DR. WILLIAM ROSS HUNTER (Orcid ID : 0000-0001-8801-7947)

Article type : Letter to the Editor

Can carbon storage in West Antarctic fjords have an impact on climate change, following glacier retreat?

William Ross Hunter

Fisheries and Aquatic Ecosystems Branch, Agri-Food and Bioscience Institute Northern Ireland. Belfast BT9 5PX, UK.

Email: Billy.Hunter@afbini.gov.uk

Abstract

Zwerschke et al's (2021) paper **'Quantification of blue carbon pathways contributing to negative feedback on climate change following glacier retreat in West Antarctic fjords'** provides an interesting insight into the potential for Antarctic fjords to store carbon, following glacial retreat. The authors used ash free dry mass (AFDM) as a proxy for carbon content in the carbon content of sediments and microbenthic infauna within the fjords to estimate their carbon sequestration potential. This equates to between 0.05 and 0.19 % of the estimated carbon buried at the seafloor. Consequently, the paper's assertion that these fjords could provide a negative feedback against climate change is tenuous when considered against the wider impacts of Antarctic deglaciation.

Main Body

Zwerschke et al. (2021) offer an insight into the potential for carbon sequestration and storage within the new benthic habitats exposed through glacial retreat in Antarctica. The paper provides a description of spatial trends in the carbon stocks of the benthic macrofauna and sediments. In this respect the paper provides an interesting insight into potential carbon storage following glacial retreat in a number of Antarctic Fjords.

I am sceptical about the potential for these fjords to provide a significant feedback against climate change. The study suggests that carbon storage in Antarctic fjords has the potential to sequester 56,909 ± 29,833 tonnes of C per year, following glacial retreat. This would equate to between 0.05 and 0.19 % of the estimated global seafloor carbon burial rates of between 29.4 and 117 million t C per year (Bauer et al., 2013; Cai, 2011). The authors, however, fail to consider the wider context of carbon storage in marine sediments and 'blue carbon' habitats, such as saltmarsh, mangroves, seagrass beds etc., or the global impacts of Antarctic glacier and sea-ice loss. Given that conservative estimates of Antarctic sea ice loss will cause global sea-levels to rise by 4.5 to 5 cm by the end of this century (Rignot et al. 2019) it is difficult to rationalise small gains in sediment carbon storage in Antarctica against the accelerating global loss of vegetated marine systems (e.g. Fagherazzi et al. 2019; Williams et al. 1999). In addition, Barnes (2020) highlights the fact that carbon storage in Antarctica's coastal sediments is limited by disturbance from Ice-berg-seabed interactions, similar to the effects of trawling on seabed carbon storage in other systems. As such, it seems strange to me that the authors are so keen to herald their results as a potential feedback mechanism against climate change, without consideration of the potentially catastrophic impacts of Antarctic glacier and sea-ice loss.

I am also concerned about the use of ash free dry mass as a proxy for the carbon content of both the sediments and microbenthic fauna analysed. In both cases, Zwerschke et al. (2021) applied mathematical conversions to derive estimates of faunal carbon content and sediment total organic content (TOC). The gold standard for this work is through Organic Elemental Analysis to directly quantify the percentage of carbon in a sample. The use of AFDM as a proxy is acceptable but introduces errors into the estimates of carbon storage. These errors are compounded by the authors' conversion of faunal AFDM to Carbon content used a fixed assumption that skeletal material (carbonates) accounted for 13 % of the ash weight (following Salonen et al. 1976). Why not carry out an acid digestion of the ash and estimate carbonate content by mass loss? This would at least allow differences in the skeletal material present in macrofaunal groups from different sites to be included within the wider assessment of carbon storage. Likewise, there are established methods for acid digestion of marine sediment to quantify the relative organic and inorganic carbon content (e.g. Hedges and Stern, 1984). Ultimately, I feel it would be more appropriate to present the data as Ash Free Dry Mass, which does not diminish the observations in any way.

Furthermore, the authors do not quantify microbial processes in the sediment, and assume no remineralisation of carbon in anoxic sediments. There are a wide range of microbial metabolic pathways which support carbon remineralisation in anoxic marine sediments, including denitrification, manganese (IV) reduction, Iron (III) reduction, Sulphur reduction and Methanogenesis (Jorgensen and Boudreau, 2001). As such, the authors do not provide a complete assessment of the carbon storage potential of the Antarctic fjords, nor do they provide any insight into the diagenetic processes that influence the residence time of carbon within marine sediments. This makes it difficult to fully assess their global significance in terms of climate feedback mechanisms.

Given these issues, I believe there is a danger of overstating the significance of carbon storage in deglaciated Antarctic fjords as a negative climate change feedback. As scientists we have an ethical duty to report our results without bias or unnecessary fanfare. The paper would not have suffered from a more conservative approach, reporting ash free dry mass values and discussing the potential for carbon storage and the potential processes which may control this in a rapidly changing polar system. I worry that this paper extends its interpretation of the data too far, without directly measuring carbon concentrations, considering the biogeochemical processes that govern carbon preservation, or the wider impacts of Antarctic deglaciation. That said I do believe it makes valuable contribution to our understanding of the potential for carbon storage within polar benthic ecosystems.

Acknowledgements

I would like to acknowledge Nadescha Zweschke and her co-authors for producing an interesting and thought-provoking paper.

Conflict of Interest

I declare no conflicts of interest related to this work.

References

Barnes, D. K. A. (2017). Iceberg killing fields limit huge potential for benthic blue carbon in Antarctic shallows. Global Change Biology, 23(7), 2649– 2659. DOI: 10.1111/gcb.13523

Bauer, J. E., Cai, W. J., Raymond, P. A., Bianchi, T. S., Hopkinson, C. S., & Regnier, P. A. G. (2013). The changing carbon cycle of the coastal ocean. Nature, 504, 61–70. DOI: 10.1038/nature12857.

Cai, W. J. (2011). Estuarine and coastal ocean carbon paradox: CO2 sinks or sites of terrestrial carbon incineration? Annual Reviews of Marine Science, 3, 123–145.

Fagherazzi, S., Anisfeld, S.C., Blum, L.K., Long, E.V., Feagin, R.A., Fernandes, A., Kearney, W.S., Williams, K. (2019) Sea Level Rise and the Dynamics of the Marsh-Upland Boundary. Frontiers in Environmental Science, 7, 25. DOI: 10.3389/fenvs.2019.00025

Hedges, J.I., Stern, J.H. (1984) Carbon and Nitrogen Determinations of Carbonate-Containing Solids. Limnology and Oceanography, 29, 657-663. DOI: 10.4319/lo.1984.29.3.0657

Jorgensen, B.P, Boudreau, B.B. (2001). Diagenesis and sediment-water exchange. In Jorgensen, B.P, Boudreau B.B. (Eds), The Benthic Boundary Layer: Transport Processes and Biogeochemsitry. Oxford University Press, Oxford, UK. 211-244.

Rignot, E., Mouginot, J, Scheuchl, B., van den Broeke, M., van Wessem, M., Morlighem, M. Four decades of Antarctic Ice Sheet mass balance from 1979-2017. Proceedings of the National Academy of Sciences of the United States of America, 116, (4), 1095-1103. DOI: 10.1073/PNAS.1812883116

Salonen, K., Sarvala, J., Hakala, I., Viljanen, M.-L. (1976). The relation of energy and organic carbon in aquatic invertebrates. Limnology and Oceanography, 21(5), 724– 730. DOI: 10.4319/lo.1976.21.5.0724

Williams, K., Pinzon, Z., Stumpf, R. P., Raabe, E. A. (1999). Sea-Level Rise and Coastal Forests on the Gulf of Mexico. U.S. Geological Survey Open File Report 99-441. p. 121. DOI: 10.3133/ofr99441

Zwerschke, N., Sands, C. J., Roman Gonzalez, A., Barnes, D. K. A., Guzzi, A., Jenkins, S., Muñoz Ramírez, C., Scourse, J. (2021). Quantification of blue carbon pathways contributing to negative feedback on climate change following glacier retreat in West Antarctic fjords. Global Change Biology. DOI: 10.1111/gcb.15898