Sediment geochemistry in South Eastern Georgian Bay

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Background and Objectives

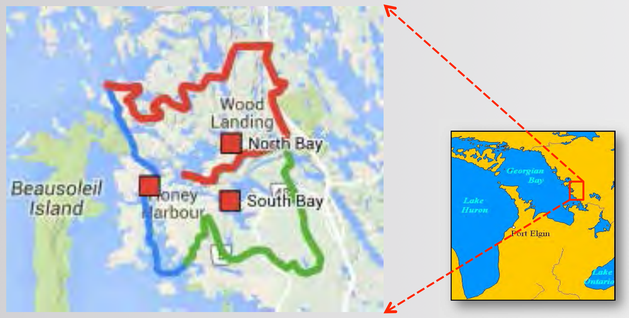
- Under favorable biogeochemical conditions sediments can be a source of nutrients to the overlying water column. Therefore, good understand of processes that take place in the surface sediments is essential for management of freshwater ecosystems.
- Honey Harbour area of South Eastern Georgian Bay is heavily used by cottagers and consequently, there are concerns about impact of recreational use on water quality.
- While water quality monitoring suggests that sediments are a source of phosphorus (P) in this area, its flux is not quantified and processes controlling phosphorous release are not well understood.

The objectives of this study were:

- To identify the dynamics of phosphorus (P) in sediments
- To gain insight into the mechanism of P release from sediments.

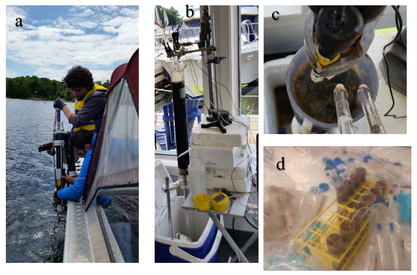
Study sites

- North Bay and South bay are small semi-enclosed bays in South-Eastern GB area. Both bays are oligo- to mesothrophic, with a history of seasonal hypolimnetic oxygen depletion. Honey Harbour site is located in shallow (~ 9 m) channel connecting Georgian Bay and Severn Sound.
- Samples were collected from three (3) locations 6 times during 2014 and 2015 .
- Over the course of two years we determined P binding forms in surface sediment, pore-water concentrations of nutrients and metals, measured dissolved oxygen, redox potential and pH at the sediment water interface (SWI).



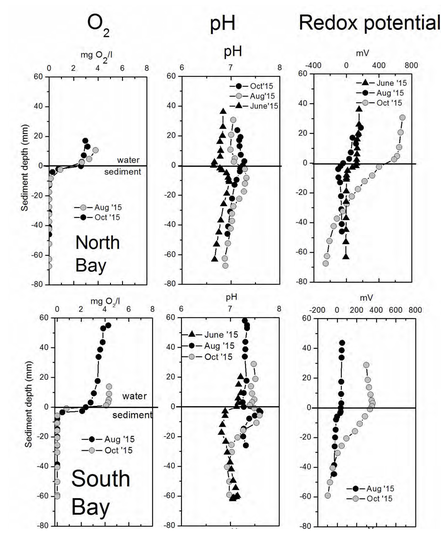
Methods

- Sediments were collected with gravity corer and sliced in layers under N_2-atmosphere
- Pore water was extracted using rhyzosphere filters
- Metals and P in pore water were measured by ICP-MS
- Alkalinity was mesaured by Gran titration
- P binding forms were quantified using sequential extraction after Psenner and Pucsko (1988)
- Contents of Fe, Mn, Ca, Si, Al and P were determined using ICP – MS in each extraction
- Oxygen, pH and redox potential were determined by microsensors



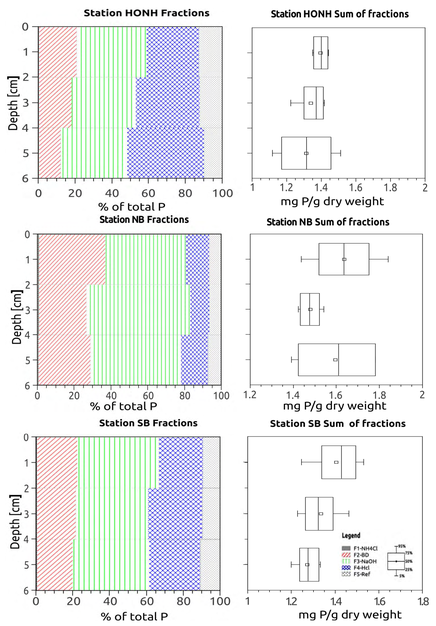
a) Sediment sampling using gravity corer; b) and c) measurements of depth profile of pH, O_2 and redox potential at the SWI and d) pore water sampling

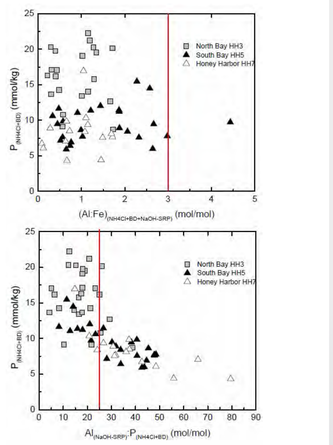
O_2, pH and redox potential at the SWI



- The distinct pH minima at the SWI at stations SB and Honey Harbour was observed during June and August. It likely caused by intense microbial oxidation of organic matter.
- The Eh gradients suggest presence of organic carbon oxidation by oxygen, followed by nitrate reduction, iron and manganese reduction.
- Sediments were anoxic below 2mm depth at stations NB and SB and below 4mm at station Honey Harbor.

Linking P release and its binding forms in sediments

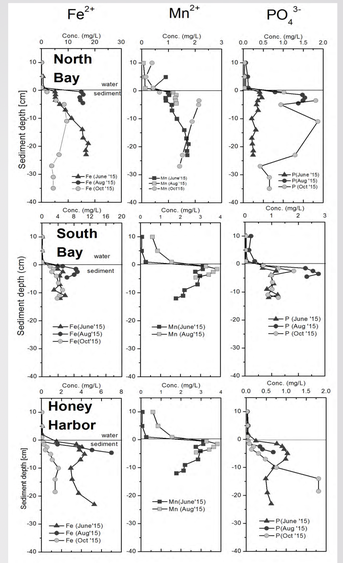




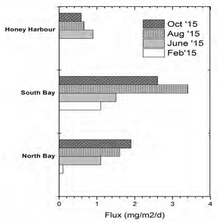
- Surface sediments at all sites have Al :Fe ratios lower than threshold value from Kopacek et al. (2005).
- Al:P ratios are below Kopacek et al. (2005) threshold value at North Bay and generally above threshold value at other sites.
- At South Bay and Honey Harbour sites P release is inhibited by adsorption on Al hydroxides (Al-NaOH : P (NH_4-Cl +F_2-BD) >25).

Dittrich, M. et al 2013. Phosphorus retention in a mesotrophic lake under transient loading conditions: Insights from a sediment phosphorus binding form study. Water Research. 47, 1433
Kopáček, J. et al 2005 . Aluminum control of phosphorus sorption by lake sediments. Environment Science and Technology. 39, 8784-8789
Psenner, R., Pucsko, R., 1988. Phosphorus fractionation: advantages and limits of the method for the study of sediment P origins and interactions. Advanced Limnology 30, 43-59.

Pore water chemistry and internal loading



P diffusive fluxes



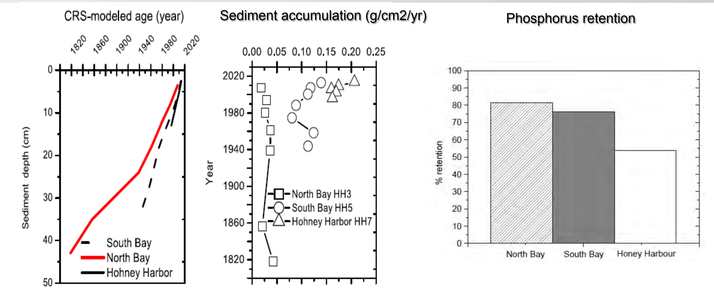
The SRP in pore-water is used to calculate P release from sediments into the overlying water by Fickian law

$$F_{release} = \frac{\varphi \cdot D_0}{\theta} \frac{\partial C}{\partial z}$$

F release is Flux (mg P m^{-2} d^{-1}); D_s is f(T, φ) is solute diffusion coefficient (m^2 d^{-1}); T is sediment temperature at SWI (°C); θ = 1-ln (φ^2) is sediment tortuosity, φ is sediment porosity ;C is solute concentration (mg L^{-1}); z is sediment depth (m).

- P fluxes were the highest at South Bay.
- At North Bay, the P fluxes were lower, with the highest values in October.
- The P fluxes were the lowest at Honey Harbor station.

P retention and sediment accumulation



Summary

- Our results suggest that P cycling at the sediment-water interface is driven by redox processes and controlled by organic matter input and hydrologic regime in particular basin.
- Release of redox sensitive P during summer anoxia is likely the main contributor to internal P loading at all sites,
- P immobilization is mainly driven by sorption on Al hydroxides.

Acknowledgments
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