

Harmful algal blooms threats in drinking water works and bbe products application in this field

Detlev Lohse and Tobias Boehme

Agenda

- Reviewing the algae bloom and its threats
- Algae treatment methods
- Why Cyanobacteria are a main threat to the drinking water works?
- How online measurements in different treatment process steps
- Questions and open discussion

Reviewing the algae bloom and its threats



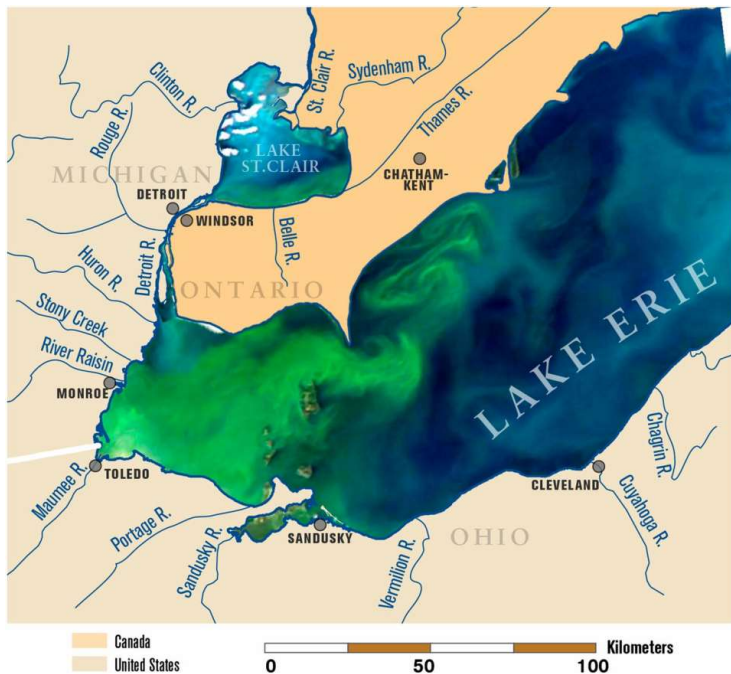
Algae blooms and harmful algae blooms (HAB)

- Production of toxins
- Become too dense, displace other algae
- Consume the oxygen in the water
- Release taste and odor compounds



Microcystis (Cyanobacteria)
= Bluegreen Algae

The occurrence of algae blooms in the different water bodies



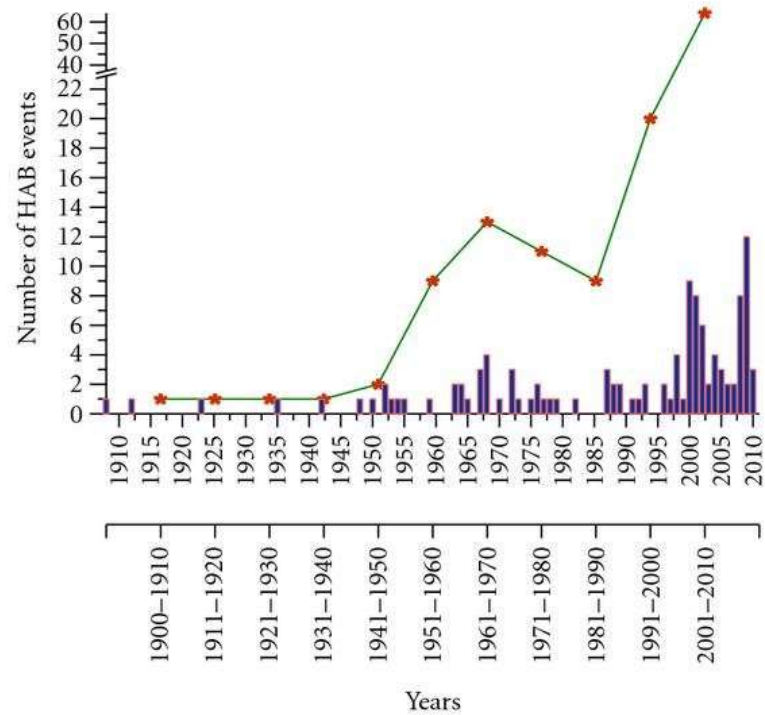
Fresh water

In the United States, cyanobacterial blooms have been found in freshwater bodies in all 50 states, Puerto Rico, and the U.S. Virgin Islands. These blooms more often occur in still water, such as lakes or ponds, but can also happen in rivers or streams. Cyanobacteria cause most freshwater blooms of public health concern.

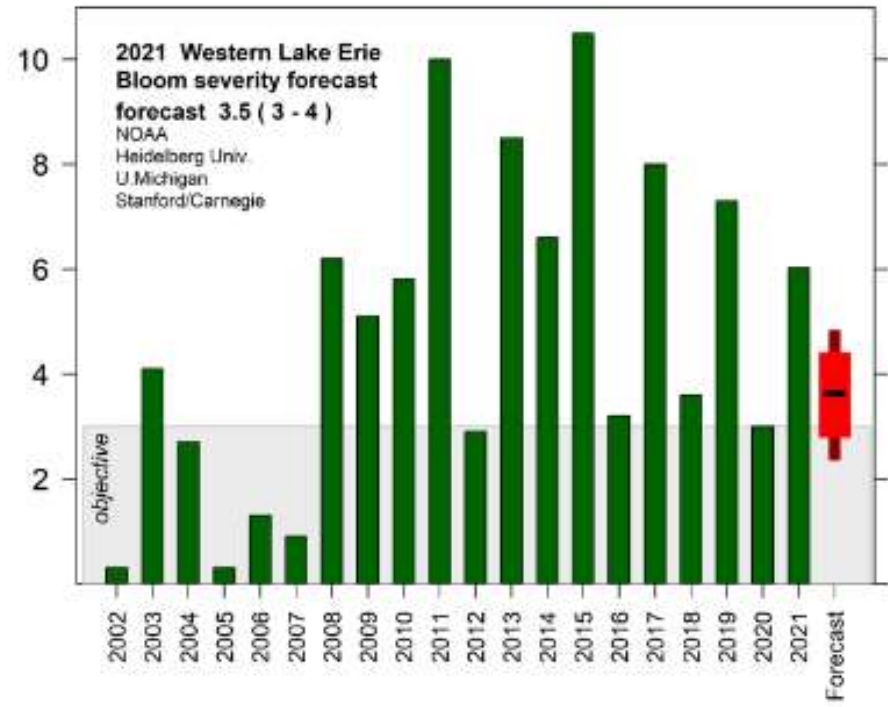
Marine water

Blooms in marine environments such as oceans and bays have affected all coastal U.S. states. They are most commonly caused by dinoflagellates or diatoms but can also be caused by cyanobacteria.

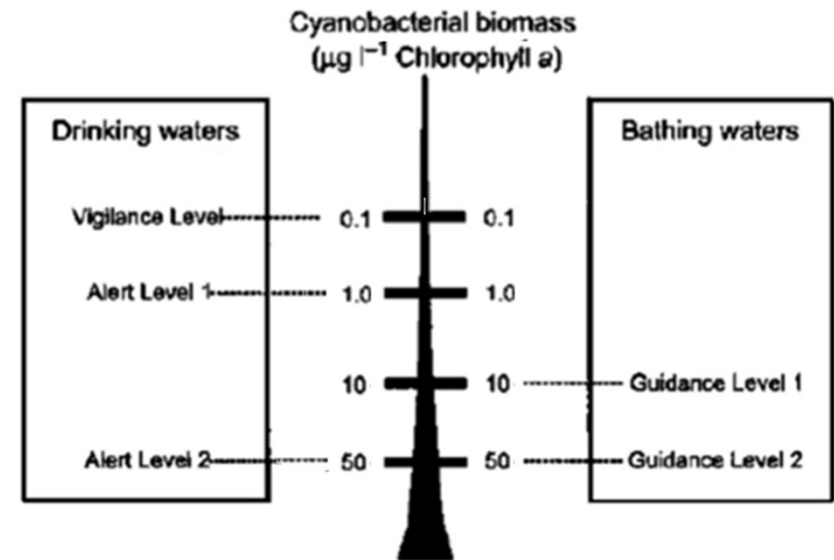
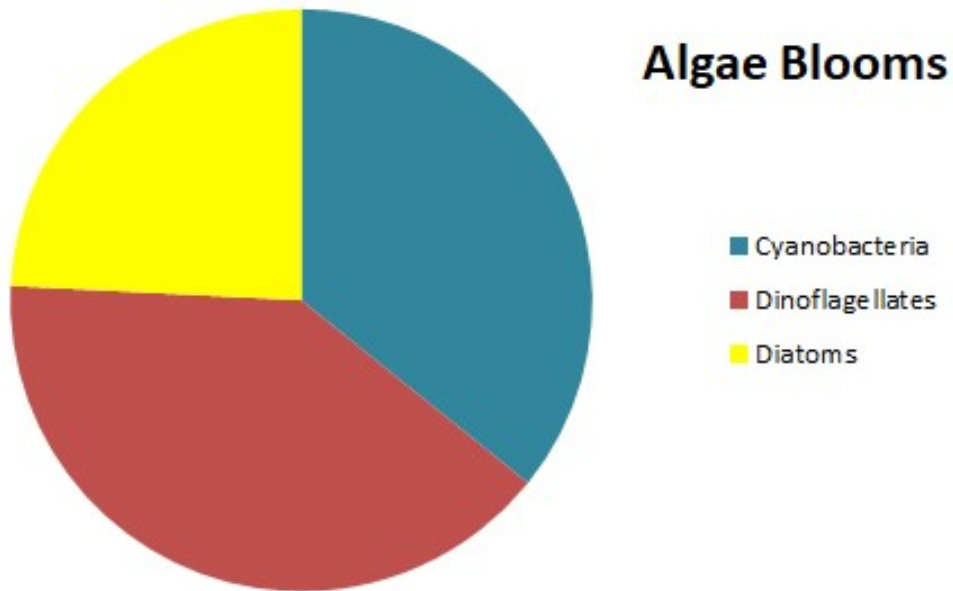
Increasing algae blooms occurrences all around the world



* * * HAB events in 10 year interval
■ Yearly HAB events



Cyanobacteria increasing problem and reviewing the international regulations and guidelines



WHO Guidelines 1998 < 1 μg Microcystin/L in drinking water



Toxins, Taste and Odor raised by cyanobacteria - what are the reasons & problems?

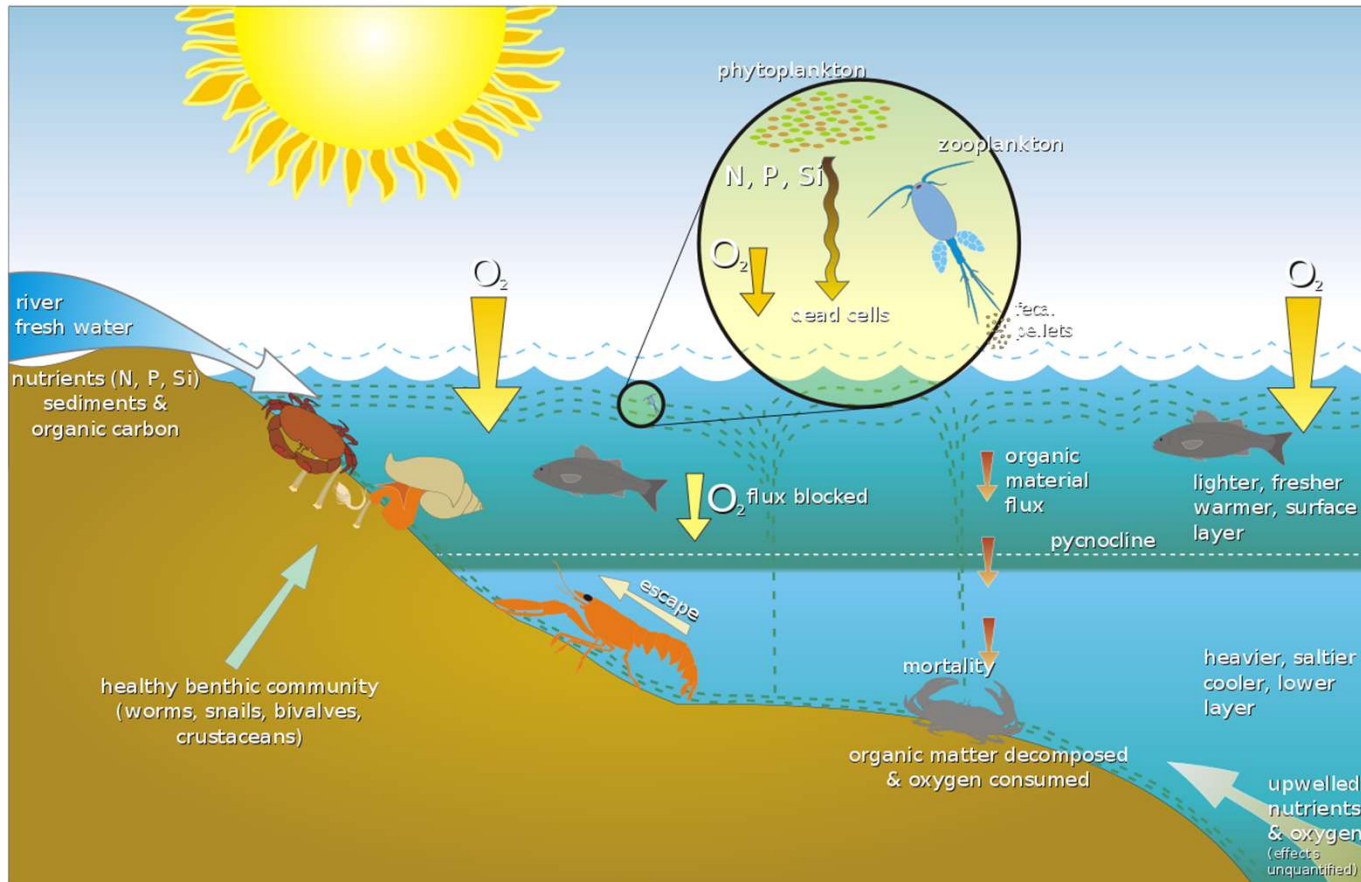
Blue-green “algae” Cell-Proliferation

- Fertilizer
- Bright sunlight
- Increased temperature

Consequences

- irreversible hepatotoxicity and tumor promoting reactions
- correlation between microcystins in drinking water and primary liver cancer
- possible connection to degenerative nerve diseases (Alzheimer’s, Parkinson’s)
- skin irritant
- unacceptable taste
- unacceptable musty odor

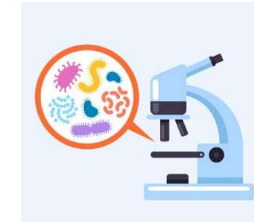
Reviewing the different algae treatment methods and common threats arise by algae



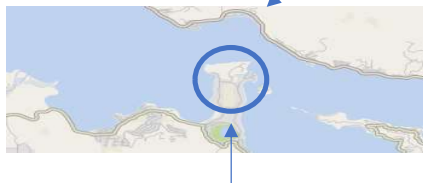
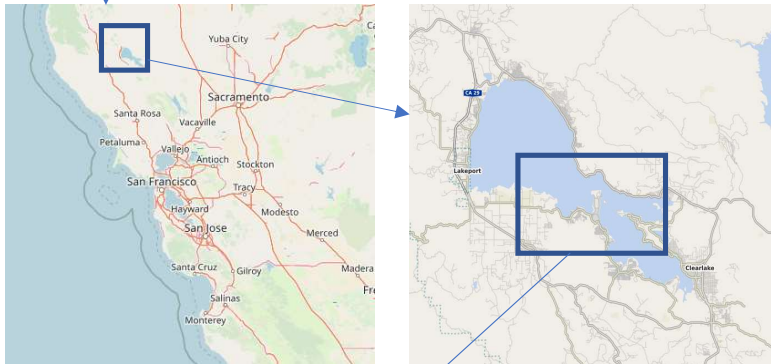
- Rivers -> nutrients suspended matter and biomass
- Air -> oxygen, dust
- Wind -> upwell -> nutrients, mod, oxygen
- Growth -> fish, benthic, Zooplankton, Phytoplankton

Monitoring and detection of the biomass

- Different Methods are available for different compounds
 - ATP, Microscope counting, HPLC, Flowcam, ..
 - Most of them are laboratory Instruments or automated laboratory instruments
- Algae are a major problem in open water
 - Fluorescence measurements is an easy way to measure the *in-situ* or *in-vivo*
 - Fluorescence is related to the phytoplankton biomass
 - The method is fast and reproducible



Water treatment plant Buckingham



Buckingham park water district



Water intake pipes
Oxidation with 12.5% sodium hypochlorite



2 pressure filters (anthracite and sand) run parallel.



Coagulant for sedimentation in tank

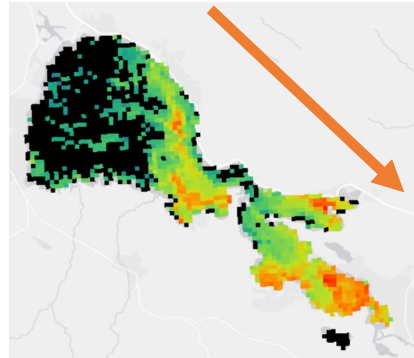


Monitoring with a bbe PhycoLA at different treatment steps

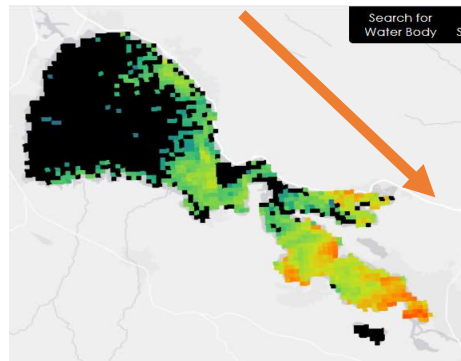
Beta version of Satellite determination



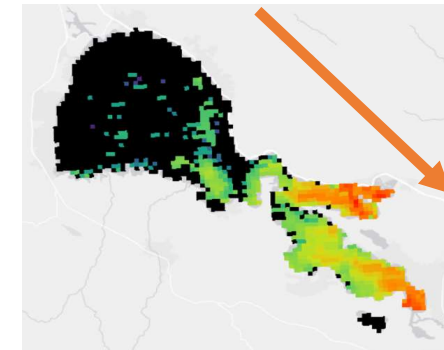
30.07.2019



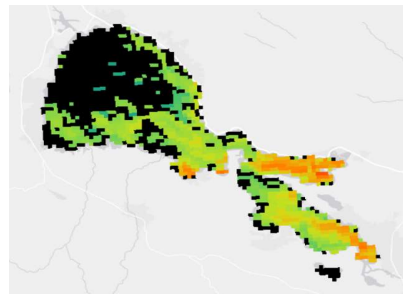
06.08.2019



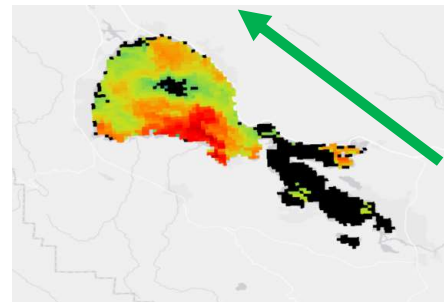
11.09.2019



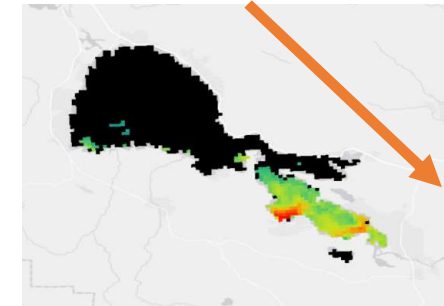
16.09.2019



23.09.2019



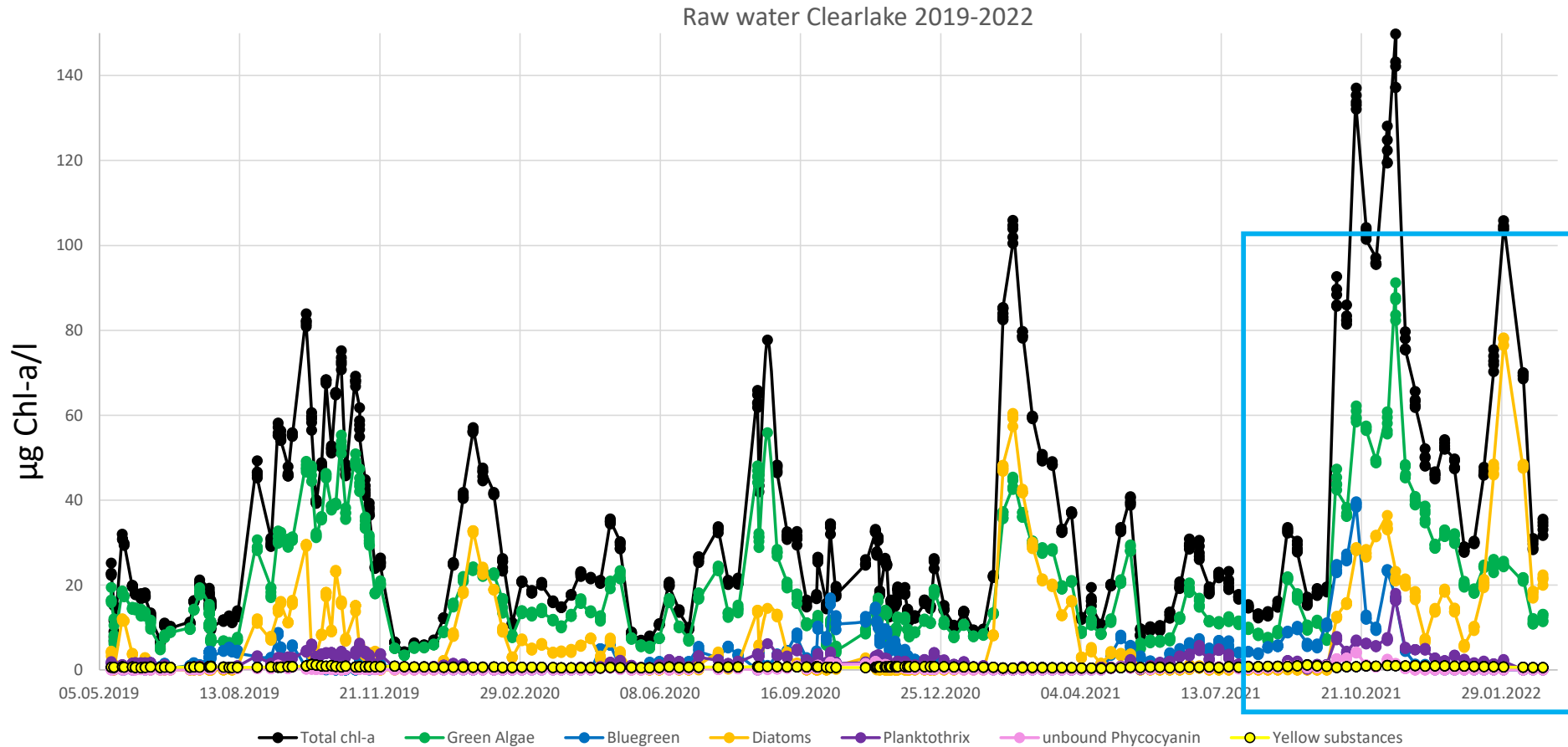
28.09.2019



<https://fhab.sfei.org/>

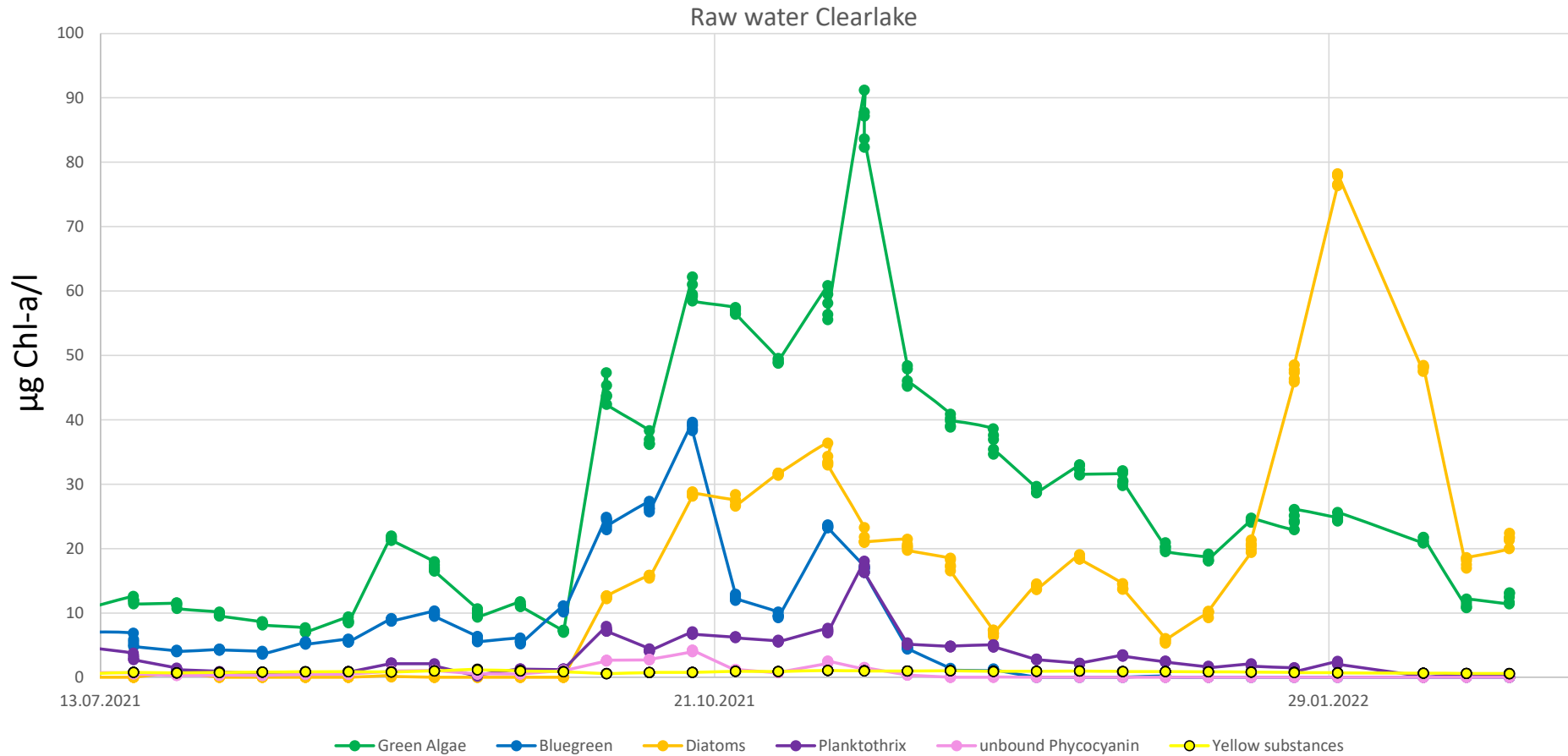
Main wind direction from north/west

Case study: Variability of two years algae composition data at Buckingham Clearlake (USA)

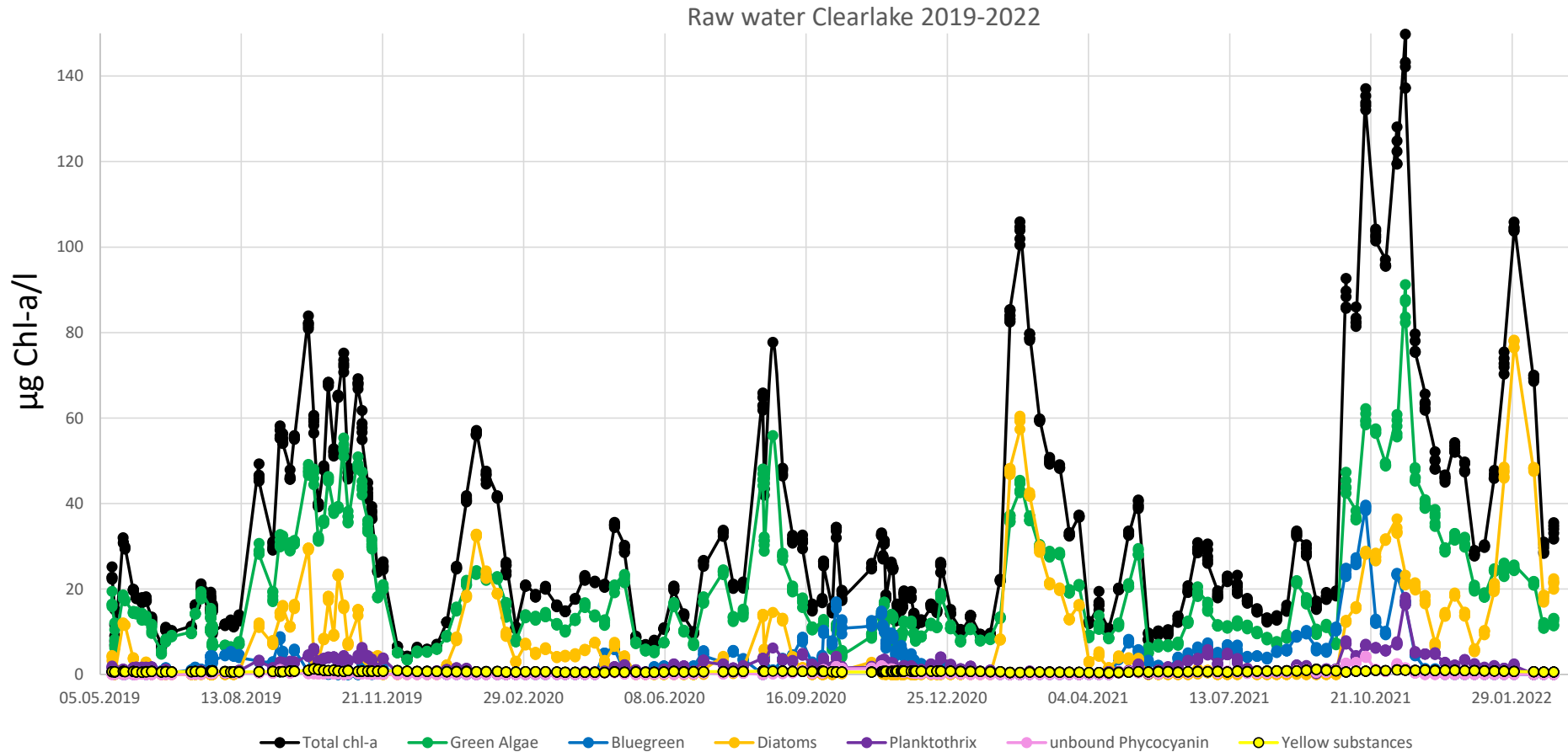


Thanks to Will Rae Buckingham Park Water District, weekly dataset measured with a PhycoLabAnalyser

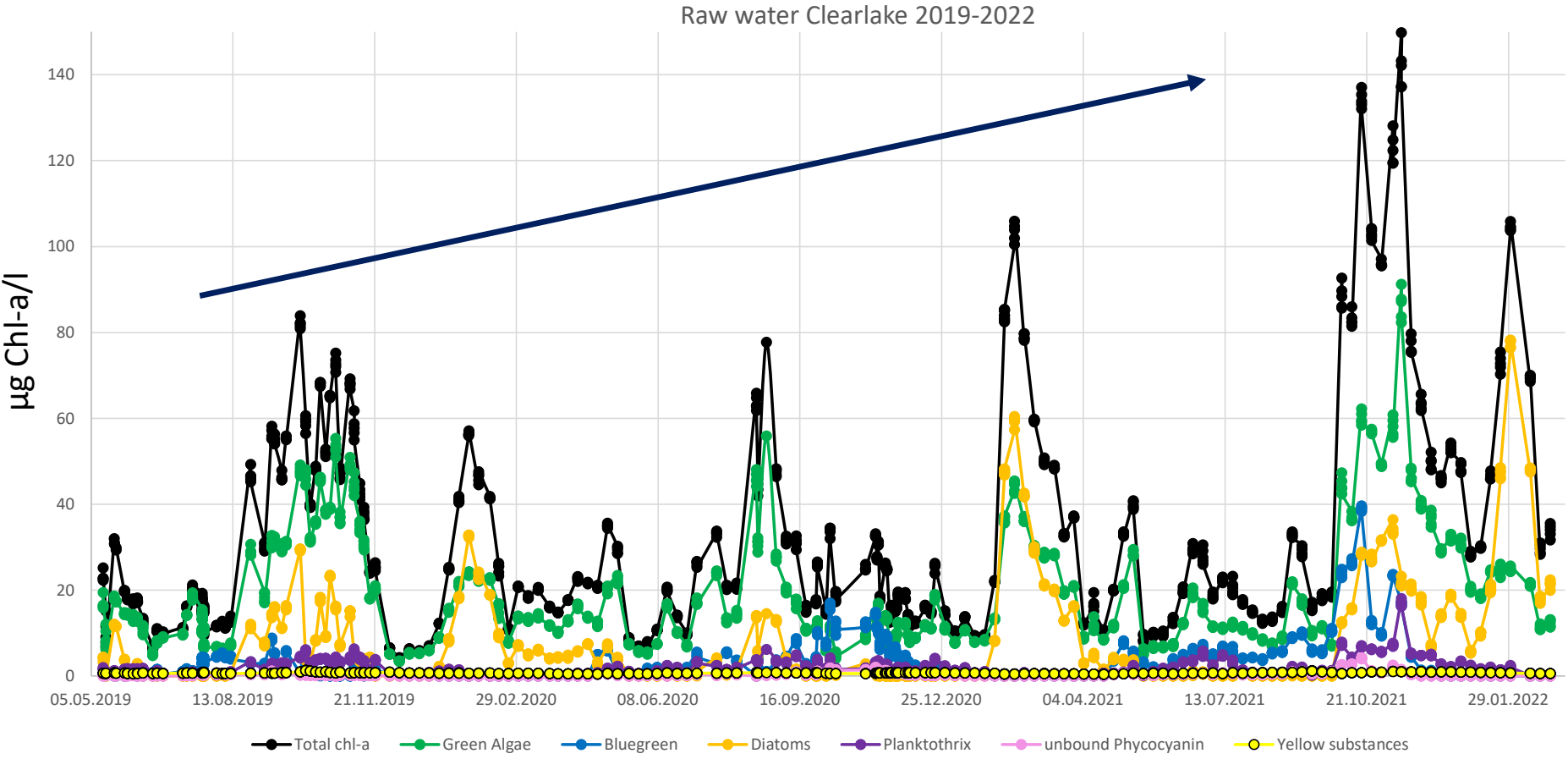
Measured algae composition



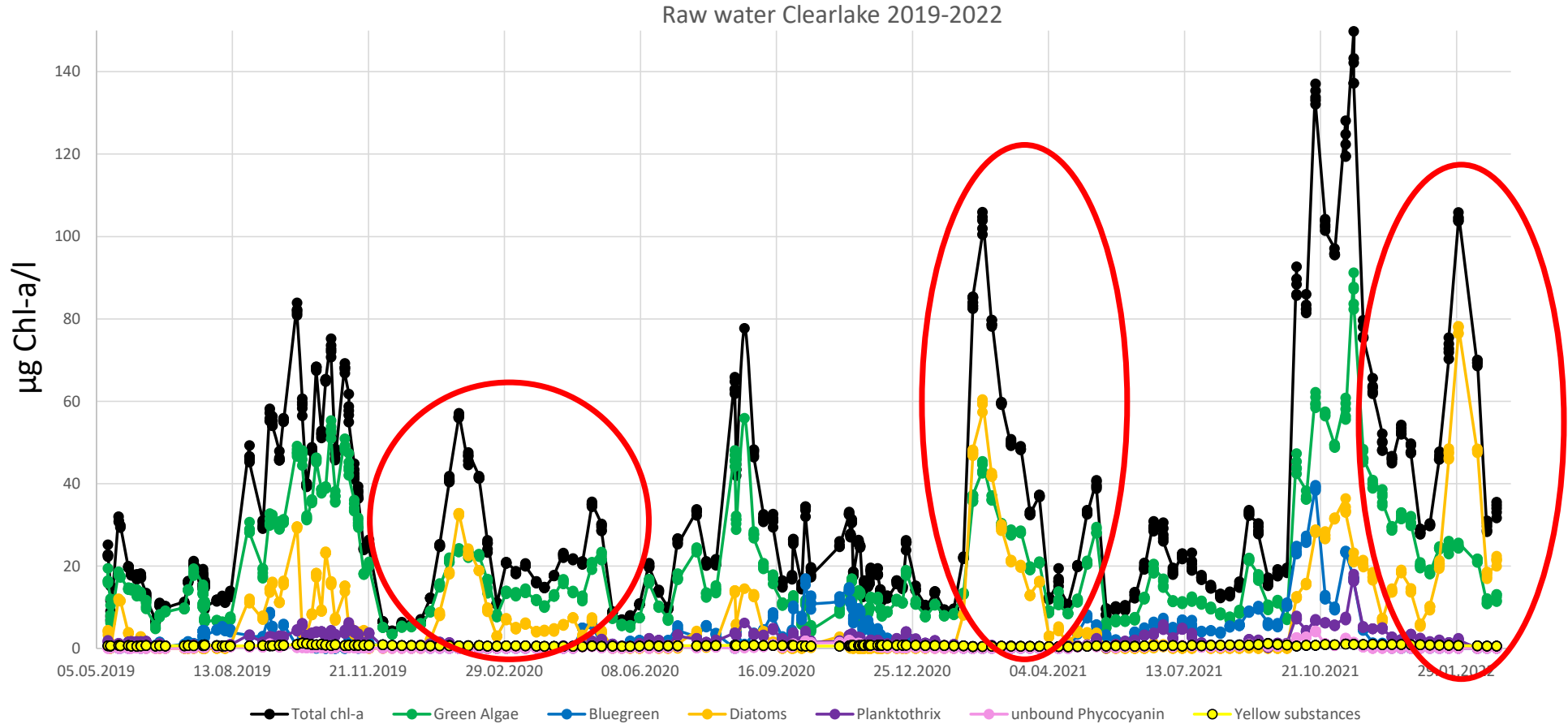
Variability of two years algae composition data at Buckingham Clearlake (USA)



Increase of all of algae classes over 2.5 years

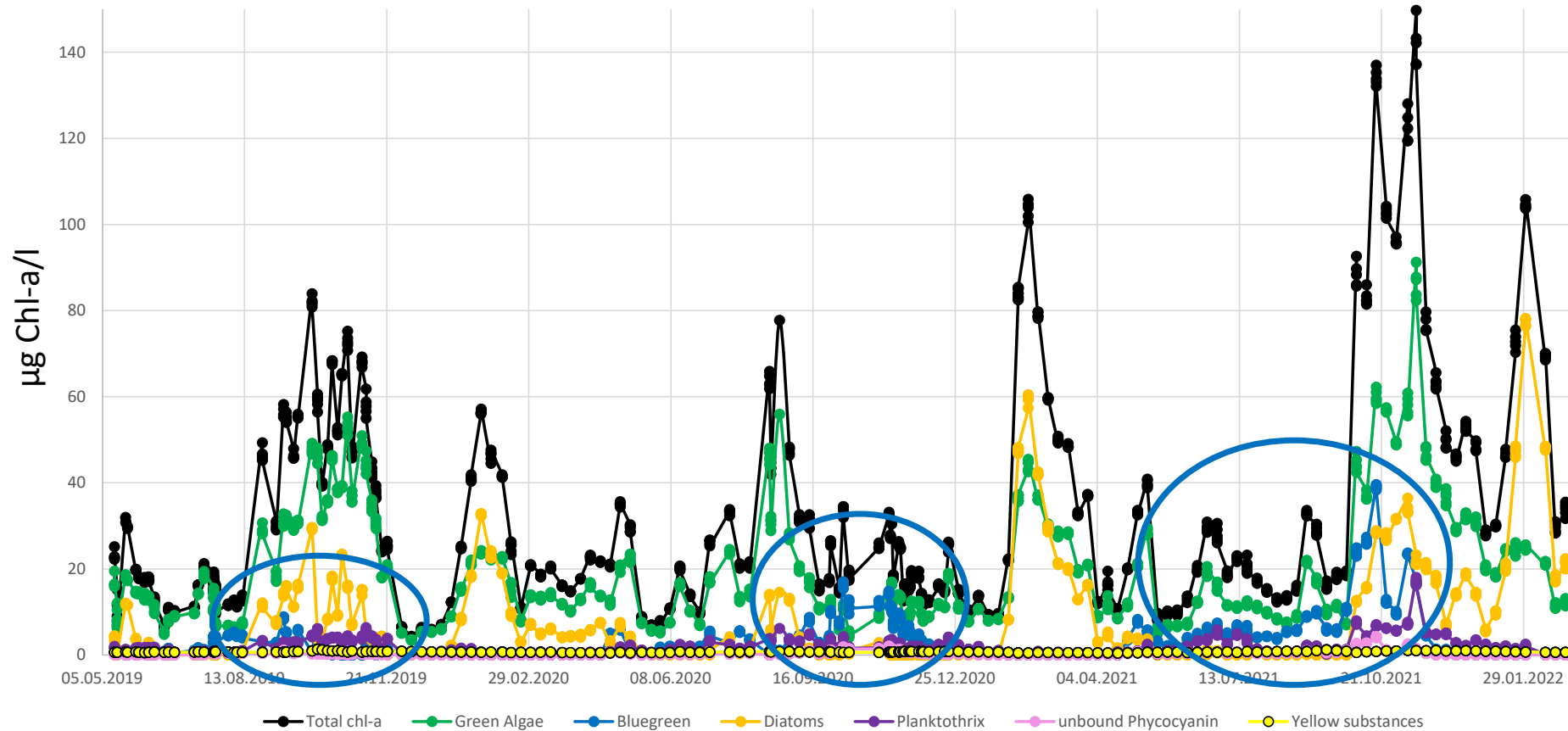


In spring the diatoms and green algae dominate

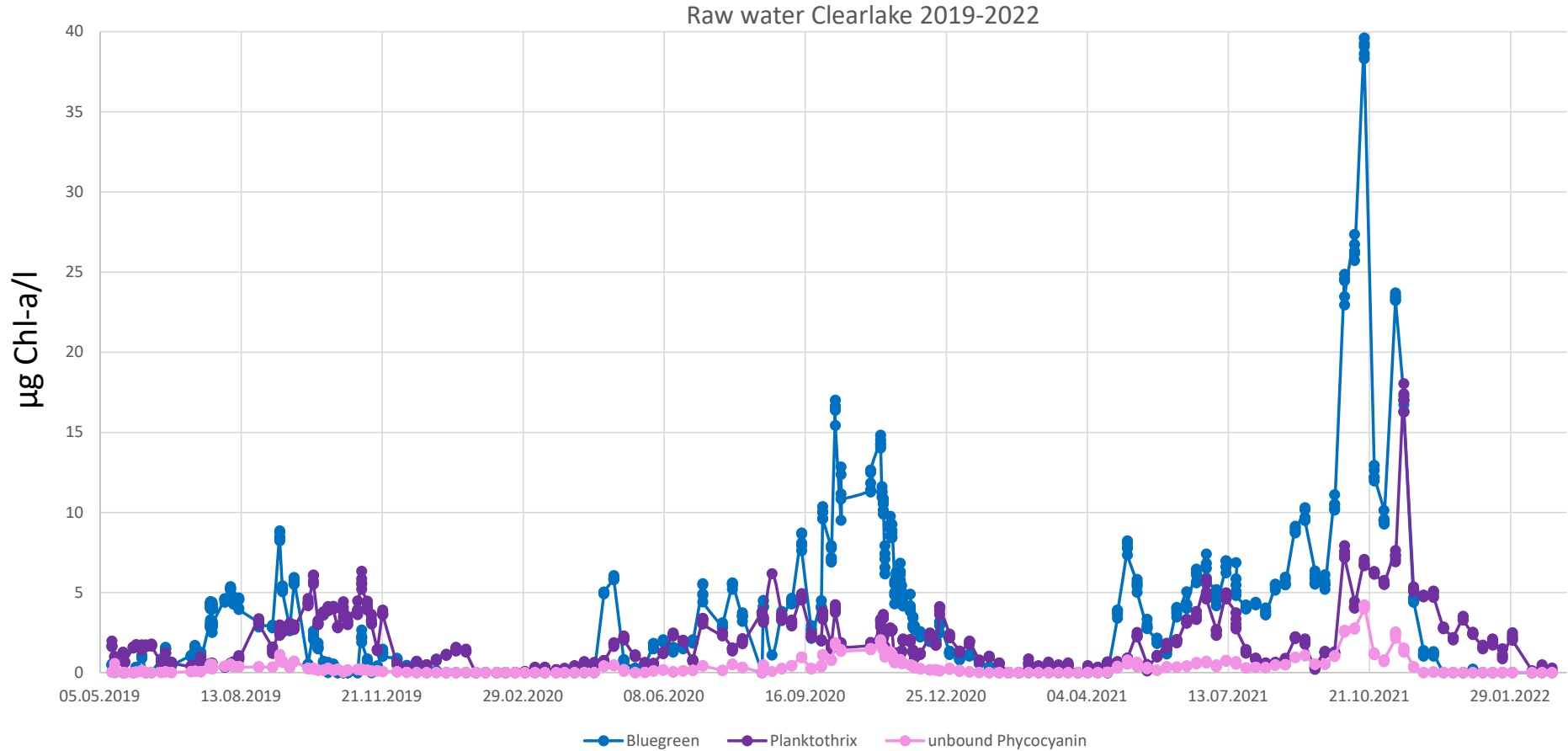


In autumn the cyanobacteria dominate

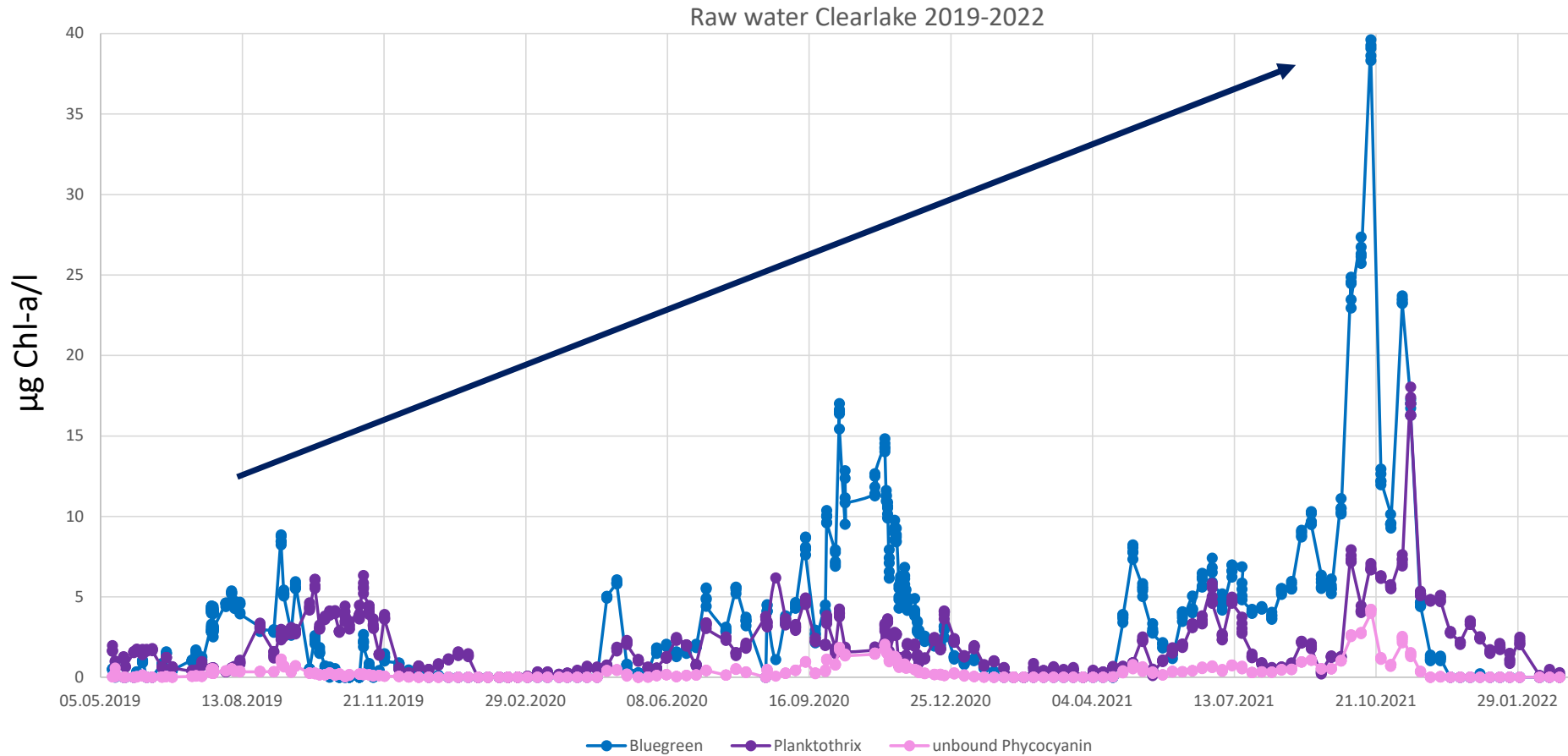
Raw water Clearlake 2019-2022



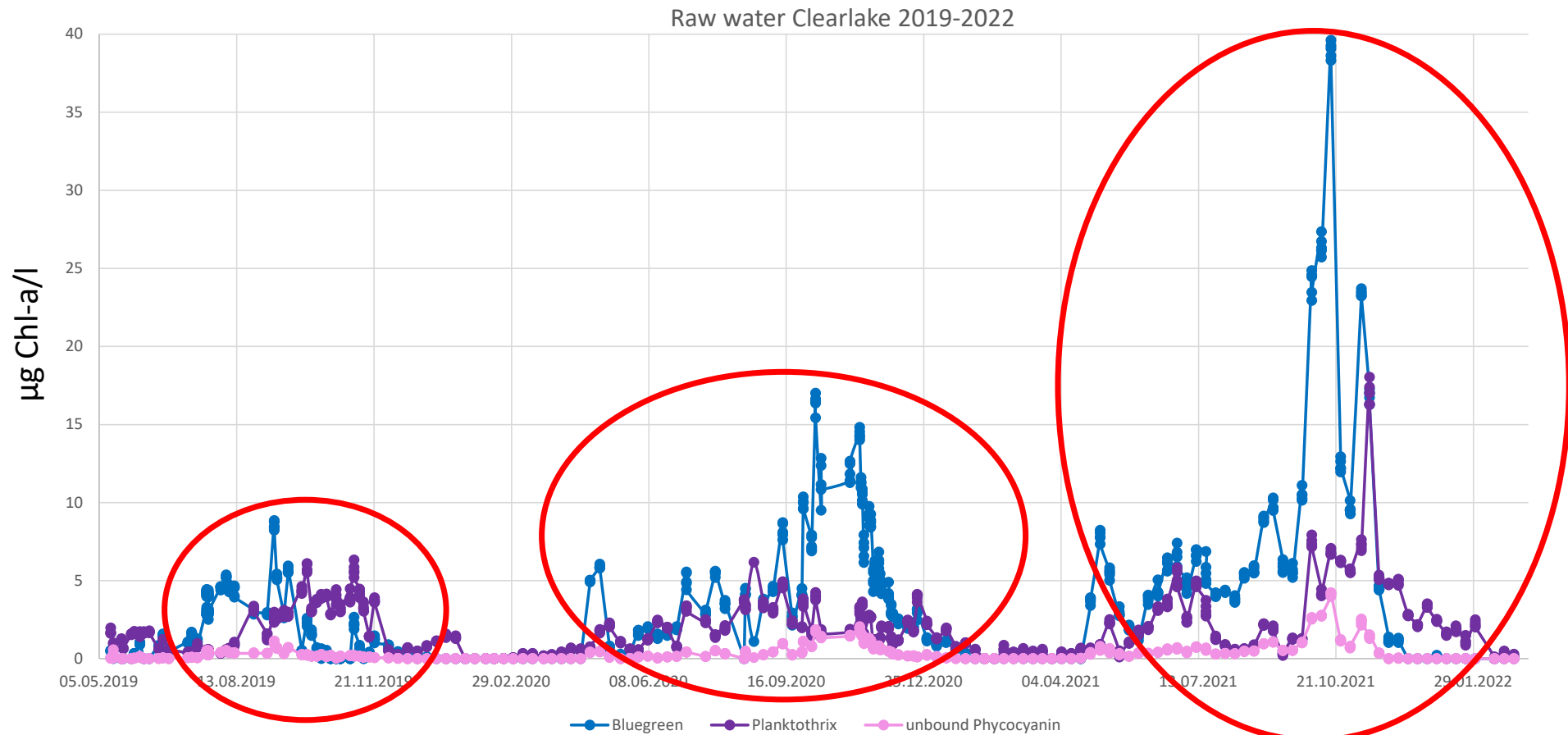
Variability of the cyano bacteria (blue green) and unbound Phycocyanin



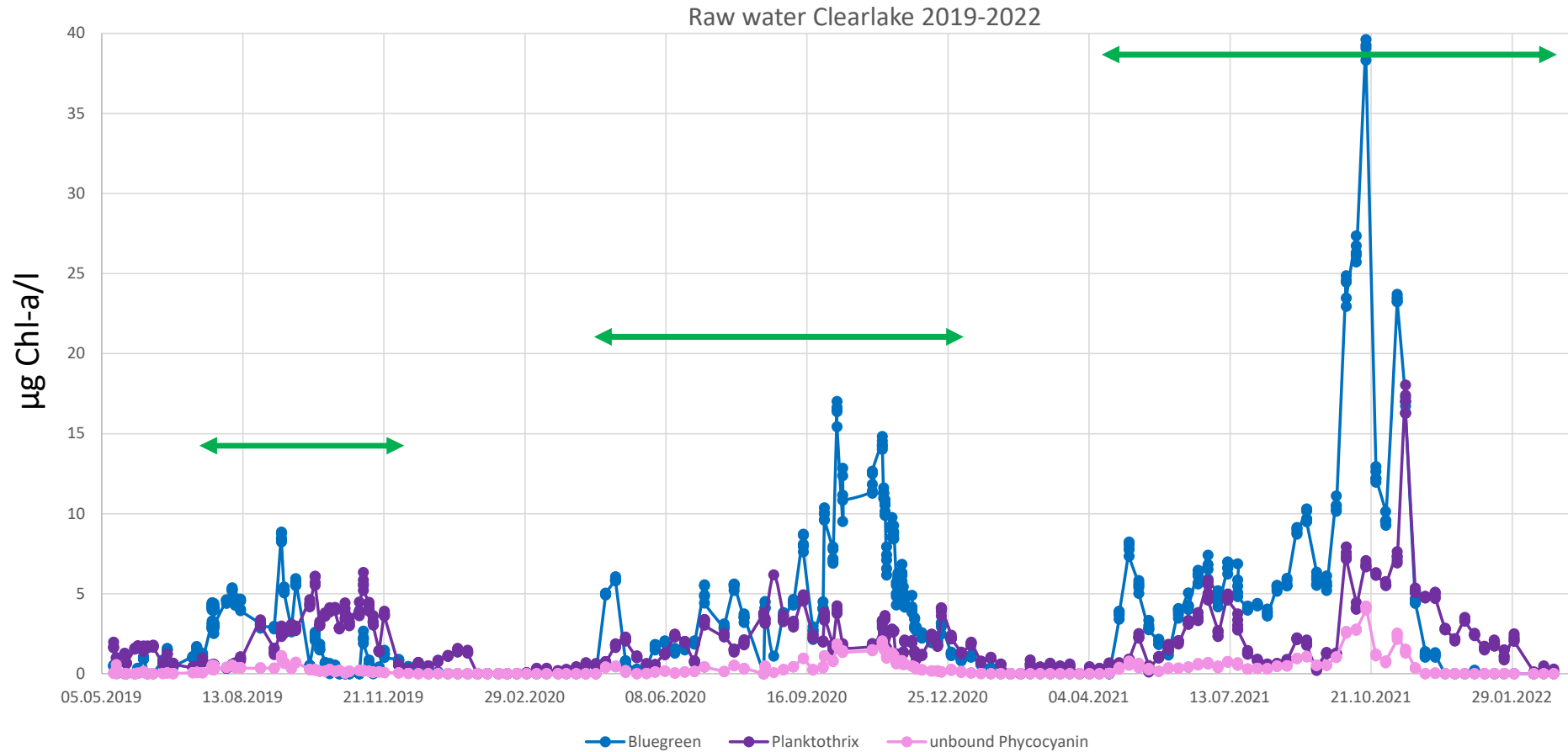
Dramatic Increase of cyano bacteria over 2.5 years



In autumn the cyanobacteria dominate



The duration of the cyano blooms gets longer



Common algae treatment methods and some disadvantages

- Chemical treatment of cyanobacteria
- Ultrasonics
- Water circulation
- Skimming
- Removal of fertilizer



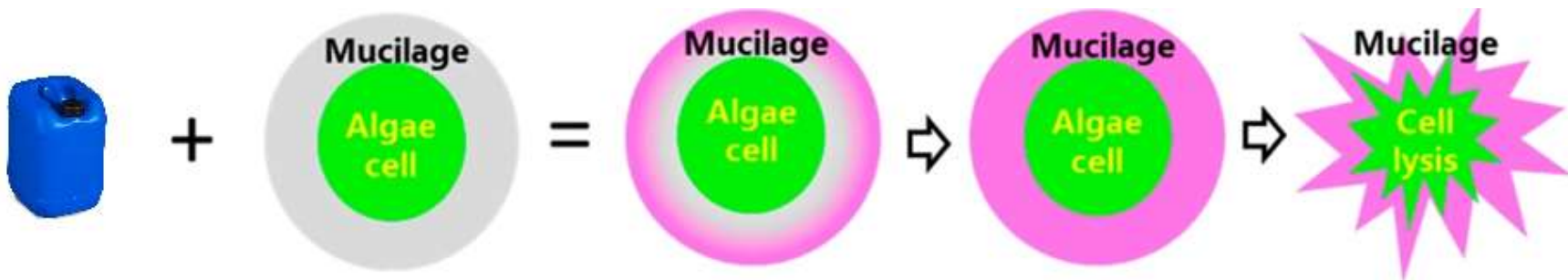
hydrogen peroxide Adelaide



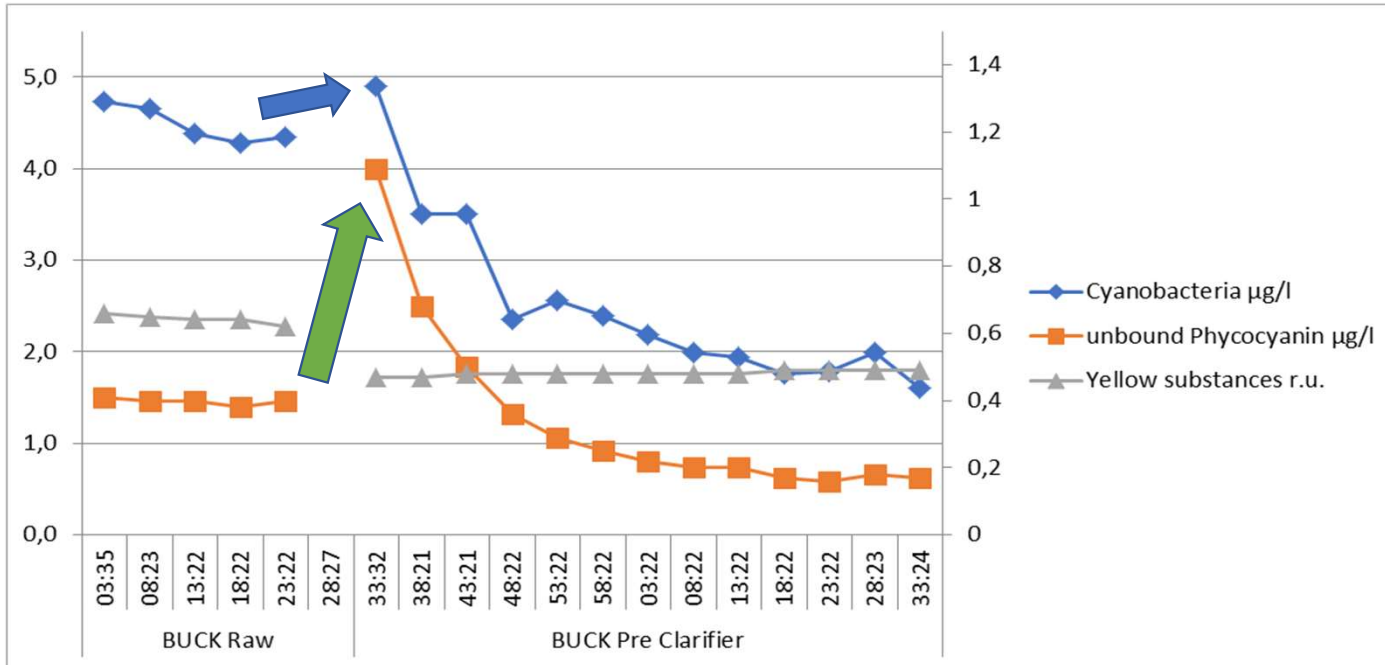
aluminum sulfate Plymoth US



ultrasonic transducer



Using Disinfectors like chlorine oxidizers like Ozon (releasing the toxins, cell lysis)



Microcystine analyses show high values at Buckingham (Microcystin)

Measurements: Karola Kenedy

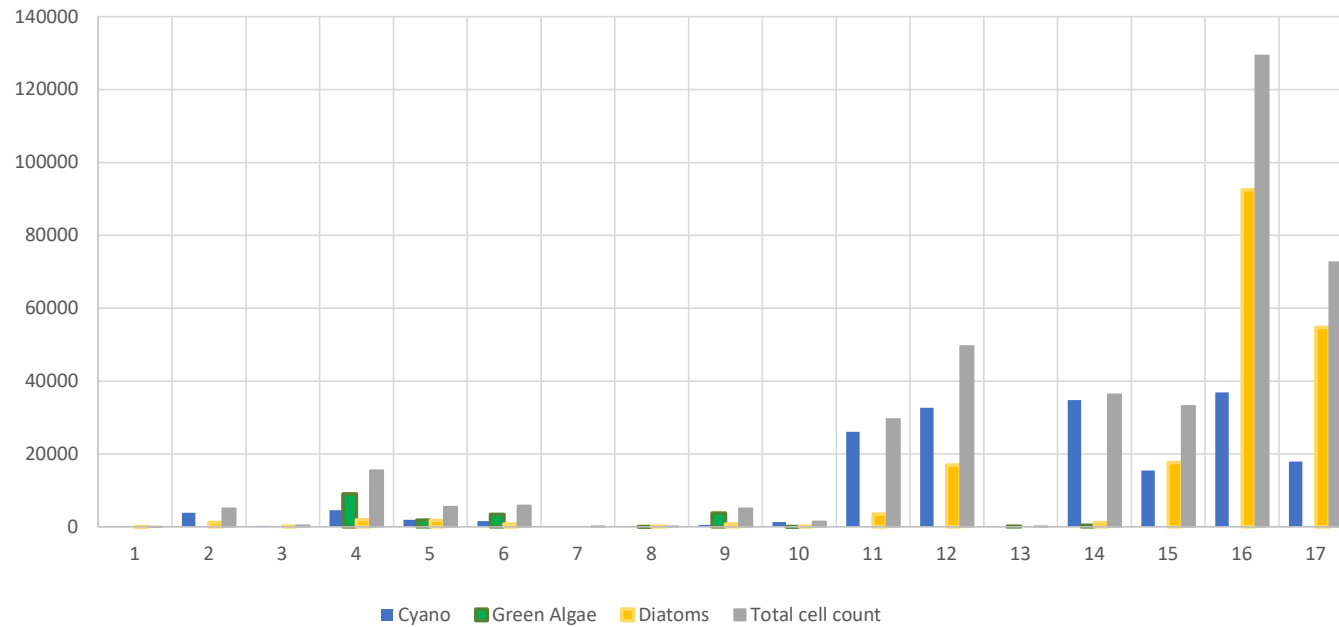
- Oxidation with 12.5% sodium hypochlorite
- Cyanobacteria affected by clarifier, decrease over time
- Dramatic increase of free phycocyanin caused by application of clarifier, possible release of toxins

Sand filter monitoring using the BenthosTorch in the Peru



Results of the sand filter monitoring using the BenthosTorch in the Peru

BenthosTorch measurements ($\mu\text{g Chl-a}/\text{cm}^2$)



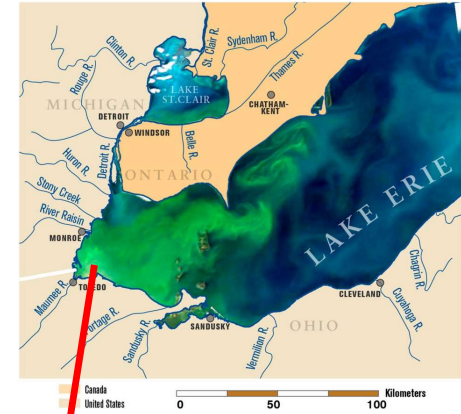
Benthic Algae at the walls and Sand filter as indicator to change the sand

Why Cyanobacteria are a main threat to the drinking water works?

- Pass filter elements
- Soluble biotoxins in ppb and ppt range
- Cyanobacterial toxins are invisible, taste and odorless
- High toxicity, both acute and chronic effects
- Detection needs sophisticated laboratory equipment or laborious observation
- Online biotoxin monitoring not available
- Costly counter measurements

The Toledo Water Crisis

On August 2nd, 2014, residents of Toledo, Ohio **awoke to urgent warnings not to drink or use their tap water**. Half a million people were unable to drink their water, cook with it, or brush their teeth. The cause? Toxins from a harmful algal bloom growing in Lake Erie entered the water supply system.

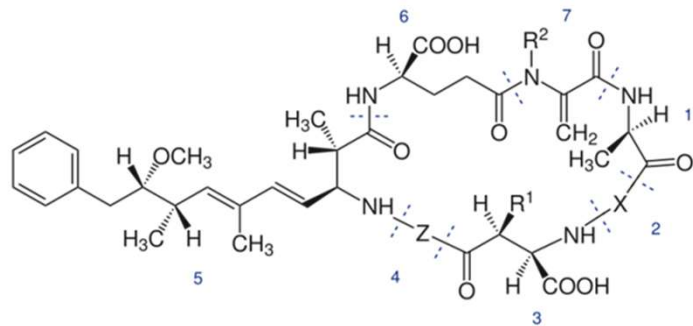


Normal situation

after the HAB event

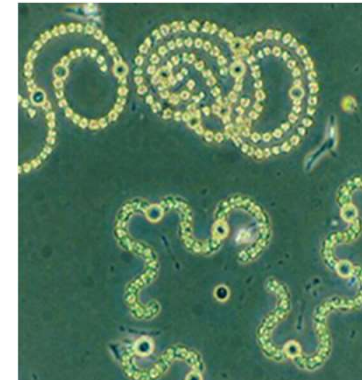
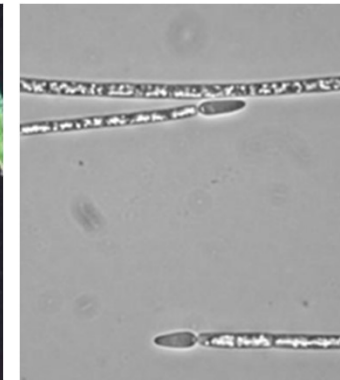
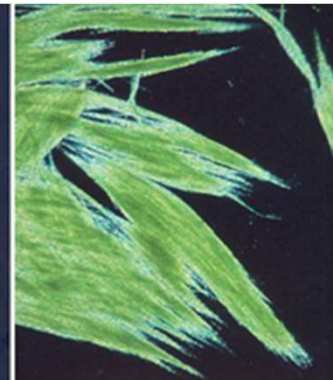


Cyanobacteria and their toxic compounds



Microcystis aeruginosa

Microcystins
Nodularins
Anatoxin A - Very Fast Death Factor



Case study of Solingen Waterwork in Germany



17,9 Mio. inhabitants (2020)

2,2 Mio. m³/day total

North Rhine-Westphalia



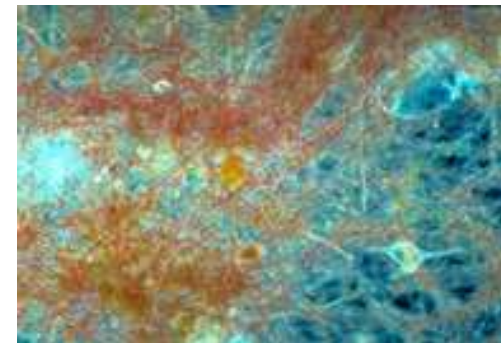
Recreation area and drinking water reservoir



Drinking Water dam



20 ha, 2,8 Mio. m³ maximum **depth 36 m**
Massive dam with towers for extraction
Dog died drinking the water from the lake



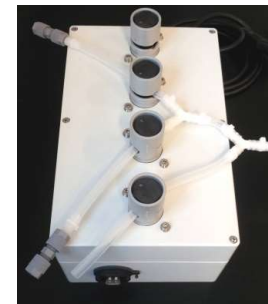
Planktothrix rubescens

Uninterrupted Monitoring at the Waterwork



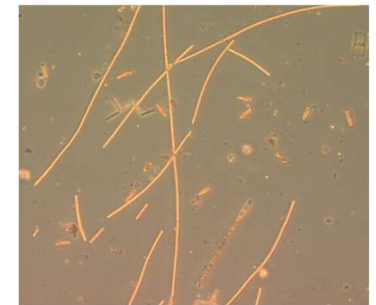
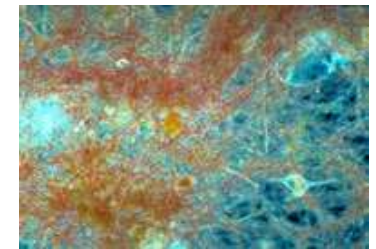
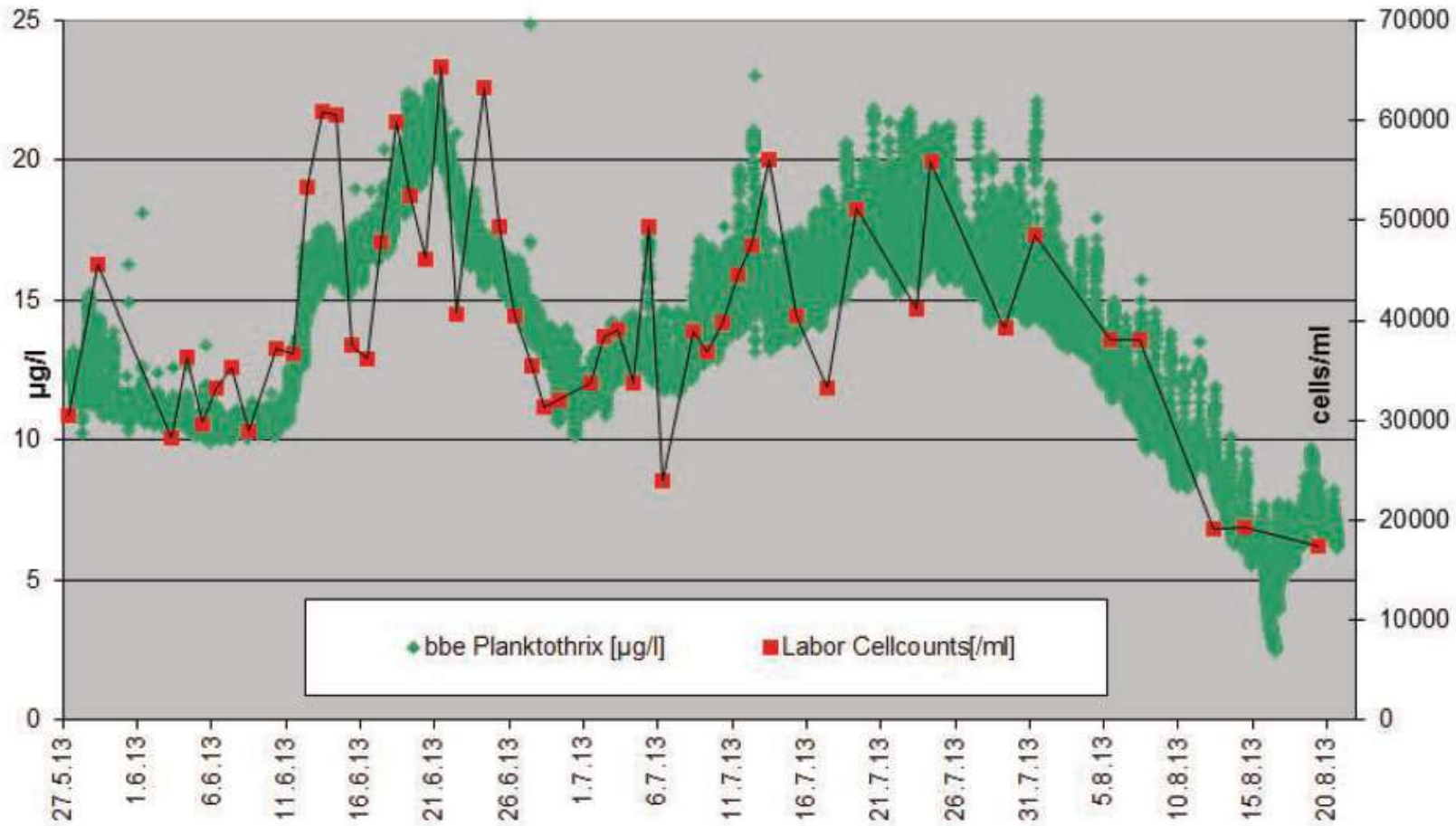
24/7 online detection with alarm levels for all algae classes

- AlgaeOnline analyser at the waterworks Glüder



- Valve system to measure different treatment steps

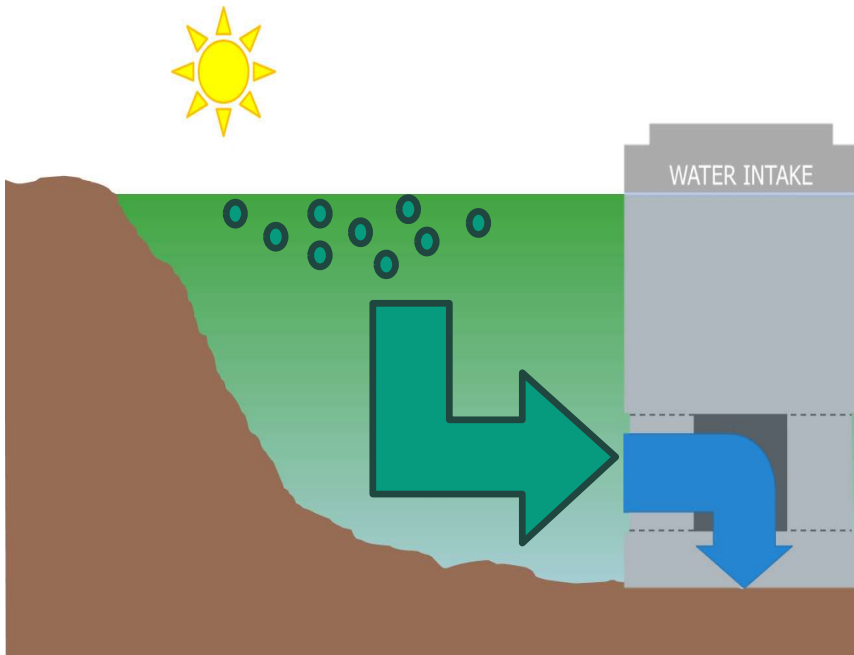
AlgaeOnlineAnalyser versus Cell Counts



Planktothrix rubescens

Difficult to count a filamentous building algae

Water intake of water works often at optimal depth



The algae composition is strongly depth dependent



FluoroProbe
for depth profiling



Wiper

ADD-ON Options



Dissolved Oxygen



Multi Parameter (DO, C, pH)



Cuvette extension

Depth distribution of *Planktothrix rubescens* and total Algae

08.06.2014

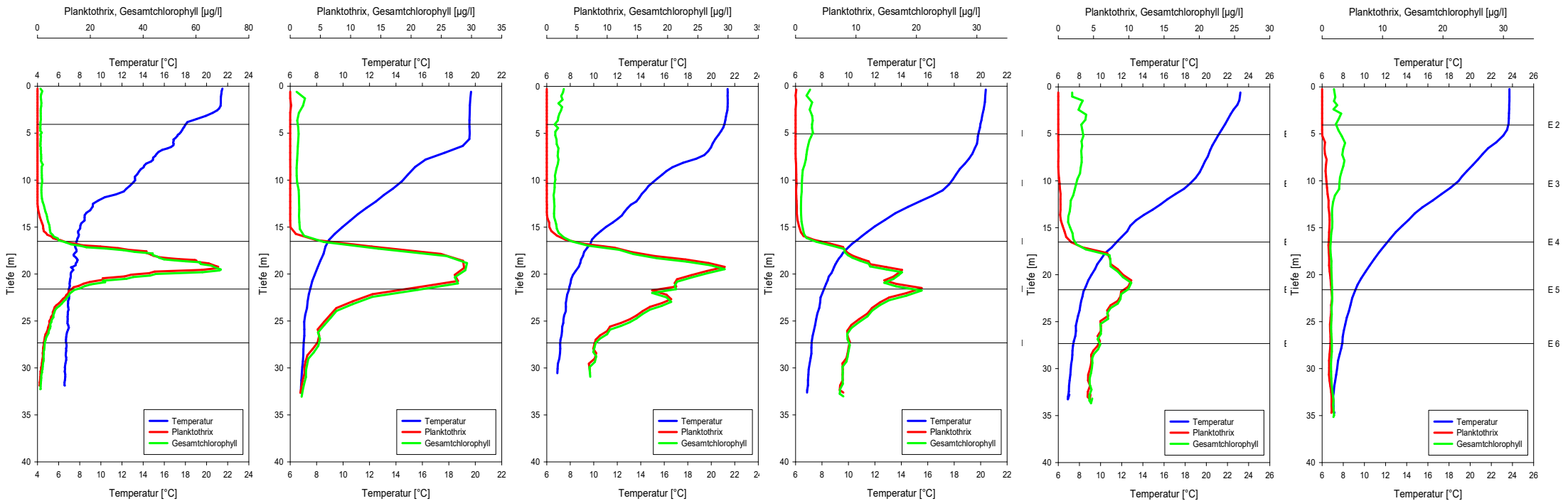
24.06.2014

08.07.2014

14.07.2014

22.07.2014

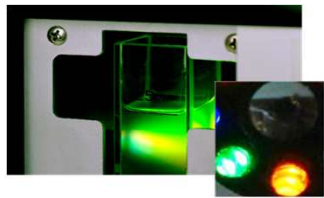
05.08.2014



The bbe Fluorometer



AlgaeGuard



AlgaeLabAnalyser



AlgaeOnlineAnalyser



FluoroProbe



AlgaeTorch

NEW



Add-On DO



Add-On DO, C, pH

Thank you very much
for your attention



Questions

Your experiences

Remarks