Ecosystem Dynamics in an Extreme Environment: Lake Fryxell, Taylor Valley, Antarctica.

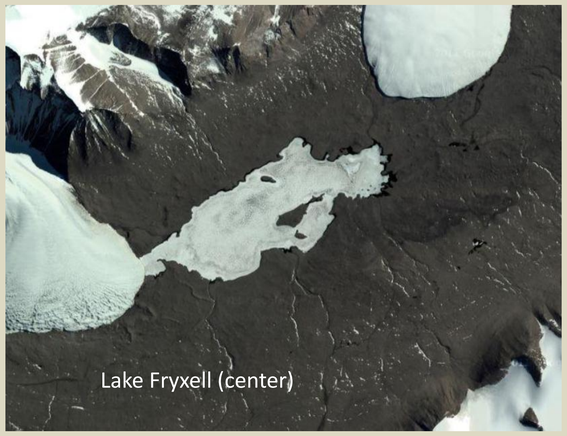
Alex Rytel
Radu Herbei
W. Berry Lyons

THE OHIO STATE UNIVERSITY SCHOOL OF EARTH SCIENCES

BYRD POLAR RESEARCH CENTER
THE OHIO STATE UNIVERSITY

Introduction

- The McMurdo Dry Valleys are a large and mostly ice free area under desert conditions.
- The lakes there are stratified, closed-basin systems and are permanently covered in ice.
- **Biological activity in the lakes is mostly driven by ice thickness** because this controls how much sunlight penetrates into the water below. (Fritsen et al 1998)
- **Why Do We Care?** This is part of a larger study that seeks to understand the impact of climate on all of the biological processes in Taylor Valley, including the lakes.



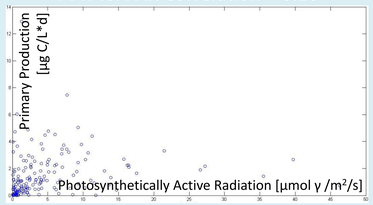
- **In this study** we used a statistical approach to link the physical, chemical, and biological processes within the lake.
- We used profiles of light, phosphorus, nitrogen, and other lake data to try and explain the behavior of the biological production and amounts of biomass within the lake.

Methods

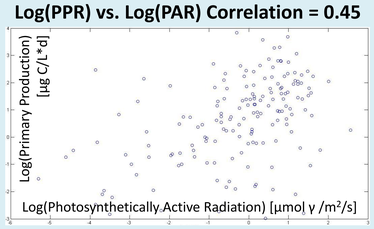
Lake Fryxell is a complex system. The association between biological variables is highly non-linear.

- For example, PPR vs. PAR.
- Linear regressions were run on logarithms of the data because it smoothed/compressed the data by scaling down large numbers:

PPR vs. PAR Correlation = 0.16

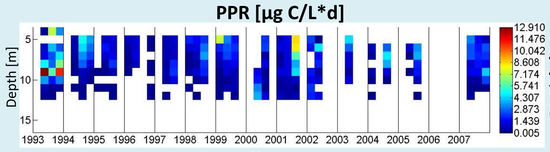


Log(PPR) vs. Log(PAR) Correlation = 0.45

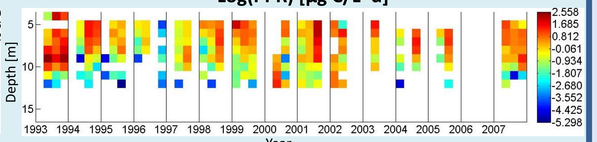


- **Logarithmic relationship vs. linear relationship:** increased contrast. (Note the gaps in the data.)

PPR [µg C/L*d]

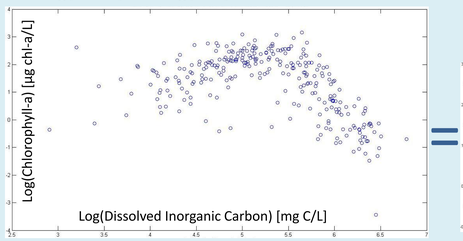


Log(PPR) [µg C/L*d]



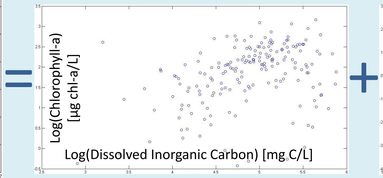
- In some situations – such as the example below – it was prudent to run one regression on the data above the oxy-pause , and one regression below the oxy-pause, rather than one for the entire water column.

Log(Chl-a) vs. Log(DIC) Correlation = -0.44



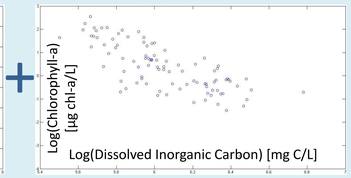
=

Log(Chl-a) vs. Log(DIC) in Oxygenated Zone Correlation = 0.37



+

Log(Chl-a) vs. Log(DIC) in Anoxic Zone Correlation = -0.75



(Graph Units Breakdown) **Depth** = Water depth, as measured from bottom of lake ice. (meters) [m]

PPR = Primary Productivity, measured as inorganic carbon uptake using 14C-bicarbonate. (micrograms of carbon per liter each day) [µg C/L*d]

PAR = Underwater Photosynthetically Active Radiation. (micromoles of photons per square meter per second) [µmol γ /m²/s]

DIC = Dissolved Inorganic Carbon concentration found at lake depth. (milligrams of carbon per liter) [mg C/L]

Chl-a = Chlorophyll-a concentration, as averaged from 2 replicates, and measured by Turner Designs Fluorometer. (micro grams of chlorophyll-a per liter) [µg chl-a/L]

NO_3 = Nitrate concentration found using Lachat. (micro molar nitrate) [µM NO_3]

BE = Total Bacterial Enumeration. (cells per milliliter) [cells/mL]

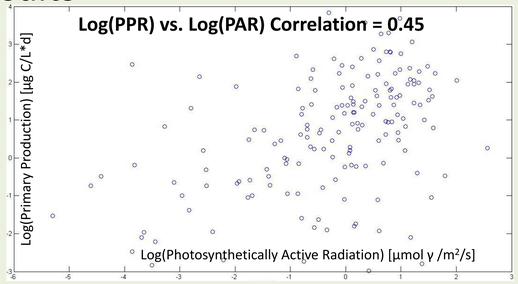
BP = Bacterial Production measured as thymidine uptake using tritiated thymidine. (nanomolar tritiated thymidine per day) [nM TDR/d]

References

Fritsen, C. H., E. E. Adams, C. P. McKay, and J. C. Priscu. (1988) Permanent Ice Covers of the McMurdo Dry Valleys Lakes, Antarctica: Liquid Water Contents, *Ecosystem Dynamics in a Polar Desert: The McMurdo Dry Valleys, Antarctica*, J. C. Priscu, Editor, 269-280

Results

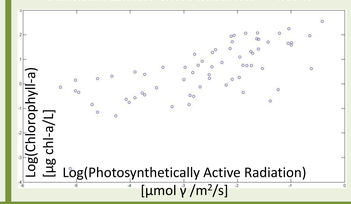
Log(PPR) vs. Log(PAR) Correlation = 0.45



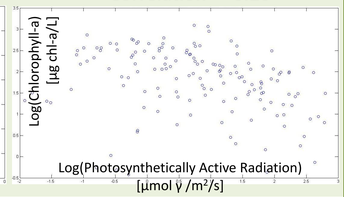
- PAR is the biggest limiting factor of PPR.

- In the oxygenated zone, as light increases nutrient levels decrease.
- Below 10 M, nutrients are abundant, so the more light, the more photosynthetic biomass (Chlorophyll-a).

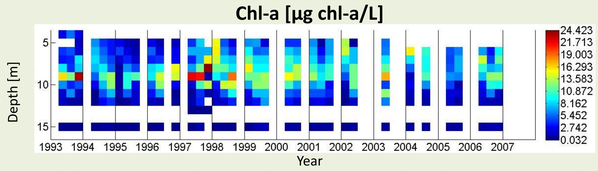
Log(Chl-a) vs. Log(PAR) in Anoxic Zone Correlation = 0.70



Log(Chl-a) vs. Log(PAR) in Oxygenated Zone Correlation = -0.26

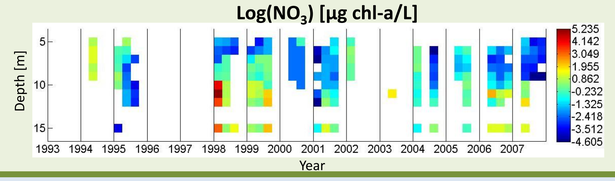


Chl-a [µg chl-a/L]



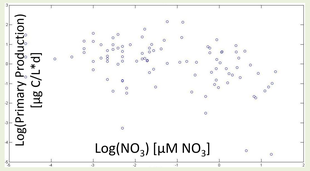
- Most life exists on the overlap between the photic zone and the nutrient rich zone below.

Log(NO_3) [µg chl-a/L]

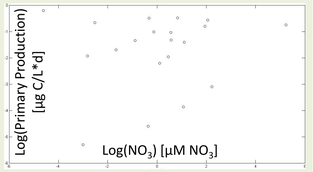


- Biological activity depletes available nutrients.
- As PAR and thus PPR increases, nutrient levels (NO_3) decrease.
- In the anoxic zone, PPR is not significantly limited by NO_3.

Log(PPR) vs. Log(NO_3) in Oxygenated Zone Correlation = -0.38

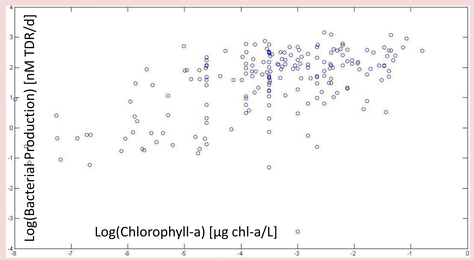


Log(PPR) vs. Log(NO_3) in Anoxic Zone Correlation = 0.12



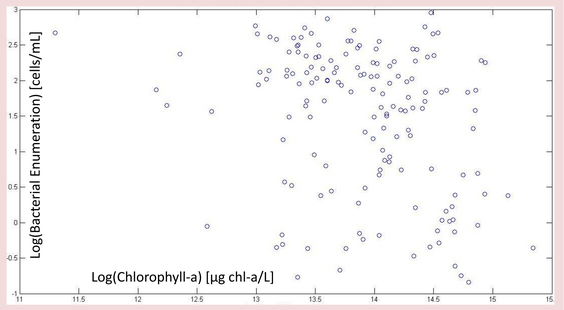
Work In Progress

Log(BP) vs. Log(Chl-a) Correlation = 0.57



- The same conditions that favor bacterial production (BP) favor photosynthetic biomass (Chlorophyll-a) as well. Why?
- This could be an indicator that almost all of the bacterial production in the lake is due to photosynthetic activity.
- It could also mean that most of the bacteria in the lake is either mixotrophic or autotrophic, and if true that must be taken into account in data processing.

Log(BE) vs. Log(Chl-a) Correlation = -0.29



- Bacterial enumeration (bacterial biomass) negatively correlates with chlorophyll-a (mostly autotrophic and somewhat mixotrophic biomass).
- One possible explanation is that these two different sets of fauna dominate different regions of the water column.
- Determining how much of the planktonic community is represented by the available biological data is also important when making interpretations.

Conclusions

- These are complex multivariable systems and therefore explaining variables is difficult to do with certainty.
- The interpretation of the causes of change in primary and bacterial production, and bacterial and photosynthetic biomass is difficult to discern due to the mixotrophic component and possible predator-pray relationships.
- Further work is required. We are also analyzing the influence of stream discharge into Lake Fryxell.

Contact info:
rytel.4@osu.edu