Algae in the Front Range and beyond

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Image: *Gleotrichia,*
a HABS forming cyanobacteria
Credit: B. Rosen, USGS

Image: mixed assemblage of cyanobacteria and diatoms

Credit: B. Rosen, USGS

Plan

Algae – what are they? How do they function in aquatic ecosystems?

Algae – who are they? What is their biodiversity and why does it matter?

Starting at the top – high elevation lakes

In the middle – creeks and rivers

On the plains – reservoirs

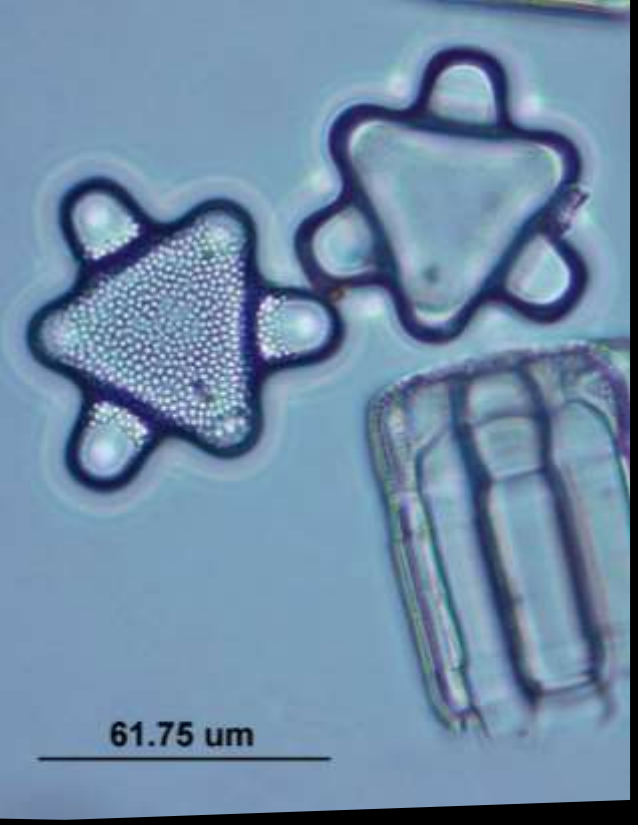
And beyond – measuring algal biomass and species change across the country

How do we live in a changing climate?

What are algae?

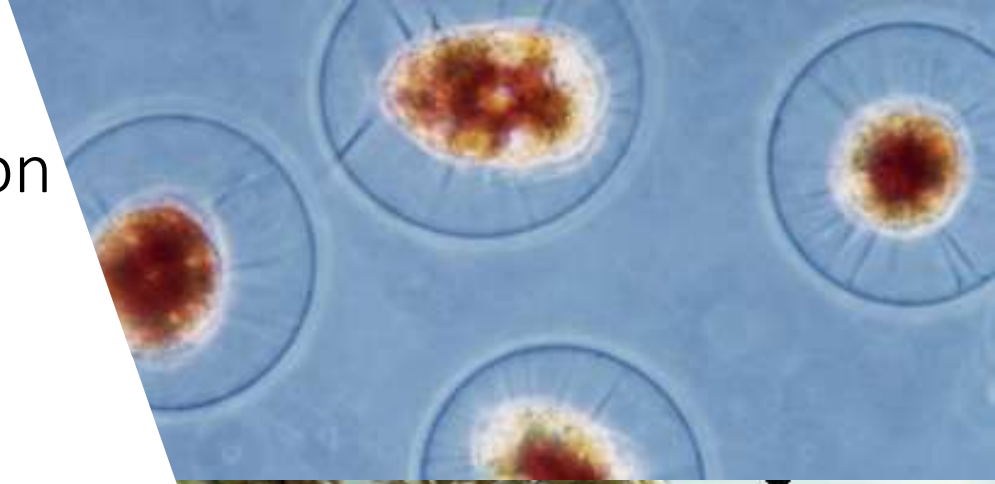
How do algae function in aquatic ecosystems?

Image: Nick Schulte wrapped in the green alga, *Cladophora*, within the Grand Canyon. USGS Grand Canyon Monitoring Research Center and Grand Canyon Youth
Credit: Nick Schulte



Algae *are not* plants
Algae *are not* a taxonomic group

Algae are an eclectic collection of organisms that belong to different kingdoms and divisions (phyla).



DIVISION	PHOTOSYNTHETIC PIGMENTS	STORAGE
Cyanobacteria	Chl *a*, phycoerythrin, phycocyanin, allophycocyanin	glycogen
Green algae	Chl *a, b*	cellulose
Chrysophyte	Chl *a*, c_1, c_2, c_3, fuxoxanthin	chrysolaminarin
Diatoms	Chl *a*, c_1, c_2, c_3, fuxoxanthin, diatoxanthin, diadinoxanthin	chrysolaminarin
Dinoflagellates	Chl *a*, c_2, peridinin	cellulosic theca
Cryptomonads	Chl *a*, c_2, phycocyanin or phycoerythrin, alloxanthin	periplast
Brown algae	Chl *a*, c_1, c_2, c_3, fuxoxanthin	laminarin

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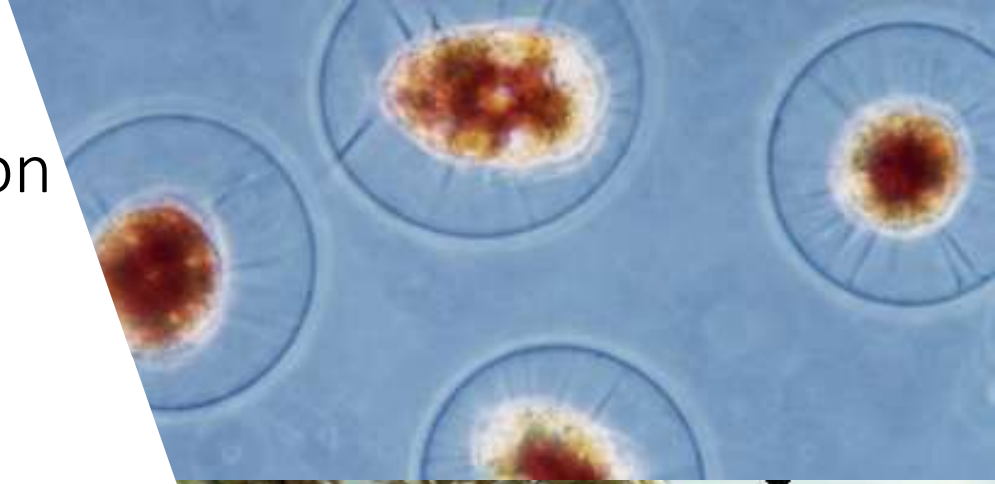

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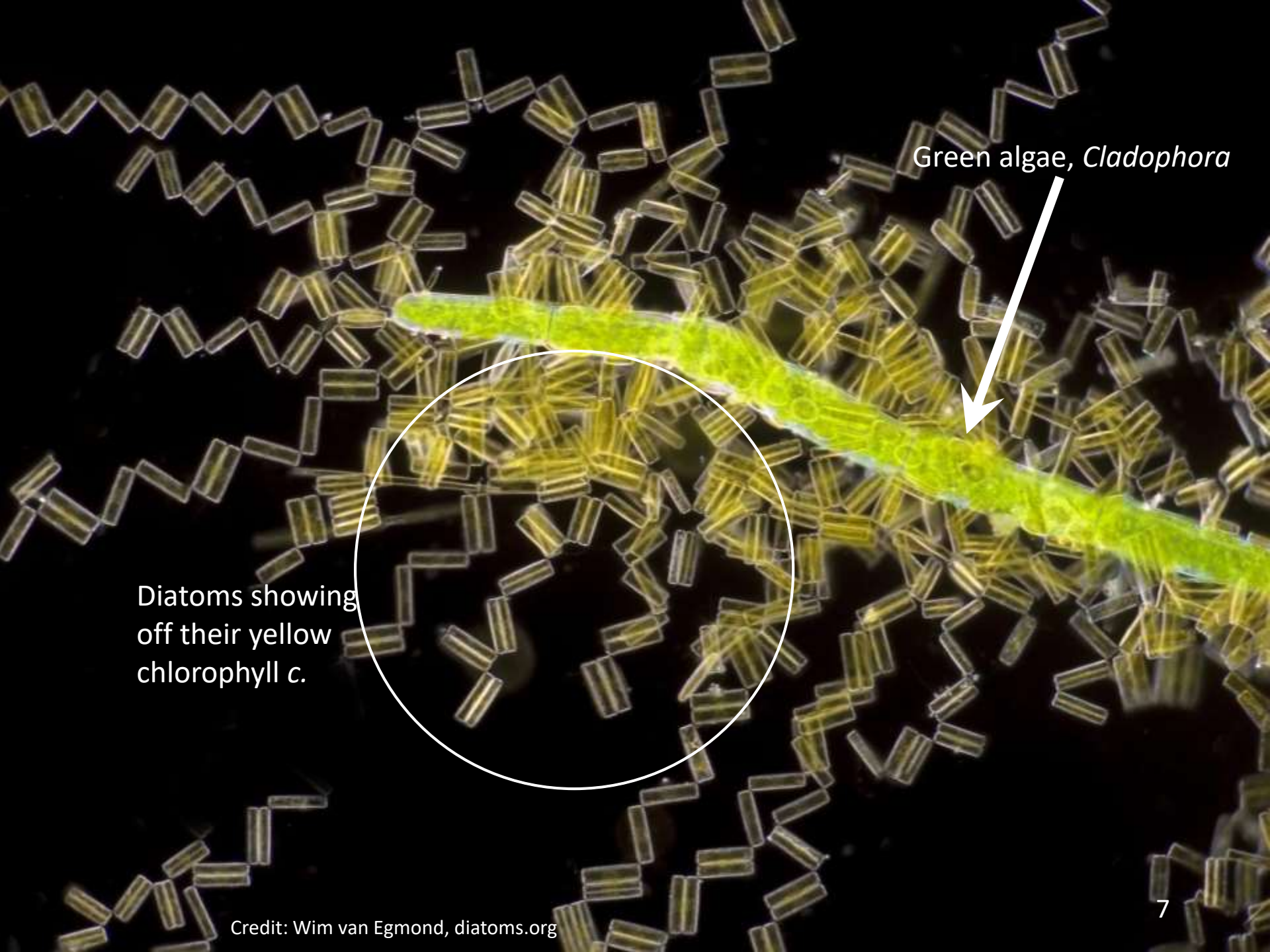
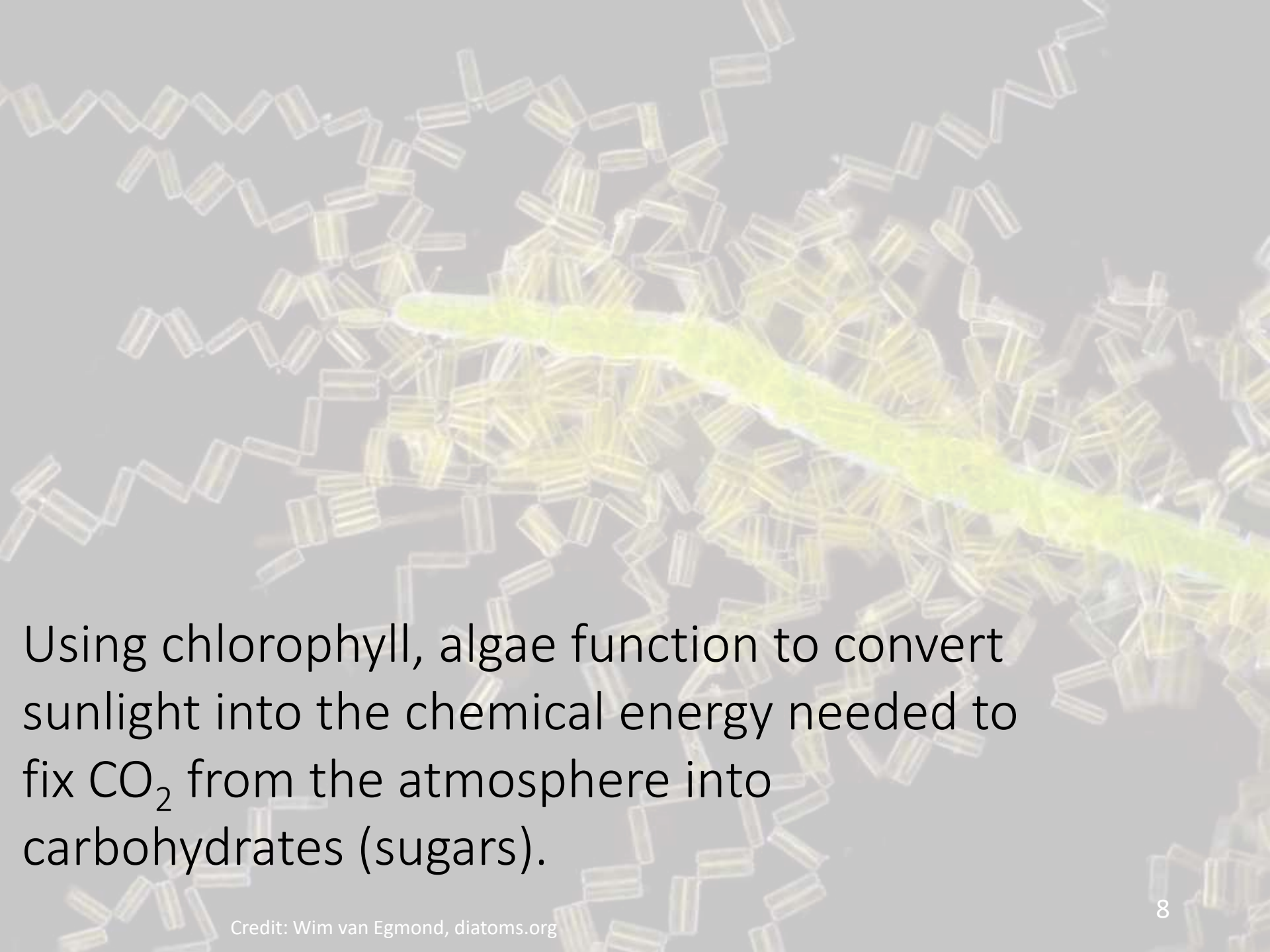
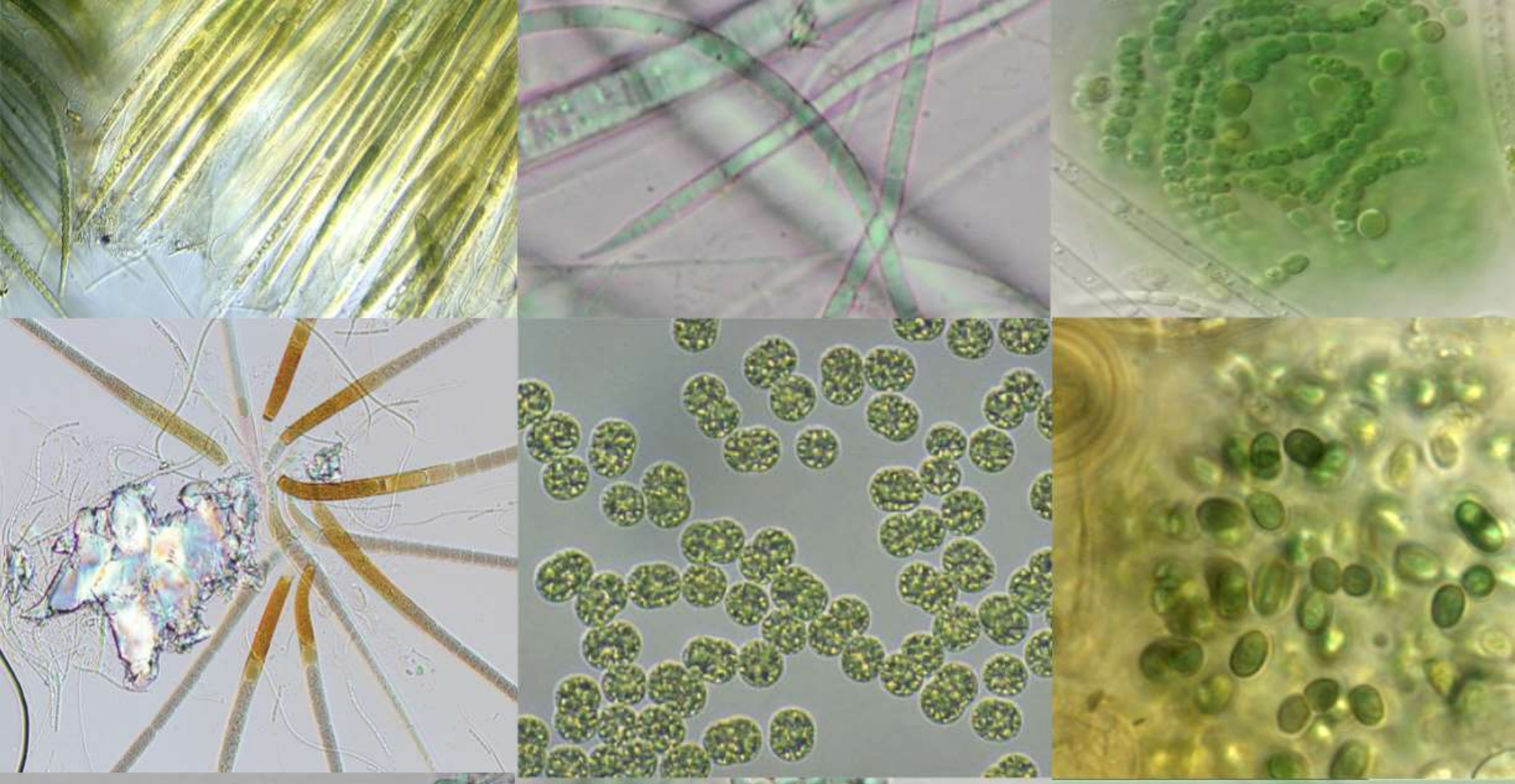


Credit: Wim van Egmond, diatoms.org



Using chlorophyll, algae function to convert sunlight into the chemical energy needed to fix CO_2 from the atmosphere into carbohydrates (sugars).

Credit: Wim van Egmond, diatoms.org

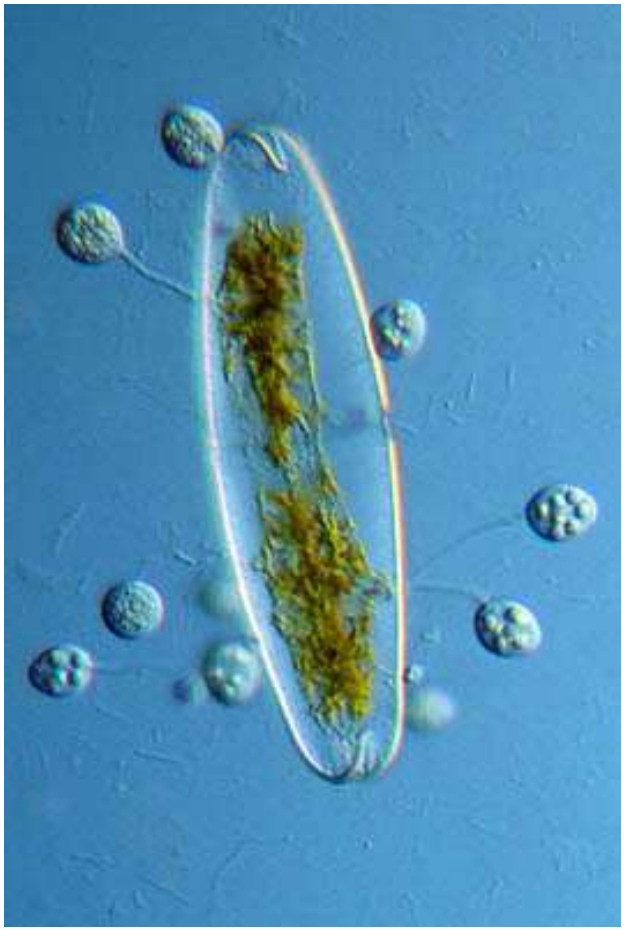


Cyanobacteria = blue-green algae

Cyanobacteria evolved 3.5 billion years ago, they are the earliest forms of life on earth

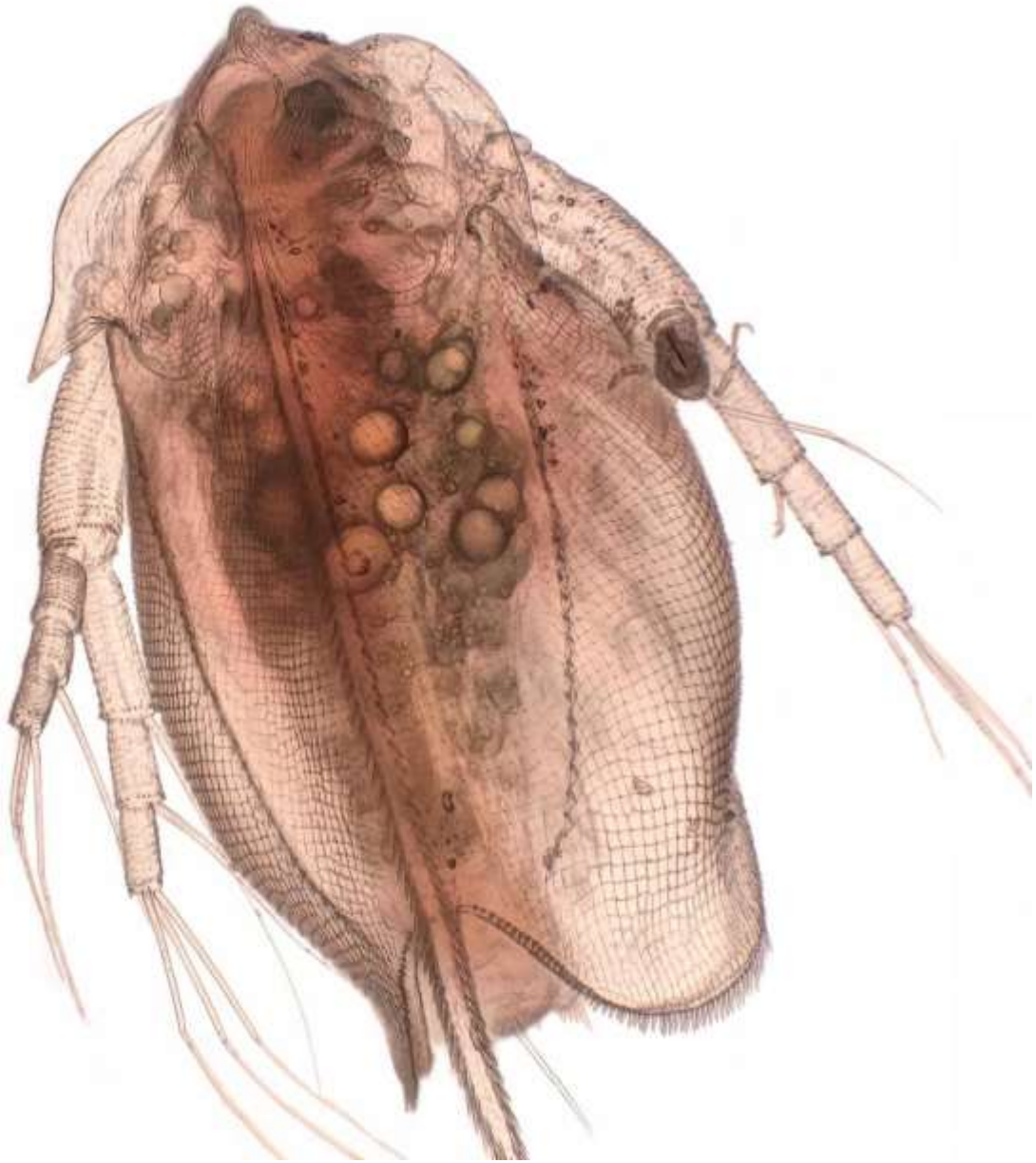
Some cyanobacteria (= blue green algae) have heterocytes that function to **fix atmospheric N_2** .

Some cyanobacteria are capable of producing toxins, forming harmful algal blooms, or HABs.



Algae feed other organisms –

Chytrid fungal parasite on a green alga



Algae are the base of the food web. They feed zooplankton like this *Daphnia*.

Cyanobacteria are an inedible or poor-quality food for most zooplankton.

Algae – who are they?
What is their biodiversity?
Why does algal biodiversity matter?

Image: Claire Couch enjoying *Cladophora*, within the Grand Canyon. USGS Grand Canyon Monitoring Research Center
Credit: S. Spaulding, USGS

Diatoms are the most diverse protists on earth

Diatoms are eukaryotes, one of the Heterokont algae.

Estimates of the number of diatom species range from 20,000 - 2 million. We are discovering new species every year.

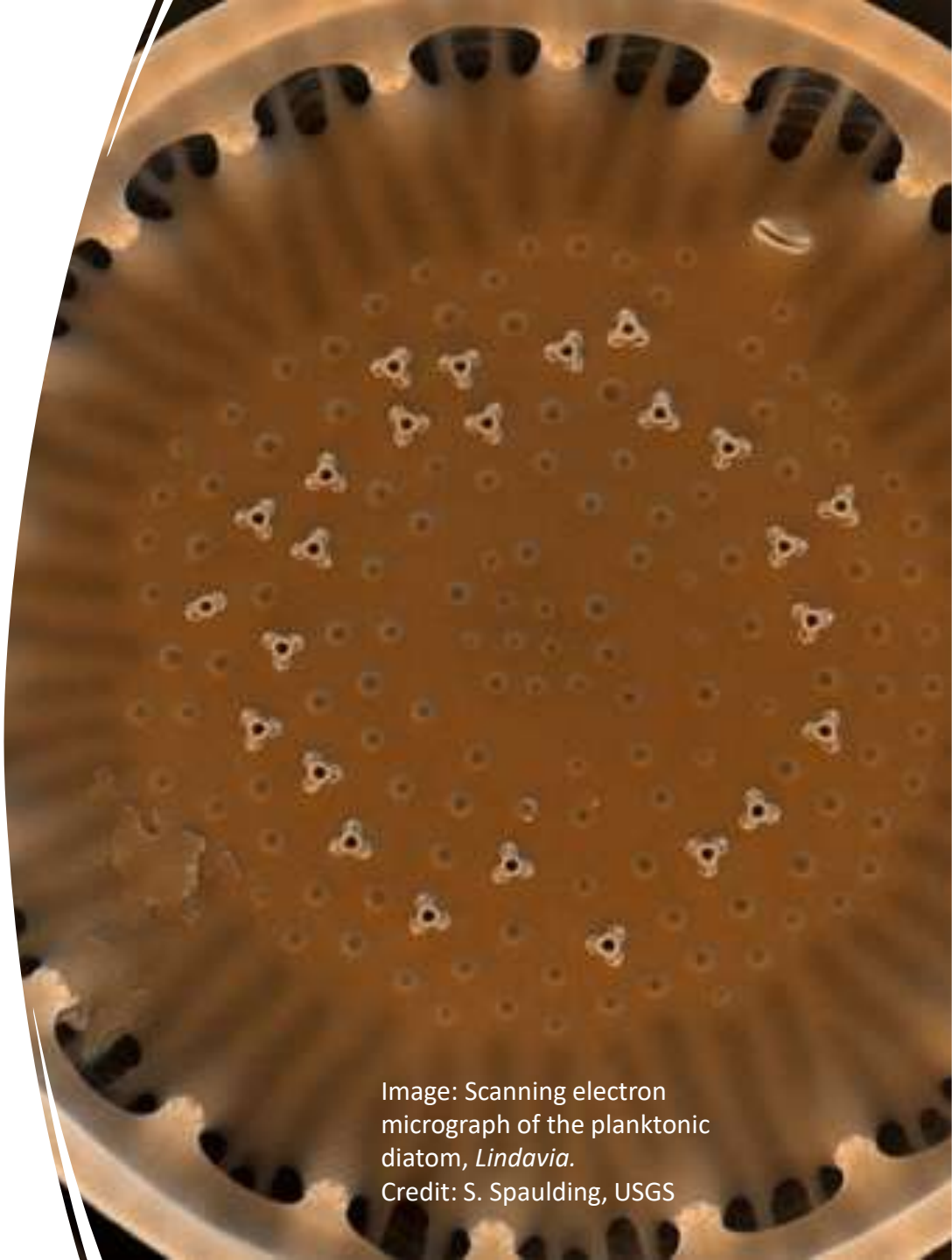


Image: Scanning electron micrograph of the planktonic diatom, *Lindavia.*
Credit: S. Spaulding, USGS

Image: Chattachoochee River, Georgia
Credit: A. Cressler, USGS

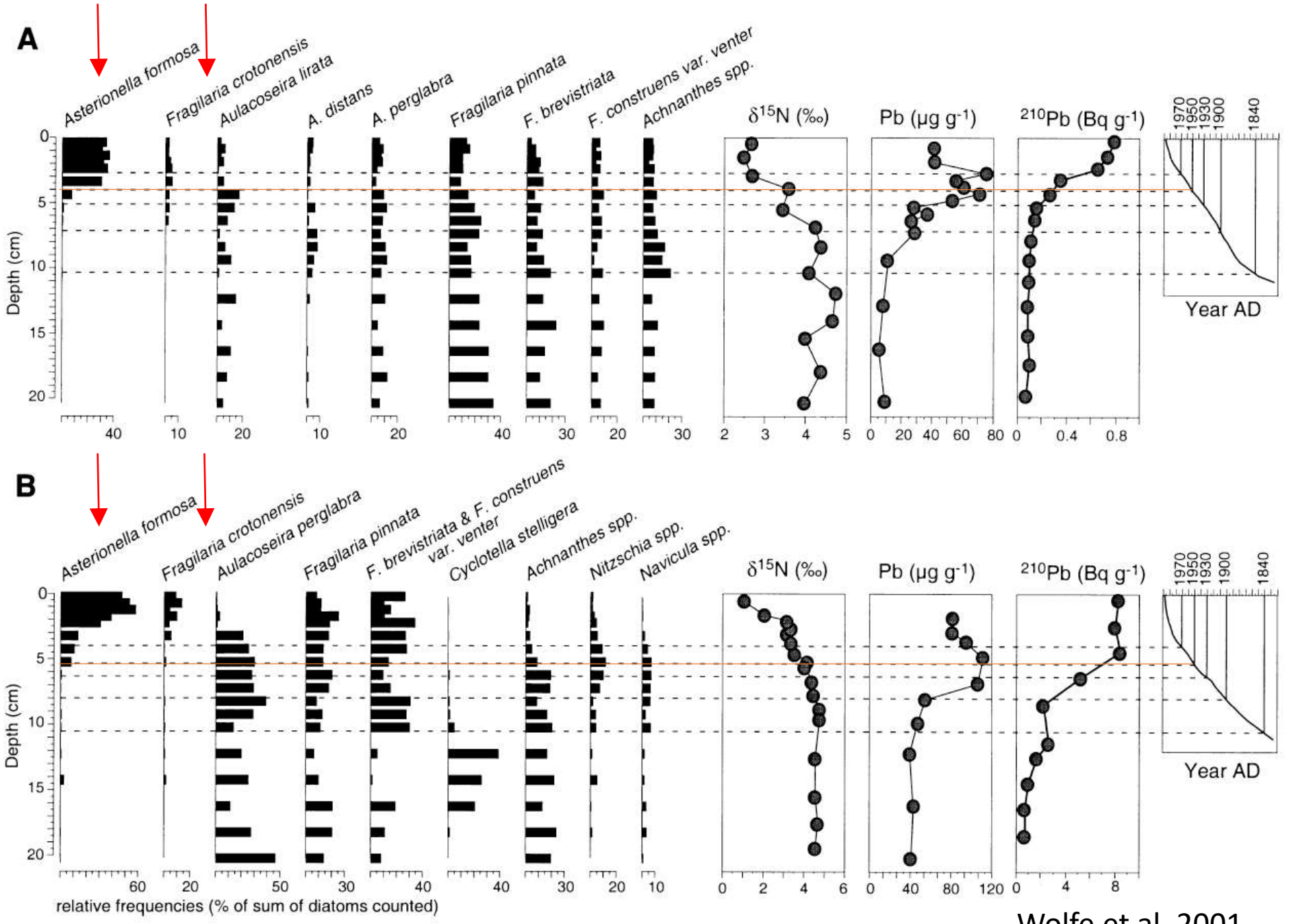
Algae, particularly diatoms, tell us about the health of aquatic systems

Diatoms are selective about the quality of water in which they live.

distinct ranges of pH, salinity, nutrient concentration, suspended sediment, flow regime, elevation, and other parameters

Starting at the top – high elevation lakes

Lake sediment core records extend across the Rocky Mountains and western North America



Wolfe et al. 2001

Image: *Zygnema* and *Tetraspora,* green algae in The Loch, Rocky Mountain National Park, CO
Credit: Oleksy et al. 2020

In The Loch, Rocky Mountain National Park, total algal biomass has more than doubled since 1950 (Oleksy et al. 2020).

Image: Lake Tahoe, Nevada & California
Credit: Vadeboncoeur et al. 2021

Clear lakes, such as Lake Tahoe are increasingly experiencing filamentous algal blooms (FABS) (Vadeboncoeur et al. 2021).

FABS are thought to be the result of complex changes in climate, nutrient transport, lake hydrodynamics, and food web structure.

In the middle – Boulder Creek

Image: Colorado River @ Cameo with filamentous green algae, *Cladophora*.
Credit: Natalie Day, USGS

Image: Colorado River, below Glen Canyon Dam (2021), diatom *Didymosphenia*.
Credit: S. Spaulding, USGS

With drought, there is an increasing frequency of high biomass of attached algae.

During periods of low flow, scour is decreased, water transparency and temperature increase, and attached algae accumulate.

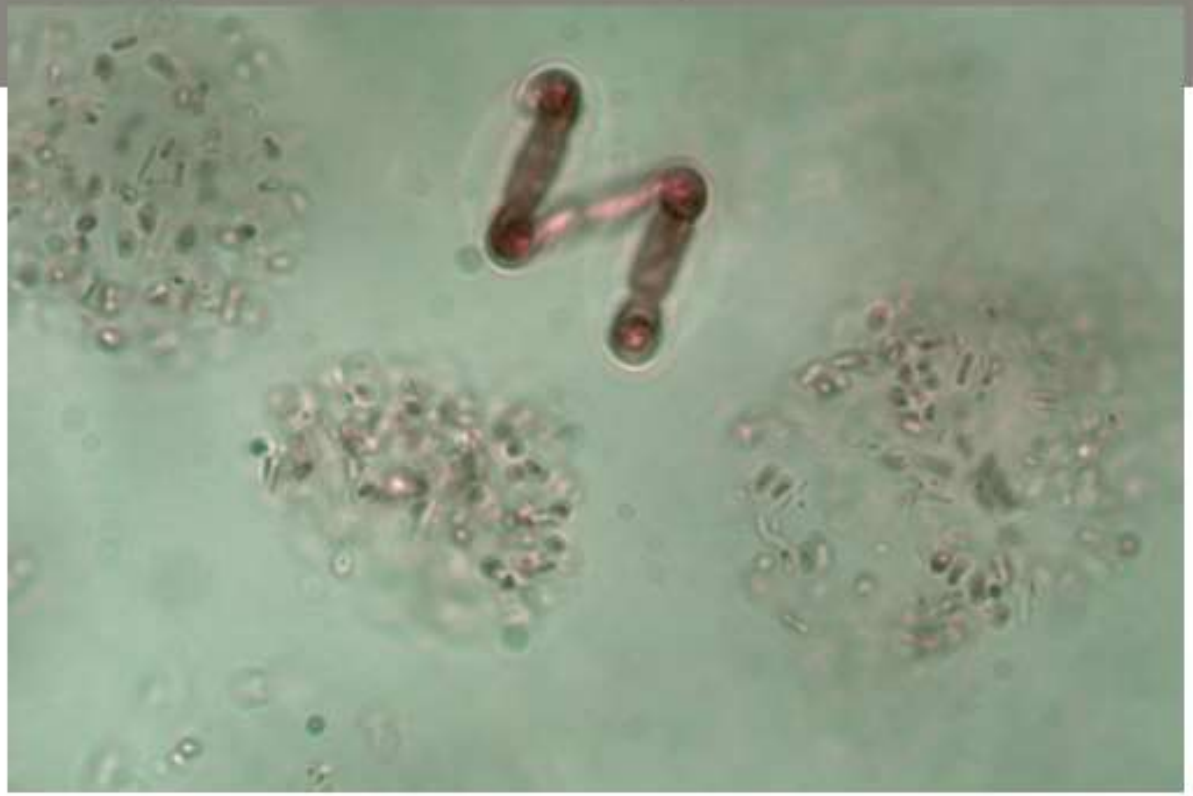
These FABS alter streams and river ecosystems, although they are not typically toxin producing.

On the plains – reservoirs
More nutrients, warmer water temperatures

Wonderland Lake
Image: Dylan Williams

FINAL REPORT

Ecological Status of Lagerman Reservoir



Lagerman Reservoir is dominated throughout the year by cyanobacteria, including the colonial *Synechococcus*.

Primary Researcher: Maggie Anderson

Principal Investigator: Dr. Sarah Spaulding

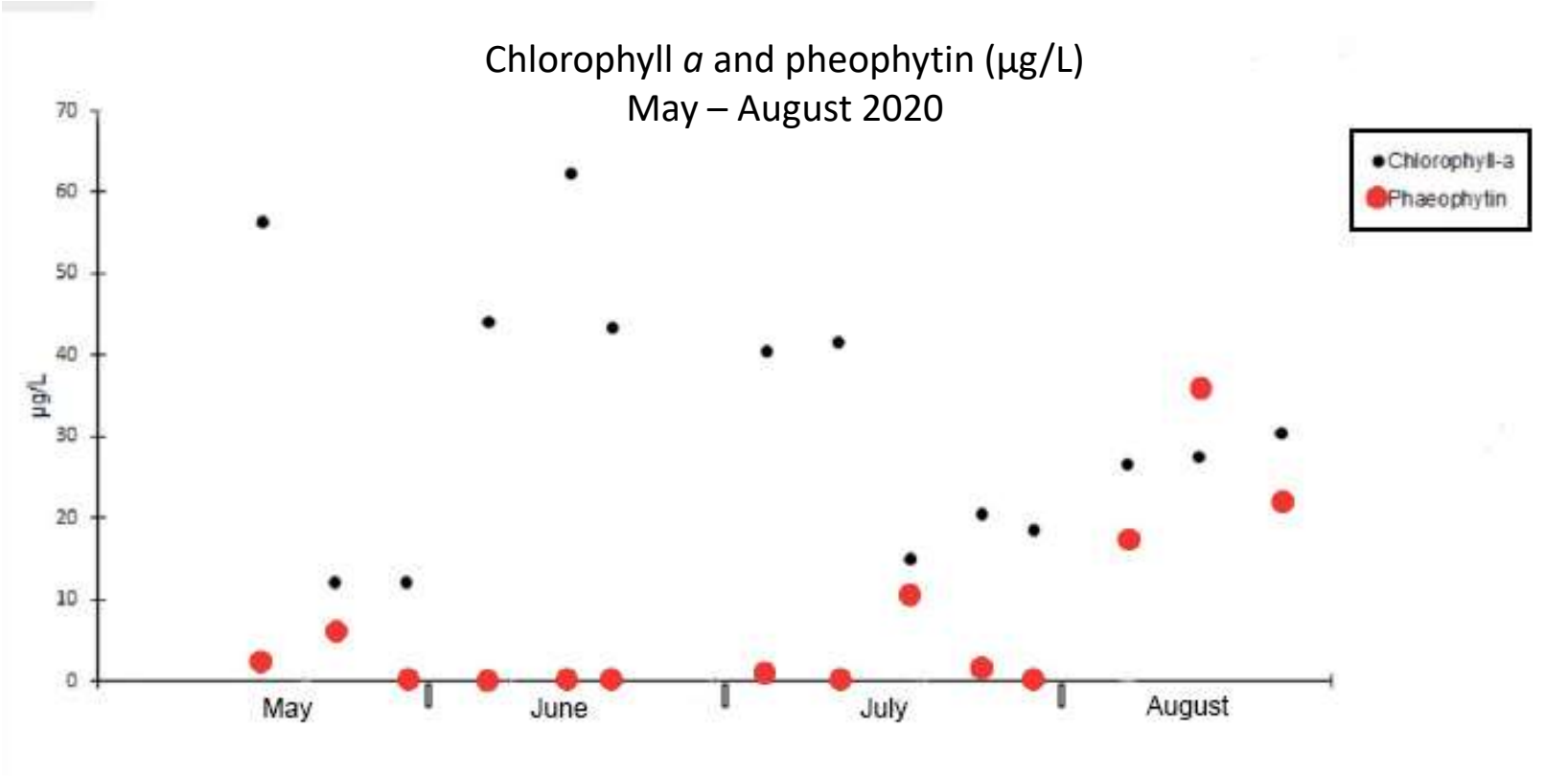
CoPrincipal Investigator: Dr. Diane McKnight

High phosphorus concentrations (8.67 mg/L, Summer 2020), close to being considered hypereutrophic.

Secchi depth (transparency) of 0.2-0.3 m also indicates hypereutrophic conditions.

Based on these measures, Lagerman Reservoir is unsuitable for fish and is vulnerable to toxic algal blooms that could be hazardous to human health.

Bloom of the cyanobacteria *Synechococcus* in Lagerman Reservoir. Peaks of the bloom are marked by the concentration of chlorophyll *a*. Pheophytin concentration increases as the algal cells are dying.



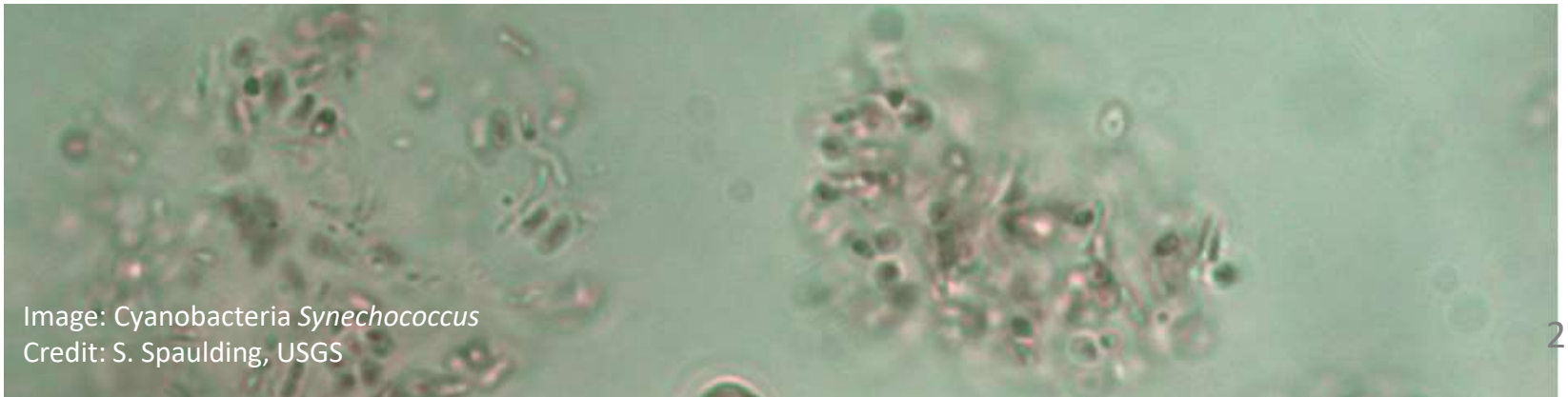


Image: Cyanobacteria *Synechococcus*
Credit: S. Spaulding, USGS

Cyanobacteria Assessment Network v1.1.27

Compare

Notifications

Composition of diatoms in Boulder drinking water intakes

Boulder reservoir, issues with clogging filters

Image: Bloom forming diatom, *Stephanodiscus*, in a water treatment reservoir, Colorado Springs.
Credit: S. Spaulding

And beyond – measuring algal biomass and species change across the country

Harmful algal blooms (HABS) are an issue in freshwaters at the national scale.

Nearly every state is impacted by HABS events.

Toxins may harm domestic animals and wildlife, present a risk to humans through drinking water, and are transferred through food webs.

Image: Lake Erie
Credit: USGS

Image: Kansas River
Credit: USGS

HABS thresholds

Threshold values of chlorophyll are used for defining onset and severity of HABS.

Updated guidelines include algal cell concentration, along with ranges of 3 - 12 µg/L for low-level recreational waters and 12 - 24 µg/L for level 1 alert.

Image: Cyanobacteria *Aphanizomenon* in Klamath Lake, Oregon
Credit: S. Spaulding, USGS

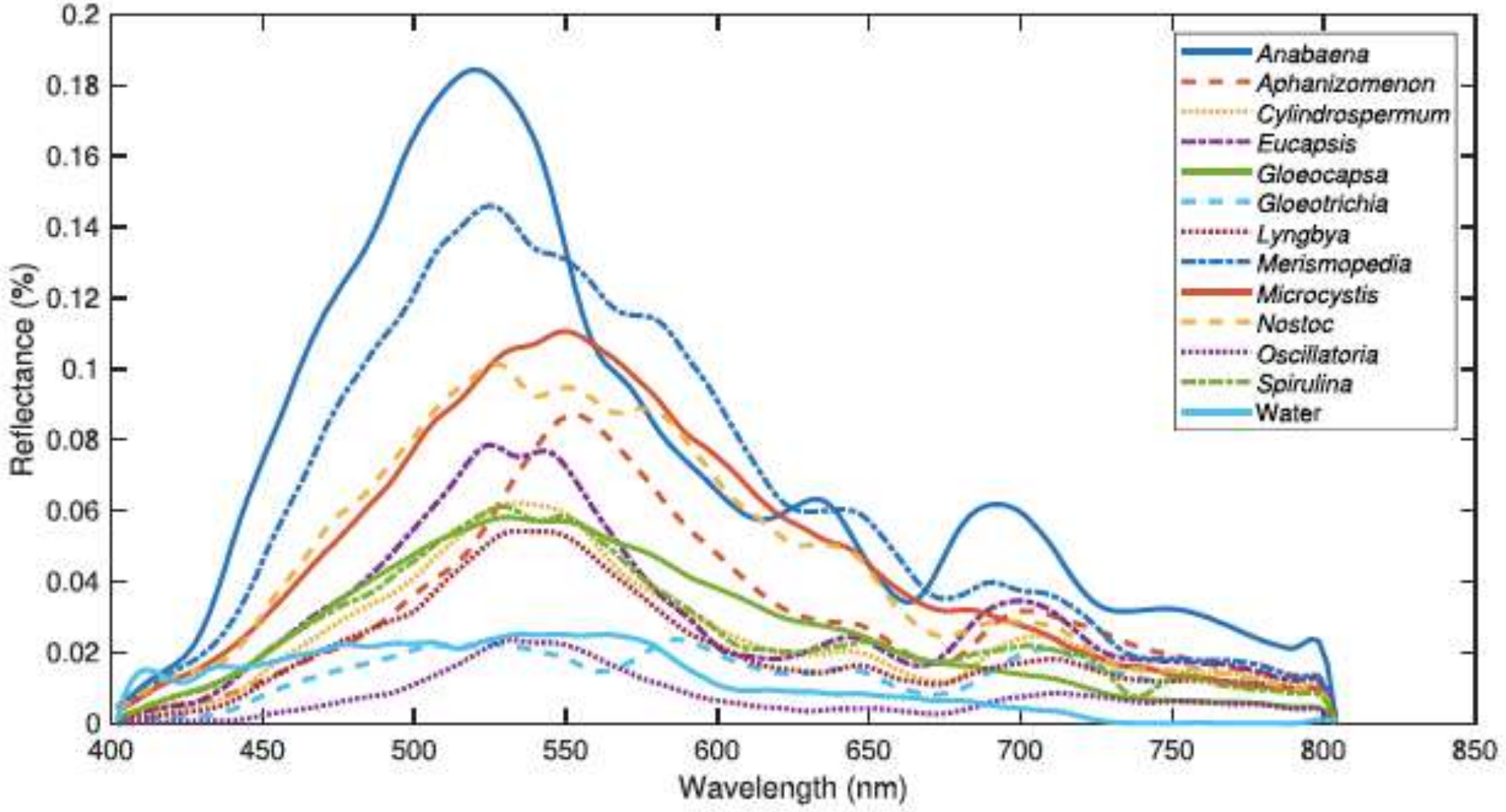
Field sensors

Continuous chlorophyll sensors are an important component of USGS national network. Sensors measure fluorescence in the field as relative fluorescence units (RFU).

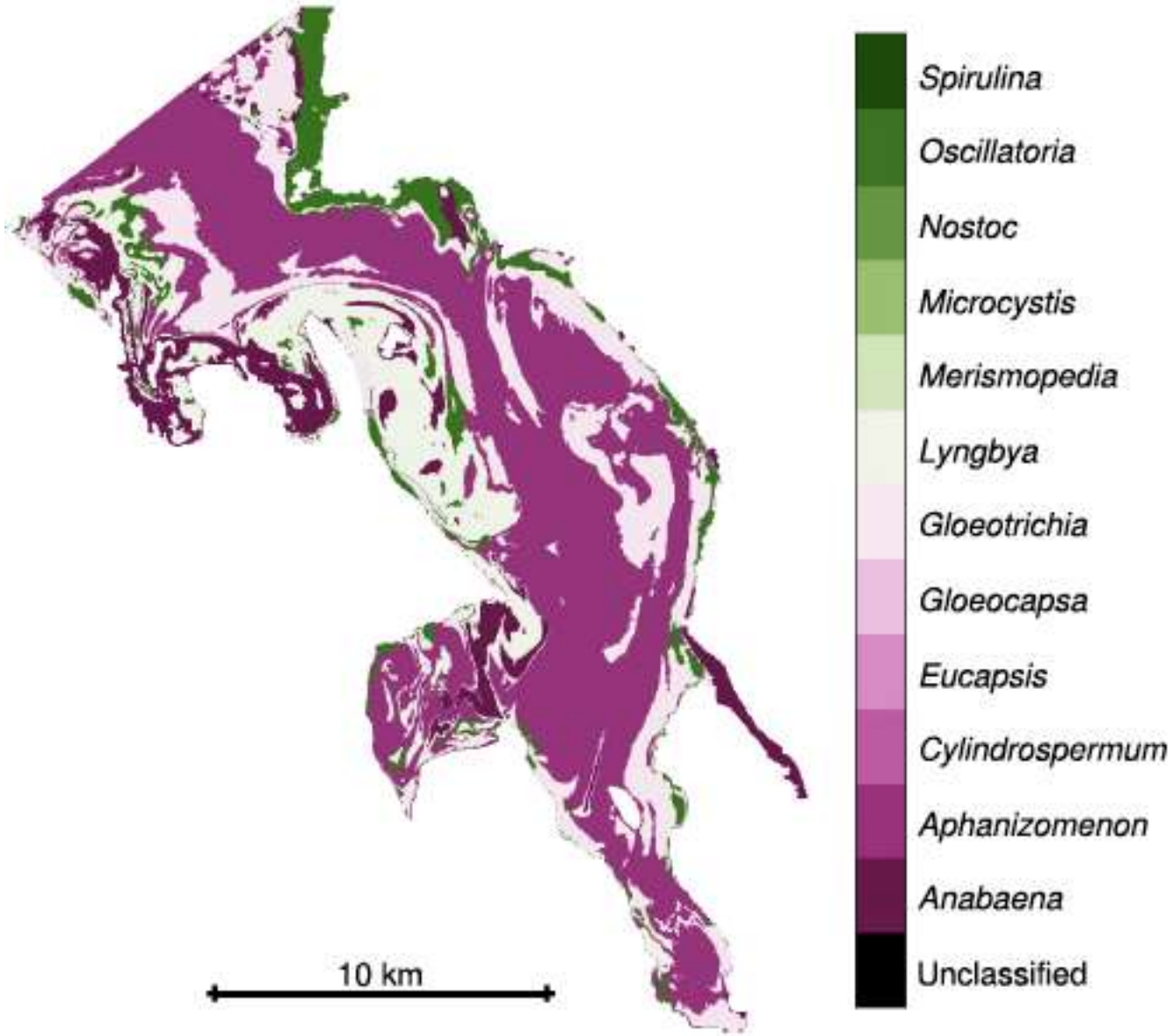
Sensors produce measures that represent *all* chlorophylls (chlorophyll *a* + *b* + *c* + pigments + other interferences).

Foster et al. 2022. Field techniques for the determination of algal pigment fluorescence in environmental waters— Principles and guidelines for instrument and sensor selection, operation, quality assurance, and data reporting. U.S. Geological Survey Techniques and Methods, book 1, chap. D10, 34 p., https://doi.org/10.3133/tm1D10

Spectral characterization of cyanobacteria



Legleiter et al. 2022. Spectral mixture analysis for surveillance of harmful algal blooms (SMASH): A field-, laboratory-, and satellite-based approach to identifying cyanobacteria genera from remotely sensed data. Remote Sensing of Environment 279



MESMA-based classification of algal genera derived from a DESIS image of Upper Klamath Lake.

Legleiter et al. 2022. Spectral mixture analysis for surveillance of harmful algal blooms (SMASH): A field-, laboratory-, and satellite-based approach to identifying cyanobacteria genera from remotely sensed data. Remote Sensing of Environment 279

Our waters are changing in different ways, depending on their position on the landscape and there are consequences for our local aquatic ecosystems.

Image: Cyanobacteria *Dolichospermum, Microcystis* and *Aphanizomenon*
Credit: B. Rosen, USGS


How do we live in a changing climate?

Thank you to my collaborators, colleagues, friends, algae

Lindsay Platt, Gretchen Oelsner, Jenny Murphy, Diane McKnight, Sarah Stackpoole, Phil Savoy, Nino Raynor, Tyler King, Dan Button, Sheila Murphy, Jeni Keisman, USGS HABS proxies group, Nick Schulte, Claire Couch.

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