

## ***Interactive comment on “The impact of sedimentary alkalinity release on the water column CO<sub>2</sub> system in the North Sea” by H. Brenner et al.***

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### Overall Statements

The manuscript “Impact of sedimentary alkalinity release on the water column CO<sub>2</sub> system in the North Sea” by H. Brenner, U. Braeckman, M. Le Guitton, and F.J.R. Meysman presents North Sea wide pelagic-benthic fluxes of TA, DIC and O<sub>2</sub> in the North Sea. This comprehensive data set is to my knowledge the first one covering the total North Sea. Publishing this data set is of great value for the scientific community. The manuscript would become even stronger when the authors would refer and compare their data with existing data in relevant papers (Kempe & Pegler, 1991; Reimer et

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al. 1999; Hoppema, 1990; Brasse et al. 1999; Winde et al. 2014; Moore et al. 2011). The authors use their data set to construct an alkalinity budget for the southern North Sea in order to estimate the impact of sedimentary alkalinity release on the pelagic DIC dynamics. This is a big challenge, which is only partly fulfilled. My main points of criticism are:

The authors use mean values of strongly spreading data. They should discuss the sensitivity of their budget in relation of the (mean) input data.

Very strong assumptions and “guestimates” were made (steady state, R<sub>min</sub>,...). They must be justified and discussed in more detail. I will pinpoint these items in my detailed remarks.

There are faults in Tab. 5 and even in the equations ((7) and (9)). Most of them do not change the authors’ overall statements. I think parts of the conclusion must be rewritten when the bugs are fixed. I will give a recalculated table 5.

The impact of sedimentary alkalinity flux on pelagic DIC dynamics does not take into account the simultaneous sedimentary DIC flux, even though the authors claim this.

The authors compare their summer fluxes with annual fluxes. It is known that summer fluxes are the largest all over the year. They must discuss this point and give the reader hints about this problem at all places in the text where this occurs.

The title is misleading as it reflects only the last chapter. I suggest something like “North Sea wide pelagic-benthic flux measurements of Alkalinity, Dissolved Inorganic Carbon and Oxygen and their impact on ..”.

The unit mmol Eq should be replaced by mmol C

Taking these items all together I recommend publishing the manuscript in Biogeosciences after major revisions.

Detailed remarks

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P12396

L14 “.. should be considered as an important factor”

L21 Liu et al 2010 never discussed shelf uptake

P12397 L8 “.. the question .. which particular drivers ..

P12399

L4 Pättsch and Kühn 2008 used the 50 m depth contour to separate SNS and NNS. So your definition of SNS is very special. Perhaps you can use another acronym?

L29 “is the only net outflow ..”

P12400

L2 “.. by strong .. currents..”

L12 “ .. and near Helgoland in the German Bight (Hebbeln et al., 2003)”

P12404 O2 and pH microprofiling: Please give an estimate of the accuracy of the profiling data. I guess you took these measurements on board. The movement of the ship might have impacted the quality of the measurements. Could you please comment on this?

P12405

L15 Fig. 2b: Station 11 cannot have a depth < 500m. Fig.. 2c there is only one profile displayed.

L21-22 Could you show this?

P12406

L3 the minimum median grain size of 21  $\mu\text{m}$  cannot be found in Tab. 1

L3-4 Do really both areas exhibit the same (215  $\mu\text{m}$ ) mean median grain size?

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L10 22  $\mu\text{m}$  cannot be found in the table. Please also add acronyms into Tab. 1 to identify the membership in SNS, SKNT and NNS

L19 Which criterion did you use to determine the representativeness?

L22 What is the difference in the numbers of subsamples? It seems that there is systematic noise at the DIC and TA data.

P12407 L15: In this case I do not know which correlation was tested.

P12408 L10 and the following:

Please give an estimate of the accuracy of the profiling data. I guess you took these measurements on board. The movement of the ship might have impacted the quality of the measurements. Could you please comment on this?

P12409 L1 give ranges or mean and stdv

P12410 L29 “ .. is the bottom temperature exhibiting a north – south gradient in summer, with higher temperatures in the south.”

P12411 L11 “a nearly doubling ..”

L14 “.. compared to the SNS (Tab. 3).”

L14 Discuss the deviating TOU of station 38 and 45 (Tab. 3 and Tab. 1)

L17 I cannot identify a correlation between water depth and TOU, TA-flux, DIC-flux in Fig 6. Black and blue dots show more or less the same values. The red ones show almost all values for depth < 50m. Try to plot only the red dots with a higher depth resolution.

L24 Are porosity and grain size dependent on (or correlated with) depth? If this is so, you should use only probes with similar depths for checking the correlation between porosity/grain size and TOU and TA/DIC fluxes.

P12412 L4 “The importance of wind and tidal induced advective transport (at station

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11) ..(Fig. 5a). This is reconstructed by the strong ..”

L16-L20 “A second .. determined” this sequence should be cancelled.

L24 This inverse relationship is based on the balance between the diffusive flux and the aerobic degradation with the assumption of steady state dynamics. Please help the reader to understand equation (3).

L24 Fig. 7a does not contain empty circles

L25 Is L the theoretical OPD?

L26 “ , and [O<sub>2</sub>]<sub>bw</sub> is the oxygen concentration in bottom water”

L26 what is F<sub>0O2</sub> in eqn (3)?

L27 Fig 7b does not show the theoretical OPD from measured DOU. It shows the correlation between measured and theoretical OPD.

L27 Why is the number of red dots in Fig 7 so small?

P12413

L1 The measured OPD is in two cases smaller than the calculated ones. Discuss this. For which stations is this true?

L2 use “equation (3)” instead of “model 3”

L4 It is clear that non-diffusive transport increases the oxygen availability. You should discuss whether your DOU-measurements include some other than diffusive transport or input variables of eqn (3) are not chosen adequately.

L7 ff: You should refer to Tab. 2. In the text you should mention that the values in line 9-10 are mean values.

L16 Same as for TOU: Fig. 6 should be improved. The dependency of depth and grain size/porosity must be excluded.

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L19 “DIC-flux is correlated with TOU”

L20 Fig. 8b is called before 8a. Exchange 8a and 8b.

L24 you mean Fig. 8b?

P12414

L2 You mean Fig. 8b?

L8 “one mole DIC”

L10 “re-oxidized”

L13 “(Fig. 8a)”

L22 “is in good agreement..”

L23 “The disagreement (e.g.at station 38) ..”

P12415

L4 mention that these number are mean values.

L12 “(Fig. 8a)”

L26 more precise please. The recalculation of 131.2 Gmol from Tab. 1 in Thomas et al. (2009) yields 7.6 mmol d<sup>-1</sup> m<sup>-2</sup>

P12416 L16 “assumptions”

P12417

L1 “a high benthic respiration ..”

L6-7 “.. invoke the question which processes are generating AT in the sediment”

L16 omit “now”

P12418

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L15 please insert here an acronym for the flux, say  $f_{CD} = \dots$ . Then you can recall this acronyms afterwards (e.g. in eqn (12))

L19 Make clear that OM is derived from eqn (1) in Paulmier et al (2009)

L24 this is surely a conservative estimate.

L26 Give a justification for the estimate  $R_{min} = TOU$ . Why not taking the DIC efflux as estimate? This estimate is central for the following budget. How sensitive is the budget on variations of  $R_{min}$ ?

P12419

L3 call this flux  $f_{AR} = ..$

L3 this is a very conservative estimate

L7-12 This is a very progressive estimate. You never measured  $NH_4$  efflux?

L15 on the right hand side 148.4  $H_2O$  is generated

L16 It is not "per mole organic matter" but "per carbon atom in organic matter"

L25 You use  $nit=1.51 \text{ mmol N m}^{-2} \text{ d}^{-1}$  to calculate  $denit = nit/0.8$  which should result in  $1.89 \text{ mmol N m}^{-2} \text{ d}^{-1}$ . You give the  $denit$  rate in C units! Please check whether all following calculations must be revised.

P12420

L11 eqn (9) should produce 742  $H_2O$

L12 It is not "per mole organic matter" but "per carbon atom in organic matter"

L12-20 In this context the assumption that the amount of iron reduced equals that used for pyrit formation must be explained.

L21 eqn (10) is rather simplified. Please write a sentence describing the real two-step process.

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P12421

L11 should be Table 5

L14 Due to my calculations (new Tab. 5) the percentages are 15%, 19%, 0.4% and 62% which does not sum up to 100% because these relations refer to  $R_{min} = 10 \text{ mmol C d}^{-1} \text{ m}^{-2}$ .

L25 the observed RQ was  $\sim 1$  as claimed on P12413 L22

P12422

L4 In the following the total budget is presented. Here you should remind the user that this budget refers to the time your observations were taken. The transfer to annual fluxes is problematic.

L5 eqn (12) should be simplified by using the acronyms I suggested above:  $R_{sed} = f_{CD} + f_{AR} ..$

L8 My calculations resulted in  $R_{sed}=5.88$

P12423

L15 use  $f_{CF}=5.4 ..$

L24 Joint and Pomroy estimated the annual production. Comparing this with summer values is problematic. The value of  $199 \text{ g C m}^{-2} \text{ yr}^{-1}$  not only includes new but also regenerated production. So your derived daily value is a very high estimate for nitrate fed production. In the end both problems may cancel out. Please discuss this.

P12424

L8 Please use the exact number of  $45.45 \text{ mmol C m}^{-2} \text{ d}^{-1}$

L8 should be  $36.36 \text{ mmol C m}^{-2} \text{ d}^{-1}$

L14 should be  $37.36 \text{ mmol C m}^{-2} \text{ d}^{-1}$

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L15 should be 5.99 mmol C m<sup>-2</sup> d<sup>-1</sup>

L15 What about pelagic nitrification and the consequences for AT?

L22 eqn (16) can be written without factors:  $R_{wc} = f_{pp} - f_{ar} ..$

L22 Please discuss the possibility of alkalinity advected from the tidal dominated areas (i.e. the Wadden Sea).

L23 My calculations result in -4.1

P12425

L3 and L4 Define  $V_{sed}$  and  $V_{wc}$ . A volume? It should rather be a depth integral.

L5 Especially in summer I would not expect steady state. So be careful with such words.

L5-6 According to my table the values must be corrected.

L6 If you recalculate the number of AT generation for the whole SNS give the area you use. I assume that the area with depth < 100 m is larger than 190.411 km<sup>2</sup> which is used here.

L6-8 My calculations resulted in 15% nitrogen cycle and 85% sulfur and iron cycling because I only used primary production, pelagic respiration, benthic aerobic respiration, benthic denitrification and nitrification for the nitrogen cycle. Otherwise one could argue that phosphorus is also involved in all cycles.

L20-25 Caution with annual and daily fluxes. Pätsch and Kühn (2008) also gave numbers for the SNS: 58.6 Gmol N yr<sup>-1</sup>

P12426

L7 here you claim that the pCO<sub>2</sub> is governed by the DIC over AT release. DIC release is neglected in the following discussion.

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L11 My calculations resulted in 1.78

L10-15 please give the choice of CO<sub>2</sub> constants and the pH scale when using CO<sub>2</sub>SYS

L24 20-25%

L21 Direct measurements were taken by Winde et al. 2014 and Moore et al. 2011. Compare their results with your estimates and observations.

P12427

L5 -0.7 mmol C m<sup>-2</sup> d<sup>-1</sup> is only the offset induced by AT generation.

L 21 ff. The page numbers at the end of each reference must be cancelled.

P12437

Are the positions for station 2 and 7 correct?

Add identifiers for the membership in SNS, NNS, SKNT

P12440

Table 4 is very small. The month of this study in 2012 should be 6

P12441

Table 5 is very small. Omit b in the eqn for benthic denitrification. Use acronyms for defining the different fluxes. Then you can use them to calculate the budget. "WAR" is pelagic respiration? Say "TA turnover linked to" instead of "Linked to". IR+SR should not be counted for the nitrogen cycle. Omit the P cycle.

P12442 The ticks for lon and lat should match even numbers

P12443 There is something wrong with these profiles: Station 11 cannot have a depth of 500 m. In c) there is only one station shown.

P12447 Say "scatter plots" instead of "correlation plots". Indeed the reader cannot see

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any correlation. Please discuss the rank adjustment and the consequences.

P12449 Fig 8b: The overall regression line is misleading as the slope of the regression lines for each region should result in  $RQ \sim 1$ .

Fig8 The auxiliary lines should match the labels at the axes

P12451 Say “scatter plots” instead of “correlation plots”. I do not understand the p value. There is no correlation calculated. Where do the horizontal and vertical bars at some dots come from? In the Figure caption 4 lines are described. In the plot I only see 3. The assignment is not clear.

P12452

“Contribution .. to the benthic AT budget ..”

Measured AT flux seems to small in this Fig.

P12453 Where does  $F_{air} = 1.3 \text{ mmol C m}^{-2} \text{ d}^{-1}$  comes from?. In the text  $F_{air} = 0.7 \text{ mmol C m}^{-2} \text{ d}^{-1}$

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Please also note the supplement to this comment:

<http://www.biogeosciences-discuss.net/12/C5140/2015/bgd-12-C5140-2015-supplement.pdf>

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Interactive comment on *Biogeosciences Discuss.*, 12, 12395, 2015.

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