Predicting Algae Blooms by Remote Sensing and Comparing to *In Situ* Measurements in Washington Lakes

Violette Lafferty[a], Josh Heinlen[a], Emese Hadnagy[b], Gopal Mulukutla[c], Jim Gawel[a]
UWT Environmental Science[a]; UWT Civil Engineering[b]; Pierce County Water Quality[c]

Abstract

Efficiently monitoring harmful algal blooms in lakes is essential for the safety of recreational users. Harmful algae blooms (HABs) are indicated by high concentrations of phycocyanin, the photosynthetic pigment of cyanobacteria. Cyanobacteria produce cyanotoxins which can be deadly to humans and animals at high concentrations. To monitor these blooms in a cost-effective, timely manner, a remote method is needed that will allow public health agencies to predict algae blooms without a physical visit to the lakes. We are testing the use of remote sensing data, consisting of multispectral imagery from the Sentinel-2 satellite, to estimate temperature, chlorophyll-a, turbidity, and phycocyanin levels in Washington lakes over 30 acres in size. We are currently comparing satellite data from Snohomish County lakes with *in situ* chlorophyll and phycocyanin measurements to look for correlation between the two data sources. These results will ultimately be used to create an index based on satellite data to estimate HABs more efficiently, which can be used by the WA Department of Health to communicate health risks to ensure the safety of lake users.

Introduction

- HABs caused by cyanobacteria are a threat to global water resources and human health (Figure 7, Handler et al. 2023).
- Cyanotoxins are among the most toxic naturally occurring compounds (Chorus and Bartram 1999).
- Remote sensing has the potential to augment *in situ* visual inspection while increasing the spatial scale of coverage (King et al. 2022).
- The purpose of this study is to create an index based off satellite data to estimate HABs more efficiently in Washington; this allows us the ability to get water quality measurements without a trip to the field.
- Creating a satellite-based water quality index will allow timely public health advisories to keep humans and animals safe during HABs.
- More comprehensive water quality data available through remote sensing can be used to predict potential HABs and allow public health agencies to be proactive.

Methods

REMOTE SENSING

Remote Sensing Data Source: European Space Agency, Sentinel-2 L2A, processed from the multispectral instrument aboard the satellite

Extraction: We used algorithms shortlisted by the US Army Corps of Engineers (Johansen et al. 2020) to extract water quality indices for chlorophyll-a and phycocyanin

Calibration: Mean summertime (Jun-Sept) *in situ* chlorophyll-a in Snohomish County lakes (Figure 4; pulled from SnoCo Water Quality Data Portal) was compared to mean summertime satellite chlorophyll-a index to initially calibrate satellite data.

GROUND TRUTHING

Field Data collection: This summer we will collect *in situ* data from selected Pierce County lakes (Figure 2) on the same days the satellite passes.

- Must be cloud free, smoke free days.
- Will measure chlorophyl-a. phycocyanin, turbidity, temperature with calibrated probes and will compare to satellite data

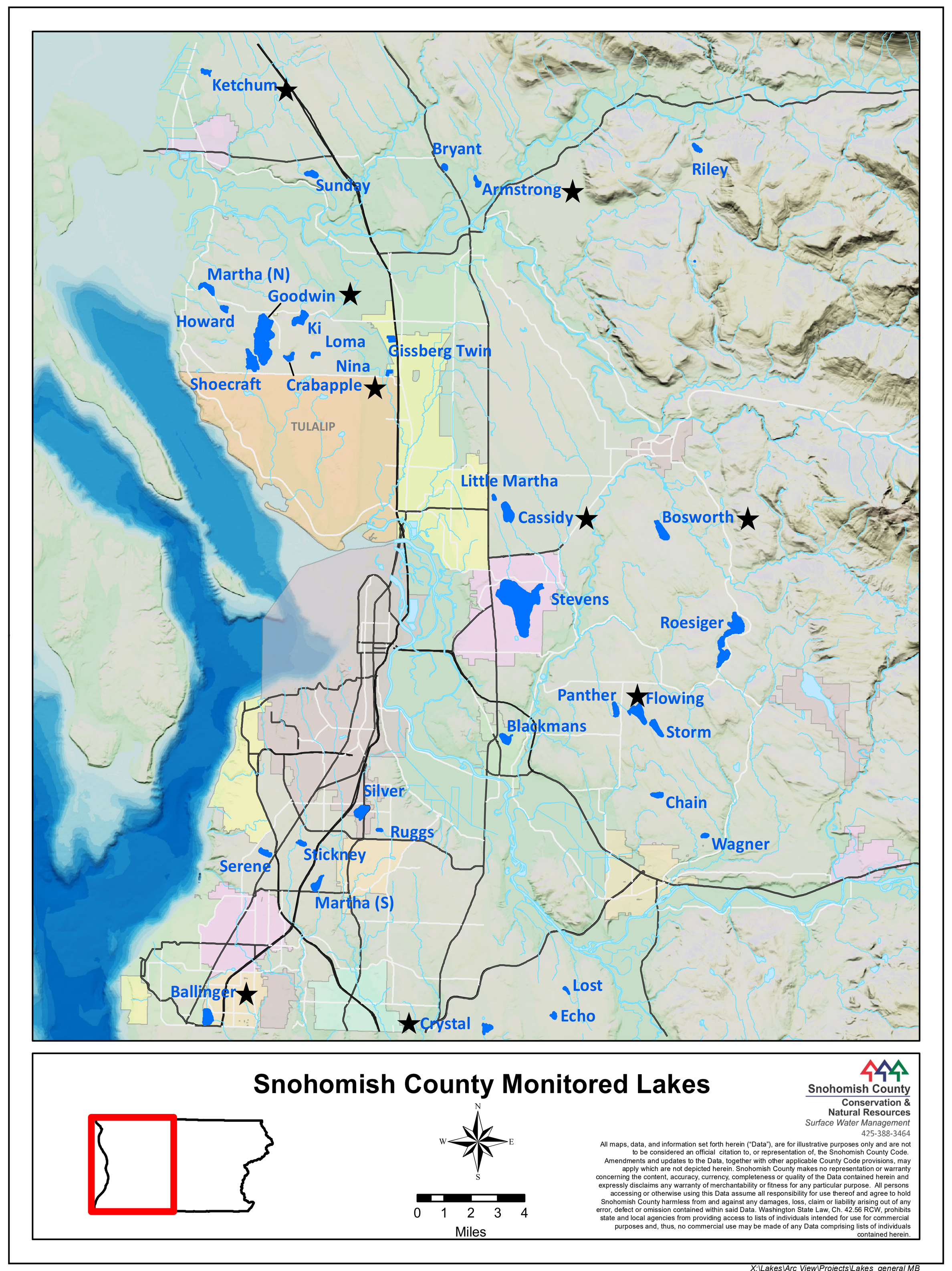

Figure 1: Map of Snohomish County lakes. Stars indicate lakes graphed in result section. (Snohomish County Monitored Lakes, 2024)

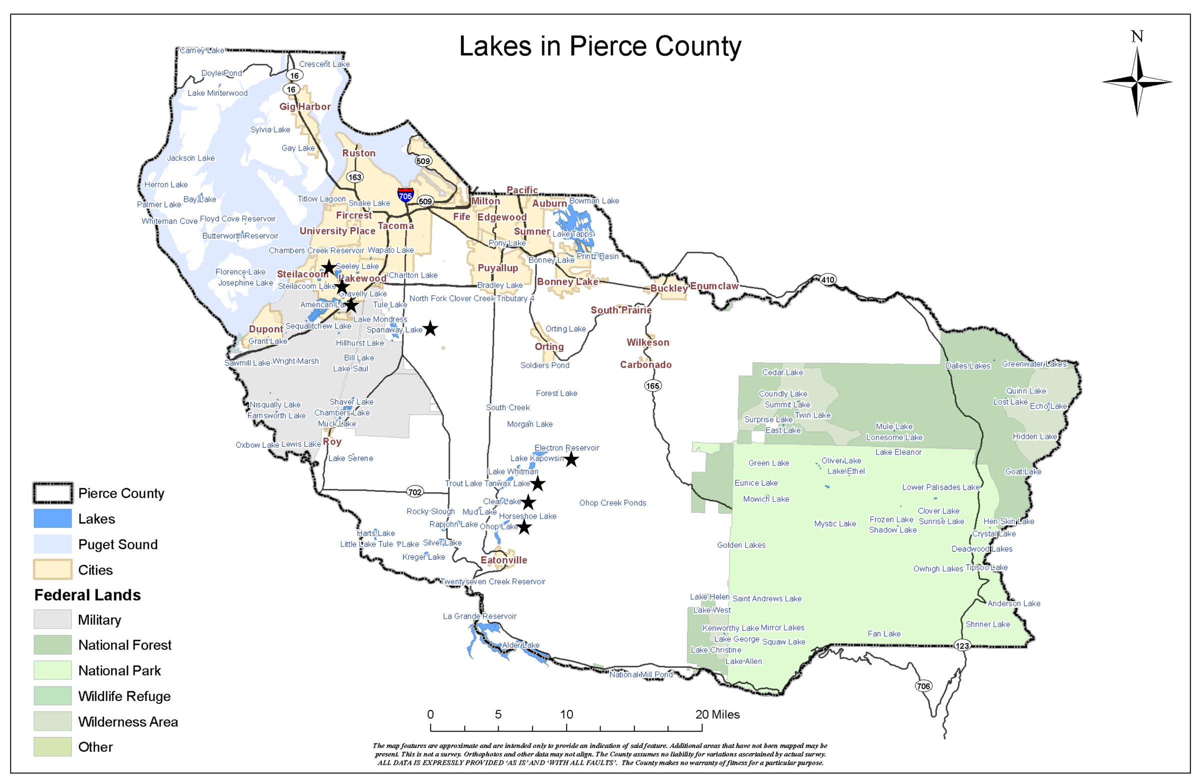

Figure 2: Map of Pierce County Lakes. Stars indicate lakes that will be sampled this summer. (Pierce County Monitored Lakes, 2024)

Results

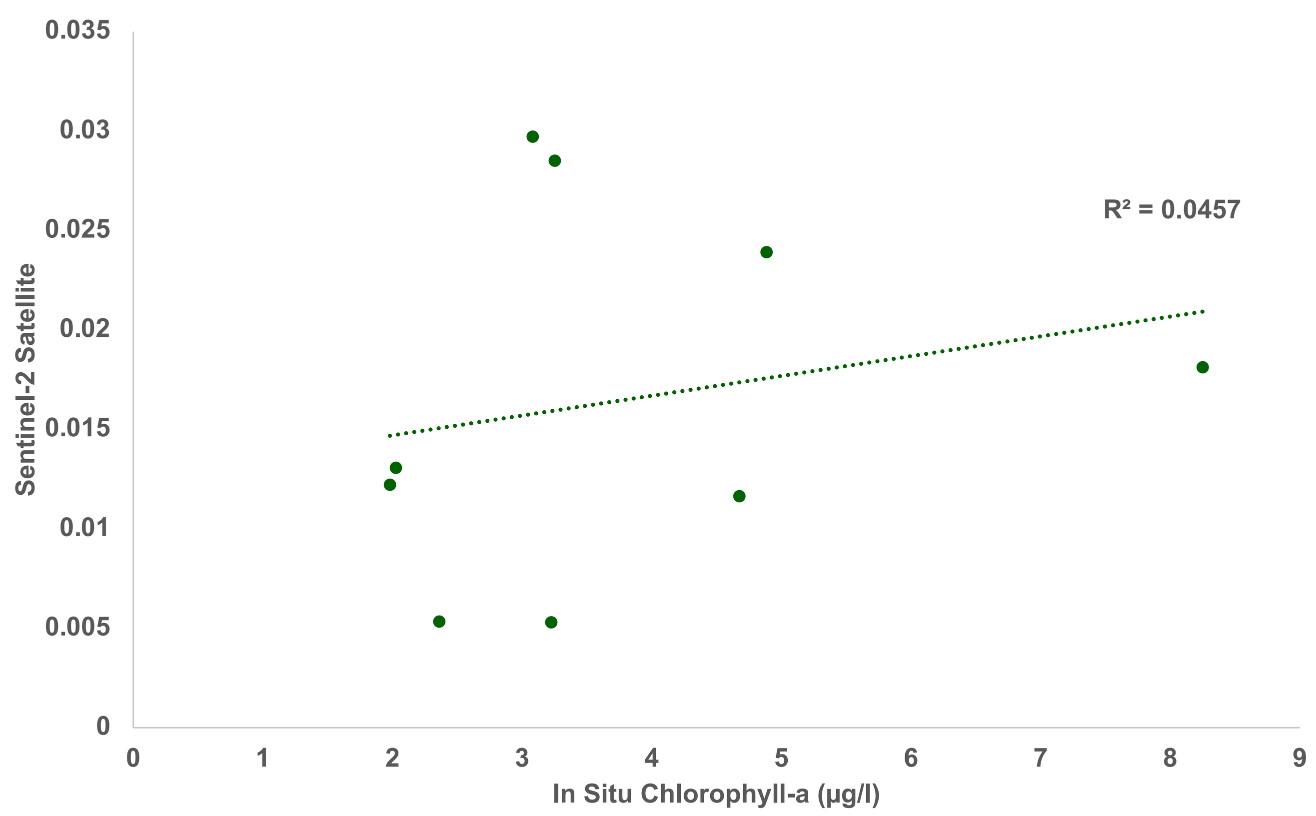

Figure 3: Satellite data vs volunteer-collected chlorophyll-a concentrations (µg/L) in 2023 in 9 lakes in Snohomish County (see starred lakes in Figure 2).

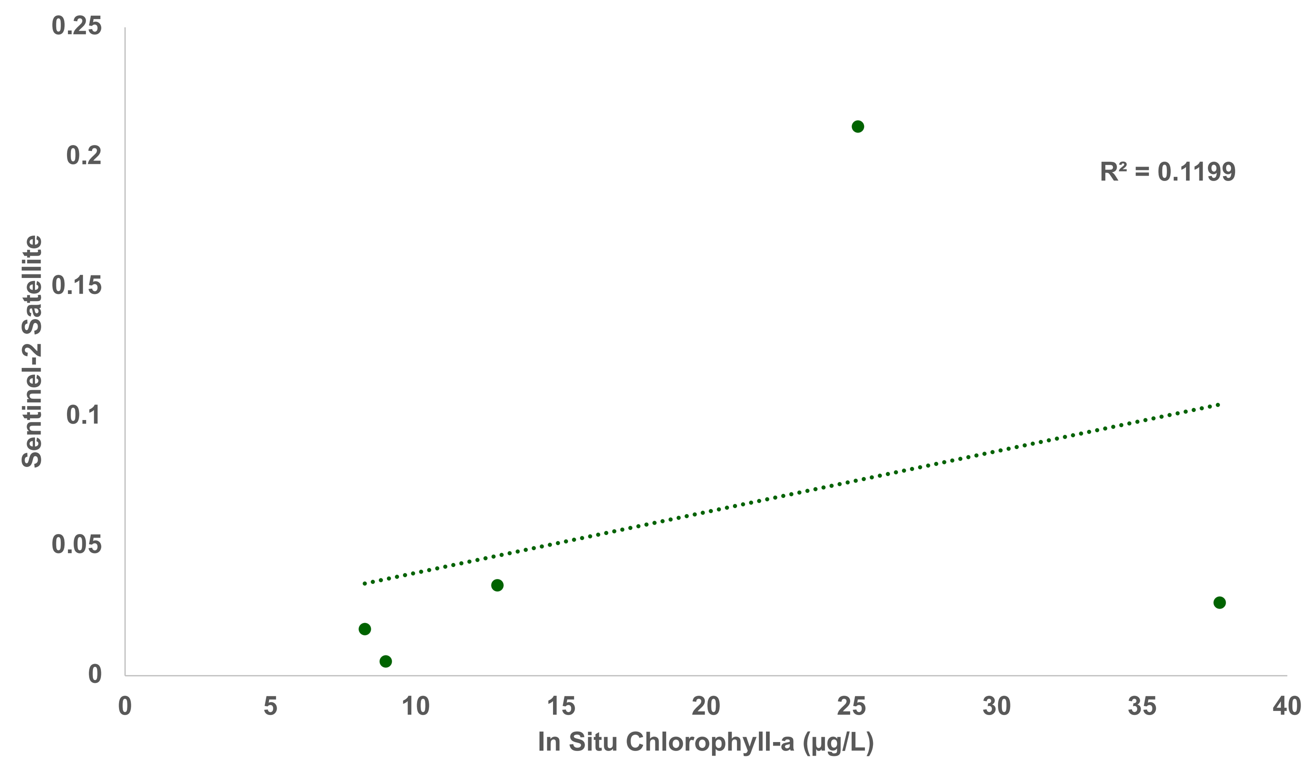

Figure 4: Satellite data vs volunteer-collected chlorophyll-a concentrations (µg/L) for Lake Cassidy in 2019-2023 (see starred lakes in Figure 2)

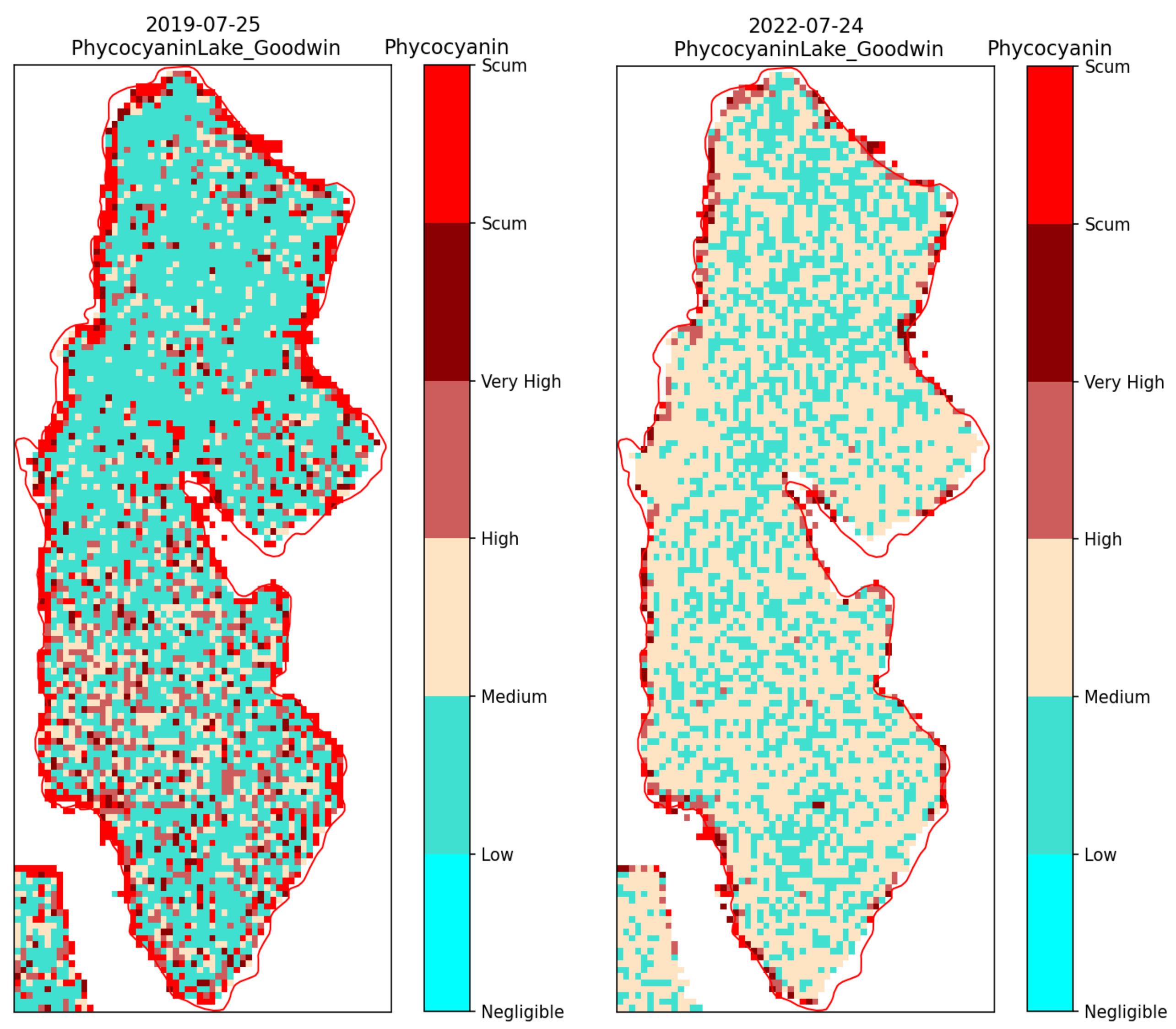

Figure 5: Sentinel-2 phycocyanin index measurements for Lake Goodwin in 2019 and 2022

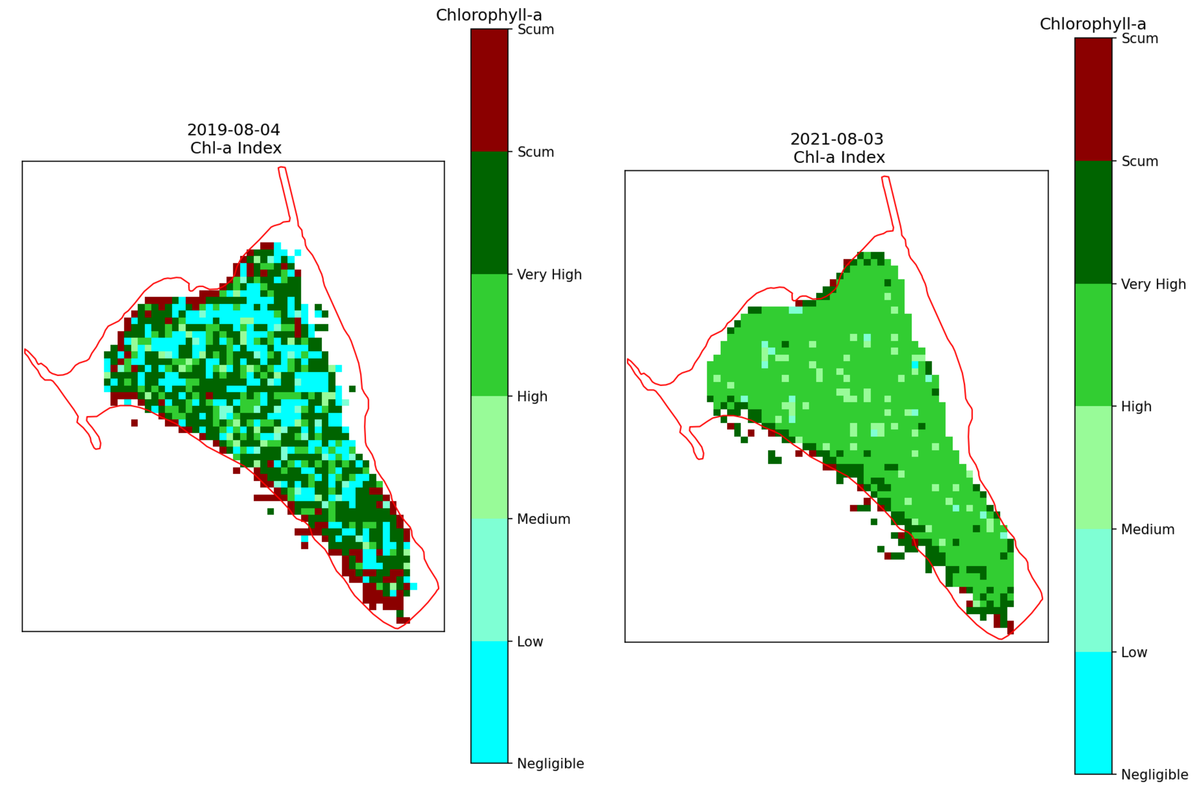

Figure 6: Sentinel-2 L2A Chlorophyll-a imagery for Lake Cassidy in 2019 and 2021

Discussion

- Correlation between mean satellite index data and *in situ* volunteer data is poor (Figure 3 and 4)
- Current volunteer data does not match collection dates from satellite passes.
- Algae blooms are evident in satellite data from different years/months in Lakes Cassidy and Goodwin (Figures 5 and 6).
- There are edge effects from tree canopy (Figures 5 and 6) overhanging the lake, which needs to be corrected for.
- This summer we will be collecting *in situ* data on the day the satellite passes for lakes in Pierce County (Figure 2)
- We will screen historic Sentinel-2 satellite data to compare to historic volunteer data across Snohomish County on matching dates.
- This study will help create an index to be used by the Department of Heath to monitor algae blooms in Washington lakes.

Figure 7: Satellite imagery of algae bloom in lake (NASA, 2024)

References

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