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Interactive comment on "Review Article: How does glacier discharge affect marine biogeochemistry and primary production in the Arctic?" *by* Mark J. Hopwood et al.

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This review was comprehensive in its scope of biogeochemical impacts of freshwater discharge in the cryosphere. Using multiple case studies of Arctic fjords, Hopwood et al. capture the range of biogeochemical settings, and in doing so, identify and summarize multiple drivers for diverse phytoplankton response. The review was written with a broad audience in mind, with detailed discussions and patient explanations. The figures aided the discussion and were generally appropriate to the text. I support the publication of this much-needed review pending the appropriate revisions are made.

I feel the authors were diligent in their discussion of state-of-knowledge and take a con-

servative stance when estimating fluxes of dissolved nutrients. I support this approach. However, I am cautious about language which aims to describe ecosystem function as similar in both the Arctic and Antarctic. Few studies exist which focus on the ice-ocean interface (within 1km of marine-terminating glaciers) in the Antarctic. The geochemical gradients are intense here and logistically more challenging to study. It is apparent to me that the Antarctic lacks a robust assessment of the fjords, and so the authors should acknowledge that comparatively less is known about the Antarctic.

I think the authors should include in their discussion mention of katabatic wind events and the efficiency at which they mix the upper water column, and the result this would have on export of the surface layer and upwell subsurface sources (see Lundesgaard et al. 2019). Katabatic wind events are important interactions between the atmosphere and ice sheets.

Lastly, I am pleased with the discussion about new approaches being required to address these highly dynamic ecosystems. Namely, higher resolution (in space and time) studies are needed to understand how this system function and will respond to climate forcing.

Specific comments:

L281-282: I do not think we have a well-constrained estimate for the Antarctic. Subglacial discharge is one of the critical fluxes discussed in this review. Recent attention has been given to the subglacial environment and I think it is worth mentioning the uncertainty which surrounds this source. There are biotic and abiotic factors which influence the quality and quantity of iron released to the ocean. Weathering rates are controlled in part by regional geology, but also the microbial communities (namely, chemolithoautotrophs) and exposure to oxygen may be important controls. (Wadham et al. 2010; Tranter, Skidmore, and Wadham 2005)

Further, it is nearly impossible to differentiate the effects of tidal uplift, sediment resuspension, glacial calving and subsequent scouring of the sediments at the glacier terminus from purely subglacial discharge. Our understanding of these effects would be greatly increased if measurements were made proximal to cold-based, low velocity marine-terminating glaciers. We can then begin to pick apart the contributions of these different processes.

L288: Seasonal variation may be an important theme for future directions, both in the Arctic and Antarctic. The authors make this note. Without the aid of the ocean modeling community, we do not yet know how subglacial discharge responds to climate forcing.

My general feeling is that while the comparisons may be obvious, there are important functional differences between the Antarctic and Arctic. And so supporting information should be appropriate. For example L203-206 has two well-known studies of particulate iron in the Antarctic (Gerringa et al., 2012, and Annett et al., 2017). The authors may choose to mention this is an important question in general for particle-enriched iron sources. (Fitzsimmons et al. 2017)

L192-195: I think it is important here to discuss the potential for dissolved-particle exchange, facilitated by undersaturated organic ligands or by dissolution in the guts of zooplankton. (Gledhill and Buck 2012; Barbeau et al. 1996)

L452-455: This discussion is accurate, however nutrient stoichiometry (both supply and demand) is what drives primary production and selects for specific phytoplankton taxa, especially in enriched environments. In the instance of diatoms, the N:Fe ratio is a good predictor of iron limitation, where a threshold describes the point at which diatoms begin to grow sub-optimally. The application of geochemical proxies (N:Fe, Siex) for nutrient stress should be applied where such data exists (see King and Barbeau 2007; Hogle et al. 2018).

L511-512: This is indicative of Fe-limitation of the phytoplankton community, which is dominated by diatoms during the sampled summer growth season. Please indicate this is a log-transformed ratio.

L496: “islands occur within”

The phytoplankton community must meet several requirements for a pronounced increase in growth to occur. They must be physiologically adapted to use glacially-derived iron sources. It is unknown the degree to which phytoplankton in the Antarctic use colloidal iron, which would require biotic and abiotic processes to transform it in to a bioavailable form (ie organic complexation, dissolution, photoreduction). I challenge the simplistic view of HNLCs and acknowledge this to be a grand question of our time.

L584-596: This is a great discussion on the uncertainties which remain largely in marine iron biogeochemistry.

L672: “. . .additional subsidies of labile carbon. . .”

L731: Our data for Antarctica is spares, and biased towards summer growth periods. We have little information about the community dynamics throughout the ice-free growth season.

L742: We see the same in Antarctic fjords, but lack an early Spring diatom bloom. Instead, flagellates dominate the fjords. A pronounced diatom bloom and sedimentation event spans ∼2 weeks, and overall production falls dramatically early-Fall.

L758: “of Patagonia”

L792: It is becoming more apparent that fjords in the Antarctic are highly productive relative to their Arctic counterparts. Primary production in the fjords rivals that of the Fe-limited shelf regions during the summer. Indeed, we find that organic carbon export is greatest in the inner-fjord environment (unpublished). This is more evidence of the differences in behavior between the Arctic and Antarctic.

L819-822: How then do we reconcile the expansion of the icesheets and the decreased availability of sediments eroded by wind?

L862-863, 865: Autonomous gliders with optical backscatter and seawater sampling capabilities would we a great way to begin to address this. I agree!

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