



UMN stormwater pond research update (part II)

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Erin Mittag & Winnie Winikoff- nitrogen research

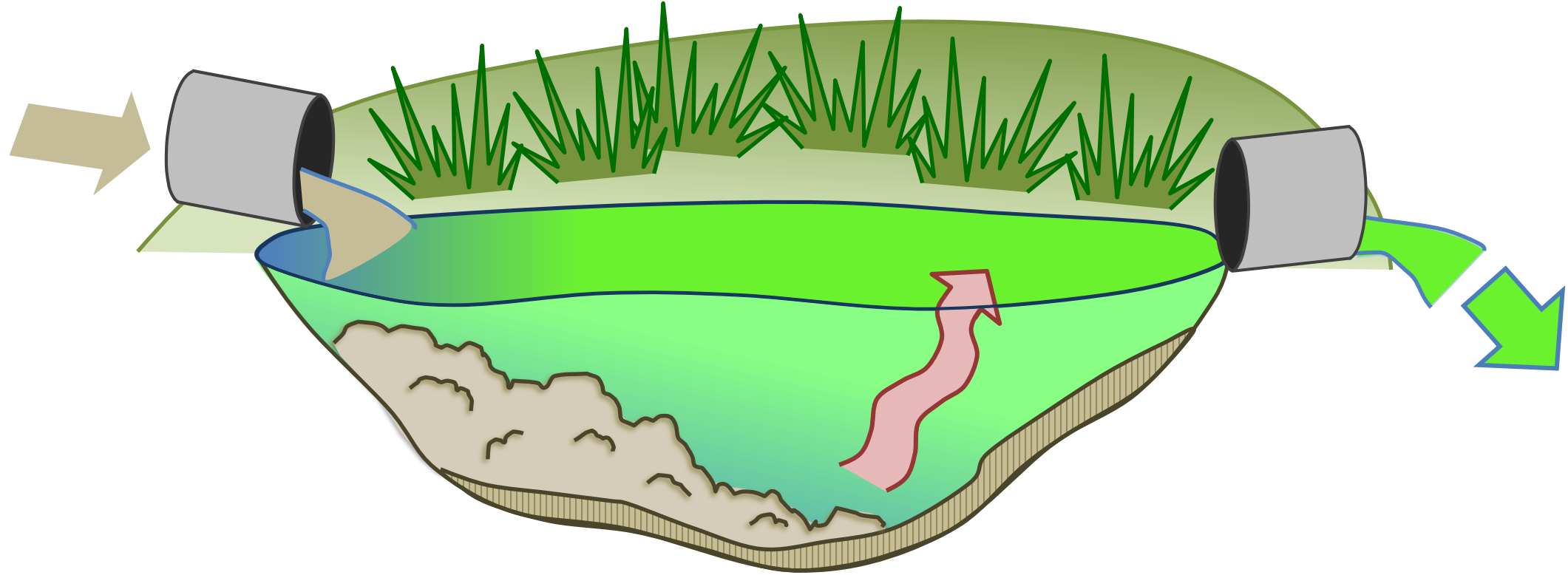


UNIVERSITY OF MINNESOTA
Driven to DiscoverSM

Why are ponds releasing phosphorus?

Hypothesis: Excessive Watershed Loading

Land cover or time lead to sediment release

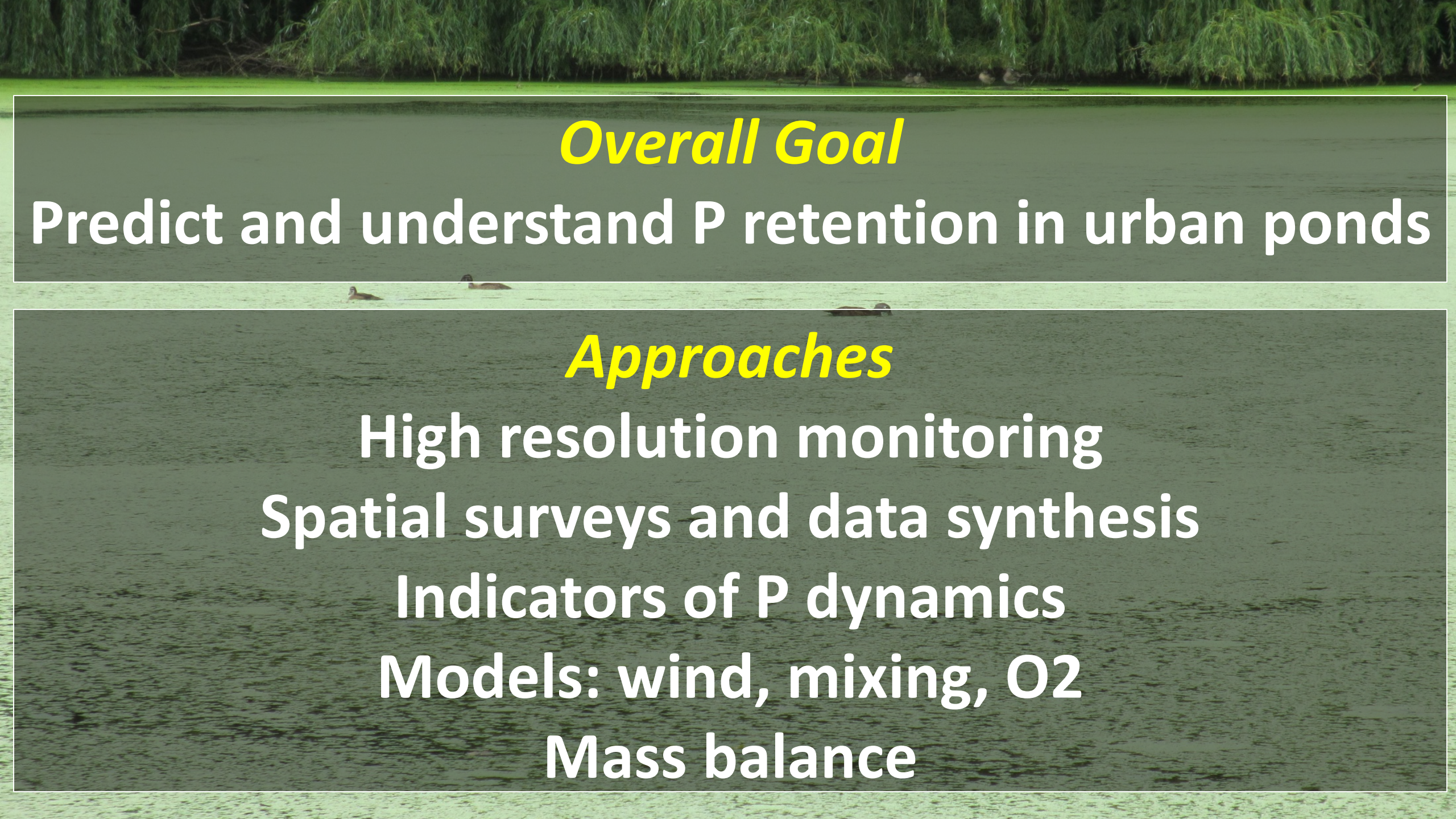


Hypothesis: Internal Processes

Variation in pond features leads to sedimentary phosphorus release

**Sampling 2016-2020
And data compilation**



The background of the slide is a photograph of a pond. In the foreground, there are several ducks swimming in the water. The water is dark and reflects the surrounding environment. In the background, there is a dense line of green willow trees with long, drooping branches. The overall scene is a natural, outdoor setting.

Overall Goal

Predict and understand P retention in urban ponds

Approaches

High resolution monitoring

Spatial surveys and data synthesis

Indicators of P dynamics

Models: wind, mixing, O₂

Mass balance

Key findings

1. **Ponds are persistently stratified** (chemically, thermally)

- Many strongly stratified for open water period
- Stratification driven by:
 - **Salt**, esp. winter → spring
 - **Temperature**, despite shallow depth due to wind sheltering
- As a result, many do not mix during the summer

Analyses of pond mixing and stratification

Roseville / SW Metro, 2019 & 2020

Goal: Development of simplified monitoring approaches and data analysis techniques to predict degradation of P retention

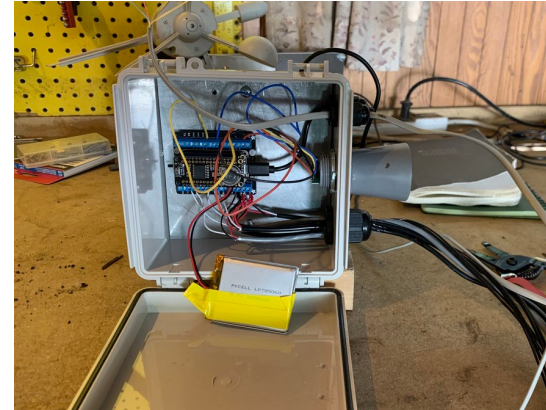
Pond Monitoring Stations (<\$500/each)

- Wind Speed ~5-6 ft height
- Temperature profile time series
- Water Level time series
- 10- or 15-minute resolution

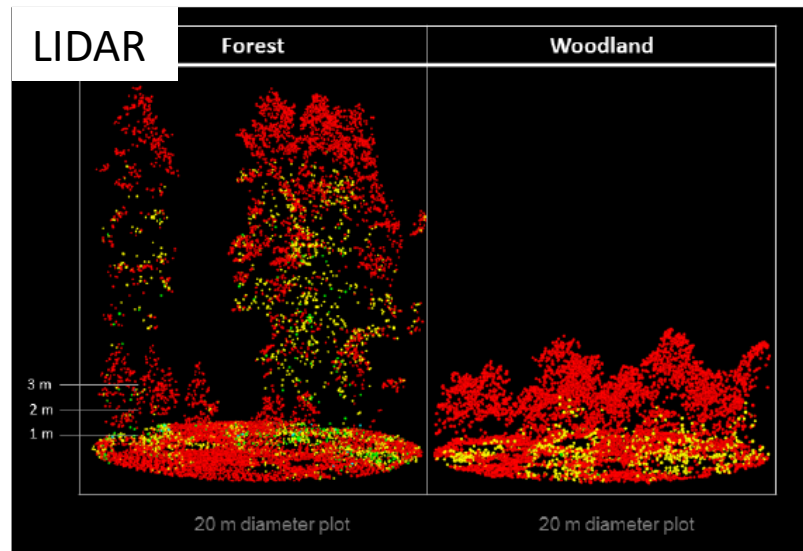
Manual Profiles every 2-3 weeks of Temp, DO, Cond + Grab Samples for Nutrients

17 Stations installed during summer 2019

- 2 stations lost during storms
- 1 station with unusable data
- 14 stations' data currently analyzed

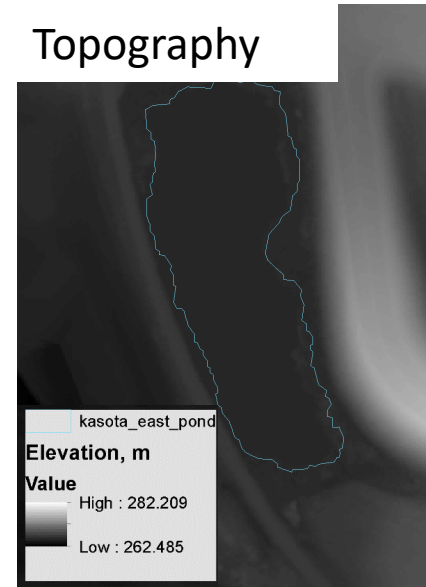


Assessing Wind Sheltering / Canopy

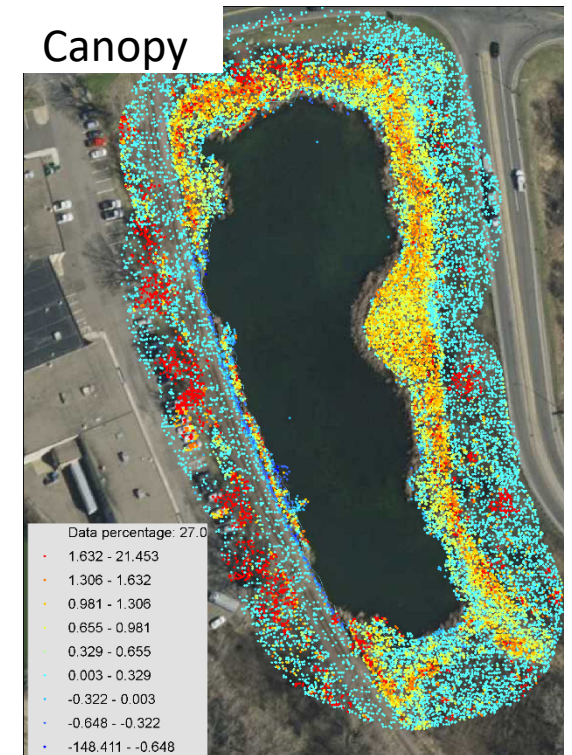


US Forest Service, 2014 (K. McCallum, M. Beaty, and B. Mitchell)

Topography



Canopy

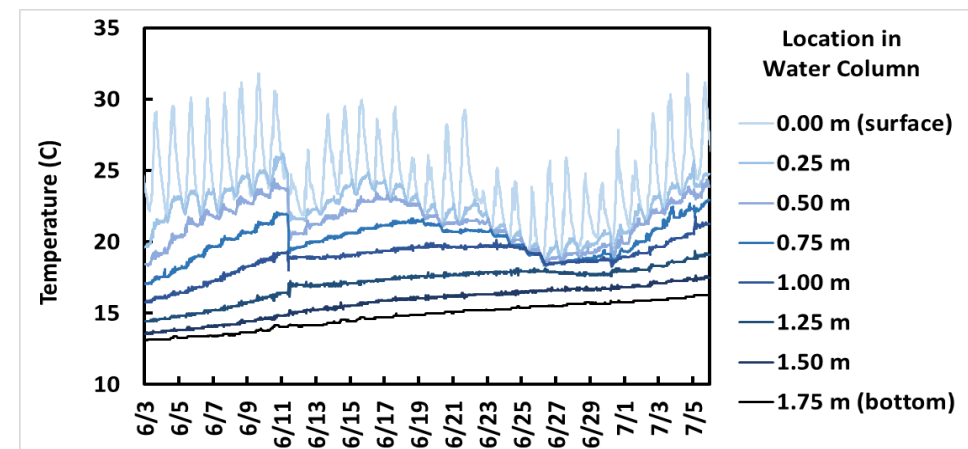


Assessing Stratification: Relative Thermal Resistance to Mixing (RTRM)

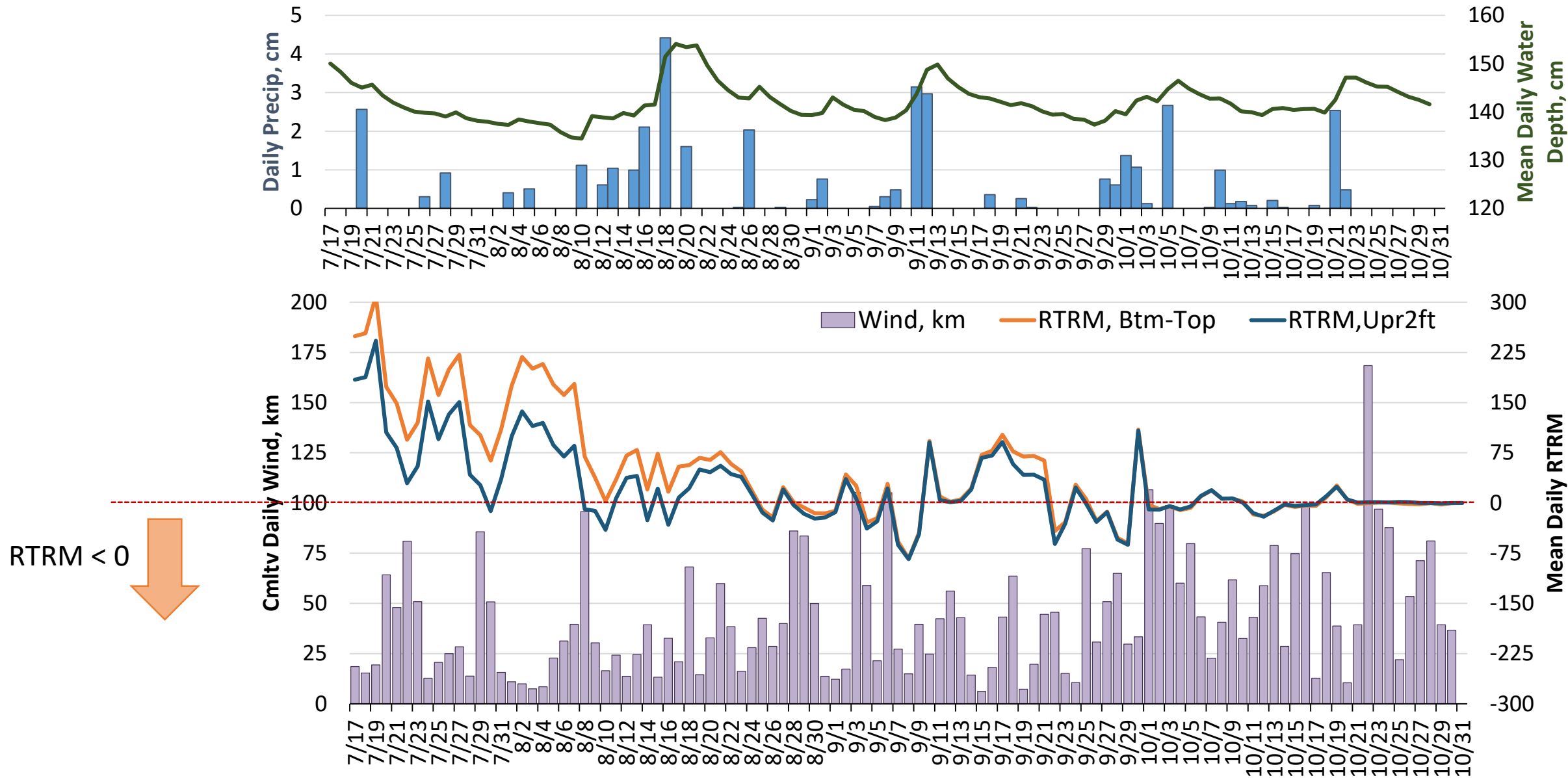
Relative Thermal Resistance to Mixing (RTRM):

Strength of Stratification (Stable for $RTRM > 0$)
between “layers” (points) i and j in **temperature profile**

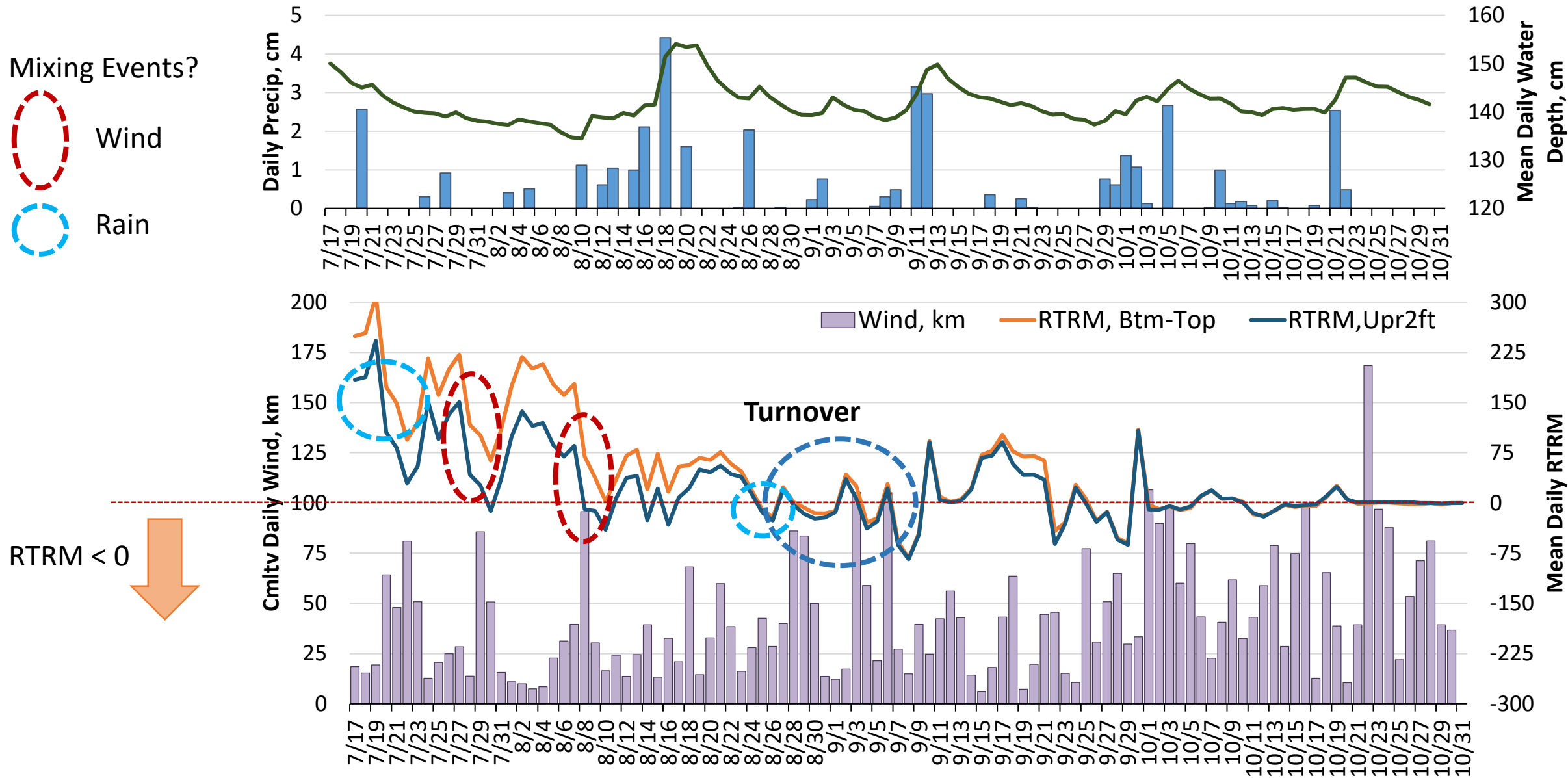
$$RTRM = \frac{\rho_i - \rho_j}{\rho_{T=4C} - \rho_{T=5C}}$$



Mixing Event Screening (daily mean quantities)



Mixing Event Screening (daily mean quantities)



Key findings

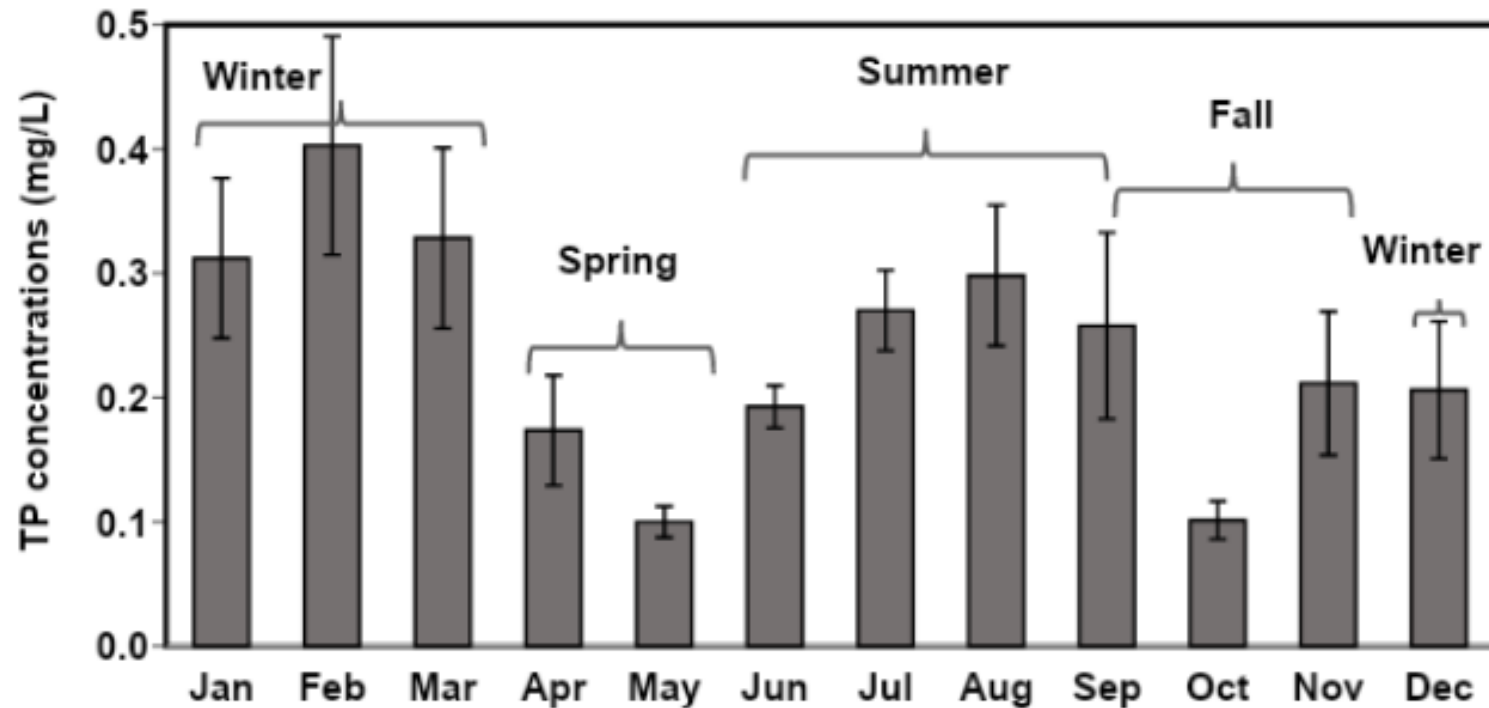


2. Oxygen regulates water column TP

- Oxygen is more scarce and variable than expected
- Seasonal and spatial variation O_2 drives variation in P

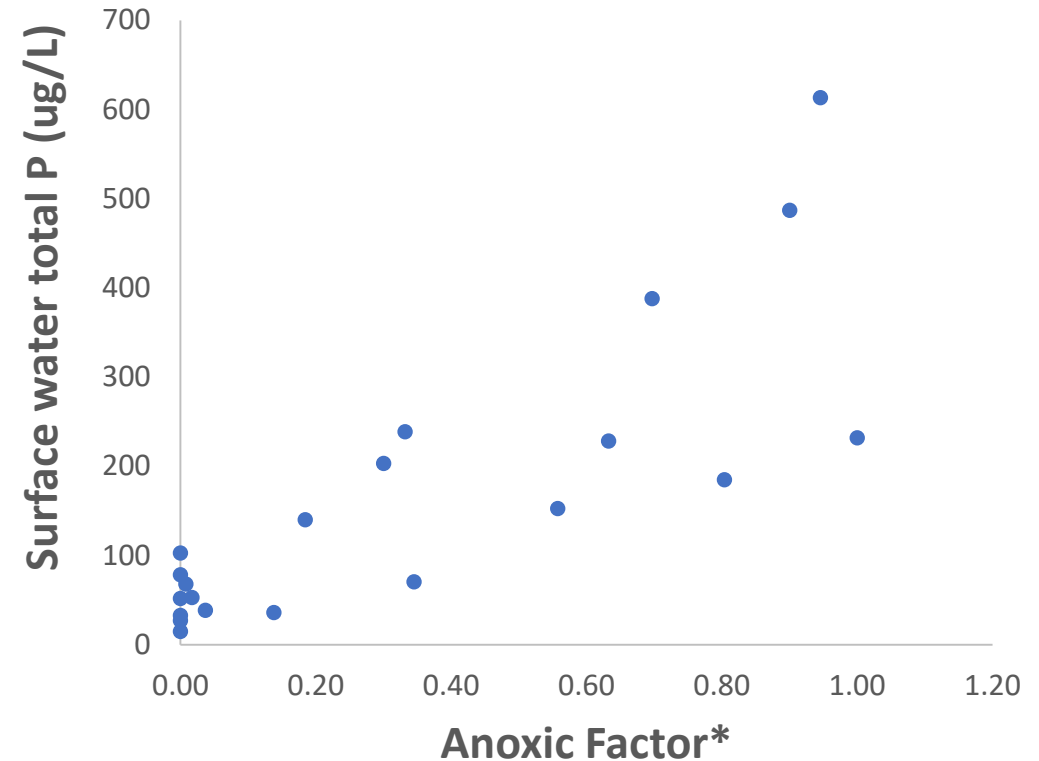
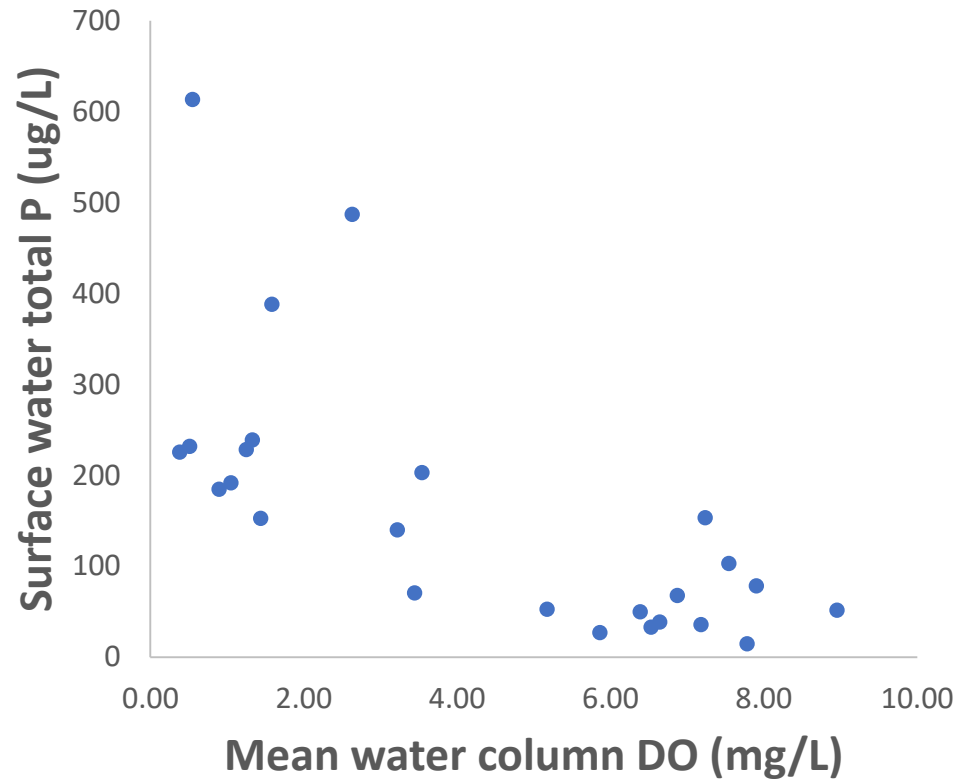
Data compilation: 1998-2019 Metro ponds

Winter and summer peaks correspond to low oxygen conditions



No. of sites	8	8	9	11	26	59	59	59	30	20	9	8
No. of measurements	44	37	45	78	133	439	466	460	159	92	38	33

Oxygen and surface water TP: examples



Note: these data are from 2020. Data from 2019 were Considerably more variable, perhaps due to heavy rainfall

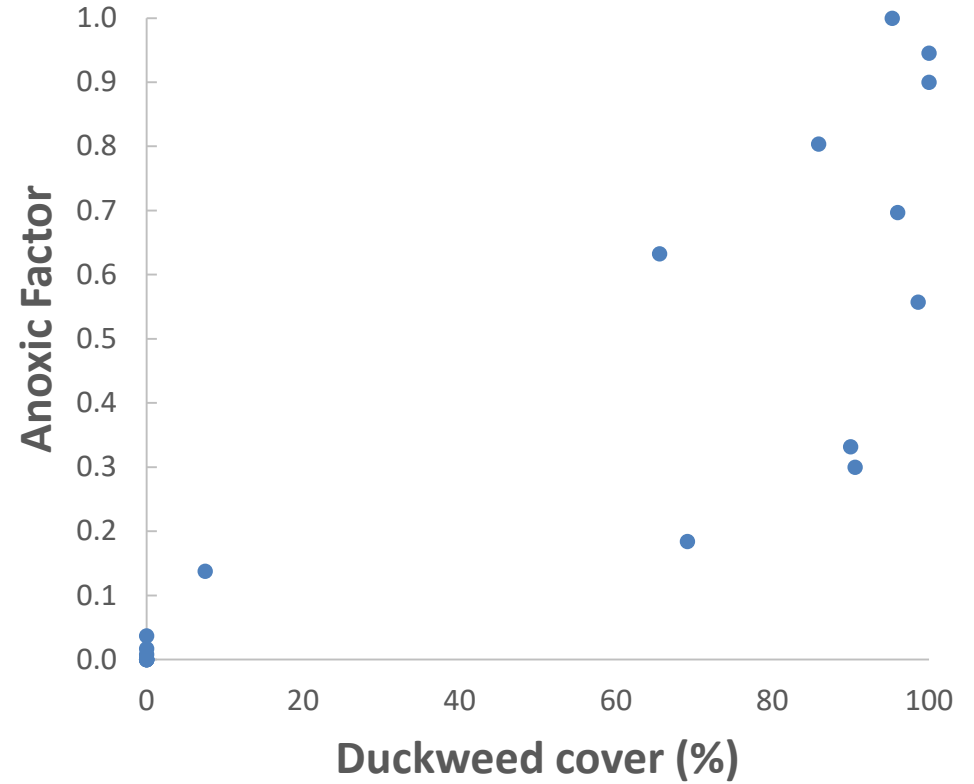
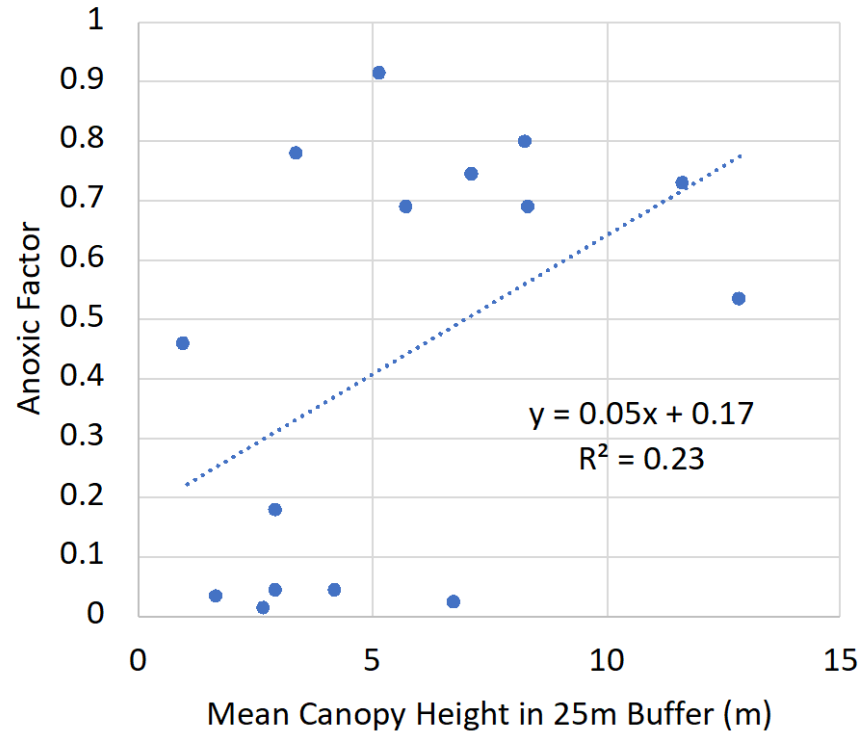
*modified from Nurnberg

Key findings

3. Oxygen status determined by interacting factors

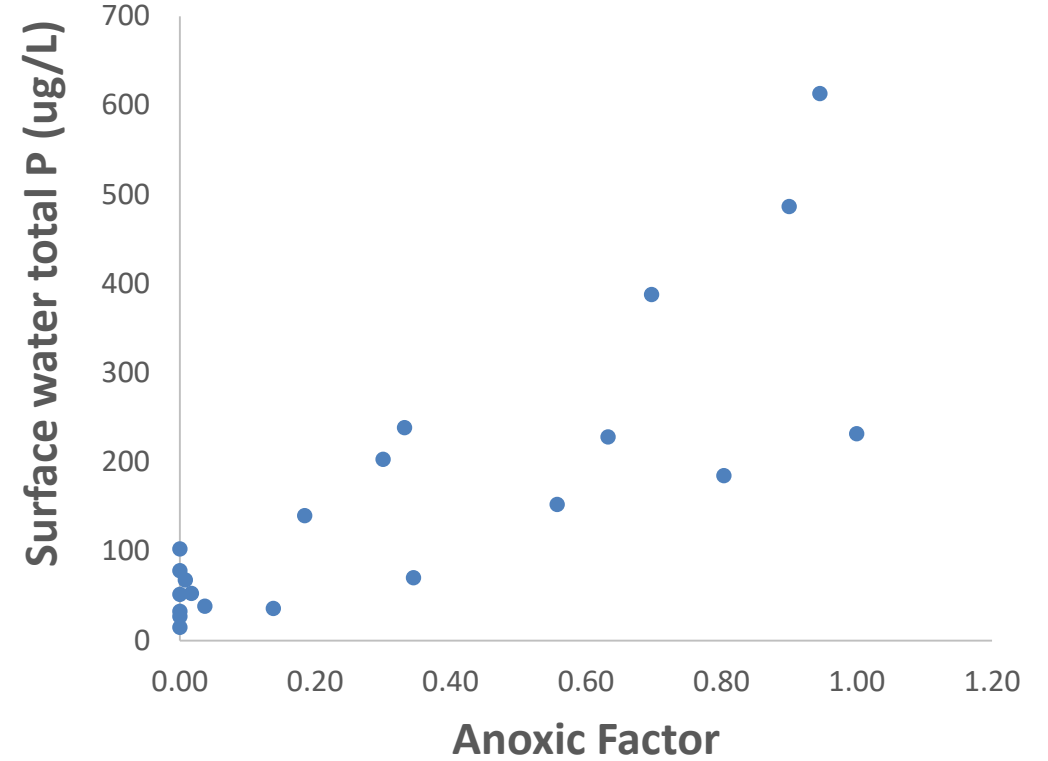
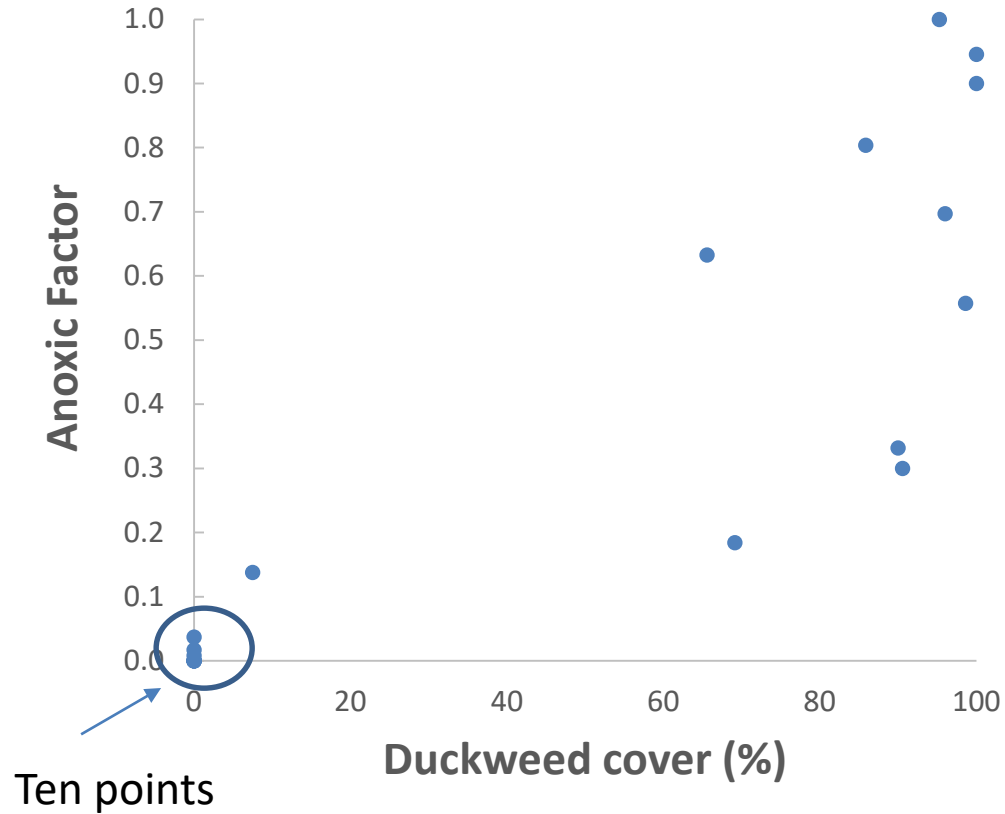
- **Duckweed** (floating plants), cutting off O_2
- **Trees**, via wind sheltering
- **Depth & salt**, leading to mixing resistance

Trees and weeds



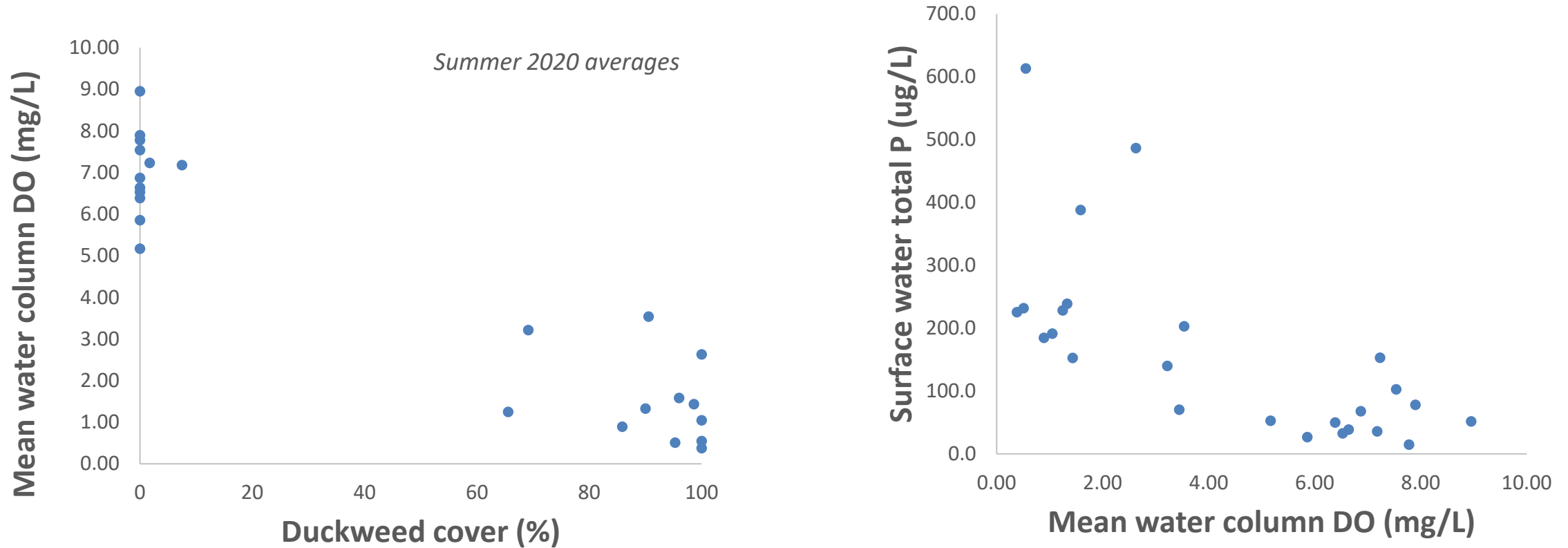
Duckweed, DO and phosphorus

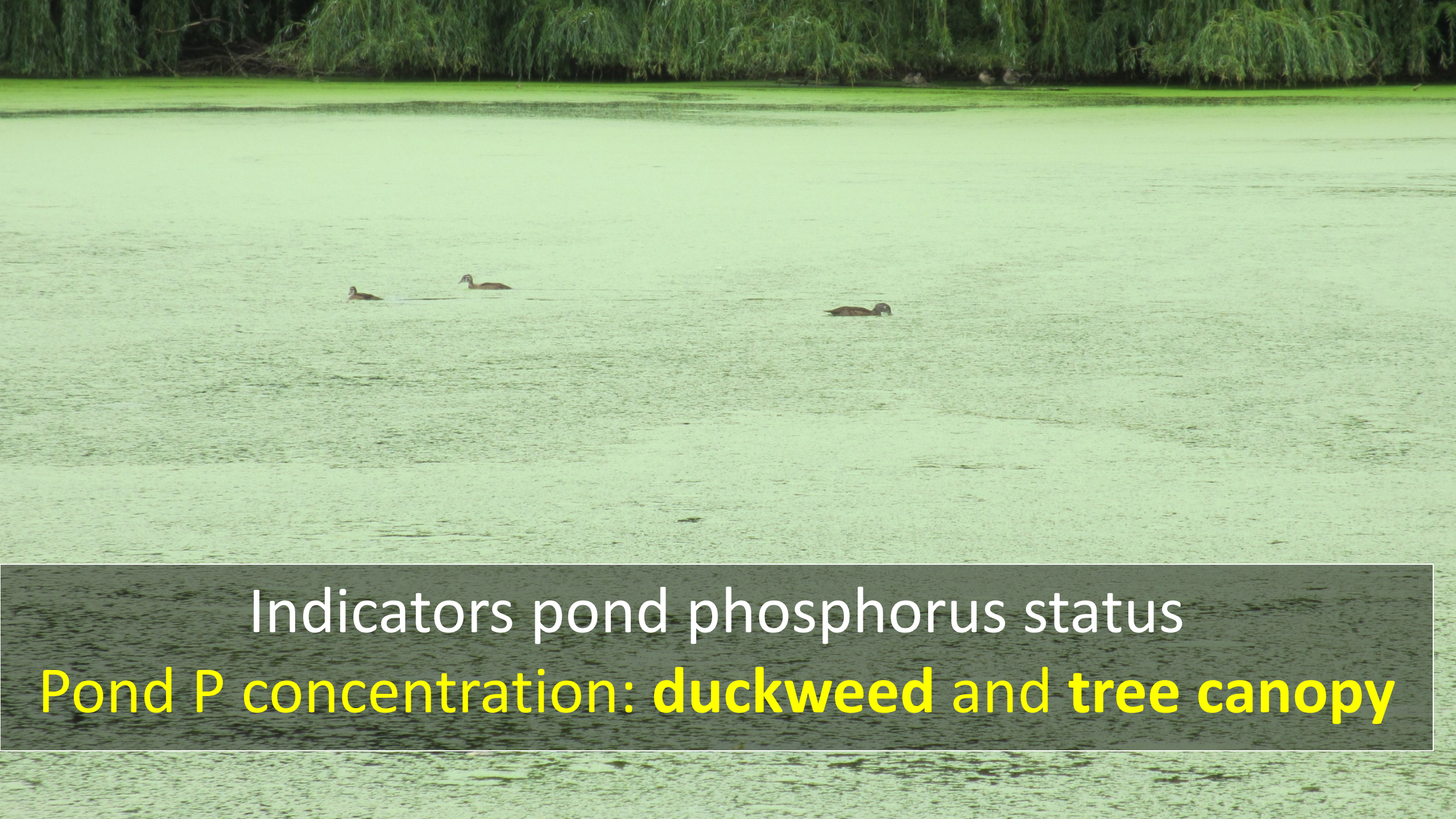
modified anoxic factor



Duckweed, DO and phosphorus

mean water column DO

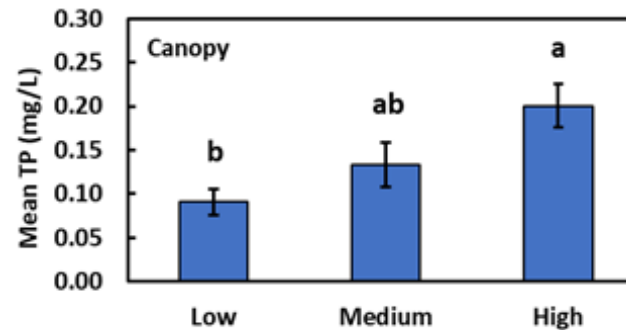
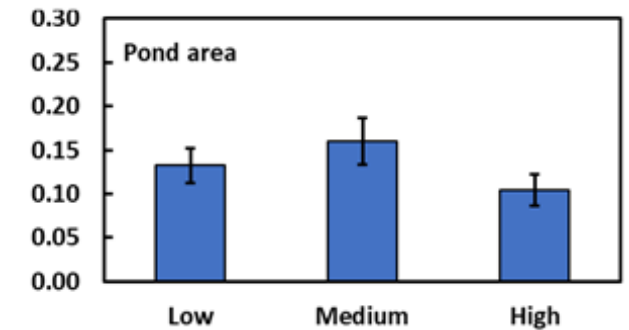
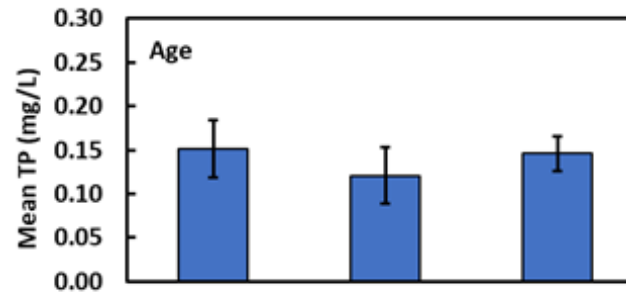
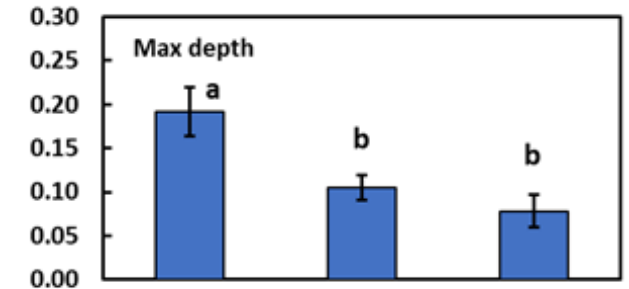
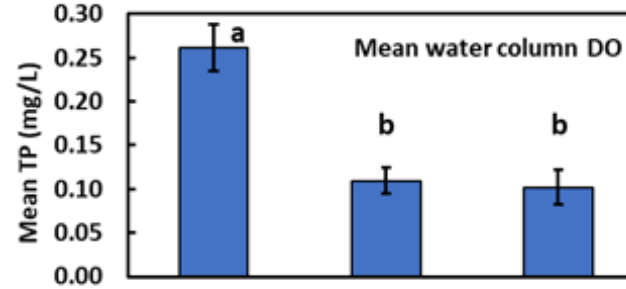
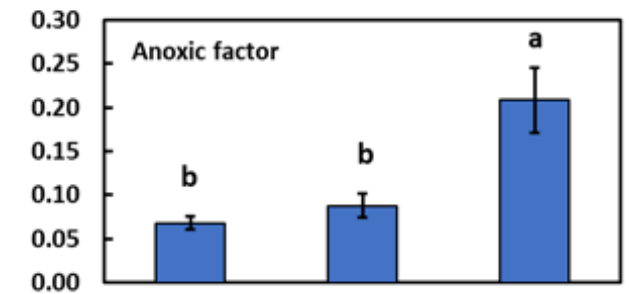
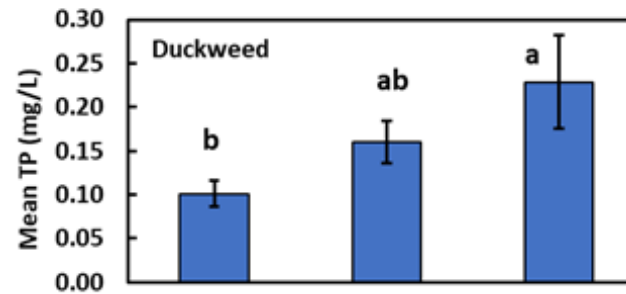




Indicators pond phosphorus status

Pond P concentration: **duckweed and tree canopy**

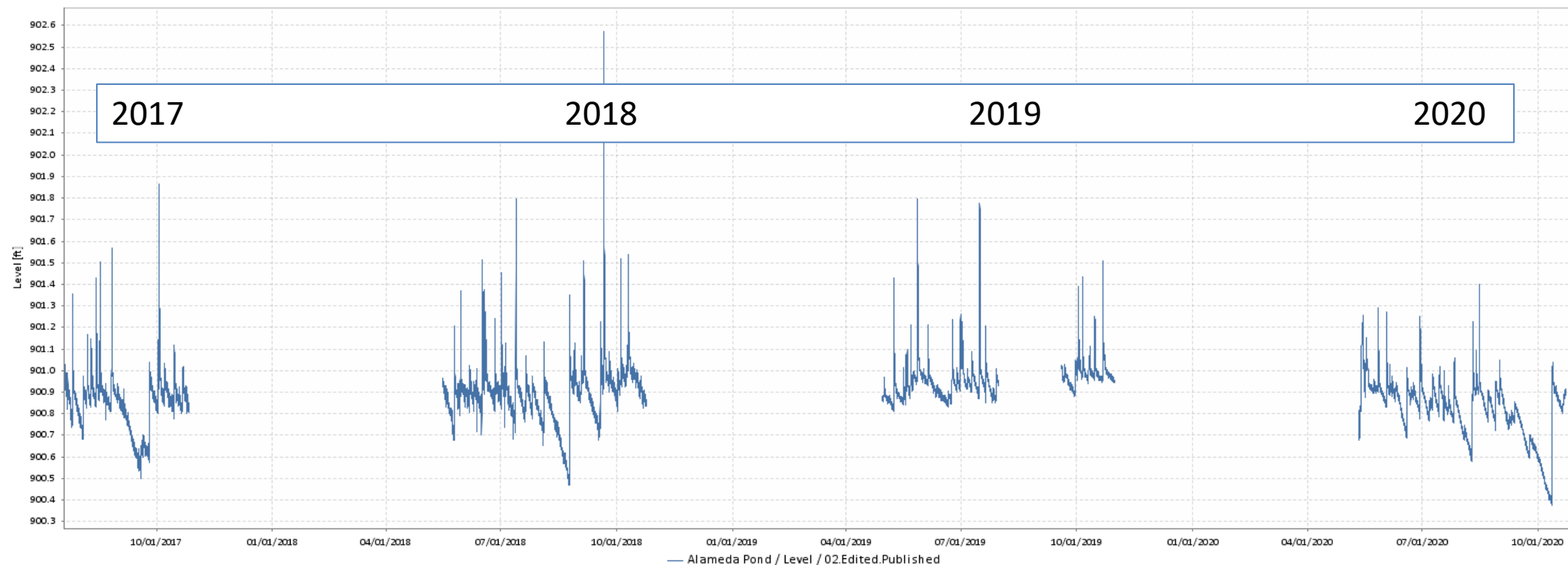
Indicators of P concentration work in progress!



Indicators pond phosphorus retention

Work in progress

Estimating pond water balance from **water level data**



Generated at: 01/06/2021 02:55

Alameda Pond, Roseville. Data: Capitol Region Watershed District

2020 Results (summer)

Pond Name	Water retention (Outflow / Inflow (%))
Shoreview Commons	98
Minnetonka 849 W	34
Chanhassen	91
Cle. - Roselawn	5
Alameda	75
Langton	9
35E- Larp.	9

Thanks!



Photo: Bell Museum