

NOTE

Phytoplankton nutrient control in the oligotrophic South Pacific subtropical gyre (Tuamotu Archipelago)

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ABSTRACT: The identification of the nutrients likely to limit phytoplankton in the Tuamotu Archipelago ocean (South Pacific subtropical gyre) is deduced from DIN ($\text{NO}_3^- + \text{NO}_2^- + \text{NH}_4^+$), PO_4^{3-} , and SiO_2 *in situ* concentrations and strengthened by the results of 4 other studies on the same area: (1) ϕ_{max} , the maximum quantum yield of photosynthesis, (2) phytoplankton cell size, (3) nutrient enrichment on natural populations, (4) bacterial biomass and nutrient limitation of bacteria. The low ϕ_{max} and the small size of phytoplankton support the idea of nutrient control. Low DIN concentrations (mean = 0.02 μM), low average DIN:P- PO_4^{3-} ratios = 0.3 at:at, low average DIN: SiO_2 = 0.04 at:at, and significant increases of phytoplankton standing stock and bacterial production after N enrichments point to N as the main limiting nutrient. P is the second limiting nutrient as evidenced by the relative low phosphate concentrations (0.2 μM) and by the synergetic effect of DIN + PO_4^{3-} enrichments. Silicon concentrations appear to limit the proliferation of siliceous taxa as evidenced from its average concentration of 1 μM and from the scarcity of diatoms. Natural concentrations of vitamins, Mo, Mn, Fe and chelators are sufficient to support the increase of phytoplankton standing stock induced by N and P additions and therefore are not limiting.

KEY WORDS: Phytoplankton · Nutrient control · South Pacific · Central gyre · Oligotrophy

The oligotrophic area constitutes more than 75% of the surface of the world's ocean. Within this vast area, nitrogen has been, for a long time, considered as the limiting nutrient of phytoplankton production and standing stock (Howarth 1988). However, the oligotrophic ocean cannot be considered as homogeneous and other nutrients should control phytoplankton: P (Eppley et al. 1973), Si (Brzezinski & Nelson 1996), Fe (Lindley et al. 1995). This note presents a comprehensive study on the phytoplanktonic nutrient control in the South Pacific central gyre where the control of

phytoplankton has never been studied, to our knowledge. It was conducted in the oceanic area of the Tuamotu Archipelago where extremely low concentrations of nutrients are maintained in surface waters by a permanent thermal stratification between 150 and 200 m depth (Rancher & Rougerie 1995).

Fisher et al. (1988) argued that concentrations $<K_s$ are associated with reduced uptake rates, potentially lowered enough to reduce phytoplankton growth rates or phytoplankton biomass accumulation. Indeed, in such environments with constant low limiting nutrient supply, nutrient luxury consumption and storage (Droop 1983) are unlikely to occur, and growth depends on the uptake of the limiting nutrients. In this note, we compare the concentrations of the major nutrients N, P and Si, measured in the oceanic area of the Tuamotu Archipelago, with their half-saturation constants for uptake (K_s), reported in the literature. The conclusions issued from these comparisons are improved by the results of 4 other studies in the same area: (1) light-photosynthesis curves (Pagès pers. comm.), (2) cell size and taxonomic composition of phytoplankton (Charpy & Blanchot 1998), (3) enrichment experiments (Dufour & Berland 1999) and (4) nutrient control of bacterial production (Torréton et al. 1998).

Materials and methods. The study took place during 2 oceanographic cruises, Typtoll 3 and Typtoll 4, on the RV 'Alis' in November 1995 and March 1996. Surface water (0.5 m depth) was sampled at 12 oceanic sites located between 15° 30' – 18° 30' S and 142° – 145° W (Fig. 1). Sampling was done leeward from a small plastic boat and at more than 1 km away from the RV. Water was sampled in acid-cleaned polyethylene bottles and processed within 1 h.

Analyses for PO_4^{3-} and NH_4^+ were performed according to Murphy & Riley (1962) and Koroleff (1969) with a precision of 0.02 μM . $\text{NO}_2^- + \text{NO}_3^-$ and SiO_2 measurements were done according to Wood et al.

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