

A Preliminary Investigation on Turbidity and Chlorophyll-a patchiness in Lake Tanganyika, Kigoma Bay

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Introduction

A possible linkage may exist between biological patchiness and hydrodynamic mixing events. This was investigated by measuring the spatial and temporal variations in chlorophyll-a, temperature, and wind events. The hypothesis is that during periods of cool temperatures and high wind velocities the water column is unstable and deep nutrient rich water is more likely to mix with the epilimnion bringing useful nutrients to phytoplankton in the euphotic zone. The mixing due to internal waves may be a controlling factor for higher chlorophyll-a concentrations, higher turbidity levels and lower Secchi disc transparency throughout the first 60 meters.

Study Area, Materials, and Methods

For the study beginning on the 7/19/00, and continuing through 8/4/00, three nearshore to offshore transects were chosen based on location and coastal substrate. Transect A is located in Kigoma Bay, partially protected from open water. Transect B abuts the mountains that extend down to the water line, and transect C extends from a cliff point out into the lake, and is exposed to open water. The shore of transect A has a sandy substrate while B and C have large pebbles. Along each transect, three sites were chosen for study, one at the shore, one intermediate site 200m offshore and an offshore site about 500m from shore. The exact latitude and longitude positions are detailed in table 1. In an effort to remain constant through the experiment, it was important to sample at the same time each morning. The sampling period began around 8:00 am at line A and continued with line B and C before returning to site A for a second sampling at about 12:00.

The following materials were used: 20' boat, GPS, spectrophotometer, Whatman filters, Secchi disc, turbidity meter, temperature gauge, thermistors and a Nansen sampling bottle.

Samples were taken at depths of 0, 20, 40 and 60 meters at each of the three pelagic sites in order to investigate vertical change. The pelagic sample of site A was measured in the early morning and again in the early afternoon for a daily vertical comparison. Horizontal change was monitored using surface samples filtered from the coastal, intermediate and pelagic sites. A recording thermistor was placed at each of the coastal sites near the shore, and a recording thermistor chain with thermistors positioned at 10, 40, 70, 100, and 110 m was placed at a position of 4°51.13 S, 29°35.79 E. A standard 25cm Secchi disc was used to measure water transparency. Turbidity was measured using a turbidity meter (Hach) and results were expressed as nephelometric turbid units (NTU). Chlorophyll-a was measured by filtering four liters of sample water through a Whatman filter, and extracting the chlorophyll-a pigment using methanol over a period of 24 hours, and then measuring the absorbance of 665nm wavelength light using a spectrophotometer.

Results

Vertical Analysis

A temporal chlorophyll-a comparison revealed that the morning values ranged between 0.79 and 2.5 micrograms per liter, decreased throughout the morning in the surface to range between 0.55 and 1.08 micrograms per liter by the early afternoon (figure 1). This follows closely with the data recorded by R.E Hecky and E.J. Fee in their study of chlorophyll-a values at Kigoma Bay (Hecky and Fee, 1981). Spatially there seems to be little change in chlorophyll-a with depth, and the water was basically homogeneous except a chlorophyll-a peak that seemed to develop around 20-40 meters in the afternoon data.

TABLE 1: Location of sites sampled

Site location	A	B	C
Coastal	4 52.82 S	4 51.17 S	4 55.38 S
	29 37.35 E	29 36.61 E	29 36.70 E
Intermediate	4 52.55 S	4 51.12 S	4 55.58 S
	29 36.53 E	29 35.20 E	29 36.63 E
Pelagic	4 52.66 S	4 51.18 S	4 56.05 S
	29 35.17 E	29 34.75 E	29 36.60 E

TABLE 2: Chlorophyll A and turbidity average, standard deviation and number of observations.

Chlorophyll a	Coastal	Intermediate	Pelagic
average	2.30	1.43	1.25
STD	1.02	0.75	0.37
Count	19	19	20
Turbidity	Coastal	Intermediate	Pelagic
average	0.31	0.18	0.18
STD	0.16	0.05	0.10
Count	20	20	20

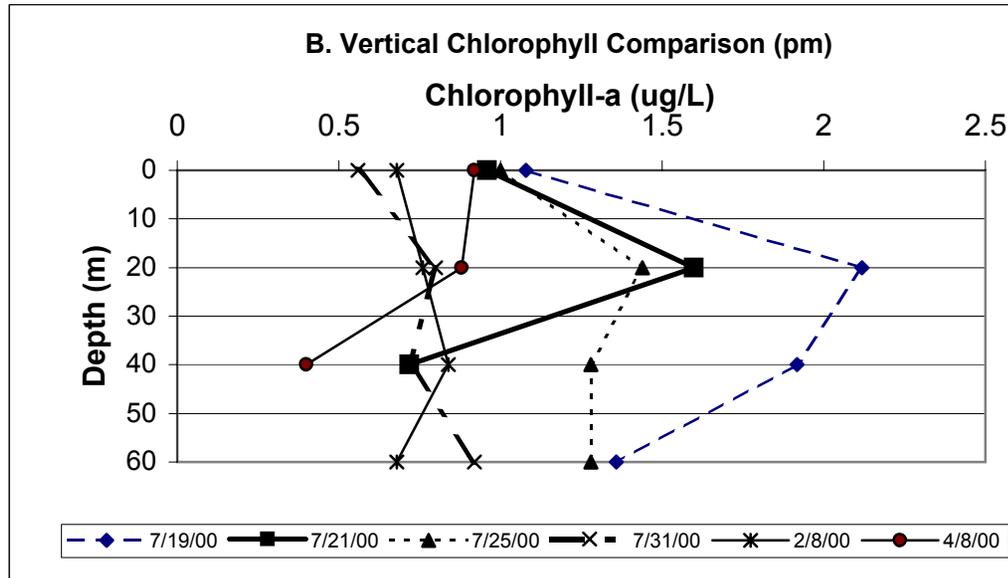
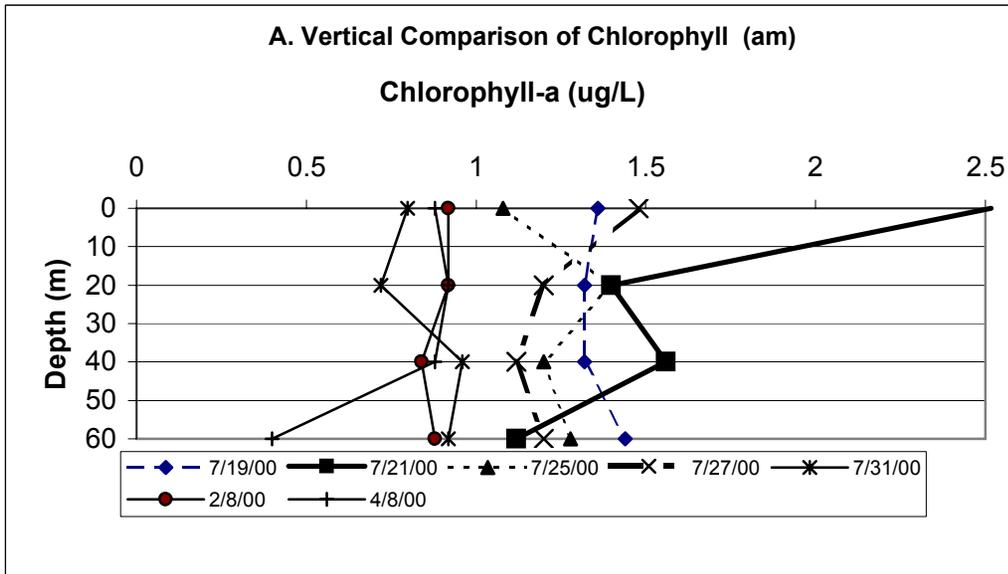
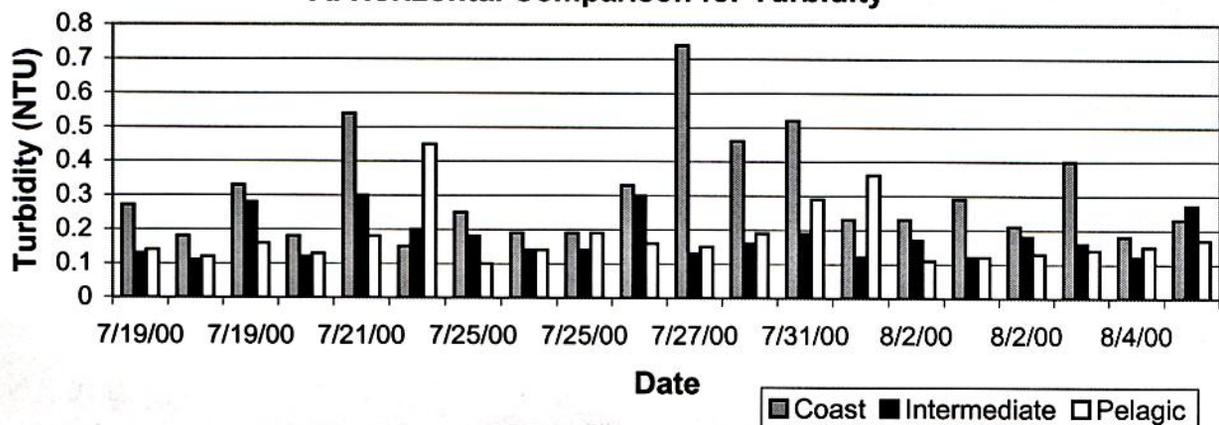
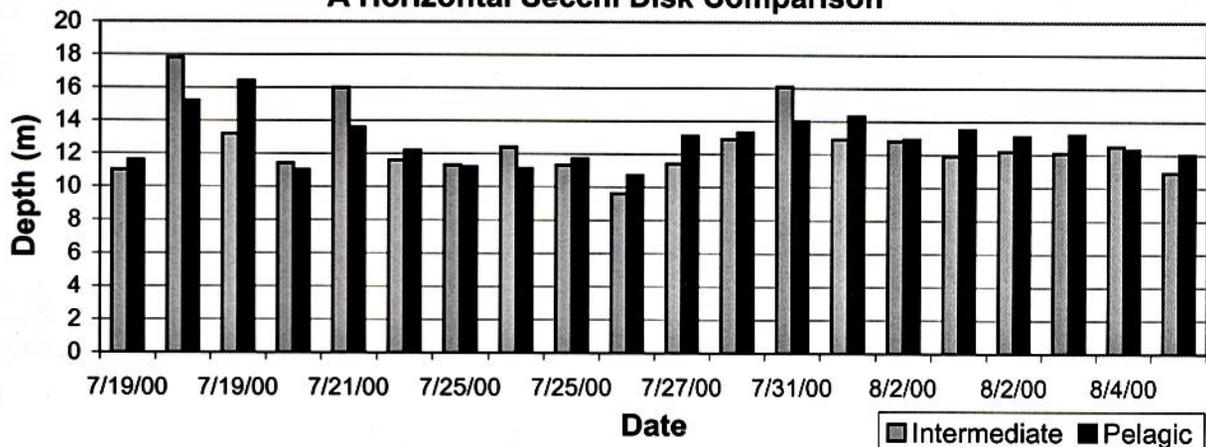


Figure 1: Vertical Chlorophyll Comparison

A. Horizontal Comparison for Turbidity



A Horizontal Secchi Disk Comparison



C. Turbidity Comparison

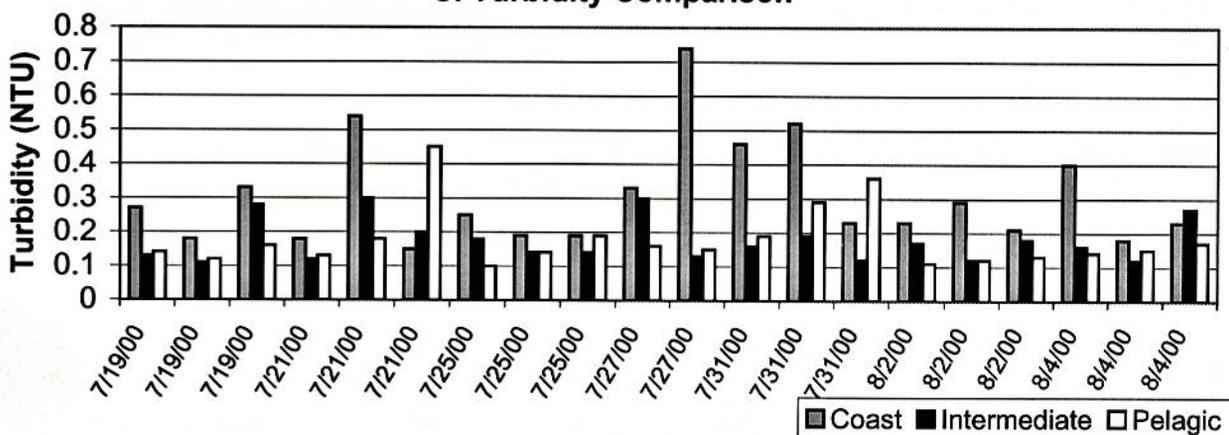


Figure 2 : (A) Chlorophyll a, (B) secchi disk transparency and (C) turbidity in three sites (coastal, intermediate and pelagic) near Kigoma during the period of investigation.

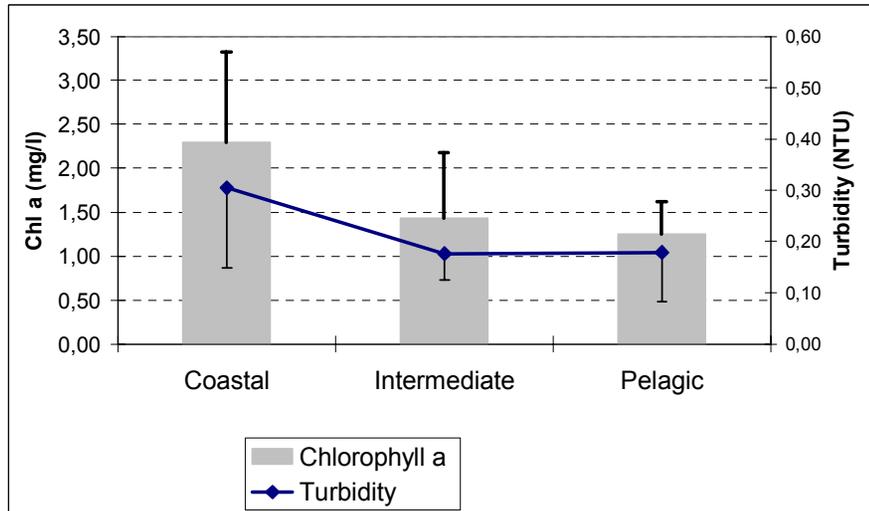


Figure 3 : Average concentrations (+ standard deviations) of chlorophyll a and turbidity at three coastal, intermediate and pelagic sites near Kigoma.

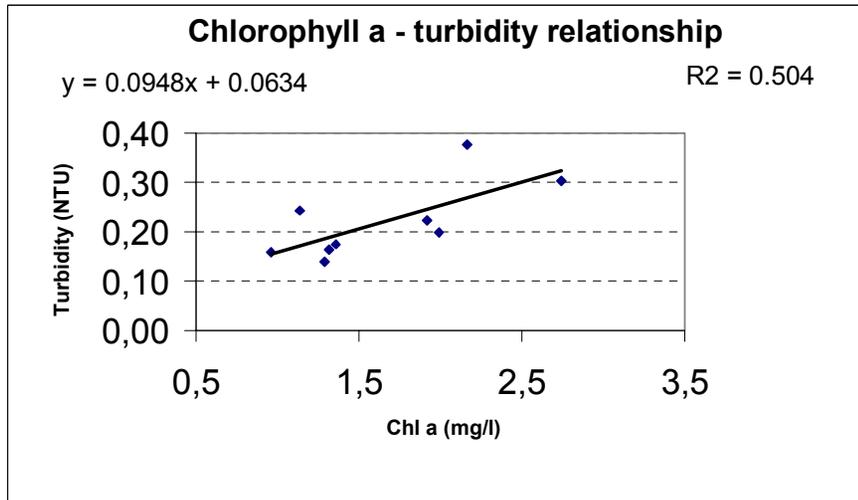


Figure 4: Linear regression of average chlorophyll concentrations v.s. turbidity measurements at the sampled sites.

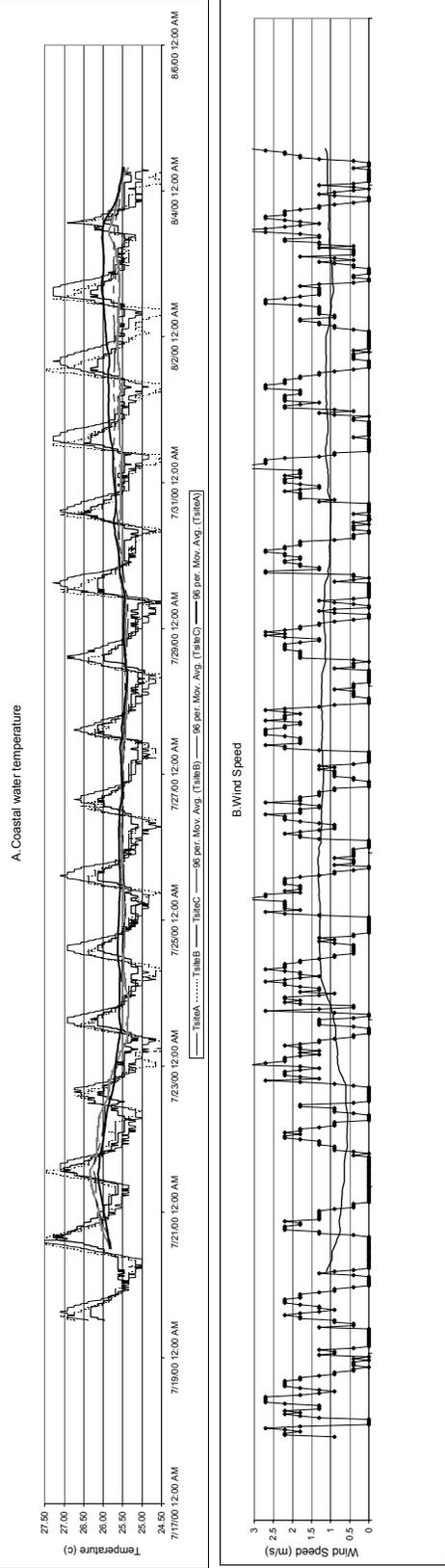


Figure 5: Coastal water temperature (A) and wind speed (B)

Horizontal Analysis

A temporal chlorophyll-a comparison revealed two distinct periods. The first between 7/25/00 through 7/30/00 where the chlorophyll-a values were high and then a second from 7/30/00 through 8/2/00, where the chlorophyll-a values decreased (figure 2). The first few days of data are ignored due to sampling error. Spatially there was not much change between transects, but a large difference was observed (1 microgram/L) between near-shore and offshore sites within each transect (figure 4), with higher concentrations at the near shore sites.

Discussion

Vertical Analysis

Temporally the noticeable peak of chlorophyll-a in the afternoon around 20-40 meters was most likely caused by photoinhibition, as some of the plankton may deepen in the water column because of the increase in sunlight throughout the day. They may adapt their depth to find the optimal conditions of radiation. (figure 1). Deeper in the water column the decrease in chlorophyll-a concentrations was most likely a result from a decrease in sunlight, and nutrients.

Horizontal Analysis

Horizontally at the surface, the most probable controls over the fluctuating chlorophyll-a values were meteorological events. Figure 5 compares wind speed data and coastal water temperatures over the study period. There is a noticeable decrease in water temperatures and a noticeable increase in wind speed during the period between 7/25/00, and 8/2/00. This is the same period of time during which an increase in chlorophyll-a concentrations can be seen (figure 2). There may be a link between high wind speed, colder temperatures, and an increase in the mixing of nutrient rich water from the deep as can be seen in figure 6. Two processes effect the nutrient distribution. Winds induce internal waves, and colder water temperatures induce mixing of the epilimnion, and when these two processes are combined nutrient rich water is supplied to the surface, providing the phytoplankton with nutrients. This is supported by the Secchi disc data, and turbidity measurements. As the chlorophyll-a values increase, the Secchi disc depths decrease, and turbidity measurements increase (figure 2). The period between 7/30/00, and 8/2/00 saw an increase in coastal temperatures, a decrease in wind speeds, and a decrease in chlorophyll-a values. Again this supports the link between meteorological events, and chlorophyll-a fluctuations.

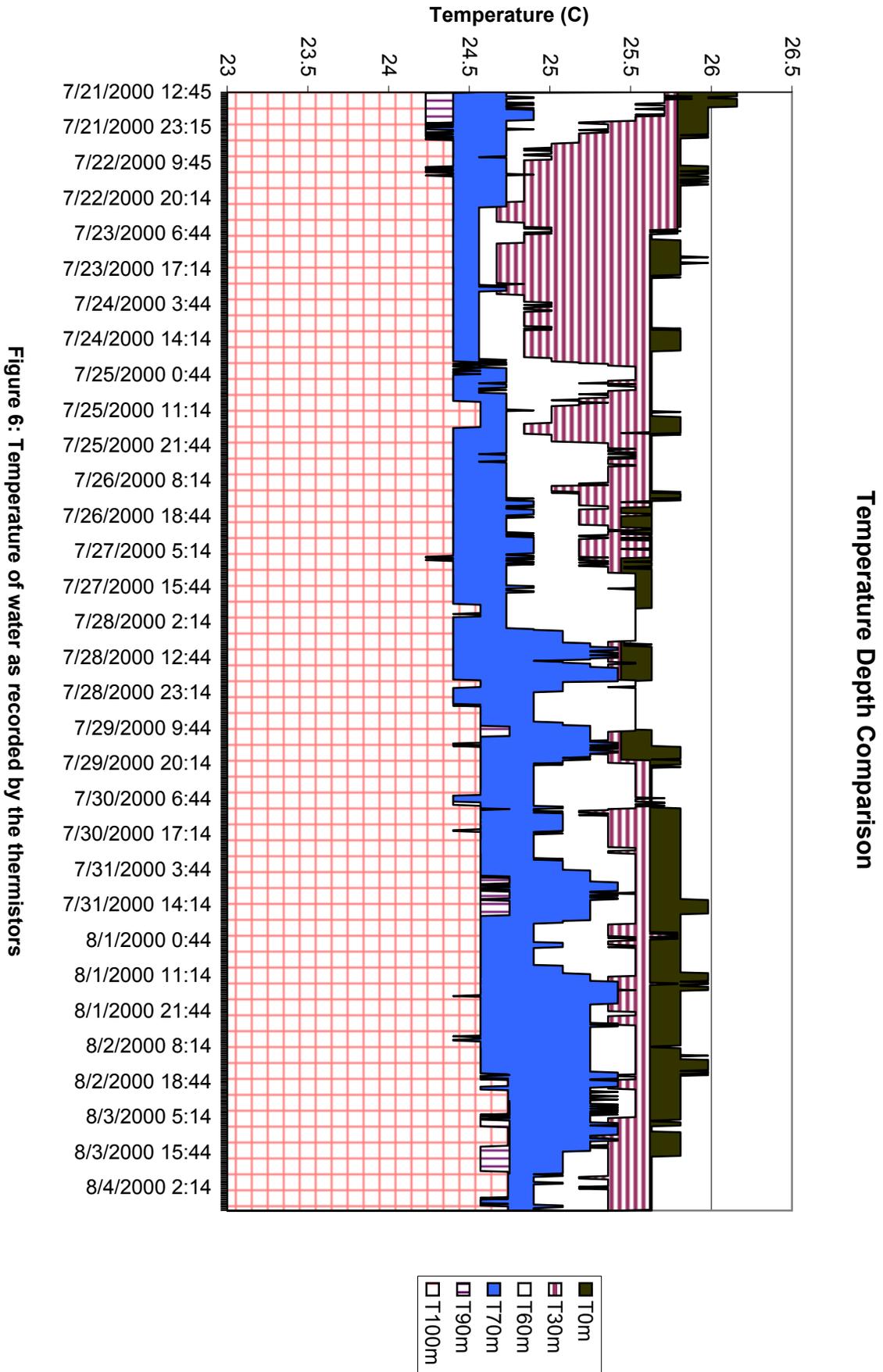
Spatially there was not a large difference between transect lines perhaps due to their relatively close proximity, however there was a noticeable increase from offshore to inshore. The shore site had about a 1 microgram/liter higher concentration than the offshore sites (table 2). This could suggest a close proximity to a nutrient source, coastal upwelling, or the resuspension of material due to wave energy (figure 3+4).

Conclusion

Chlorophyll-a may have a possible link to meteorological processes such as wind speed and water temperature. By comparing the chlorophyll-a values at sites chosen intentionally with different spatial locations, different distances from shore and different vertical depths in the pelagic, a possible link is suggested from observations of extreme wind events, water temperature anomalies and the changes seen in the chlorophyll-a levels. High winds and cold temperatures cause less stratified water, which allows the epilimnion to mix, bringing nutrients to the surface and possibly raising chlorophyll -a values.

Recommendations

Some points to improve the sampling method are to make sure the positions are all the same distance from shore. This regularity is important to maintain so the sites are comparable. Also sampling should occur at the same time every day due to daily fluctuations, again so they can be compared easily. For accurate wind data ideally measurements should be taken at each site, instead of relying on data collected from a weather station in a protected bay such as Kigoma. The most important change however, would be to sample over a



longer period of time in order to document the changes in chlorophyll-a and changes in weather, and make a better comparison.

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References

Hecky, R.E and Fee, E.J. 1981. Primary production and rates of algal growth in Lake Tanganyika. *Limnology & Oceanography*, 26(3): 532-547.