Phytoplankton dynamics in Lake Bonney through the polar night measured by an autonomous in situ profiler

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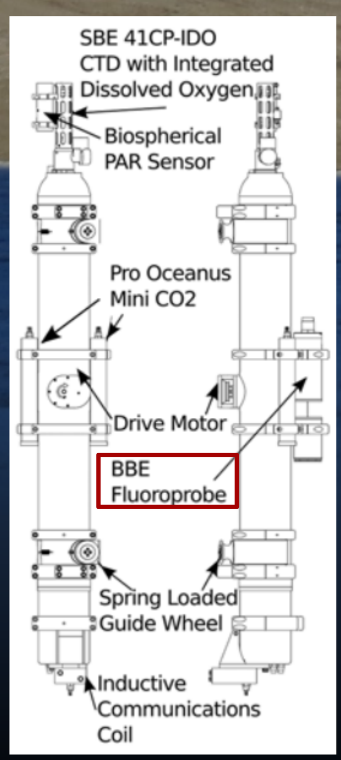
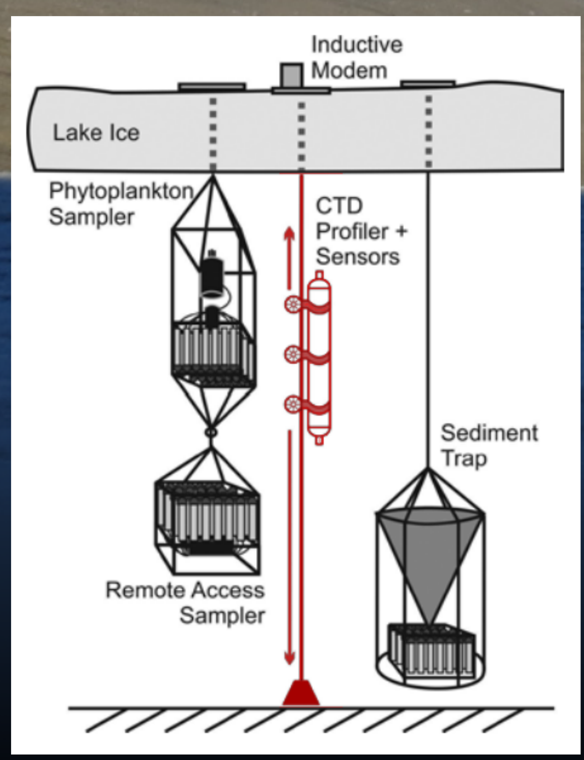
Introduction:

Lake Bonney is a perennially ice-covered hypersaline closed-basin lake located in the western Taylor Valley, Antarctica. Separated by a narrow ~17 m deep sill, two distinct lobes (East and West) maintain physically stratified water columns with unique biogeochemical signatures. Considered separate lakes, East Lake Bonney (ELB) and West Lake Bonney (WLB) support simplified microbial food webs which have been subject to much scientific scrutiny for more than 30 years. Extreme temperatures and a strong bimodal light regime make sampling during winter exceedingly difficult. This has created a gap in our knowledge as to how phytoplankton communities respond to the darkness of the austral winter. Beginning in December of 2013, autonomous lake profiling systems (ALPS) were deployed in ELB and WLB, providing the first glimpse of phytoplankton community dynamics year round.

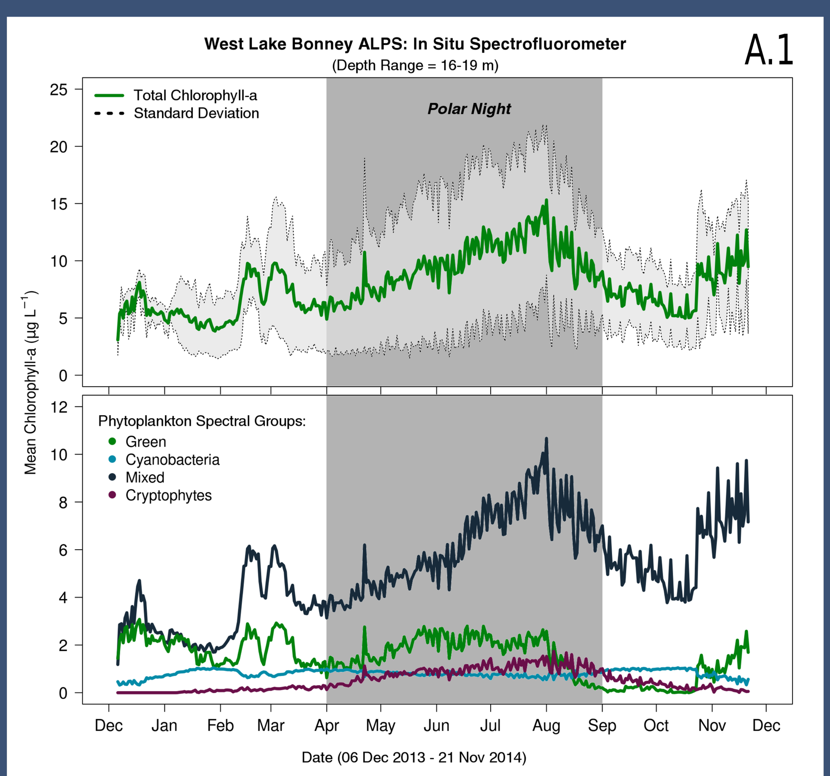
Methods:

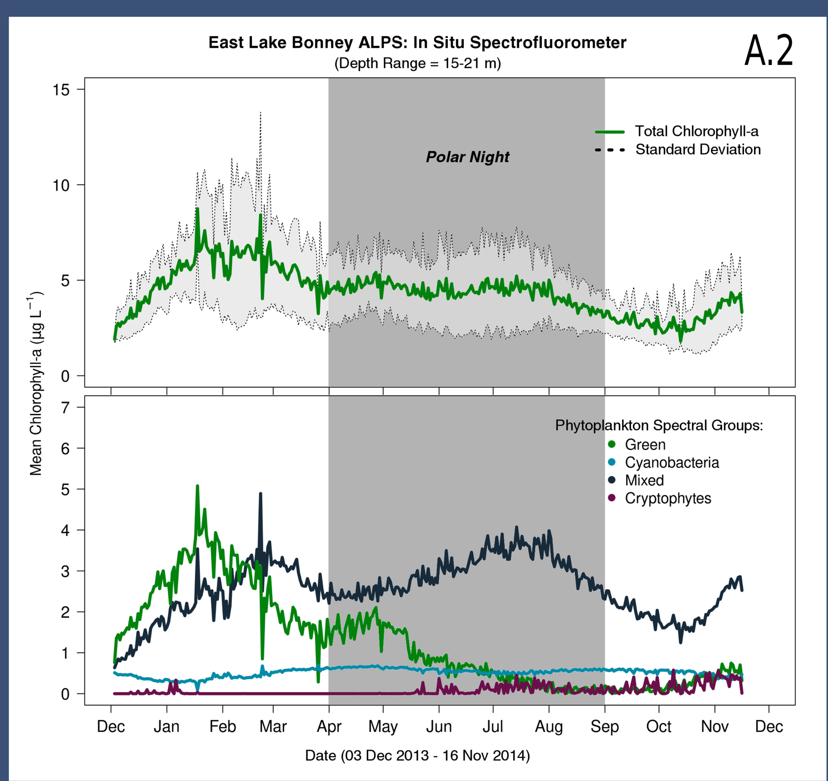


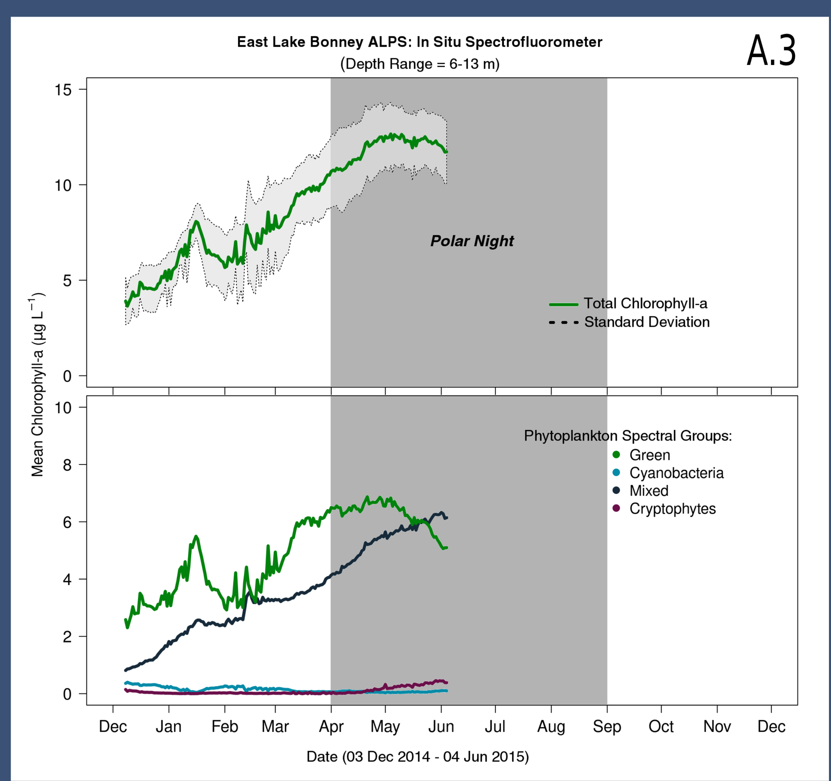


- In 2013 and 2014 McLane ice tethered profilers (ITP) were deployed in WLB and ELB. Among the sensors included was a sumbersible spectrofluorometer (BBE FluoroProbe).
- Daily profiles of the water column were made while the ITP logged measurements obtained by the attached sensors.
- The FluoroProbe detected chl-a fluorescence from specfic excitation/ emission spectra. The concentration of 4 spectral classes of phytoplankton (green algae, cyanobacteria, cryptophytes, mixed) were differentiated by their unique compositions of photosynthetic antennae pigments.
- ITPs were retreived during November of 2014 and 2015 following year-long deployments. Data were downloaded and then processed using R Statistical Software.

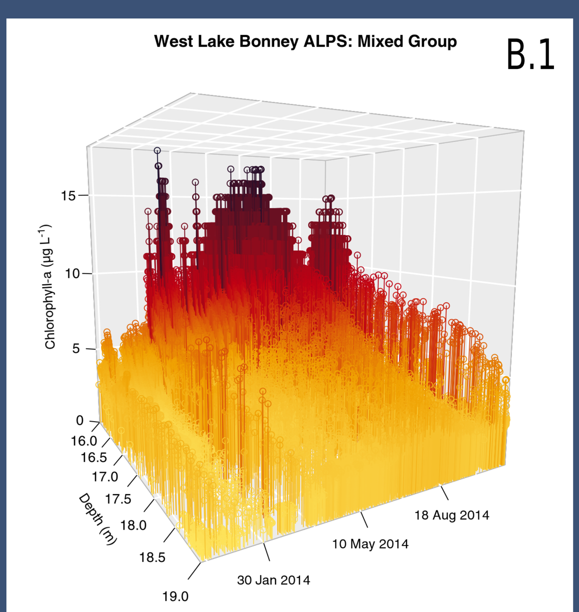
Results:

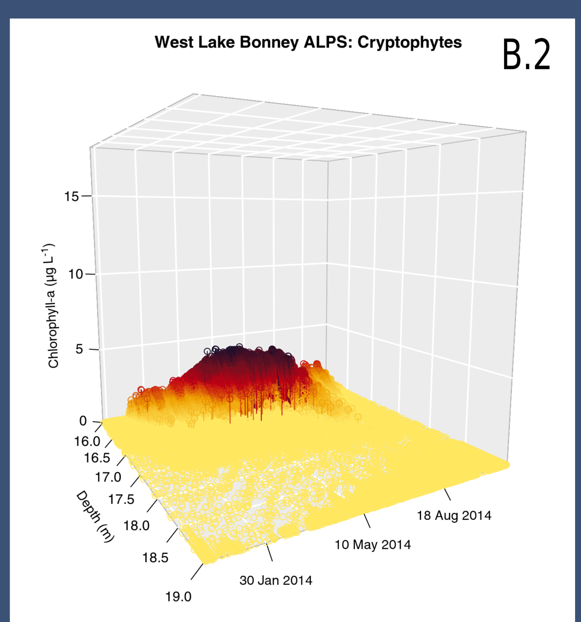


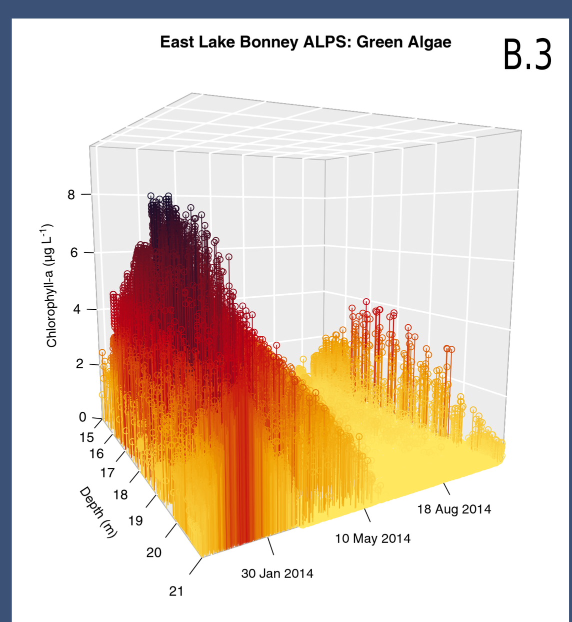


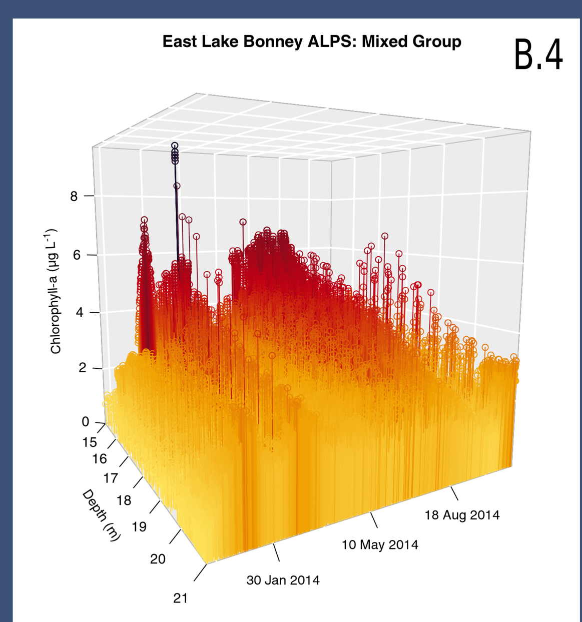


Mean total chlorophyll-a and mean phytoplankton spectral group chlorophyll-a concentrations measured by ITP Fluoroprobe. Periods of 24 hr darkness are shaded and labeled "Polar Night". WLB chlorophyll-a increased by 0.06 $\mu g\ L^{-1}\ day^{-1}$ during the polar night (A.1). ELB community shifts occured in fall and chlorophyll-a concentration remained stable through winter (A.2). Surface water of ELB mean chlorophyll-a increased steadily by 0.08 $\mu g\ L^{-1}\ day^{-1}$ from Feb. into May as the mixed group continued to grow and green algae began declining (A.3)

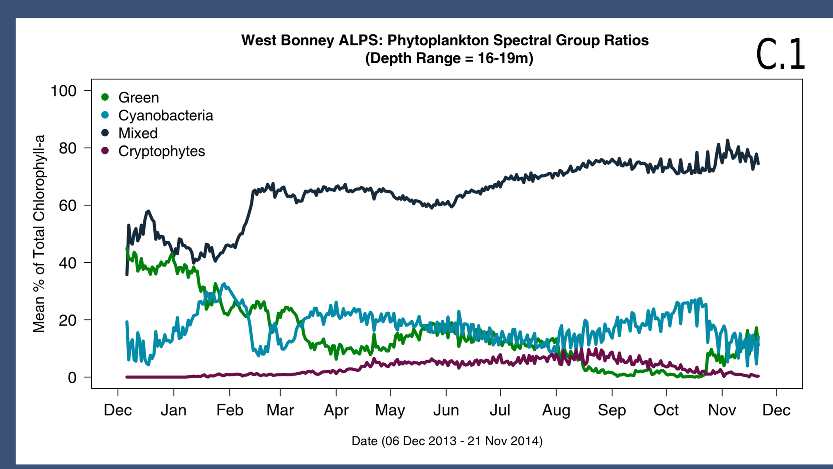


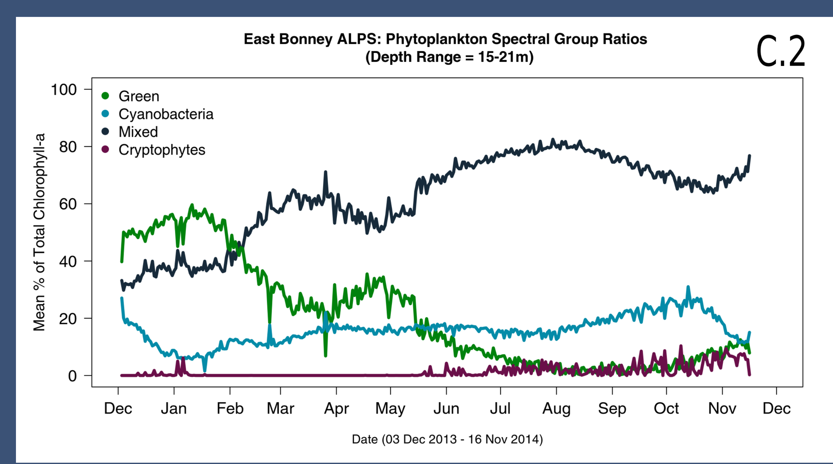


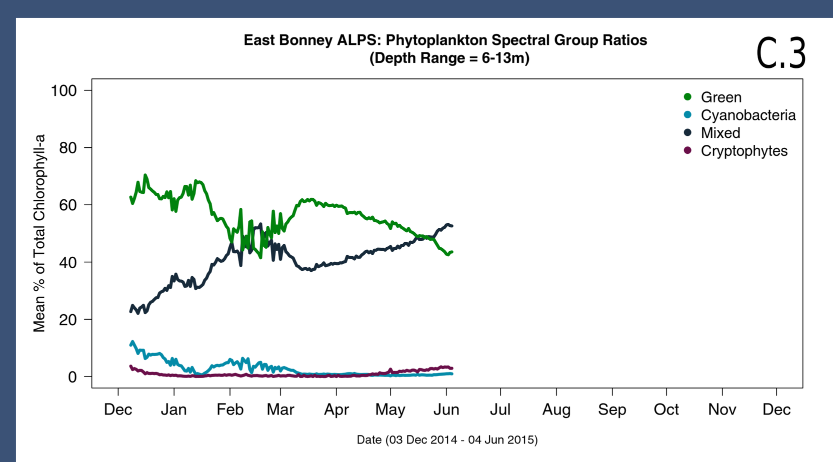




3-D visualizations of phytoplankton spectral class chlorophyll-a concentration as profiled by the ITP. Mixed and cryptophyte spectral classes measured in WLB increased in concentration during the darkness of winter (B.1, B.2). Green algae increased rapidly when sunlight was available, and declined during the winter (B.3). The mixed group increased during the darkness of winter as well as spring and summer when sunlight became available (B.4).







Phytoplankton spectral class mean percentage of total chlorophyll-a concentration throughout the year. Mixed group increasingly dominated WLB (C.1). ELB shift in dominant group observed in austral fall (C.2). Mixed and green classes dominate surface of ELB (C.3)

Conclusions:

The loss of sunlight during the Antarctic winter triggers a cascade of changes in the phytoplankton community. Mixotrophy appears to be a competetive physiological advantage in Lake Bonney. Mixotrophic organisms such as cryptophytes and those in the mixed spectral class (haptophytes and stramenopiles) likely shift their metabolism from phototrophy to heterotrophy. Well suited for life without sunlight their populations are observed increasing in concentration during the darkness of winter. Obligate phototrophs (green algae and cyanobacteria) presumably enter vegetative states to wait out the extended darkness or attempt to survive using lipid reserves built up during the short growing season. These results show autonomous instrumentation can be used to observe phytoplankton community dynamics year round.

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