

Interactive comment on “Late holocene trends of phytoplankton productivity and anoxia as inferred from diatom and geochemical proxies in Lake Victoria, Eastern Africa” by M. Andama et al.

M. Andama et al.

andamamorgan@gmail.com

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Comment; The paper is well-written but the data provided are not extensive enough alone, without additional context and/or data to add substantially and convincingly to our existing knowledge.

Response; The challenge has always been that most of the information on productivity and anoxia in lake Victoria are for the recent periods but not for a long time scale like is the case for this study. For example, in this particular case, it was challenging to get literature and/ or data on productivity and anoxia extending hundreds or thousands of years back that can compare with the temporal scope of this study, hence

C7993

posing substantial gap in the existing knowledge especially on the lake's productivity and anoxic nature in the past. Therefore the current available data set presented in this paper will contribute in filling this gap in existing body of knowledge. Besides, the available literature accessed especially for the recent years are consistent with the results of this study and agree very well with the data obtained/presented. Of course in paleo studies, practical challenges involved notwithstanding, the more proxies evaluated the better especially if the findings reinforce/complement each other, but this does not necessarily mean that studies based on evaluation of few proxies are not valuable at all.

Comment; The single sediment core was taken a bay within Lake Victoria, and there is no discussion as to whether conditions in this bay are representative of those within the larger lake.

Response; The conditions at Napoleon Gulf are not representative of those within the entire lake but only restricted to the gulf because according to Nadomba et al. (2005), lake Victoria is spatially inhomogeneous and any conditions obtained at a site neither reflect conditions representative of the lake as a whole. That is why the focus and conclusions of the study were restricted only to Napoleon Gulf and immediate environ but not the entire lake covering three different parts of East Africa.

Comment; The authors use diatoms as an indicator of productivity, but it is not clear whether diatoms are consistently the dominant group of phytoplankton or if other types of phytoplankton are potentially more abundant as certain times (such as when the diatom and anoxia records do not correspond).

Response; The only phytoplankton studied were diatoms among other phytoplanktons in lake Victoria. Of course diatoms are not the only dominant group of phytoplanktons throughout the core. Other phytoplanktons were possibly more abundant at certain sections where diatoms were less abundant. These were not directly investigated by the study as they were not the main focus. However, some existing literature, at dif-

C7994

ferent time scopes, documented trends of other Phytoplankton. For example, most of the existing literature also cited in this paper especially those covering the recent past showed that blue green algae have overtaken diatoms in lake Victoria (e.g Johnson, 1996; Sitoki et al. 2010). Again, it was not possible to obtain data/literature for the earlier periods e.g. for hundreds or thousands of years on other phytoplanktons in the lake especially at Napoleon Gulf.

Comment; In general, there is some over-interpretation of the results, and more detailed comparison to other studies would be helpful. Because there is so little variation in diatom counts and Fe/Mn ratio within the core, it is difficult to make any strong statements about lake conditions, and I think the author's interpretations extend beyond what can be conservatively based on the data. Most of the statements regarding productivity are based on the diatoms record, and there is really very little change in the diatom record and it is not clear that diatoms are representative of productivity. The changes in the Fe/Mn record are slight.

Response; Not really, no over-interpretation of results at all in my view, as attempts for more detailed comparison to other studies were made as reflected in the discussion section of the paper (e.g. Lehman and Branstrator, 1993; Johnson, 1996; Sitoki et al. 2010 etc). It is true that comparison to other studies covering the entire time scope of the study period would have been helpful, but again this was not possible due to scarcity of information on long term productivity and anoxic conditions of the lake at Napoleon Gulf extending way back for hundreds or thousands of years, and based on same or related proxies to enable comparison.

The scarcity of diatoms and the little variation in their counts was noted in most of the sediments. However, the diatom counts recorded were the total counts of the valves obtained per slide except that they were less abundant in most of the sediments. Nothing much could have been done to increase the diatom counts in the sediments considering the abundance of total diatom valves were generally low as indicated in the results section. Nevertheless, most of the changes in the total diatom counts recorded

C7995

were significant.. For example a change in diatom counts of 169 at 24.5 cm depth to 47 at 22.5 cm depth show statistically significant result using chi-square test ($\chi^2 = 68.907$, $df = 1$, $p = 0.000$), making it possible to make strong statements about lake conditions.

It is true that there is little variation (in numerical terms and by just visual inspection) in Fe/Mn ratio in some of the depths. But in statistical terms, the variation in Fe/Mn ratio throughout the core with minimum value of 100.00, maximum value of 241.32 and standard deviation of 39.81 can't be very little variation not to warrant strong statements about the lake conditions.

Not all the interpretations extend beyond what can be conservatively based on the data as some of them were supported by the available existing literature. Those for which there was no available supporting literature may be considered as gaps for further scientific inquiry.

Diatoms were considered as representative of productivity because they constitute part of the primary producers in a lake though they are not the only representative of productivity in the lake. Their presence can give valuable information on lake productivity trends..

E.g. Battarbee R.W (1986) documented that the assemblages of diatoms preserved in lake sediments can reflect the floristic composition and productivity of Lake Diatom communities, and can indirectly reflect lake water quality, especially pH and alkalinity, nutrient status, and salinity.

Comment; The four zones delineated in the core data seem wishful thinking— personally I see a trend within the core towards more diatom and higher Fe/Mn ratios, without distinct zones.

Response; You are right about the fact that only a trend is observed within the core towards more diatoms but the four zones seen are relatively visible for Fe/Mn ratios and even clearer for TN (%). These four zones identified were mainly based on trends

C7996

of TN (%) and Fe/Mn in order to facilitate description, interpretation, comparison and discussion of the results in the paper for convenience purposes.. Otherwise it would be hard to interpret the results if no zones were identified at all. Besides, readers will find it hard to follow reading such a paper I think.

Comment; The use of the Fe/Mn ratio as an indicator of anoxia is a good geochemical tool (are the ratios in mass or molar?).

Response; The Fe/Mn ratios are in mass.

Comment; Other geochemical indicators, such as total phosphorus would also have helped clarify the status of nutrient limitation in the lake – diatoms tend to be limited by phosphorus and silica rather than by nitrogen. Changes in Total Nitrogen may actually have greater impact on other algal groups, such as cyanobacteria. Light availability may also be limiting to phytoplankton, and increased turbidity could also be a factor in phytoplankton abundance (such as was found in a recent paper by Giuma-Njuru et al. 2013. Strong spatial differentiation of N and P deficiency, primary productivity and community composition between Nyanza Gulf and Lake Victoria and the implications for nutrient management. *Freshwater Biology* 58:2237-2252).

Response; It is absolutely true that other geochemical indicators like total phosphorus would also have helped to clarify the status of nutrient limitation in the lake. My choice of nitrogen (N) was based on the fact that nitrogen (N) is the most limiting nutrient element for the phytoplanktons of Lake Victoria according to Lehman and Brandstrator (1993). Since diatoms are phytoplanktons, they can also be influenced by nitrogen in addition to phosphorus and silica.

Other authors have further suggested that in the presence of abundant phosphorous, nitrogen became limiting nutrient in lake Victoria and induced an emergence of cyanobacteria dominance over other phytoplankton during the Holocene (Johnson et al., 2000; Talbot and Lærdal, 2000), as well as in modern times (Talling, 1966; Hecky, 1993; Lehman and Brandstrator, 1993; Mugidde, 1993).

C7997

I agree that changes in Total Nitrogen may actually have impact on other algal groups, such as cyanobacteria but they would also have impact on diatoms since according to Gilpin et al. (2004), Nitrogen (N) and silicon (Si) are fundamental inorganic nutrients required for diatom growth.

I totally agree that light availability may also be limiting to phytoplankton, and increased turbidity could also be a factor in phytoplankton abundance (such as was found in a recent paper by Giuma-Njuru et al. 2013). However our study did not investigate other limiting factors for phytoplankton (diatom) productivity other than nitrogen. This may therefore be a window of opportunity for scientific community to investigate in future in a similar setting.

Technical comments; Total Nitrogen is shown in Figure 3, but there is no information about these data in the methods. Diatoms were identified to genus, but there is no presentation nor discussion of these data. While this information could provide additional insights into lake conditions, my guess is that the counts are just so low overall, that changes in composition are not necessarily significant.

Response; The information about Total Nitrogen shown in Figure 3, and the methods were already published in the paper: Andama, M., Lejju, B. J., Tolo, C. U., Kagoro-Rugunda, G., Ssemmanda, I., and Ayebare, J.: Late holocene environmental history of Lake Victoria Basin: evidence from geochemical proxies, *J. Environ. Sci. Eng. B*, 1, 1054–1063, 2012. For this reason, Andama et al. (2012) is often times quoted in this paper so as to give these details. We thought that describing and discussing Total Nitrogen (TN) again in this paper would be a repetition.

In deed changes in diatom genera composition were not significant and that is why they were not presented and discussed in the paper at all and this information could truly provide additional insights into lake conditions. Furthermore identifications to species level should have even provided better information. The challenge was with proper species identification. However the key information the paper wishes to

C7998

pass are the changes in diatom productivity based on their abundance per sediment depth/chronologically but not their diversity. Therefore, total diatom valve counts were obtained per sediment depth/chronologically and most of the changes in the counts were significant as previously shown by chi-square test.

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C7999