The Past Is The Key To The Future: Lessons Paleoecological Data From Lake Tanganyika Can Provide For Future Planning

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Talk Outline

Rationale/need for paleoecological records.

- -What kind of information can we learn?
- -Examples that made a difference for lake management and why?

Length of records useful for lake management?

Limitations to integration with modern observational time series

Examples from Lake Tanganyika

- -Sedimentation Impacts
- -Climate Change

Future work and recommendations: Reconciling results on different time scales, more realistic paleo-inferences of interactive effects, training needs

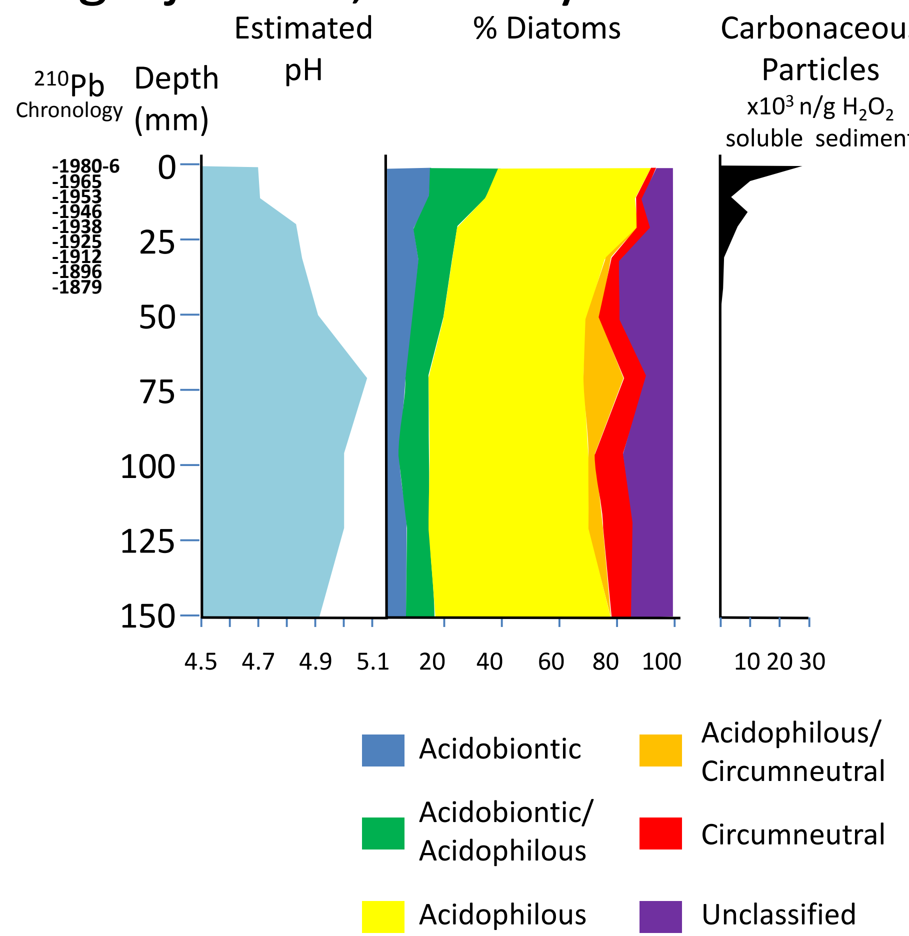
Issues Paleo-records Can Address

- Timing/rate of environmental & ecosystem changes
- Range of pre-impact variability?
- Disentangling interactions(e.g. L. Victoria (e.g. Hecky et al., 2010)
- Implications for mitigation measures
- Importance of QA/QC
  -the legal side of impacts

Paleo-pH Records:

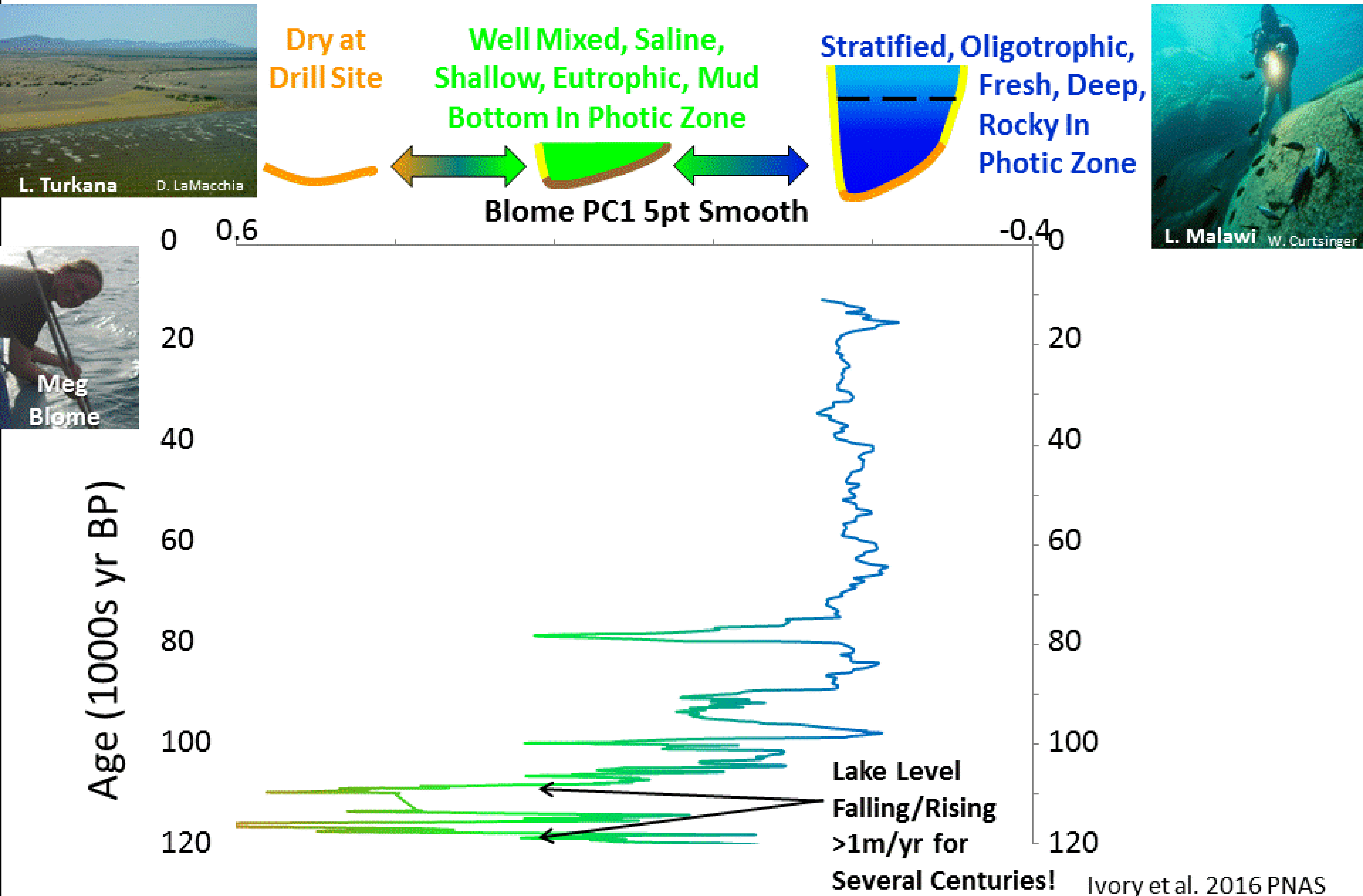
Key to Resolving Acid Precipitation Debates in N. America & Europe

e.g. Ljosvatn, Norway



H.J.B. Birks et al. 1990 JOPL

Rates of Change-Example from L. Malawi Drill Core

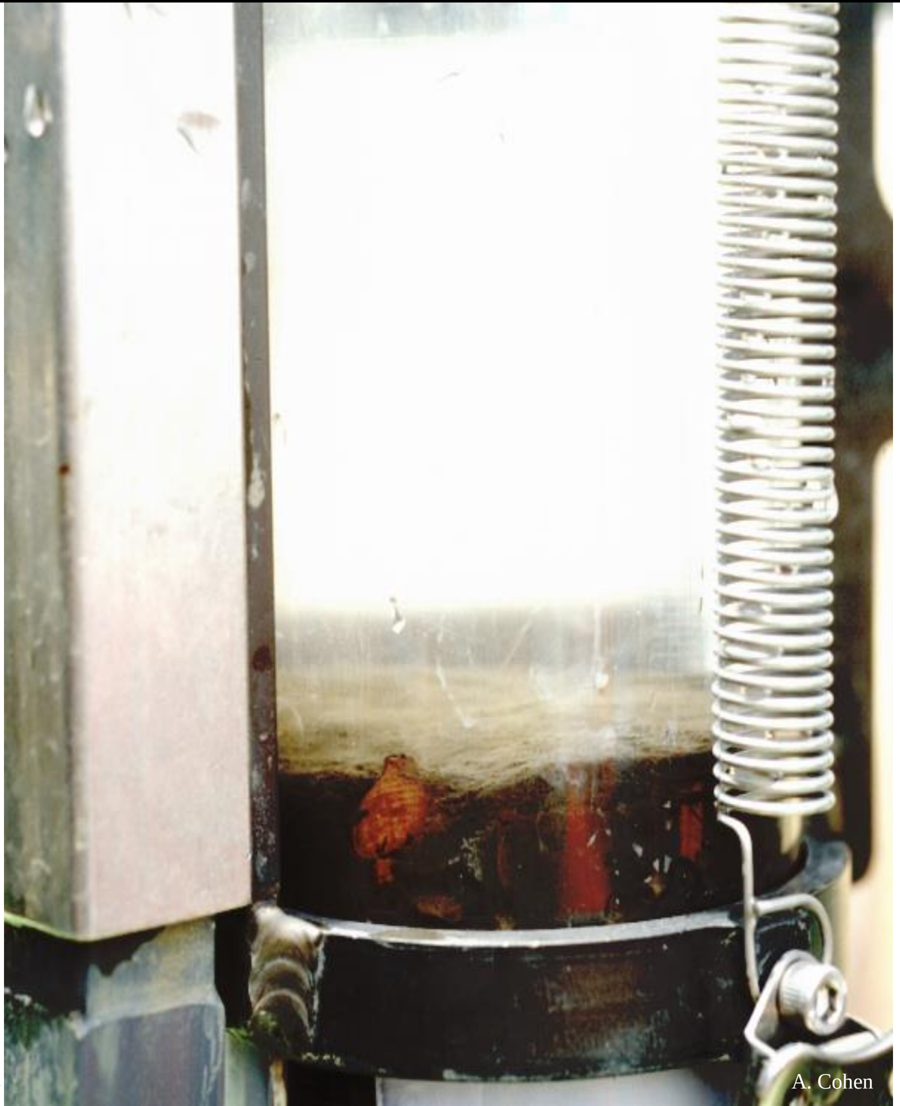


Case Studies From Lake Tanganyika Cores

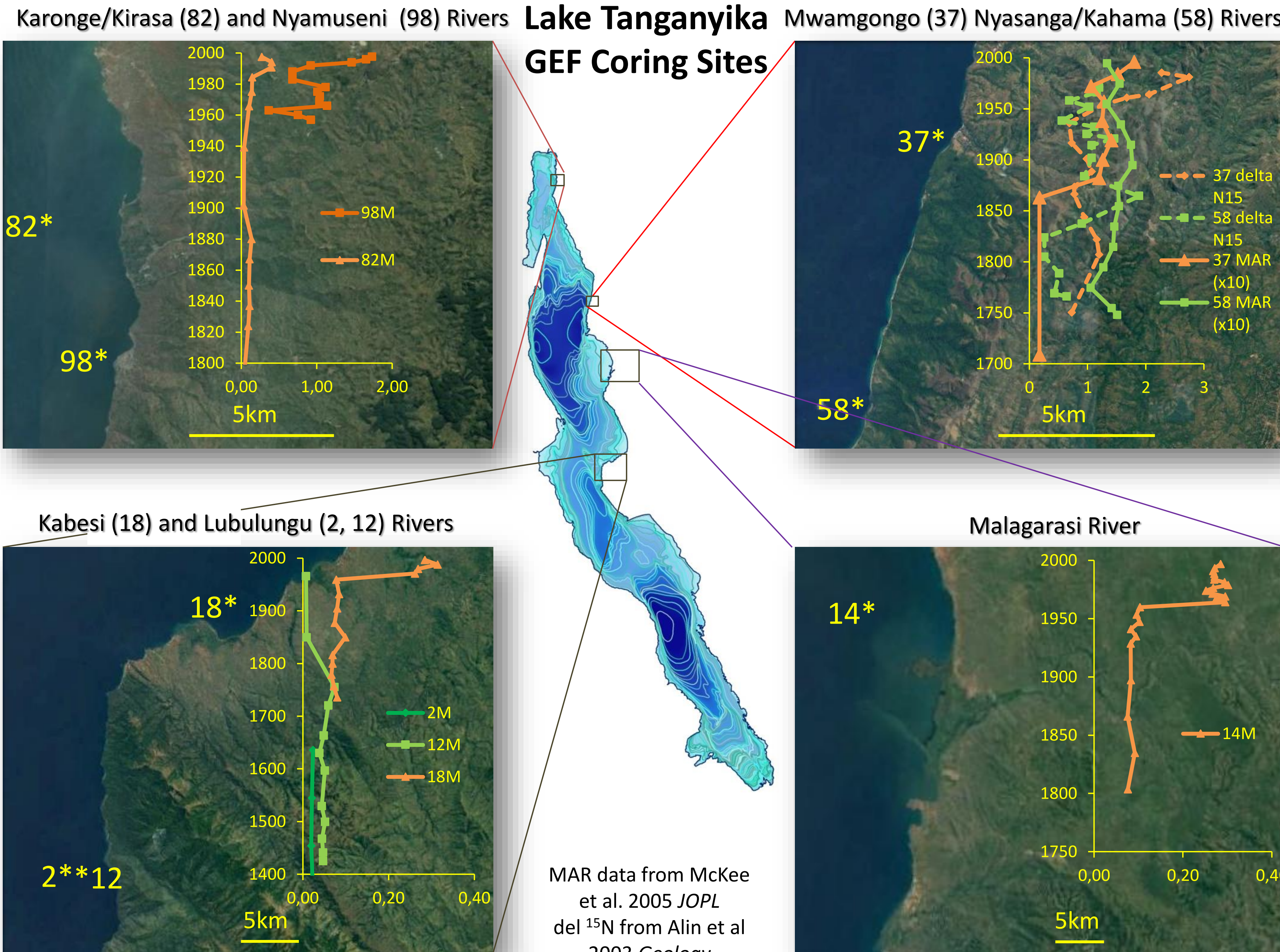
- Sedimentation Impacts From Deforestation In Lake Tanganyika Watersheds
- Impacts from Lake Warming on the Tanganyikan Ecosystem

A. Cohen

Approaches to Studying Watershed Deforestation
Experimental (Subannual-Multiannual Time Scales; Distributional-Timescales Uncertain; Paleoecological-Annual to >Millenial Time Scales

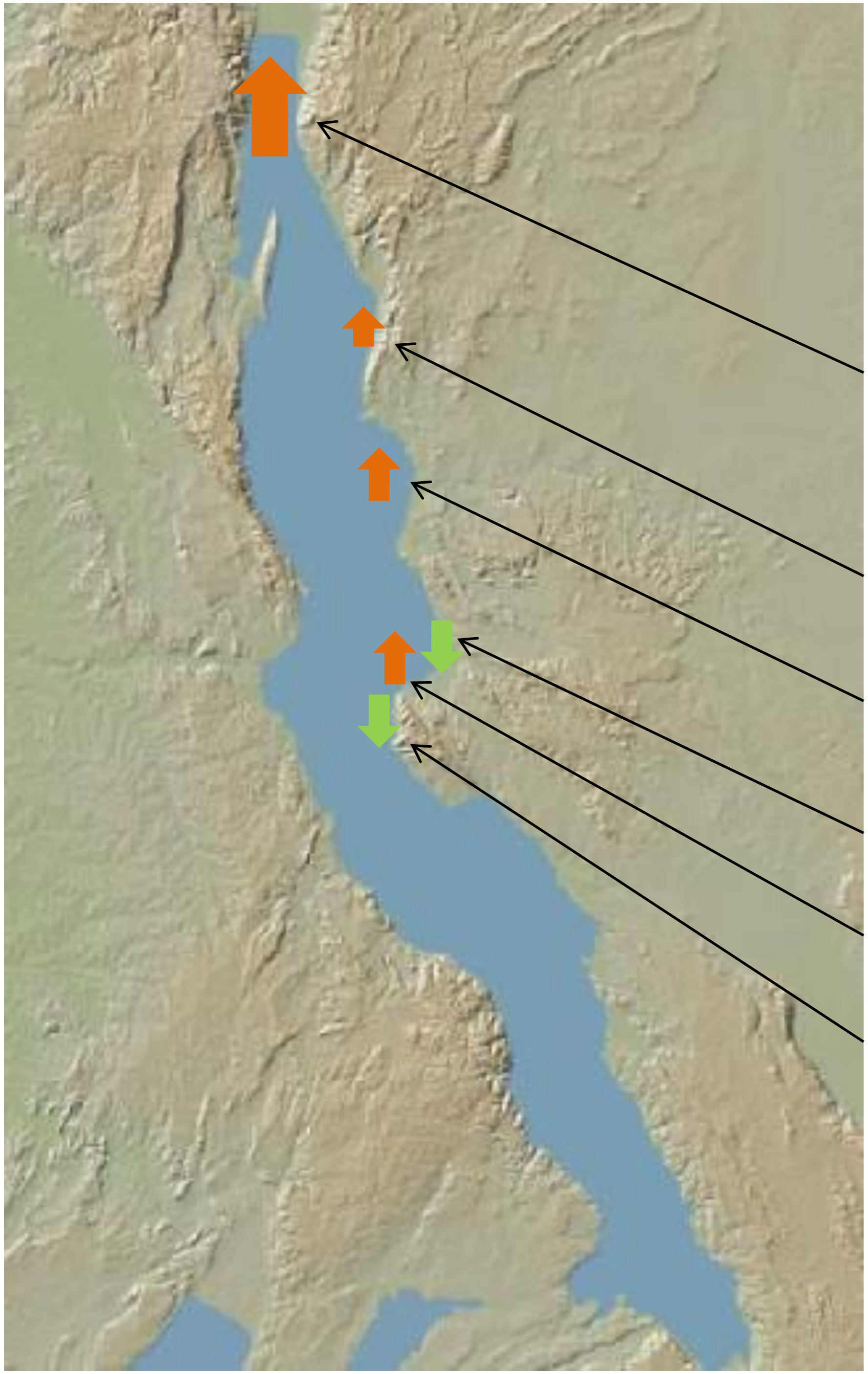


Lake Tanganyika GEF Coring Sites



MAR data from McKee et al. 2005 *JOPL*
del ^{15}N from Alin et al 2003 *Geology*

Timing Of Major Sedimentation Changes East Coast of Lake Tanganyika



Mid 19th C. (Karonge/Kirasa), ~1960/mid 20th C. (82R, 98R, Kar #3)

19th C. and early 1960s (37R, MWA-1), No change at 58R

1961 (Malagarasi, 14V)

40% decline (S. Malagarasi Platform, 57V)

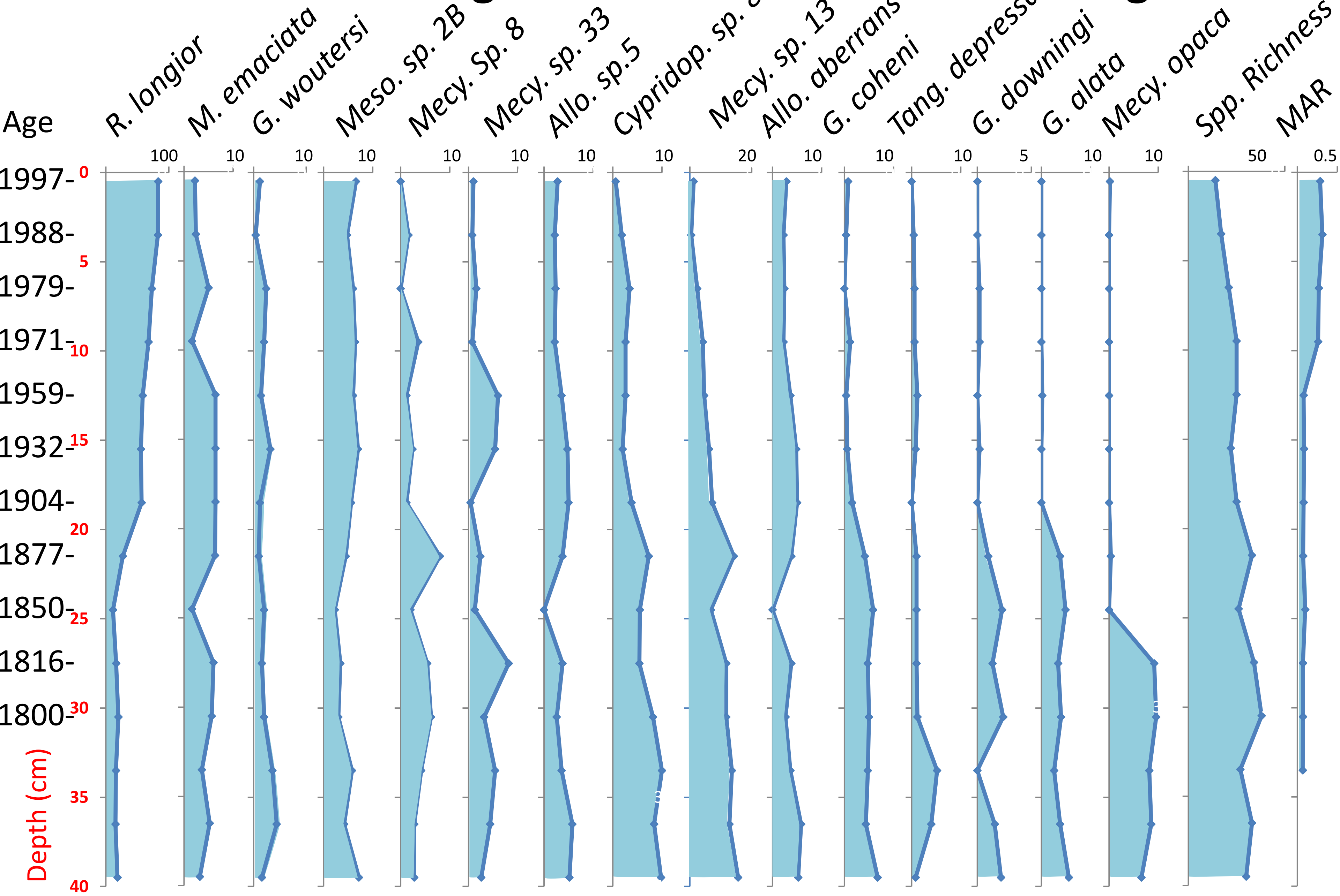
1961 (Kabesi 18R, no change at 61V)

85% decline in 18th C, constant since then (12M)

McKee et al., 2005 *JOPL* and Alin et al., 2003 *Geology*

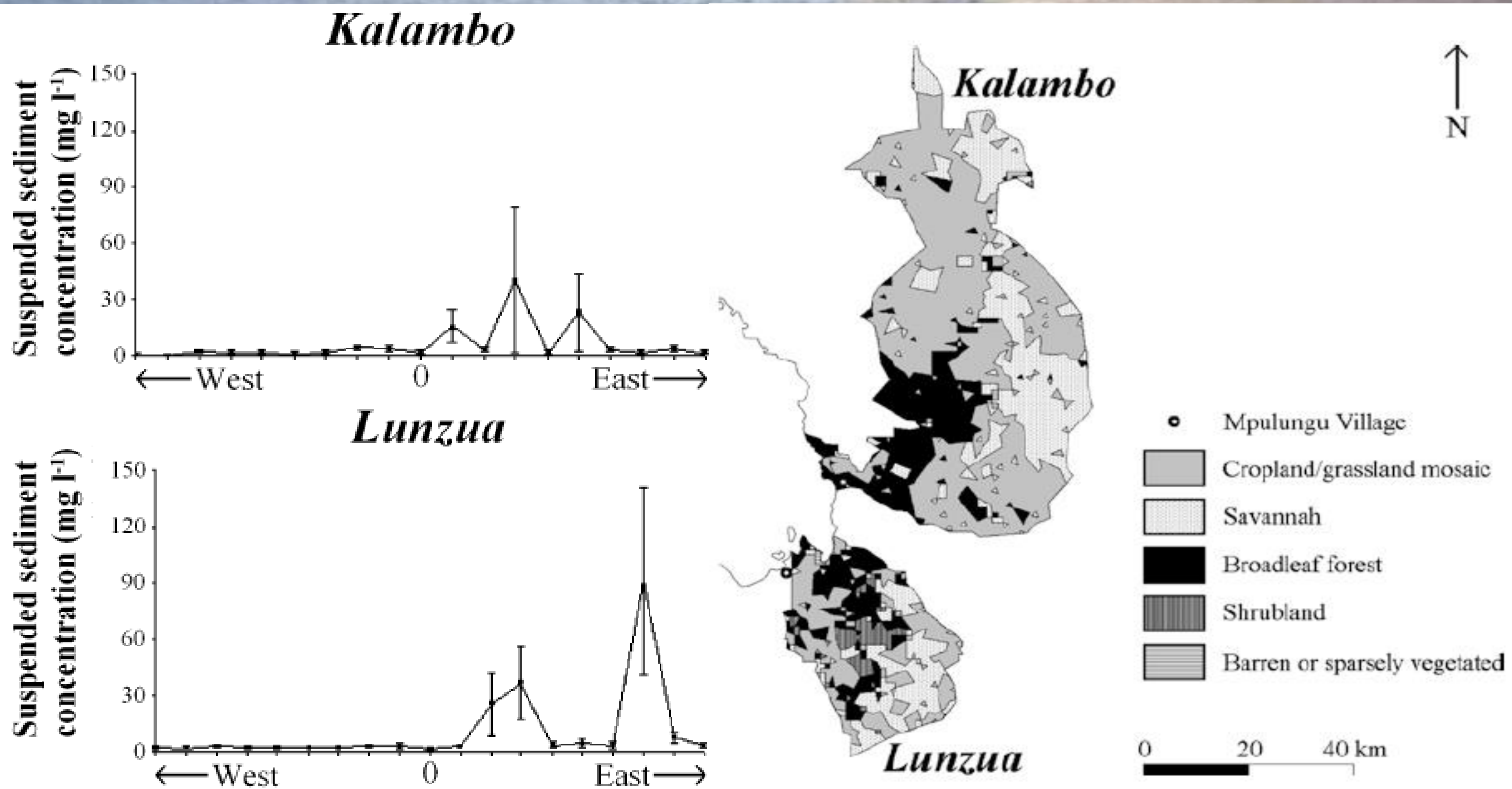
OSTRACODE STRATIGRAPHY-98-18M (KABESI RIVER DELTA)

Faunal Change Starts Before Sed. Rate Change

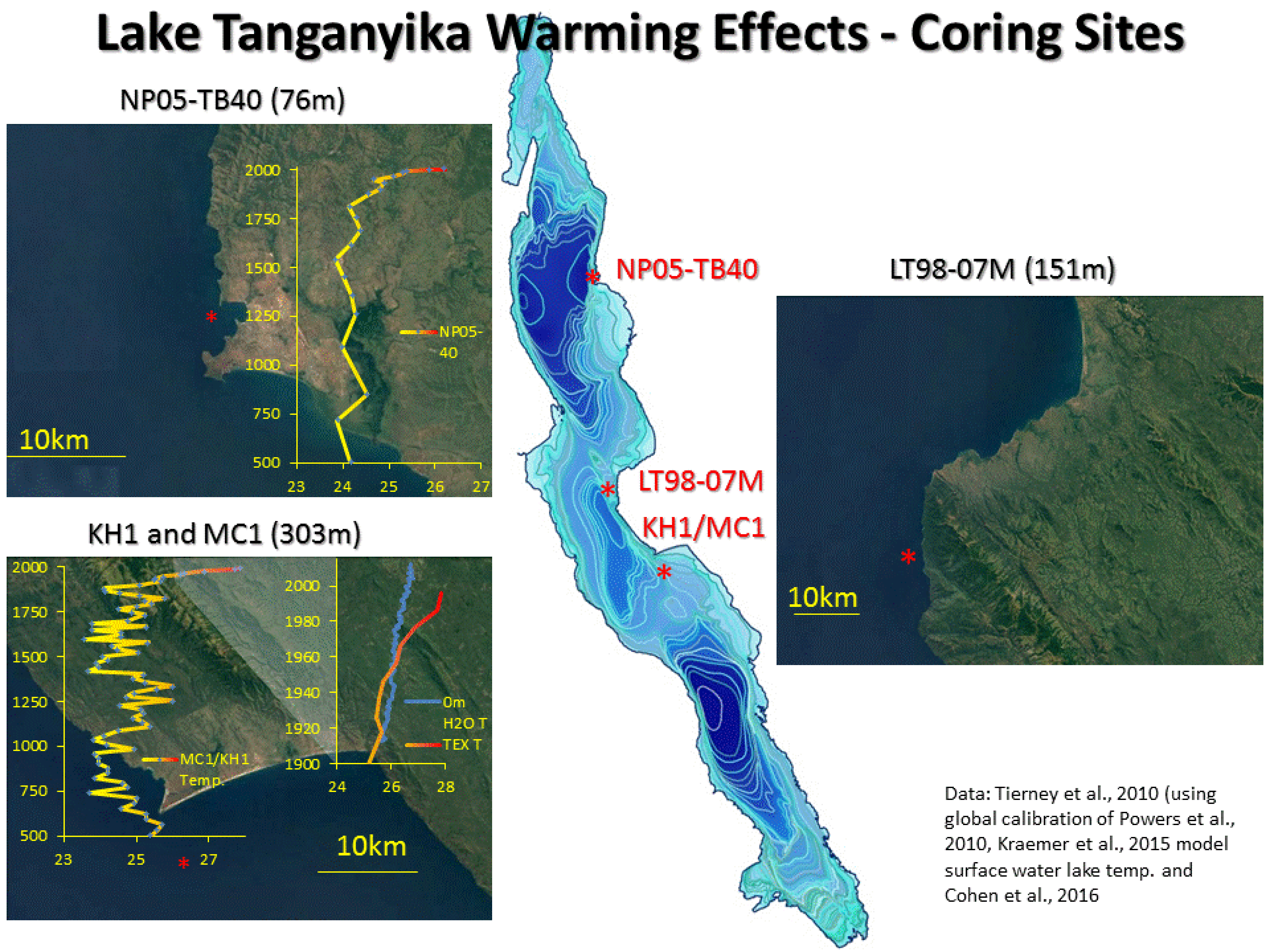


Lessons Learned for Lake Management

- Reconciling Short Term Monitoring Results with Long Term Paleorecords
- Donoghue et al. (2003) higher sediment discharge in a small mountain stream with less sediment retention than larger catchment. Erosion resistance also important
- Alin et al. (2003) and Cohen et al (2005)-longer term changes in fauna appear more muted adjacent to smaller catchments. Sublacustrine slope important
- Other factors at play? Timing suggests climate change and interactive effects



Donohue et al., 2003 Envir. Geology

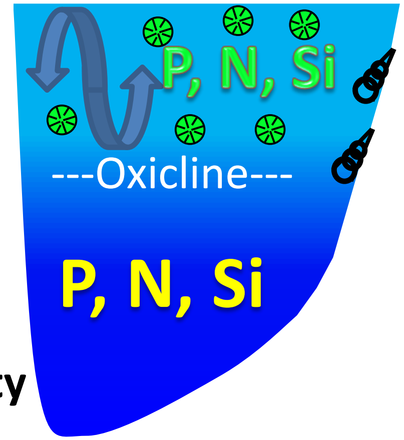


Lake Tanganyika Warming Effects - Coring Sites
NP05-TB40 (76m)
2000
1750
1500
1250
1000
750
500
23
24
25
26
27
NP05-40
10km
KH1 and MC1 (303m)
MC1/KH1 Temp.
0m H2O T
TEX T
1980
1960
1940
1920
1900
28
NP05-TB40
LT98-07M
KH1/MC1
LT98-07M (151m)
Data: Tierney et al., 2010 (using global calibration of Powers et al., 2010, Kraemer et al., 2015 model surface water lake temp. and Cohen et al., 2016

Hypothesized Responses To Warming

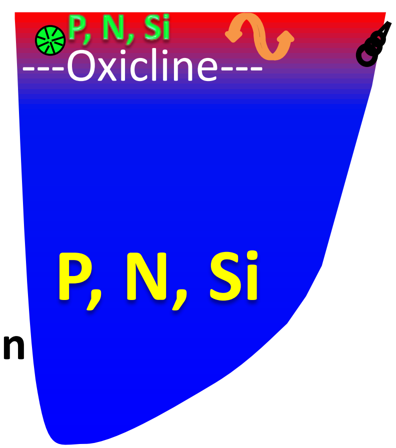
Cooler Lake

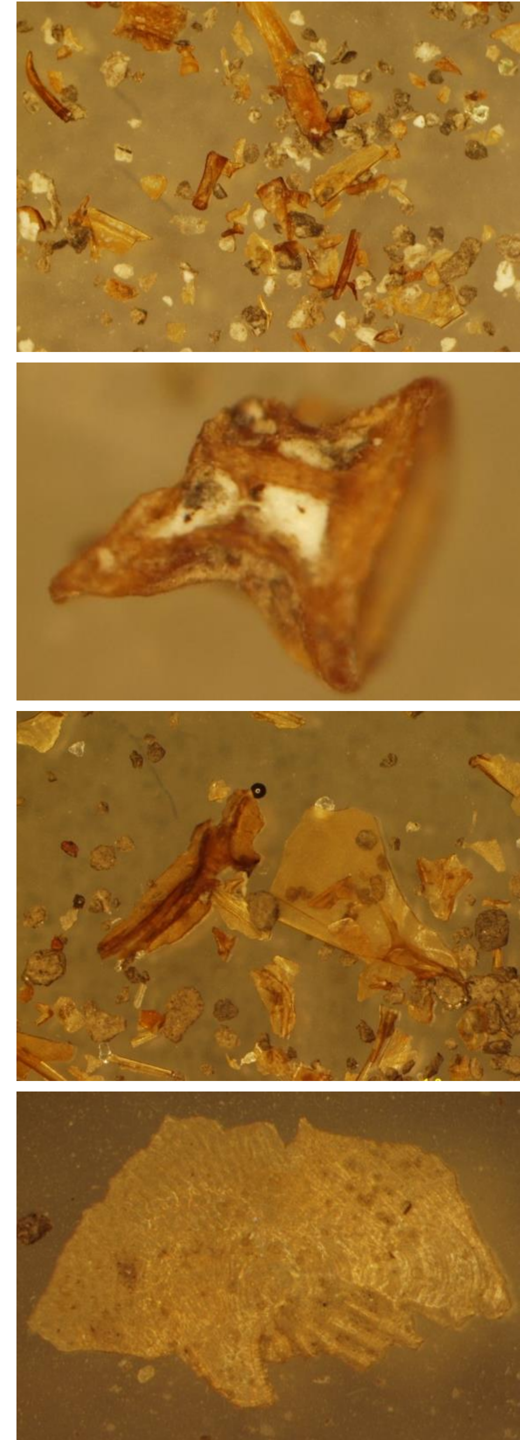
- Deeper Mixing
  Nutrient Increase
- Higher Surface
  Primary
  Productivity
- Higher Secondary
  & Fish Productivity
- Deeper Oxicline
  And Benthic Habitat



Warmer Lake

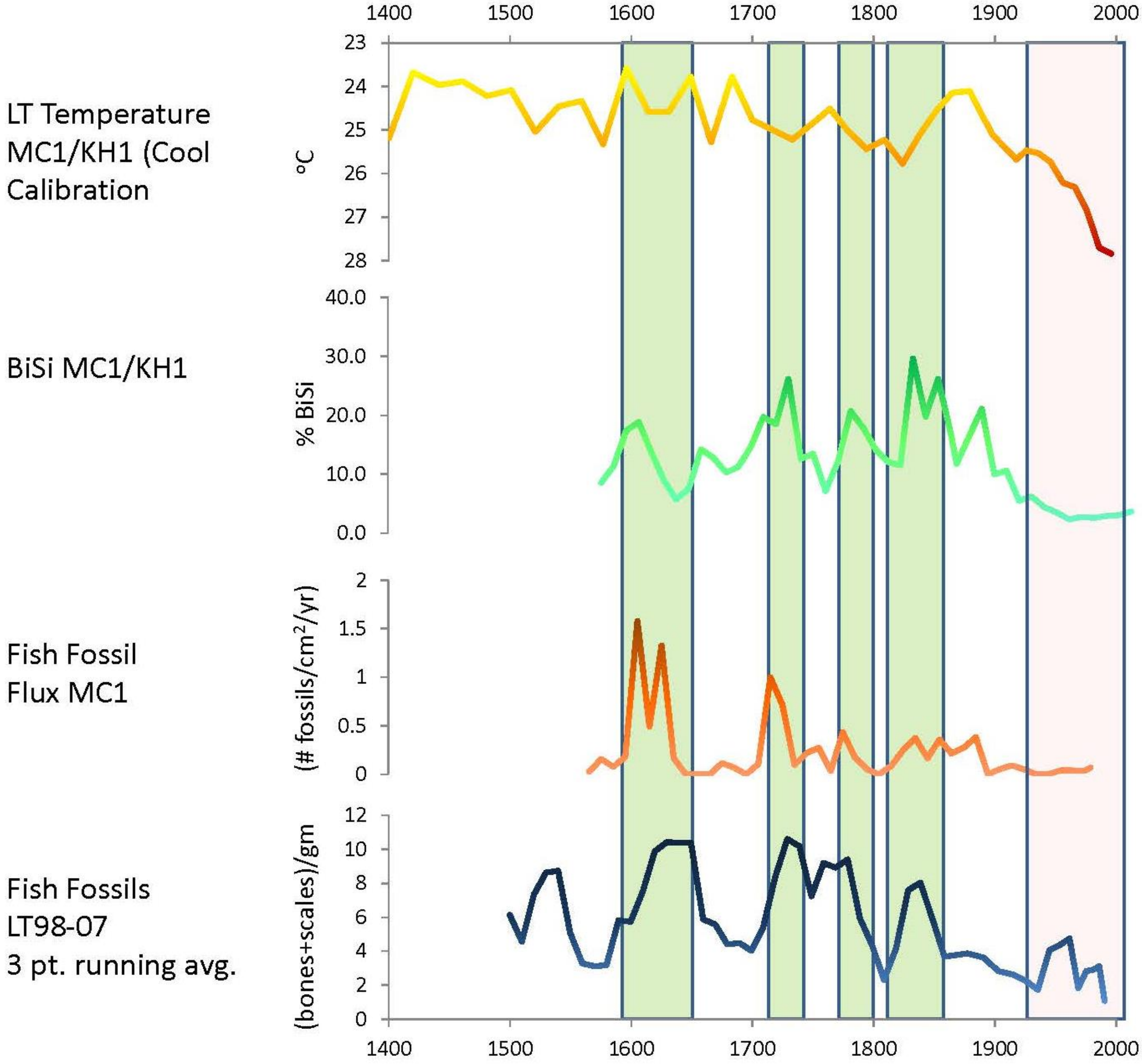
- Reduced Mixing
  Epilimnion
  Nutrient Pool
  Decline
- Less Surface
  Primary Production
- Fish Decline
- Oxicline Shallows
  Benthic Habitat Shrinks





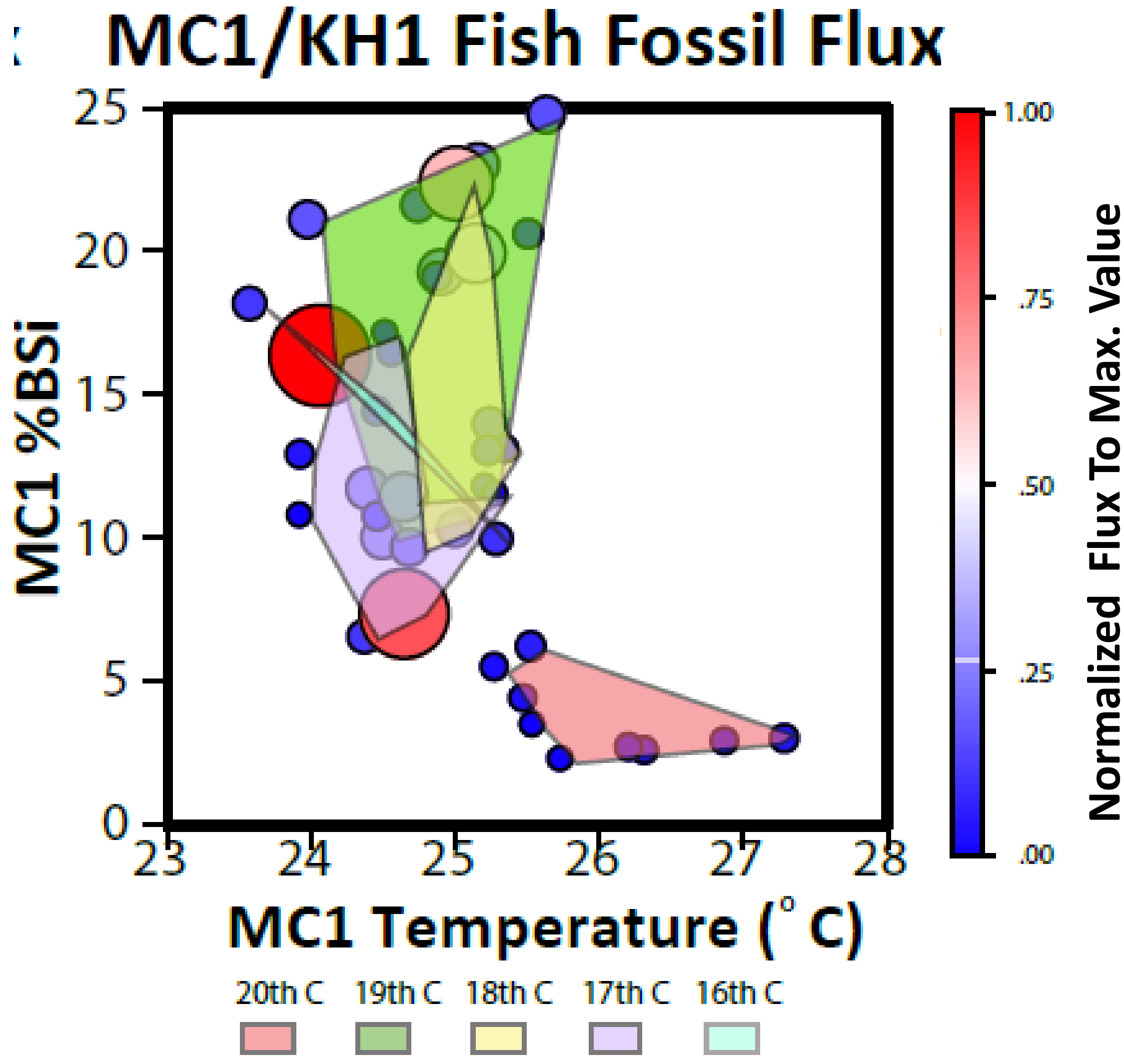
Fossil fish bones, teeth and scales: Lake Tanganyika KH1 core

Paleoecological Responses To Warming



Cohen et al., 2016 PNAS

20th C Abundances of Fish and Molluscs Outside Pre-20th C Norms



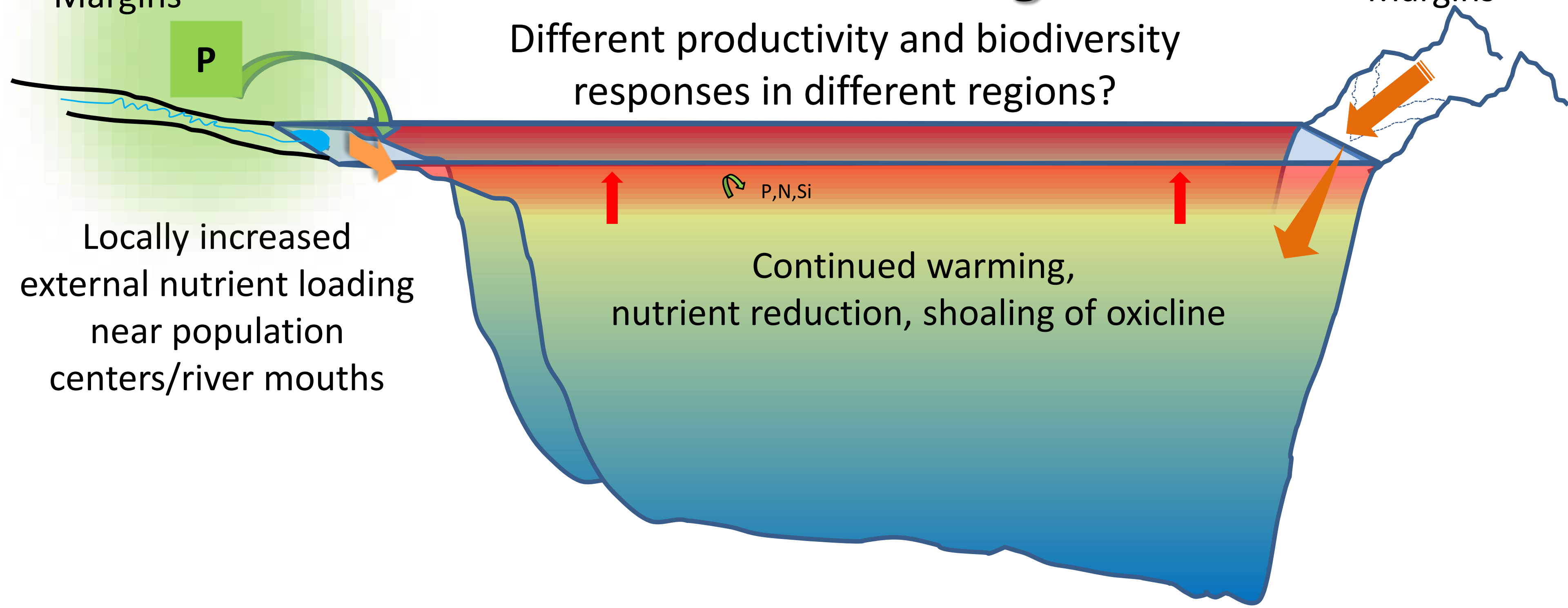
Cohen et al., *PNAS*, 2016

Interactive Effects Going Forward?

Platform/Axial Margins

Escarpment Margins

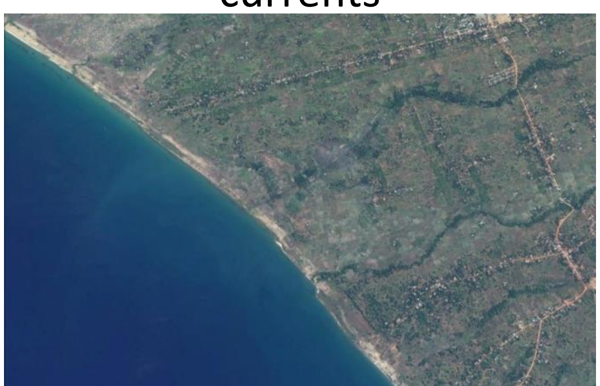
Different productivity and biodiversity responses in different regions?



Locally increased external nutrient loading near population centers/river mouths

Sediment loading from deforestation & construction redistributed by longshore currents

Sediment loading from deforestation & construction mostly mass-wasting and underwater gravity flows



Nyanza-Lac Platform (southern Burundi)

Could Paleorecords (Coupled with Modeling) Help?

Gombe Escarpment (northern Tanzania)

Conclusions

- Paleo-data provide long-term view of African lake ecosystem response to change, particularly for conditions not previously encountered over instrumental time scale

- At Tanganyika both sedimentation and climate change have had major impacts on decadal to centurial time scales. Need for replication and understanding of interactions -Paleo-records plus modeling?

- Need to incorporate paleorecords into “monitoring” programs throughout GLA: Training of African students for conducting this research as routine part of lake management.