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LEARNING FROM THE PAST TO INFORM LAKE OKEECHOBEE MANAGEMENT IN THE LOSOM ERA

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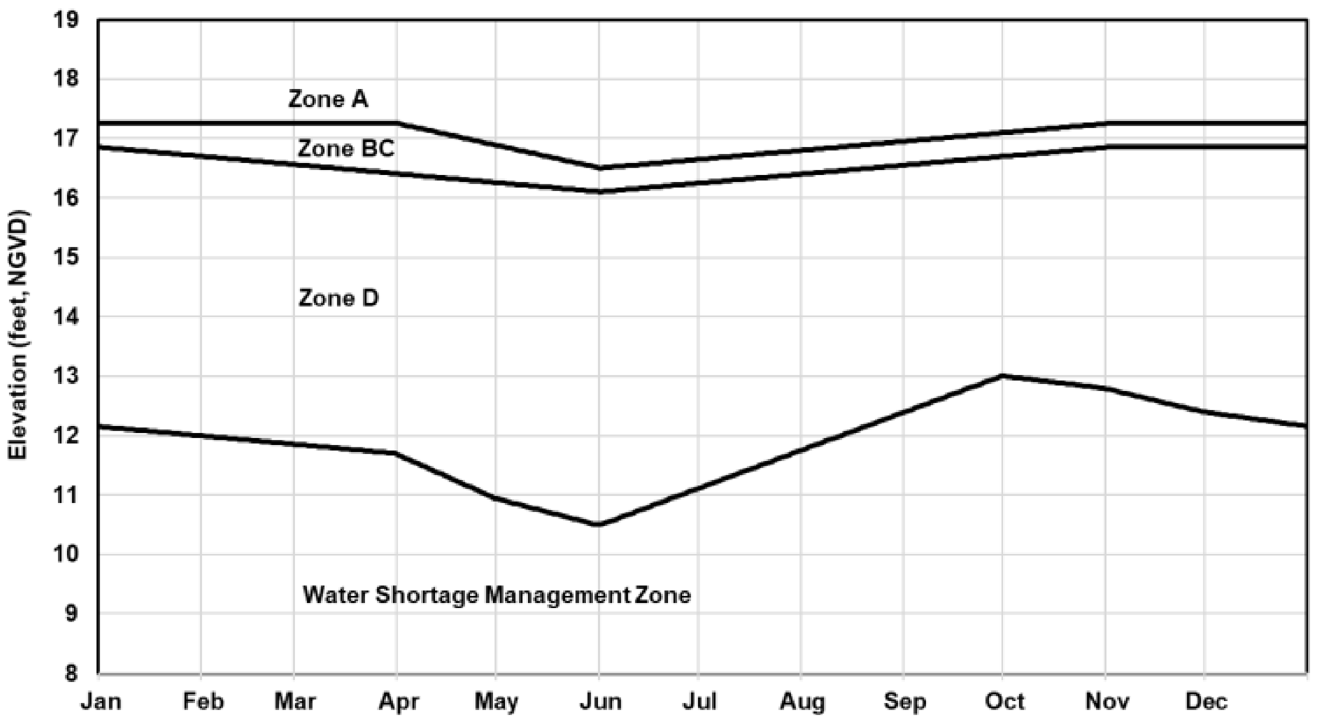
Transitioning From LORS2008 To LOSOM202X



ZONE	RELEASES	NOTES
Zone A	Maximum capacity	Canals 43 and 44 may be maintained above their optimum water elevations (Table 7-3)
Zone BC	Up to 1,550 cfs at S-351 Up to 1,350 cfs at S-354 Up to 7,200 cfs at S-77 Up to 3,500 cfs at S-80 Up to 300 cfs at S-271 or S-352	Canals 43 and 44 should be maintained within their optimum water elevations (Table 7-3)
Zone D	Up to 1,100 cfs at S-351 and S-354 combined Up to 2,000 cfs at S-79 Up to 300 cfs at S-271 or S-352	Canals 43 and 44 should be maintained within their optimum water elevations (Table 7-3) except when Lake Okeechobee is lower than the optimal, then maintain canal with the lake.
Water Shortage Management Zone	Water supply releases as needed	Canals 43 and 44 may be maintained below their optimum water elevations (Table 7-3)

CENTRAL AND SOUTHERN FLORIDA PROJECT

DRAFT 2023 LAKE OKEECHOBEE
INTERIM REGULATION SCHEDULE
Lake Okeechobee System Operating Manual (LOSOM)

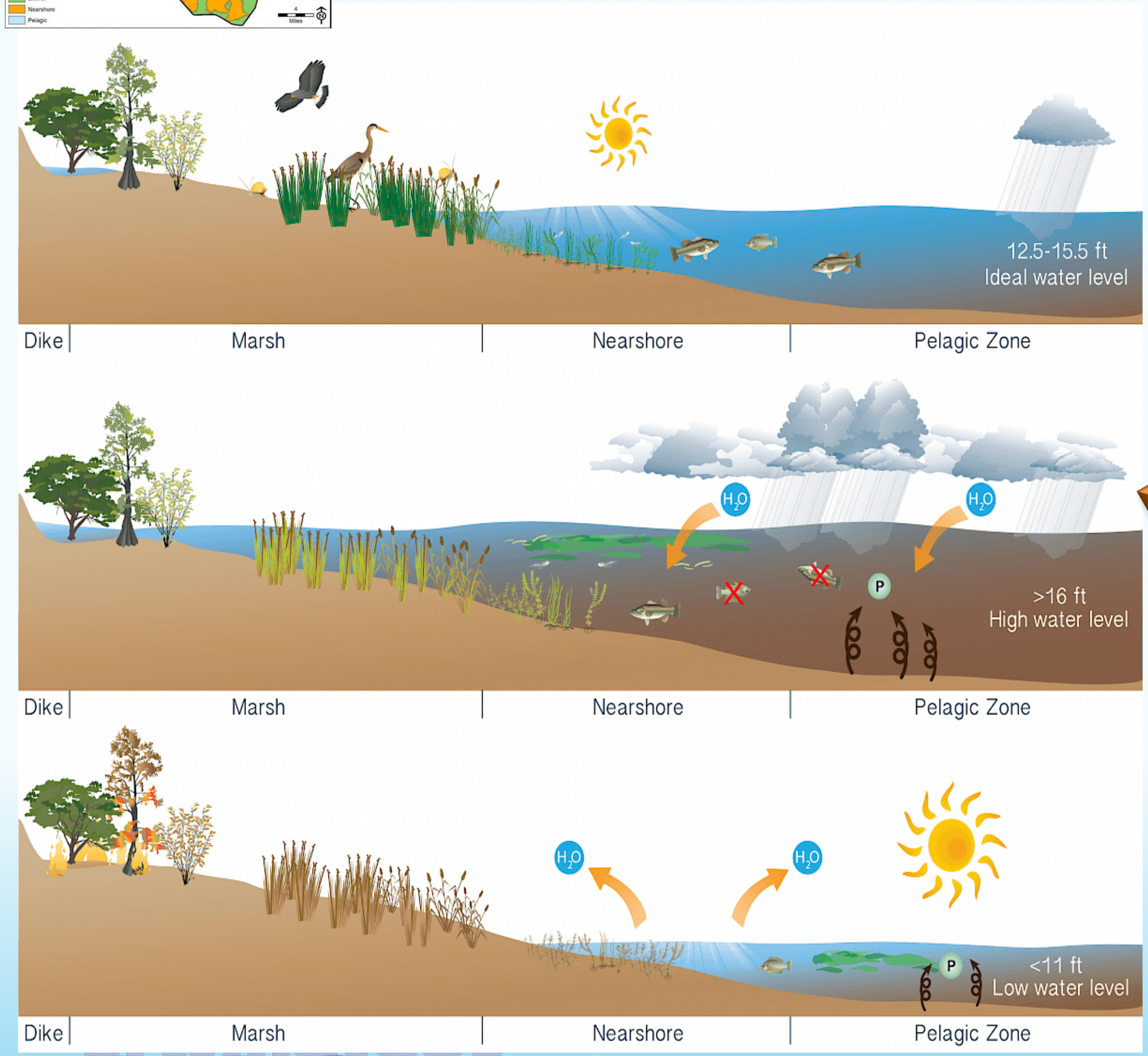
DATED: May 2023
DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

Source: USACE WCP, 2023

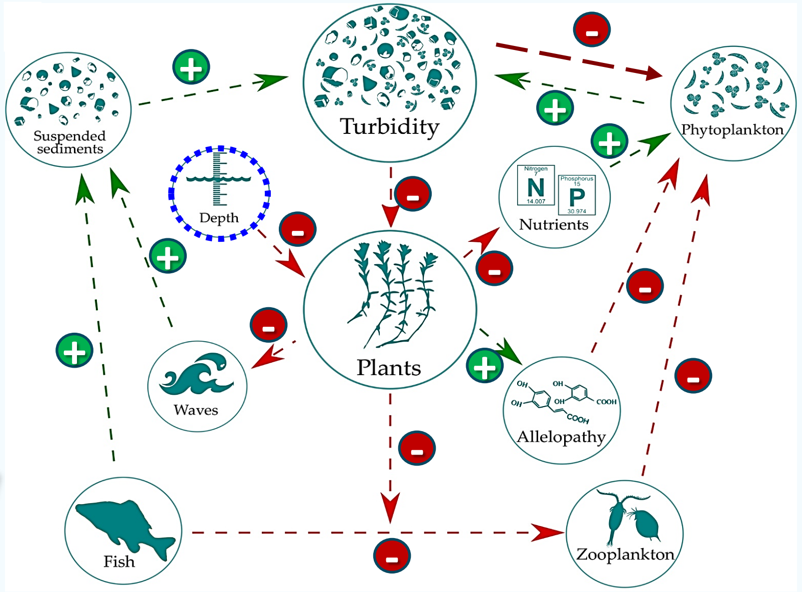
What to Expect?

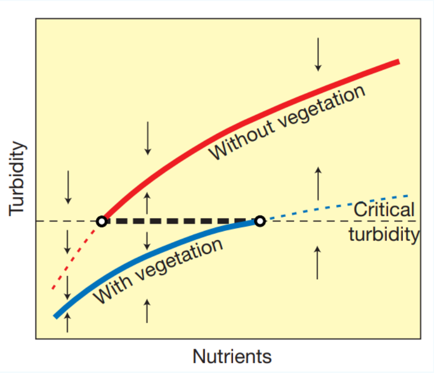
- ❑ Increased frequency and duration of high Lake O. stages/reduced time in eco envelope
- ❑ Increased low and optimal flows and reduced extreme flows to CRE
- ❑ Reduced lake releases to SLE
- ❑ Enhanced Everglades ecology by sending more water south
- ❑ Improved water supply performance

Potential Adverse High Stage Effects on the Littoral Zone Ecology and Water Quality



Source: RECOVER, 2017





Modified from Scheffer et al. 2001

- ❑ Littoral zone reduction
- ❑ SAV and native mash veg. loss / spread of cattail in littoral zone
- ❑ Fewer foraging opportunities for wildlife that use littoral zone marsh and SAV
- ❑ Adverse impact to wading bird nesting (loss of woody veg.)
- ❑ Decrease in fish diversity and prey abundance
- ❑ Decrease in water quality

Source: UF, 2020; EIS 2022; USACE WCP, 2023

Phytoplankton – A Sensitive Indicator of Lake Okeechobee Ecosystem Health

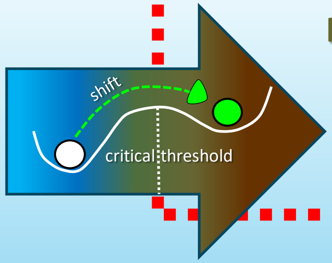
Drivers of Cyano-HAB Prevalence in the Lake

- Constant and high internal and external nutrient loadings; N:P ratios imbalance (often too low)
- Year-round warm waters & abundant sunlight
- Sufficient light availability in the littoral zone
- Long water residency time (>2 years)
- Periods of water column stability (when winds calm)

Pre-Development/Healthy/Balanced Ecosystem

Current Eutrophic/Imbalanced Ecosystem

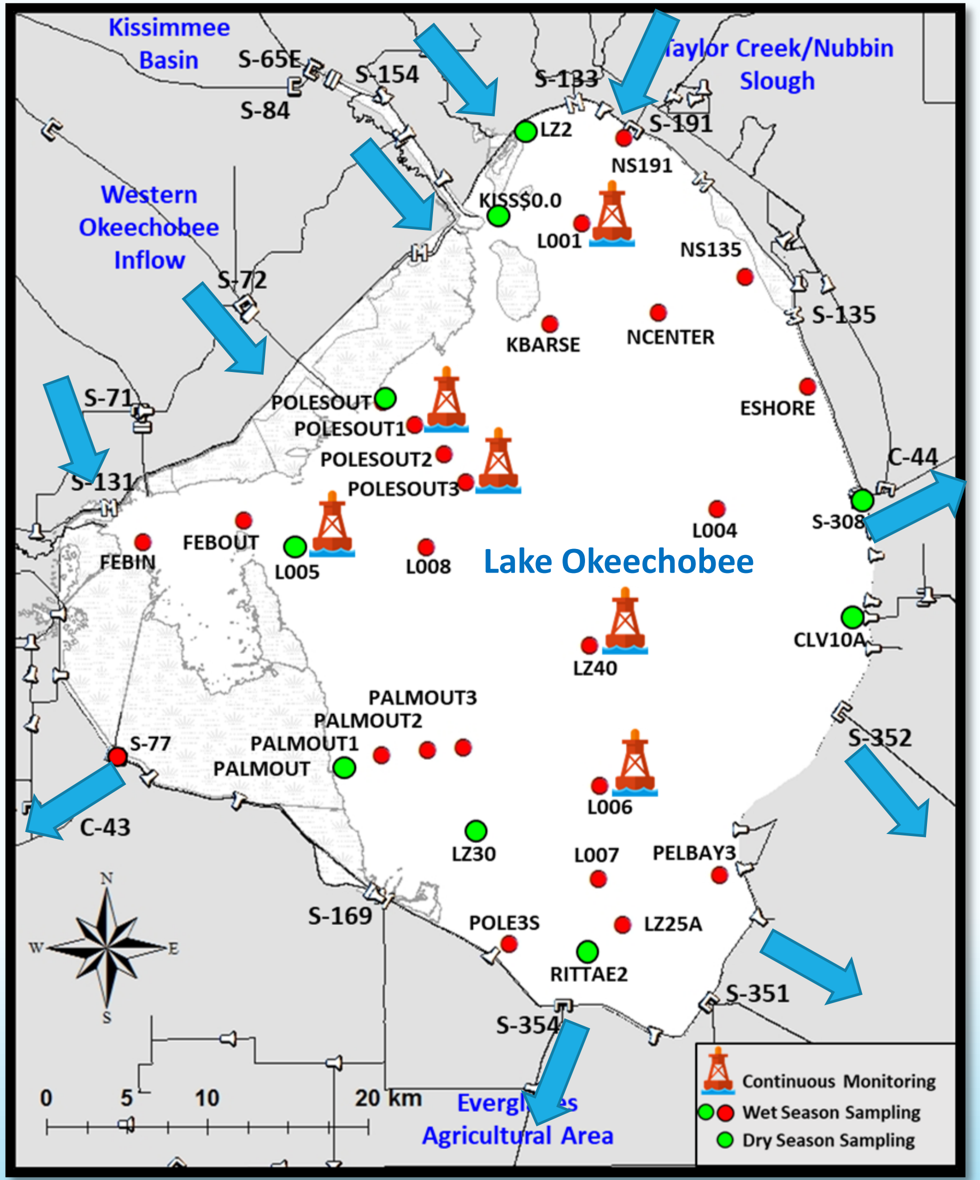
Balanced nutrient + sediment inputs = high water clarity = balanced phytoplankton and SAV growth = DO levels suitable for healthy fish and benthic communities



High nutrient + sediment loads = low water clarity = widespread HABs + SAV loss = low DO levels = fish and benthic community die-offs

How will HAB Dynamics Change in the LOSOM Era?

The Past is the Key to the Future – Long-Term Water Quality and Phytoplankton Monitoring



Why do we monitor?

- ❑ To detect current, ongoing, and emerging problems
- ❑ Determine-trends in water quality
- ❑ Provide a valuable foundation for developing predictive models
- ❑ Determine compliance with drinking water standards
- ❑ Measure effectiveness of water policies and restoration efforts

Where and how frequently do we monitor?

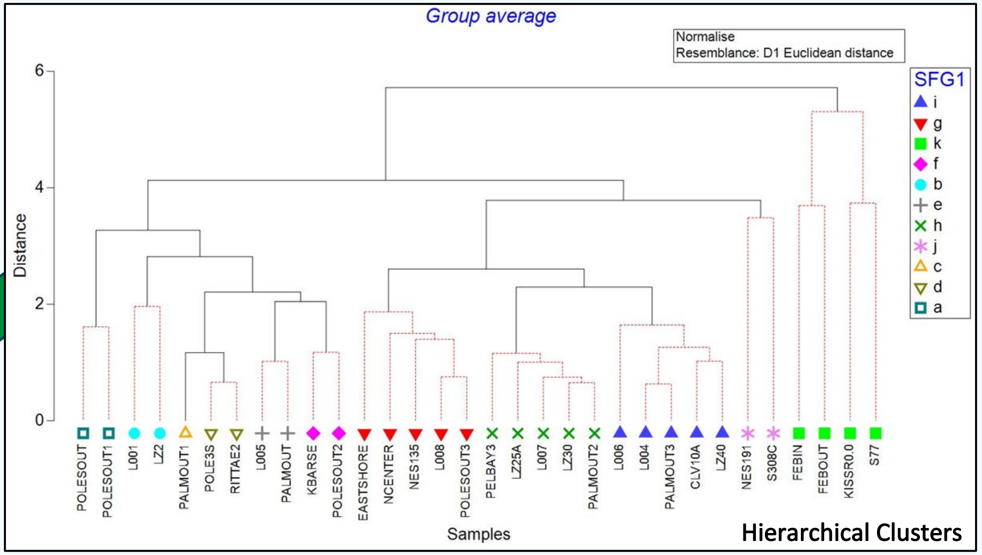
- ❑ 32 routine monitoring sites (19 original + 13 new) + 6 continuous
- ❑ Expanded monitoring since March 2020 (orig. sites POR since mid-1970s)
- ❑ Bi-monthly during wet season and monthly during dry season

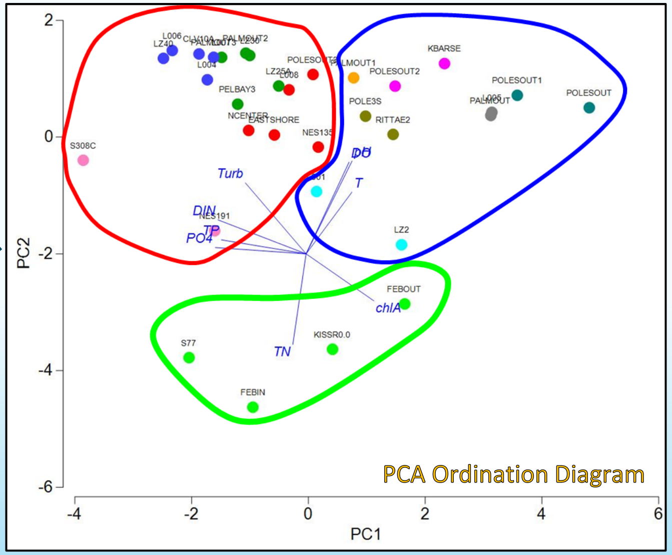
What do we monitor?

- ❑ Temperature, Turbidity, Color, TSS
- ❑ Total Depth; Secchi Depth
- ❑ Dissolved Oxygen, pH
- ❑ TN, NH4+, NO_X, TP, SRP, Si
- ❑ Chlorophyll *a* (phytoplankton biomass proxy)
- ❑ Toxins (microcystins, cylindrospermopsin, anatoxin-A, nodularin-R)
- ❑ Dominant phyto-taxa, and diatoms and soft algae counts

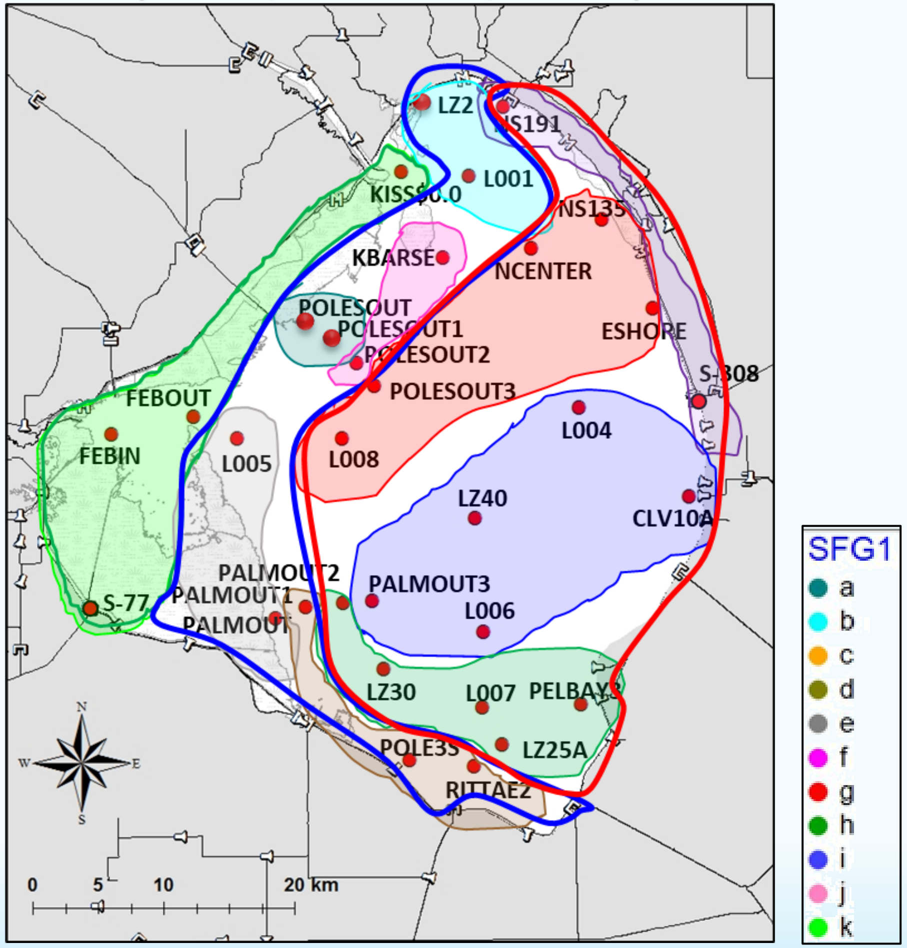
**pink color indicates new Lake O. monitoring network components*

Regional Water Quality Differences Drive Cyano-HAB Dynamics





Spatial Water Quality Differences (POR: 05/WY2020 – 12/WY2023)



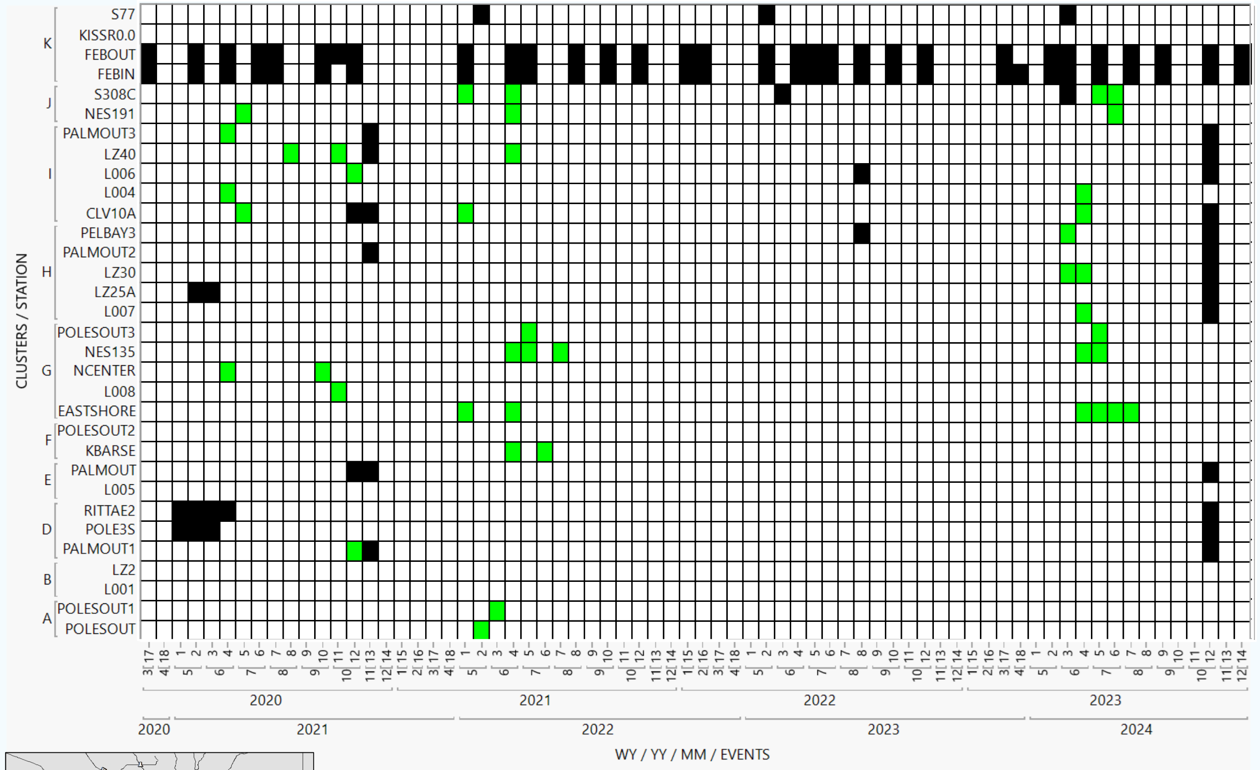
Major Zones

- Shallow Water Littoral
- Intermediate Depth Transitional
- Deepest Pelagic

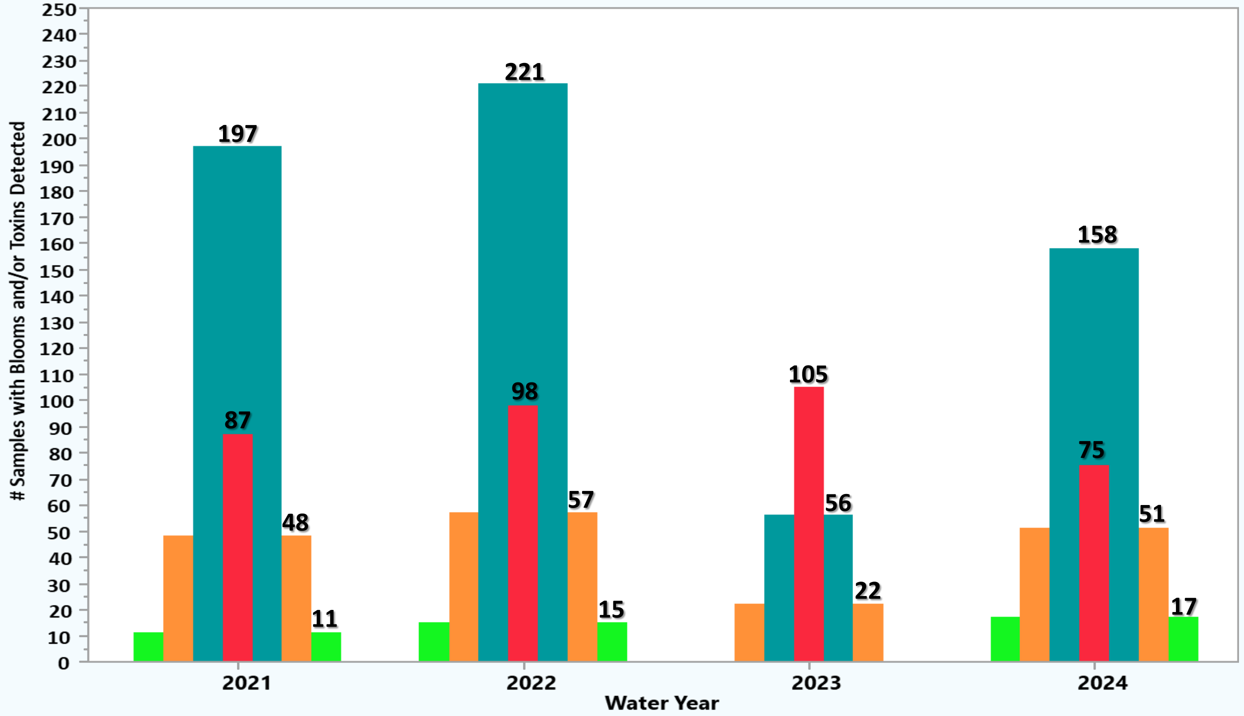
- ❑ Cluster analysis distinguished 9 site clusters and 3 major zones with distinct water quality conditions (PERMANOVA, $F = 8.31$, $p = 0.001$)
- ❑ Regional water quality differences drive HAB dynamics in the lake

Not All Cyano-Blooms Are Created Equal

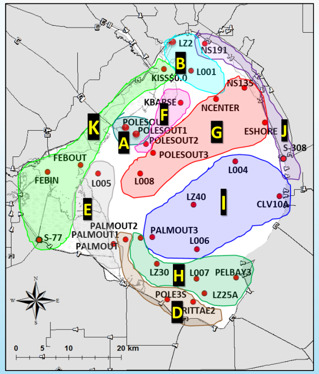
Spatiotemporal Differences



Annual Differences



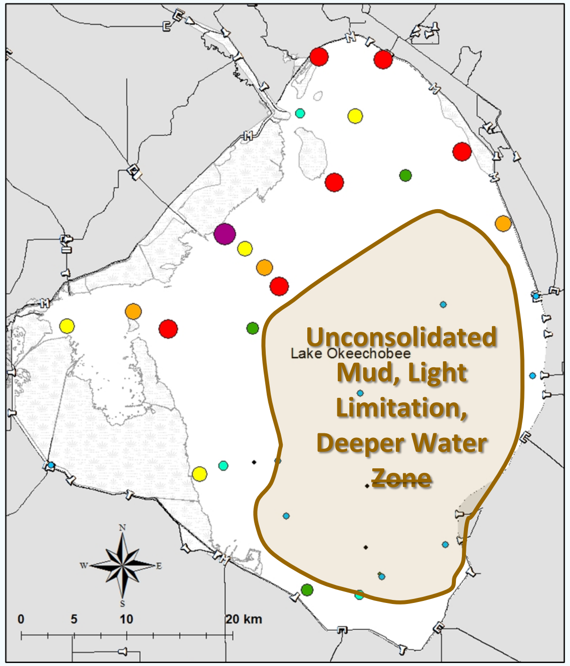
Blooms (chl a >40 µg/L)
Toxins (Tot. MC >MDL)
Blooms & Toxins (Tot. MC >MDL)
Blooms & Toxins (Tot. MC >8 µg/L (EPA Rec.))
Not Sampled



- Not all Cyano-Blooms are toxic (strain-dependent); MC-Toxins often detected at sites with NO blooms (bloom defined as chl *a* > 40 µg/L)
- Out of the 1621 samples collected since March 2020, where both MCs and chl *a* were measured, only 178 (~11%) indicated presence of toxic blooms and 43 (~3%) toxic blooms with MC >8 µg/L (EPA Rec.))
- Highest number of toxic blooms (MC > MDL) was detected in north-central and NW transitional zones (Cluster G, A and F, respectively) and toxic blooms with MC > 8 µg/L in central, central-north and NE zones (Clusters G, I, and J)

Not All Cyano-Blooms Are Created Equal

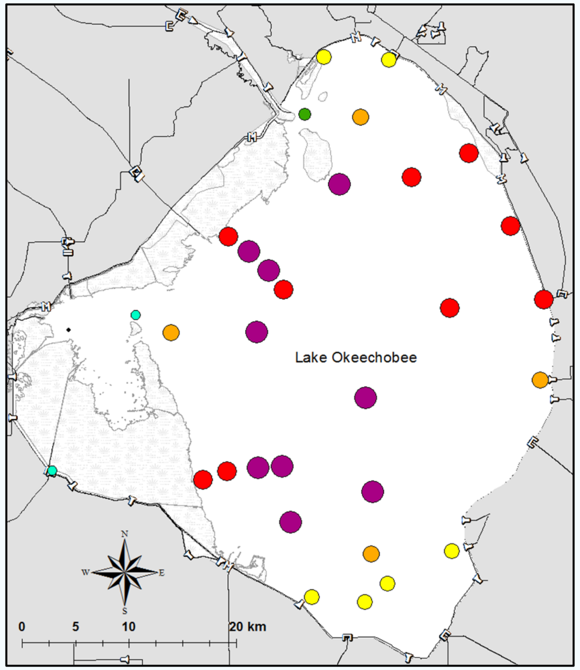
Spatial Differences in Bloom Detections (POR: 05/2020 – 12/2023)



 # Bloom Events

<= 2, > 2 - 5, > 5 - 9, > 9 - 11, > 11 - 13, > 13 - 18, > 18 - 26, > 26 - 32

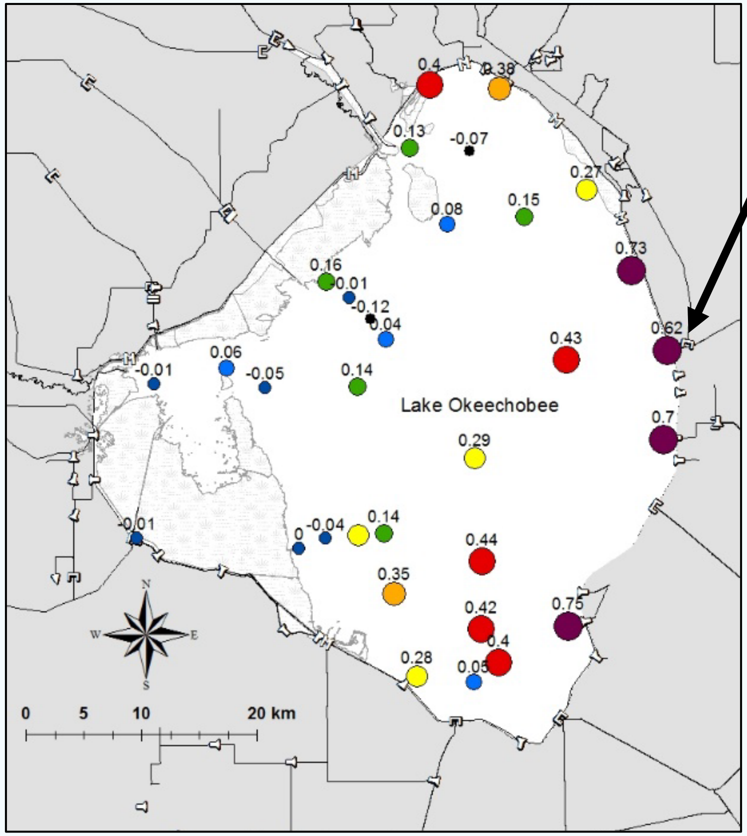
Spatial Differences in Toxin Detections (POR: 05/2020 – 12/2023)



 # Toxic Events

<= 2, > 2 - 6, > 6 - 10, > 10 - 12, > 12 - 16, > 16 - 20, > 20 - 24, > 24 - 31

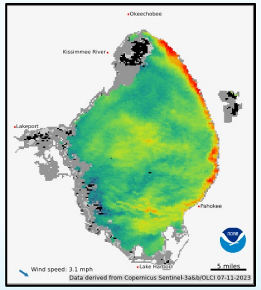
Pearson's Correlations chl *a* and Tot. Microcystins Toxins

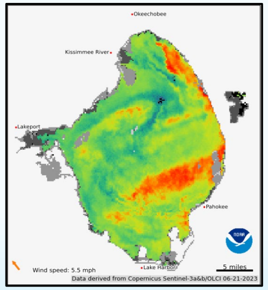


Correlation Coefficients (r)

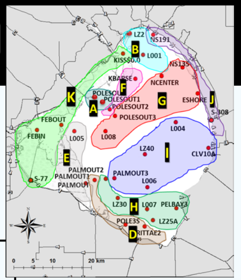
<= -0.07, > -0.07 – 0.00, > 0.00 – 0.08, > 0.08 – 0.16, > 0.16 – 0.29, > 0.29 – 0.38, > 0.38 – 0.44, > 0.44

June/July 2023 BGA Accumulation Along the East Coast



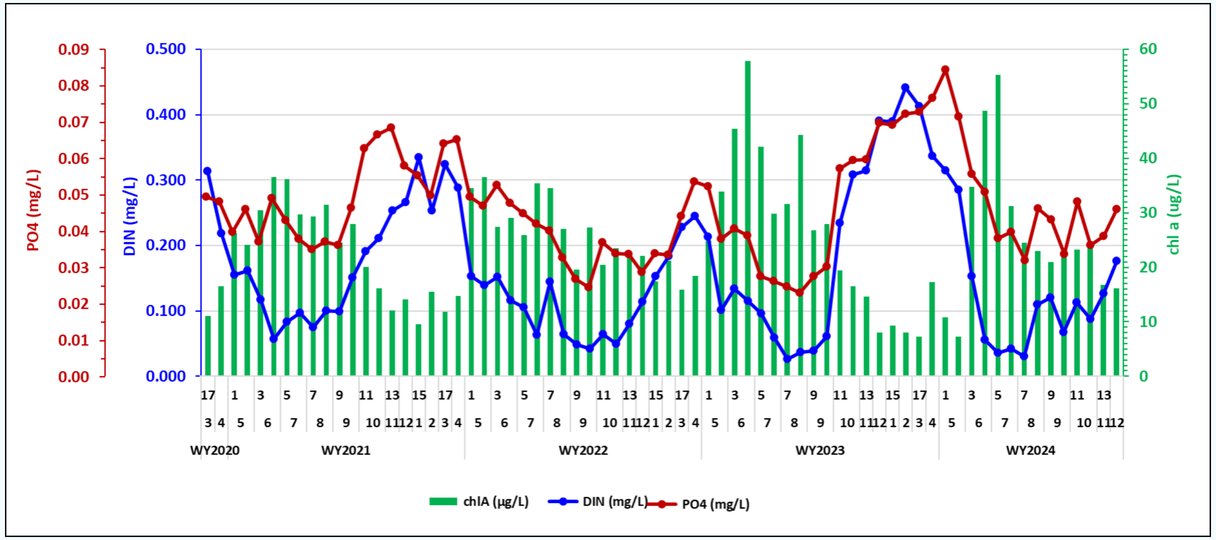


- ❑ Blooms less frequently detected in central-south region, while toxins detected at all sites with most common detections in western and central-south regions
- ❑ Highest toxicity associated with biomass accumulations along the east shore driven by winds, currents, and the lake circulation



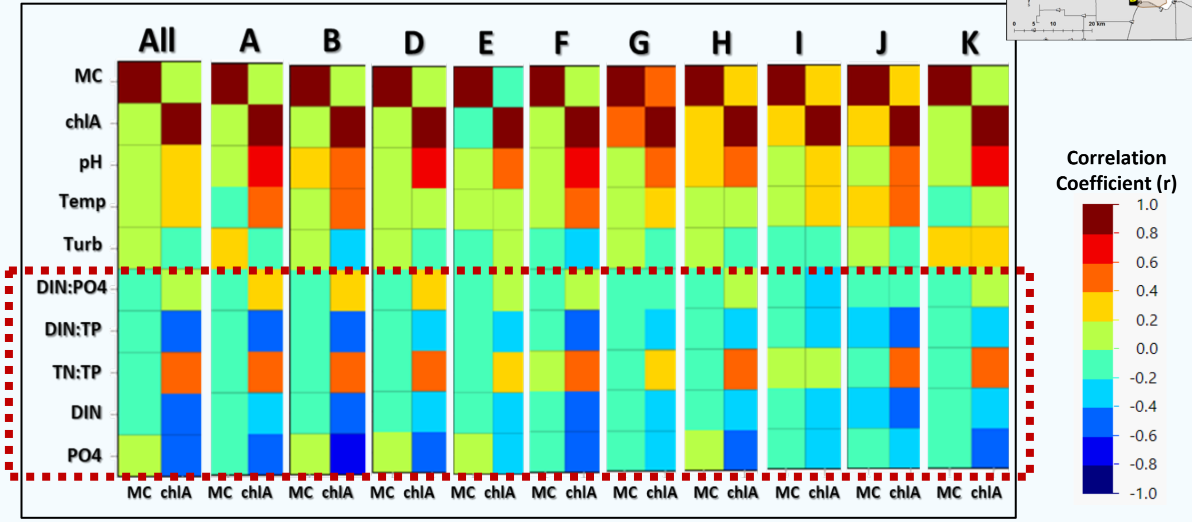
Role of Nutrients in Bloom and Toxicity Dynamics

Temporal Changes in Chlorophyll *a* vs. Inorganic Nutrients



- DIN limitation in the summer due to high uptake by cyanos and algae, and denitrification; SRP & TP abundant in the system
- Strength of correlation between inorg. nutrients and chl *a* vary by region (max. DIN vs. chlA r=-0.60 in J-Cluster and SRP vs. chlA r=-0.63 in B-Cluster)
- Weak negative correlations between MC toxins and DIN imply that other factors may affecting toxin production in the lake
- The molecular make-up of microcystins toxins (produced by *M. aeruginosa*) are nitrogen-rich; high DIN needed for production

Regional Differences in Pearson's Correlations



Partial least-squares (PLS) regression

X	VIP
T	0.7951
TN	1.4879
TP (mg/L)	0.8941
PO4_MG_L	1.2127
Turb (NTU)	0.7498
Secc (m)	0.7373
Depth (m)	0.4870
DIN (mg/L)	1.2415

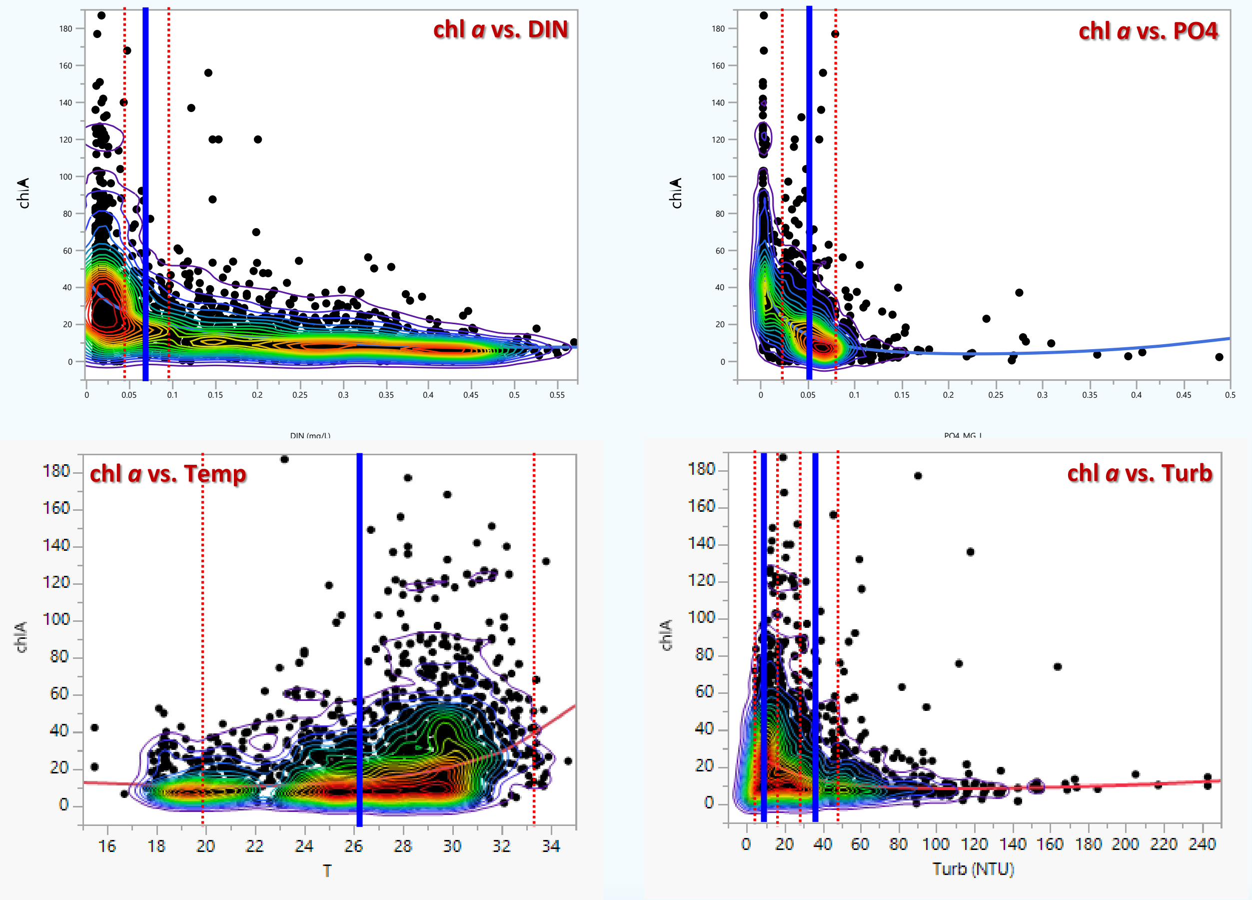
VIP = Variable Importance in Projection

- About 58% ($R^2 = 0.58$) of variance in chl *a* data can be explained by 8 WQ variables, which TN, DIN and PO4 explaining most of that variance

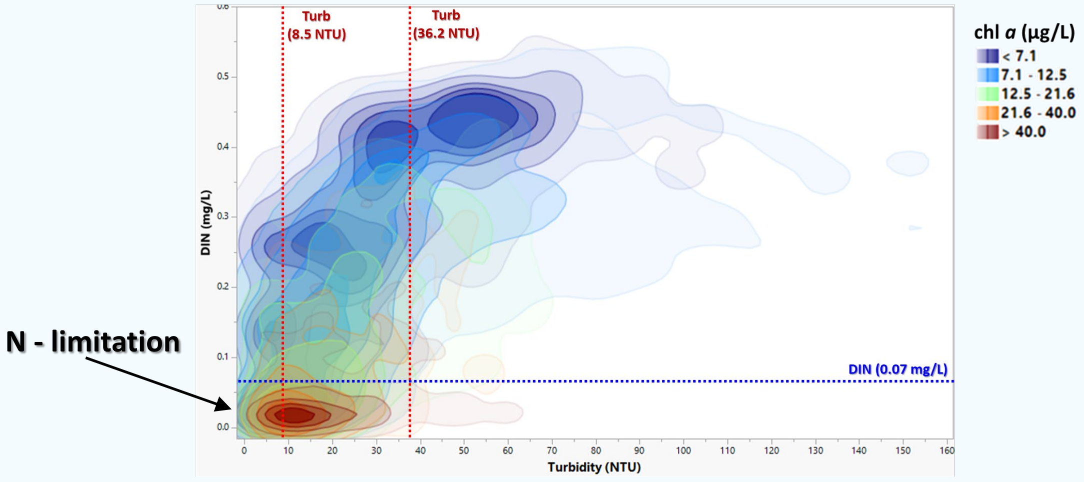
Presenter: Anna Wachnicka

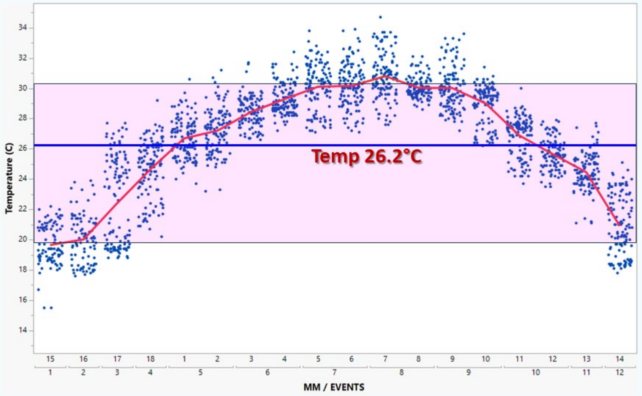
Estimated Optimal Conditions for Cyano-HAB Formation

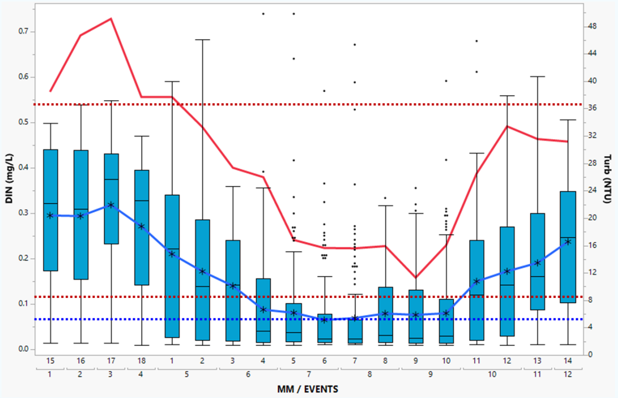
Estimated Breakpoints



change point   97.5% confidence intervals of the estimate







- ❑ Piecewise linear regression estimated DIN (0.07 mg/L), PO4 (0.05 mg/L), Temperature (26.2 °C) and Turbidity (8.5 NTU and 36.2 NTU) breakpoints define optimal conditions for cyano-HAB formation in the lake
- ❑ Temperature is conducive to cyano-HAB formation in the lake between April and November; cyano growth can be inhibited by N-limitation and/or high turbidity associated with storms during summer

Conclusions

- Potential increases in high stage frequency and duration may lead to increases in nutrient concentrations (due to possible vegetation loses resulting in lower nutrient uptake) in the littoral zone and consequently more frequent blooms in that zone.
- However, potential increases in turbidity (due to vegetation loses) may adversely affect formation of blooms, potentially causing shorter, more intense bloom events, vs. prolonged, moderate bloom conditions.
- Additional data mining, modeling and experimental work is needed to better understand the possible consequences of higher stages' frequency and duration on HAB formation in the littoral zone, and toxin production triggers.

Thank You!

Questions?