Phosphorus and Metals' Flux in Missisquoi Bay Sediments

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What can lake sediments tell us about water quality?

- In the Northeastern United States, water quality and aquatic ecosystem function may be at a greater risk due to more intense, frequent seasonal storms and warmer, wetter winters (Pealer and Dunnington 2011).
- The positive feedback cycles in Missisquoi Bay contribute to the persistence of cyanobacterial blooms during the summer months.
- The internal loading of phosphorus (P) from lake sediments may be an important source of P to algae or a sink for P during less productive seasons of the year such as winter.
- Oxygen depletion at the sediment-water interface (SWI) may occur overnight, during the summer season and especially when a cyanobacterial bloom is present (Smith et al. 2011).

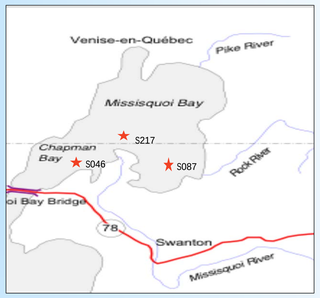


Fig. 1: Study Site. Missisquoi Bay is in the northeastern section of Lake Champlain where external P loading from the surrounding watershed is very high (Smith et al. 2011). Core collection sites are indicated by red stars.

Photo credit: http://www.ijc.org/rel/boards/missisquoi_bay/map_champlain_e.pdf

Specific Questions

- How does the concentration of reactive phosphorus in sediments at the sediment-water interface (0-1 cm) change over time?
- Is there a relationship between phosphorus and metals flux at the SWI?
- Are the fluxes at the SWI due to changes within the sediment profile (1-10 cm) or in the water column?

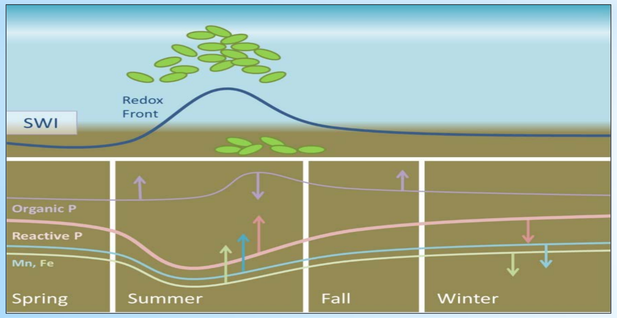
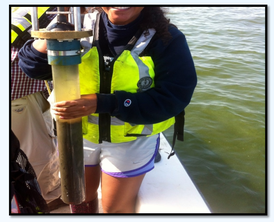


Fig. 2: Conceptual diagram of P loading in sediments. The diagram displays the P and metals flux by season and impact on algal blooms. Courtesy of Dr. Courtney Giles.

Methodology

- Collect sediment cores from each site using gravity coring device (A. Lini, UVM Geology)
- Extrude and divide sediments into 6 layers from 0-10 cm below the surface
- Freeze and Freeze-dry sediments for further geochemical analysis



ICP-OES machine used to measure sediment AR and ASC P and metals' concentrations

(A) **ASCORBATE CITRATE-BICARBONATE EXTRACTION**—measures the concentration of 'reactive' phosphorus and metals, such as those associated with the amorphous phase of sediments. Ascorbic acid reduces the amorphous metal hydroxides in the sediment layer which influence the release of reactive phosphorus.

(B) **AQUA REGIA DIGESTION**—measures the concentrations of total acid-extractable P and metals in sediment. This method involves several additions of concentrated acids and heating cycles. (Anschutz et al. 1998, Smith et al. 2011, Wetzel 1999)

Time-Series Analysis of Sediment P, Fe and Mn Fractions

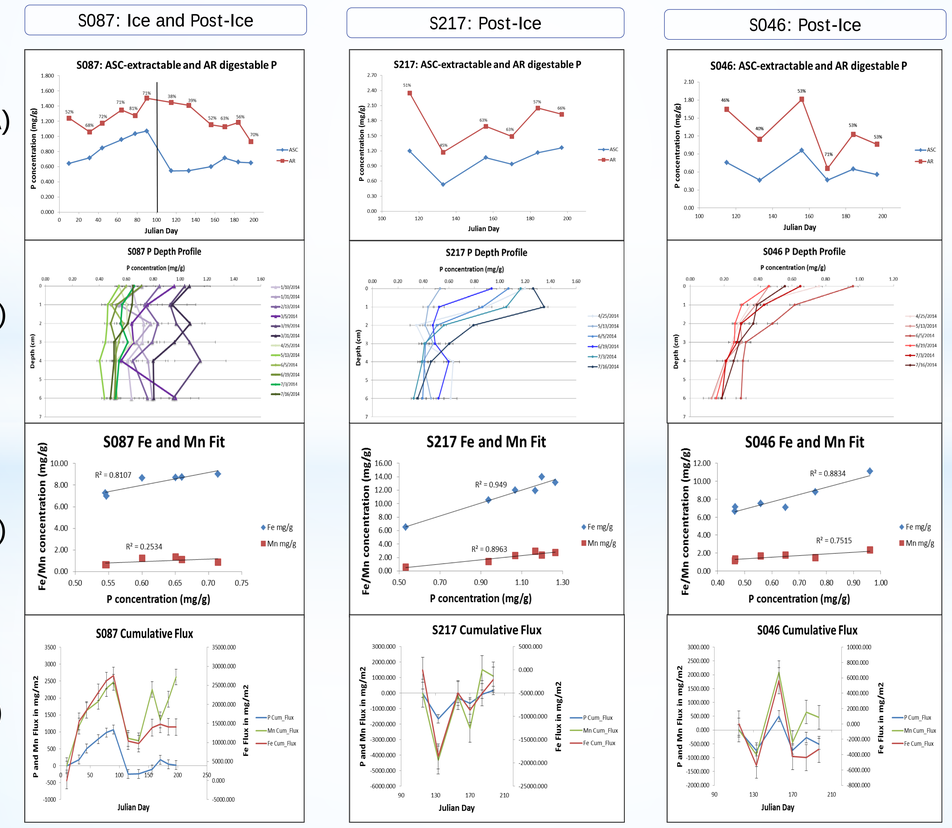


Fig. 3: Time-series analysis of sediment P, Fe, and Mn fractions in the 0-10 cm depth collected from the three sites in Missisquoi Bay (S087*, S217, S046).

(A) Ascorbate (ASC) and Aqua regia (AR) extractable P concentrations. The relative percentages demonstrate how much reactive P makes up the total P content.
(B) Depth profiles of ASC-P concentration in mg/g in the top 0-10 cm.
(C) Correlations of ASC-P concentrations to ASC- Fe and Mn concentration at 0 cm depth.
(D) Cumulative Flux of P, Mn, and Fe in mg/m² with relative error bars; represents the sum of previous period fluxes for a given date. Positive fluxes indicate release of P and metals from the sediment into the water column while negative fluxes indicate accumulation into the sediment.

*Vertical lines divide ice and post-ice measurements.

Discussion

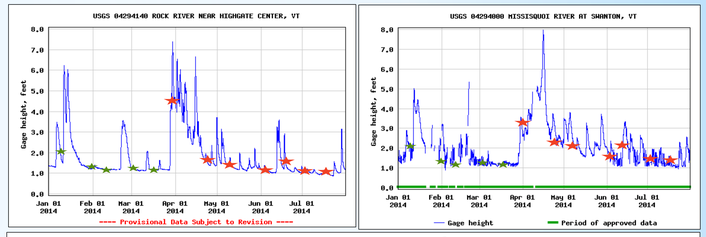


Fig. 4: Rock River and Missisquoi River discharge (ft³/s) and gage height (ft.) during sampling dates before (green stars) and after (red stars) 'ice out' on Missisquoi Bay. Rock River showed strong January gage heights and discharge but had less major fluctuation after April. The discharge for Missisquoi River continued to be variable in the following summer months (USGS).

- **Reactive P accumulated in sediments under ice but was rapidly depleted following ice-out (S087 only)**
- **Net loss of P from sediments from April to July, then accumulation in late July (all sites).**
- **Water depth and proximity to river inflows may influence the stability of reactive P in deeper sediments**
  - **S217 and S046**: Sediment reactive P concentrations were stable below 2cm at S217 and S046 (>3.5m), but more variable at S087 (~3.5m)
- **The direction of P flux between sampling periods varied with time and was not the same across sites.**
- **Intrinsic factors, such as the changing seasons, with their changes in temperature and precipitation, appear to have the largest effects on the flux into or out of the water column.**

Acknowledgments

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**"USGS 04294140 ROCK RIVER NEAR HIGHGATE CENTER, VT." http://nwis.waterdata.usgs.gov/vt/nwis/uv/?cb_00065=on&cb_00060=on&cb_00055=on&cb_99237=on&cb_99234=on&format=gif_default&site_no=04294140&period=&begin_date=2014-01-01&end_date=2014-07-31
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