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***Interactive comment on “The complementary power of pH and lake water organic carbon reconstructions for discerning the influences on surface waters across decadal to millennial time scales” by P. Rosén et al.***

**P. Rosén et al.**

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We thank John Smol for his careful and thoughtful suggestions for our paper. We have made almost all of the suggested changes and a point-by-point list follows below. The review and a detailed response to the editor and reviewer follows below.

Regards, Peter Rosén

This paper is well organized and clearly written. I found that it contains some of the clearest explanations of cultural alkalinization (understandably not a term common in

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North American paleo studies). I believe that this is important work that has been well conducted.

My comments are minor. P. 2400. First line of Abstract, give location of the lake (i.e. southwest Sweden)

-Rephrased

P. 2400. The second line of the Abstract, I found the wording a bit awkward. “over which is” – do you really mean “both of which are”. In any event, the sentence needs some editing.

-Rephrased

P. 2400. Line 14 of Abstract, encapsulated is not the right work, in my view. Maybe “distinguished”

-Rephrased

P. 2400. Opening lines of introduction. It is true DOC has increased in areas, but also decreased with climate warming, such as droughts, etc. Maybe needs an extra sentence there.

-Rephrased

p. 2411. References are fine, but a few are a bit out of date. For example, why not refer to Battarbee et al.’s new review on using diatoms to track pH, instead of a reference from almost 2 decades ago? See: Battarbee, R.W., Charles, D.F., Bigler, C., Cumming, B.F., and Renberg, I. 2010. Diatoms as indicators of lake-water acidity. In: Smol, J.P. and Stoermer, E. F. (Eds.). The Diatoms: Applications for the Environmental and Earth Sciences, 2nd edition. Cambridge University Press. pp. 98-121.

-Changed to Battarbee et al 2010

Line 18 on page 2442, I don’t think ANC has yet been defined in the paper.

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8, C2511–C2519, 2011

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-Changed

p. 2444. Line 9. I find this a bit confusing...so did you use also apply a Di-pH model on the newer core for the intervals spanning 1986 - 2003?

-We do not have diatom data for that period.

p. 2446, line 4. How were these periods identified? By visual inspection? You could delineate diatom zones with CONISS etc, but I don't think that's absolutely necessary. But perhaps at least state how the zones were picked out (e.g. visually based on large congruent changes in the different proxies). -This has been clarified. p. 2447, line 19, should this be 35 cm and not 30 cm?

-Changed

P. 2557, line 8. What is the error associated with the DI-pH model? What is the error with the tri-protic ANC model? Are the values of DI-pH at 5.9 and the lakewater pH of 6.2 (assuming a constant ANC value of 116  $\mu\text{eq L}^{-1}$ ) actually within range of model errors?

-The error for the ANC model is 0.16 pH units and the error for the Di-pH is 0.3 pH units. This has been added to section 2.2.

p. 2448, lines 7-8, the wording "of species taking advantage of human activities" seems odd to me. Maybe "species more competitive following human disturbances"

-Changed

p. 2448, line 22, PC2 and PC3 show some of the largest changes here and in the following period (whereas PC1 follows the very early stages of lake development).

-Clarified

p. 2449, title of section 3.4. Looking at the changes in the figures, I would add another zone line lower than 10cm ...maybe around 15-20 cm?- this will match up with changes

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8, C2511–C2519, 2011

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in Di-pH, PC1, PC2, PC3, ANC, as well as a modest change in NIRS TOC etc.

-There is already a zone at 10 cm. If we add another one at 15 cm the figure might become more difficult to read.

If this is possible, it would be nice to enlarge (in the vertical direction) the top \_20 - 25 cm of the profiles as it is difficult to see the most recent and important changes in such a small figure.

-A new figure (4B) has been added which shows the details for the topmost 40 cm.

p. 2449, line 21. Particularly for this part of the core, it would be better to have a higher resolution scaling of the y-axis here so that the reader could more readily identify where 7 cm (even to 10 cm scaling rather than 25 cm?).

-See comment above

p. 2449, line 25, Again, because of the coarse scaling on both y-axes, it is difficult to identify where this is on the figures.

-See comment above

This peak in Di-pH is a natural spot to delineate a zone of change as suggested in comment above.

-The suggested spot can be good but we have chosen the start of major anthropogenic emissions of eg. [Pb], the increase in PCA 3 scores and minima values for NIRS inferred TOC as a zone instead (10cm). This depth correspond to c. AD 200 and correspond to the start of the industrial revolution. We think that can be as good for the reader.

p. 2450, line 4 (heading). Understandably, this small zone is difficult to see - particularly in Figs. 2 and 3.

-See new figure 4B

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Line 6. This increasing trend in Di-pH is difficult to see even in the larger figure 4.

-See new figure 4B

p. 2451, line 17. Both autochthonous and allochthonous are mis-spelled. (missing an H in both).

-Changed

At the bottom of p. 2452 and the top of p. 2453: This is interesting but seems to be a bit of a leap at times in terms of interpreting the inferred biogenic silica increase (based on Si:Ti). Greater diatom abundances from original counted slides – indicating higher benthic diatom production as a response to clearer waters and improved light conditions. I understand that a decrease in TOC could result in improved light conditions etc. but how would a more open forest with an increase in the delivery of base cations (stated in previous paragraph) at this time lead to improved water clarity?

-Karlsson et al (2009, Nature) found a positive correlation between light conditions (well correlated to lake water TOC) and increased benthic production in high latitude lakes. Since our results indicate a similar response in a lake situated further south we think it is worth mention it. We agree that increased benthic production should increase lake water TOC in contrast to the reduction in the inferred lake water TOC. The reason might be that the reduction in allochthonous carbon is more important due to large catchment changes and the allochthonous carbon can be more important for the increase in lake water pH since it contains humic acids. A difference is that the allochthonous carbon is more colored so even if the in lake production increase the lake can retain a good light climate. However, this question needs much more research and can be the scope for another paper.

P 2452, line 19. Not clear to me as to how a more actively worked catchment (small scale cutting and agriculture) would result in reduced TOC transport from catchment to lake. Would not these activities increase TOC transport to the lake?

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8, C2511–C2519, 2011

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-Renberg et al (1993) discussed that the cultural alkalization was partly due to the combined effects of small-scale cutting, forest grazing and burning of forest for agricultural use. This might have resulted in a relatively more open forest with a lower canopy and lower biomass production per unit area. If we have a lower production of organic carbon for decades/centuries in the catchment this should lead to a reduction in allochthonous carbon transported to the lake. We agree that this hypothesis needs more research to clarify.

P. 2453, Line 3. An increase in pH - through increased primary production: Do you mean through in-lake alkalinity generation including from increased biological productivity and sulfate reduction processes – e.g. Psenner and Schmidt (1992) and Schindler et al. (1996) etc.

-Yes

p. 2453, Line 13. Would not one expect that a change to a more coniferous forest might result in increases in DOC and declines in pH?

-We agree, but the results indicate that the effect from human impact was more important (eg. forest burning, grazing, more open forest, less biomass production).

p. 2453, Line 14, “During” on my copy is missing a “g” – my copy has it spelled as Durin.

-Checked

But in lines 14-23 – not sure about the interpretation here? p. 2453, Line 21, not totally clear. So land use was more intense prior to 300 years ago? Then post-1900 it increases substantially?

-The sentence has been clarified by adding information on the intense clear cutting around AD 1900.

P 2454, line 10. Guaranteed not guarantied.

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-Changed

I like the last section on implications – but it should also perhaps include some text that it becomes more complex with recent warming trends. -We would like to avoid any speculation on the possible effect of recent warming since the resolution of our data does not allow us do such interpretation. References: Some references have only DOI numbers. Authors should probably add the vol and page numbers.

-Changed

Figures: To better enable the reader to locate the changes that the authors refer to in the paper (particularly in the more recent sediments), I would suggest increasing the scale of the y-axes. For example, the depth scale is set to every 25 years – even increasing this to every 10 years will greatly aid the reader to better pinpoint the changes discussed in text.

-We have added graph 4B to help the reader.

In terms of the zones/periods identified in the stratigraphic profiles: how were these zones realized? Was it through visual inspection? I find that zone 3 is a bit odd in where the line of change was placed. I think that a more natural placement of a zone of change here would be at the peak of ANC, Di-pH etc. ca. 15-20 cm (again it is hard to pinpoint where this occurs given the coarseness of the y-axis scaling. However, I understand that putting a zone here may not correspond to the timing of interest (ca. last 200 years). Perhaps adding this line in addition to the delineation of zone 4? Although this may be difficult to resolve, it is difficult to see the changes discussed over the last ca. 200 years given the very small scale of the figures (e.g. Figs. 2 and 3). Even the larger Fig. 4 it is very difficult to see the increase in Di-pH in the last period of the record as suggested on in section 3.5 of the results. If there is a way to expand the y-axis for the last \_200 years or so, that might help.

-See comments above

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Fig. 4. Need to include in your figure caption “diatom-inferred pH”.

-Changed

Fig 2. You tell readers that filled circles represent biogenic silica, but not what open circles represent.

-Changed

Interesting paper.

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Interactive comment on Biogeosciences Discuss., 8, 2439, 2011.

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