Fluorometric monitoring of phytoplankton as a predictive indicator of cyanobacteria blooms in a eutrophic lake.

Current situation

- Cyanobacteria (and cyanotoxin) laboratory tests are costly
- Special training and expensive equipment are required
- Delay for results is lengthy, often received too late to take preparatory or advisory action
- No *in situ* tests available

Objectives

- Establish a proxy for cyanobacteria bloom risk assessment
- Provide warning of cyanobacteria blooms weeks in advance
- Low- to no-cost involved for tests
- Obtain immediate results
- Can be used *in situ*
- Little to no training required

Method

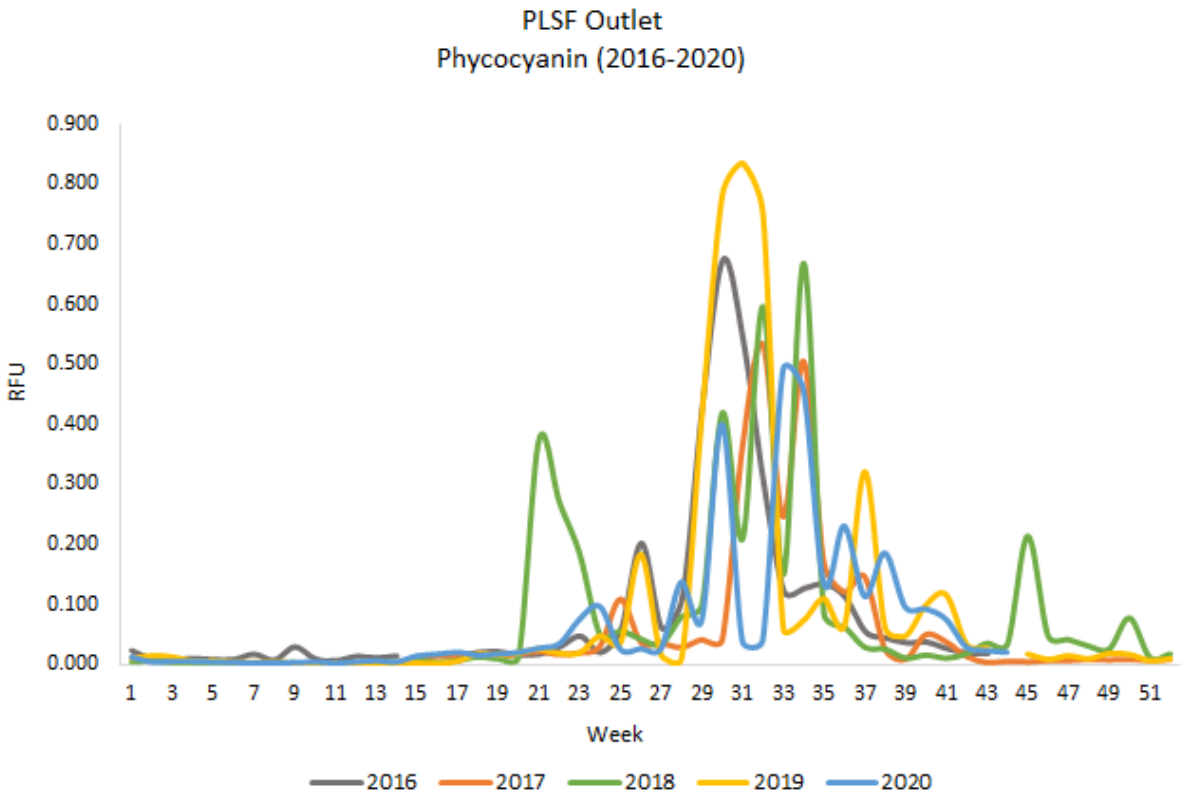
- Monitor a shallow, temperate, eutrophic lake with a history of cyanobacteria blooms
- Monitor for 5 years
  - 2016 to 2020
- Undertake weekly monitoring of chlorophyll *in vivo* and phycocyanin by fluorometry
  - (n=245)
- Undertake parallel monthly monitoring of phytoplankton taxonomy by light microscopy to obtain biovolumes and concentrations
  - (n=45)

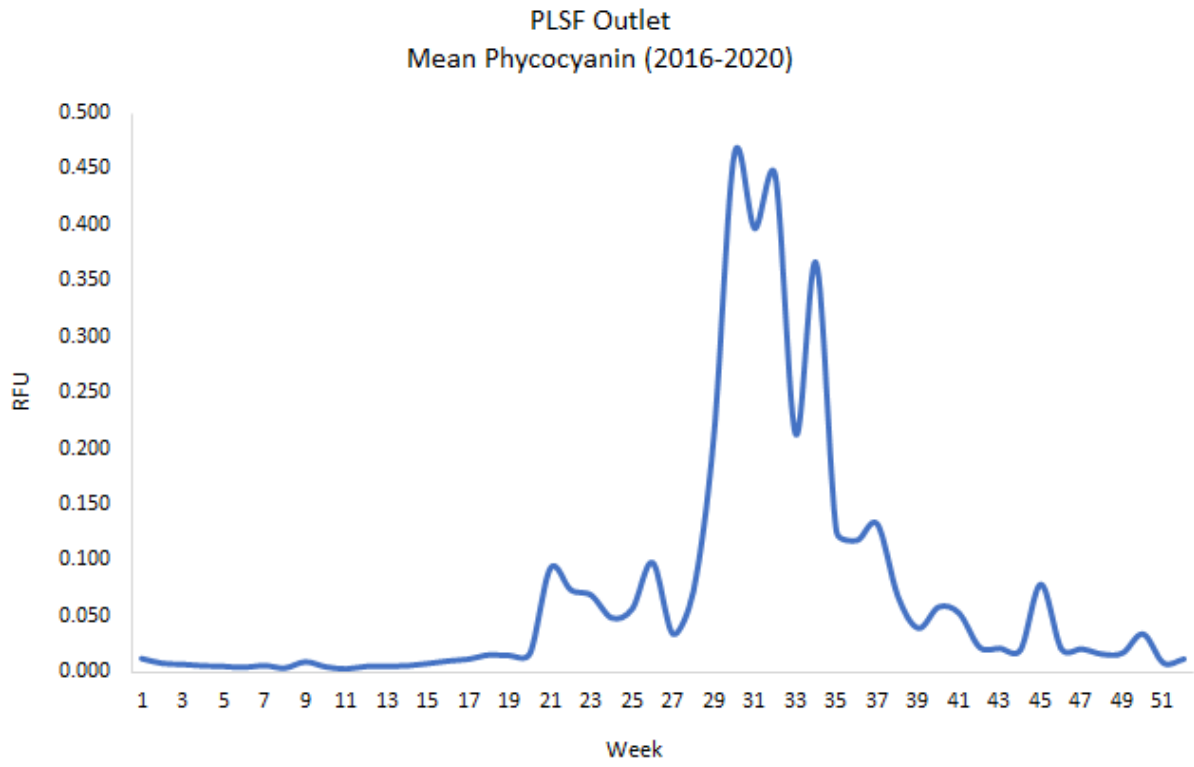
Method cont'd.

- Method based on seasonal succession of phytoplanktonic genera from chlorophyta (i.e., ↑ chlorophyll) to cyanophyta (i.e., ↑ phycocyanin)
  - (References required)
- Calculate the ratio of chlorophyll *in vivo* to phycocyanin
- Establish "trigger" levels through correlation of Chl:Phy ratio with taxonomy results
- Use of *Aqua*Fluor® handheld fluorometer (Turner Designs, Inc., San Jose, CA, USA)

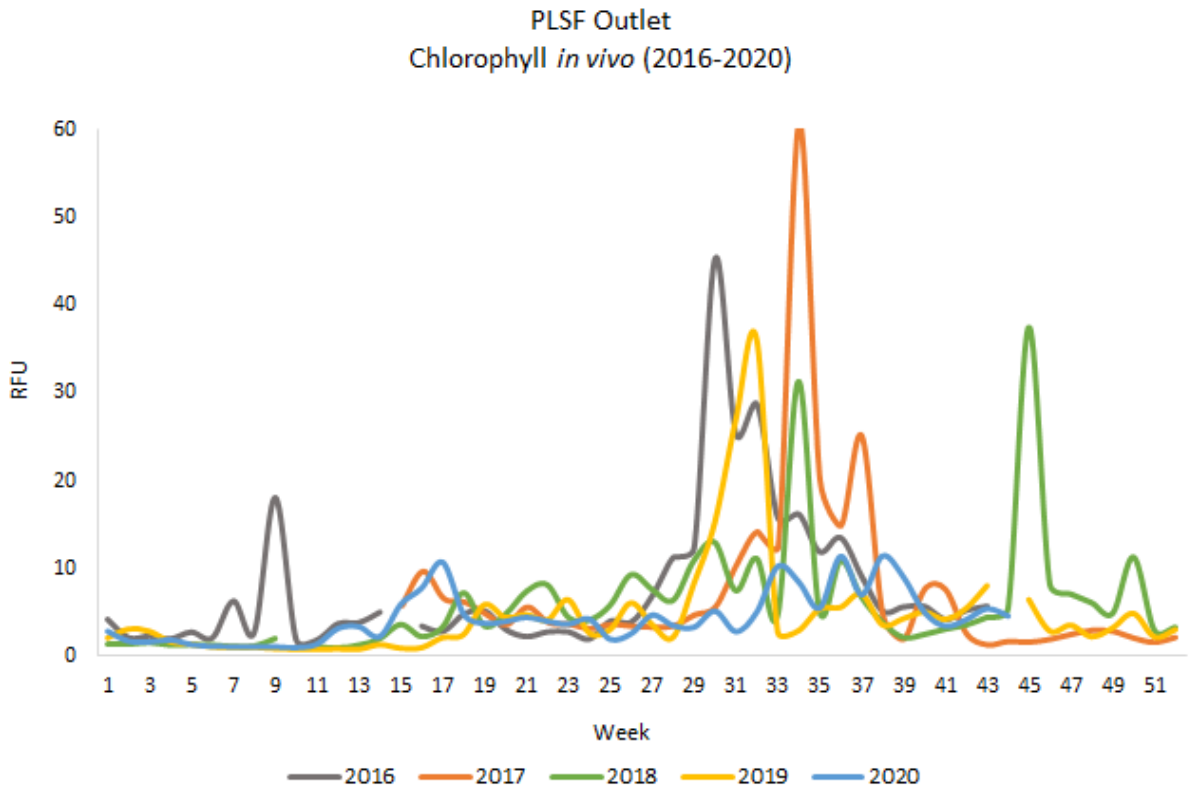
Results

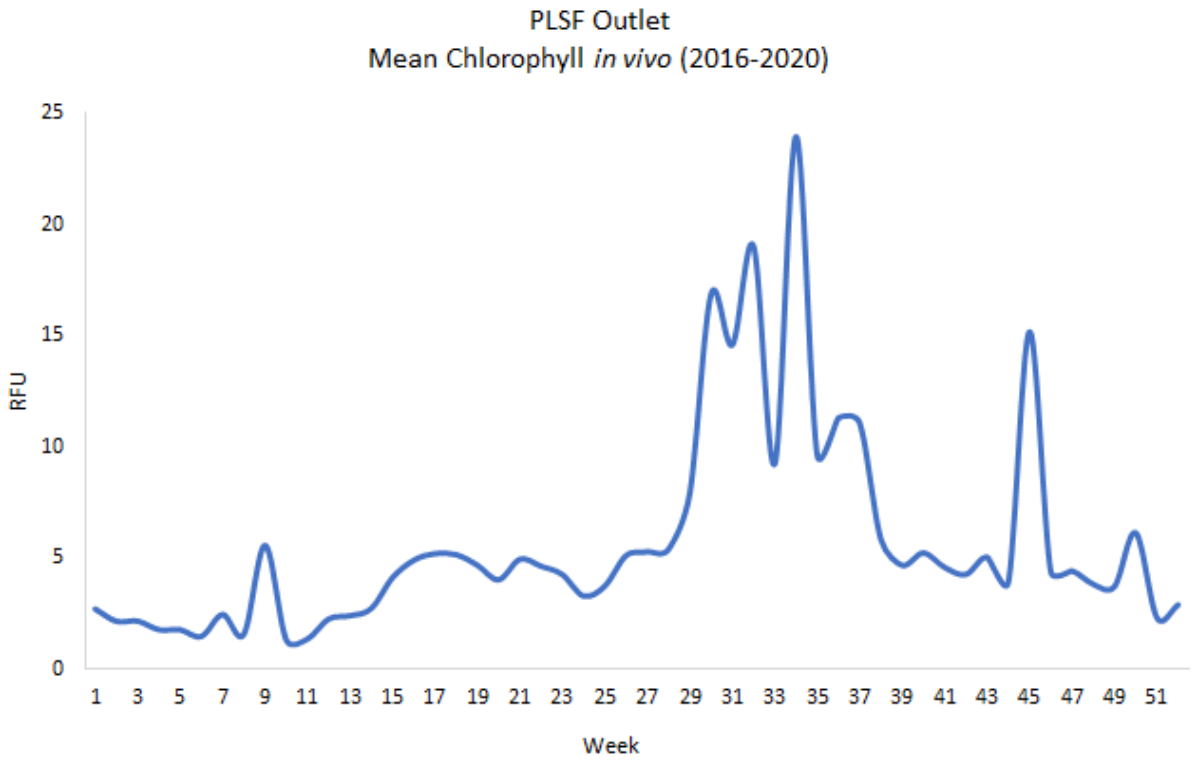
Phycocyanin by Fluorometry
2016-2020



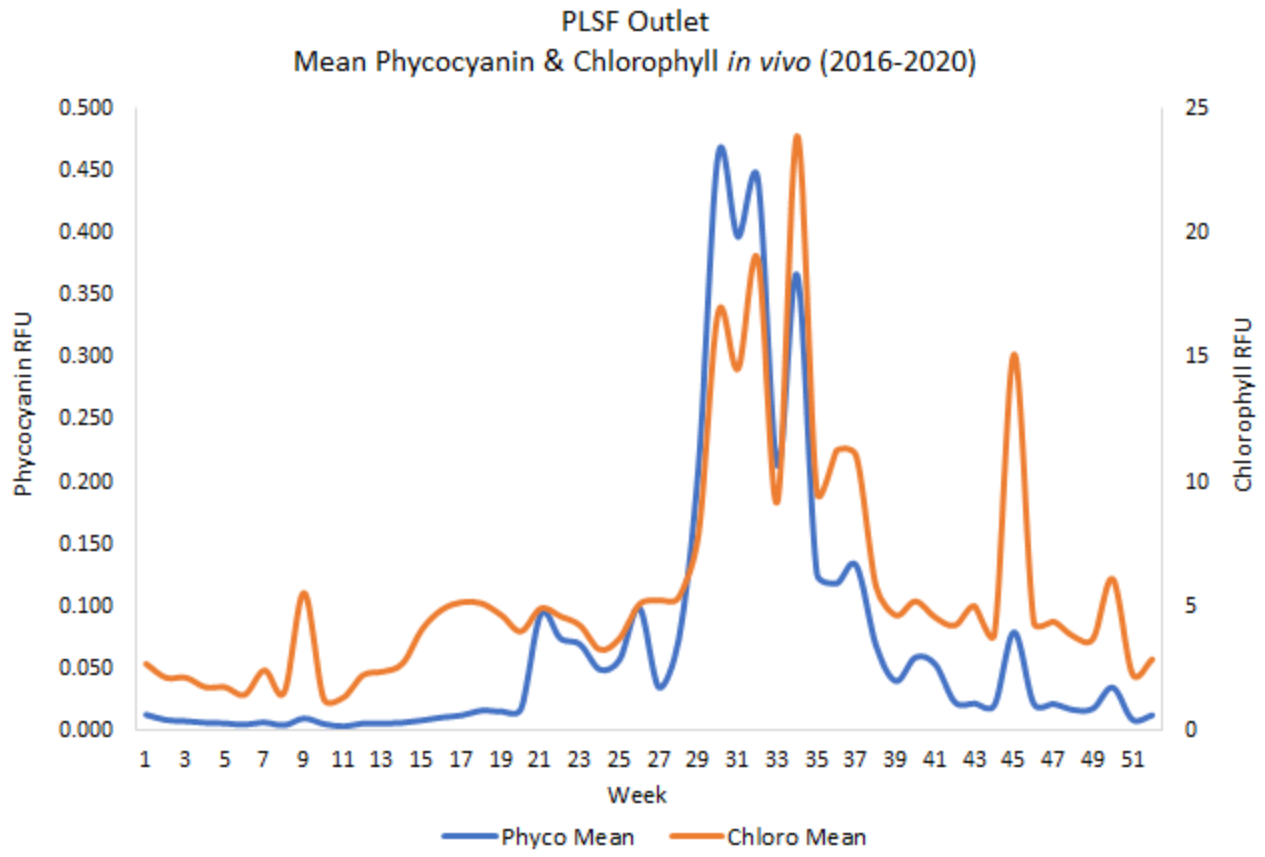


Chlorophyll *in vivo* by Fluorometry
2016-2020

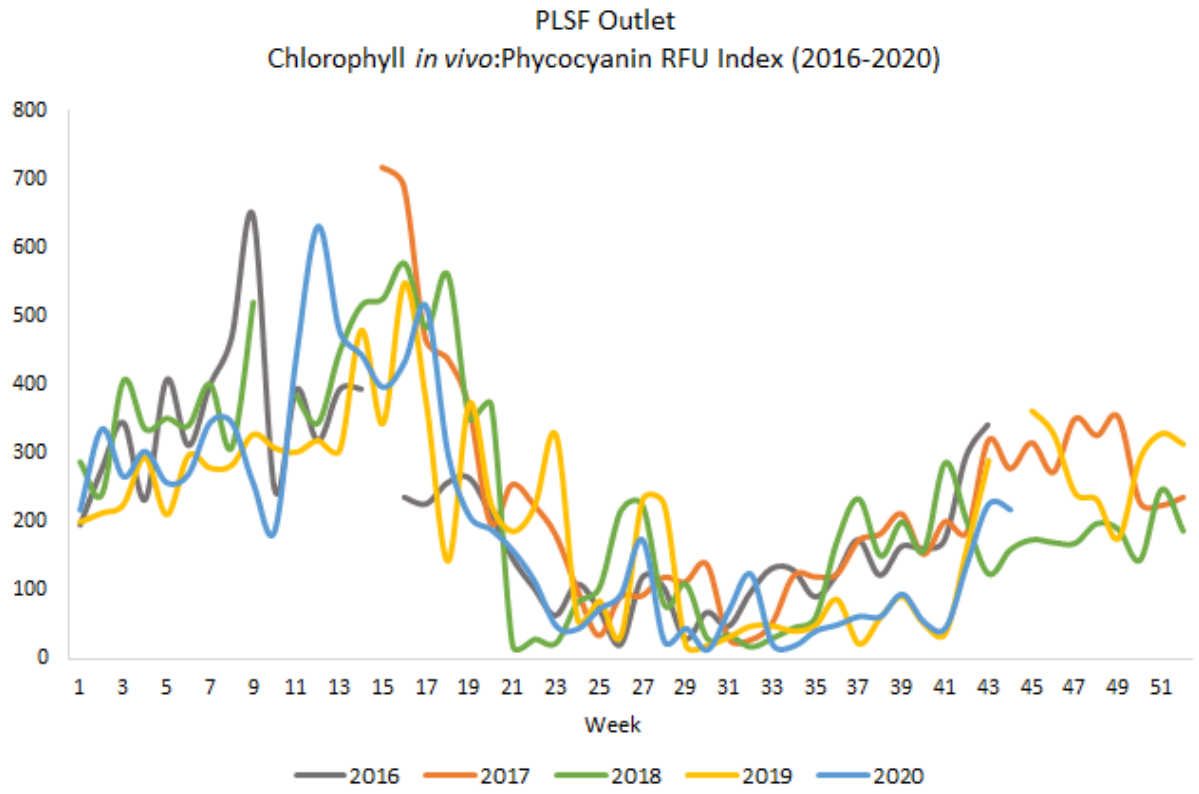


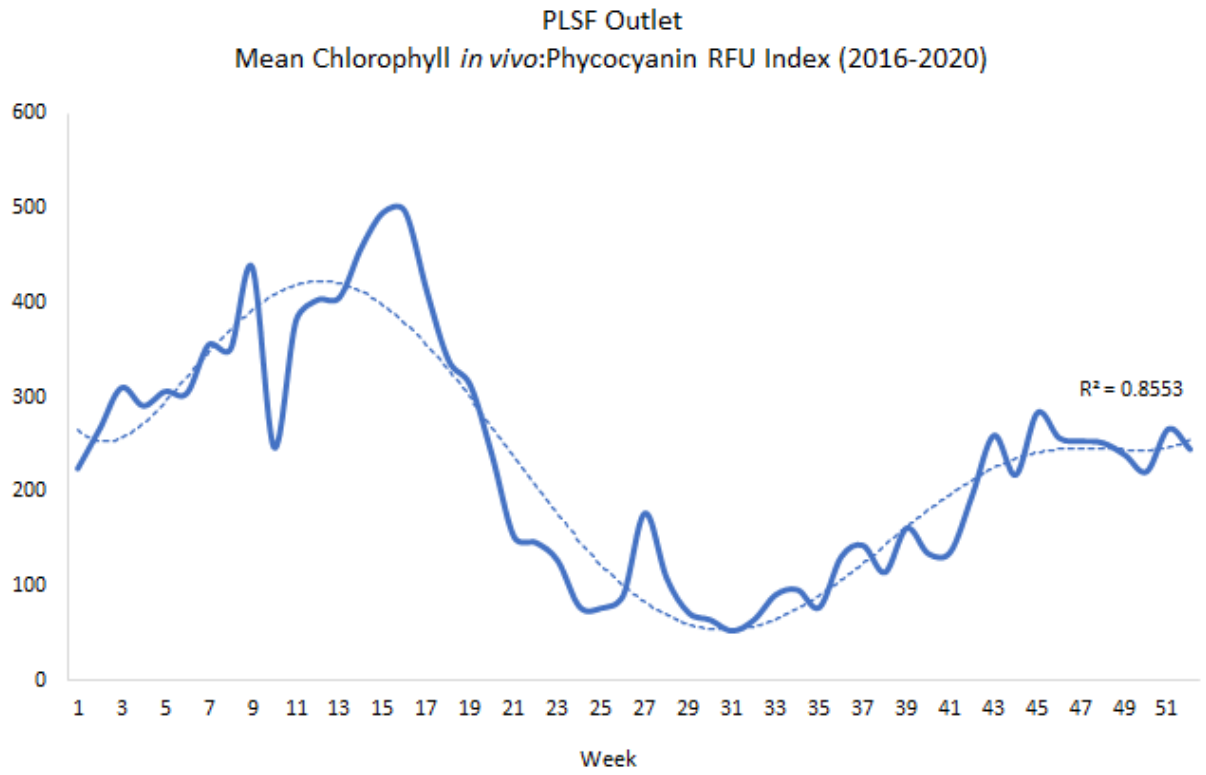


Mean Chlorophyll *in vivo* & Phycocyanin by Fluorometry 2016-2020



Chlorophyll *in vivo* : Phycocyanin Ratio
2016-2020



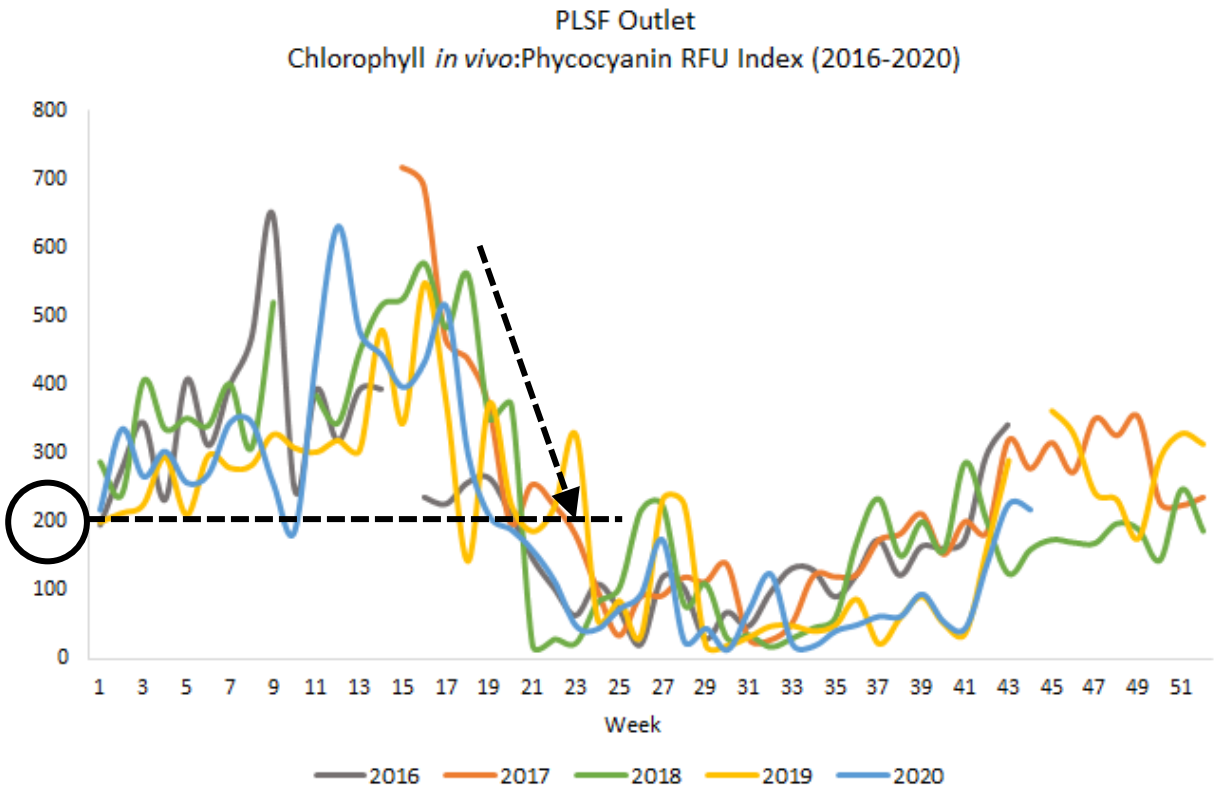


Correlations
Total Cyanobacteria by Microscopy with Fluorometric Measurements (5 years, n=45)

With Cyanophyceae				
Parameter	Concentration (cells/ml)		Biovolume (µm³/ml)	
	Correlation R^2	*p*-value	Correlation R^2	*p*-value
Chlorophyll *in vivo*	0.142	< 0.01	0.094	< 0.01
Phycocyanin	0.807	< 0.01	0.825	< 0.01

With Chlorophyceae				
Parameter	Concentration (cells/ml)		Biovolume (µm³/ml)	
	Correlation R^2	*p*-value	Correlation R^2	*p*-value
Chlorophyll *in vivo*	0.251		0.246	
Phycocyanin	0.050		0.199	

Once the ratio descends below 200, it continues to fall and it tends to stay below 200 until the end of the bloom season. We therefore propose to use 200 as the “trigger” for predicting the occurrence of a cyanobacteria bloom.



This information may or may not be pertinent:

What constitutes a “bloom”?

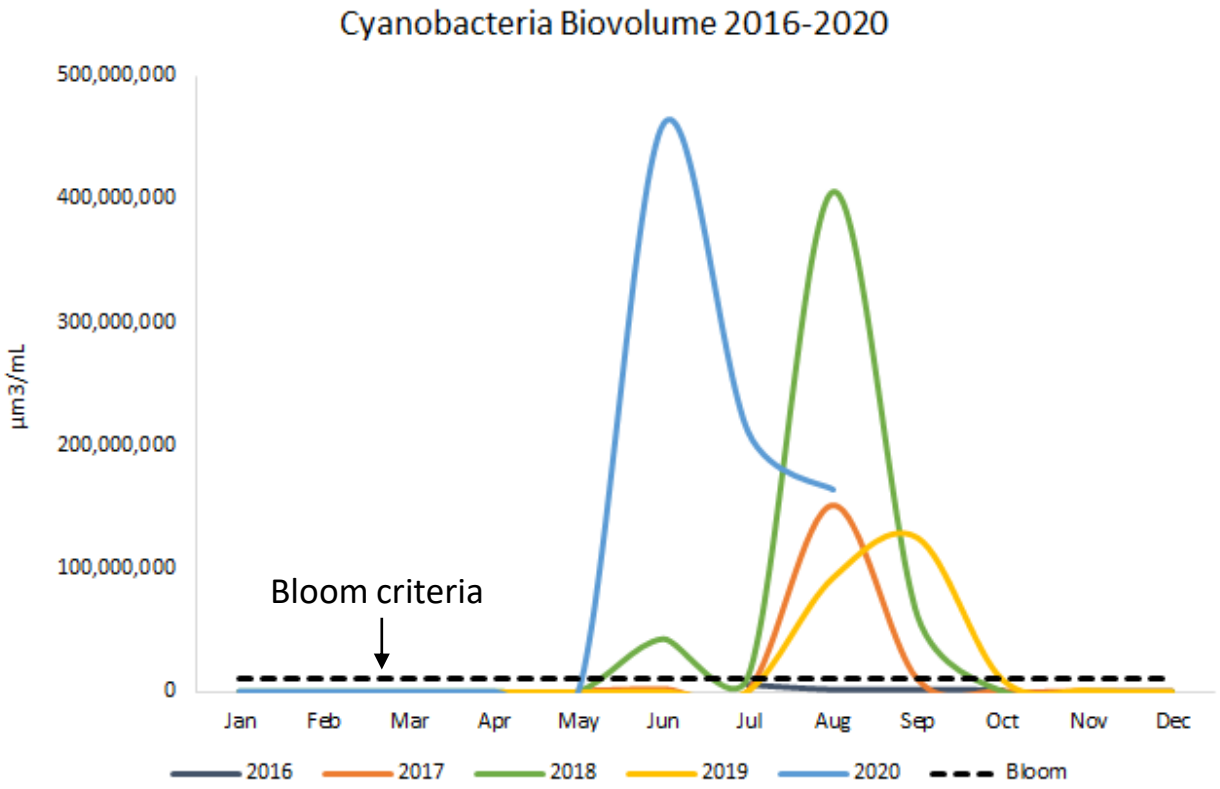
Health Canada consultation, proposed guidelines, 2020
“Cyanobacteria and their Toxins in Recreational Water: Guideline Technical Document for Public Consultation”
https://www.canada.ca/en/health-canada/programs/consultation-cyanobacteria-toxins-recreational-water/document.html#a1.2

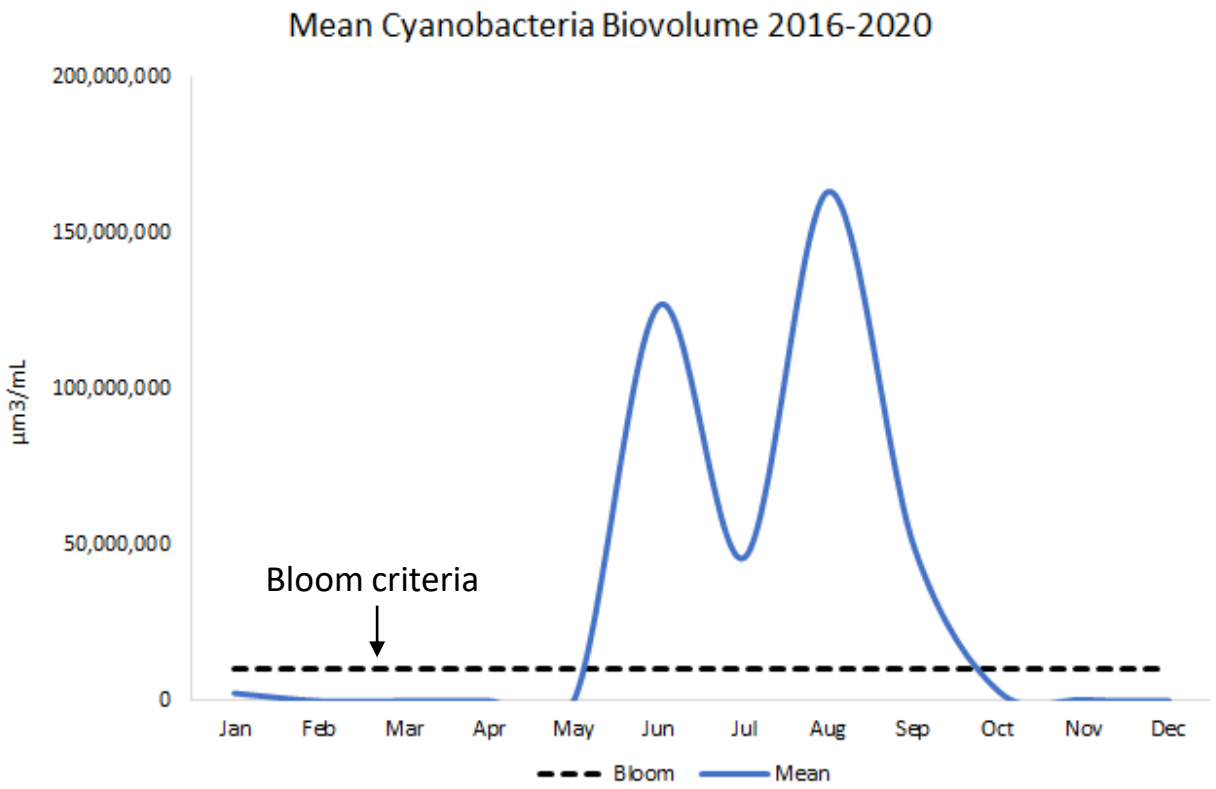
- Total cyanobacteria: 50 000 cells/mL
- Total cyanobacterial biovolume: 4.5 mm^3/L

Bloom Criteria

- Chlorophyll *in vivo* : Phycocyanin Ratio
  - **≤ 50**
- Biovolume
  - **≥ 10,000,000 cells/ml**

Cyanobacteria Biovolume 2016-2020

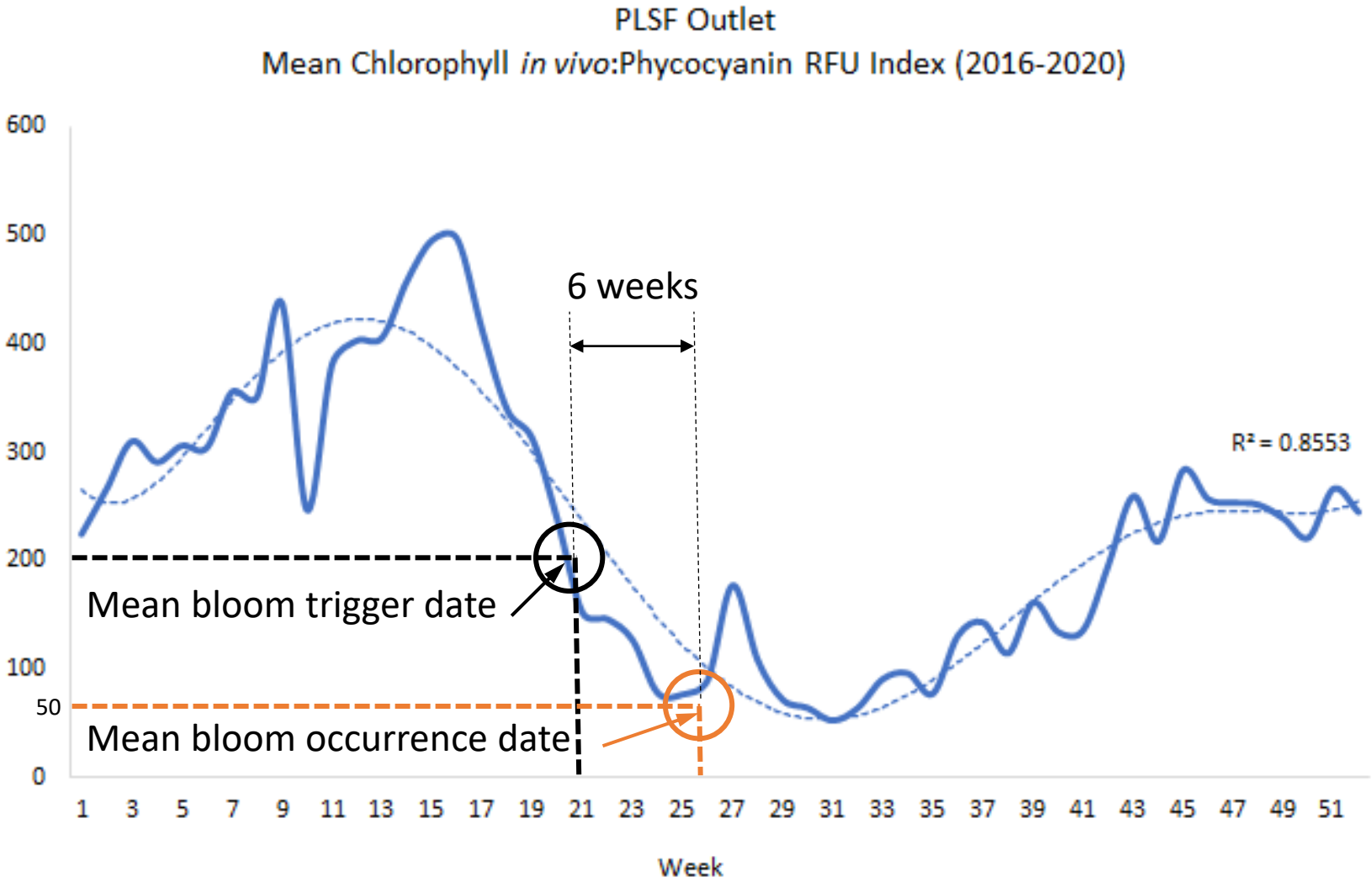




Lead time (Early Warning)

- Based on the criteria of a trigger Chl:Phy ratio of **≤ 200** and bloom occurrence definition as **≤ 50**, these are the lead times experienced during the 5 years of this study:

	Trigger (200)		Response (50)		**Lag Time**
Year	Week	Date	Week	Date	**Days**
2016	21	2016-05-29	29	2016-07-03	35
2017	20	2017-05-23	25	2017-06-26	34
2018	21	2018-05-29	28	2018-07-17	49
2019	18	2019-05-07	24	2019-06-18	42
2020	20	2020-05-19	23	2020-06-09	21
Mean	20		26		**36**


PLSF Outlet
Mean Chlorophyll *in vivo*:Phycocyanin RFU Index (2016-2020)
600
500
400
300
200
100
50
0
6 weeks
R² = 0.8553
Mean bloom trigger date
Mean bloom occurrence date
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51
Week

Conclusions

- The chlorophyll *in vivo* : phycocyanin ratio is an strong precursory, predictive indicator of the occurrence of cyanobacterial blooms in this eutrophic lake
- It provides several weeks advance warning of cyanobacterial blooms
- This method is low-cost
- It can be performed *in situ*
- It provides rapid (immediate) results
- It requires little to no training to perform