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COMMENTARY

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# Blue carbon pathways in West Antarctic fjords

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Habitats in polar regions are among the most severely affected by climate change, especially due to temperature rises, resulting in losses from glaciers, ice shelves, and sea-ice extension and cover (Barnes et al., 2018). Until 2014, the trends for the Southern Ocean (SO) showed marked regional differences with clear temperature increments and ice losses (bluing) around the Antarctic Peninsula, and the Bellingshausen and Amundsen Seas, and the opposite trend (whitening) in the Ross Sea and eastern Weddell Sea (Parkinson, 2019). However, since 2014, the general trend for the SO is that of bluing (Parkinson, 2019). The changes in terms of ice cover and extension have quickly and profoundly affected benthic fauna, community structure, biological traits, and ecosystem services they provide across multiple spatial (e.g., Barnes et al., 2018) and temporal scales (e.g. Pineda-Metz et al., 2020). The recent paper of Zwerschke et al. (2021) is one of the latest publications dealing with temporal changes of benthic fauna ecosystem services in relation to glacier loss in fjords of the west Antarctic Peninsula (WAP) and aims to provide a more holistic quantification of carbon gains driven by glacier retreat.

Provision of ecosystem services (such as the storage of blue carbon) is clearly changing in the SO (Barnes et al., 2018; Pineda-Metz et al., 2020). Blue carbon refers to the carbon pathway of capture by phytoplankton and storage by animals such as benthic invertebrate fauna, and its generation represents one of the largest negative feedback to climate change in the SO (Barnes et al., 2018; Bax et al., 2020). For the Antarctic continental shelf, the amount of carbon sequestered by benthos has an estimated value between £0.65- and £1.76 billion-pounds sterling (Bax et al., 2020). The study of Zwerschke et al. (2021) with its focus on fjord systems of the WAP sheds new lights on a poorly known system, on infauna and sediment carbon inventories, and shows the big contribution of small invertebrates to blue carbon inventories and $CO_2$ immobilization.

The WAP is composed of 674 fjords with glaciers, from which almost 216 are retreating (Cook et al., 2016). This makes the WAP fjord system one of the most rapidly changing and novel habitats, but one for which little information exists on benthic fauna and how this is affected by glacier retreat (e.g., Barnes et al., 2020; Granger & Smith, 2013). Studies on benthic invertebrate fauna of fjord systems has been mainly focused on epifauna, which is dominated by suspension feeders and young pioneers with marked diversity differences between closely located fjords (Barnes et al., 2020; Granger & Smith, 2013). Invertebrate assemblages in fjords have an estimated epibenthic blue carbon production of 4536 t zC/year. The study of Zwerschke et al. (2021) showed infauna to greatly vary between fjords too, with assemblages dominated by suspension feeders, deposit feeders, or a mix of both. The blue carbon stocks from infauna averaged 2.58 gC $m^{-2}$, which is similar to that found for epifauna in the same study region (2.54 gC $m^{-2}$; Barnes et al., 2020). This represents one of the most interesting findings of Zwerschke et al. (2021), showing (1) the major importance of infauna in terms of benthic carbon stocks, and; (2) that current calculated blue carbon stocks (based on epifauna only) for SO shelves might be greatly underestimated. Thus, the role played by infauna in terms of ecosystem services and the negative feedback to climate change provided by Antarctic invertebrate benthos could be much greater than previously thought.

The main focus of Zwerschke et al. (2021) is the effect of glacier retreat for infaunal blue carbon and sediment total organic carbon (TOC) stocks. Evidence for other SO shelves show that, after ice shelf collapses or sea-ice concentration losses, primary production increases and, consequently, so do benthic biomass and blue carbon stocks (e.g., Barnes et al., 2018). Based on this, we could assume infaunal carbon stocks should show a gradient, with greater stocks after longer ice free periods (i.e., the farther away

This article is a Commentary on Zwerschke et al., https://doi.org/10.1111/gcb.15898 from glacier terminus). However, Zwerschke et al. (2021) disproved this hypothesis, finding no gradient for blue carbon stocks. This, in combination with data on epifauna for the same fjords, further suggests fjord benthic assemblages to be relatively young and far from reaching an apex or mature stage (Barnes et al., 2020). Although no trend was found for infaunal blue carbon, sediment TOC stocks did show a gradient of increasing TOC concentration with longer ice free periods (i.e., with increasing distance from the glacier), suggesting an increase of immobilized carbon since glacier retreat. Overall, the findings of Zwerschcke et al. (2021) show the potential of soft sediment of the SO's fjords as a negative feedback to climate change by means of blue carbon production, thus supporting the premise of soft sediment habitats as providers of a larger than thought contribution to carbon immobilization and sequestration (Bax et al., 2020).

The paper of Zwerschke et al. (2021) on carbon gains driven by glacier retreat comes at a point where blue carbon is increasingly attracting not only scientists, but also management organizations, governments, and international bodies committed to the conservation of marine environments (Bax et al., 2020). Indeed, blue carbon and its mitigation potential have been international recognized, including being addressed by the Intergovernmental Panel on Climate Change (IPCC). The IPCC's Special Report on the Ocean and Cryosphere in a Changing Climate (IPCC, 2019) addresses the potential of blue carbon as a mitigation tool. However, the report mainly focuses on coastal environments where tidal marshes, seagrass meadows, and mangroves are found, leaving soft sediment environments of the SO on a secondary plane. The potential of the SO soft sediments as a negative feedback for climate change as well as a theoretical framework on the topic was discussed by Bax et al. (2020). One important point risen by the authors is the need to protect the potential of the SO soft sediment habitats. Based on the expected ice losses for the SO, blue carbon and sediment TOC stocks will increase as a result of increasing primary production. The findings of Zwerschke et al. (2021) in combination with those of Barnes et al. (2020) for fjords of the WAP, prove this for sediment TOC stocks, and suggests that we have not reached the full potential of benthic blue carbon due to the young age of the local assemblages.

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## DATA AVAILABILITY STATEMENT

No data available.

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