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Iron and Nitrogen Limitation of Primary Production in the South Pacific Oceanic Gyre

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Primary production in the ocean is limited by one of the major nutrients (primarily, nitrogen or phosphorus) or by the essential micronutrient, iron. While the equatorial Pacific and the Southern Ocean are well known iron-limited areas, the South Pacific Gyre, the area with the least aerosol deposition on Earth, remain unexplored. We report the first biophysical and biogeochemical assessments of primary production in the South Pacific on transect from French Polynesia to Chili (the BIOSOPE experiment). The physiological status of phytoplankton was assessed using chlorophyll variable fluorescence technique. In all areas outside the Gyre (French Polynesia and off Chilean Coast), the phytoplankton photosynthetic efficiency was remarkably low (Fv/Fm ˜ 0.15), suggesting severe iron limitation of photosynthetic reactions in phytoplankton. The iron limitation was also evident from the characteristic diel cycles of Fv/Fm and the cross section of Photosystem II, with a striking increase in Fv/Fm and a proportional decrease in the cross sections at sunrise and their recovery at sunset. In contrast, Fv/Fm increased dramatically (up to 0.5) in the Gyre, together with disappearance of the diel cycles, suggesting the absence of iron limitation. To get further insight into the factors limiting primary production in the area, we conducted short-term nutrient enrichment experiments in ondeck incubators. The results revealed that in the Gyre only nitrogen enrichment stimulated phytoplankton growth, whereas iron addition did not produce any visible effect. In other areas, iron addition produced a striking increase in photochemical efficiency, indicating recovery in the photosynthetic competence. However, subsequent growth and accumulation of biomass required additional

nitrogen. Our data suggests that although iron concentrations are remarkably low over the entire area, only less oligotrophic regions (off French Polynesia and off Chilean Coast) are severely limited by iron. In contrast, the center of the South Pacific Gyre is limited by the lack of nitrogen. These data suggest that the primary producers in the South Pacific Gyre may have adapted to the extremely low iron concentrations and are limited by the flux of nitrogen from beneath the extremely deep nitrocline.