Phosphorus and phytoplankton dynamics in the Les Cheneaux Islands during a rapid rise in Lake Huron water level.

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Abstract: Nutrient concentration and algal biomass dynamics are reported for multiple sites throughout the Les Cheneaux Islands (LCI) during a three-season period of unprecedented rise in Lake Huron water level which followed aggressive growth of Eurasian watermilfoil (*Myriophyllum spicatum*), an exotic aquatic macrophyte.
In the same time frame LCI phytoplankton populations decreased fivefold based upon chlorophyll-a concentrations while nutrients in the form of soluble phosphorus doubled. It is not known if the observed shifts in phytoplankton density and phosphorus concentration were in response to an abrupt water level increase, the rapid demise of *M. spicatum*, a combination of the two, or if a review of LCI water chemistry archive data will exhibit a similar pattern.

Introduction: Basic water chemistry characteristics have been monitored since 2001 at ten sites throughout the Les Cheneaux Islands (LCI) for the purpose of tracking the recreational water quality. During this period local waters, although ranging significantly in depth and degree of nuisance weed growth, have remained excellent for all recreational endeavors, to include full body contact.

During the summers of 2011 and 2012 a combination of record low water not experienced since the 1960s and intense growth of the exotic aquatic plant, Eurasian watermilfoil (*Myriophyllum spicatum*), severely restricted boating, fishing and swimming. Weed-choked channels also discouraged recreational cruising boats from using LCI waterways and visiting local marinas which resulted in significant loss to the tourist-based economy.

January of 2013 marked a record low lake level and from that time through 2015 Lake Huron has risen 96 cm (38 inches), an unprecedented two-year rate. This paper tracks changes in nutrients (phosphorus) available for algal and aquatic plant growth. Algal population density was determined indirectly by measuring chlorophyll-a extracted from planktonic (free-floating) algal forms. Sample analysis was conducted at the Univ Michigan Biological Station at Douglas Lake. With increased interest in nutrients, aquatic weeds and algae populations, two additional sites in Sheppard Bay were added to the ten sites normally monitored.

For purposes of this discussion, consider phosphorus to occur in two primary forms in the aquatic environment: (1) as particulate phosphorus (PP): a form not readily metabolized by aquatic plants and phytoplankton and (2) as soluble reactive phosphorus (SRP): a soluble form readily metabolized by aquatic plants and phytoplankton. The combined PP plus SRP is reported as Total Phosphorus (TP). In this discussion we will pay attention to the concentration SRP relative to chl-a, an indicator of phytoplankton populations.

Methods: To be developed…

Results and discussion: Figure 1 shows mean chlorophyll-a (chl-a) levels throughout the sampling season from May through September for 2012 through 2015. Chl-a values in 2014 were one half the 2013 concentration and 2015 values were one fourth the 2013 level. All these levels are within the range of high-to-moderate recreational quality water and could be expected to be in a range reported for any given site from one sampling event to another. These trends are of interest in that they are seasonal means for twelve different sites within the Les Cheneaux Islands (LCI). Values graphed for each of the three seasons were generated from the arithmetic mean of 60 data points, thus reinforcing validity of the year-to-year differences.

Figure 1 includes chl-a data from 2012, one season prior to the rapid rise in lake level. Note that the chl-a concentration more than doubled during the first year of lake level rise of over one foot in 2013. The focus of this report is on nutrient (phosphorus) and plankton (chl-a) response to a rapid rise in lake level during a two year period.

Comparison of 2013-2015 phosphorus concentrations and plankton populations prior to 2013 will be the topic of another report.

One explanation for the doubling of chl-a in 2013 compared to island-wide mean values recorded in 2012 (Fig. 1) may relate to the rapid demise of intense Eurasian watermilfoil (EWM, *Myriophyllum spicatum*) growth in 2011 and 2012. Another study (Clymer & Smith) showed EWM declining 95% from over 300 acres in two LCI bays from 2012 through 2015. Decomposing EWM biomass would increase the phosphorus loading in the water, even though the phosphorus was somewhat diluted by the one foot increase in lake level that year. Therefore, the plankton could be expected to flourish in 2013 with excess phosphorus available from the decomposing EWM biomass.

Chl-a levels decreased linearly fivefold over two years while SRP increased greater than twofold in a linear fashion. With plankton as the primary users of SRP and it follows that SRP would appear in excess as the plankton (chl-a) levels declined (Fig.2).

A combination of plankton metabolizing most of the phosphorus excess in 2013 coupled with another 18 inch rise in lake level in 2014 and another 12 inches in 2015 could explain the dropping chl-a levels in those two years. Fig. 2 shows that excess SRP measured during 2013 was no longer present in 2014; chl-a was lower and more SRP was available. The chl-a / SRP gap was wider in 2015 indicating minimal energy demand from plankton, thereby leaving an excess of SRP.

When TP is considered (Fig.3), the findings are internally consistent in that both TP and SRP increased in concentration during two years as the chl-a decreased. Lowered SRP demand to support plankton growth is also supported by the Total Phosphorus (TP) concentrations shown in Fig. 3. The TP curve tracked with the SRP curve from 2013 to 2014 and the gap was even wider between 2014 and 2015, whereby TP concentrations are consistent with the explanation of lower demand on phosphorus as a nutrient for plankton growth. A steeper TP slope than SRP from 2014 to 2015 may be due to residual TP resulting from the continued EWM die off noted earlier.

Another way to view the SRP / chl-a dynamic is presented in Fig.4 where seasonal means 2013-2015 are shown for each sample station. These curves illustrate the decline in chl-a relative to SRP by the distance between the two curves from 2013 to 2014 and from 2014 to 2015. The SRP in 2013 tracks closely with chl-a, indicating a strong demand for SRP by phytoplankton. SRP and chl-a curves are farther apart during 2014 suggesting less SRP demand by plankton and the mean seasonal curves are even farther apart in 2015 where chl-a for all sites were less than 0.5 mcg/L, indicating less demand in 2015 than in 2014.

Summary: During a three year period LCI plankton populations decreased fivefold, as determined by extractable chlorophyll-a concentrations, while nutrients in the form of soluble phosphorus doubled. These events follow a period when LCI water levels were at historic lows and during a time of explosive EWM growth. The period of plankton decrease and phosphorus increase followed an abrupt demise of the EWM density with a simultaneous rise in lake level of over three ft. in two years.

It is not known at this point how much a detailed analysis of the LCI phosphorus cycle fits into the picture. In addition to the normal microbial and iron cycling of particulate phosphorus in the sediment, a zebra mussel factor also becomes part of the phosphorus cycling cascade in LCI waters whereby zebra mussel populations are estimated to excrete about one third of the PP ingested as SRP and another third as PP (refs).

Although numerical differences are unequivocal, given that all levels of TP and chl-a are dealing with the upper oligotrophic and lower mesotrophic nutrients range, it is not clear if the differences noted in this three-year study are significant from a limnological perspective.

Lake Huron is expected to be slightly above 2015 levels in 2016. At that water level, provided the findings and conclusions herein are valid, plankton populations can be expected to remain low and total phosphorus levels are expected to remain high in 2016.

Literature cited:

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Fig. 1. SEASONAL MEAN CHL-A TALLIED FOR 10 SITES DURING A FOUR YEAR PERIOD.VALUES ARE REPORTED AS μg/L

TSIDAT 4YR COMBINED 170116 SHT2 BV184 / TSIRPT2015 AJ

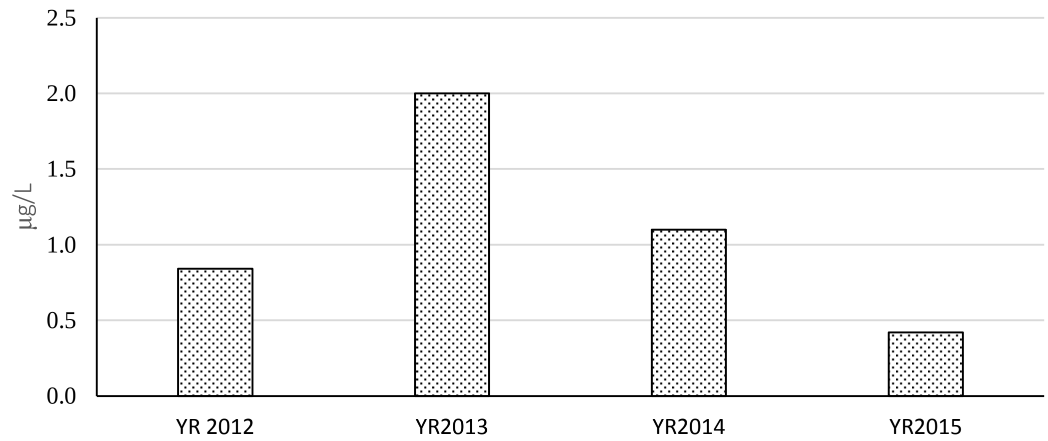
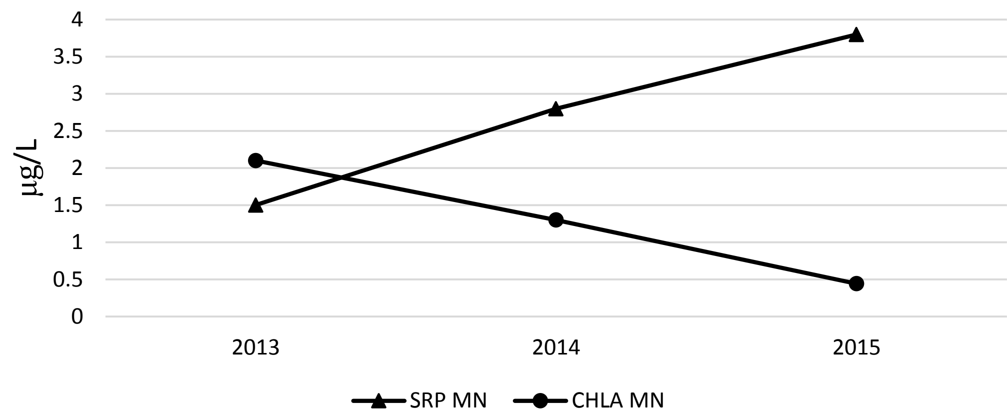


Fig. 2. SHIFT IN SRP VS CHL-A FROM 2013 TO 2015. VALUESEXPRESSED AS SEASONAL MEANS FROM 12 LCI SITES AS µg/L <TSIDAT UMBS PHOS241115> SHT4 FG90> <TSIRPT SH1 AJ81>



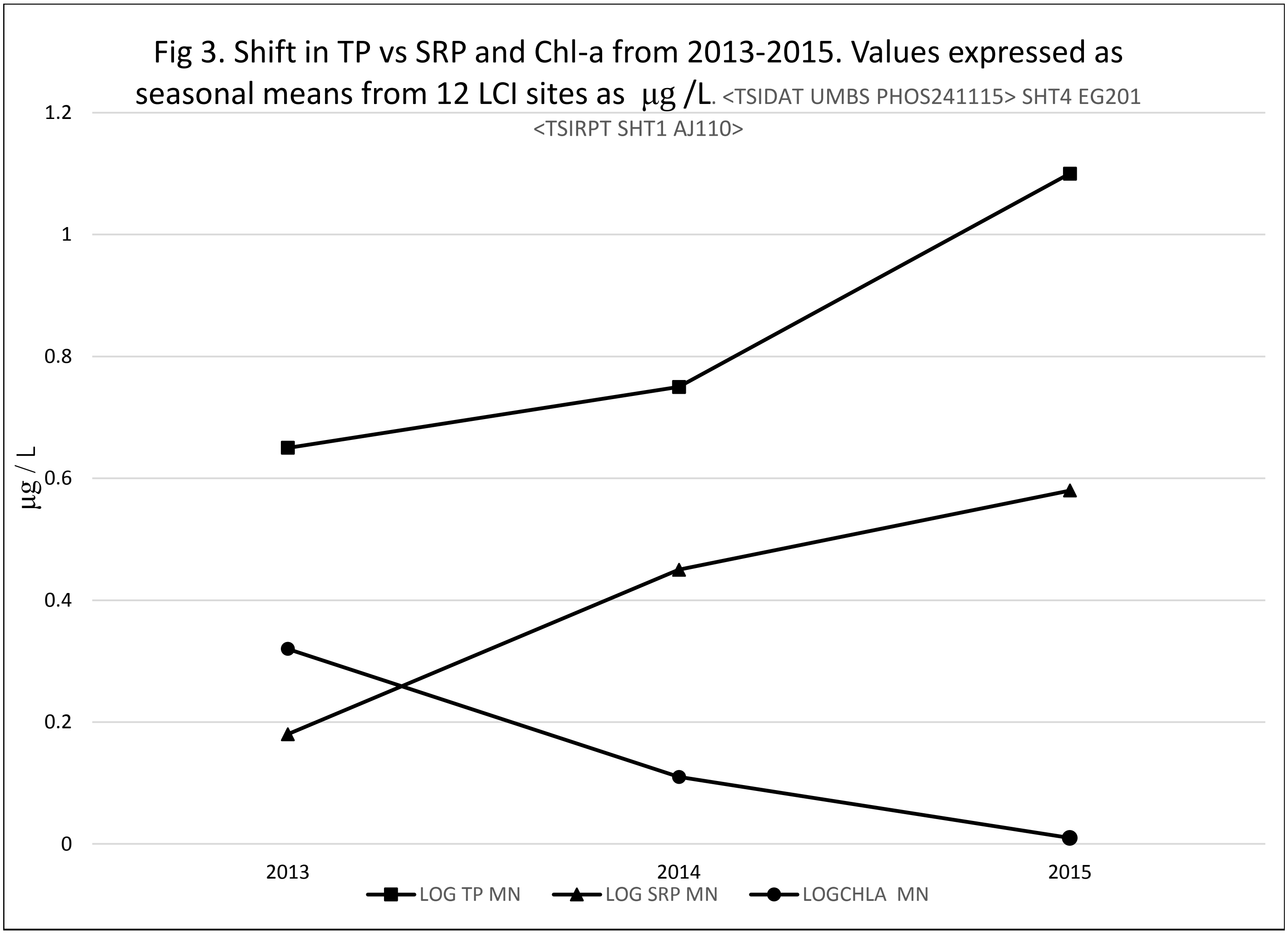


Fig 3. Shift in TP vs SRP and Chl-a from 2013-2015. Values expressed as seasonal means from 12 LCI sites as µg /L. <TSIDAT UMBS PHOS241115> SHT4 EG201 <TSIRPT SHT1 AJ110>

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Fig. 4. Relation of SRP and Chl-a during a three year period based on seasonal mean values. Values expressed as µg/L.
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