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Climatological nutrient budgets and remineralization rates in the Eastern boundary of the North Atlantic subtropical gyre

Bieito Fernández-Castro and Xosé Antón Álvarez-Salgado
Insituto de Investigacións Mariñas, IIM-CSIC, Vigo, Spain (bieitof@iim.csic.es)

The classical one-dimensional view of the biological carbon pump in which vertical sinking fluxes dominate the organic carbon (OC) export to the deep ocean is being challenged. Lateral advection of slowly sinking particulate OC and dissolved OC can also represent a significant source of biogenic carbon to the dark ocean. The eastern boundary of North Atlantic subtropical gyre (EB-NASG) receives OC transported by the mean flow (i.e. the Canary Current), eddies and filaments from the nearby upwelling region of Northwest Africa (Álvarez-Salgado et al., *Limnol. and Oceanogr.*, 52 (3): 1287–92, 2007; Alonso-González et al., *Glob. Biogeochem. Cycles*, 23 (2): GB2007, 2009; Helmke et al., *Glob. Biogeochem. Cycles*, 19 (4): 1–16, 2005). This OC fuels epipelagic nutrient recycling and primary productivity and mesopelagic respiration. Here, the absolute geostropic transport and net budgets of oxygen and inorganic nutrients (nitrate, N, and phosphate, P) were determined in a large box over the EB-NASG using annual climatologies from the World Ocean Atlas 2013 and an inverse modelling approach. The surface waters (<100 m) of the box exported 1.2 $\pm$ 0.7 mol m^{-2} y^{-1} of oxygen to the ocean and atmosphere and imported 0.17 $\pm$ 0.17 mol m^{-2} y^{-1} and 0.010 $\pm$ 0.009 mol m^{-2} y^{-1} of nitrate and phosphate respectively, indicating that net autotrophy prevailed on the surface layer of the eastern NASG. On the other hand, the central waters (100-700 m) imported 4.3 $\pm$ 1.6 mol m^{-2} y^{-1} of oxygen and exported 0.70 $\pm$ 0.19 mol m^{-2} y^{-1} and 0.028 $\pm$ 0.019 mol m^{-2} y^{-1} of nitrate and phosphate, respectively, indicative of net remineralization in the mesopelagic. Those remineralization rates significantly exceeded epipelagic net community production, implying an net annual OC deficit of 28.6 TgC, that may be likely imported from the nearby NW African upwelling. The required carbon flux represents about 9% of the annual primary production of the NW African upwelling region (Carr, *Deep Sea Res. II*, 49 (1–3): 59–80, 2002), and is consistent with previous studies suggesting that a significant fraction of the OC produced in the upwelling region is remineralized within the subtropical gyre (Lovecchio et al., *Biogeosciences*, 14 (13): 3337–69, 2017). Furthermore, mesopelagic remineralization occurred at high molar N:P ratios ($\sim$27), and thus, excess nitrogen (DINxs = NO_3-16·PO4) was produced at a rate of 2.67 $\pm$ 0.43 $\cdot$ 10^{11} mol yr^{-1}. This excess nitrogen was exported to the gyre interior within the Canary – North Equatorial Current system, contributing to 34% of the total nitrogen excess annual production estimated for the North Atlantic (Hansell et al., *Marine Chemistry*, 106 (3–4): 562–79, 2007). Our results highlight the importance of the Eastern Boundary and the NW Africa upwelling system for the cycling of carbon and nutrients in the North Atlantic Ocean.