were from Lake Fryxell and Lake Vanda (Priscu et al. 1987). Deep phytoplankton (57.5 meters) from Lake Vanda had P_{max} and α values approximately 10 times higher than ours but with a similar I_k value; higher rates may be a function of higher temperature (19.2 °C). P_{max} for Lake Fryxell phytoplankton are similar to our results, but α appears to be greatly overestimated (possibly due to insufficient data to define the curve), yielding unusually low I_k values. Lake Fryxell is similar to Lake Bonney with respect to ice cover and temperature profiles. Therefore, it may be reasonable to assume that phytoplankton of Lake Fryxell, and of similar water columns in other dry valley lakes, would have photosynthesis-irradiance characteristics similar to those we found in Lake Bonney.

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Structure and function of the photochemical apparatus in the phytoplankton of ice-covered Lake Bonney

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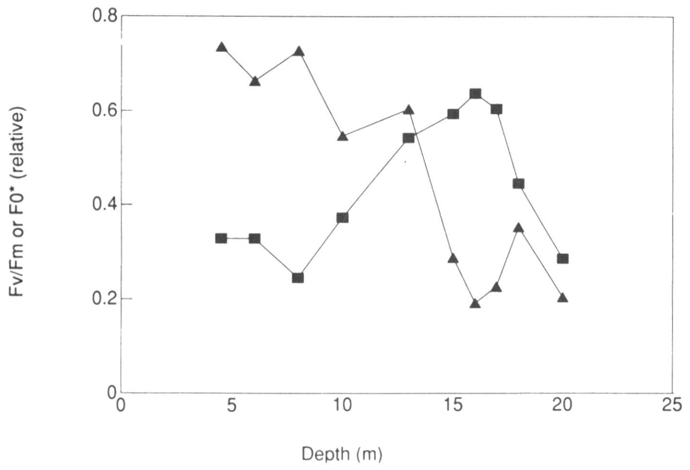
Lake Bonney, like other lakes in the dry valleys, has a perennial ice cap that reduces total irradiance to a few percent of incident, is a spectral filter with highest transmittance in the blue-green region (Palmisano and Simmons 1987), and prevents wind-induced vertical mixing. The stratified phytoplankton populations experience an unusual degree of irradiance constancy, at least in comparison with an ice-free surface mixed layer. Our study addresses the physiological basis for photoadaptation given the possible benefit to the phytoplankton of fine-tuning the photochemical apparatus to the lake's light intensity and spectral range. See Priscu et al.; Lizotte and Priscu; Sharp and Priscu; and Spigel, Sheppard, and Priscu, *Antarctic Journal*, this issue for related studies.

Phytoplankton were collected through a hole drilled in the center of the east lobe of Lake Bonney at piezometric depths between 5 meters (approximately 1 meter below ice cover) and 17 meters. Temperature varied from 0 °C below the ice to 6 °C at 17 meters. Populations are dominated by phytoflagellate species such as *Chlamydomonas subcaudata* and *Chroomonas lacustris*. Detailed studies were made of the populations within the shallow biomass peak at 5 meters and the deep peak at 17 meters.

The phytoplankton are adapted to low-light, "shade" conditions. The irradiance at which photosynthesis begins to saturate, or I_k, ranged from 15–45 microeinsteins per square meter per second (Lizotte and Priscu, *Antarctic Journal*, this issue). These phytoplankton would be expected to show maximal efficiency in converting light to photosynthetic energy (quantum yield) and have a large number of chlorophyll pigments associated with each of the photosynthetic reaction centers. Preliminary results suggest, however, that Lake Bonney phytoplankton do not entirely conform to this model of shade adaptation, and point to the importance of other mechanisms.

The *in vivo* fluorescence yield was used to define the depth profile of relative changes in quantum yield of photosynthesis. The dark adapted *in vivo* fluorescence per unit chlorophyll was higher and the fluorescence ratio F_v/F_m lower in the shallow populations compared to the deep populations (figure). The F_v/F_m data in particular suggests a low quantum yield in shallow populations, increasing quantum yield in the region of 10–15 meters and near maximal values in the deep populations around 16–18 meters (cf., Demmig and Bjorkman 1987). This is in agreement with the trend of increasingly higher initial slopes of the photosynthesis-irradiance curve, (EQN "alpha"), measured using samples from 5, 10, and 17 meters, respectively (Lizotte and Priscu, *Antarctic Journal*, this issue). The shallow populations exist in conditions of highest light level



Profile of *in vivo* fluorescence parameters for Lake Bonney phytoplankton collected 12 December 1989. Samples were dark adapted 30 minutes, initial fluorescence was measured (F_0), DCMU was added to 10 micromolar and fluorescence was remeasured (F_m). The difference F_v was calculated as $F_m - F_0$ and is plotted as the ratio F_v/F_m (squares). The ratio of F_0 to the chlorophyll *a* concentration in acetone extracts, F_0*, is also plotted (triangles). See Priscu et al., (*Antarctic Journal*, this issue) for further details on the chlorophyll measurement. (m denotes meter.)

but lowest temperature and nutrient concentrations in the Lake Bonney water column. The physiological mechanism for depression of photosystem II quantum yield by nutrient starvation or low temperature is not clear, but such metabolic stress factors may limit the extent of photoadaptation.

A large number of light harvesting pigments in association with each reaction center, resulting in a large absorbance cross-section or "antenna size" for photosynthesis, is another characteristic expected of shade-adapted populations. Study of the light harvesting characteristics of Lake Bonney phytoplankton was initiated through a measurement of the photosystem I reaction center (P_{700}) content. The P_{700} concentration was determined from the light-induced absorbance change measured in detergent solubilized membrane fragments isolated from Lake Bonney phytoplankton (Neale and Melis 1986). A molar ratio of about 450 chlorophylls (chlorophyll *a* and accessory chlorophylls) to each P_{700} reaction center was measured for the shallow community, a similar or lower ratio was observed in the deep community although more measurements are needed to confirm this. In contrast, shade adapted sea-ice microalgae often have 1,000 or more chlorophylls per P_{700} (Barlow et al. 1988). One possible reason for the large difference is that a high proportion of light harvesting is being performed by non-chlorophyll accessory pigments. The chlorophyll *a*/*b* ratio at all depths typically exceeds 6. Acetone extracts also have high relative absorbances at 480 nanometers typical of carotenoids. A more detailed analysis of pigment composition will have to await future high-performance liquid chromatography measurements. Chlorophyte spp. phytoplankton sampled from Lake Bonney at a depth of 17 meters were grown in an enrichment culture at ambient temperature. The fluorescence kinetics (Neale and Melis 1986) of these algae normalized to absorption were the same in 480-nanometer (carotenoid absorbed) light as in 660-nanometer (chlorophyll-absorbed) light. This differs from light utilization by a common chlorophyte, *Chlamydomonas reinhardtii*, which displayed a 40 percent lower efficiency in 480-nanometer light compared to 660-nanometer light. Carotenoids in most chlorophyte algae are thought to play a photoprotective role; however, the organization of the photosynthetic apparatus may be radically different for phytoplankton in Lake Bonney, where blue-green light dominates the scalar irradiance spectrum (cf., spectrum of Lake Hoare, Palmisano and Simmons 1987) and phytoplankton never require protection from exposure to full solar irradiance.

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