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Discussions

Interactive comment on "Seasonal distribution of dissolved inorganic carbon and net community production on the Bering Sea shelf" *by* J. T. Mathis et al.

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We would like to thank Review #2 for taking the time to critique this manuscript and provide valuable comments that have greatly improved our work.

Reviewer 2 commented on this point as well: "This manuscript looks like a sequel of a previous one by Bates et al. (Deep-Sea Research II, 52, 3303-3323, 2005) in the adjacent Chukchi and Beaufort Seas. . . . The article by Bates et al. (2005) was one of more than twenty contributions to a special issue on the Western Arctic Shelf-Basin Interactions (SBI) Project. In that context, focusing just on the DIC based NCP looks satisfactory. However, it is a poor objective for an independent research paper in which

oxygen, phosphorus, nitrogen, and silicon based NCP could have also been calculated to present and discuss the stoichiometry of the net utilization of these key elements."

Response: The authors have updated section 4.2 to include a discussion of seasonal distribution of phosphate and silicate (nitrate was already discussed), and section 5.1 to include NCP estimates based on net utilization ratios of nitrate, phosphate, and silicate. Section 5.1 also features an inter-comparison and discussion of the strengths and weaknesses of each approach. Overall, we found that NCP measurements based on nitrate were much lower than those based on DIC, as is expected of highly productive, high-export systems (Sambrotto et al., 1993). Phosphate measurements tended to overestimate NCP with respect to NCP (DIC), except in the middle domain. NCP calculated from silicate drawdown was low, but this is also expected in iron-limited systems (Aguilar-Islas et al., 2007). However, this discussion is peripheral to the core objectives of the paper. While we appreciate Review #2's opinion that this paper is a sequel to previous works by Mathis and Bates, we would like to point out that this is the first time a comprehensive survey of DIC has been done in the Bering Sea and has been utilized to estimate NCP. We feel that this is a valuable contribution to the marine carbon community and beyond and hope that Biogeosciences recognizes the value of the work. Therefore, the paper continues to focus primarily around seasonal distributions of dissolved inorganic carbon and the NCP values calculated from these data.

Reviewer 2 also commented on the need for a discussion of alkalinity, "NCP is the result of the balance between the utilization of DIC during photosynthesis minus the release of DIC due to the whole community respiration. This definition implies that changes of DIC over time due to CaCO3 synthesis and dissolution should be corrected by -0.5*(TA+NO3) to estimate NCP. To do that, total alkalinity (TA) measurements should have been performed. If you cannot apply this correction, then you are not really measuring NCP but just "net carbon utilization" unless you can demonstrate that the contribution of CaCO3 is negligible. However, in page 268 you say "similarly, this remineralized DIC lowers the pH of these bottom waters suppressing the carbonate mineral saturation states (Mathis et al., 2010).” Therefore, the carbonate chemistry seems relevant.”

Response: The authors did measure total alkalinity in conjunction with DIC and have applied the suggested correction to the NCP estimates based on DIC. We found that seasonal changes in alkalinity were highly variable across the shelf; in some cases, alkalinity decreased from spring to summer, but increased in others. The authors have added a brief discussion of this correction factor to section 3.3 and included a fourth subsection in Section 4 to describe the seasonal distributions of alkalinity across the shelf. Section 5, Tables 3, 4, and 5, and Figures 7, 8, 9, and 10 now all reflect this correction factor. However, in response to these comments, we would like to note that pH changes due to the remineralization of DIC in bottom waters are excluded from the upper 30m, and do not affect our NCP measurements. Any remineralization of DIC occurring in the upper 30m is likely very small, and as Reviewer 2 goes on to comment, “NCP includes by definition the remineralization processes. Note that NCP is not the same as primary production (PP) or Net Primary Production (NPP).”

Reviewer 2 also commented on the normalization procedure: “My second concern refers to the use of nDIC to correct the effect of freshwater mixing. This correction would be suitable if the DIC concentration in the freshwater end member(s) is nil. According to the web page of the USGS, Alaskan rivers are “moderately hard”. Therefore, the assumption is not correct. For each domain, NCP should be calculated as: NCP = 35*[DICj/Sj/-DICr*(1-Sj/Sa)-DICa/Sa]/time, Where DICj and Sj are the DIC and Salinity of the domain in July; DICa and Sa are the DIC and salinity of the domain in April; and DIC r as the DIC of the incoming freshwater. Assuming that DICr=0 implies an overestimation of NCP. Note that for DICr=500 um/kg, Sj=30 and Sa=32, the overestimation would be of the order of 10 mmol C/m2/d.”

Response: Ideally, the freshwater end members for ice melt and river water and their resultant volume fractions in seawater should be calculated in order to perform the

most correct normalization procedures. These end members are typically determined through the analysis of δO18 samples, which are unfortunately unavailable with this dataset. As a secondary estimation, however, the salinity-variable normalization equation provided by Reviewer 2 is also not correct. Much of the salinity change between spring and summer across the shelf in the upper 30m was due to ice melt. Ice melt has a DIC concentration of near zero, and a much greater shelfwide influence than riverine discharge. Assuming that all salinity change is due to river water drastically overestimates the amount of DIC contributed to the shelf over 100 days.

In order to estimate the greatest possible effect of rivers on our NCP calculations, we performed the following estimation. While the Kuskokwim River, which discharges over the southern shelf, discharges less water and has a lower DIC value than the Yukon River, we assumed that influence of each river would be equal, and that all areas of the upper 30m of the inner domain would be affected equally. While stream flow data was unavailable for 2008, we referenced the average stream flow and DIC concentrations in the Yukon River from 2001 - 2005 as reported by Striegl et al., 2007. Assuming that all this DIC was confined to the upper 30m in the coastal domain, the authors estimated that ~12 μmol kg-1 of DIC should be subtracted from the DIC deficit in the coastal domain. Rivers also contribute a minimal amount of alkalinity, and this riverine alkalinity must also be included in the correction factor suggested by the reviewers as above. Using the stream flow and alkalinity data for the Yukon River reported for the period of 2003-2006 by Cooper et al., 2008, we determined (again assuming that the Yukon and Kuskokwim Rivers were equal, and that all alkalinity was confined to the upper 30m in the coastal domain), that ~12 μmol kg-1kg alkalinity were contributed over a 100 day period. Applying these alkalinity and DIC corrections to the inner domain NCP results in a <1 mmol C m-2 d-1 change in the rate of NCP. Because this is likely a dramatic overestimation of the influence of river water, we are reasonably certain that this value is much lower and that the river contribution of DIC and alkalinity is therefore negligible.

Because the estimation of the actual influence of river waters over the shelf is inaccurate without δO18 data, the authors have decided to briefly mention the influence of river waters in section 5.3, but retain the fixed-salinity normalization procedure originally used in their calculations.

Reviewer 2 provided comments on minor errors (typographically, formatting, etc.)

Response: We have addressed all typographic, grammatical and other small errors in the text identified by Reviewer 2.

Interactive comment on Biogeosciences Discuss., 7, 251, 2010.