

Agenda

- Overview of Tri-Lakes Nanobubble Oxygenation Project
- 2024-2025 study data
 - Moleaer's conclusions
 - Dissolved oxygen results
 - Total Phosphorus results
- Results from another phased nanobubble treatment project
- Next steps
 - Recommended treatment
 - Recommended monitoring
- Conclusions

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Introduction



- MSc and PhD in Limnology
- Expertise: Water quality
(nutrients and microbes)



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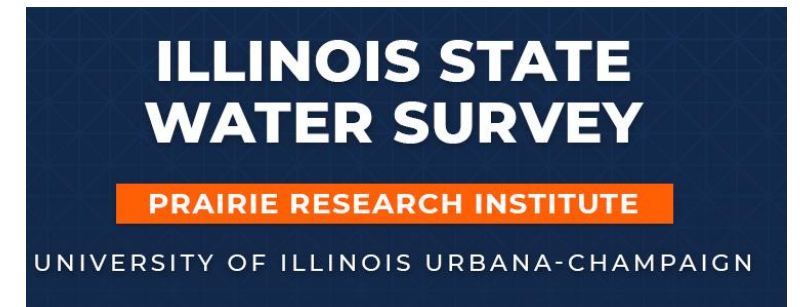
Dr. Denise Devotta
Senior Limnologist

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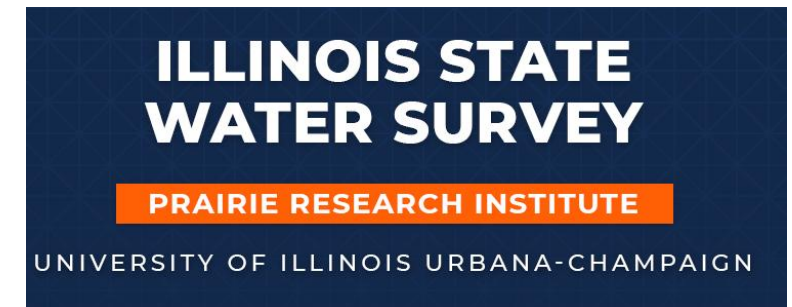


Introduction



Dr. Denise Devotta
Senior Limnologist

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(nutrients and microbes)
- 22 years of experience



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Overview of Tri-Lakes Management District Nanobubble Oxygenation Project

- Goals:
 - (1) Make your lake usable and safe to recreate in
 - (2) Protect lifestyle and increase property values
- How will this be measured?
 - (1) Continuous water quality data from sensors
 - (2) Grab samples of water for water chemistry and biological analyses



Overview of Tri-Lakes Management District Nanobubble Oxygenation Project

- **Full Rx: 10,000 lbs/day**
 - **5 container units + 80 small units**
- 2025: 1,740 lbs/day (17% of full Rx)
 - 1 container unit + 10 small units
- 2026: 1,920 lbs/day (19% of full Rx)
 - 1 container unit + 20 small units
- 2027: 2,580 lbs/day (25% of full Rx)
 - 1 container unit + 30 small units





Shane Hoyt

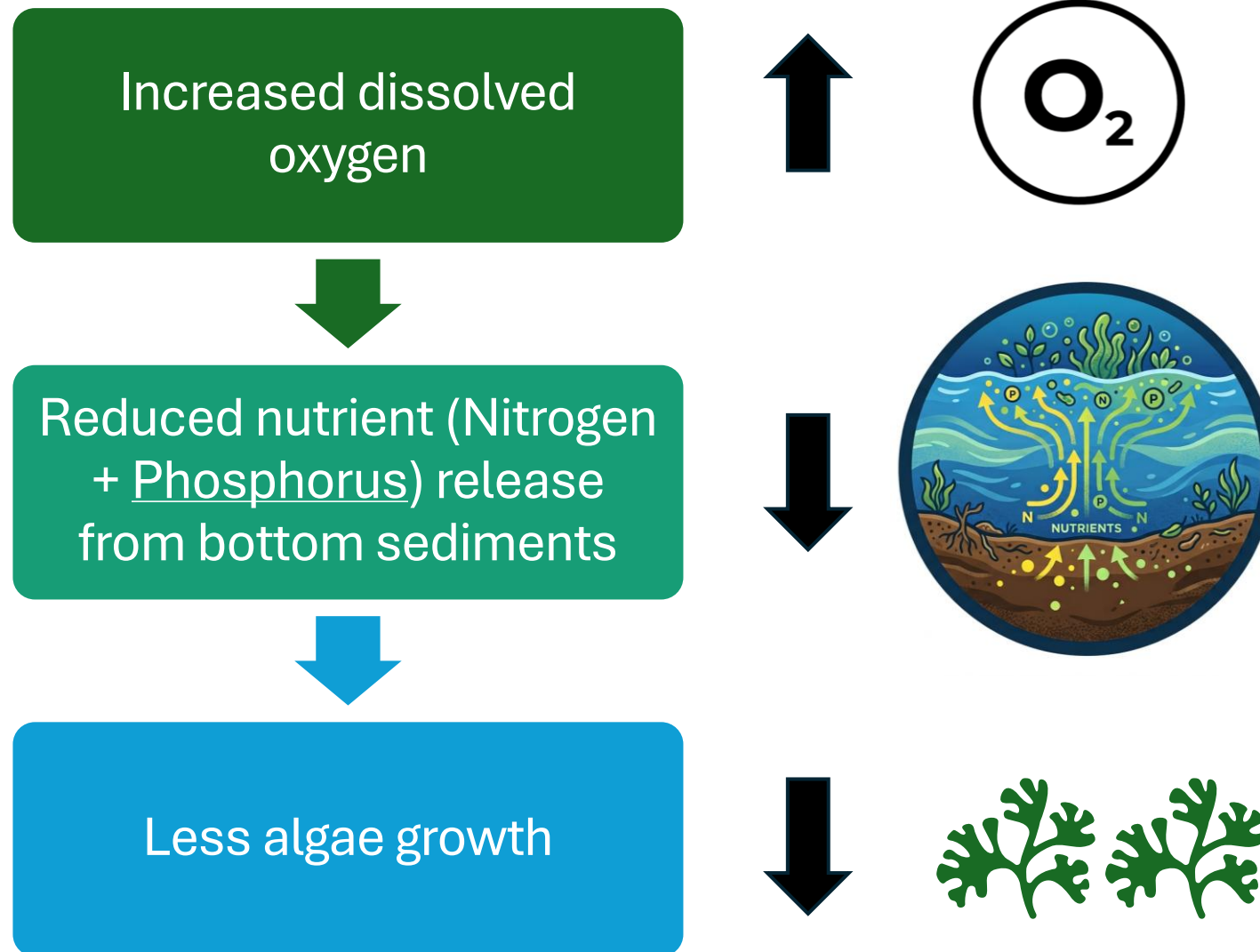
Limnologist, Application
Development

Agenda

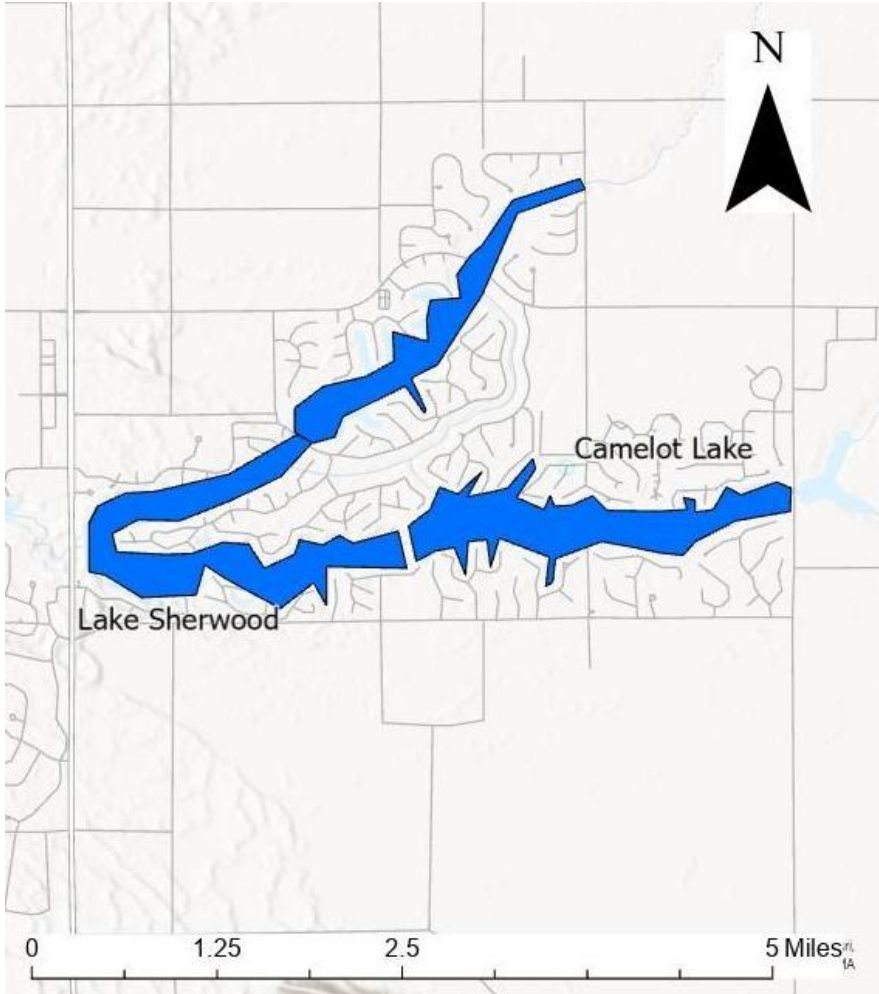
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Dissolved Oxygen, Total Phosphorus, and Algae

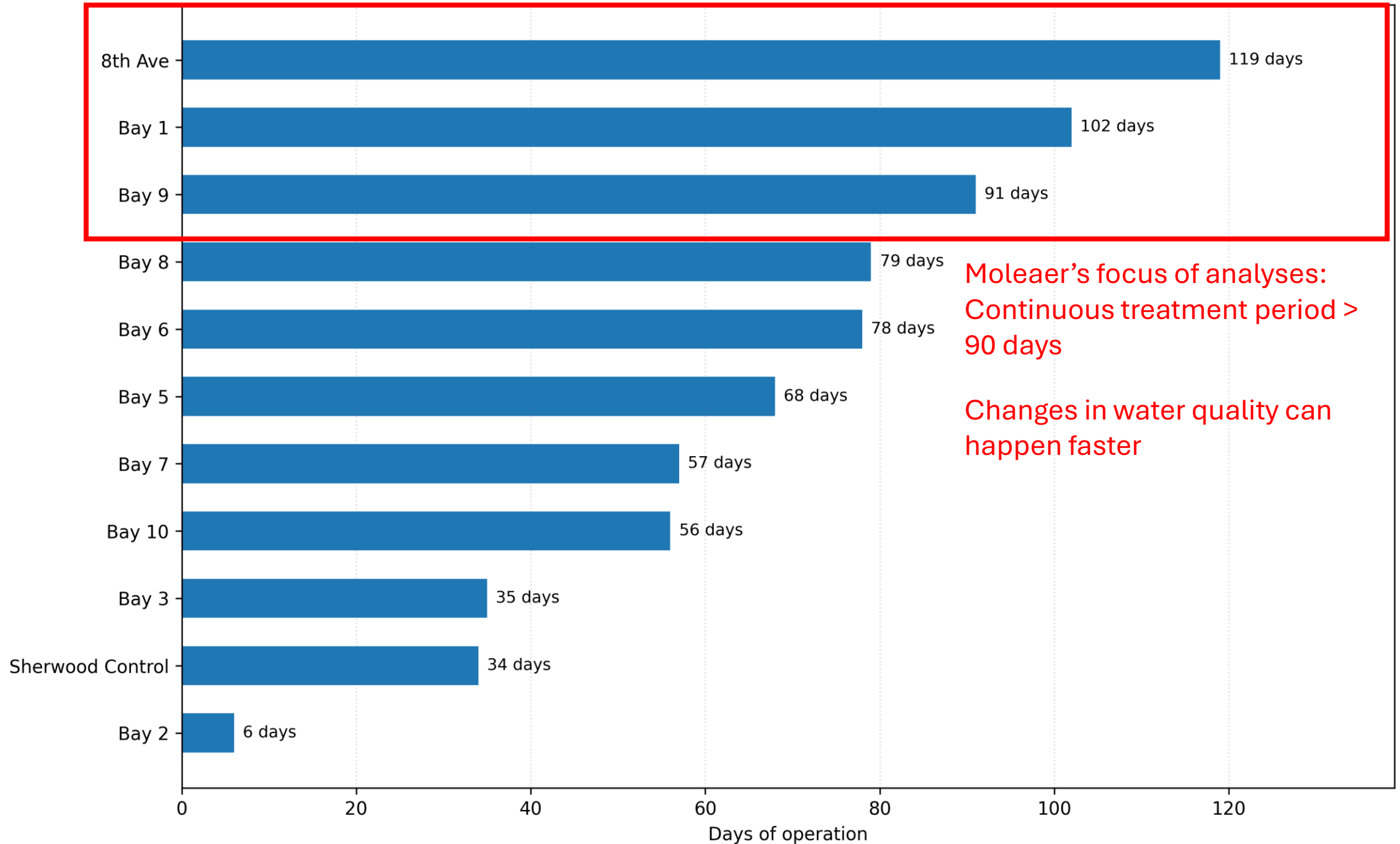


Moleaer's conclusions

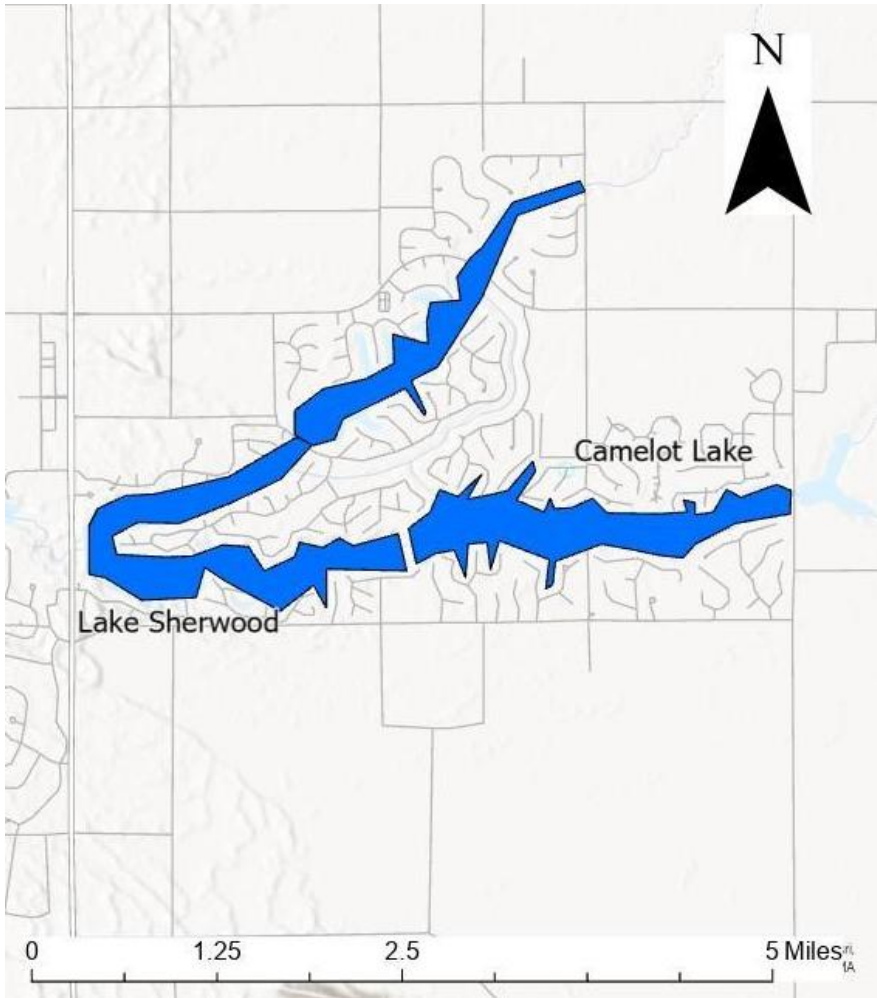


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 - Increased dissolved oxygen (DO) levels
 - Reduced hyper-saturation of DO- potentially reflects less algae
 - Reduced Total Phosphorus (TP) release ratesunder NB treatment vs. no-NB treatment.

Treatment Duration by Site

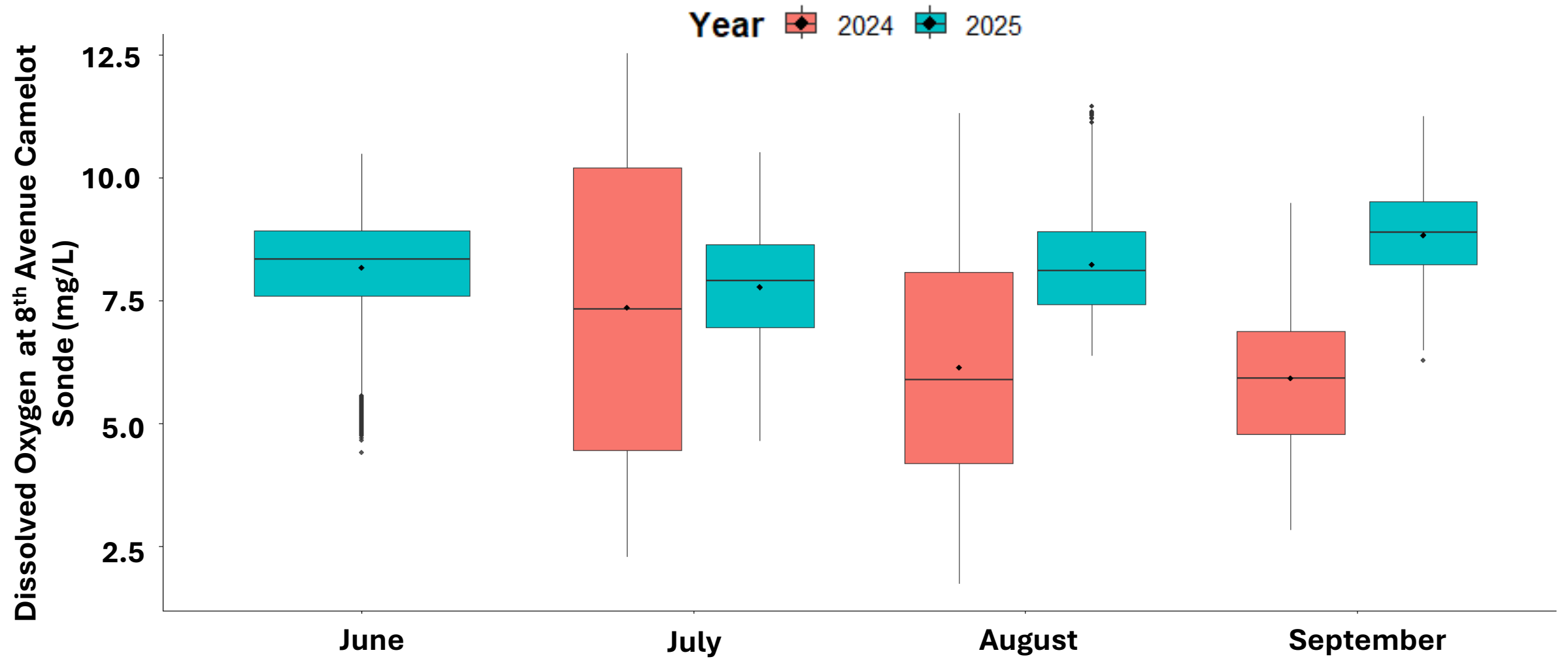


Moleaer's conclusions

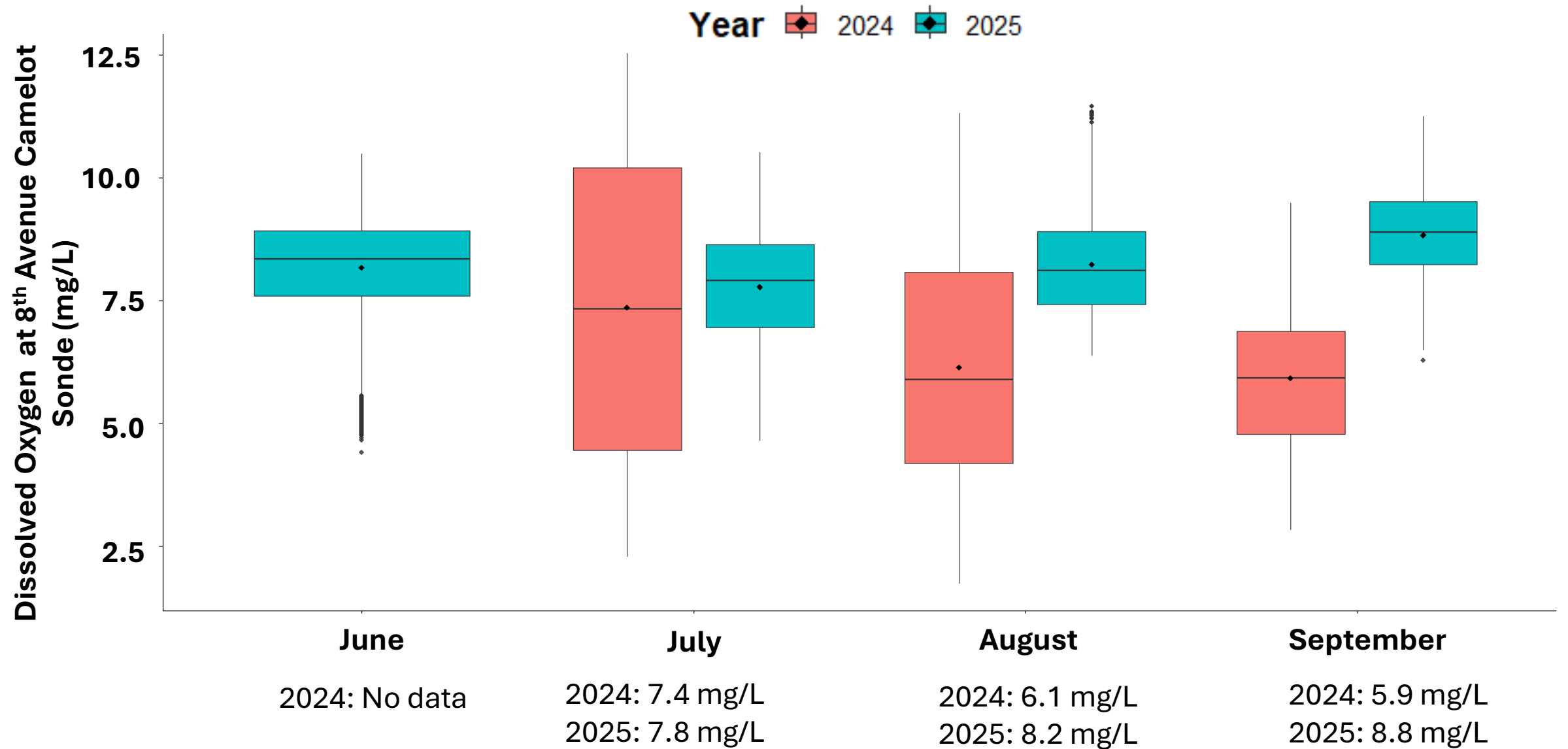


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8th Ave Camelot Monitoring Buoy



8th Ave Camelot Monitoring Buoy



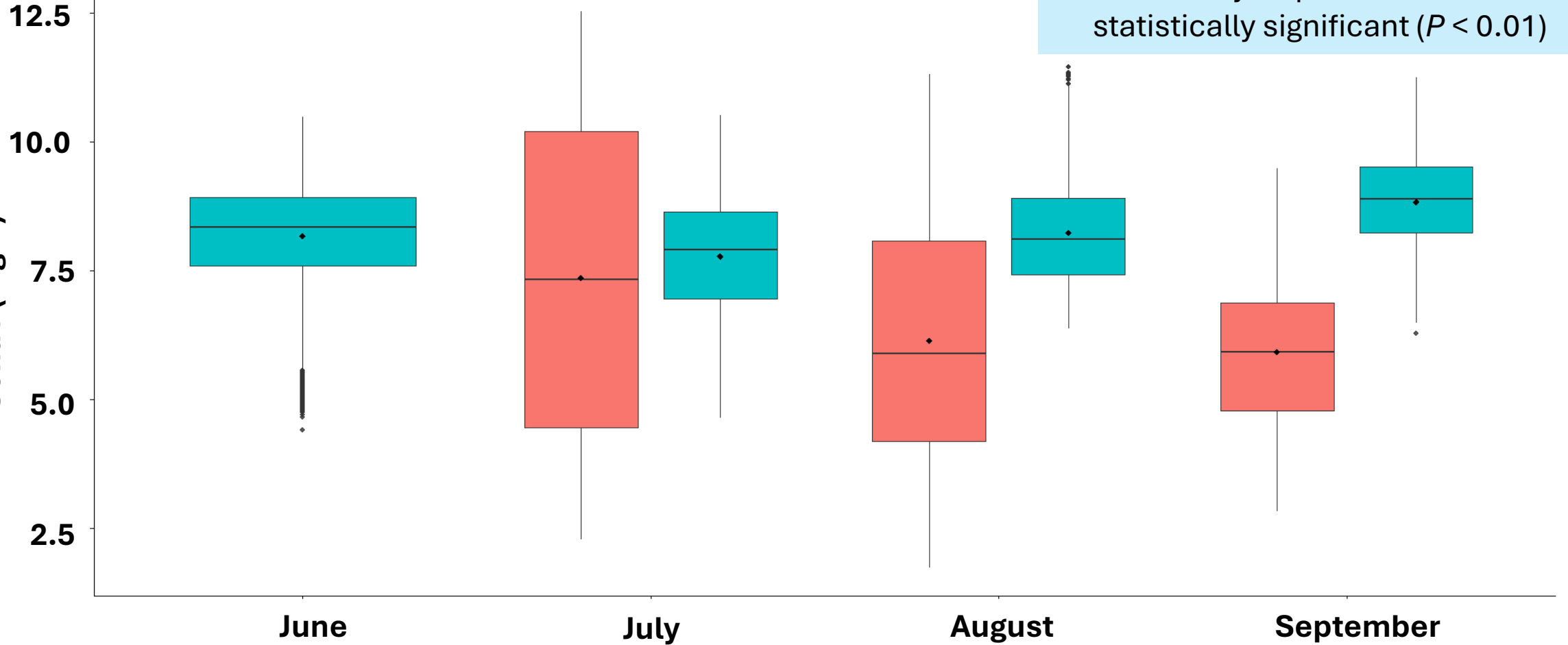
8th Ave Camelot Monitoring Buoy

Dissolved Oxygen at 8th Avenue Camelot

Sonde (mg/L)

Year  2024  2025

- Higher mean DO in 2025 vs. 2024
- Differences in 2024 vs. 2025 averages across July-September were statistically significant ($P < 0.01$)



2024: No data

2024: 7.4 mg/L
2025: 7.8 mg/L

2024: 6.1 mg/L
2025: 8.2 mg/L

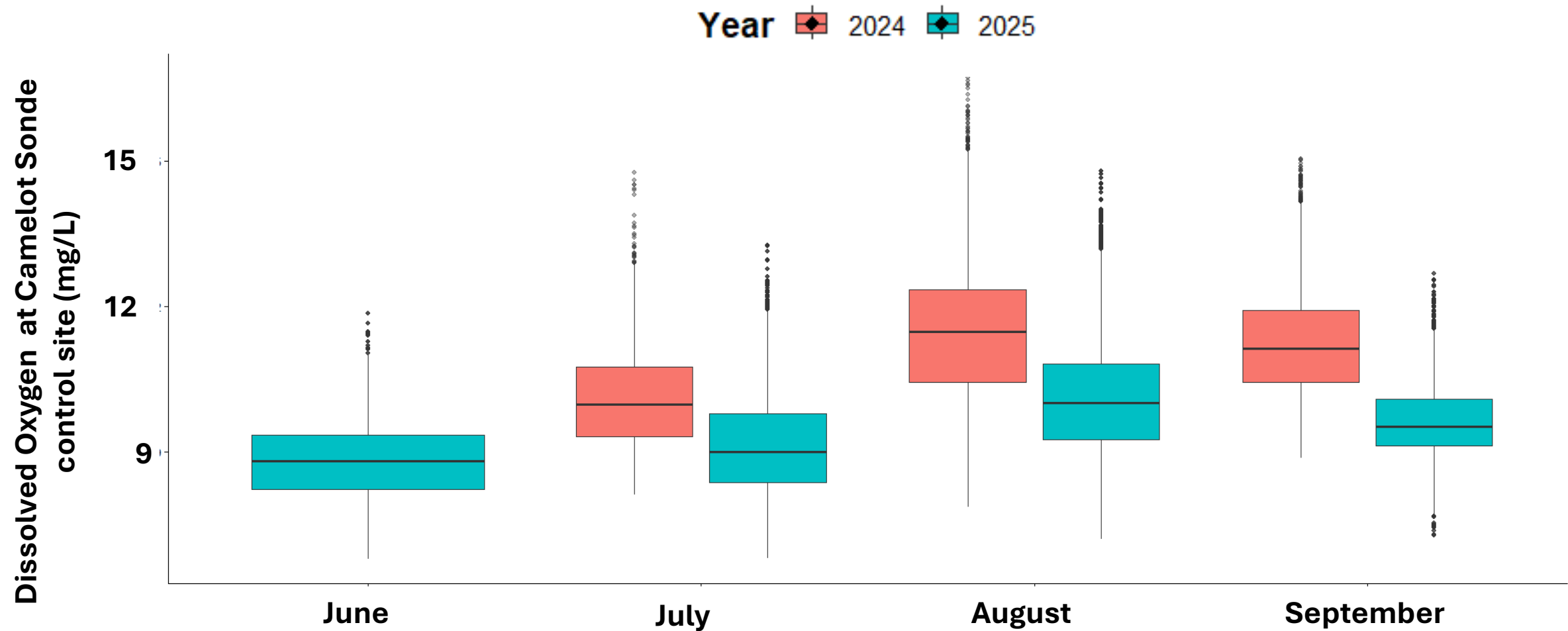
2024: 5.9 mg/L
2025: 8.8 mg/L

Established control site for Camelot

Year  2024  2025

If what caused this pattern was natural variation, DO levels at the control site should also be higher in 2025 vs. 2024

Established control site for Camelot

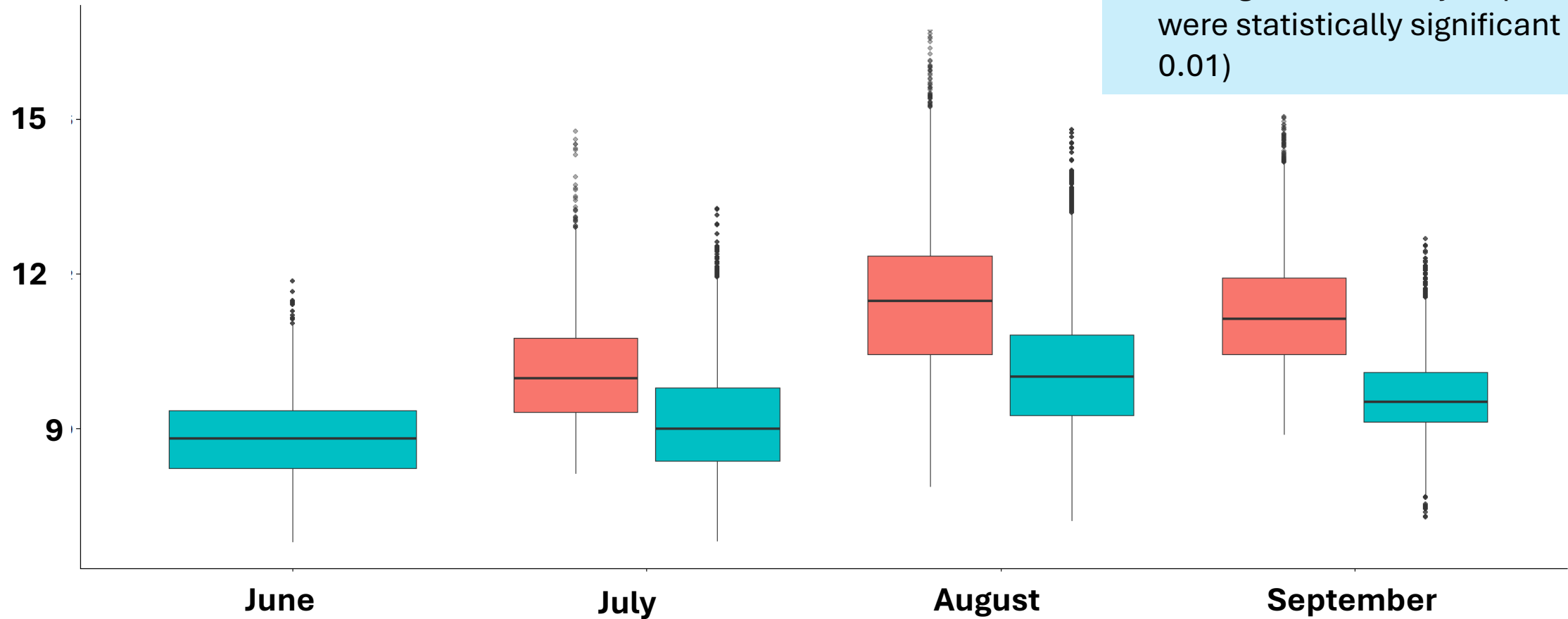


Established control site for Camelot

- Reverse trends are apparent here.
- Differences in 2024 vs. 2025 averages across July-September were statistically significant ($P < 0.01$)

Dissolved Oxygen at Camelot Sonde
control site (mg/L)

Year 2024 2025



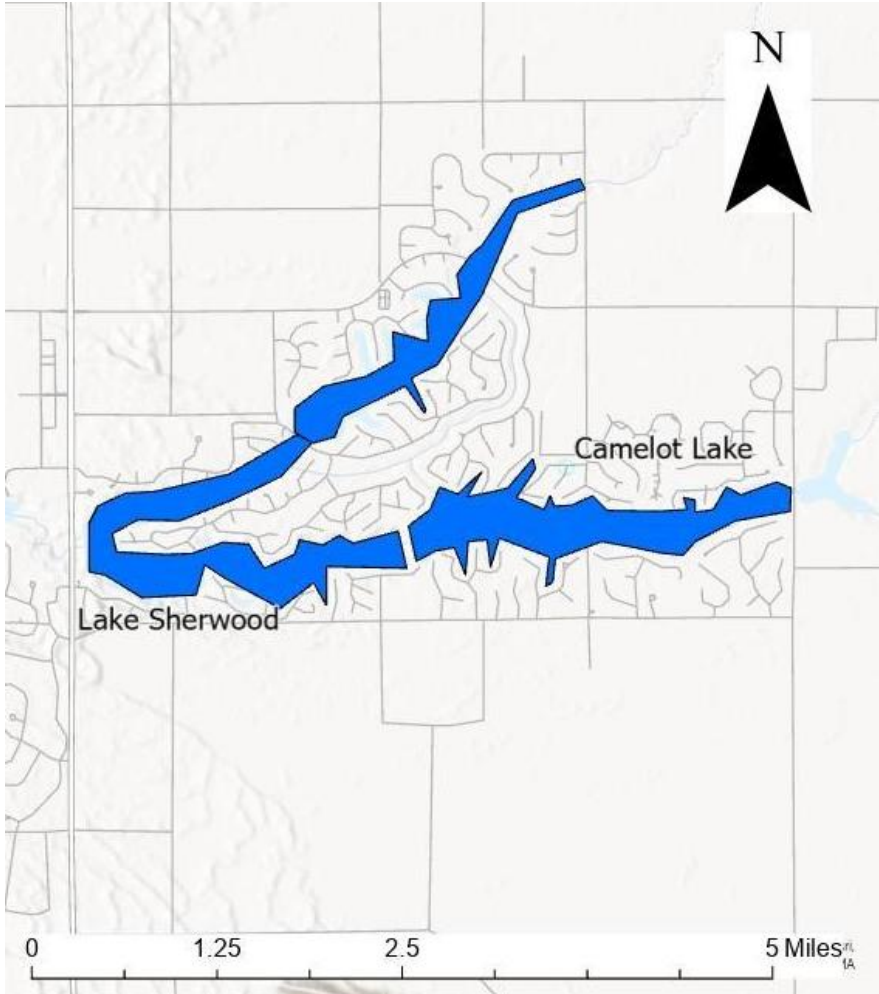
2024: No data

2024: 10.1 mg/L
2025: 9.2 mg/L

2024: 11.5 mg/L
2025: 10.2 mg/L

2024: 11.3 mg/L
2025: 9.6 mg/L

Moleaer's conclusions



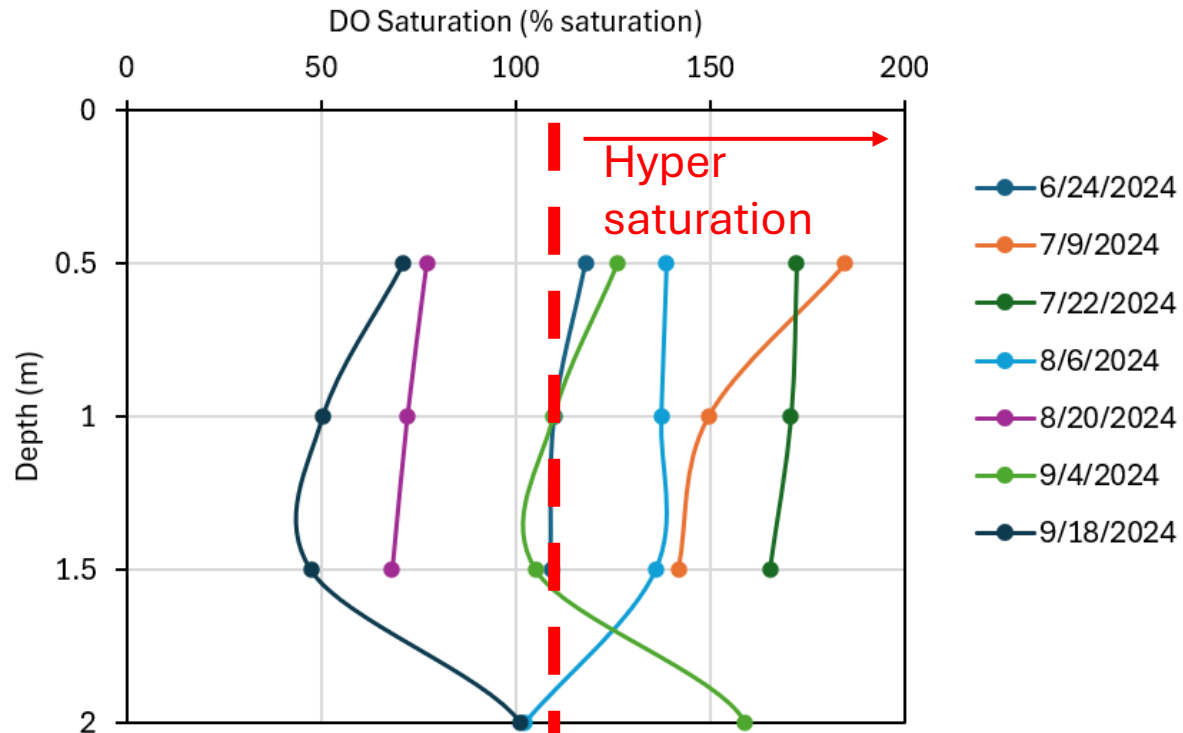
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 - Increased dissolved oxygen (DO) levels, even under incorrect anoxia threshold
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Vertical profiles of dissolved oxygen

- Hyper-saturation of DO usually reflects presence of excessive algae
- No hyper-saturation under NB treatment in 2025 vs. 2024 in Lake Camelot

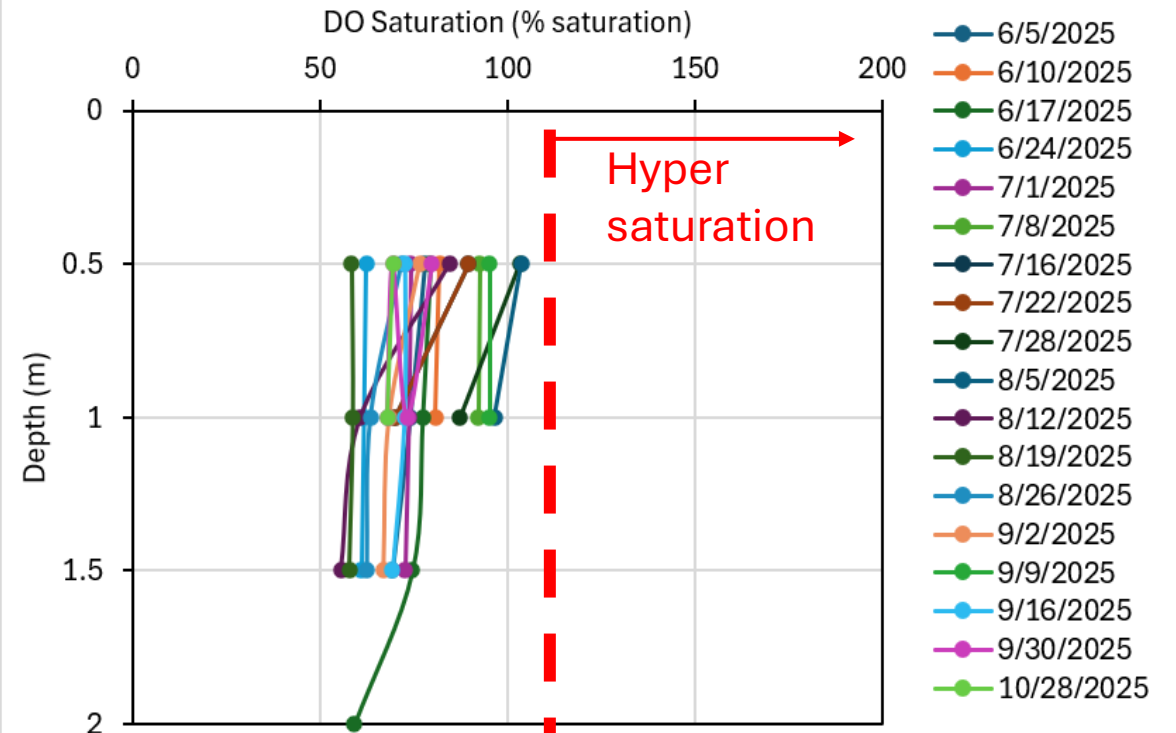
No NB Treatment

2024 8th Ave Camelot



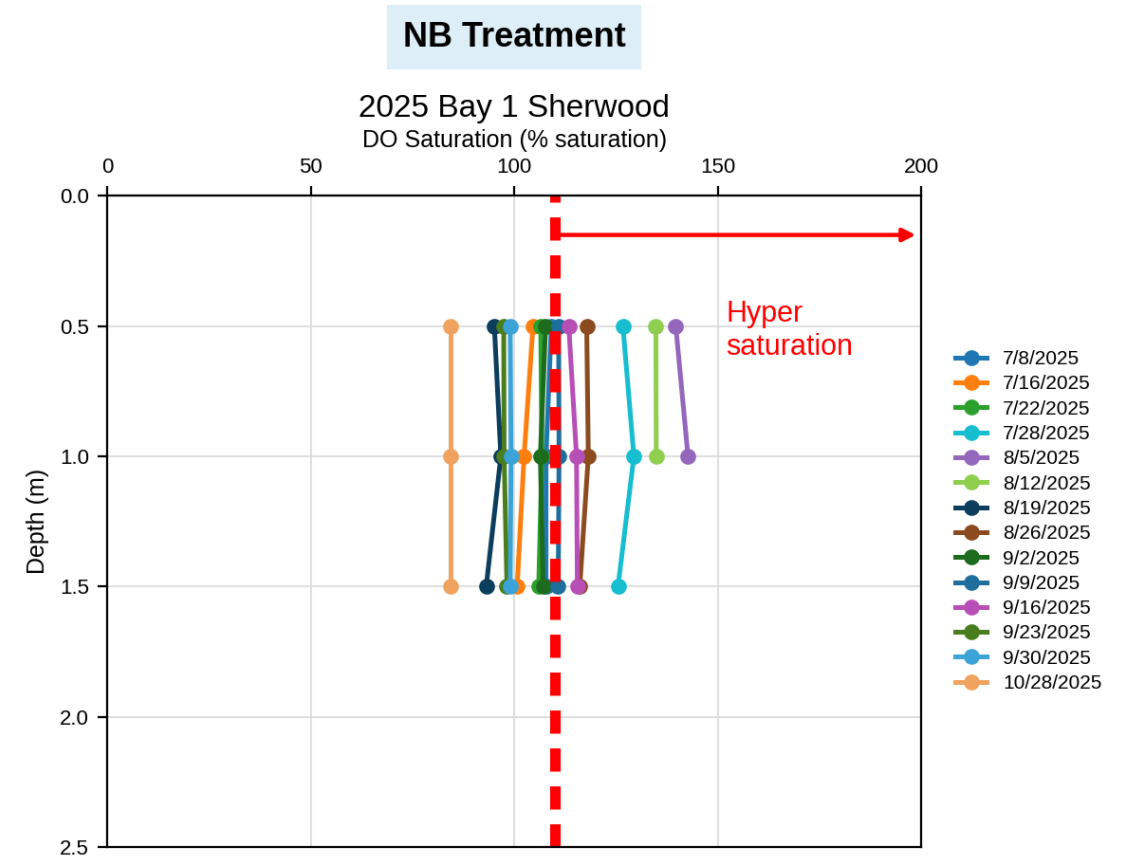
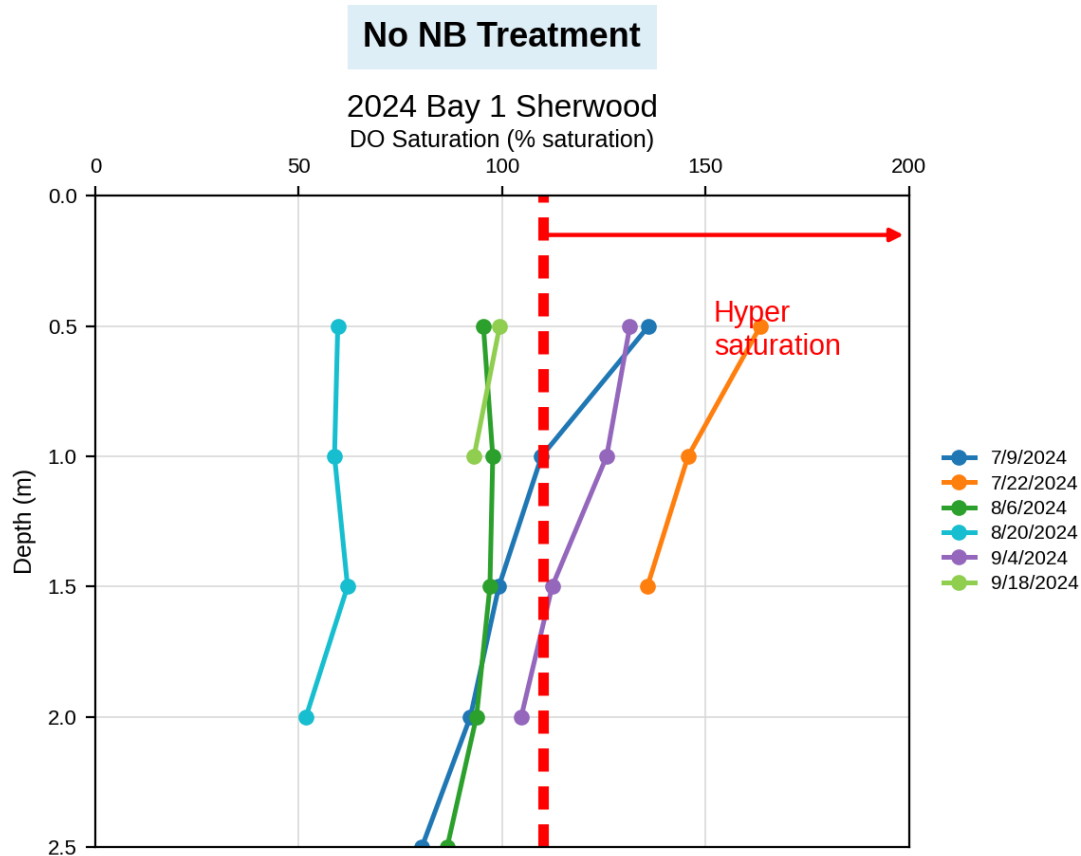
NB Treatment

2025 8th Ave Camelot

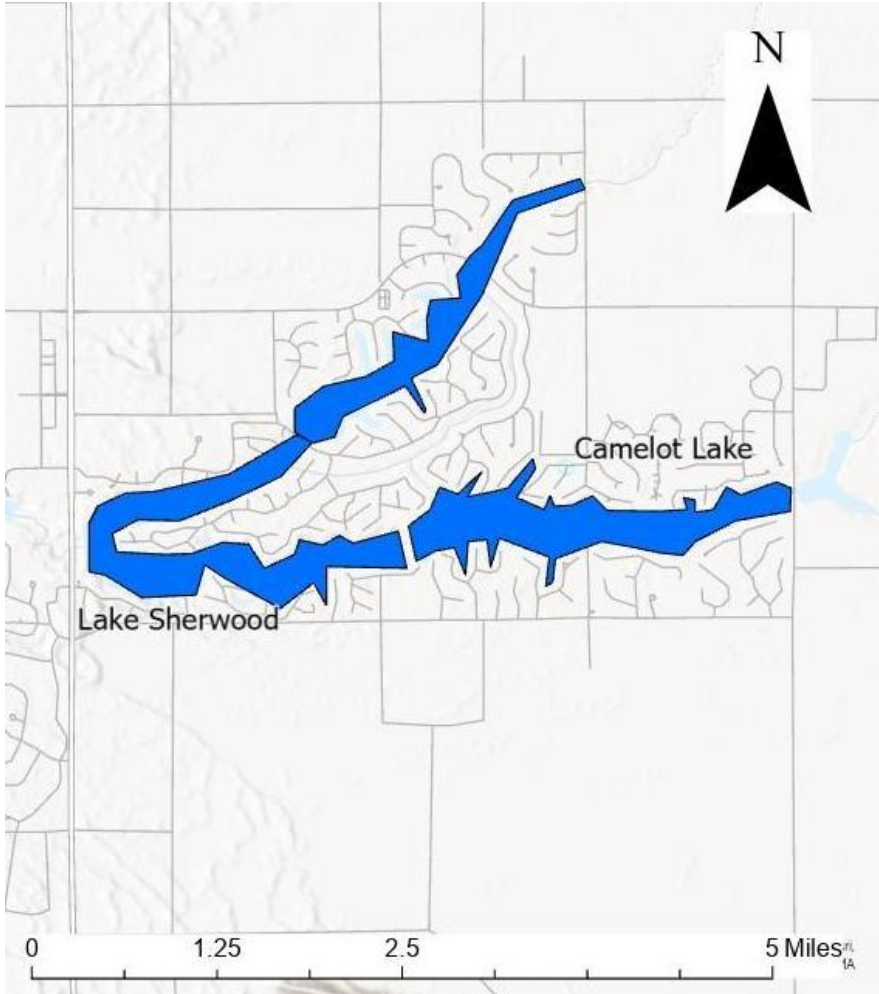


Vertical profiles of dissolved oxygen

- Hyper-saturation of DO usually reflects presence of excessive algae
- No hyper-saturation under NB treatment in 2025 vs. 2024 in Lake Camelot
- Less obvious in Sherwood, likely due to smaller treatment unit and later NB oxygenation start date

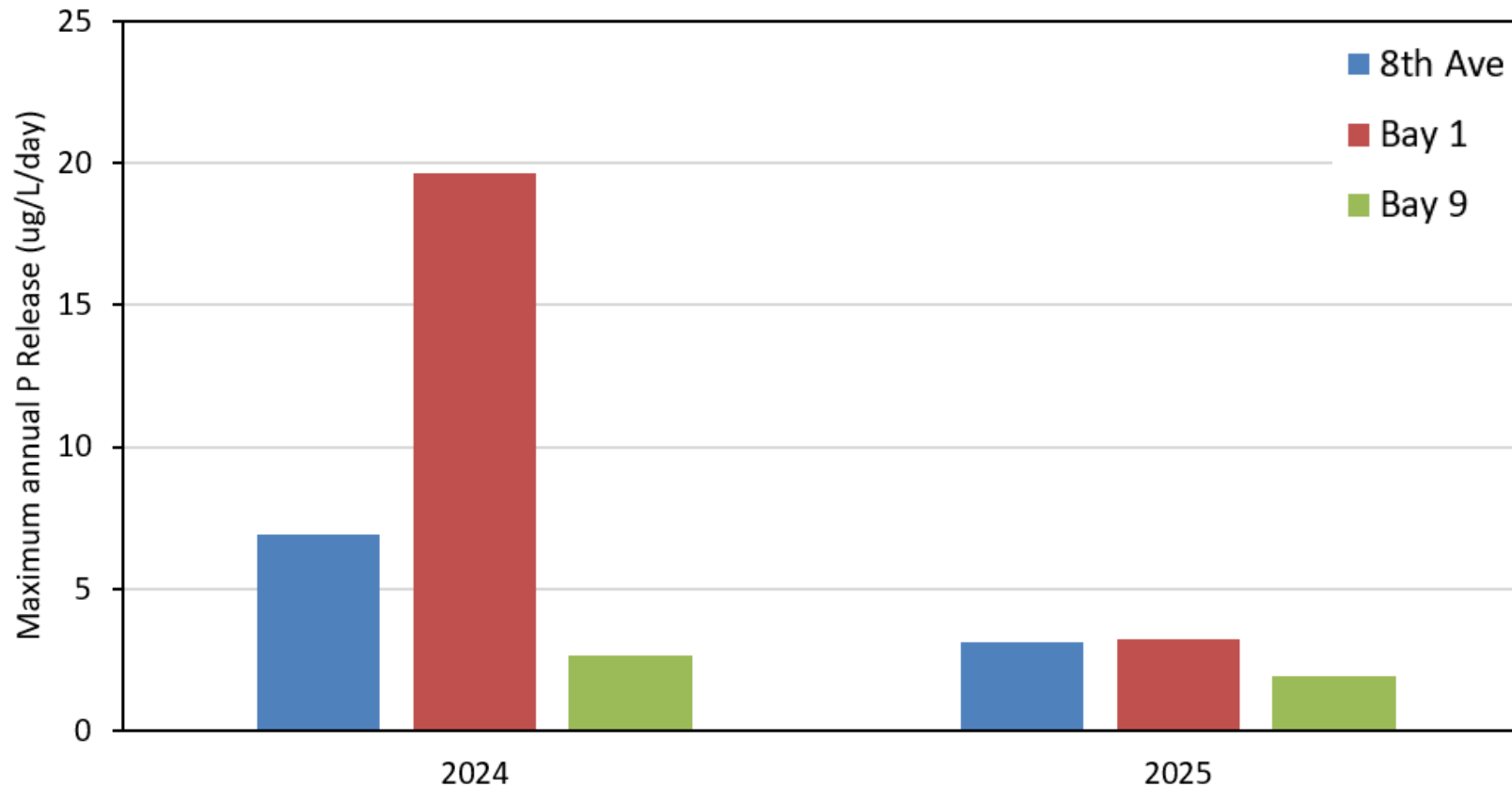


Moleaer's conclusions



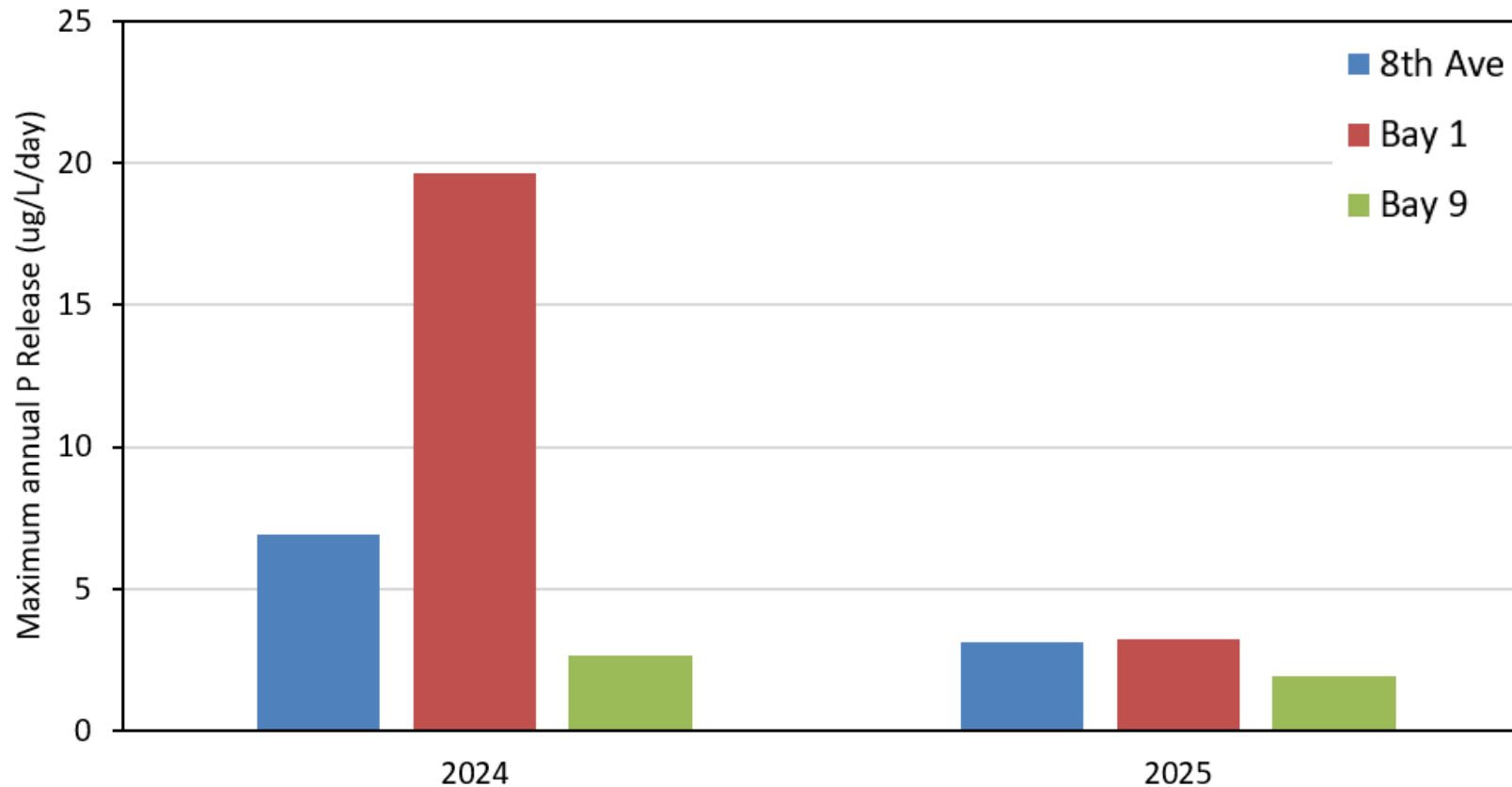
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 - Reduced hyper-saturation of DO - potentially reflects less algae
 - Reduced Total Phosphorus (TP) release rates
- under NB treatment vs. no-NB treatment.

Total Phosphorus release rates during NB treatment



- Using established method to calculate internal P release developed by former NALMS Director where only over-bottom TP values are used
- At all three sites where NB treatment > 90 continuous days, less phosphorus (P) was released under NB treatment in 2025 vs. 2024
- Similar trend of reduced TP release rates in 2025 vs. 2024 under 60-90 days of continuous NB treatment

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Conclusions of Moleaer's review of 2024-2025 Tri Lakes Nanobubble Study design and monitoring data

- Based on monitoring data from sites where continuous NB treatment > 90 days,
 - Increased dissolved oxygen (DO) levels
 - Reduced hyper-saturation of DO (potentially reflects less algae)
 - Reduced internal phosphorus release

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Lake Elsinore: Nanobubble Treatment Strategy

- Estimated total summer lake O₂ demand: ~ 15,000 lbs/day
- Phase 1 (Feb 2024): 2,400 GPM, 500 lbs O₂/day (< 1% of total estimated Rx)
- Phase 2 (Oct 2024): 9,000 GPM, 4,900 lbs O₂/day (~ 37% of total estimated Rx)



Lake Elsinore: Nanobubble Treatment Strategy

- Estimated total summer lake O₂ demand: ~ 15,000 lbs/day
- Phase 1 (Feb 2024): 9,000 GPM, 5,184 lbs O₂/day (upgraded unit)
- Phase 2 (Oct 2024): 9,000 GPM, 4,900 lbs O₂/day
- Phase 3 (Jan 2027): 9,000 GPM, 5,184 lbs O₂/day (~ 100% of total estimated Rx)



10 Years at Lake Elsinore: Aerial Views Tell the Story



Dec. 14, 2015



Dec. 8, 2016



Dec. 19, 2017



Dec. 17, 2018



Dec. 9, 2019



Jan. 4, 2021



Dec. 9, 2022



Dec. 12, 2023



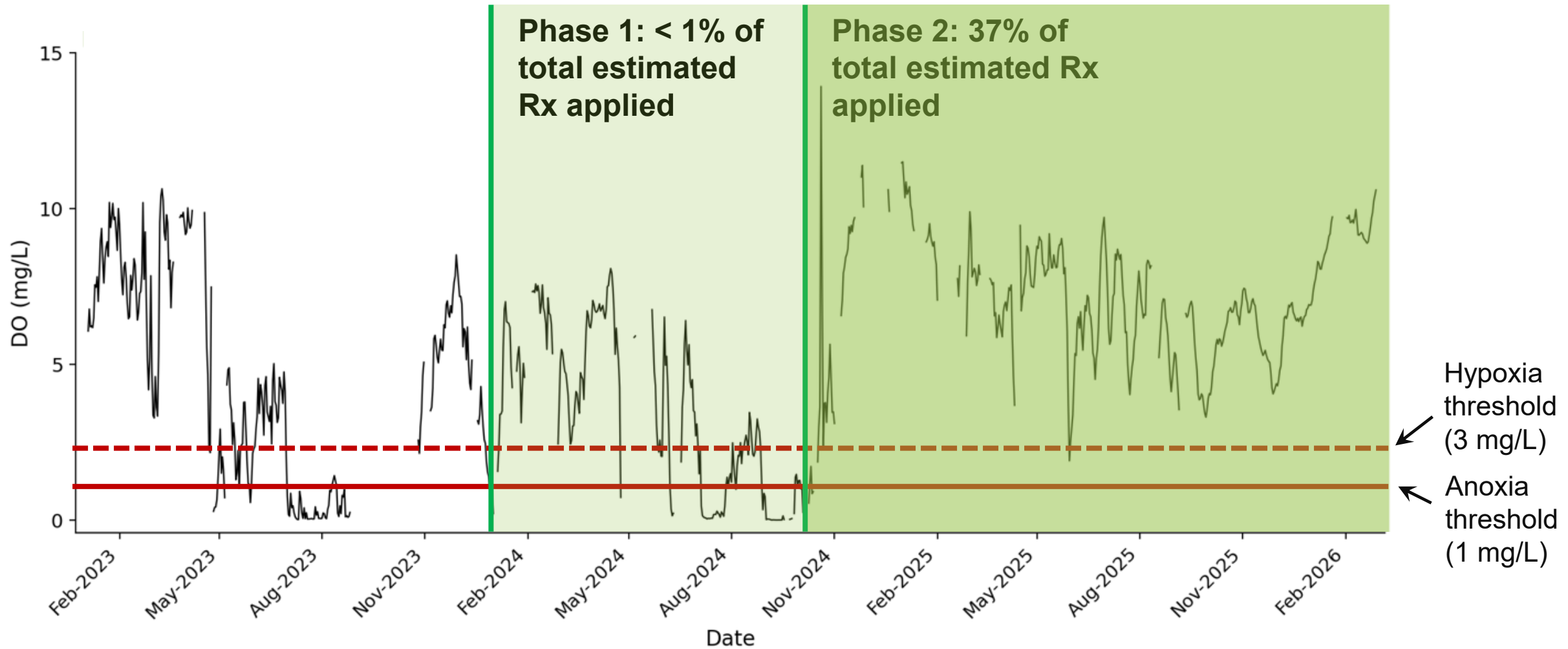
Dec. 6, 2024



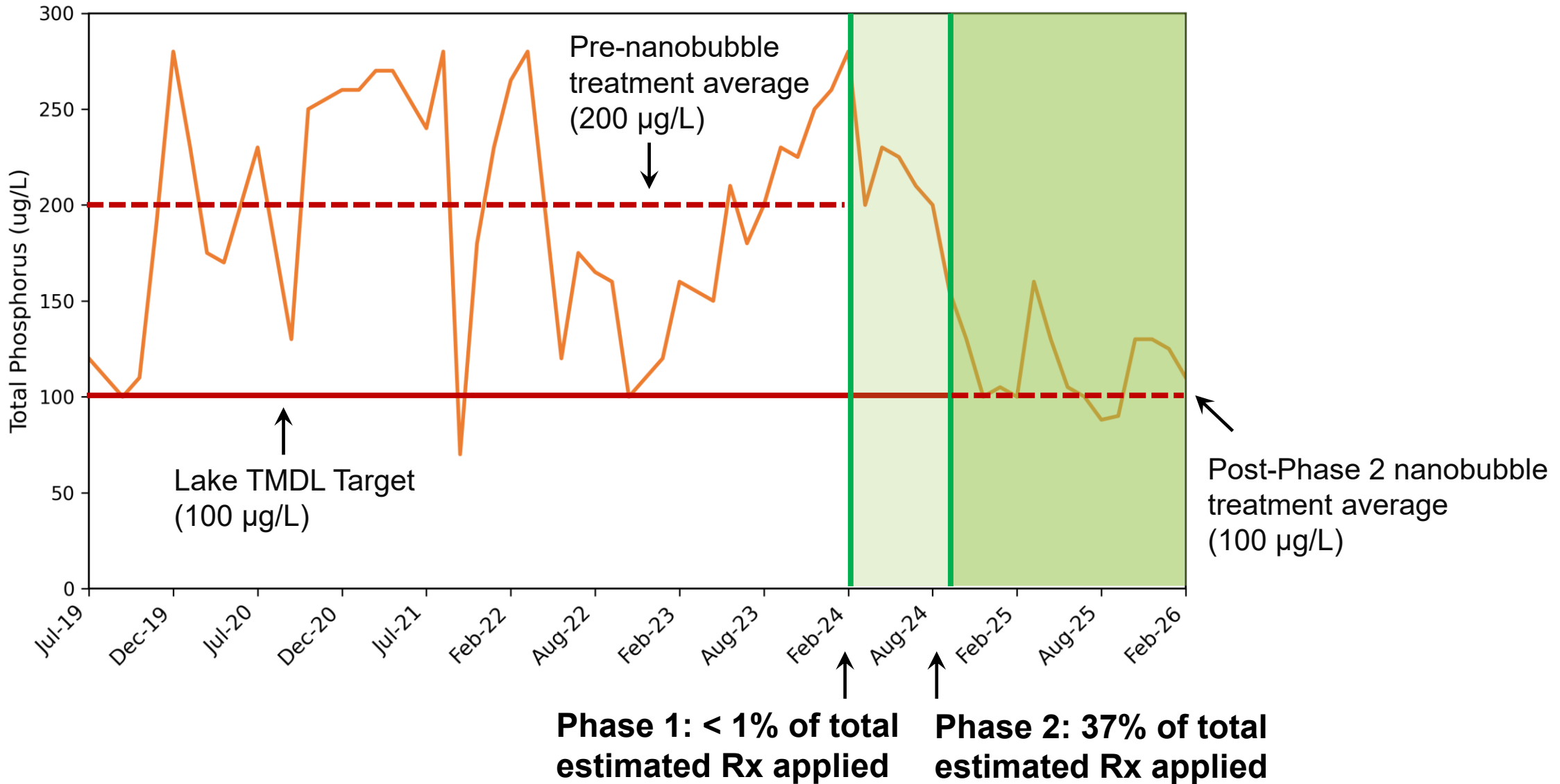
Dec. 9, 2025

Images from Landsat 7, 8, and 9

Lake Elsinore: Dissolved oxygen levels



Lake Elsinore: Total Phosphorus levels



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Moving forward: Recommended monitoring at Tri Lakes

Pivoting from the historical weekly, bay-specific program to a monthly design designed to assess impacts of whole-lake nanobubble treatment.

Weekly → **Monthly sampling**

Isolated bays → **Whole-lake coverage**

In-lake only → **In-lake + watershed**

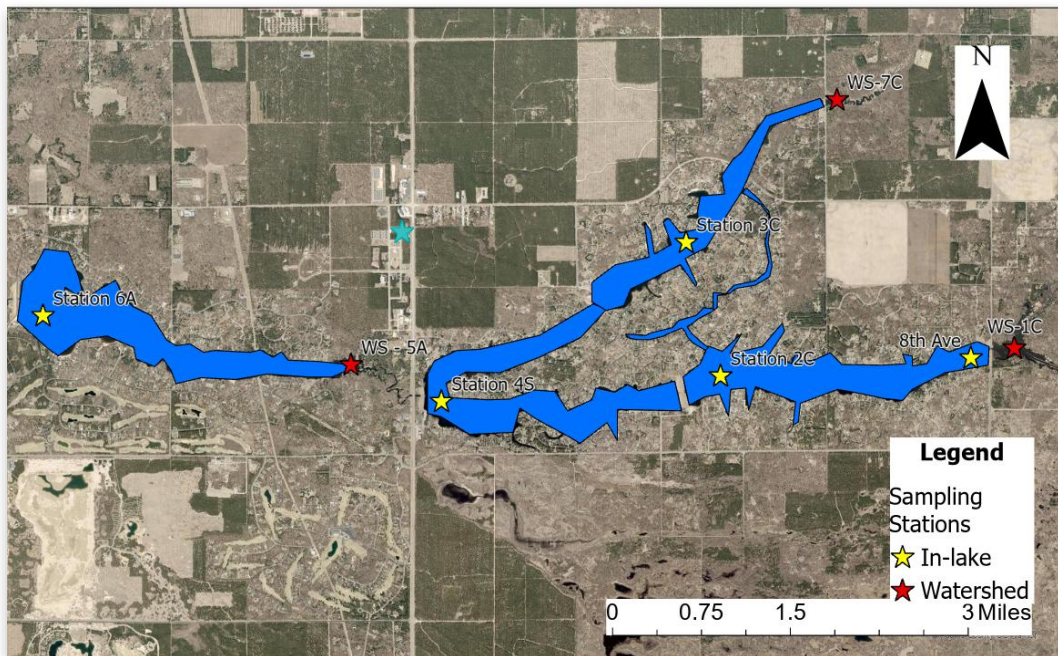
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Five in-lake stations (yellow) and three watershed inflow sites (red).

**Blue Water Sciences Contractor
(recommended)**

\$33,774 total · \$11,258 / lake / yr

Citizen-science hybrid
(alternative)

\$26,995 total · \$8,998 / lake / yr

- 1 Sample the open-water (deep) areas**
Cover the majority of where the sediment–water interface occurs.
- 2 Maintain 8th Ave / Camelot**
Continues long-term record, allowing for trend comparison.
- 3 Cut monitoring from weekly to monthly**
Six in-lake sampling events per season instead of weekly.
- 4 Quantify watershed nutrient loading**
TP and TN only at WS-1C, WS-5A and WS-7C — inexpensive to add.
- 5 Repurpose existing In-Situ® buoys**
Collect monitoring data at the sediment–water interface, add ORP sensors.
- 6 Add PME miniDOTs at the surface**
Capture diurnal fluctuations in dissolved oxygen levels between monthly visits.

Totals cover all three lakes for a six-month season, lab fees plus labor. Add ~\$5,000 one-time for four PME miniDOTs (\$38,774 all-in for the contractor option).

Conclusions

- **Recalling your goals....**
 - (1) Make your lake usable and safe to recreate in**
 - (2) Protect lifestyle and increase property values**
- **Great progress! At 17% applied Rx, there are already measurable results.**

Conclusions

- **Recalling your goals....**
 - (1) Make your lake usable and safe to recreate in**
 - (2) Protect lifestyle and increase property values**
- **Great progress! At 15% applied Rx, there are already measurable results.**
- **Moving forward,**
 - **Continue treatment deployment plan. Focus on getting the large oxygenation unit out in the main basin of the lakes.**
 - **Start oxygenation as early in the year as possible. Ensure treatment runs all season (~ 6 months), year-after-year.**
 - **Continue monitoring via scaled-back, whole-lake version to track progress and inform adaptive management.**



Thank you!