

Review of Kulinski et al. "Structure and functioning of the acid-base system in the Baltic Sea" (revised re-submission)

The authors have prepared a substantially revised manuscript, which addresses the issues raised by myself and another previous reviewer. This revision improves the readability and presentation greatly over the first version, and I commend the authors for their work. I still think some sections are light on citations, and I will try to indicate those places below. I also have a couple significant comments which I think should be addressed before publication, as well as a number of technical language suggestions which the authors may choose to implement or not.

Overall Comments

P2L2-11: This section describing the difference between structure and functioning is a nice addition.

P6L10-11: why is this advisable? What are the limitations of derivation? Discuss error propagation, uncertainties in K values, alkalinity contributors.

P7L21-28, P8L1-13: Other Ks are available for brackish water in addition to those of Buch, for example those of Cai and Wang 1998.

P8L14-27. This explanation is a good addition. What temperature is used for the calculations in Figure 2c?

P12L4-13: This paragraph discusses pH changes mostly in terms of pCO₂ in equilibrium with atmospheric pCO₂, and mentions that at equilibrium AT drives pH changes. The opposite of course is also true, that at constant AT pCO₂ disequilibrium drives pH change, as in Figure 5. Indeed from Figure 5 we see that pCO₂ is rarely at equilibrium with atmospheric levels in the Baltic, and that the observed pH range at constant AT (about 8.1-8.5) is narrower and lower than that cited in this paragraph (7.7-8.3). So I suppose my question is, why frame this paragraph in terms of pCO₂ conditions that rarely occur in the Baltic, and by the same token why present the data in Figure 5 in terms of constant AT? Figure 3 indicates that there is a fair amount of in situ AT data in the Baltic (and that AT is really variable!).

Figure 4: the text for "Current Range of Baltic AT" and "Current Atmospheric pCO₂" is really hard to read. I'd suggest putting a white background behind this text, similar to the pH labels, to improve readability.

P16L5-11: pK_{DOM} is cited as 7.34, while the pK_a of "organic matter (as represented as fulvics)" is below 4.5. This is a big difference! Is this <4.5 pK_a only for some fulvic groups, and not for the overall DOM? Some explanation for this discrepancy should be added.

Figure 5. Temperature has a big effect on pCO₂ and pH. Can some discussion of temperature influence vs. other biogeochemical factors be added?

P19L3-4: "without distinguishing between mineralization pathways". This could be an important point: the mineralization pathway affects the relative production of CT vs. AT, right? Some more discussion of this might be useful.

P21L22: This phrase "permanent stratification" seems to contradict the assertion made in P17L25 where 'deeper CO₂-enriched water" is transported to the surface via mixing in autumn and winter. How can both be true?

P23L5-13: a citation here would be good- perhaps the SOCAT project?

P24L27: Is sulphate reduction the dominant anerobic process in the Baltic? From the previous discussion this is not clear, as other processes (Mn reduction, denitrification, etc) are presented as more energetically favorable.

Technical/Language Comments

P1L14: Change to "a number"

P1L20: remove "we"

P2L12: change to "of atmospheric CO₂"

P2L19: "by the scientific community"- this seems like it needs some citation

P2L29: AT not defined

P2L30-31: try to avoid shorthands like "etc" or "and/or"

P2L28-30: should terrestrial inputs be included in this list of processes?

P2L31: what are the specific gaps and shortcomings?

P3L22-23: "low buffer capacity", "various anthropogenic influences"-citations needed. Specify the anthropogenic influences.

P3L26: "well characterized during the last decades"- citation(s) needed

P3L28-29: remove the sentence beginning "However, this was done...", not really sure what it is saying.

P4L21: "BONUS PINBAL", most readers will not be familiar with this project

P4L30: change to "the pH as described by a set..."

P5L3: change to "of the marine CO₂ system. Many biogeochemical models...". Also citations of these models are needed.

P5L9: change to "for the calculation"

P5L8-17: another limitation is that current sensor technology is mostly focused on pH and pCO₂ observations

P5L21-26: citations needed

P6L9: change to "in brackish water"

P6L14: change to "determination of CO₃²⁻...". Also, I don't think CO₃²⁻ has been previously defined.

P9L1: change "possibilities" to "capabilities"

P10L27: Need to state that the differences are presumed! Citations needed here.

P10L28: Lower alkalinity and lower buffer capacity are not necessarily the same thing. Either discuss the difference or remove the reference to buffer capacity.

P11L2: change to "This results in alkalinity..."

P11L3: remove "is"

P11L11: change to "characterization of the..."

P11L17: change to "depends"

P11L20: this section discusses AT, so there is a need to explain the connection between AT and these CT concentrations- the link is not clear between the two.

P12L8: need to provide the open ocean pH range with citations

P13L9-11: this is nicely said.

P13L11: change to "It also implies"

P13L1: needs citation

P15L17: change to "were 27-56: lower..."

P15L20: change to "2009), because they are..."

P15L23: change to "include an Aorg..."

P15L27: perhaps replace "catch also Aorg" with something like "include all inorganic and organic contributors, while subsequent..."

P15L31: change to "dissociation constants"

P16L5 and throughout: change to "They also estimated..."

P16L7: I don't really understand this sentence, please rephrase.

P16L8: change to "They also suggested that the method..."

P16L10: change to "They also showed..."

P16L13: change to "also found "

P16L23: change to "the anion"

P16L24: change to "means that..."

P16L28: change to "for oceanic waters"

P16L30-31: this is a great point

P16L33: change to "Baltic Sea, where the experimentally..."

P17L4: change to "effect of the anomaly"

P17L9: change to "In the case"

P17L10: change to "of pCO₂, because the atmospheric CO₂ is then the only driver..."

P17L29: change "enhances" to "raises"

P17L30: change to "This assimilation also decreases..."

P18L1: is this low P concentration specific for the Baltic?

P18L4: remove "thus"

P19L13: change to "produces CO₂, and..."

P19L21: add space between "Eq.8"

P20L6-26: It might improve readability to include the names of the reactions alongside the delta AT values, so it's obvious which reaction is which. For instance, change line 10 to "Manganese Reduction $\Delta AT = +472$ "

P21L6: change to "sulphide or ammonia only influence the acid-base system locally"

P21L12: Change to "Challenges for future research..."

P21L21: change "perfect" to "model"

P21L29: change to "water are made available..."

P22L3: change "is" to "are"

P22L19: Aorg already defined

P22L24: change to "would require substantial progress in analytical techniques, as the..."

P22L26: change to "Problems also arise..."

P23L3: remove "potentially missing"

P23L10: change to "Hence, agreement..."

P23L11: change to "indication of..."

P23L14: change to "was the focus..."

P23L17: change to "did not reflect"

P23L19: change to "This meant...", also remove comma after "production"

P23L23: change "upon" to "after"

P24L2: change "shown" to "proposed", change "confined to" to "explained by"

P24L3: change to "and, presumably, other marginal..."

P24L6-7: change to "in connected catchment areas."

P24L11: change to "to the immediate effect of riverine input of acidic substances. This riverine input refers mostly..."

P24L13: change to "et al. 2014), but also to boric..."

P24L16: remove "(ion anomaly)"

P24L17: change to "mineralization also have the potential..."

P24L19: remove "."

P24L20-21: change to "which reduces the alkalinity, but the abundance..."

P24L24: remove ", which however is nothing specific for the Baltic Sea."

P24L26 remove ", "

P24L31: change to "event and do not affect..."

P24L32: change to "do influence the..."

P24L33: remove "But"

P25L9: remove "and", change "It" to "This"

P25L13: change "hopeless" to "impossible"

P25L16: change to "in other coastal..."