

US EPA ARCHIVE DOCUMENT

Predicted changes in toxic cyanobacteria in response to climate change -NH Lakes

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**Will Climate Change
Alter NH Lakes and Ponds and
Impact Public Health?**

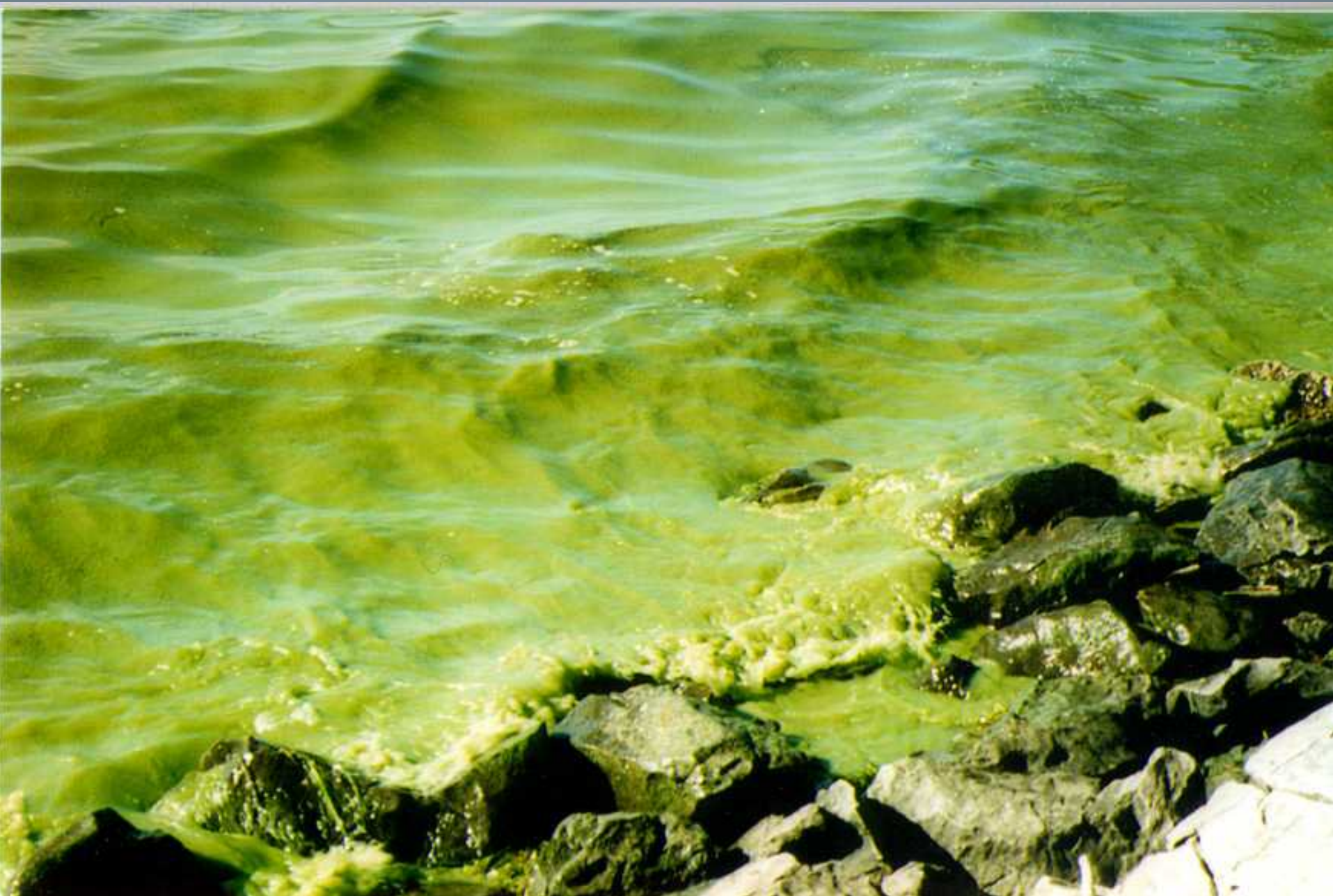
Consider:

- Problems of cyanobacteria “blooms”
- Impacts through lake food web

Cyanotoxins :

- | | | |
|-----------------------|-------------|-------------------|
| 1. Anatoxin <i>a</i> | Neurotoxin | Fast acting (min) |
| 2. Saxitoxin | Neurotoxin | Fast acting (min) |
| 3. BMAA | Neurotoxin | May be long-term |
| 4. Microcystins | Hepatotoxin | Hours-Days |
| 5. Nodularins | Hepatotoxin | Hours-Days |
| 6. Cylindrospermopsin | Hepatotoxin | Hours-Days |

**So,
in what despicable
habitats does one find
cyanotoxins?**







Microcystins

- **Implicated in episodes of toxicosis worldwide:**
 - **Livestock & Pets**
 - **Birds & Waterfowl deaths**
 - **Fish kills**
 - **Humans – Deaths, skin & sinus irritations, vomiting, diarrhea, gastroenteritis**
- **Best documented: Toxic episodes are generally associated with blooms of toxic cyanobacteria → highly concentrated**
- **Chronic & food web effects?**

Microcystins

- **Very small substances**
- **Present in minute quantities (parts per trillion)**
- **Resistant to decomposition (e.g. resists boiling)**

Cyanobacteria Problems = HABs

What is a “bloom”?

- How does it form?

Cyanobacteria as Competitors

Cyanobacteria Dominance

Nutrients (high levels of phosphorus followed by low)

Warm Temperature

Thermocline Stability (increase w/ temp)

Low Light (low water clarity)

Summer heatwaves promote blooms of harmful cyanobacteria

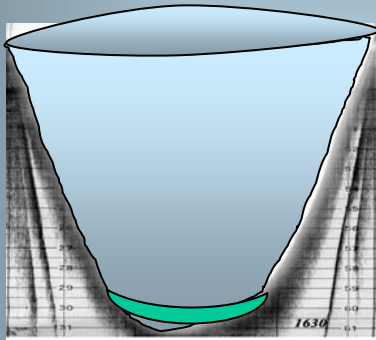
•KLAUS D. JÖHNK et al. 2008

•Global Change Biology 14 (3): 495-512

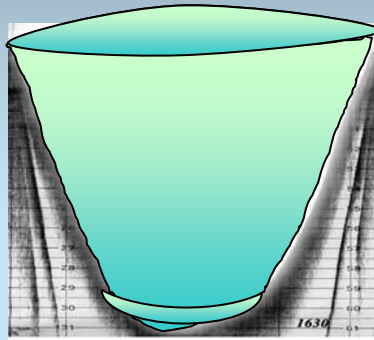
Increase in
light & temp

Temp=Growth

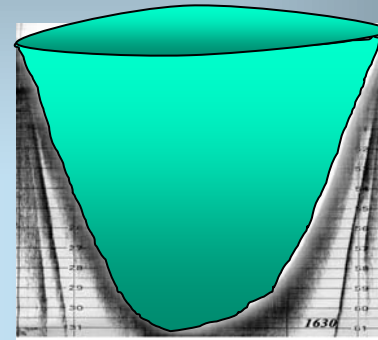
Sub-surface
Bloom



Winter



Spring

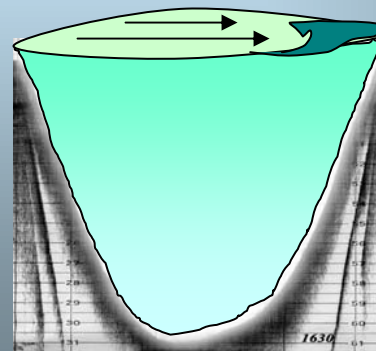
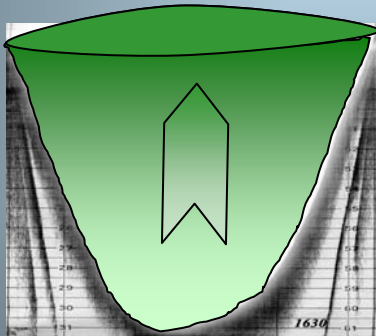


Sunny & Calm

Surface Bloom



“Alarm Bloom”



Thermal
stability: little
vertical mixing
Cyanobacteria
float;
competitors
sink

Summer



A 1957 Classic



Lake 226

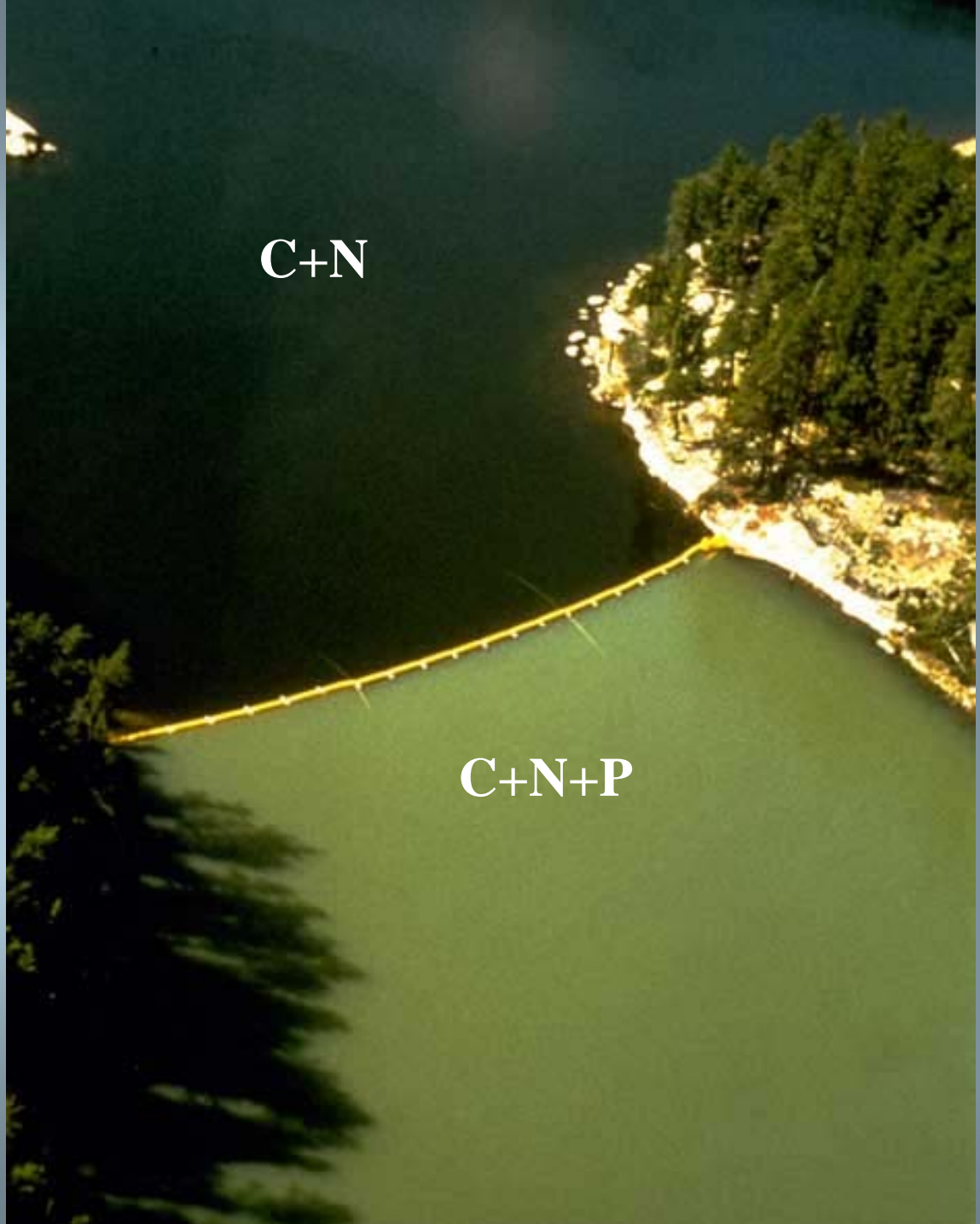
C+N

Phosphorus:
Important Limiting
Nutrient

A 1973 Classic

From: Schindler ELA, Ontario

C+N+P



Which Lakes have the highest
risk?

- “The largest pond is as sensitive to atmospheric changes as the globule of mercury in its tube.” - Henry David Thoreau

Susceptibility of Lakes to Nutrient Enrichment & Cyanobacteria

Lake Depth affects :

- Lake volume
- Internal loading through circulation
 - Area of lake suitable (euphotic) for benthic cyanobacteria

Importance of Physical Features of Lakes

- **Mean Depth [lake volume (m^3)/lake area (m^2)]**

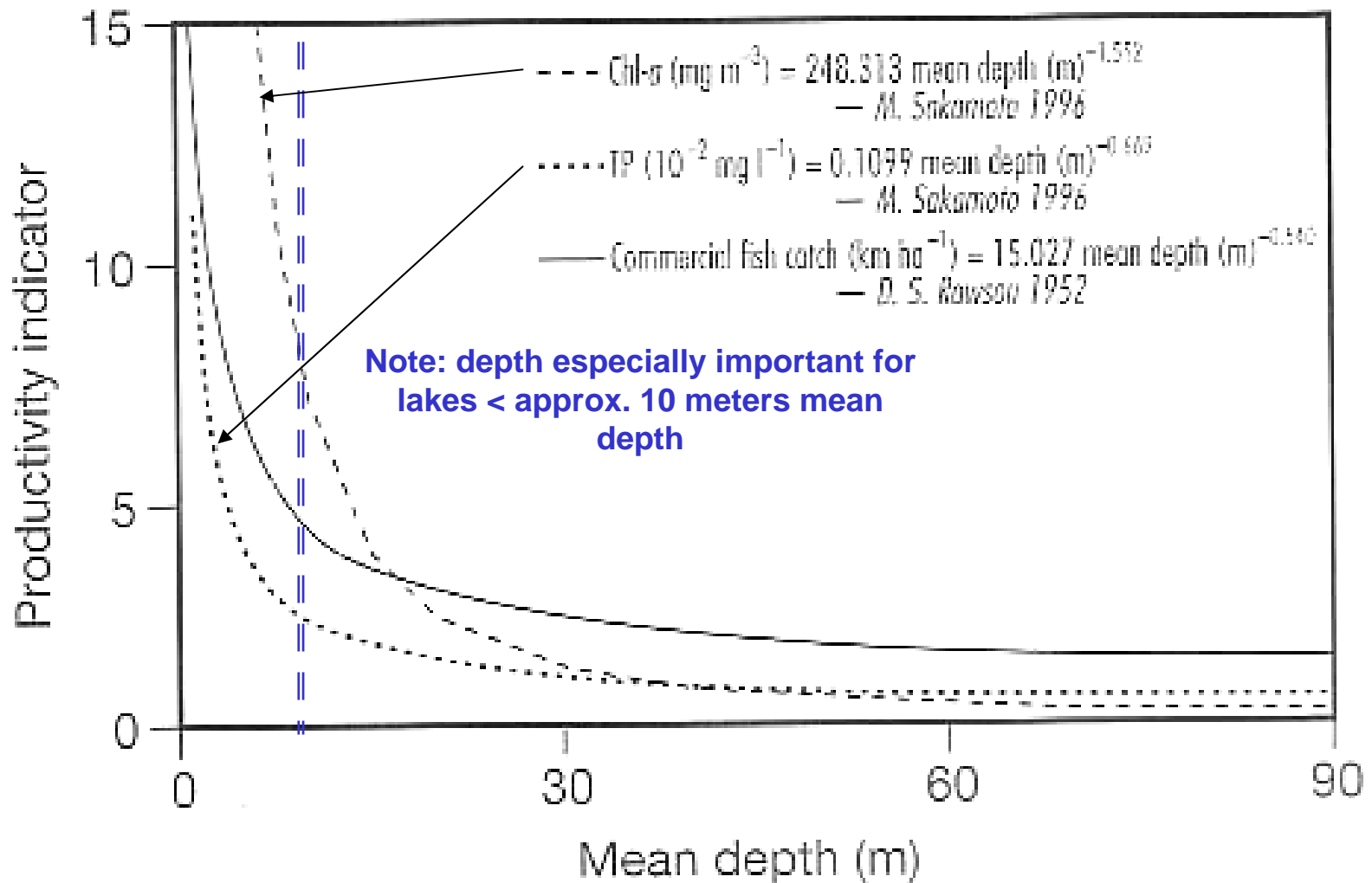
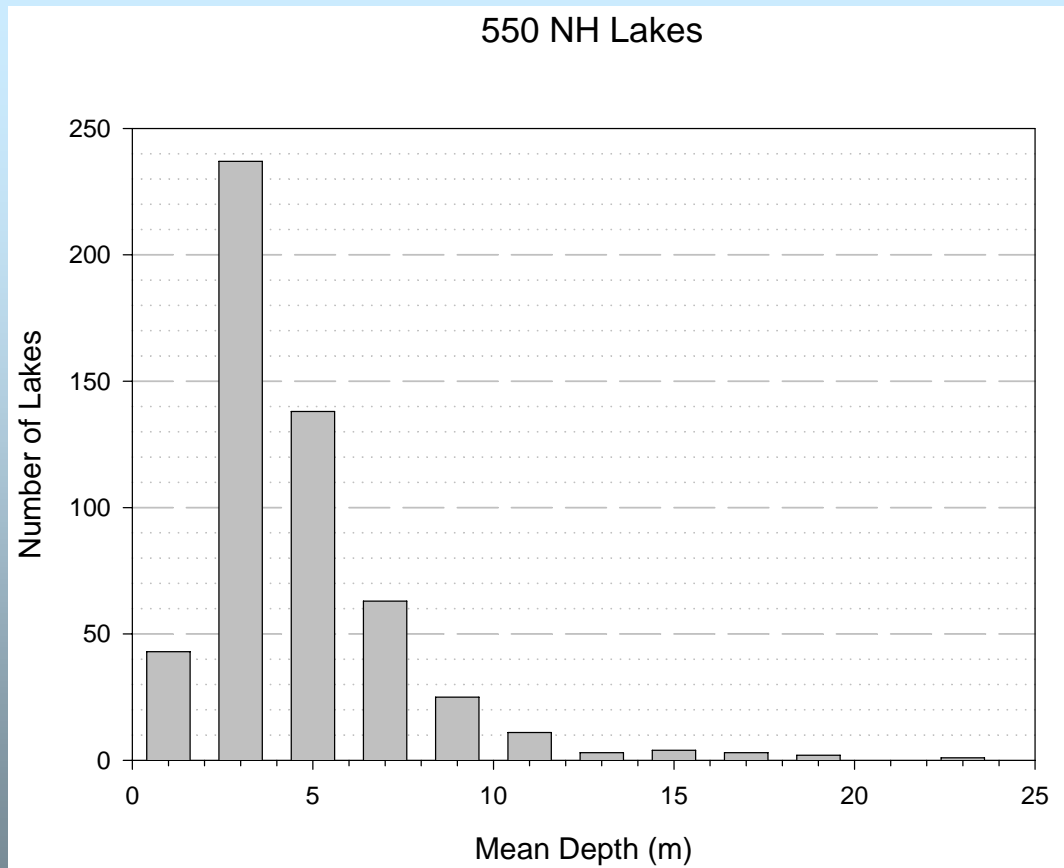
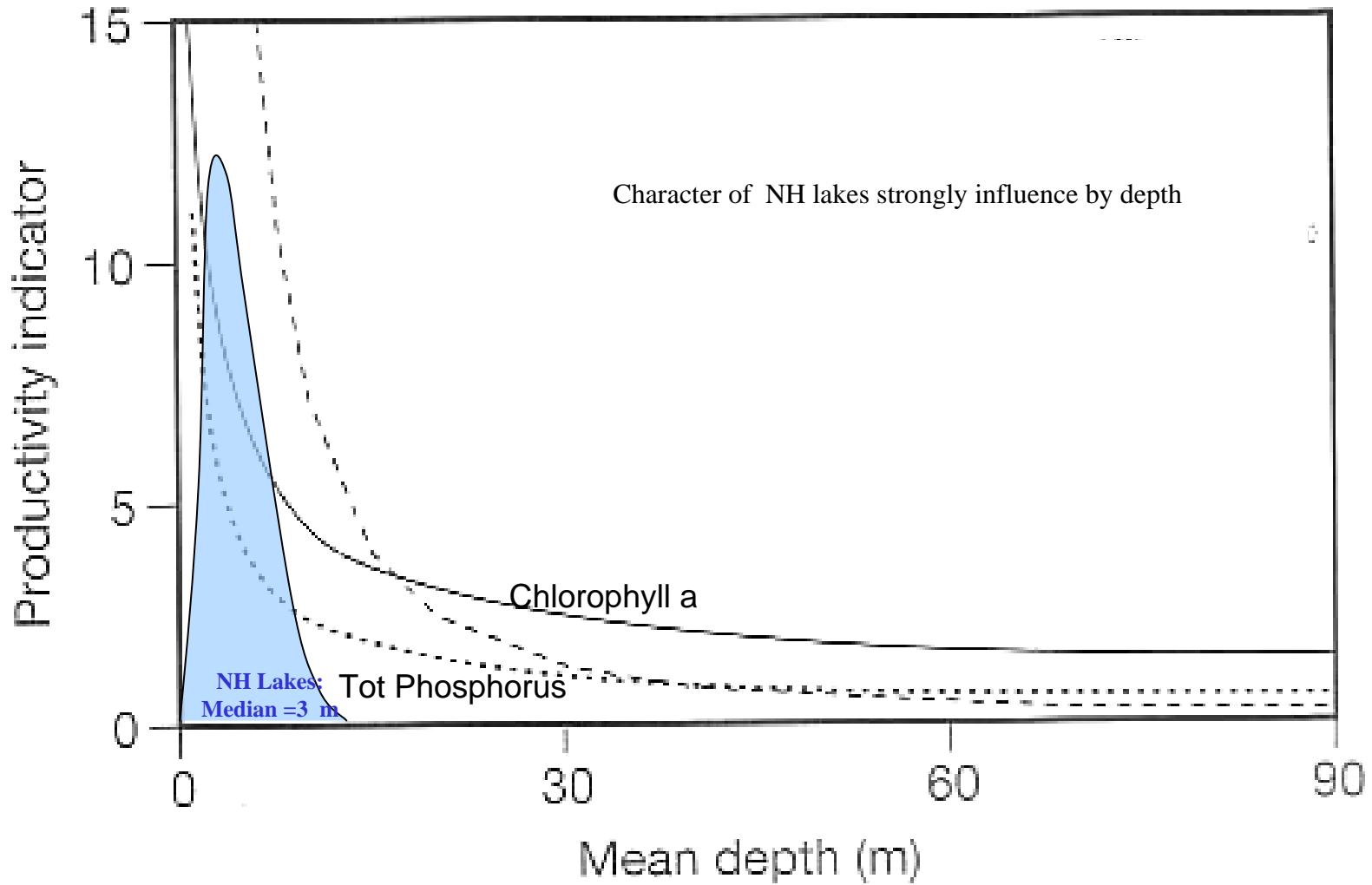


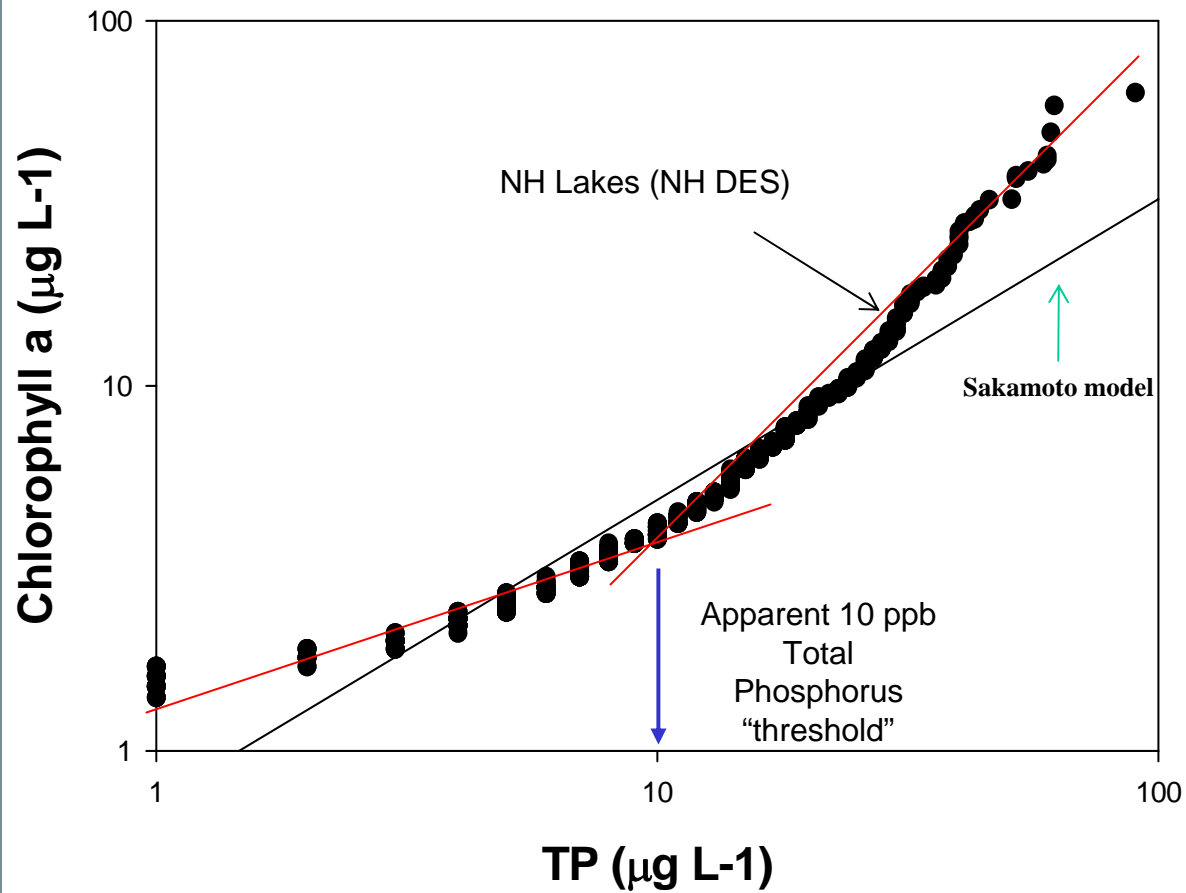
Figure 7-3 Empirical relationships between indicators of lake productivity and mean depth. (Modified after Straškraba 1980.)

New Hampshire Lakes





Emperical relationships between indicators of lake productivity and mean depth. *(Modified after Straškraba 1980.)*



What if all ponds were shallow? Would it not react on the minds of men? I am thankful that this pond was made deep and pure for a symbol. Thoreau

Cyanobacteria as Competitors

Cyanobacteria Dominance

Nutrients (high levels of phosphorus followed by low)

Warm Temperature

Thermocline Stability (increase w/ temp)

Low Light (low water clarity)

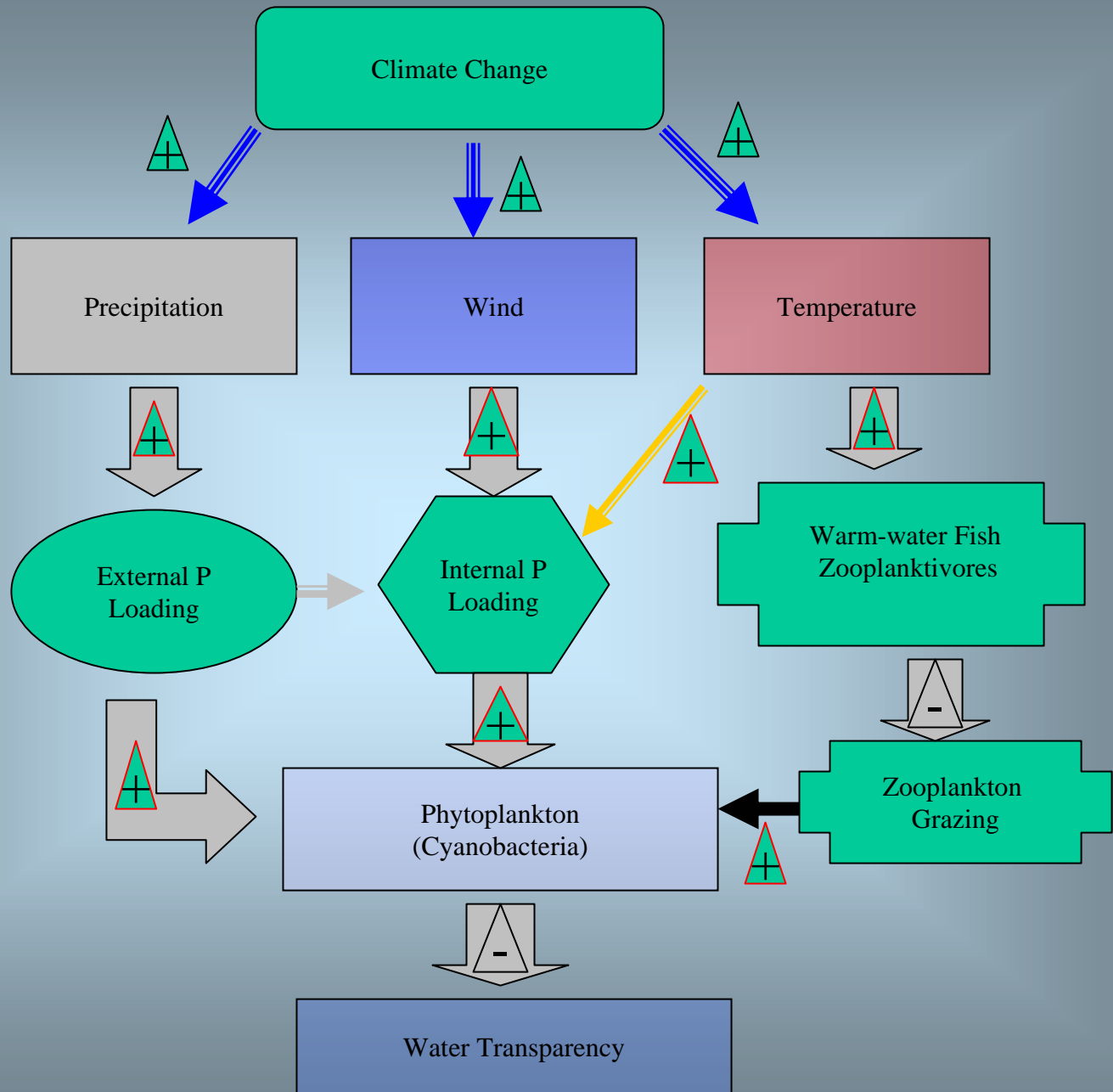
What do we know about how NH lakes respond to climate?

- **Results from the ~ 30 years of the UNH NH Lakes Lay Monitoring Program**

Most, but not all lakes respond:

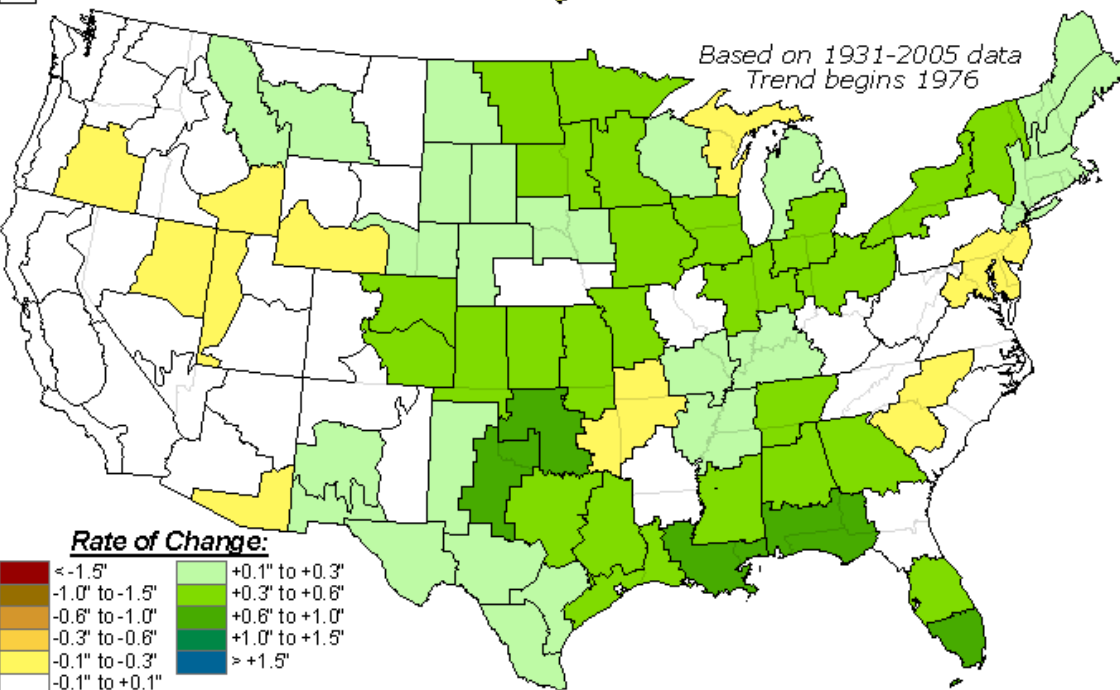
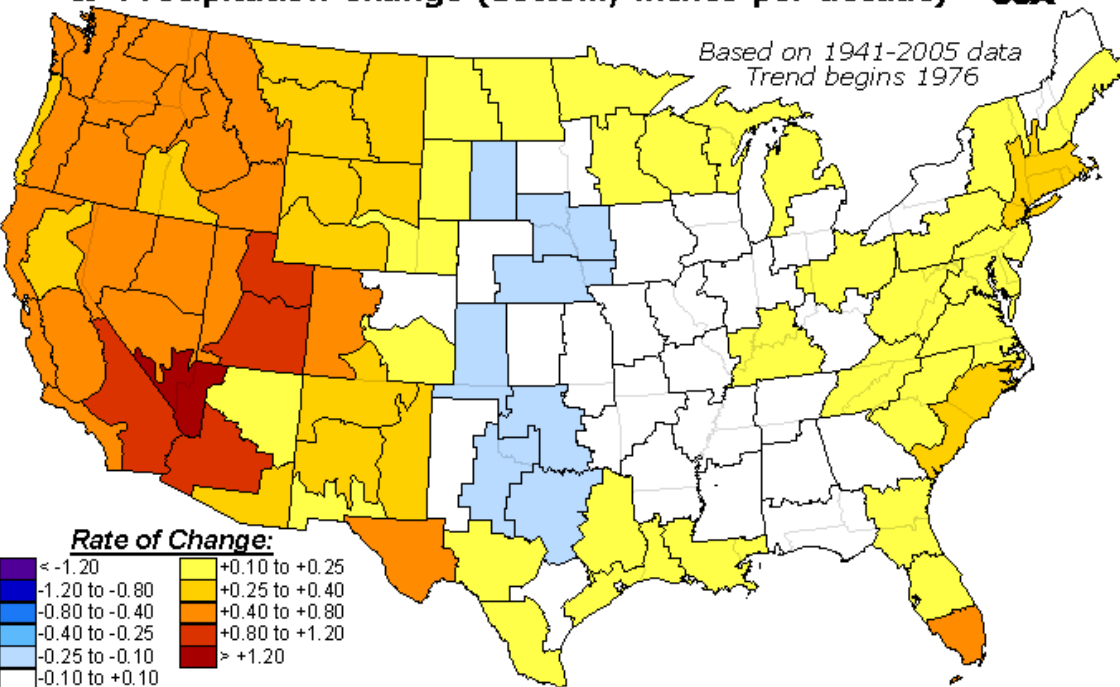
Dry years: low TP, low chlorophyll, low CDOM, high transparency

Wet years: high TP, high chlorophyll, high CDOM, low transparency



How will climate change?

**Rate of Long-Term Trend Temperature Change (top; °F per decade)
& Precipitation Change (bottom; inches per decade) – JJA**



How has climate been changing?

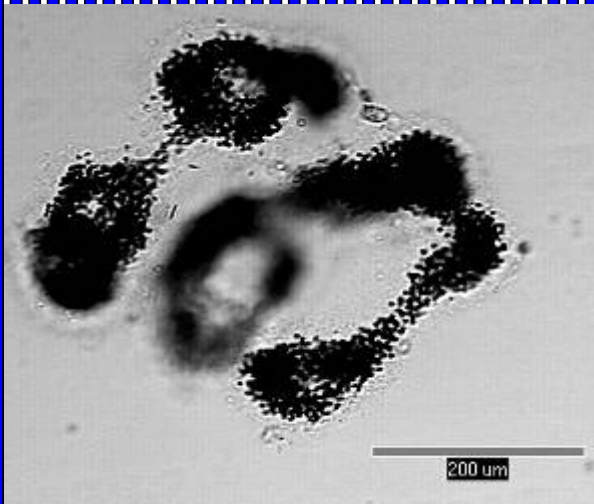
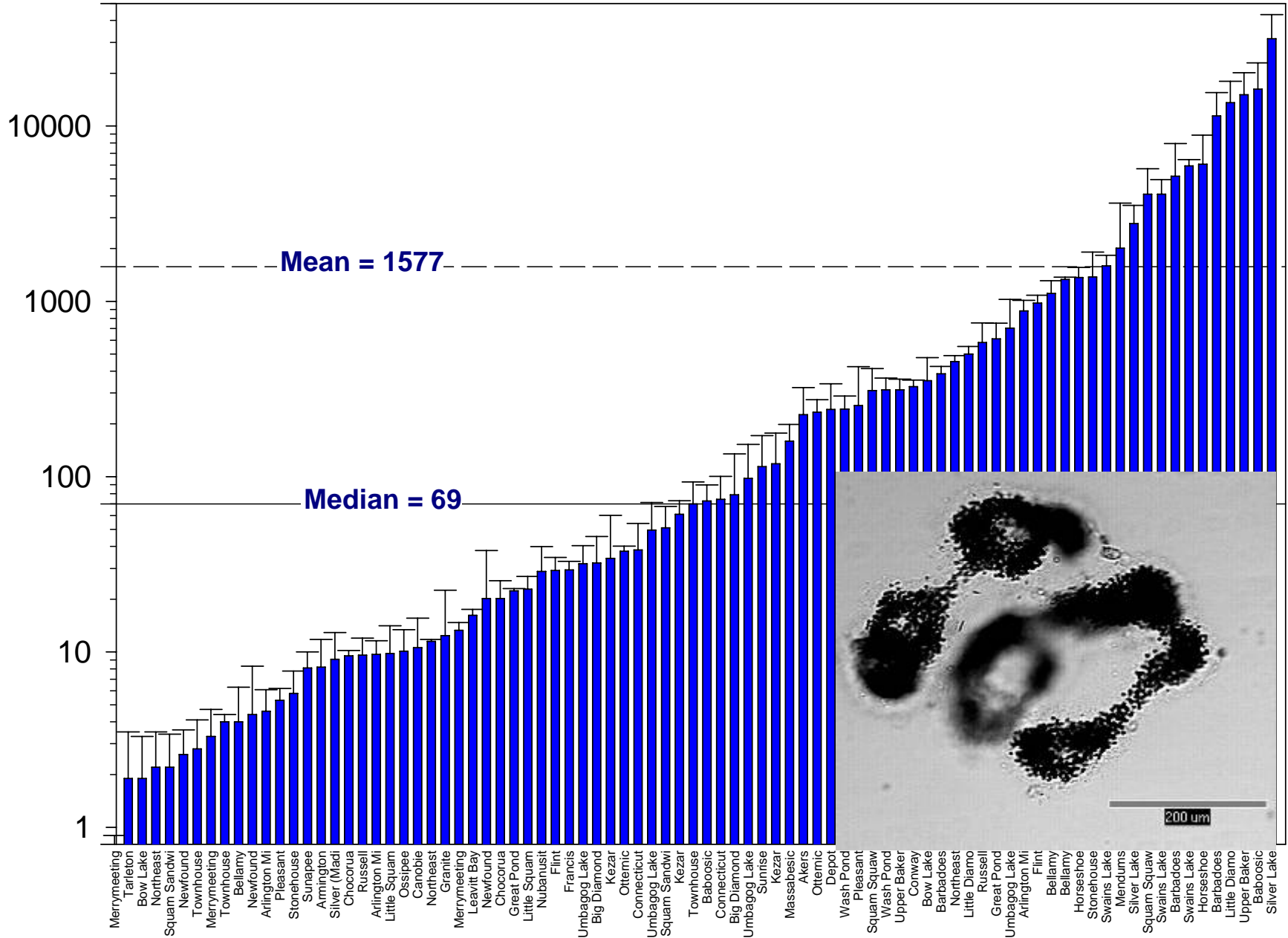


ELISA Technique for Microcystin Analysis

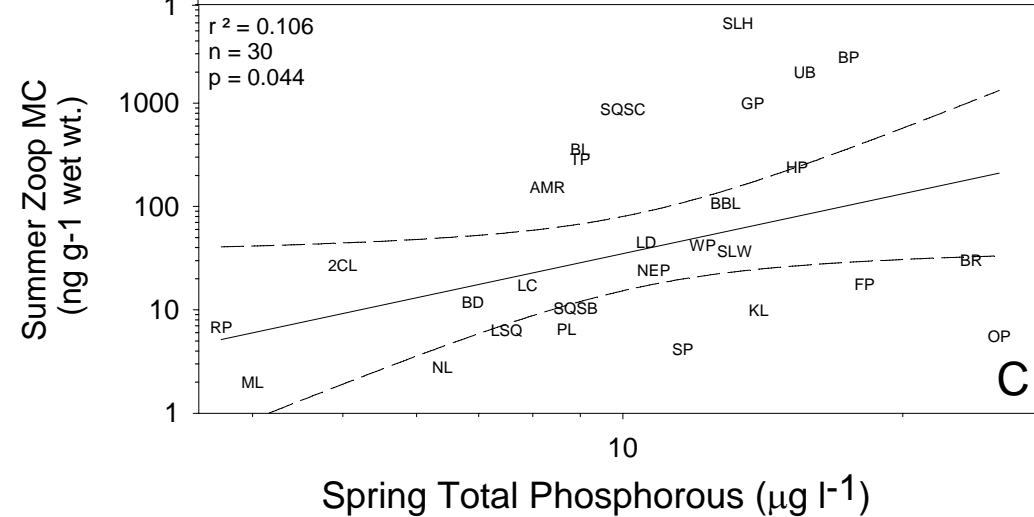
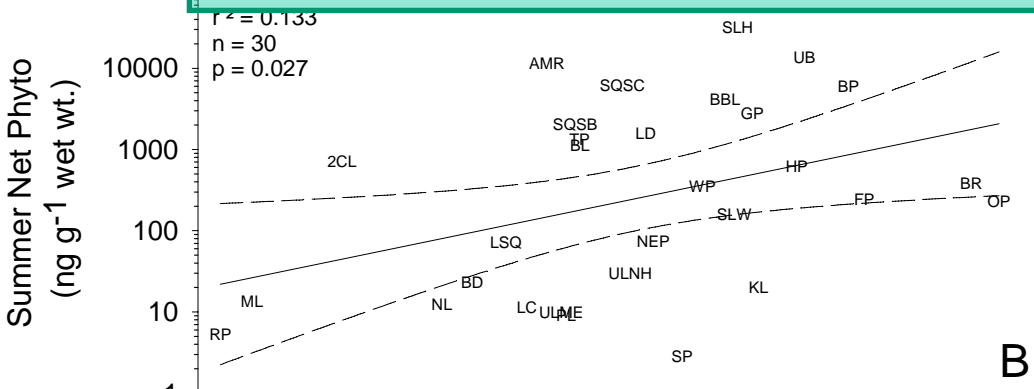
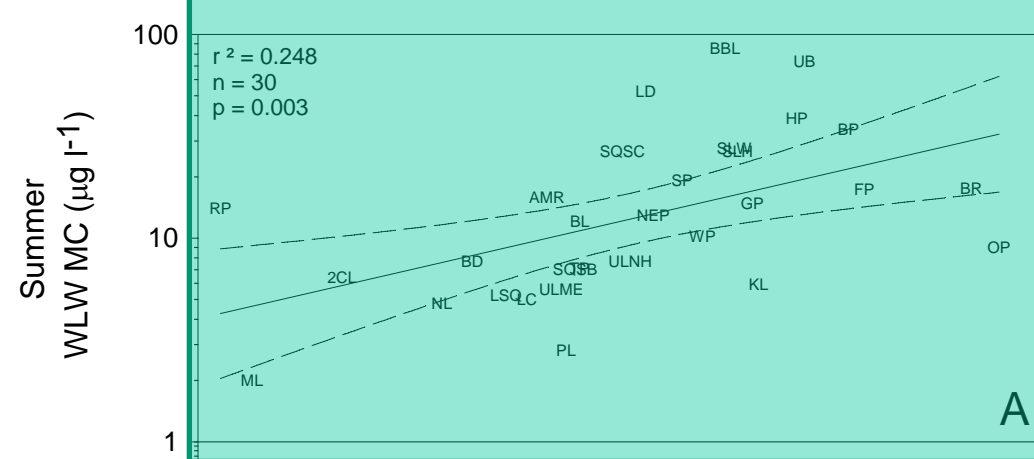
Microcystin toxins were found in **all** NH study lakes (92), from the most pristine to the most polluted

Phytoplankton Toxicity

Phytoplankton Microcystins (ng g⁻¹ wet wt.)

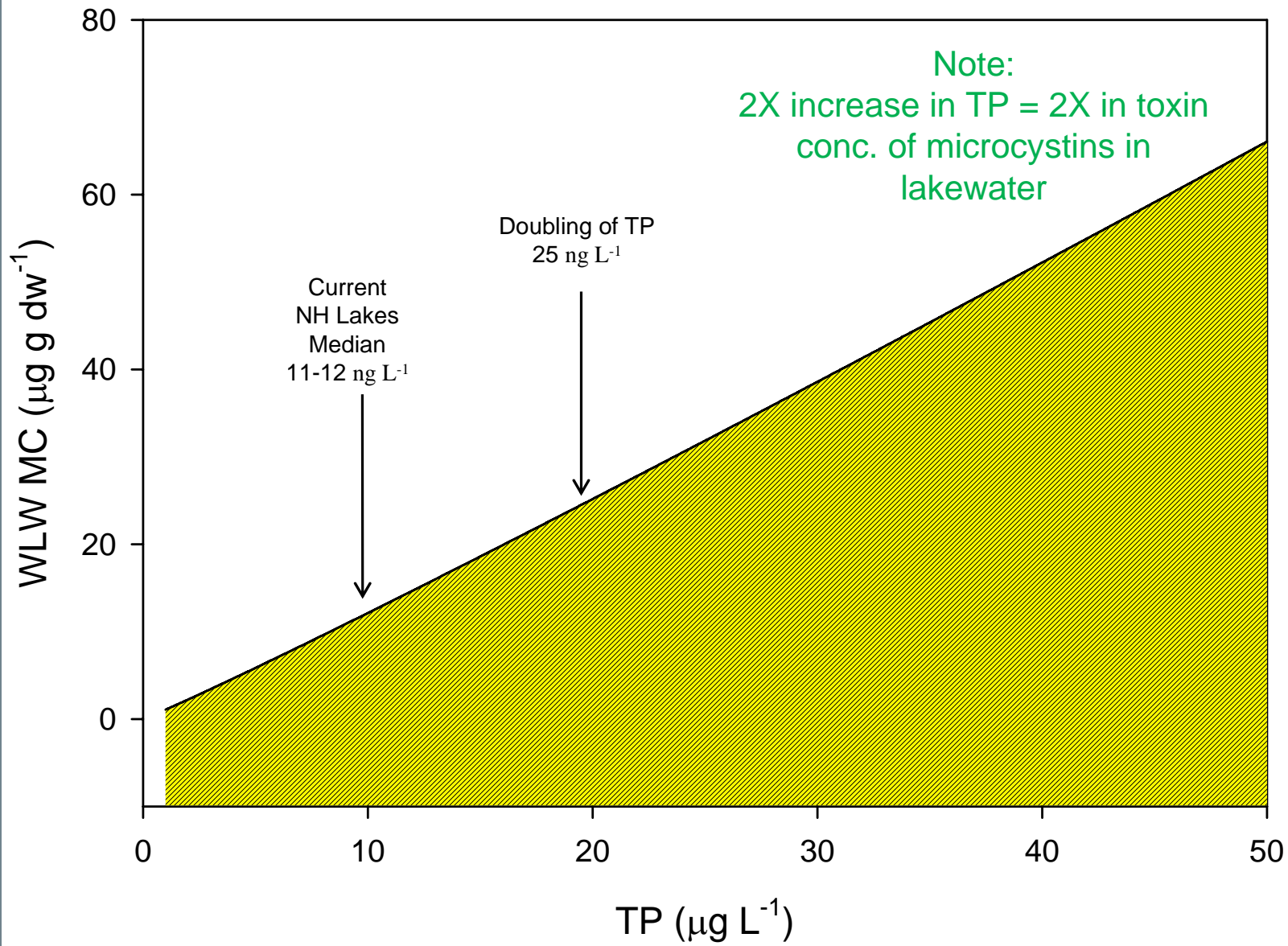


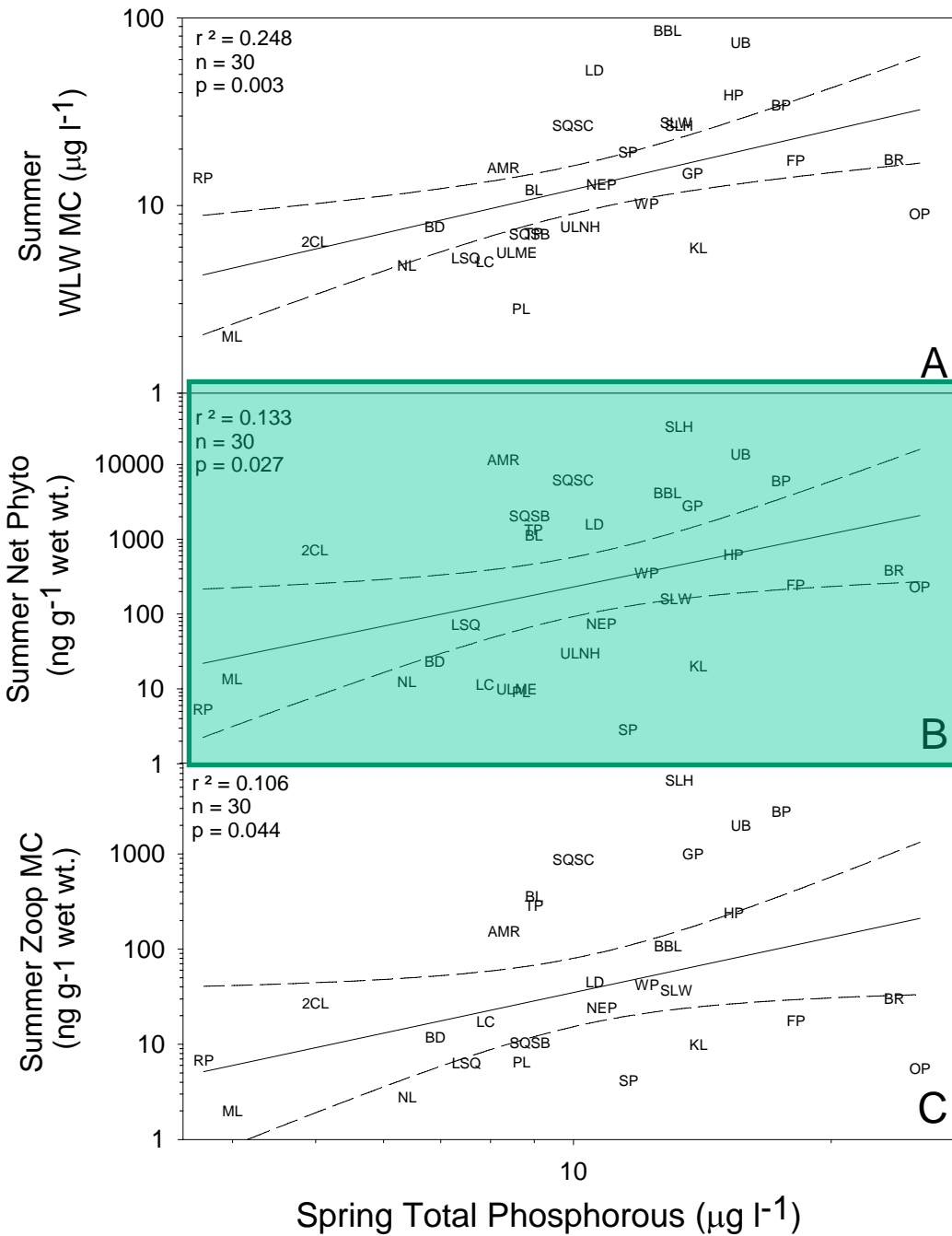
There was a significant trend of **increasing microcystin levels** with **increasing phosphorus concentration**



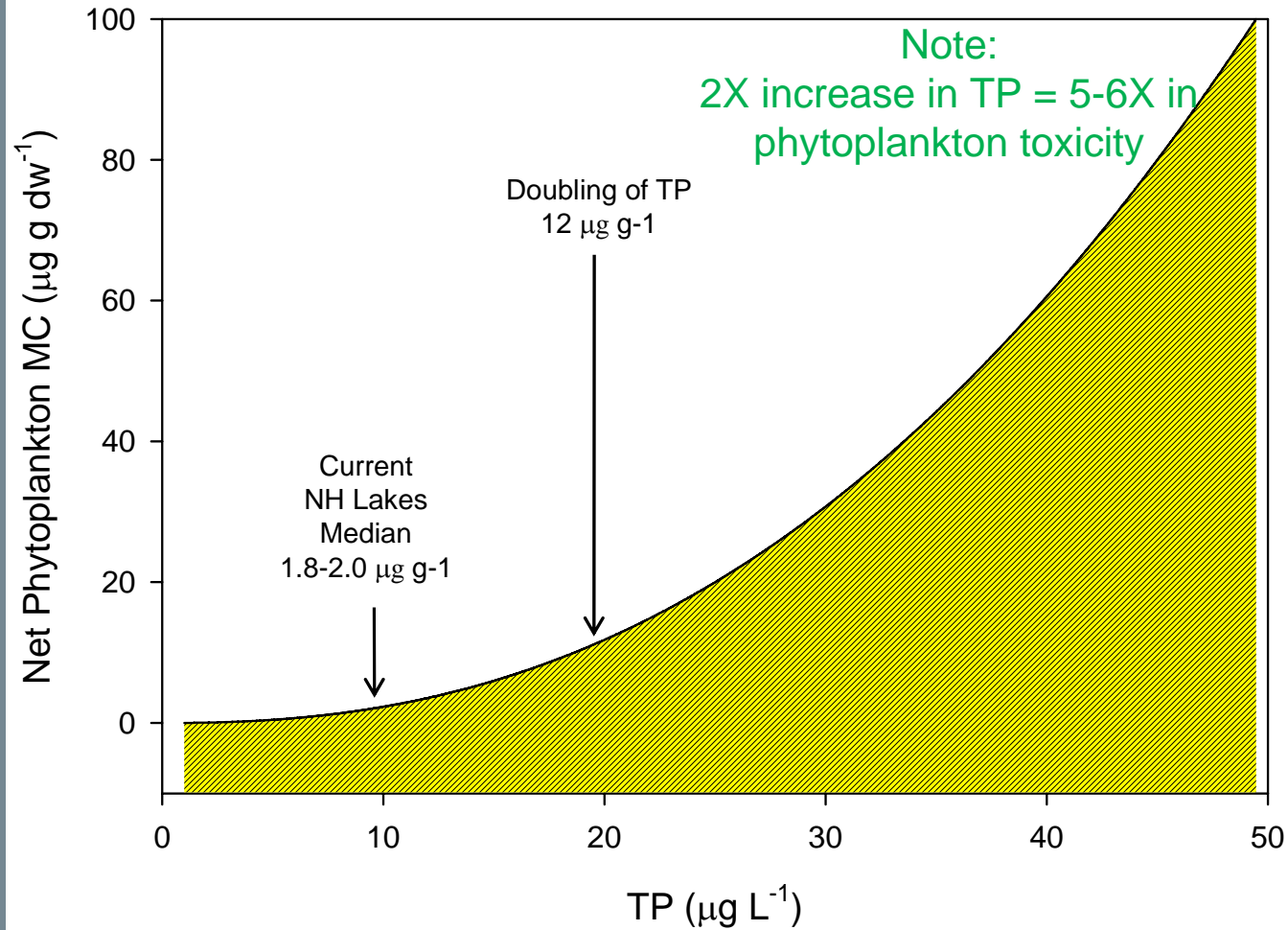
Assume a “typical” NH lake undergoes a doubling of phosphorus

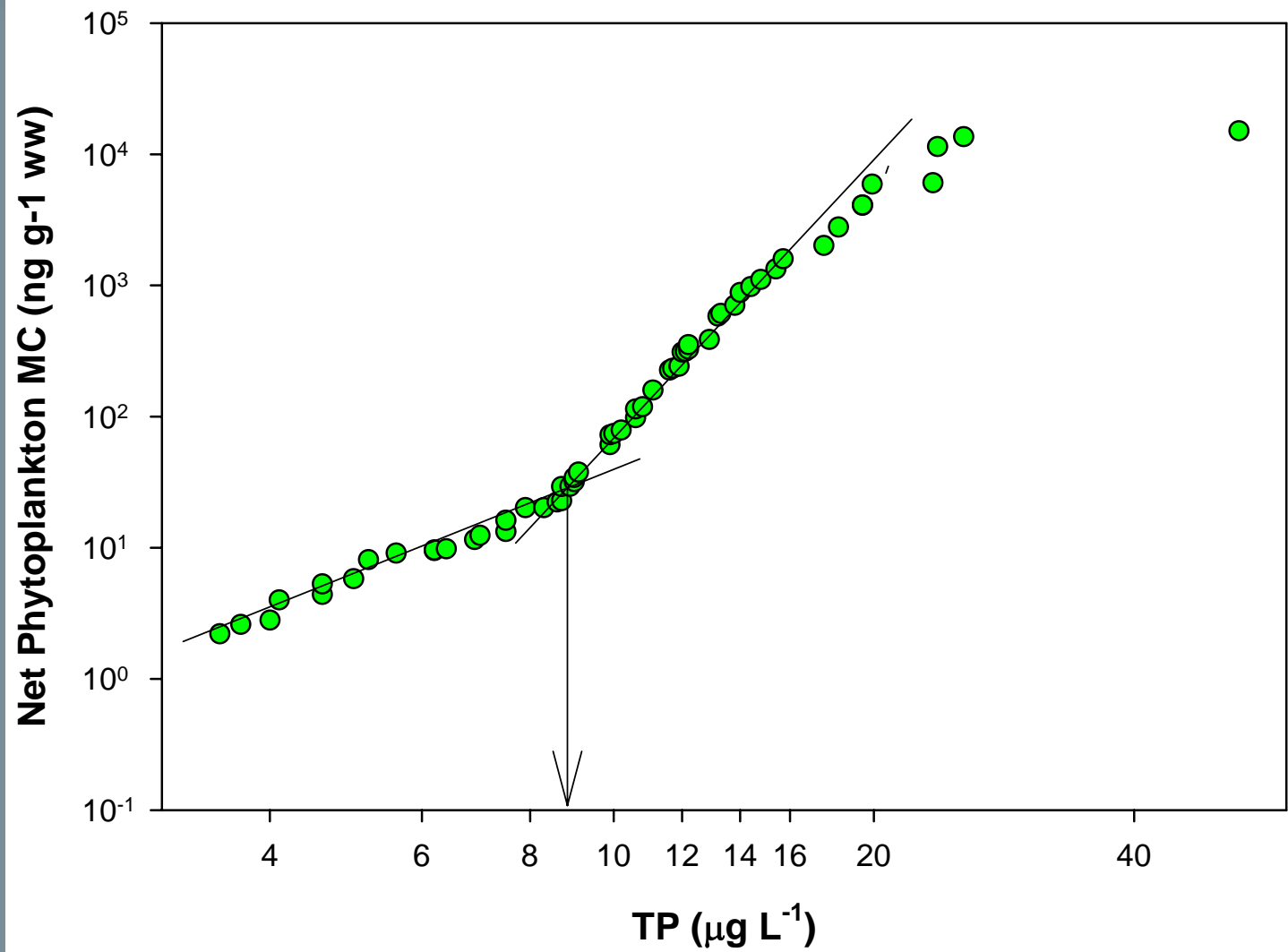
Model: SpringTP vs WLW Toxicity



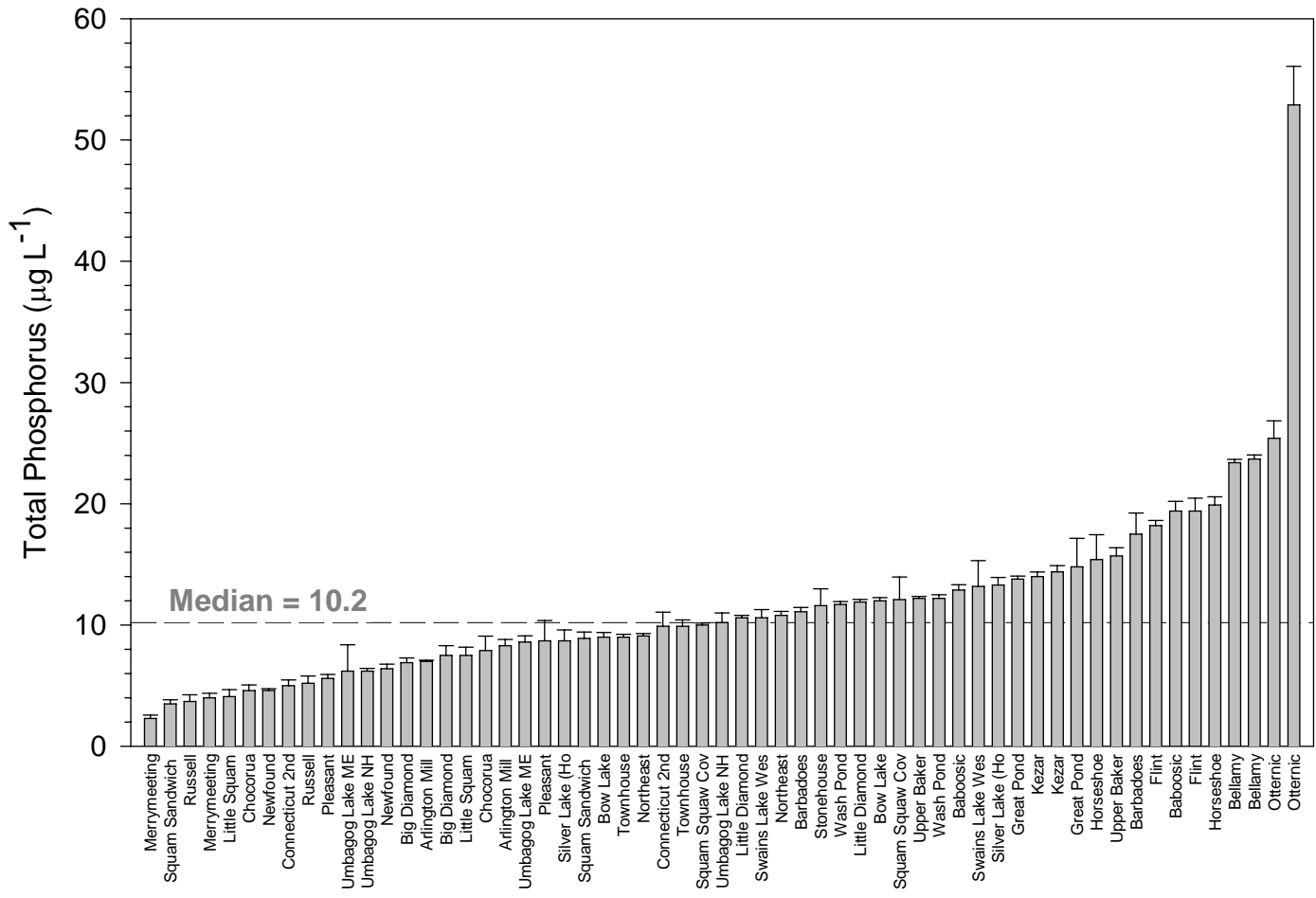


Model: SpringTP vs Summer Phytoplankton Toxicity



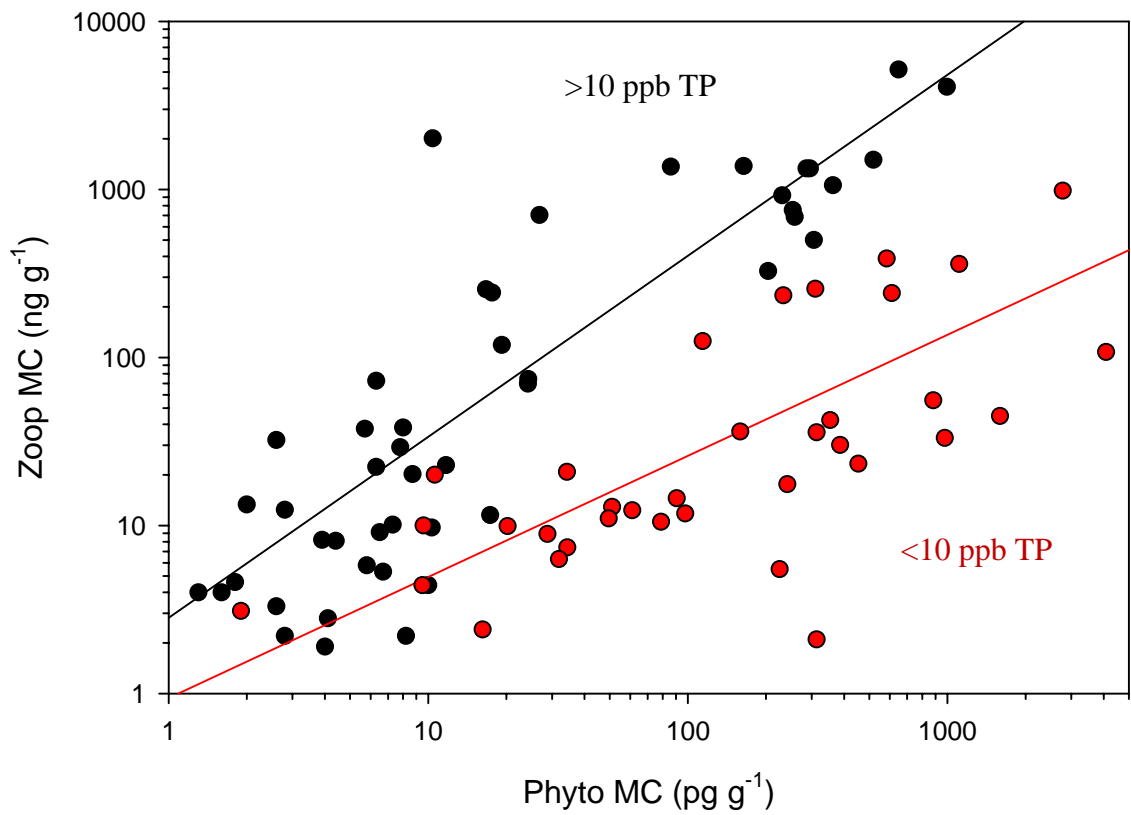




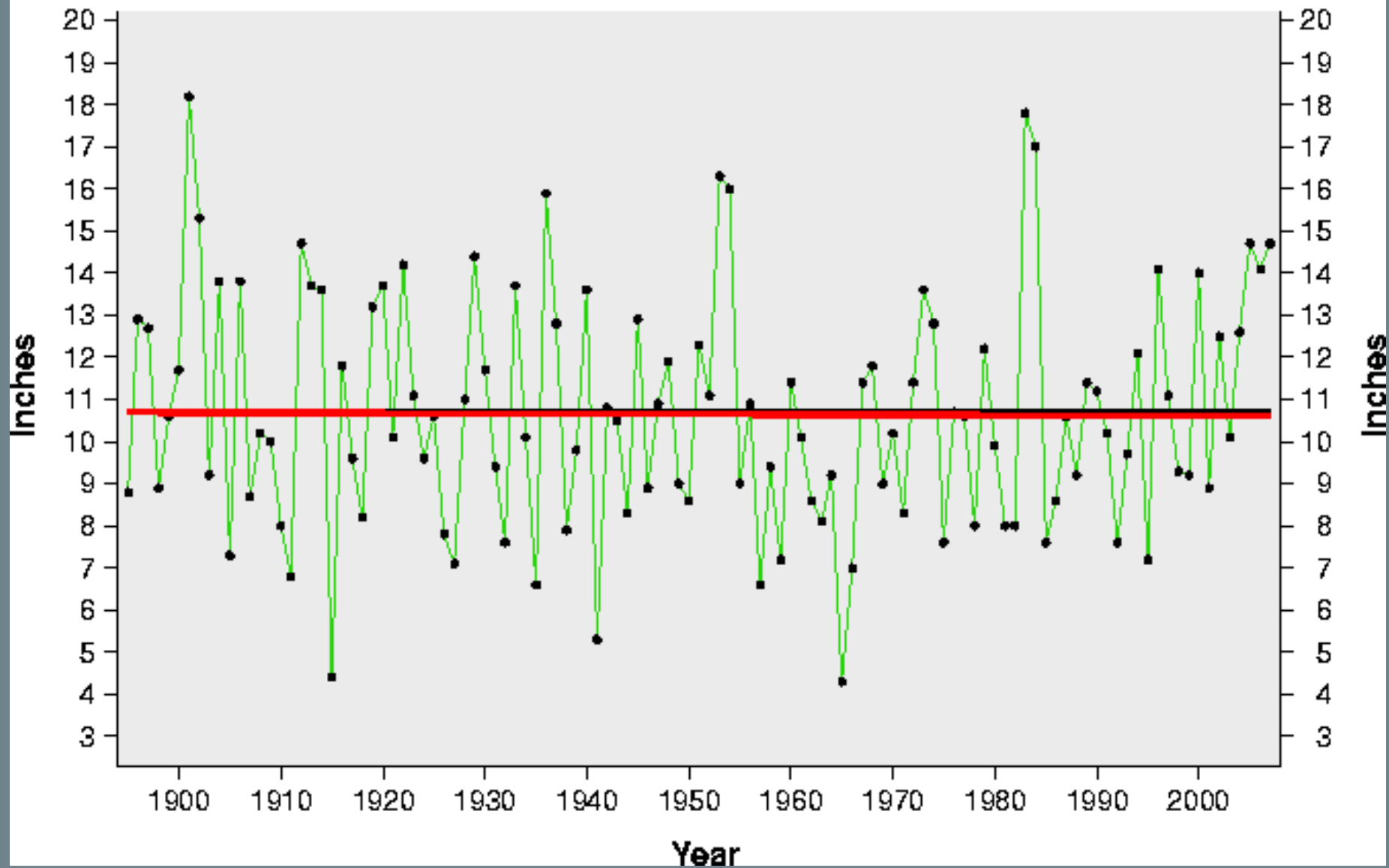


LAKE CYANOTOXIN PROBLEMS

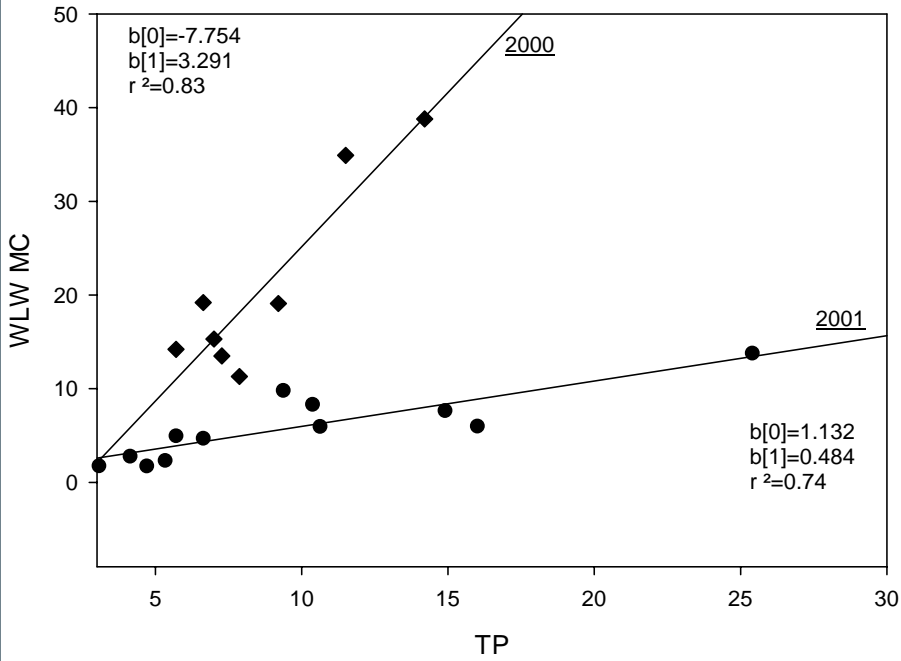
1. The Obvious Problem: Surface “blooms”
2. The less-visible problem: Food web bioaccumulation



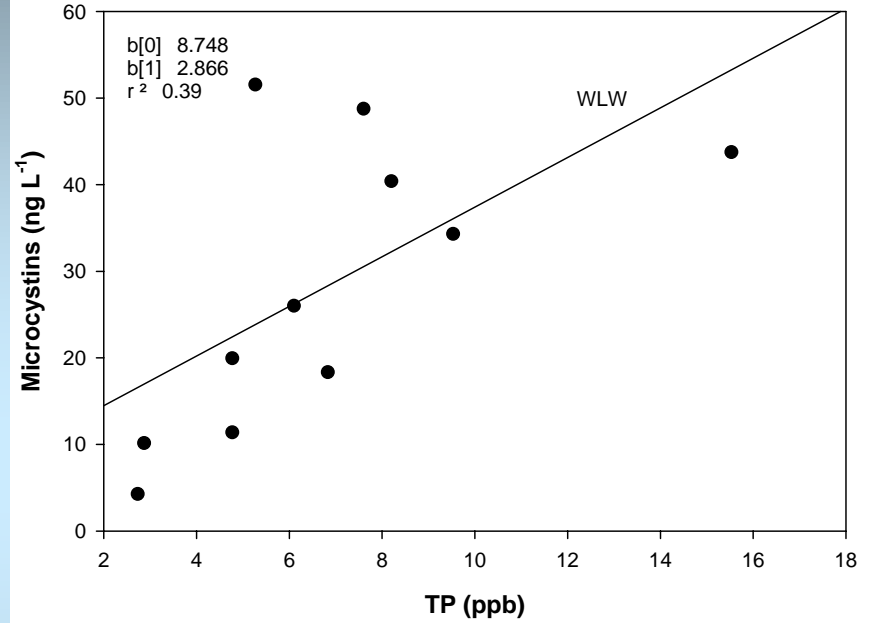
- Actual Precipitation
- Average Precipitation
- Trend



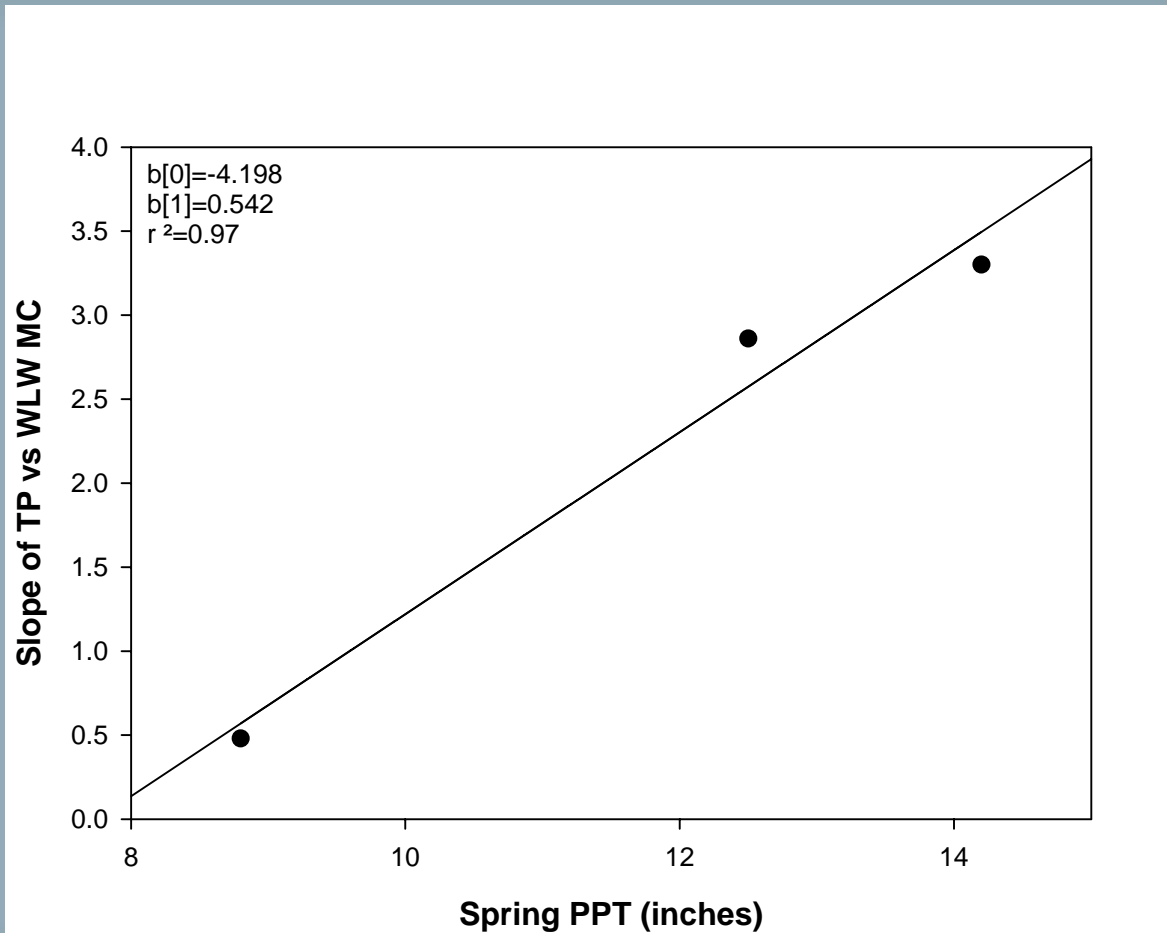
Comparison of class data: 2000 vs 2001



2002



Could weather alter the toxicity that results from TP?



Movement and Accumulation of MC in the Food Web

Zooplankton Grazers

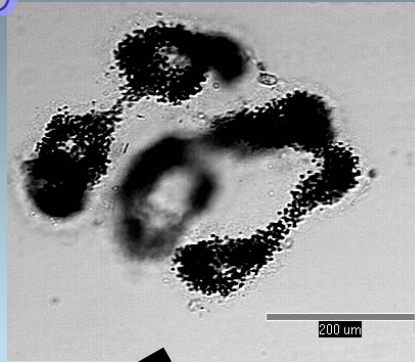
Small



Large



Transfer of cyanotoxins to Filter feeders

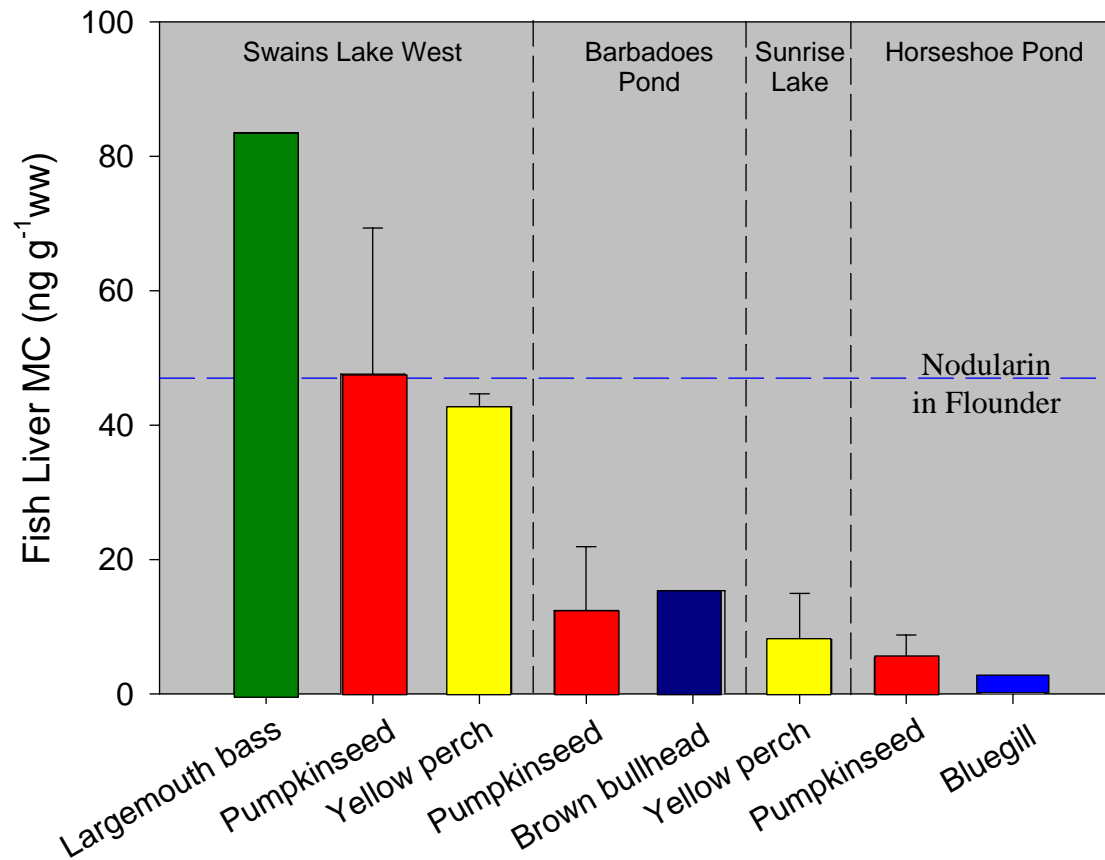


Daphnia spp



Elliptio complanata

Microcystin concentration in livers of each fish species caught in four NH Lakes.



- Microcystin was present in all fish species sampled.
- Largemouth bass had the highest level of microcystin.



- Surface bloomers: Net Cyanoplankton
- Hidden cyanobacteria: Picoplankton
(smallest: 2-0.2 μm)

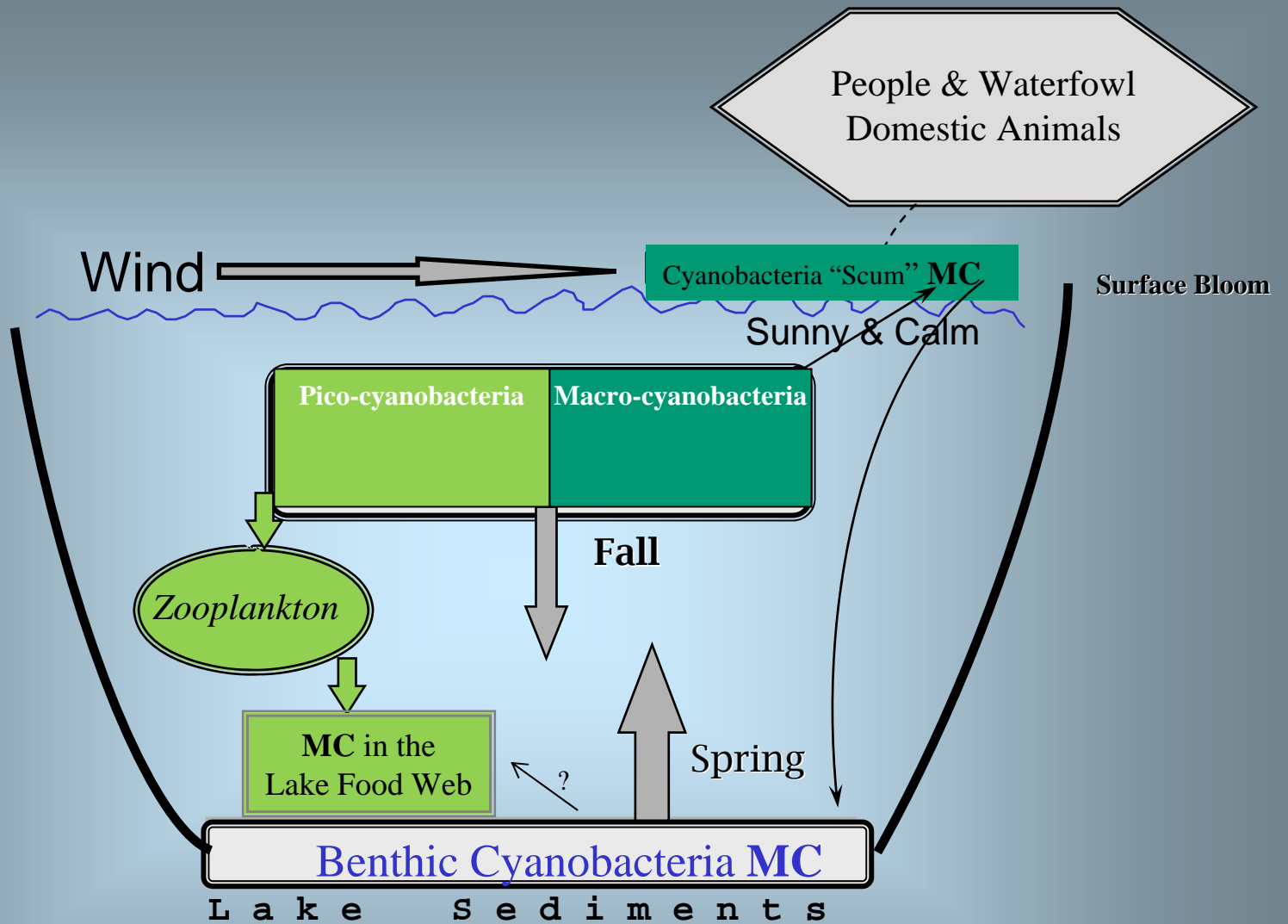
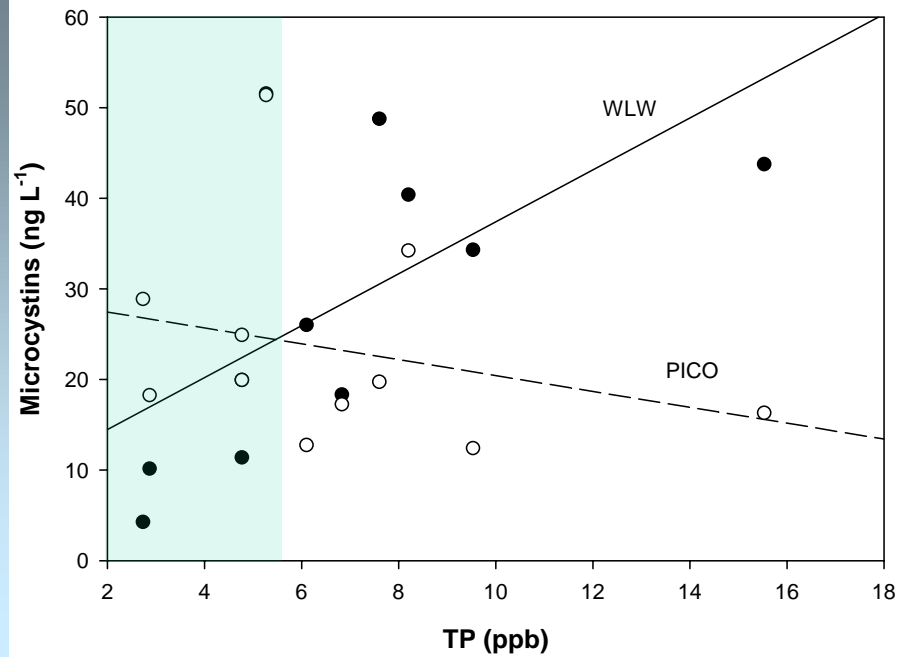
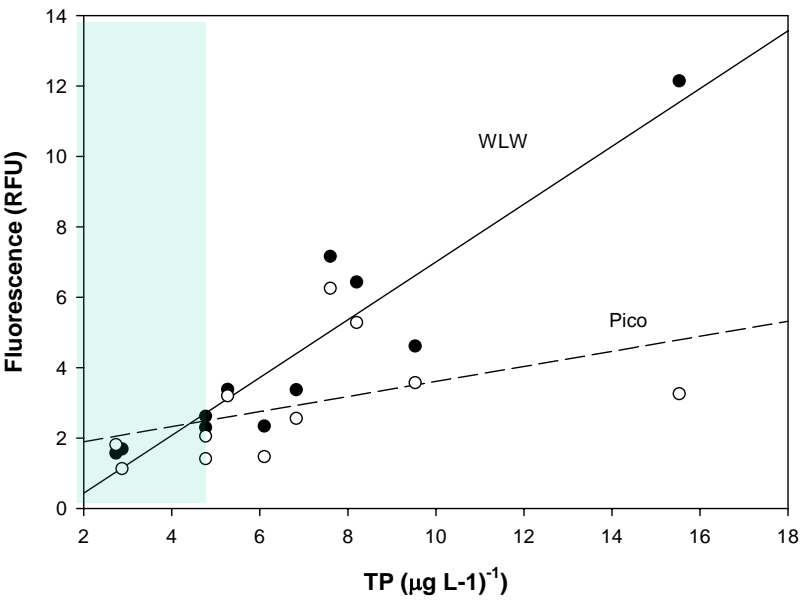


Figure 1. Movement of Microcystins in the Lake Food Web

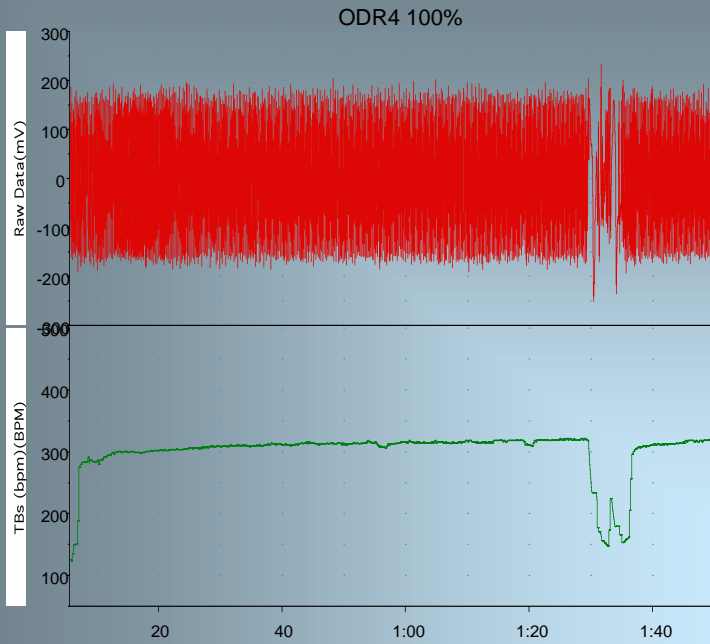


Need to better understand the
lake food web

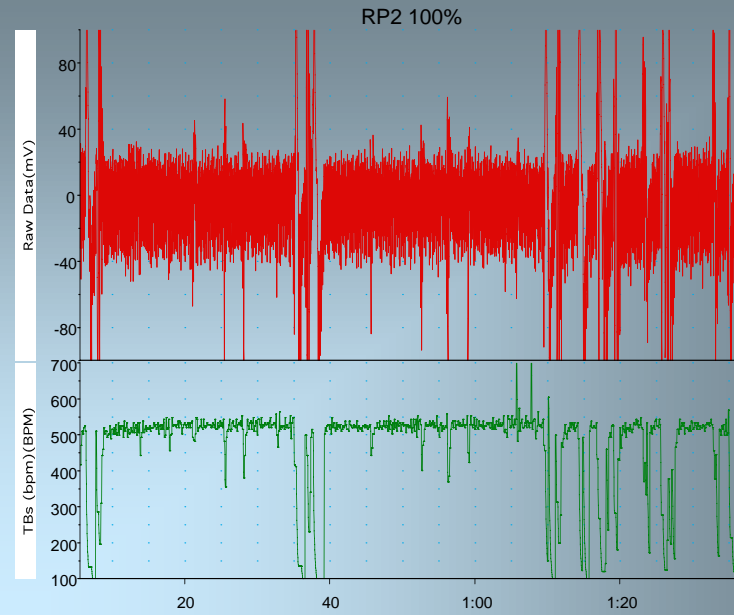
Anabaena &
Microcystis

50 μm





Daphnia pulex
Eutrophic Old Durham
Reservoir



Daphnia pulicaria
Ultra-oligotrophic Russell Pond
Woodstock, NH



Need to better understand the
lake “blooms”

Summer 2007

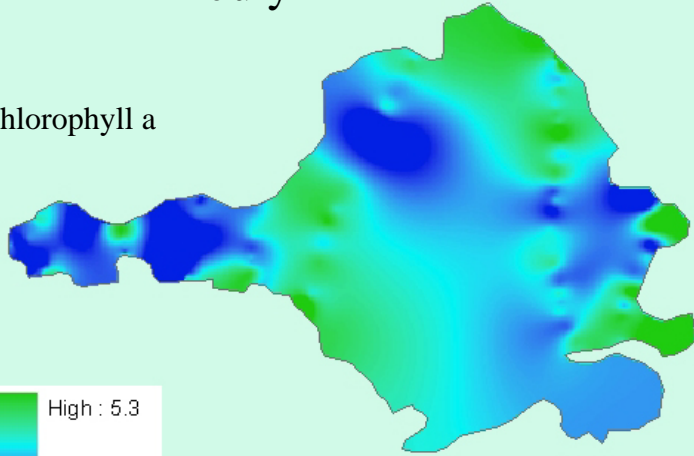


Willand Pond Dover NH

Willand Pond (NH)

July

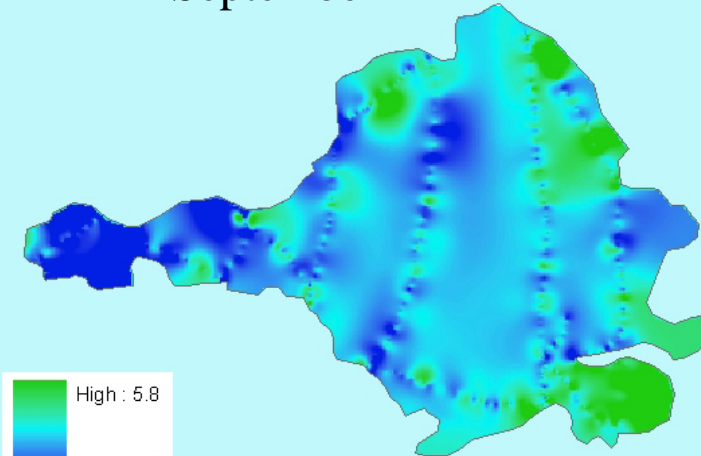
Chlorophyll a



High : 5.3

Low : 1.0

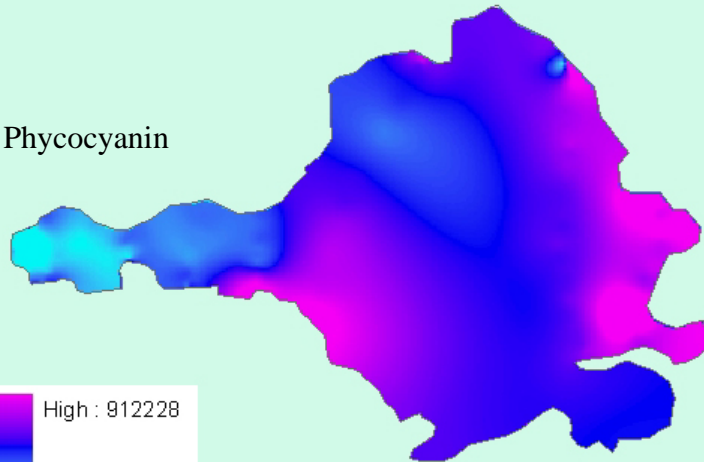
September



High : 5.8

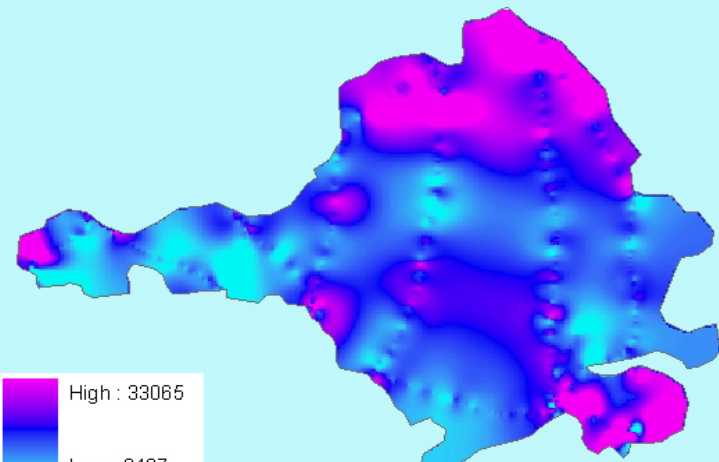
Low : 2.8

Phycocyanin



High : 912228

Low : 92771



High : 33065

Low : 6437