Ocean Science Discussions

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Comment on os-2021-59

Anonymous Referee #1

Referee comment on "Winter observations alter the seasonal perspectives of the nutrient transport pathways into the lower St. Lawrence Estuary" by Cynthia Evelyn Bluteau et al., Ocean Sci. Discuss., https://doi.org/10.5194/os-2021-59-RC1, 2021

Review for manuscript # os-2021-59 "Nutrient transport pathways in the Lower St. Lawrence Estuary: seasonal perspective from winter observations" by Bluteau et al.

Formal review:

The manuscript is well written, scientifically sound and addresses relevant societal and scientific questions within the scope of Ocean Science. A nutrient budget analysis based on newly collected and previously published data sets is presented. Unlike previous results, which had suggested that vertical nutrient fluxes due to diapycnal mixing dominate the nutrient supply in the Lower St. Lawrence estuary, the authors conclusively show that fluvial advection of nutrient rich waters from the St. Lawrence River dominate the budget throughout most of the year. The results thus modify current understanding of relevant nutrient supply processes in the estuary.

The contribution is well structured and clear. The results fully support the authors interpretations and the description of experiments and calculations are sufficiently complete and precise to allow their reproduction. I also appreciated the open access of scripts and data. Below, I provide a few minor remarks with reference to lines in the manuscript that the authors may want to consider to improve the manuscript. Most of the remarks are related to the discussion of possible biogeochemical processes that could also impact the nitrate budget and the nutrient distributions shown. Throughout the contribution, the authors refer to nutrient "consumption" as the only biogeochemical process being relevant. Although not explicitly defined, it seems that this term refers to uptake of nitrate during primary production. On the one hand, I find the word "consumption" in this context rather unfavorable. In biological oceanography, consumption is widely used related to oxygen and describes the loss of oxygen due to respiration of organic matter, i.e. a chemical reaction. In the same context, nitrate consumption occurs in anoxic waters in the form of denitrification or ANAMOX where bacteria respire nitrogen nutrients instead of oxygen. However, these biogeochemical processes are very different from nutrient uptake during photosynthesis. Thus, I would

suggest to replace "consumption" with "uptake" in most places of the manuscript. On the other hand, there is also a biogeochemical nitrate source term. During the degradation of organic matter, nitrification enriches inorganic nitrate concentrations in the water column. While box models suggest that this term in not dominating nitrate supply in the Lower St. Lawrence Estuary, it does seem to contribute between 10% and 20% to the nitrate budget (e.g. Jutras et al., 2020, Thibodeau et al., 2013) and should thus not be completely ignored when interpreting nutrient distributions and their seasonal variability. In my detailed remarks below, I am pointing to a few but not all passages which the authors may want to improve.

Detailed remarks with reference to lines in the manuscript:

Line 31, "…, but the low nutrient consumption provided a better representation …". I can understand this statement as far as nutrient uptake during primary productivity is concerned. However, I wonder about the seasonality of biological nutrient sources due to processes such as organic matter remineralization with subsequent nitrification and nitrogen fixation.

Lines 33-34, "upwelling" and "entrainment": I had difficulties understanding the two terms, here. To me, the term "upwelling" refers to vertical advection and involves vertical velocities (e.g. due to Ekman divergence). However, here, I think the authors associate "upwelling" to a vertical flux of nutrients due to diapycnal mixing that does not involve any vertical velocity. Furthermore, the term "entrainment" is unclear to me. How does it differ from mixing? Please clarify the processes that are referred to here.

Line 75: add a period after "saltier".

Line 175, "The historical dissolved nitrate concentrations at Quebec City were digitized from published sources (Figure 4 of Hudon et al., 2017)." This is a bit unclear. I could not find any nitrate values in Fig. 4 of Hudon et al (2017). There, only the sum of nitrate and nitrite is shown. How were nitrate value derived from this graph? Were nitrite concentrations neglected here? Please clarify.

Line 192, functional dependence of N: The Greek symbol rho is not introduced and should be potential density (otherwise, compressibility needs to be account for in the equation).

Line 213: add potential before density.

Line 222, "indicating that nitrate was being consumed": I would suggest to rephrase this sentence to include biological production of inorganic nitrate, e.g. "indicated that nitrate

uptake exceeded biogeochemical nitrate sources" or "indicated a net nitrate loss through biogeochemical processes".

Line 229, "Nitrate concentrations in winter …": I think the statement made in this sentence also applies to nitrate distributions during the other seasons.

Line 291, "higher consumption": I think that the authors solely refer to nitrate uptake during phytoplankton growth here. However, there are also other nitrate sinks such as denitrification. What may be the seasonal variability of these processes? Furthermore, I would suggest to use "biological uptake" instead of consumption.

Line 306, "Hence, the minimum nitrate load required to …": This statement is incorrect, as it neglects local nitrate sources e.g. due to aerobic remineralization of organic material (nitrification).

Lines 326-327, "… period when biological consumption is greatest": See comments to line 291 above.

Line 373-408, discussion section: I think that adding a few sentences on the relative importance of biogeochemical flux contributions to the nitrate budget would strengthen this work even further.

Figure 3 caption: Add "winter" between the and field in the first line. In the text before referencing to Figure 3 for the first time you were mentioning historic data and it is thus somewhat unclear which data are shown.

References:

Jutras, M., Dufour, C. O., Mucci, A., Cyr, F., & Gilbert, D. (2020). Temporal changes in the causes of the observed oxygen decline in the St. Lawrence Estuary. Journal of Geophysical Research: Oceans, 125, e2020JC016577. https://doi.org/10.1029/2020JC016577

Thibodeau, B., Hélie, JF. & Lehmann, M.F. Variations of the nitrate isotopic composition in the St. Lawrence River caused by seasonal changes in atmospheric nitrogen inputs.

Biogeochemistry 115, 287–298 (2013). https://doi.org/10.1007/s10533-013-9834-4.