From the Lake to the Lab: Understanding the History of Maine's Lakes Together

Avery N. Lamb

1865 THE UNIVERSITY OF MAINE

CLIMATE CHANGE INSTITUTE

University of Maine Land Acknowledgement

The University of Maine recognizes that it is located on Marsh Island in the homeland of the Penobscot Nation, where issues of water and territorial rights, and encroachment upon sacred sites, are ongoing. Penobscot homeland is connected to the other Wabanaki Tribal Nations — the Passamaquoddy, Maliseet, and Mi'kmaq — through kinship, alliances and diplomacy. The university also recognizes that the Penobscot Nation and the other Wabanaki Tribal Nations are distinct, sovereign, legal and political entities with their own powers of self-governance and self-determination.

University of Maine Lake Ecology Lab

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Vendy Hazukova (PhD)
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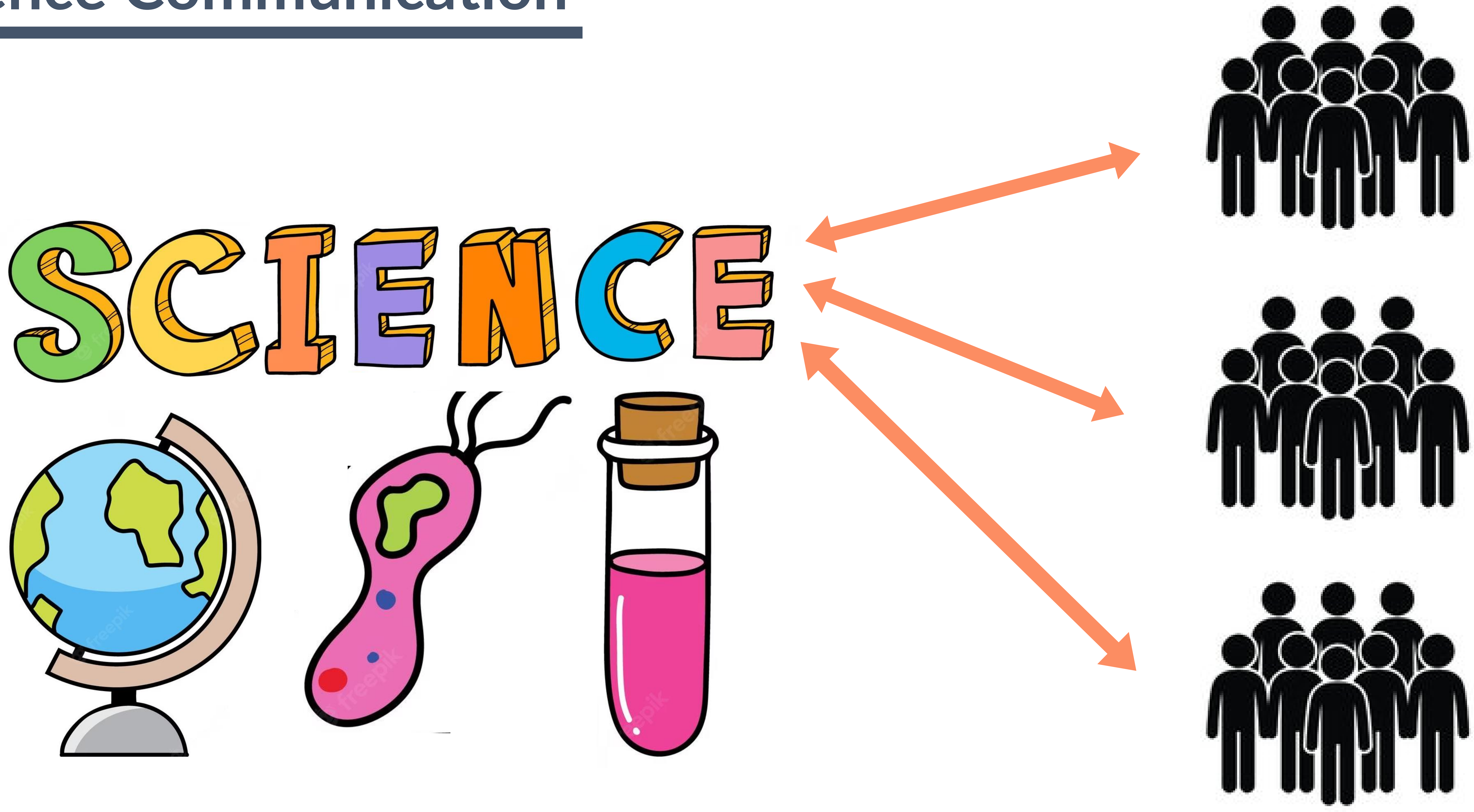
Science Communication



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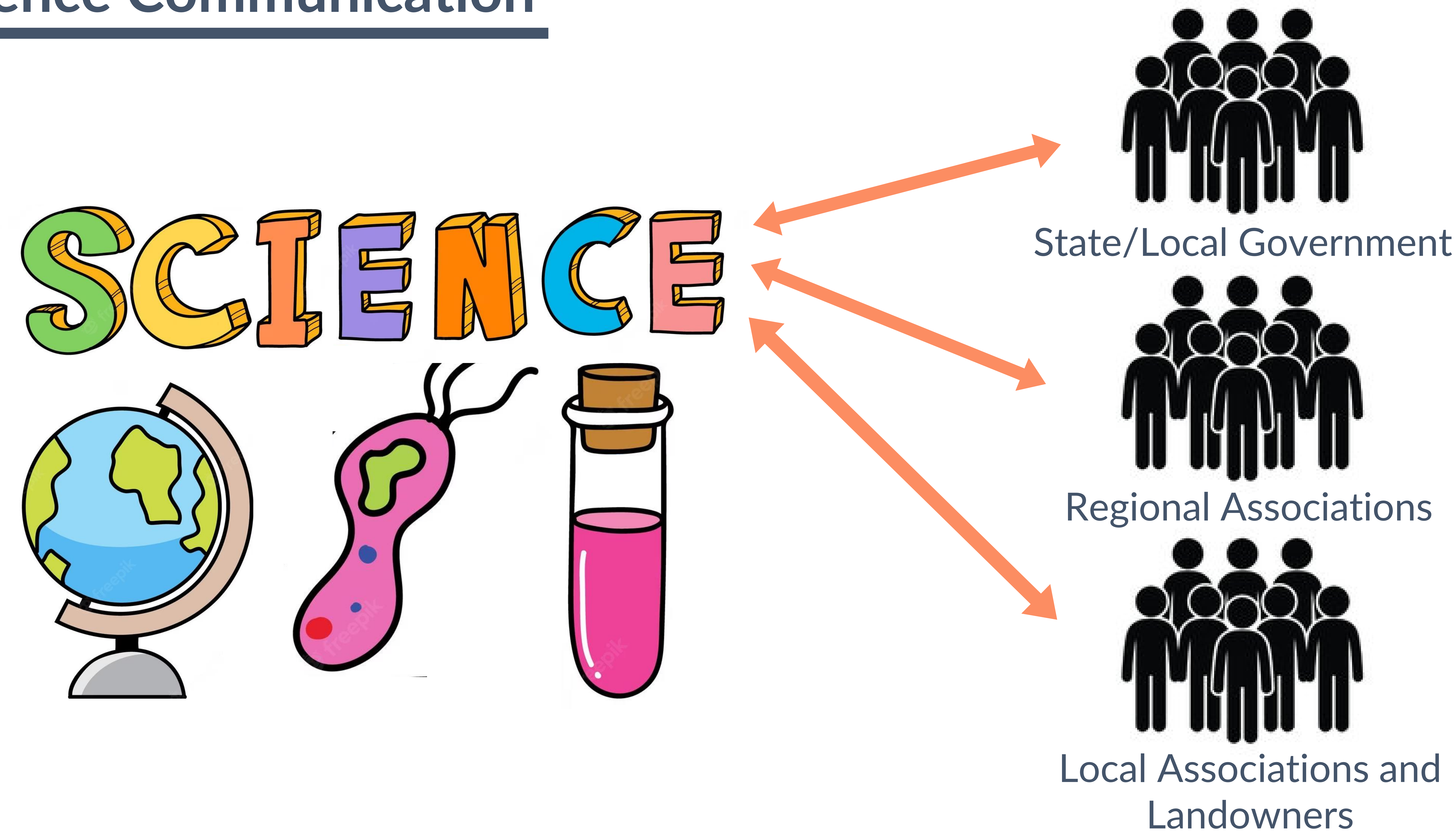

What to take away from today:

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4. The answers to these questions are valuable for both the scientific sphere and your local communities.
5. Collaborating with, learning from, and communicating to the public throughout the scientific process makes science more **understandable** and more **actionable**.

CyanoHABs

- cyanoHABs = **cyano**bacterial **H**armful **A**lgal **B**looms
- Synonymous with:
  - Cyanobacterial bloom
  - Algal bloom
  - Blue-green algae

CyanoHABs

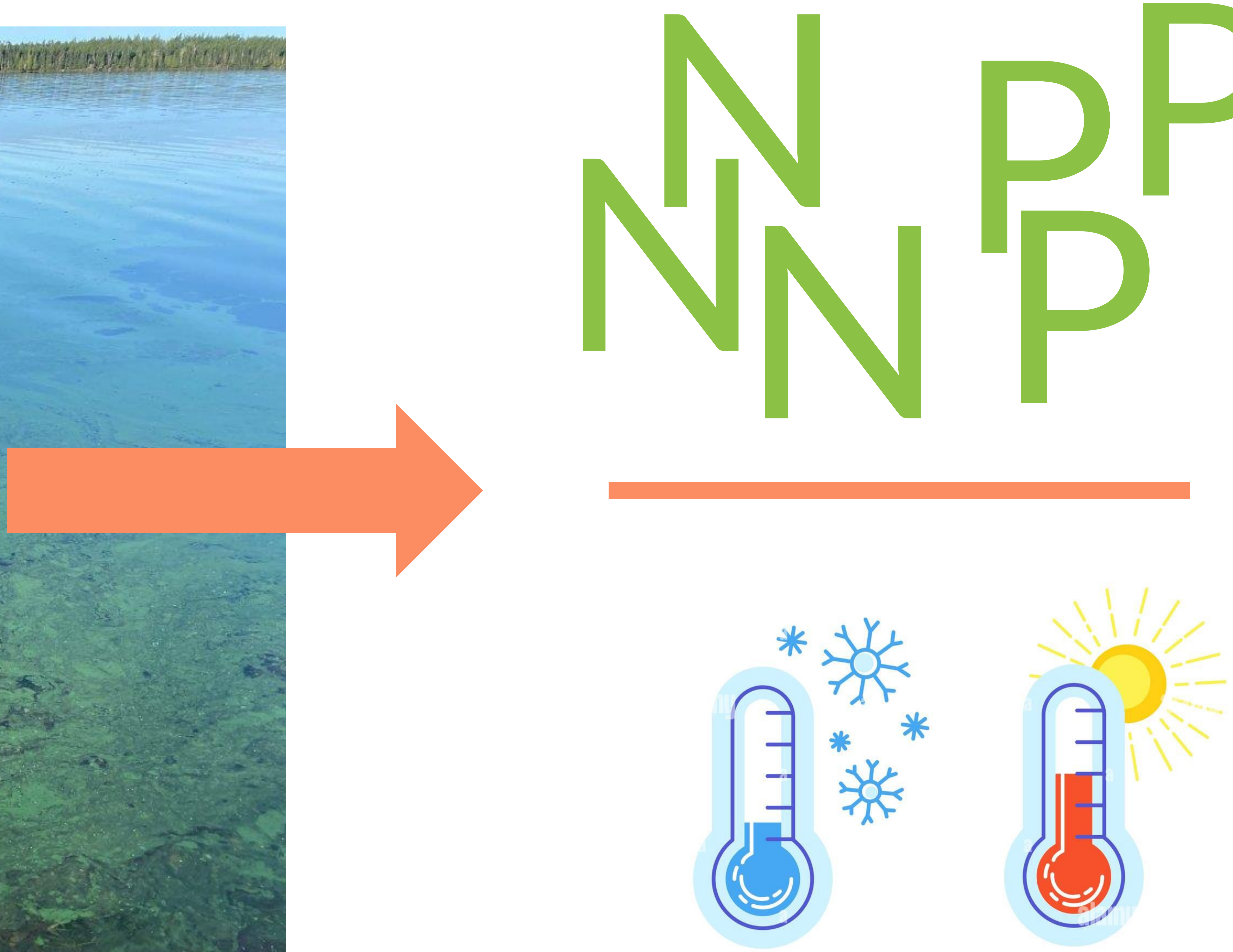
- Possible environmental effects of cyanoHABs
  - Clogs fish gills
  - Decreases light availability
  - Creates oxygen dead zones and fish kills
  - **Produces cyanotoxins**

- And for people? Impacts to **RECREATION**

  CONSUMPTION

  INDUSTRIES

Triggers of CyanoHABs?



Cyanobacterial Blooms in the U.S.

The National Lakes Assessment (NLA) 2012

Are conditions getting better or worse?

A comparison of the 2007 and 2012 National Lakes Assessments indicates little change between surveys. In most cases, the percentage of lakes in degraded biological, chemical and physical condition did not change over this five year period, with a few notable exceptions.

13% ↓ **Lake drawdown:** Drawdown of lake water levels, whether by natural process or through direct manipulation, can adversely affect physical habitat conditions. Between 2007 and 2012, the NLA shows improving conditions with *13% fewer lakes in the most disturbed condition.*

The NLA offers a unique opportunity to frame discussions and plan strategies for the protection and restoration of lakes across the United States. Additional information from the NLA is available online at epa.gov/national-aquatic-resource-surveys/nla. Website visitors can explore NLA results with interactive dashboards, find assessments of regional conditions, examine differences between natural lakes and reservoirs, and more.

8.3% ↑ **Cyanobacteria:** The NLA measured the density of cyanobacteria cells, which can produce cyanotoxins, as an indicator of toxic exposure risk. The analysis reveals worsening conditions, with *8.3% more lakes in the most disturbed condition in 2012 than in 2007.*

9.5% ↑ **Microcystin:** The NLA shows a *9.5% increase in the detection of an algal toxin, microcystin.* However, concentrations of this algal toxin remain low and rarely exceeds World Health Organization recreational levels of concern (<1% of the population) in both assessments.

Cyanobacterial Blooms in the U.S.

Nutrient-dependent

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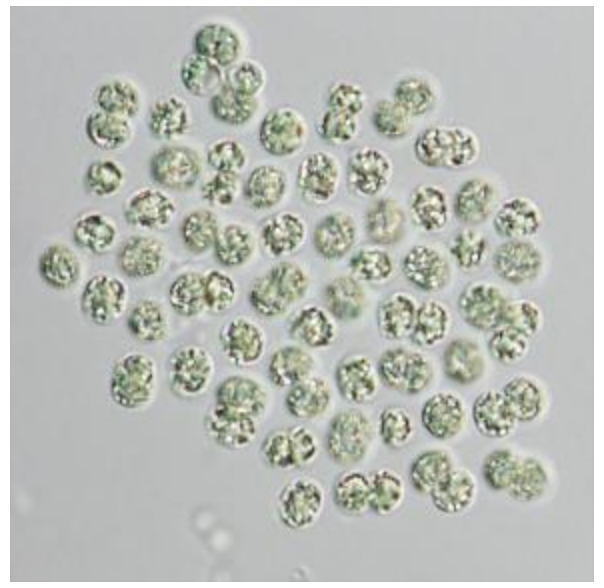
Microcystin-producing Cyanobacteria

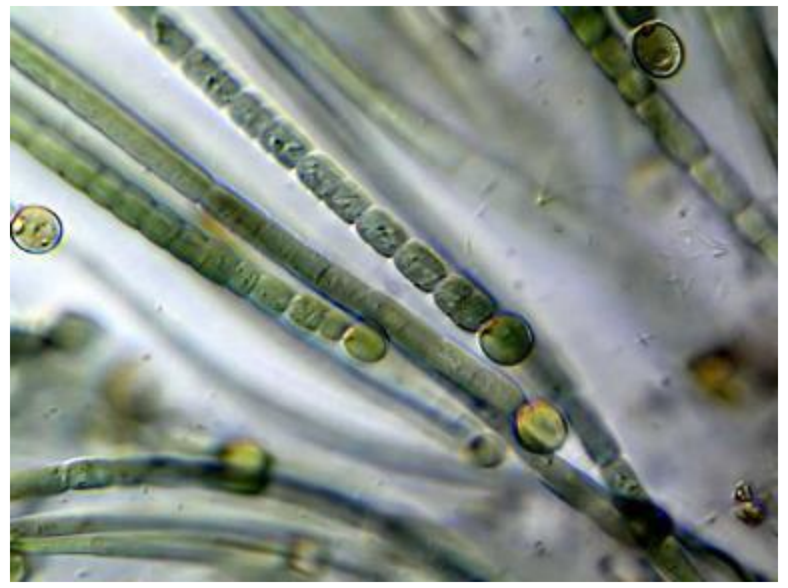
High Nutrient Lakes
Eutrophic, Hypereutrophic



Microcystis spp.

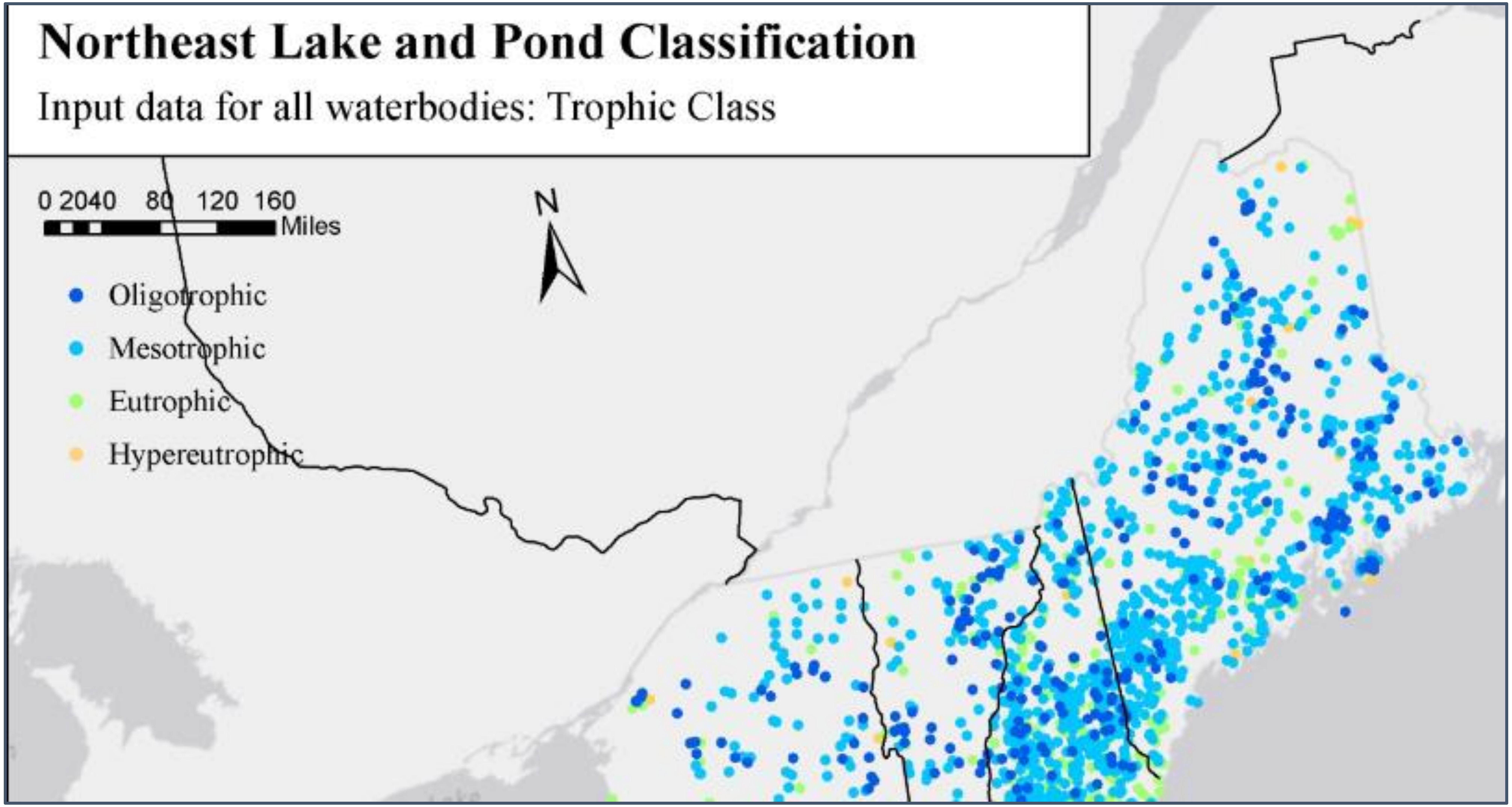
Dolichospermum spp.

Low Nutrient Lakes
Oligotrophic, Mesotrophic



Gloeotrichia spp.

Trophic States in Maine Lakes



From Sheldon and Anderson 2016

Cyanobacterial Blooms in Maine Lakes

Worsening algae blooms are making Maine's lakes and ponds more toxic

by Julia Bayly, Bangor Daily News | Wed, August 17th 2022, 7:56 AM EDT

Toxic blue-green algae may be forming in Maine lake

by WGME | Mon, August 17th 2020, 10:19 AM EDT

Maine Lakes Expected To See More Intense, Frequent Toxic Algal Blooms Due To Climate Change

Maine Public | By Patty Wight
Published September 18, 2019 at 2:42 PM EDT

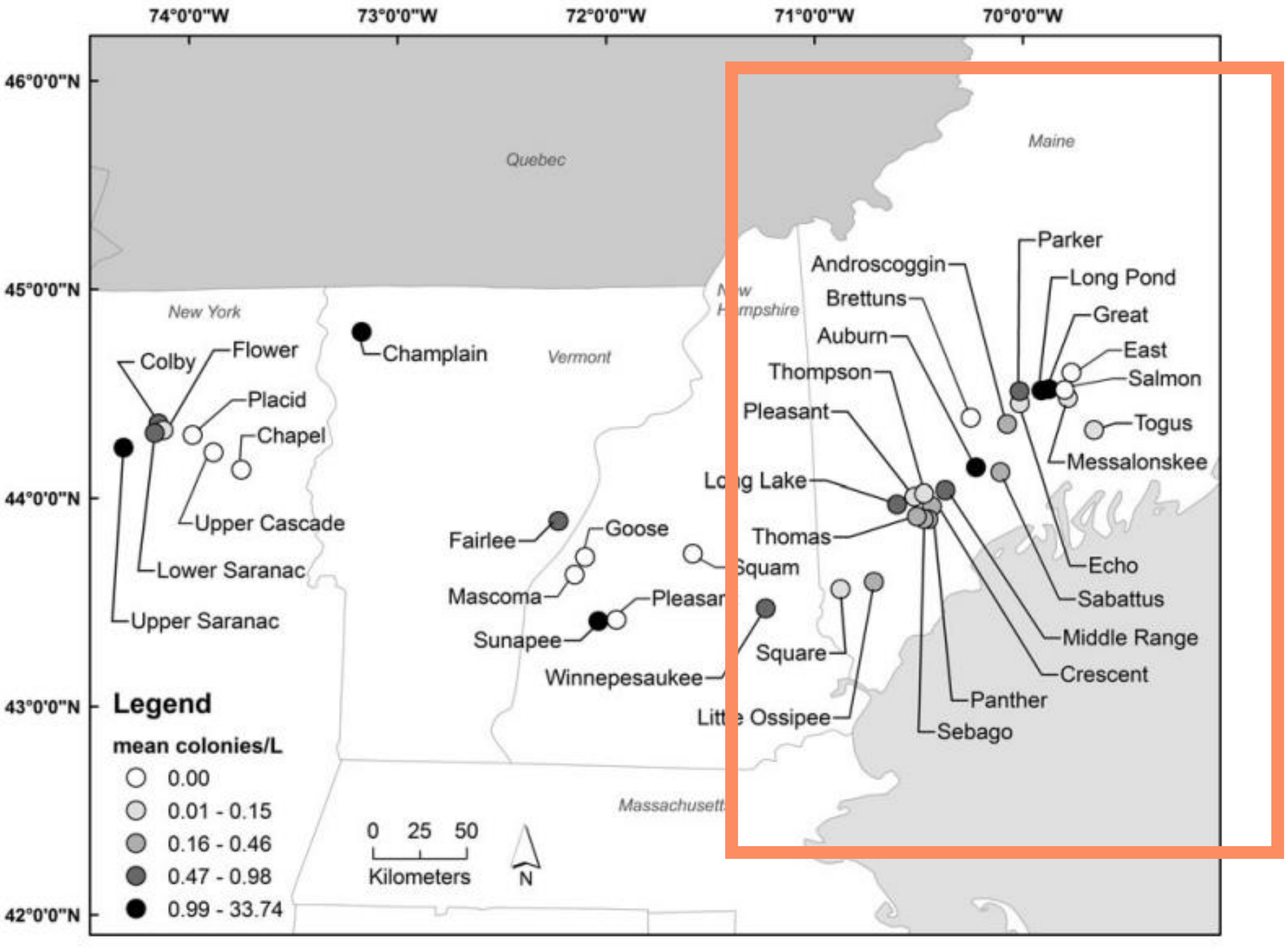
Algae Bloom at Damariscotta Mills Potentially Harmful

August 11, 2021 at 9:21 am

Paula Roberts

Gloeotrichia in Maine Lakes

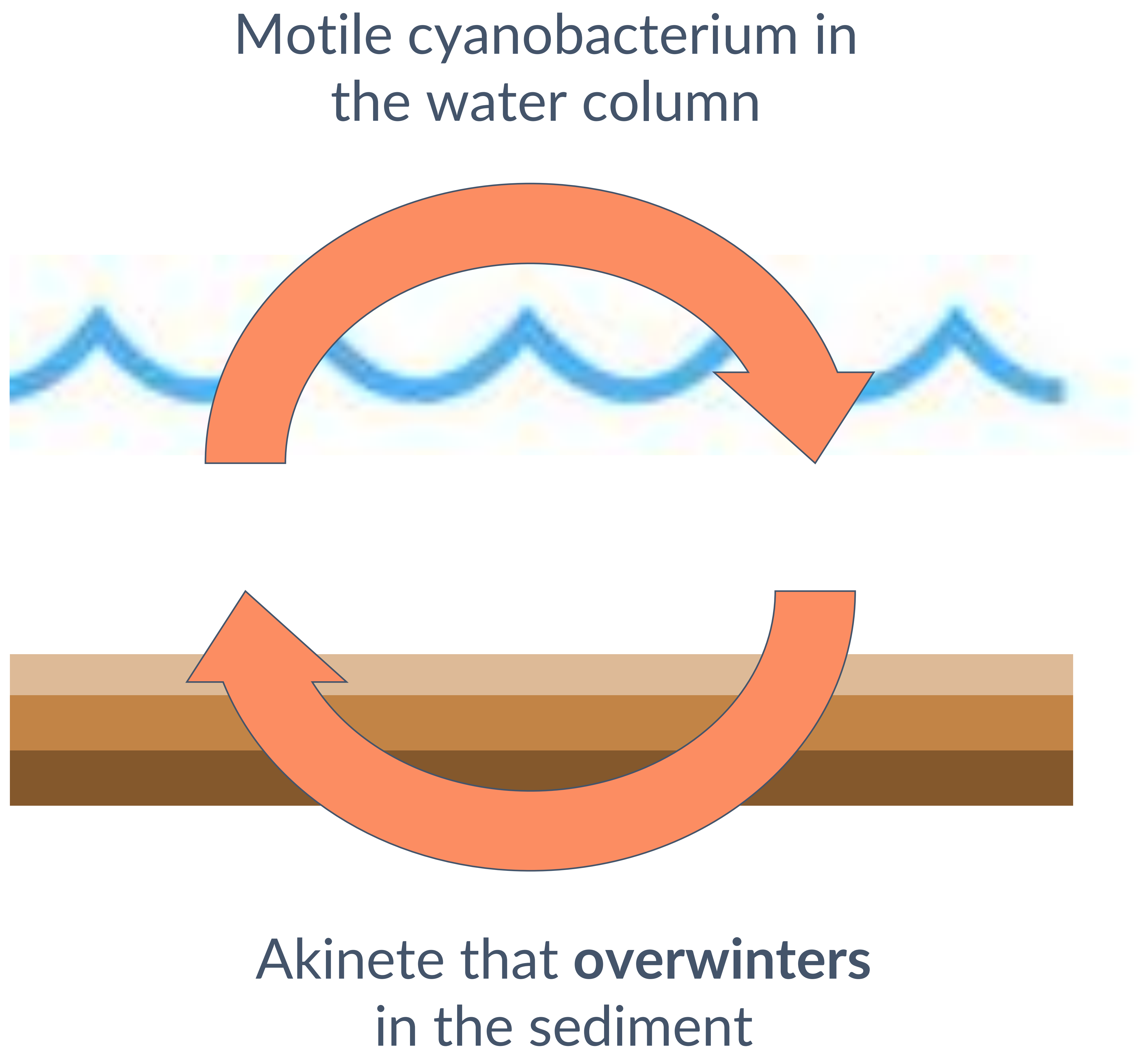
- *Gloeotrichia* already identified in 19/22 lakes sampled in Maine



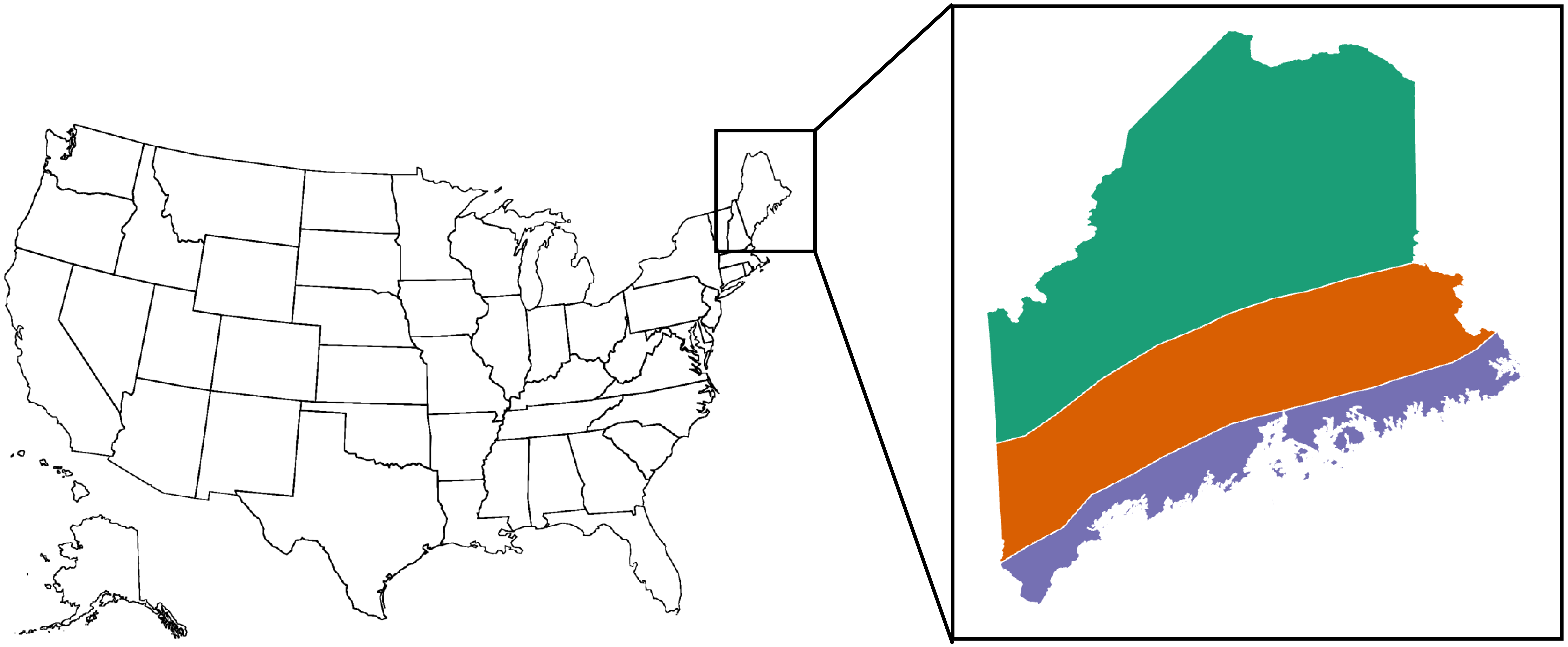
From Carey et al. 2012

Gloeotrichia in Maine Lakes

- *Gloeotrichia* has a meroplanktonic life cycle
- **Light** and **temperature** affect recruitment from sediment



Climate Change in Maine



Average Temperature Anomaly (°C)	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Northern	+0.28°	+0.09°	+0.14°	+0.20°
Central	+0.30°	+0.10°	+0.12°	+0.20°
Coastal	+0.92°	+0.31°	+0.28°	+0.61°

From Fernandez et al. 2020

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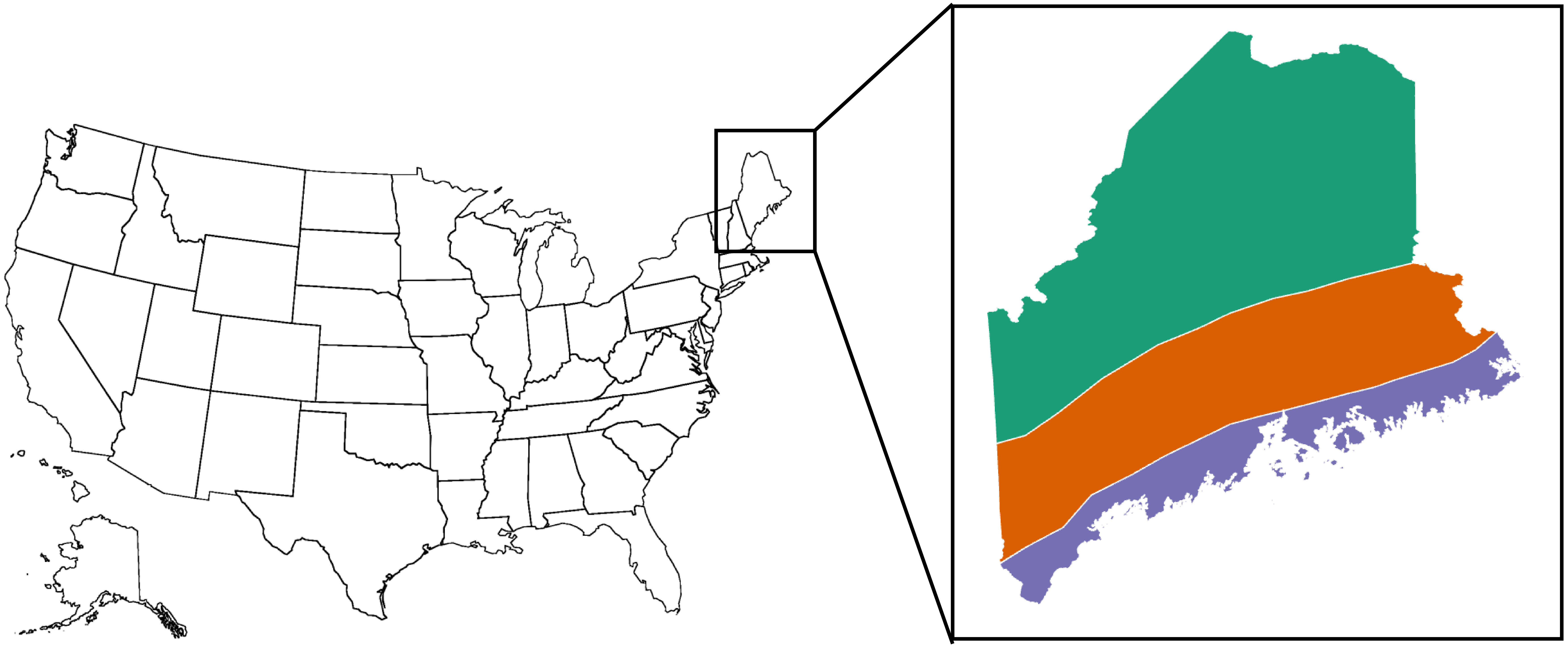

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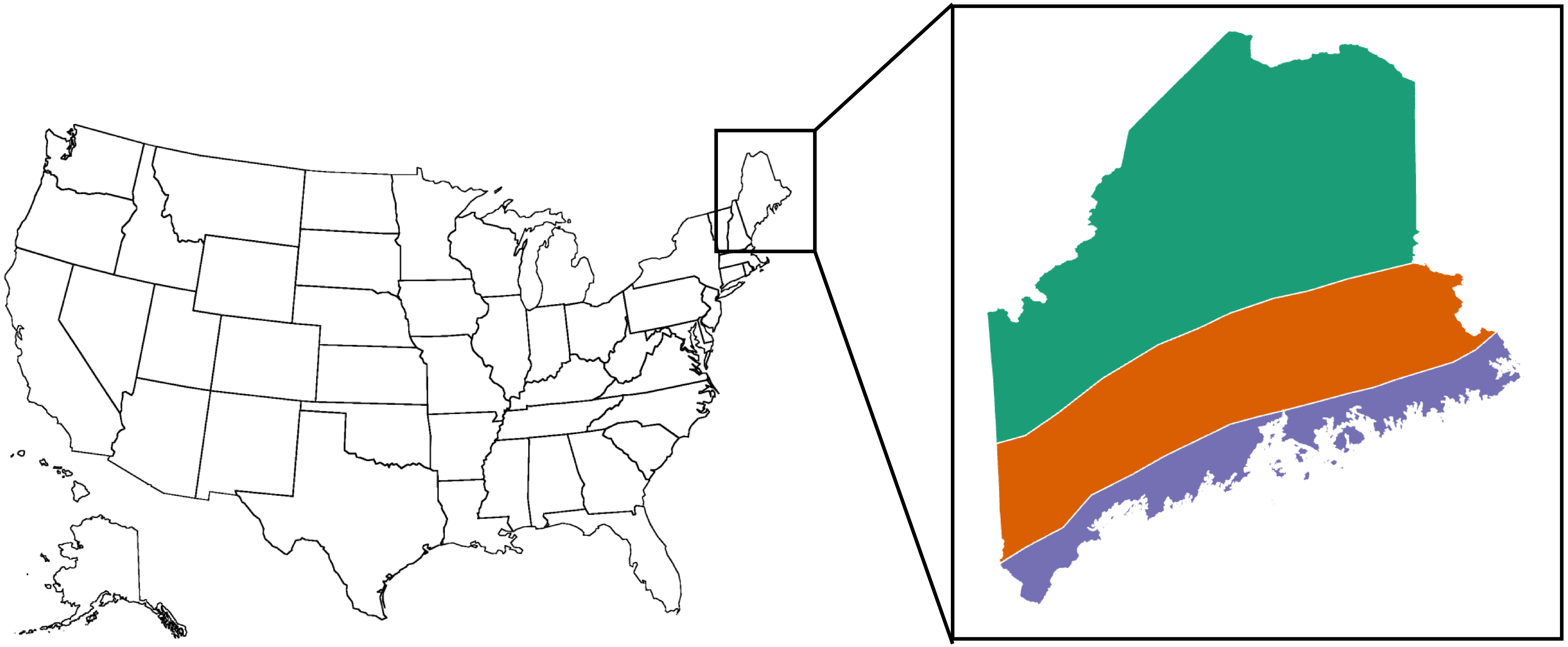

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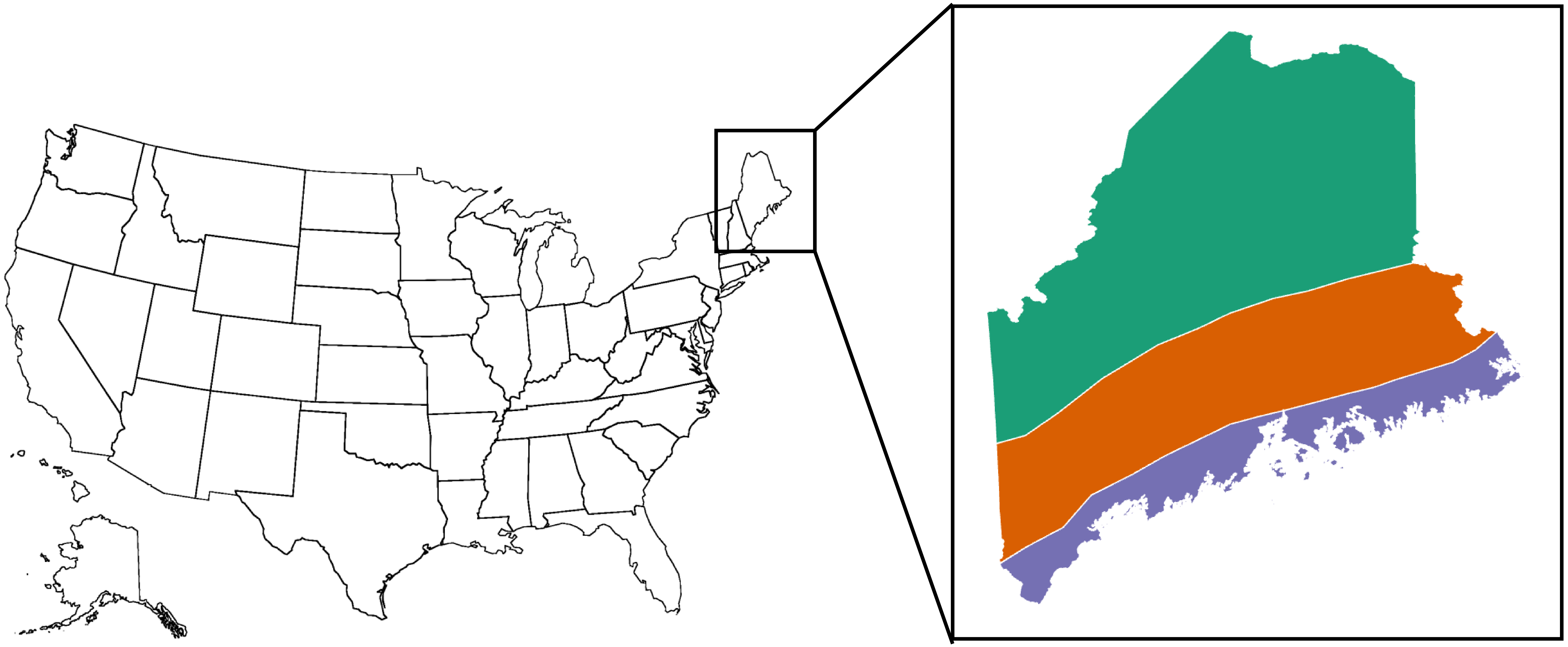

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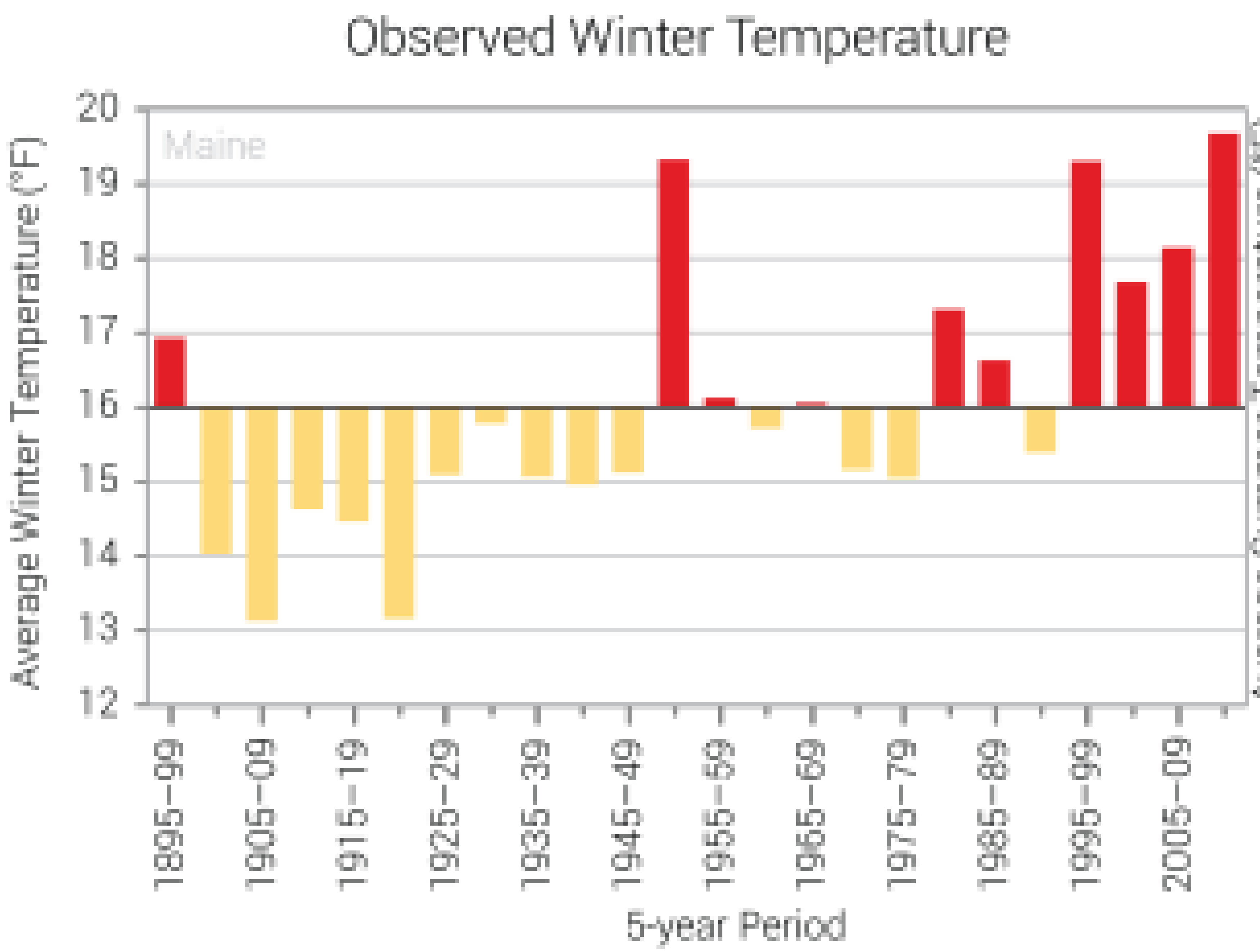
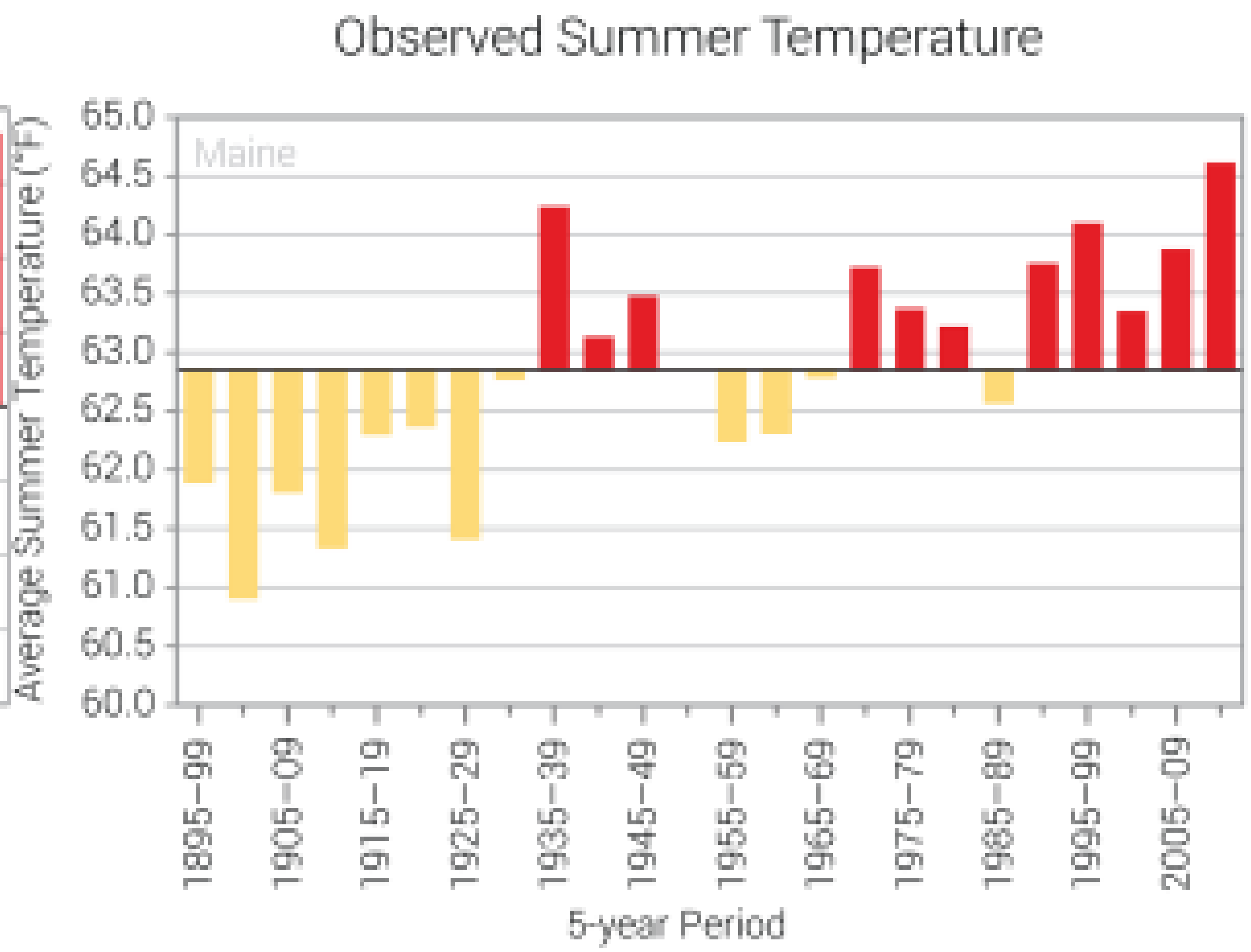
Climate Change in Maine

- Periods of warmer and cooler seasons (winter and summer) in Maine





From Runkle et al. 2017

Uncertainty about cyanoHABs

Uncertainty of Climate Change + Triggers of cyanoHABs due to:

- **Focus on high-nutrient lakes**
- **Different species response**
- **General climate parameters**
- **Insufficiently long time series**

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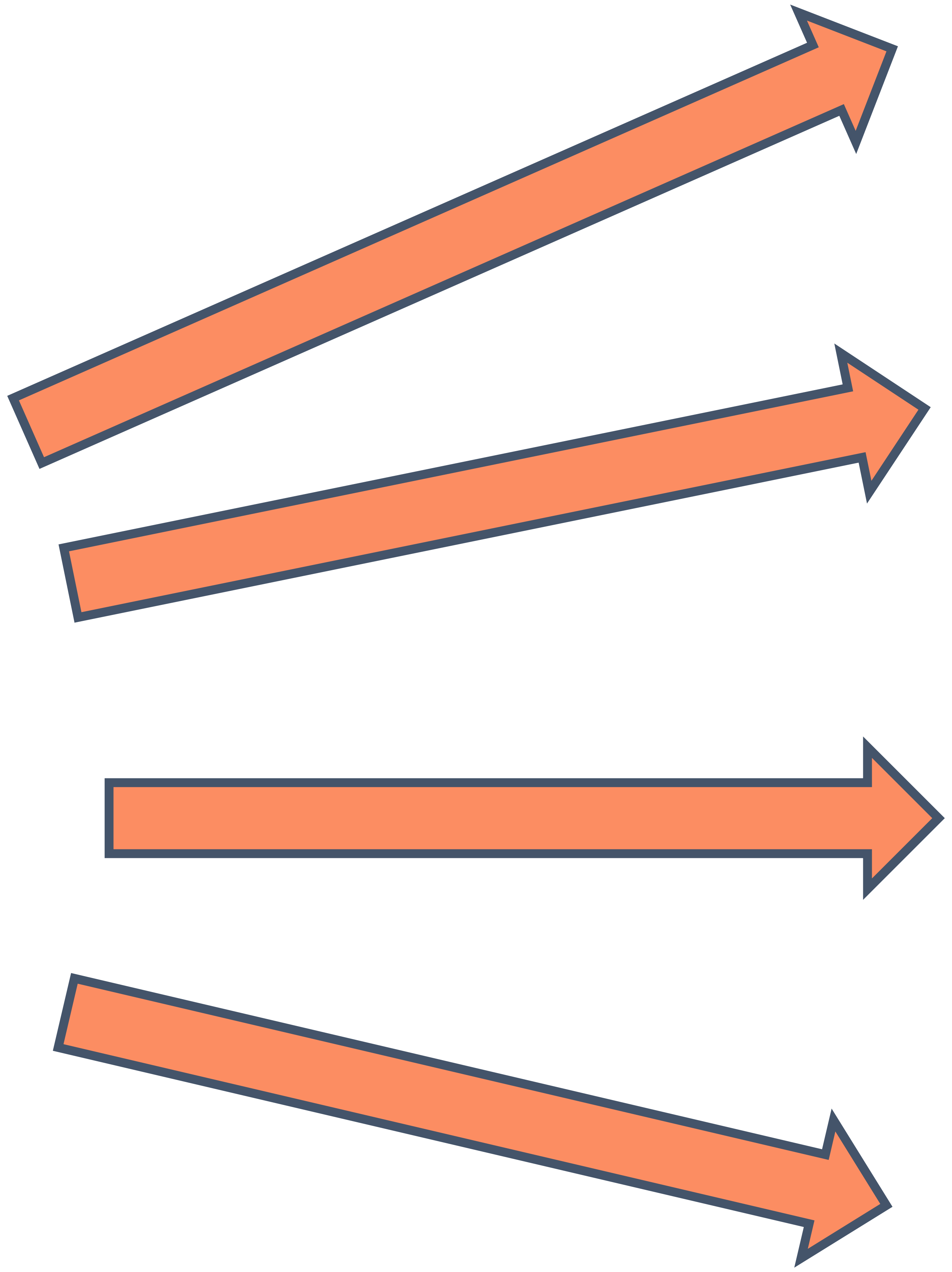

Focus on high-nutrient lakes

Maine's low-nutrient lakes

Different species response

General climate parameters

Insufficiently long time series

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  - ***Gloeotrichia*, specifically**
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- **Different species response** → *Gloeotrichia*, specifically
- **General climate parameters** → Periods of warmer/cooler seasons
- **Insufficiently long time series** → ??????

Monitoring Limitations

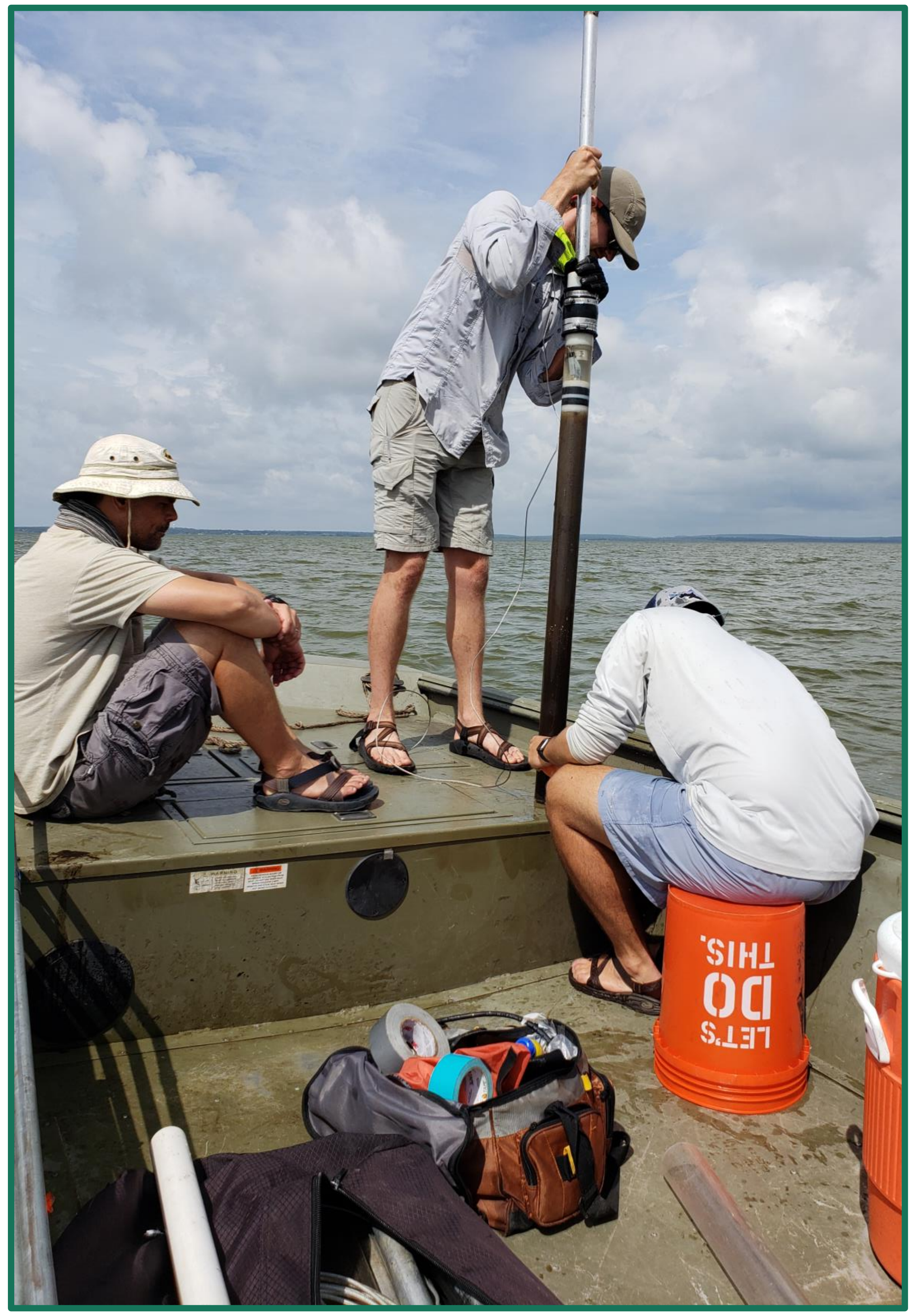
- Monitoring bodies: EPA National Lakes Assessment, USGS, Maine Lakes, Lake Stewards of Maine

- Lack of knowledge prior to current monitoring programs

- Rapid response to environmental changes that can complicate interpretation from monitoring efforts

Paleolimnology

- Paleolimnology: the study of lakes and lake sediments to reconstruct past climatic and environmental changes

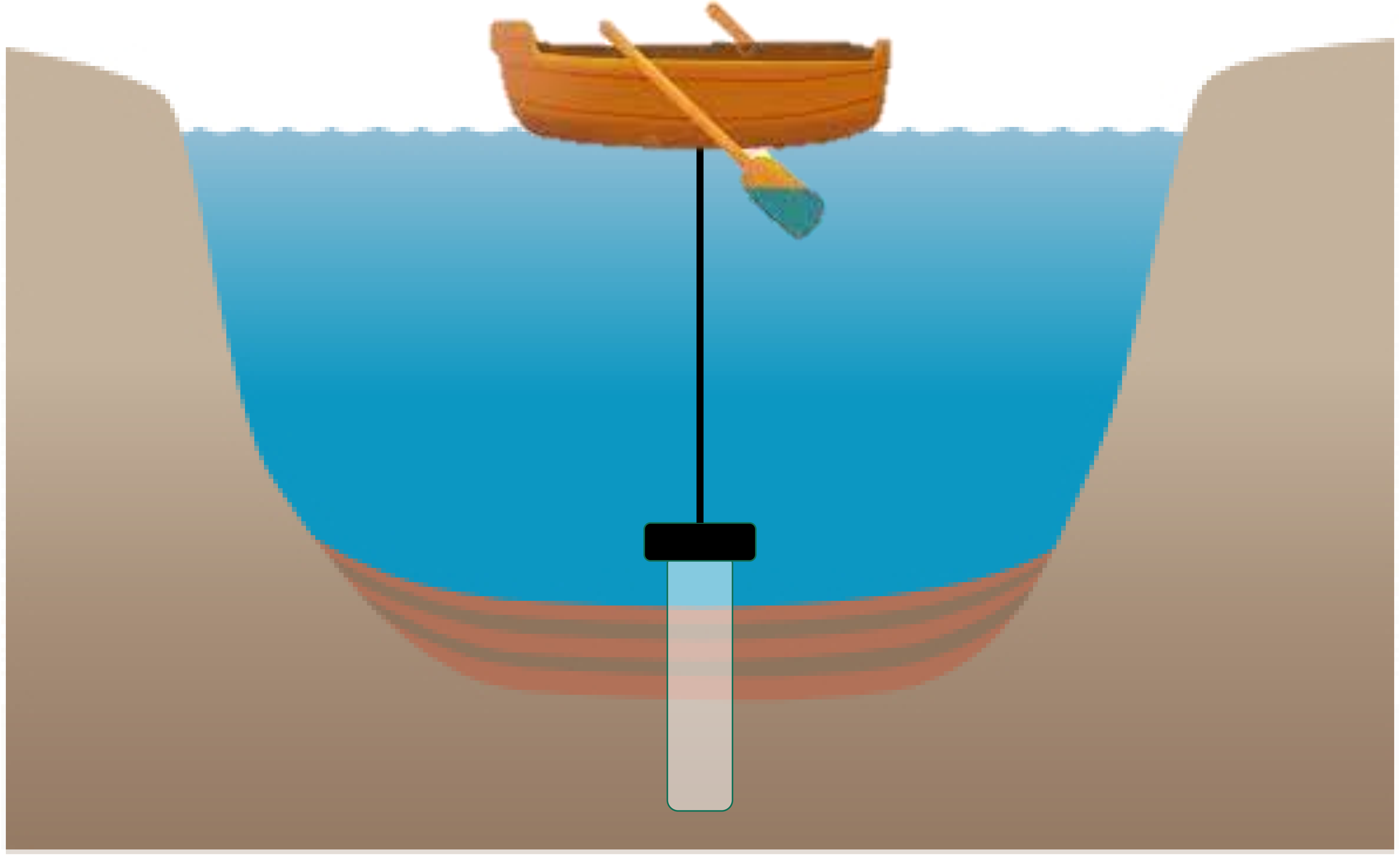


Paleolimnology

- Paleolimnology: the study of lakes and lake sediments to reconstruct past climatic and environmental changes

- Temporally integrative

- Proxies and techniques to infer the past



Paleolimnology

Methods:

- Sectioning
- Dating
- Measuring proxies to infer environmental conditions
  - Photosynthetic pigments
  - Sediment DNA

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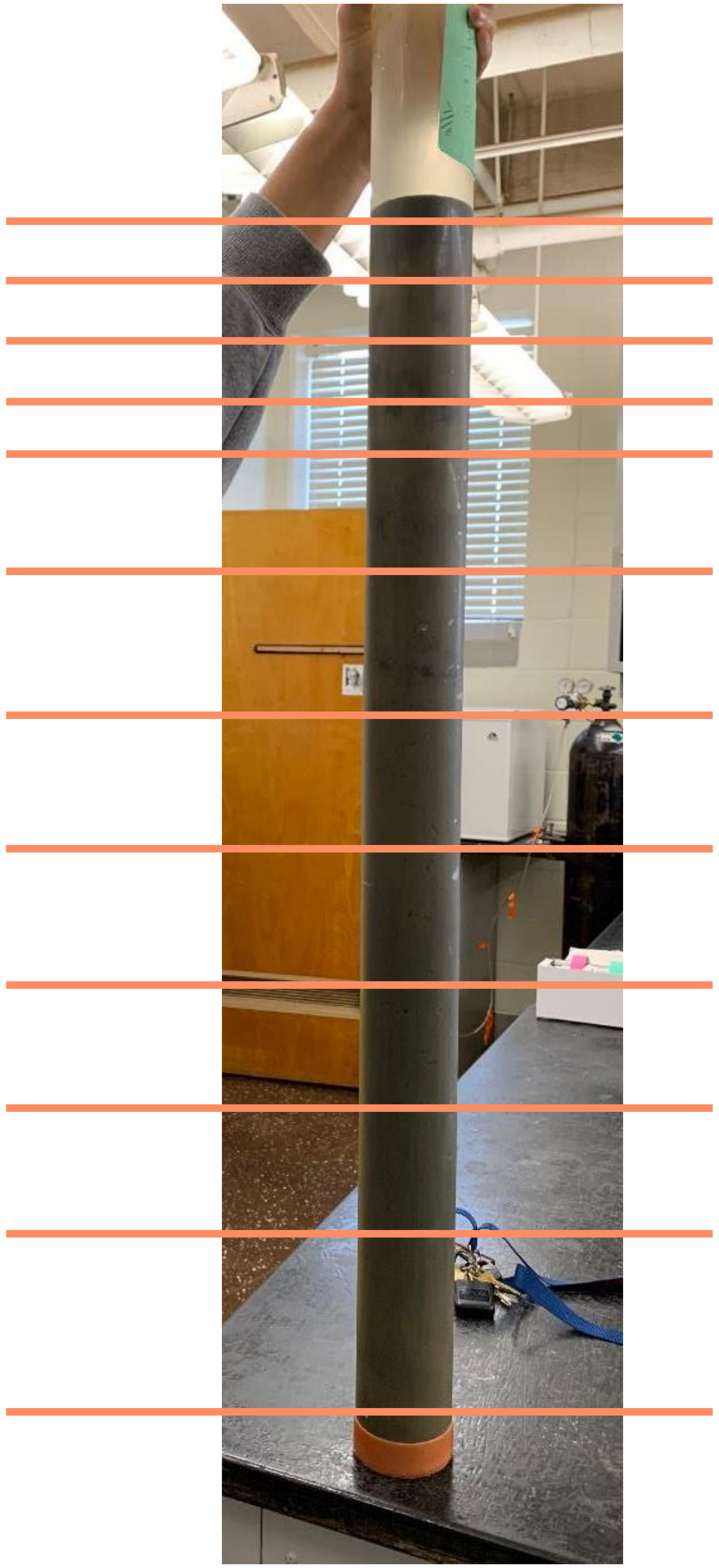

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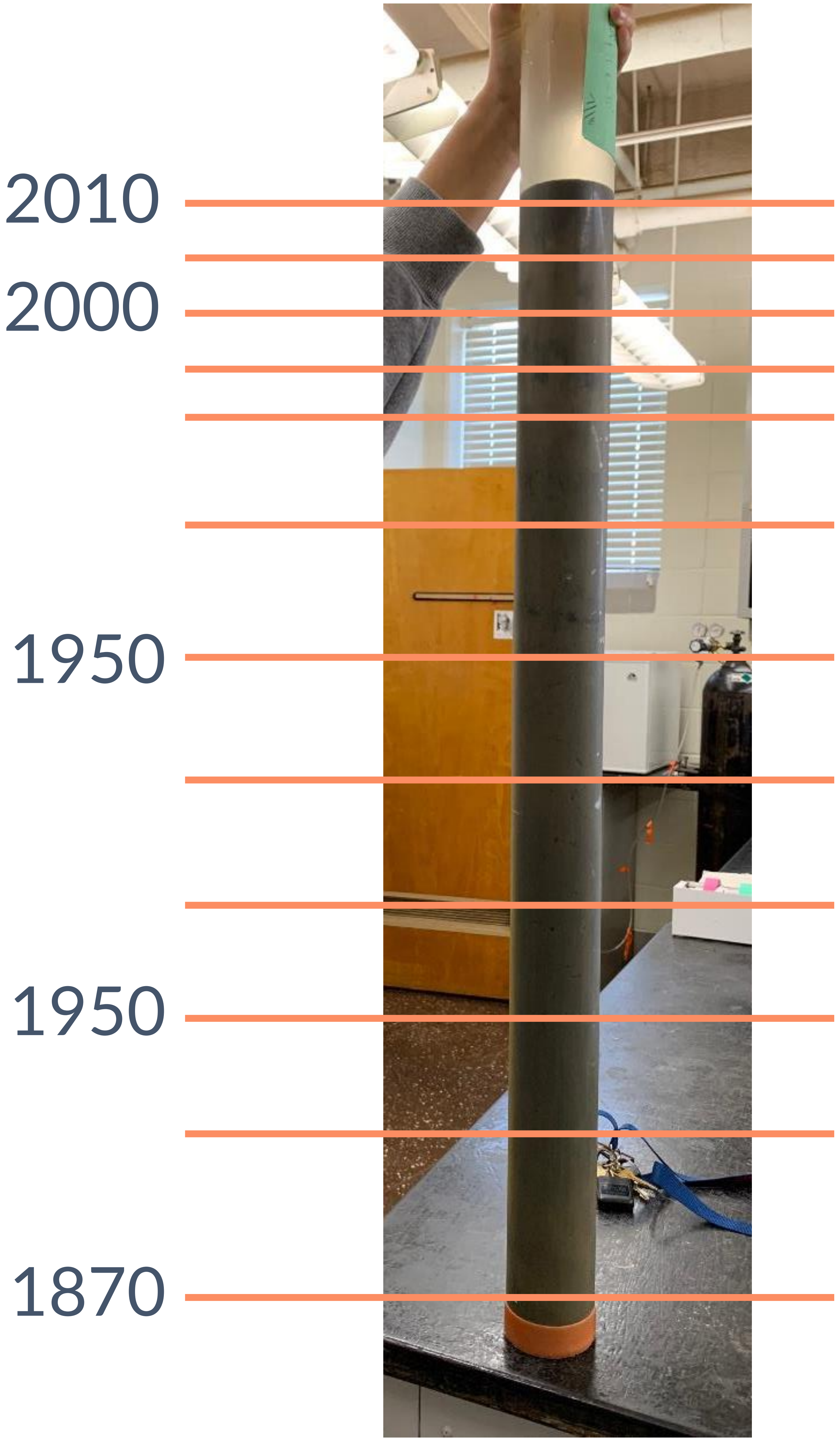

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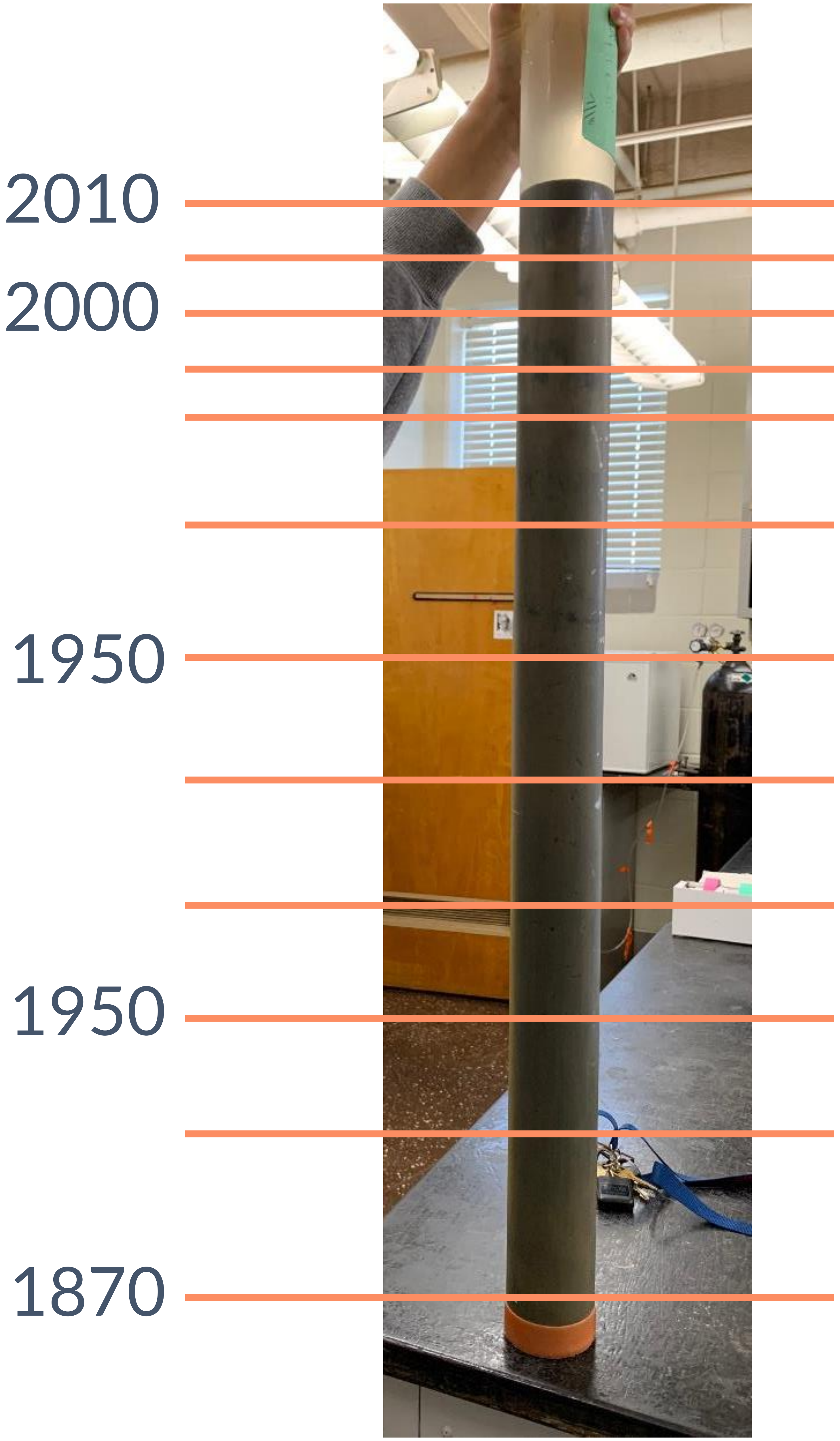
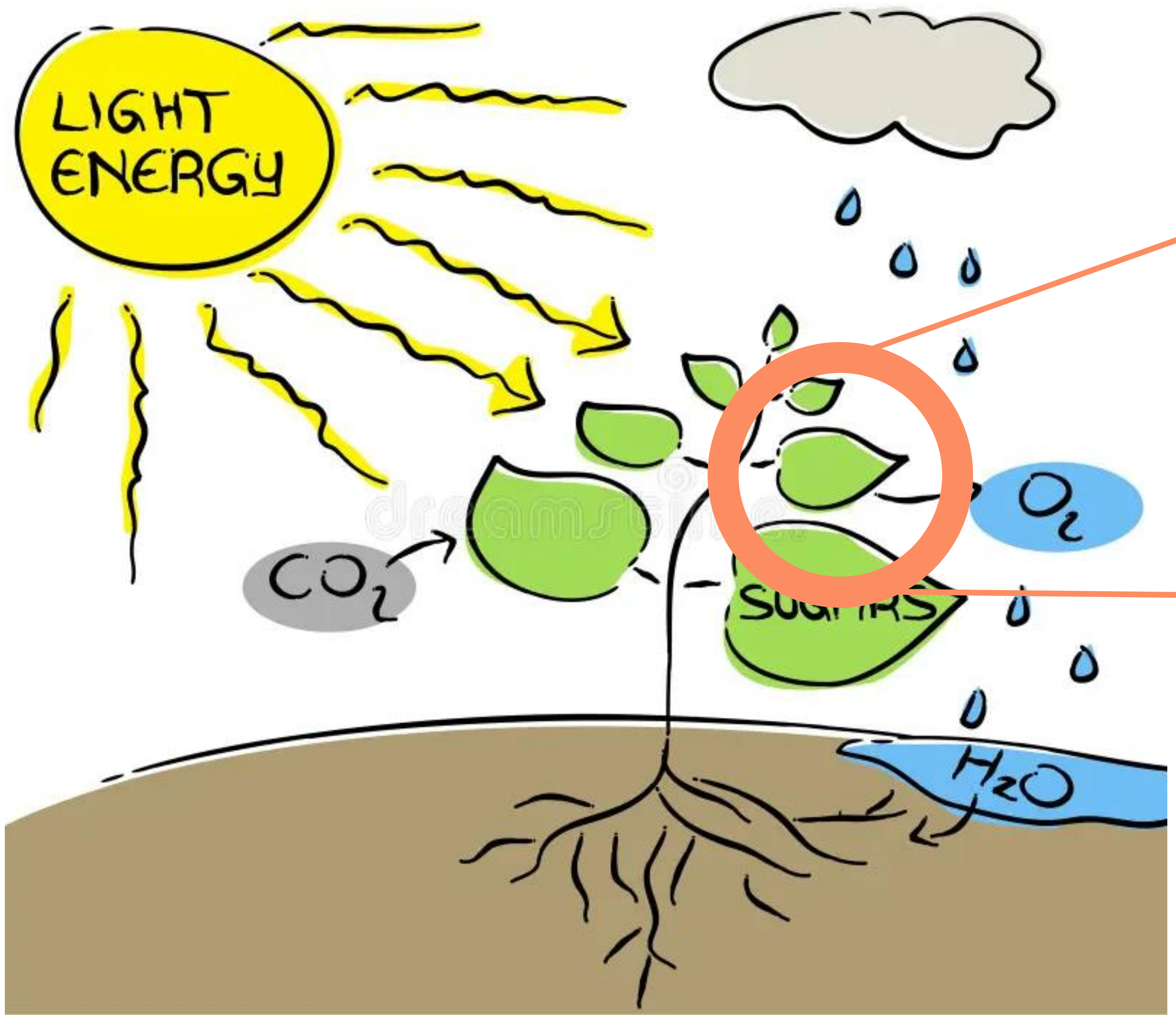


Paleolimnology – Photosynthetic Pigments

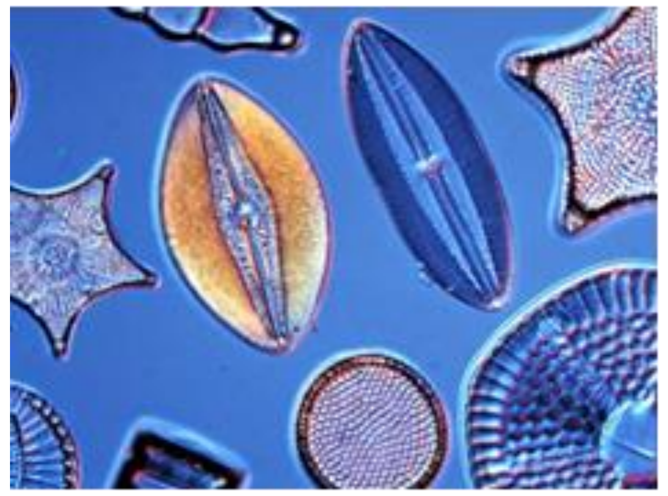


Chlorophylls

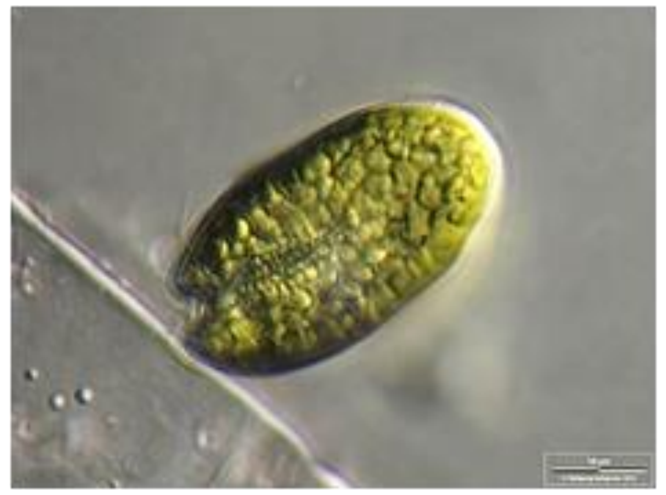
and

Carotenoids

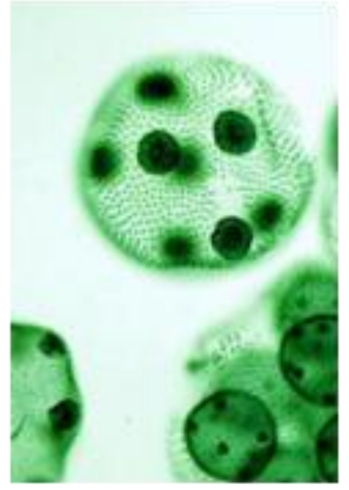
Paleolimnology – Photosynthetic Pigments



Diatoms
- Fucoxanthin
- Diatoxanthin

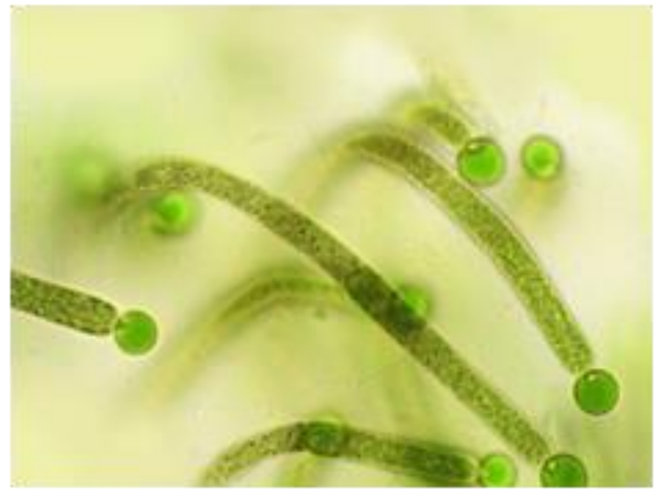


Cryptophytes
- Alloxanthin



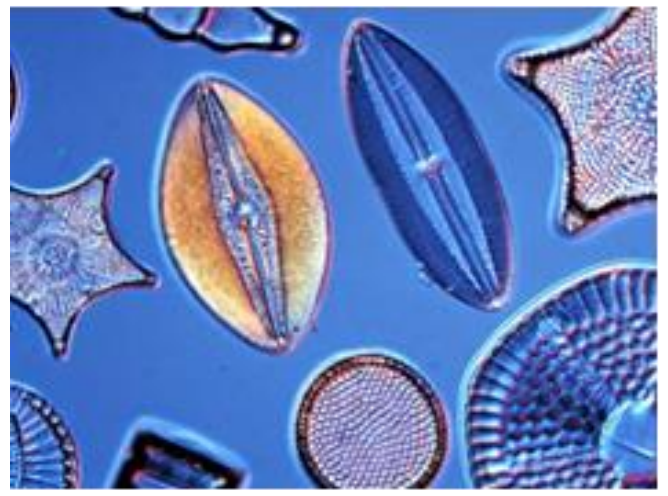
Green Algae and Macrophytes
- Lutein
- Chlorophyll-b
- Pheophytin-b

Primary Producers
- Chlorophyll-a
- Pheophytin-a
- Beta-Carotene



Cyanobacteria
- Echinenone
- Myxoxanthophyll
- Canthaxanthin
- Zeaxanthin
- Aphanizophyll
- Oscillaxanthin
- Scytonemin

Paleolimnology – Photosynthetic Pigments



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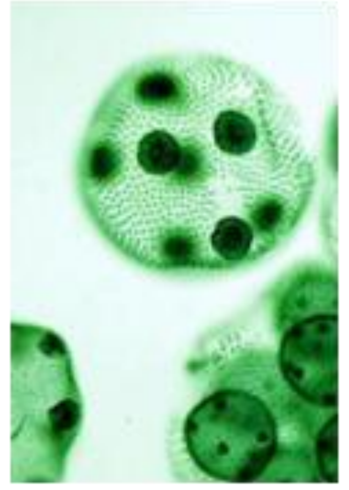

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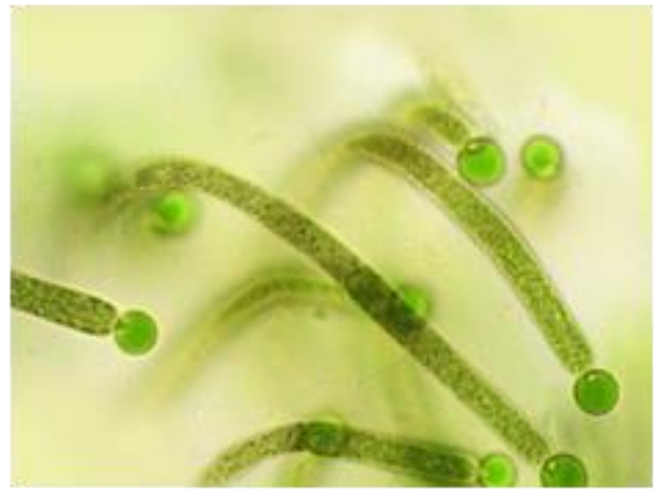

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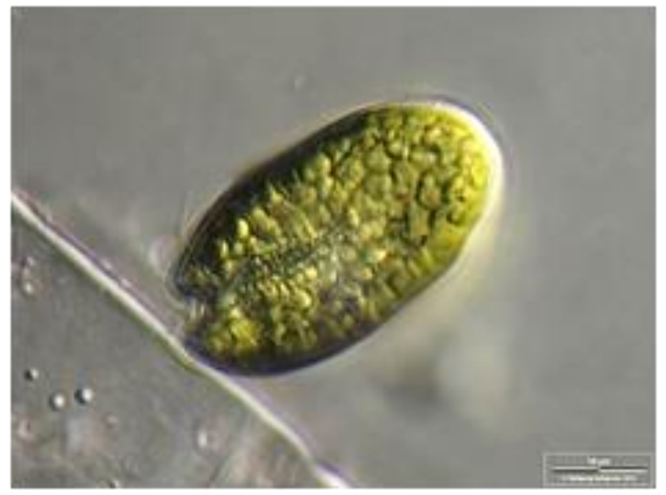

Cryptophytes
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<u>Primary Producers</u>
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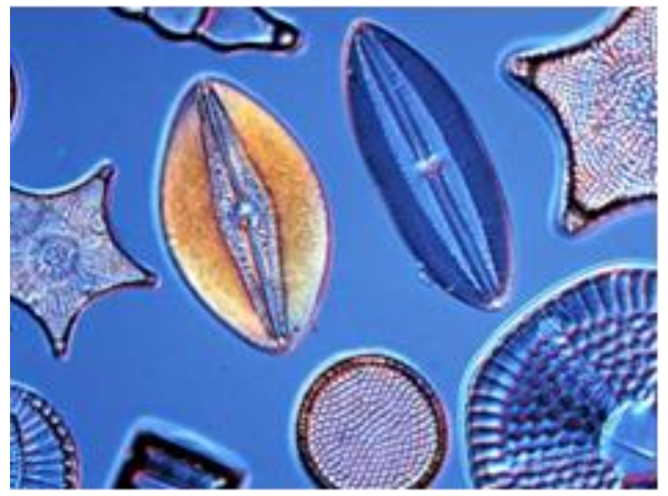
Paleolimnology – Photosynthetic Pigments



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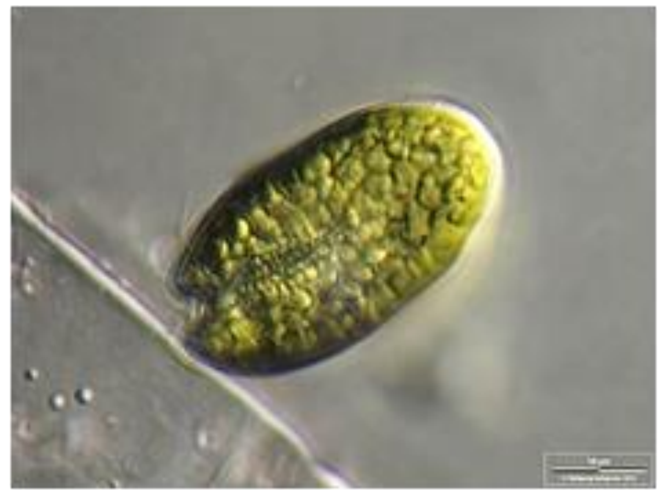

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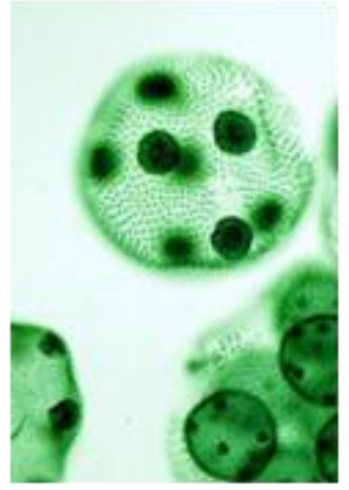

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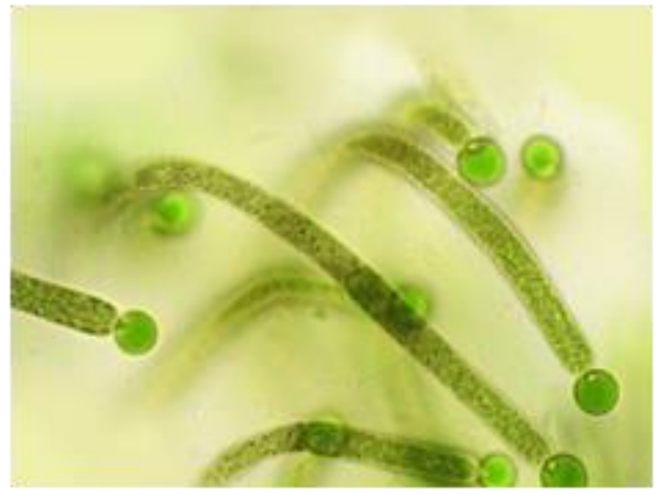

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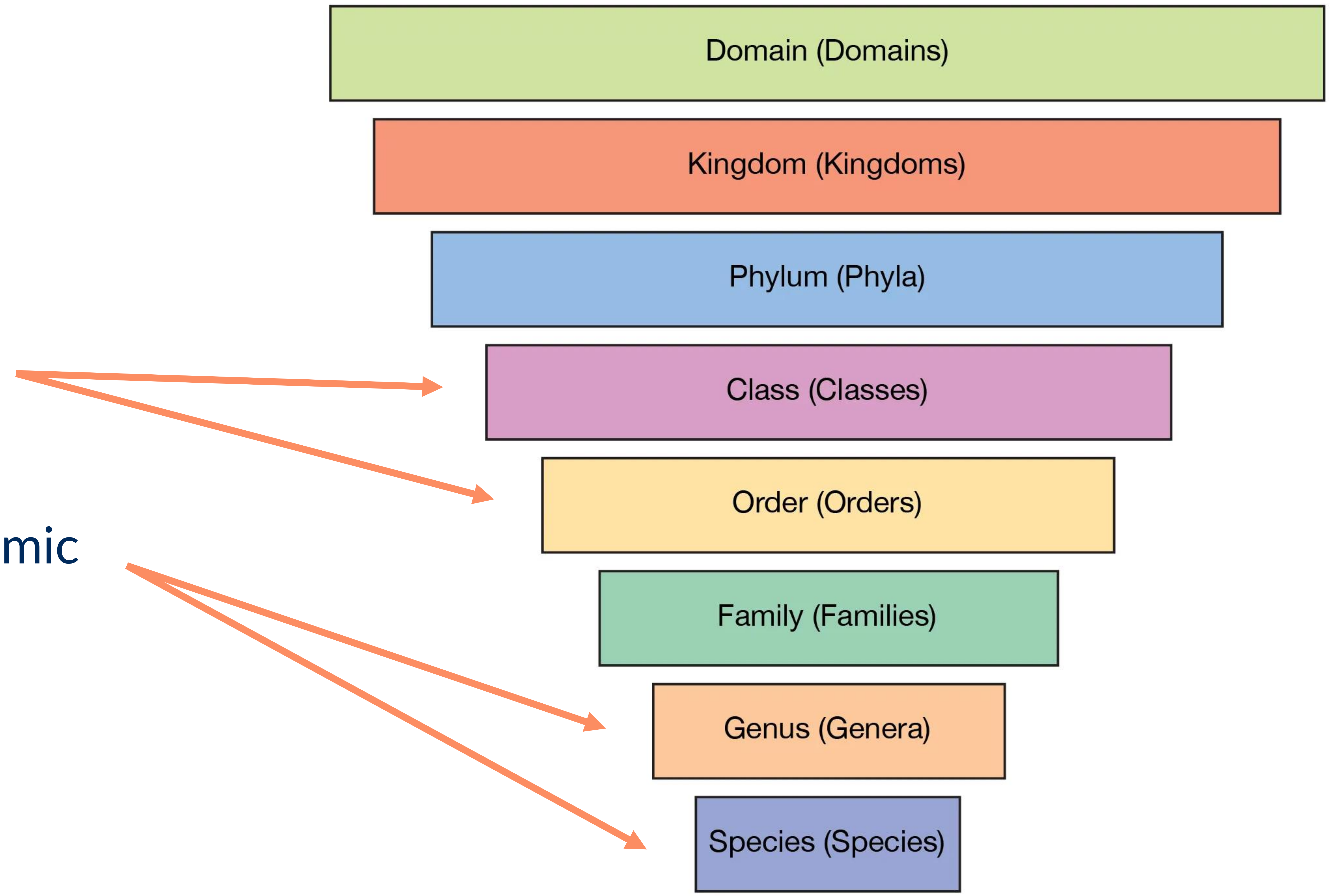
Paleolimnology

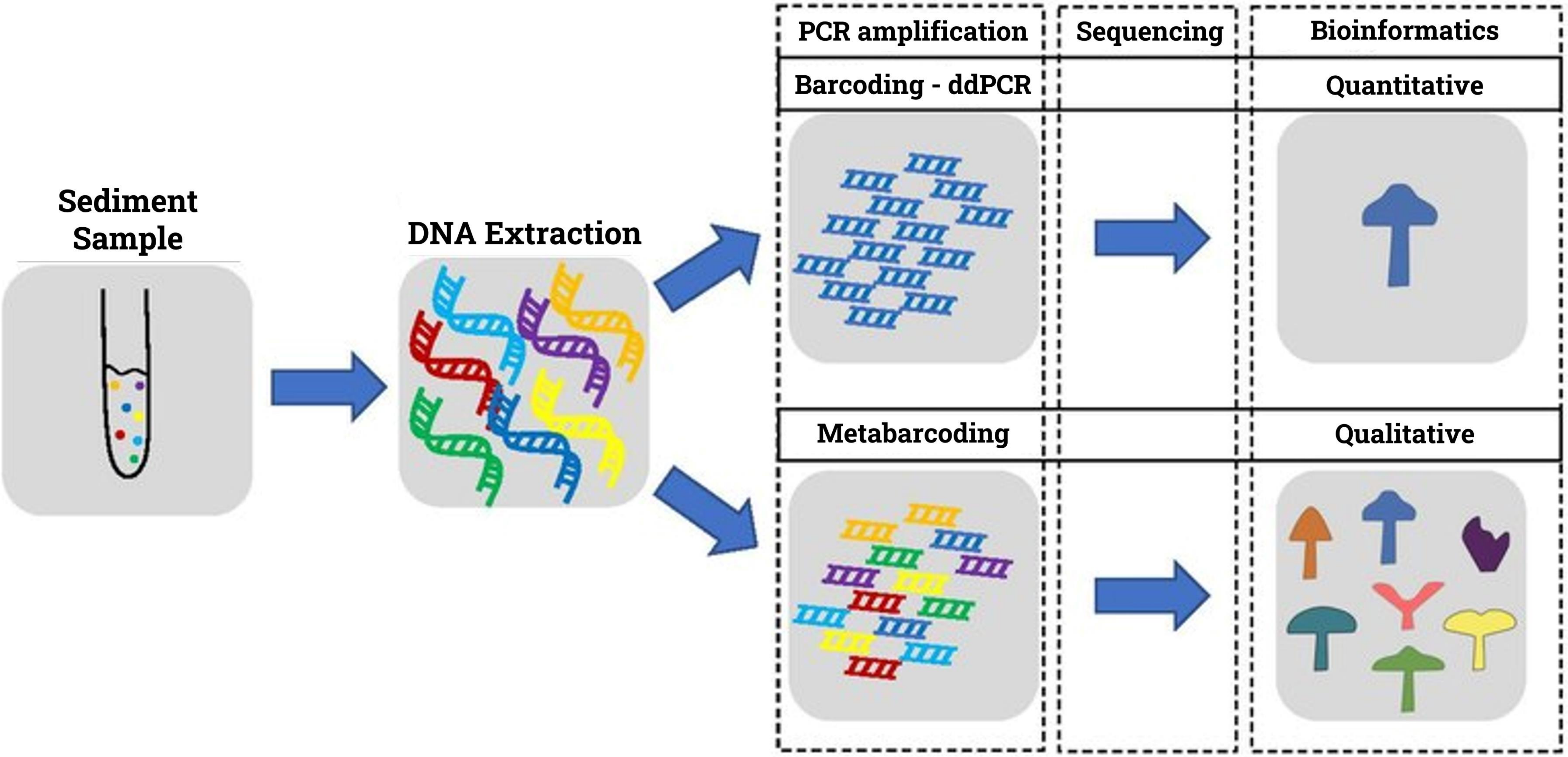
- Pigments = taxonomic classes/orders
- Sediment DNA = taxonomic genera/species



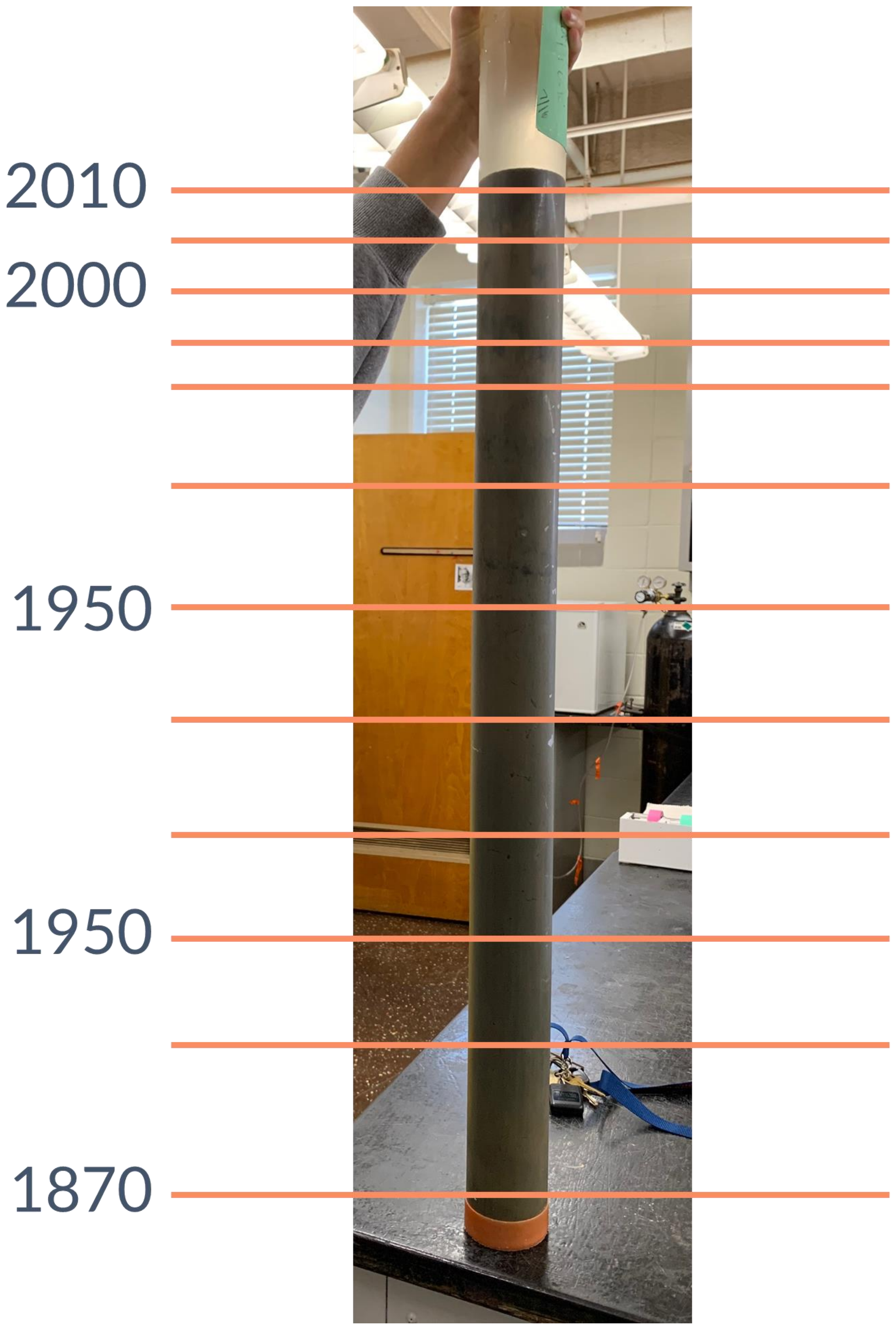
Paleolimnology – Sediment DNA

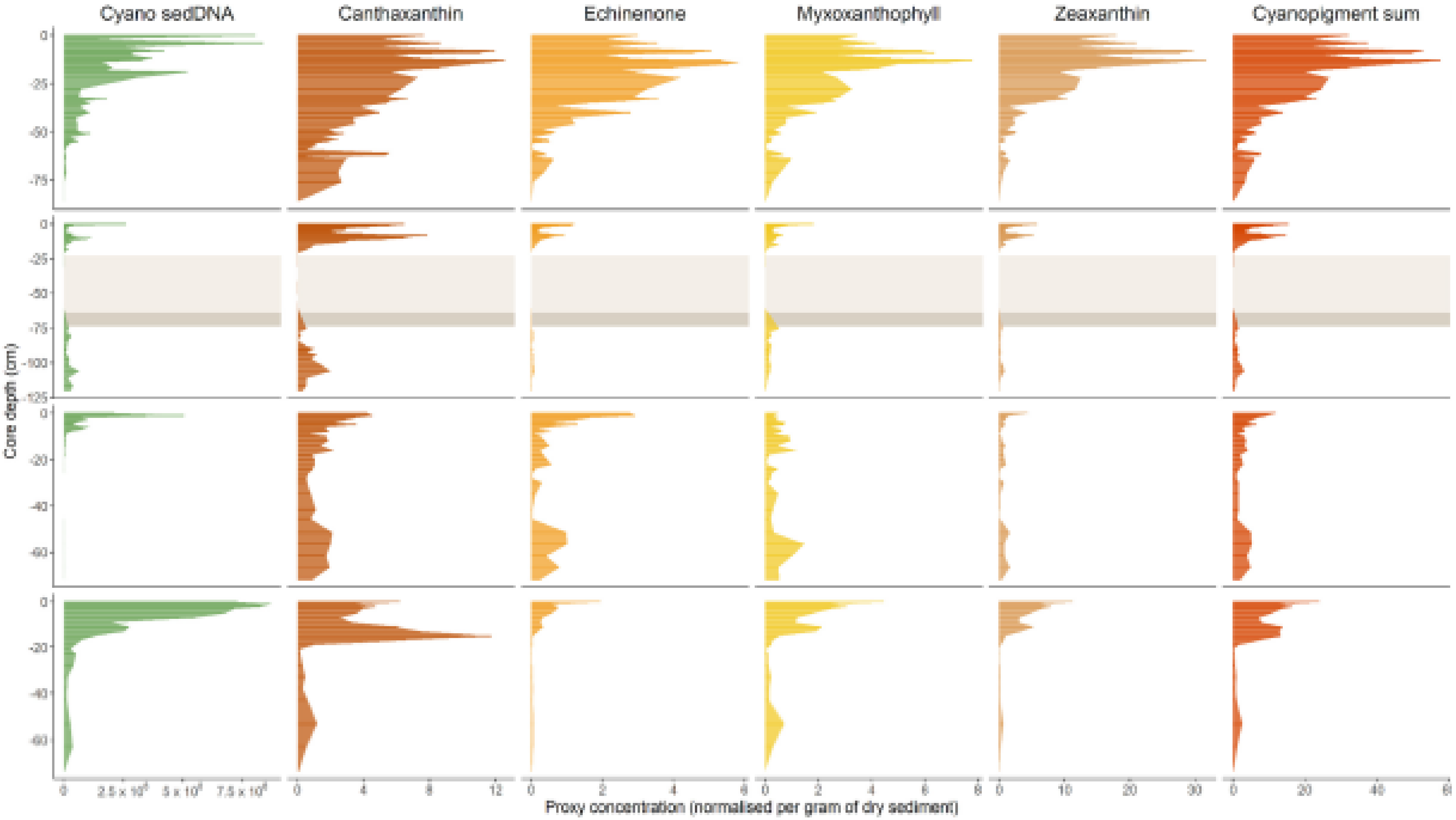
- **Quantitative PCR (qPCR)**: measures DNA concentrations

- **Metabarcoding**: measures biodiversity to describe community composition



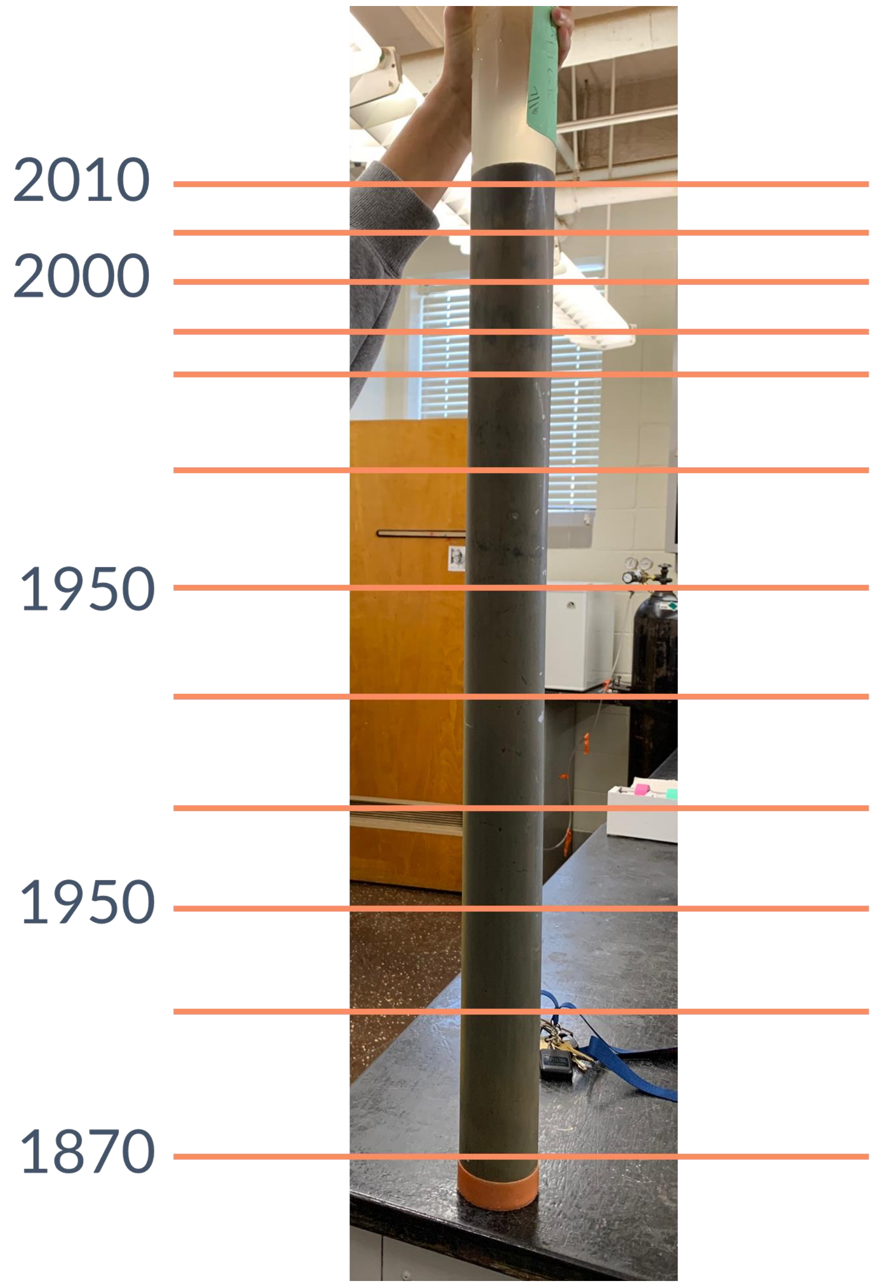
Paleolimnology





From Picard et al. 2022

Adding it all together



Photosynthetic pigments

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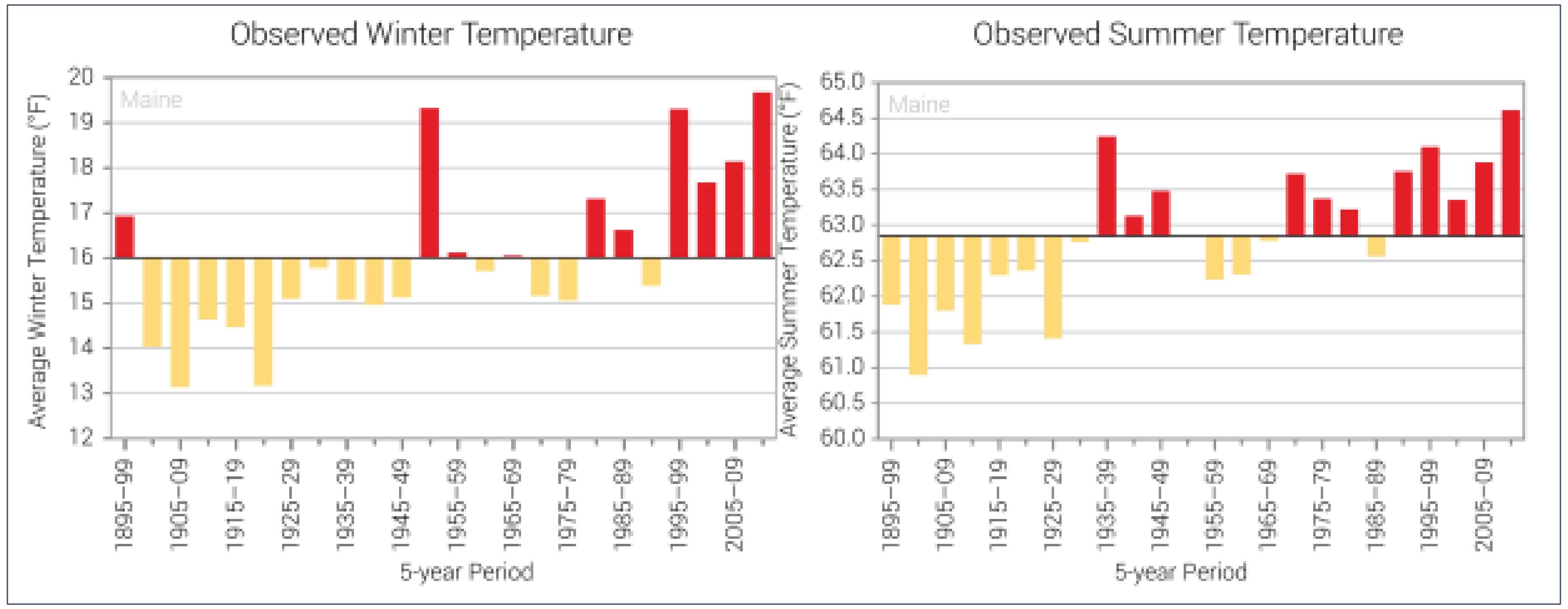
Sediment DNA

Temperature records



Adding it all together

Sediment DNA

Use photosynthetic pigments and sedDNA records at a decadal resolution across lakes in Maine that vary in nutrient concentration and climate zone to determine the seasonal drivers of cyanoHABs (especially, *Gloeotrichia*) over the past 150 years.

+

Implications

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Different species response
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General climate parameters
Periods of warmer/cooler seasons

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Paleolimnology

Implications

- Implications for lake managers and landowners, especially in areas of high recreational and drinking water use

- **Informing scientists and managers about how to anticipate summer conditions and modify management plans as needed**

What to take away from today:

1. Cyanobacteria and cyanoHABs are increasing in Maine lakes.

2. We have questions about how possibly harmful cyanobacterial species respond to lakes with **different nutrient concentrations** and **different rates of climate change**.

3. Reconstructing lake conditions using sediments can help to fill in these knowledge gaps.

Study Sites

Region	Change in winter temperature since 1850 (°C)	Lake	Trophic state	Avg TP (µg L^{-1})	Chl (µg L^{-1})	*Gloeotrichia* present	Marine clay layer (Y/N)
Northern	+3.7	Gardner	O	5	1.7	NA	N
		Pleasant	O	4	1.2	NA	N
		Meduxnekeag	M	13	4.1	H	N
		Monson	E	40	16	NA	N
Central	+4.0	Echo	O	6	2.5	L	N
		Long	O	10	2.8	M	N
		Great	M	14	5	H	Y
		Sabattus	E	48	27	M	Y
Coastal	+4.3	Sebago	O	3	1.8	M	N
		Square	O	8	2.6	L	N
		Damariscotta	M	12	4.6	NA	Y
		Sennebec	E	22	5	NA	Y

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Collaborations

Regional Associations
- 30 Mile River Watershed Association
- Maine Lakes - Lakes Environmental Association
- Lake Stewards of Maine
- Midcoast Conservancy
- 7 Lakes Alliance

Local Lake Associations and Landowners
- Red River Camps
- Island Falls Lake Association
- Little Ossipee Lake Association
- Belgrade Lakes Assocations
- **MANY** local landowners

Federal/State Partners
- Portland Water District
- Maine Department of Environmental Protection
- USGS New England Water Science Center

Research Centers
- University of Maine
- Colby College
- Bigelow Laboratory for Ocean Sciences
- Netherlands Institute of Ecology

What to take away from today:

1. Cyanobacteria and cyanoHABs are increasing in Maine lakes.

2. We have questions about how possibly harmful cyanobacterial species respond to lakes with **different nutrient concentrations** and **different rates of climate change**.

3. Reconstructing lake conditions using sediments can help to fill in these knowledge gaps.

4. The answers to these questions are valuable for both the scientific sphere and your local communities.

5. Collaborating with, learning from, and communicating to the public throughout the scientific process makes science more **understandable** and more **actionable**.

...so THANK YOU!

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Understanding the history of Maine lakes TOGETHER allows us to better understand the current conditions and project the future of cyanoHABs in Maine lakes.

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Dr. Jasmine Saros

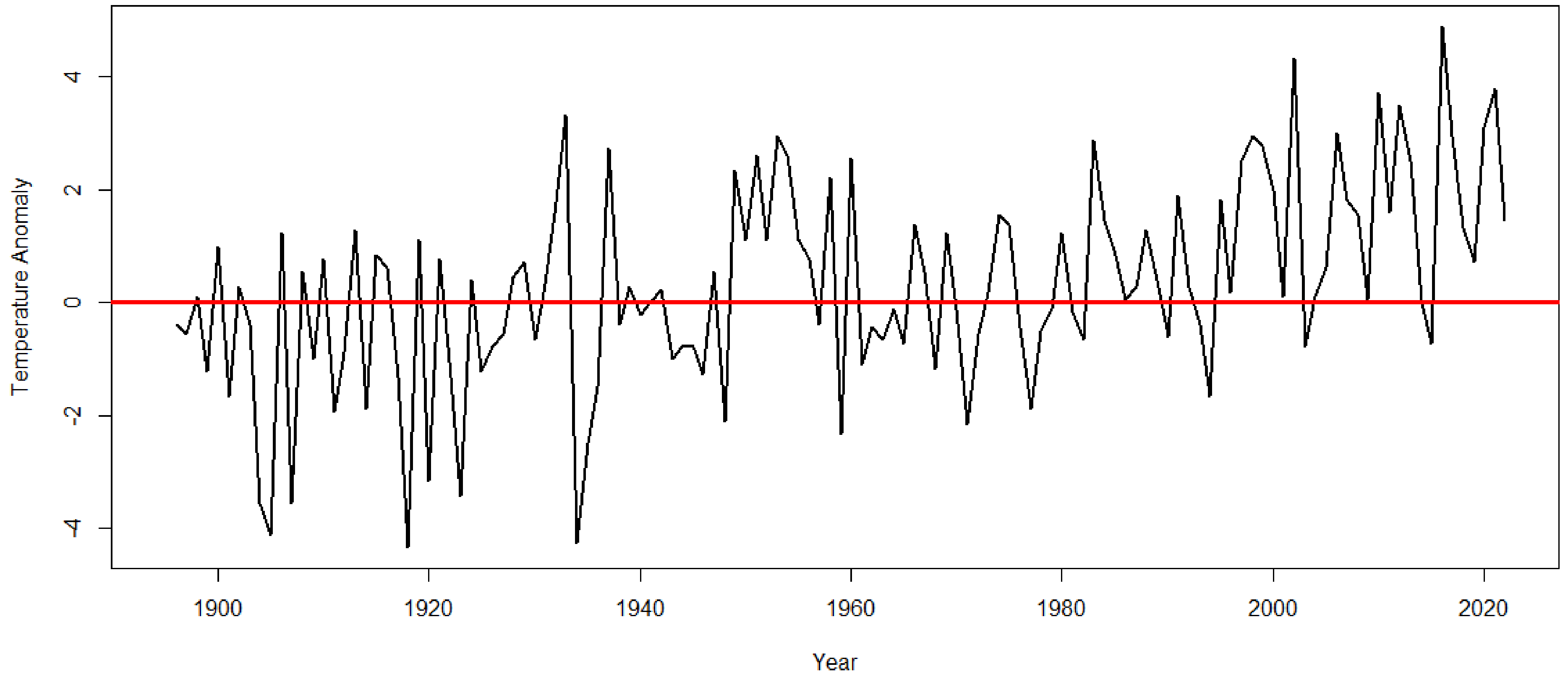
The Lake Ecology Lab at
The University of Maine

Questions or Feedback?

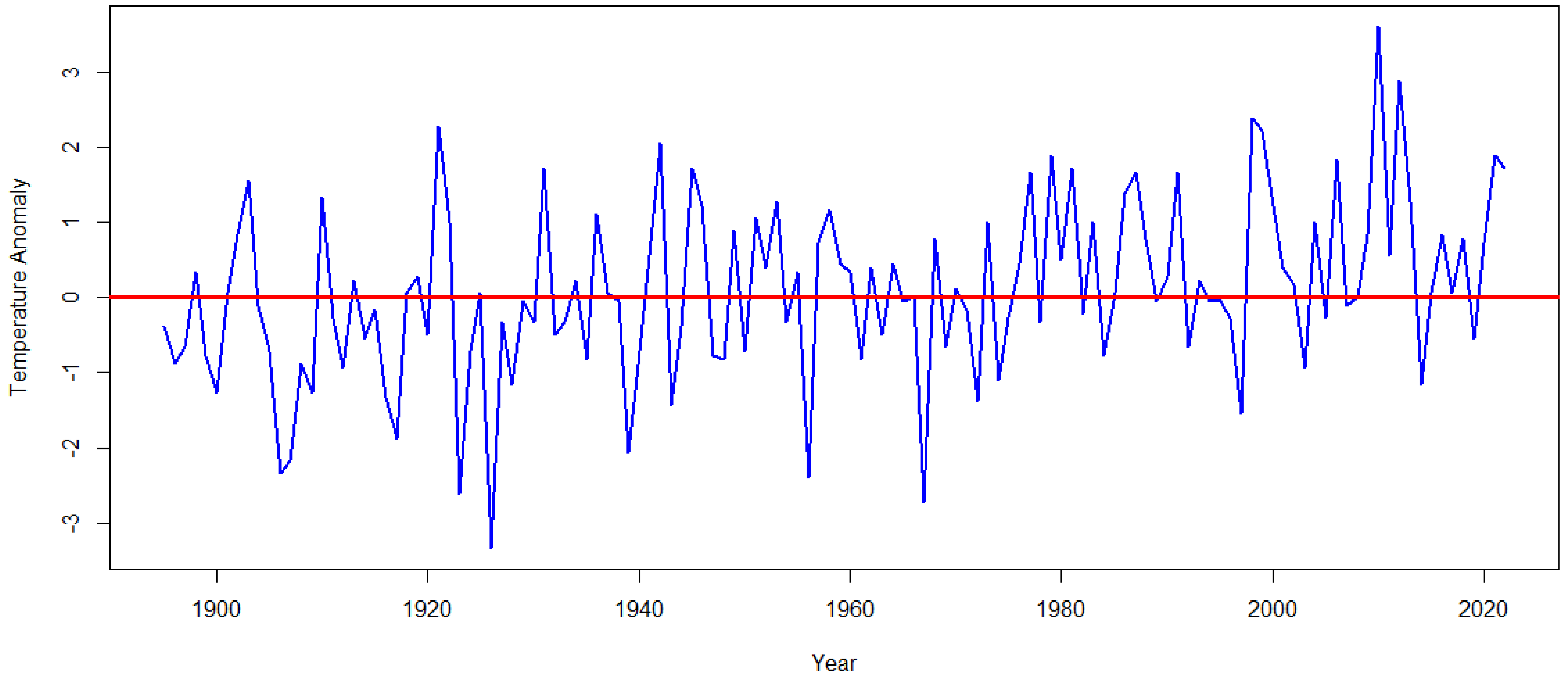
Email: avery.lamb@maine.edu

Temperature Anomaly by Season

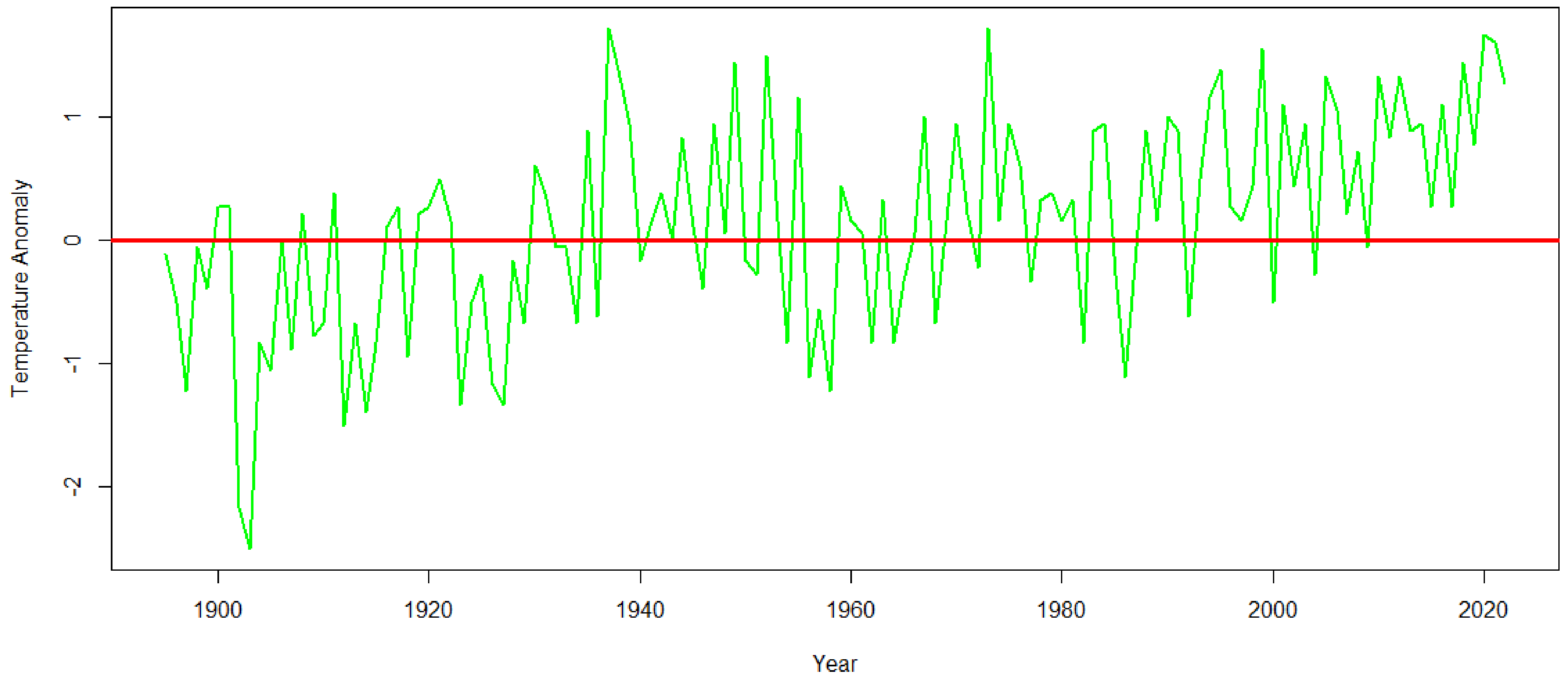
Winter



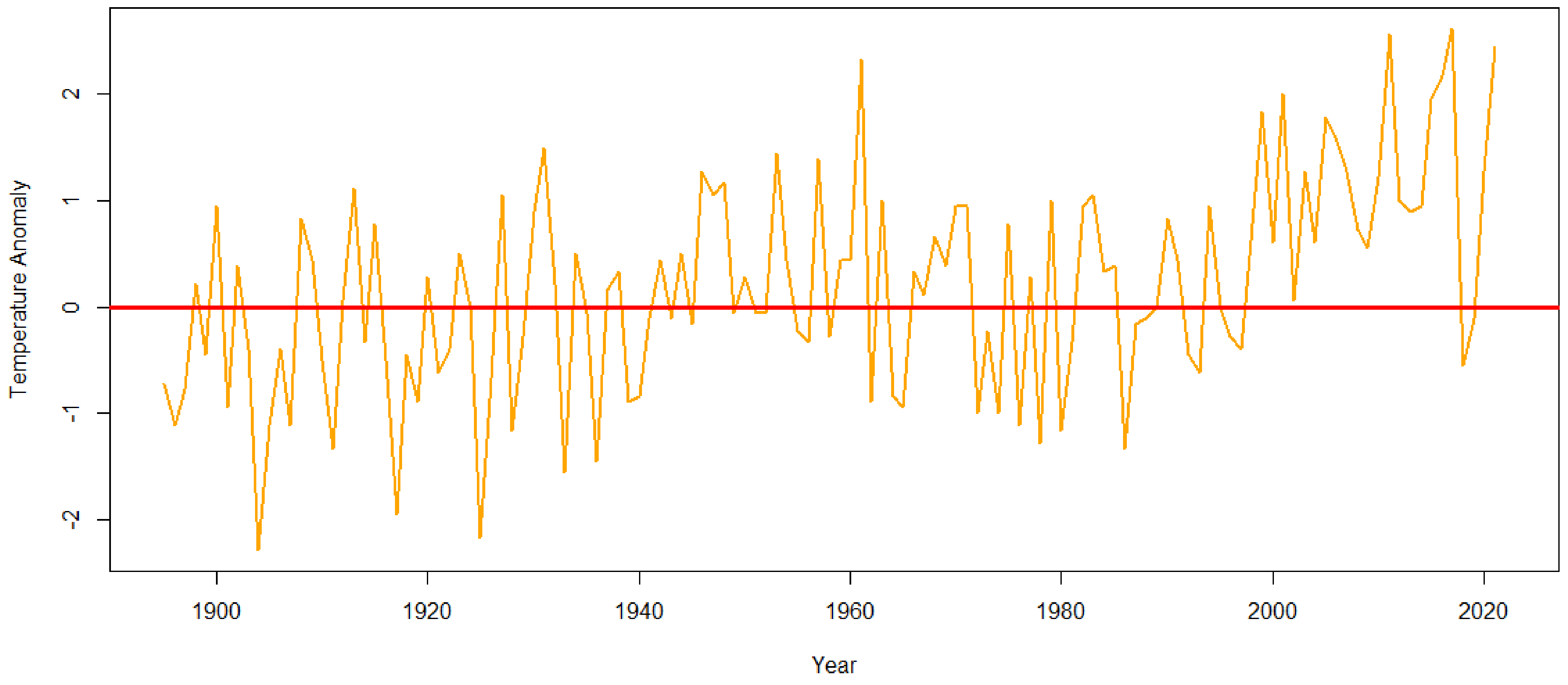
Spring

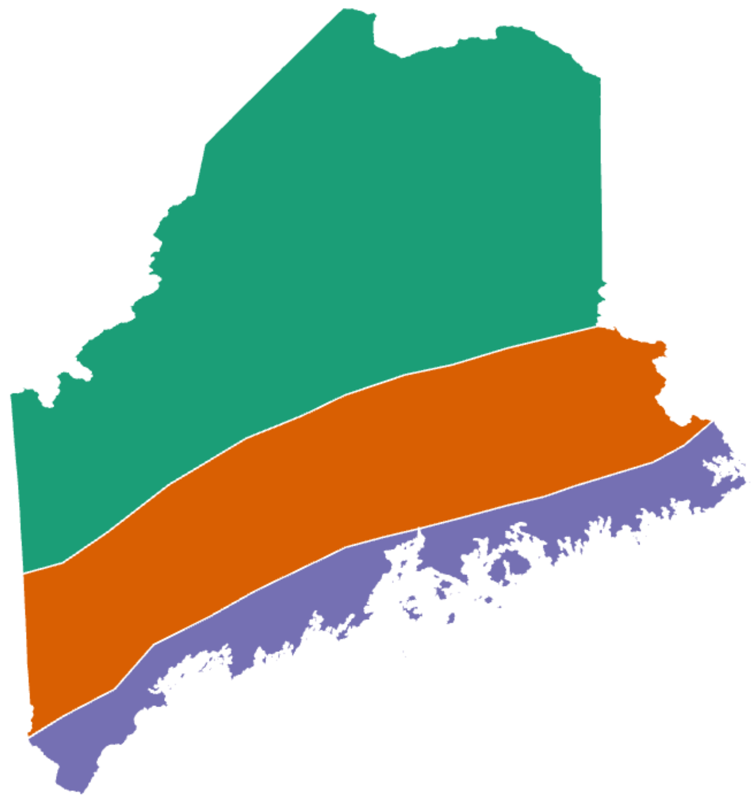


Summer



Fall





Raw Temperature Anomaly

↓

10-year Running Mean