Changes in primary productivity and chlorophyll a in response to iron fertilization in the Southern Polar Frontal Zone

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ABSTRACT: EisenEx□the second in situ iron enrichment experiment in the Southern Ocean□was performed in the Atlantic sector over 3 weeks in November 2000 with the overarching goal to test the hypothesis that primary productivity in the Southern Ocean is limited by iron availability in the austral spring. Underwater irradiance, chlorophyll a (Chl a), photochemical efficiency, and primary productivity were measured inside and outside of an iron-enriched patch in order to quantify the response of phytoplankton to iron fertilization. Chl a concentration and photosynthetic rate (14C uptake in simulated in situ incubations) were measured in pico-, nano-, and microphytoplankton. Photochemical efficiency was studied with fast repetition rate fluorometry and xenon-pulse amplitude modulated fluorometry. The high-nutrient low-chlorophyll waters outside the Fe-enriched patch were characterized by deep euphotic zones (63-72 m), low Chl a (48-56 mg m^{-2}), low photosynthetic efficiency (F_v/F_m ~ 0.3), and low daily primary productivity (130-220 mg C m^{-2} d^{-1}). Between 70 and 90% of Chl a was found in pico- and nanophytoplankton. During the induced bloom, F_v/F_m increased up to ;0.55, primary productivity and Chl a reached the maximum values of 790 mg C m^{-2} d^{-1} and 231 mg Chl a m^{-2}, respectively. As a consequence, the euphotic depth decreased to ~41 m. Picophytoplankton biomass hardly changed. Nano- and microphytoplankton biomass increased. In the first 2 weeks of the experiment, when the depth of the upper mixed layer was mostly <40 m, primary productivity was highly correlated with Chl a. In the third week, productivity was much lower than predicted from Chl a, probably because of a reduction in photosynthetic capacity as a consequence of increased physical variability in the upper water column. These results provide unequivocal evidence that iron supply is the central factor controlling phytoplankton primary productivity in the Southern Ocean, even if the mixing depth is >80 m.