The impact of climate change in Lake Tanganyika by using physical parameters

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Objective

The aim of the study was to investigate changing hydroclimate in Lake Tanganyika by using physical parameters and to investigate how global warming influences the rate of upwelling in the pelagic zone of Lake Tanganyika (Kigoma bay) during my research period. I also made a comparative study of the limnological data for the last nine years of the Nyanza Project.

Introduction

Lake Tanganyika is a large Rift valley lake (length 65 km, mean width 50 km, mean and maximum depth 570 m and 1470 m) near the equator (3 to 9 degrees). Along with its high water temperature (23.25° to 27.25°C), thermal stratification is well marked and varies seasonally above an apparently permanent anoxic hypolimnion. The lake can be classified as meromictic. The lake experiences two main seasons: a 4 month dry season from May through August characterized by cooler dry conditions and a fairly constant southerly wind and a wet season during the rest of the year when winds are generally lighter and mainly northerly. In the lake environment most cooling and mixing takes place in the dry season and maximal stratification occurs during the warmer wet season. The lake is oligotrophic and permanently thermally stratified into:

1. *Epilimnion* (mixed layer Craig et al, 1974), which can approach thermal and gaseous equilibrium with the atmosphere. This is the upper stratum of relatively uniform warm and circulating water.
2. *Metalimnion*: The stratum just below the epilimnion where wind energy is not sufficient to mix the water at these depths. This is a region of greatest change in temperature and the plane of maximum rate of decrease of temperature with depth (Thermocline).
3. *Hypolimnion*: The lowest stratum in the lake, which is anoxic and generally colder.

Local climate change can be influenced by different factors including: human activities such as cutting down trees, pollution and global warming. Climate warming through increased water density gradient slowed vertical mixing and reduced primary productivity in Lake Tanganyika (O´Reilly et al 2003).

Study site

The water samples of pelagic zone were collected at Kigoma Bay (S04°, 51.605'and E029°, 35.324') on the 13th, 16th, 19th, 23rd, 26th, 30th of July and 2nd of August 2007 between 9:30 and 12:00 am. Sampling was conducted twice per week, Monday and Thursday. Also I used a meteorological data from the Kigoma airport for an investigation of wind intensity.

Materials and methods

Water samples were collected from different seven depths at 0m, 10m, 20m, 40m, 60m, 80m, and 100m using a 7.4 liter water sampler bottle and put into four liter bottles. Transparency measurements were taken using a 20cm diameter Secchi disk (SD) at the start of the sampling period .The mean value of three readings was recorded. CTD profiles Dissolved Oxygen (in % or mg/l), pH, Conductivity (mg/l) and

Temperature (°C) in the pelagic zone were conducted from the surface to 150 m depths using the *R/V Echo* winch, and then downloaded to a PC. Unfiltered water was taken to the wet lab for turbidity measurements (NTU) using a Hach Turbidity meter 2100P model, and for alkalinity measurements.

Results

Wind Velocity

The mean wind run on June 2007 was 5.1km/hr and July was 6.0km/hr. Mean air temperature was 26.1°C over the course of the year.

Transparency

Turbidity ranged between 0.10 NTU to 0.30 NTU on all sampling days, except for the first day on 13th of July at 80m, when it was 0.96 NTU. The Secchi depth was observed to be between 10.3m and 13.4m with the maximum value on July 30th. During the sampling days water sampling was observed to be clear.

Alkalinity

Alkalinity fluctuated over the sampling period. On the 19th day of sampling at 40m and 100m the alkalinity value was as high as 295, while on 30th from 20m-100m alkalinity value decrease to 275.

Temperature

Temperature decreased both over time and with depth, and the thermocline shallowed over the period of study. The highest water temperature was observed on the surface with the maximum value of 26.41°C with STD (0.01) on 13th of July and minimum value of 26.10°C with STD (0.15) on July 23rd and 2nd of August, which was the last day of sampling. On the first day of sampling the epilimnion ranged from 0m-79m, the themocline was between 79m –100m and the hypolimnion was below this, and on the last day of sampling which was on 2nd August 2007, the epilimnion was between 0m - 50m, the thermocline was ranged from 50m-90m, and the hypolimnion was below that.

Conductivity

The conductivity of the lake was generally very high and was found to decrease with the sampling days and depth. The highest conductivity recorded was 685.83µS/cm (0.87 1□), which was observed on 30th of July, and the lowest value of conductivity was 684.74µS/cm on the 26th of July. The changes of conductivity were relevant as they could be used as indicators of metalimnion movement.

pH

pH was found to be low in deeper waters and high in surface waters that were observed to be increase with the sampling days. The highest pH was 9.20 on 2nd of August which was the last day of sampling. The lowest value was 9.12 on 13th of July (Fig.1c).

Dissolved Oxygen

Generally the amount of dissolved oxygen was increased over time and at shallower depths. The highest value of DO was found to be 6.45 (mg/L) with STD (0.22) on 26th of July and lowest value was 5.86 (mg/L) with STD (0.1). On the first day of sampling (13th of July) the epilimnion ranged from 0m-70m, and the oxycline was between 70m-91m. On the last day of sampling (August 2^{nd}) the epilimnion was 0m-59m, and the oxycline ranged from 59m-80m (Fig.1f).

Discussion

It would appear that the productivity of Lake Tanganyika is highly dependent on the hydrodynamic state of the lake and on climatic conditions particularly the wind and the heat budget (Coulter et al 1974). Through my research period, temperature of the lake was observed to decrease with depth and the sampling days. The thermocline was increasing as on the 13th of July, which was the first day of sampling was ranged from 79m-107m, and on the last day on 2nd of August was ranged from 60m-100m (Fig 1a). Dissolved oxygen was observed over the sampling period and decreased with depth, the oxycline increased from 70m-90m to 60m-80m at the end of the sampling period (Fig.1f). Alkalinity and turbidity were both higher on the first day of sampling (Fig.1d and 1e).

By comparison with the last nine year, in order to get upwelling the wind run in June must be greater than 5km/hr and July greater than 5.5km/hr. In the year 2003, the wind run in June averaged 5.1km/hr, July 5.6km/hr, in 2004 was 5.7km/hr in June and July, in 2007 was observed to be 5.1km/hr in June and 6.0km/hr in July that made provided support for upwelling (Fig.1a, 2a-2d).

Temperature was observed to increase with years as in 1999 temperature was 25.5°C and 2007 temperature was 26.1°C, with the correlation value (r^2=0.1072). In the epilimnion temperature was observed to be higher and increase with years ($P<0.001$), which shows that there is a very significant change in temperature with years. The thermocline was observed to fluctuate over time due to upwelling during the sampling period in some years and not in others. But over time the thermocline generally deepened. In 1999 thermocline was between 0m-47m and in 2007 was ranged from 0m-75m. Dissolved oxygen was observed to decrease compared to other years due to upwelling fluctuation (Fig.1f). The winds speed was observed to decrease with increasing air temperature (r^2 = 0.1408).

Conclusion

Changing climatic conditions, mainly increasing heat and reduced wind speed, seems to be altering the trends of upwelling in Lake Tanganyika. It seems that global warming has impacted Lake Tanganyika as winds speed decreased, and air temperature increased, causing changes in the epilimnion.

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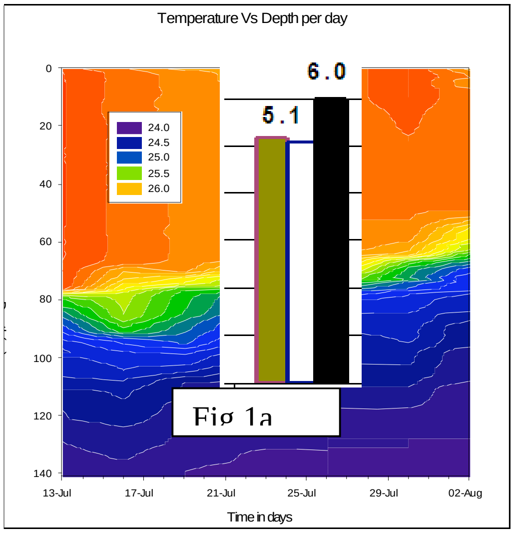
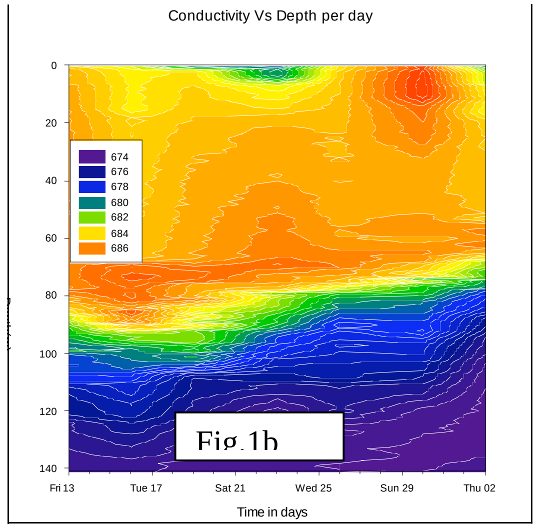
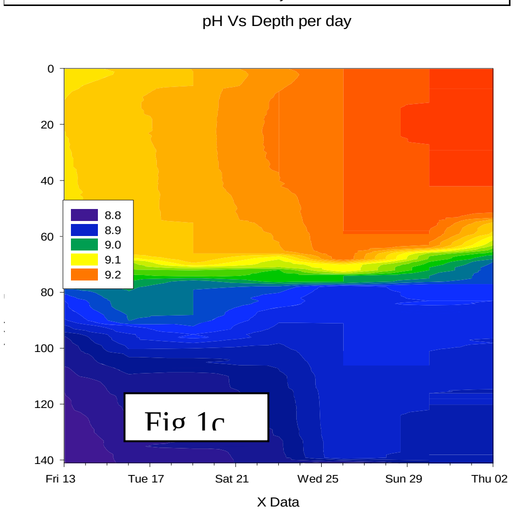
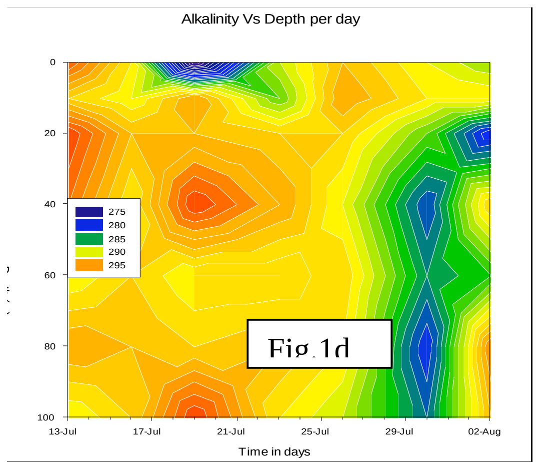

Temperature Vs Depth per day
24.0
24.5
25.0
25.5
26.0
5.1
6.0
Fig 1a
13-Jul 17-Jul 21-Jul 25-Jul 29-Jul 02-Aug
Time in days


Conductivity Vs Depth per day
674
676
678
680
682
684
686
Fig 1b
Fri 13 Tue 17 Sat 21 Wed 25 Sun 29 Thu 02
Time in days


pH Vs Depth per day
8.8
8.9
9.0
9.1
9.2
Fig 1c
Fri 13 Tue 17 Sat 21 Wed 25 Sun 29 Thu 02
X Data


Alkalinity Vs Depth per day
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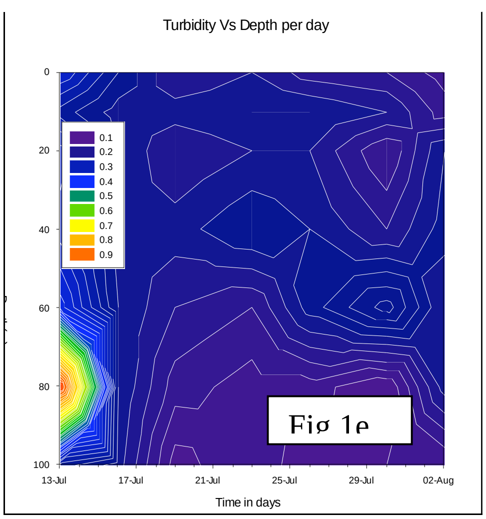
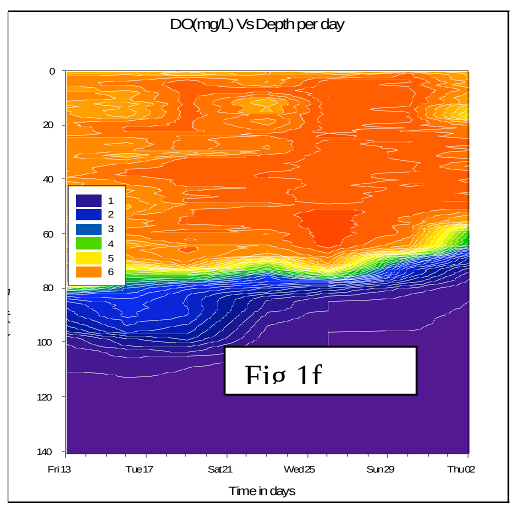
280
285
290
295
Fig 1d
13-Jul 17-Jul 21-Jul 25-Jul 29-Jul 02-Aug
Time in days


Turbidity Vs Depth per day
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Fig 1e
13-Jul 17-Jul 21-Jul 25-Jul 29-Jul 02-Aug
Time in days


DO(mg/L) Vs Depth per day
1
2
3
4
5
6
Fig 1f
Fri 13 Tue 17 Sat 21 Wed 25 Sun 29 Thu 02
Time in days

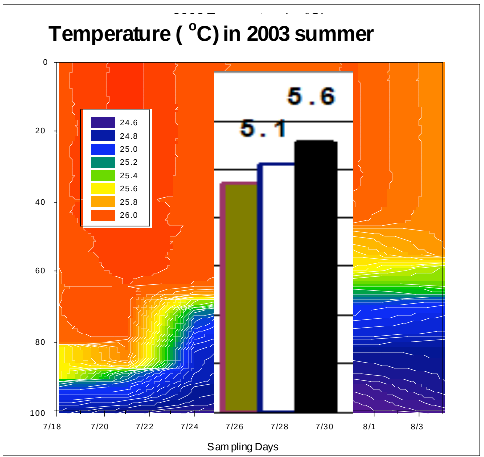


Figure 2a

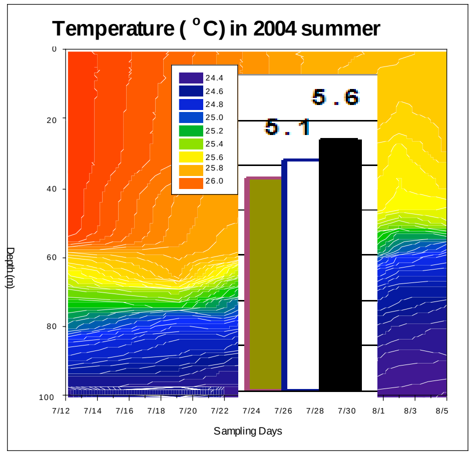


Fig. 2b