

# Fossil diatom communities in Tafiri Bay: Implications for lake level reconstruction

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## Introduction

Diatom communities respond to varying ecological conditions and are therefore useful in applications to paleolimnological and paleoclimate studies. Factors such as lake level, upwelling, sediment input, wind, evaporation, and precipitation govern nutrient availability, affecting the relative distributions diatom taxa and the abundances of peryphytic (benthic) and planktonic diatoms (Gasse et al., 1989; Stager et al., 2003). The preservation of siliceous frustules composing the diatom cell, coupled with their widespread distribution, makes diatoms robust indicators of varying limnological fluctuations in lacustrine environments. High-resolution studies on the timing of Holocene lake levels have been reconstructed using diatoms in southern Lake Tanganyika (Haberyan and Hecky, 1987).

As the second deepest lake in the world (>1400m) with an estimated age of 12-14Ma, Lake Tanganyika contains a long paleoenvironmental archive (Cohen et al., 1993). Kigoma Bay, located on the eastern coast of Lake Tanganyika, is relatively protected from winds from the north and southwest and has no major river source bringing large influxes of sediment into the catchment area. Previous diatom studies have been conducted on cores and surface sediments from Tafiri Bay, the central portion of Kigoma Bay, but surface sediment studies were limited in their spatial extent and the depth distribution of samples analyzed (Meeker, Mallya, Currano, Nyanza 2003 Report).

Does the distribution of diatom genera vary significantly with water depth in a localized area such as Tafiri Bay? What role does lake-floor topographic variability play in this relationship? Herein, this study aims to examine the relationship between depth and the distribution of diatom genera by comparing two transects of varying bathymetry in Tafiri Bay in order to ultimately reassess the applicability of diatoms as indicators of paleo-lake levels.

## Field Methods

Surface samples were collected along two transects in Tafiri Bay, the central bay of the three bay assemblage comprising Kigoma Bay (Figures 1 and 2, Geology and Paleoclimatology Introduction, this volume). Surface samples TB1- TB22 were collected aboard the *R/V Echo* in July of 2005 using a Ponar grab sampler at water depths ranging from 5-110 meters, spaced at 5-10 meter intervals. Eleven samples were analyzed along transect 3, located in the middle of the bay, and nine samples from transect 4, located 300 m north of transect 3 (Smith, G., this volume). The grab samples were brought to the Tanzania Fisheries Research Institute (TAFIRI) for treatment and analysis.

## Laboratory Methods

Approximately 0.5 g wet sediment samples were transferred to 150 ml glass beakers. 10-15 ml of H<sub>2</sub>O<sub>2</sub> were added to each sample, and boiled on a hot plate for one hour to remove all organic material. After one hour, 2 ml of H<sub>2</sub>SO<sub>4</sub> (50%) were added to the boiling peroxide and allowed to react for 10 minutes to remove carbonate and metal salts. The heat source was removed and 100 ml of distilled water was added to rinse each sample. The samples were allowed to settle in the beakers for 8 hours, after which 90% of the supernatant was poured out and an aliquot of each diatom slurry and remaining supernatant was transferred to a 15ml centrifuge tube and centrifuged for 15 minutes. The supernatant was removed and an additional 10 mL of distilled water were added. Samples were re-centrifuged for 15 minutes and the supernatant rinse removed. 5 ml of deionized water were added to each pellet containing the diatom slurry, re-suspended by pipette, an aliquot evenly applied to ethanol treated glass coverslips and allowed to dry for ~12 hours. After drying, coverslips were mounted on glass slides with Permout mounting medium and heated until coverslips were securely fastened. Coverslips were pressed onto each slide to remove air pockets.

Slides were analyzed using a Leica CM EX3 light-microscope at 1000X under oil immersion. Approximately 300 diatom frustules were counted from two slides of each sample to ensure an accurate representation of the diatom assemblage from each sample. Diatoms were identified to the genus level based on Gasse (1986) and Cocquyt

(1998). To avoid overcounting genera with fractured valves, valve ends of long *Nitzschia* spp. were counted and final counts halved. For other genera, only valves with identifiable central portions were counted.

## Results & Discussion

A total of 6250 valves were identified and counted. Samples counts ranged from 281 to 364 diatoms per sample. Six planktonic and fourteen benthic genera were identified; planktonic forms were dominated by *Nitzschia* spp. (long), *Nitzschia* spp. (short), and *Fragilaria* spp. while *Amphora* spp., *Cymbella* spp., *Diploneis* spp. and *Navicula* spp. were the dominant benthic genera. The five most dominant genera composed 73% of the total number of valves counted.

### % planktonic and % benthic genera distributions relative to depth

In transect 3 and 4, the percentage of planktonic and benthic genera do not appear to vary linearly with increasing water depth. Combining data from both depth transects, the relationship between planktonic/benthic percent distributions and depth observed (Figure 1) suggests benthic forms are increasing with depth, counter to previous interpretations applied to sediment cores (Scholz et al., 2003; Stager et al., 2003; Gasse et al., 1989).

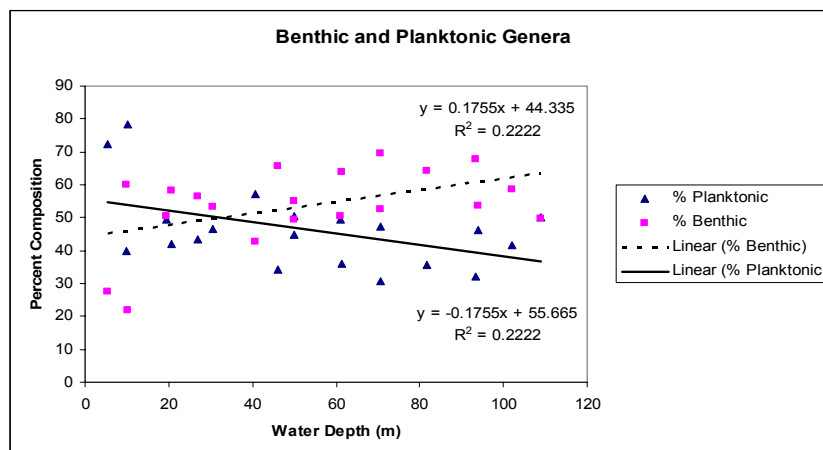


Figure 1: Combined data from two Tafiri Bay transects suggests the distribution of benthic genera increase with depth while planktonic forms decrease. The relationship is inconclusive based on low  $R^2$  ( $< .25$ ) values.

### Distribution of individual genera

Investigation of individual genera with respect to depth suggests stronger correlations exist than those obtained by grouping diatoms into benthic and planktonic communities. Regressions conducted on the six most abundant diatom genera suggests *Nitzschia* spp. (long) and *Nitzschia* spp. (short) correlate with water depth, *Amphora* spp. and *Fragilaria* spp. correlate with depth in transect 3 but not transect 4 (although the lack of correlation in *Amphora* spp. with water depth in transect 4 may be related to one outlier at ~10 m water depth). Omitting one outlier (TB 14) along transect 4 shows a much stronger *Amphora* spp. correlation with depth in that transect. *Navicula* spp. and *Cymbella* spp. do not correlate with depth (Figure 2).

Data combined from both transects show the same trend: *Nitzschia* (long) spp. increases roughly linearly with depth while *Nitzschia* (small) spp. decreases non-linearly with increasing depth (Figure 3). The distribution of *Nitzschia* spp. (small) shows a stronger correlation with depth than *Nitzschia* (long) spp. when data from both transects are combined. The results of a linear regression analysis of depth regressed on % *Nitzschia* spp. (small) on JMP suggests a greater than 99.99% probability that the linear regression is significant. *Amphora* spp. and *Fragilaria* spp., *Navicula* spp. and *Cymbella* spp. show weaker to no relationship with depth when combining data from both transects. Omitting one outlier (TB 14) from the *Amphora* spp. distribution plot suggests a reasonable correlation with depth ( $R^2 \sim 0.53$ ) although the correlation may not be linear. Correlations between genera were not investigated due to bias from percent data.

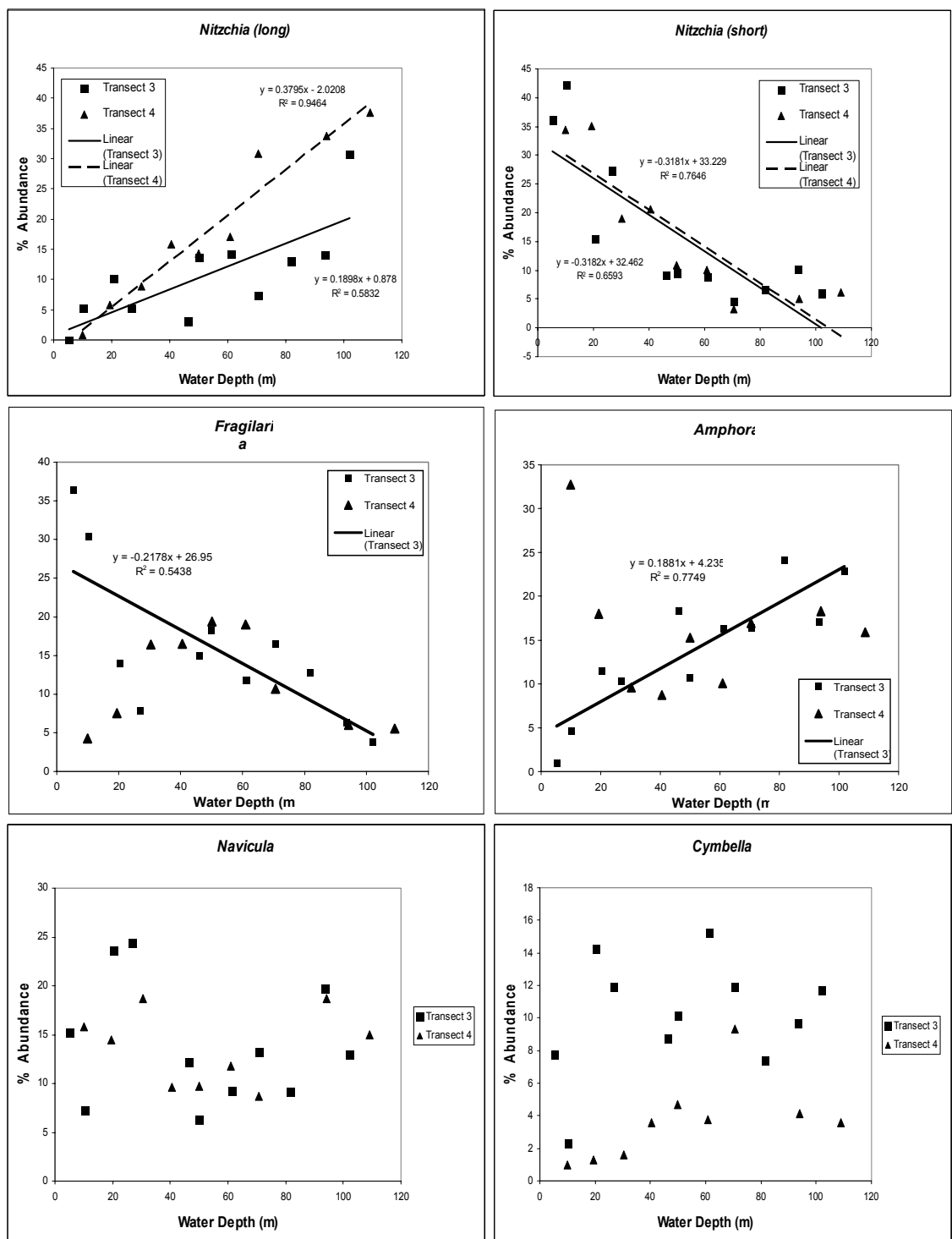


Figure 2: Distributions of the six most abundant diatom genera shows *Nitzchia (long)* spp. and *Nitzchia (short)* spp. most strongly correlate with depth in both transects. *Fragilaria* spp. and *Amphora* spp. correlate less strongly and display inter-transect variability, while *Navicula* spp. and *Cymbella* spp. do not correlate in either transect.

### Bathymetric Considerations

Grab sample TB-5 (4.88052S, 29.6132E) taken at the base of a steep cliff (slope > -0.5) (bathymetric analysis courtesy G. Smith, this volume) appears as an outlier with respect to *Nitzschia* spp. (long) distribution. Omitting data from TB-5 shows a better correlation between *Nitzschia* spp. (long) and water depth (an  $R^2$  value of 0.68, Figure 3) when data from both transects are combined. The *Nitzschia* spp. (short) distributions do not appear as anomalous with respect to the bathymetric feature.

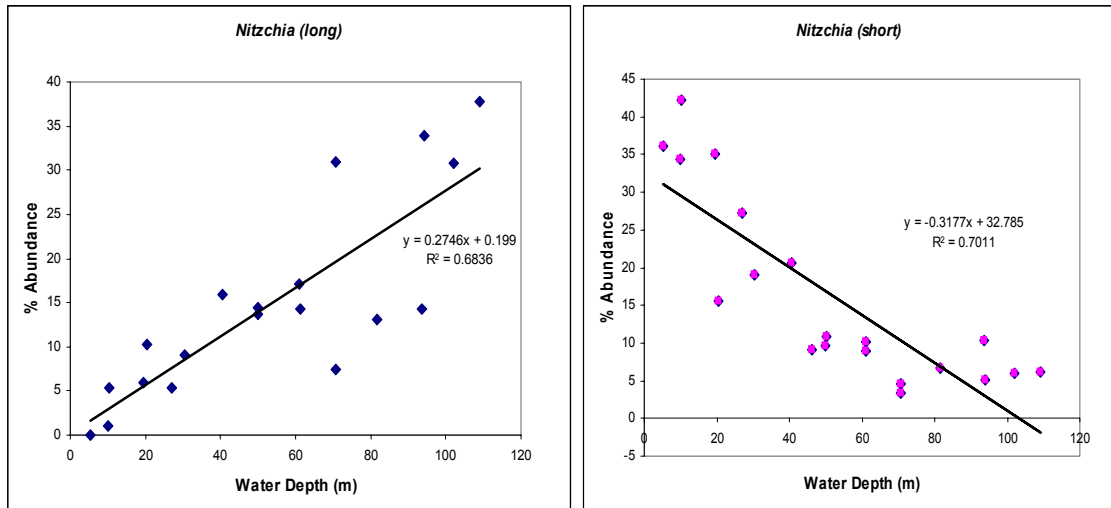


Figure 3: Plots showing *Nitzschia* spp. (long) and *Nitzschia* spp. (short) distributions as a function of depth from data combining both transects. Omitting data (TB-5) taken at the bathymetric feature increases the correlation (refer to Figure 2 for comparison)

### Diversity and Evenness Measure

Simpson's measure of diversity and evenness suggests genera are most diverse and evenly distributed at mid-water depths (40-70 m) along both depth transects (Figure 4). A gradual bathymetric slope (<0.1) at mid-water depths along both transects of the bay slopes quite gradually. Conversely, steep escarpments and flat platforms (slope ~0) characterize the sediment platforms of both transects at low (0-40 m) and high (70-110 m) water depths.

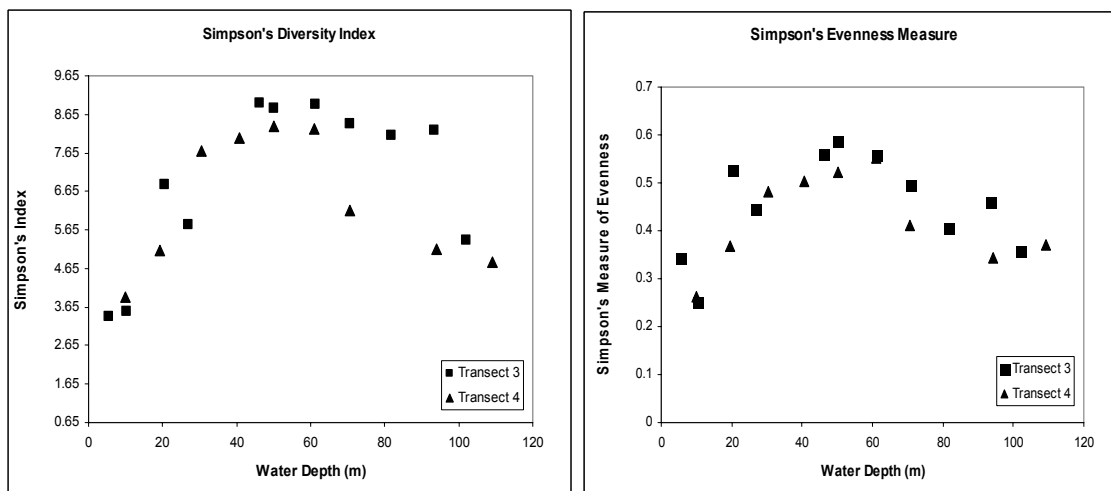


Figure 4: Simpson's indices of species diversity and evenness with respect to water depth.

## Summary & Conclusions

Diatom data collected from Tafiri Bay suggests the proportion of benthic genera is increasing with water depth, counter to previous interpretations of diatom community patterns applied to reconstruct fluctuating paleo-lake levels (Stager et al., 2003; Scholz et al., 2003; Gasse et al., 1989) and counter to what one would predict from the diatoms' ecologies. This depth distribution may result from low concentrations of limiting nutrients, i.e. phosphorus, present today in the bay, which could limit the productivity of planktonic diatoms at off-shore, deeper sites in the bay. The dominance of benthic genera at water depths greater than 60 m, beyond the range of the photic zone, suggests low planktonic production in deep water in Tafiri Bay, which, combined with high rates of sediment influx from shallow regions containing living benthic diatoms, could result in a high benthic/planktonic ratio offshore. Decreases in the proportional abundance of *Nitzschia* spp. (long) and the increase in *Amphora* spp. with increasing depth, supports this hypothesis. Furthermore, this relationship could imply that changes in the planktonic/benthic ratio in cores from the bay could be more strongly affected by changes in planktonic productivity than by changes in water level. This conclusion is supported by the findings of Powers (this volume), whose results also imply low planktonic diatom productivity in the Tafiri Bay region.

The diatom data suggests bathymetric features influence diatom community patterns by affecting sediment distribution and water depth. A strong deviation from the *Nitzschia* spp. (long) regression is most likely the result of a steep escarpment of an isolated bathymetric feature. Peaks in both genera diversity and species evenness coincide with areas of gradual bathymetric slope ( $<0.1$ ) reflected in the mid-water depth range (40-70 m) along both transects. These peaks in genera diversity and evenness may dually result from gradual influx of littoral taxa due to low-sloping bathymetry and the presence of the oxycline, creating a greater ecological range of habitats in the water column. These data underscore the importance of examining local factors such as bathymetry and nutrient availability influencing the proportion of benthic and planktonic distribution when using diatoms to reconstruct paleo-lake levels. This conclusion is supported by a grab sample study conducted in northern Lake Tanganyika which discusses the importance of water chemistry (nutrient availability) as a driving factor of diatom community distribution (Cocquyt et al., 2000). Core sites should be chosen to avoid bathymetric anomalies, e.g. steep escarpments, as these features will significantly impact benthic/planktonic distributions from isolated depositional events. Finally, individual genus distributions, i.e. *Nitzschia* spp. (short), *Nitzschia* spp. (long), *Amphora*, and measures of generic diversity and evenness are promising indicators of paleo-lake level changes in localized areas.

## Acknowledgements

Asante sana Dr. Jim Russell for teaching me all I know about diatoms and being a true mentor. Vielen Dank Lindsay Powers for reminding me of the importance of lab safety, for boundless positive energy and excellent tunes in the field. Christine Gans supplied the technical support to make my outdoor fume-hood possible. Many thanks to the geo team whose solidarity in times of Ponar failures, extended departure times, and lost objects at sea made collecting samples possible. Without the *Nyanza* cast, fellow participants, Tanzanian Fisheries Research Institute (TAFIRI), the crew aboard the *Echo*, and my Kiswahili walimu from the University of Dar es Salaam, my experience would not have been nearly as interesting. Finally, I want to extend my thanks to the staff at the Lake Tanganyika beach hotel George, Mrua, Sophia, Michael, na marafiki- and Nanay, Tatay, Bong, Lea, and Sher for their love and support. This study was funded by a grant from the National Science Foundation (ATM-0223920) as part of the International Decade of East African Lakes (IDEAL).

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