Variation with time of physical- chemical parameters and nutrients in pelagic zone of Lake Tanganyika: (Kigoma Bay)

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Objective:

The aim of the study was to evaluate the variation of selected physical - chemical parameters in the pelagic zone of Lake Tanganyika, and to investigate how wind intensity influences the rate of upwelling in the pelagic zone of that lake at Kigoma Bay. I also compared my results on the limnological conditions with those recorded during the last three years of the Nyanza Project.

Introduction:

Lake Tanganyika is one of the oldest Rift valley lakes, with an estimated age of 9~12 Ma (Cohen, 1993). Lake Tanganyika hosts one of the largest inland fisheries in Africa and is a significant source of food and livelihood to millions dwelling inside and outside of its basin (Lindqvist et al. 1999). It supports a highly productive pelagic fishery that provides 25-40% of the animal protein supply for the people of the surrounding countries (Mölsä et al, 1999). The lake is oligotrophic and permanently thermally stratified.

Upwelling events and internal waves occur in the lake during the dry windy season (May to September), which forces nutrient-rich water upwards, displacing warmer oxygenated water and boosting nutrient availability to the entire biotic community. These mixing events provide the dominant source of some limiting nutrients (phosphorus and silica) to the surface water and are important in maintaining the pelagic food web. This upwelling tends to weaken the thermocline by changing the temperature profile, resulting in decreased surface water temperatures following high winds.

The effects of the climatic warming coupled within decreased windiness around Lake Tanganyika has been an increase in the stability of the water column and a reduction in mixing, diminishing the productivity of the lake (O'Reilly et al 2003).

Materials and methods

Study site:

Water samples from the pelagic zone of Lake Tanganyika were collected at Kigoma B at a site located at S 04^o 51.577' E 029^o 35.382' on the 13th, 17th, 20th, 24th, 27th and 31st of July 2006 between 9:30 and 12:00 am. Sampling was conducted twice per week, Monday and Thursday. Also I used wind data from the Tanzania Metrological Agency from Kigoma Airport to investigate wind intensity (Fig. 1).

Water Sampling

Water samples were collected from seven different depths (0, 20, 30, 40, 60, 80 and 100m) using a 7 litre water sampler bottle. Transparency measurements were taken using a 20 cm. diameter Secchi disk (SD) at the beginning of each sampling period, with mean values recorded. A Sea Bird CTD was deployed between 0-120 m depths from the *R/V Echo* winch. CTD data was uploaded using *Sea Bird Software*, to determine vertical profiles of dissolved oxygen (in % or mg/l), pH, conductivity (µS/cm), temperature (°C) in the pelagic zone. Unfiltered water was used for turbidity measurement (NTU) using a Hach Turbidimeter 2100P model. Water from each depth in the pelagic zone was filtered (3 l) through Gelman A/E glass fiber filters. Measurements for nutrients (soluble reactive phosphorus, nitrate and silica) were taken using a Hach DR 2400 Portable Spectrophotometer. Chlorophyll *a* was extracted in 10 ml of 96% ethanol for at least 24 hours in a refridgerator in darkness, and determined using a Turner Designs Aquafluor fluorometer after 15 minutes of centrifuging. Finally, I used the following Microsoft Excel, JMP IN and Sigma Plot 8.0 to tablulate, analyze and plot my data.

Results:

Epilimnion:

The epilimnion ranged from 0-67 m on the first study day (July 13th) and 0-71 m on the last day (July 31st). The maximum temperature was 26.23° C and the minimum was 25.72°C. The maximum dissolved oxygen value was 7.28 mg/l and the minimum value was 4.86 mg/l. The maximum conductivity value was 672.80 µS/cm and the minimum was 660.72 µS/cm. The maximum pH value was 9.02 and the minimum value was 8.92 (Fig. 2).

Metalimnion and thermocline:

The metalimnion ranged from 67-90 m on the first day of sampling (July 13th) and between 71-93 m on the last day (July 31st). Temperature ranged from 26.20° C to 24.27° C, Dissolved oxygen ranged from 7.06 mg/l to 0.33 mg/l, Conductivity was between 683.93 and 671.68 $\mu S.cm^{-1}$ and pH value was between 9.01 and 8.7 (Fig. 2).

Hypolimnion:

The top of the hypolimnion ranged between 97 m on the first day (13th) and 93 m on the last day (31st). The maximum hypolimnetic temperature within the measured range (≤120m) was 24.61° C and the minimum was 24.16° C. Dissolved oxygen values within the measured ranged were between 0.35 mg/l and 0.27 mg/l whereas conductivity ranged from 682.92 to 683.78$\mu S.cm^{-1}$ and pH was between 8.60 and 8.73 (Fig.2).

Nutrients and Chlorophyll a:

Nitrate values ranged between 0.0 and 0.33 mg/l (Fig. 4a). Soluble reactive phosphorus ranged between 0.0 and 0.30mg/l (Fig. 4b). Silica ranged between 0.06 mg/l and 0.90 mg/l (Fig. 4c) and chlorophyll *a* values ranged from 0.06µg/l to 0.90µg/l (Fig. 4d).

Transparency:

Turbidity ranged between 0.12 NTU and 0.36 NTU, with the highest values measured at the end of the study period. The Secchi depth shifted between 10.4 m and 14.8 m, with minimum values measured at the end of the study period (Fig. 8).

Wind velocity:

In 2003 the June wind speed averaged 5.1 km/h and for July it was 5.6 km/h. In 2004 it was 5.7 km/h for June and 5.7 km/h for July. In 2005 the June winds averaged 4.8 km/h and for July 6.1 km/h. In 2007, average wind speed was 5.3 km/h in June and 5.3 km/h in July (Fig. 9).

Discussion:

During my research period thermal stratification was well marked and the thermocline moved slightly deeper on the last day (Fig. 2). The values for the physical-chemical parameters and nutrients were similar to those found by Plisnier (1999) and Chitamwebwa (1999) in prior dry seasons at Kigoma. During my research period the values of these parameters were almost the same from the first day to the last day. The high transparency and low turbidity indicates that there was no mixing and low productivity, and an absence of upwelling. Increasing turbidity at the end of my study period corresponded with the lowest Secchi depth values (SD) and a cooling of the epilimnion, suggesting there could have been some upwelling. This increasing turbidity was probably caused by the suspension of allochthonous particles, as opposed to algal growth, because chlorophyll *a* values did not show any increase during my research period (the latter ranged between 0.06µg/l to 0.90µg/l). At Kigoma, Plisnier (1999) found a correlation between water-cooling and reductions in Secchi depth in the epilimnion. Oxygen solubility decreases with depth because of decomposition (Fig. 3b), so it is common to find low concentrations in deep water. Conductivity increases with depth (Fig. 3d), as it depends on dissolved solutes in the water column.

By making a comparison of my data with that of the last three years of the Nyanza Project, and using weather data from TMA/Kigoma Airport, it is possible to infer that upwelling occurred in 2003 and 2004, but not in 2005 and 2006.

Conclusion:
This study suggests that wind intensity is a major parameter influencing the rate of upwelling in Lake Tanganyika. If the effects of the climatic change at Lake Tanganyika is to decrease wind speed and increase temperature thereby increasing the stability of the water column, then there will be reduced mixing, and hence diminished productivity in the lake.

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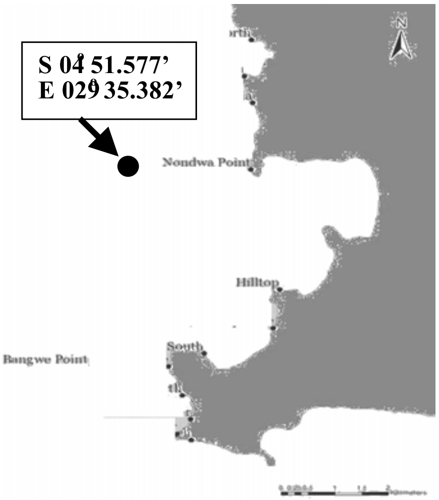


Fig. 1. : Pelagic sampling

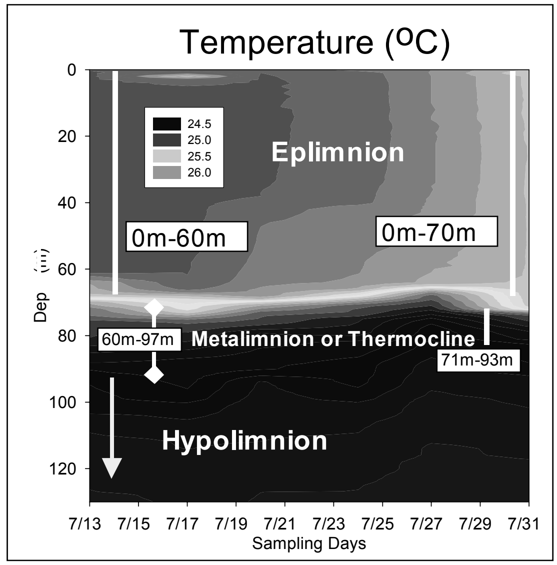


Fig. 2: Lake stratification during my research period

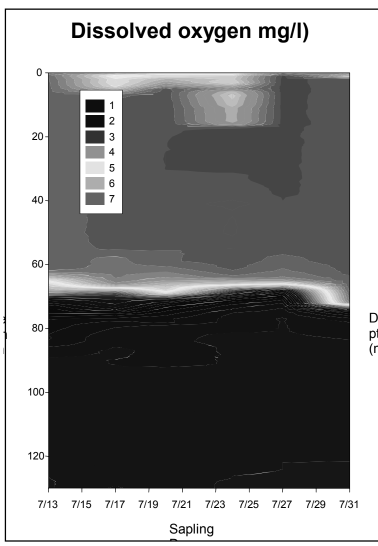


Fig. 3b

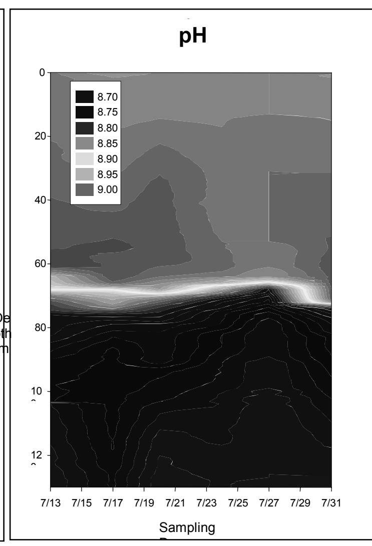


Fig. 3c

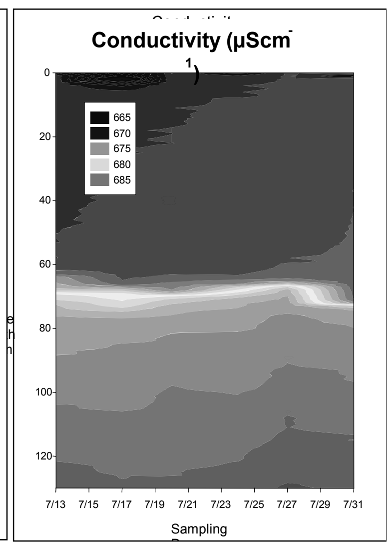
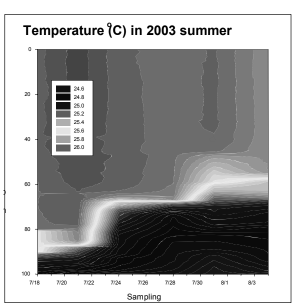


Fig. 3d



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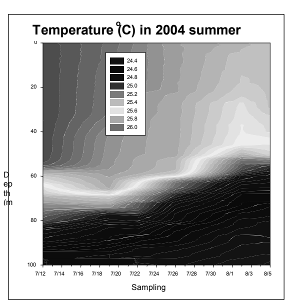

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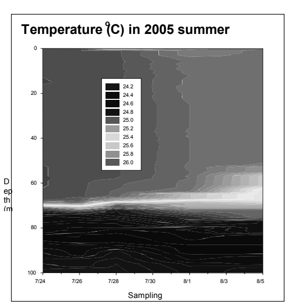

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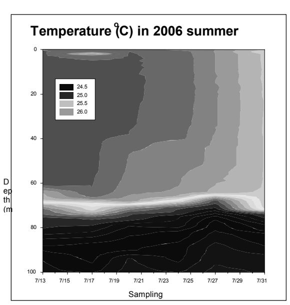

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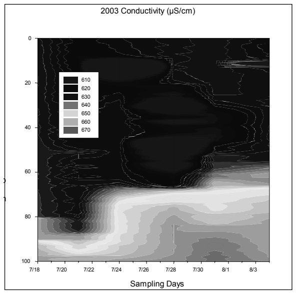

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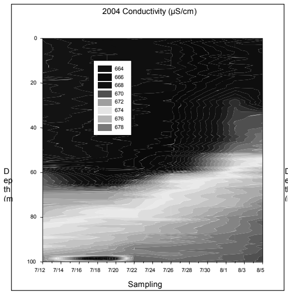

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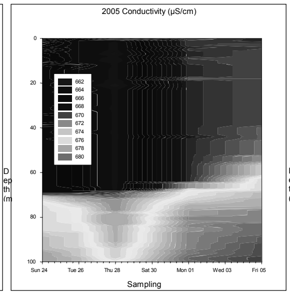

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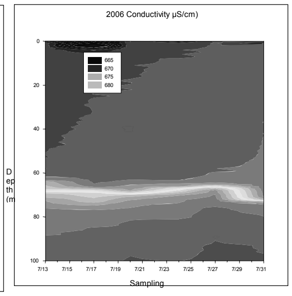

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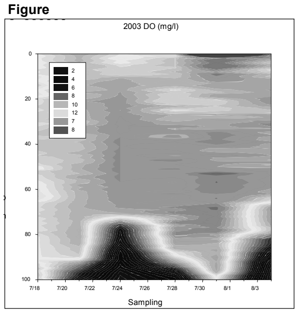

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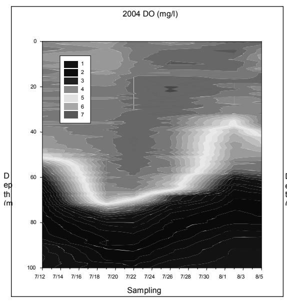

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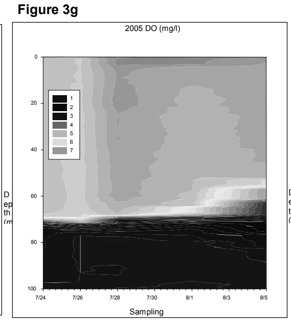

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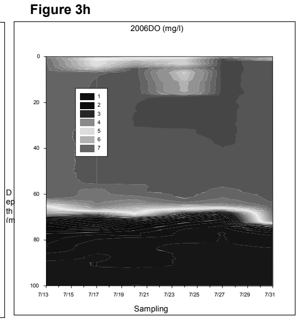
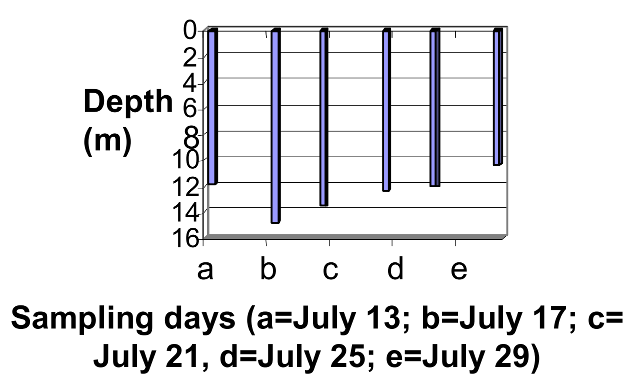


Figure 3l

Figure 4. Secchi Depth



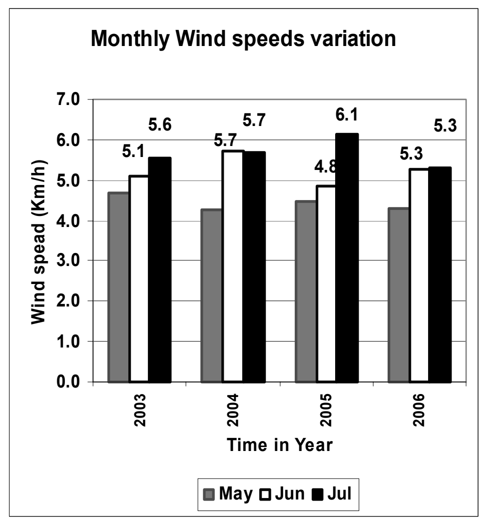


Fig. 5: May, June and July Wind speed from 2003 to 2006