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Marine Ecosystem Assessment for the Southern Ocean

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Distribution of planktonic biogenic carbonate organisms in the Southern Ocean south of Australia: a baseline for ocean acidification impact assessment

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The Southern Ocean provides a vital service by absorbing about one sixth of humankind's annual emissions of CO2. This comes with a cost – an increase in ocean acidity that is expected to have negative impacts on ocean ecosystems. The reduced ability of phytoplankton and zooplankton to precipitate carbonate shells is a clearly identified risk. The impact depends on the significance of these organisms in Southern Ocean ecosystems, but there is very little information on their abundance or distribution. To quantify their presence, we used coulometric measurement of particulate inorganic carbonate (PIC) on particles filtered from surface seawater into two size fractions: 50-1000 m to capture foraminifera (the most important biogenic carbonate forming zooplankton) and 1-50 m to capture coccolithophores (the most important biogenic carbonate forming phytoplankton). Ancillary measurements of biogenic silica (BSi) and particulate organic carbon (POC) provided context, as estimates of the biomass of diatoms (the highest biomass phytoplankton in polar waters), and total microbial biomass, respectively. Results for 9 transects from Australia to Antarctica in 2008-2015 showed low levels of PIC compared to northern hemisphere polar waters. Coccolithophores slightly exceeded the biomass of diatoms in Subantarctic waters, but their abundance decreased more than 30-fold poleward, while diatom abundances increased, so that on a molar basis PIC was only 1% of BSi in Antarctic waters. This limited importance of coccolithophores in the Southern Ocean is further emphasized in terms of their associated POC, representing less than 1 % of total POC in Antarctic waters and less than 10% in Subantarctic waters. NASA satellite ocean colour based PIC estimates were in reasonable agreement with the shipboard results in Subantarctic waters, but greatly over-estimated PIC in Antarctic waters. Contrastingly, the NASA Ocean Biogeochemical Model (NOBM) shows coccolithophores as overly restricted to Subtropical and northern Subantarctic waters. The cause of the strong southward decrease in PIC abundance in the Southern Ocean is not yet clear. Poleward decrease in pH is small and while calcite saturation decreases strongly southward it remains well above saturation (>2). Nitrate and phosphate variations would predict a poleward increase. Temperature and competition with diatoms for limiting iron appear likely to be important. While the future trajectory of coccolithophore distributions remains uncertain, their current low abundances suggest small impacts on overall Southern Ocean pelagic ecology.

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