

# Physical parameters as indicators of upwelling in the pelagic zone of Lake Tanganyika

**Student: Charles B. Athuman**

**Mentor: Dr. Catherine O'Reilly**

## Introduction

Lake Tanganyika is situated between 3°30' and 8°50'S and 29°05' and 31°15'E. It occupies a deep and narrow trough of the Western branch of the Rift Valley of East Africa (Coulter, 1994). It is also one of the oldest lakes with estimated age of 9-12 Ma (Cohen, 1993). It supports a highly productive pelagic fishery that provides 25 – 40% of animal protein supply for the people of the surrounding countries (Molsa et al, 1999). The lake is oligotrophic and permanently thermally stratified with an anoxic hypolimnion (O'Reilly, 2003). The upwelling events during dry season (May to September) force the nutrients-rich water upward, displacing warmer oxygenated waters and boosting nutrient availability to the entire biotic community. This occurs, according to Coulter (1991), every 26-33 days in water column due to Southeast winds. This then tends to weaken the thermocline through the changes in temperature, leading to decrease in surface-water temperature. A study by O'Reilly (2003) showed that there was an increase of 0.31°C in pelagic water temperature from 1938 to 2003, which is a significant climatic warming and comparable to that found in other African Great Lakes. Along with increased temperatures, wind speeds in Lake Tanganyika watershed have declined by 30% since the late 1970s. Therefore, by studying the dry season water chemistry, we may better understand the changes in physical parameters and hence pelagic upwelling.

## Objectives

The purpose of this study was to investigate the physical parameters changes in the pelagic zone of lake Tanganyika and how they lead to upwelling at various depths. However, I hypothesized that temperature changes indicate upwelling.

## Methods

The water column of a pelagic site was sampled (04°51.260'S, 029°35.540' E) on the 15<sup>th</sup>, 18<sup>th</sup>, 21<sup>st</sup>, 24<sup>th</sup>, 28<sup>th</sup>, and 31<sup>st</sup> of July, 2003 between 9 and 12 am. Sampling took place at depths of 0 m, 20 m, 40 m, 60 m, 80 m and 100 m. Unfiltered sampled water was taken to the lab where turbidity was measured using a Hach turbidimeter, model 2100P. Results were expressed in Nephelometric Turbid Units (NTU). Secchi (transparency) measurements were made with a 20 cm diameter Secchi disc. The mean value of measurements made by two separate observers was recorded. The CTD was connected to the winch on the *R/V Echo* and then lowered in the water. The CTD collected the data for temperature (°C), conductivity (µS/cm), pH and Dissolved Oxygen (mg/L) at depths ranging from 0 to 175 m. The collected data were downloaded in the computer at the Climplake office and converted to the exact units before they were taken to Excel and then to SigmaPlot for interpretation.

## Results

### *Temperature*

Temperature showed fluctuations throughout and ranged from 24.0°C to 26.0°C (Figure 1). High temperature zones (epilimnion) were observed between 0 m and 80 m on day 4 of my sampling and between 0 m and 45 m on day 17. Low temperature zones (hypolimnion) were observed below 90 m on day 7 and below 80 m on day 17 of sampling. Further, the shallowest peak for hypolimnion was observed at 76 m on day 14. The intermediary layer between the epilimnion and the hypolimnion that includes the thermocline fluctuated between 60 m and 80 m. The air temperature as recorded by TAFIRI ranged from 24°C to 28°C throughout the sampling time (Figure 5). The wind speed ranged from 1.0 m/s and 3.5m/s and varied throughout the time of sampling (Figure 4). The highest wind speed was observed on the 10<sup>th</sup> day between 10:00am and 11:00am.

### *Dissolved Oxygen*

The highest dissolved oxygen was recorded between 0 m and 70 m and 10 m and 40 m on days 4 and 17 of sampling, respectively (Figure 2). The lowest dissolved oxygen was recorded below 82 m on day 4 and below 50 m on day 17. The oxycline was observed to be between 70 m and 82 m on day 4 and between 40 m and 50 m on day 17. Oxygen was found even at depths below the thermocline. (Figure 2). This seemed to agree with the findings of Kimirei et al. (2000).

### *Turbidity*

Turbidity ranged from 1 NTU to 5 NTU (Figure 3). The turbidity was observed to be 5 NTU between 0 m and 20 m and 3 NTU between 60 m and 95 m on the 14<sup>th</sup> day. However, turbidity generally decreased with increasing depth from the surface except on the 10<sup>th</sup> and 11<sup>th</sup> days where the turbidity of the water was less than 1 NTU and 2 NTU to 100 m.

### *Transparency*

The Secchi disk (transparency) measurements ranged from 9 m and 11.8 m (Figure 6). The highest transparency was 11.8 m and it was observed on the 17<sup>th</sup> day of sampling. The lowest measurement was 9 m and this was observed on the 4<sup>th</sup> sampling day. The average transparency of the pelagic waters was 10.8 m throughout the sampling days.

## **Discussion**

### *Temperature*

The highest surface temperature recorded on the 4<sup>th</sup> day probably results from the temporal warming of the water surface due to high radiation during the sampling time. The changes in temperature on days 7 and 17 suggest the presence of upward movement of the deep cold waters above the thermocline (Figure 1). The highest peak observed on the 14<sup>th</sup> day seemed to fit with the findings by Coulter (1991) and indicated the presence of pelagic upwelling events. Probably this was due to the high wind speed on the 10<sup>th</sup> day of sampling which forced the deep cold waters to move upwards in the 14<sup>th</sup> day and hence cooled the surface waters up to 60m (Figure 1). Generally, Figures 4 and 5 revealed that air temperature decreased as the wind speed increased. O'Reilly (2003) noted that the combined effect of increasing temperatures and decreasing wind speeds is to increase the stability of the lake and to reduce the mixing depth and hence diminish deep-water nutrients inputs to the surface waters as the result causing the decline in primary productivity rates.

### *Dissolved Oxygen*

The lowest dissolved oxygen (Figure 2) observed suggests the presence of turbulent mixing of deep waters with less oxygen concentration. This may probably be linked with the upwelling events. According to Wetzel (1983) dynamics of oxygen distribution in lakes are governed by a balance between inputs from the atmosphere and photosynthesis, and losses due to chemical and biotic oxidation. The highest dissolved oxygen observed might be due to the inputs from the photosynthesis as the result showing that water was in equilibrium with the atmosphere. Because oxygen is the basic to the understanding of the distribution, behavior and growth of aquatic systems, the difference in amount of oxygen indicated also changes in productivity (Wetzel, 2001).

### *Turbidity*

The high turbidity observed on the 14<sup>th</sup> day of sampling suggests the presence of mixing of the deep water with many nutrients, probably increasing phytoplankton and small zooplankton. Therefore, the high turbidity on that particular day of sampling indicated the presence of upwelling events and thus, eutrophication. This has also been observed by the results for temperature (Figure 1). However, the low turbidity observed on the 10<sup>th</sup> and 11<sup>th</sup> days showed that upwelling events were not continuous. The increase in turbidity towards the thermocline from the 13<sup>th</sup> to the 15<sup>th</sup> days suggested a deep pulse of production (Figure 3).

### *Transparency*

The highest transparency recorded on the 17<sup>th</sup> day indicated that there was no mixing of the deep-waters. This however, suggested probably low productivity of the lake on that particular day. The lowest Secchi

disk measurement done on the 4<sup>th</sup> day indicated the presence of mixing processes of deep-waters, probably introducing phytoplankton into the water mass and reducing transparency. This might be after the upwelling events as the result, high productivity.

## **Conclusions and Recommendations**

The results obtained showed fluctuations in temperature and dissolved oxygen indicating upwelling events in the pelagic zone of Lake Tanganyika. It is recommended that future work be focused on monitoring and evaluation of changes in physical parameters and their effects on the availability of nutrients, and consequently their influences on the Lake Tanganyika aquatic ecosystem productivity.

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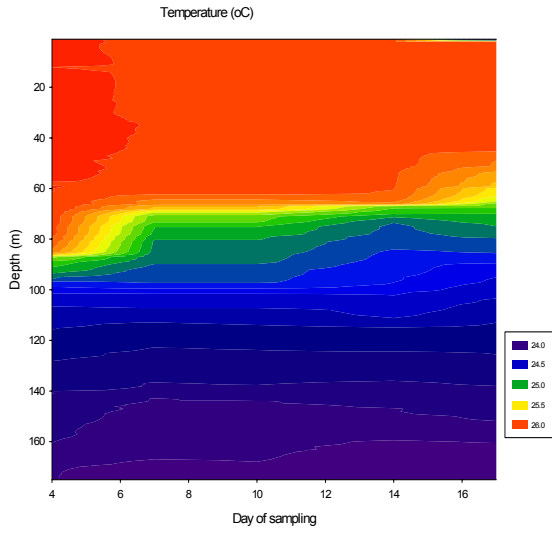


Figure 1

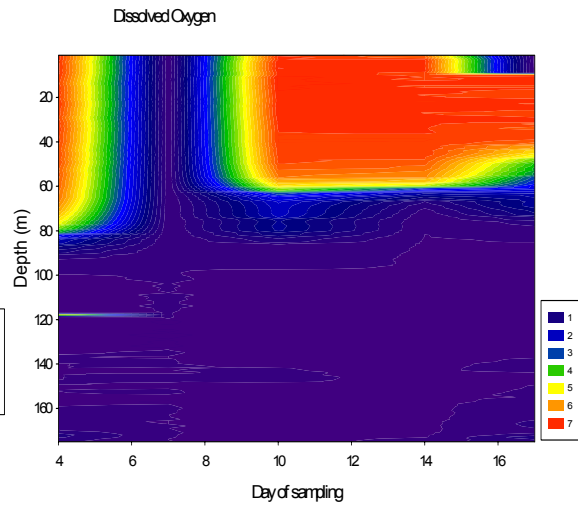
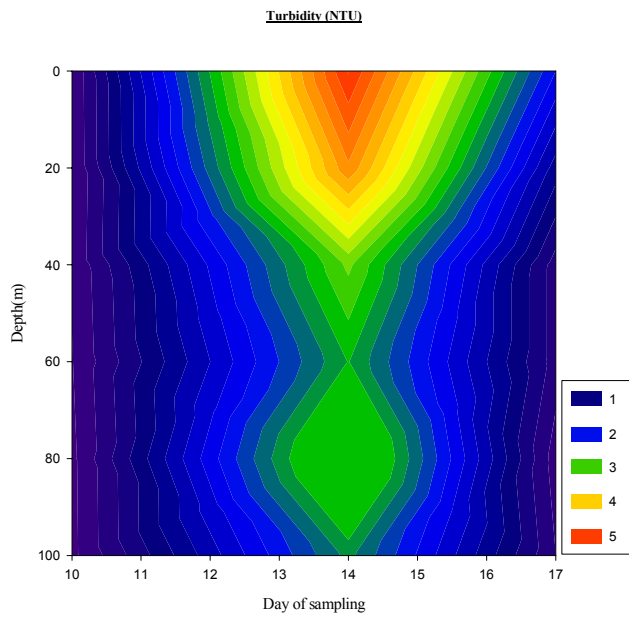
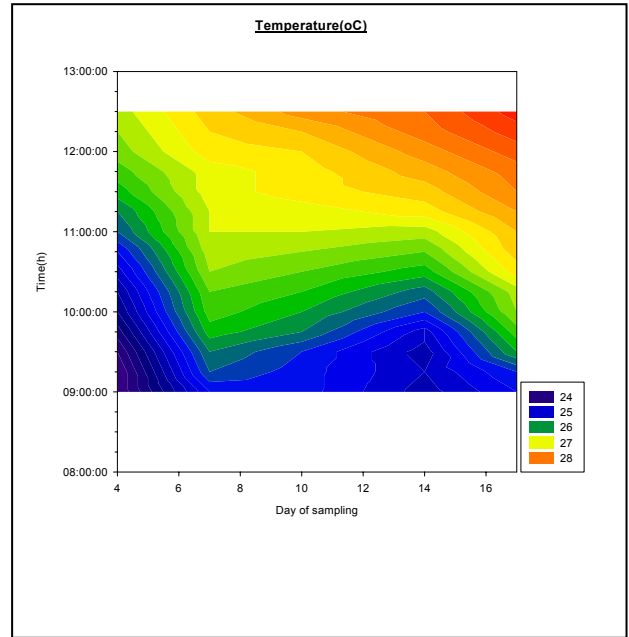
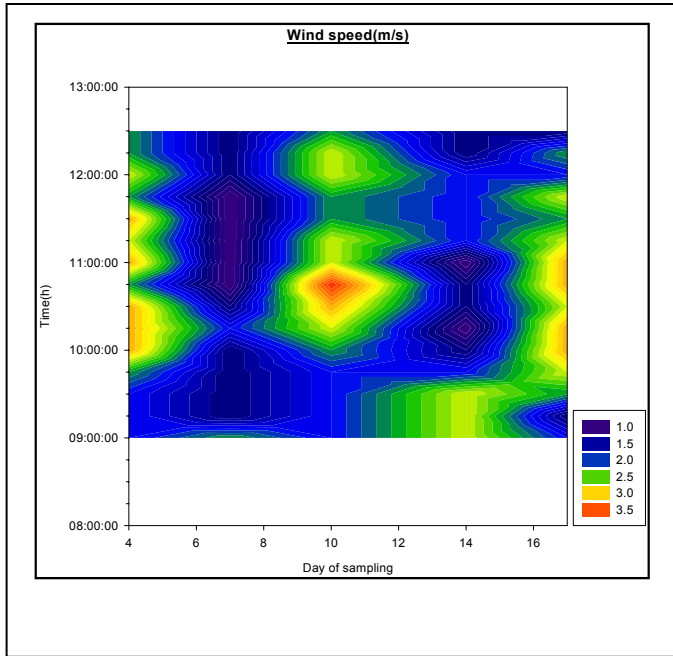


Figure 2

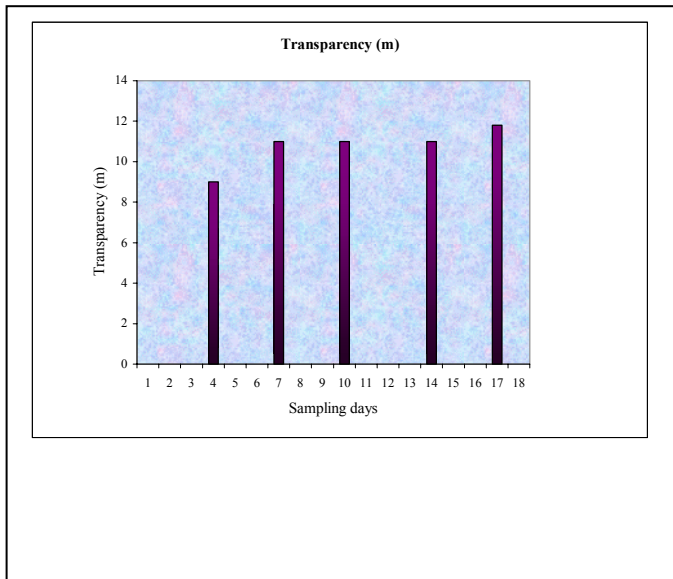
Figure 3





**Figure 5:** Air temperature throughout the sampling days.

**Figure 4:** Wind speed throughout the sampling days.



**Figure 6:** Water transparency throughout the sampling days.