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Unravelling Carbon Fixation under Nutrient limited Conditions - a Water Column Perspective

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Phytoplankton plays a critical role in the uptake of atmospheric carbon dioxide (CO_2) by the ocean, and is comprised of a spectrum of cell sizes that are strongly regulated by oceanographic conditions. Elevated CO_2 fixation relative to nutrient availability, also called carbon overconsumption, has been observed in various mid to high latitude systems, such as the Baltic and North Seas, the North Atlantic Ocean, the Canadian Arctic Archipelago or the Scotian Shelf. We shed light on this phenomenon relying on an extensive data set of water column observations of the CO_2 system and phytoplankton cell counts from the Scotian Shelf, a temperate shelf sea. We show that in the summertime, the population of numerically abundant small cells, which favour warmer, nutrient poor conditions, accounts for approximately 20% of annual carbon uptake. At the broader scale, the neglection of this "non-Redfieldian" contribution typically leads to an underestimation of net community production by approximately 20% to 50%. These small cells are not well represented by chlorophyll a – the ubiquitously used proxy of phytoplankton biomass – but rather, are strongly correlated with surface water temperature. Given the persistent near-zero nutrient concentrations during the summer, it appears that small cells drive carbon overconsumption, and suggest that their role in carbon fixation will become increasingly important in a warming, increasingly stratified ocean.