Three Perceptions of St. Mary Lake Challenged by SSIWPA Studies

A Synopsis of 2014-15 In-lake Studies at St. Mary Lake and Implications for Interpretation of the Long-term Phosphorus Record

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Synopsis of 2014-15 Studies

What was done The 2014-15 in-lake study was designed to compare the relative magnitude of nutrient loading from the watershed (external) versus nutrient loading from lake sediments (internal). To assess the relative effect on lake nutrient and algal biomass levels of external versus internal loading, the amount of phosphorous (P), nitrogen (N), and iron (Fe) (dissolved and total) in surface and bottom waters, and the amount of algal biomass in surface waters was measured every two weeks across seasons, as follows: 1) during the period of summer stratification; 2) before, during, and after fall overturn; 3) during the period of winter rain; and, 4) during spring pre-stratification period. In addition, potential for biomanipulation (or restructuring) of the lake food web to lower algal biomass was assessed based on sampling in 2014-15 of phytoplankton and zooplankton abundance and biomass, and analysis of past gillnet and fish stomach contents data (Squires 2015).

Results and what was learned In 2014-15, across seasons both dissolved phosphorus (DP) and algal biomass were at minimum levels during the summer, increased modestly at fall overturn, and increased sharply with the onset of winter rains (see Squires 2015).

The pattern of change in water column nutrient levels before, during and after overturn suggests modest internal P loading controlled by iron, as follows: release of P from sediment iron complexes during anoxia followed by re-complexation and settling of P with Fe when bottom waters are re-oxygenated during and after overturn.

Following onset of winter rains and initiation of runoff in late 2014/early 2015 was a period of relatively high P and algal biomass levels in the lake. The sharp rise in lake water P was not accompanied by a corresponding rise in N level and, as a result, the biomass of N-fixing cyanobacteria increased.

The results suggest the following: 1) during the summer period of stratification, draw-down of available P in surface waters and in turn P-limitation of algal growth results in nutrient and algal biomass levels that correspond with oligotrophy (low nutrient status); 2) during the winter rainy season, relatively plentiful P results in relatively high level of algal biomass, possible N (and light) limitation of algal growth, and P and algal biomass levels that correspond with mesotrophy (moderate nutrient enrichment); and, 3) external P loading related to runoff from the watershed (plus any P loading via direct precipitation) greater than internal P loading from lake sediments to surface waters. Results of the assessment of the potential for biomanipulation to reduce algal biomass in St. Mary Lake (Squires 2015) suggest food web manipulation may not reduce the biomass of algae and cyanobacteria in the lake. In addition, the biomanipulation assessment suggests the littoral (shallow water) zone, which is colonized by macrophytes and benthic algae, provides habitat for a variety of benthic organisms (e.g. insect larvae, freshwater clams and shrimp) that are important to fish (see Squires 2015).

Implications for Interpretation of the Long-term Phosphorus Record

The results of the 2014-15 study challenge several common perceptions about St. Mary Lake, as follows: 1) the lake is eutrophic and getting worse; 2) cyanobacteria are bad because they produce toxins, and aquatic plants are nuisance weeds; and, 3) internal loading is more than external loading.

Although St. Mary has occasionally experienced increases in P levels, i.e. 1980-81, 2005-06, and during 2012-13, the long-term P record (1979-2015, some data gaps) does not suggest overall increase over time in P levels.

While it is true that some cyanobacteria can and do produce toxins, the cyanobacteria in St. Mary Lake also fix atmospheric N when N availability is low relative to P availability. In short, blooms of N-fixing cyanobacteria may occur more frequently than blooms of toxic cyanobacteria (some species do both). Never the less, the potential for cyanotoxins to harm to humans and wildlife warrants testing for toxins whenever cyanobacteria with potential to produce them are present.

The results of the 2014-15 in-lake study challenge a long-held 'belief' that internal P loading is much greater than external loading. In short, due to strong control by iron of net P-release from sediments, external P inputs from the watershed & direct rainfall may be greater than internal P inputs. This result raises questions related to the use of artificial aeration as a remediation strategy to improve water quality (i.e. lower algal biomass) via decreases in internal P loading. Specifically, if internal P loading is not larger than external P loading due to full-circle 'P-release at anoxia and re-sequester of P at overturn', then little or no change in overall lake P loading and in turn improvement in water quality might be expected as a result of aeration of bottom waters to prevent anoxia. Moreover, several lines of evidence (precipitation, observations of extreme runoff, landslide occurrence) can link years with peak P levels (1980-81 & 2005-06) with years of extreme runoff. Further, peak P levels in 2012-13 can be explained by sediment disturbance brought about by artificial aeration. Evidence of sediment disturbance due to aeration includes decrease in water clarity (2009-2013), hydrogen sulphide gas emissions in the vicinity of the aerators (2012-2013), and overall increase in bottom water oxygen demand. Plentiful sulphide and in turn formation of iron-sulphide compounds that are known to reduce the iron-binding capacity of sediment can potentially explain the 2012-13 peak P level.

Conclusions The results of the 2014-15 In-lake Study suggest the following: 1) St. Mary continues to be mesoeutrophic; 2) cyanobacteria can be beneficial by fixing N; and, 3) external P loading may be greater than internal P loading. From the review of trophic level interactions in St. Mary Lake by Squires (2015), a fourth suggestion is as follows: 4) the littoral zone (where growth of macrophytes and benthic algae is highly visible) may support a suite of benthic organisms important to fish diets. The results of the 2014-15 in-lake study have implications for the selection of remediation strategies aimed at lowering P inputs to the St. Mary Lake.

Selected Reading List on the role of iron and sulphide in the P-binding capacity of sediment:

Gunnars, A. et al. 2002. Formation of Fe (III) and oxyhydroxide in freshwater and brackish seawater, with incorporation of phosphate and calcium. Geochim Cosmochim Atca 66: 745-758.

Caraco, N.F. et al. 1989. Evidence for sulphate-controlled phosphorus release from sediments of aquatic systems. Nature 341:316-318.

Hoffman, A.R. et al. 2013. Influence of phosphorus scavenging by iron in contrasting dimictic lakes. Can J Fish Aquat Sci 70:941-952.

Complete Reference List available by request.