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Marine Ecosystem Assessment for the Southern Ocean

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Major influence of Southern Annular Mode on phytoplankton communities and biogeochemistry: Astrolabe Southern Ocean monitoring program (2002-2013)

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Regular monitoring of phytoplankton and biogeochemistry on 60 crossings between Hobart and Dumont d'Urville from M.V. l'Astrolabe has revealed an average increase of 44% in Chlorophyll (Chl_a) stocks from 2002 to 2013, correlated with an increase in the Southern Annular Mode index (SAM). Preliminary analysis of the entire data set (1506 samples) found a highly significant relationship between Chl_a and SAM ($r^2=0.078$, $p<0.0001$), with average Chl_a stock anomalies ranging from -39% to +53% across the observed range of SAM. Non-uniform meridional responses and the links to observed surface CO_2 drawdown are yet to be fully explored.The response time of phytoplankton to SAM was tested by correlating the Chl_a content of each sample against the SAM indices for each of 100 days before the sample was taken. There were distinct peaks in correlation 37, 70 and 80 days before sampling. The same peaks were found for increases in water temperature, salinity and phosphate in particular, suggesting that upwelling or deep mixing may be driving the phytoplankton response. CHEMTAX analysis of phytoplankton pigments revealed different groups of phytoplankton associated with the different peaks, possibly a species succession (Day -37 –chlorophytes, cyanobacteria, prasinophytes, haptophytes; Day -70 – cryptophytes, cyanobacteria, diatoms2, dinoflagellates1, haptophytes8, prasinophytes; Day -80 – haptophytes8 and haptophytes6B). CHEMTAX also revealed a southward enhancement in stocks of haptophytes6B (representing coccolithophorids), complementing microscopical studies from this program showing southward range extension of Emiliania huxleyi. Furthermore, microscopy of phytoplankton in the marginal ice zone found that the influence of SAM was equivalent to, and independent of, that of seasonal succession. This work provides insights into the response of Southern Ocean ecosystems and the biological pump to SAM, with implications for projected strengthening of SAM under climate change. Further data, particularly from different areas, would enhance these insights.