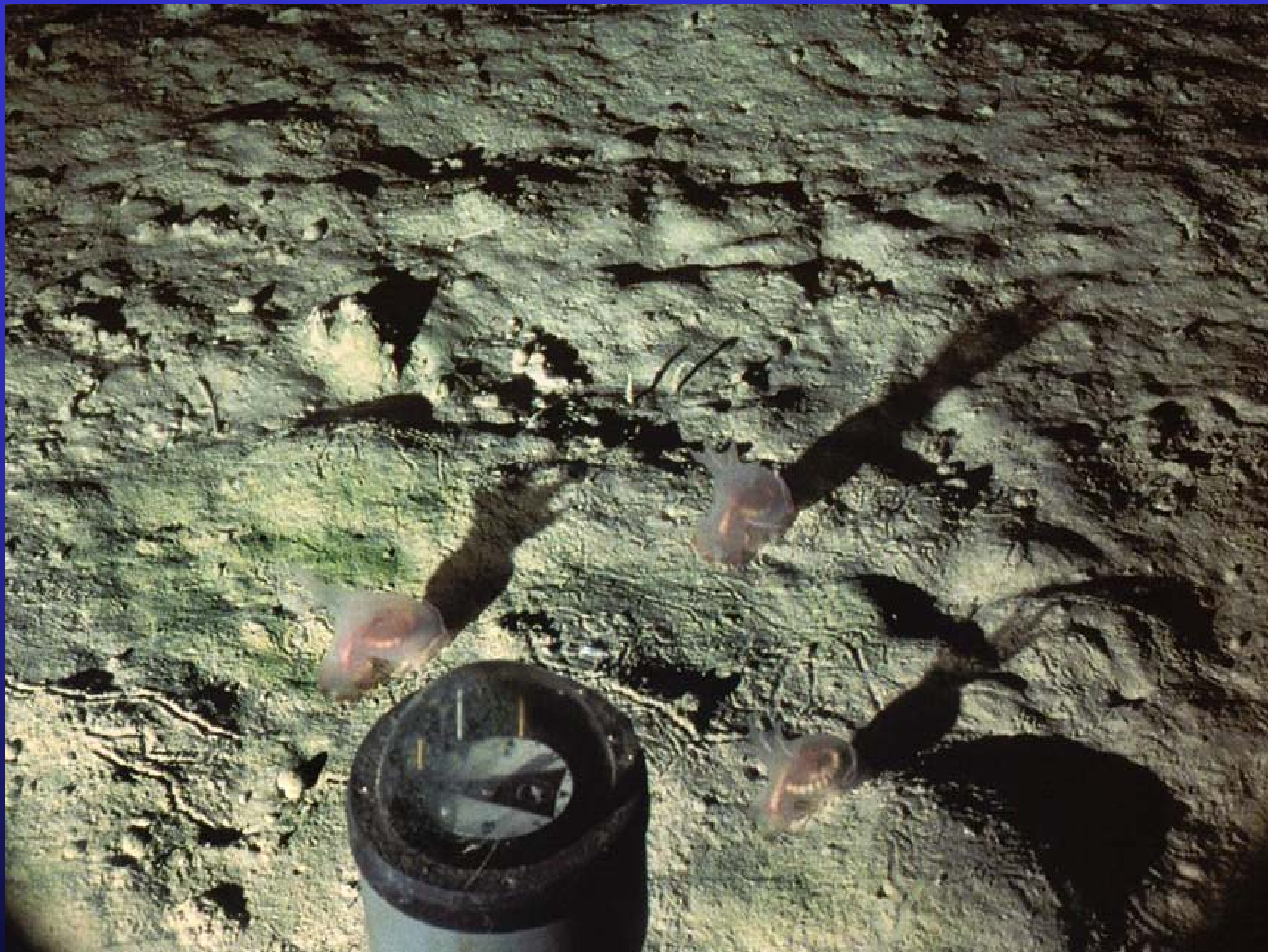
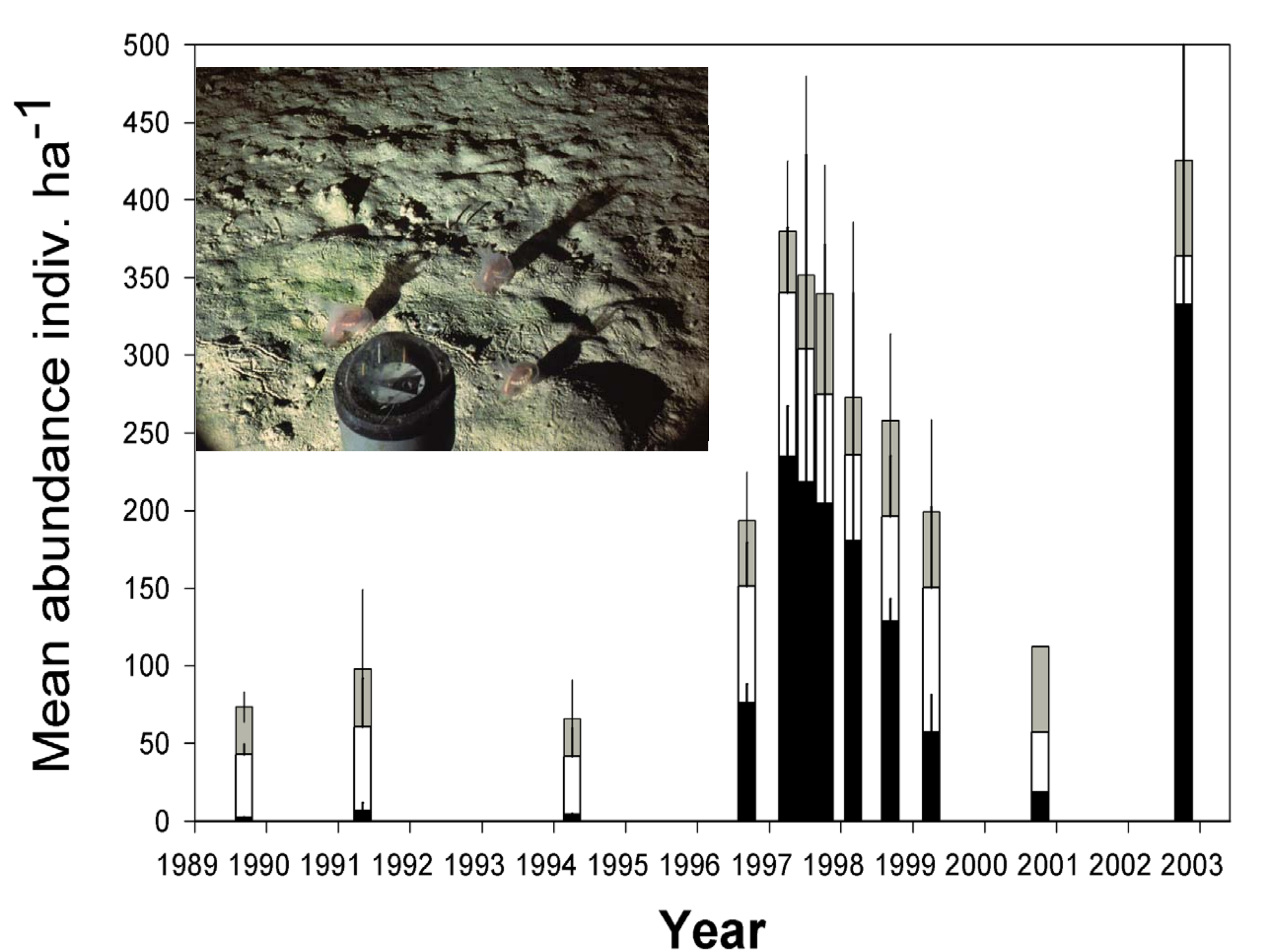
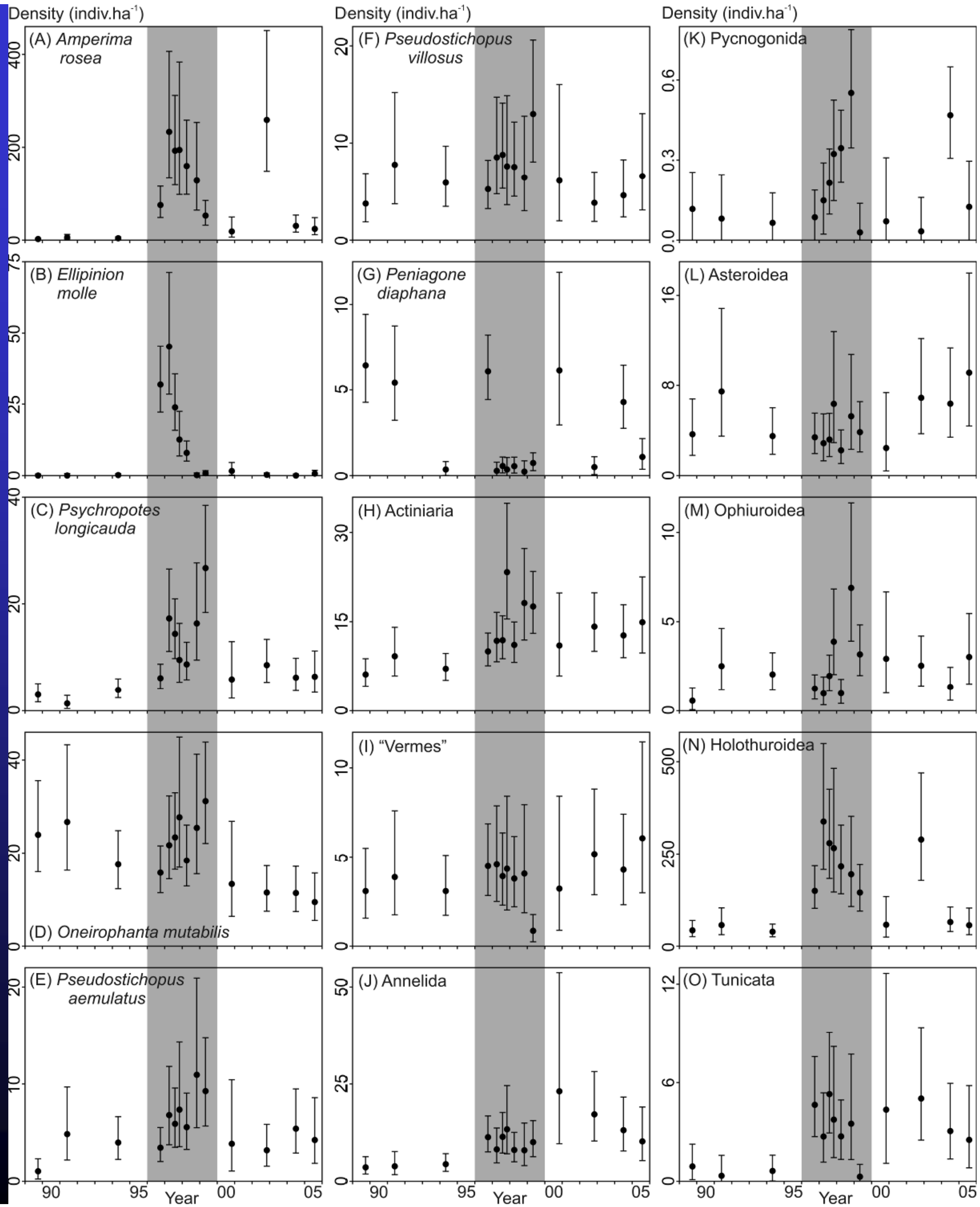


The seabed below (4800m)



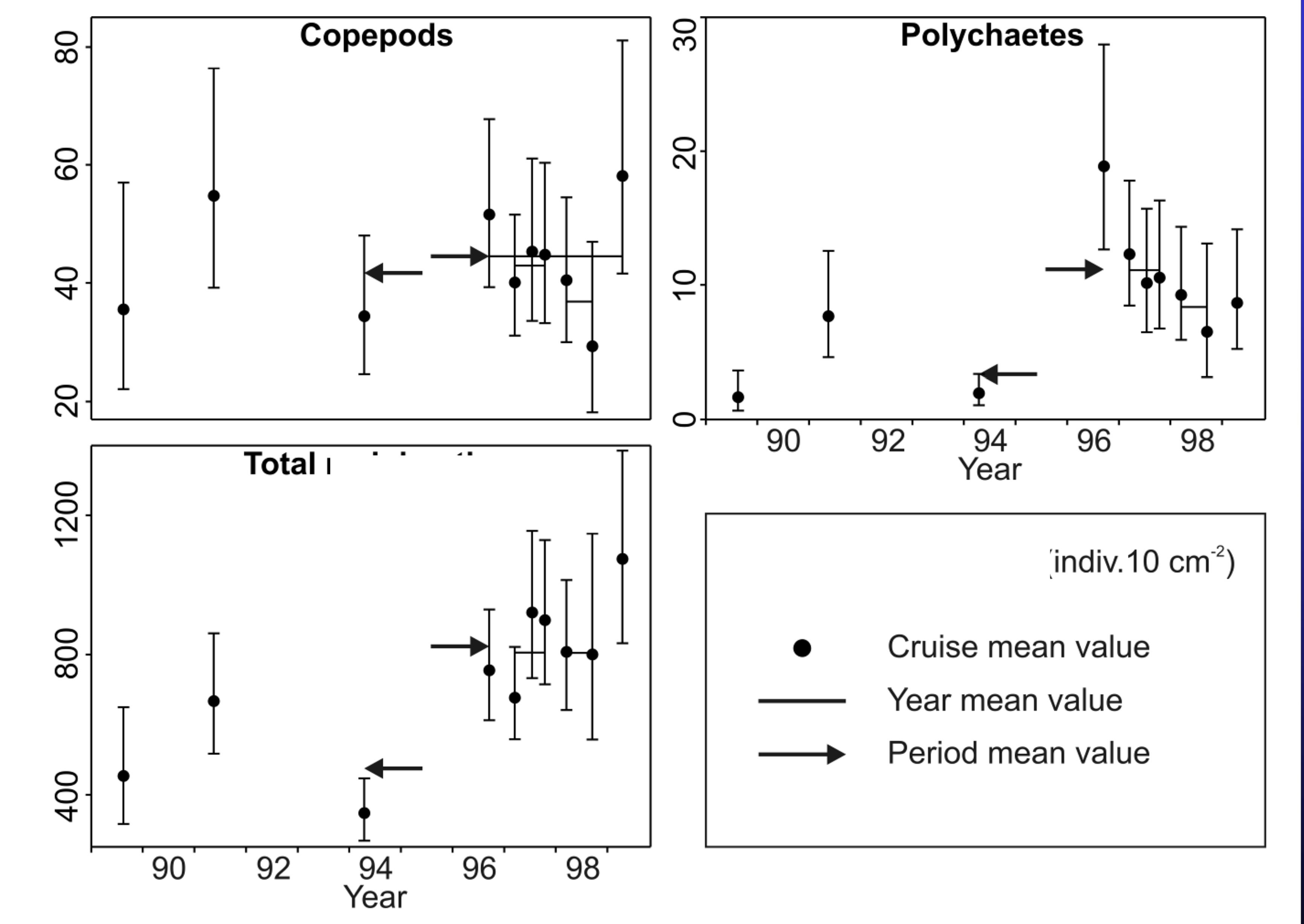
Wigham et al. 2003

Megabenthos



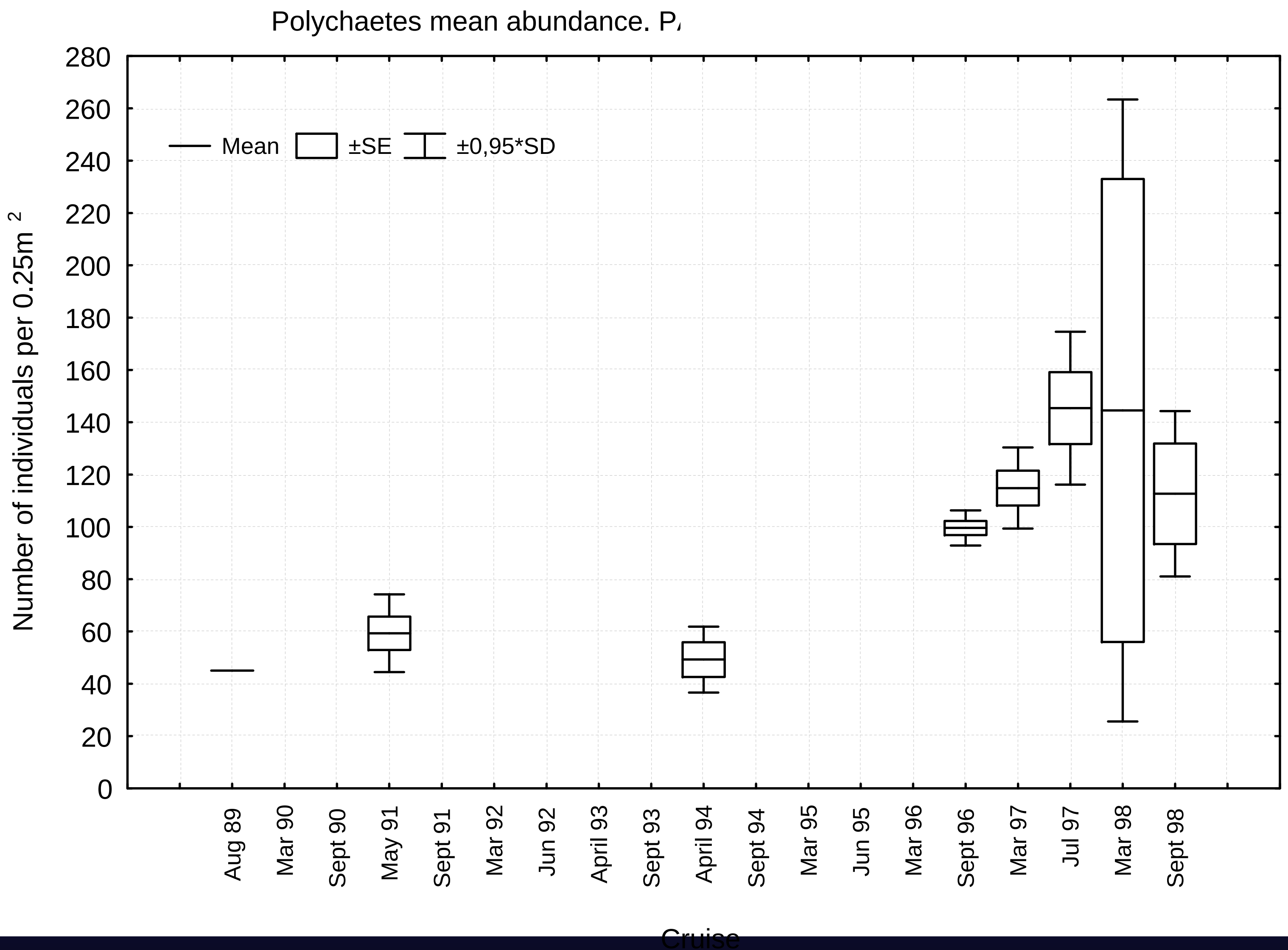
Billett et al. 2010

Macrobenthos



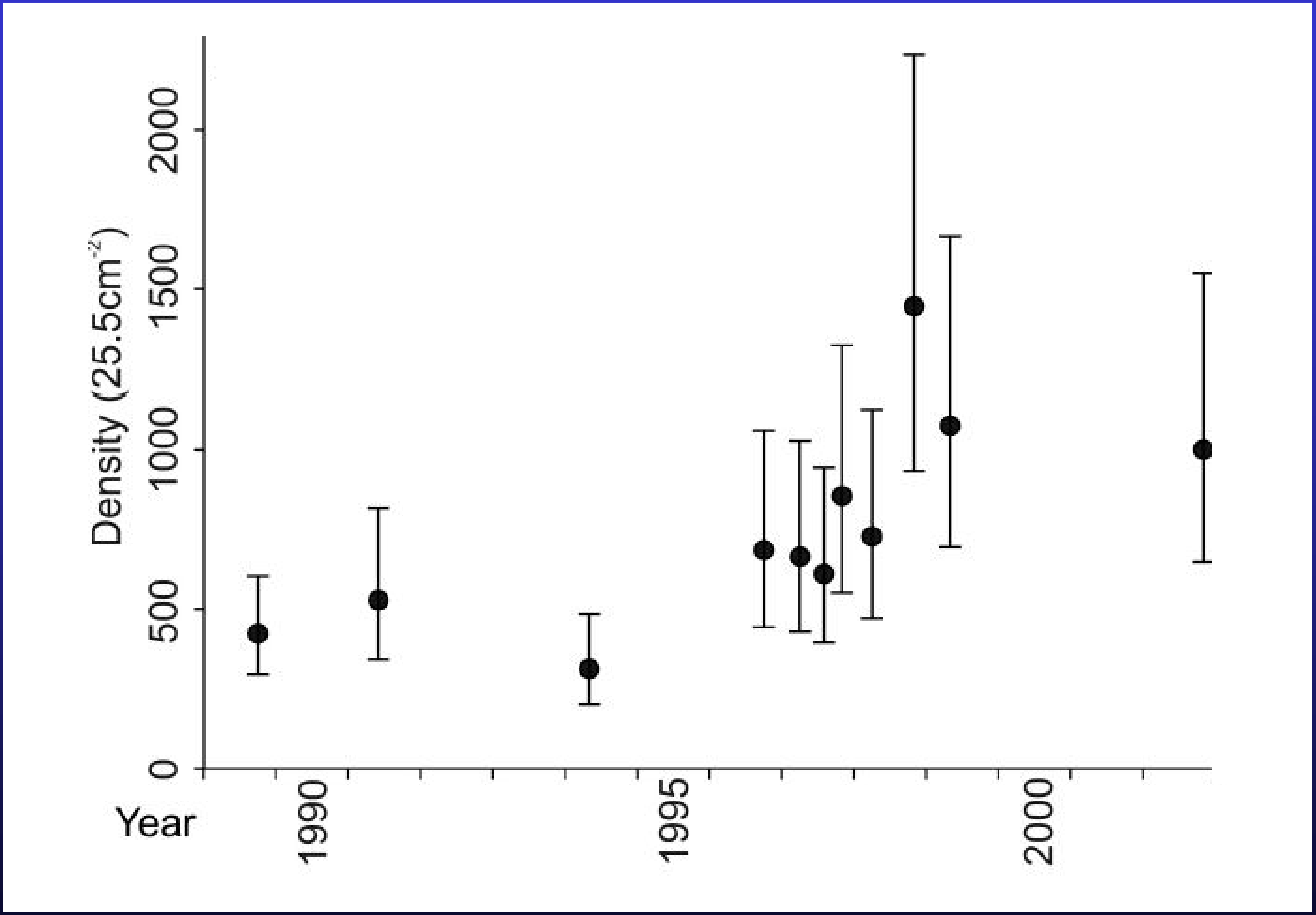
Kalogeropoulou et al. 2010

Meiofauna

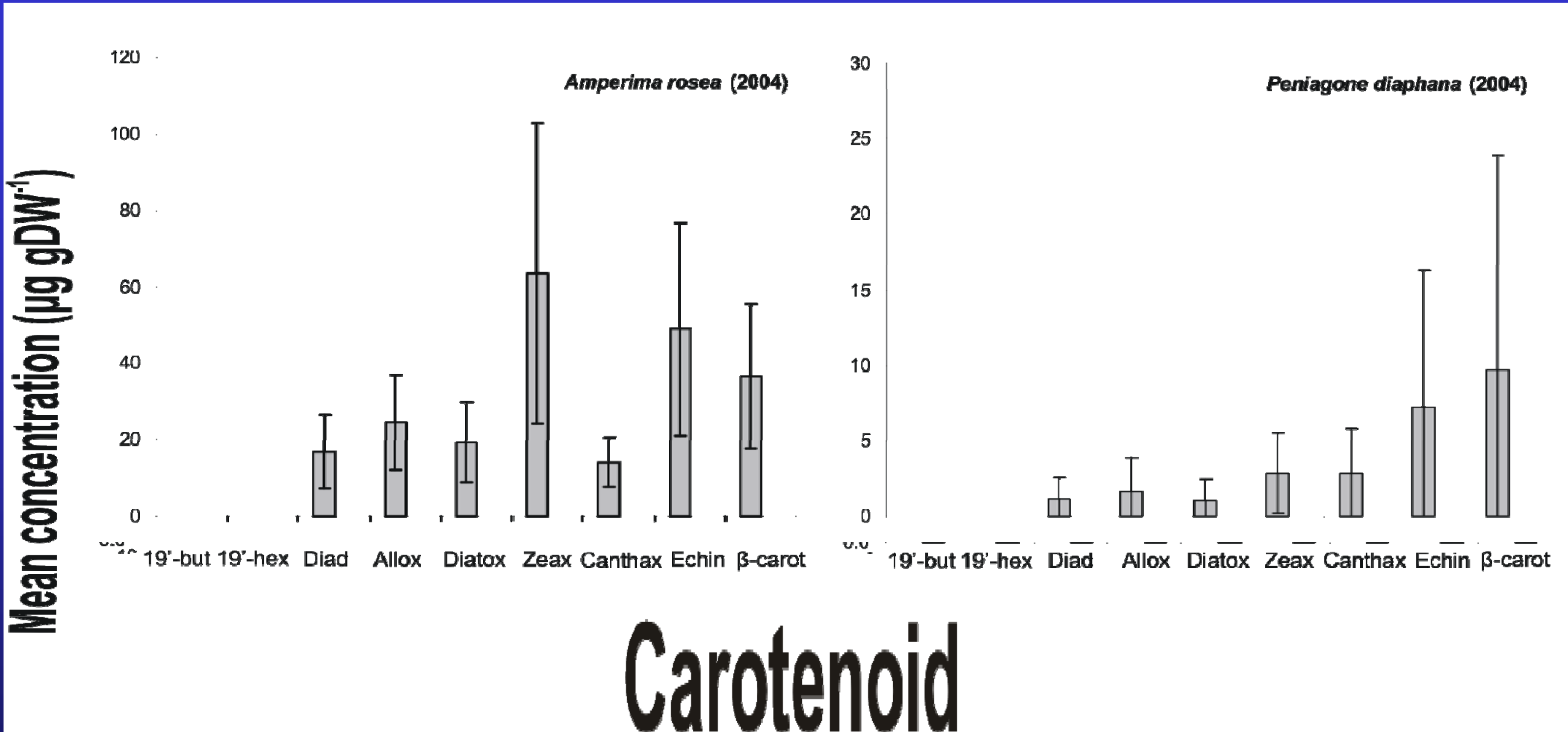


Soto et al. 2010

Foraminifera

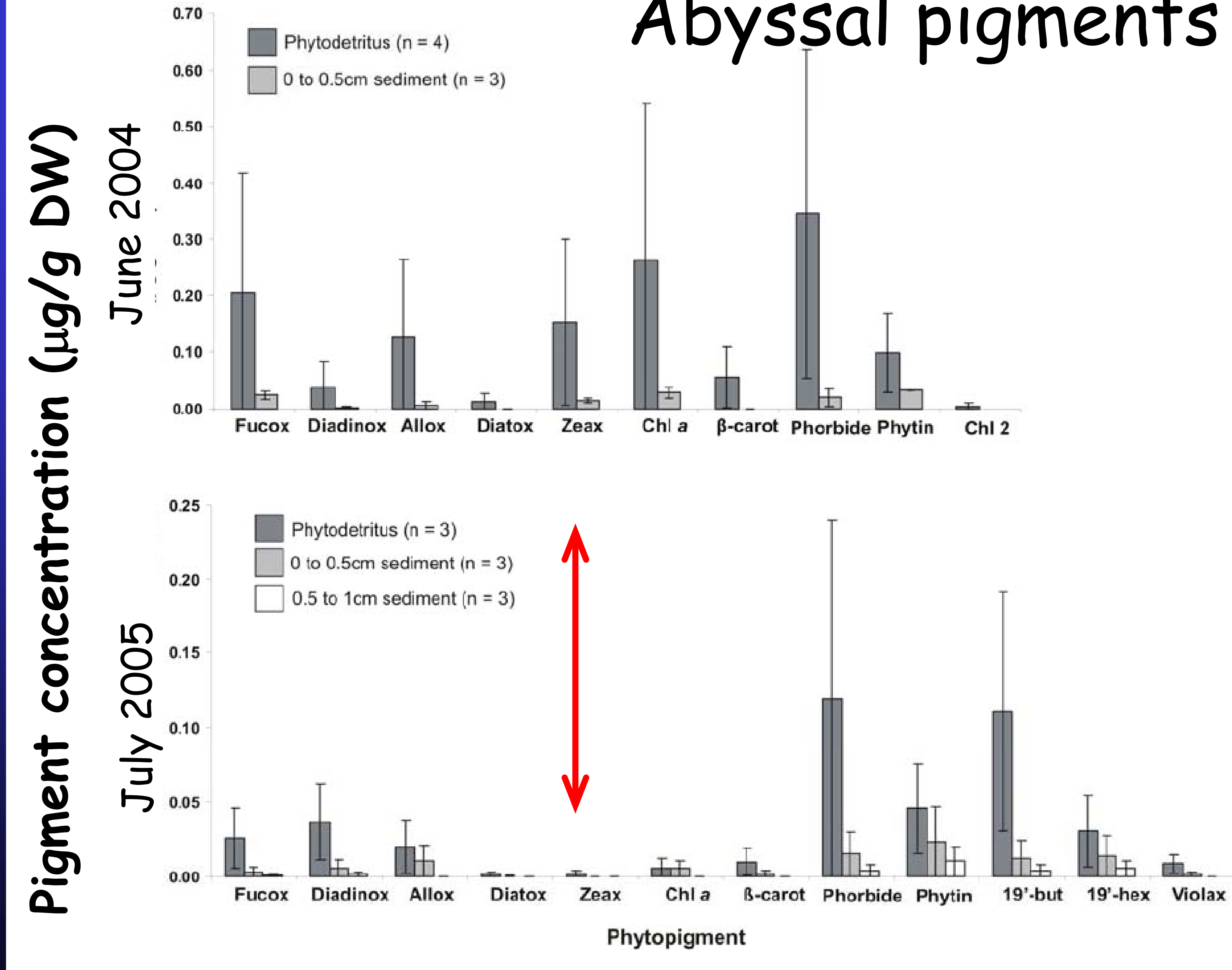


Gooday et al. 2010

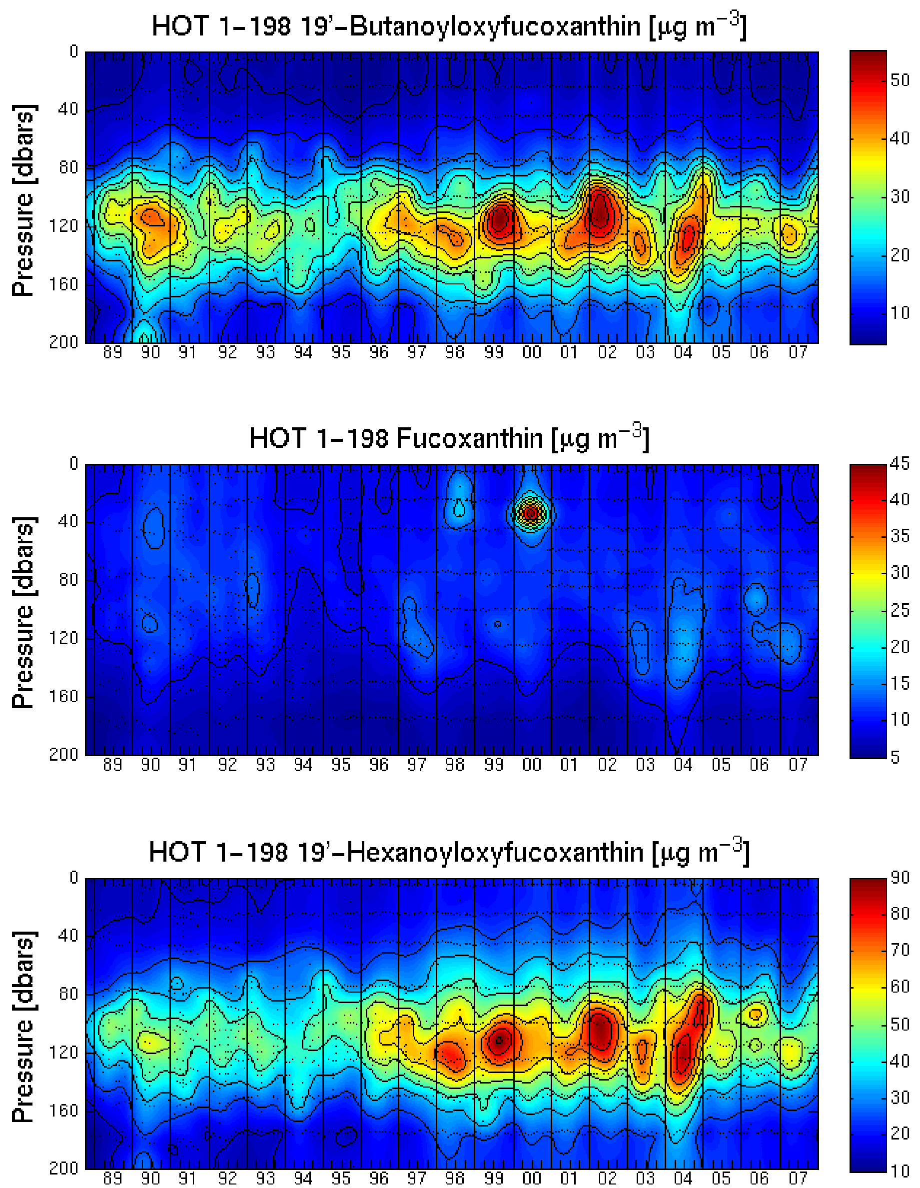


FitzGeorge-Balfour et al 2010

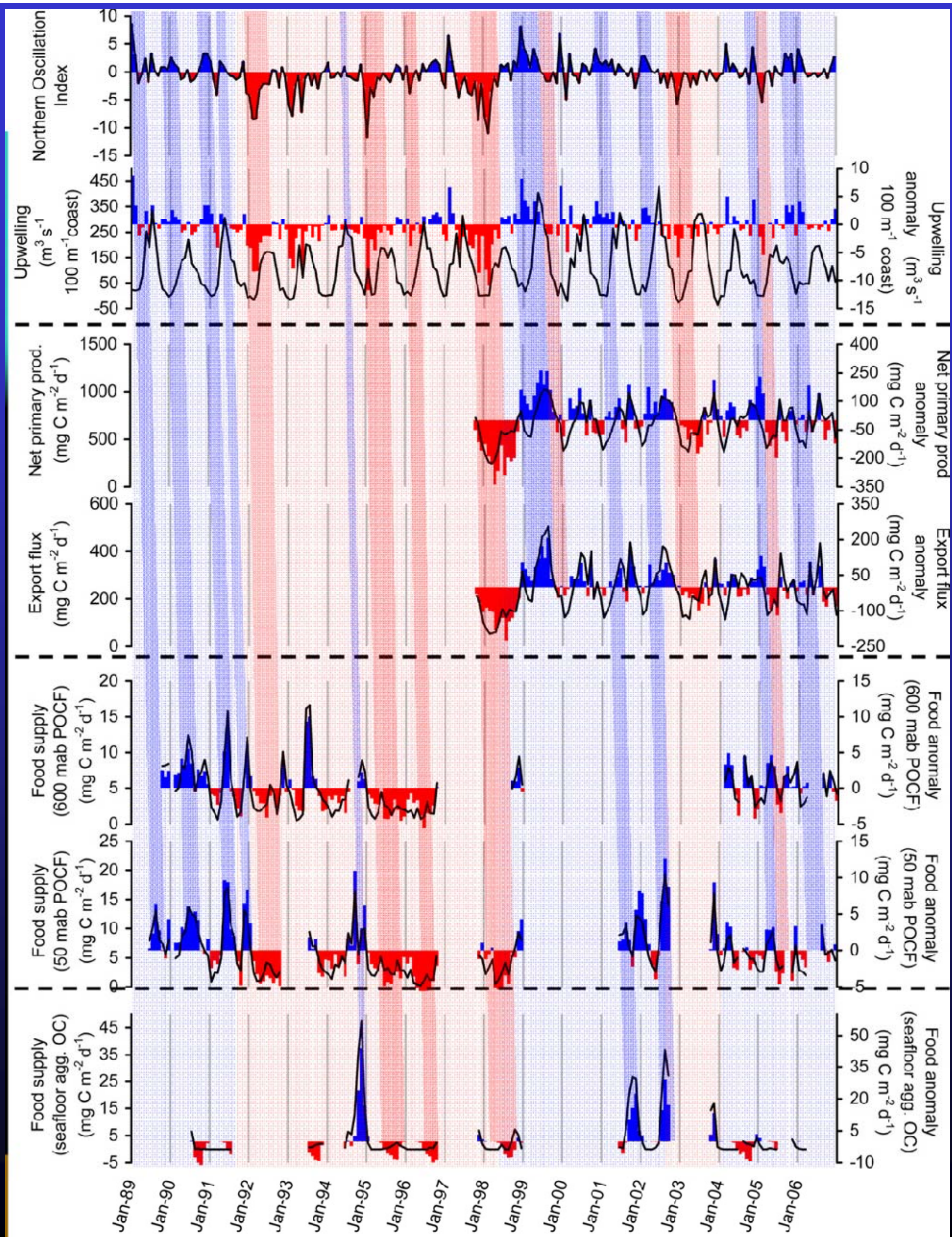
Abyssal pigments



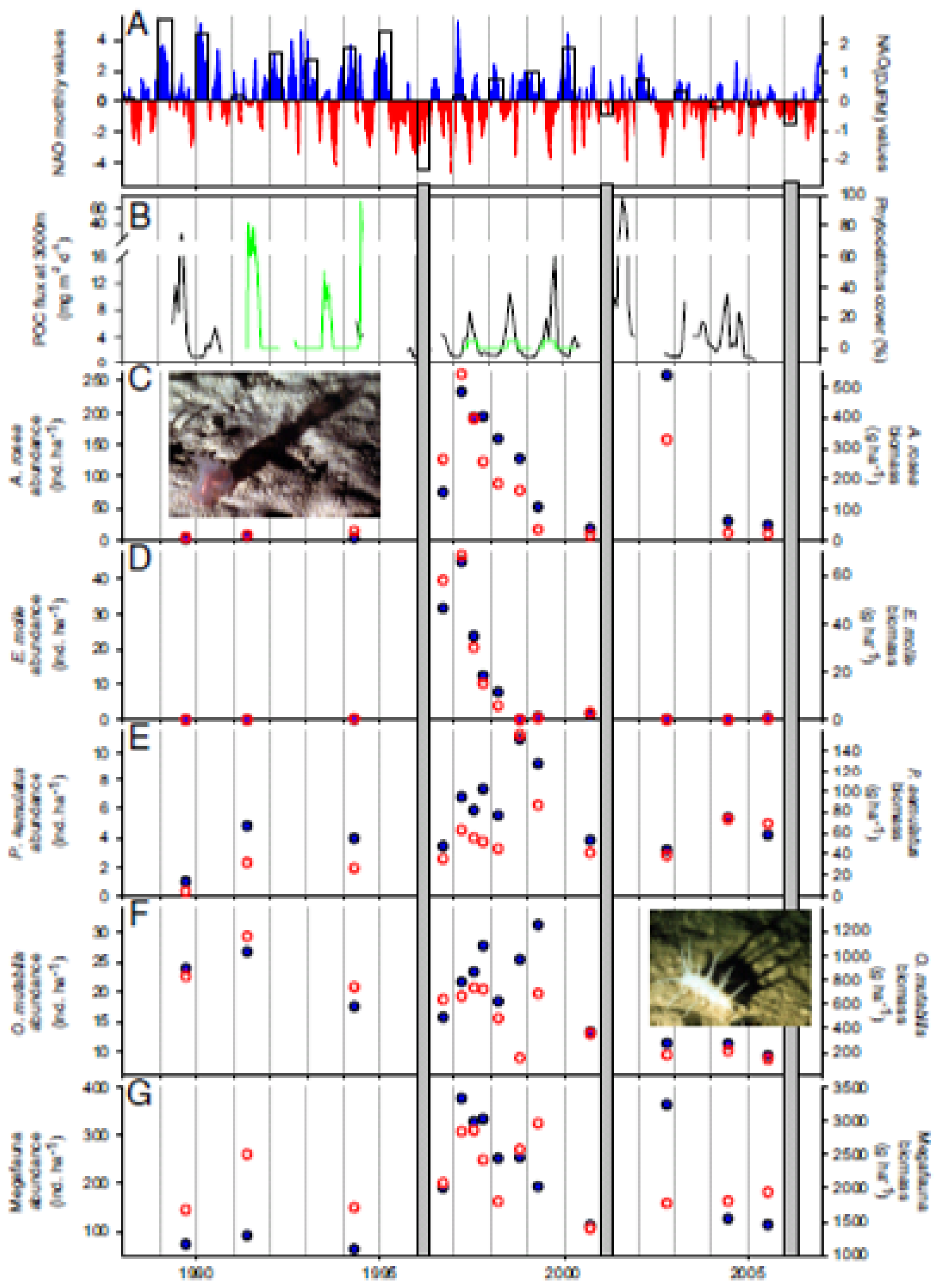
FitzGeorge-Balfour et al 2010


HOT 1–198 19'–Butanoyloxyfucoxanthin [μg m⁻³]
Pressure [dbars]
0 40 80 120 160 200
89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
10 20 30 40 50
HOT 1–198 Fucoxanthin [μg m⁻³]
Pressure [dbars]
0 40 80 120 160 200
89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
5 10 15 20 25 30 35 40 45
HOT 1–198 19'–Hexanoyloxyfucoxanthin [μg m⁻³]
Pressure [dbars]
0 40 80 120 160 200
89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
10 20 30 40 50 60 70 80 90

Smith et al 2009



Smith et al 2009



Year

Smith et al 2009

1. Comparison of benthic communities at Station M and PAP at >4,000m depth.
2. Large changes in deep-ocean ecosystems correlated to climate-driven changes in the surface ocean.
3. Climate-driven variation affects oceanic communities from surface to deep sea.

Is the community ready for the challenge?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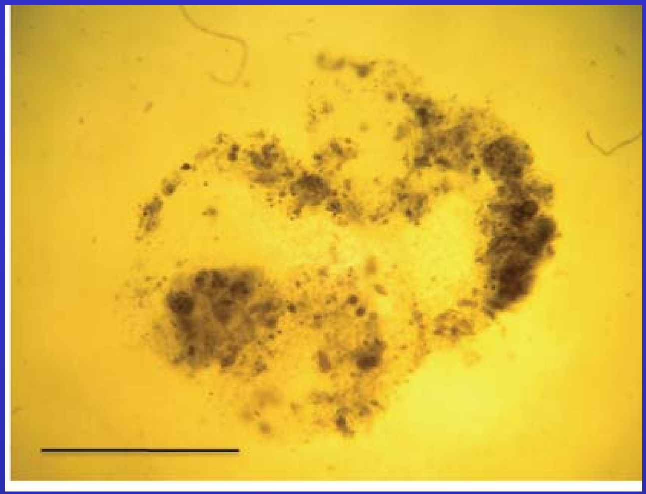
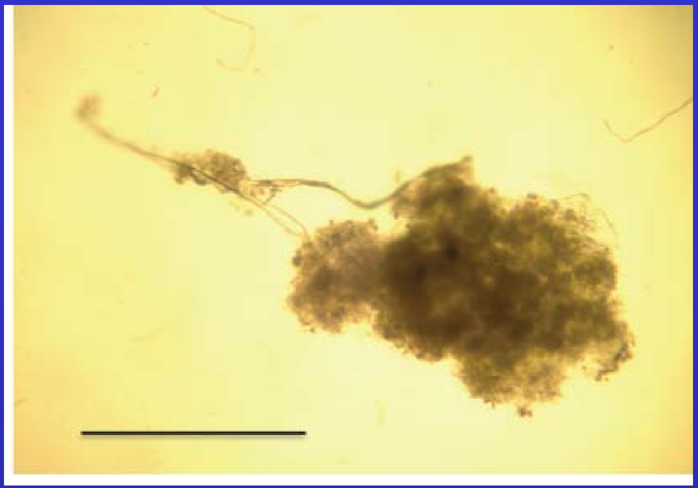
Ken O. Buessler
Richard S. Lampitt
Understanding the Ocean's Biological Pump:
results from VERTIGO
www.elsevier.com/locate/dsr2

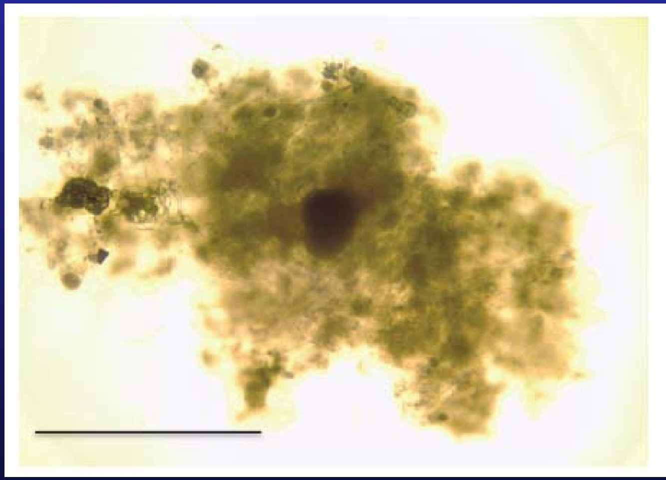
.“The Snatcher“



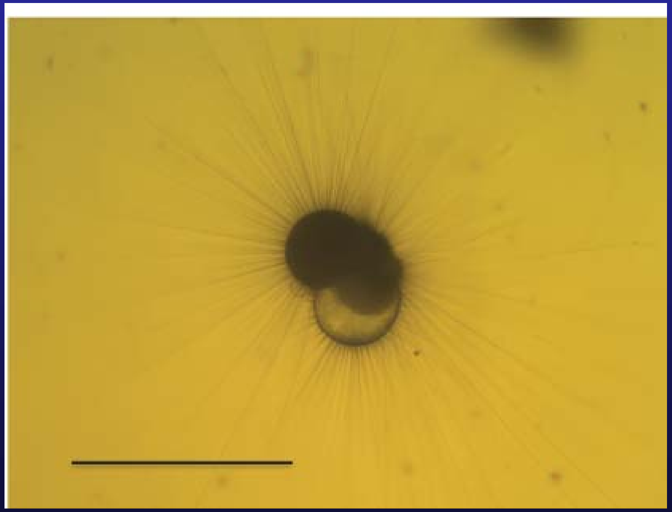
Diffuse Particle



Dense Particle

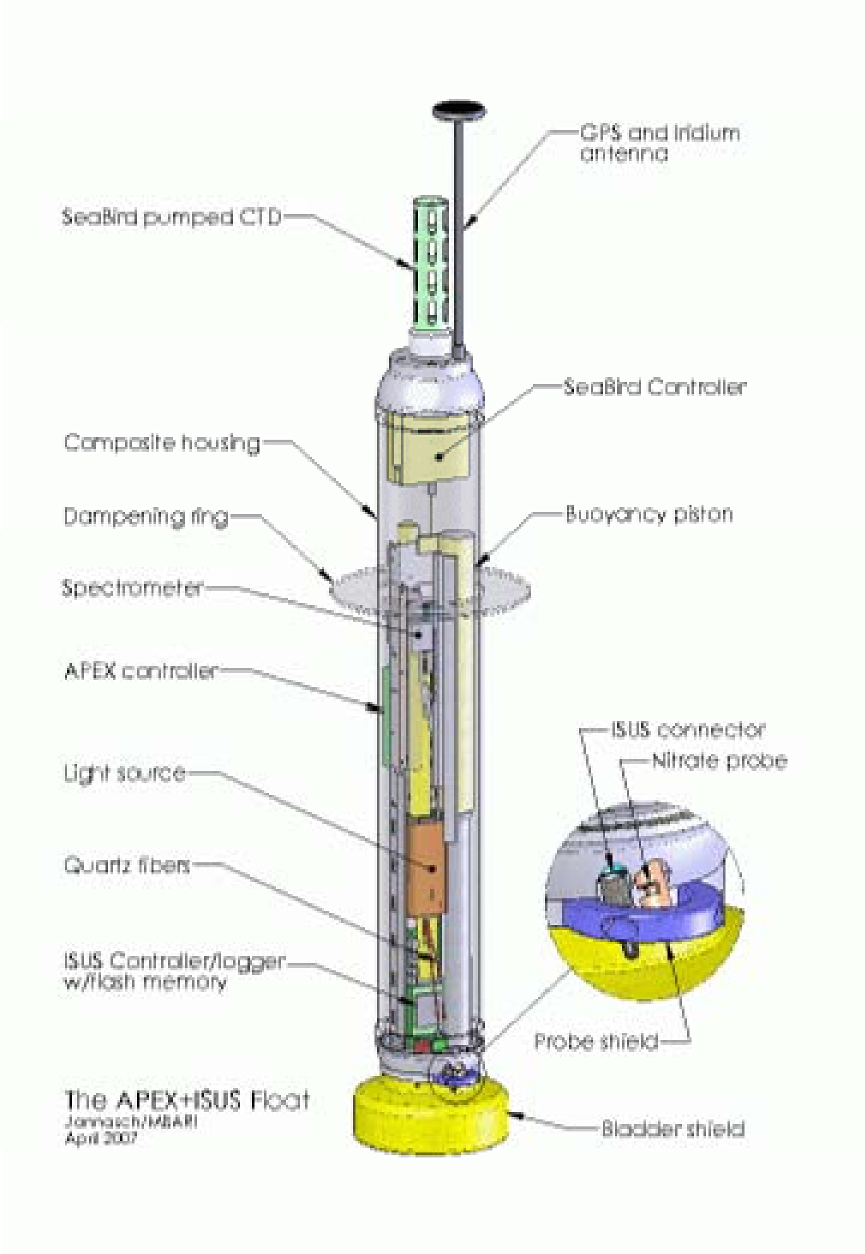


Centred Particle



Organism

Jen Riley



APEX profiling float with optical nitrate sensor

From Ken Johnson

IODA

In situ oxygen consumption

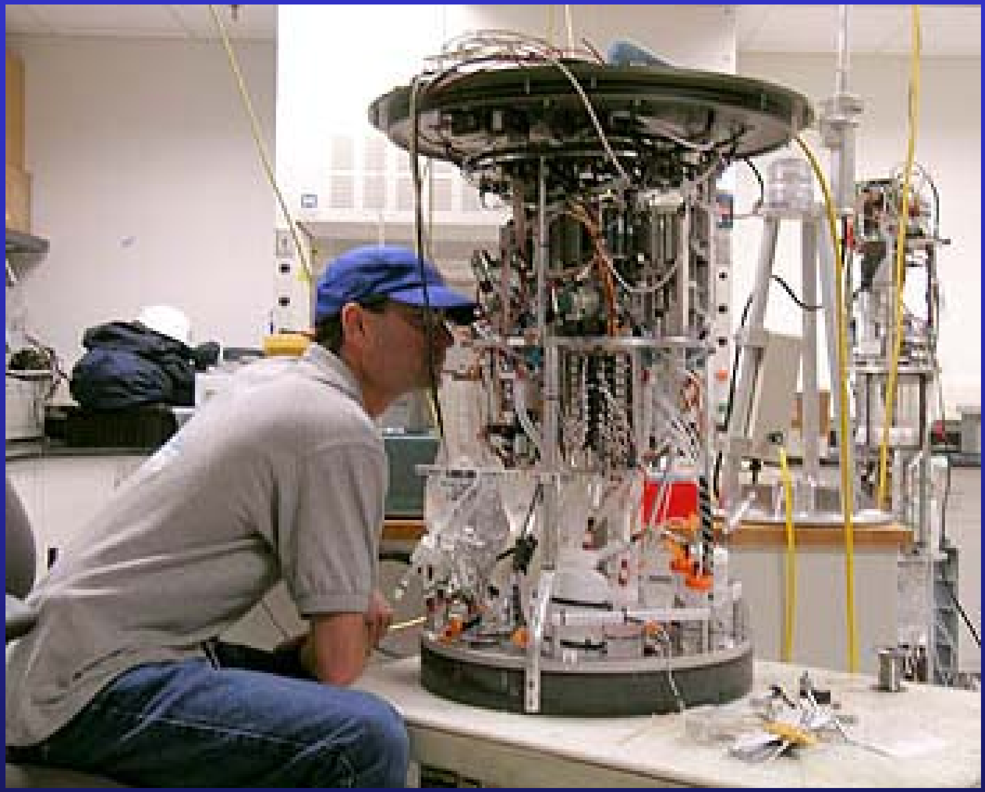
Tamburini et al

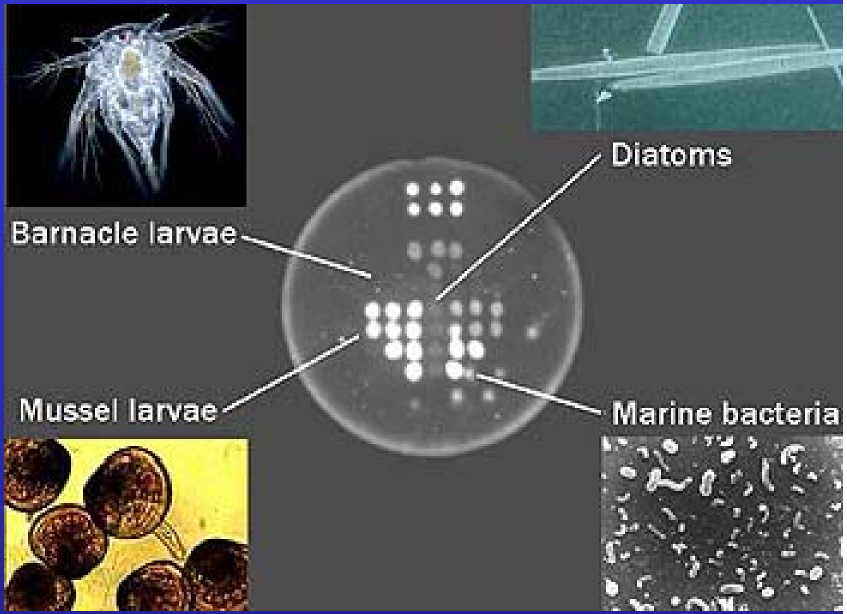
Sinking particle simulation experiments

High Pressure Bottles:
- 500 ml

Simulate sinking of
150 m/day

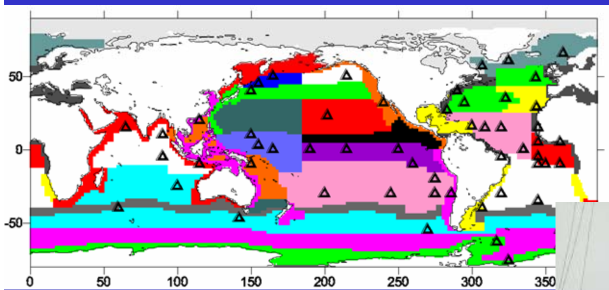
Tamburini et al,2005

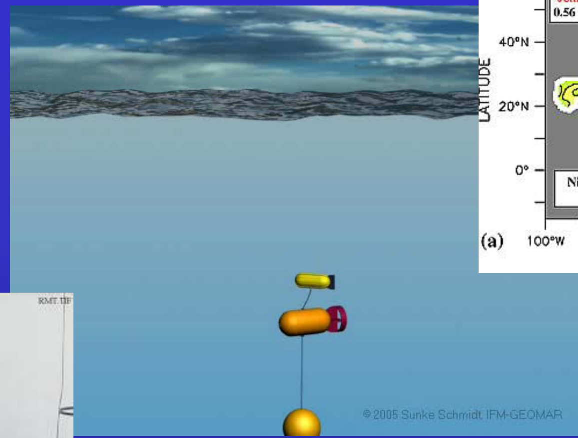


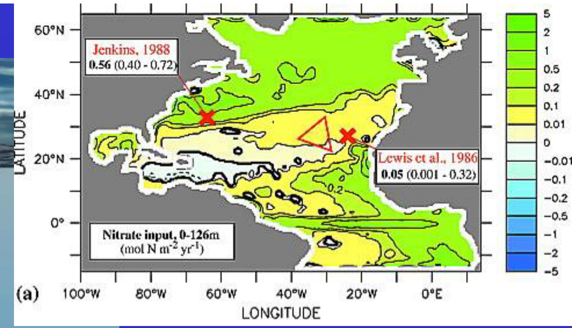


The MBARI Environmental Sample Processor

Sample collection with in situ molecular probe technology

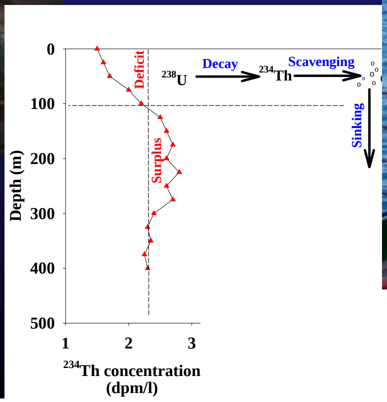

50
0
-50
0
50
100
150
200
250
300
350

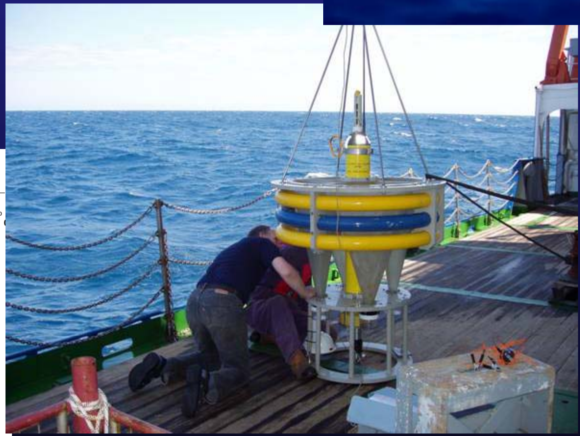

©2005 Sunke Schmidt IFM-GEOMAR

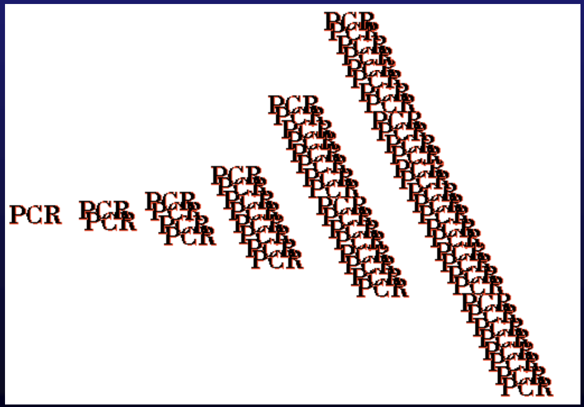

Jenkins, 1988
0.56 (0.40 - 0.72)
Lewis et al., 1986
0.05 (0.001 - 0.32)
Nitrate input, 0-126m
(mol N m^{-2} yr^{-1})
(a)
60°N
40°N
20°N
0°
LATITUDE
100°W
80°W
60°W
40°W
20°W
0°E
LONGITUDE
5
2
1
0.5
0.2
0.1
0.01
0
−0.01
−0.1
−0.2
−0.5
−1
−2
−5


IX
INSU


OPTODE 3830


Deficit
Surplus
^{238}U
Decay
^{234}Th
Scavenging
Sinking
Depth (m)
0
100
200
300
400
500
1
2
3
^{234}Th concentration
(dpm/l)




PCR