Automatic and Near-Real Time Monitoring for Cyanobacteria

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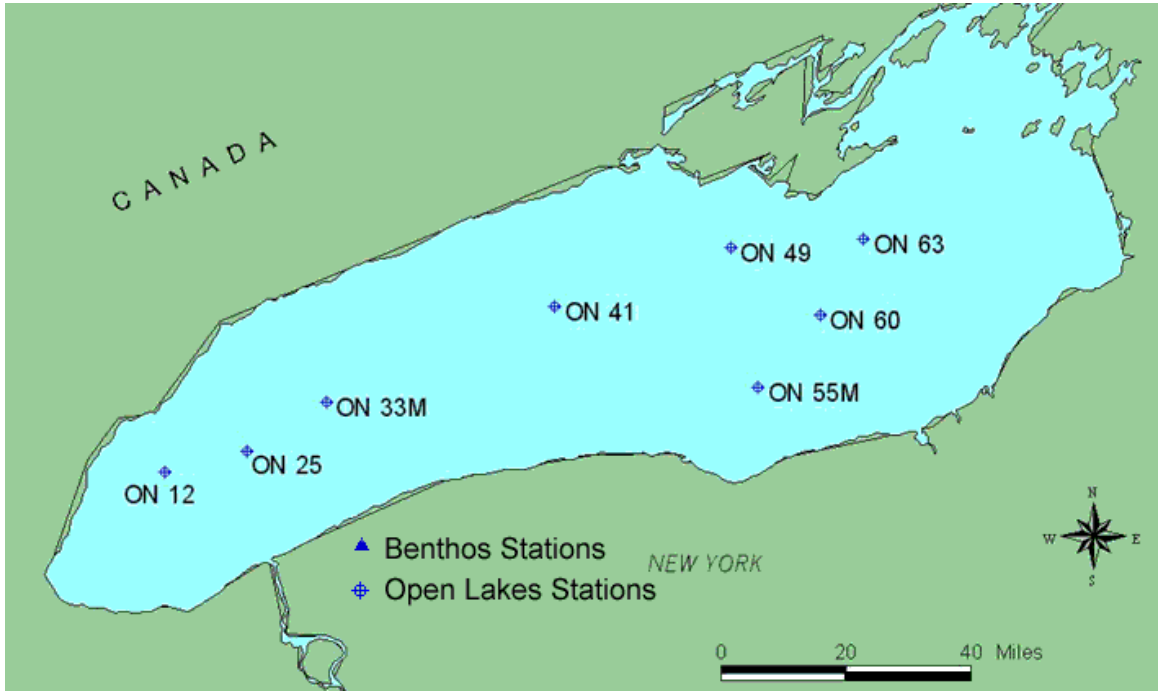
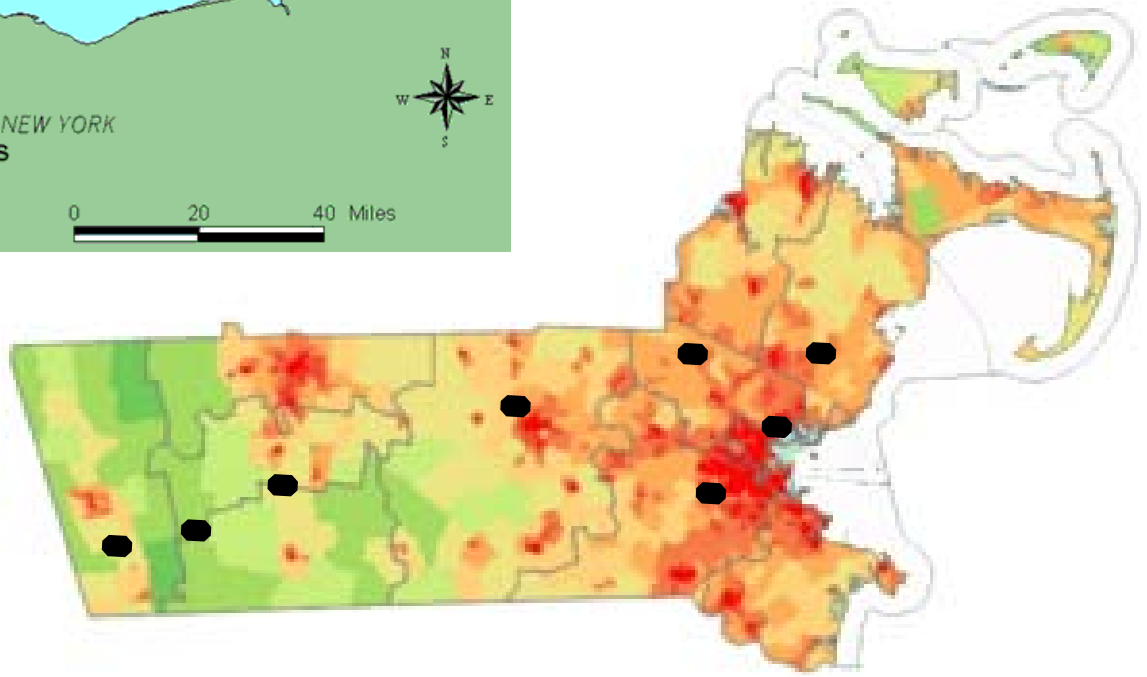
MERHAB-LGL
Harmful Algal Bloom
Monitoring and Event Response in the Lower Great Lakes

October 7th, 2007

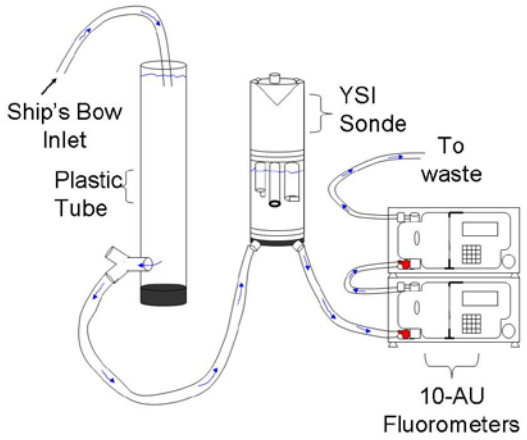
Bloom first detected by our sensor on the monitoring buoy!

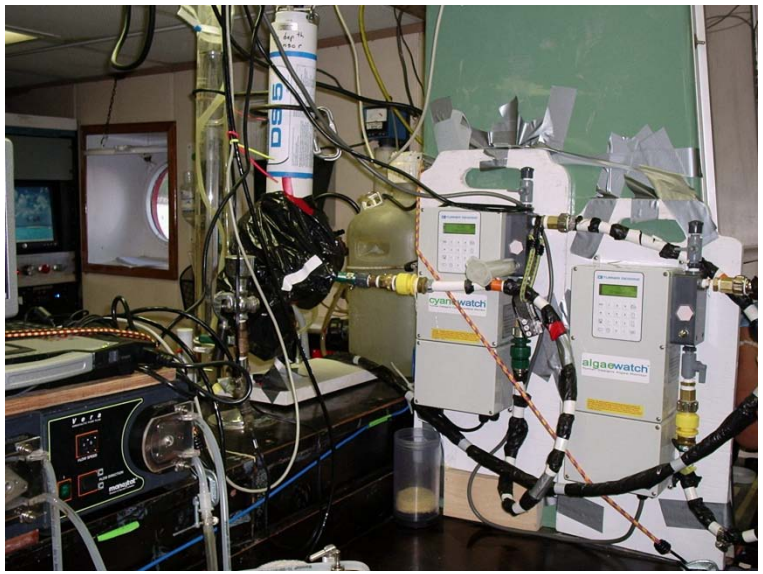
Great Lakes are big!





Ferry boxes offer a solution to this problem:





- Sample continuously while ship is underway:
- 30-60 sec per data point
- 20,000-80,000 points
- 100m resolution

Fluorometer List

Chlorophyll

- TD AlgalWatch
- HydroLab DS5
- YSI 6600 sonde

- BBE FluoroProbe
- Turner Designs 10-AU
- Turner Designs Cyclops

Phycocyanin

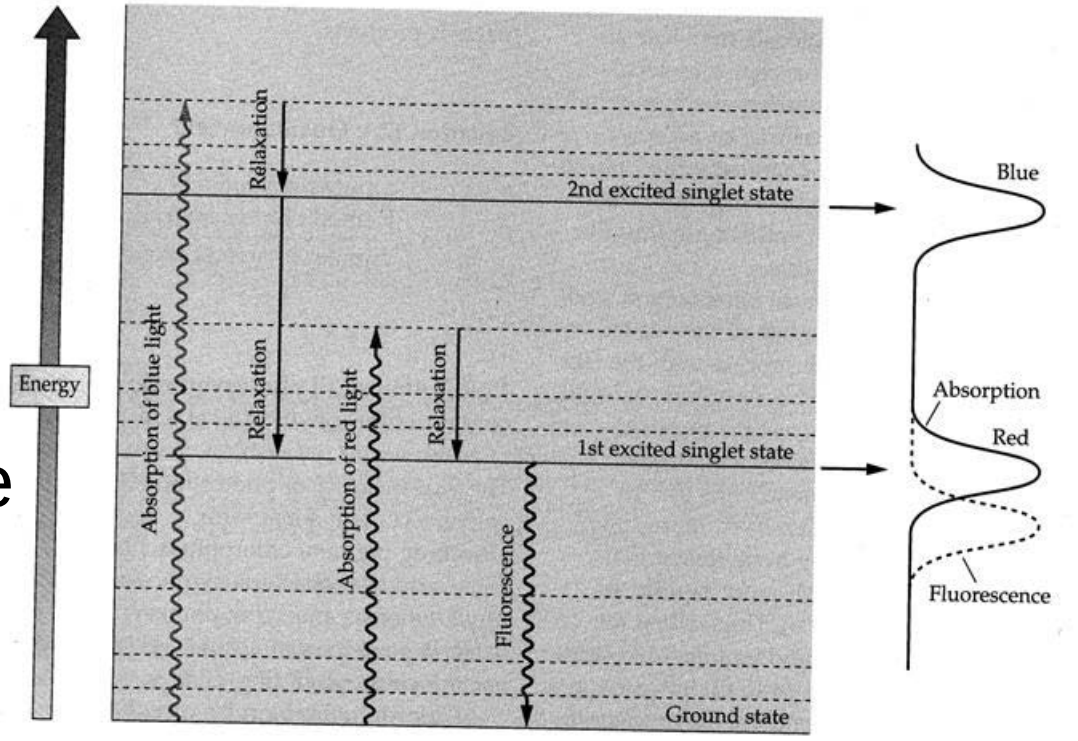
- TD CyanoWatch
- HydroLab DS5
- YSI 6600 Sonde

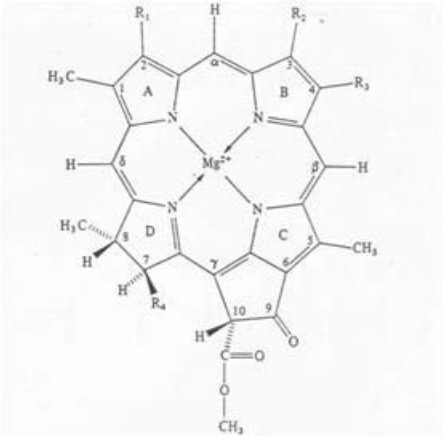
- BBE (Cyano-specific Chl)
- Turner Designs 10-AU
- Turner Designs Cyclops
  - PC, PE, CDOM, CHL

Primer on Chlorophyll fluorescence

- EPA 445.0

- Extract in acetone
- Excite the chl chromophore.
- Look at the energy given off when the chromophore relaxes.

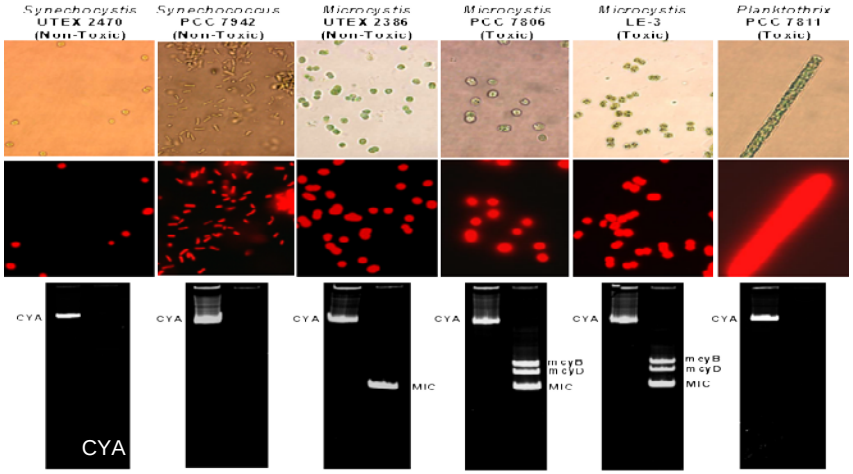


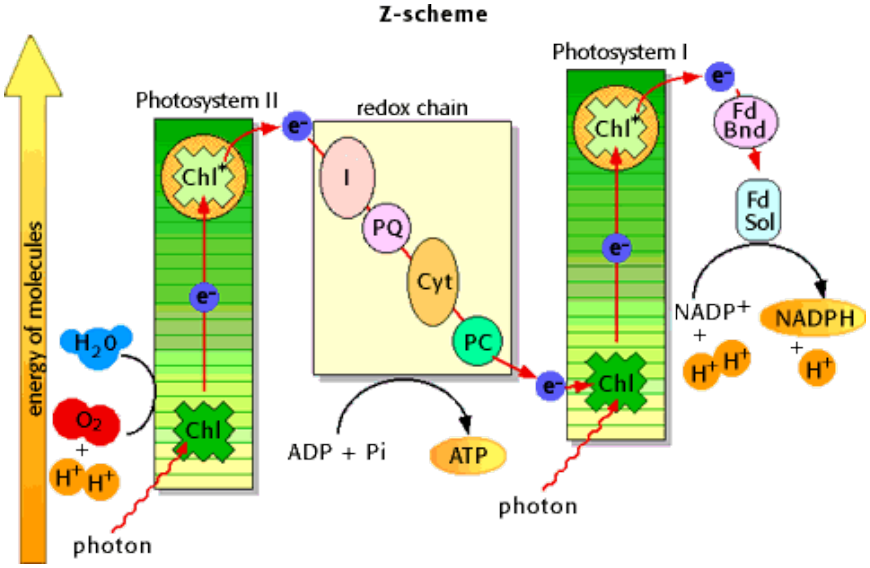


In vitro (in glass)

In vivo is not *in vitro*!

Exciting an intact organism

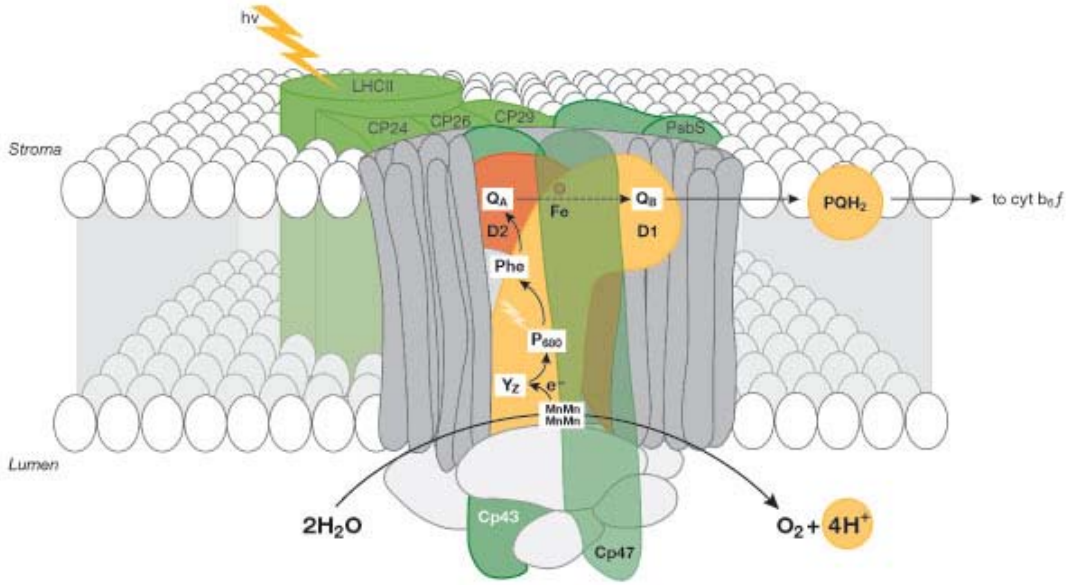


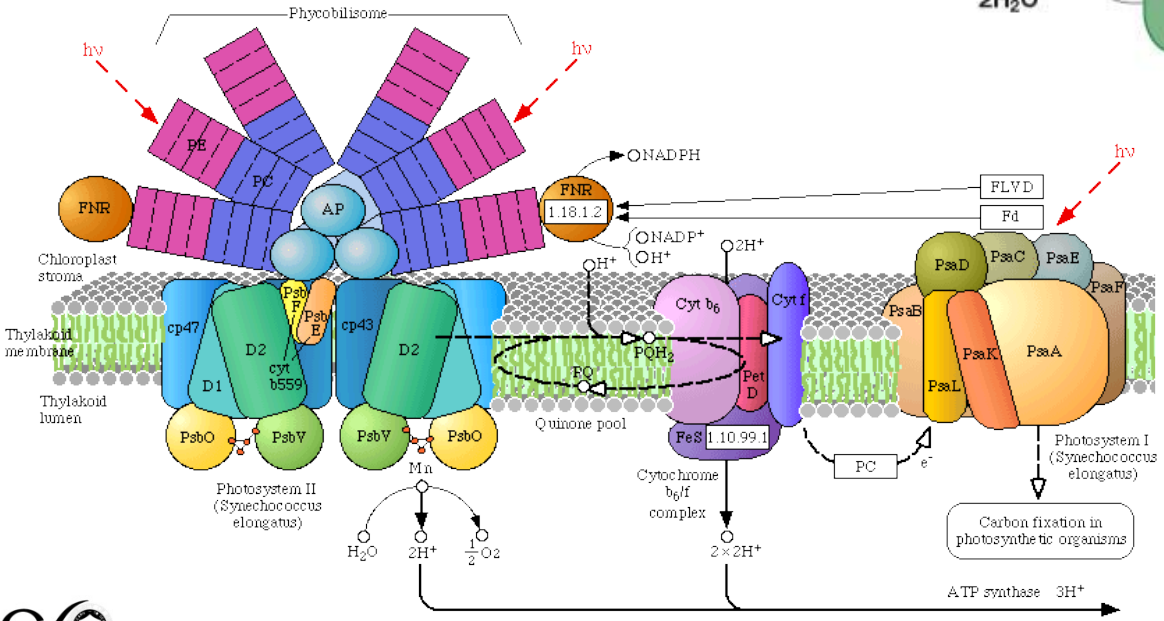


Most energy goes through the electron transport system.
Some spills out (PS II only!)
Assume that spill is a constant percentage.

Photosystems aren't equal

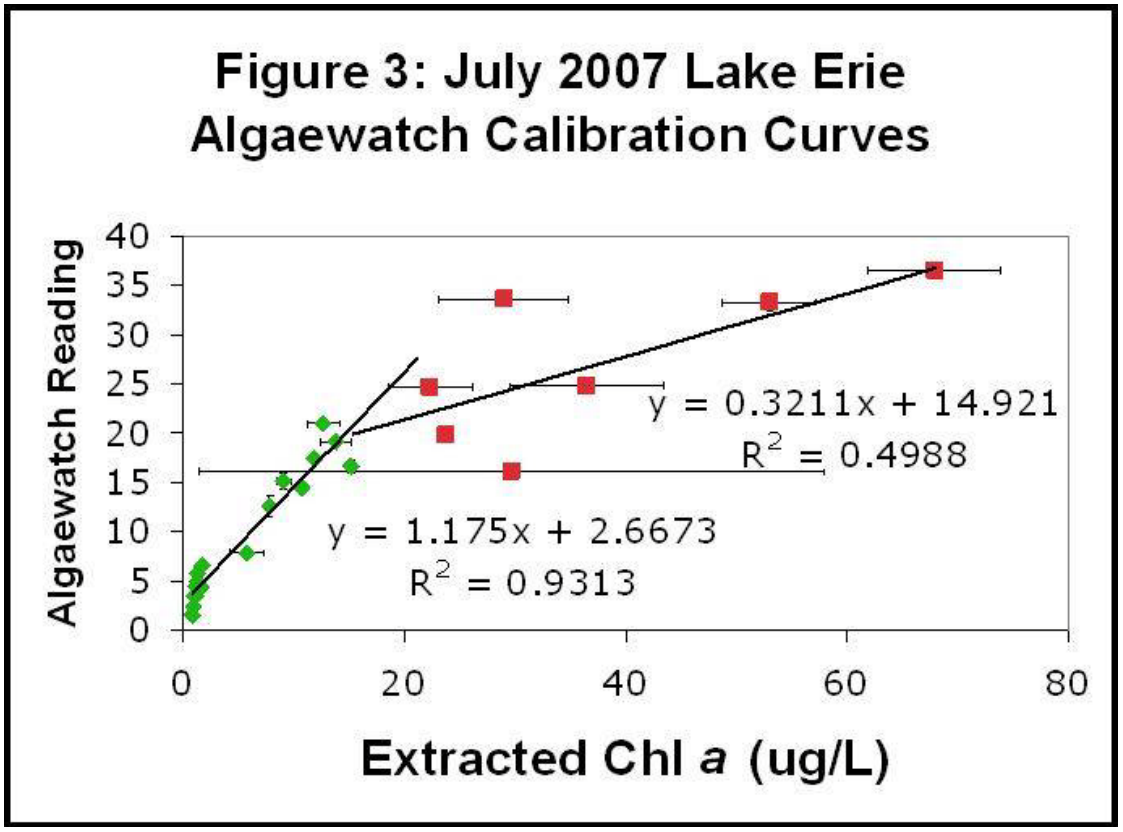
Photosystem 2
(higher plant)





Cyanobacteria

Typical Results:



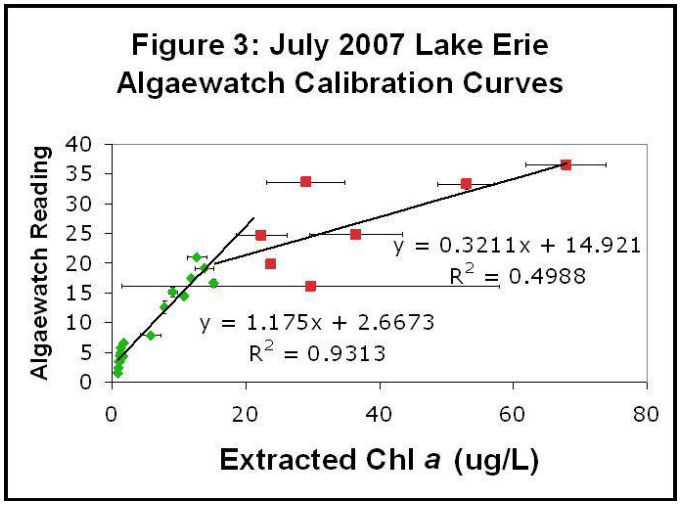
Biphaseic Curve

Eukaryotic Chl

Cyanobacterial Chl

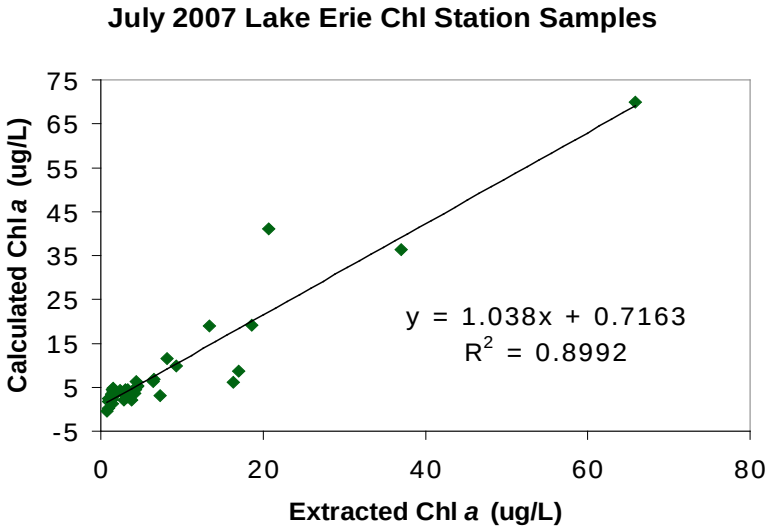
Data from M. Pavlac

Typical Results:



(1) Generate calibration curve

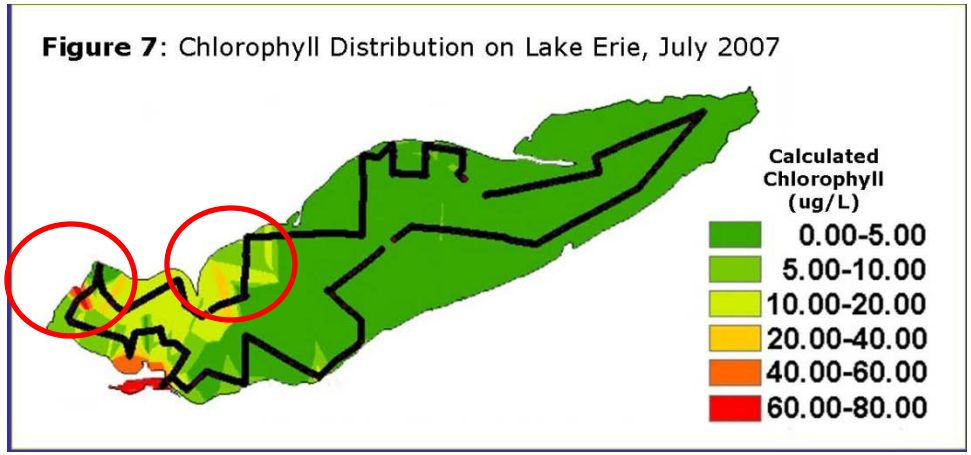
(2) Use the calibration curve used to back calibrate instrument

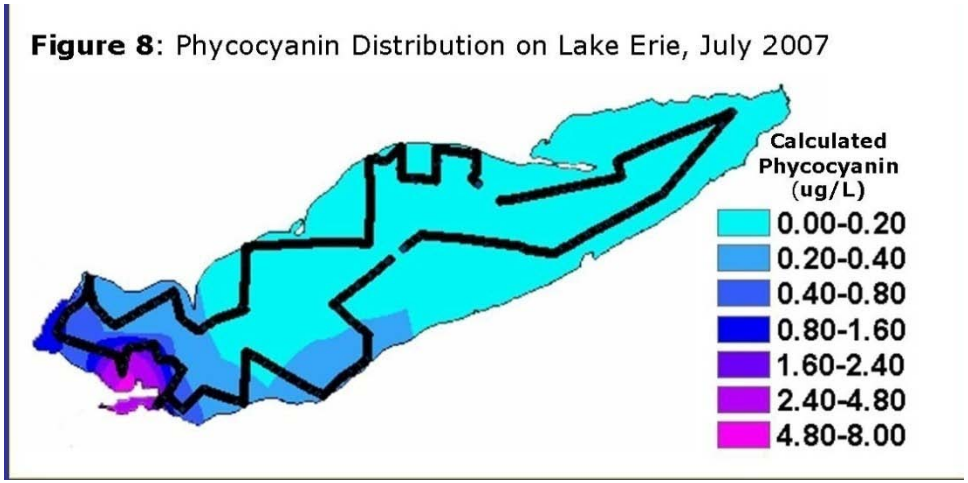


(3) Use that information to generate a chl (or PC) distribution map.

Data from M. Pavlac

Start to differentiate between blooms:



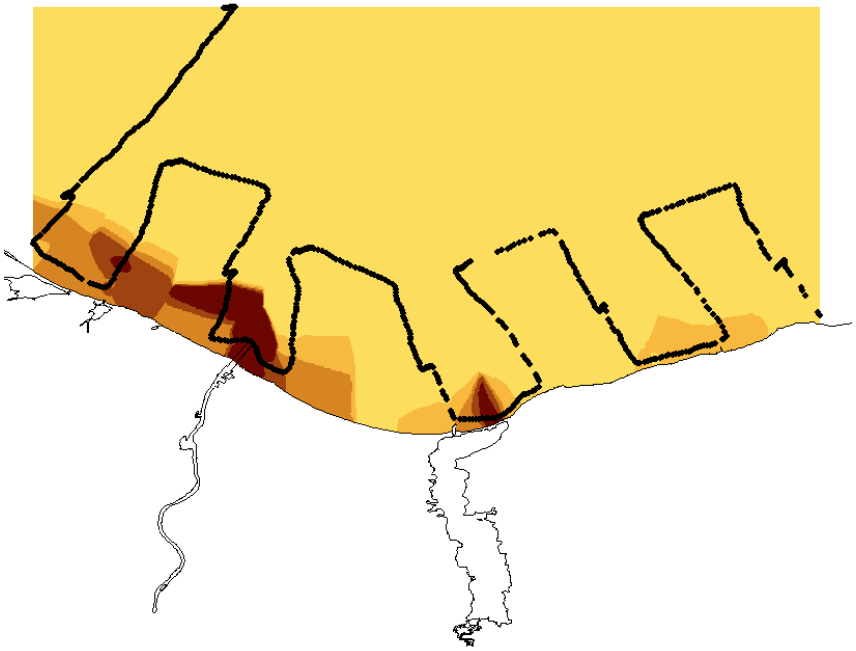


Chlorophyll-a rich blooms occurred in several areas lacking PC; these were are likely due to diatoms or green algae

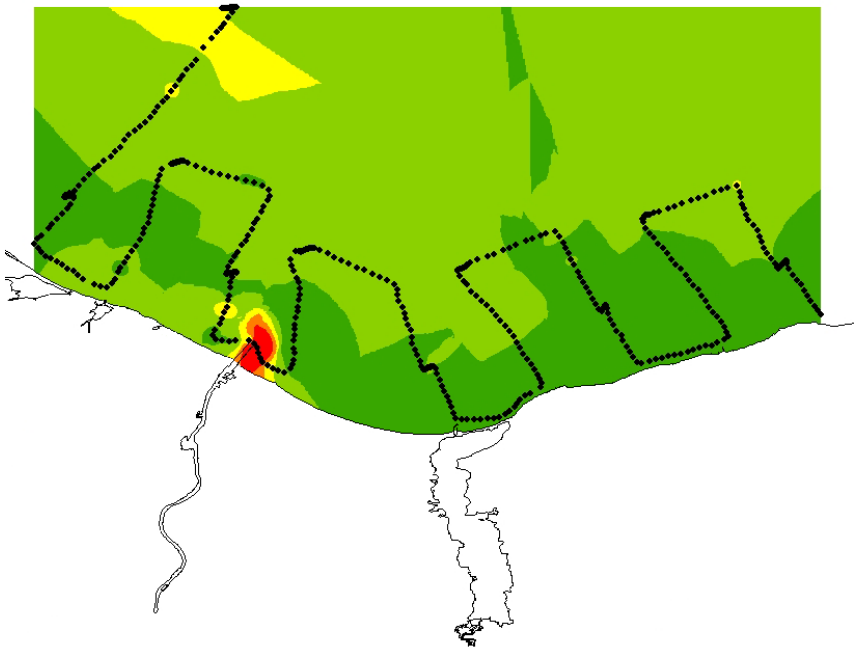
Some high chlorophyll events were associated with cyanobacterial PC

M. Pavlac et al

Very high resolution studies Genesee River (Rochester NY)



Specific Conductance



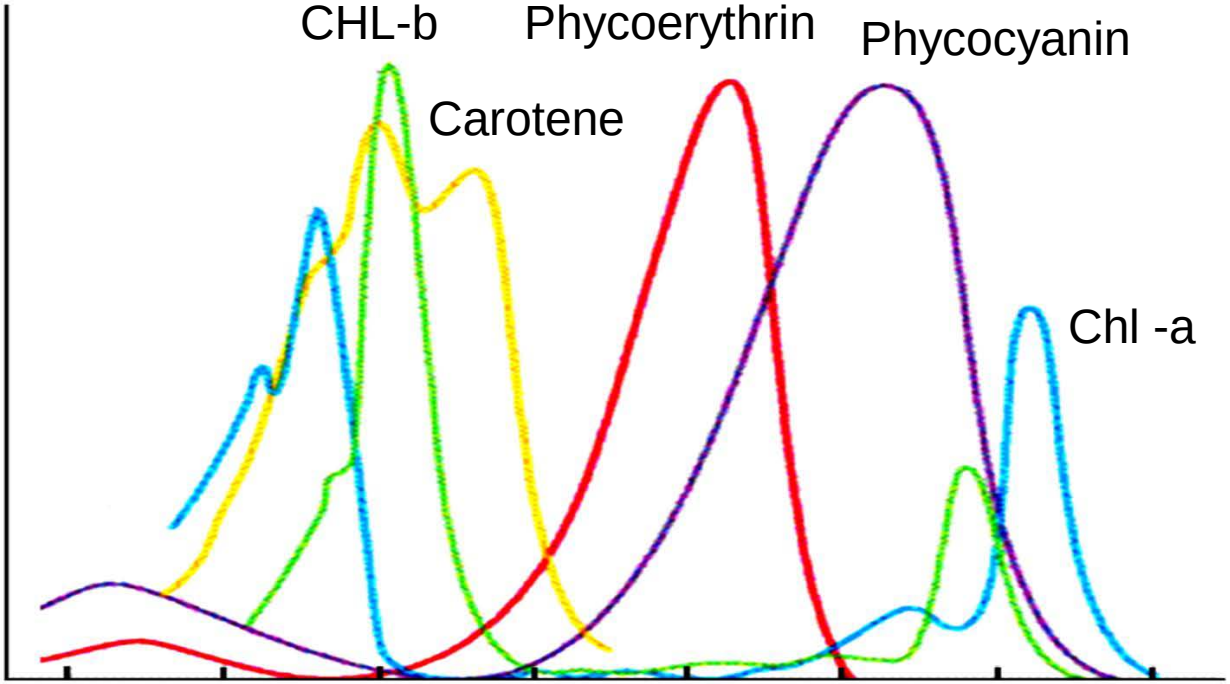
Chlorophyll

Multi-channel sensors provide even more information:

Excite at 5 different Wavelengths

Single emission

- Green Algae
- Dinoflagellates and diatoms
- Blue-green algae
  - Phycocyanin - containing
  - Phycoerythrin - containing
- Others including crytophytes
- Yellow substance correction



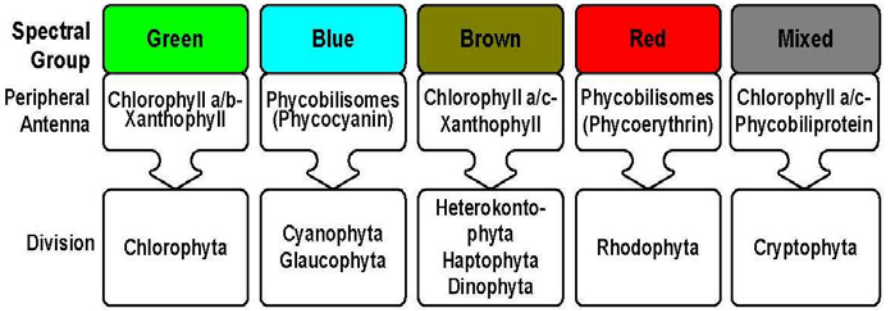
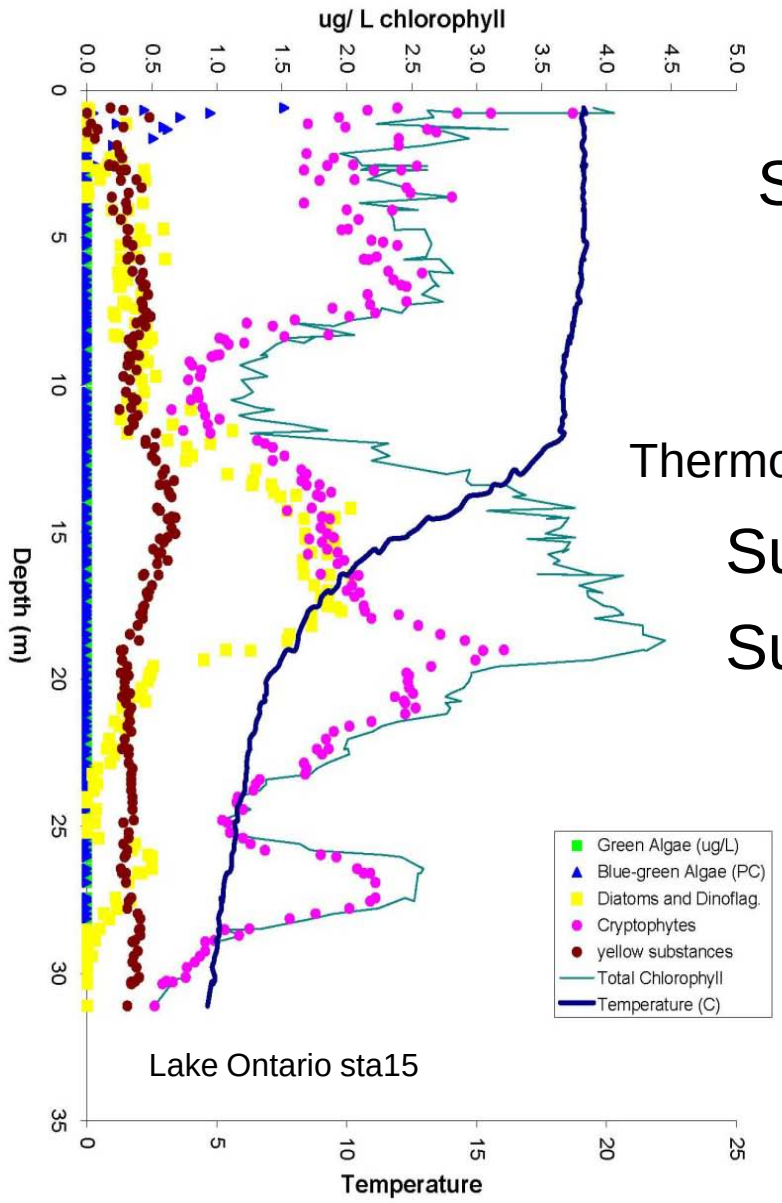


Fig. 1: Assignment of several algal divisions in spectral groups

BBE FluoroProbe



Surface Cyanobacteria bloom

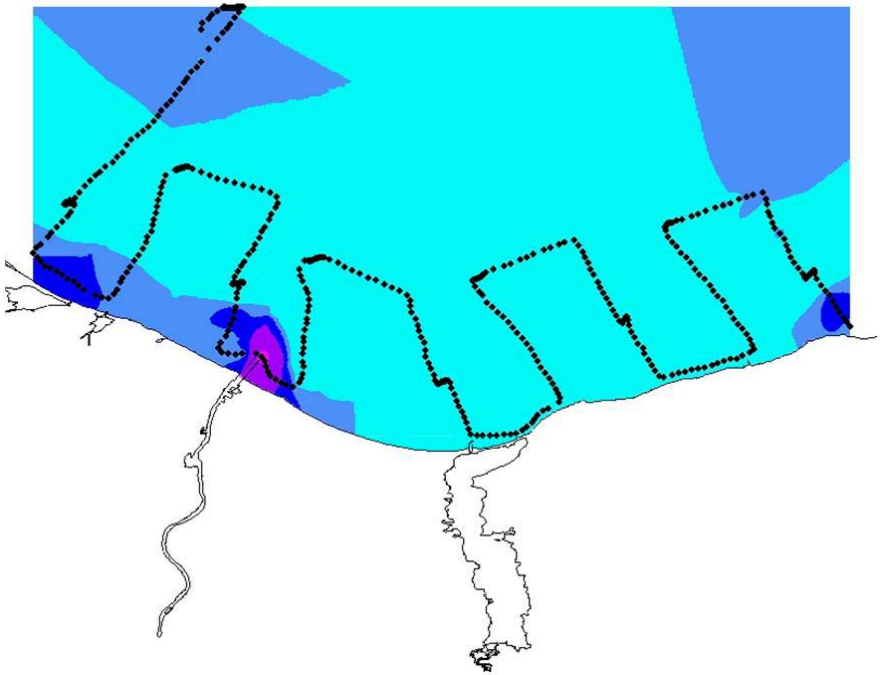
Thermocline

Sub-Surface diatom bloom

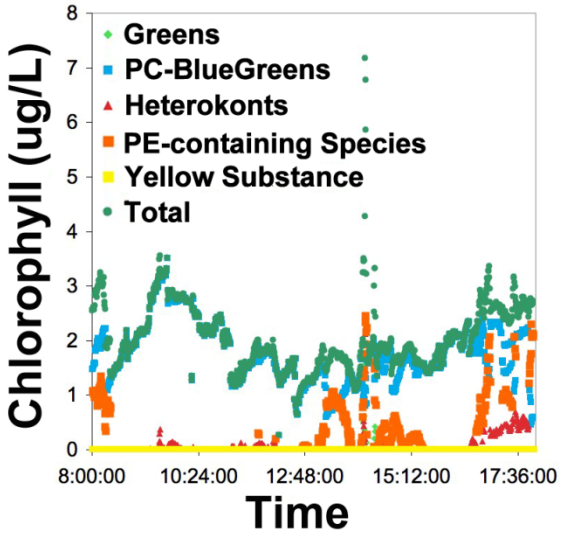
Sub-Surface PE bloom

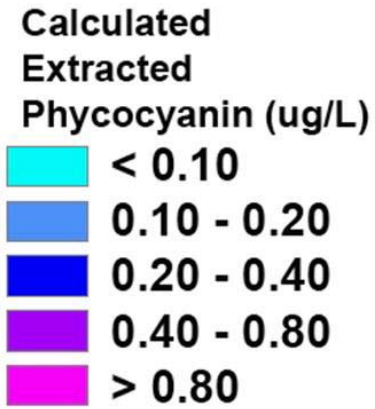
Hypolimnetic Sub-Surface PE-rich bloom

These can be installed in Ferry Box systems also…

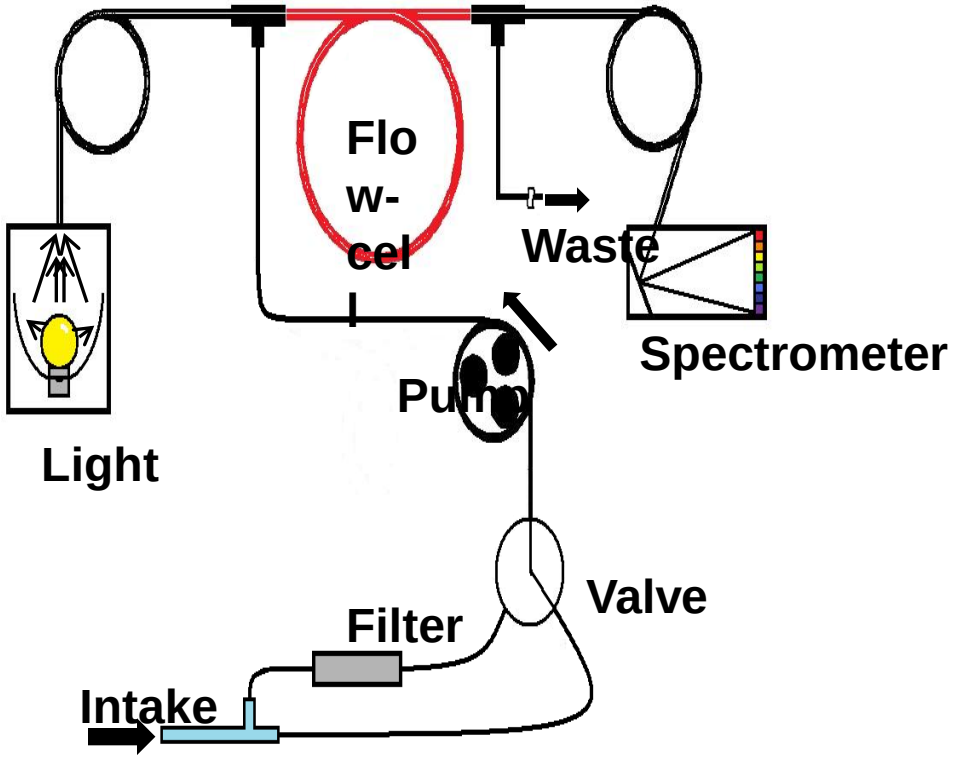


Genesee River Phycocyanin



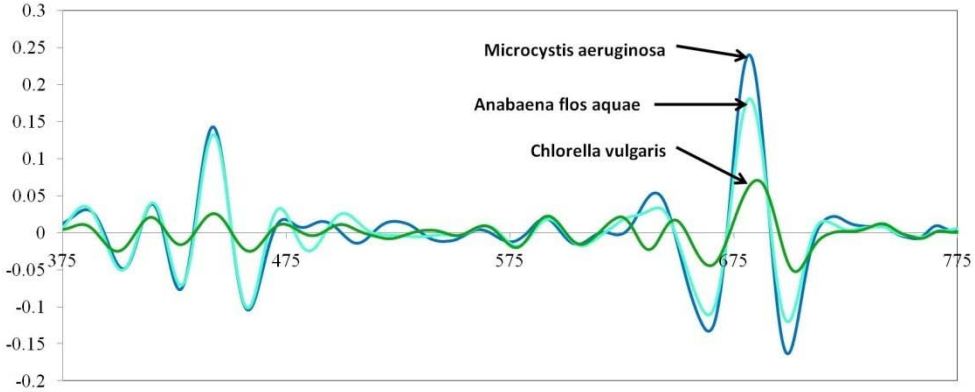


Can we differentiate at the genus level?



- OPC (aka brevebuster)
- Tuned for *Microcystis*

Figure 3: Diagram of the Optical Phytoplankton Discriminator.



Generate a similarity index based on 4th derivative spectrum

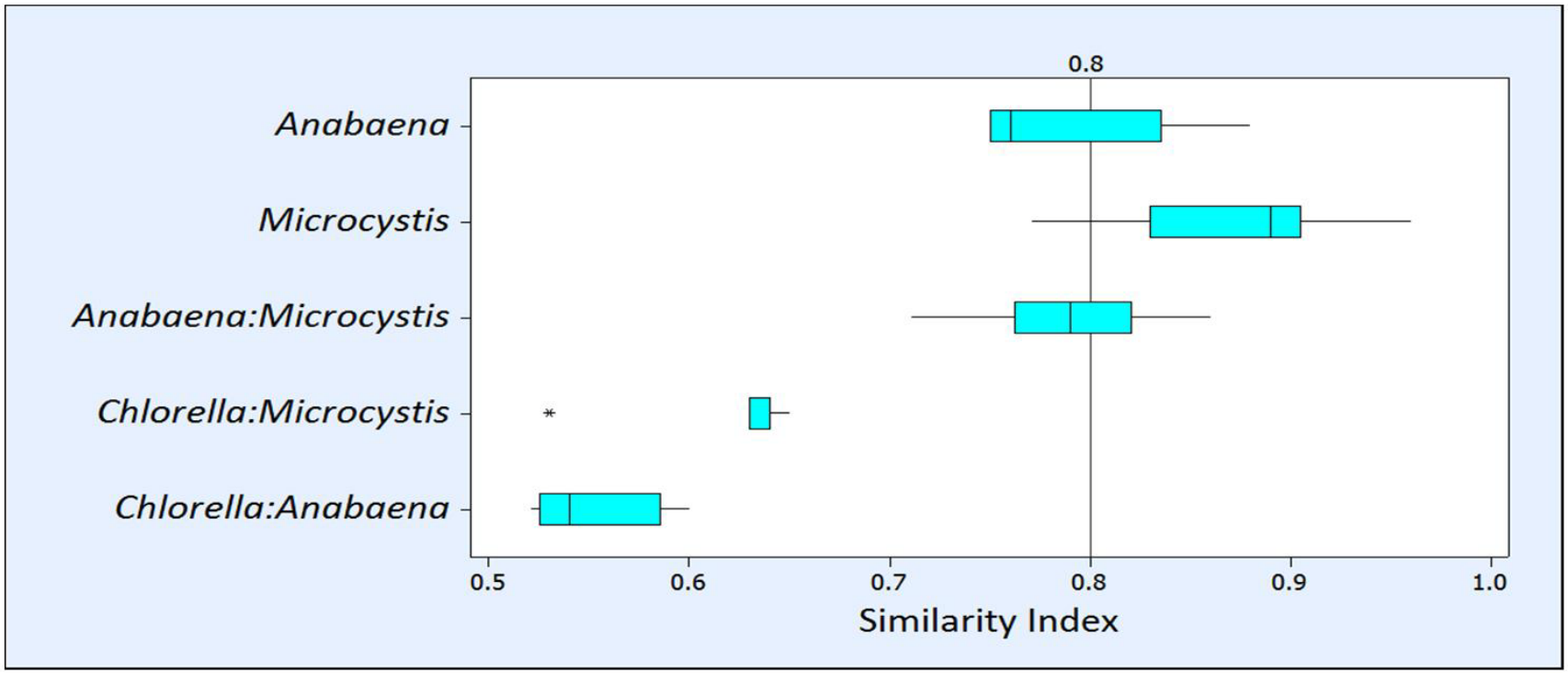
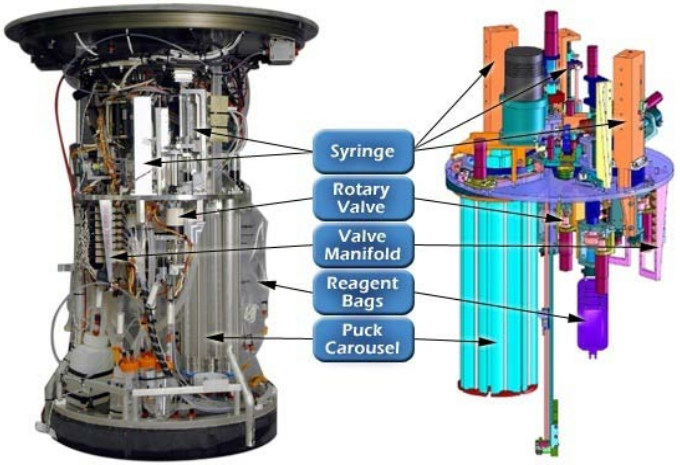


Figure 6: Similarity index results for pairwise comparisons of four *Ananabaena* strains, seven *Microcystis* strains, and *Chlorella vulgaris*.

Next generation of sensors needs to be specific for the toxins themselves….



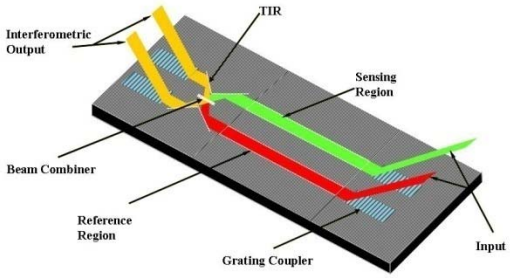
MBARI Environmental Sample Processor (ESP)

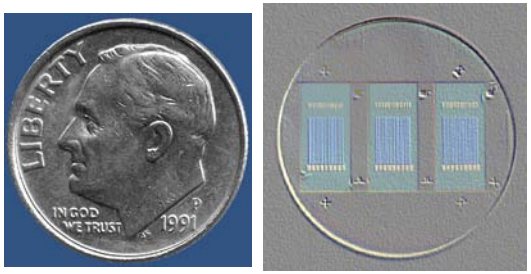
Robotic Multiprobe:
- **Species by 16S RNA**
- **Toxin by ELISA**

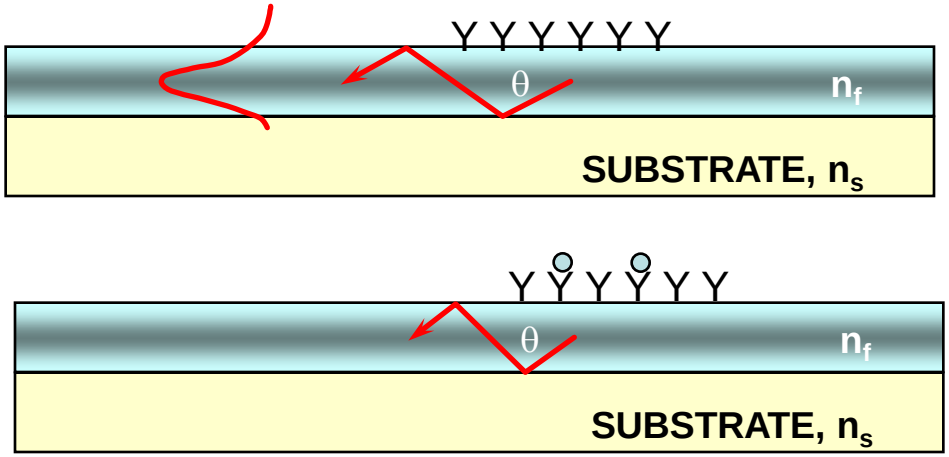
Suitable for open ocean deployment

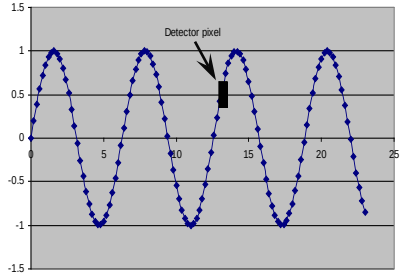
Sensor Functional Description

- **Coupled lightwave propagates inside waveguide by total internal reflection**

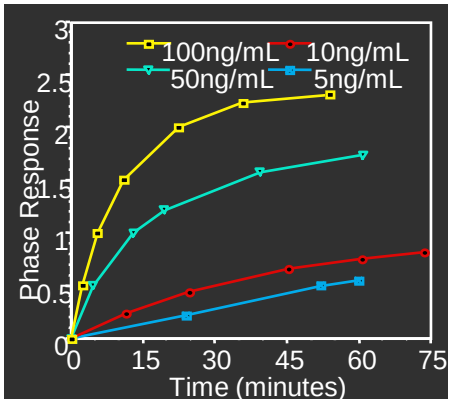








Fringe Pattern



But we have a long long way to go!

Summary

- QUALITATIVE autonomous detection of chlorophyll on buoys and boats is a here.
- QUANTITATIVE detection requires knowledge of the phytoplankton population.
- New techniques allow for detection at the family FluoroProbe) and Genus (brevebuster)
- Careful of your biochemistry!