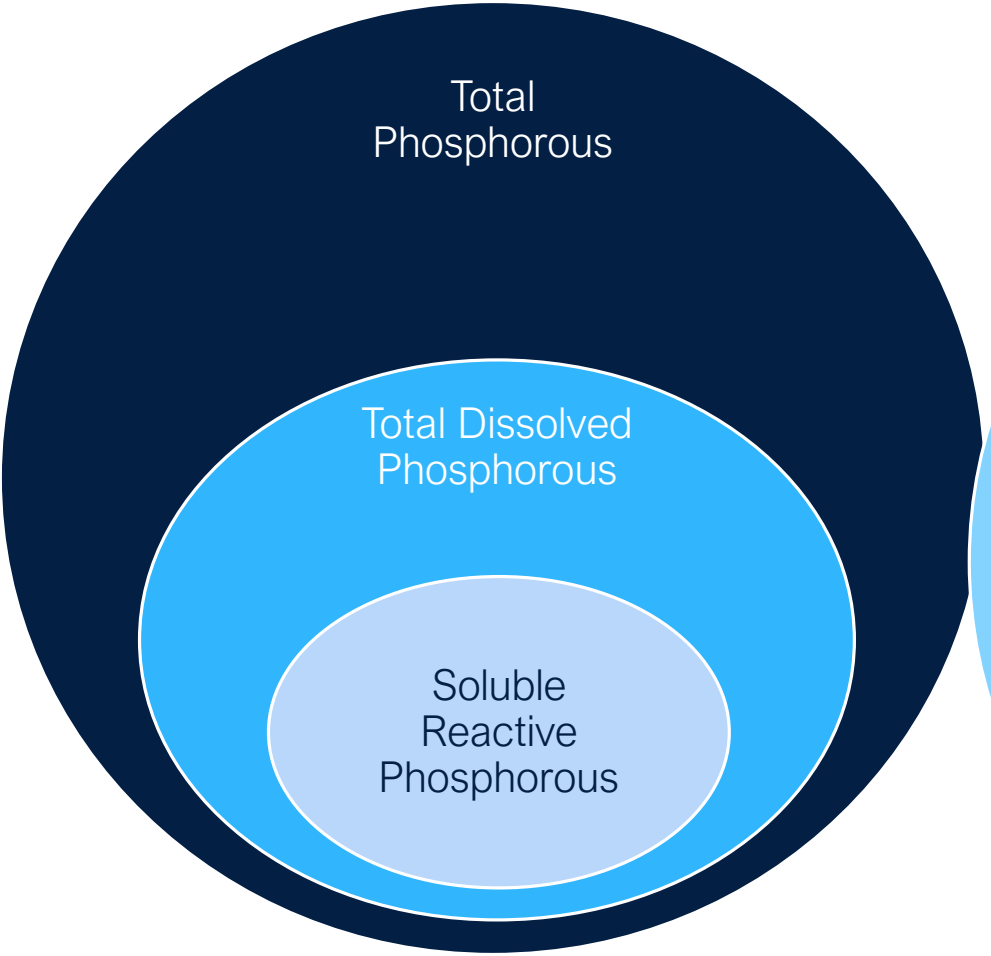
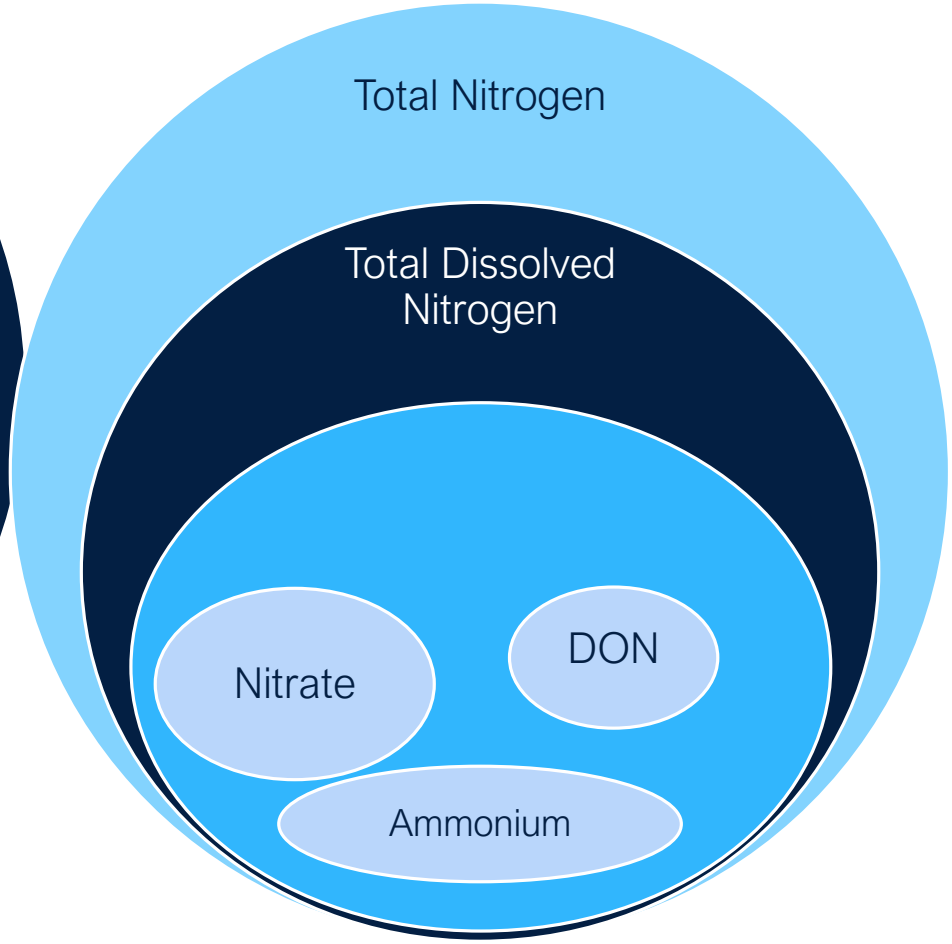
# Phosphorus, grazers, and temperatures may intensify Utah Lake HABs

Scott Collins, Erin Jones,
Dylan Dastrup (CUWCD), and
Dr. Zach Aanderud
Brigham Young University
Dept. of Plant and Wildlife Sciences

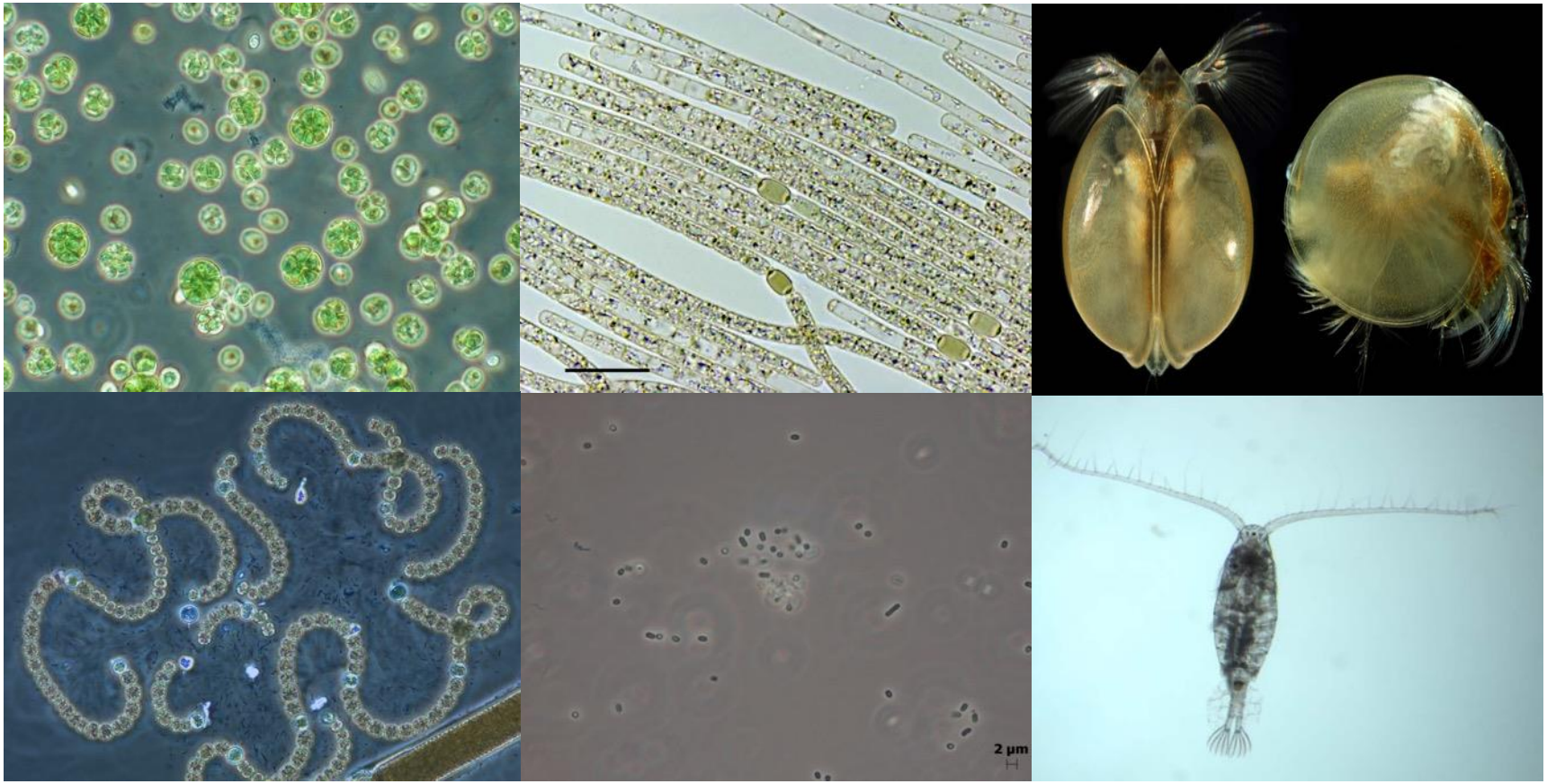

30 µm

# Not all nutrients are created equal



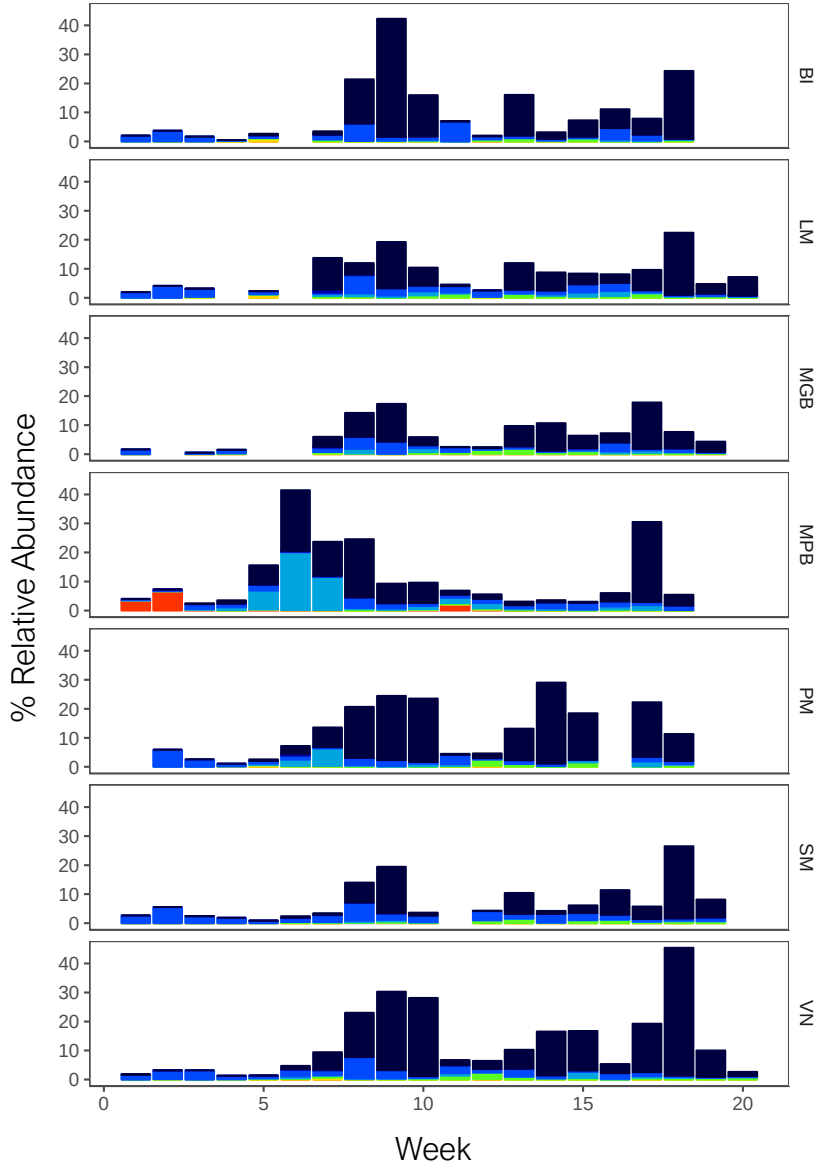



# Not all cyanos are created equal

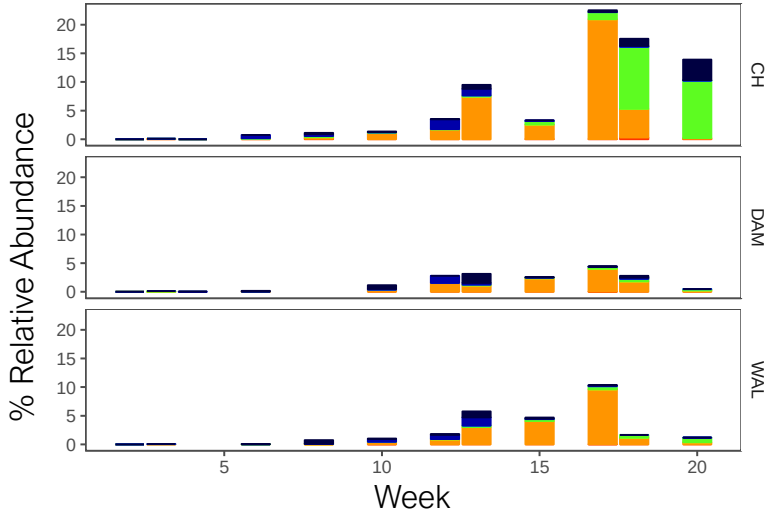


# 2017

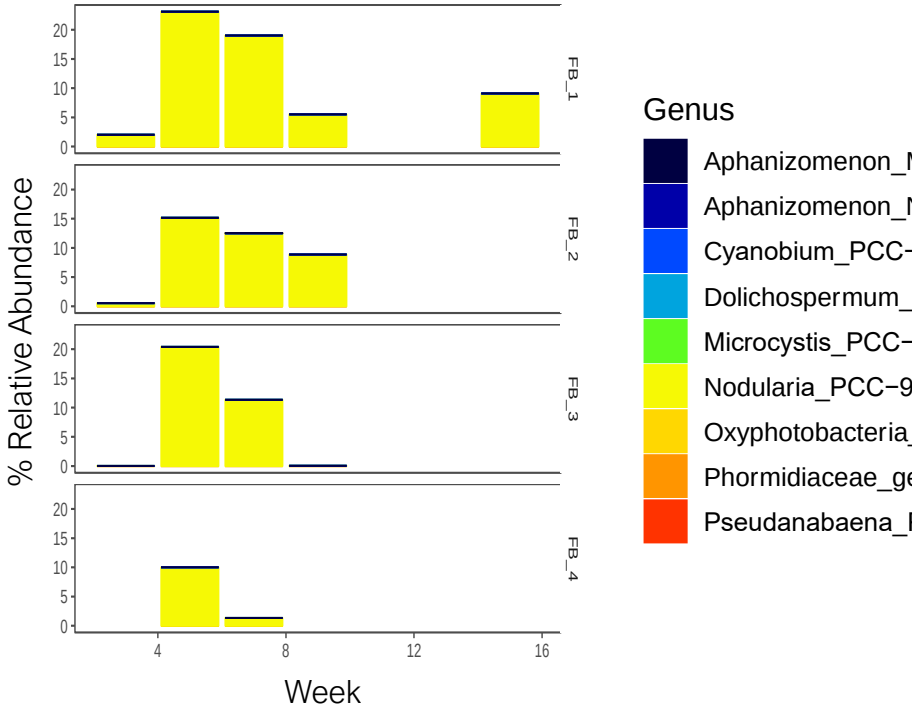
## Utah Lake




## Deer Creek




## Farmington Bay




16s rRNA gene amplicon sequencing

# What ecological factors are controlling species-specific blooms?

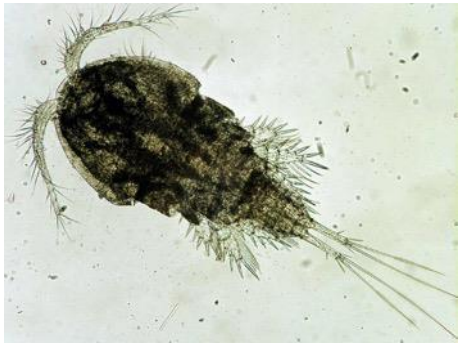
# Ecological factors

date, pH, DO (mg/L), temperature, secchi depth, TP, TDP, SRP, TOC, nitrate, ammonium +, B, Ca, Cu, Fe, K, Mg, Mn, S, Zn

Calanoida
(Calanoids)

Phyllopoda
(Diplostraca, Notostraca)

Diplostraca
(Cladocera)



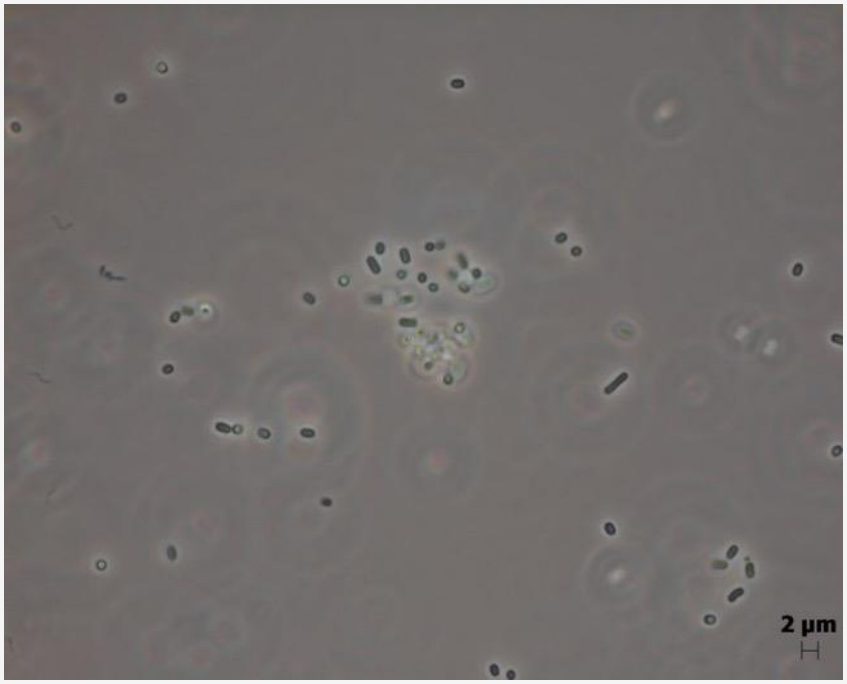
Cycolopoida
(Cyclopoids)

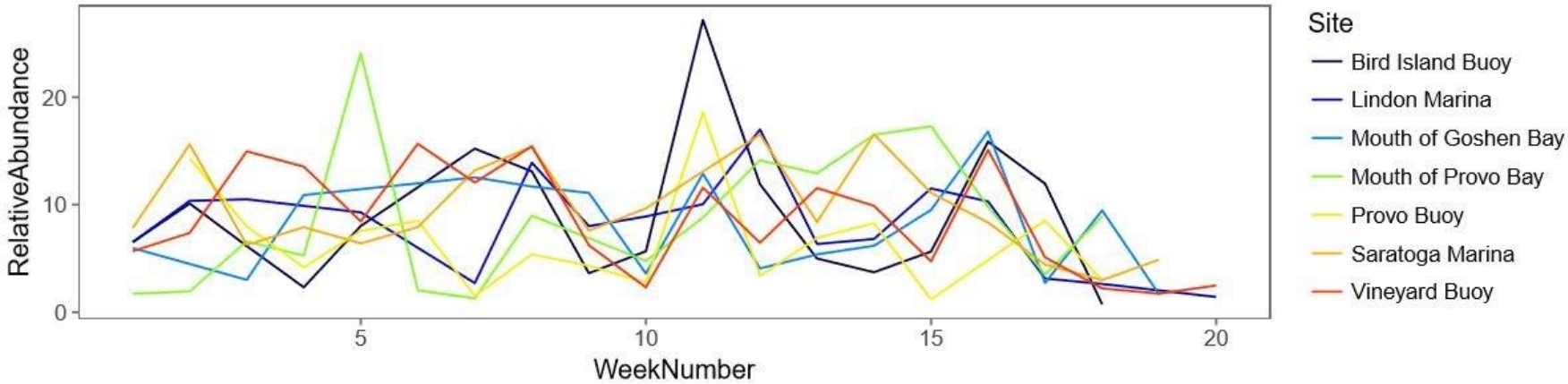
Monogononta
(Rotifers)

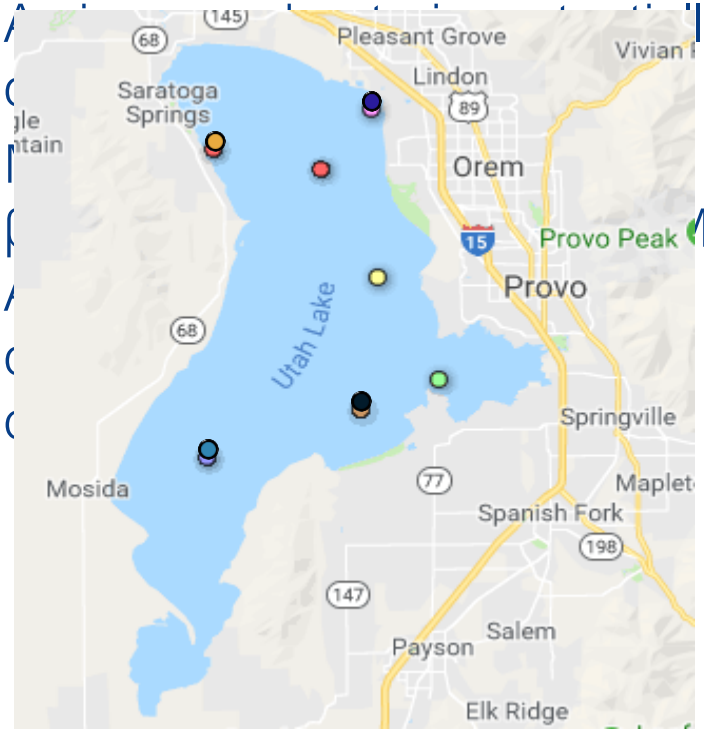

Ploimida
(Rotifers)

# *Cyanobium sp.*

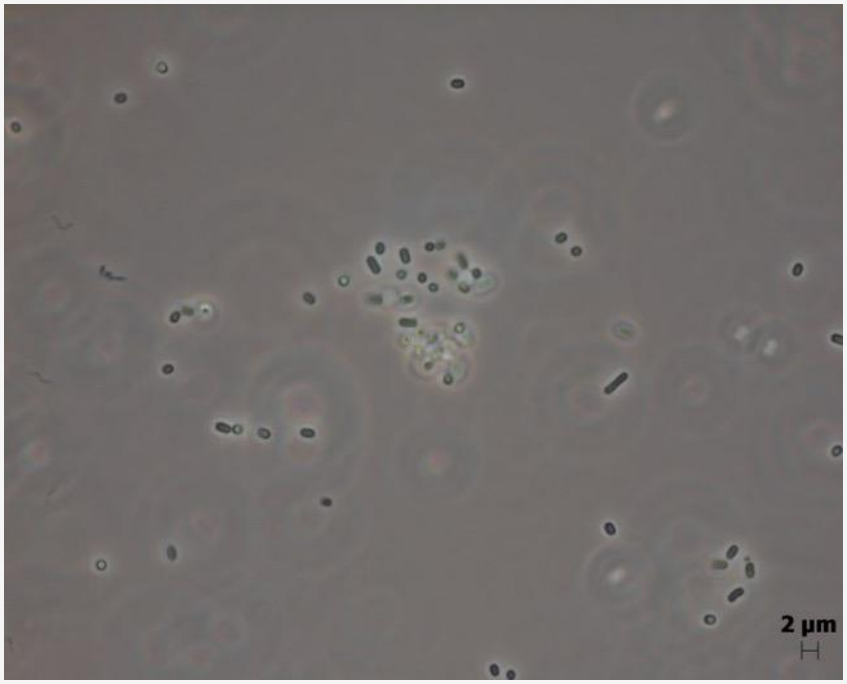
- A picocyanobacterial
- Overlooked with microscopy
- May produce microsytins, β-N-methylamino-L-alanine (BMAA), lipopolysaccharides, and other odor associated compounds

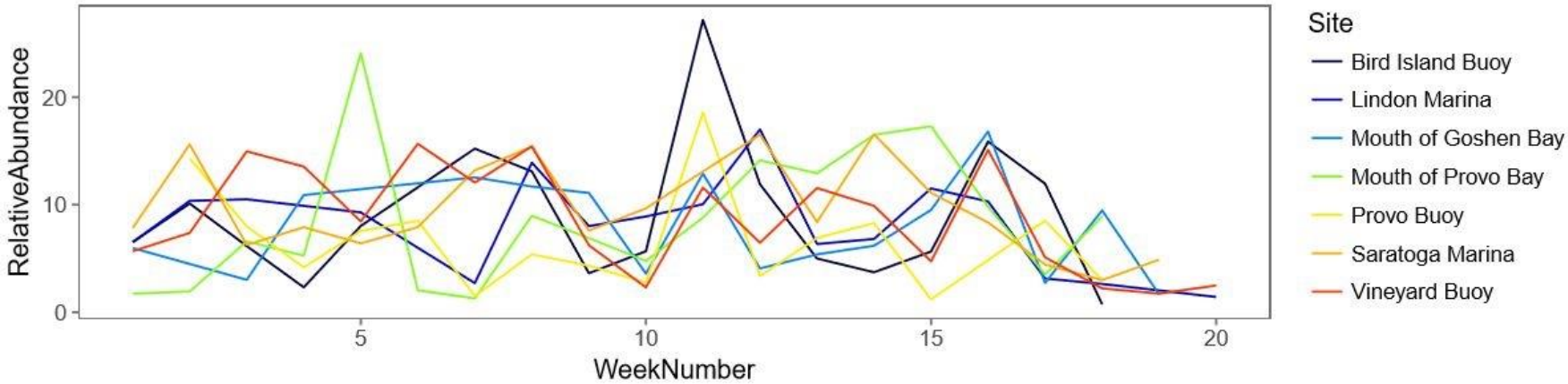





# *Cyanobium sp.*

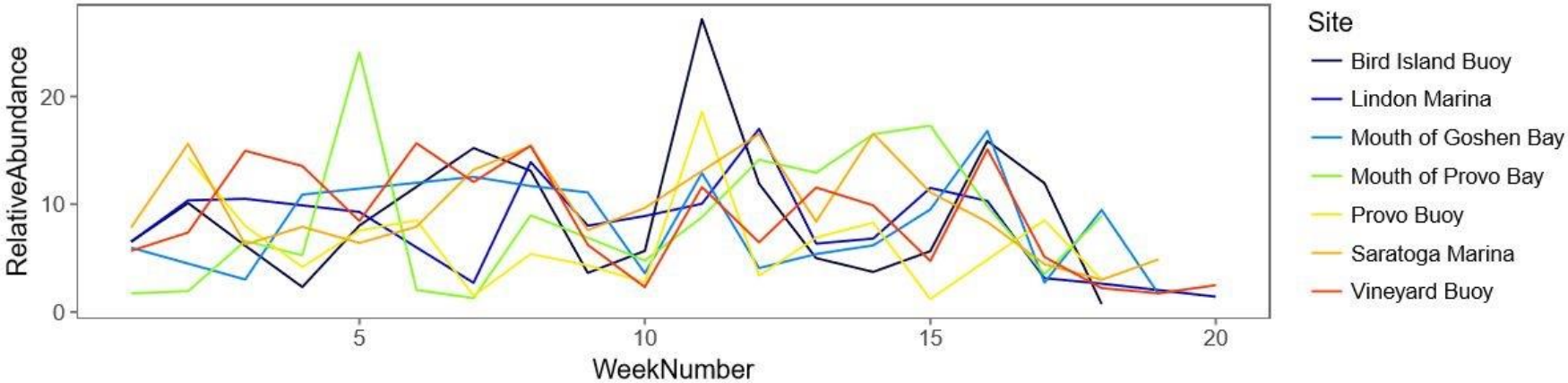


# Model *Cyanobium sp.*

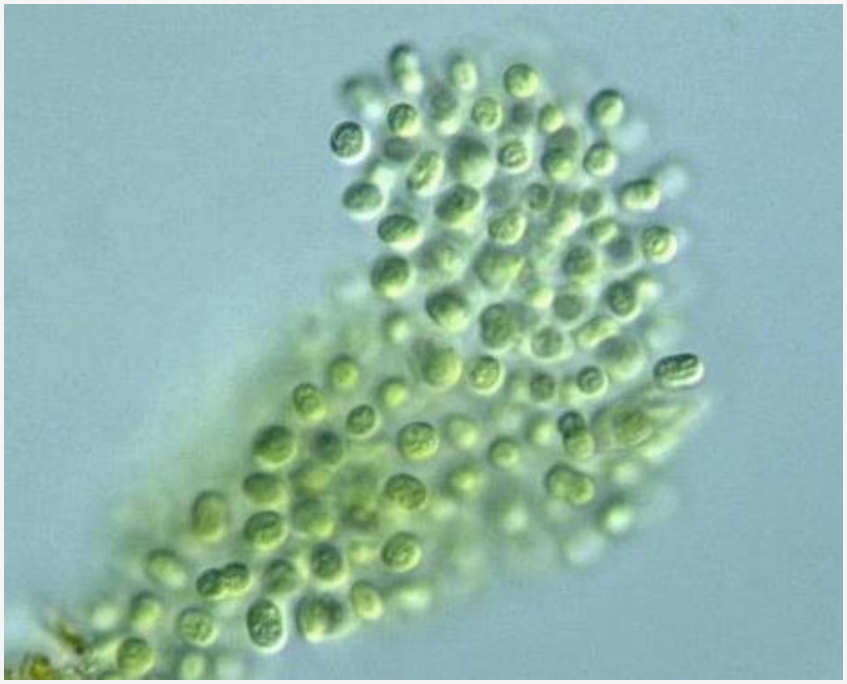
* % Rel recovery of *Cyanobium* = 17.82 +0.70(Mg) + 111.13(Zn) + 7.38(conductivity) – 2.14(pH) – 18.16(ammonium) – 0.04(Calanoida) – 300.51(Mn) – 5.10(S)

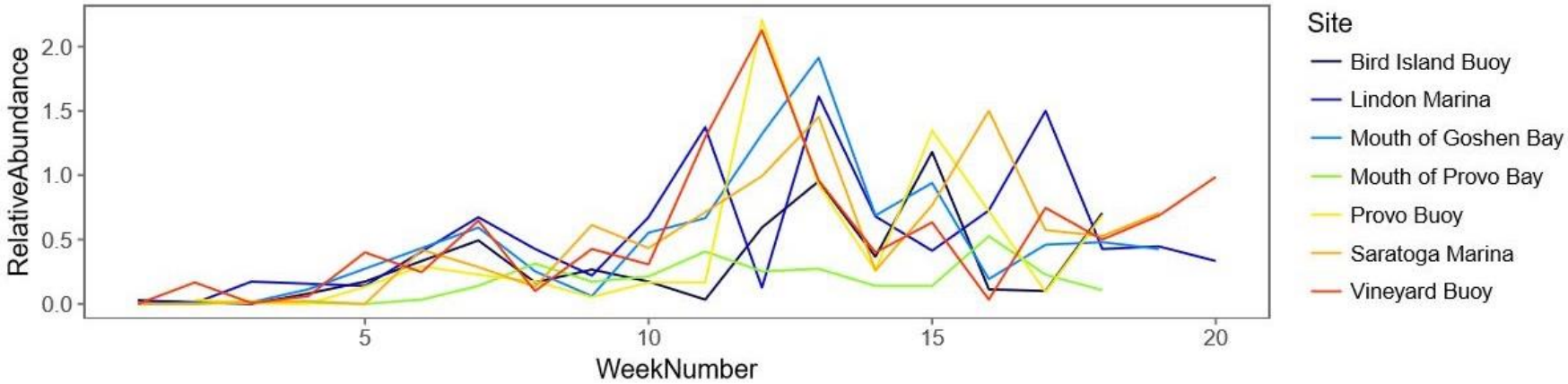
* AIC: 367.9189



- May regulate their own buoyancy
- Heavily influenced by N:P ratio
- May produce microcysitin or anatoxin-a
- Filamentous

# *Microcystis sp.*

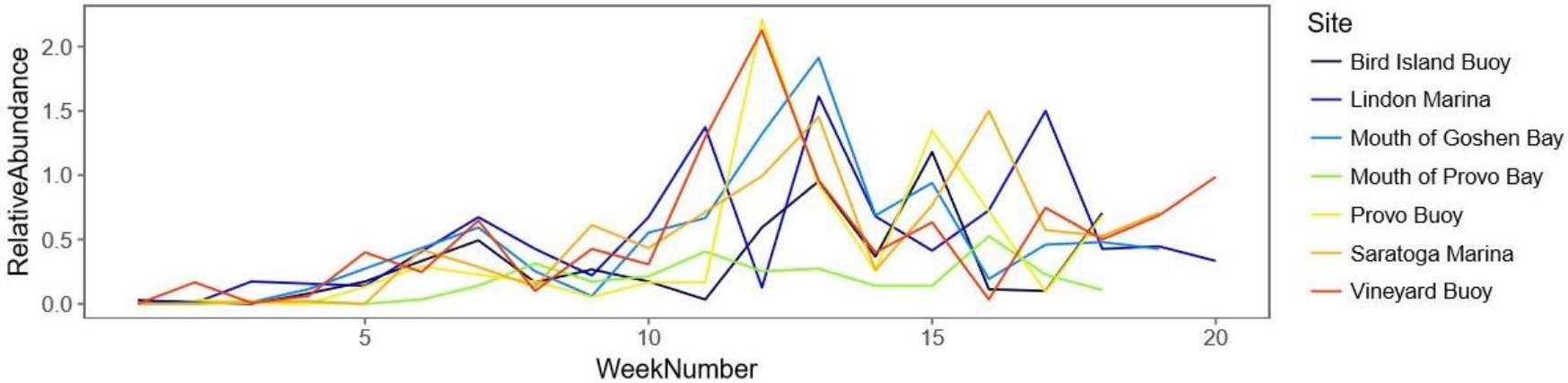




# Model *Mycrocystis*

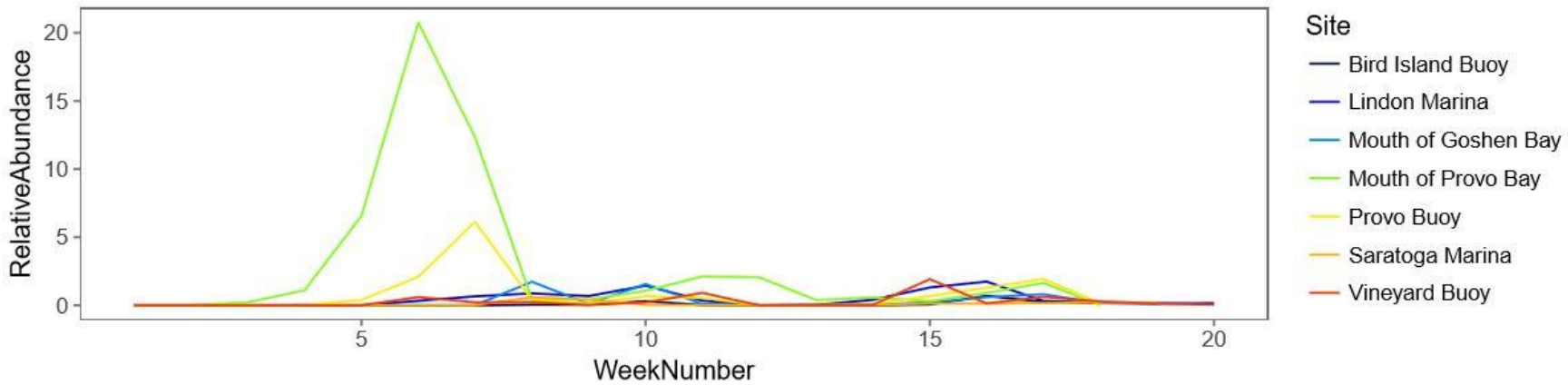
* % Relative recovery of *Microcystis* = -143.6 + 34.64(date) + 6.12(SRP) + 0.014(temperature) – 0.0061(TOC)

* AIC: 136.4564



# *Dolichospermum sp.*

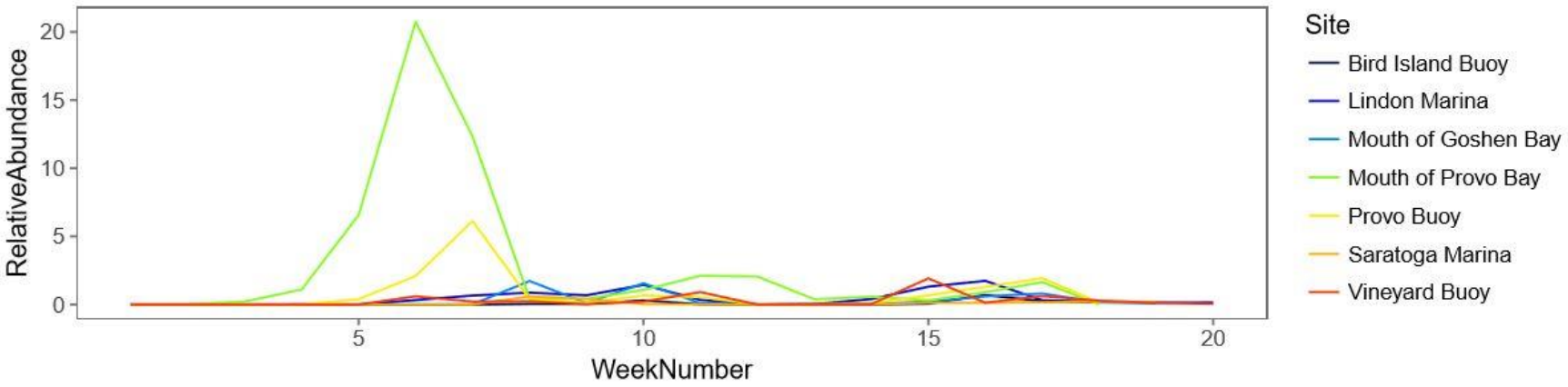
- Formerly known as *Anabena*
- May fix N with heterocysts
- Filamentous
- May produce microcystins, anatoxin-A, cylindrospermopsin, and saxitoxins



# Model *Dolichospermum sp.*

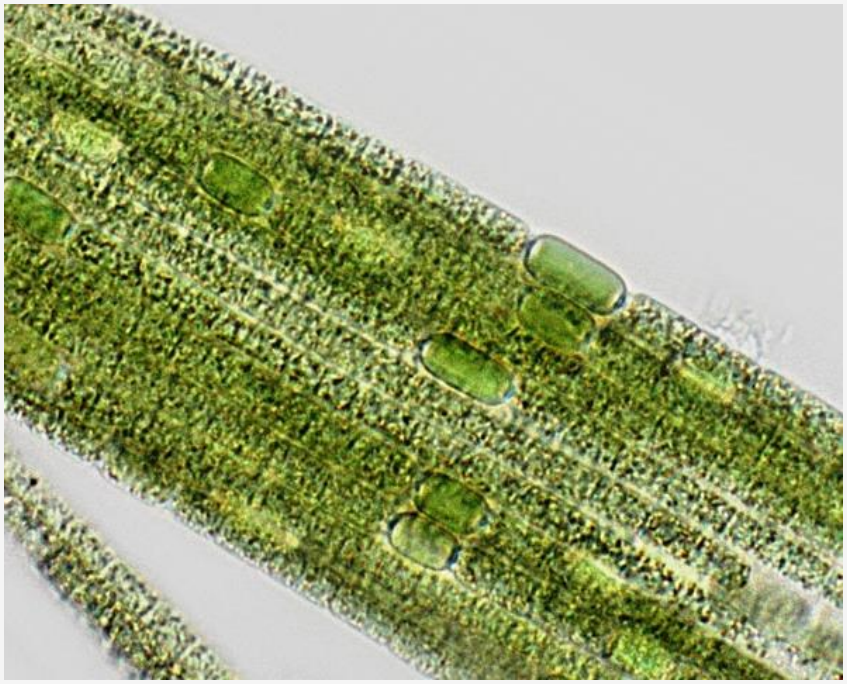
* % *Dolichospermum* = -1.04
+ 25.75(TP) + 0.0012(Calanoida)
– 41.82(SRP) – 13.42(Mn) – 4 .39(ammonium)

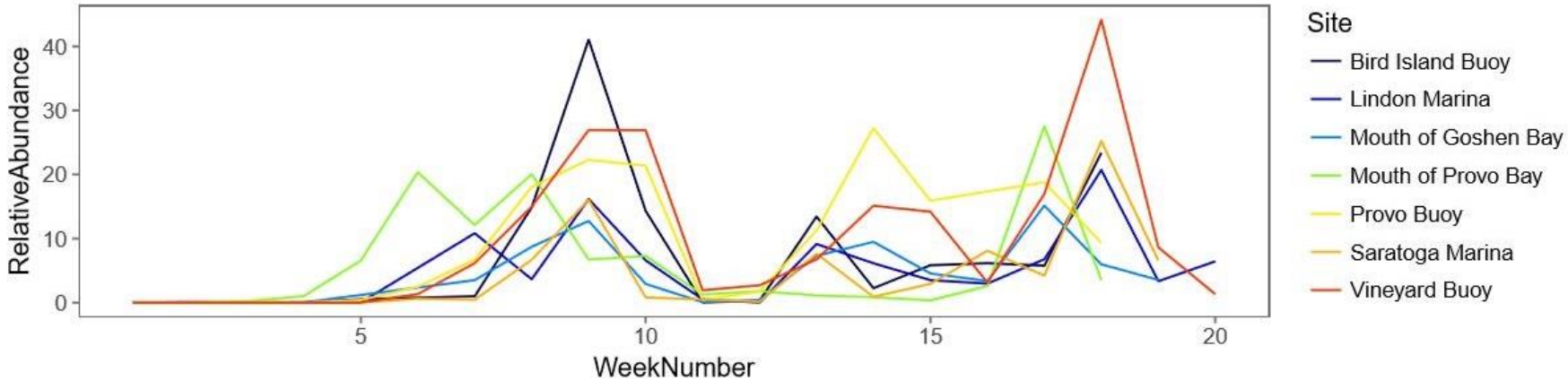
* AIC: 311.548



- Capable of fixing N through heterocysts
- Forms large colonies
- May produce anataxin-a, β-N-methylamino-L-alanine (BMAA), cylindrospermopsin, and saxitoxin
- Dominant cyano of Utah Lake blooms

## *Aphanizomenon* MDT14a

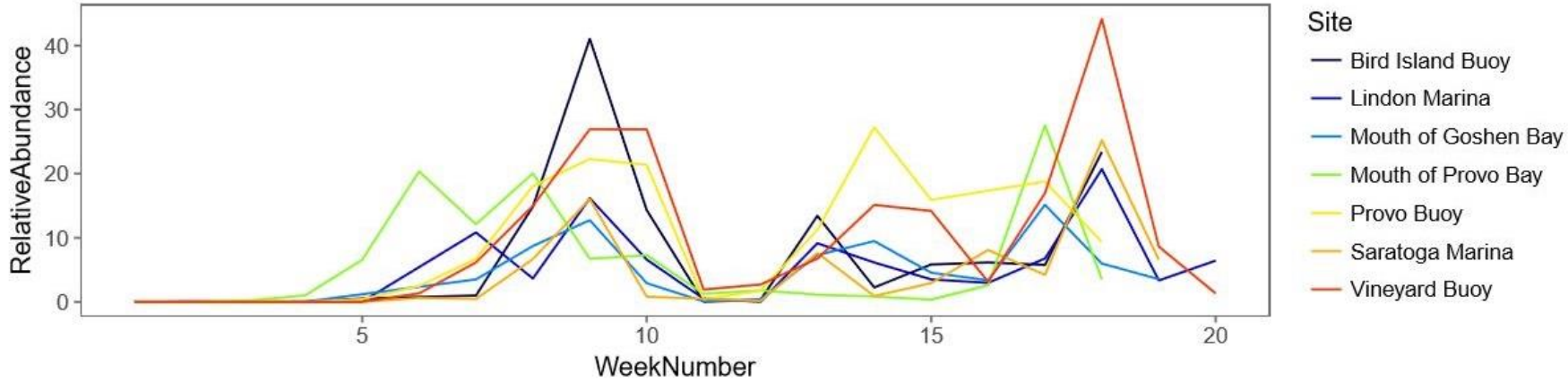




# Model *Aphanizomenon sp.*

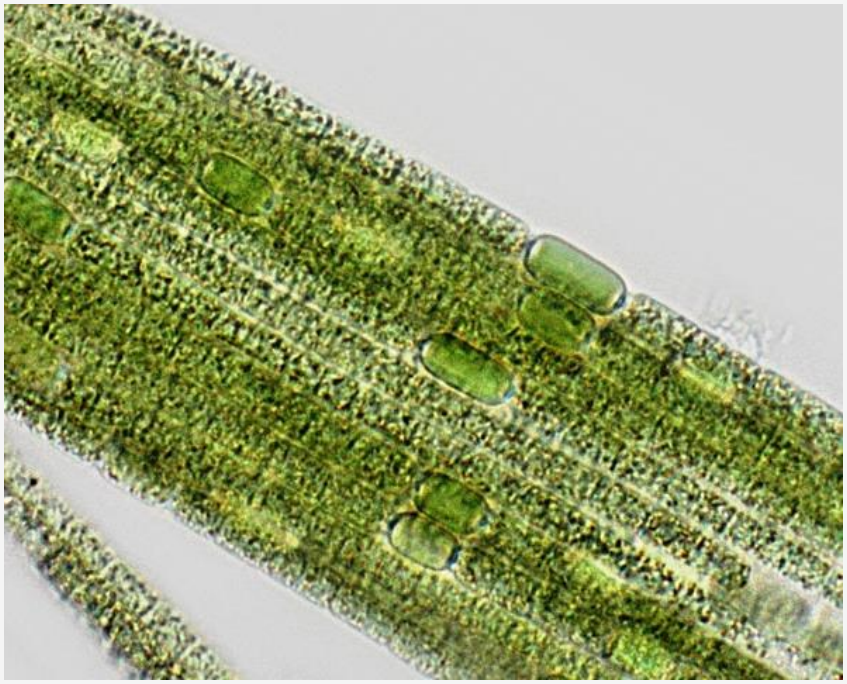
* % Relative recovery of *Aphanizomenon* = -2515.2 + 603(date) + 2.19(DO) + 0.29(TOC) + 21.43(ammonium) + 0.47(Ploimida) – 1.01(secchi) – 13.9(nitrate) – 44.54(Zn) – 1.35(TP)

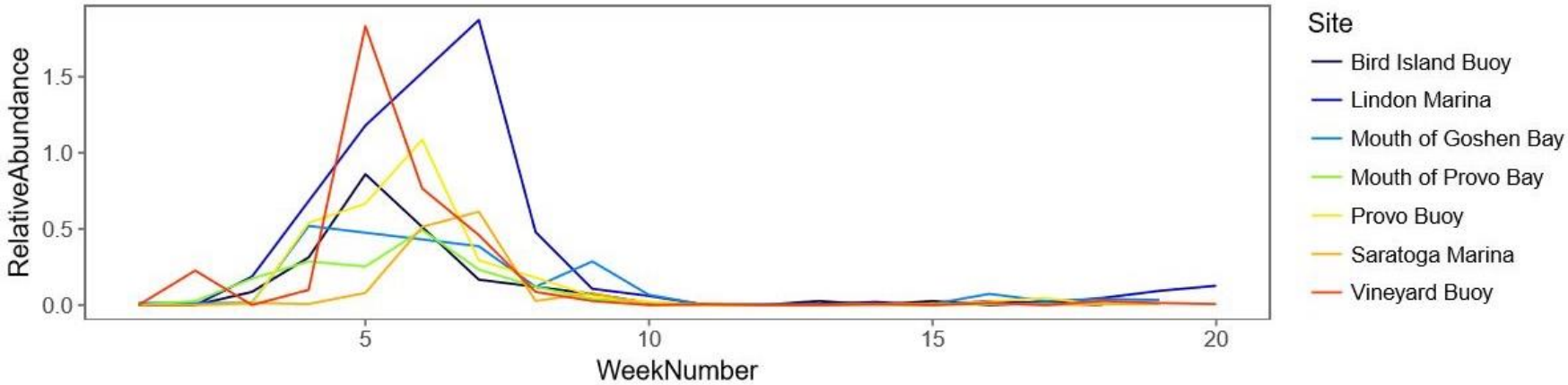
* AIC: 395.99



- Capable of fixing N through heterocysts
- Filamentous
- May produce anataxin-a, β-N-methylamino-L-alanine(BMAA), cylindrospermopsin, and saxitoxin

## *Aphanizomenon* NIES81

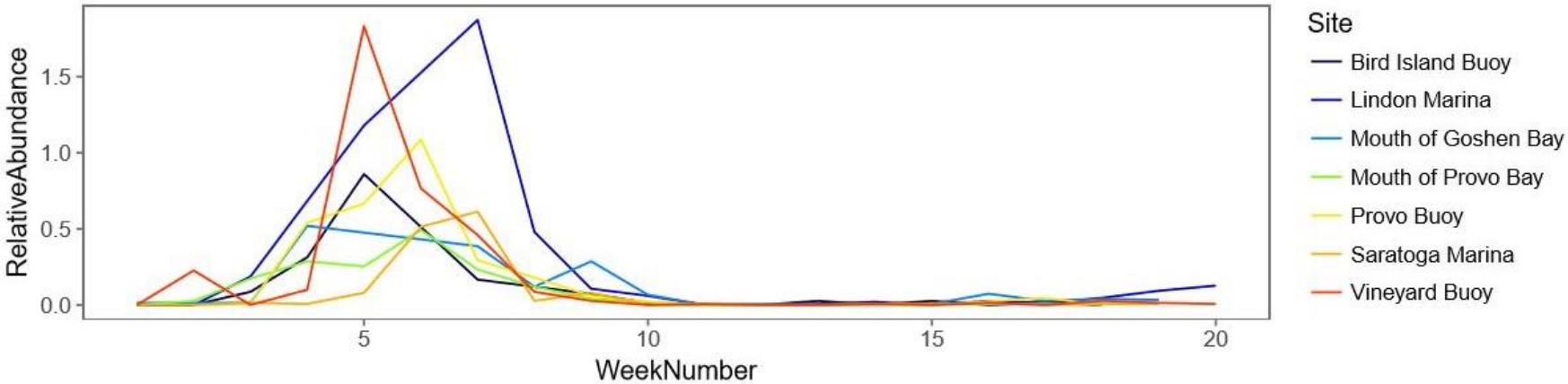




# Model *Aphanizomenon sp.*

* % Relative recovery of *Aphanizomenon* = 0.31 + 0.0061(Phyllopoda) + 7.32(Zn) – 3.77(SRP) –0.0059(Diplostraca) – 0.06(S)

* AIC: 62.74



# Models

* % *Aphanizomenon* (dominant, N fixer) = + date + DO + TOC + ammonium + **Ploimida** – secchi – **nitrate** – Zn – **TP**

* % *Aphanizomenon* 2 (N fixer) = + **Phyllopoda** + Zn – **SRP** – **Diplostraca** – S

* % *Dolichospermum* (N fixer) = + **TP** + **Calanoida** – **SRP** – Mn – **ammonium**

* % *Microcystis* = + date + **SRP** + temperature – TOC

* % *Cyanobium* = + Mg + Zn + conductivity – pH – **ammonium** – **Calanoida** – Mn – S

# Conclusions

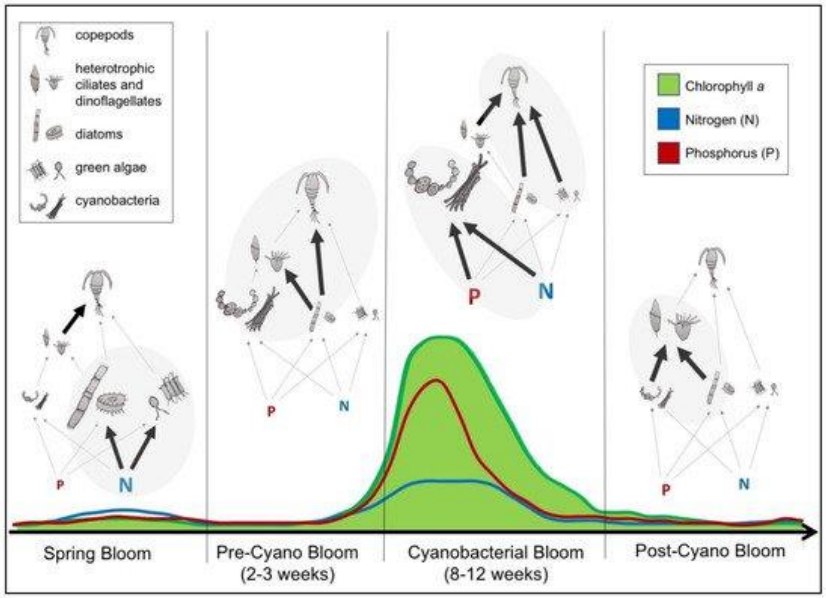
* Blooms dominant *Aphanizomenon* seems to heavily impact lake conditions (stimulates DO, TOC, and ammonium levels; decreases sunlight penetration) and the availability of TP may limit growth

* Soluble reactive P limits blooms of N fixers (fix own N and limited by reactive P availability) but stimulates blooms of *Microcystis*

* P and N form is immensely important

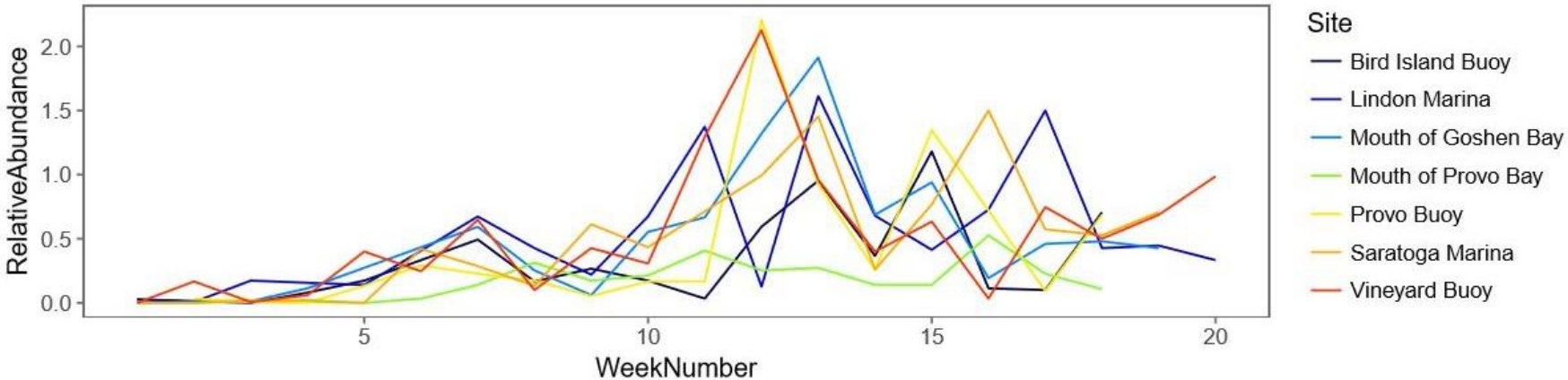
* Eukaryotic grazers are positively related to blooms of all N fixers and grazing may lead to a decline in growth

# New bloom and bust models

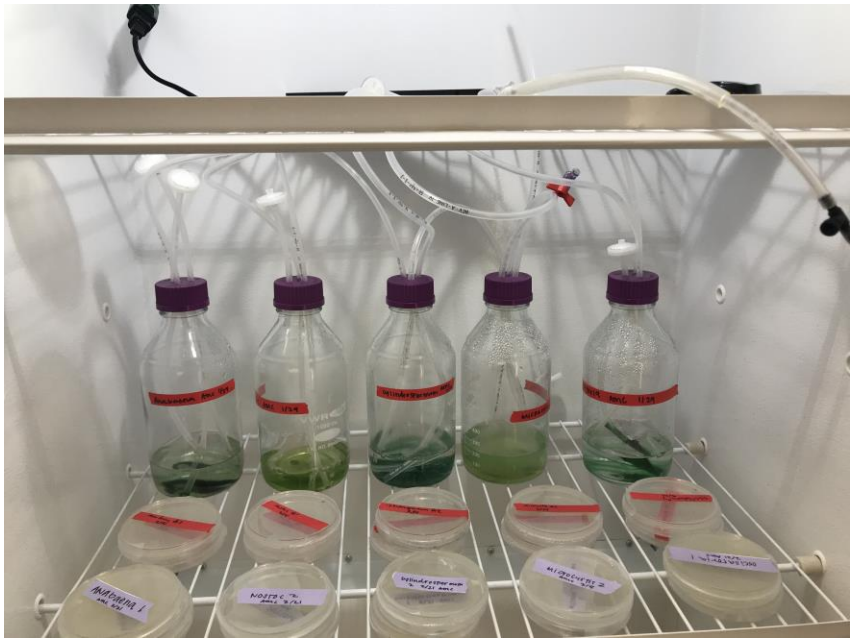



Rollwagen-Bollens 2018

What causes a specific cyanobacteria to bloom?
What causes a specific cyanobacteria to bust?



# Trait-based approach for understanding HAB blooms



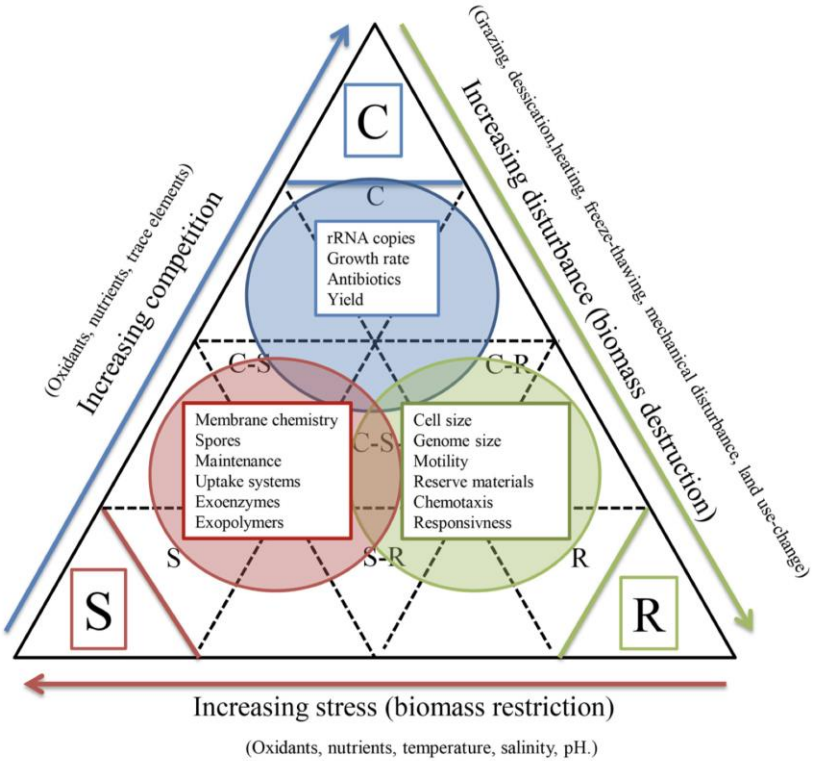



**FIGURE 2 | Reflection of microbial traits on the Competitor-Ruderal-Stress tolerator life strategy framework as was proposed for plants (Grime, 1977).** The scheme has been adapted for Ho et al. (2013) who used this framework for assigning life-strategies to methane-oxidizing bacteria. The scheme groups subsets of microbial traits which collectively would be of most importance for the respective strategy. The traits collectively accommodate exploring and exploiting habitats, competing with other organisms, tolerating or avoiding surviving stress, and deprivation. This classification is purely qualitative but, for some traits, life-history strategies have been proposed in earlier studies (Fierer et al., 2007; Portillo et al., 2013).

Krause et al 2014, Grime 1977

# Early HAB detection system

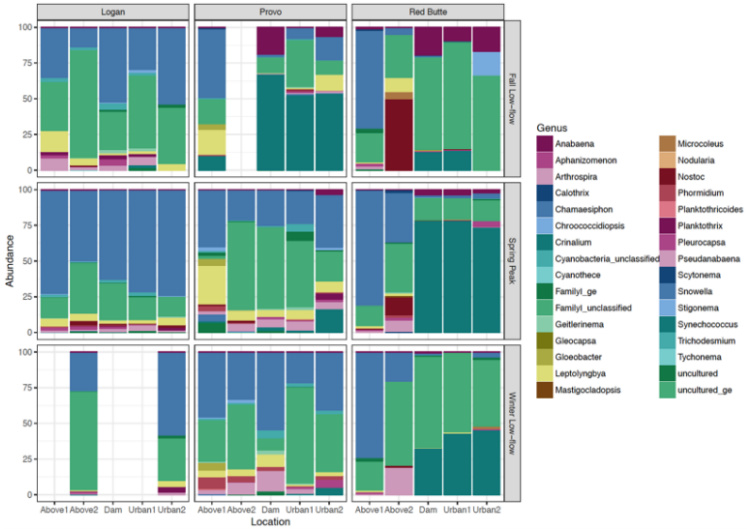
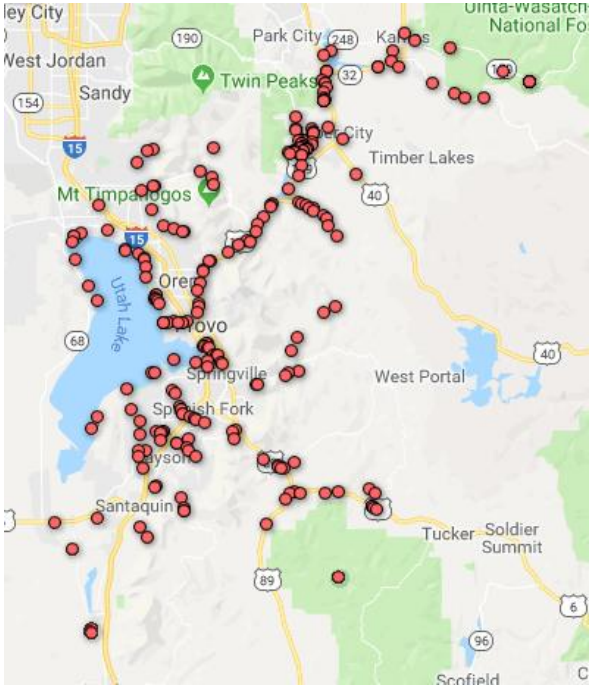



Table 3. Cyanobacteria and algae identification.

| Analysis | Responsibility |
|---|---|
| DNA or RNA extraction from water samples | BYU |
| Target metagenomics of cyanobacteria and algae | BYU |
| qPCR of cyanobacteria and bacteria genera | CUWCD |
| Direct counts via microscopy | CUWCD |
| Cyanotoxin quantification | BYU, CUWCD |

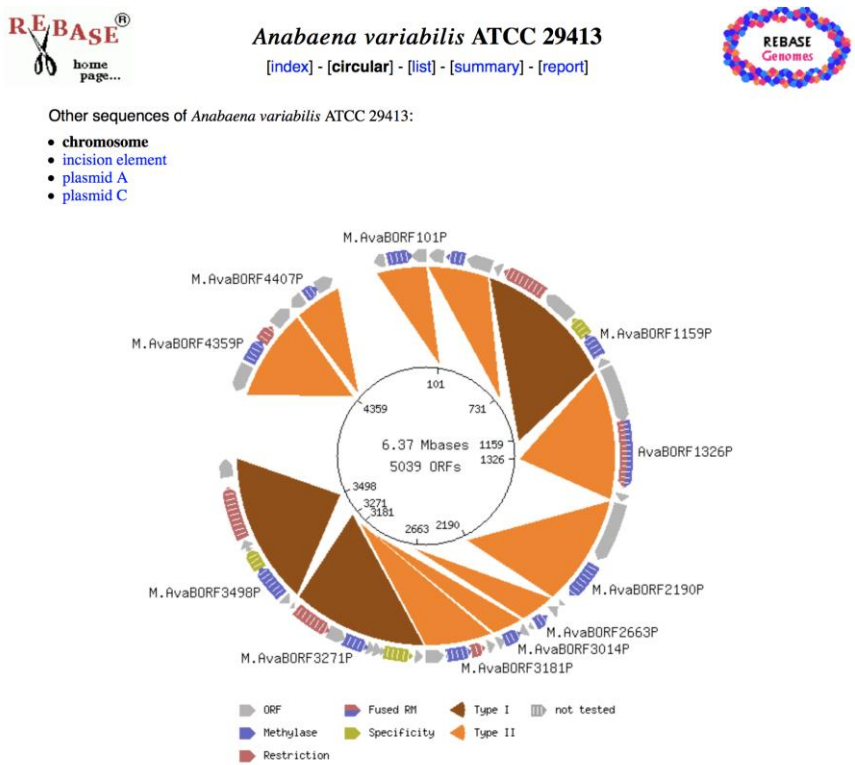
Identify water chemistry triggers and thresholds that facilitate the bloom of individual HAB species.
Identify HAB triggers and thresholds related to different physical parameters (i.e., temperature, turbidity, photosynthetic radiation) that facilitate the bloom of individual HAB species.

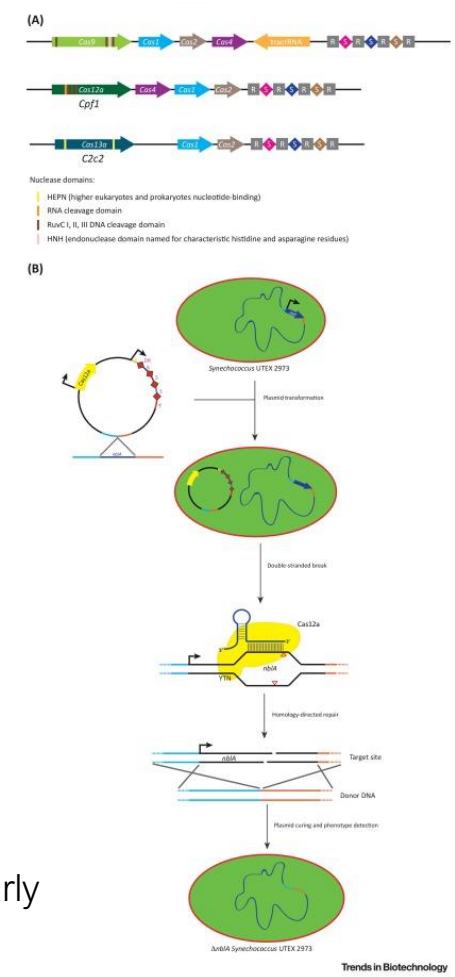
# Public Engagement




Utah Lake Research Collaborative

# Self-destruct switch




Gene editing with clustered regularly interspaced short palindromic repeat CRISPR (short pieces of DNA that are the same backwards and forwards spaced out regularly bacteria defense mechanism against viruses). Protein chops up virus DNA CRISPR associated protein-9 and -12

Behler et al 2018

# BYU is committed to Utah Lake

Acknowledgements
Dr. Neil Hansen
Dr. Greg Carling
Dr. Ben Abbott
Dr. Michelle Baker

Amber Call
Eric Shipp

*PC: Jeffery D Allen, Deseret News*