The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2066-12

Workshop and Conference on Biogeochemical Impacts of Climate and Land-Use Changes on Marine Ecosystems

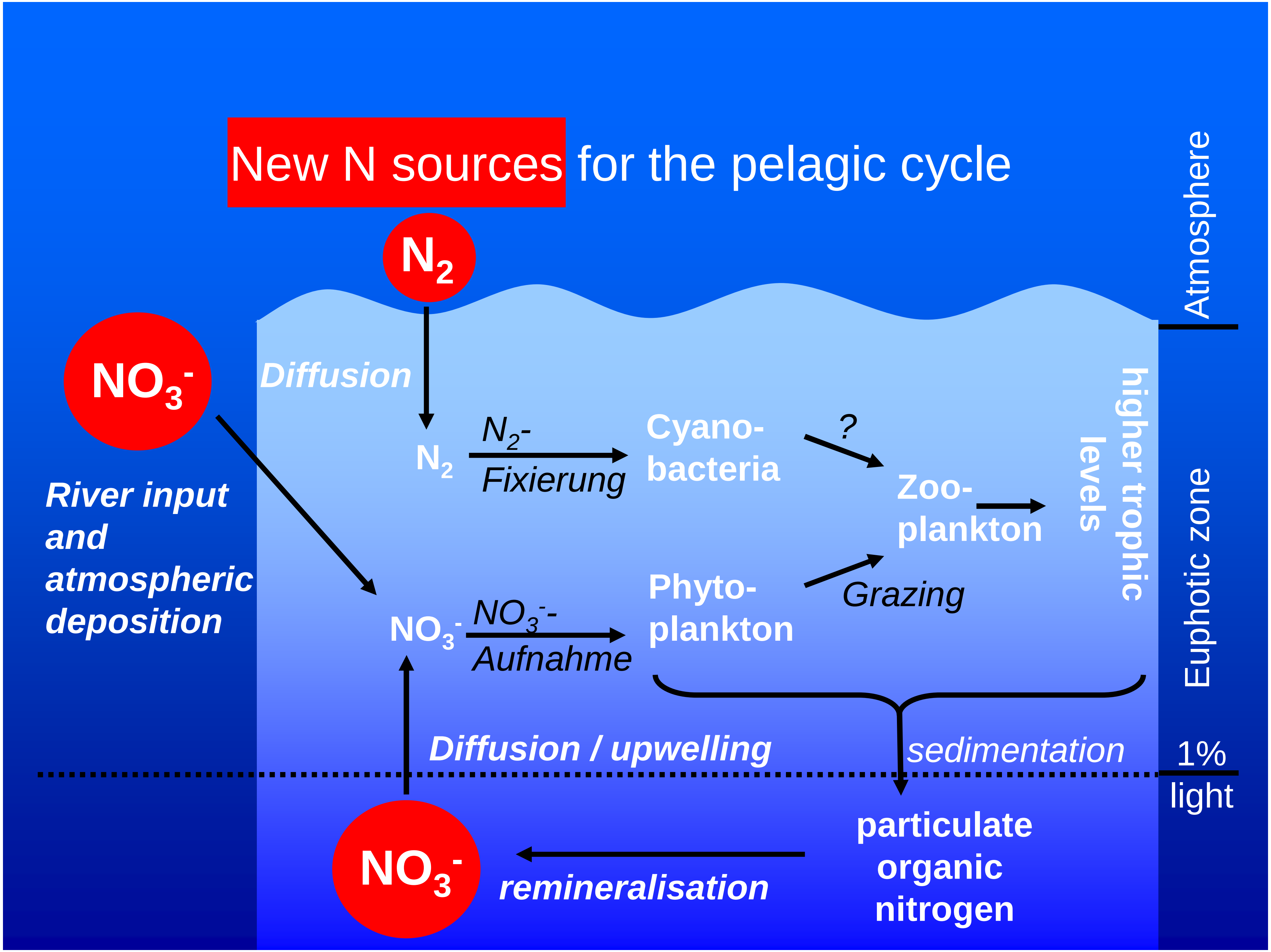
2 - 10 November 2009

Nutrient cycling in the Mekong River plume

M. Voss
IOW
Germany

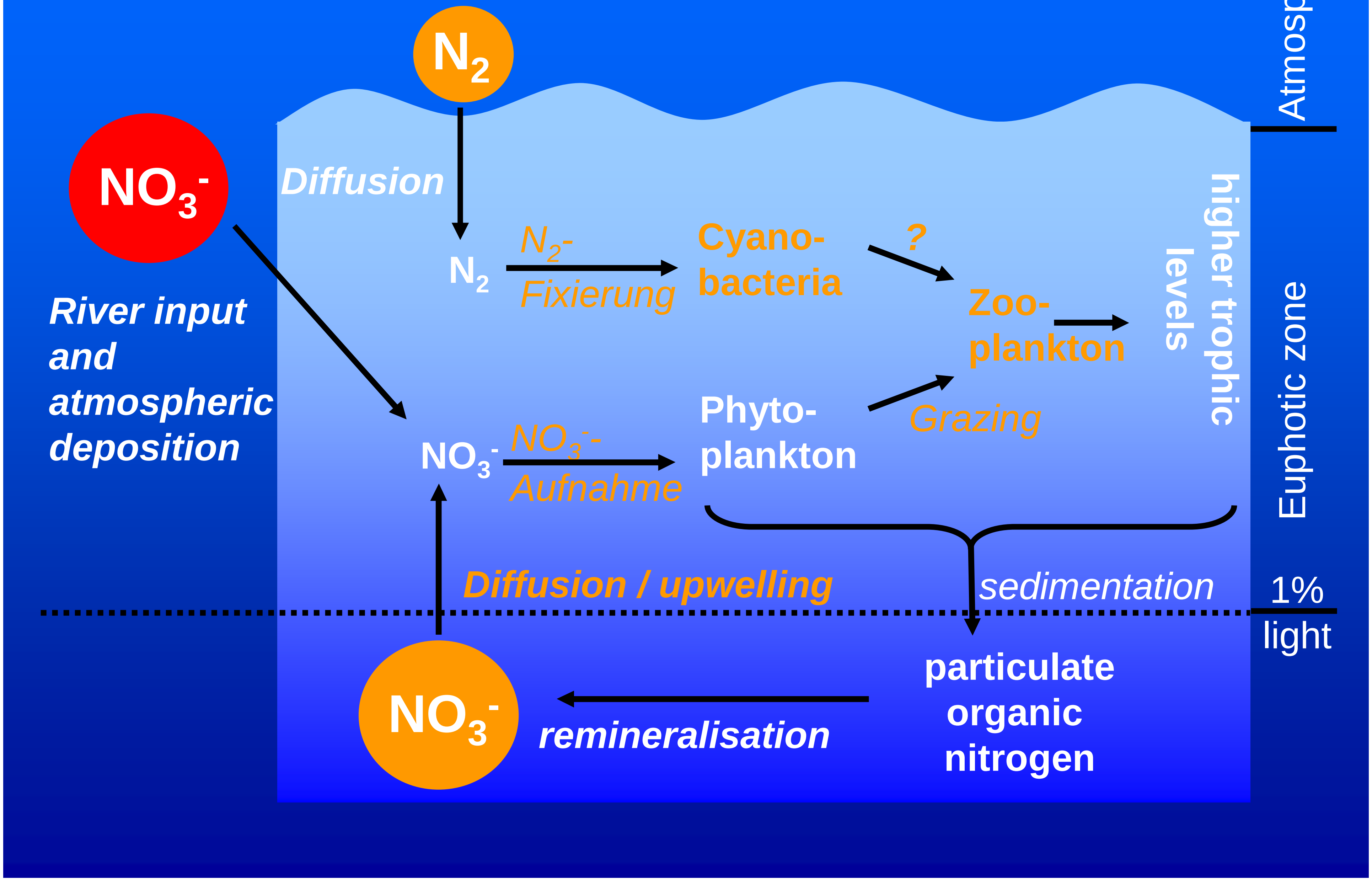
Nutrient cycling in the Mekong River plume

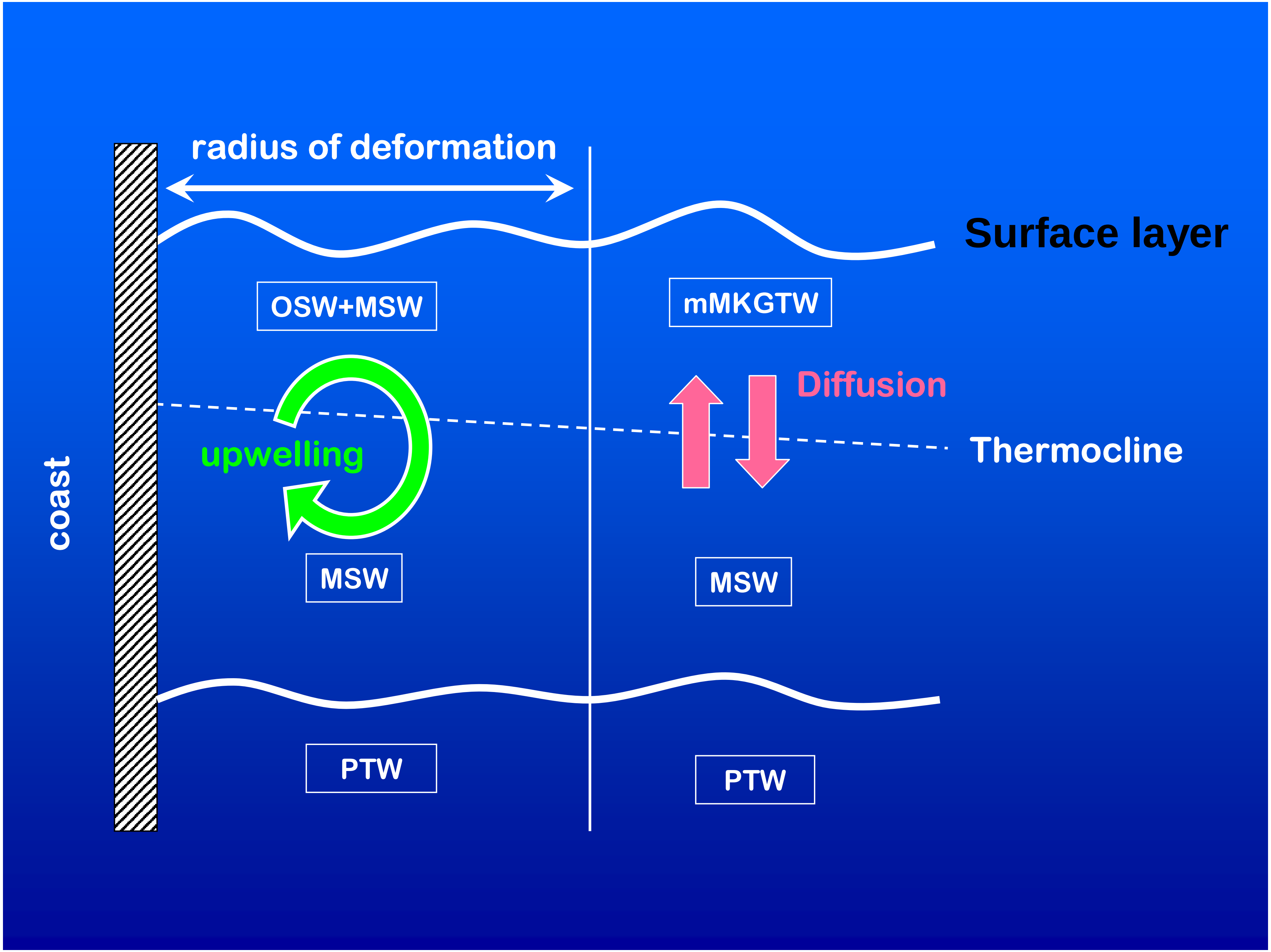
Maren Voss, Deniz Bombar, Joachim Dippner, Julia Grosse, Doan Nhu Hai, Frederike Korth, Nguyen Ngoc Lam, Iris Liskow



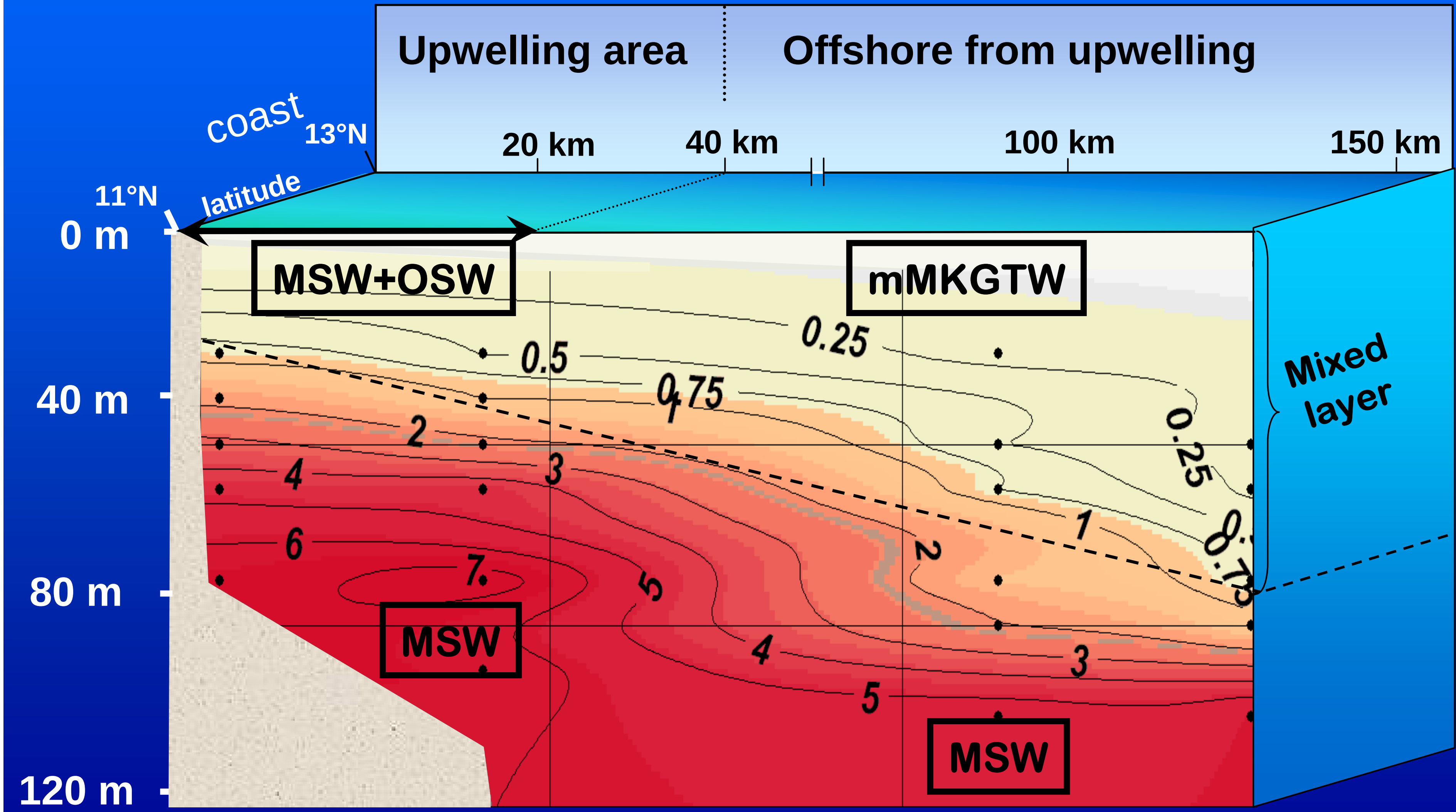
New N sources for the pelagic cycle
Atmosphere
N_2
NO_3^-
Diffusion
N_2
N_2-Fixierung
Cyano-bacteria
?
Zoo-plankton
higher trophic levels
River input and atmospheric deposition
NO_3^-
NO_3^--Aufnahme
Phyto-plankton
Grazing
Euphotic zone
Diffusion / upwelling
sedimentation
1% light
NO_3^-
remineralisation
particulate organic nitrogen

New N sources for the pelagic cycle

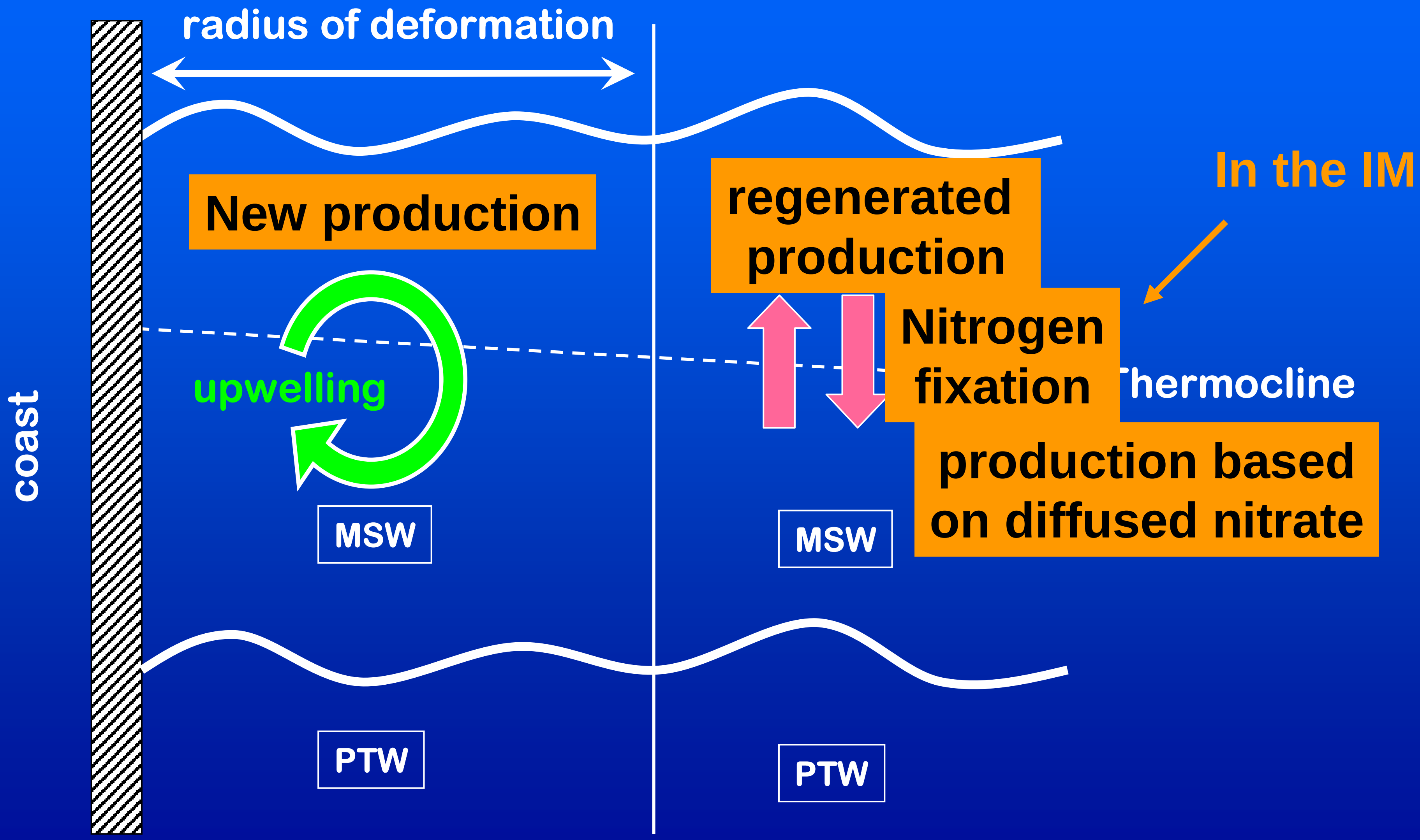



radius of deformation
Surface layer
OSW+MSW
mMKGTW
Diffusion
upwelling
Thermocline
coast
MSW
MSW
PTW
PTW

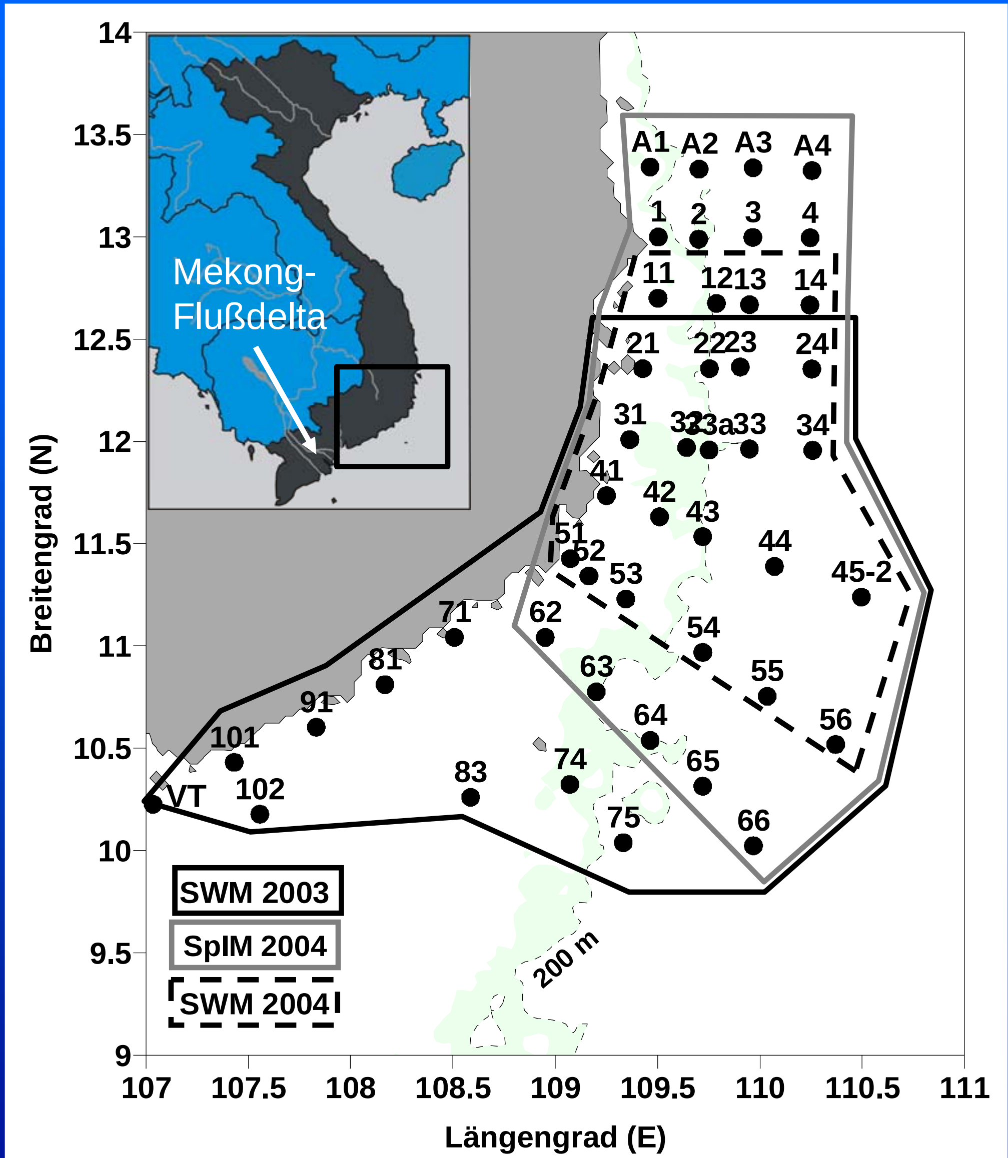
Nitrate concentrations (µmol L^{-1}) SWM 2003



Expecations for the production



Station Map



SW Monsun (SWM)
Post El Nino
18. - 28. Juli 2003

Spring intermonsoon (SpIM)
21. April - 2. Mai 2004

SW Monsun (SWM)
„Normal year“
8. - 26. Juli 2004

Determination of fixation rates

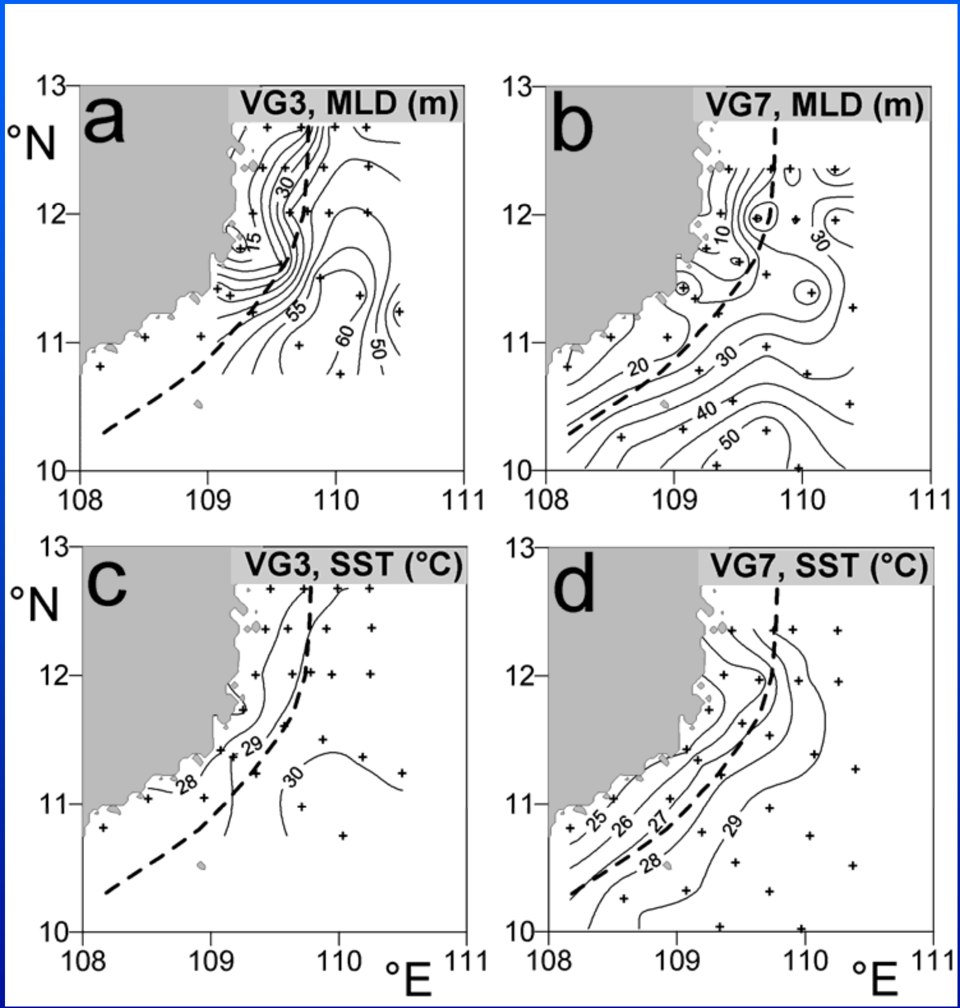
A) 2,3 liters of natural sample +
2,4ml $^{15}N_2$ - gas

B) Incubations of 6-7 hr on deck,
cooled by flowing seawater,
different depths simulated with neutral density screening

C) End of experiments: Vacuum filtration of samples through GF/F-filters.

D) Combustion of dried GF/F-filters, determination of POM - $\delta^{15}N$ in mass spectrometer, calculation of N-fixation rates

Comparison of SWM periods in 2003 and 2004

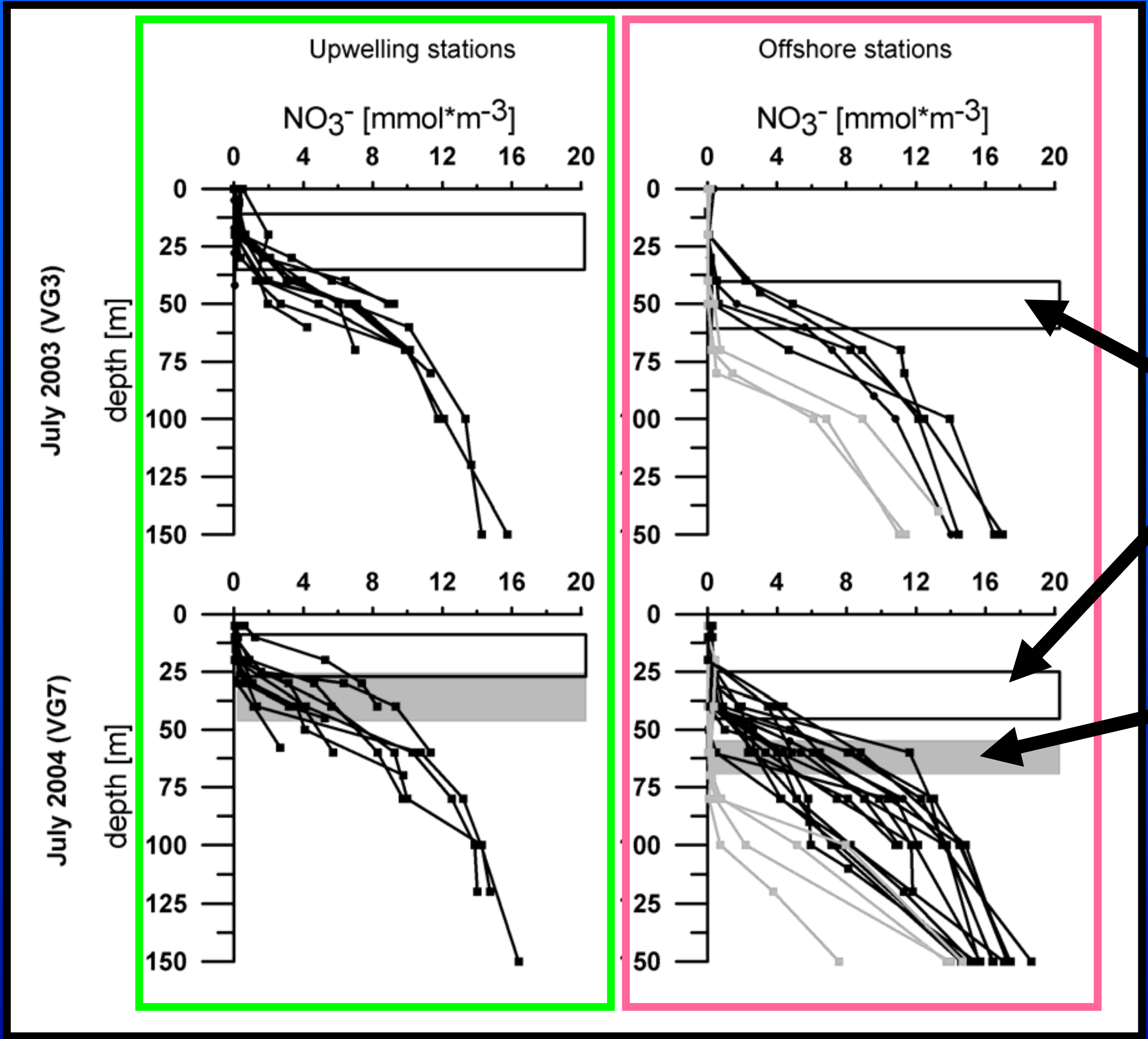


- MLD Mixed layer depths (m)
- SST Sea Surface Temperature (°C)

- Contour intervals are 5m for MLD and 1°C for SST.

Bombar et al. sub.

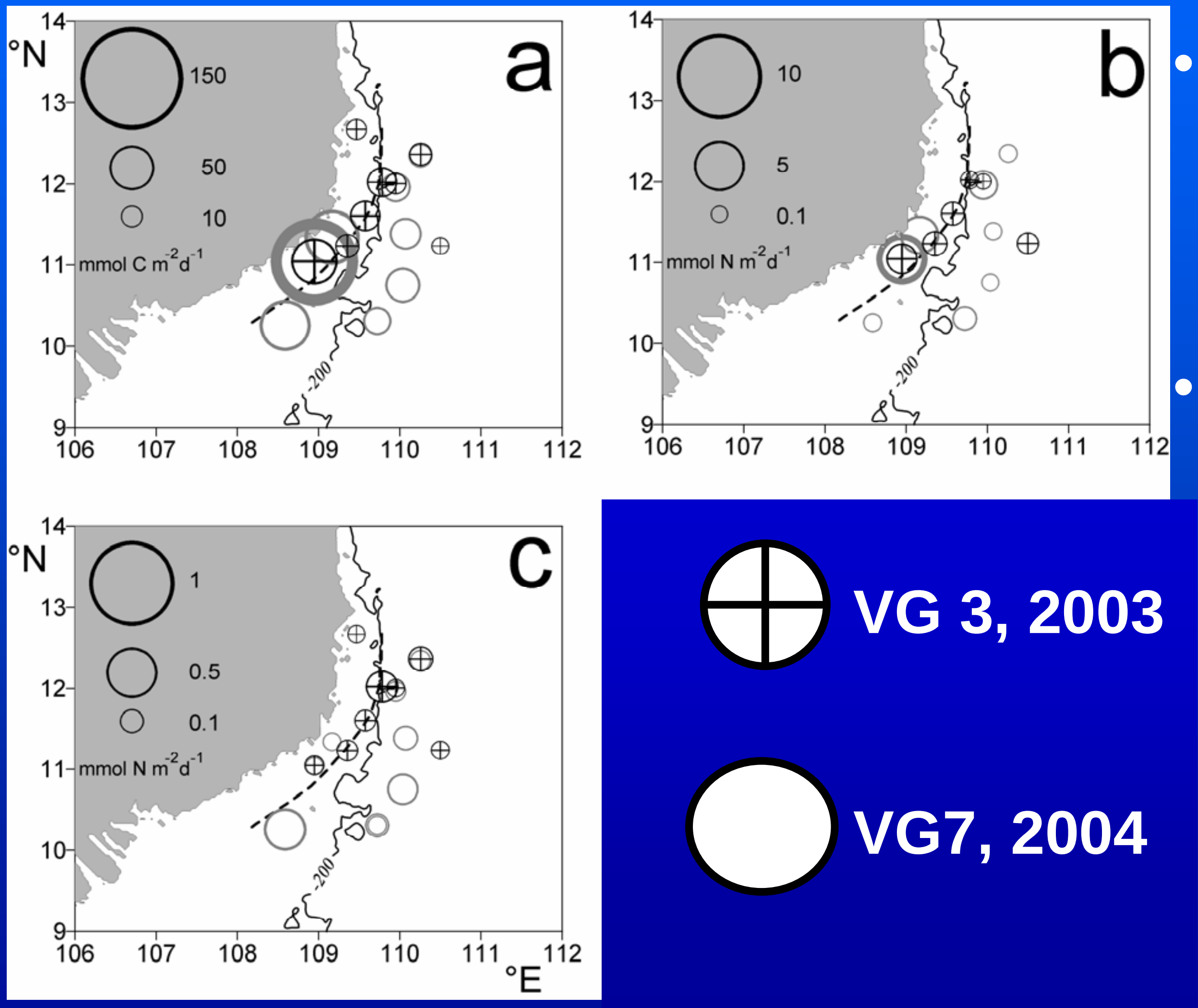
Clear differences in NO_3 concentraitions



- NO3 within the upwelling-
-
- The white boxes represent mixed layer depths,
- The grey boxes represent of euphotic zone depths.

Bombar et al. sub.

Comparison of SWM periods in 2003 and 2004

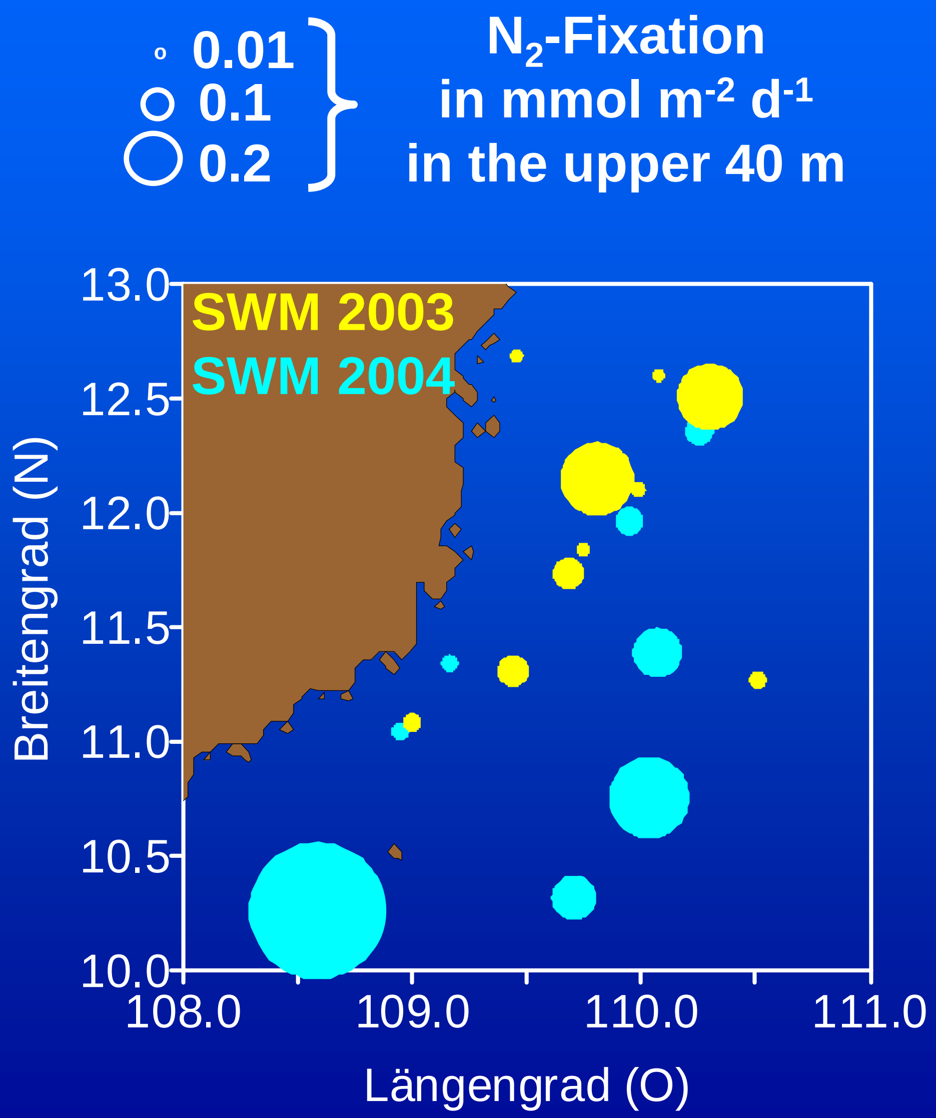


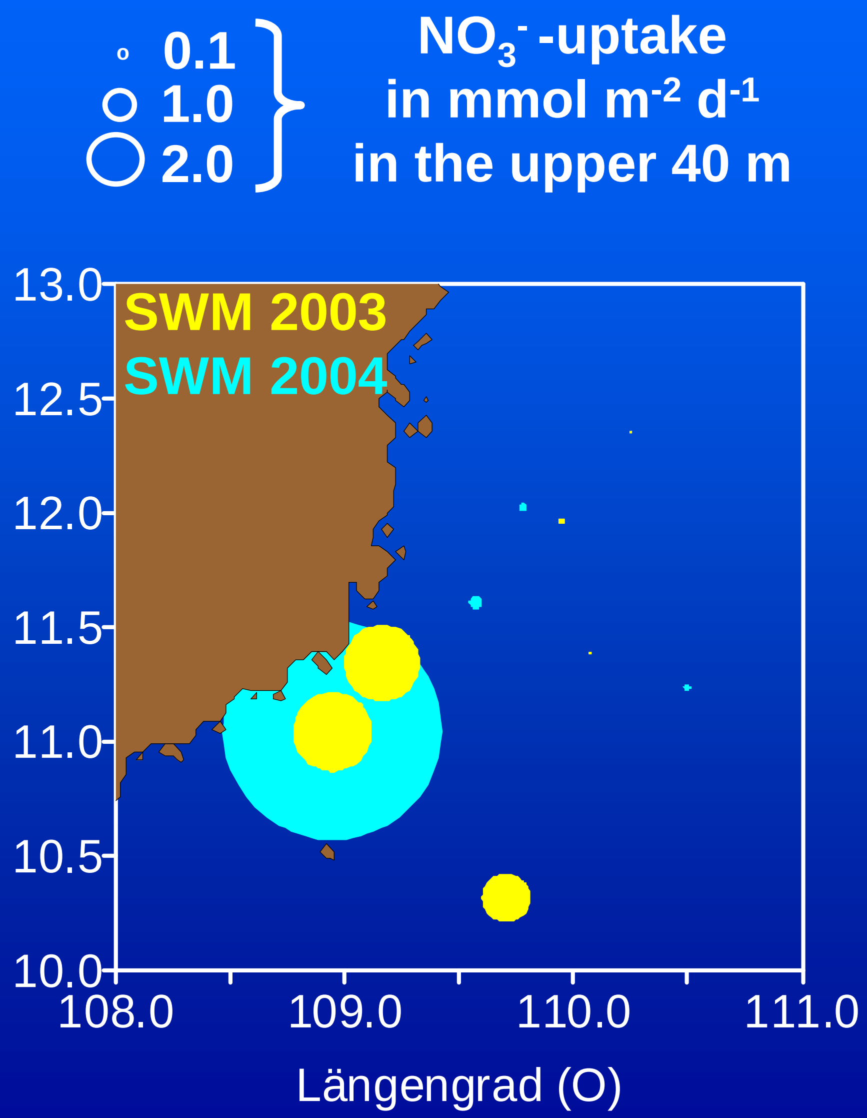
- (a) primary production (mmolC $m^{-2}d^{-1}$)
- (b) nitrate uptake

(c) nitrogen fixation

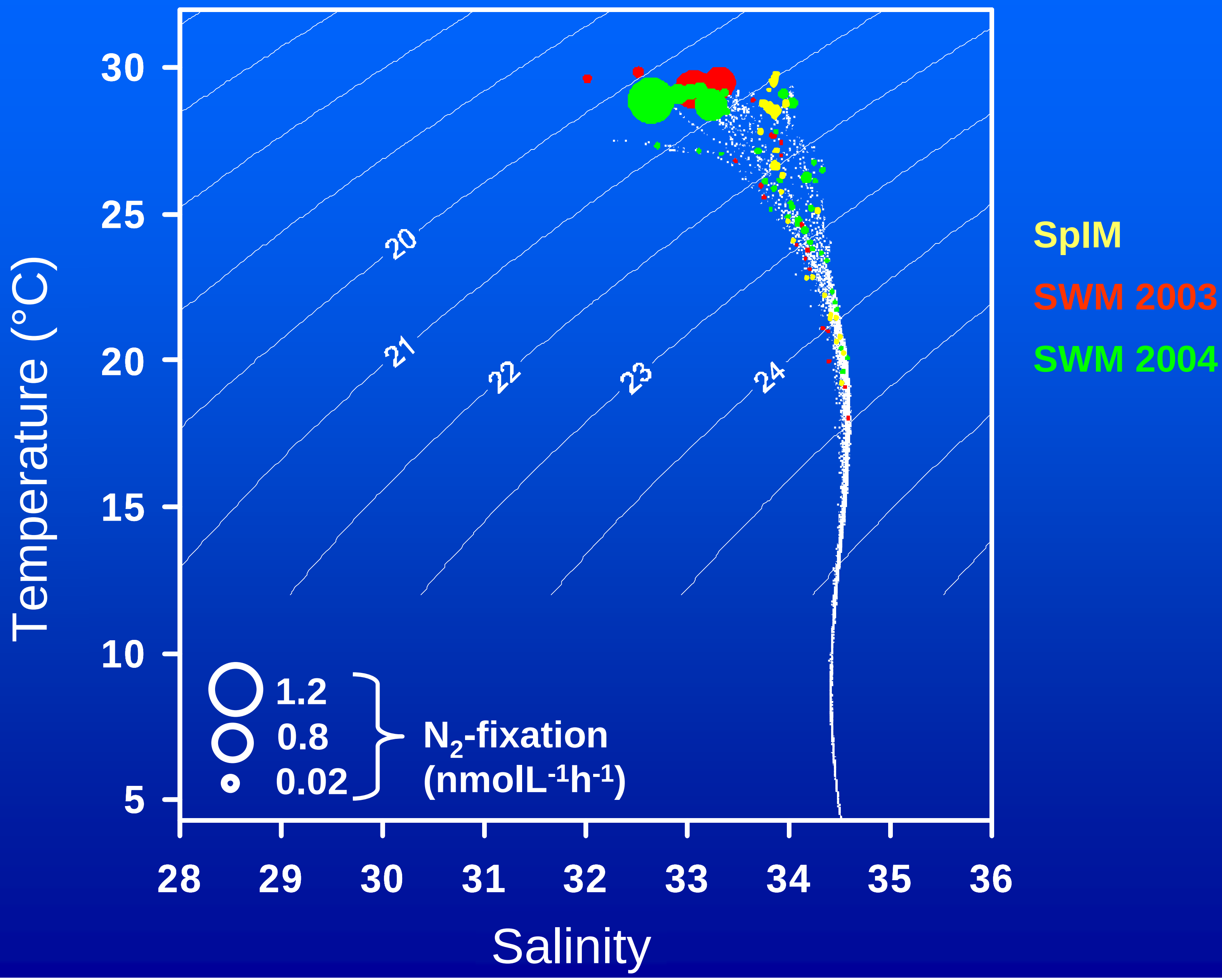
Bombar et al. sub.

N_2-Fixation and new production in the Mekong river plume



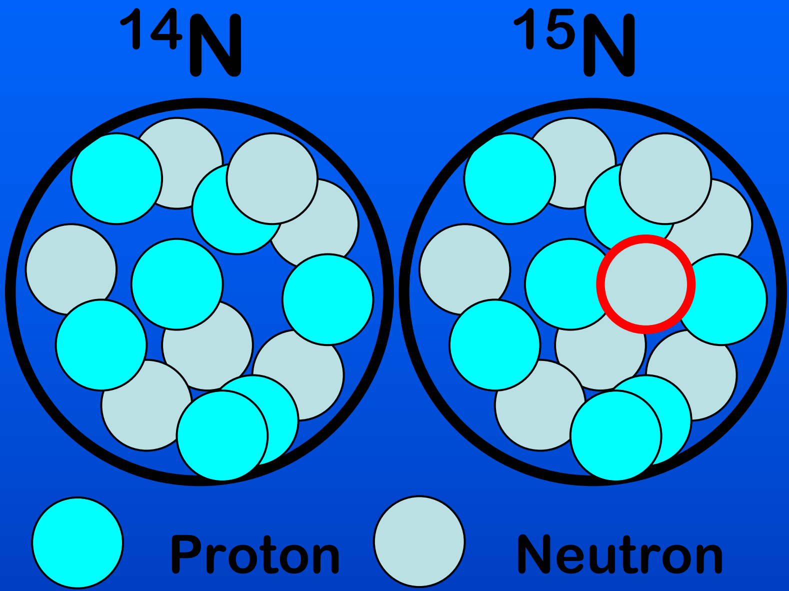


Water masses and nitrogen fixation

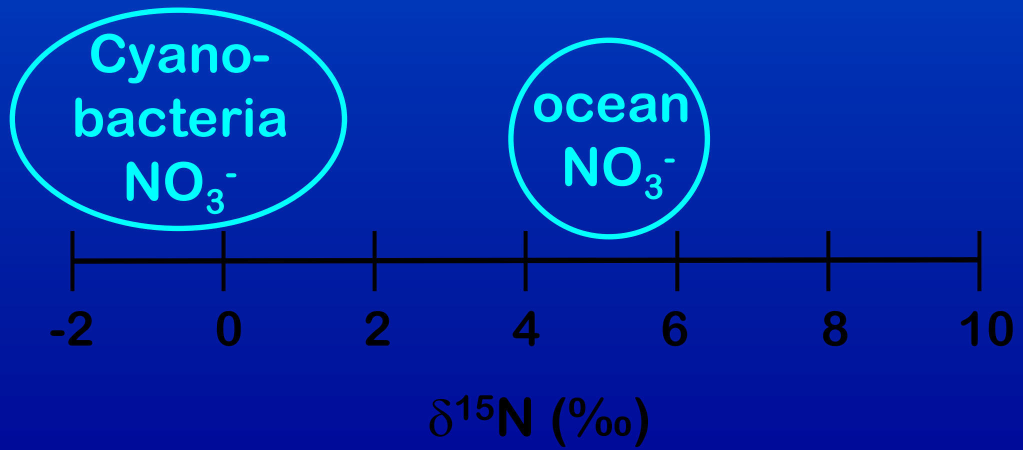


The fate of nitrogen

Stable isotopes



$$\delta^{15}N\,[‰] = \left(\frac{^{15}N/^{14}N_{(sample)}}{^{15}N/^{14}N_{(standard)}} - 1 \right) \times 1000$$



Typical $\delta^{15}N$ values in the ocean

when N_2-fixation occurs

N_2
0‰

Cyanobacteria
-2 to 1 ‰

POM
3 bis 10 ‰

Phytoplankton
4 to 10 ‰

Zooplankton
2 to 6 ‰

Zooplankton
5 to 12‰

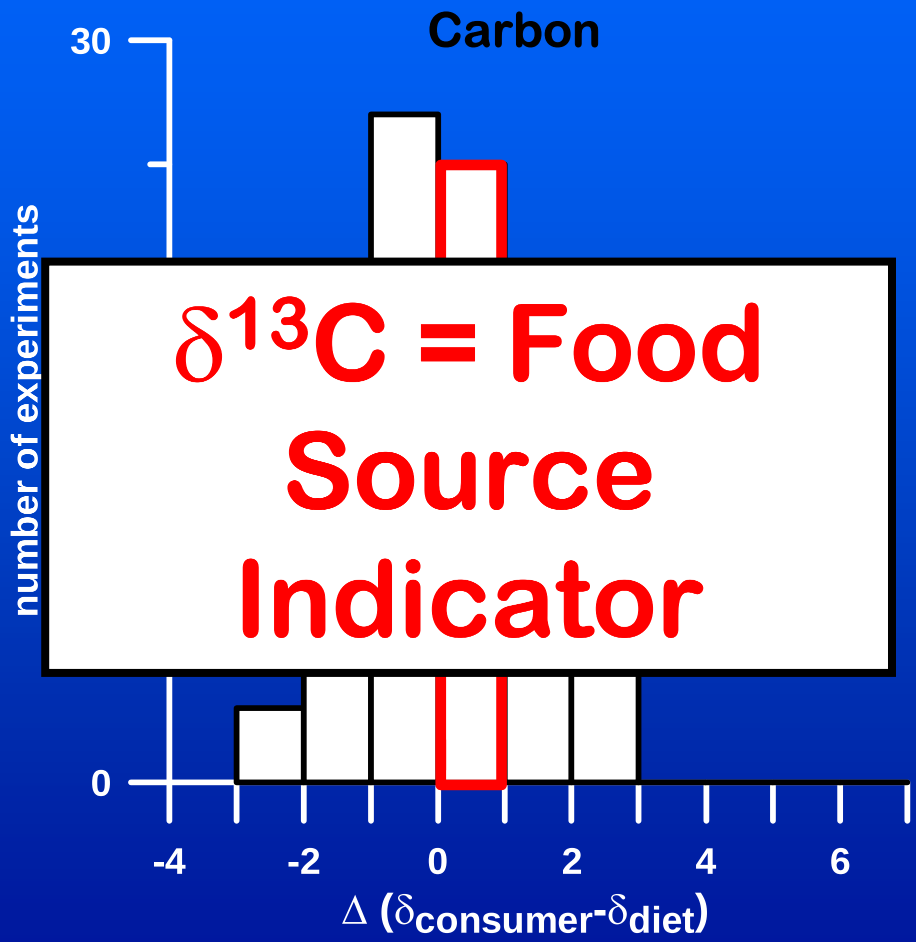
NO_3^-
3.5 ‰

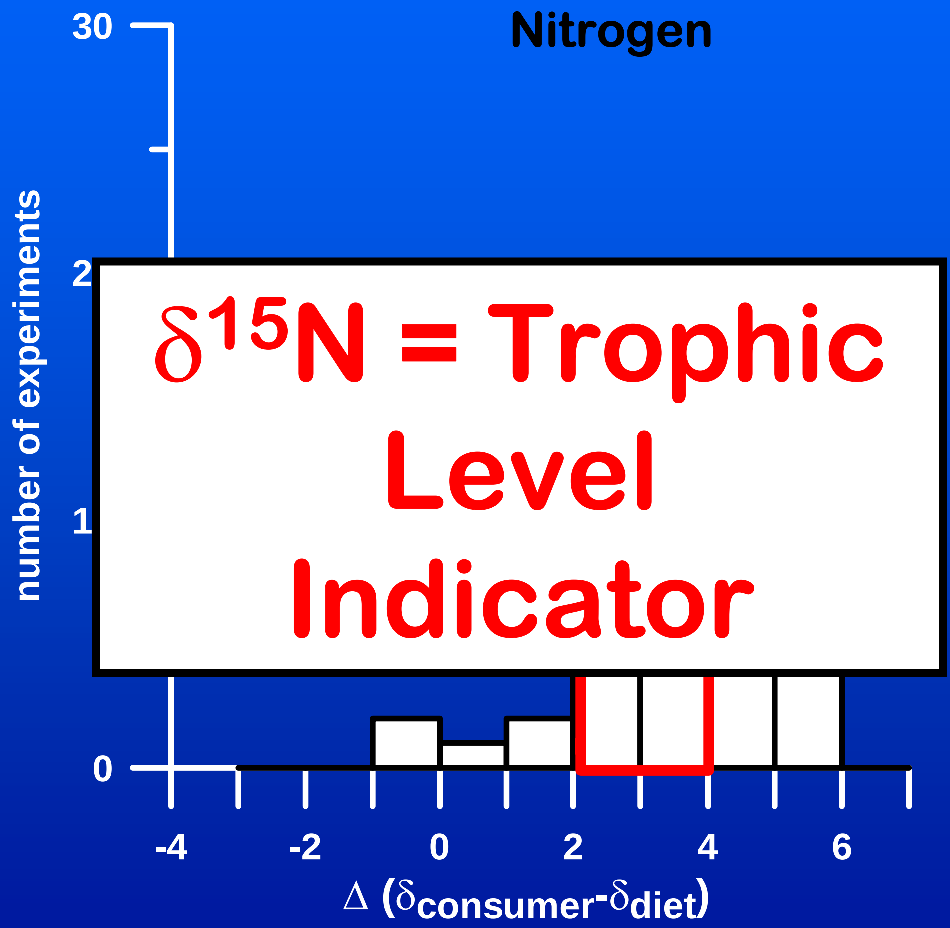
NO_3^-
4.5 ‰

Fish
7 to 14 ‰

sources: this study, Montoya et al. 2002, Owens 1987, Liu and Kaplan 1989

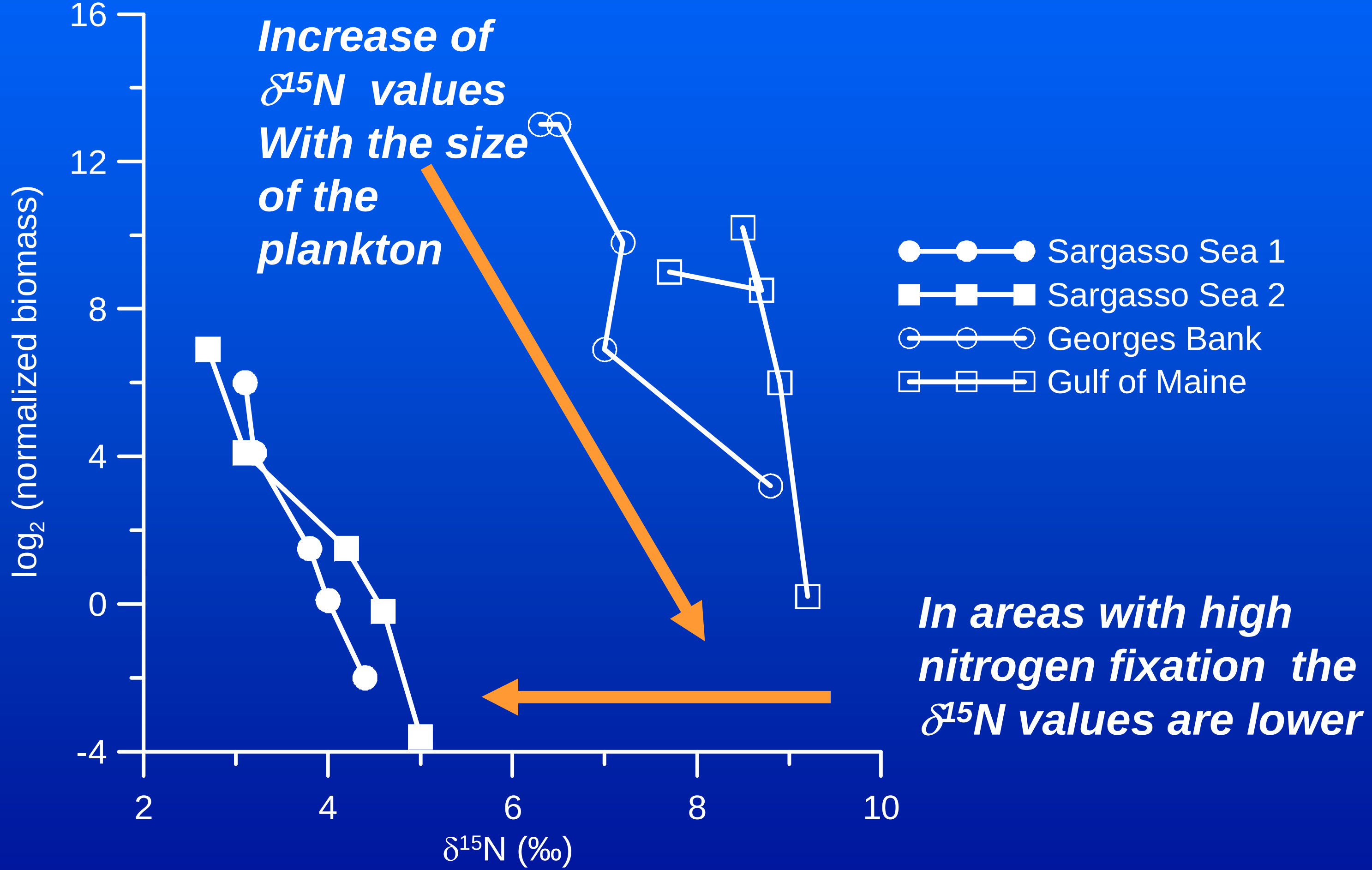
Relationships between animal and diet isotopic compositions for carbon and nitrogen stable isotopes





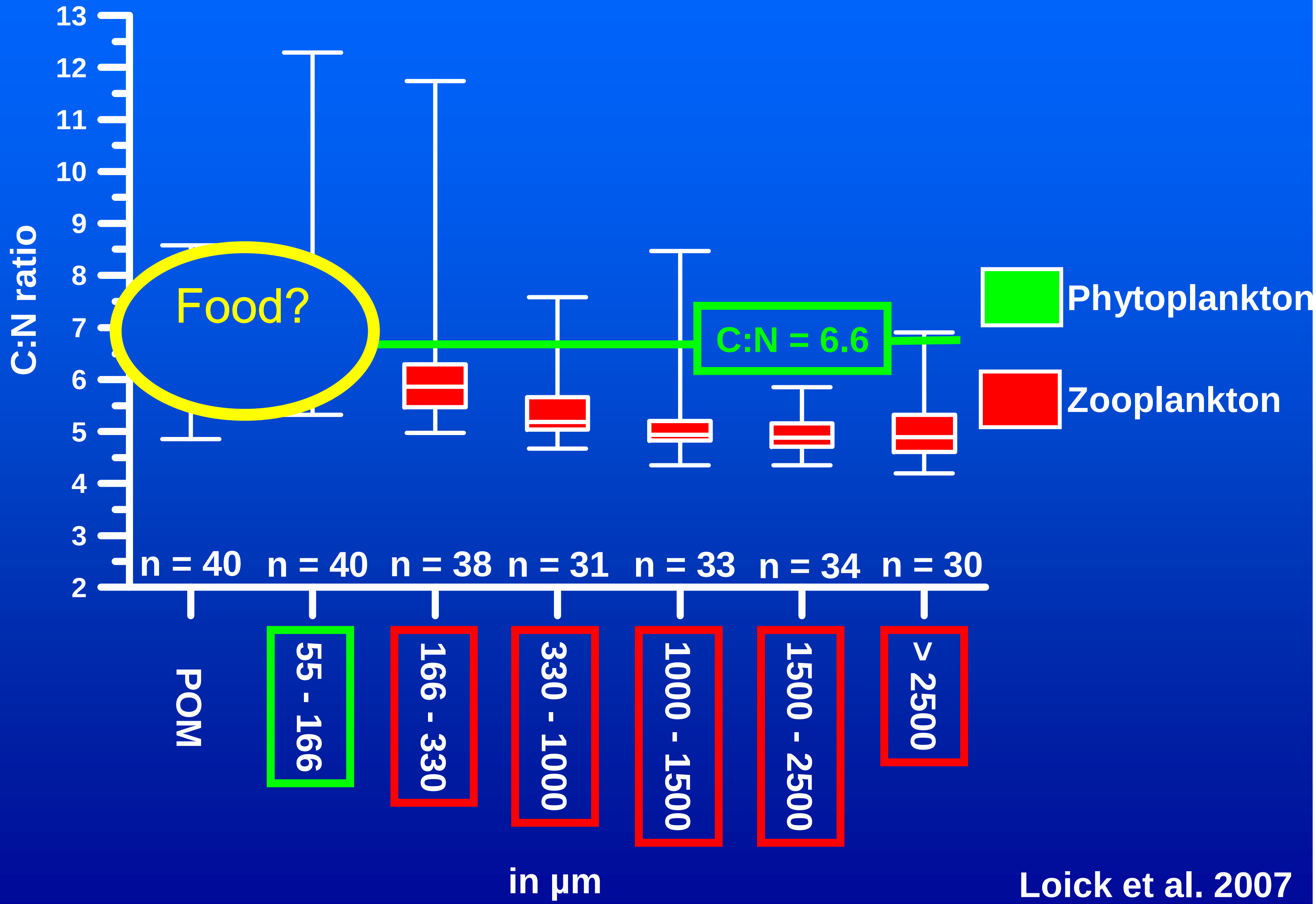
from Peterson and Fry 1987

Biomass decreased in 5 zooplankton size fractions (250 – 8000 µm) with increasing trophic level



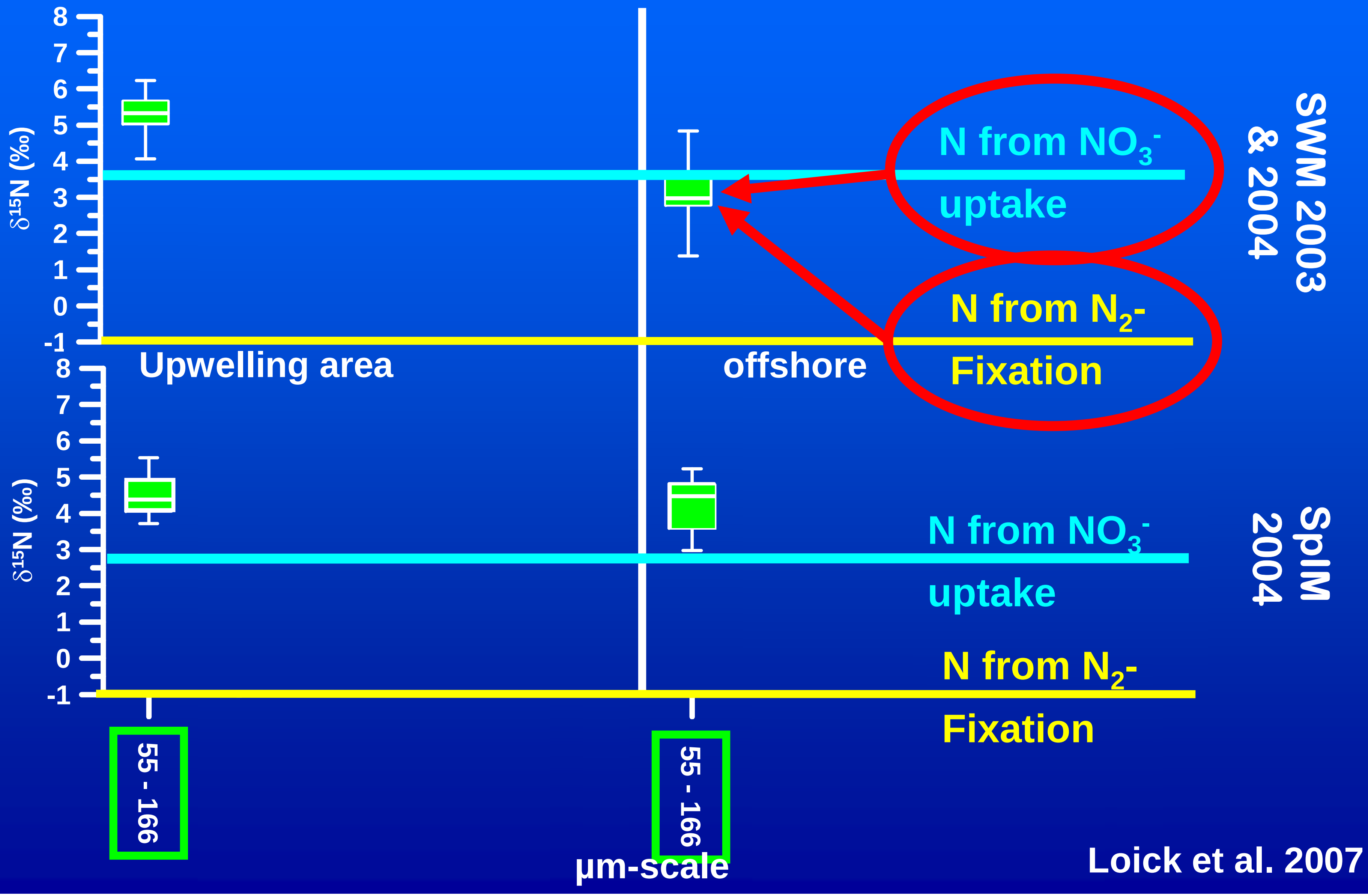
Quelle: Fry und Quinones 1994

Plankton ID (all seasons)



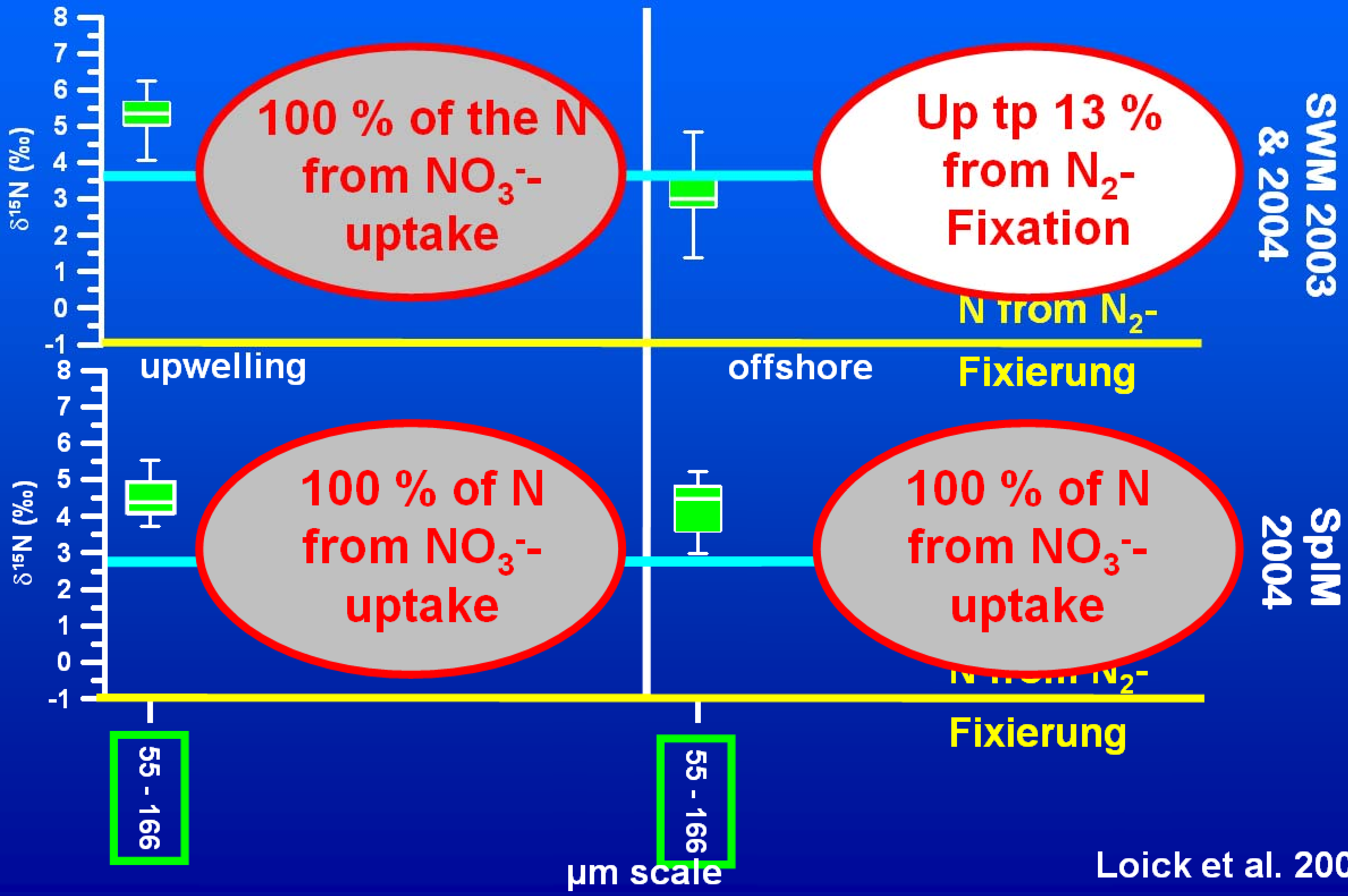
Loick et al. 2007

Quantification of the importance of nitrogen fixation



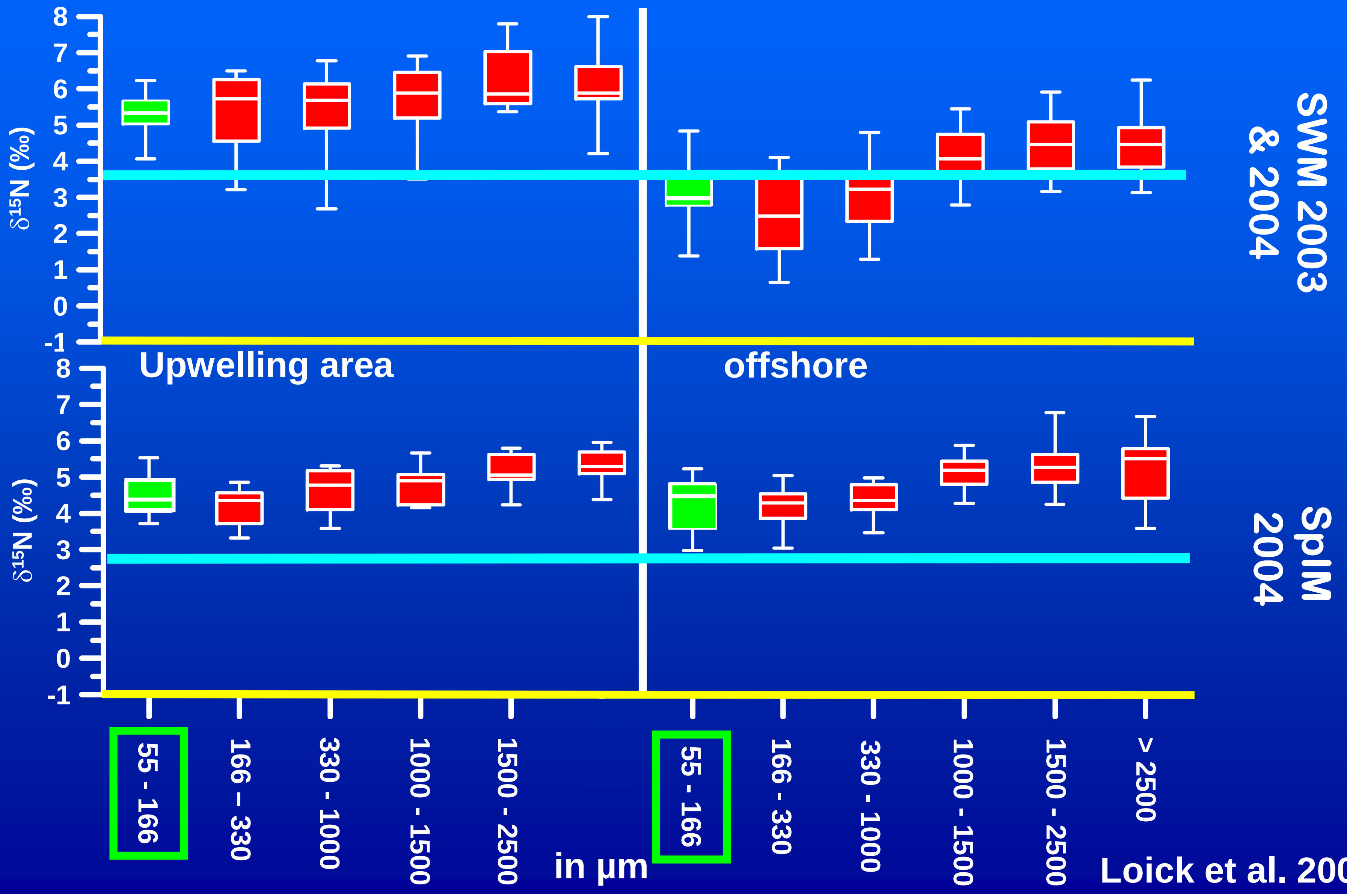
Loick et al. 2007

Quantification of the importance of nitrogen fixation



Loick et al. 2007

Quantification of the importance of nitrogen fixation

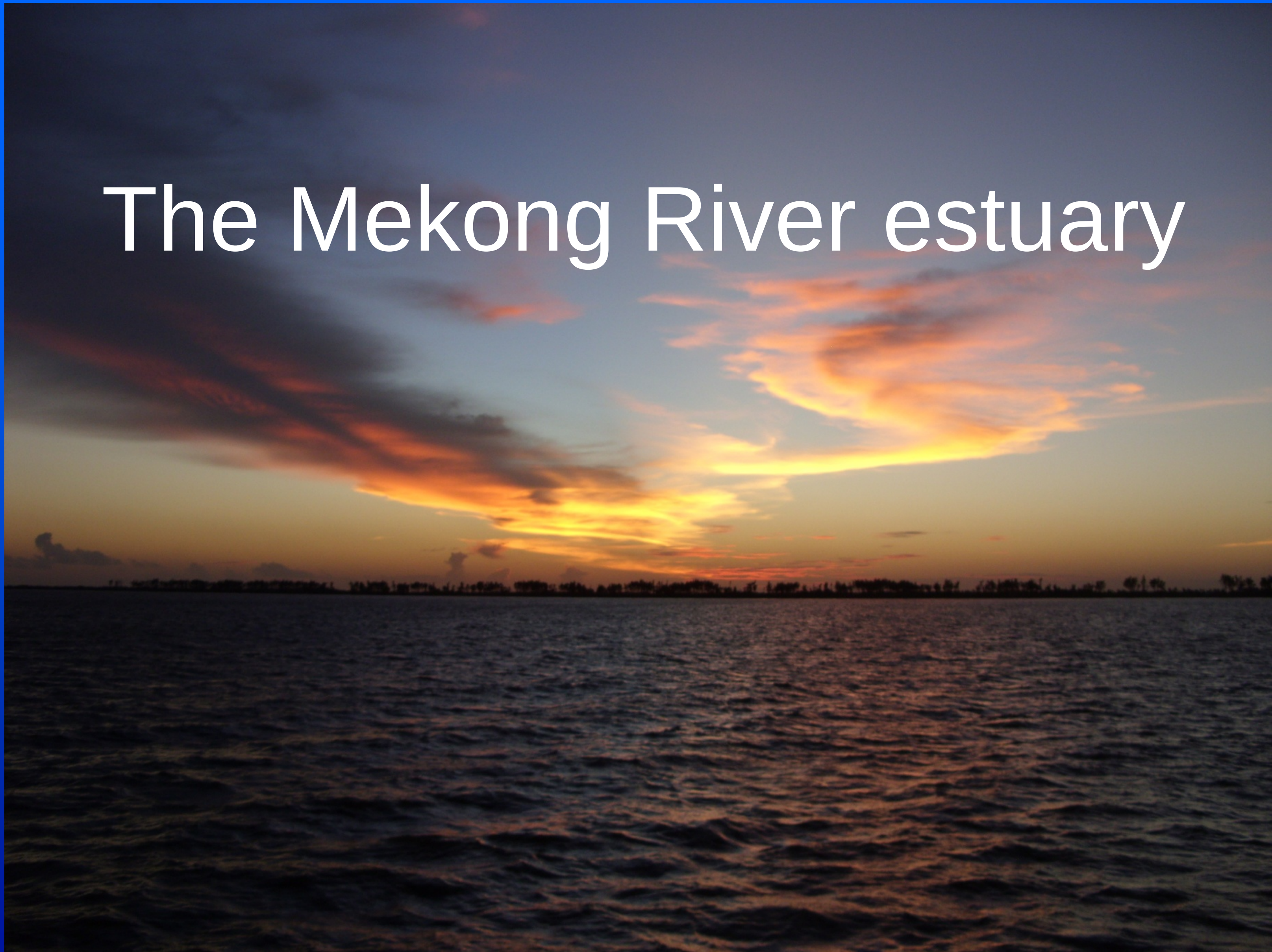


Loick et al. 2007

In the offshore region nitrogen fixers are an important food source for higher trophic levels

Summary

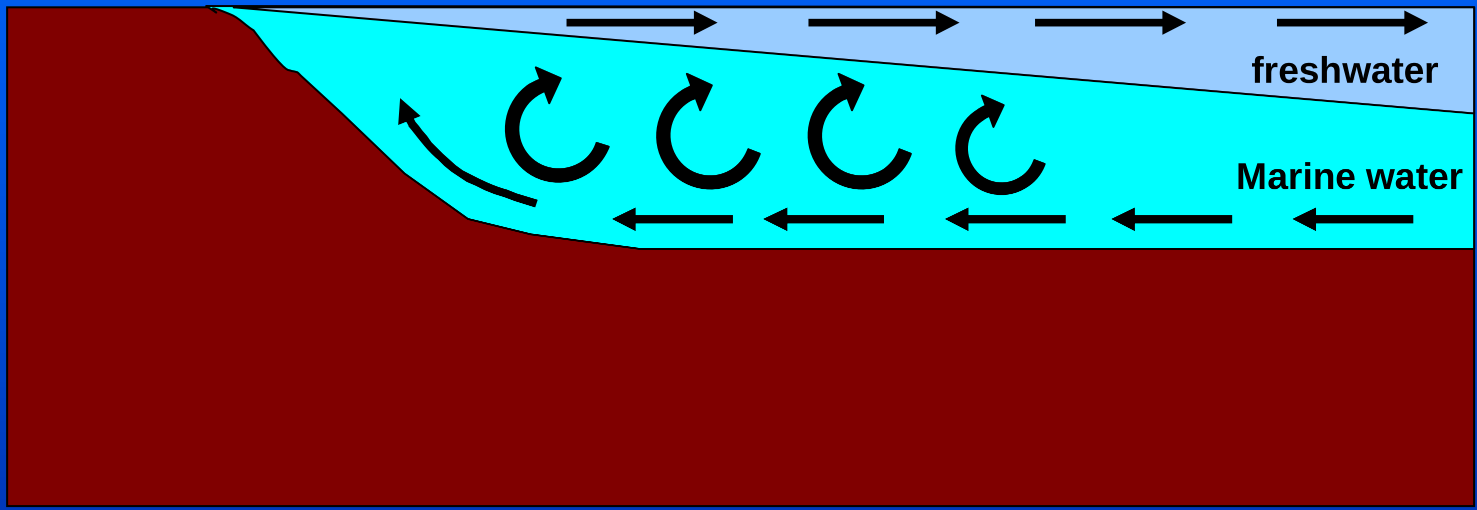
- Due to El Niño influence, upwelling was weaker in July 2003, average primary productivity
  - 2003 28 ± 18 mmol C m-2 d-1
  - 2004 103 ± 25 mmol C m-2 d-1
- Upwelling nitrate fluxes of 17 ± 2 mmol N m-2 d-1 in July 2004 was consistent with N-demands of primary productivity, but not in 2003.
- Nitrogen fixation was a significant N-source in the area, (up to 375 µmol N m-2 d-1 in offshore waters) - equal to 2% - 25% of diffusive nitrate fluxes.
- Nitrogen from fixation is a significant source for higher trophic levels.


The Mekong River estuary

„A semienclosed coastal body of water, which has a free connection with the open ocean and within which sea water is measurably diluted with the fresh water dervied from land drainage“

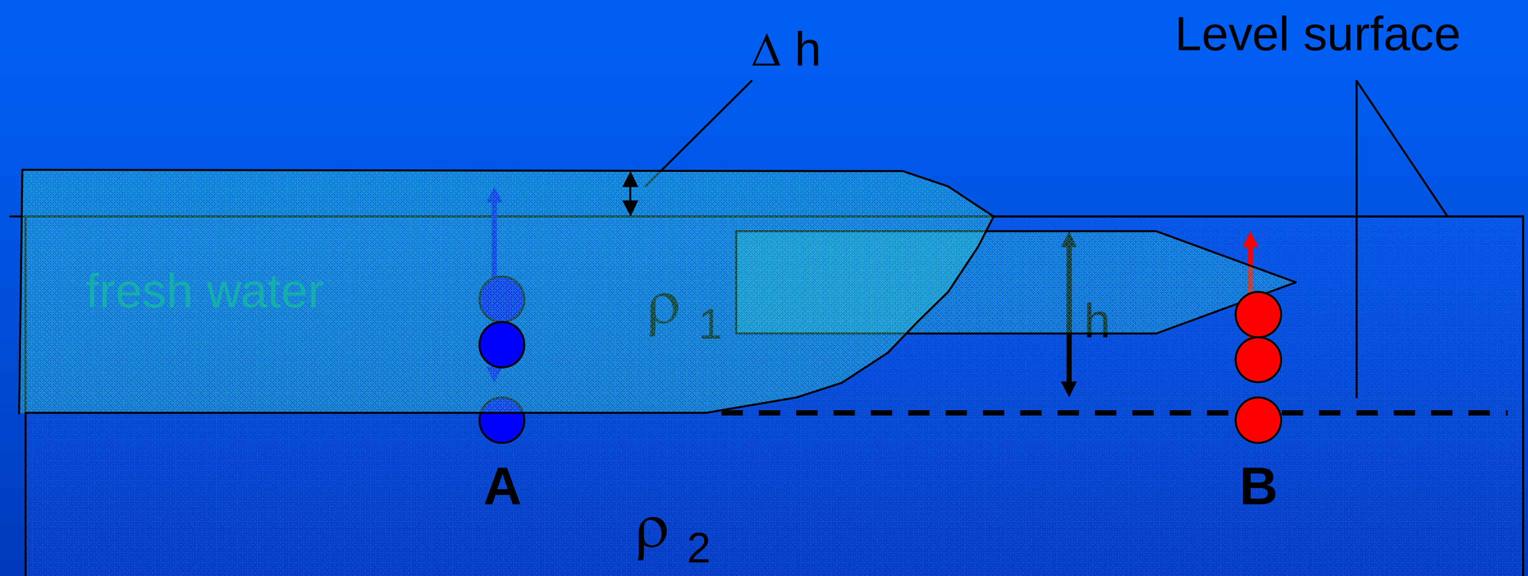
Pritchard, 1967

Estuarine Circulation



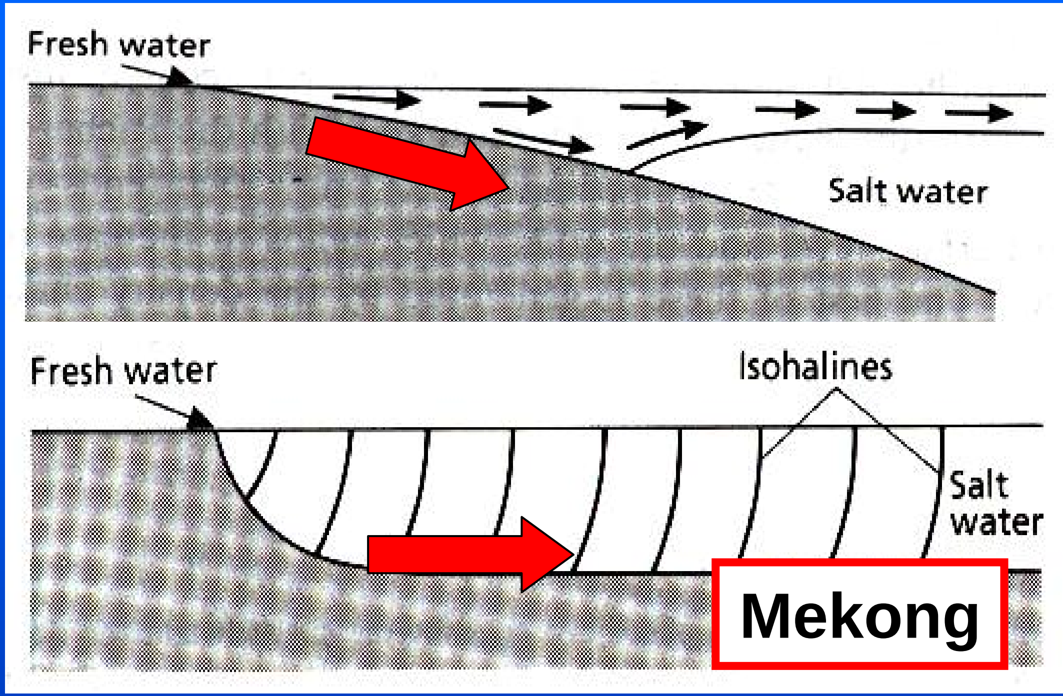
Outflow is characterised by the amount of outflowing water
And the bottom topography.

Estuarine Circulation

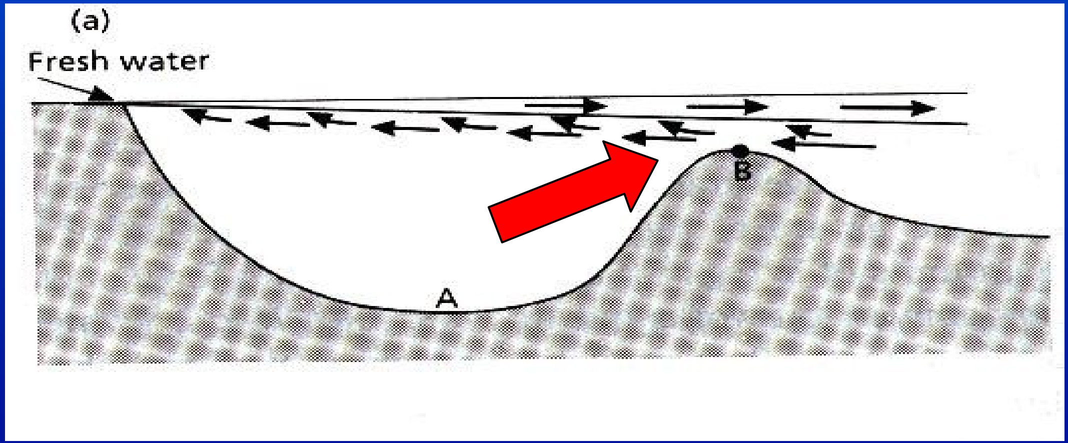


1. $\rho_2 > \rho_1$
2. The pressure upon A is the same as upon B, from the difference in height Δh can be calculated
   → no horizontal movement of the water.
3. All points above and A have a higher pressure than above B
   → the pressure gradient moves the freshwater over the salt water.

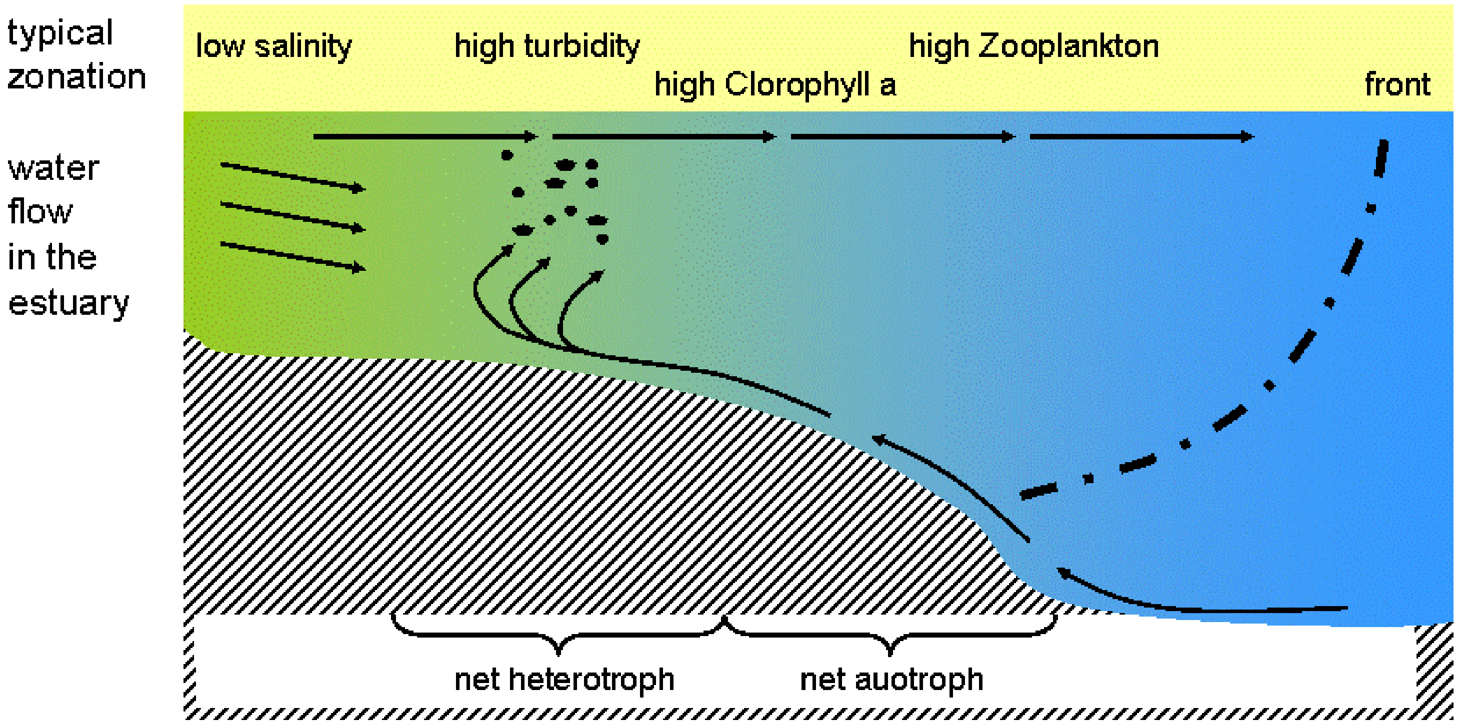
Mann & Lazier, 1991



- Saltwedge estuary
- Tidally mixed estuary
- Fjord type estuary

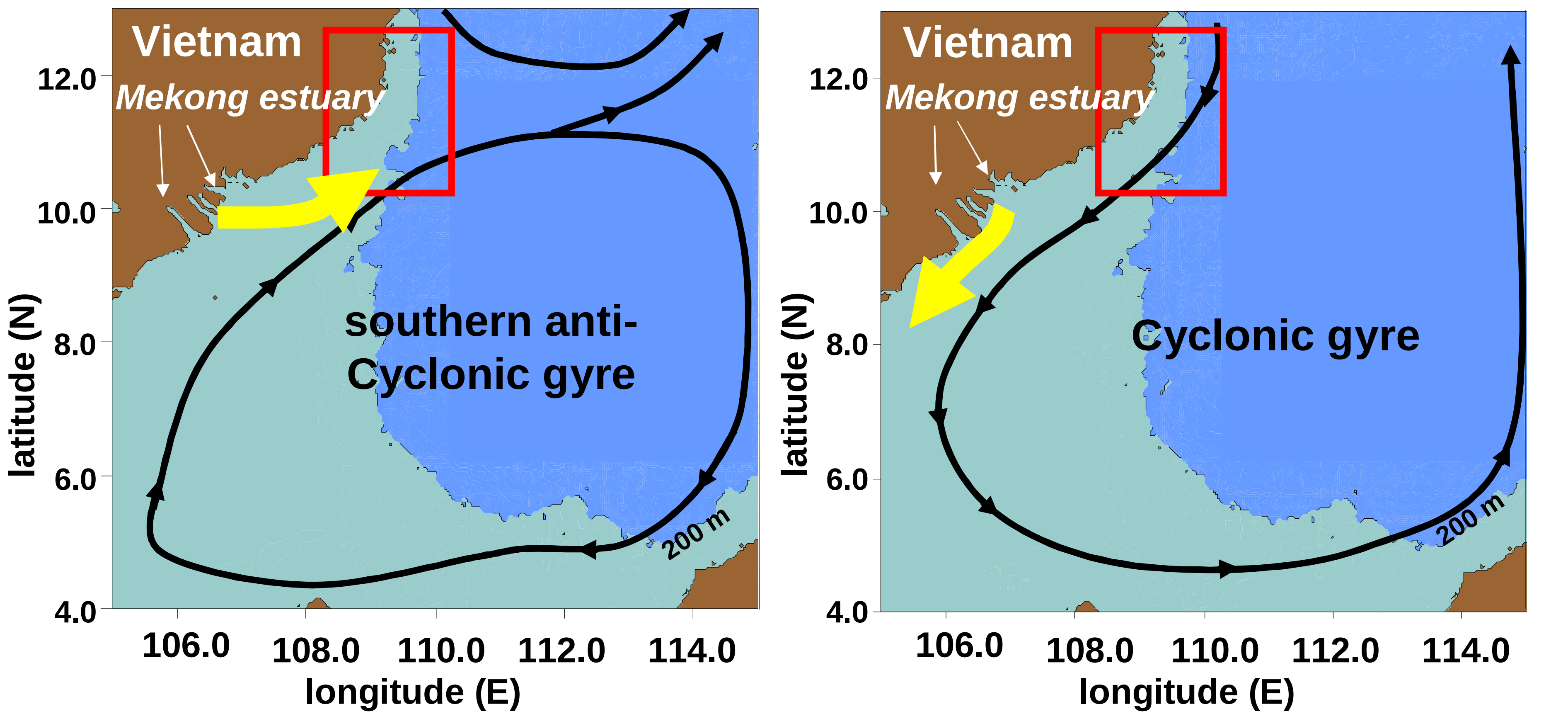


Mann & Lazier, 1991


typical
zonation
low salinity
high turbidity
high Zooplankton
high Clorophyll a
front
water
flow
in the
estuary
net heterotroph
net auotroph

Hydrography-seasonality

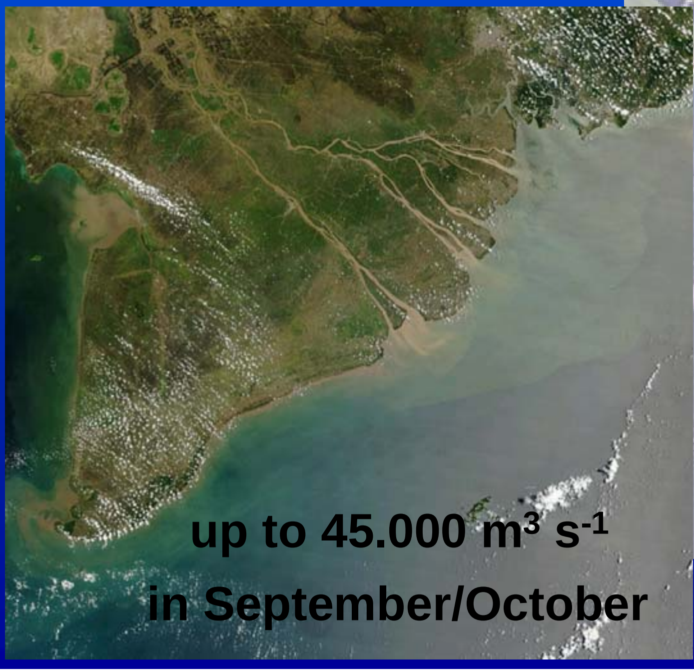
Southwest monsoon | Northeast Monsoon



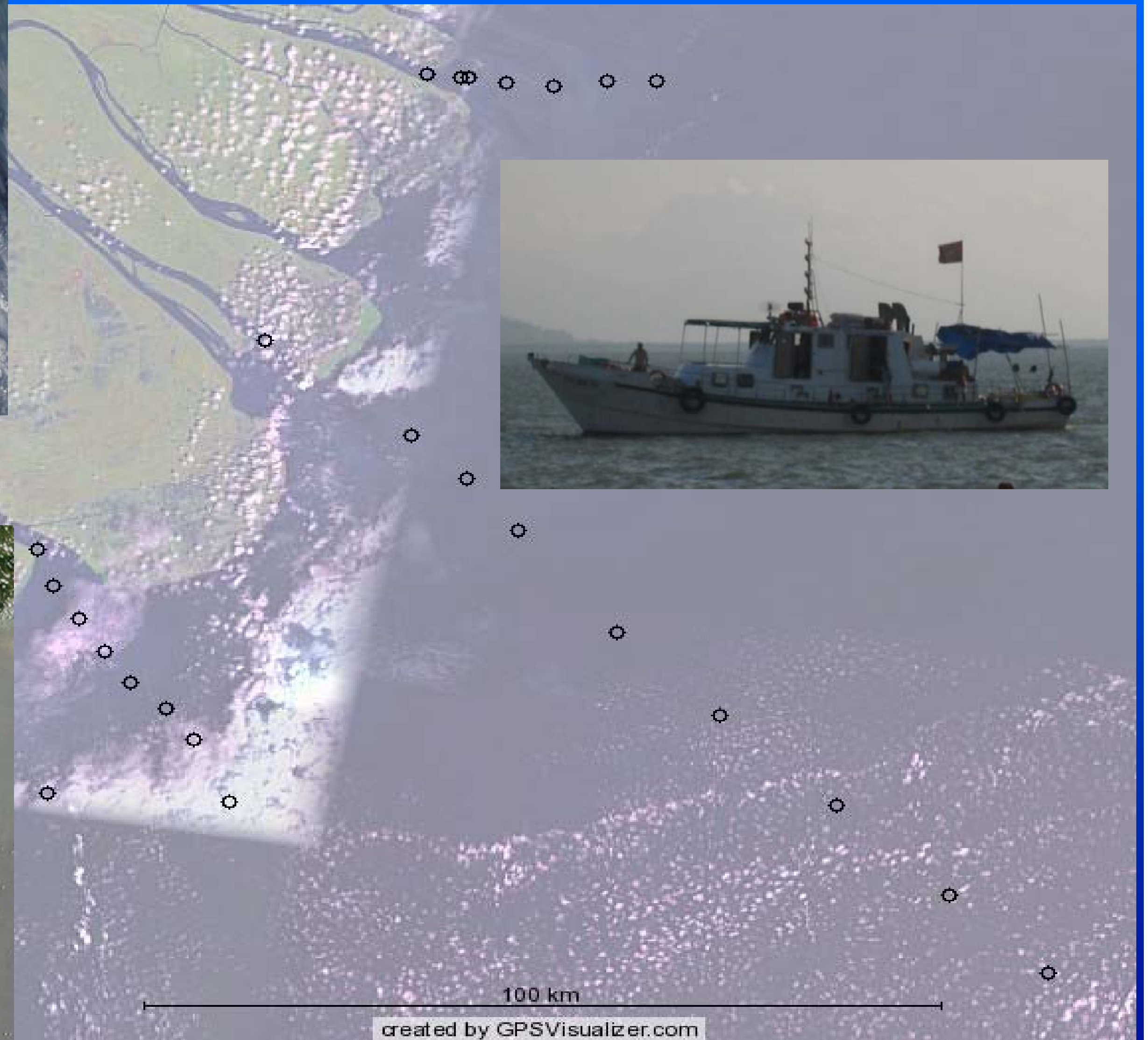
nach Hu *et al.* 2000

Mekong estuary

$1.500\ m^3\ s^{-1}$ in March/April



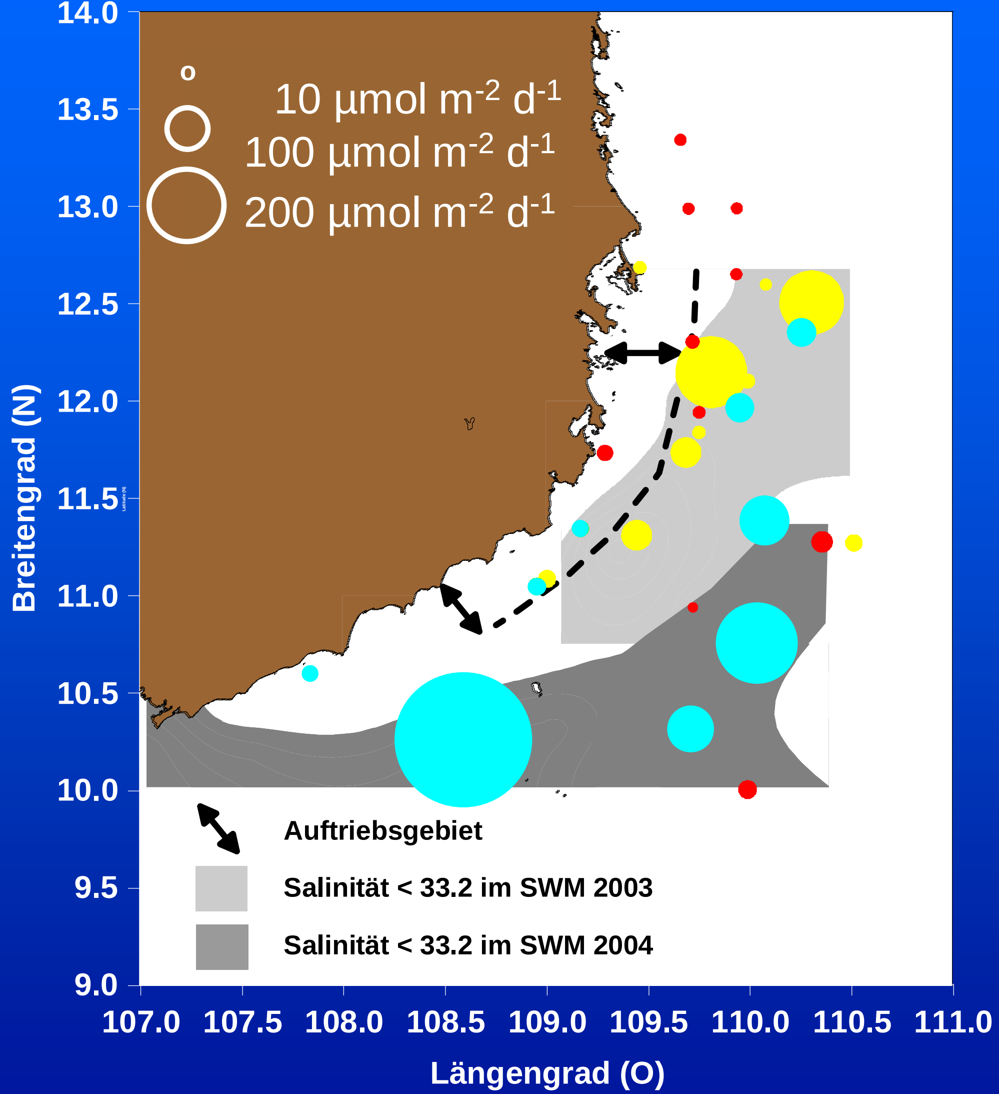
up to $45.000\ m^3\ s^{-1}$ in September/October



True Colour Satellite image (NASA)


THANH TRA THUY SAN BINH THUAN

N_2-Fixation in the Mekong river plume



SWM 2003

SWM 2004

SpIM 2004

Voss, Bombar, Loick, Dippner GRL 2006

Summary

- The plume extension depends on the monsoon season and rainfall
- Nutrient concentrations are not extremely high in the Mekong (like some eutrophied European Rivers), but moderate except fo silica
- The Mekong plume seems to support various nitrogen fixers - even as far offshore as the upwelling zone.
- DDAs seem to grow well in a certain band of the Mekong plume.
- We are only beginning to understand the biogeochemistry of the estuarine waters.

YANMAR