Ambient nutrient levels and the effects of nutrient enrichment on primary productivity in Lake Bonney

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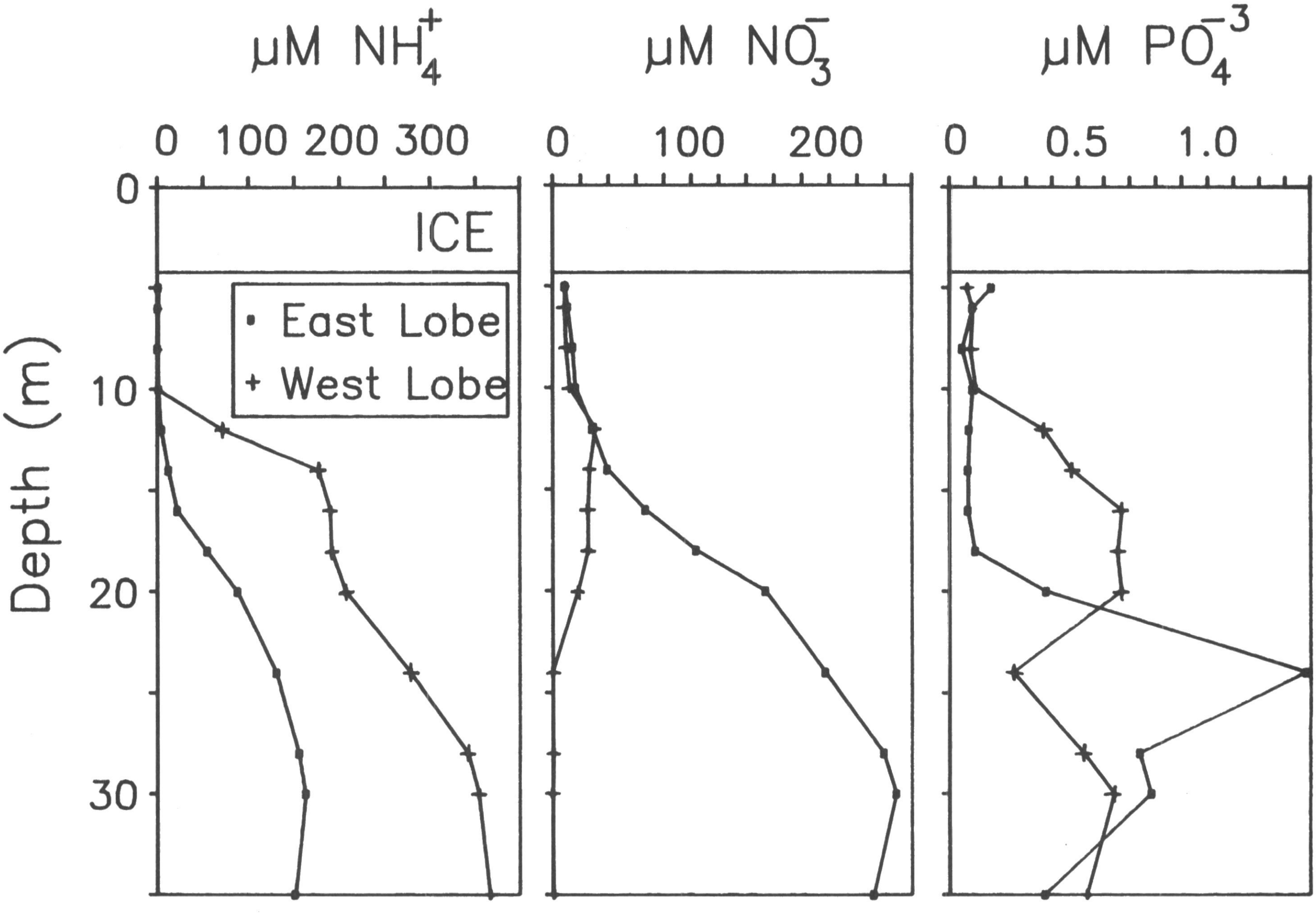
Lake Bonney is divided into two lobes by a narrow, shallow channel, and in many respects, each lobe could be considered a separate, distinct water body. Each lobe has different vertical profiles for temperature and conductivity (Spigel, Sheppard, and Priscu, *Antarctic Journal*, this issue). In this article, we report the nutrient distributions of the east and west lobes and results from preliminary experiments suggesting nutrient deficiency in the surface phytoplankton populations in the east lobe (see Priscu et al., *Antarctic Journal*, this issue) collected during the austral spring and summer, 1989–1990.

Soluble inorganic nutrient concentrations were determined in water samples collected at 2-meter intervals from below the ice at the center of the east lobe on 24 November, 11 December, and 16 January, and at the center of the west lobe on 28 November. Ammonia was measured by the phenolhypochlorite method (Solorzano 1969), nitrate by the cadmium-reduction method, and soluble reactive phosphorus by the ascorbic acid molybdenum-blue method (APHA 1986). Samples from below 12 meters were diluted tenfold with deionized water before analysis, owing to the high concentration of nutrients and other salts in the monimolimnion.

Nutrient bioassays were conducted on 15 to 17 November, 29 November to 2 December, and 5 to 7 January for the 5 and 17 meter phytoplankton populations. Four treatments were compared: a control; a 50-micromolar ammonia addition; a 10-micromolar phosphate addition; and one amended with both ammonia and phosphate. All treatments were returned to depth for a 24-hour preincubation period. The treatments were then split into three replicate light bottles and a single dark bottle (150 milliliters), inoculated with 27 microcuries (5 meters) or 57 microcuries (17 meters) of carbon-14-bicarbonate, and incubated at depth for 7 hours to measure photosynthetic rates. A Student's t-test was used to determine significant differences in photosynthetic rates between treatments.

Concentrations of soluble nutrients ranged over more than an order of magnitude in Lake Bonney, with steep gradients in their vertical profiles (figure). Nutrient concentrations in the east lobe ranged from 0.9 to 163 micromolar ammonia, 9.5 to 259 micromolar nitrate, and 0.051 to 1.41 micromolar soluble reactive phosphorus. Nutrient concentrations in the west lobe



Nutrient profiles from the east and west lobes of Lake Bonney on 24 and 28 November, 1989, respectively. (m denotes meter. µM NH_4^+ denotes micromolar ammonia. µM NO_3^- denotes micromolar nitrate. µM PO_4^{-3} denotes micromolar soluble reactive phosphorus.)

ranged from 0.9 to 321 micromolar ammonia, 1.5 to 30.8 micromolar nitrate, and 0.069 to 0.672 micromolar soluble reactive phosphorus. The vertical gradients in nutrient concentrations are related to vertical gradients in conductivity (Spigel et al., *Antarctic Journal*, this issue) and dissolved oxygen (Sharp and Priscu, unpublished data). Ammonia concentrations increased as the water approaches anoxia below 20 meters in both lobes. Nitrate (oxidized nitrogen) concentrations in the west lobe decreased as the water becomes anoxic while, paradoxically, nitrate concentrations increased in the anoxic waters of the east lobe. Soluble reactive phosphorus concentrations increased below the chemocline of the east lobe (at approximately 20 meters) but increased within the chemocline of the west lobe.

Our nutrient profiles differed from those previously published for the east lobe of Lake Bonney (Weand, Hoehn, and Parker 1977): they reported much higher nitrate and ammonia concentrations in surface waters (above 15 meters) than we found, while concentrations below 15 meters were similar. Weand et al. (1977) noted that high nitrate concentrations could be due to a nitrate-rich stream entering the lake at their site, and enriching waters above the chemocline. Vertical profiles of soluble reactive phosphorus concentrations were similar.

Preliminary experiments indicate that photosynthesis by shallow phytoplankton populations in Lake Bonney may be nitrogen deficient (table). Phytoplankton from 5 meters had a significantly greater rate of photosynthesis in the treatment enriched with ammonia ($p<0.03$) relative to the control, while the phosphate and ammonia plus phosphate treatments showed no significant difference from the control. Although the rate of photosynthesis in the ammonia plus phosphate treatment showed no significant difference from the control, the rate was also not significantly different from the rate in the ammonia treatment. Nutrient additions to the 17-meter population did not significantly increase the rate of photosynthesis, indicating that this population was not deficient in nitrogen or phosphorus. These experimental results suggest that the hypothesis of Weand et al. (1977), that nutrient deficiency does not control primary productivity in Lake Bonney, may be an oversimplification for surface populations not influenced by stream water inputs.

These preliminary results show that large vertical gradients in nutrients exist and these nutrient gradients appear to have a role in the regulation of primary productivity in Lake Bonney. In future field work, we hope to expand these studies on nutrient effects on primary production to include work on the phytoplankton of the west lobe (where nutrient gradients differ from the east lobe) and to examine growth responses of the phytoplankton to nutrient enrichment.

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Photosynthetic rate (mean ± standard deviation) from 29 November to 2 December, 1989 nutrient bioassays in the east lobe of Lake Bonney. All units are disintegrations per minute for the amount of carbon-14 incorporated per hour.

Depth (meters)	Control	Ammonia	Phosphate	Ammonia and phosphate
5	147 ± 27	238 ± 31	187 ± 15	174 ± 53
17	75 ± 9	74 ± 4	72 ± 7	77 ± 30

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