

Climate Change Impacts on the Biology of the Pelagic Zone of Lake Tanganyika

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Objective

This study, which was performed in 2007, was able to continue data collection on the pelagic zone of Lake Tanganyika and also compare data collected by previous participants. Using 10 years of data, changes in nutrient upwelling and chlorophyll *a* concentrations could be addressed, particularly with respect to how they relate to changes in climate.

Introduction

Temperature change on a global scale has been observed to be changing from 0.4-0.8°C since the late 19th century (National UK Statistics, 2006). However, how this global change may be impacting unique regions has been largely unexplored. Temperature variability in the African region has some natural basis driven by El Nino/Southern Oscillation and some changes that may be due to anthropogenic activities (Hulme, 2001). A warming of 0.5°C throughout the 20th century has already been experienced so far in Africa (Hulme, 2001). Tropical lakes of equatorial regions such as the great lakes in Africa may be a good indicator of climatic changes since these systems usually are thermally stratified and have somewhat similar climatic conditions year round. Changes of ecosystem dynamics such as nutrient fluxes, dissolved oxygen levels, and temperature profiles in tropical lakes, such as Lake Tanganyika, may be able to provide a correlation between climate change and impacts on water ecosystems. Productivity in East African lakes also is especially imperative to investigate since the growing population in the region tends to rely on the protein in which these lakes can provide.

In order to keep the lake productive, certain climatic conditions are necessary to keep limiting nutrients such as silica, nitrate, and phosphorous available to phytoplankton in the oxic zone. Upwelling events, which move cooler, nutrient-rich water up from deeper regions, are especially important (Coulter, 1991). Nitrogen, a limiting nutrient for phytoplankton in Lake Tanganyika, is added to the epilimnion by rainfall, nitrogen fixation, runoff, and upwelling events (Edmonds, 1993). Phosphorous is brought to the surface waters most significantly by upwelling events (Edmonds, 1993). Therefore, changes in climate such as a decrease in wind velocity, rainfall, and air/water temperature, can have a significant impact on the availability of nutrients.

A recent decrease in rainfall throughout Africa has already been studied by Nicholson (2001). However, other changes in climate such as wind velocity and temperature and how they affect the productivity of the lake have not been adequately studied. Less wind may decrease the number and intensity of upwelling events, which can limit nutrients available for phytoplankton. By limiting the nutrients available in the oxic zone, overall productivity of the lake may be altered. Temperature increases may also affect productivity since oxygen solubility is affected significantly by temperature (Wetzel, 2001). Decreases in oxygen availability can impact productivity as well since it is fundamental for all aerobic organisms. With a decrease in the available limiting nutrients for phytoplankton and a decrease in oxygen, there may be effects on the entire pelagic zone of Lake Tanganyika since phytoplankton are a vital part of the pelagic food web.

Methods

The sample site was similar to past years of data collection at GPS coordinates S04° 51.605 E029° 35.324. Measurements and samples were taken between 9am-12am two times per week throughout the month of July. Using the *R/V Echo*, water samples were collected using a 7 liter sampler at depths of 0, 10, 20, 40, 60, 80, and 100 meters. A Sea Bird CTD probe was used to collect general data such as temperature, conductivity, depth, pH, and dissolved oxygen down to 100m. A 20cm diameter Secchi disk was used by 3-4 people to determine an average transparency of the water.

When returned to the lab, water samples of 2L from each depth were prepared using vacuum filtration with a 0.45µm filter. These filters were used for the chlorophyll *a* analysis and soaked in 95% ethanol for 24 hours. After

24 hours, filters were removed and centrifuged for 15 minutes. Absorbance readings were taken using a Turner Designs Aquafluor fluorometer after the initial preparation and then a second reading was taken after 2 drops of 2M HCl were added.

Nitrate, silica, and phosphorous concentrations were measured as well using a Hach DR 2400 Portable Spectrophotometer. Data was analyzed using Microsoft Excel and Sigma Plot 8.0.

Results

2007 Data

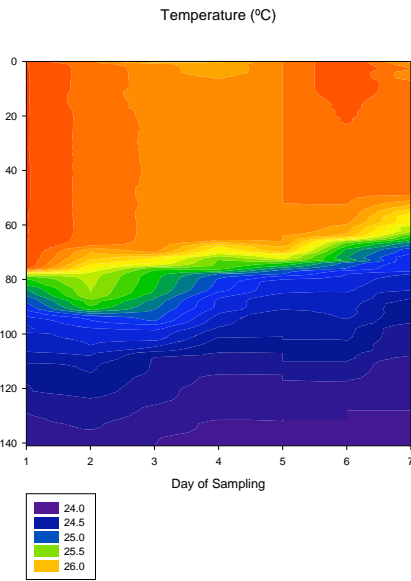


Figure 1. Temperature related to depth over the sampling period

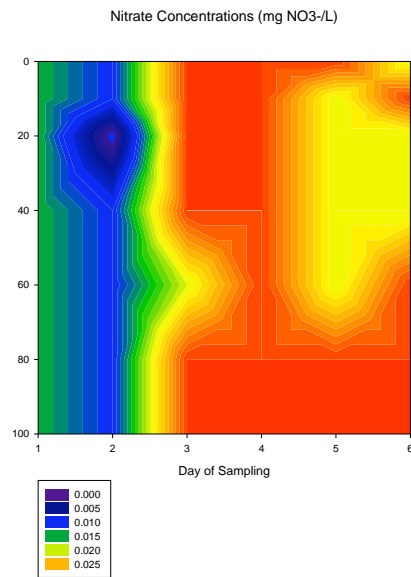


Figure 2. Nitrate concentrations related to depth over the sampling period

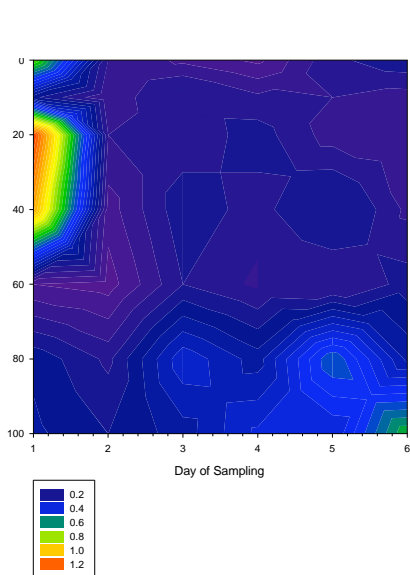


Figure 3. Phosphorous concentration related to depth over the sampling period

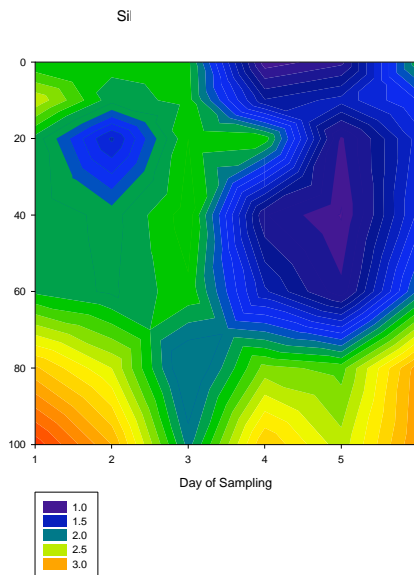


Figure 4. Silica concentration related to depth over the sampling period

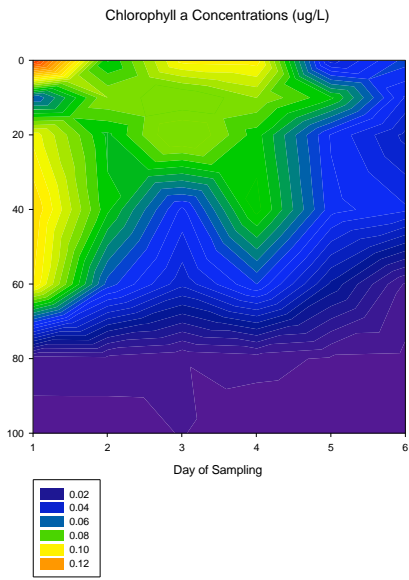


Figure 5. Chlorophyll a concentrations related to depth over the sampling period

1998-2007 Data

Maximum Temperature 1985-2007
P-Value= 0.0613

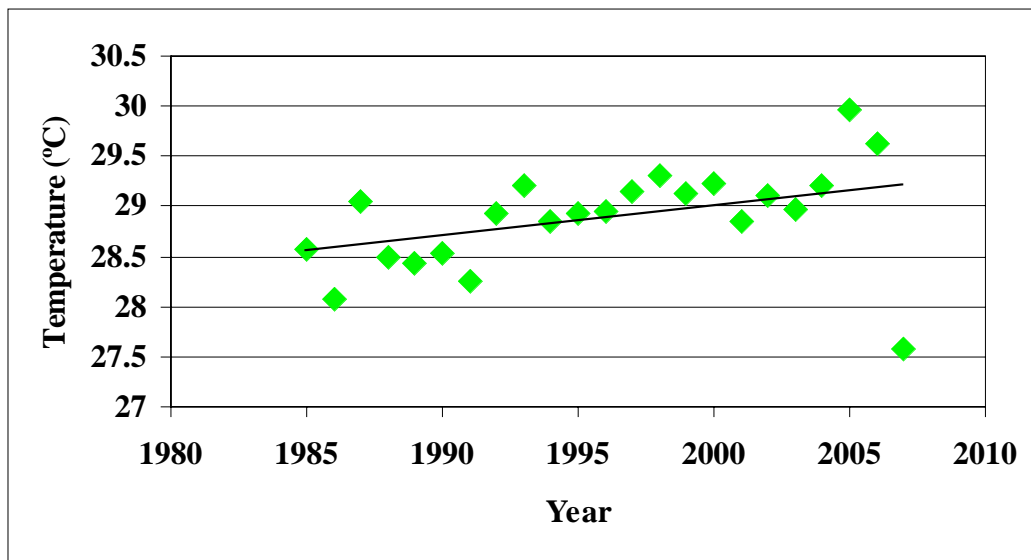


Figure 6. Maximum mean yearly air temperature over 10 years from 1985-2007 collected from Tanzania Meteorological Agency-Kigoma Observatory

Mean Summer (May, June, July) Windrun

P-value= 0.0426

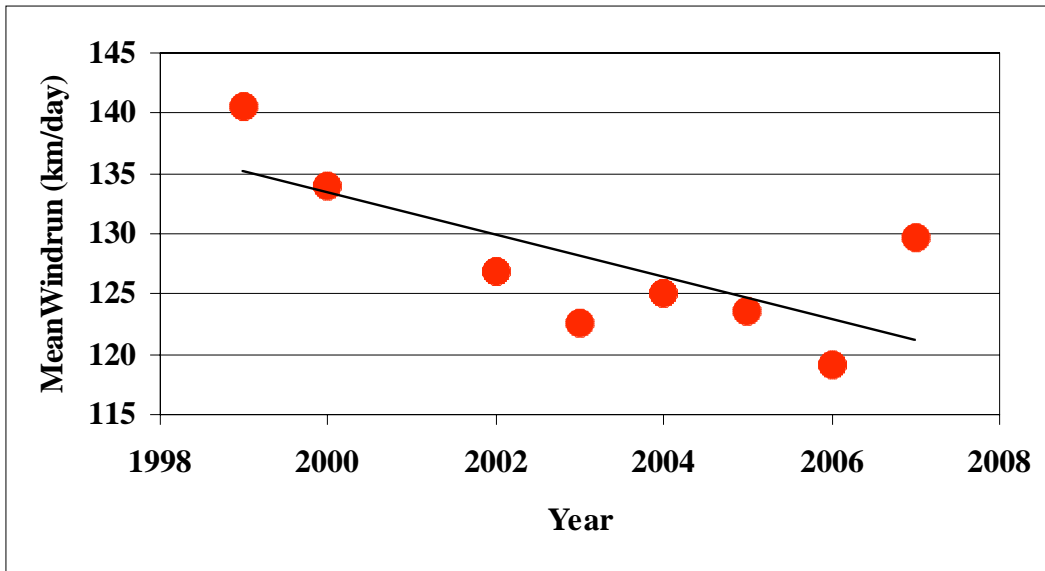


Figure 7. Mean windrun of May, June, July from 1998-2007 collected from Tanzania Meteorological Agency-Kigoma Observatory

Mean Surface Water Temperature

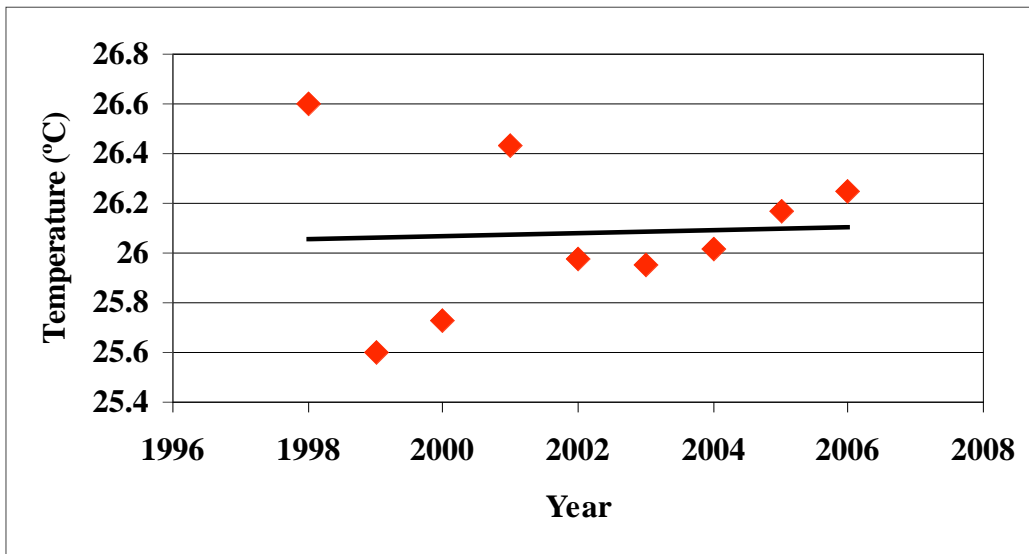


Figure 8. Mean surface water temperature from sample periods of 1998-2007 collected by previous Nyanza students

Correlation Between Phosphorus and Chlorophyll a

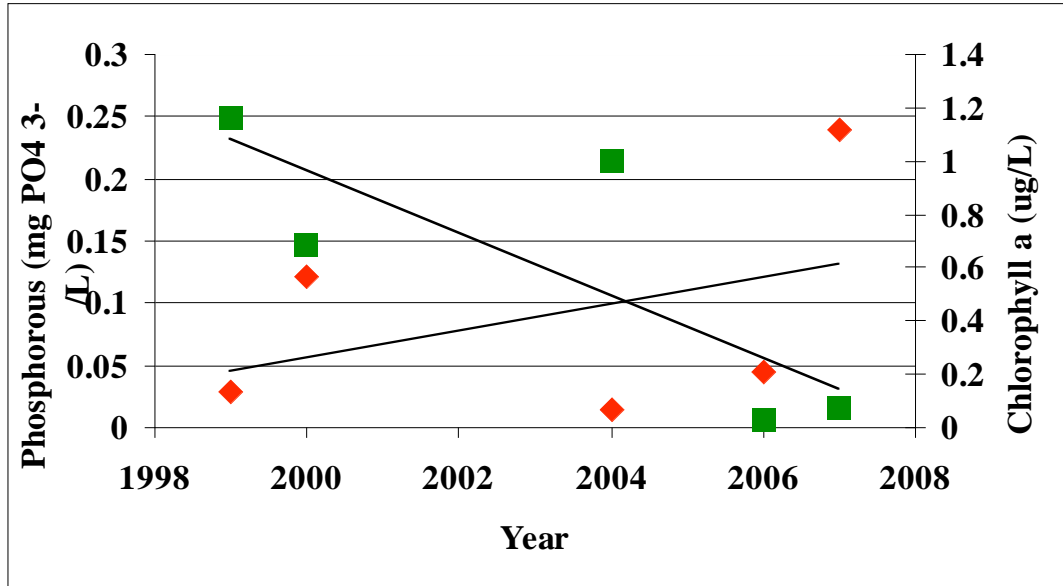


Figure 9. Mean phosphorus (diamond) and chlorophyll a (square) concentrations from sample periods of 1998-2007 collected by previous Nyanza students

Discussion

Data collected from the Kigoma Airport showed that there was an increase in maximum and minimum temperature and also a decrease in wind run during the summer months. This supports the idea that climate change has been occurring in the Kigoma region. The p-value for this correlation may be even lower as well since data for 2007 was only collected until July (which is still in the cooler season) instead of the whole year.

The data that I collected this year suggested that there may be been some upwelling on the last day of sampling because of the slight increase in cooler waters. Meteorological data supports this upwelling because the July wind run for 2007 was the third highest out of the past 10 years. However, the nutrient data did not seem to correlate with the temperature decrease. There was a decrease in nutrients and chlorophyll a over the sample period. This may be due to a time lag between the increase in nutrients and ability of phytoplankton to utilize them (pers com Ishmael Kimirei). In that case, the sampling period would not have recorded the increase in phytoplankton.

Analysis of 1998-2007 data showed some trends that may be related to climate change. There has been an overall increase in nutrients and a decrease in chlorophyll a. This may be explained by the fact that we only analyzed nutrients that were left in the filtered water. Therefore, any nutrients within the phytoplankton would not have been accounted for. So, if there is a lot of phytoplankton in the water, all the nutrients would be utilized by the organisms and trapped within their bodies, while a decrease of phytoplankton would cause an increase of nutrients due to the lack of uptake. Also, Ishmael Kimirei's hypothesis that there is a time lag between input of nutrients and uptake by phytoplankton could explain the inverse relationship between nutrients and chlorophyll a concentrations.

Some complications with the study were encountered through the data collection from past years. There was a lot of nutrient data missing from the past ten years—only about 5 years were recovered so far. Also the collection methods from the past ten years varied greatly. Each year there were different students collecting the data,

from slightly different locations, and using different technology. Temperature readings alone varied from a basic thermometer to the CTD probe in recent years.

Although there was some inconsistency in the data set, some conclusions can be made about the available information. With a decrease in summer winds, there is an increase in surface water temperatures. Also, there is an inverse relationship between available nutrients in the water and chlorophyll a concentrations.

Acknowledgements

I would like to thank Dr. Catherine O'Reilly and Willy Mbemba for their guidance in teaching me all about the methods to study the limnology of Lake Tanganyika. I also must thank all the mentors for their hard work behind the scenes to organize this project and give us all a unique research experience. I would like to acknowledge Ishmael Kimirei for his intellectual input into my project—he was a great asset in the analysis of my data. My project also relied on TAFIRI and the Kigoma Airport for their generosity of facilities and data. The staff of Nyanza—Issa, Mupape, and Mbata—must be thanked as well for keeping everything running properly during our time at TAFIRI. Finally I am very grateful additionally to the National Science Foundation for their financial support (NSF grant #s ATM 0223920 and DBI-0608774).

References

- Edmonds, J.M. et al. (1993). Nutrient chemistry of the water column of Lake Tanganyika. *Limnology and Oceanography* 38(4): 725-738.
- Hecky, R.E. et al (1991). *Lake Tanganyika and its Life*. G.W. Coulter, ed. London: Natural History Museum Publications.
- Hulme, M., R. M. Doherty, T. Ngara, M.G. New, and D. Lister. (2001). African Climate Change 1900-2100. *Climate Research*, Vol. 17, No. 2, pp. 145-168
- National UK Statistics (May 26, 2006). Hadley Centre for Climate Prediction and Research.
- Nicholson, S. and Yin, X., 2002. Mesoscale patterns of rainfall, cloudiness and evaporation over the Great Lakes of Africa. In: *The East African Great Lakes: Limnology, Palaeolimnology and Biodiversity*, eds. E. O. Odada and D. O. Olago. Kluwer Academic Publishers, Dordrecht, Netherlands, pp. 93-120.
- Wetzel, Robert G. (2001). *Limnology*. 3rd ed. San Diego: Academic Press.