

Trait-based Approaches to Understanding and Predicting Harmful Algal Blooms

Elena Litchman

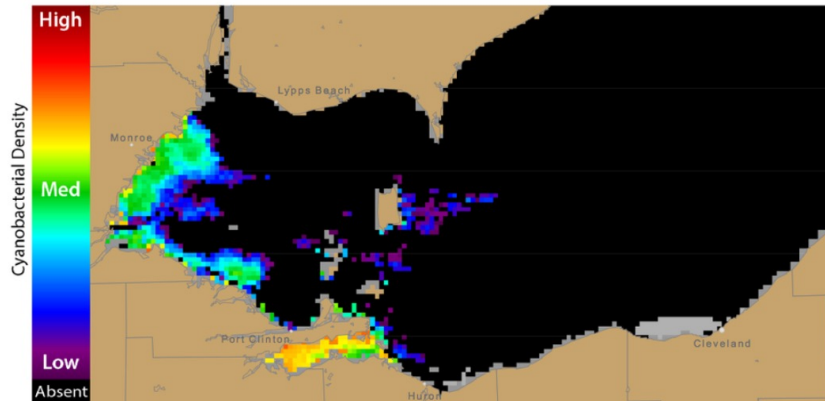
Carnegie Institution and Michigan State University

HABs are becoming more frequent but still hard to predict

METRO NEWS

Lake Erie harmful algal bloom less severe than expected. Why?

Updated Oct 5; Posted Oct 5



This map shows the height of the 2018 Lake Erie harmful algal bloom on Sept. 3. (NOAA)

Uncertainties:

- Magnitude
- Timing
- Species identity
- Toxicity level

Identity of HAB taxa (not only *Microcystis*)

Lake Superior
(*Dolichospermum*)



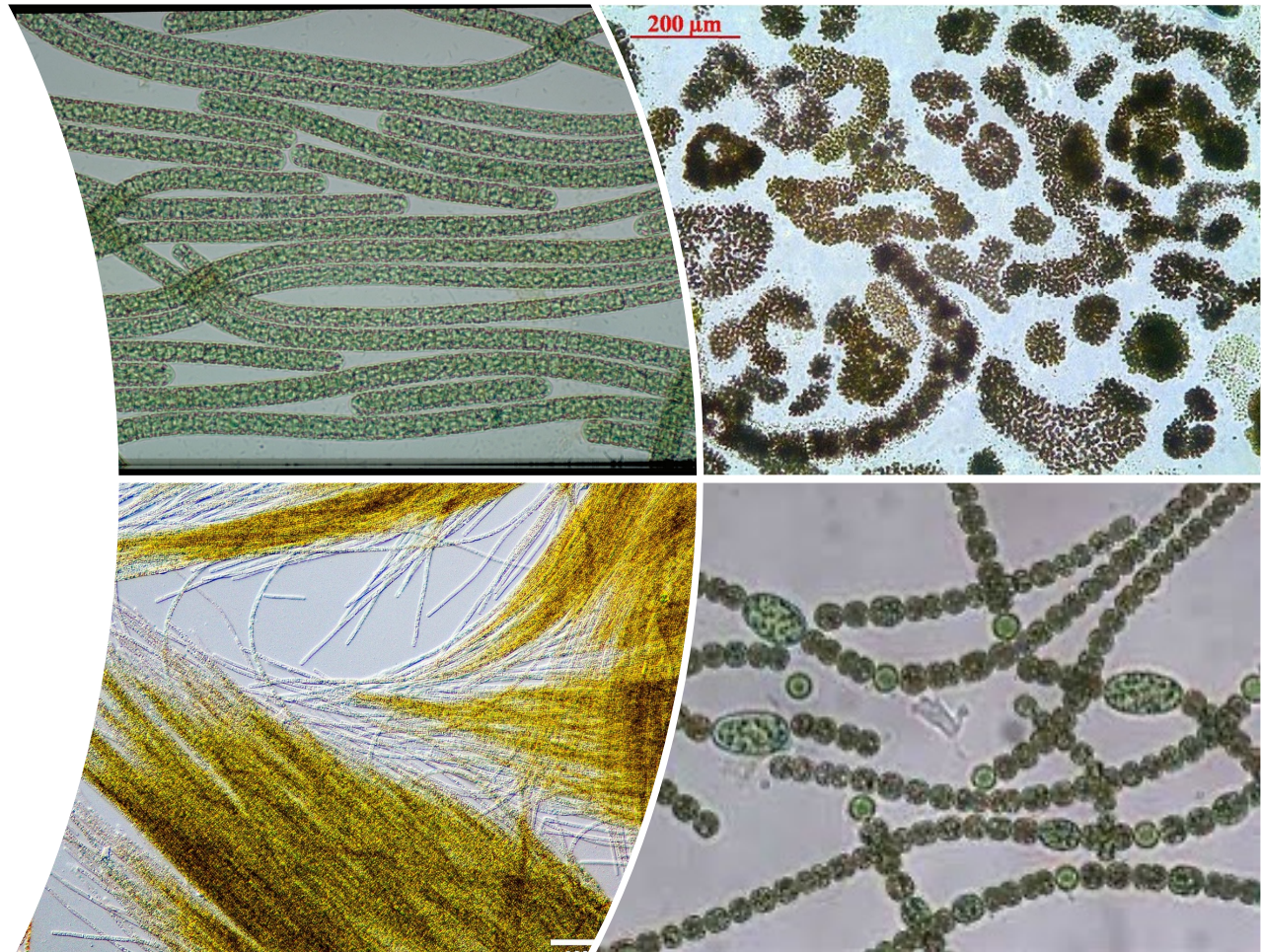
Brenda Lafrancois, National Park Service

Lake Baikal, Russia
(*Spirogyra* and *Dolichospermum*)



Several key cHAB genera

- *Microcystis*
- *Dolichospermum*
(aka *Anabaena*)
- *Aphanizomenon*
- *Planktothrix*



Key Questions in HAB Research

- What environmental factors stimulate HABs?
- How different are HAB taxa from each other and from non HAB taxa?
- What are the temporal trends in frequency, duration and composition of HABs?
- Can we predict HAB occurrence and severity?
- How do we prevent and mitigate HABs?

Key Questions in HAB Research

A need for a predictive mechanistic framework!

- Can we predict HAB occurrence and severity?
- How do we prevent and mitigate HABs?

Trait-based Approaches

- The focus is on functional traits not on species *per se*
- Can help identify general patterns of community structure and dominance by certain groups
- Can help uncover mechanisms of community responses to environmental factors

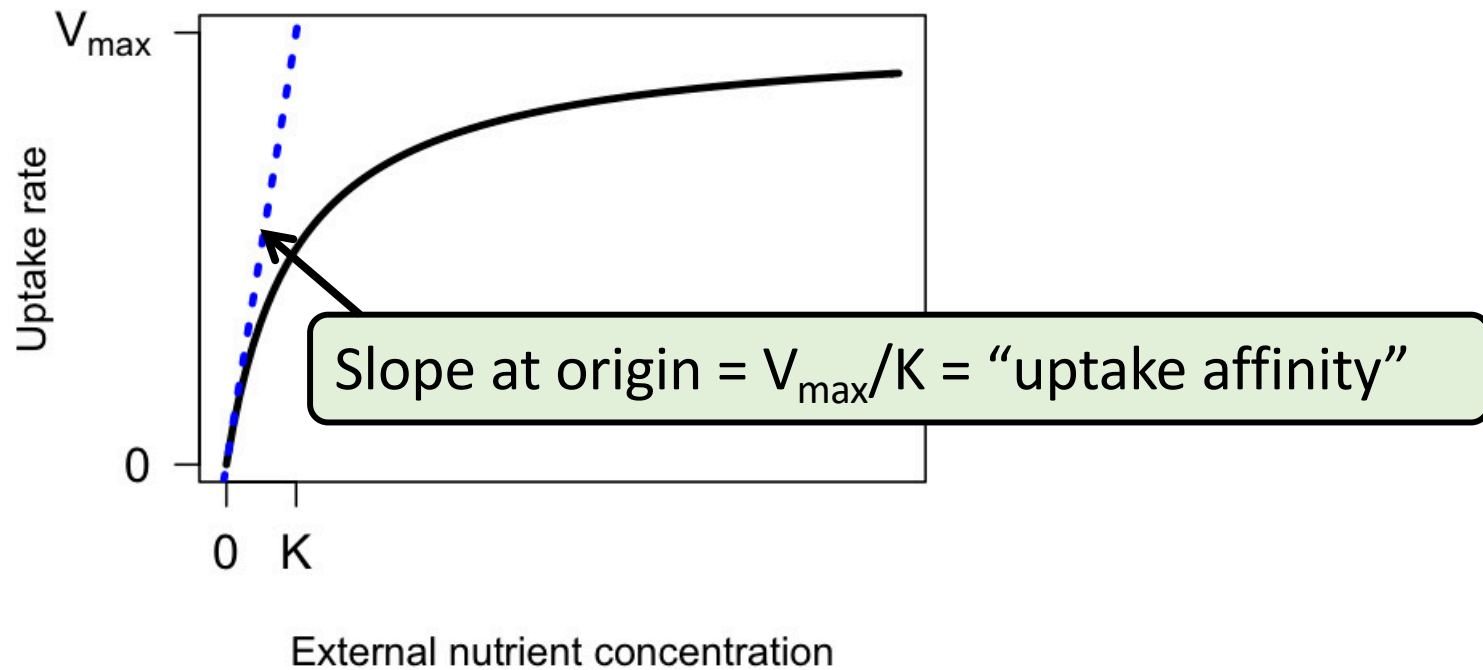
What are the important traits?

Depends on the question but often:

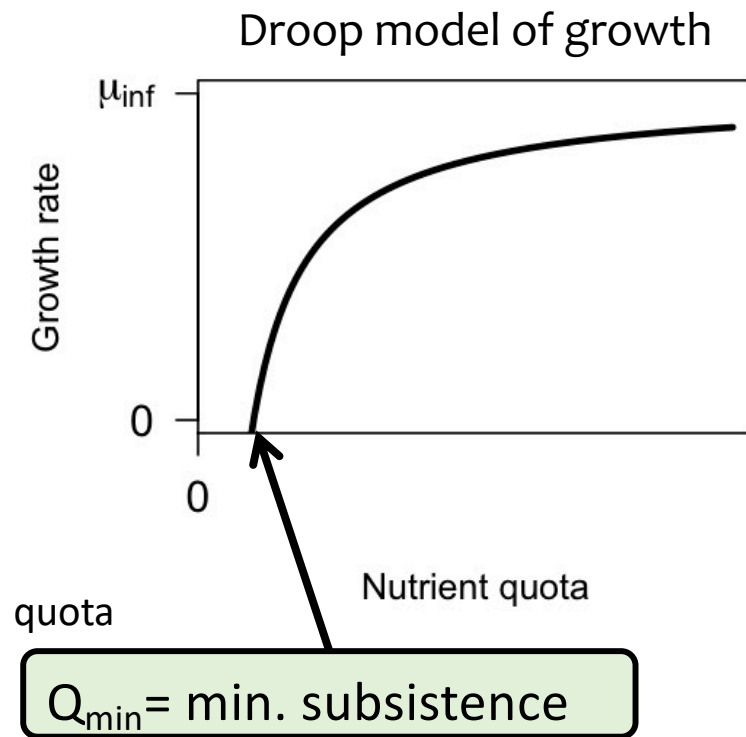
- Growth rate
- Nutrient and light utilization traits
- Temperature traits
- Grazer resistance
- Buoyancy
- Resting Stages
- Toxin production
- N-fixation

Nutrient utilization traits

Michaelis-Menten nutrient uptake

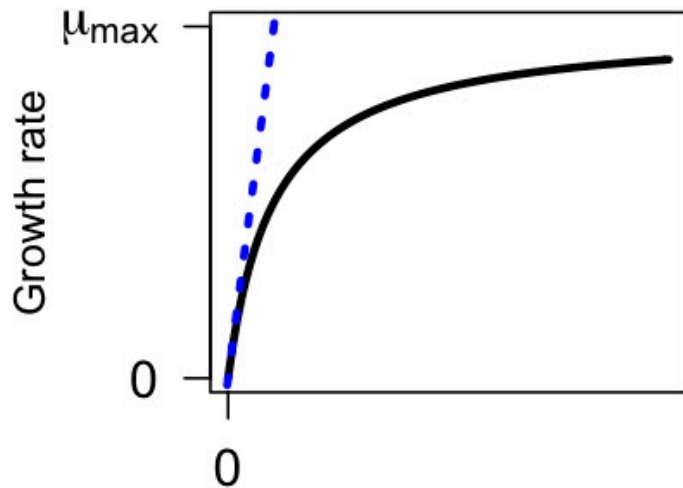


Nutrient utilization traits

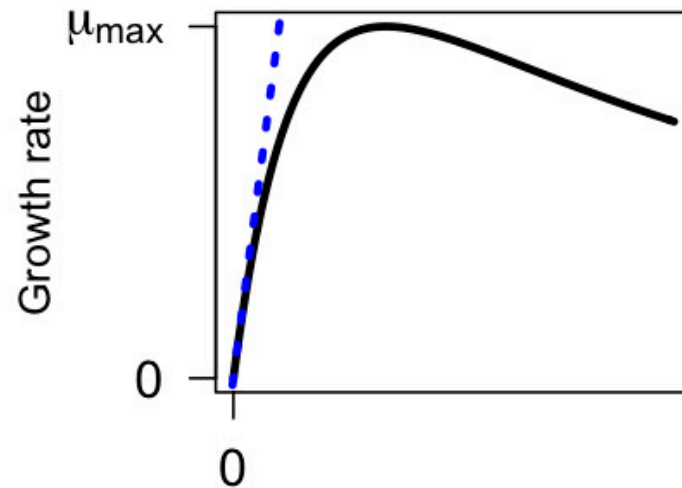


Michael R. Droop, circa 1980

Light utilization traits



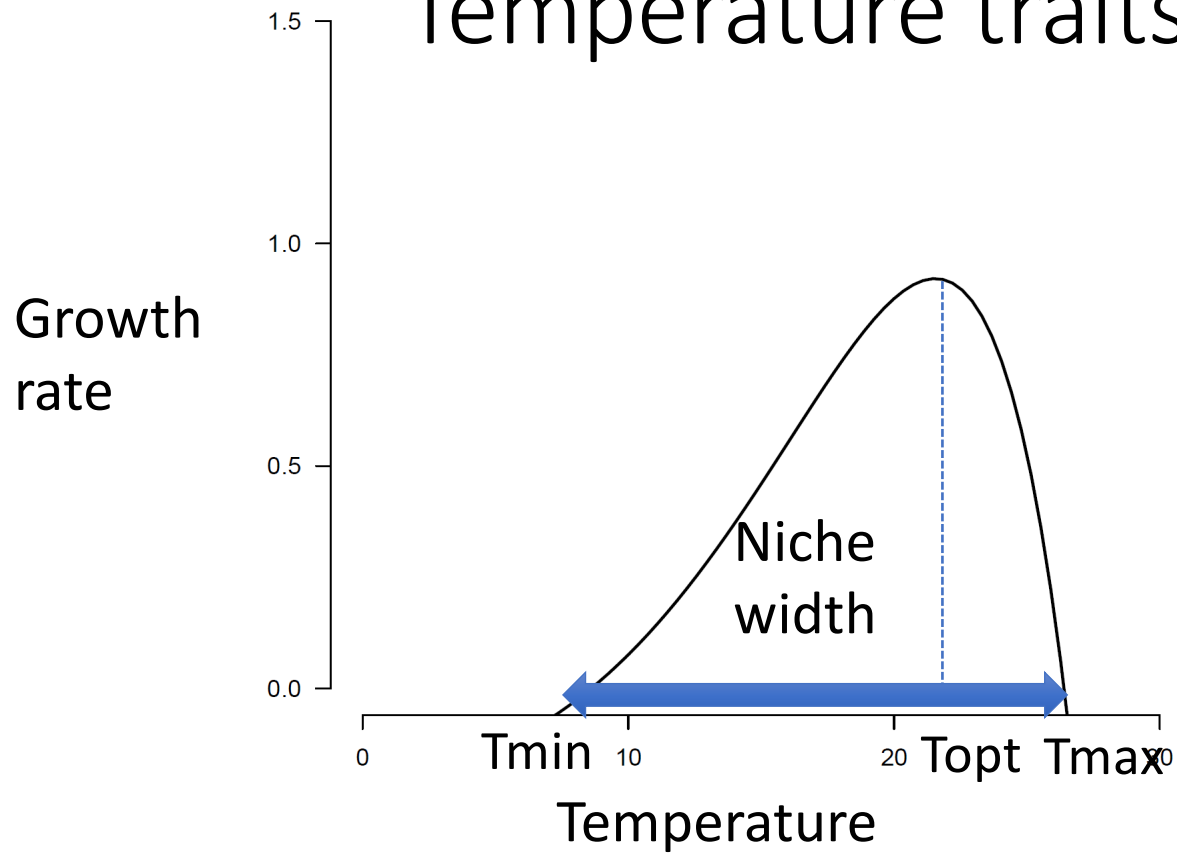
Irradiance



Irradiance

Slope at origin = “growth affinity for light” = α

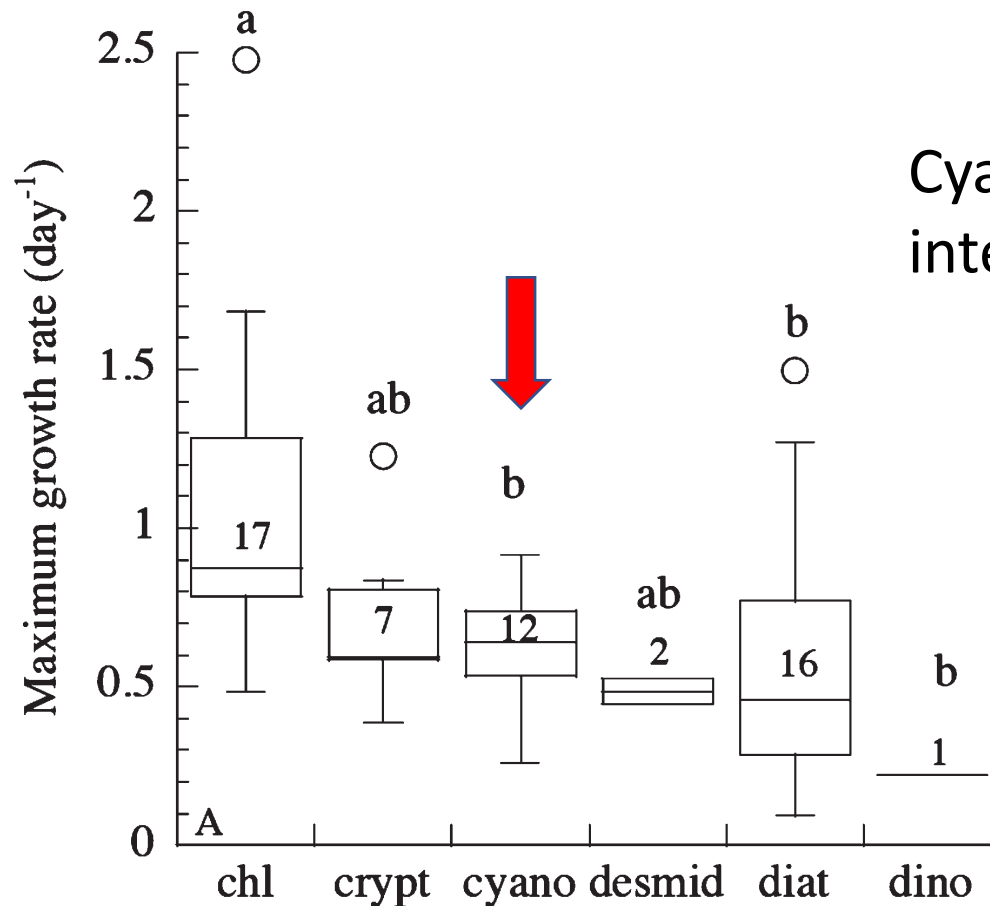
Temperature traits



Next step:

- Collect traits for a wide range of HAB and other taxa and compare them
- Also use these traits to parameterize predictive models

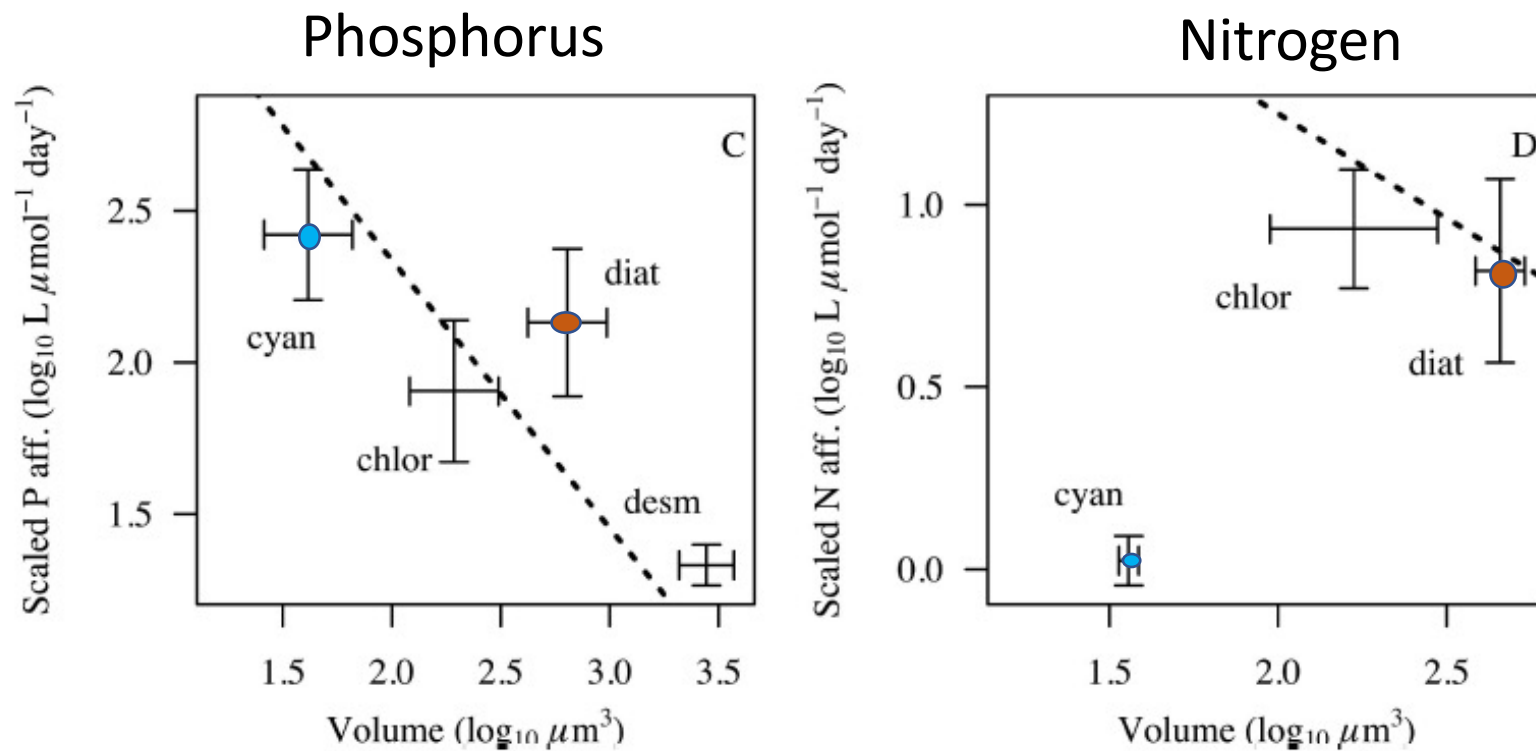
Trait comparisons: growth rates



Cyanobacteria have intermediate growth rates

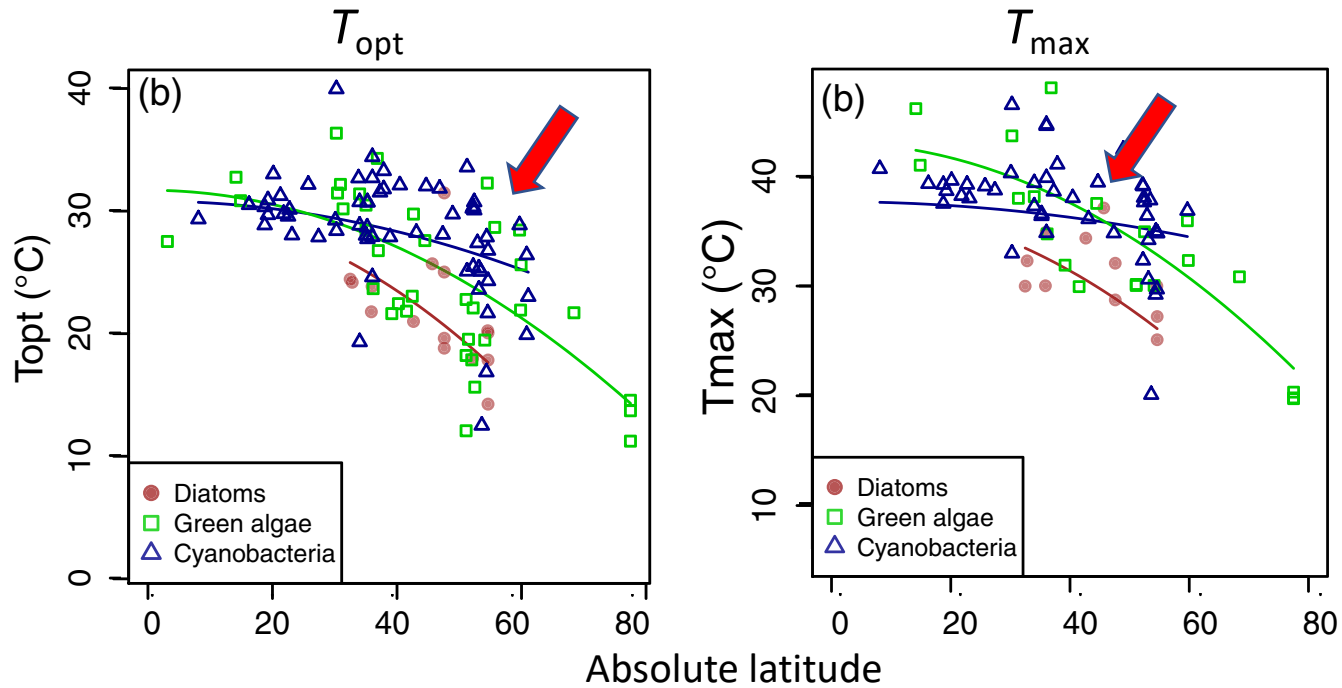
Scaled nutrient uptake affinity in freshwater phytoplankton

Edwards et al. L&O 2012



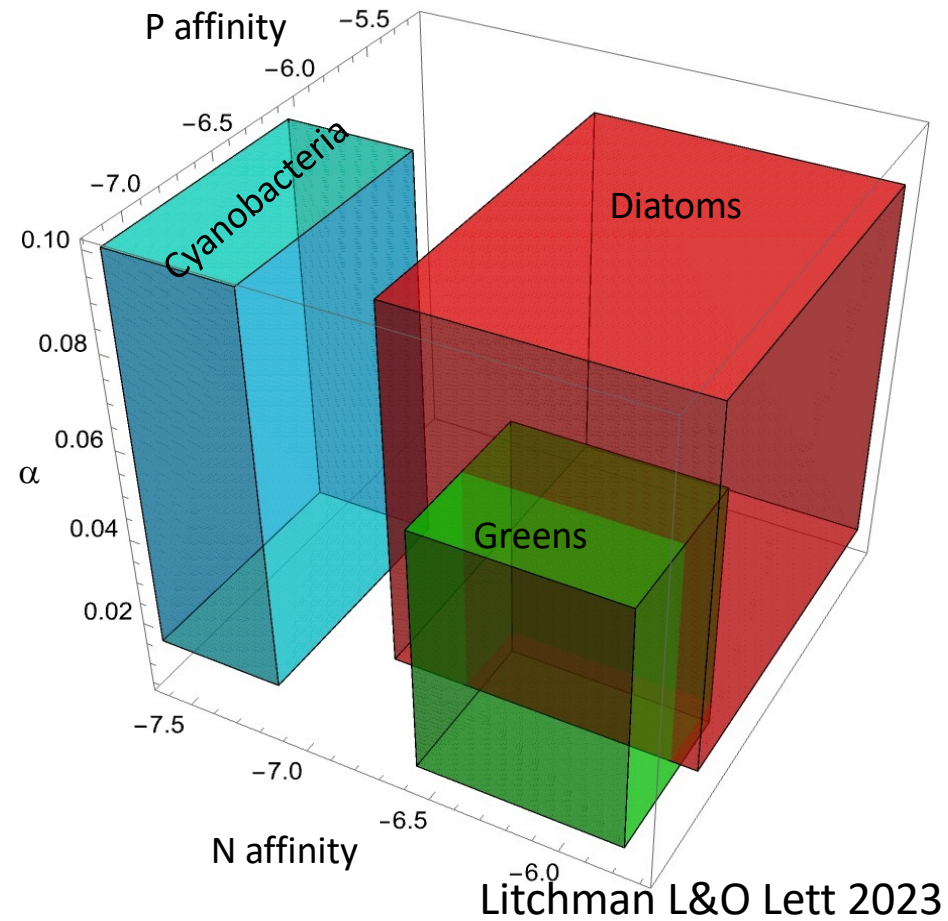
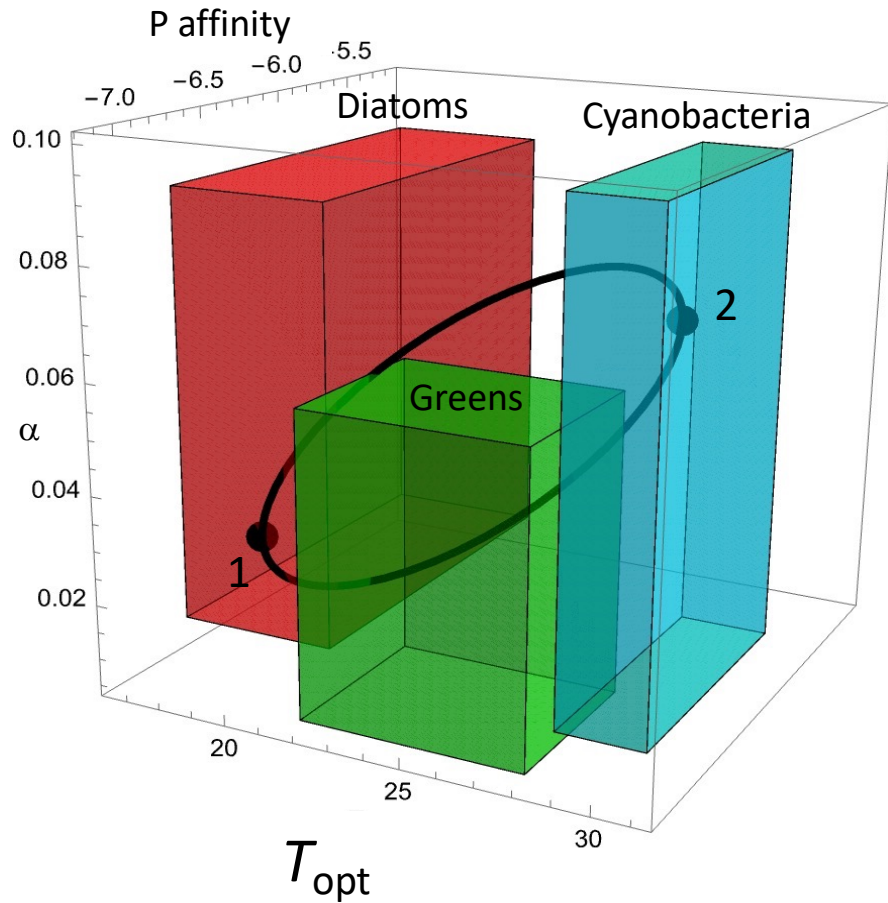
Temperature traits

Cyanobacteria have higher T_{opt} and T_{max} (in temperate latitudes)



Thomas et al. GEB 2016

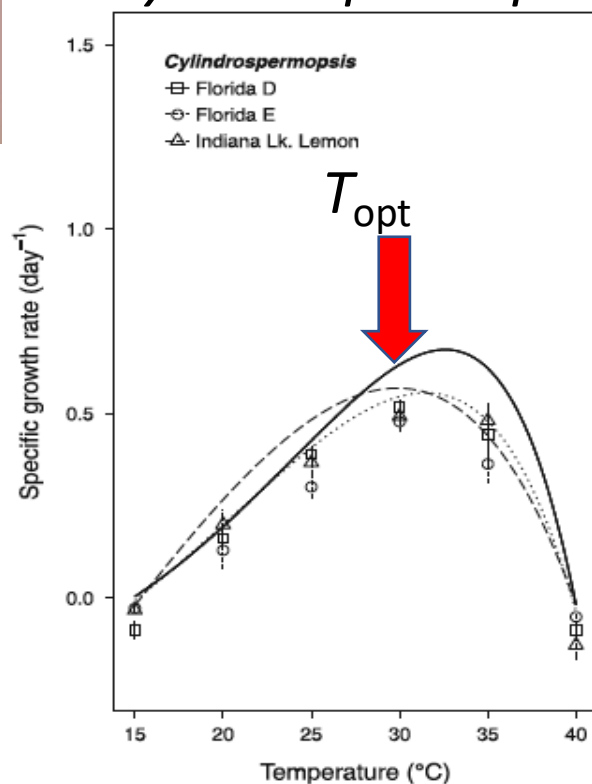
Multiple traits together



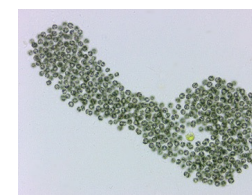
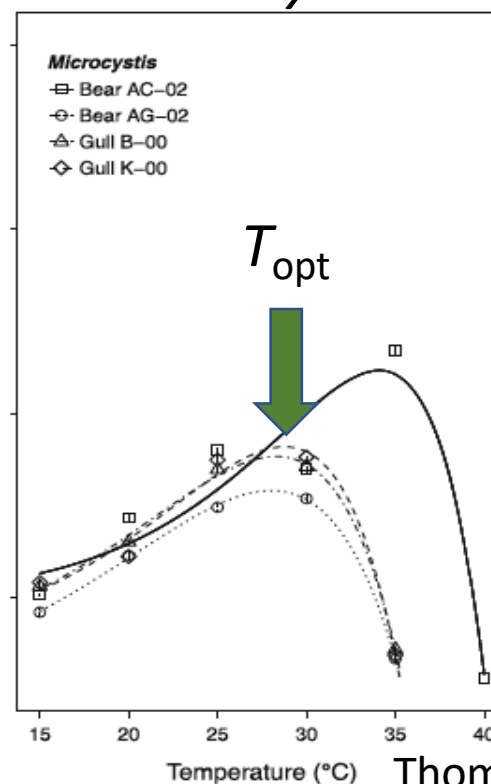
Temperature traits differences within HAB taxa



Cylindrospermopsis



Microcystis



Thomas & Litchman 2015

Cyanobacteria

Nitrogen fixers vs non-fixers

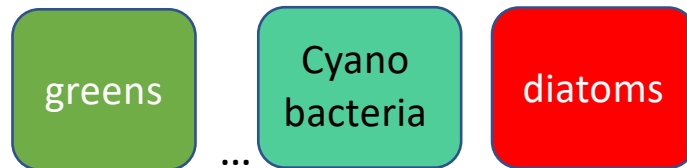
Relative abundance

Env. Factor	N-fixers	Non-fixers
Temperature	(-)	+
log(TN)	ns	+
log(TP)	ns	ns
log(TN/TP)	-	ns
pH	+	+
log(total biovolume)	-	ns

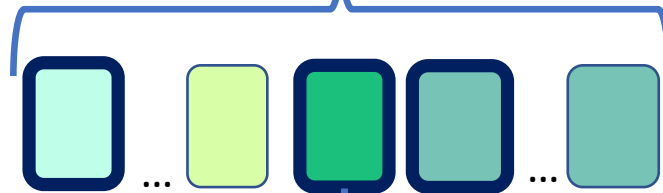
Kremer et al. in prep.

Trait comparison level

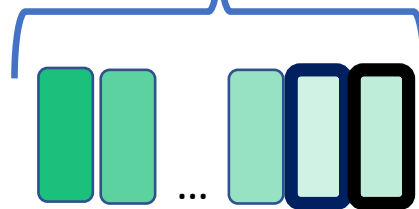
Major taxa



Interspecific



Intraspecific



Relevant questions

- Is cyanobacterial dominance likely?
- Will there be a bloom?

- What cyanobacterium would dominate?
- Will it be a N-fixer?
- Will the bloom be toxic?
- Will there be a species succession within a bloom?

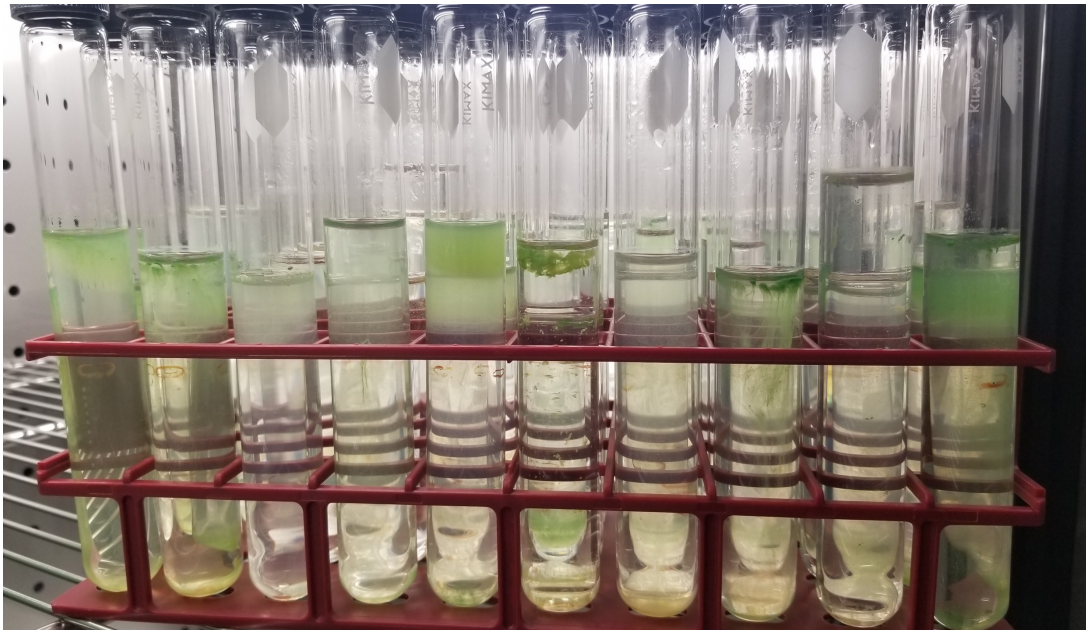
- Will there be a change in toxicity within a bloom?
- What is the potential for evolutionary adaptation for that species?

Cyanobacterial isolates from the Great Lakes

>150 strains in culture (L. Superior, Michigan, Erie, Huron)



Carol Waldmann
Rosenbaum

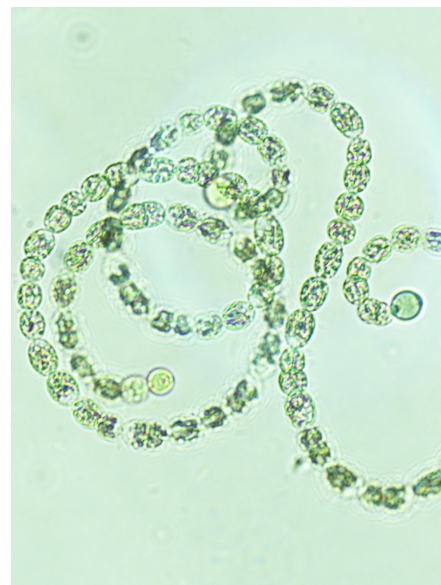
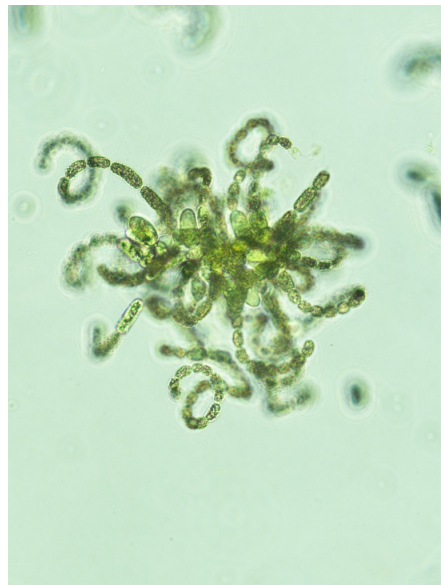
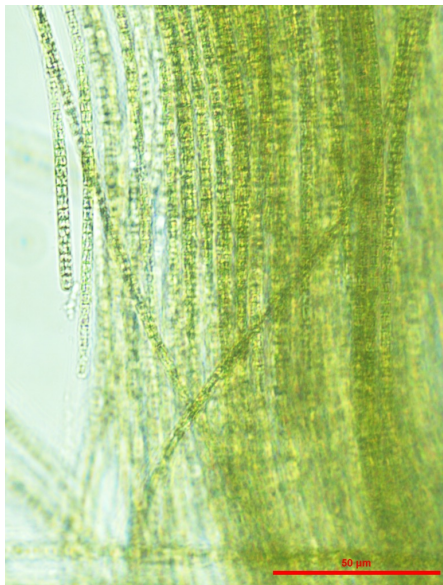


Cyanobacterial isolates from the Great Lakes

>150 strains in culture (L. Superior, Michigan, Erie, Huron)

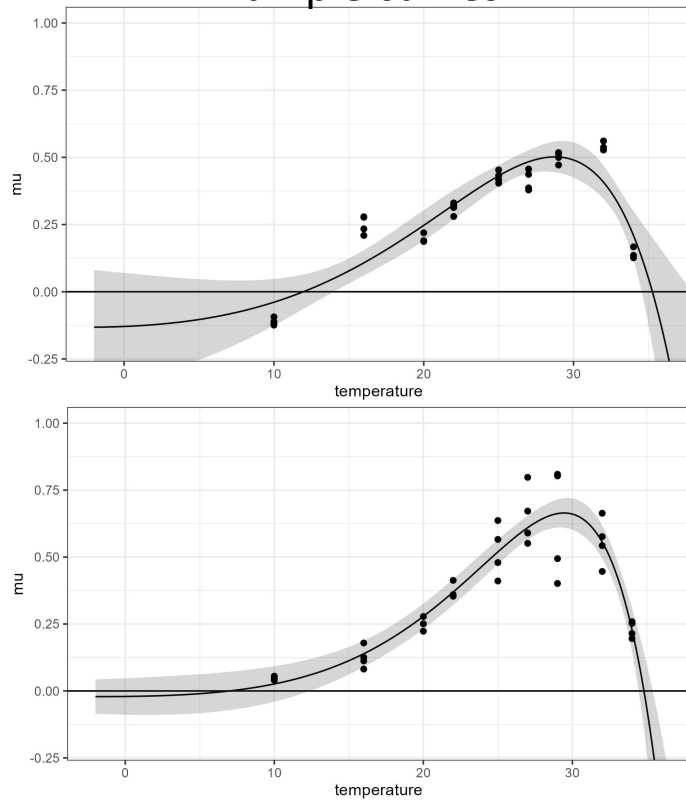


Carol Waldmann
Rosenbaum

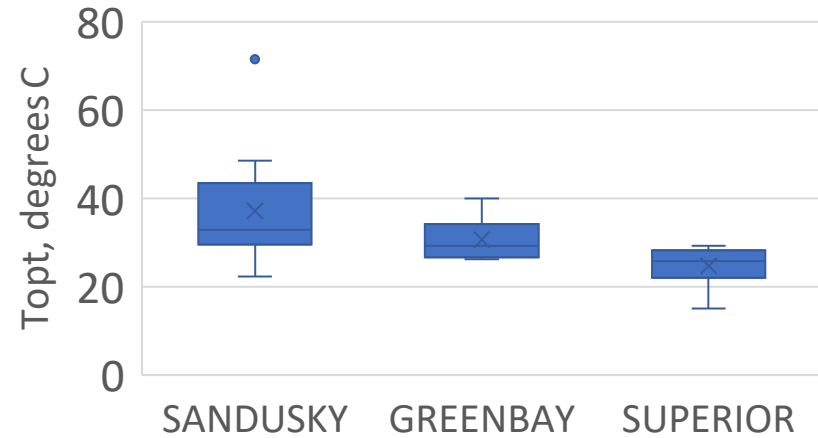


Temperature curves for the GL isolates

Example curves



Optimum temperature for growth,
Topt



Waldmann Rosenbaum et al. in prep.

What we can do:

- Collect trait data for diverse **HAB** taxa and compare them to **non HAB** taxa (multi-trait response surfaces)
 - Inter- and intraspecific differences
- Determine trait values for key HAB taxa and what conditions select for certain traits
- Develop mechanistic models that include key traits to predict trait selection under different scenarios (mixing, nutrient levels, temperature, etc.)
- Test models with data