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Freshwater Biological Association
Romanian Ecological Society
University of Bucharest
Department of Systems Ecology and Sustainability

Microbial communities in large tropical lakes (East African Rift Lakes) Response to environmental changes

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FNRS
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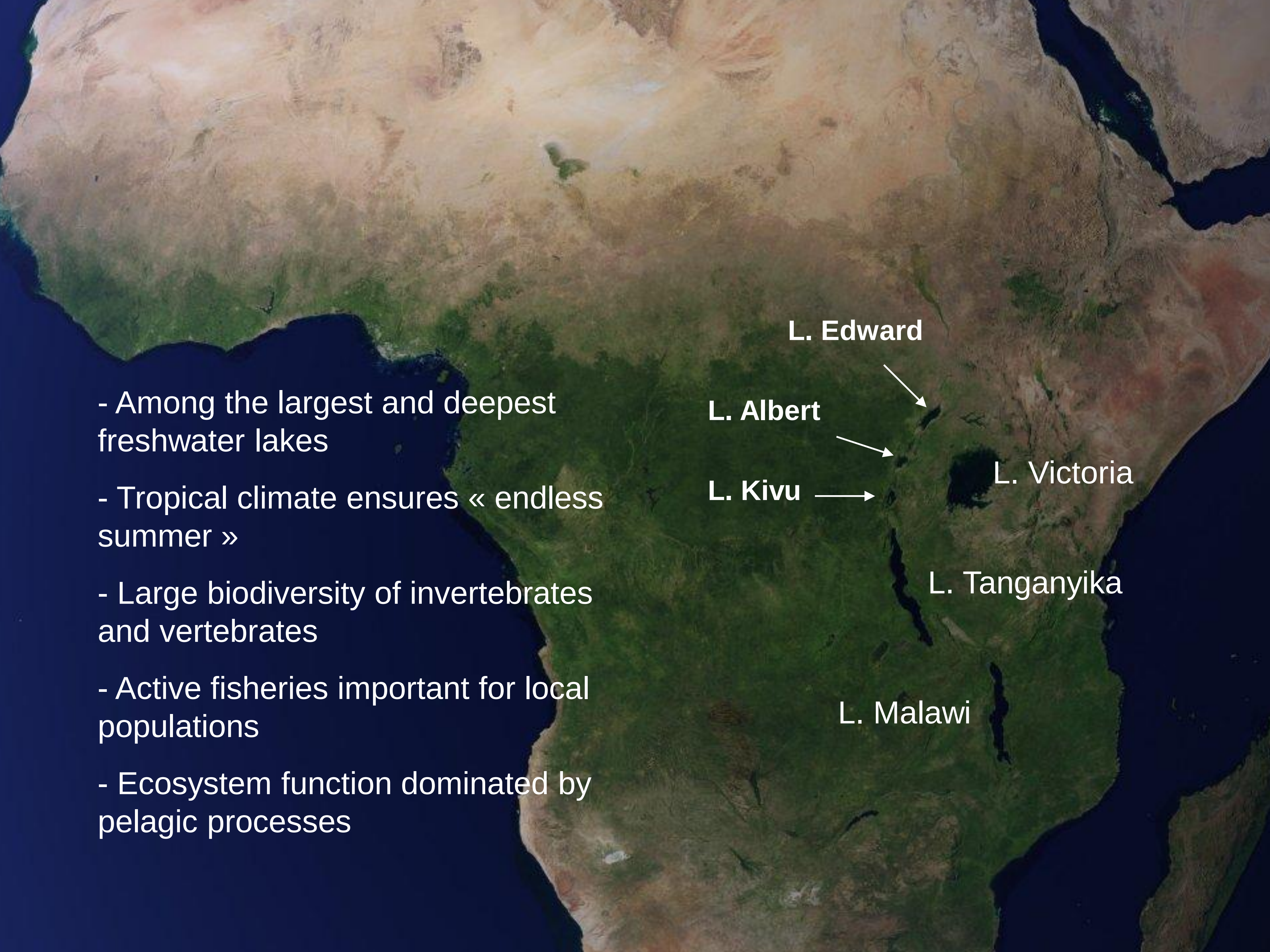
Summary

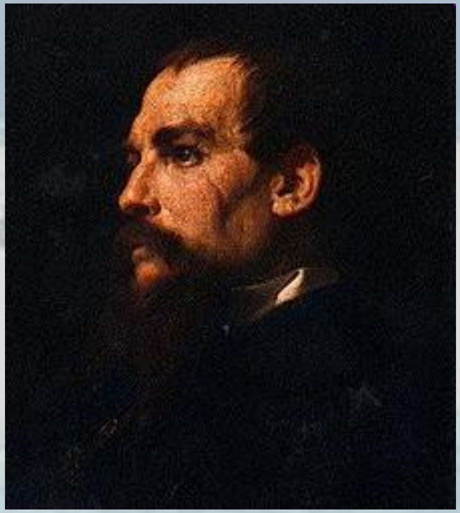
- Introduction :
  - Common features of East African Great Lakes; history and early discoveries
  - A focus on phytoplankton and other microorganisms
- Lake Tanganyika: strong response to climate change? Evidence at different scales
- Lake Kivu: a lakeful of trouble?
- Conclusions and perspectives

- Among the largest and deepest freshwater lakes
- Tropical climate ensures « endless summer »
- Large biodiversity of invertebrates and vertebrates
- Active fisheries important for local populations
- Ecosystem function dominated by pelagic processes



Some history and discoveries

1857-58: journey of Richard Francis Burton and John Hanning Speke, who were in search of the source of the Nile. They « discovered » lake Tanganyika in February 1858



JH Speke, officer and explorer, 1827-1864

RF Burton, and explorer, 1821-1890

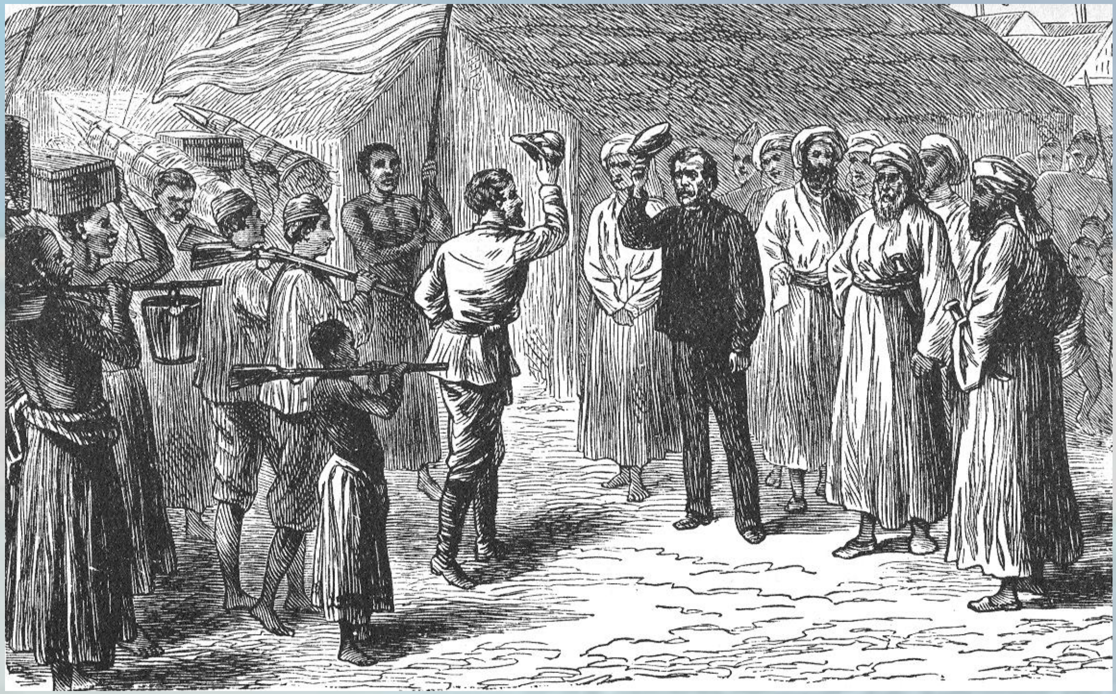
http://en.wikipedia.org/wiki/Richard_Francis_Burton#Exploring_the_lakes_of_central_Africa_.281856.E2.80.931860.29

Some history and discoveries

D. Livingstone : Zambezi and Nile expeditions; discovery of several lakes, incl. Lake Malawi

D. Livingstone, missionary and explorer

1813-1873



Stanley meets Livingstone in Ujiji, 27 October 1871

Some history and discoveries

Limnological studies of the Rift lakes began only in the 20th century. Before that, scientists mostly described animal life (fishes, invertebrates)

Several Belgian expedition were conducted in the 1940’s and 1950’s in the Great Lakes Region, then part of national parks (Parcs Nationaux du Congo Belge)

Examples :

- Exploration du Parc National Albert, mission H. Damas (1935-1936)
- Exploration hydrobiologique des Lacs Kivu, Edouard et Albert (1952-1954)

But information on the plankton were scarce in the publications …

Lake Tanganyika

Located in East Africa

> 10 million years old

maximum depth : 1470 m

Surface area: 33,000 km²

Volume: 18,000 km³

18 % of surface fresh water

Very productive fishery, compared to that of marine fisheries

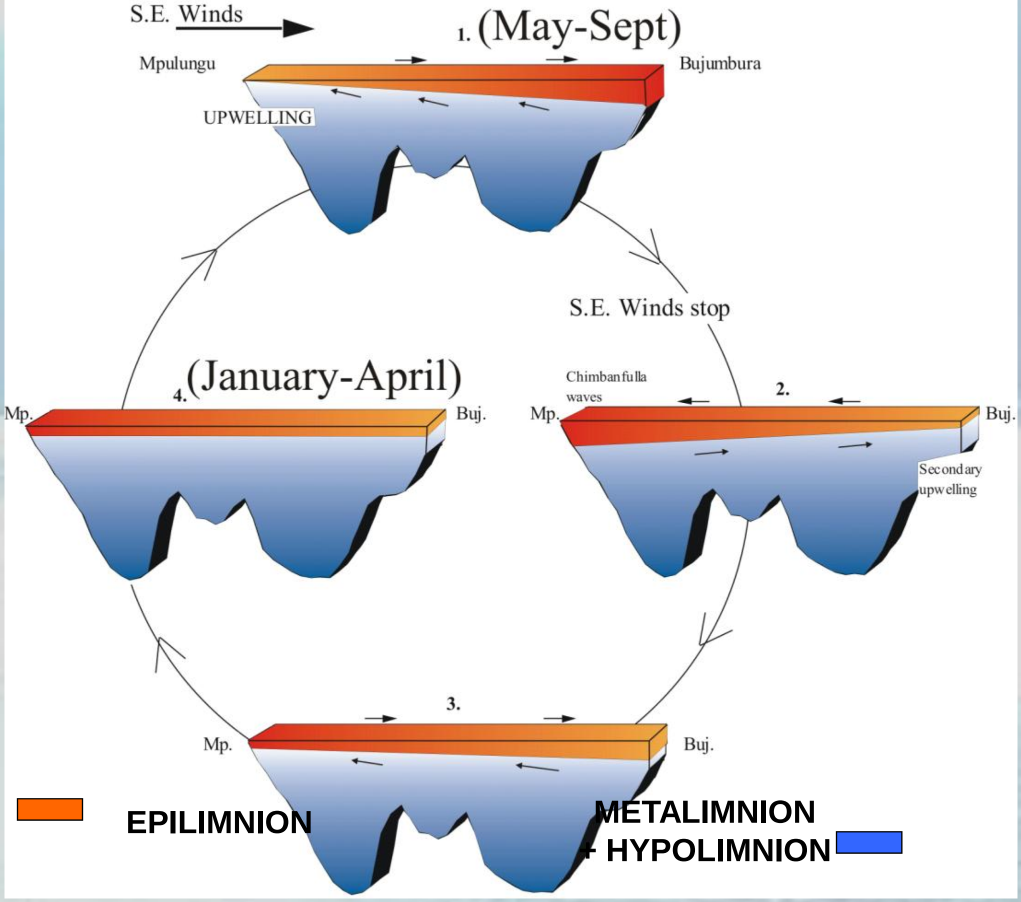
Typical annual limnological cycle in Lake Tanganyika as depending on air temperature and wind regime

Wind regime influences hydrodynamics, depth of the mixed layer and nutrient distribution

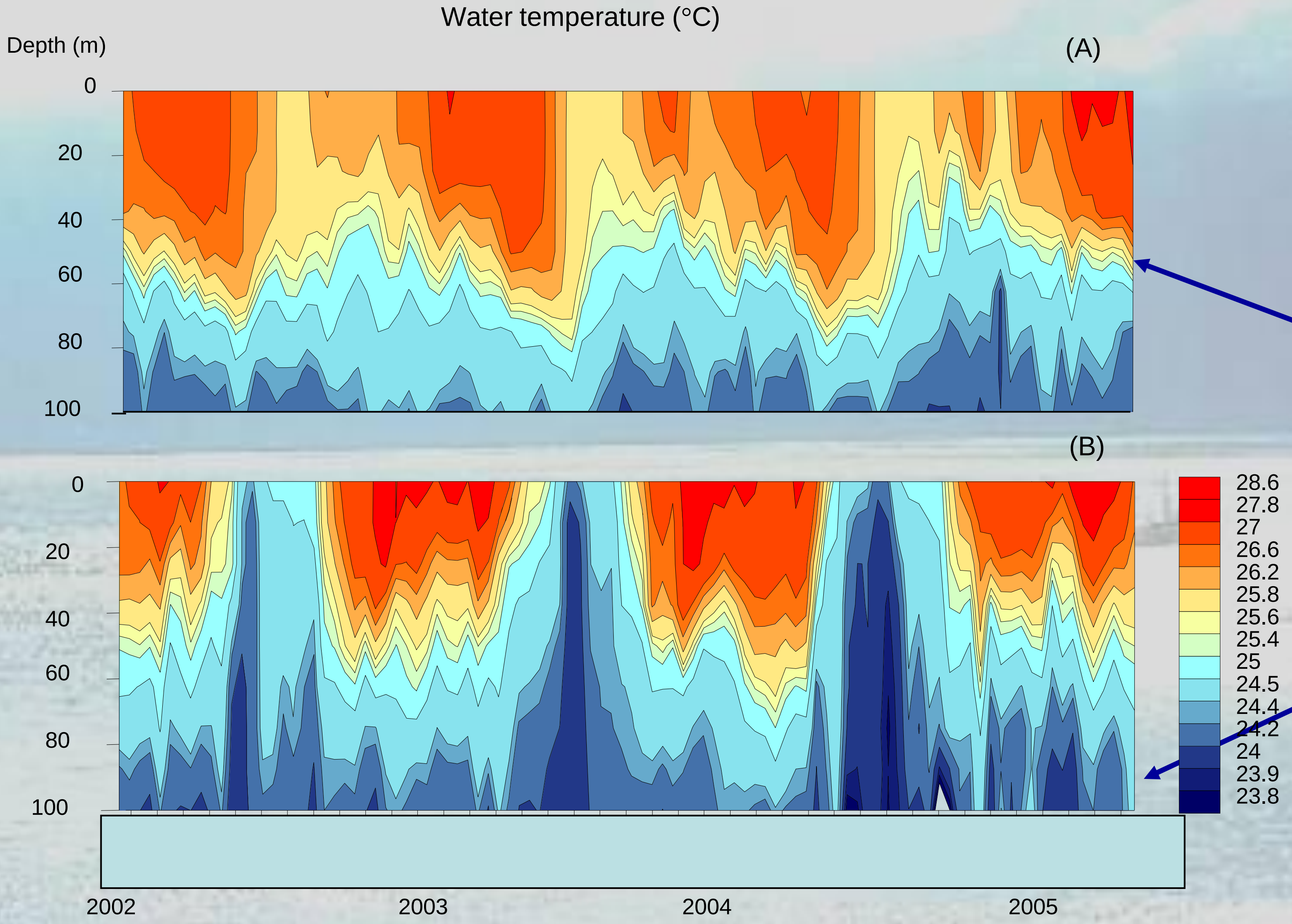
South East Trade winds (in the dry season, May - September) generate an « upwelling » in the South

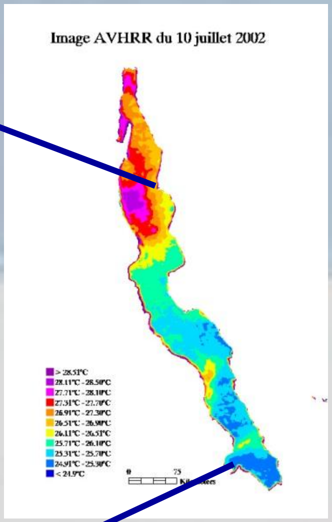
A secondary upwelling may occur in the North

Internal waves are generated



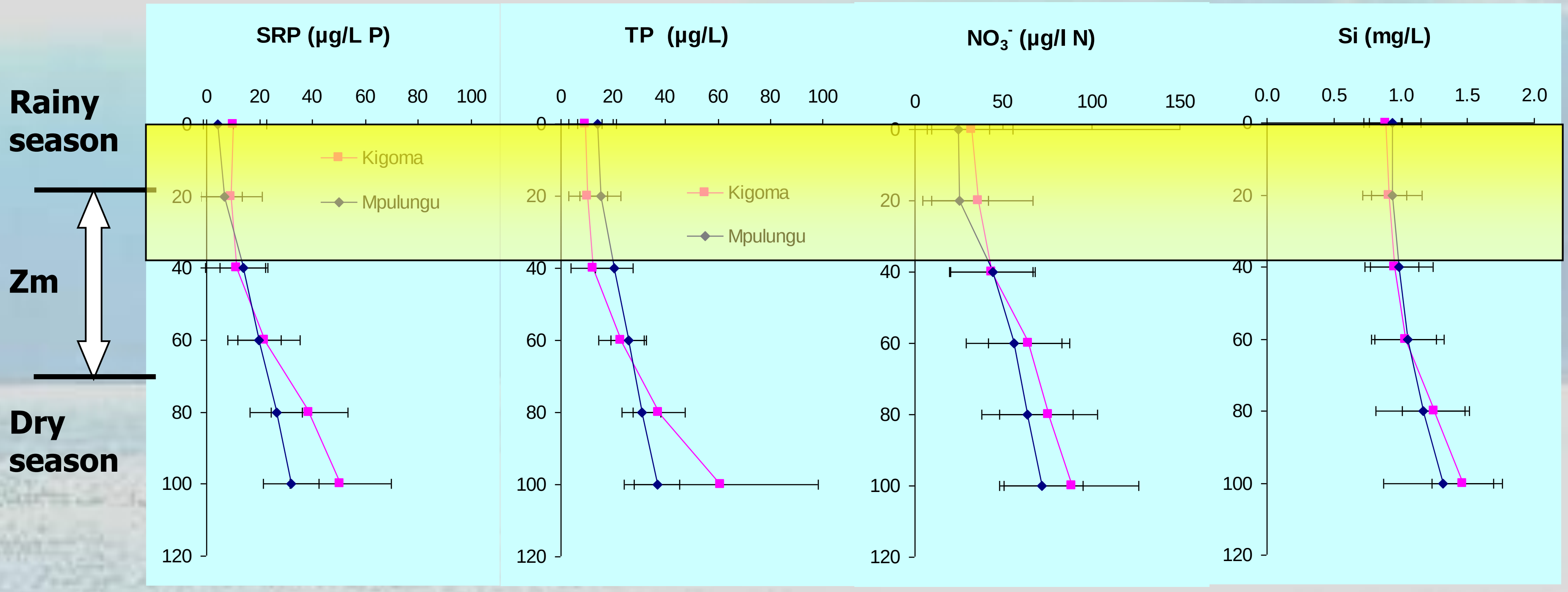
Isotherms in the northern and the southern basins of Lake Tanganyika





The lake is stratified, but a weak thermal gradient makes it sensitive to small variations in air temperature → strong responses to climate variability

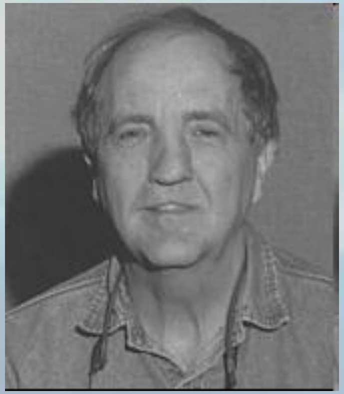
Endless summer, but strong seasonal variation



The depth of the mixed layer influences nutrient availability

Rainy season Zm : Ze ≤ 1 **Dry season Zm : Ze > 1**

Earlier descriptions of the phytoplankton



- Hecky and Kling, 1981, 1987
  - Chlorophyll a ~ 1 µg L^{-1}
  - Wet season : green algae – cyanobacteria
  - Dry season : diatom peaks
  - End of dry season : *Anabaena* surface "blooms"
  + study of protozooplankton, dominated by ciliates, incl. *Strombidium* with green endosymbionts

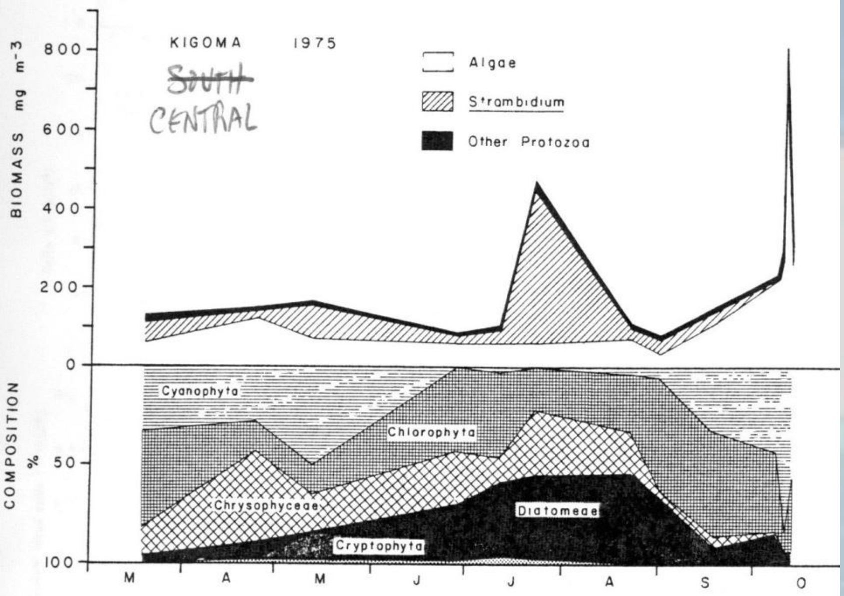


Fig. 4 Season cycle of phytoplankton and protozoan abundance and composition on Lake Tanganyika in 1975 (Fig 2 and Fig 3 of Hecky & Kling 1981). a) A station near Bujumbura at the northern end of the lake, b) a station off Kigoma in the central portion of the lake.

Earlier descriptions of the phytoplankton (Hecky & Kling, 1987)

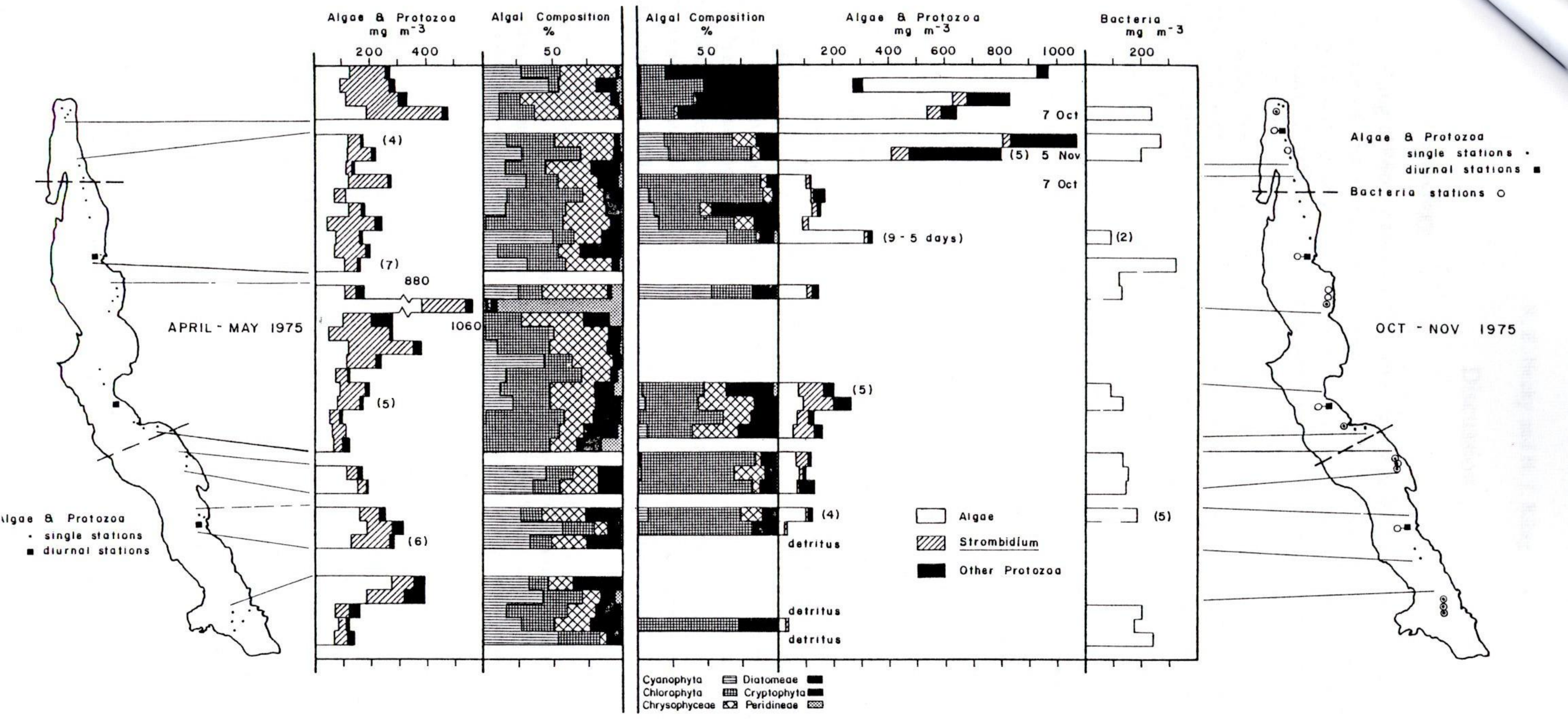
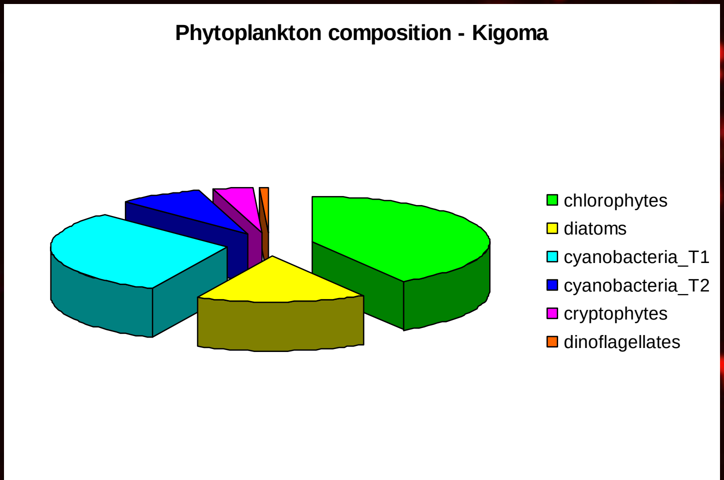
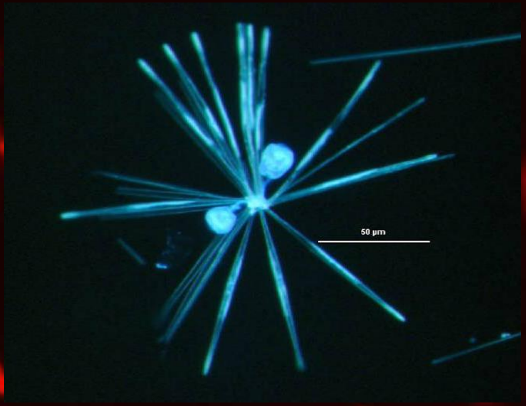
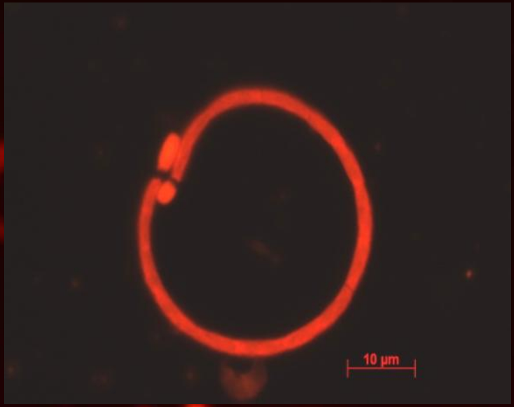


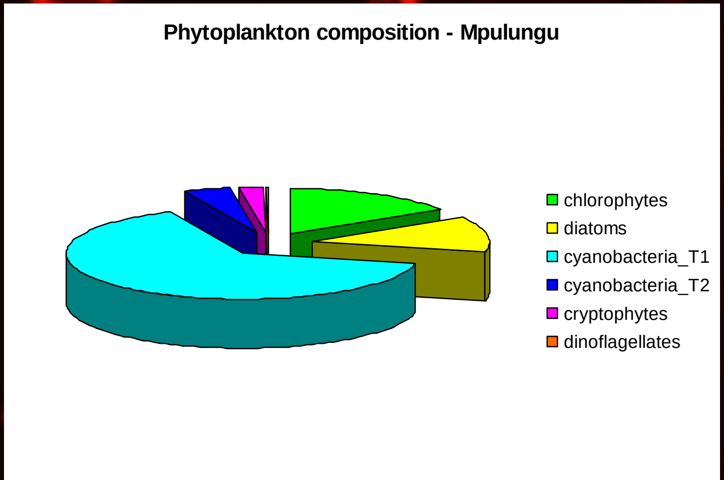
Fig 6 Horizontal distribution of phytoplankton and protozoan abundance and composition in Lake Tanganyika at two seasons of the year.

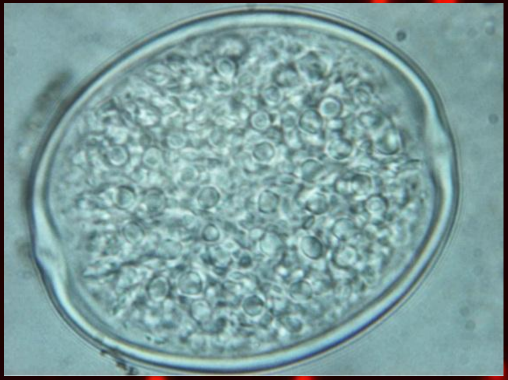
Recent studies (2002-2006) Phytoplankton : Cyanobacteria and green algae + diatoms





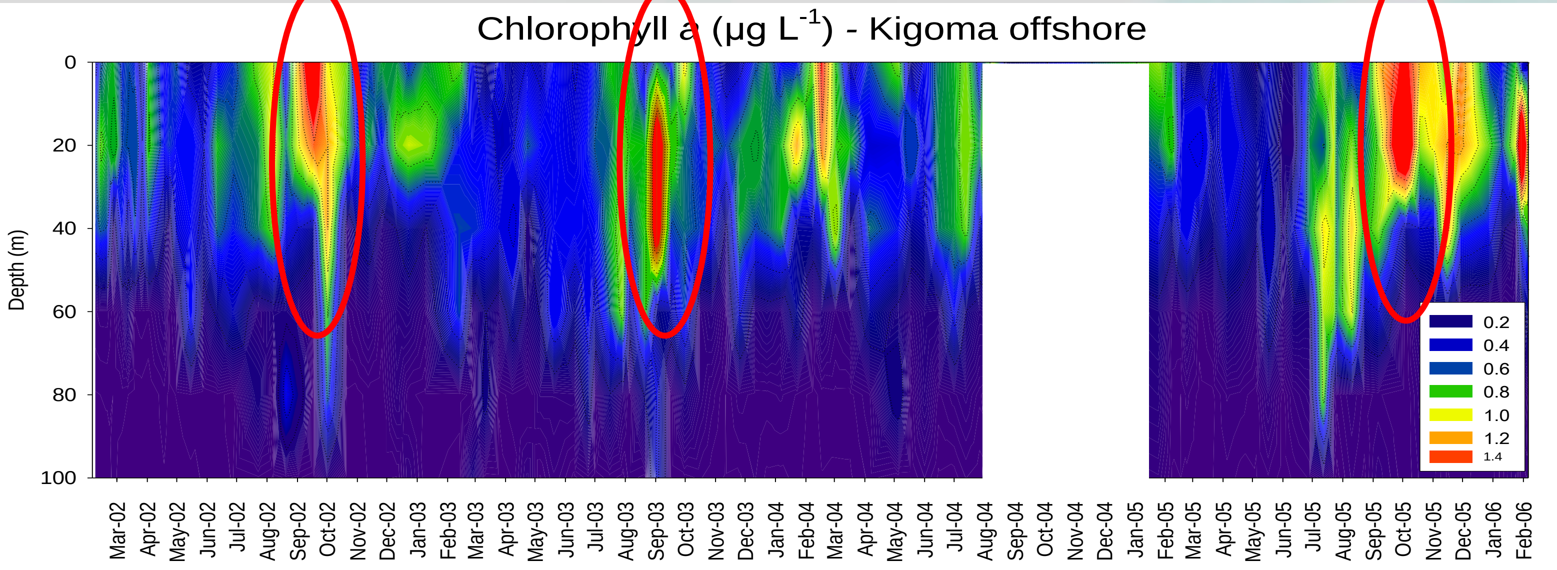


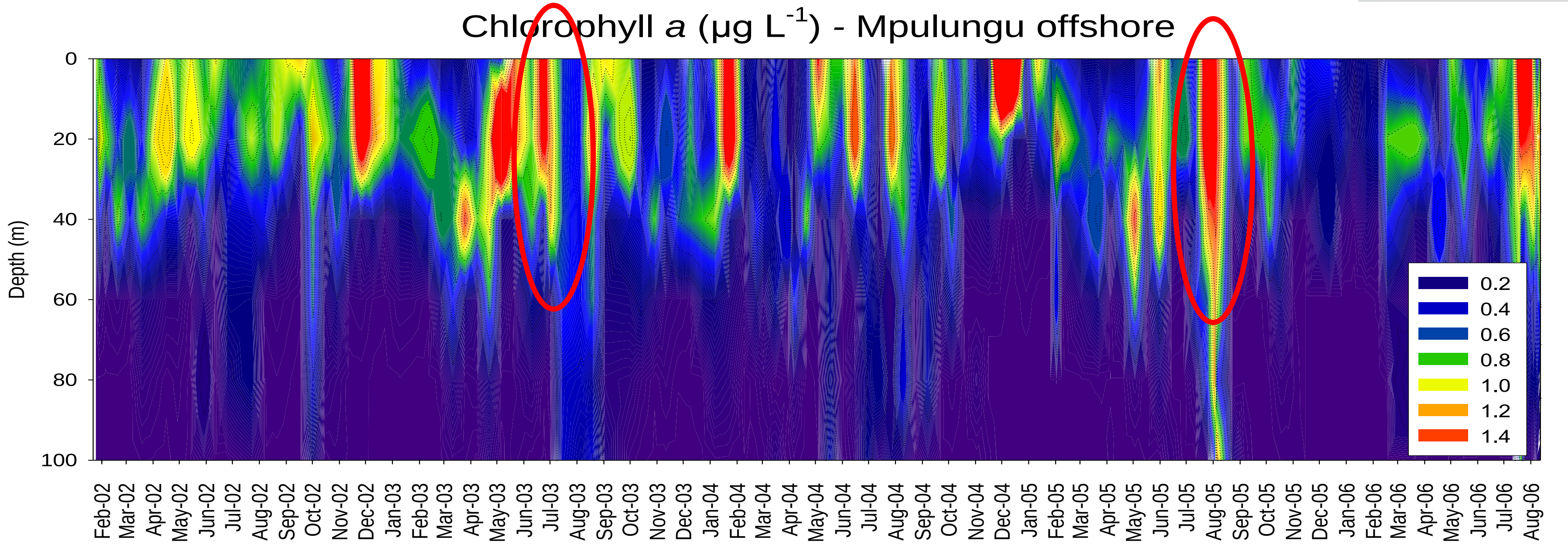




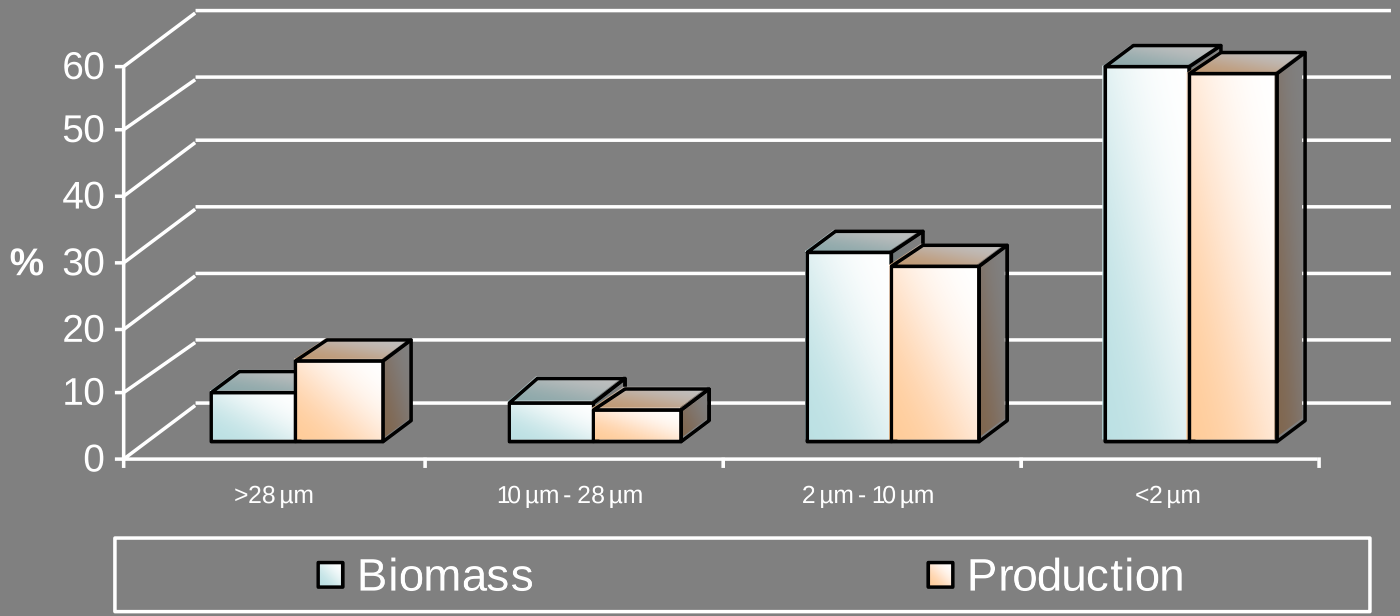
10 µm

Large seasonal and spatial variation of biomass and composition, driven by Zm (hence light), nutrient availability and grazing



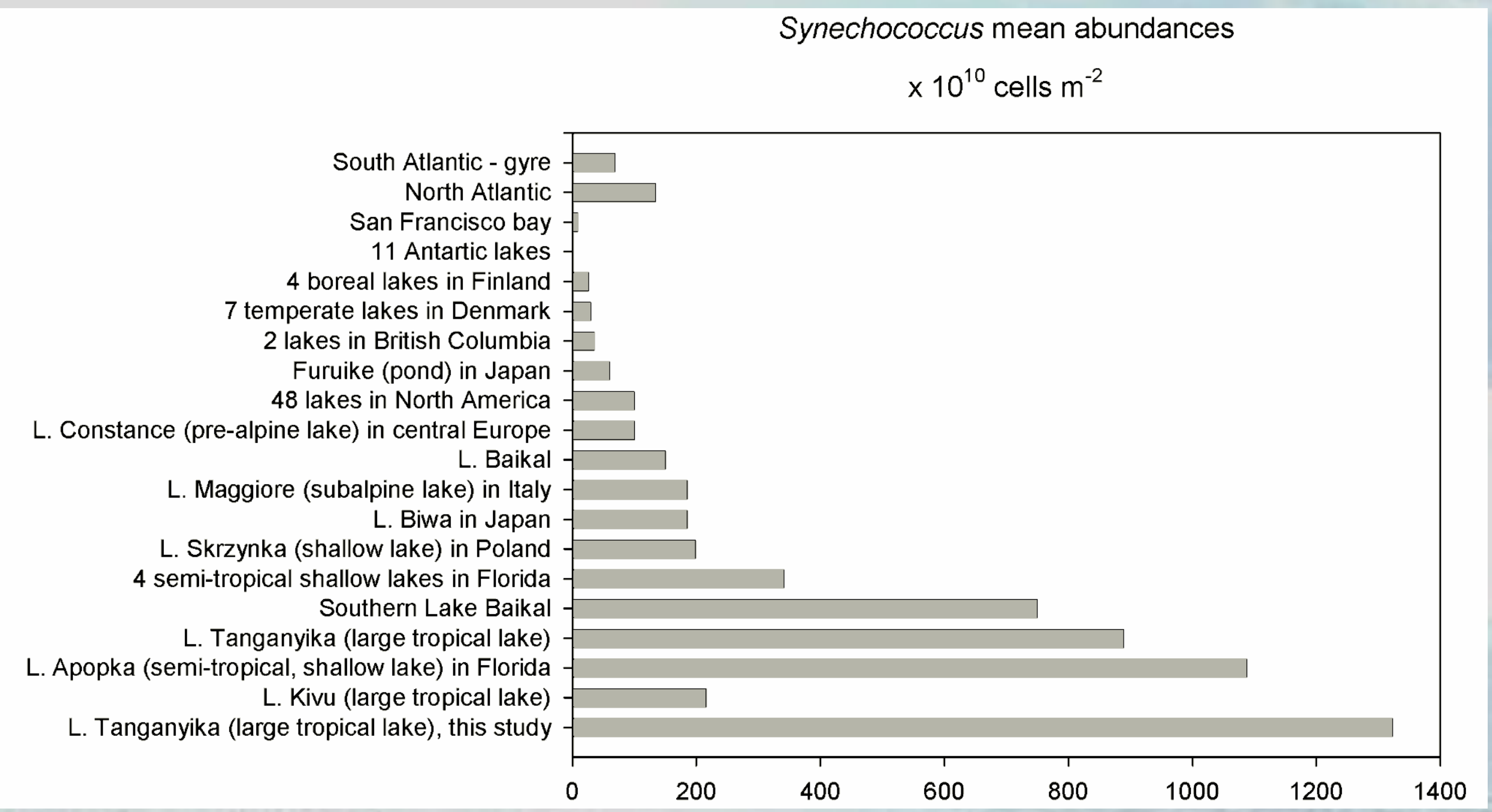


Pico-sized organisms make most of the biomass of photosynthetic plankton



Fractionated primary production (Mpulungu, rainy season 2003)

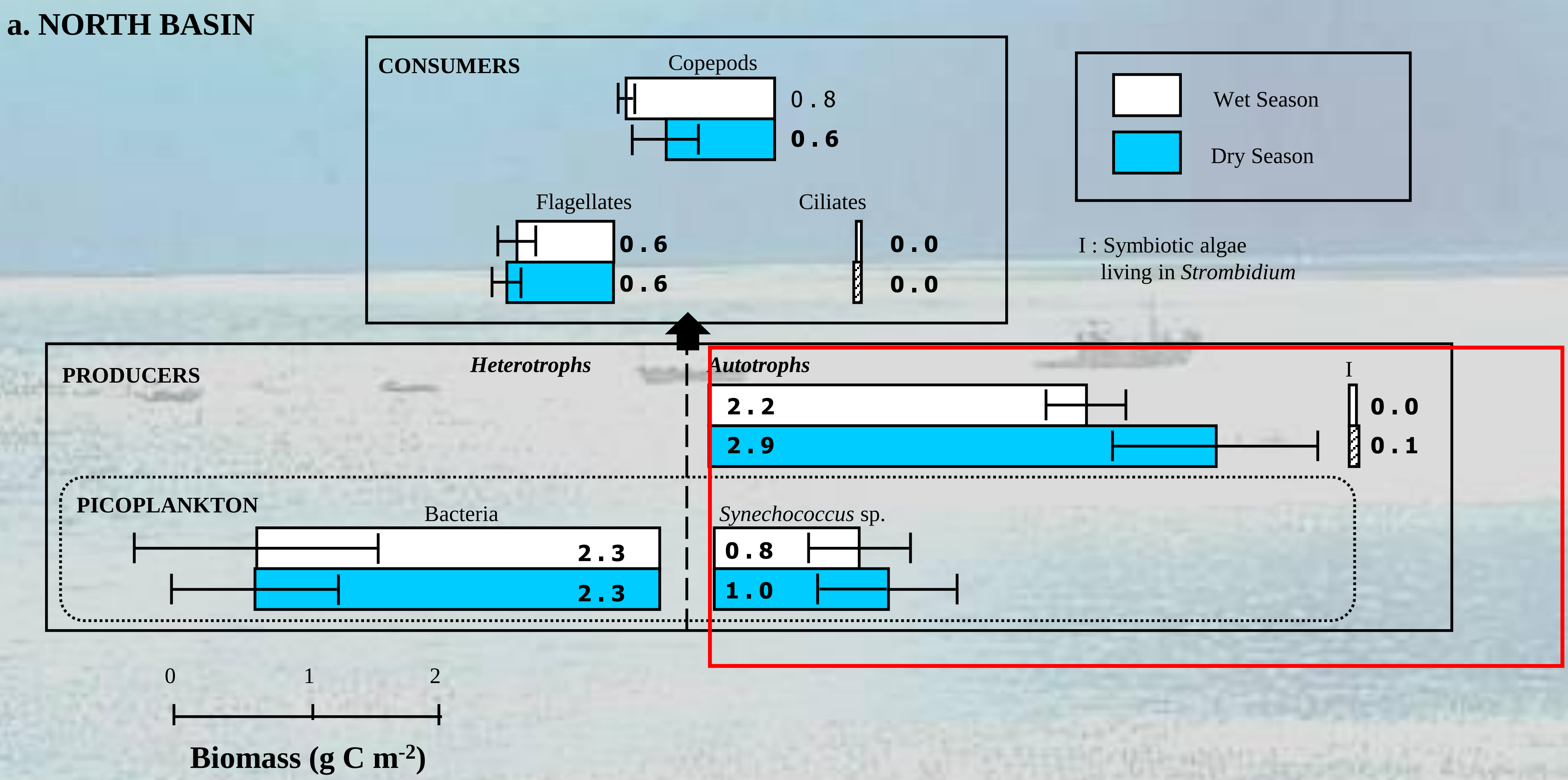
Synechococcus abundance is comparatively very high in lake Tanganyika



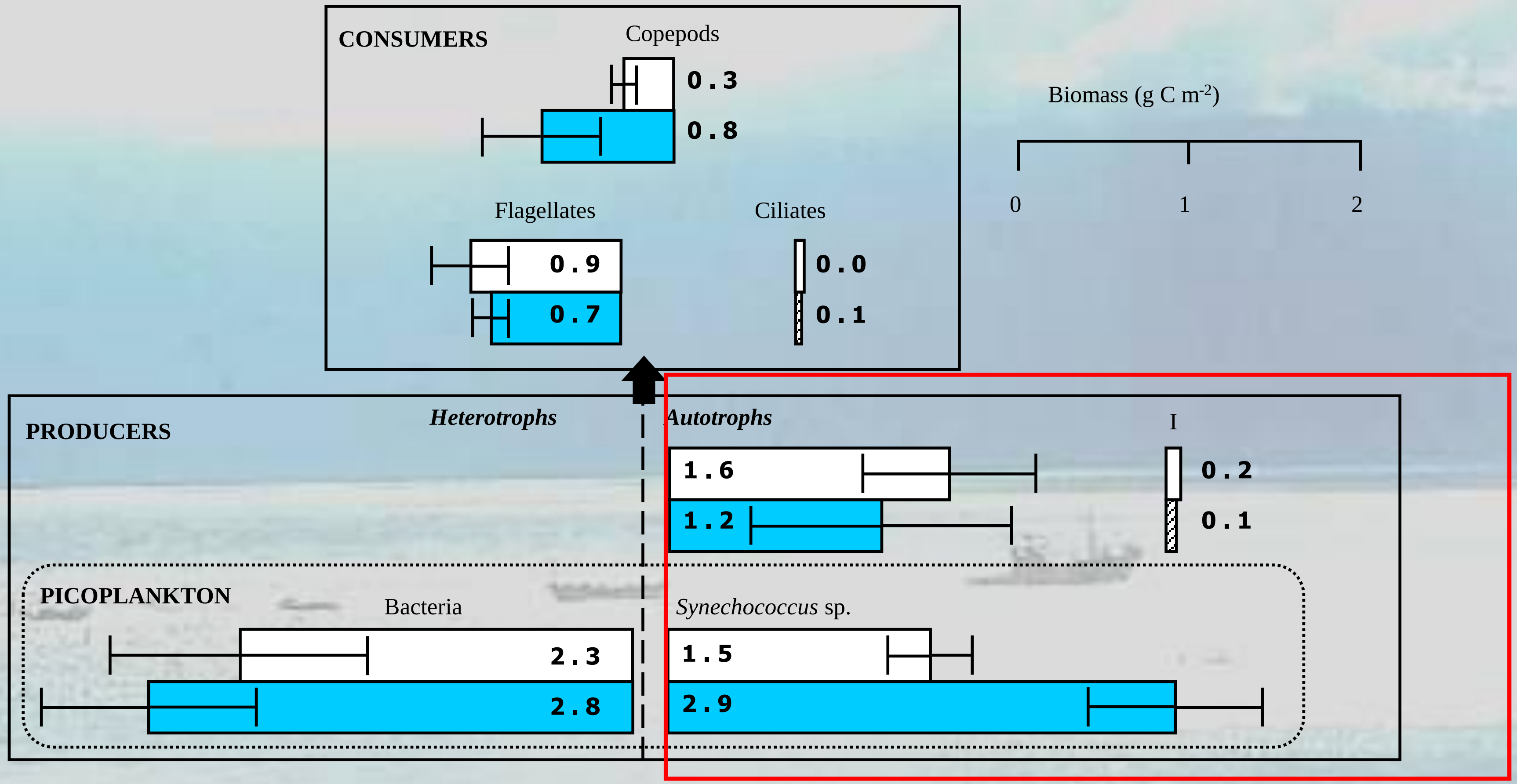
Sarmento, H., F. Unrein, M. Isumbisho, S. Stenuite, J. M. Gasol et J.-P. Descy
***Freshwater Biology*, 2008**

AUTOTROPHS vs. HETEROTROPHS

(after Pirlot, 2006)

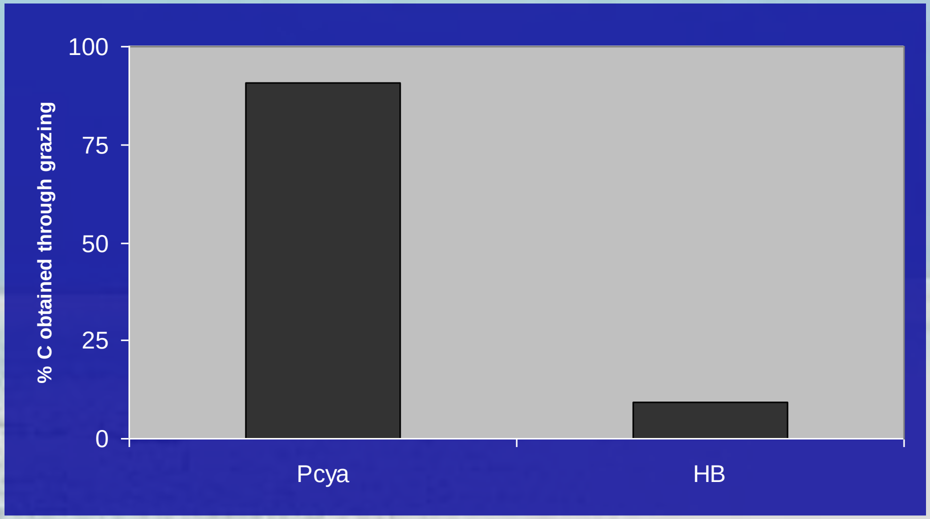


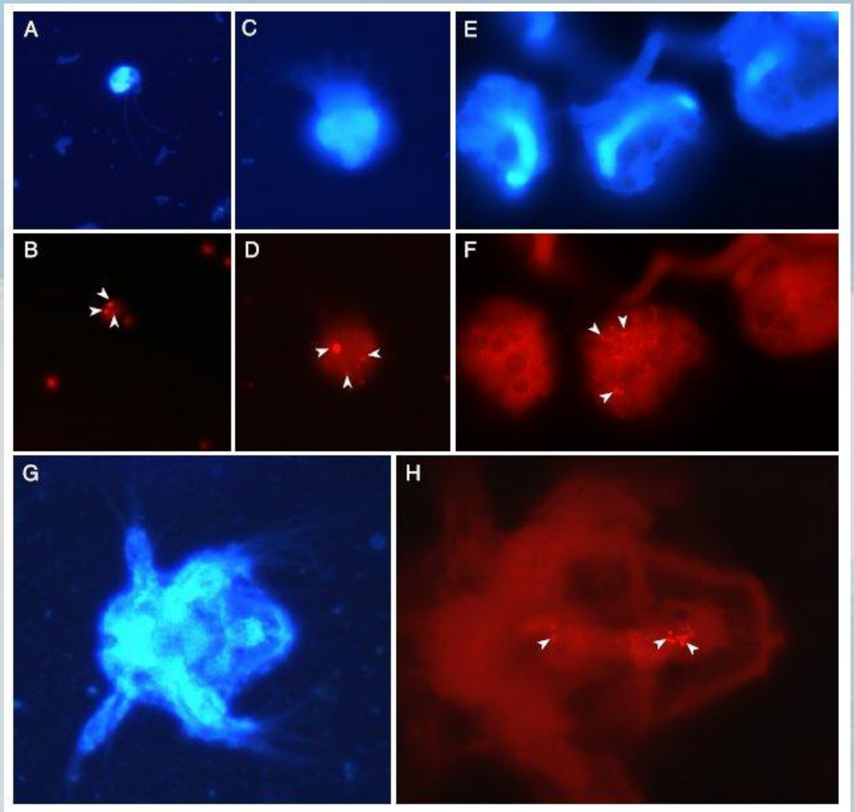
b. SOUTH BASIN



Pirlot S., Vanderheyden J., Descy J.-P. & Servais, P., 2005
Abundance and biomass of heterotrophic micro-organisms in Lake Tanganyika.
Freshwater Biology, 50 (7), 1219-1232

Ongoing: Microzooplankton grazing on PPP vs. heterotrophic bacteria





Significant, climate-driven productivity change ?

Global Climate Change Strikes a Tropical Lake

Daniel A. Livingstone

The heat on Lake Tanganyika

Dirk Verschuren

Warming of surface waters and declining fish catches in Lake Tanganyika have been linked to global climate change. The impact of global warming on natural ecosystems may be starting to affect local economies.

Climate change decreases aquatic ecosystem productivity of Lake Tanganyika, Africa

Catherine M. O'Reilly[1*], Simone R. Alin[1*], Pierre-Denis Plisnier[2], Andrew S. Cohen[1] & Brent A. McKee[3]

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[2]*Royal Museum for Central Africa, 3080 Tervuren, and Department of Biology, Namur University, B-5000 Namur, Belgium*
[3]*Department of Earth and Environmental Sciences, Tulane University, New Orleans, Louisiana 70118, USA*

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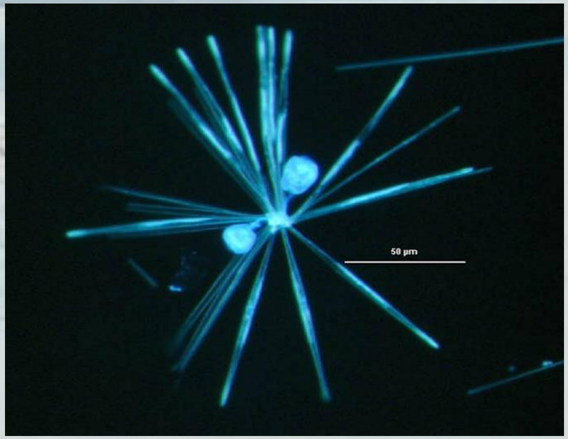
Ecological Consequences of a Century of Warming in Lake Tanganyika

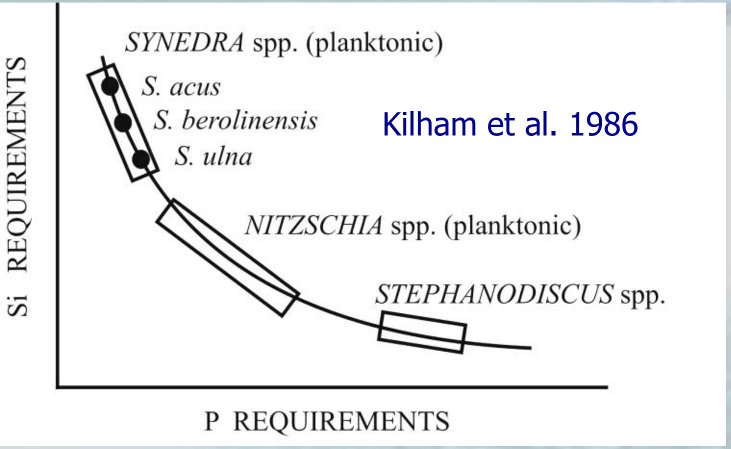
Piet Verburg,[1*] Robert E. Hecky,[1] Hedy Kling[2]

Deep tropical lakes are excellent climate monitors because annual mixing is shallow and flushing rates are low, allowing heat to accumulate during climatic warming. We describe effects of warming on Lake Tanganyika: A sharpened density gradient has slowed vertical mixing and reduced primary production. Increased warming rates during the coming century may continue to slow mixing and further reduce productivity in Lake Tanganyika and other deep tropical lakes.

Changes in phytoplankton composition since the 1970s ?

- **Caution is required** : lack of detailed / comparable records; earlier studies did not report picoplankton
- A sure fact: present abundant diatom: *Nitzschia asterionelloides* in the dry season; *Stephanodiscus* (found in the 1970s) and *Aulacoseira* (found in the sediment) are absent





Kilham et al. 1986

This points to increased Si:P ratios, and is consistent with Si concentration increase in surface waters and reduction of P supply from deep waters (Verburg et al., 2003)

Recent discoveries on LT microbial assemblages are:

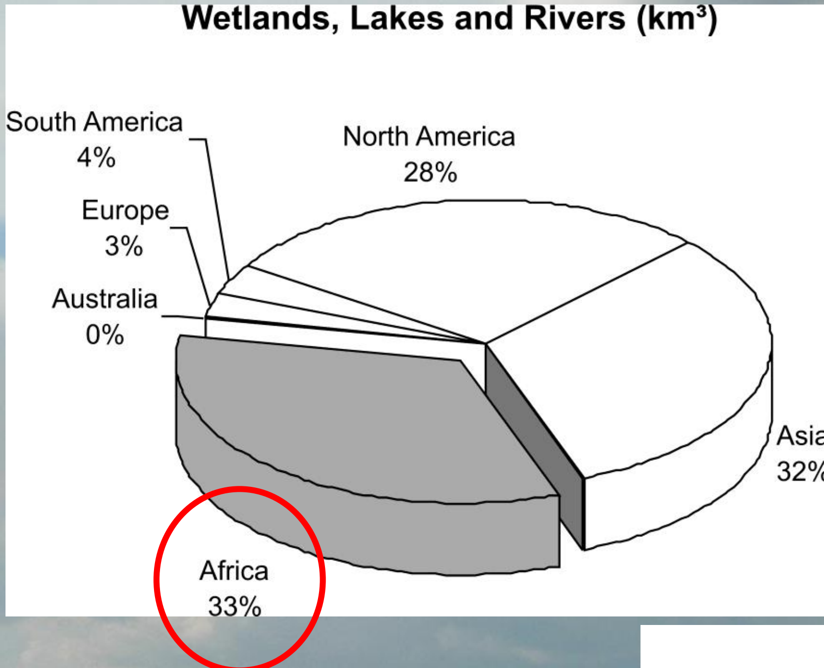
- Changes in phytoplankton composition since the 1970s point to oligotrophication, possibly from increased stratification reducing nutrient availability
- Heterotrophic bacteria and photosynthetic picoplankton are major producers in the lake
- Primary production studies in the field and by remote sensing (e.g. Stenuite et al., 2007) show a substantial decrease from the 1970s
- In present Lake Tanganyika, the microbial food web may dominate over the classic food chain. **Is that another a result of climate change ?**

Conclusions

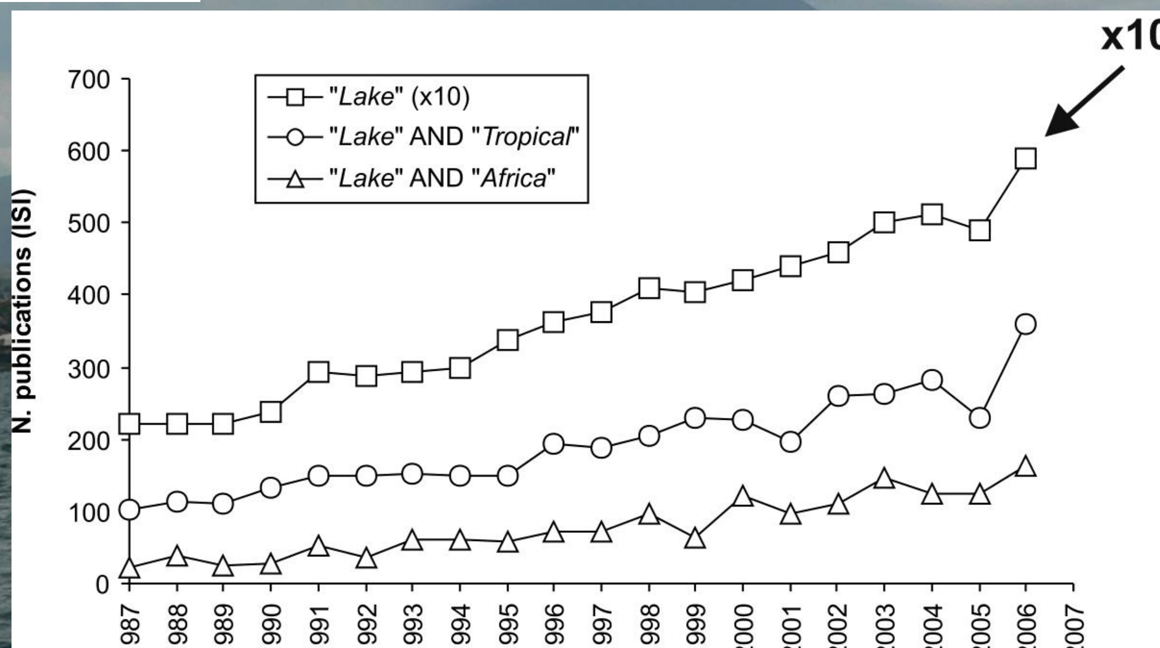
- Here I have illustrated two cases in which the knowledge of microbial components of the ecosystem do help understanding ecosystem function
  - with regard to environmental changes
  - in the management of ressources essential for local populations

Despite the key role of the « microbes », they were practically ignored for half a century of research in tropical lakes …

Still nowadays, conducting modern research in tropical areas is difficult … compared to the facilities available in temperate areas



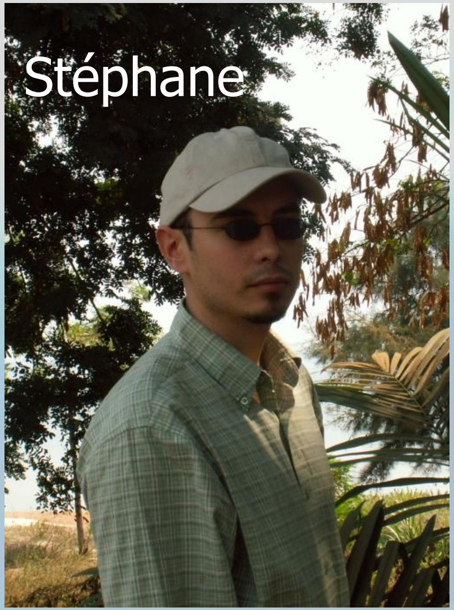
… and the most studied lakes have essentially attracted scientists from the North

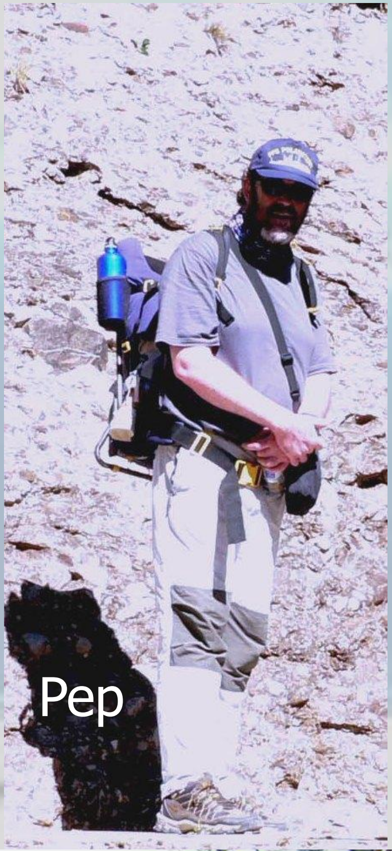


Need for more involvement of African students and scientists

~ 5% of lake studies in the tropics, half of them in Africa

The main players …





Thanks to the crew of the «Maman Benita»

… and thanks for your attention