Metal and phosphorus behavior during ice and non-ice covered periods in Missisquoi Bay, VT

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Background

- Biogeochemistry of trace metals and nutrients under ice has not been fully understood.
- It's potentially be very important in understanding how spring blooms develop (Smith et al. 2011, Schroth et al. 2015).
- P and metals at the sediment water interface (SWI) ➔ redox conditions that are dependent on dissolved oxygen (DO), temperature, and weather disturbances (Smith et al. 2011, Søndergaard et al. 2003).

Hypothesis

Sedimentary release of Fe, Mn and P in winter will be higher than the summer in Missisquoi Bay due to the persistent low oxygen conditions under the ice, while frequent atmospheric disturbances during summer cause less stable reducing conditions.

Method

- Missisquoi Bay: shallow eutrophic lake with average depth of 2 m (max. 4 m; surface area of 77 km^2) and avg. TP conc. of 40 ug/l.
- Missisquoi River: main tributary (79% of total discharge).
- Watershed: mainly forested (62%) and agricultural (25%)
- Whole bay is frozen in winter (Dec.-Apr.)

- Weekly water and bi-weekly sediment samples
- Sediment: gravity core, separated into 6 depths (fig. 2),
  ➔ freeze dried ➔ digested.
  Aqua Regia: produces total fractions of Al, Fe, Mn, and P in the sediment.
  Ascorbic Acid: produces labile fractions (mainly Fe/Mn-(hydr)oxides), which react the most at the SWI where frequent redox changes.
  ➔ Determined Al, Ca, Fe, Mn and P using the ICP-OES (See Fig. 3)
- Water samples: filtered using filters of 0.45 µm (Total dissolved), and 0.02 µm (Truly dissolved): Al, Fe, Mn and P were measured using the ICP-MS.

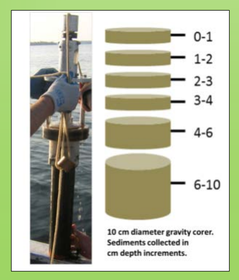
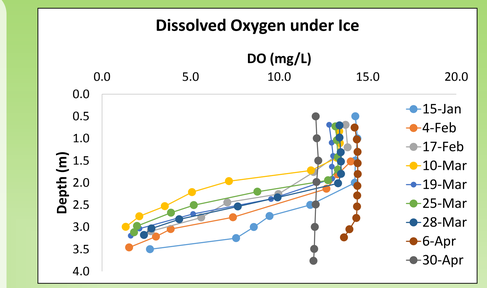
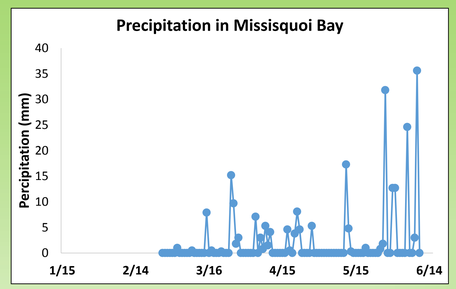


Fig. 2 (right) gravity core and depth increments
Fig. 3 (above) ICP-OES at UVM

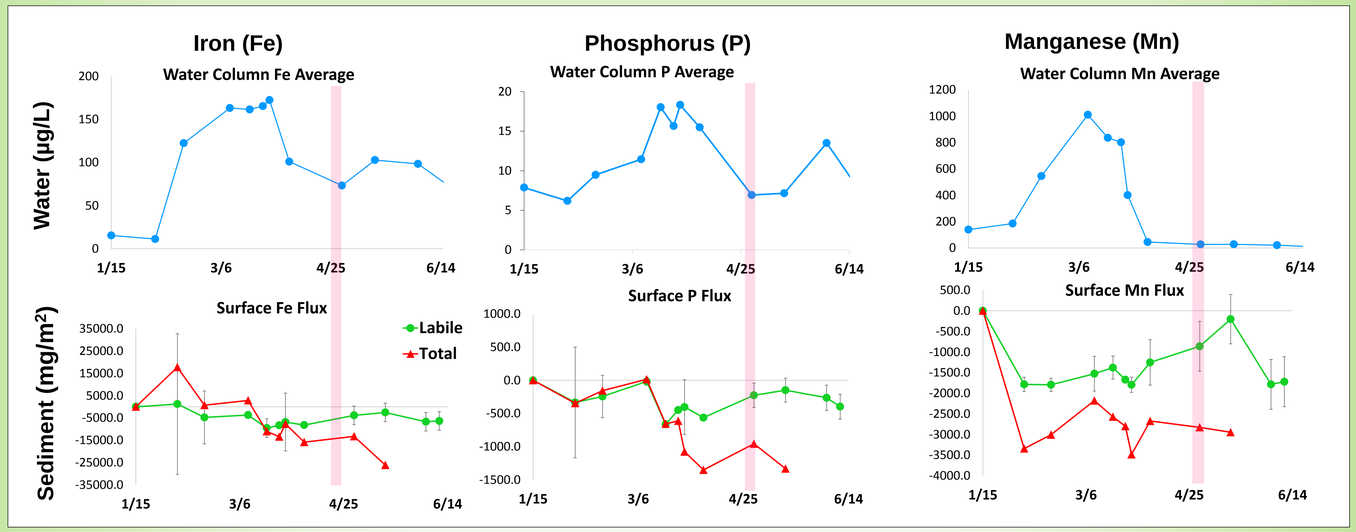
Environmental Parameters



- Well stratified DO and temperature produce hypoxic conditions at the SWI underneath the ice, along with a lack of surface water disturbances
- During the thaw, the DO and temperature profiles are less stratified, and inputs from the watershed may help SWI mixing



Sediment Water Interaction

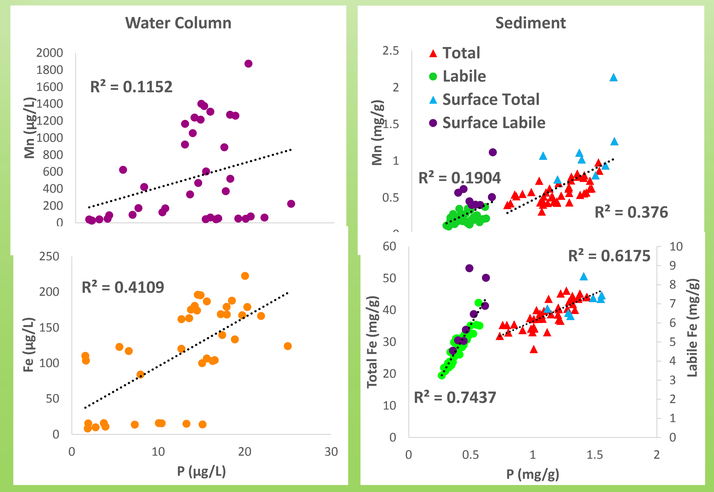


(*Red bar is the first ice free sample (4/25), Water: total dissolved (< 0.45 um) and averaged all depths, Sediment: represents the 0-1cm depth)

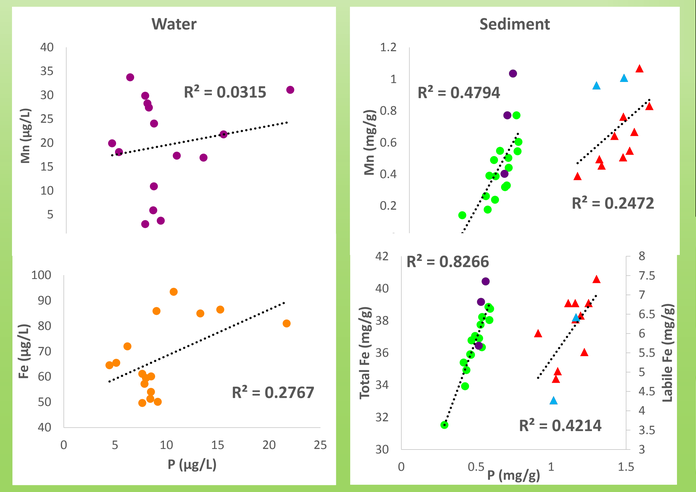
- Underneath the ice, water column P, Fe and Mn concentrations increased, while in the sediment profile a decrease was observed until March
- In April during the thaw and no ice period, Mn concentrations in the water column returned to the original levels before the ice coverage period; whereas with P and Fe the water concentrations decreased at first then increased continuously after the thaw.

Regressions

During Ice Period



Post-Ice Period



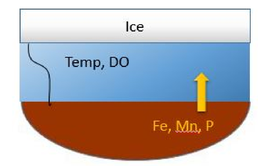
Conclusion

- Underneath the ice, P, Fe, and Mn are being released from the sediment into the water column due to reducing conditions at the SWI.
- In the non-ice period, P, Fe, and Mn are being deposited from the water column into the sediment.
- Correlation between P and Fe (or Mn) in sediments during ice/non-ice periods: important role of and Mn on P distributions in this bay.

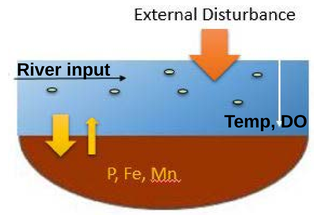
Take Home Points

- **Different P and metal distributions between ice and non-ice periods were dependent on redox conditions at SWI related to water stability and DO.**
- **External inputs, such as river discharge and rain events introduce external P, Fe, and Mn into MB.**
- **Sedimentary release and external inputs during ice meting, may be contribute to the nutrients supply during the spring biological production in MB**

Under Ice



Non-Ice



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