

Water Level Regulation and Great Lakes Coastal Wetlands: How does regulation impact nutrient release and aquatic productivity?

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Background

Water levels in the Lake Ontario and St. Lawrence River system (LOSLR) have been regulated for shipping and power generation since 1960. The Moses-Saunders dam provides power for industry, homeowners, and businesses in NY and Canada and the St. Lawrence Seaway has allowed over \$375 billion in cargo to travel to and from cities including Duluth, Milwaukee, Chicago, and Detroit. Some stakeholders criticize the current regulation plan for not balancing environmental needs with these economic needs.

Lowering and stabilizing water levels in the LOSLR for shipping and power generation has adverse effects on adjacent wetlands that provide crucial habitat, most notably spawning habitat for Great Lakes sport fish. The regulation plan was recently changed to address environmental concerns, but still does not mimic the natural regime. With climate change affecting the amount and timing of precipitation, the plan is likely to change in the future. For these reasons, it is important to understand the effects of regulation on the wetlands of the St. Lawrence River (SLR).

Stabilizing and lowering water levels in the LOSLR may influence sediment-water nutrient exchange within wetlands by decreasing the amount of submerged sediment and altering sediment chemical properties. Aquatic nutrient concentrations, particularly of nitrogen and phosphorus, control productivity in the base of food webs. Changes in the base of the food web will be transferred upwards, ultimately affecting fish and waterfowl.

The Thousand Islands Biological Station, the Thousand Islands Land Trust, and Ducks Unlimited have installed water control structures in wetlands along the Thousand Islands region of the SLR to alleviate some of the negative effects of water level regulation and create a more natural water level regime. Generally, these structures in managed sites hold water about 0.5m higher than unmanaged sites. This difference in water level provides an ideal opportunity to compare a more natural, managed regime with the dam-regulated regime in the unmanaged marshes.

My objective for the 2013 field season was to use these managed wetlands to test the hypothesis that higher, more natural water levels promote greater nutrient release and therefore greater aquatic productivity in wetlands. Measurements of water levels, nutrient concentrations, and density and diversity of aquatic invertebrates were taken and this data is being used to compare managed vs. unmanaged wetlands to evaluate this hypothesis.

Summary of 2013 work

There were three unmanaged sites and three managed sites included in this study. Samples from surface water were taken bi-weekly in the spring for a total of four sampling dates. On each sampling date at each of the six sites a 1L water sample was taken to be analyzed for water chemistry. Additionally, 10L of water was sieved through 100 μ m mesh and all remaining solids were preserved in 70% ethanol so that zooplankton could be counted and identified. A YSI multiprobe was used to take in situ readings of temperature, pH, conductivity, DO concentration, and DO percent saturation.

Samples of sediment pore water were collected once monthly from early spring through late summer from shallow wells at each of the sites. Each site had three wells at a high, mid, and low elevation for a total of eighteen wells. When available, a matching surface water sample was also taken with each pore water sample.

Water levels were monitored in two ways. Water level measurements were taken manually on each sampling date by measuring the distance from a reference point on the wells and on staff gauges to the water level. The reference points are at known elevations so that absolute water level can be determined. Additionally, there were two water level monitoring devices, one in a well and one in the surface water, installed at each site that recorded data every two hours.

In the lab, multiple instruments were used to analyze water samples for soluble reactive phosphorus (SRP), nitrate, ammonium, and chlorophyll-a, as well as multiple cations and anions. These analytes allowed a complete picture of water quality to be developed for each of the treatments, managed and unmanaged. Sieved zooplankton samples were processed by concentrating the sample to a known volume and then counting and identifying all zooplankton in entire subsamples of known volume. Subsamples were counted until 100 individuals of each of the common (>10% of sample) taxa were counted.



Collecting a zooplankton sample at Delaney Bay, Grindstone Island, NY.

Preliminary results and discussion

Since sample analysis is still underway for the 2013 field season, much of the data is still being collected and organized. SRP concentration results are presented here. SRP is measure of biologically available phosphorus. Phosphorus is an important nutrient for aquatic biota that often limits productivity in freshwater systems, and so these results are of special interest in this study.

Seasonal Patterns in surface water

Figures 1 and 2 show how surface water SRP concentrations varied throughout the field season in restored and dam-regulated sites, respectively. Each sampling site has a separate graph with a three letter name. The prefixes denote wetland sites and the suffixes denote elevation. Recall that surface samples were taken consistently for two months in the spring at the lower sites (those with the -L suffix), and monthly at all sites when available (those with the -U suffix are upper elevation sites and the -M suffix are mid elevation sites). Upper and mid sites sometimes dried out and this is the reason for missing data in some of the graphs, especially those for the dam-regulated sites where the water was not held higher by water control structures.

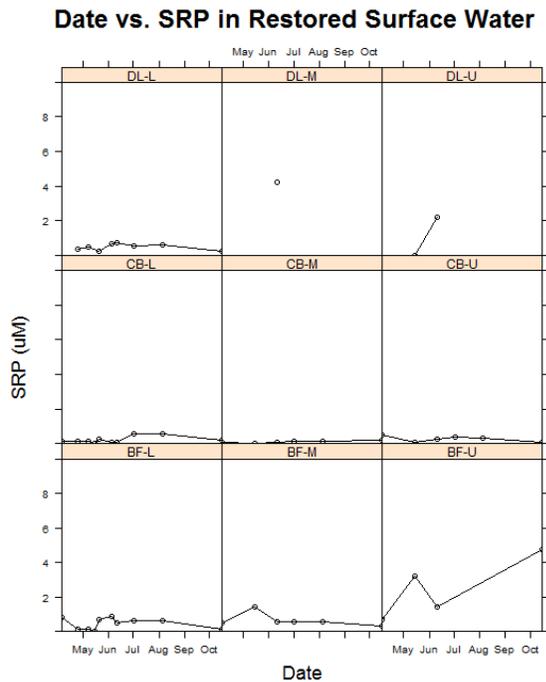


Figure 1.

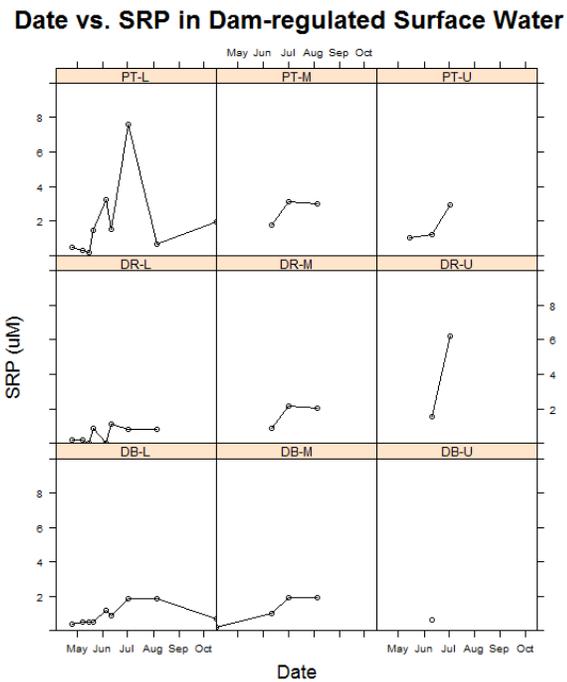


Figure 2.

Both figures 1 and 2 show a lack of a seasonal pattern of SRP concentrations in surface water. There is some evidence that the upper site samples have higher concentrations than the lower site samples. When figures 1 and 2 are compared, there is evidence that dam-regulated sites have overall higher concentrations of SRP throughout the season than the restored sites.

Seasonal patterns in pore water

Figures 3 and 4 show how pore water SRP concentrations varied throughout the field season in restored and dam-regulated sites, respectively. These graphs are set up the same way as figures 1 and 2, but recall that these samples were taken once monthly throughout the spring and summer.

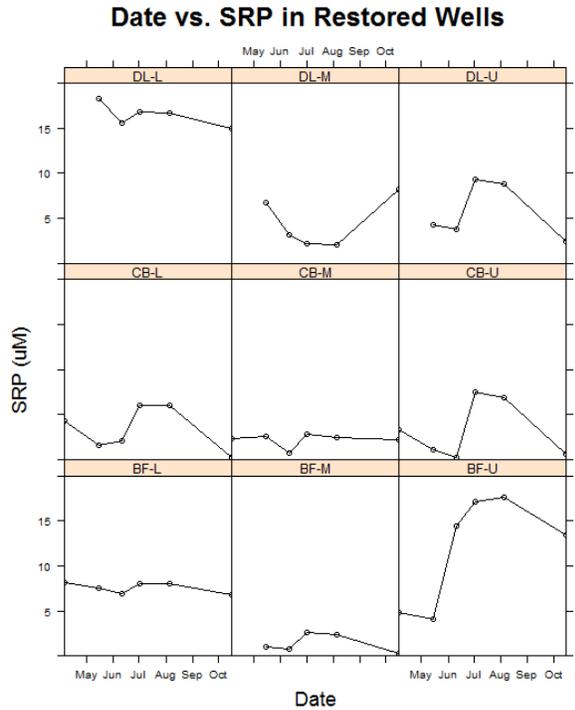


Figure 3.

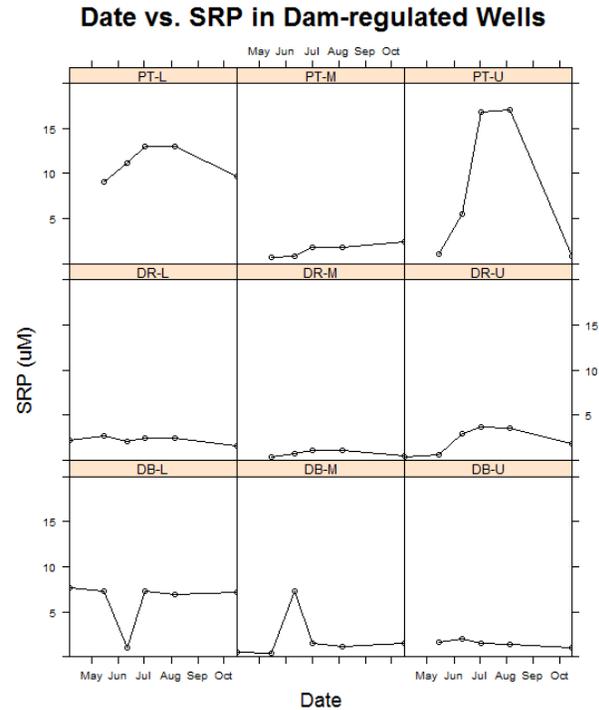


Figure 4.

Both figures 3 and 4 show a lack of an overall seasonal pattern of SRP concentrations in pore water. Upper restored sites all follow a general pattern of low concentrations in the spring followed by a peak in mid-summer and lower concentrations in late summer. This is most likely related to water level as water levels also follow this pattern throughout the year. Furthermore, mid sites in both the restored and dam-regulated wells have lower SRP concentrations overall than upper and lower wells in the same site. This may be due to differing redox conditions, sediment composition, or biotic communities at the mid sites.

Surface water treatment comparison (ANOVA)

Table 1 shows the mean SRP concentrations in surface water for the spring and summer of 2012. As you can see there is a general pattern of higher concentrations in dam-regulated sites, but this difference is only significant at mid and lower elevation sites. This is the opposite pattern than was expected, and it is unclear at this time what might be causing this pattern.

Elevation	Restored Mean (µM)	Dam-regulated mean (µM)	Anova p-value
Upper	1.166	2.259	0.218
Mid	0.686	1.801	0.019
Lower	0.371	1.155	0.009

Table 1.

Pore water treatment comparison (ANOVA)

Table 2 shows the mean SRP concentrations in pore water for the spring and summer of 2013. There seems to be a pattern of higher concentrations in restored sites, the opposite pattern exhibited by surface water. However, these differences are not significant at any elevation. This pattern was expected but it is very interesting that the pattern is opposite that of pore water, as pore water and surface water concentrations were thought to mirror one another. This may be due to different redox states, which affect chemical speciation and availability, in the surface water and pore water.

Elevation	Restored Mean (μM)	Dam-regulated mean (μM)	Anova p-value
Upper	7.067	3.872	0.102
Mid	2.667	1.502	0.087
Lower	8.715	6.274	0.158

Table 2.

Preliminary conclusions and future work

There is evidence in the SRP concentration results that water level restoration with water control structures has an effect on surface water and pore water chemistry. It is likely that this effect will also be apparent when the results of other chemical species measured are available. If there is a substantial chemical difference between the restored and dam-regulated treatments, the chlorophyll-a (proxy for phytoplankton biomass) and zooplankton results may show that this chemical difference also affects productivity in the lower food web.

In the next several months the remaining sample analysis and data analysis will be completed. The comprehensive results of this study will be used to evaluate the original hypothesis and produce a complete picture of the differences between the restored and dam-regulated treatments.

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