

Plankton Dynamics in the McMurdo Dry Valley Lakes During the Transition to Polar Night - A Project Contributing to EBA

John C. Priscu jpriscu@montana.edu

Research on the lakes of the McMurdo Dry Valleys (MCM) began with the advent of the International Geophysical Year (IGY) in the late 1950's. IGY research revealed the physical/chemical nature of the lakes, showing that they were the only year-round liquid water environments on the continent, and inferred that the biological systems in the permanently ice-covered lakes must possess novel physiological strategies that allow them to survive at low temperature and under extended darkness. The seminal studies during IGY provided the framework for subsequent hypotheses driven research which now forms the basis for the ongoing MCM Long Term Ecological Research (LTER) lake program (now in its 15th season; www.mcmlter.org) and the MCM dry valley lake Microbial Observatory (www.mcm-dvlakesmo.montana.edu).



Moon setting over Lake Bonney (J.C. Priscu)

Data collected on Lakes Bonney, Hoare and Fryxell (all in the Taylor Valley) as part of these long term studies have now shown that most organisms in the lakes are not just "surviving the extremes" but are actively feeding, growing and reproducing. As such, they are ecosystems in which we can identify and begin to understand physiological and genomic adaptations in the context of one of the most extreme environments on our planet.

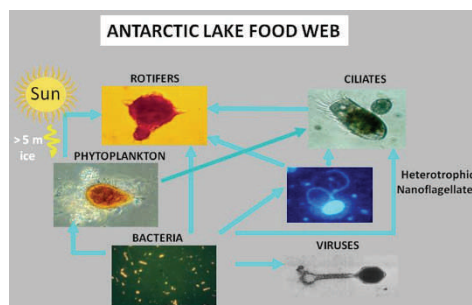
Unfortunately, almost all "hands-on" research on the MCM lakes has been restricted to the austral spring and early summer (~October through January) when logistical support has allowed access to the area. Although studies during the spring-summer period have yielded a quantum increase in our understanding of the lakes, the unique aspects of physiological adaptation, biodiversity and ecosystem function during the permanently cold and prolonged darkness of the Antarctic winter will never be understood without extended season research. Through a grant from the U.S. National Science Foundation Office of Polar Programs we were able to conduct the first research on these lakes during the transition from 24 hour sunlight to total darkness between November 2007 and April 2008.

The overarching theme of this research was that the onset of darkness induces a cascade of physiological changes that alters the functional roles of

autotrophic and heterotrophic microplankton within the lakes. This overarching theme was addressed through an interdisciplinary and international study of selected biological components of the lakes using genomic and physiological tools to understand not only how individual organisms survive, but how they control ecosystem function during this seasonal transition. This theme is directly relevant to IPY objectives, and the data will be critical to our knowledge of how polar organisms survive and function within high latitude ecosystems characterized by extreme cold and prolonged darkness.

By virtue of perennial ice covers, low advective stream flow, and saline bottom waters, lakes in the MCM are permanently stratified and have a unique and diverse set of thermodynamic and geochemical conditions. Water temperatures range from -5 to 6°C and fluctuate less than 2°C seasonally. Superimposed on these stable cold temperatures is a low light environment where measurable photosynthetically available radiation (PAR) penetrates the ice only from early October to mid-March.

Data collected during spring and early summer as part of the MCM LTER and Microbial Observatory programs have revealed multiple, well-developed phytoplankton and bacterial maxima associated with nutrient gradients down the water column. Strong microbial linkages have been defined in all of the MCM lakes and point to the tight coupling of carbon and other nutrients and the reliance of the system on phytoplankton photosynthesis during the short summer period (see figure below).



Schematic showing the microbially dominated foodweb that exists in the lakes of the McMurdo Dry Valleys. Few metazoans exist within the lakes (J.C. Priscu)

We currently know little about foodweb dynamics in late summer, autumn, or the long dark winter. Based on the extended data processed thus far, we can now produce a picture of annual bacterial and phytoplankton productivity in all lakes.

As an example interesting results were observed from the east lobe of Lake Bonney. Firstly, chlorophyll-a continues to increase after phototrophic primary production has ceased and photosynthetic efficiency (i.e. light utilization index) is lowest during mid season. Preliminary data indicate that cryptomonads, a key phytoplankton group,



April operations in the Dry Valleys (J.C. Priscu)

may switch from light driven metabolism to phagotrophy on bacteria, which is a winter survival mechanism shown to occur in lakes of the Vestfold Hills, Antarctica. The low photosynthetic efficiency apparently occurs as the result of phosphorus deficiency by the phytoplankton, a fact we corroborated through nutrient bioassay experiments which showed significant stimulation of light mediated ¹⁴CO₂ incorporation by the addition of phosphorus. The late season increase in photosynthetic efficiency apparently results from the leaching of phosphorus from sediment released from the ice permanent cover. Further analyses of our data will be required to draw stronger inferences.

The International Council for Science's outline for the IPY (ICSU 2004) states that projects should be multidisciplinary, international, and able to promote the next generation of polar scientists. Our extended season research brought scientists together with backgrounds in limnology, molecular biology, photobiology, microbiology and protozoology to address biological adaptations to cold and prolonged darkness. In addition to the multidisciplinary nature of the program, it brought together scientists from the U.S., UK, Canada and the Czech Republic and included 10 students who we hope will carry the legacy of IPY into the future.



Aurora's over a lake side tent at Lake Bonney (M. Chernesky)