# Autonomous Year-Round Sampling Sheds Light On Antarctica's Polar Night

Jeff D. Patriarche, Amy L. Chiuchiolo, John C. Priscu
Montana State University – Land Resources and Environmental Sciences Department

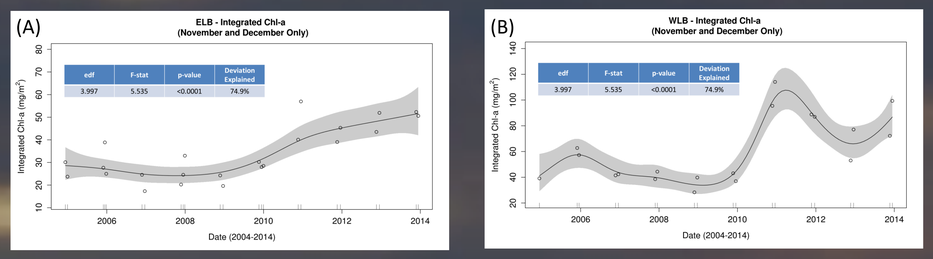
## Abstract

The perennially ice-covered lakes of the McMurdo Dry Valleys (MDV), Antarctica have been the focus of intense ecological research as part of the MCM LTER for over 20 years. Research in the MDV is typically restricted to the austral summer and, consequently, the biogeochemical and phytoplankton community responses to the darkness of winter are poorly understood. In December of 2013, we deployed autonomous lake profiling systems (ALPS) in the east and west lobes of Lake Bonney. Tethered to the surface of the ice cover, these autonomous instrumentation systems made year-round measurements of physicochemical and biological parameters, providing the most complete annual MDV lake dataset in the history of the MCM LTER. Total chlorophyll-a concentration (µg $L^{-1}$) and the relative contribution of chlorophyll-a by four functional groups of microalgae (chlorophytes, cyanophytes, cryptophytes, and chrysophytes) were recorded with a submersible spectrofluorometer. Our data show a shift in the phytoplankton community dominated by chlorophytes during the austral summer to a greater relative abundance of chrysophytes during the darkness of winter in East Bonney (15-22m). Chrysophytes were the dominant phytoplankton group at a depth range from 19-23 m throughout the year in West Bonney. Both East and West Bonney showed an increase in the total chl-*a* concentration during the darkness of winter, at the previously mentioned depth ranges. These data provide a link between the summer and spring sampling which occurs annually as part of the MCM LTER project, and begin to fill our knowledge gap regarding organisms responsible for primary production in a microbially-dominated aquatic ecosystem during extended periods of complete darkness.

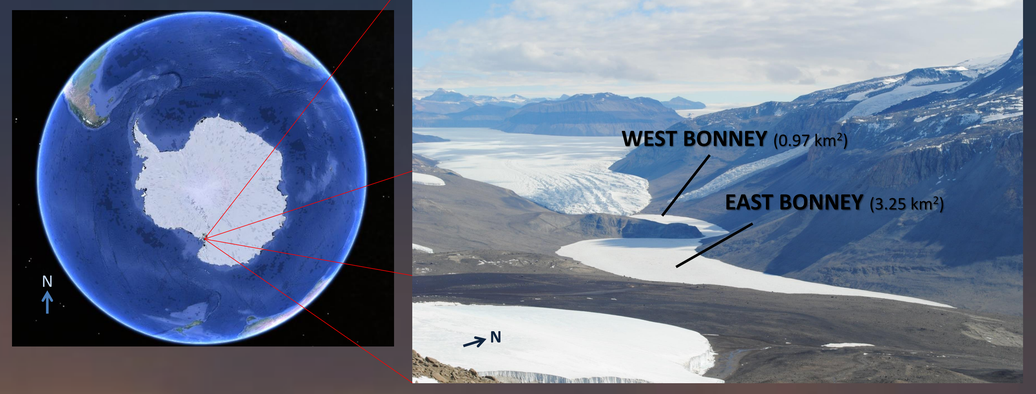
## Long-Term Trends in Chl-*a*

Generalized additive models (GAM) suggest trends in the chl-*a* concentration (November and December data only) within each lobe of Lake Bonney. It appears that the integrated chl-*a* concentration has increased in both lobes of Lake Bonney since the FluoroProbe was first used in 2004 as part of the MCM LTER limnological sampling runs. Restricted to summer data collection, there is currently a coarse record of chl-*a* with only ~3 sampling events each year. Over-winter data is missing from long-term chl-*a* record prior to ALPS.

**Figure 1:** GAM models of 10 year trend of Chl-*a* concentration for East Bonney (A) and West Bonney (B). November and December FluoroProbe data only.




## Site Description




As part of the McMurdo Dry Valleys LTER (MCM) site, the 35 km Taylor Valley (TV) helps to form the largest ice-free region of the Antarctic continent. With an average temperature of -17 °C and <10 mm of precipitation (water equivalent), combined with a strong bimodal light regime, this is one of the most extreme deserts on our planet. One of several perennially ice-covered lakes, Lake Bonney, is situated at the head of the TV. Receiving the majority of its inflow from the Taylor Glacier and having no outflow, Lake Bonney is separated into two lobes (East and West) by a narrow 17.7 m deep sill. Only diffusive mixing of surface waters occurs between the lobes, creating two distinct ~40 m deep highly physically stratified bodies of water with their own unique geochemistry at depth. Lake Bonney provides and oasis for life in an otherwise harsh environment, maintaining year-round phytoplankton communities, which are important primary producers in this desert ecosystem.

## Methods

In the spring of 2013 modified McLane ice tethered profilers (ITP) were deployed in both lobes of Lake Bonney as part of the ALPS project. Included in the instrumentation suite was a bbe-Moldanke FluoroProbe, a submersible spectrofluorometer capable of recording total chl-*a* concentration and distinguishing the chl-*a* contributions of four functional groups of phytoplankton based on the variations in excitation wavelenghts of the chl-*a* antennae pigments associated with the functional groups of phytoplankton. The FluoroProbe profiled the water column (15-22 m ELB, 19-23 m WLB) once daily and sampled continuously until the profile was completed. The devices were retrieved from Lake Bonney in the spring of 2014. Data were processed and analyzed using R statistical software.

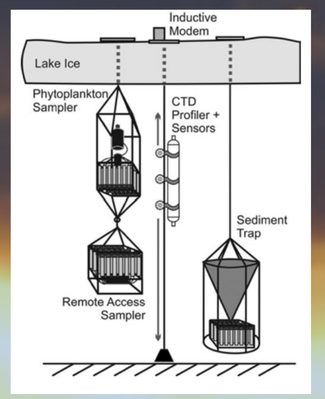



**Figure 6:** Schematic of the ice-tethered profiler (Not to scale)

## East Bonney Results

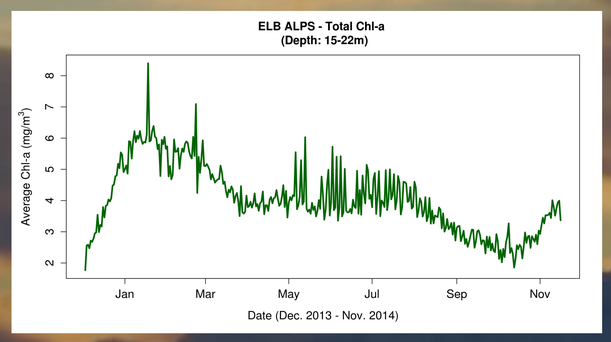



**Figure 2:** Average concentration of Chl-*a (mg m $^{-3}$)* over the depth range of 15-22 m from December 2013 – November 2014 for East Lake Bonney.

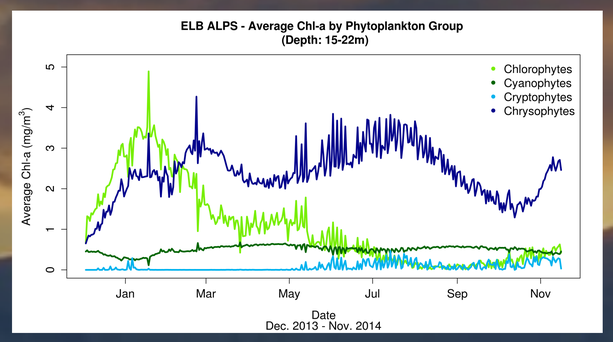



**Figure 3:** Average concentration of Chl-*a (mg m $^{-3}$)* associated with four functional groups of phytoplankton over the depth range of 15-22 m from December 2013 – November 2014 for East Lake Bonney.

## West Bonney Results

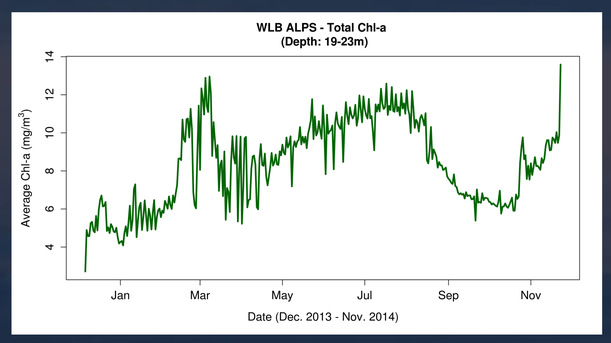



**Figure 4:** Average concentration of Chl-*a (mg m $^{-3}$)* over the depth range of 19-23 m from December 2013 – November 2014 for West Lake Bonney.

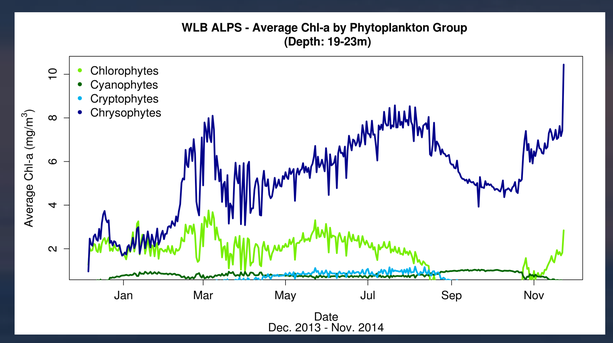



**Figure 5:** Average concentration of Chl-*a (mg m $^{-3}$)* associated with four functional groups of phytoplankton over the depth range of 19-23 m from December 2013 – November 2014 for West Lake Bonney.

## Conclusions

- Total chl-*a* concentrations have increased over the last 10 years in both East and West Bonney.
- At our sample depths there was a shift in the phytoplankton community structure in February 2013 from a greater abundance of chlorophytes to a greater abundance of chrysophytes in East Bonney.
- During the 24 hr darkness of the austral winter the chl-*a* concentration associated with chrysophytes increased and then began declining in August, shortly before detectable PAR returned.
- At a our sample depths chl-*a* concentrations associated with chrysophytes was the greatest of all functional groups of phytoplankton throughout the year in West Bonney. This chrysophytes chl-*a* also showed an increase during the 24 hr darkness of winter.
- Average total chl-*a* concentrations increased from 8.28 mg $m^{-3}$ to 12.6 mg $m^{-3}$ in West Bonney and from 3.46 mg $m^{-3}$ to 4.99 mg $m^{-3}$ in East Bonney during the 4 months of total darkness.
- The ALPS project has provided us with the first year-long dataset with daily measurements of chl-*a* in the history of the MCM LTER.

## Acknowledgements

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*Background photo credit: antarcticfudgesicles.wordpress.com*