SPANAWAY LAKE SEDIMENT PHOSPHORUS STUDY

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Abstract

Spanaway Lake, Washington, has a history of recreational closures due to cyanobacteria blooms triggered by excess phosphorus loading. We measured internal phosphorus loading rates to better assess their contribution to lake phosphorus concentrations. Thirty microcosms were created with lake surface sediment and water and incubated in the dark at 13°C, mimicking the summer sediment-water interface. After confirming hypoxia/anoxia in the microcosms using internal oxygen sensors, 3 unopened microcosms were sampled for soluble reactive phosphorus (SRP), total phosphorus (TP), and total Mn/Fe every other day for 14 days. We estimated a flux rate of 1.29 ± 0.70 mg P m-2 dy-1 using SRP, which is consistent with our other flux estimate (1.2 mg P m-2 dy-1) using the change in hypolimnetic TP concentrations reported by Herrera Environmental Consultants. Average unfiltered TP, Mn, and Fe in the anoxic mesocosm water (0.37 ± 0.13 mg P L-1, 0.47 ± 0.08 mg Mn L-1, and 3.64 ± 1.24 mg Fe L-1) stayed relatively constant for the duration of the experiment likely due to a non-settling solid in the microcosms, possibly a form of extracellular polymeric substances. Our directly measured internal phosphorus loading rate (1.29 mg P m-2 dy-1) was significantly lower than the previous estimate (7.5 mg P m-2 dy-1) which was based solely on sediment phosphorus concentrations. Our results shift prioritization of remedial actions to include other external sources. Microcosms provide a direct way to estimate internal phosphorus loading creating more accurate lake management models.

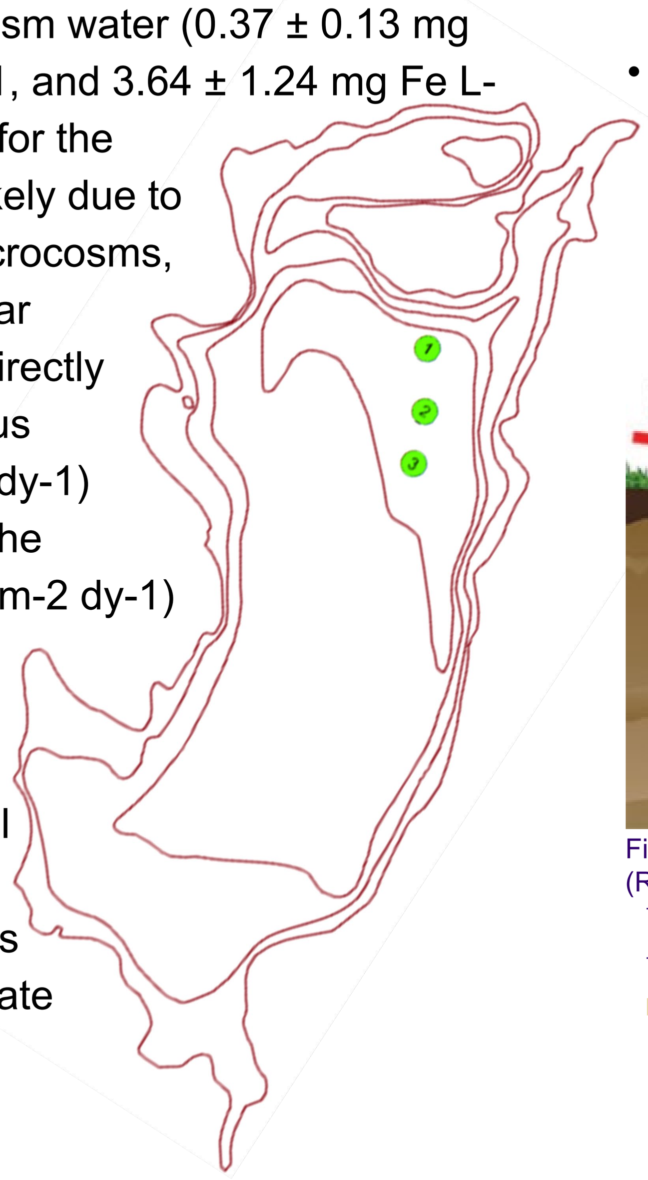
Figure 1 : Topographic map of Spanaway lake and site locations

Figure 2 : Image of Spanaway Lake

Background

- Microcystin level exceeding the WA Department of Health's guideline of 6 µg/L for the past 12 years.
- Pierce County has issued health advisories and has imposed lake closures every year for the past 12 years.
- 2006-2016 Spanaway Lake [Fig 1,2,3] was under health advisory due to toxic algae blooms on average 179 days/year (Annear et al. 2016 Dec 1)

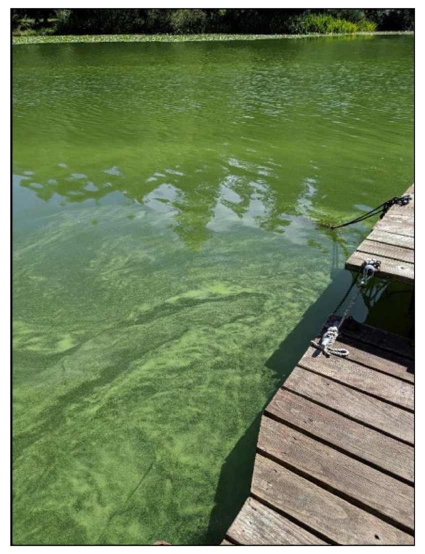
Figure 3 : Dense algae growth (Hobbs)

- Phosphorus is likely the main cause of the toxic algae blooms.
- Cyanobacteria blooms are typically the densest in mid to late summer
- Due to the long history of toxic algae blooms in Spanaway Lake, University of Washington Tacoma was hired to conduct physical testing to better estimate internal phosphorus loading rates [Fig 4].

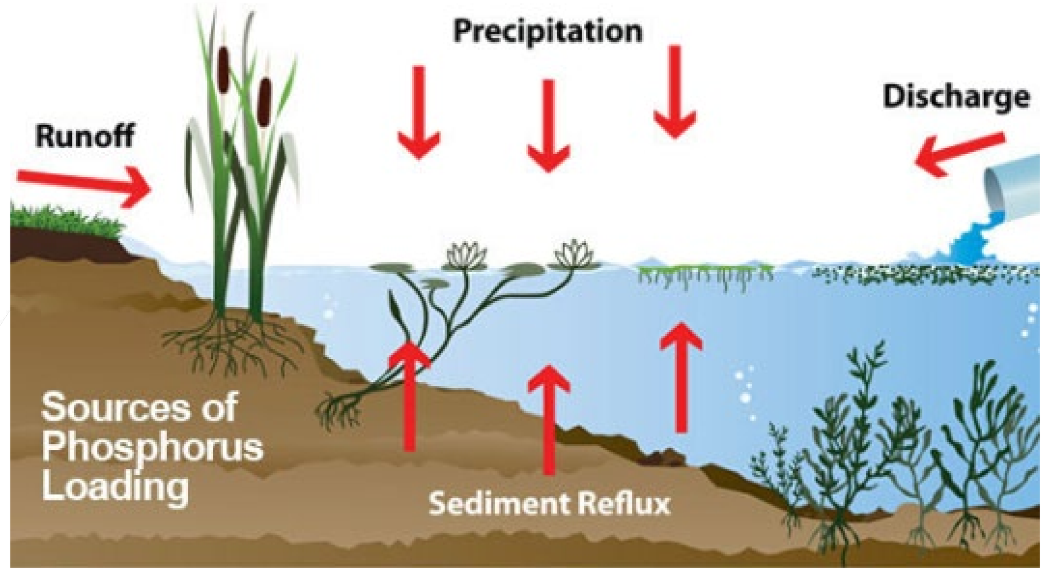

Figure 4: Phosphorus loading source diagram
(Reduce Phosphorus Pollution in Lakes and Ponds with Phoslock)

Methods

- 3 sediment samples from the lake using a dredge below the thermocline (6.5 m) [Fig 1,6]
- Surface water collected using 1 liter acid-washed bottles


Figure 5: Filtered water sample

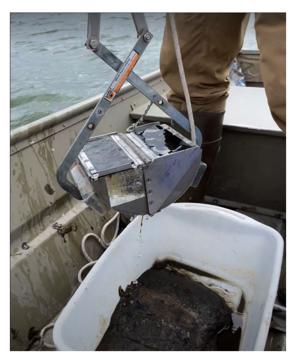
Figure 6: Small dredge (Van Veen)

- 30 microcosms in 1 L glass bottles [Fig 7,8,12]; dissolved oxygen sensor dots glued inside (PyroScience)

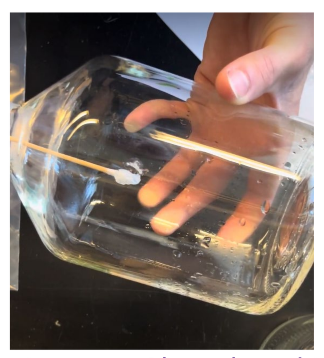
Figure 7: Glue placed inside bottle with q-tip

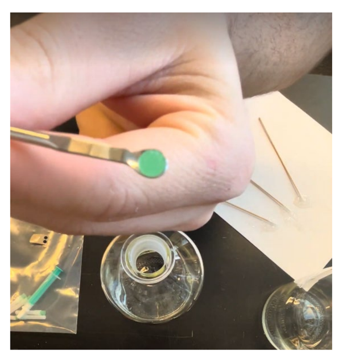
Figure 8: pyroscience oxygen sensor

- ~350 mL of sediment and topped off with lake water [Fig 9,10]
- temperature-controlled chamber set to 13 °C (approximate temperature of the bottom of the lake during the summer)

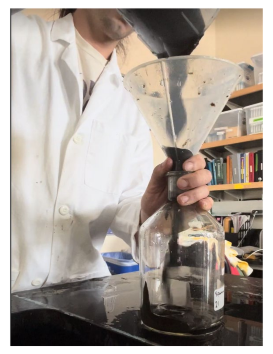
Figure 9: Lake Sediment

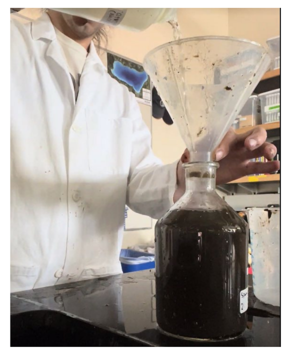
Figure 10: Rinsing funnel with lake water

- Once hypoxic/anoxic, three random microcosms were sampled every other day for 14 days [Fig 11]
- Filtered water (0.4 µm) for dissolved phosphorus [Fig 5]
- The samples were transported to AmTest for analysis of TP, SRP, and total Mn and Fe


Figure 11: Finished microcosms after resting

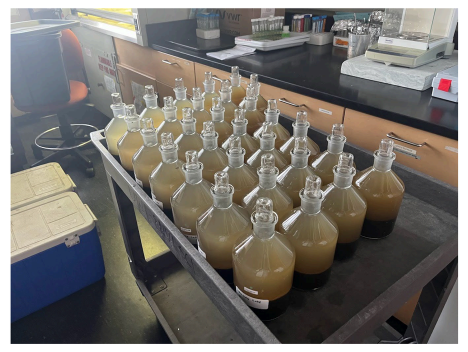
Figure 12: all microcosms before resting

$$W_{int} = \left(2.41\frac{mg}{m^2 * day}\right)\left(123\frac{days}{yr}\right)(625{,}900m^2)\left(\frac{1kg}{10^6mg}\right) = 184.77\frac{kg}{yr}$$

Results

- Mean flux rate 1.29 ± 0.70 mg SRP-P m^{-2} dy^{-1} [Fig 13].
- Mean flux rate 2.41 ± 1.24 mg TP-P m^{-2} dy^{-1}.
- Average total Mn 0.47 ± 0.08 mg L
- Average total Fe 3.64 ± 1.24 mg L
- Mn and Fe concentrations did not change significantly over the duration of the experiment.

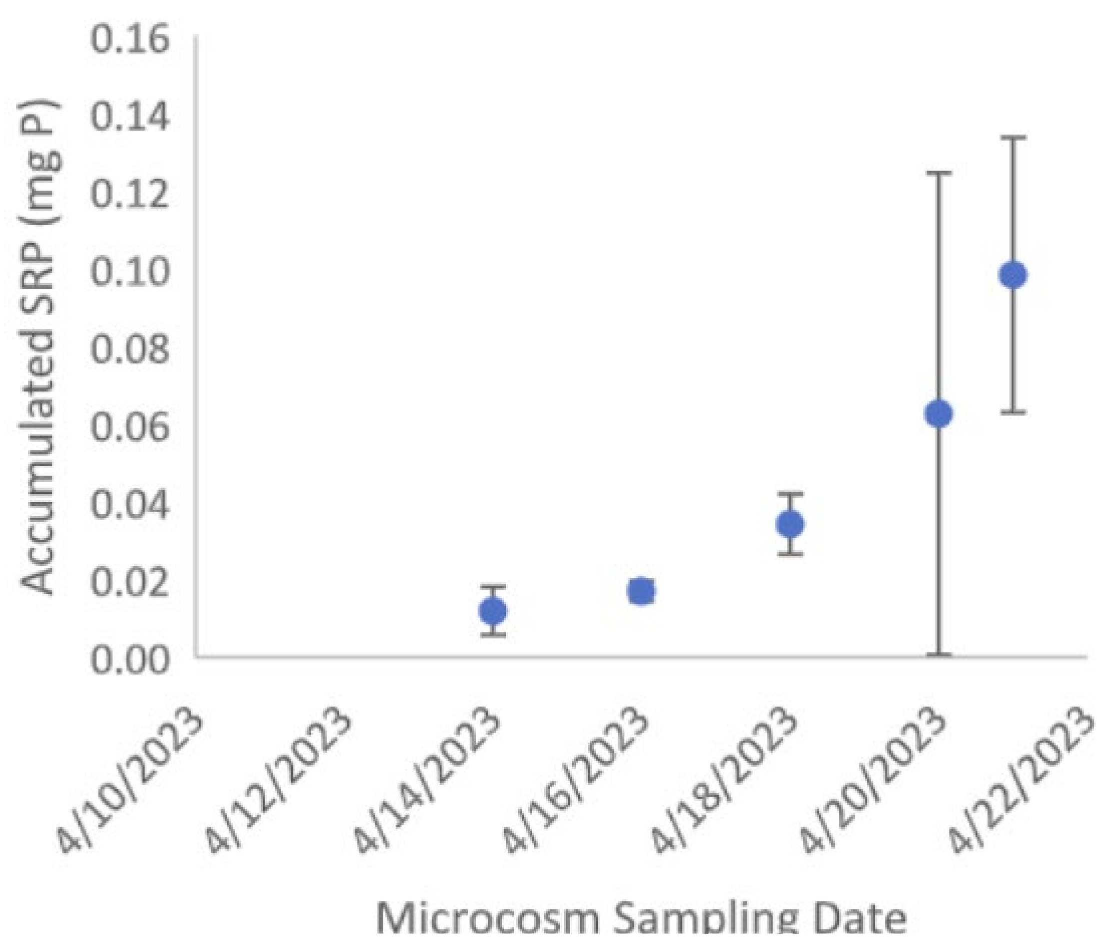

Figure 13: Graph depicting accumulate SRP (y-axis), by date (x-axis)

Discussion

- TP flux should be considered a rough estimate as the samples were confounded by unsettleable material and the lack of more data between the two dates used for calculation.
- SRP flux is conservative estimate of internal loading rate and based on triplicate samples over multiple days.
- The Nurnberg equation was used to estimate the previous result for internal phosphorus loading rates [Fig 14].
- New result from direct sediment testing shows that the majority source is NOT internal as previously thought [Fig 15].
- Our results show that phosphorus sources are not from one major source but instead evenly spread across external and internal sources. This creates a harder situation for management as now there is not a predominant source.
- To address the management methods entails
  - Source control up stream
  - Improve septic systems around lake
  - Prevention of phosphorus loading from sediments (Agstam-Norlin et al. 2020)

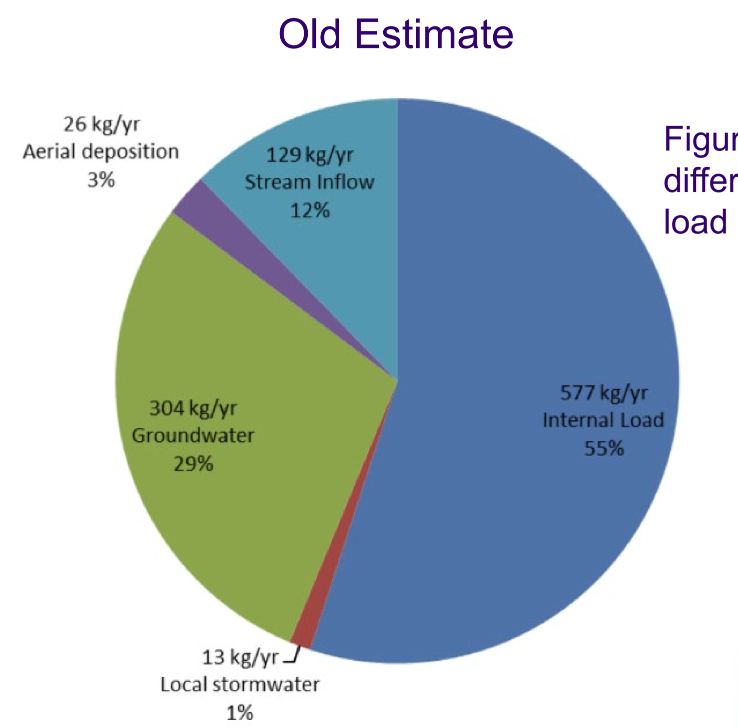

Figure 14: Ratios of phosphorus loading from different source based off old estimate of Internal load (Annear et al. 2016 Dec 1)

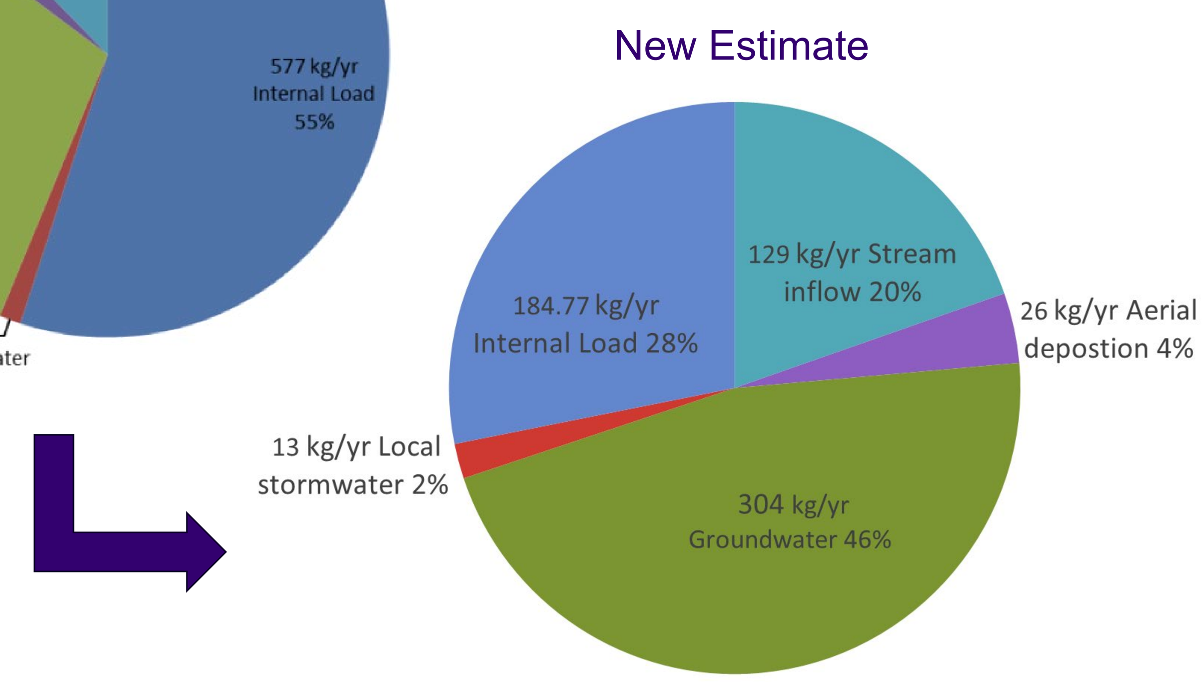

Figure 15: Ratios of phosphorus loading from different source based off new estimate of Internal load

References