Satellite Analysis of Toxic Algae Blooms in Washington State

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Introduction

- Lakes provide recreational and communal areas for outside enrichment
- Reservoir systems are a source of water for many
- Harmful Algae Blooms are frequent in the PNW, and as of 5/31/2024 there are two lakes with toxic algae above safety guidelines, Anderson Lake and Keogh Lake (Krygier, 2012).
- Cyanotoxins are lethal to humans and canines in significant doses due to liver and neurotoxic effects (Zheng, 2012)
- In order to sense harmful plankton blooms in lakes to avert this danger, we need to be able to detect them.
- Both algae and cyanobacteria contain chlorophyll, but phycocyanin is distinct to cyanobacteria (Chorus et al., 2021).
- Our research aims to establish a remote method for predicting the likelihood of cyanotoxin-producing blooms by correlating field measurements of chlorophyll and phycocyanin with spectral data collected by the Sentinel 2 satellite (Wynne et al., 2008).
- We are examining lakes in Washington State 30-100 acres in size, which is a new application for remote sensing data (Stumpf et al., 2016).
- We hypothesize that medium-sized lakes with regular occurrences of cyanobacteria blooms detected by resource-intensive in-person methods will also show a proportional spectral signature in satellite data, thus creating a faster, inexpensive way to monitor for harmful algae blooms.
- These results will be used in an effort to monitor algae blooms more efficiently in order to communicate health risk to lake users to ensure the safety of the many people and animals that use these lakes recreationally throughout the year.

Methods

- Sentinel-2 satellite collected data on each lake in wavelengths of 442.7 to 2202.4 nm for the purposes of isolating and identifying chlorophyll and phycocyanin
- Data then downloaded and extracted into visual maps of chlorophyll and phycocyanin 'hot spots'
- Comparisons made with data given from Snohomish County (Figure 7) volunteer data collection
- Ground-truthing to take place this summer to collect water samples from eight sites in Pierce County (Figure 8) over the course of twelve non-consecutive days, synchronized with Sentinel-2 satellite flyover data collection to verify validity of satellite data collection

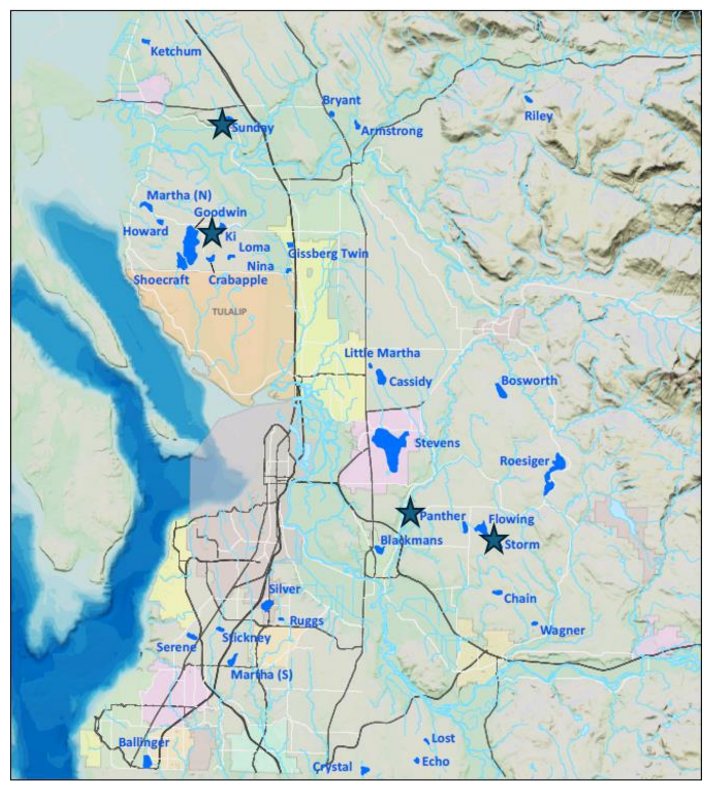

Fig 7: A map detailing the studied lakes of Snohomish County (www.snohomishcountywa.gov)

Results

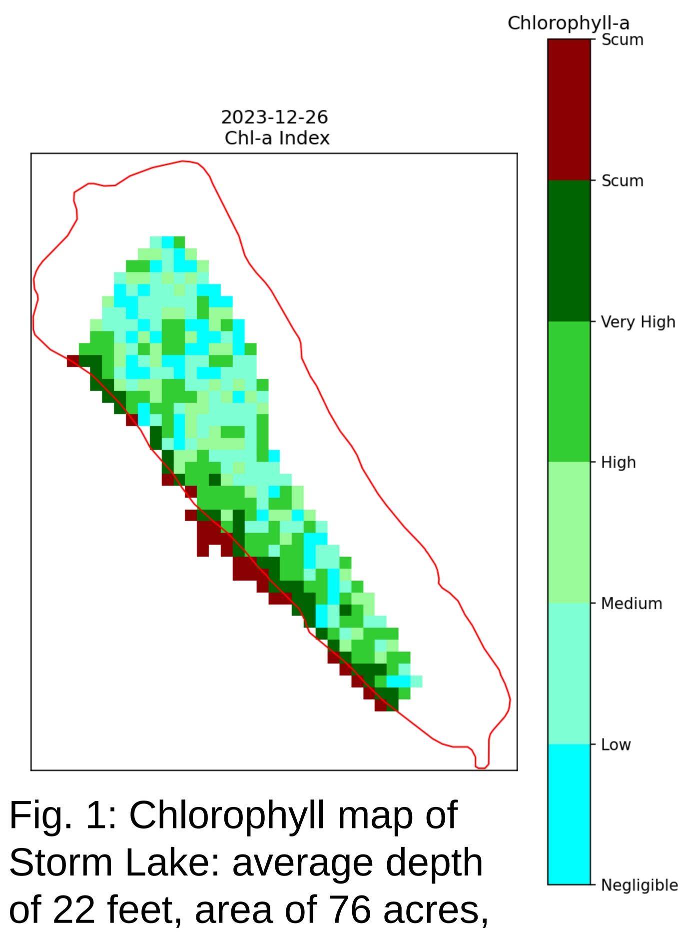

Fig. 1: Chlorophyll map of Storm Lake: average depth of 22 feet, area of 76 acres, mild history of harmful algal blooms. Notably dense foliage along the western shore.

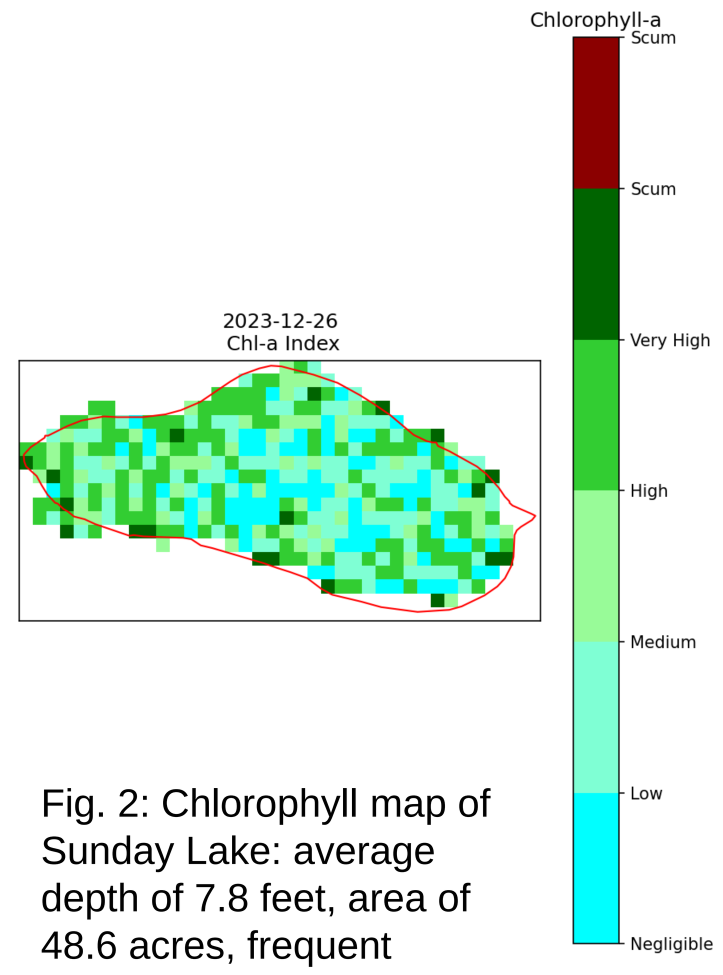

Fig. 2: Chlorophyll map of Sunday Lake: average depth of 7.8 feet, area of 48.6 acres, frequent history of harmful algal blooms.

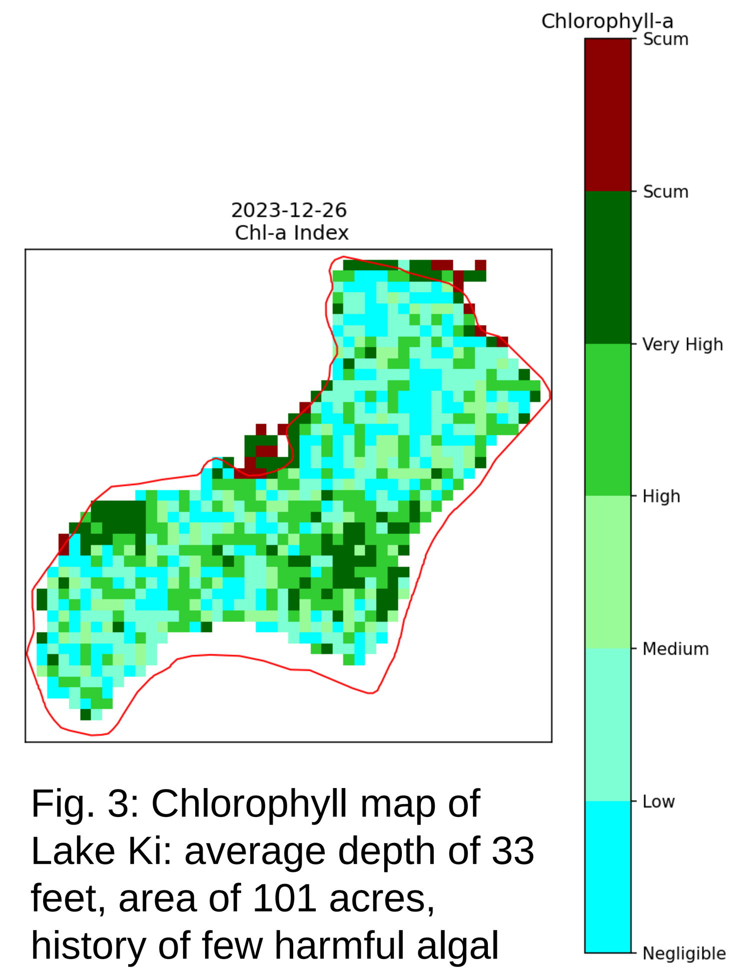

Fig. 3: Chlorophyll map of Lake Ki: average depth of 33 feet, area of 101 acres, history of few harmful algal blooms.

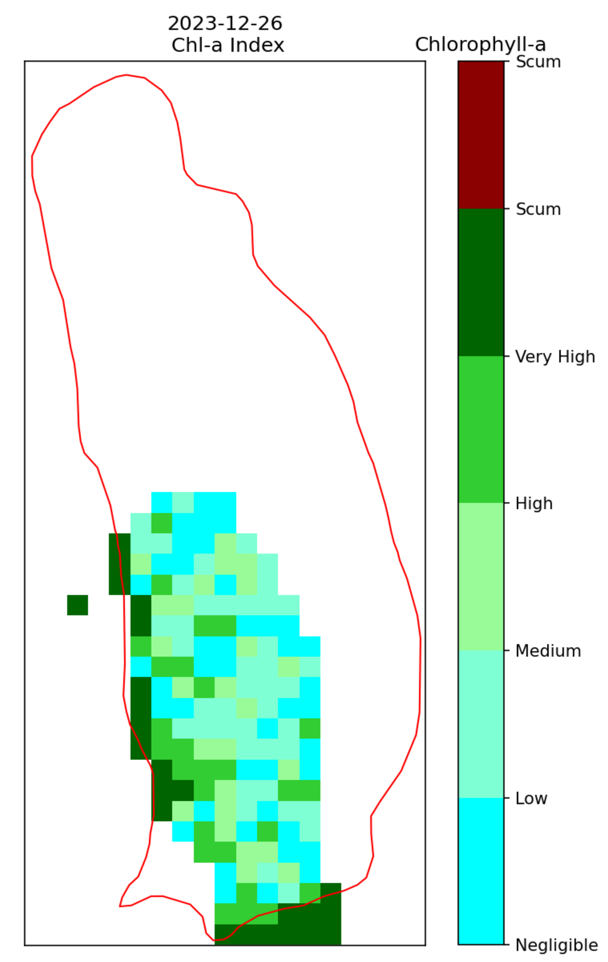

Fig. 4: Chlorophyll map of Panther Lake: Average depth of 23 feet, area of 49 acres, moderate history of harmful algal blooms

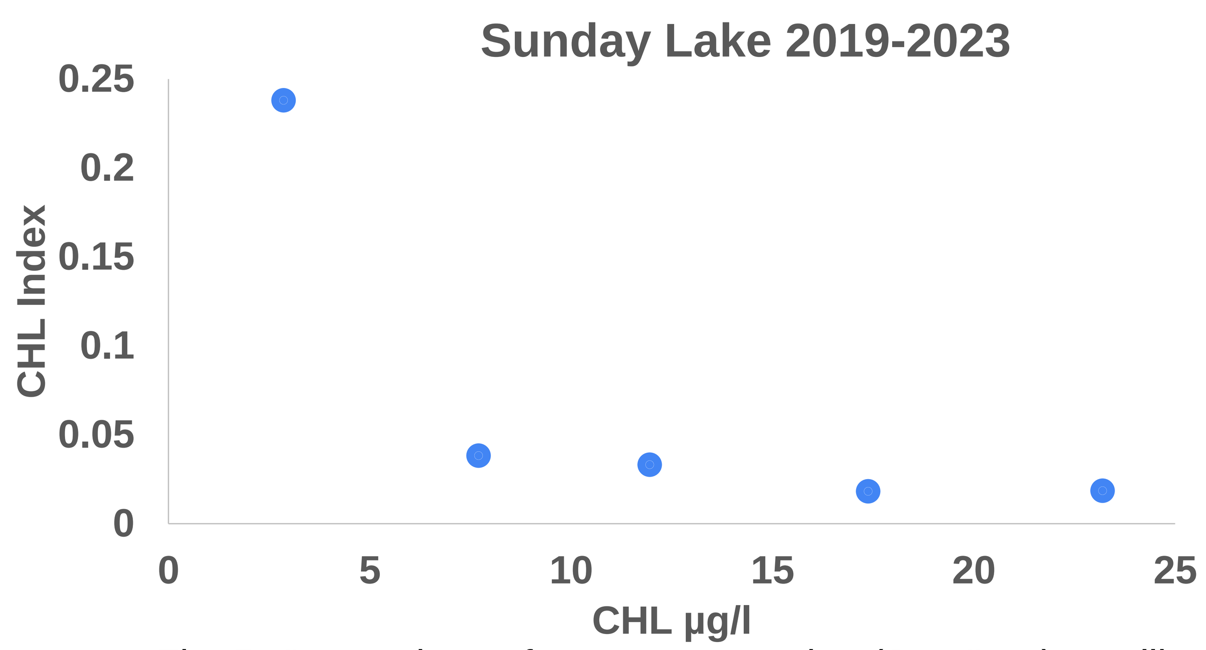

Fig. 5: Comparison of mean summertime(Jun-Sept) satellite chlorophyll index against the volunteer data in µg/l for Sunday Lake over the course of 2019-2023.

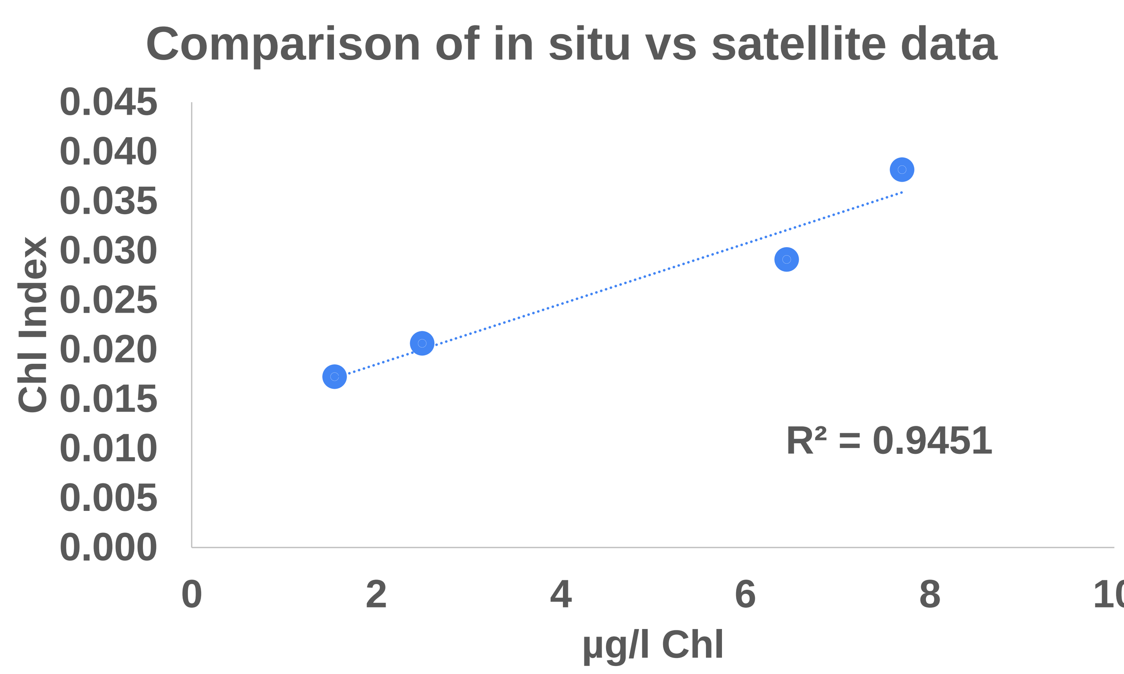

Fig. 6: Comparison of mean summertime(Jun-Sept) satellite chlorophyll index vs volunteer collected data for Sunday Lake, Lake Ki, Panther Lake, and Storm Lake in 2023.

Discussion

- Satellite imagery appears to be effective in the detection of chlorophyll in all lakes (Figs. 1-4)
- Possible problems in chlorophyll detection due to shoreline foliage: It is possible that the satellite is taking pictures of the foliage hanging over the lakes and interpreting the chlorophyll as algal chlorophyll (Fig. 1 & 3)
- The correlation between mean summertime chlorophyll measured by volunteers and the satellite in Sunday Lake across years is poor (Fig. 5)
- There is strong correlation between mean summertime chlorophyll measured by volunteers and the satellite across lakes in 2023 (Fig. 6)
- Satellite data collection does not currently match up with in situ collection times or days
- Ground-truthing to take place this summer: Water samples will be taken at eight lakes in Pierce County (Fig. 8) over the course of twelve days, selected in order to match up with period of time that the Sentinel-2 satellite will be passing over the lakes, eliminating this source of error.

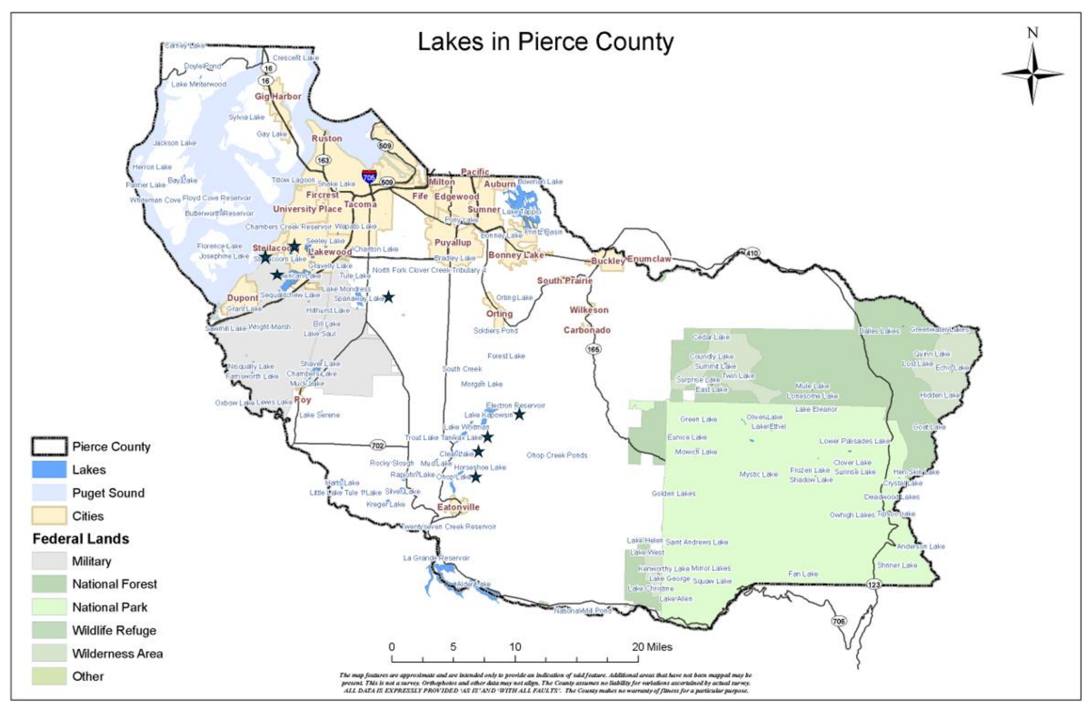

Fig. 8: Map of Pierce County lakes to be sampled this summer: American Lake, Waughop Lake, Steilacoom Lake, Spanaway Lake, Lake Kapowsin, Lake Ohop, Clear Lake, and Lake Tanwax. (https://www.piercecountywa.gov/7068/Lakes)

Acknowledgements

- Thanks to Jim Gawel, Emese Hadnagy, and Gopal Mulukutla for their knowledge and guidance throughout this project.
- Special thanks to Violette Lafferty for providing emotional and intellectual support throughout this project.

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