

The ecology of lake Kivu: a puzzle solved?



Tropical Rift Lake Systems: Integrated Volcanologic, Tectonic, and Biogeochemical, and Geohazard Assessment of Lake Kivu - Gisenyi, Rwanda - 13-15 January 2010

*F. Darchambeau, H. Sarmento, M. Isumbisho, A.V. Borges,
P. Servais, J. Guillard, P. Masilya, L. Nyina-wamwiza, M. Lirós, C. Borrego, J.-P. Descy*

A collaborative work ... (1/3)

University of Namur:
Prof. Jean-Pierre Descy

- Hugo Sarmento, PhD (2002 - 2006)
- Pascal Mwapu Isumbisho,
PhD (2002 - 2006)

Faculté des Sciences
Département de Biologie
Unité de Recherche en Biologie des Organismes  FUNDP Namur

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Ecologie du Zooplancton
du Lac Kivu (Afrique de l'Est)

Zooplankton Ecology
of Lake Kivu (Eastern Africa)

Dissertation présentée par
Pascal Isumbisho Mwapu
en vue de l'obtention du grade
de Docteur en Sciences
2 0 0 6

A collaborative work ... (2/3)

The ECOSYKI project (2004-2009):

a research and cooperative project granted by the Belgian
Universitary Cooperation – CUD, with:

- University of Namur: Prof. Jean-Pierre Descy, *et alii*
- Leuven University: Prof. Eric Deleersnijder, *et alii*
- ISP-Bukavu: Prof. Pascal Mwapu Isumbisho, *et alii*
- NUR-Butare: Prof. Laetitia Nyina-wamwiza, *et alii*
- INRA-Thonon: Prof. Jean Guillard

A collaborative work ... (3/3)

The CAKI project (2007-2010):
fundamental research project on Lake Kivu carbon and
nutrient cycles granted by the FNRS

- University of Liège:
Alberto Borges, *et alii*.
- University of Bruxelles:
Pierre Servais
- University of Namur:
François Darchambeau, *et alii*.



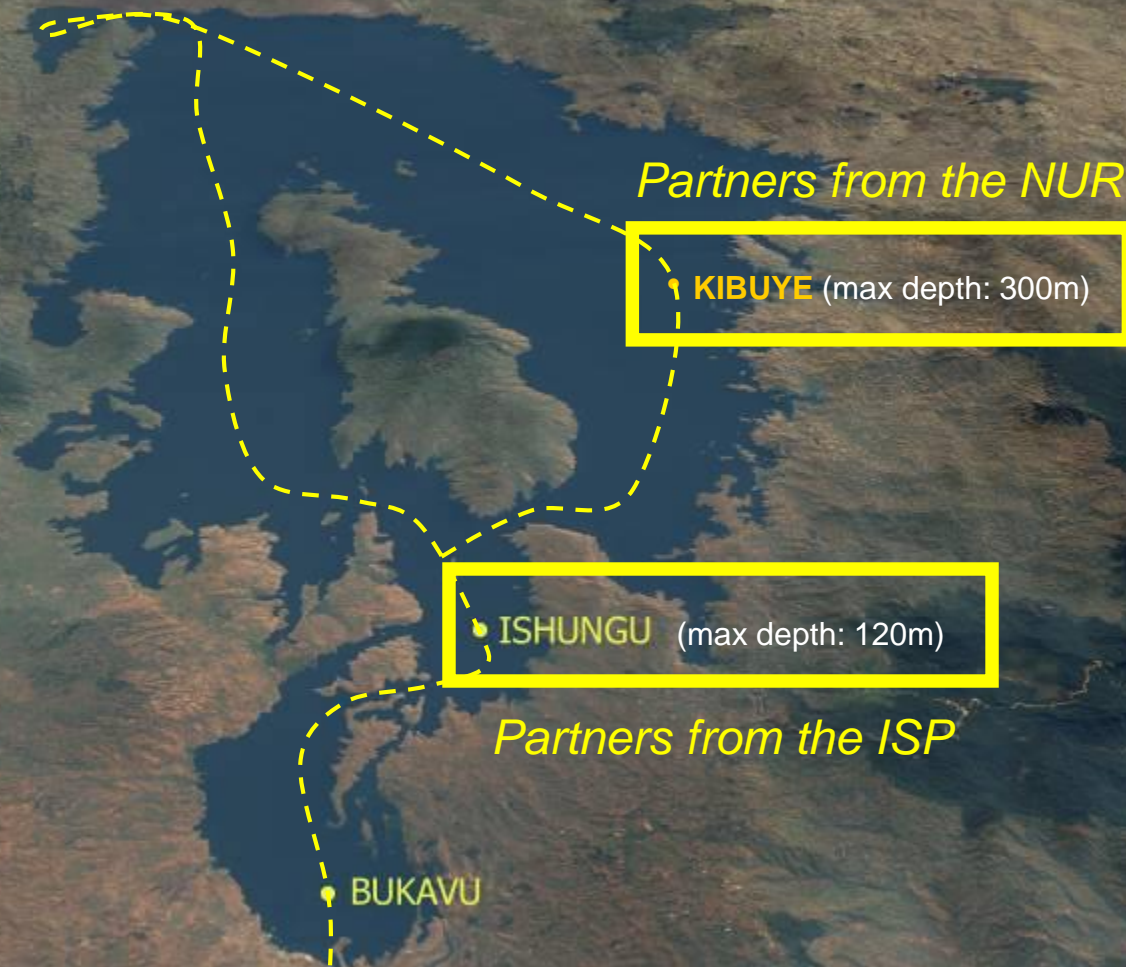
L. Victoria

L. Kivu

L. Tanganyika

L. Malawi

- Limnological samplings every 2 weeks at the southern basin (Ishungu) since 2002, and offshore Kibuye since 2006

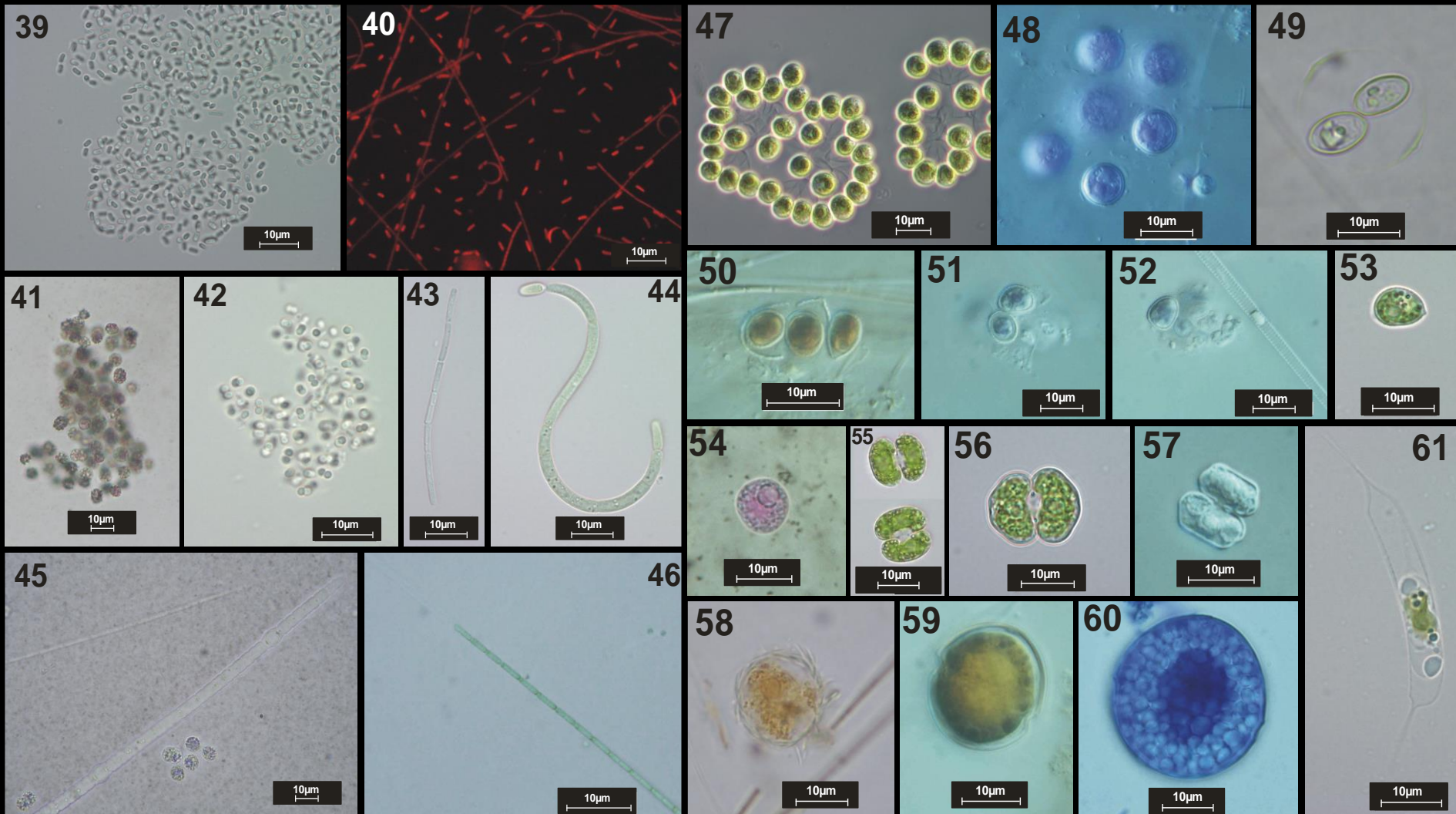


- Cruises during rainy and dry seasons (2003, 2004, 2007, 2008, 2009)
- Samplings still in progress (permanent mooring + field cruises)

Phytoplankton & Zooplankton

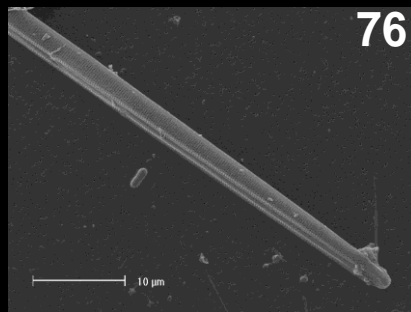
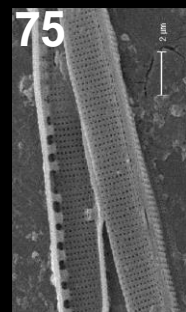
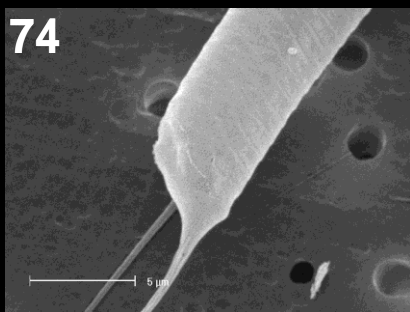
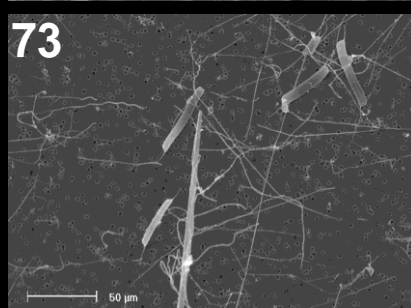
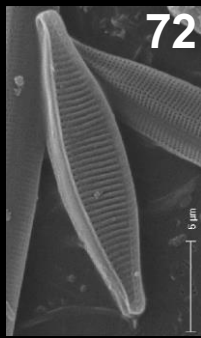
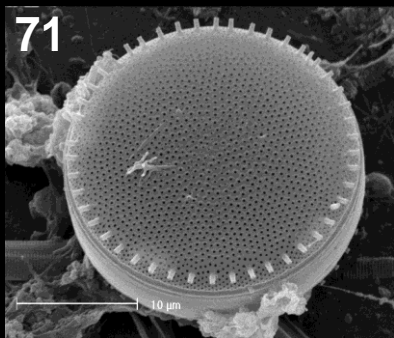
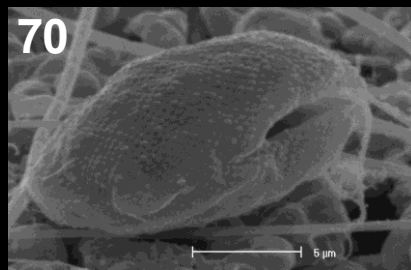
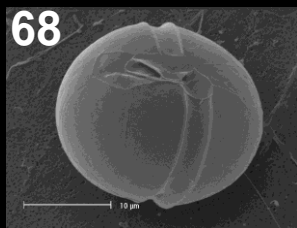
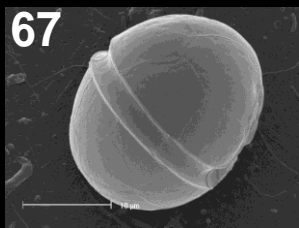
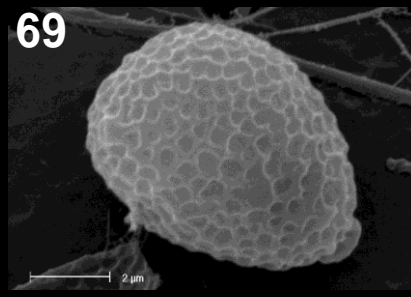
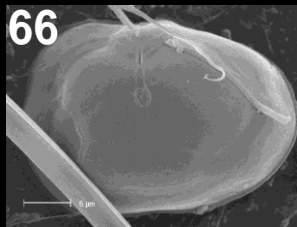
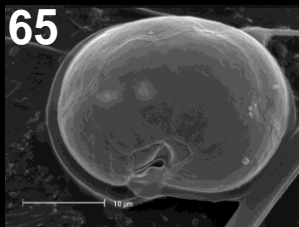
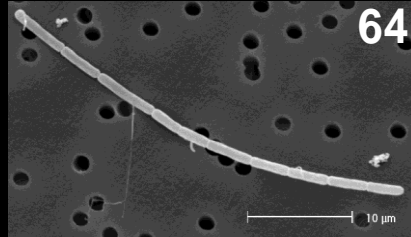
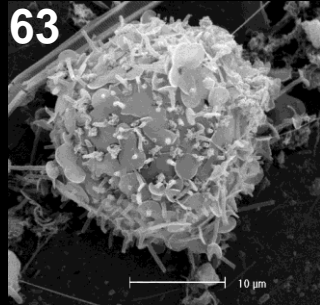
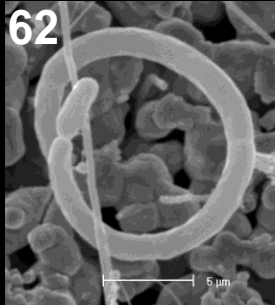


Phytoplankton & Zooplankton



Damas (1937), about the pelagic plankton of Lake Kivu:

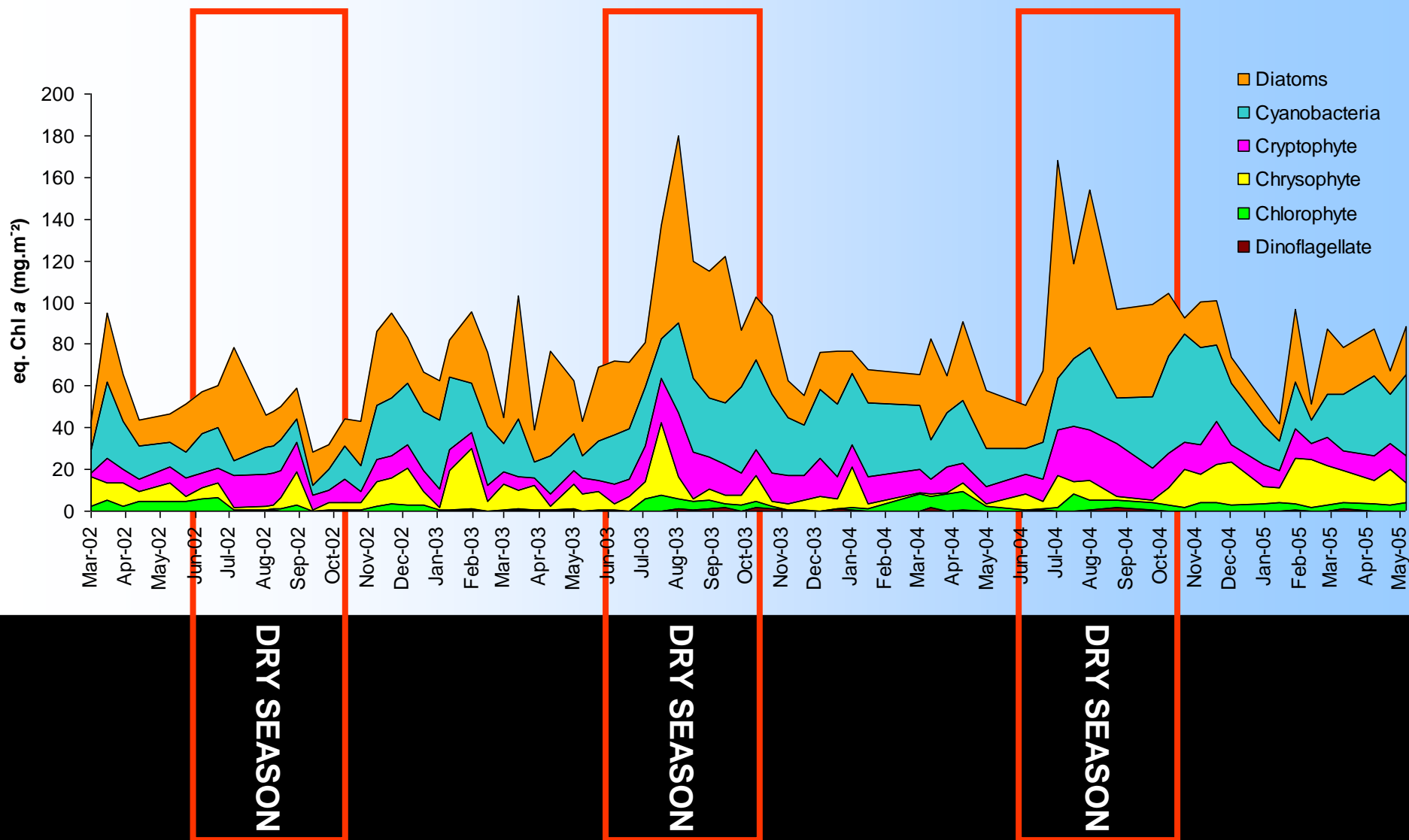
"Ses eaux claires et transparentes sont un véritable désert".



A total of 42 taxa was recorded:

- 14 Cyanophyceae
- 3 Cryptophyceae
- 3 Dinophyceae
- 7 Bacillariophyceae
- 1 Chrysophyceae
- 7 Chlorophyceae
- 3 Trebouxiophyceae
- 4 Zygnematophyceae

Phytoplankton biomass & composition





• BUKAVU

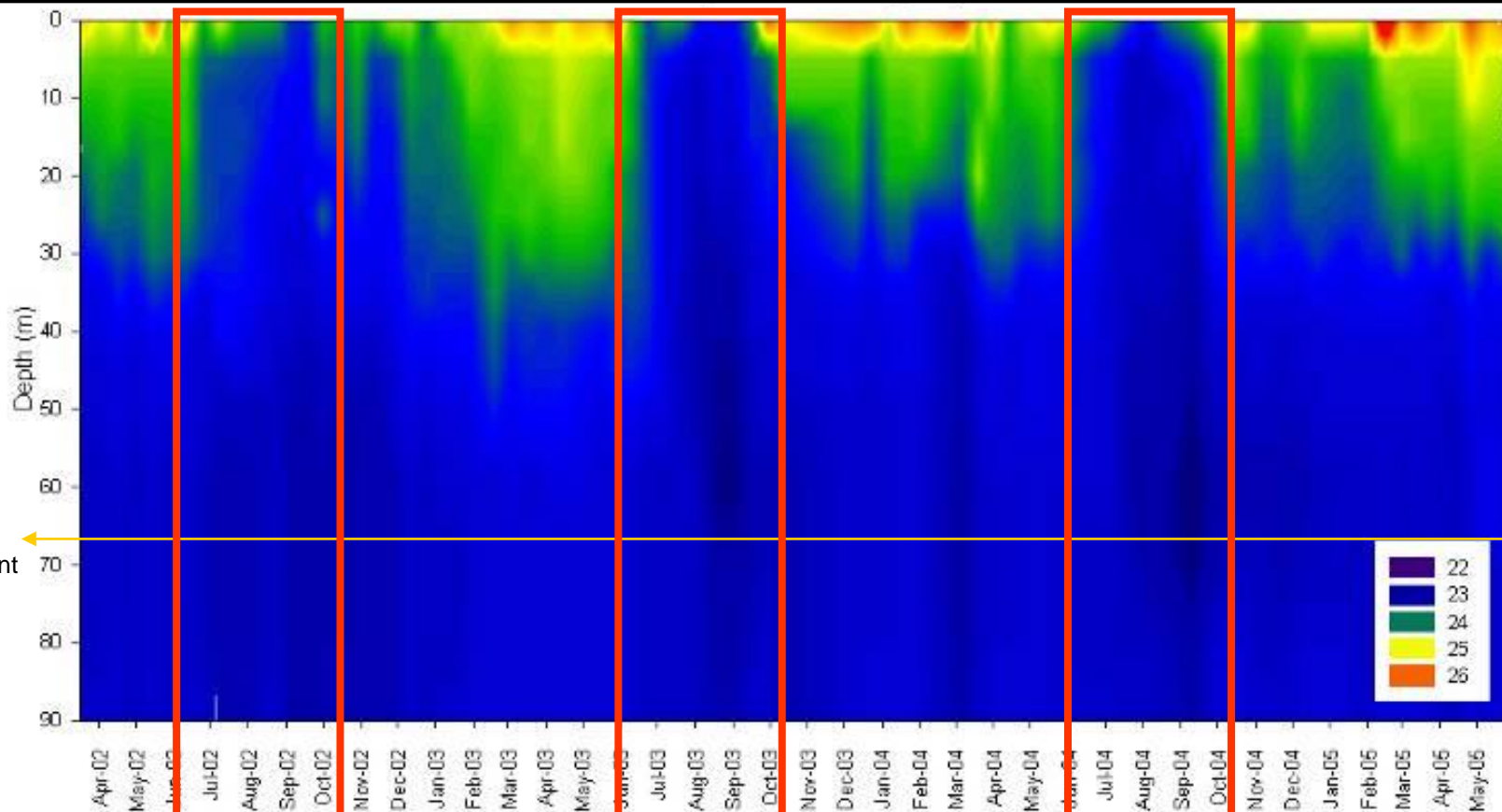
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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Rainy season

Dry season
Southeast winds

Rainy season

Temperature

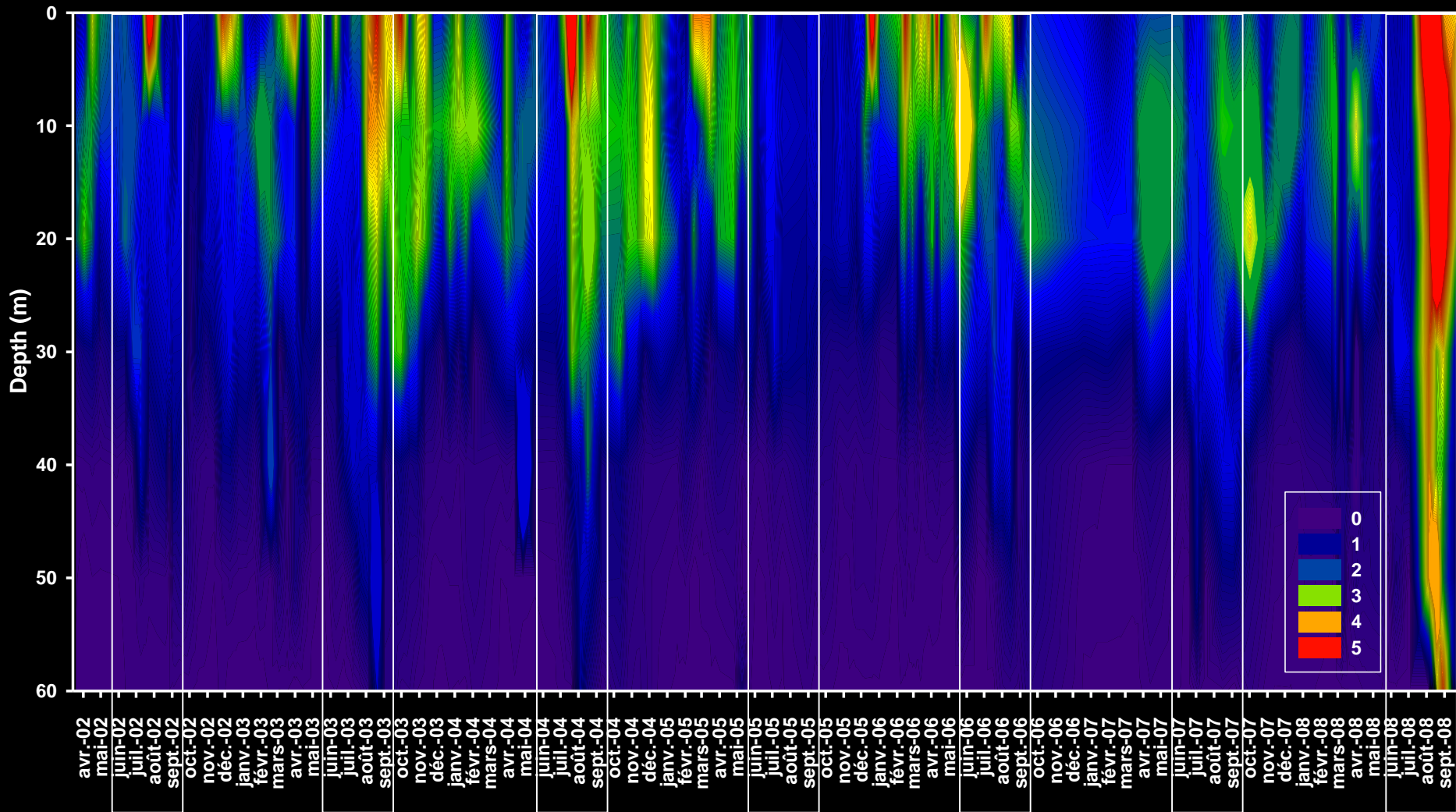


DRY SEASON

DRY SEASON

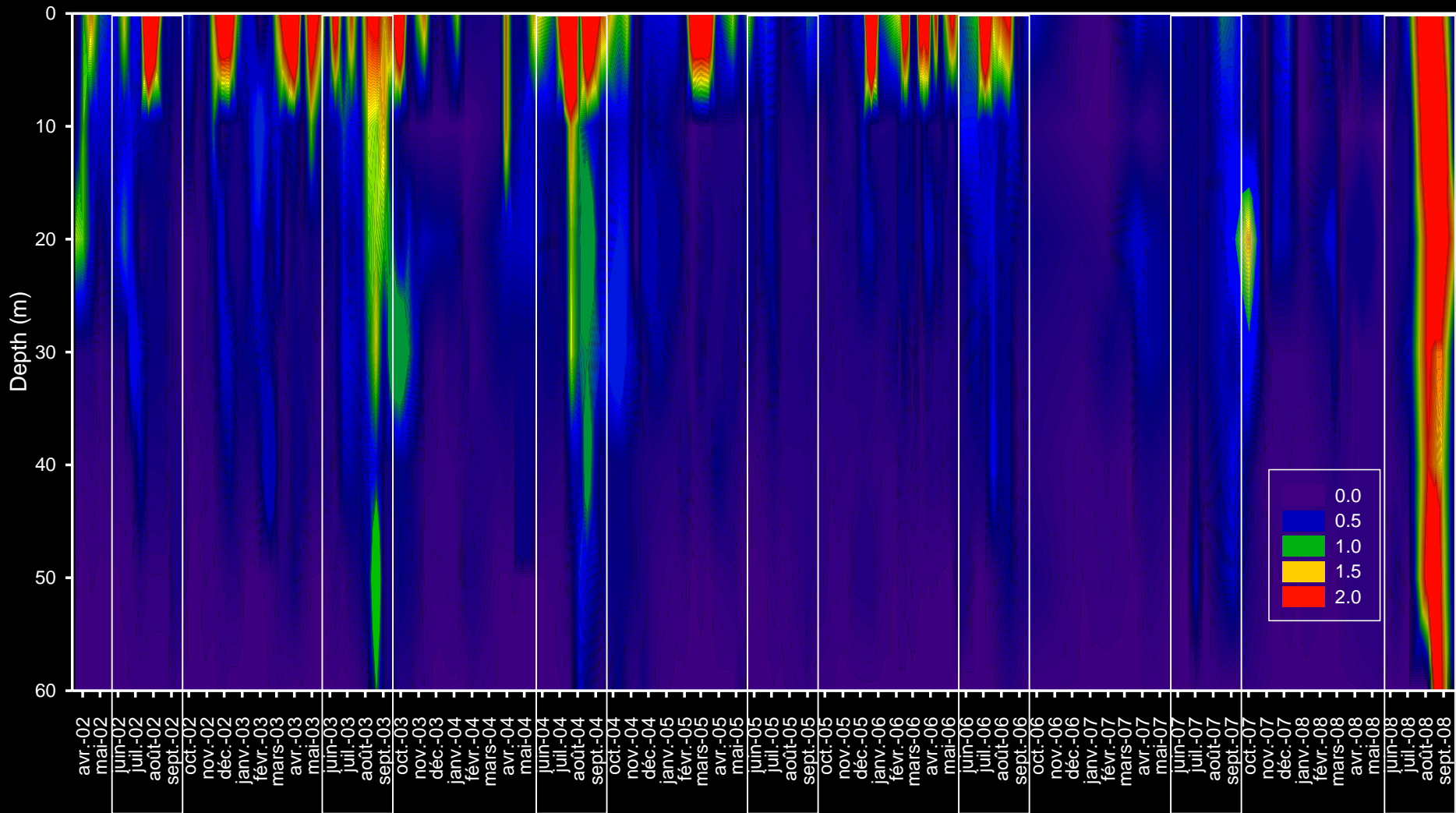
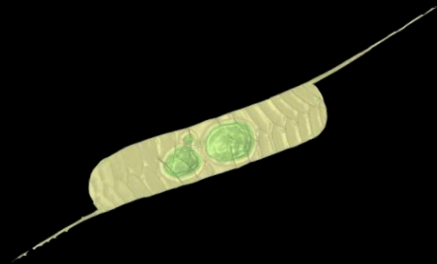
DRY SEASON

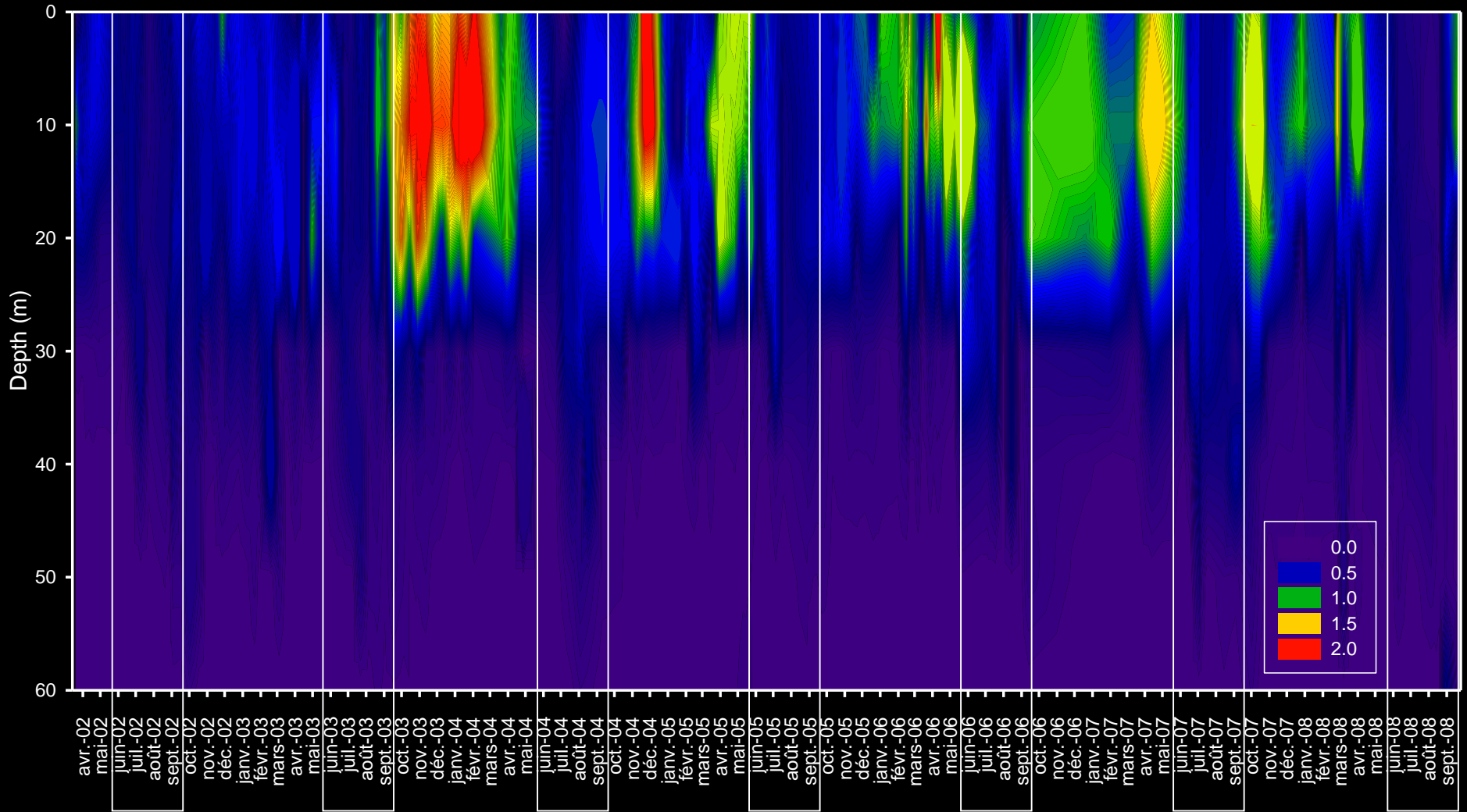
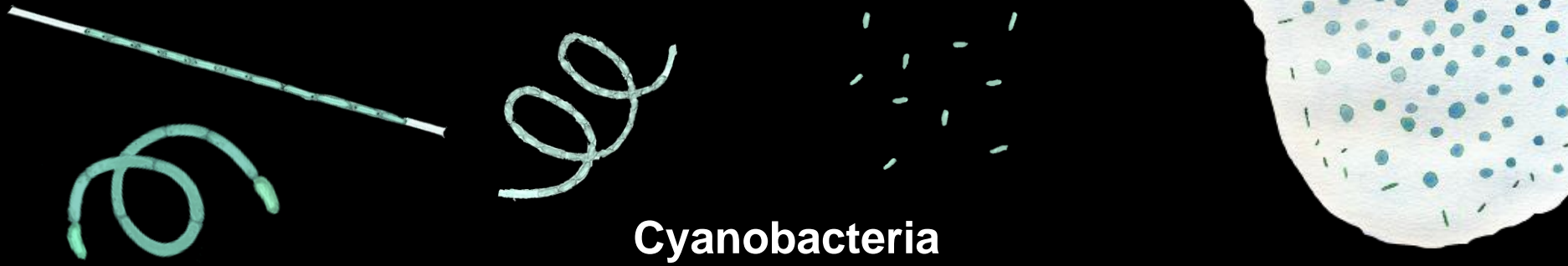
Chlorophyll a

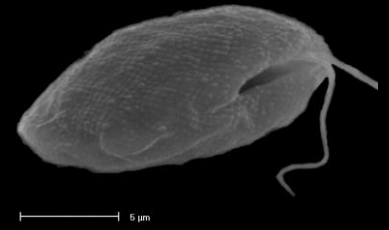




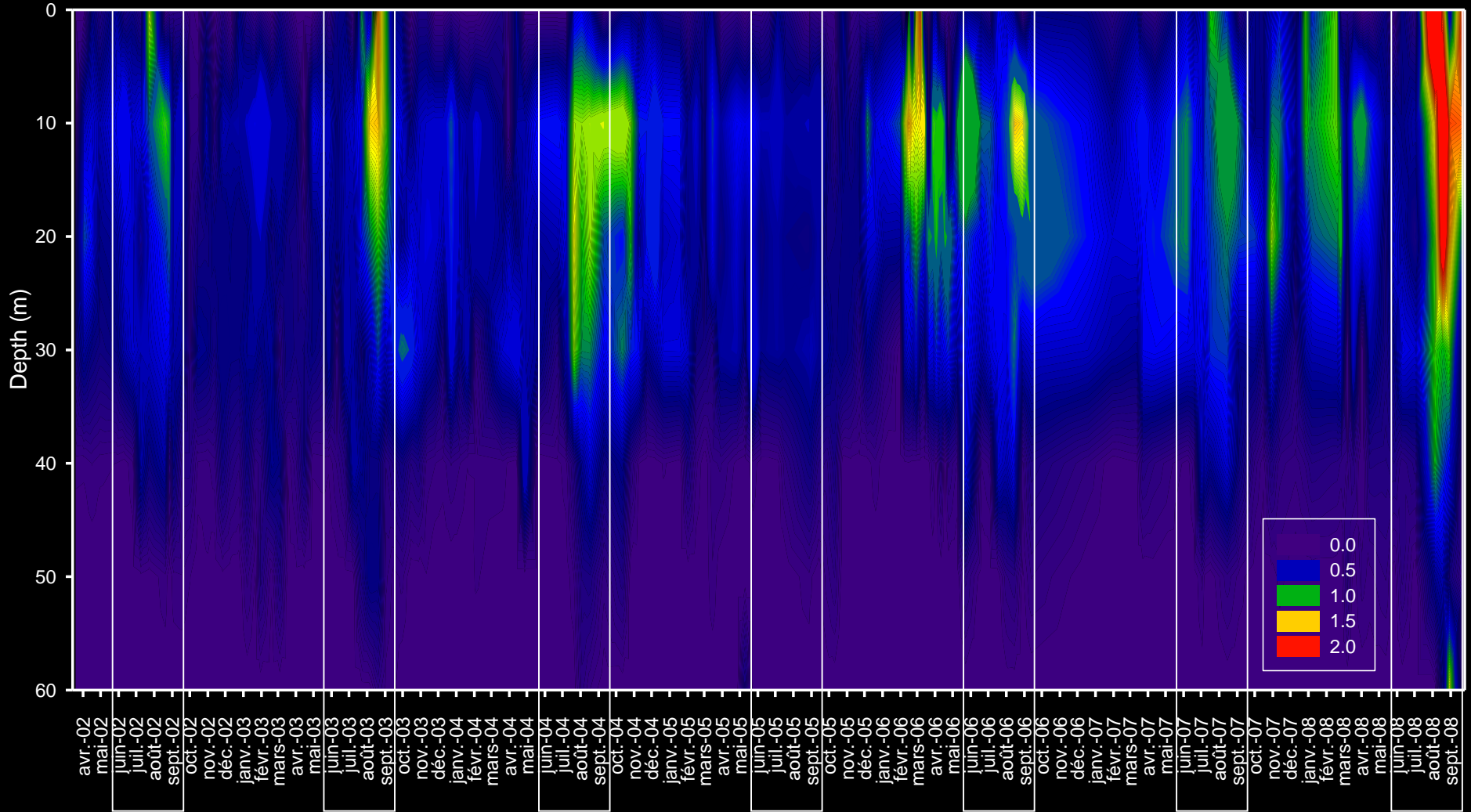
Diatoms







Cryptophytes



Phytoplankton biomass & Primary production

Lake	Period	Mean biomass $\mu\text{gChla/L}$ mgChla/m^2	Mean PP $\text{gC.m}^{-2}.\text{y}^{-1}$	References	
L. Malawi	1996-98	0.86	34	169	Guildford et al. 2007
L. Tanganyika	2002-03	1.06	43	236	Bergamino et al. in press
L. Kivu	2003-08	1.68	75	170	present study
L. Victoria	2001-2002	~50	~150	1061	Silsbe 2004, Silsbe et al. 2006

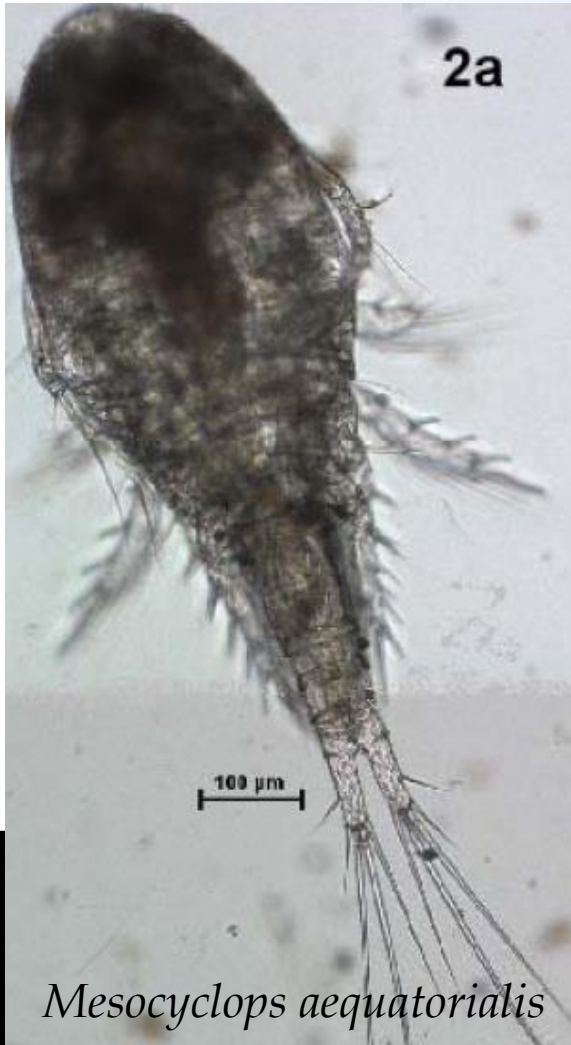
An oligotrophic lake but with higher biomass than L. Tanganyika and Malawi

Phytoplankton biomass & Primary production

Period	PP gC.m⁻².d⁻¹	n	Reference
March 1972	1.03 – 1.44	<14	Degens <i>et al.</i> , 1973
March 1972 – 73	0.66 – 1.03	8	Jannasch, 1975
October 1990	0.33	3	Descy, 1990
2002 – 2008	0.64 (0.19 – 1.18)	55	present study

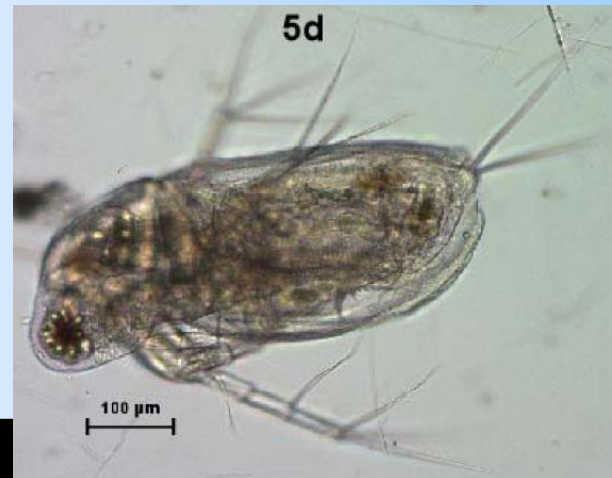
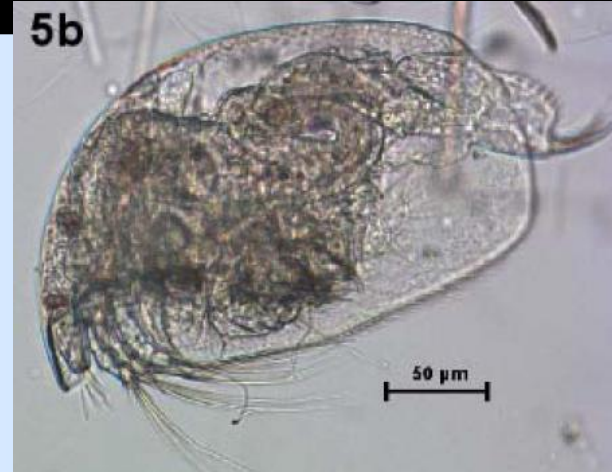
No detectable variations of PP during the last 35 years

Zooplankton composition



Cyclopoid copepods

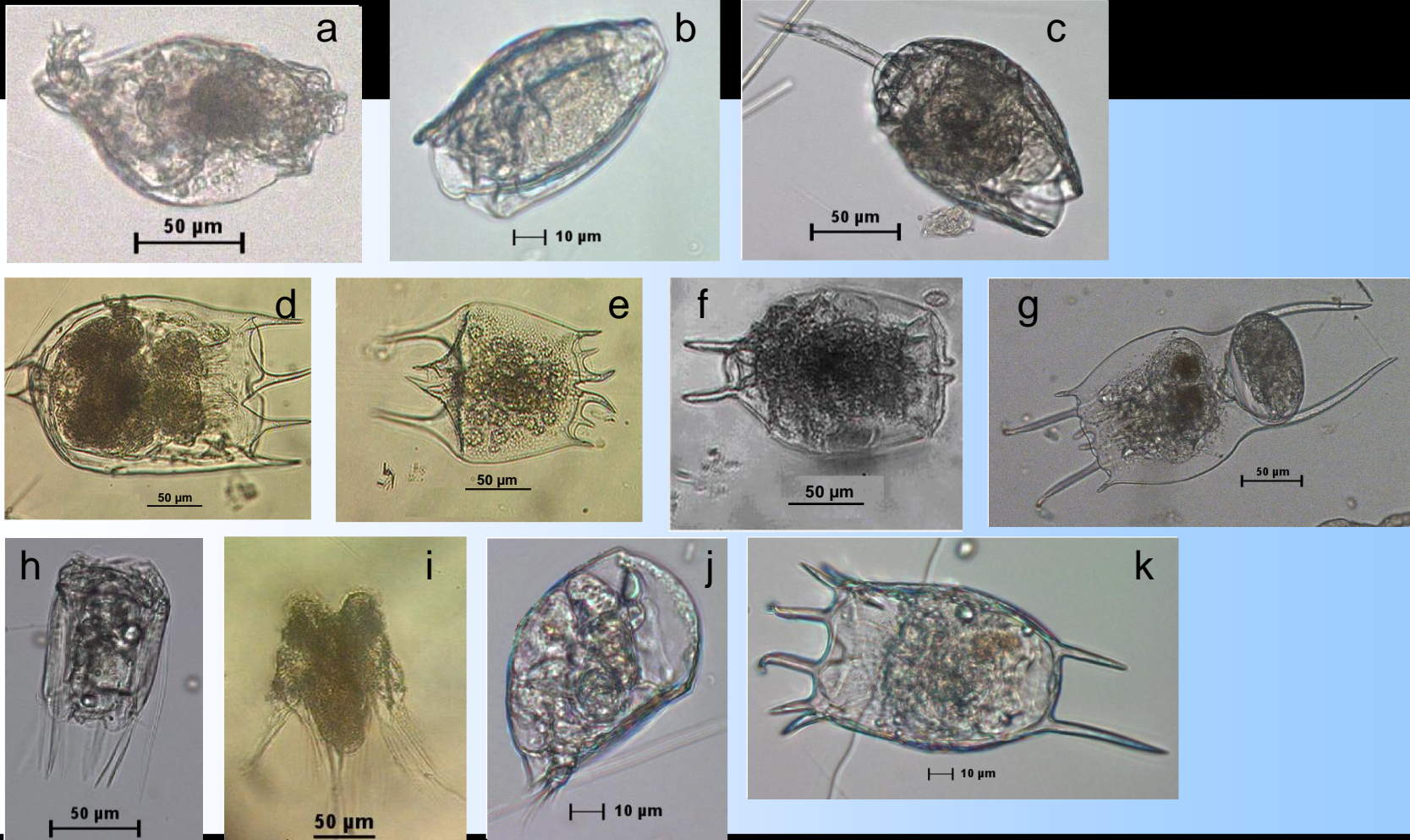
Zooplankton composition



Cladocerans

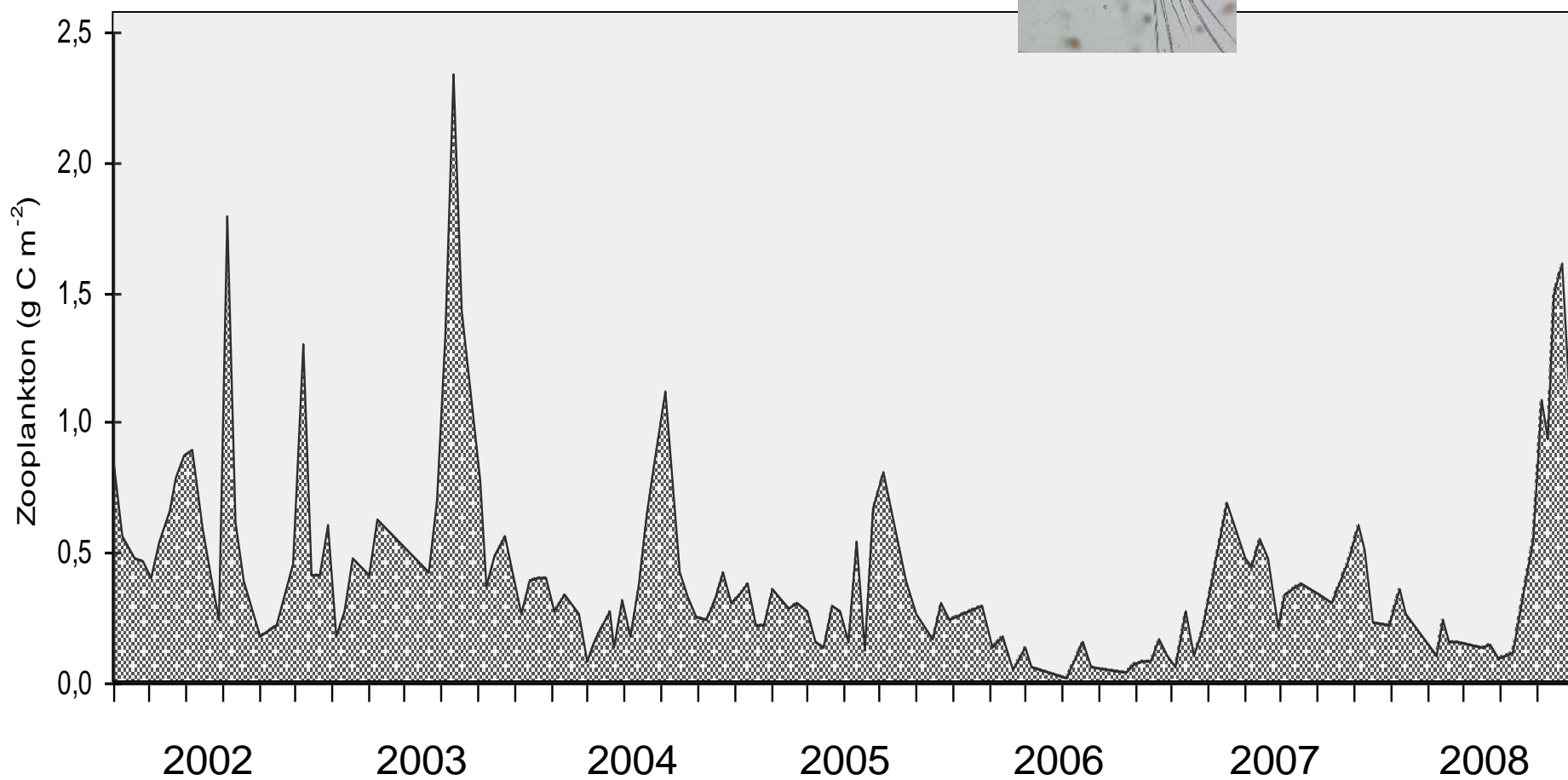
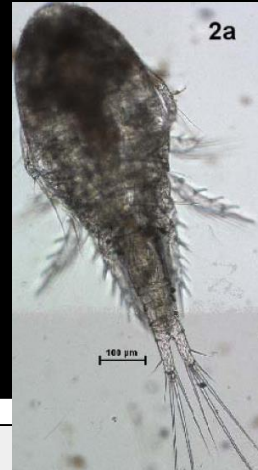
a: *Diaphanosoma excisum* b: *Alona rectangulara* c: *Ceriodaphnia cornuta* d: *Moina micrura*

Zooplankton composition

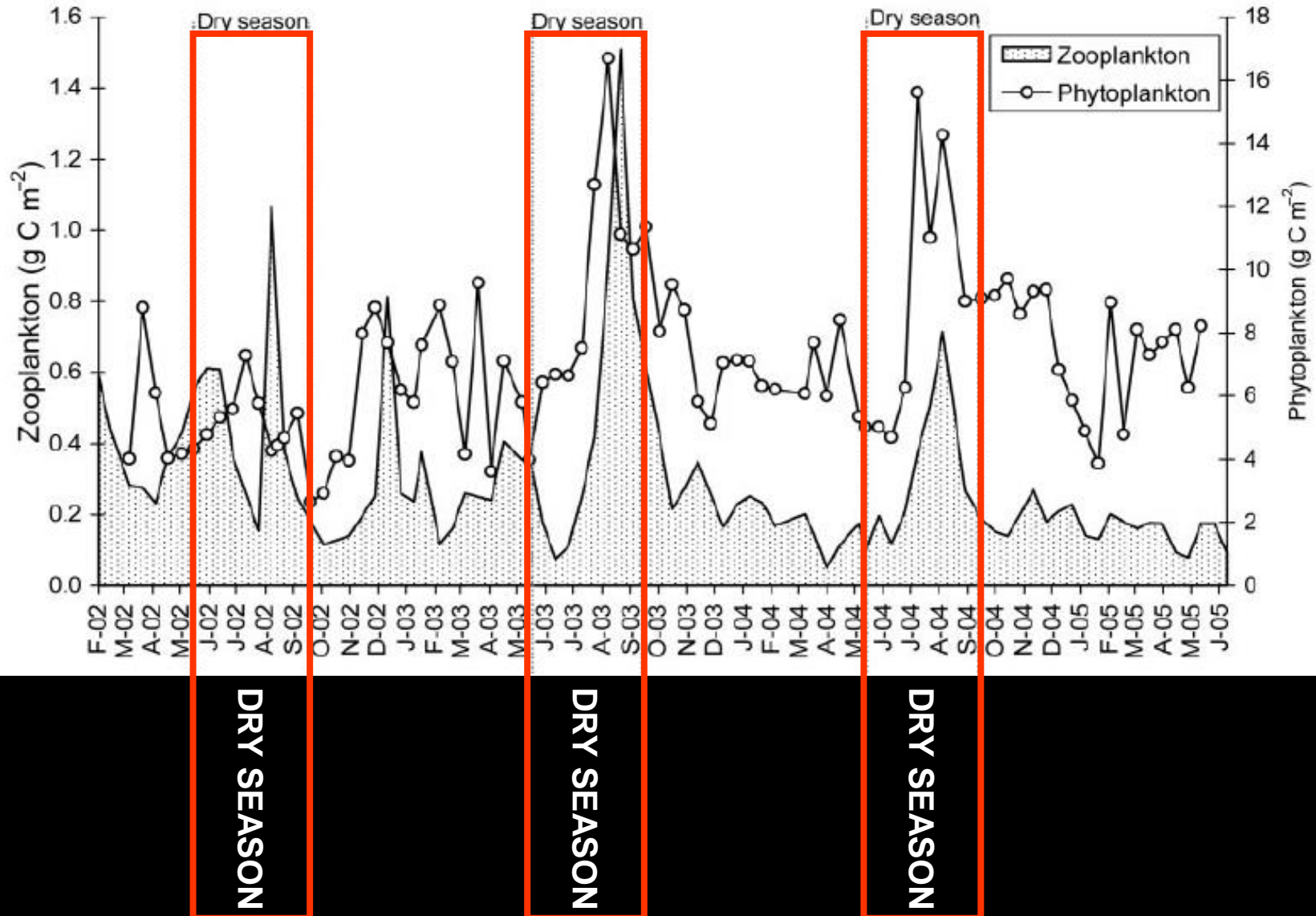


a: Bdelloid b: *Anuraepsis fissa* c: *Lecane* sp. d: *Brachionus calyciflorus* e: *Brachionus quadridentatus* f: *Brachionus caudatus* g: *Brachionus falcatus* h: *Polyarthra* sp. i: *Hexarthra* sp. j: *Collurella* sp. k: *Keratella tropica*

Rotifers



Phytoplankton and zooplankton blooms



Zooplankton biomass & production

Lake	Mean biomass gC.m ⁻²	Mean annual production gC.m ⁻² .y ⁻¹	Reference
L. Tanganyika	1.2	23	Kurki <i>et al.</i> , 1999; Sarvala <i>et al.</i> , 1999
L. Malawi	0.9	24.5	Irvine, 1995; Irvine & Waya, 1999
L. Kivu	0.3	8.3	present study

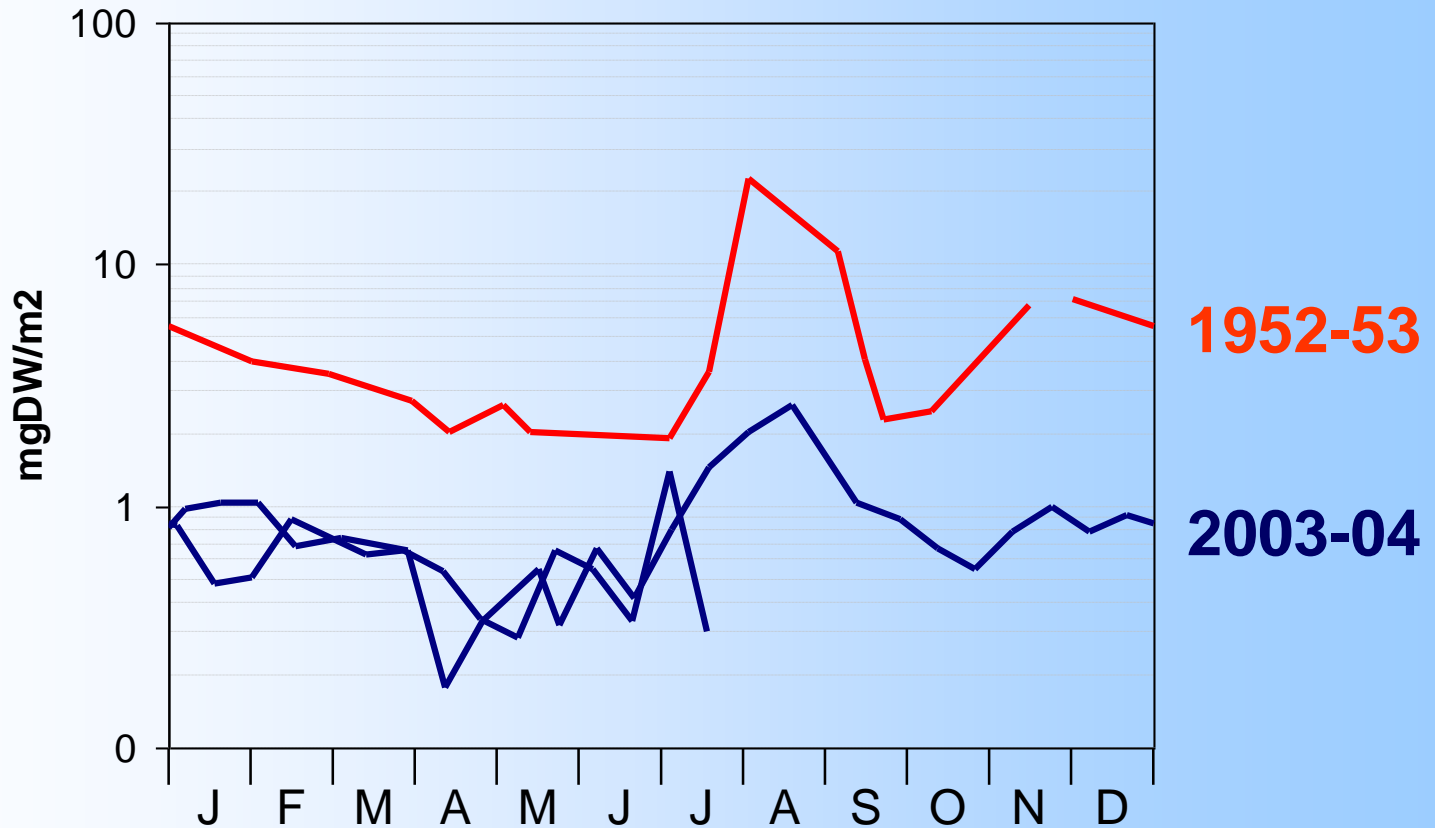
Very low secondary production ...

Zooplankton biomass & production

Lake	Trophic transfer efficiency %	Reference
African lakes	10.1	Pauly & Christensen, 1995
L. Tanganyika	3.5 – 5.4	Sarvala <i>et al.</i> , 1999
L. Malawi	5 – 8	Irvine & Waya, 1999
L. Kivu	1.3 – 2.1	present study

... and concomitant low trophic transfer efficiency

Zooplankton biomass & production



Important decrease of zooplankton biomass ...

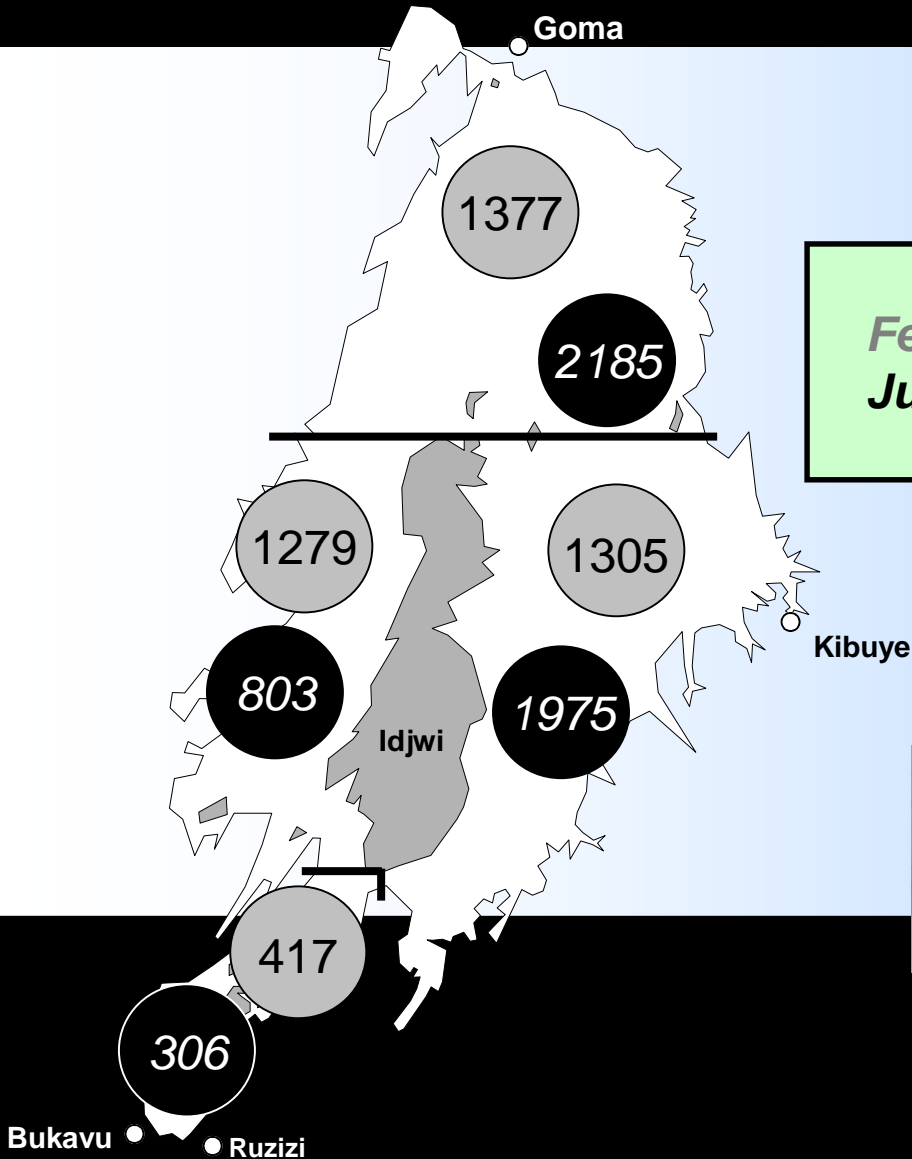
In the 20th and 21st centuries...

- Verbeke (1952-1954): study of zooplankton, no planktivore in the pelagic waters
- Introduction of *Limnothrissa miodon* from Lake Tanganyika in the late 50s
- **Success of the introduction of the freshwater Clupeid *Limnothrissa miodon* in Lake KIVU** (*Fish Farming International*, Frank, 1977 ; *Fisheries Management*, Spliethoff et al., 1983)
- **The Tanganyika sardine in Lake Kivu: Another ecodisaster for Africa?** (*Environment Conservation*, Dumont 1986)



*... since the introduction of *Limnothrissa miodon* and disappearance of the main grazer *Daphnia curvirostris**

Fish hydroacoustic surveys



Feb. 08: 5000 tons
July 08: 6000 tons

→ Production : ~8-9000 tons/year



Limnothrissa miodon

Fish hydroacoustic surveys

Lake	Sardine production gC.m ⁻² .y ⁻¹	Reference
L. Tanganyika	1.4 – 1.7	Sarvala <i>et al.</i> , 1999
L. Kivu	0.2	present study



Limnothrissa miodon

Lake Kivu Pelagic Food Web

Atmosphere

Mean particulate PP:
170 gC/m².y

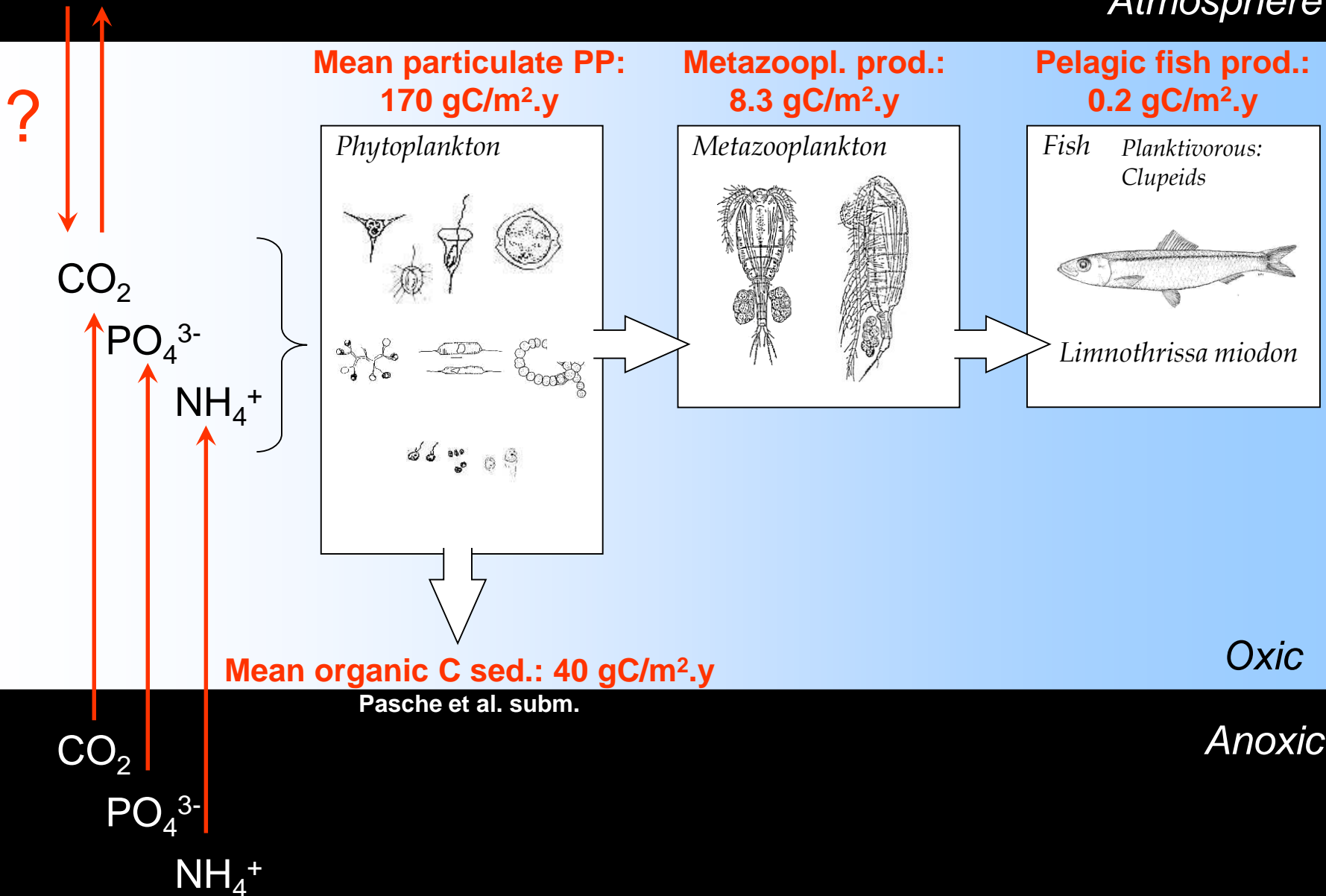
Metazoopl. prod.:
8.3 gC/m².y

Pelagic fish prod.:
0.2 gC/m².y



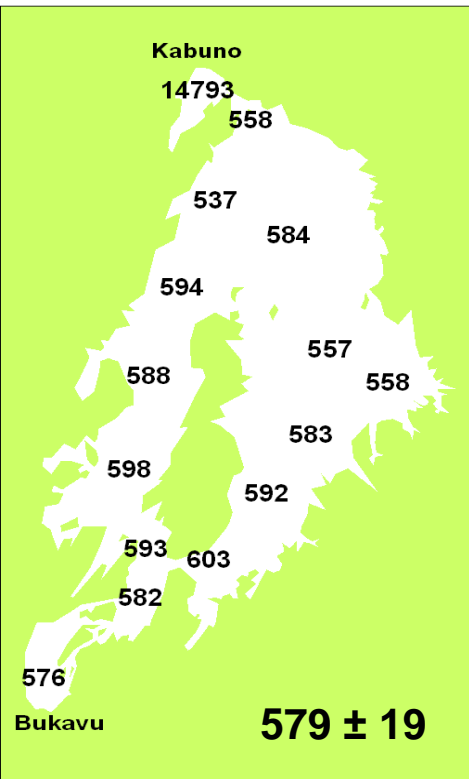
Lake Kivu: a net sink or a net source of CO₂?

Atmosphere

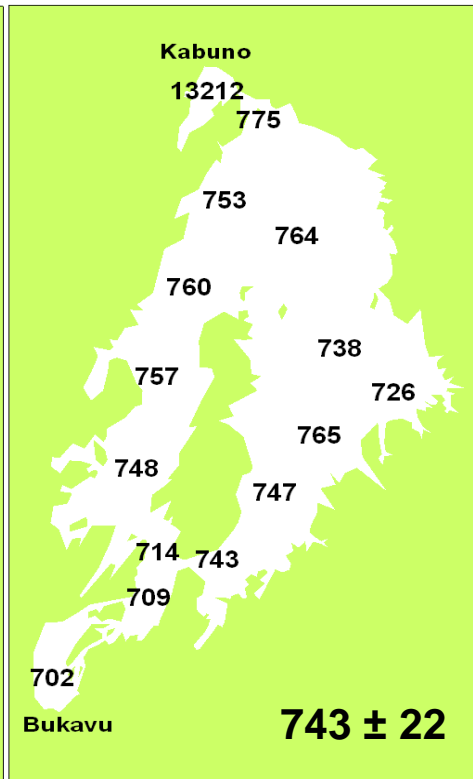


CO₂ partial pressure in surface waters (ppm)

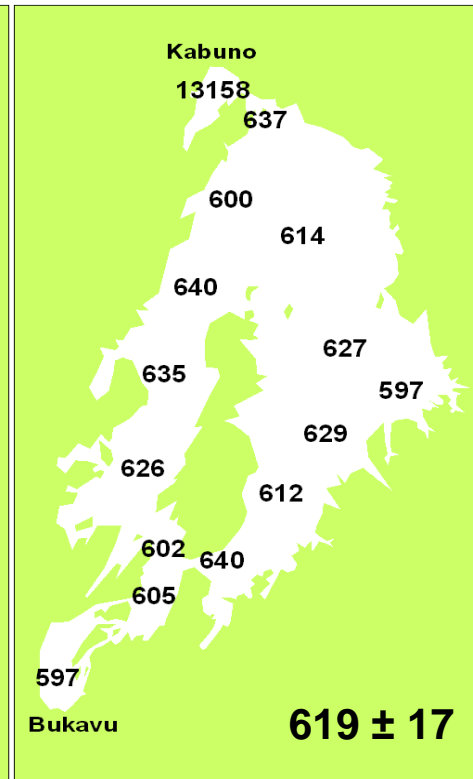
March 2007



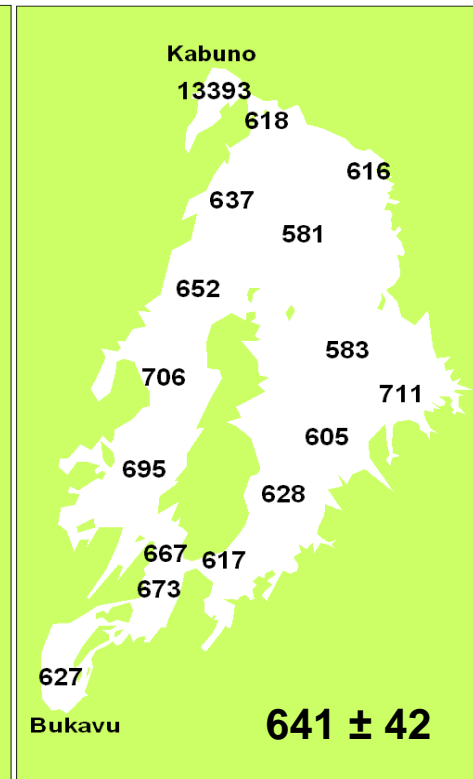
September 2007



June 2008



April 2009



Atmospheric pCO₂ = 380 ppm

→ *The lake is permanently a net source of CO₂ to the atmosphere*

Lake Kivu Pelagic Food Web

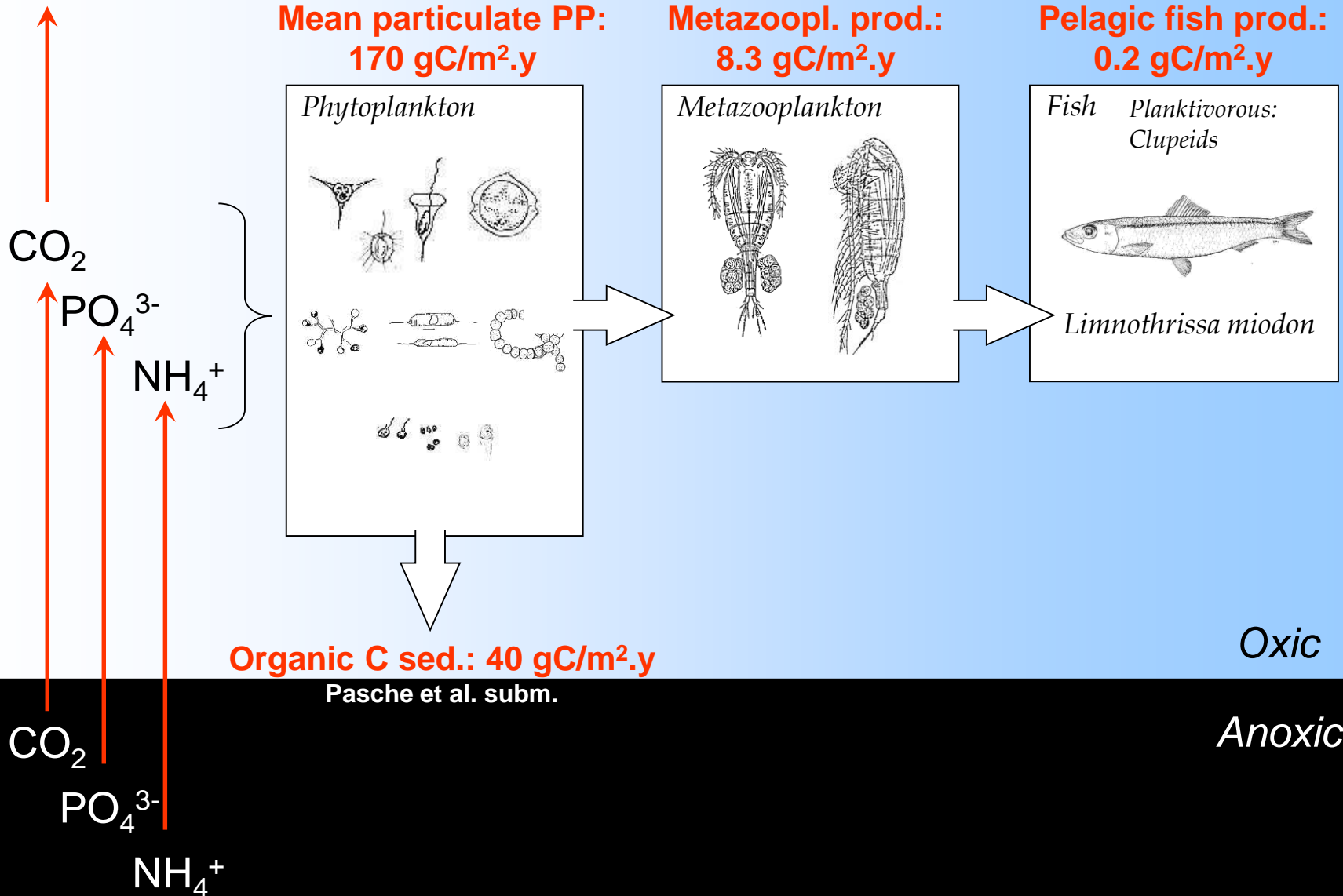
30 gC/m².y

Atmosphere

Mean particulate PP:
170 gC/m².y

Metazoopl. prod.:
8.3 gC/m².y

Pelagic fish prod.:
0.2 gC/m².y



What is the fate of the PP?

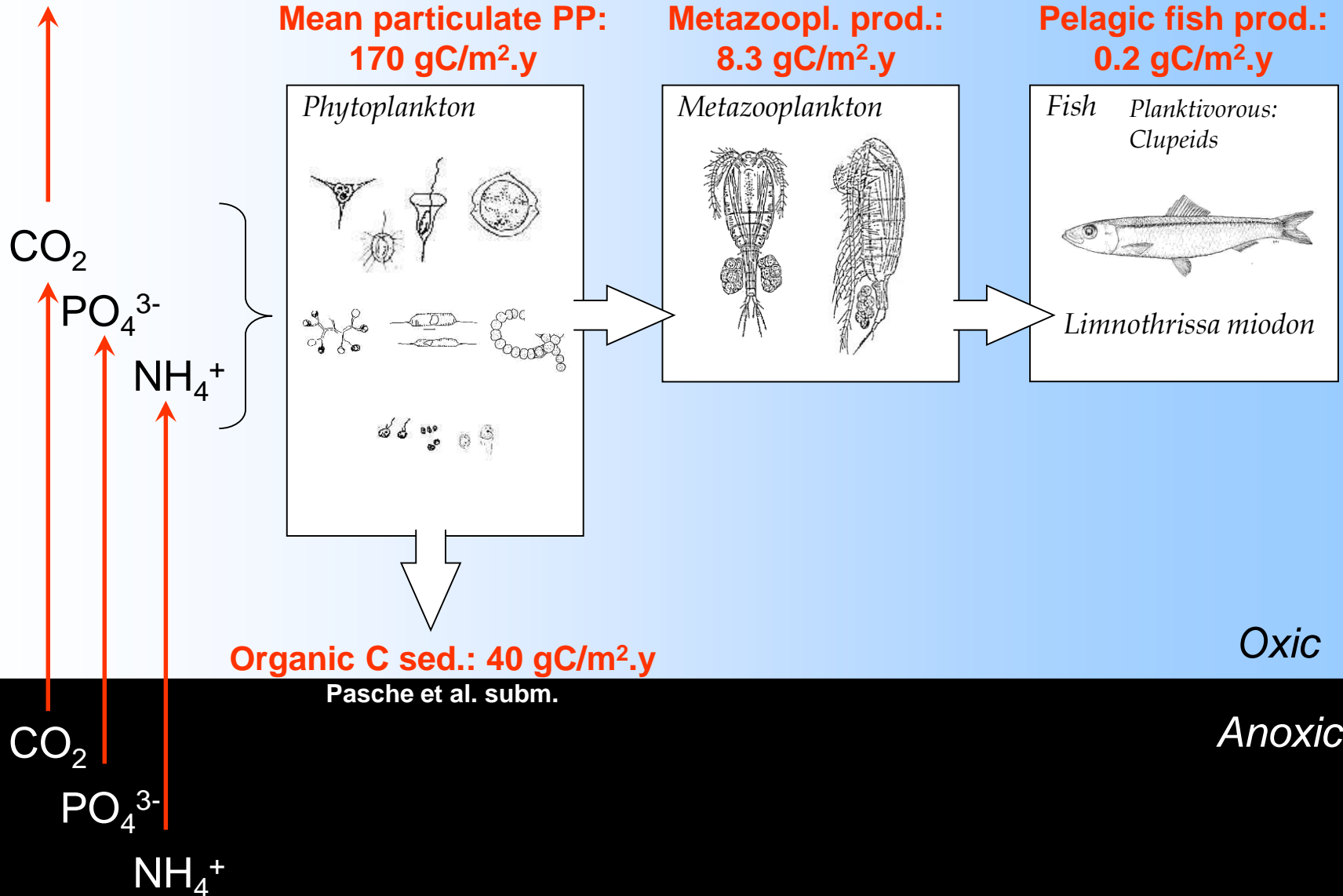
30 gC/m².y

Atmosphere

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Metazoopl. prod.:
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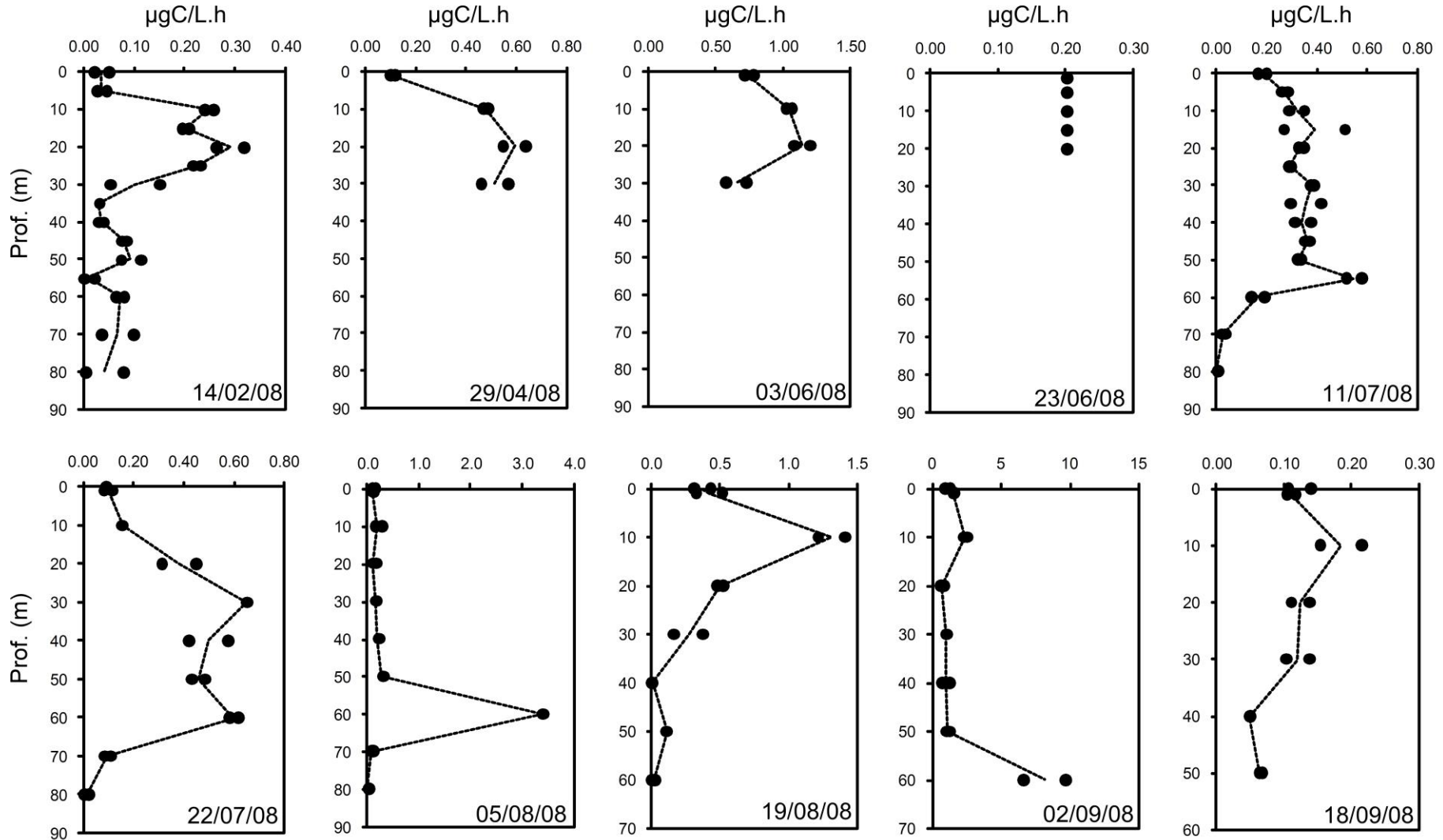


Organic C sed.: 40 gC/m².y
Pasche et al. subm.

Oxic

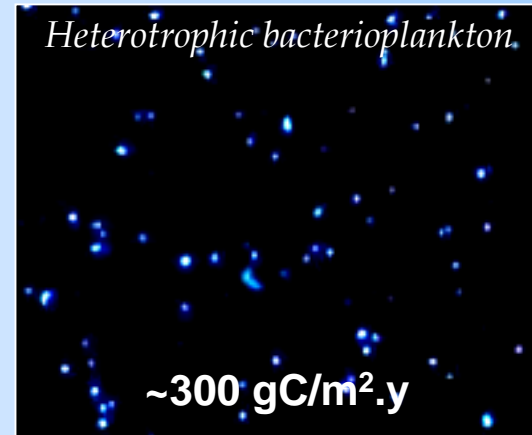
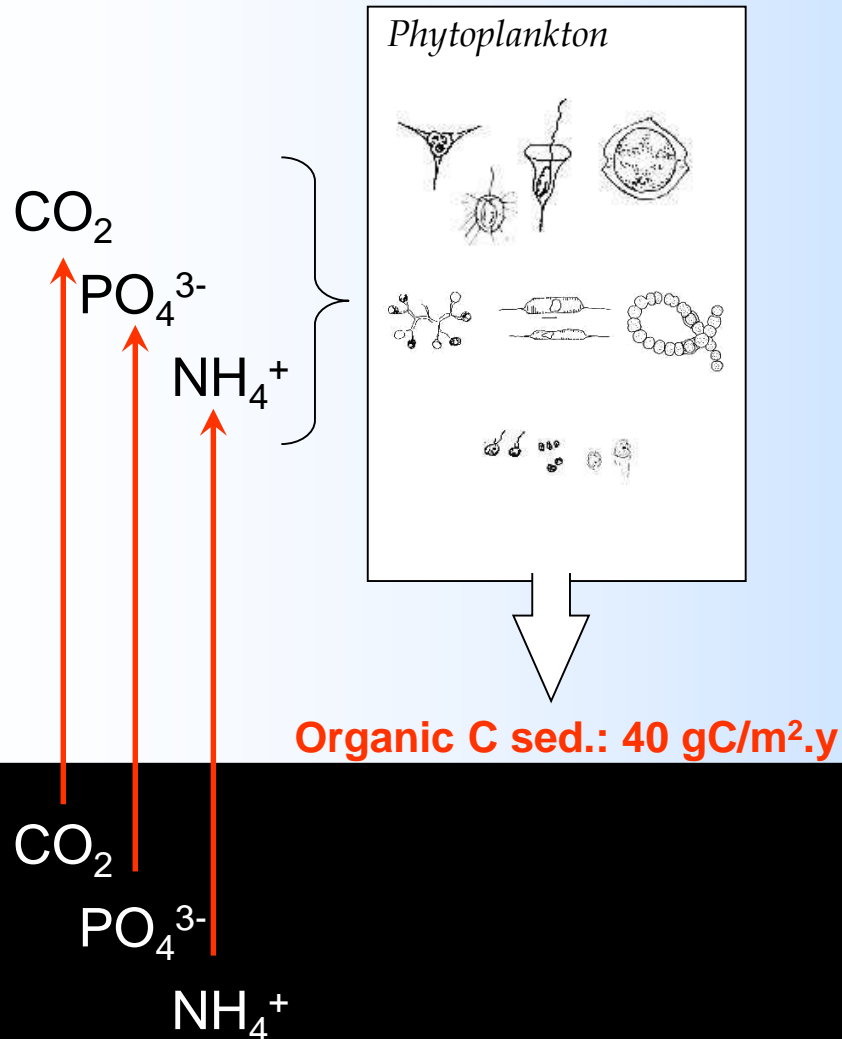
Anoxic

Heterotrophic Bacterial Production



Heterotrophic Bacterial Production

Mean particulate PP:
170 gC/m².y

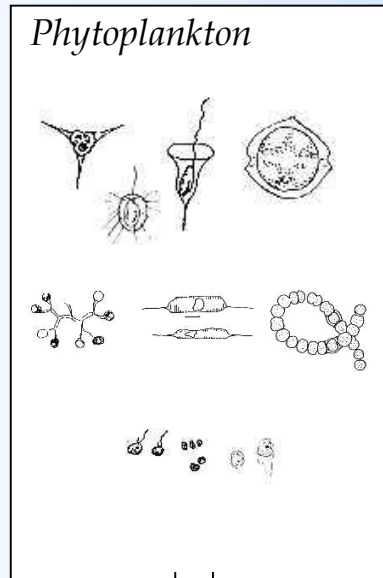


Oxic

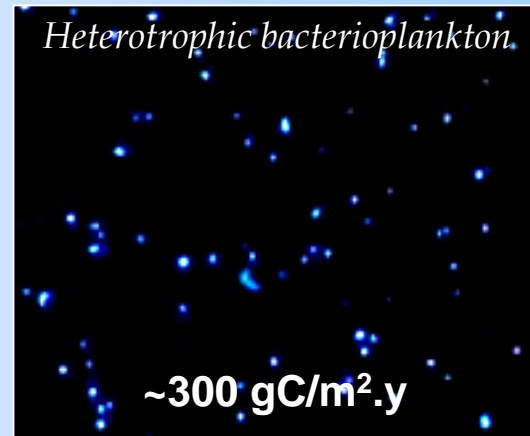
Anoxic

Origin of C consumed by bacteria?

Mean particulate PP:
170 gC/m².y

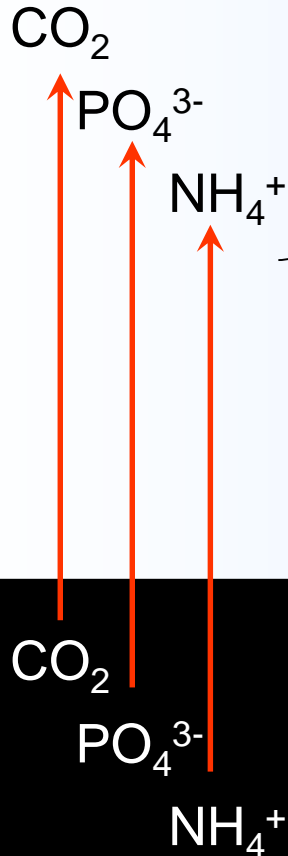


Organic C sed.: 40 gC/m².y



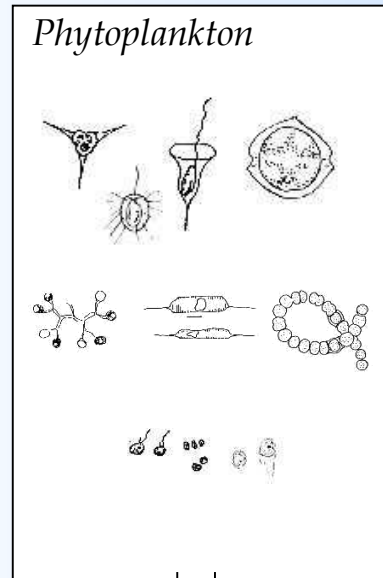
Oxic

Anoxic

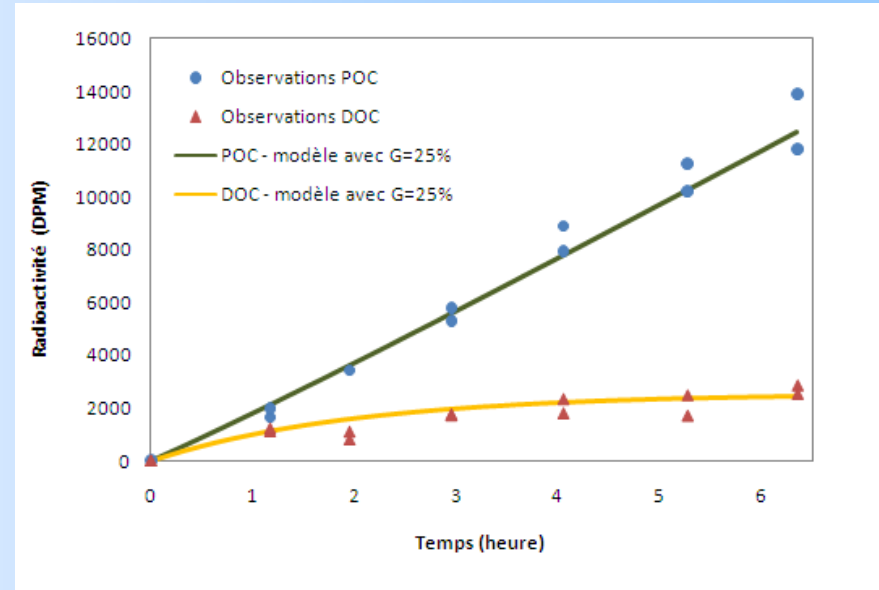


Phytoplankton release of organic C

Mean particulate PP:
170 gC/m².y



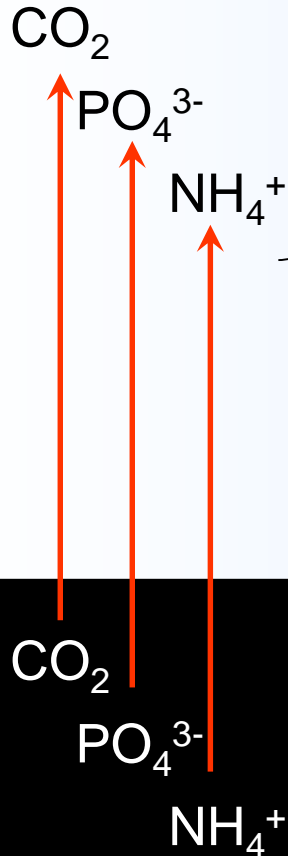
Organic C sed.: 40 gC/m².y



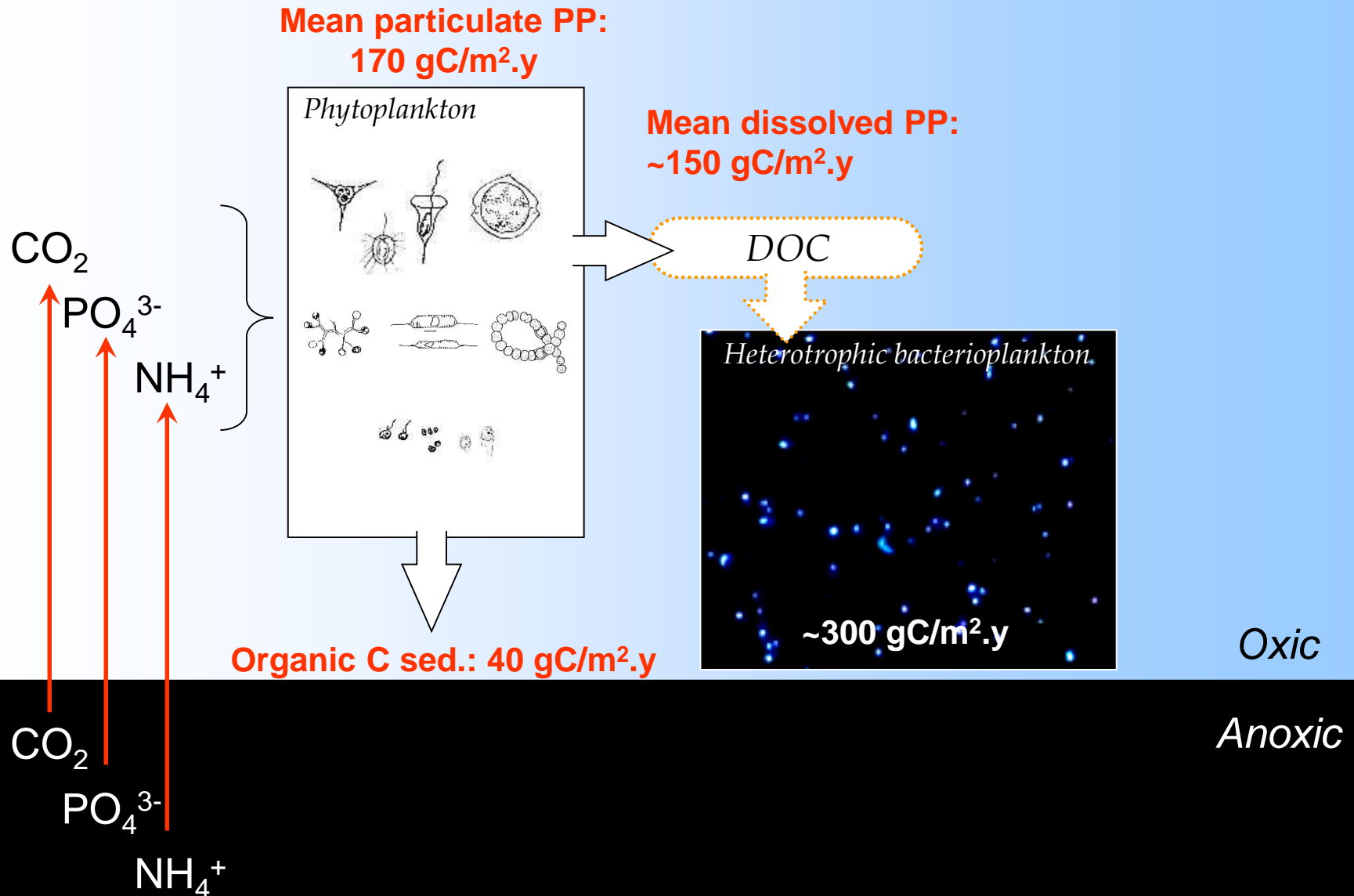
PER = 40-50%

Oxic

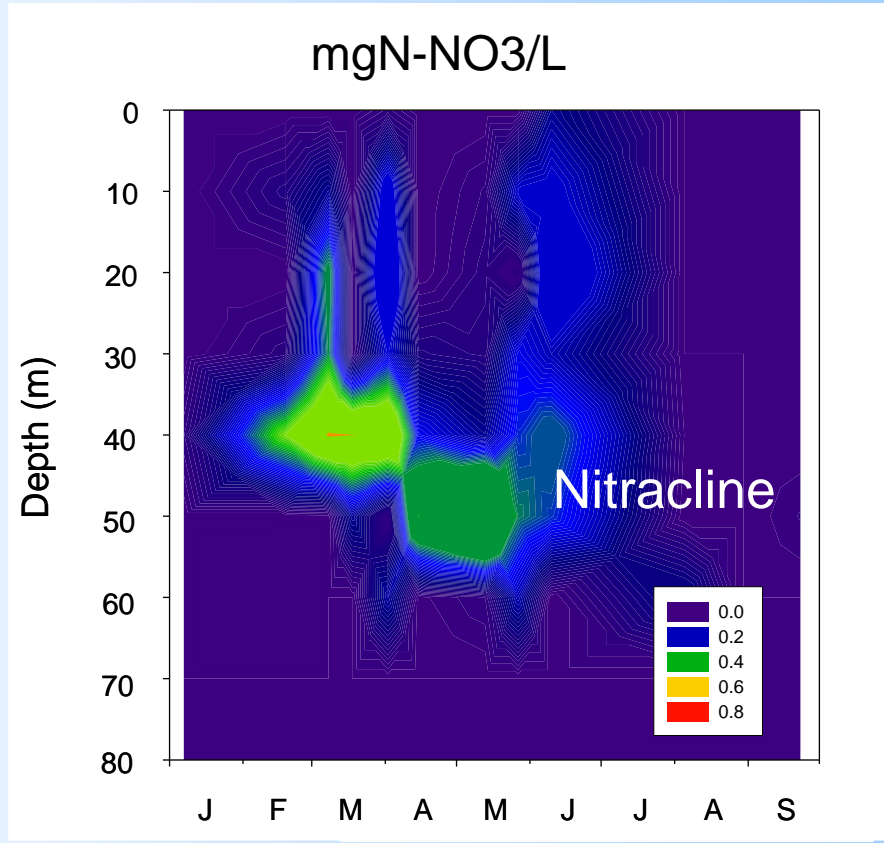
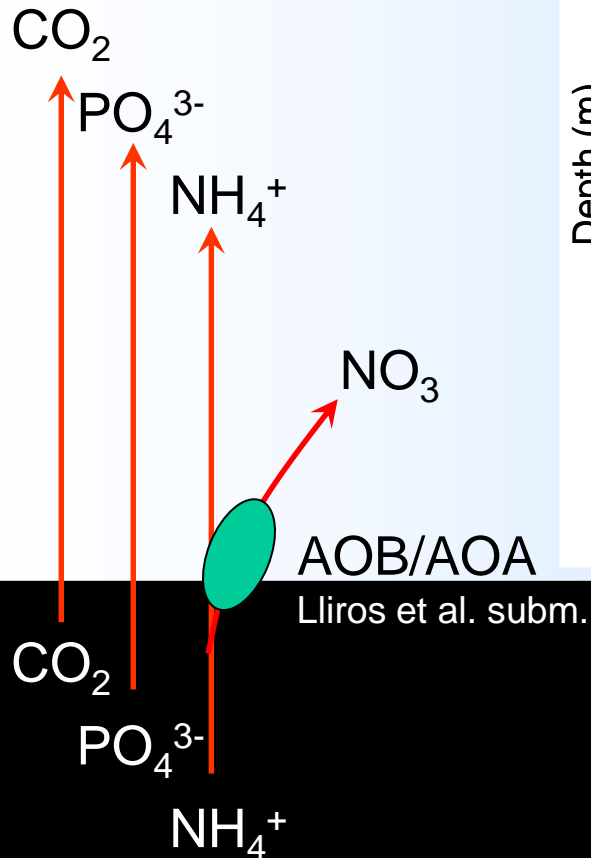
Anoxic



Phytoplankton release of organic C

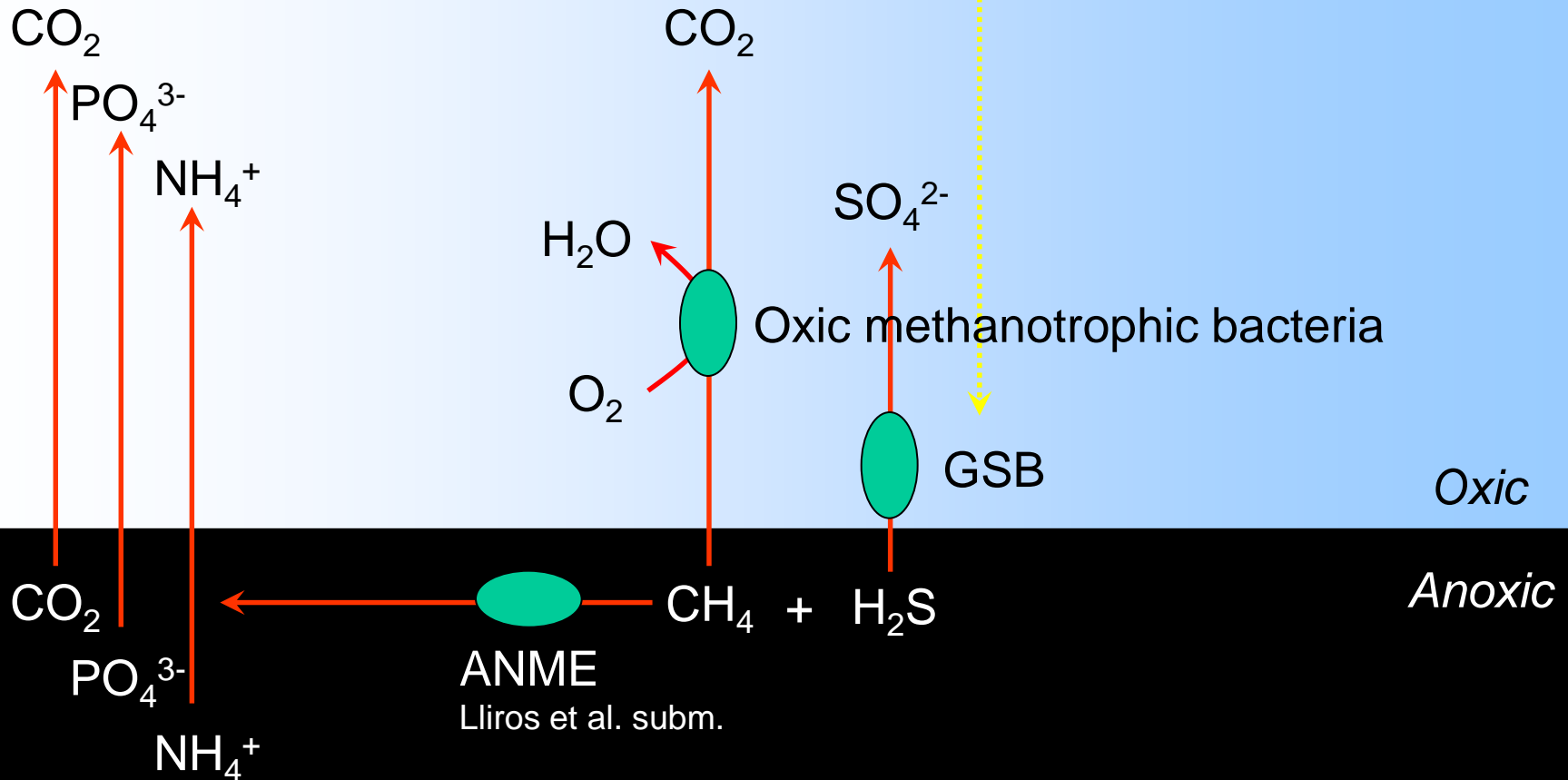
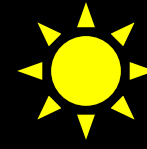


Autotrophic bacteria

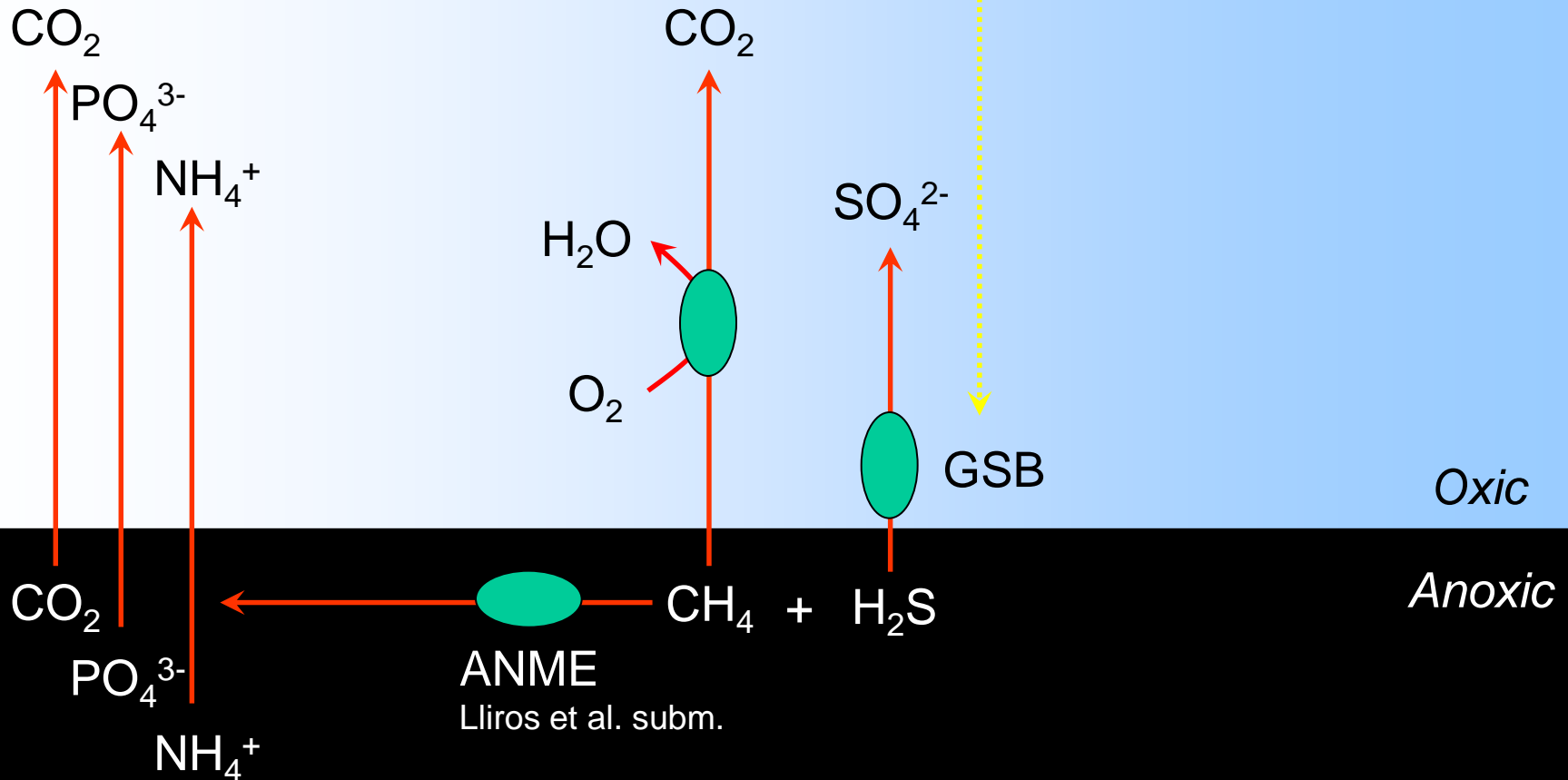
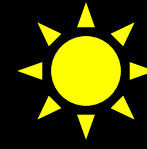


Oxic
Anoxic

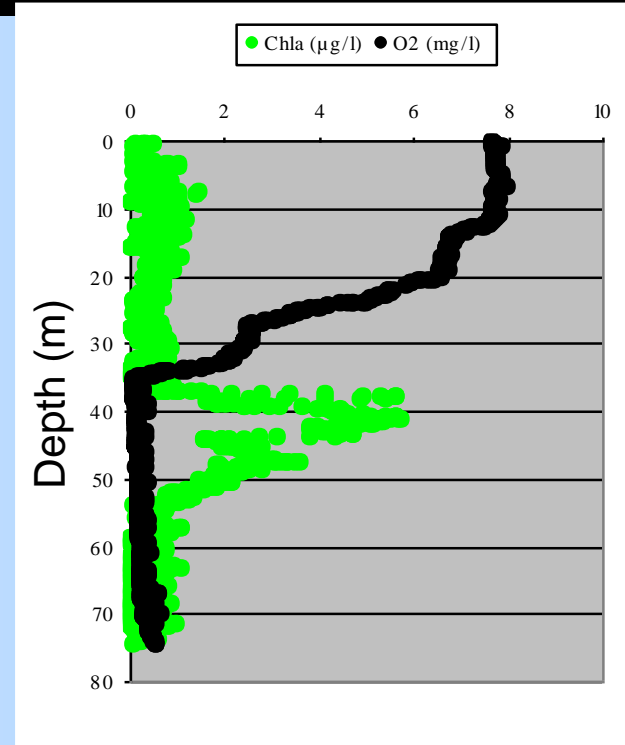
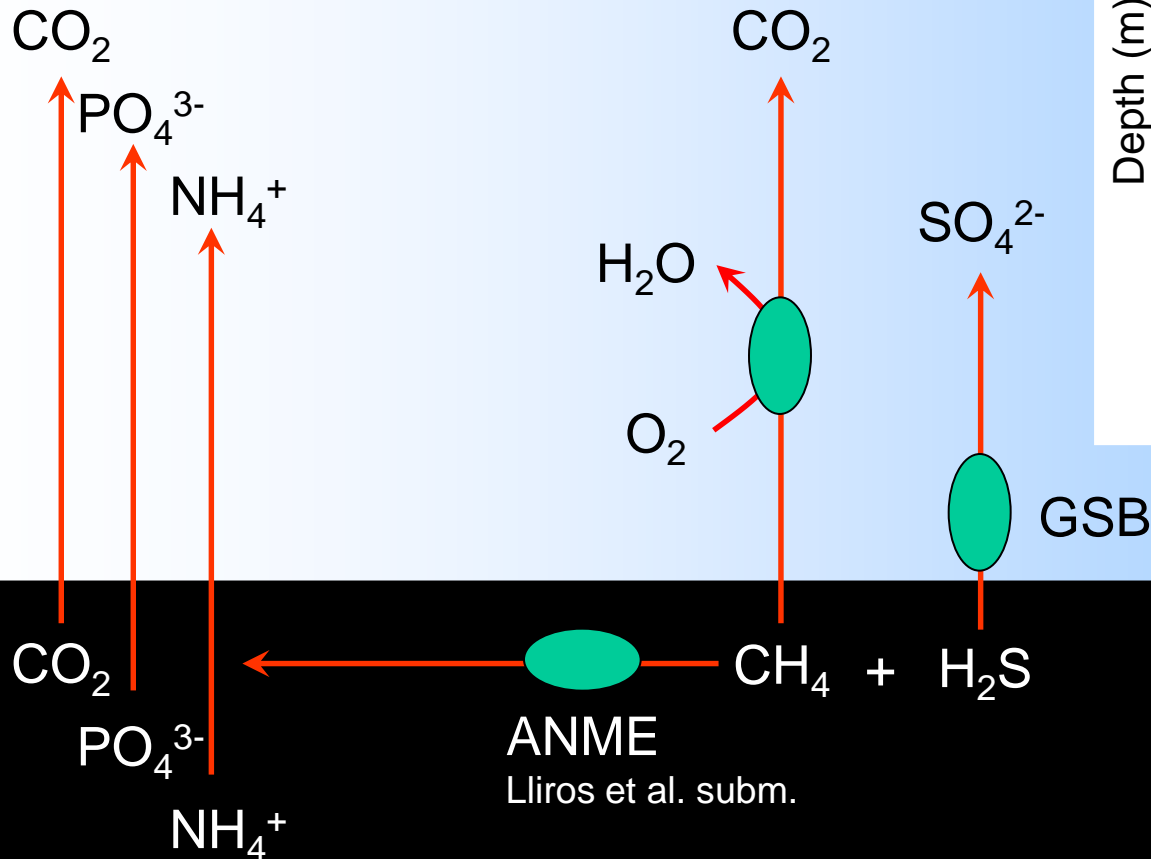
Autotrophic bacteria



Autotrophic bacteria

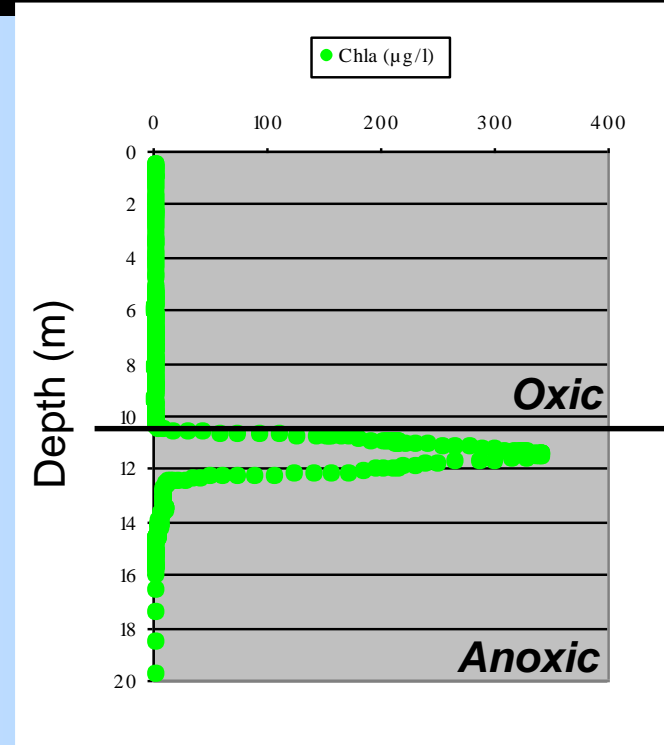
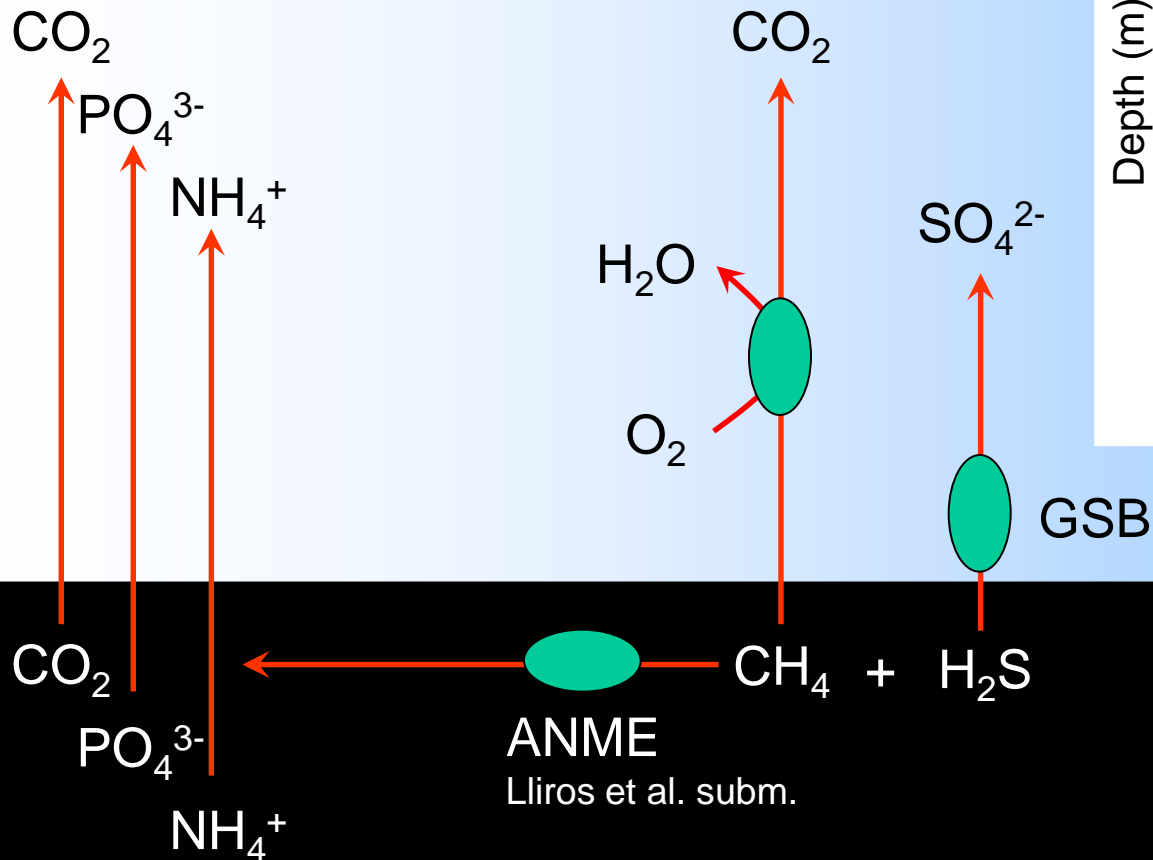


Autotrophic bacteria

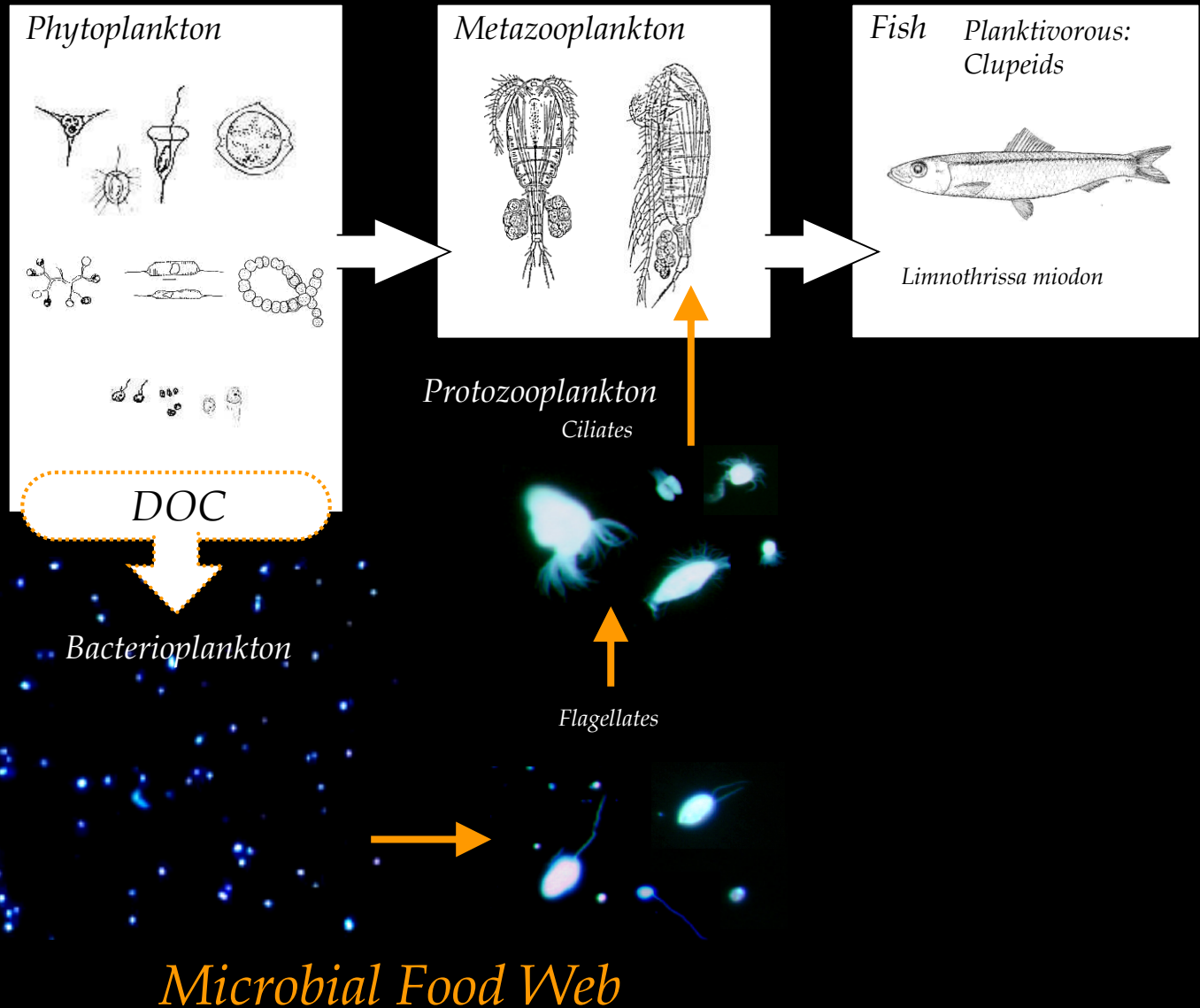


Oxic
Anoxic

Autotrophic bacteria



Lake Kivu Pelagic Food Web



Concluding remarks

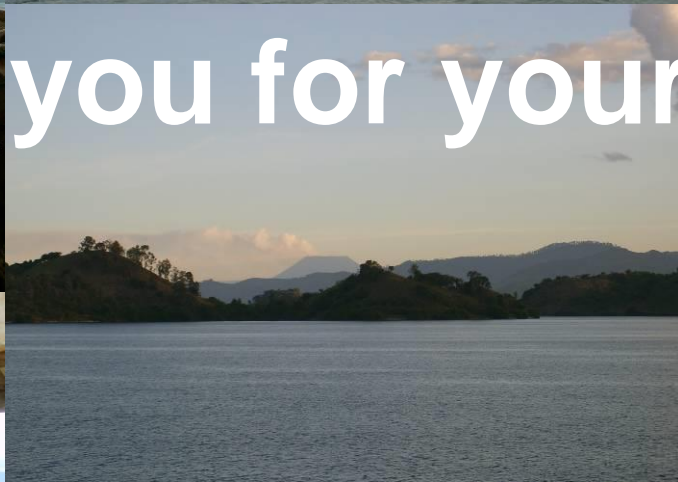
- Lake Kivu: an oligotrophic lake but with higher biomass of phytoplankton, effects of the few top-down control
 - Low trophic transfer efficiency
 - Importance of the microbial food web: dissolved primary production, heterotrophic activity, ...
 - Autotrophic bacteria
- ➔ a such unique lake !

Perspectives for 2010 ...

- permanent mooring offshore Gisenyi, with
 - Chla and phycoerythrin fluorometers
 - optode (O₂)
 - minilogs (thermosensors)
- microbial and picoeukariotic diversity
- study of trophic link between metazooplankton and fishes, specially with the interplay of a new invader *Lamprichthys tanganycanus*
- modelling of Lake Kivu ecology
- sediment core analysis (diatoms & zooplankton)



Thank you for your attention



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