Lake Carmi
Assessing Cyanobacteria Blooms with Satellite Data

Ashton Kirol, University of Vermont

Image processing assistance by Mia Pienkowski

October 6, 2022

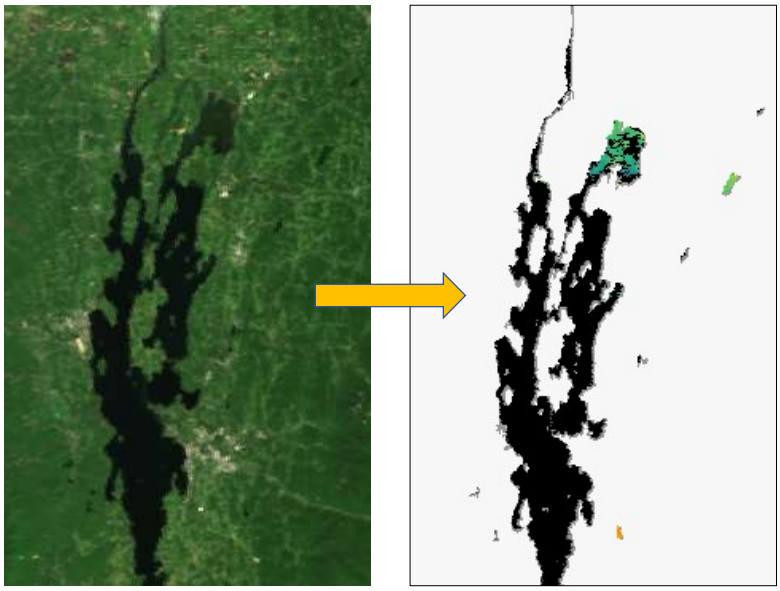
We are using satellite imagery to detect and quantify cyanobacteria blooms in Lake Carmi.

Detecting Cyanobacteria

The National Oceanic and Atmospheric Administration takes daily satellite images of the United States.

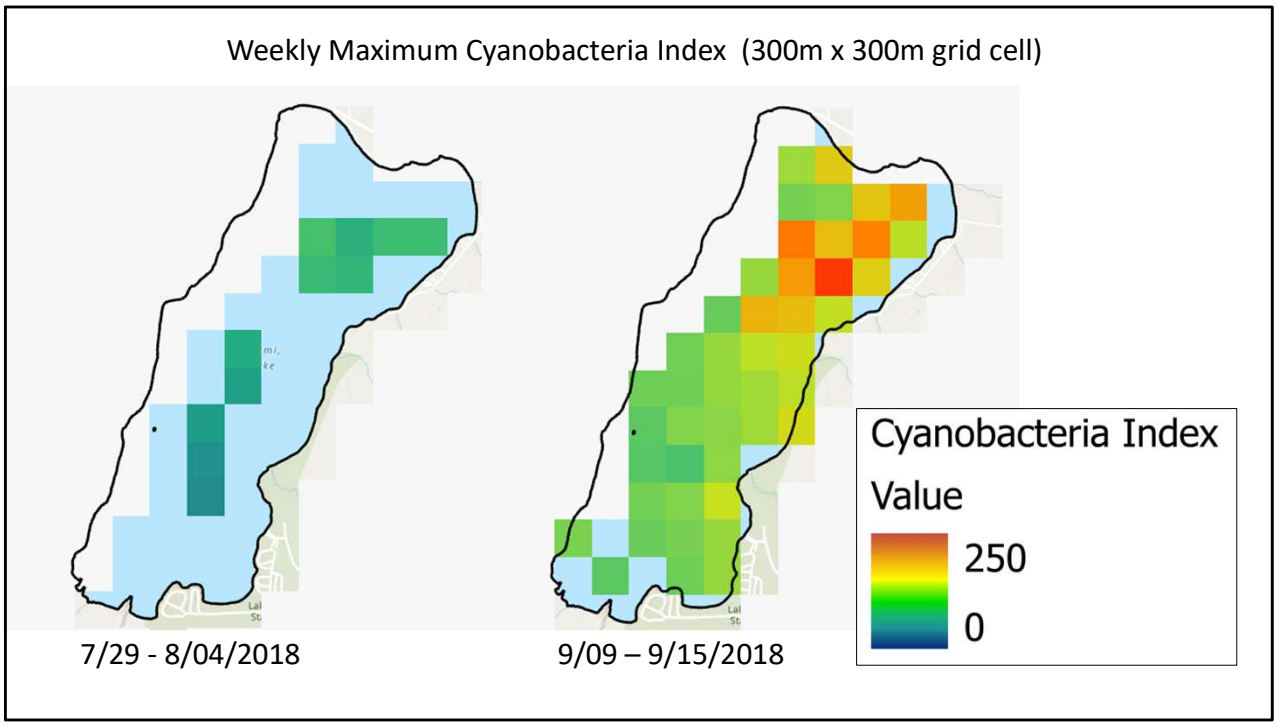
A Cyanobacteria Index is calculated for each 300m x 300m area based on the reflectance of certain wavelengths of light off of blue-green algae .

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

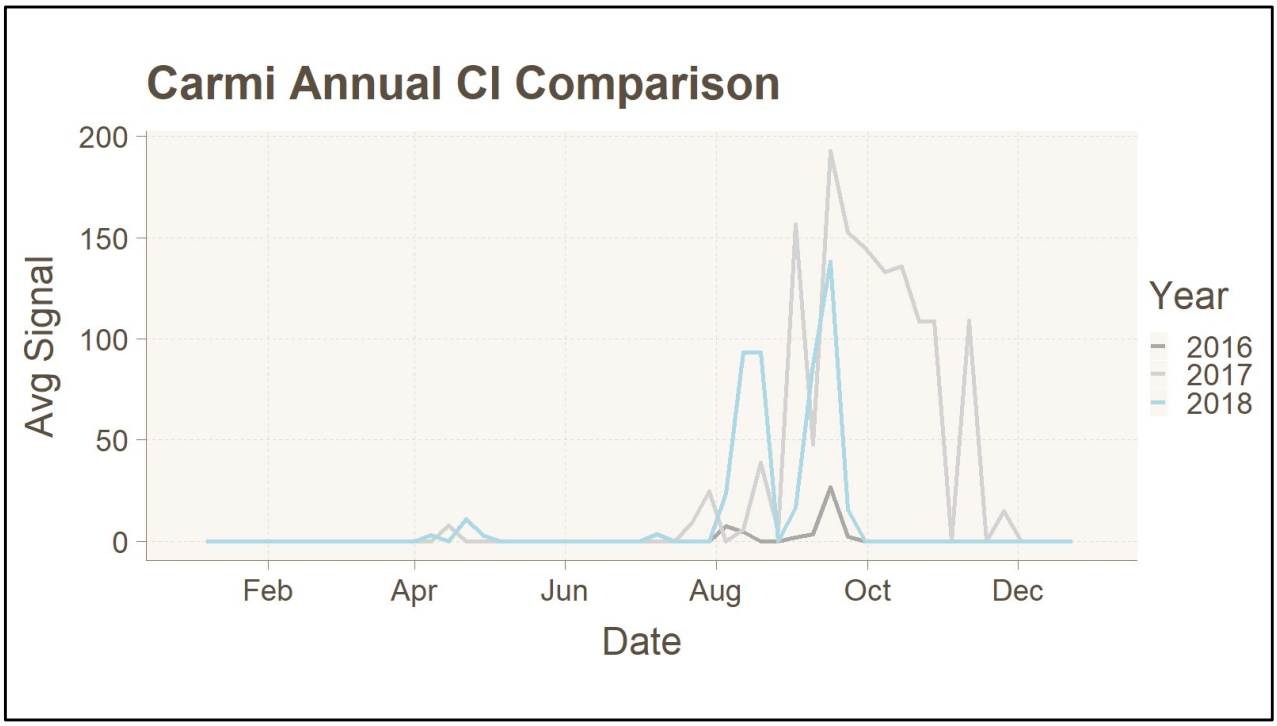


NOAA takes daily satellite images of the U.S. and processes the images based on the reflectance of certain wavelengths of light.

This is an example that covers Lake Champlain, and you can see Lake Carmi in the top right. In the image on the right, Black represents water, the off-white color is land, and anything colored dark blue through red is cyanobacteria.
One of the issues to keep in mind with this analysis is that because this is a single daily image, sometimes clouds will obscure the picture. Cloud cover is flagged in the images. For this analysis, what we did to minimize the cloud issue is we take a week of images, and for each grid cell we use the maximum value for the week.

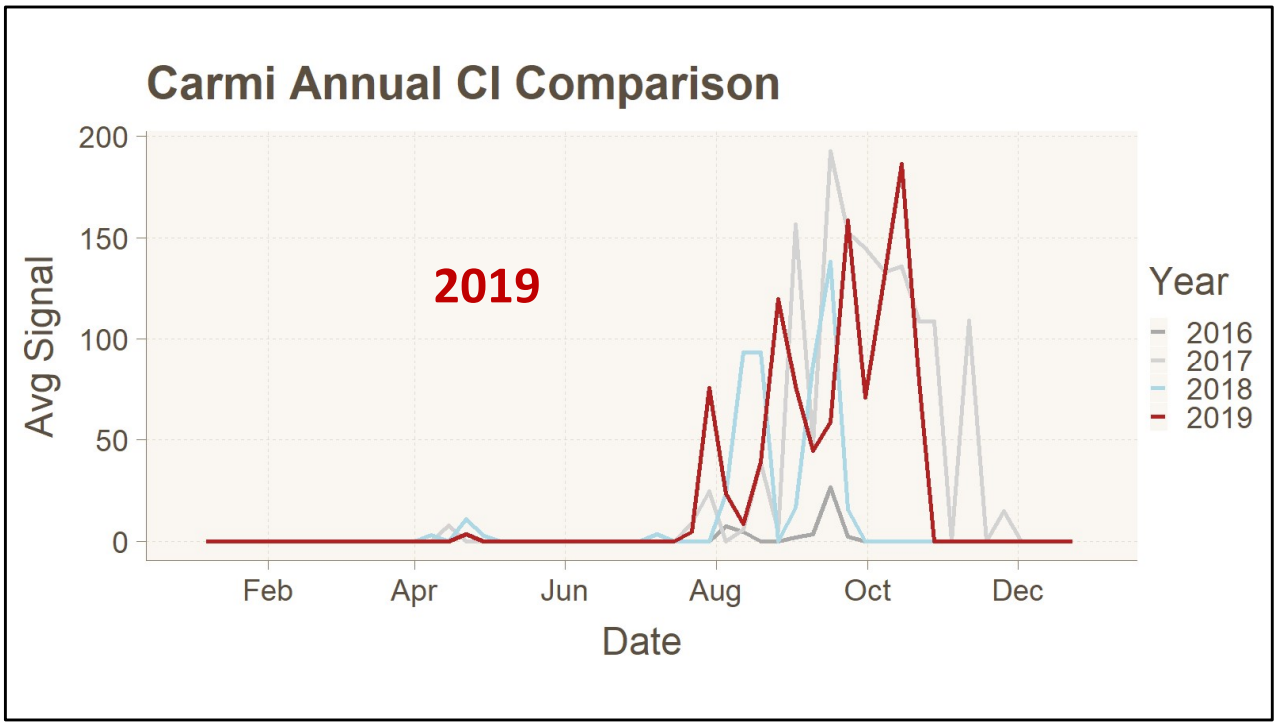


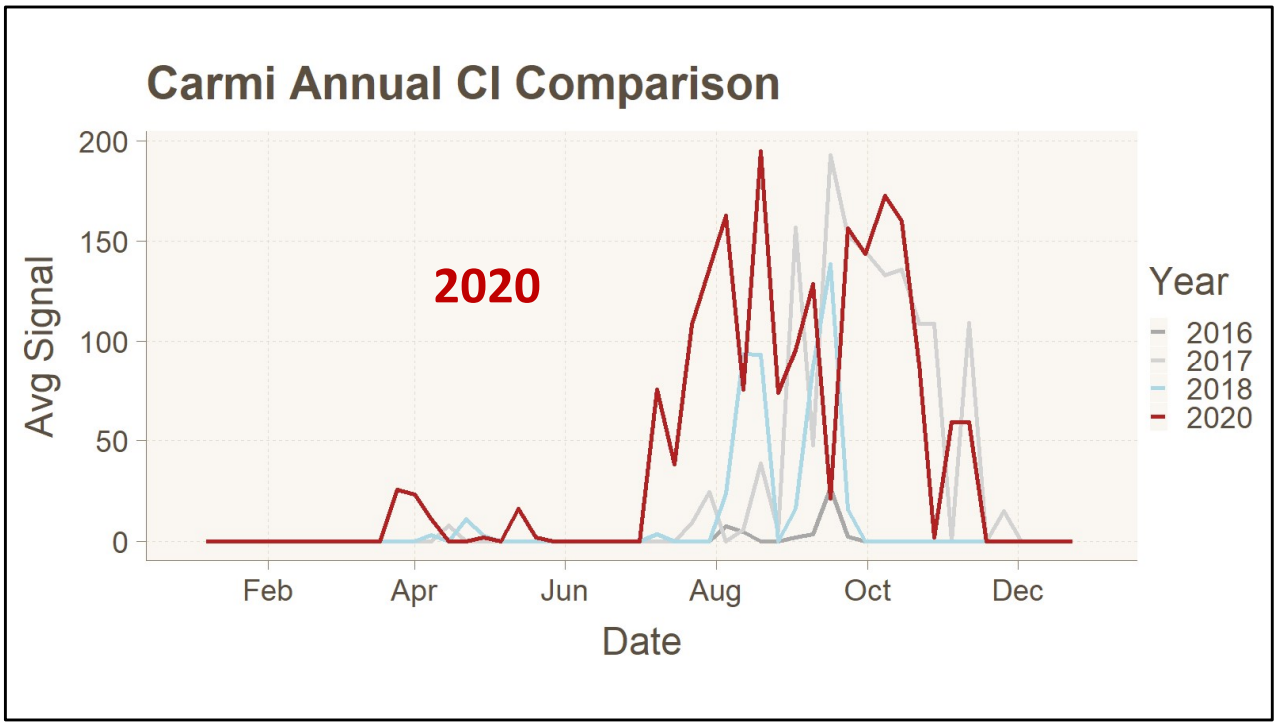
Here I have zoomed in on Lake Carmi, and you see the pixelation of those 300m grid cells. These are two example composite images that have the maximum cyanobacteria index for each cell over different weeks in 2018. This shows bloom initiation on the left at the beginning of August. On the right is closer to peak bloom in September.
A benefit of this analysis is you can see the spatial variation in the bloom.



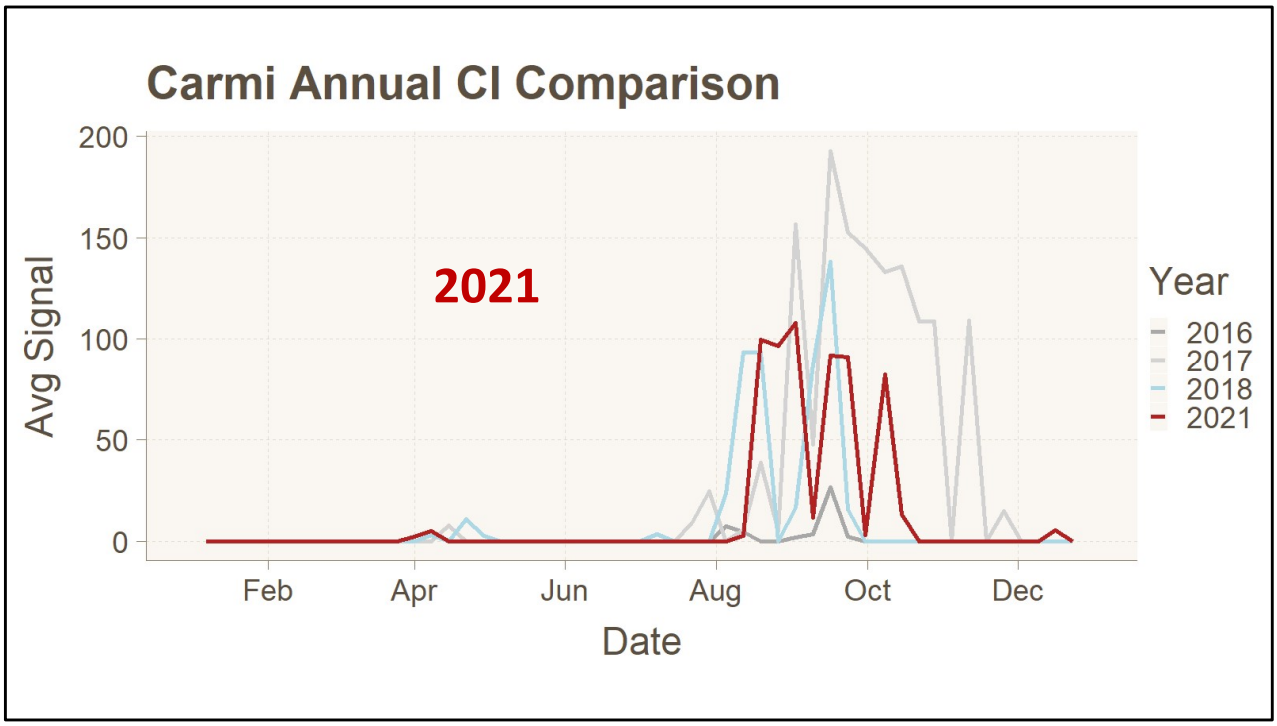
I then took those images and calculated an average Cyanobacteria Index for the entire lake as a single value. Each point represents the previous weeks image.
This satellite data goes back to 2016, and I have plotted 16 – 18 to get an idea of pre-aeration years for comparison.

Note that 2016 has a really low signal. I thought that might be an issue with the first year's data, but I have also looked at Missisquoi Bay in Lake Champlain and 2016 appears normal there. We see a small signal in the spring each year, and then the summer bloom initiates around late July/August. The peak was in the same week in mid September each of these seasons, and then really ended by October in 16 and 18, but persisted late into the fall in 2017.

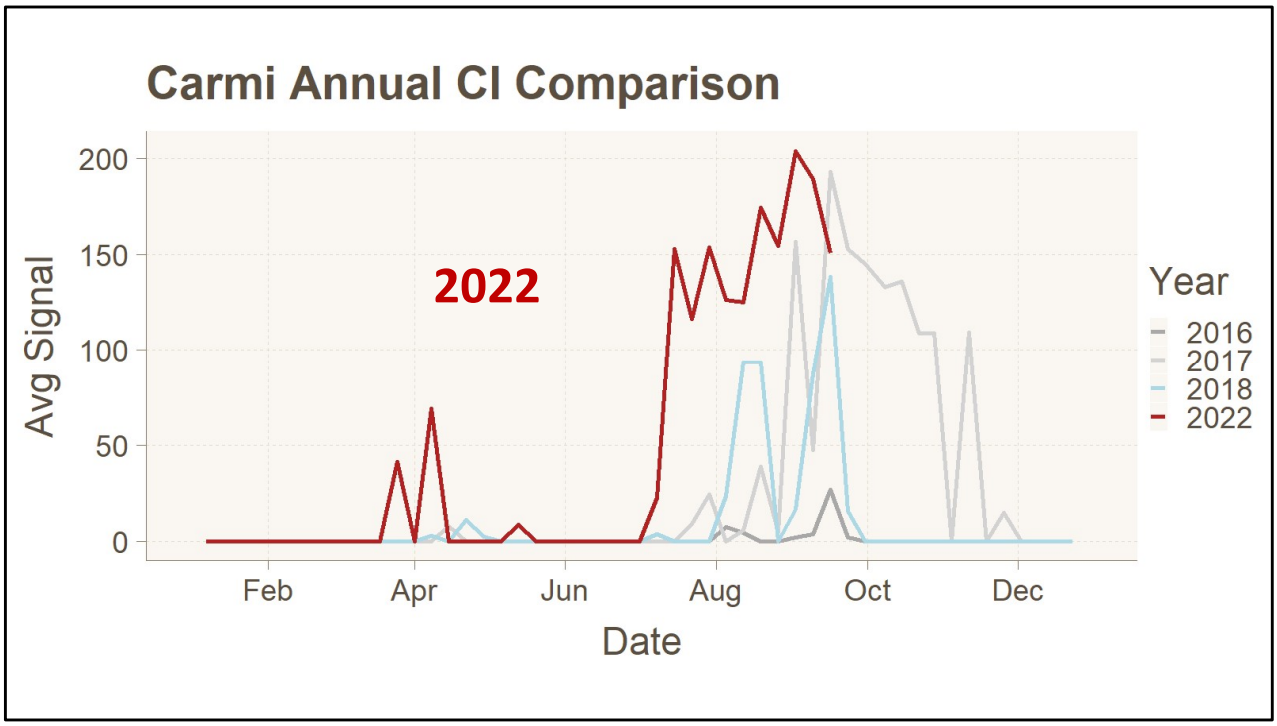

Carmi Annual CI Comparison
2019
Avg Signal
200
150
100
50
0
Feb
Apr
Jun
Aug
Oct
Dec
Date
Year
2016
2017
2018
2019



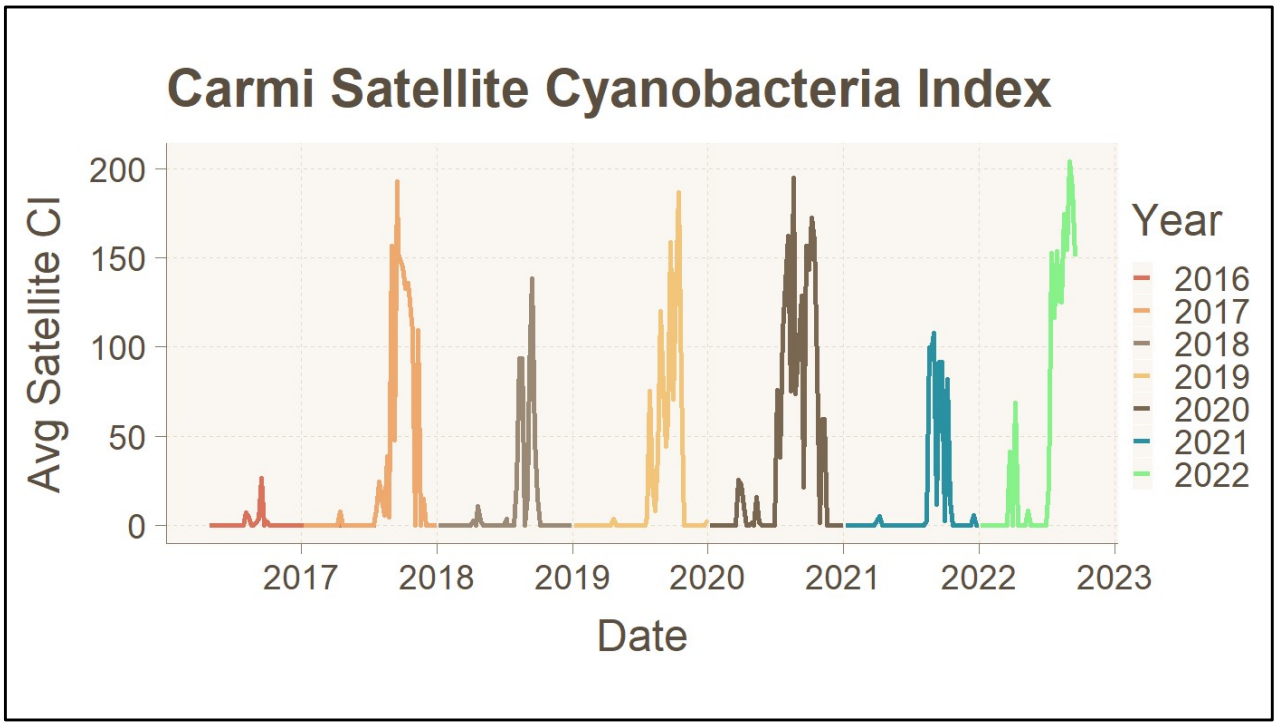
The bloom in 2020 began almost a month earlier than in the three years before aeration.

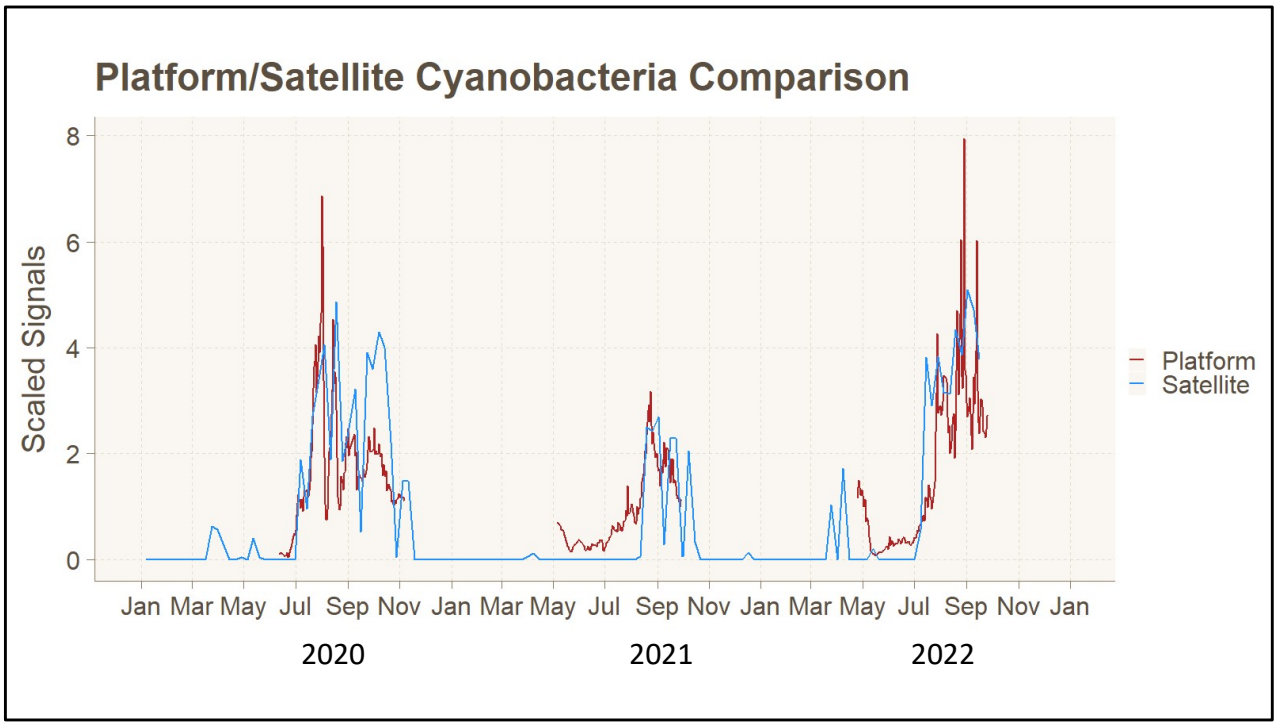


2021 was more typical, and maybe slightly better than pre-aeration.



2022 was again an early bloom and looks more severe.


Carmi Satellite Cyanobacteria Index
Avg Satellite CI
200
150
100
50
0
2017
2018
2019
2020
2021
2022
2023
Date
Year
2016
2017
2018
2019
2020
2021
2022



And finally I wanted to show a comparison of the satellite data to the monitoring platform. There have been some questions in previous meetings about how well the platform captures blooms.
Here I have plotted the platform surface readings in red, and the satellite composite average in blue for the last three years.
The scale here is kind of arbitrary, but what is important is the timing of blooms and relative magnitude between years is captured by both sensors. Peaks generally overlap. For example in 2020, the first peaks match well, and the later peaks overlap, but there is a difference in magnitude.

Some of the differences are likely due to the platform measuring one single point in the middle of the lake, whereas the satellite imagery captures the lake-wide average. There are benefits to using both of these datasets because it lets us capture some of the spatial variability in the satellite images, and the temporal variability with the profiler that is taking hourly readings.

In general they capture the same timing and relative severity of the bloom and can give us a more complete picture of the bloom response to interventions going forward.