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Biogeosciences Discussions

Interactive comment on "Spatial variability of recent sedimentation in Lake Ohrid (Albania/Macedonia) – a complex interplay of natural and anthropogenic factors and their possible impact on biodiversity patterns" *by* H. Vogel et al.

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Reply to anonymous Referee #1

We are grateful to the valuable comments of the anonymous referee #1 and reply as follows.

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Interactive Discussion

Discussion Paper

With respect to the general comments given by referee #1 we will extend our discussion on possible other mechanisms influencing sedimentation and add a full new suite of figures including data not shown in the previous version of our manuscript in form of a supplement.

Replies to specific comments and technical corrections as suggested by Referee #1:

(1) Referee comment: Distribution of different grain sizes and their relation to basin morphology is not shown.

Reply: We added two supplementary figures showing the distribution of different grain-size classes and their relation to basin morphology. One figure includes cross-plots of the grain-size classes Sand, Silt, and clay vs water depth and another shows interpolated spatial distribution maps for medium sand, fine sand, very fine sand, very coarse silt, coarse silt, medium silt, fine silt, very fine silt, and clay.

(2) Referee comment: Distribution of chemical elements could be strongly influenced by sediment grain size and water depth, usually there is an enrichment of metals in the finer sediment fraction (see e.g. Boyle 2001 for discussion of relationships between particle flux, trace element flux and sediment trace element concentration in deep lakes).

Reply: In order to address these issues we will add two figures showing the relationship of elements investigated with water depth and grain-size. We will also include a more detailed discussion of possible relationships in the text.

(3) Referee comment: Discussion of percentages could be misleading, as accumulation rates may be distinct from that. If there are no accumulation rates available, use of element ratios could be more straightforward

Reply: We are fully aware of the fact that the discussion of percentages could be misleading since accumulation rates differ strongly basinwide. Accumulation rates for each element would certainly provide a better estimate on patterns influencing sedimenta-

BGD

7, C2984–C2991, 2010

tion in Lake Ohrid today. We can, however, not provide individual radiometric controlled accumulation rates for every sampling spot due to the lack of funding for this approach. On the other hand we believe that element ratios could be misleading as well since some of the elements derive from very confined sources (eg Ni, Cr, Mg). In our opinion the discussion of percentages is therefore, taking the available data and circumstances into account, the most honest and understandable way of dealing with these issues.

(4) Referee comment: The authors decide to use a very restricted set (selected for which criteria, e.g. only Cr, Ni, or very coarse silt?) of chemical elements and other parameters and discuss it qualitatively. However, without using any kind of statistics (e.g. scattergrams, correlation matrix, factor- and cluster analysis) discussion of interrelations of different parameters remains speculative, particularly with respect to position (i.e. water depths) of sampling sites.

Reply: After a thorough review of the data available we have chosen a very restricted set of parameters/elements to be included in our manuscript in order to keep the discussion focussed on the main factors, which, we believe, control sedimentation in Lake Ohrid today. In our opinion adding more data/figures to the manuscript would have resulted in a more complicated though less focussed discussion of possible factors. However, to address the suggestion by Referee #1 we added four new figures in form of a supplement to our manuscript. One figure displays the relationship between elements/parameters and water depth; one figure displays the relationship between elements/parameters and Sand, Silt, Clay; one figure displays interpolated spatial distribution maps for elements not shown in the previous version; and one figure displays interpolated spatial distribution maps for medium sand, fine sand, very fine sand, very coarse silt, coarse silt, medium silt, fine silt, very fine silt, and clay. Furthermore the discussion of possible interrelationships is now extended in the text.

(5) Referee comment: Discussion of sediment dispersal focussed too much on the counterclockwise surface currents – no discussion of possible turbidity currents from steep basin slopes, and in general of sediment resuspension and –focusing (transport

BGD

7, C2984–C2991, 2010

and redeposition at different locations) (e.g. Hakanson 1982, Bloesch 1995, Wetzel 2001 p.633-635) – although at least some data are available (sediment focussing in near-bottom sediment trap, Matzinger et al. 2007 Fig. 6a). If surface currents are thought to be important, it would be helpful to discuss them in more detail and to refer comprehensive studies and examples from other lakes (e.g. Michigan or Ladoga). Lake surface water gyres may not simply lead to increased sediment accumulation, and also could affect productivity patterns (e.g. upwelling in the centre of a gyre).

Reply: We agree that a more detailed discussion with respect to other factors than the assumed counterclockwise surface current is necessary to give a more complete overview of possible factors influencing sedimentation in Lake Ohrid today as claimed by the title of our manuscript. We tried to add a more comprehensive literature overview with respect to surface water currents as suggested. However, given our very restricted set of data (surface sediment samples) at a relatively rough spatial resolution and the unfortunate fact that long term monitoring studies of flow velocities at different depths with a sufficient spatial coverage are lacking we believe that we can only discuss a few other possible factors without getting too much into detail. We thus added a short discussion on catastrophic processes such as mass movement events and bottom currents. Upwelling in the centre of the surface water gyre of Lake Ohrid occurs and has been described elsewhere (e.g. Stankovic et al. 1960). One would assume an increase in the availability of nutrients originating from deeper water and/or the sediment/water interface and thus increased productivity. However, taking the high fluxes of nutrients from rivers draining agricultural areas into account the surplus of nutrient availability originating from upwelling is probably comparably small today. In addition upwelling leads to colder water temperatures in the photic zone and might thus compensate for positive effects of higher nutrient availability. Hence, a clear signal perhaps due to the circumstances described above, is lacking from our data with respect to upwelling in the centre of the surface water gyre.

(6) Referee comment: Although claimed to be one of the main topics of the paper even

BGD

7, C2984–C2991, 2010

in the title, relations between sedimentation patterns and biodiversity are discussed without showing any data or figure, only based on references – hence it is hard to follow the arguments presented here.

Reply: The authors intended to raise a cautionary note on recent sedimentation and "their possible impact on biodiversity patterns". It seems that the inclusion in the title raised high expectations as to a real analysis of such impacts. This however is impossible to date since the sampling design was not prepared for such a task. It was always planned as a discussion topic using the published record available. In order to avoid confusion, we decided to simply skip the part "their possible impact on biodiversity patterns" from the title.

(7) Referee comment: Page 3912, Line 24 – it should be probably Albrecht et al., 2009, not 2006.

Reply: changed accordingly

(8) Referee comment: Page 3914, Line 15 – "irregularly every seven years" – better to give the period of observation and the number of total overturns.

Reply: "irregularly every seven years" is the figure cited from the literature.

(9) Referee comment: Page 3914, Line 24 – what does "highly" oligotrophic means? Better to cite some data.

Reply: we remove the term "highly" from the text accordingly

(10) Referee comment: Page 3915, Line 15 – what is the accuracy of the sampling positions?

Reply: We used a handheld GPS device to get high precision positioning data for our sampling sites. However, depending on weather conditions and water depth the error may well be in the order of a few tenth of meters.

(11) Referee comment: Page 3916, Line 5 – ICP-OES: what about other elements (e.g.

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7, C2984–C2991, 2010

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Ti, Fe, Mn) – have they been estimated as well and not used here, or not estimated at all?

Reply: We also measured other elements by ICP-OES, which are now also included in the text of our revised manuscript and displayed in a supplementary figure.

(12) Referee comment: Page 3916, Line 22-23 – ": : : to remove organic material" – is there any control on the amount of e.g. diatom frustules, precipitated calcite crystals, phytoliths etc. in the remaining samples?

Reply: We only removed organic material to avoid floculation of the remaining clastic material. We did not remove other materials such as diatom frustules and carbonates.

(13) Referee comment: Page 3916, Line 28 – "160 grain size classes" – from which min. to which max.

Reply: we added the min and max of the 160 grain-size classes to the text accordingly.

(14) Referee comment: Page 3916, Line 29 – "calculations of grain size parameters and statistics" – but where are the data

Reply: A figure including the 9 most important meaured and calculated grain-size classes is now made available as supplementary figure.

(15) Referee comment: Page 3917, Line 14-16. Figure 3 shows only "very coarse silt", text here is "coarse silt and fine to medium sand" – it should be a bit more precise, and again, is there any control/idea on the composition of the coarser sized classes? Why the amount of clay is so small (rather unusual for such a large and deep lake)

Reply: We added a whole new figure showing the spatial distribution of the 9 major grain-size classes as a supplement and now refer to it in the text and discuss it in more detail. Small amounts of clay can probably best be explained by the composition of the bedrock surrounding Lake Ohrid in combination with todays rather arid climate which does not particularly favour chemical weathering of the bedrock.

BGD

7, C2984–C2991, 2010

(16) Referee comment: Page 3917, Line 20 – why the only explanation could be wind induced surface currents? What about bottom currents, turbidity currents from the steep slopes, and aeolian influx?

Reply: As mentioned above we added a more thorough discussion including other potential factors influencing sedimentation in Lake Ohrid today. However, by including also other elements and/or parameters we find strong evidence that the main process controlling transport and sedimentation of clastic material can best be explained by a counterclockwise rotating surface current.

(17) Referee comment: Page 3919, Line 19-20. C/N ratios of <12 does not imply a priori autochthonous sources of organic matter – see e.g. Table II in Meyers and Teranes 2001 (lake algae 6-9, soil organic matter 13-20) – so better to give mean values. Apparently strong positive relation between TOC and C/N (Fig. 3 g, h) could points to terrestrial influence.

Reply: We agree that an estimation of autocthonous vs allochthonous sources of organic matter based on C/N ratios surface sediments of Lake Ohrid is a rather difficult task. Values of >10 are now considered as being derived from an indefinable amount from both terrestrial and aquatic sources in the text.

(18) Referee comment: Page 3920, Line 10 – what about calcite precipitated from subaquatic springs (Matter et al. 2010)?

Reply: This, although very confined, source of calcite is now added to the text of our revised manuscript.

(19) Referee comment: Page 3921, Line 17 – distribution of endemic molluscs is shown in Hauffe et al. 2010 4d, not c, and shown there is species richness, not frequency.

Reply: This citation referred to a former version Hauffe et al., in which only subfigures a,b,c existed. The correct citation must now read Fig. 4c,d. “Frequency” might be confusion in this context, however, it referred simply to presence or absence of taxa.

BGD

7, C2984–C2991, 2010

We changed it to “richness”.

(20) Referee comment: Page 3921, Line 24 – not Trajanovski et al., 2010, but Kostoski et al., 2010. Page 3925, Line 18 -20, see comment above.

Reply: Changed in the text accordingly.

(21) Referee comment: Figure 2 – Please cite the source of the bathymetric data.

Reply: We now cite the source of the data.

(22) Referee comment: Figure 3 – Some details are a bit confusing, e.g. the Feldspar plot is the only one with orange colour why?; dots on the Chl-a map are only green and blue, why are there larger amounts in the legend as well? Water depths should be indicated, and colour bars should be explained in figure caption.

Reply: The orange colour was used to highlight extraordinary high amounts of feldspar. We now explain this in the figure caption. There is actually a red dot in the Chl a plot but it was overlain by another blue dot of a sampling site close to it. We moved the red dot in front for better visibility. Water depths are now indicated.

On behalf of the authors, Hendrik Vogel

Interactive comment on Biogeosciences Discuss., 7, 3911, 2010.