

EGU21-12020

<https://doi.org/10.5194/egusphere-egu21-12020>

EGU General Assembly 2021

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Assessing the Biological Carbon Pump in the Weddell Gyre

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Biological processes in the subpolar Southern Ocean play a crucial role in the global carbon cycle, mediating CO₂ exchange between the atmosphere and the densest waters of the global ocean. While historical perspectives have centred the importance of shelf-sea regions, recent reframing emphasises the role of the open ocean, and the cyclonic gyres. Here, we investigate the operation of the biological carbon pump (BCP) in the Weddell Gyre using satellite ocean colour and bio-Argo floats. We find first that a significant proportion (>54 %) of the inter-annual variability in NPP was explained by the area of open (ice-free) water. Spatial patterns suggest that peak productivity is associated with the ice edge. The seasonal decline in NPP occurs before ice cover returns, suggesting that other controls are limiting annual NPP (e.g. the exhaustion of iron). Comparing the shelf region to the open ocean, the shelf was seen to have higher rates of productivity, but NPP in the relatively less productive open ocean region accounted for ~95% of total carbon uptake each year. The total NPP in the Weddell Gyre (97-197 Tg C yr⁻¹) is sufficient to supply the BCP-derived carbon that was previously observed to be exported from the region in Circumpolar Deep Water (~80 Tg C yr⁻¹). NPP in the open ocean Weddell Gyre could thus provide the major source of carbon exported from the Weddell Gyre to the deep ocean via the horizontal circulation.