Changes in Organic Carbon Dynamics Based on Seasonal Light Availability in Lake Bonney, Antarctica

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Photo by Andrew Baber

I. Abstract

The McMurdo Dry Valleys (MCM) of Antarctica is an extreme desert environment receiving less than 10cm of precipitation per year, averaging an annual air temperature near -20ºC, and experiencing a high latitude bimodal solar cycle. The MCM landscape, comprising the largest ice-free region on the continent, is a mosaic of perennially ice-covered lakes, ephemeral streams, glaciers, and bare mountain slopes.

Despite these conditions, perennially ice-covered lakes provide unique liquid water habitats in which biota persist throughout the entire year. However, due to logistical constraints, limnological field measurements can only be conducted during the austral summer, and little is known about primary productivity (PPR) throughout the remainder of the year.

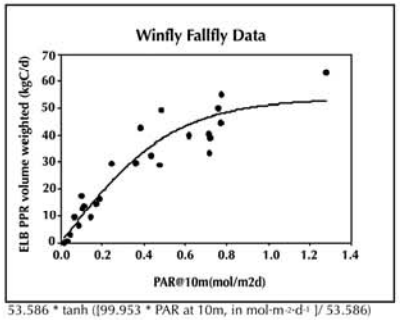
Recent data collected during the 2008 Polar Night extended (FallFly) field season, combined with previously collected data from the 1991 (WinFly) season, revealed a positive statistical relationship between photosynthetically available radiation (PAR) and PPR within the water column of East Lake Bonney in the Taylor Valley. This relationship, when applied to a hyperbolic tangent model, can predict PPR (kgC) every day of the year, enlightening our understanding of the dark winter months. Results allow for a better assessment of climate change on this extremely sensitive polar environment.

II. Materials and Methods

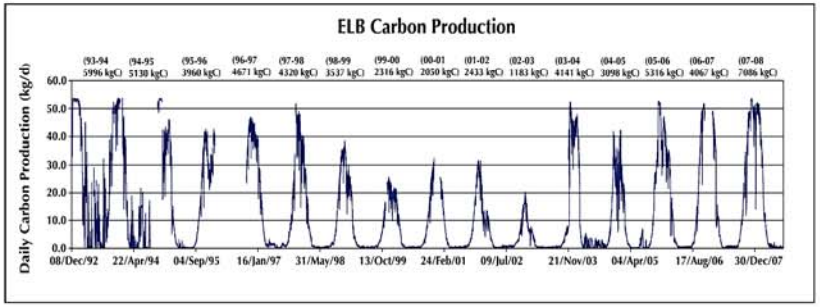
- Primary productivity was measured using an *in-situ* $^{14}CO_2$ uptake method. Water samples were collected from 11 depths in East Lake Bonney. A known amount of radiolabeled bicarbonate was added to each sample, which were then incubated for 24 hours at their respective depths in the lake. Following photosynthesis, samples were filtered, acidified, and analyzed on a scintillation counter for their amount of radioactivity incorporated.

- PAR has been shown to be a primary driver for phytoplankton photosynthesis and is used to model depth-integrated PPR. A Campbell CR10X data logger was used to log year-round underwater PAR every 20 minutes from a spherical sensor positioned at 10 m below the piezometric water level.
- The model was constructed using 1991Winfly/2008 Fallfly depth-inegrated PPR and 10m daily PAR data and applied to available data from 1993-2008.

III. Results



53.586 * tanh ([99.953 * PAR at 10m, in mol·m-2·d-1]/ 53.586)




Photos by Andrew Baber


Photo by Amy Chiuchiolo

IV. Conclusions

- Unlike ecosystems in lower latitudes, minute climate changes can greatly affect sensitive polar regions like the McMurdo Dry Valleys. This phenomenon, in which chemical, physical, and biological properties are exaggerated, is referred to as "Polar Amplification." Because of Polar Amplification, Antarctic lakes provide ideal "natural laboratories," offering insights that would remain less noticeable in more temperate and tropical environments.
- In addition to 1991 Winfly data, PPR and PAR data collected during the 2008 Polar Night extended field season yielded an improved projection of ELB carbon production throughout the inaccessible Antarctic fall, winter, and spring seasons.
- These data allow for further investigations in Lake Bonney and the McMurdo Dry Valleys regarding long-term trends in primary productivity/organic carbon dynamics and potential implications of climate change on this extremely sensitive Long Term Ecological Research Site.

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