DIATOM ECOLOGY AND LONG TERM CLIMATE-VEGETATION DYNAMICS, MAPIMBI, KNP

Dr Anneli Ekblom*, Dr Lindsey Gillson, Zara Chidoub*****

* **Oxford Long-Term Ecology Laboratory, ECI-OUCE, Oxford University (Anneli.Ekblom@ouce.ox.ac.uk),**
****Plant Conservation Unit, Botany Department, University of Cape Town, South Africa (Lindsey.Gillson@uct.ac.za)**
*****OUCE, Oxford University**

Kruger Environments

Long term vegetation dynamics

Kruger National park
(and Limpopo National park)

Coordinated by Dr Lindsey Gillson
Funded by A.W Mellon foundation

AIMS

Identifying the different drivers of vegetation change (over long term scales)

- Fossil pollen in sediments
- Microfossil Charcoal
- Isotopes

Gillson: Friday, 8.45

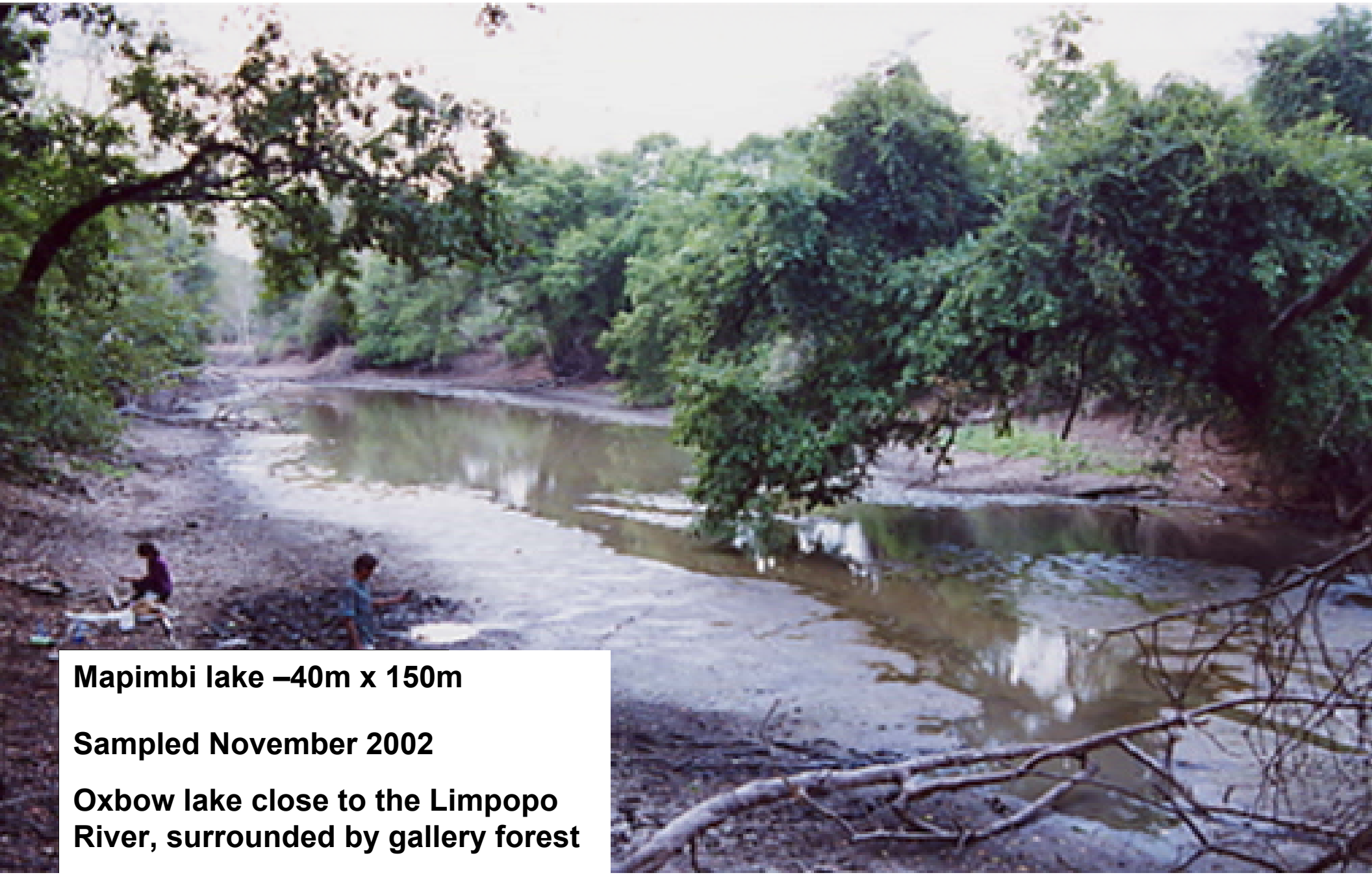
Distinguish the influence of climatic variability on vegetation dynamics

- Local climate proxies (closest paleoclimatic proxy c. 200 km away!)
- ”Independent” data ie data that respond to other variables than vegetation= **Diatoms**

TOPICS

- Evaluate the potential of diatoms as bio-indicators for environmental change
- Discuss the environmental significance of changes in the diatom assemblage of Mapimbi lake over time (c.1300-present)
- Reconstruct lake level changes
- Correlations with regional climatic data (Makapansgat, speleothem, Pietersburg, Holmgren et al 1999)
- Correlations with vegetation change (Gillson *et al* in prep)

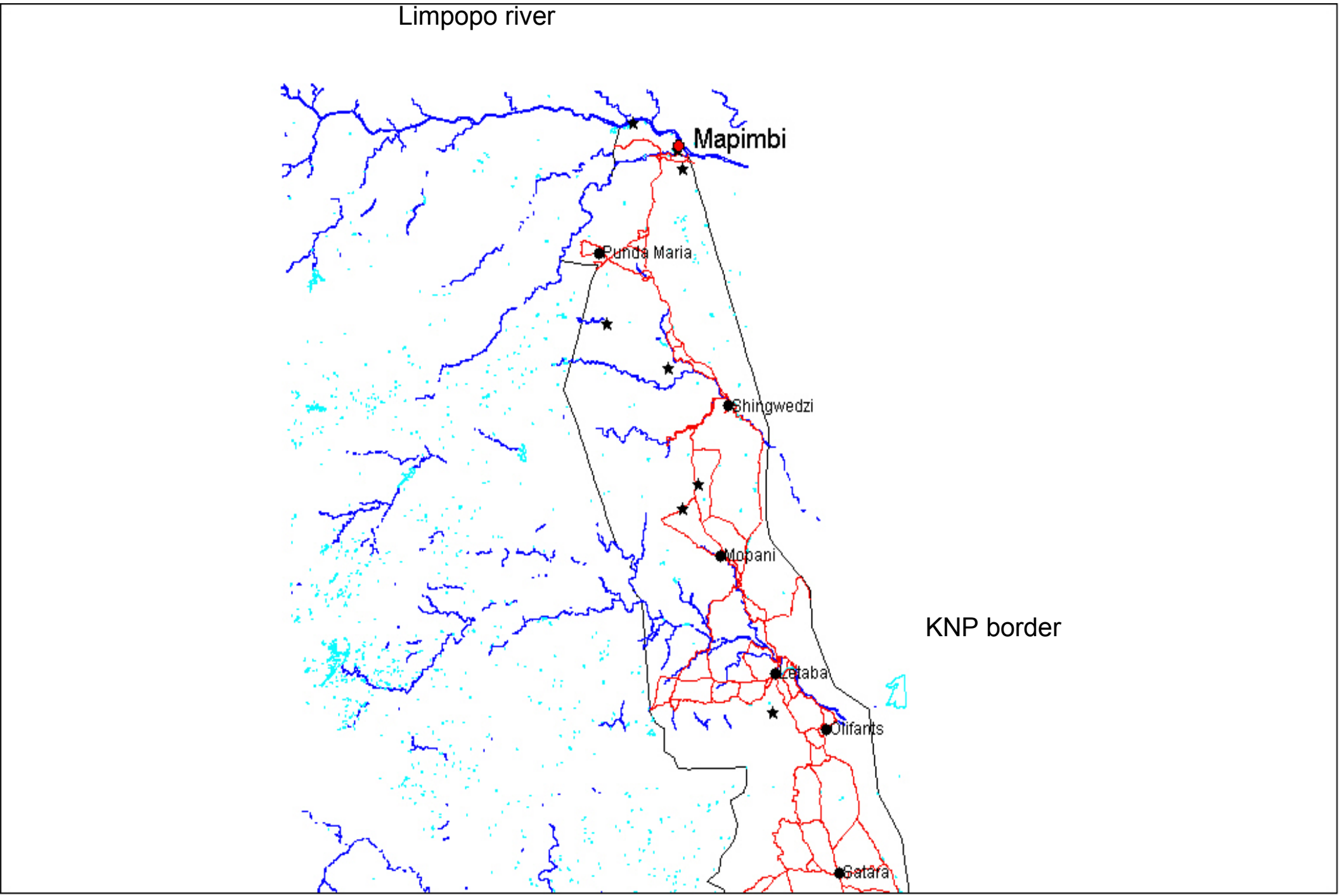
Lake Mapimbi



Mapimbi lake –40m x 150m

Sampled November 2002

Oxbow lake close to the Limpopo River, surrounded by gallery forest


Limpopo river
Mapimbi
Punda Maria
Shingwedzi
Mopani
Letaba
Olifants
Satara
KNP border

What are Diatoms?

- Phytoplankton found in waterbodies and damp soils
- Specific to certain environmental variables (similar requirements across different aquatic ecosystems and climatic zones)
- Reproduce and respond rapidly to environmental change (shorter response time than vegetation)
- Diatom frustules (made out of silica) have a lasting permanence in sediments

→ Good bio indicators for environmental change

→ Good tools for freshwater monitoring **(Harding et al 2005, Taylor et al 2005)**

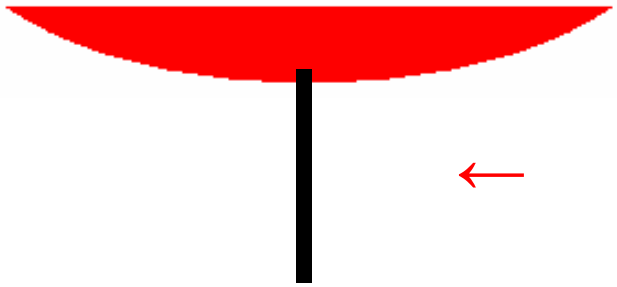
Environmental variables

- Light ←
- Salinity ←
- pH
- Oxygen ←
- Availability of inorganic nutrients
- Availability organic nutrients

Principles lake levels/diatoms

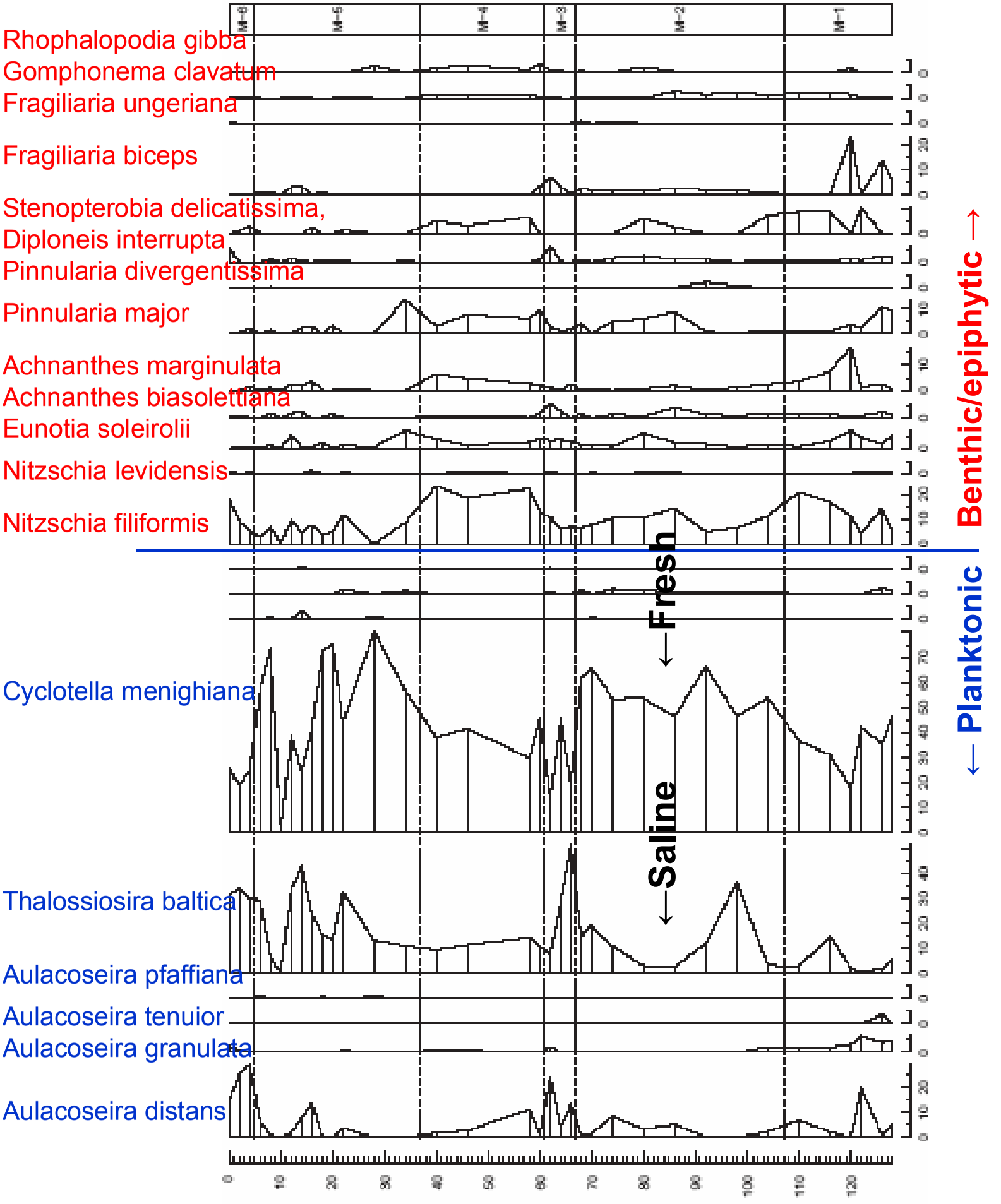
High lake levels:

- **Few benthic (bottom) species (due to less light penetration on the bottom)**
- **As a result: a relative increase in planctonic (surface) species**
- **Low salinity**

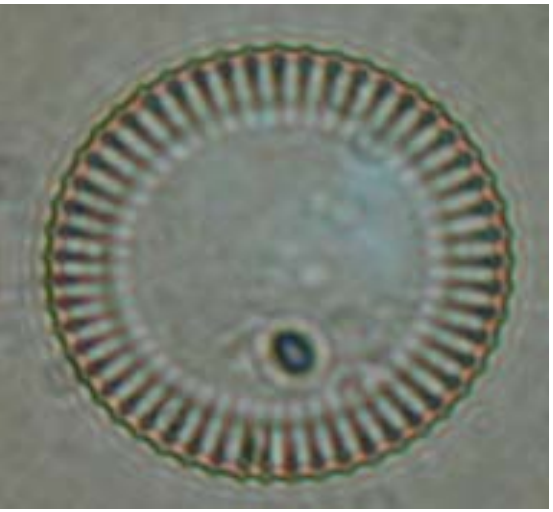


Low lake levels:

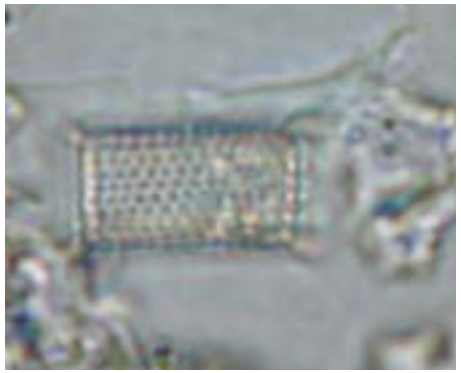
- **More benthic species (ie more light on the bottom)**
- **Relative decrease of planktonic species**
- **High salinity (high evaporation)**
- **More diatoms requiring high oxygen saturation (as core location now is closer to the shore)**


M-6
M-5
M-4
M-3
M-2
M-1
Rhophalopodia gibba
Gomphonema clavatum
Fragiliaria ungeriana
Fragiliaria biceps
Stenopterobia delicatissima,
Diploneis interrupta
Pinnularia divergentissima
Pinnularia major
Achnanthes marginulata
Achnanthes biasolettiana
Eunotia soleirolii
Nitzschia levidensis
Nitzschia filiformis
Cyclotella menighiana
Thalossiosira baltica
Aulacoseira pfaffiana
Aulacoseira tenuior
Aulacoseira granulata
Aulacoseira distans
Fresh
Saline
Benthic/epiphytic →
← Planktonic
0
10
20
30
40
50
60
70
80
90
100
110
120

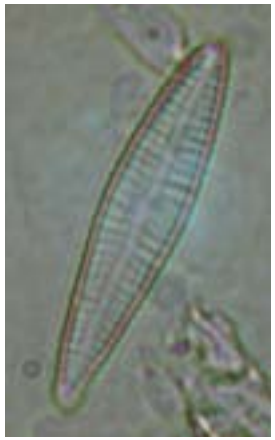
Common Mapimbi Diatoms



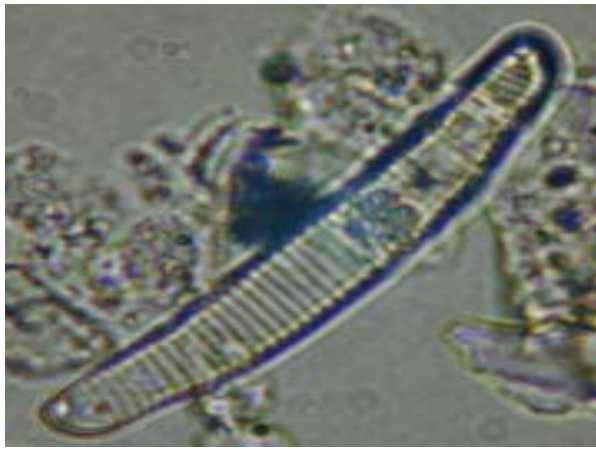
Cyclotella meneghiniana



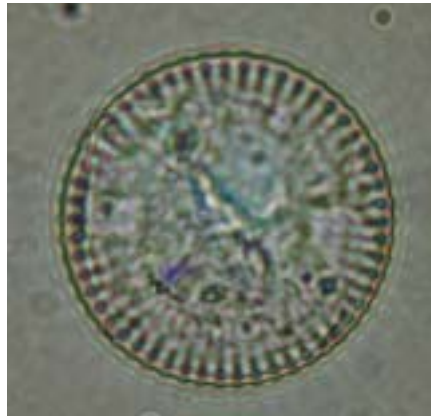
Aulacoseira granulata



Achnanthes biasolettiana

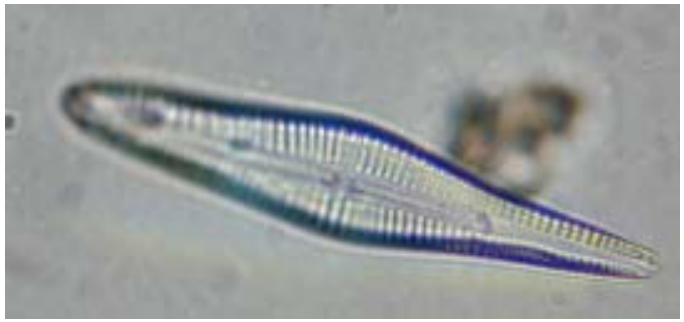


Eunotia soleirolii

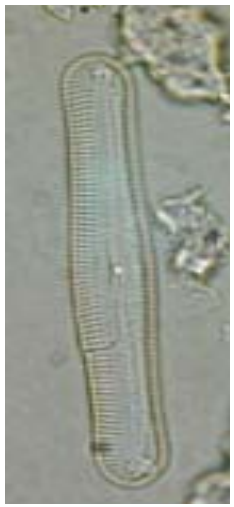


Cyclotella striata

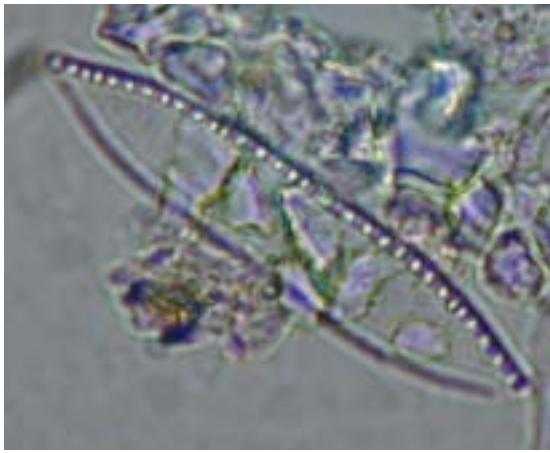
Thalassiosira baltica



Gomphonema clavatum



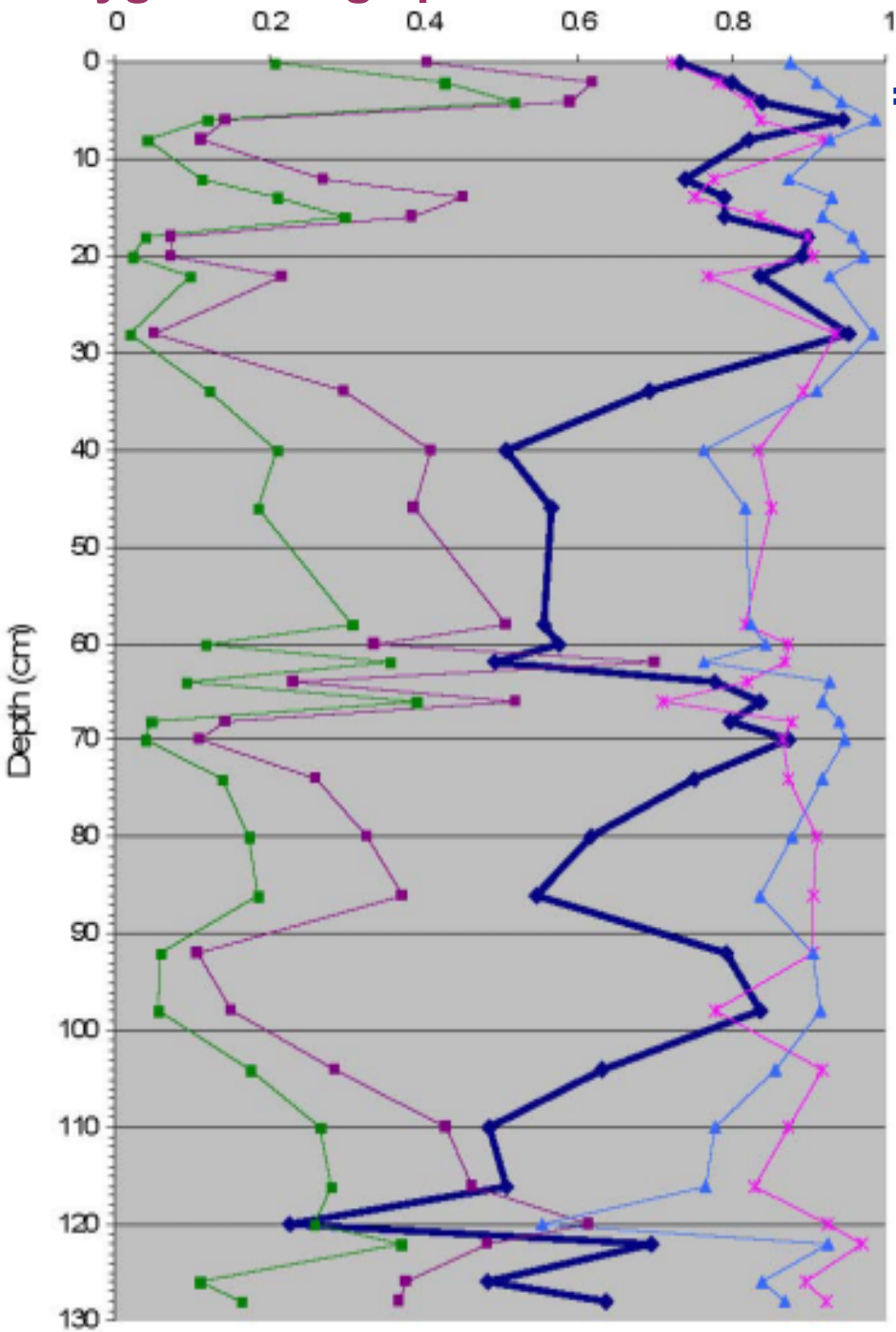
Pinnularia maior



Nitzschia filiformis

← More oxygen loving species
= LOW

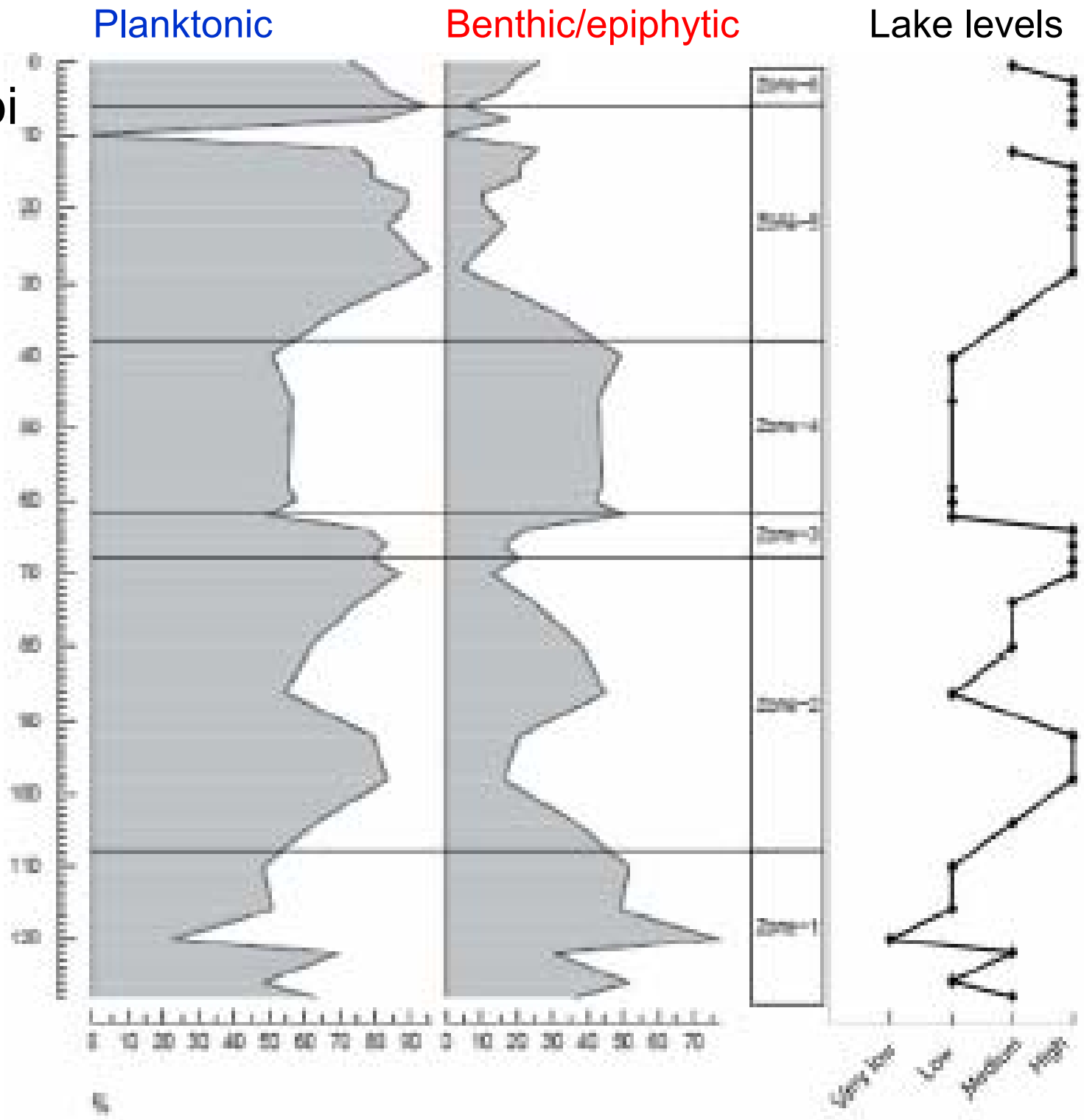
→ Few benthic species, Few saline loving species
= HIGH



High index= few benthic species=High lake levels
High index=low salinity=high lake levels
High index= more oxygen loving taxa=
low lake levels
pH=high values lower pH

← Competition between
Cyclotella meneghiana and *Thalossiosira baltica*

Reconstructed Lake levels Mapimbi



1800-pres
High accum

c. 1880

1300-1800
Slow accum.

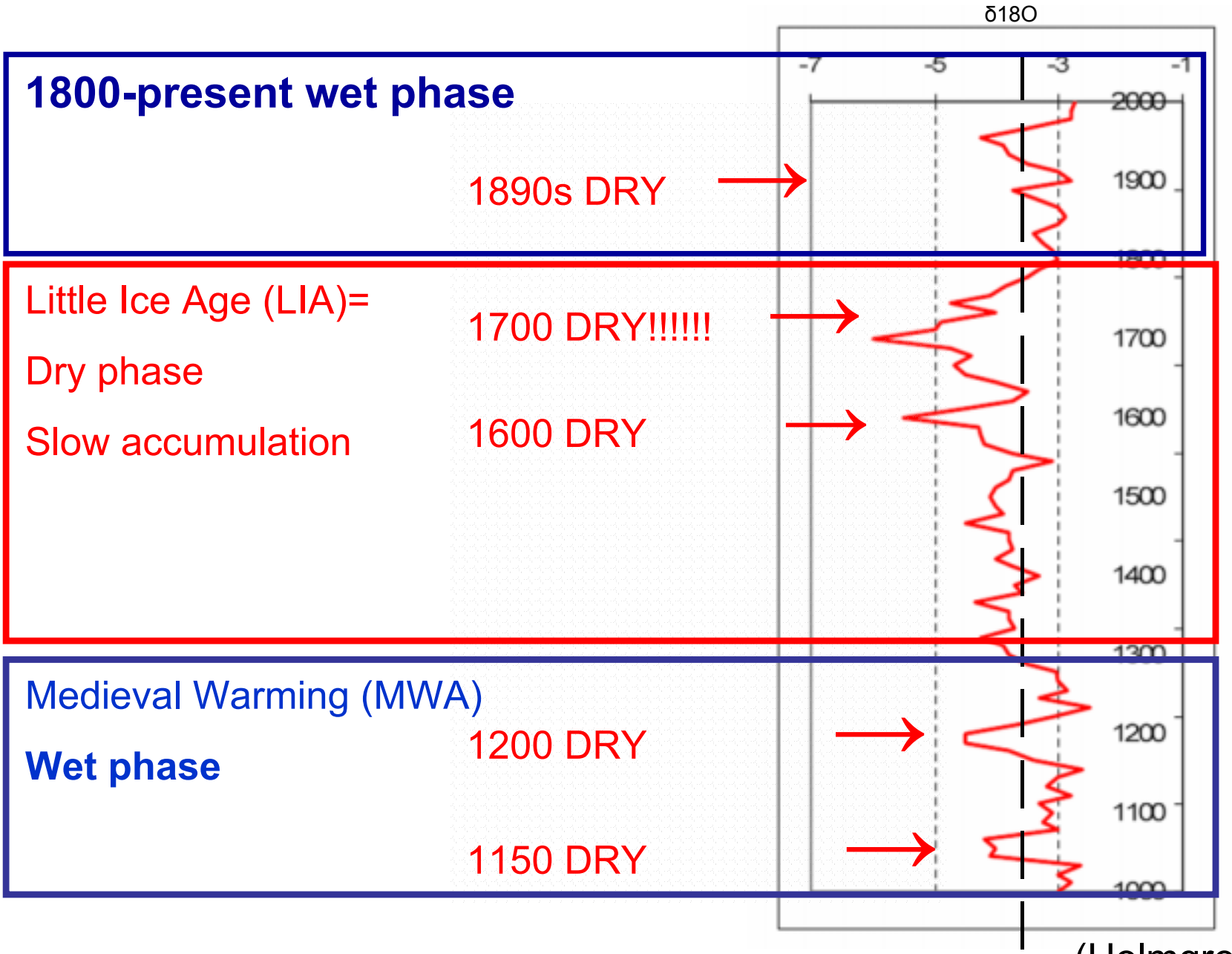
x?

1600-1750

1250-1310

Makapangsgat $\delta^{18}O$ record

Low $\delta^{18}O$ =cool and dry
High $\delta^{18}O$ = warm and wet



1800-present wet phase

Little Ice Age (LIA)=

Dry phase

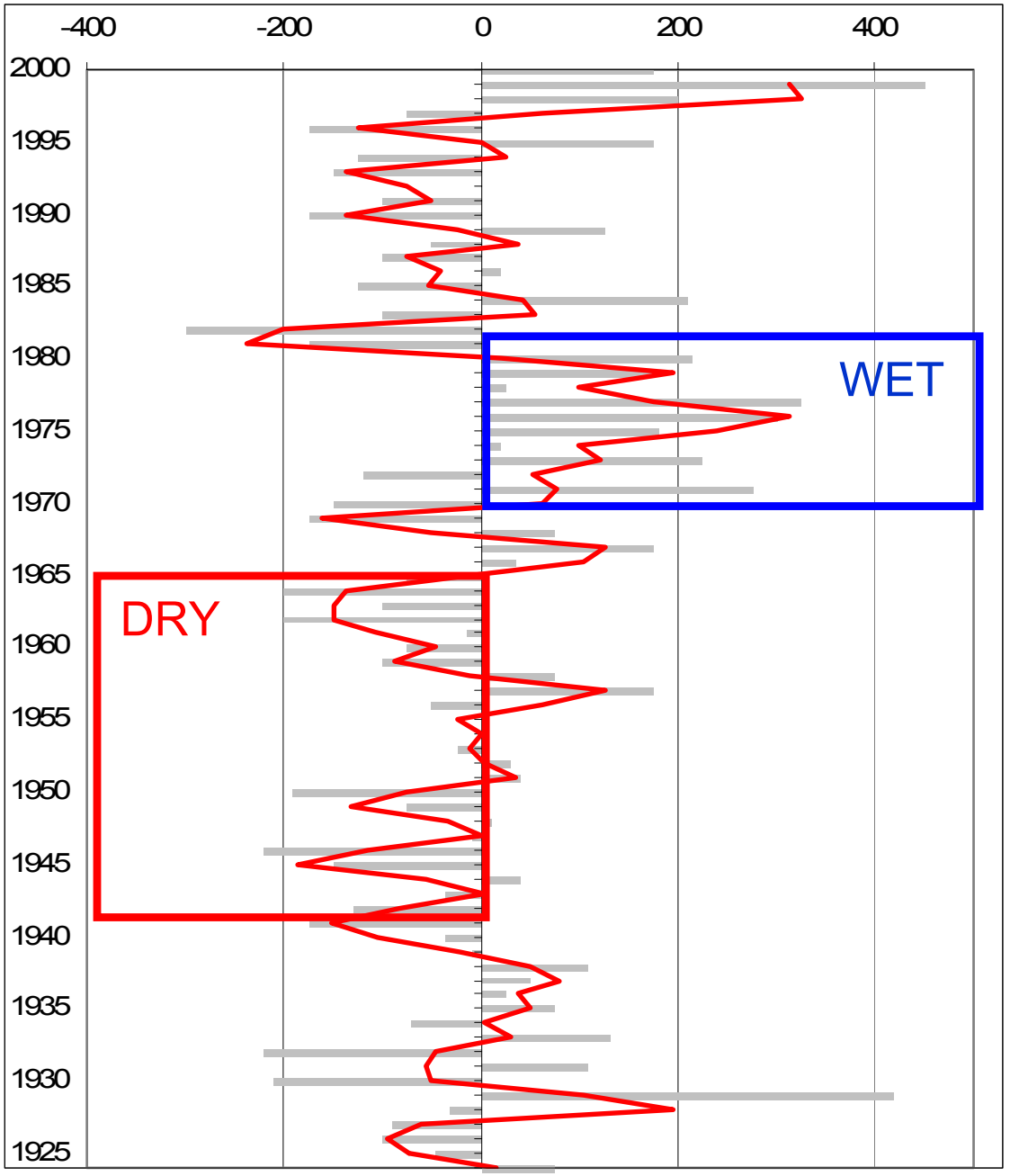
Slow accumulation

Medieval Warming (MWA)

Wet phase

(Holmgren et al 1999)

Metereological data from Pafuri station

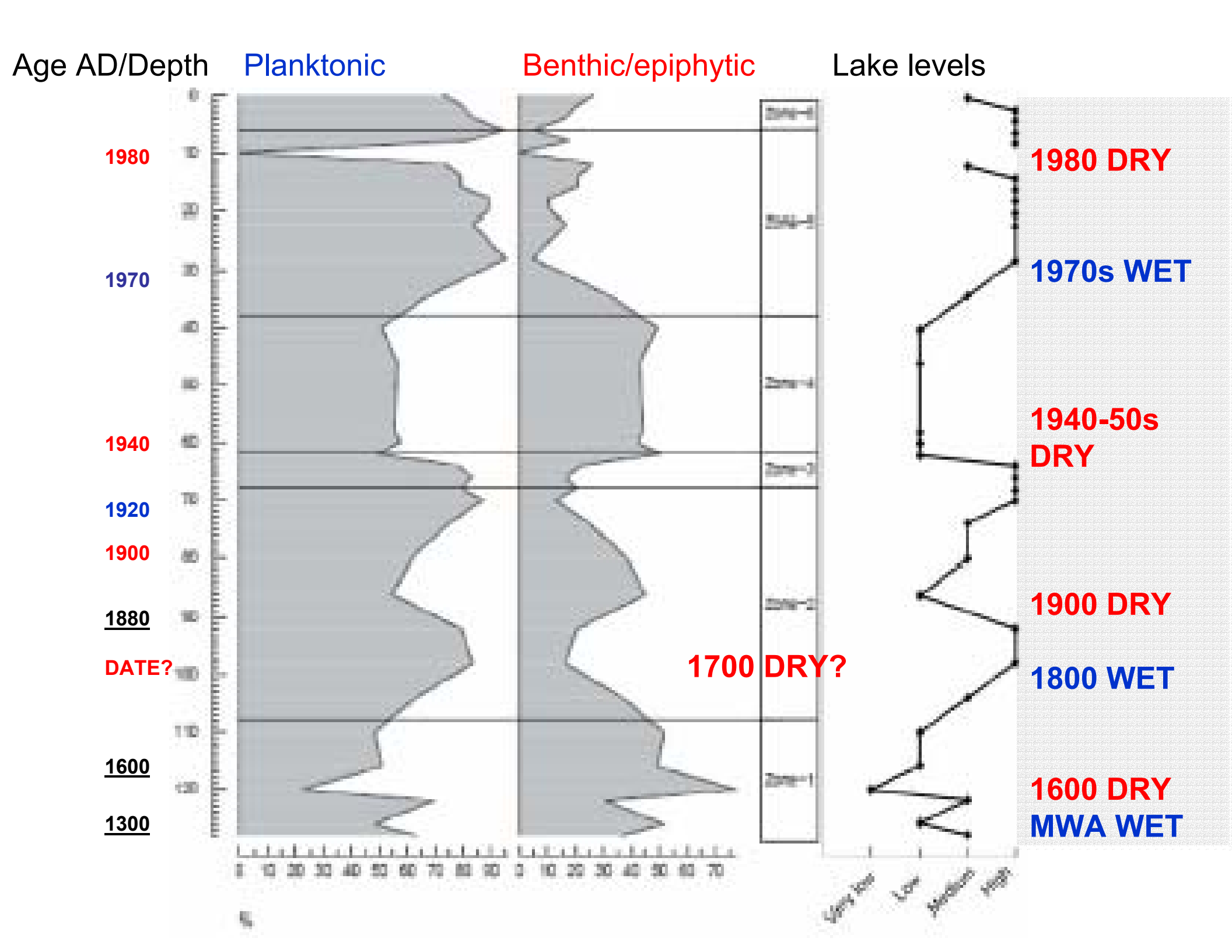


1980 DRY →

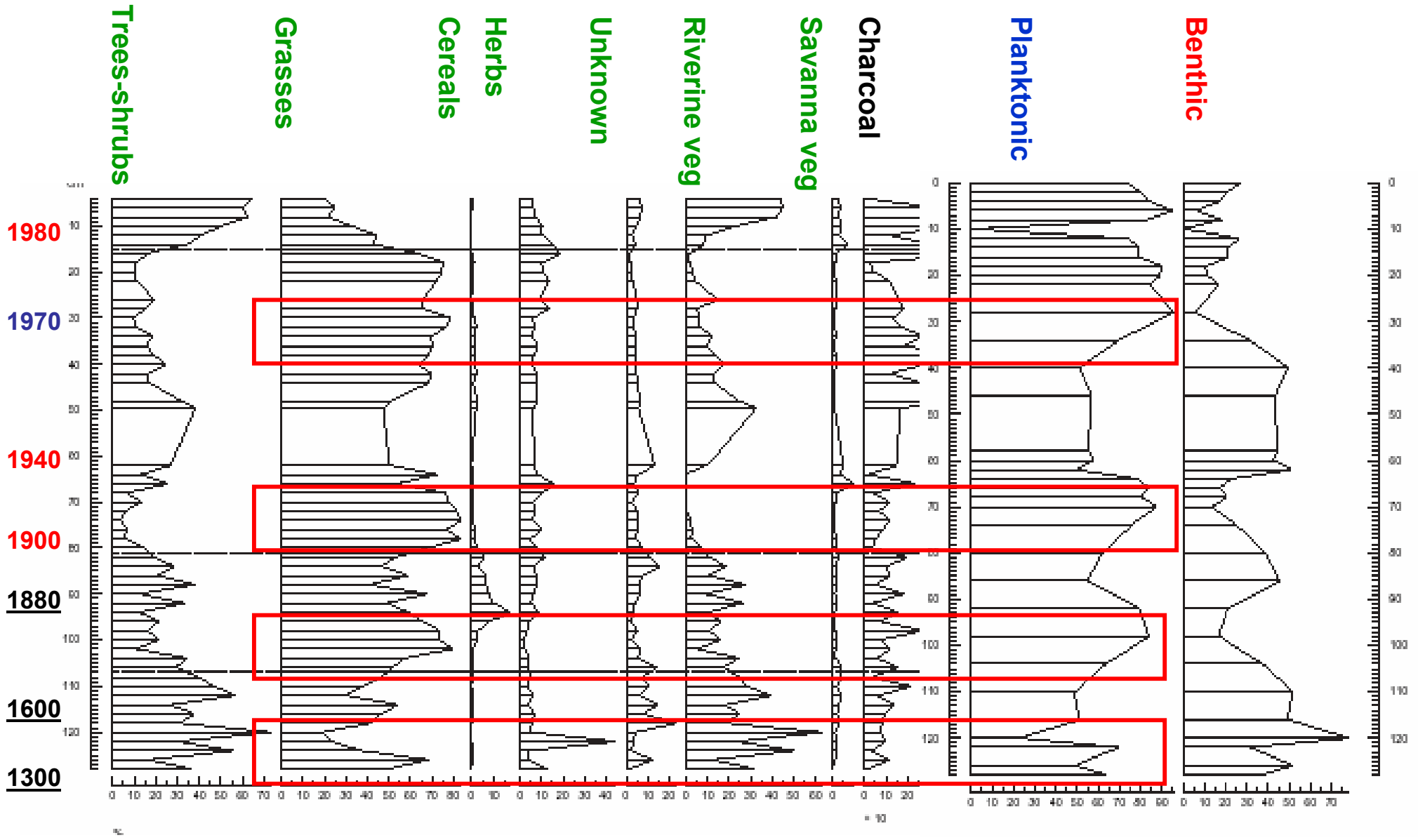
1970s WET →

1940-1960s DRY →

Source: SANParks (2006)


Age AD/Depth
Planktonic
Benthic/epiphytic
Lake levels
1980
1970
1940
1920
1900
1880
DATE?
1600
1300
1700 DRY?
1980 DRY
1970s WET
1940-50s DRY
1900 DRY
1800 WET
1600 DRY
MWA WET

Diatom-vegetation correlations



Pollen/Charcoal (Gillson et al. in prep)

Diatoms

Results

- A general correlation betw. diatoms and pollendata
- The Mapimbi dataset does show an overall correlation with regional paleoclimatic data
  - Late MWA wet conditions= beginning of latest phase of organic accumulation
  - Low rainfall in LIA, BUT! Periods of most extreme droughts missing
  - Variable rainfall in the 19th-20th century: correlations between low lake levels and dry periods 1900, 1940-50s, 1980s
- Diatomstudies can provide a long term climatic record for northern KNP and the Limpopo valley region
- More reference points needed!

Acknowledgements

- Scientific Services, Kruger National Park
- SANParks
- Andrew W. Mellon Foundation.
- Oxford Long-Term Ecology Laboratory
- Prof Jan Risberg, Stockholm University for comments on the analysis
- Zara Chidoub, Oxford University

Socio-natural dynamics

- Socio-cultural development (Shashe-Limpopo confluence)
  - Huffman (1996), Holmgren & Öberg (2006): “the whole Limpopo valley region was depopulated from beg. of LIA seen most clearly in the abandonment of Mapungubwe (1400 AD)
  - Manyanga (1996), Smith (2005): “Continued occupation in a climatically varied period (+continued high rainfall until c. 1500)
- Middle Limpopo valley Thulamela (c.1400-1640AD) population center and a center of trade decline related w 1700 AD dry period?
- 19th century depopulation linked w droughts? (Holmgren & Öberg 2006).

References

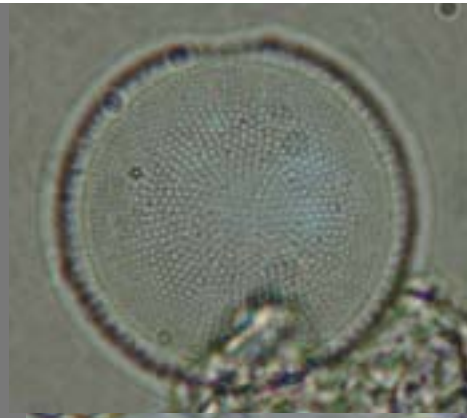
- Harding W. R.; Archibald C. G. M. & J. C. Taylor (2005) The relevance of diatoms for water quality assessment in South Africa: A position paper. Water S.A, 31, 1, pp. 41-46
- Holmgren K., Karlén W., Lauritzen S.E., Lee–Thorp J. A., Partridge T. C., Piketh S., Repinski P., Stevenson C., Svanered O. & P. D. Tyson (1999) A 3000 year high resolution stalagmite–based record of paleoclimate for northeastern South Africa. *The Holocene* 9(3), 295–309.
- Holmgren K., P.D. Tyson, A. Moberg & O. Svanered (2001) A preliminary 3000–year regional temperature reconstruction for South Africa. *South Africa Journal of Science* 97, 49–51.
- Tyson P. D., W. Karlén, K. Holmgren & G. A. Heiss (2000) The Little Ice Age and Medieval Warming in southern Africa. *South Africa Journal of Science* 96, 121–126.
- Van Dam H., Mertens A., & J. Sinkeldam (1994) A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. Netherlands Journal of Aquatic Ecology 26, 1, 117-133.

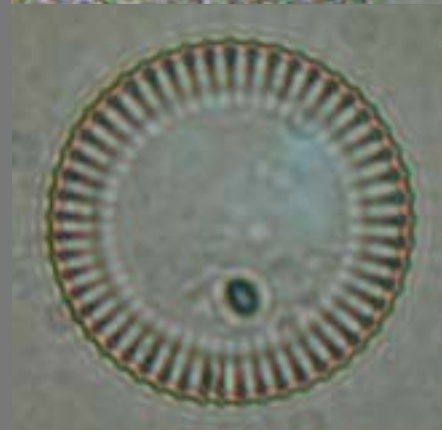
Diatoms as bio indicators in freshwater monitoring

- Cost effective
- Short response time between pertuburation and effect
- Evaluates the biological effects as supposed to mere water chemistry

- Knowledge of ecological baselines (good preservation!)
- Adaption of environmental indices for South African flora possible with the South African diatom collection

Harding et al 2005, Taylor et al 2005





Trophic state (7 classes) oligotraphentic -hypereutraphentic

Nitrogen requirements (4 classes) intolerant-const needing N

Saprobity				
Class	Pollution level	water quality class	Oxygen saturation	BOD_5^{20} (mg l^{-1})
1. oligosaprobous	non or slightly polluted	I,I-II	>85	<2
2. β-mesosaprobous	moderately polluted	II	70-85	2-4
3. α-mesosaprobous	Heavily polluted	III	25-70	4-13
4. α-mesosaprobous/ polysaprobous	Very heavily polluted	III-IV	10-25	13-22
5. polysaprobous	Extremely polluted	IV	<10	>22

Van Dam et al (1994)

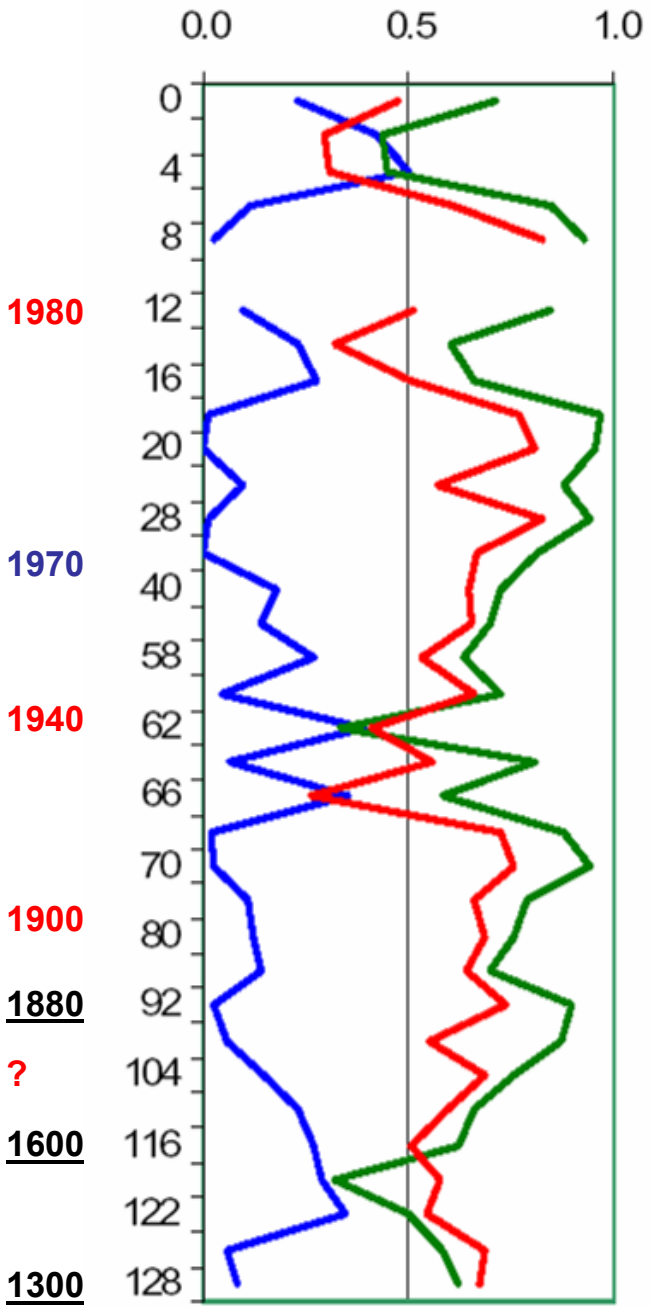
Cyclotella meneghiana:

α-mesosaprobous

meso-eutrophic

Needing periodically elevated concentrations of organic nitrogen

Oligtraphentic
Nitrogen intolerant



Presence of ”clean” water taxa
meso-eutrophic
More facultatively nitrogen-heterotrophic

— **Saprobity=** High index: pres of clean water taxa=unpolluted

— **Trophic state=** High index: more Meso-eutrophic taxa

— **Nitrogen requirements=** High index: More taxa temporarily req N for metabolism