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Interactive comment on "Fluxes of carbon and nutrients to the Iceland Sea surface layer and inferred primary productivity and stoichiometry" *by* E. Jeansson et al.

E. Jeansson et al.

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We would like to thank the reviewer for carefully reading the manuscript and providing valuable constructive comments that generally improved the manuscript. We go through the comments below, one by one, and add our response (R) after each comment.

My main concerns are related to advection, which was assumed to be zero in the region despite a lengthy discussion in the introduction of different flows to the area.

R: We agree on the mismatch and have now reduced the circulation description (since this is not a part of the focus of the paper). Secondly this would be a good data set for

investigating inter annual variability, however the year to year variations and the spread of data with respect to time was not obvious in the current write up.

R: We agree that the data should be used to evaluate the interannual variability. However, the focus of the paper is to present long-term mean fluxes; a study evaluating the interannual variability in the area, partly using the time-series data, is soon to be submitted (J. Olafsson, personal comm.).

Specific comments 1) P 15401 lines 15-23 there is a lengthy review of water flow to the region – the advection is later dismissed and set to zero. Why is this? I would suggest a 'description of the region' section with figure 1 (adding arrows to indicate flows to the figure). As it stands the introduction of water flow makes this seem like the main aim of the paper.

R: See response to the first general comment. The section is now considerably shortened to better fit the focus of the paper.

2) In the introduction there is a paragraph about different productivity estimates that a) needs references and b) may be better in the discussion (defining only the ones that you use).

R: As far as we can see there are references for all production terms mentioned, except total production. This has now been added. We believe it is helpful for any reader to clearly define different production terms already in the Introduction, to make it easier to follow later.

3) You refer to 100m as surface, is this always the surface? (eg: in march when MLD is over 150m).

R: The winter convection can reach down to approximately 200 m in the Iceland Sea (see Olafsson, 2003), but as stated on P 15404 lines 13-15 we define the upper 100 m as surface since this the seasonal drawdown in nutrients and DIC is largely confined to this layer. We have now added some more discussion and reasoning behind our

choice, and how a deeper SL affect fluxes and stoichiometry.

4) In the data section the source of temperature and salinity data (to calculate MLD) is not shown. Please add details on methods of measurement and confidence in the measurements.

R: More references to papers describing the data have now been added.

5) Also the nutrient data – where did this come from? How were the measurements made? What is your confidence in them?

R: Some more info have been added and clarification of the reference (Olafsson et al., 2010).

6) Re: DIC analysis: please include references on CARINA data quality at the very least. Surface sampling from 1983 is mentioned but was it included? Please state (as in the abstract) the range of years used.

R: Reference is now added and the included time period clarified.

7) The frequency of measurements for each month is covered in the table but the spread of the data is not shown. Survey dates with respect to time would be useful. The data sources should be acknowledged in the acknowledgement section too.

R: The data is from the CARINA database, and the reference Olafsson et al (2010), describing the data, is in the list of references. We have also added more references describing the specific parameters in the database.

8) Where there are fewer data points I understand that the median values were interpolated – please make his clear wherever it is mentioned. For example on p 15404 line 6 and p 15409 14 (In this case where you have written: due to few data this could be rewritten as 'as fewer data were available in winter the values have been interpolated'). Likewise the caption for Figure 2 should refer to '. . . MLD, for the months with few data points, was interpolated' Also add a comment re: interpolation for the caption to Figure

4?

R: This is now changed accordingly.

9) Units and chemical symbols should not be mixed to avoid confusion. For example, "C" stands for the unit "coulomb". While the risk of such confusion may be small it can be easily avoided completely by placing the chemical symbol after the unit, i.e. '1 mol m-2 a-1 C' or, better, '1 mol m-2 a-1 as C equivalent'. In this document the units are not consistent: some productivity estimates do not have 'gC' units eg: p15408 line 18, p15416 l24. In contrast some do have 'gC' eg: (line 17 on the same page). Be consistent. 'gC' is not an SI unit (& 'gN' for nitrate may be misinterpreted as Newton).

R: We have followed "standard" formulations, frequently used in biogeochemical literature. We believe that the risk of the mentioned confusion is negligible. We have tried to be more consistent, and changed accordingly. 10) The assumption of negligible horizontal nutrient supply (under biological production) should be explained, considering the lengthy description of different flows. Do the arctic and Atlantic water masses have the same nutrient concentrations?

R: As mentioned earlier we have now removed much of the circulation description. The motivation for neglecting the horizontal flow is found on P 15405, lines 20-22. "Regarding the time-series station as very thin section the horizontal fluxes will balance, and F(hor) could then be set to zero." Similar approach has been used in similar studies (see e.g., Skjelvan et al., 2001; Falck and Anderson, 2005).

11) What is the significance of the 47% (PO4) and 60% (Si) regenerated production? Is this discussed at all?

R: This is now removed.

Technical corrections 1) The partial pressure of CO2 should be abbreviated as p(CO2), with p in italics to identify it as a physical quantity.

R: The 'p' is changed to italics everywhere, as it should (Thanks), but without the

parenthesis, following standard formulation.

2) There is an overuse of the word ‘thus’ throughout the document.

R: Have removed several ‘thus’ now.

3) Overuse of ‘âĞă’, should this be used at all? Please be specific rather than using the approximation symbol.

R: Have now changed this on several occasions.

4) P 15400 line 26: add ‘a’ (a very long time. . .)

R: Done

5) P 15400 line 27 add a reference to increasing CO2

R: Done

6) P 15401 l.28. remove ‘only’ (in: are only few estimates..).

R: Done

7) P 15402 l.1. Production estimates should range from 75 to 179?

R: Now changed

8) P 15402 l.10. I suggest O2 (and later Ar) in full as oxygen (and Argon).

R: Done

9) P 15402 l.20. ‘debate during the last decades’ (change to ‘debate over the last few decades’).

R: Done

10) P 15402 l.26 ‘changes in nutrients’; l27 add a reference for model studies?

R: Done

11) P 15403 l 1. There is some query over the tenses used, please check this. For example ‘in this study we will use’ (remove ‘will’) – in the same paragraph you say ‘will estimate’. Likewise page 15405 (use of the word ‘choose’ instead of ‘chose’?)

R: Have tried to improve this.

12) P 15404 l 2. Add reference for Hermite interpolation? Line 3: ‘cause’ should be ‘course’. Line 6 use neighbouring (rather than neighbour) months.

R: Done

13) P 15405 l 24. SD if this is standard deviation please use in full the first time this appears.

R: Had missed this. Changed now.

14) p 15407 l 3 repeat of ‘the the’.

R: Done

15) P 15407 l 9. Partial pressure of CO2 in the atmosphere (not partial pressure of the atmosphere)?

R: Now changed

16) P 15408 line 1. ‘ reduced rate of deficit increase’ needs to be reworded for clarity. Line 3: deduced from ‘a’ change (add ‘a’); line 5: in the following ‘section’ and ‘are’ summarised. . .(add these words for clarity).

R: The paragraph is now somewhat rewritten to make this more clear. The suggested changes are implemented.

17) P 15409 line 24: ‘silicate gives a total production. . .’; l27. Recommend changing text to: ‘but also shows a negative flux. . .’.

R: Now changed and somewhat rewritten.

18) P15410 l4. Carbon-to-nitrate ratio is written in full (this should be at the start only and henceforth C:N.

R: Checked, and could not find any place this was written earlier.

19) There are a few long sentences that could be broken up eg: p15410 line 5 (‘the seasonality between DIC and nitrate. During the first part. . .’). Line 24: replace ‘but’ with ‘Another aim is to see how representative. . .’ to break this into 2 sentences.

R: Have changed this now.

20) p15410 line 5 ‘rather high agreement’? How high?

R: Changed ‘rather high’ to ‘good’

21) P15411 l 26: relative to nitrate (add ‘to’).âĂĺ

R: Done

22) P 15412 l 4. Low-N (define N earlier on)?

R: Changed to ‘low nitrogen’

23) P15412 line12 to 29 (this paragraph needs to be altered in a few places to make it easier to read: eg: line 12: ‘As previously mention the different season lengths with net N or C based production makes it difficult’. . ..; eg: line 26: ‘Furthermore C:N ratios have been observed. . .’.

R: Done

24) P15413 l3: ‘this value represents the. . .’; l8: ‘mechanistic explanations of uptake ratios’.

R: Done

25) P 15414 l6: If equating. . . (rather than equalling).âĂĺ

R: Done

26) P 15414 l24-26. ‘This will aid understanding of variability drivers in biological production...’

R: Yes, better. Changed now.

29) P 15415 l4: ‘With this mentioned’ could be ‘with this in mind we..’; l16: reword as follows:- ‘when the concentrations are lowest by 20-30%’; l23: add ‘an’ (in an absolute sense).

R: Done

28) P15416 line 2. ‘With some bends?’ What does this refer to? This needs to be clarified.

R: This is now removed.

29) P15416 line 7: Slight changes here to: ‘Since we mainly want to evaluate the fluxes of importance for production, and these seem to be confined. . .’; l22: omitted words & repeats as follows: ‘due to the spread in mean pCO2 values’.

R: Done

30) P 15419 l 31 remove ‘on internet’, it is sufficient to put the ‘ftp’ address in place.

R: Done

31) Table 1: ‘MLD’, spell this out in full when used for the 1st time in the caption. What is the range of years used? Footnote a: ‘surface layer to be negative’. Footnote b: are these all averages anyway? Do you mean interpolated rather than averaged?

R: MLD spelled out in full now. The footnotes are changed. (Yes, should be interpolated, and not averaged. Thanks.) The range of used years for each month has not been shown for any parameter, since the focus is not to do a detailed study of interannual variability.

32) Table 2 caption. Replace ‘thus’ with ‘were’.

R: Done

33) Figure 1: add arrows for water mass movement and flows?

R: Since the circulation description is now much reduced we omit to show the currents in the figure.

34) Figure 2: Why are there more data points in Feb? It would be interesting to see the variability with respect to year? What about the higher than usual MLD in one year for March (and lower than usual value in June) – these are not discussed. Which years are they? Is this the reason for deviations in the profiles in figure 3?

R: The sampling program of the time-series station largely covers four months every year

35) Figure 3: 'An increase in MLD' – relative to what? Which years are presented? Where is the y-axis label? R: Clarification for the MLD change now added. The y-axis label is now added. Concerning which years are shown, since the study does not aim to evaluate the interannual variability this information has been omitted. We are here just interested to see the spread in MLD for the different years, for each month.

36) Figure 5: If you use molC m-2 in the text this could be used in the y-axis labels? Remove legend within the figure if explained in the caption.

R: Done

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/11/C7478/2014/bgd-11-C7478-2014-supplement.pdf

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Interactive comment on Biogeosciences Discuss., 11, 15399, 2014.

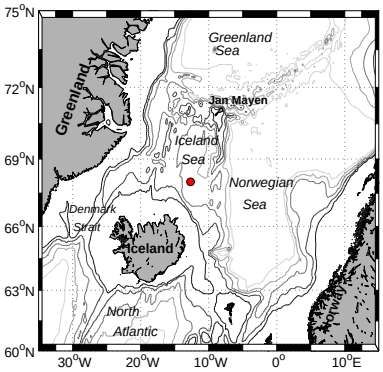

Fig. 1. Map of the Nordic Seas region. The red filled circle marks the position of the time-series station.

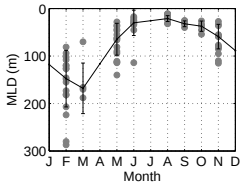

Fig. 2. Calculated mixed layer depth (MLD) at the Iceland Sea time-series station, using the density difference criteria of $\Delta\sigma\theta$ 0.05 kg m-3. The grey dots show the MLD for each year, and the line is the media

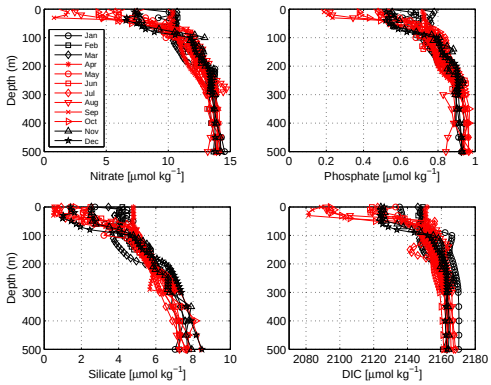

Fig. 3. Mean monthly concentration profiles (upper 500 m) in the Iceland Sea, of nitrate (upper left), phosphate (upper right), silicate (lower left), and DIC (lower right). The black profiles indicate months

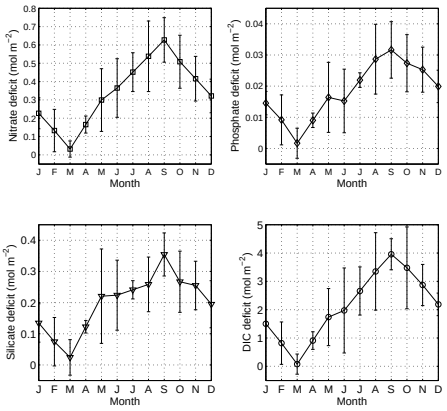

Fig. 4. Calculated monthly-mean deficits of nitrate, phosphate, silicate, and carbon, in the upper 100 m in the Iceland Sea. For the calculations we used mean monthly values for the 100-200 m depth range as r

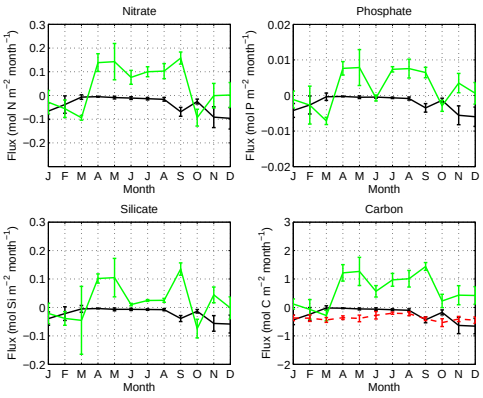

Fig. 5. Calculated seasonal fluxes to the upper 100 m in the Iceland Sea, for nitrate, phosphate, silicate and DIC. All fluxes are in mol m-2 month-1. The figures show the vertical flux (Fvert; solid black li

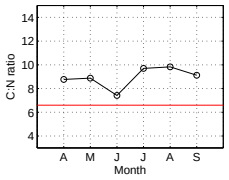

Fig. 6. Average monthly C:N ratios for biological production (see Fig. 5) during the period of seasonal drawdown (April–September) of DIC and nitrate in the Iceland Sea. Then red line show the Redfield C:N ra

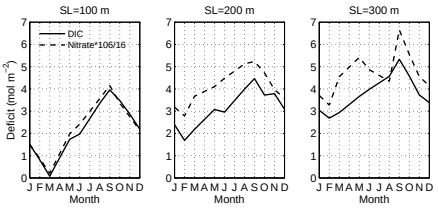

Fig. 7. Comparison of calculated monthly-mean deficits of DIC and nitrate in the Iceland Sea, for different thickness of the surface layer (SL). The nitrate deficits are multiplied with the Redfield C:N ratio