Characterizing high-frequency dynamics of internal phosphorus loading in a eutrophic, polymictic basin of Chautauqua Lake, New York

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The Jefferson Project at Lake George

Rensselaer IBM LGA Lake George Association

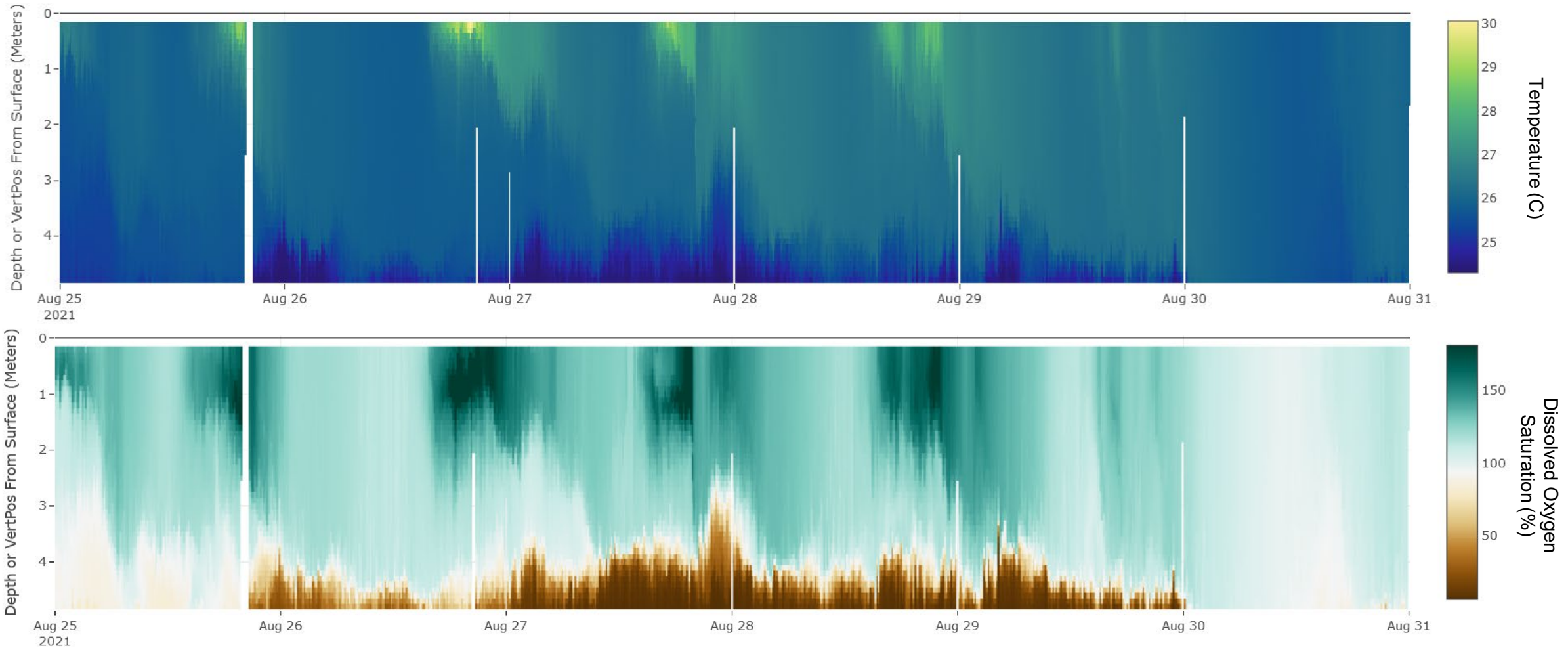
Study site

Chautauqua Lake - Chautauqua County, New York

- 13,156 acres with two distinct subbasins
  - **North Basin:** deeper ($\bar{z}$ = 9.1 m, z_{max} = 23 m), dimictic, mesotrophic
  - **South Basin:** shallower ($\bar{z}$ = 4.7 m, z_{max} = 5.7 m), polymictic, hypereutrophic

- The Jefferson Project has deployed vertical profilers seasonally at two locations in Chautauqua Lake since 2020
- Lake sampling occurred every two weeks seasonally

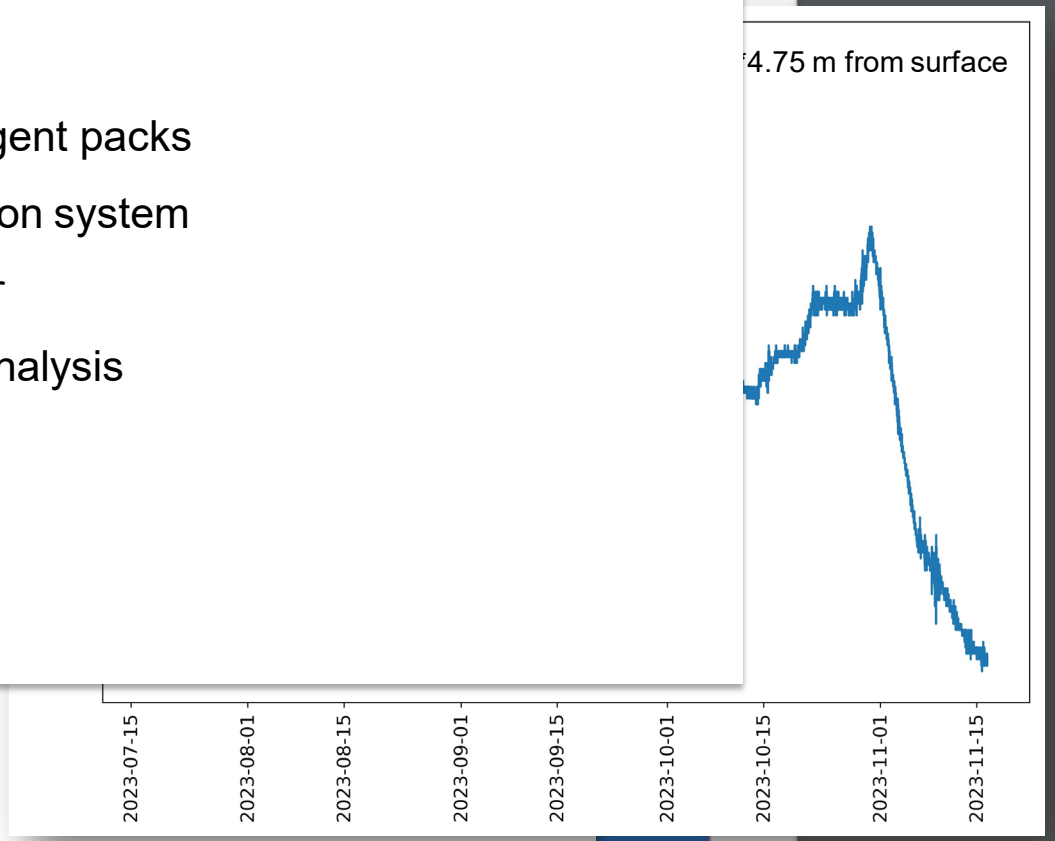
Transient stratification



METHODS

SeaBird HydroCycle PO4 wet chemistry sensor

- Colorimetric method (based on EPA standard method 365.1) for soluble P
- MDL 2.3 µg P/L
- Replaceable reagent packs
- No waste collection system
- Replaceable filter
- 15 minutes per analysis



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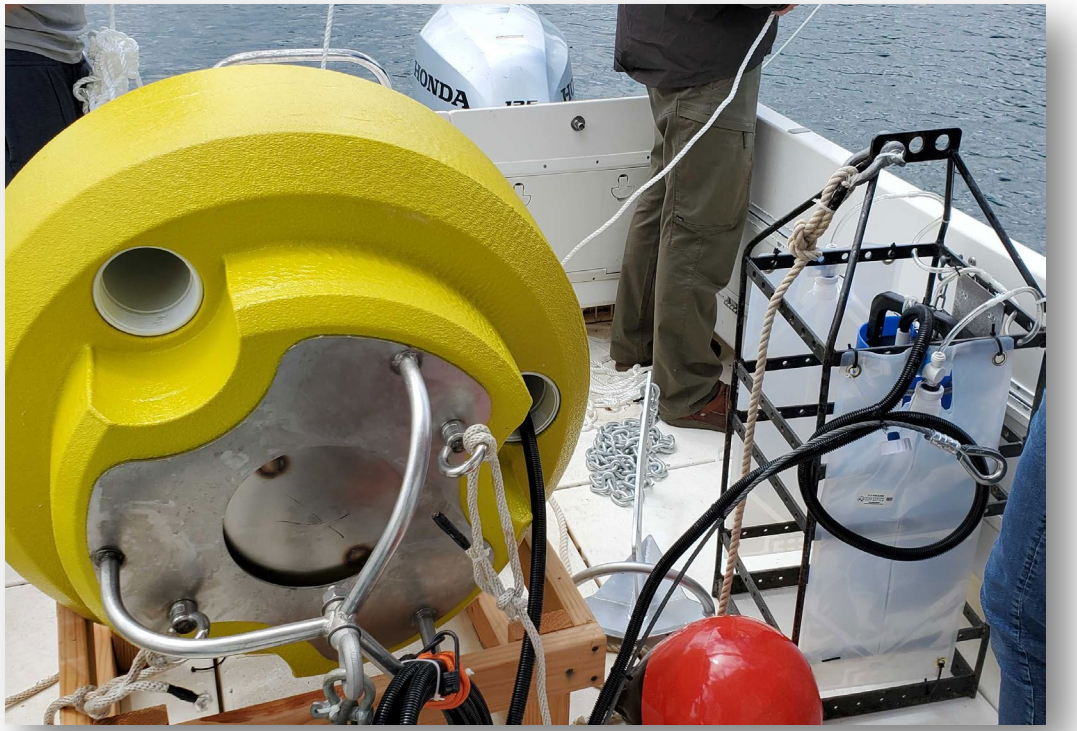
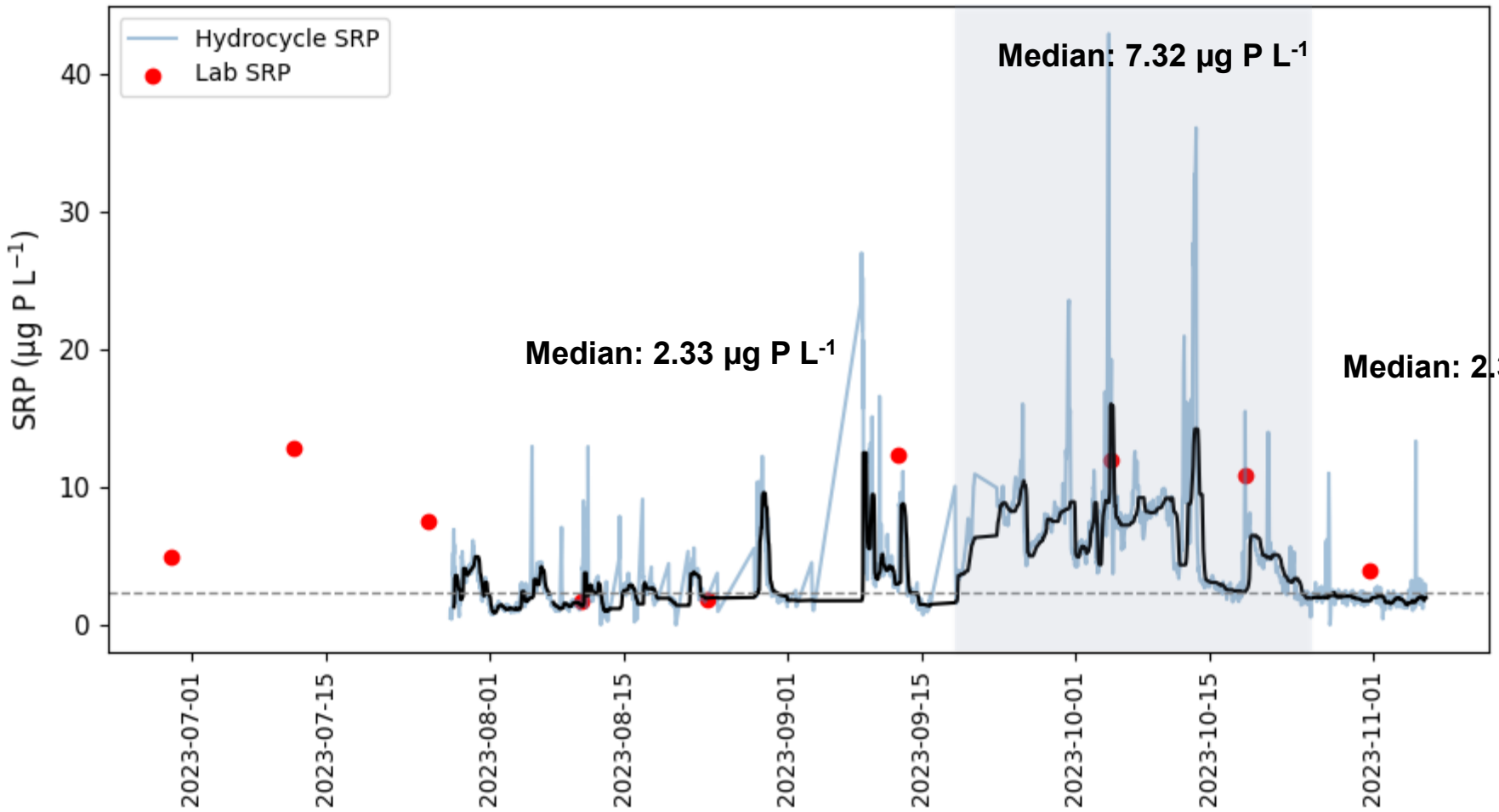
- Three ADCPs (300, 600, 1200 kHz)
- Weather station
- Real-time data streaming

Deployment Details

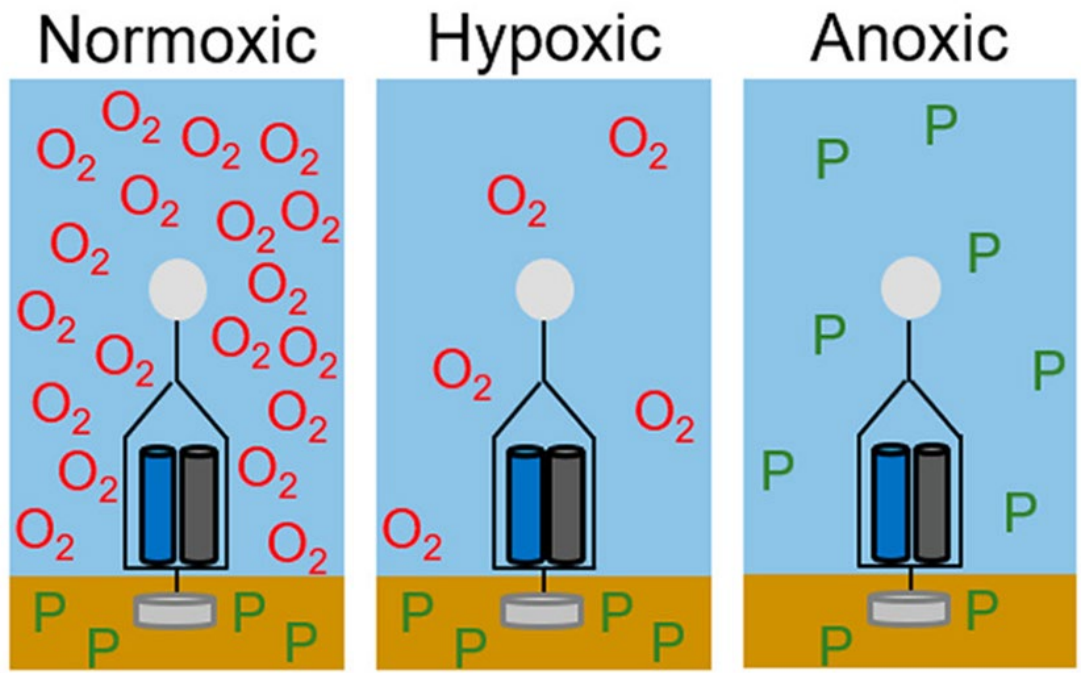
- Deployed 7/19/2023 – 11/13/2023
- Maintenance occurred every two weeks
  - Filters changed
  - Empty waste bags
  - Reagent packs changed (if needed)
- Sensor was controlled by Python code
- Sampling rate was dynamically adjusted
- USGS lake level data was scraped every hour



Results


Hydrocycle SRP
Lab SRP
Median: 7.32 µg P L-1
Median: 2.33 µg P L-1
Median: 2.33 µg P L-1
MDL 2.3 µg P L-1
SRP (µg P L-1)
0
10
20
30
40
2023-07-01
2023-07-15
2023-08-01
2023-08-15
2023-09-01
2023-09-15
2023-10-01
2023-10-15
2023-11-01

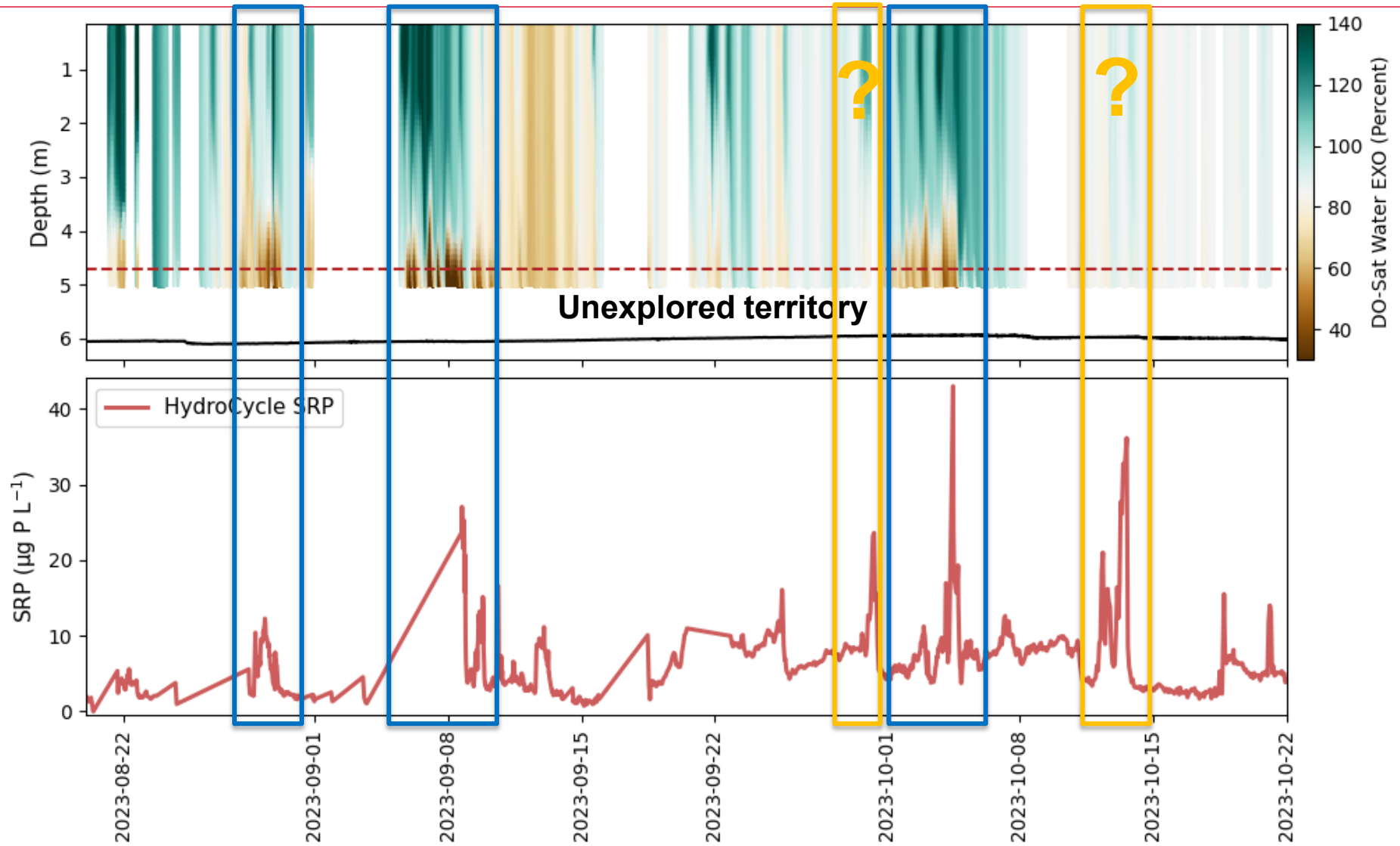
Reductive dissolution



Anderson et al. 2021

- Phosphorus is adsorped to ferric iron [Fe(III)] oxyhydroxides under normoxic conditions
- Hypoxia/anoxia lead to reduction of iron [Fe(II)] and release of ferrous Fe, Mn, and P into pore water followed by diffusion to water column
- Widely observed and studied form of internal phosphorus loading in dimictic lakes

Spikes - Reductive dissolution



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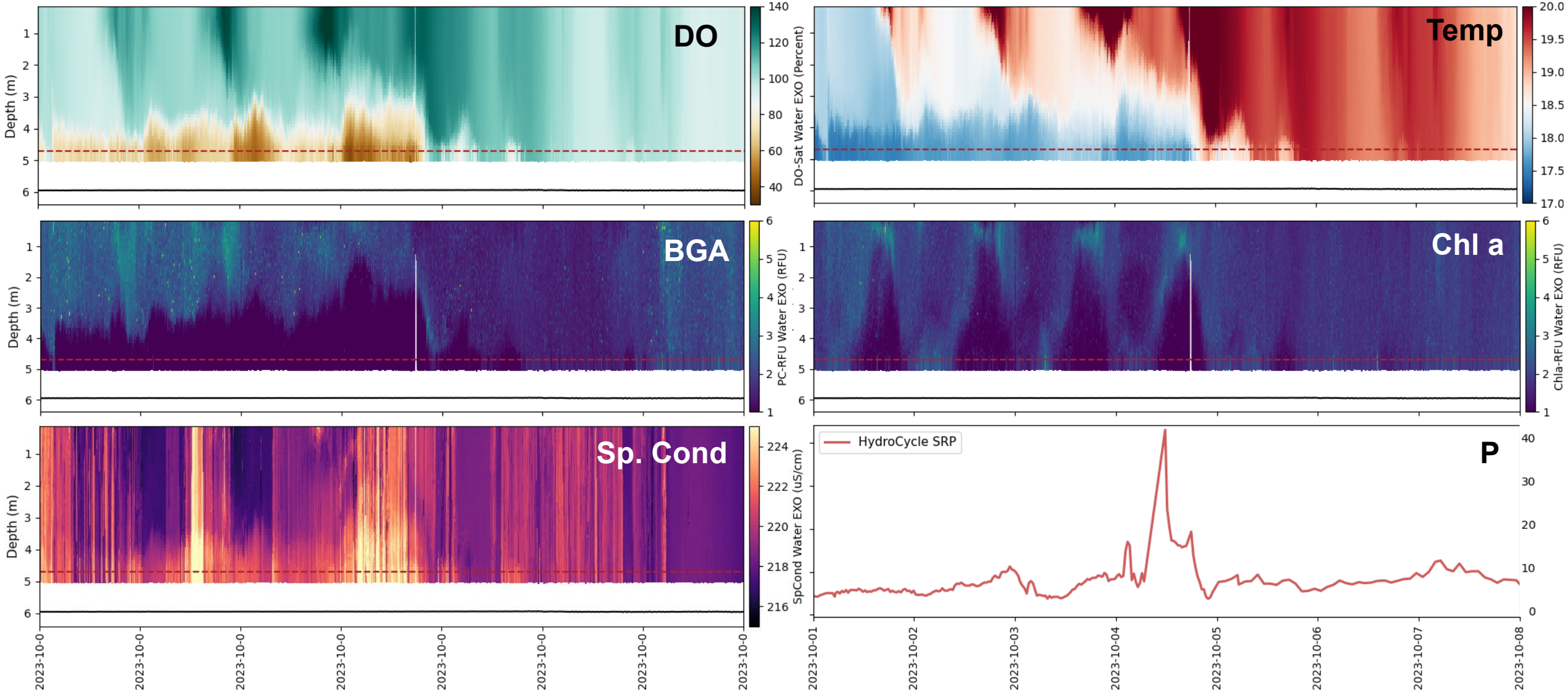
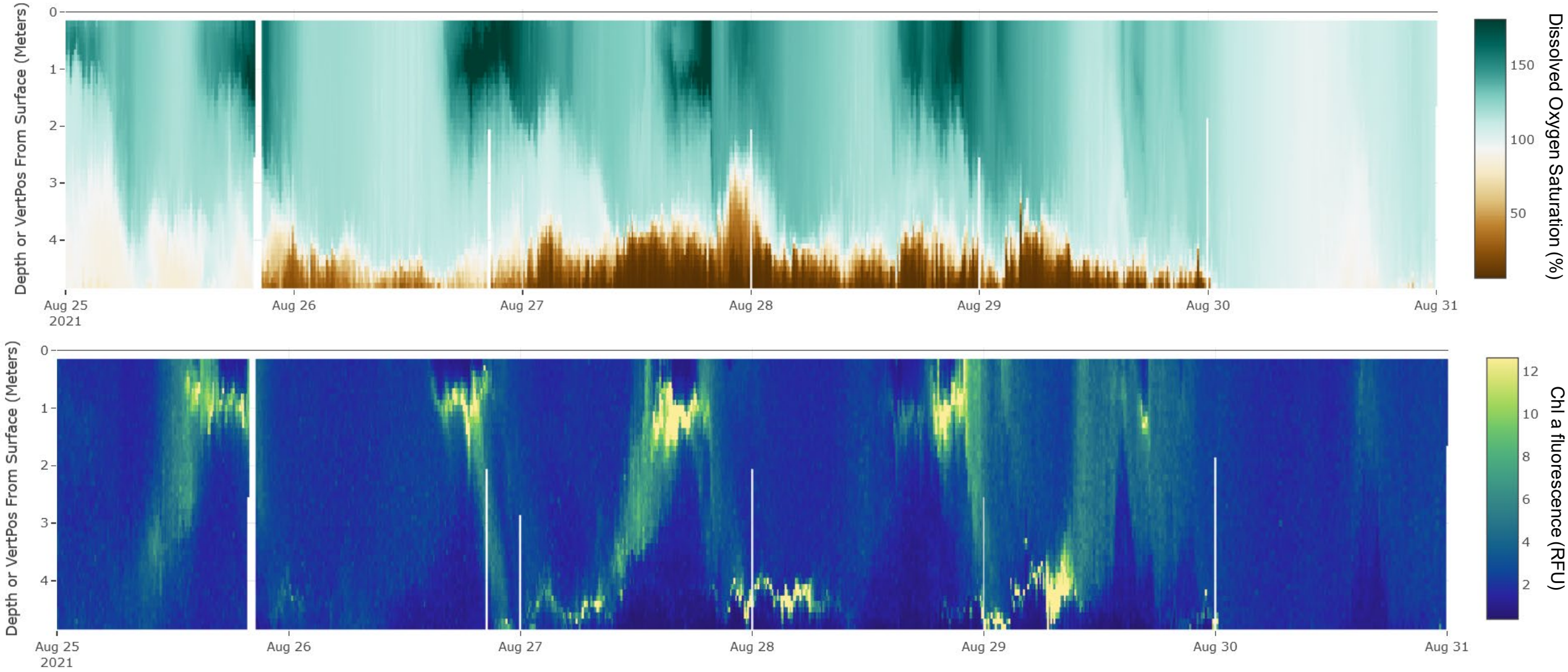


The key drivers of stratification and internal loading in the south basin are….

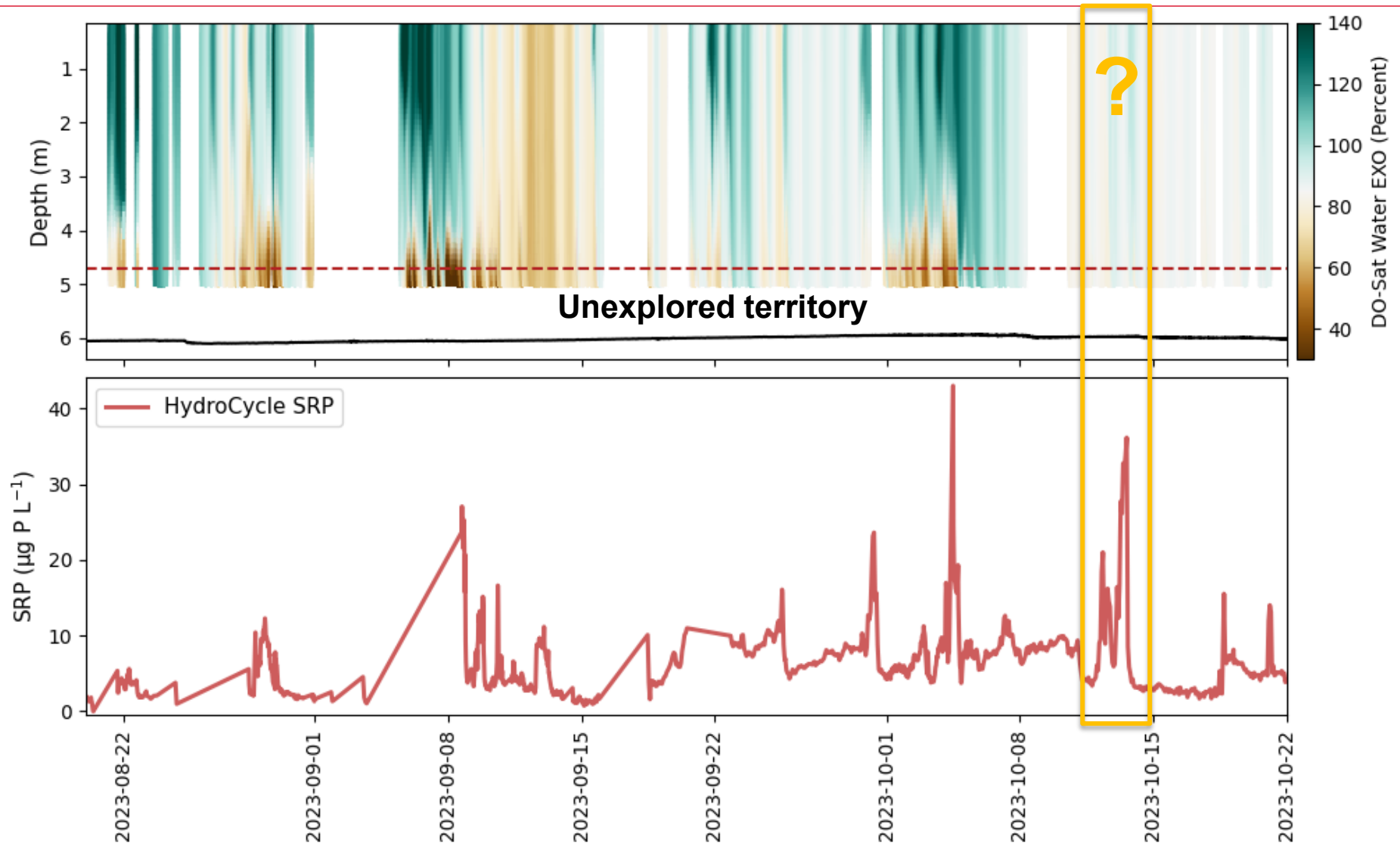
…warm, calm conditions.

Sound familiar?

Spikes - Reductive dissolution



Spikes – Other possibilities



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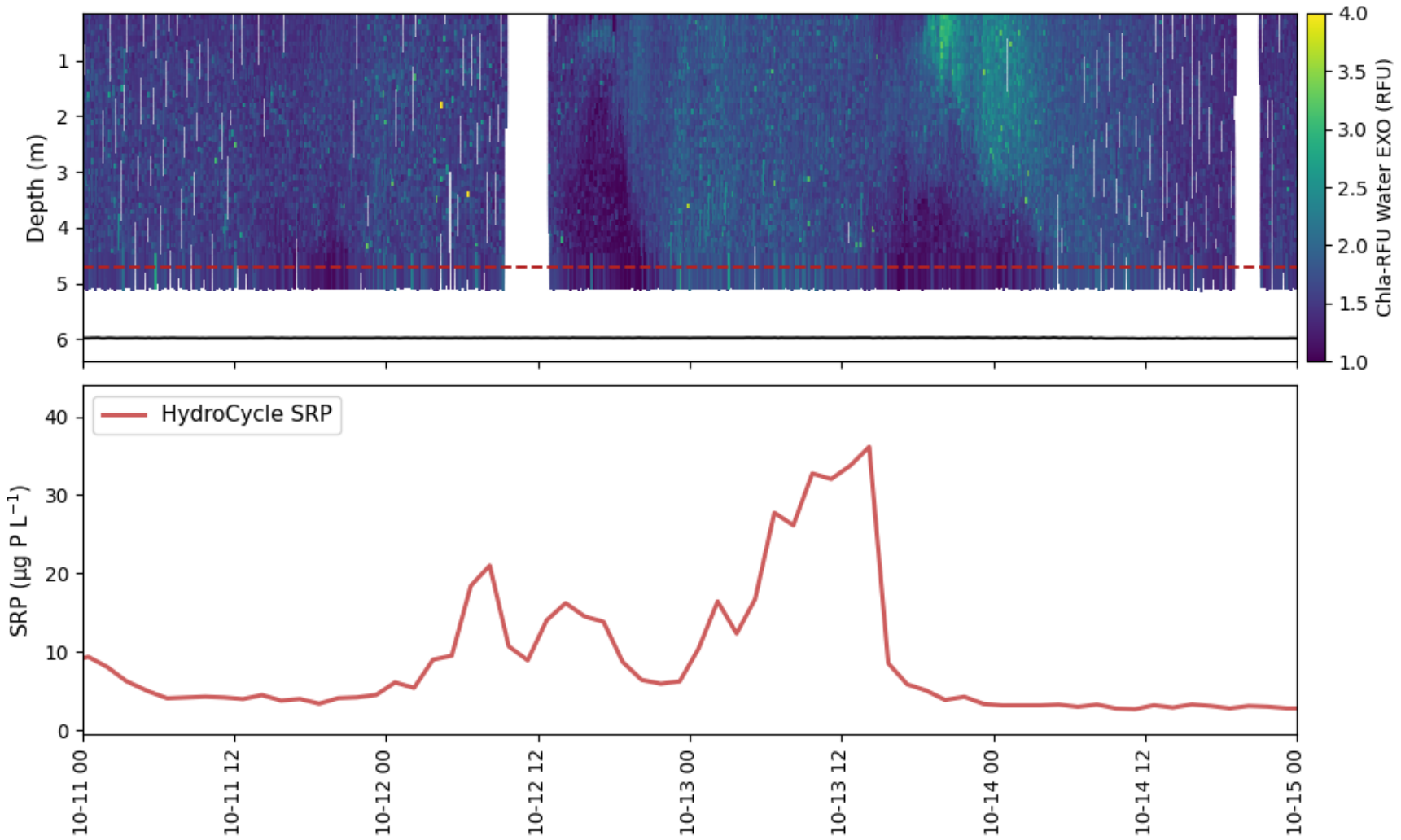


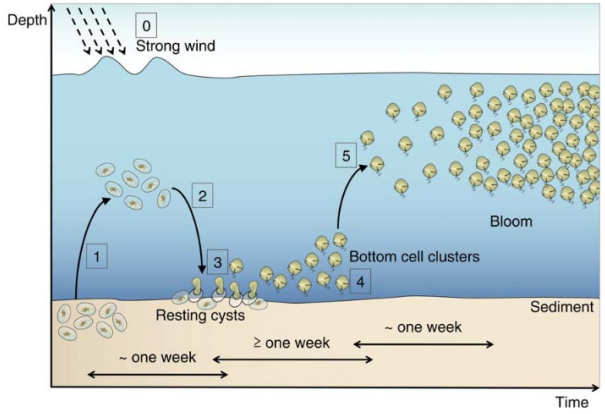
Spikes – Other possibilities

Internal

External

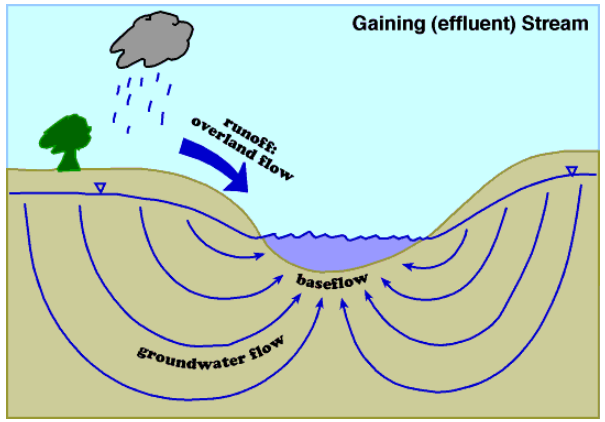
Sediment resuspension

Hatching of resting stages/cysts and plankter DVM



Stormwater

Groundwater



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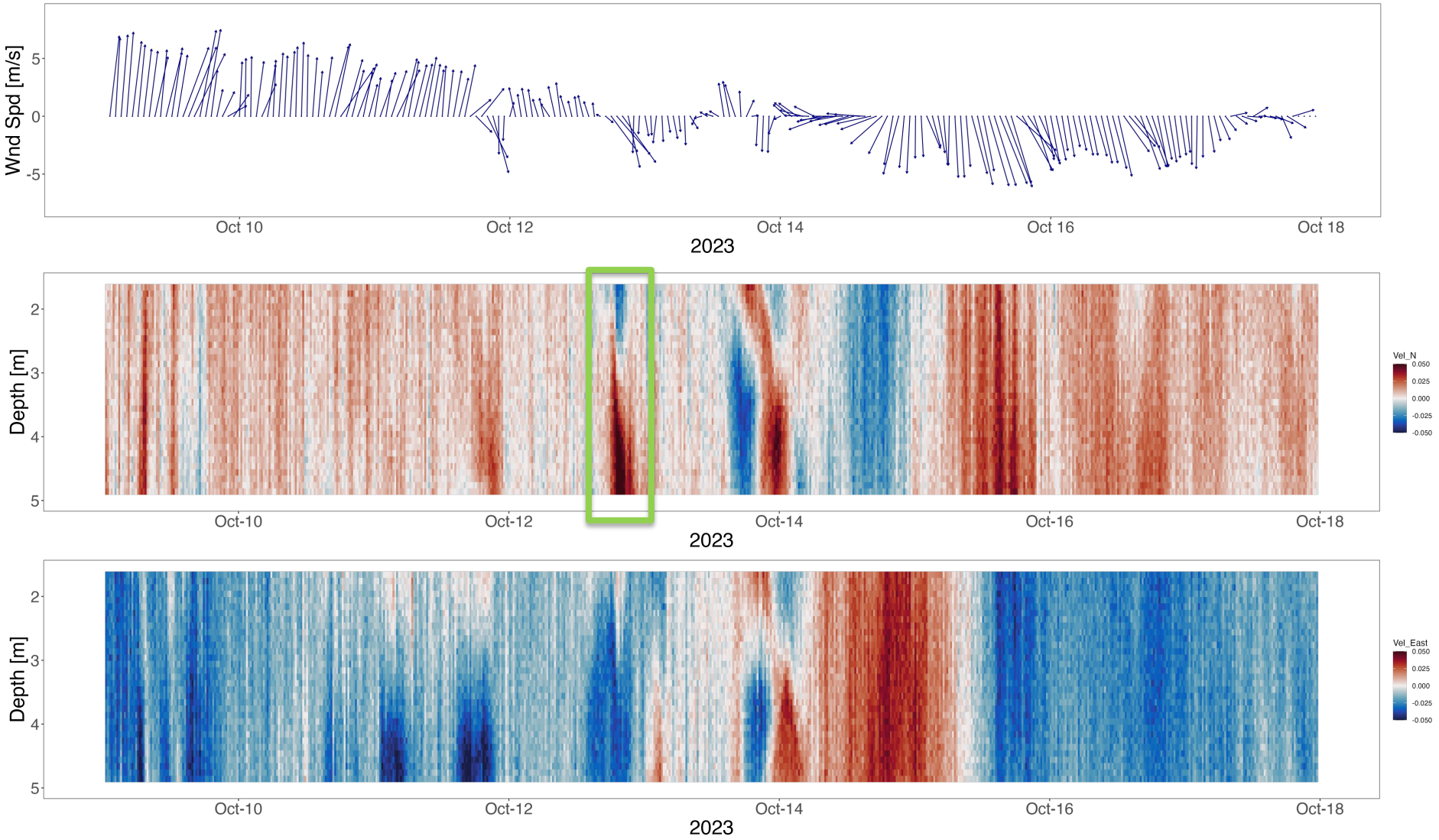

- Calculated bed shear stress of 0.022 N/m^2
- Not enough to resuspend “fine silt” per USGS
- Maybe enough to disturb unsettled flocculant layers

Spikes – Other possibilities

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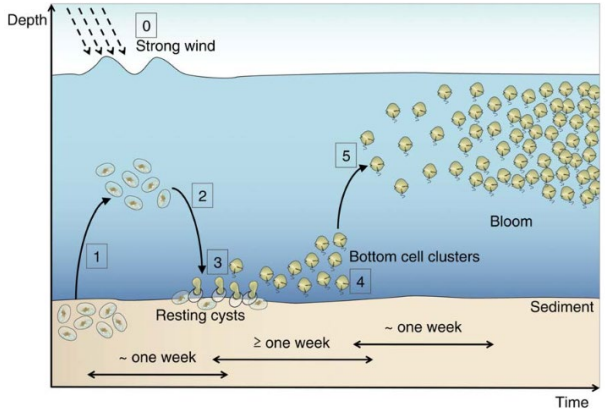

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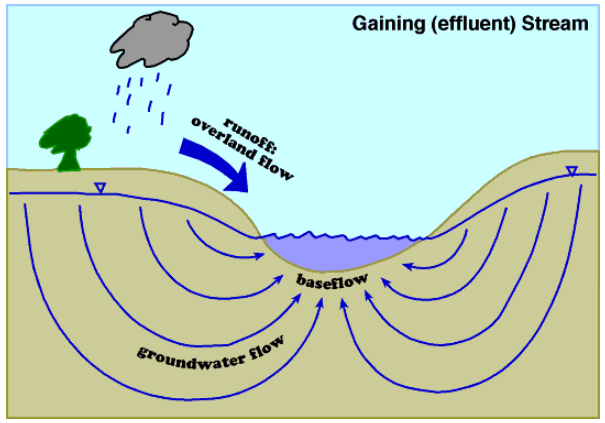

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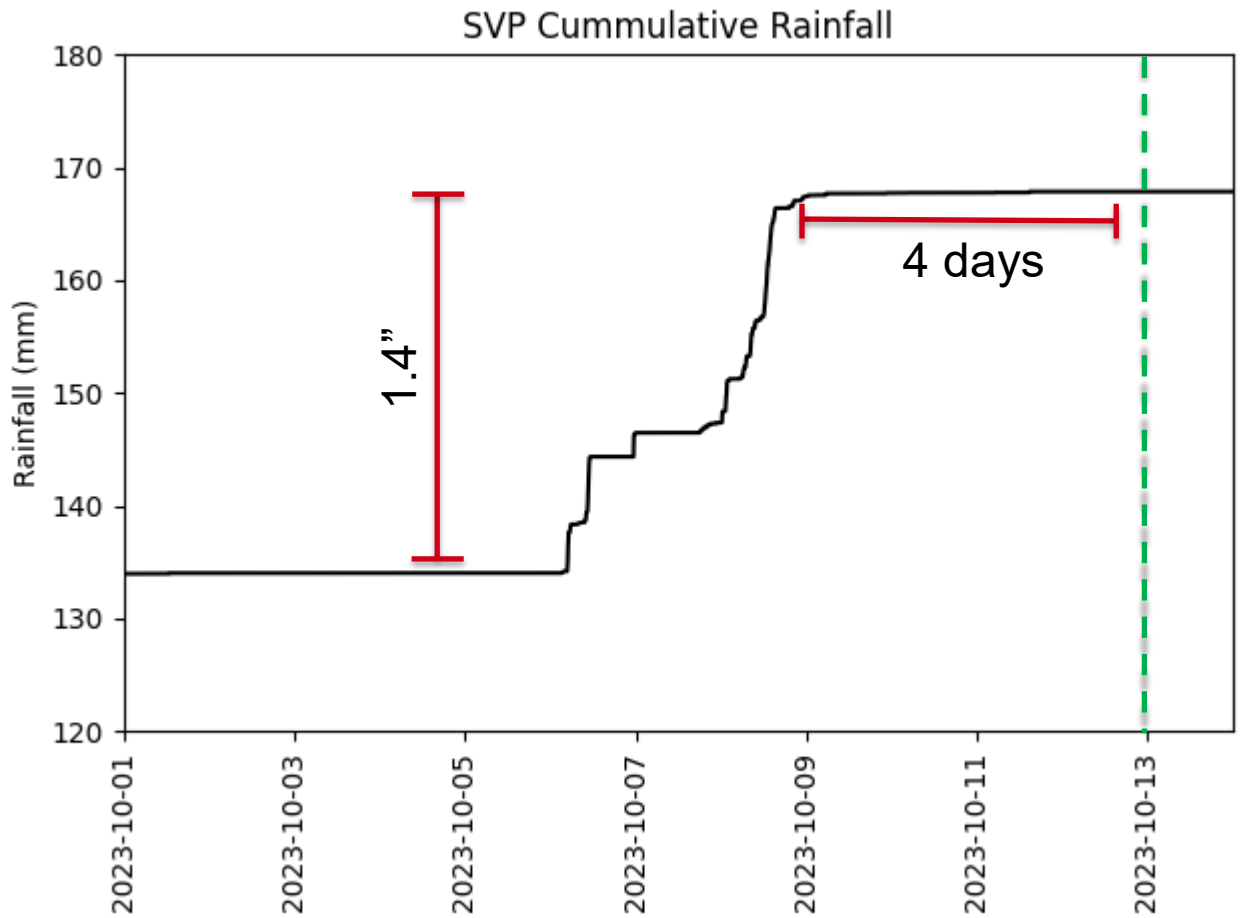

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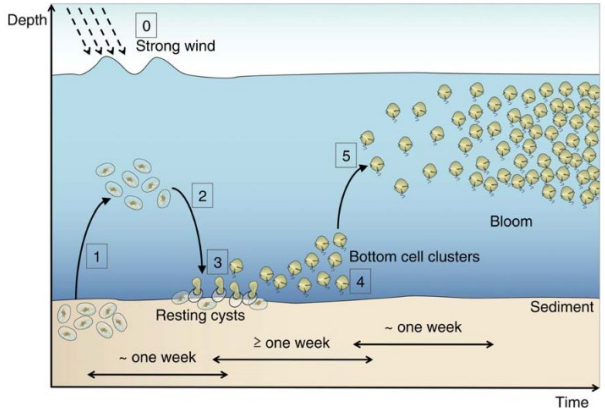

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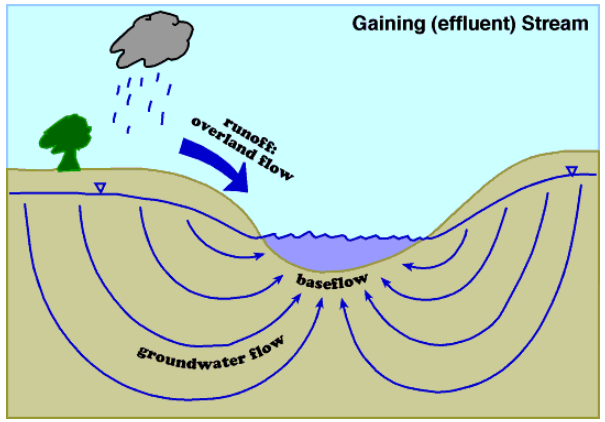

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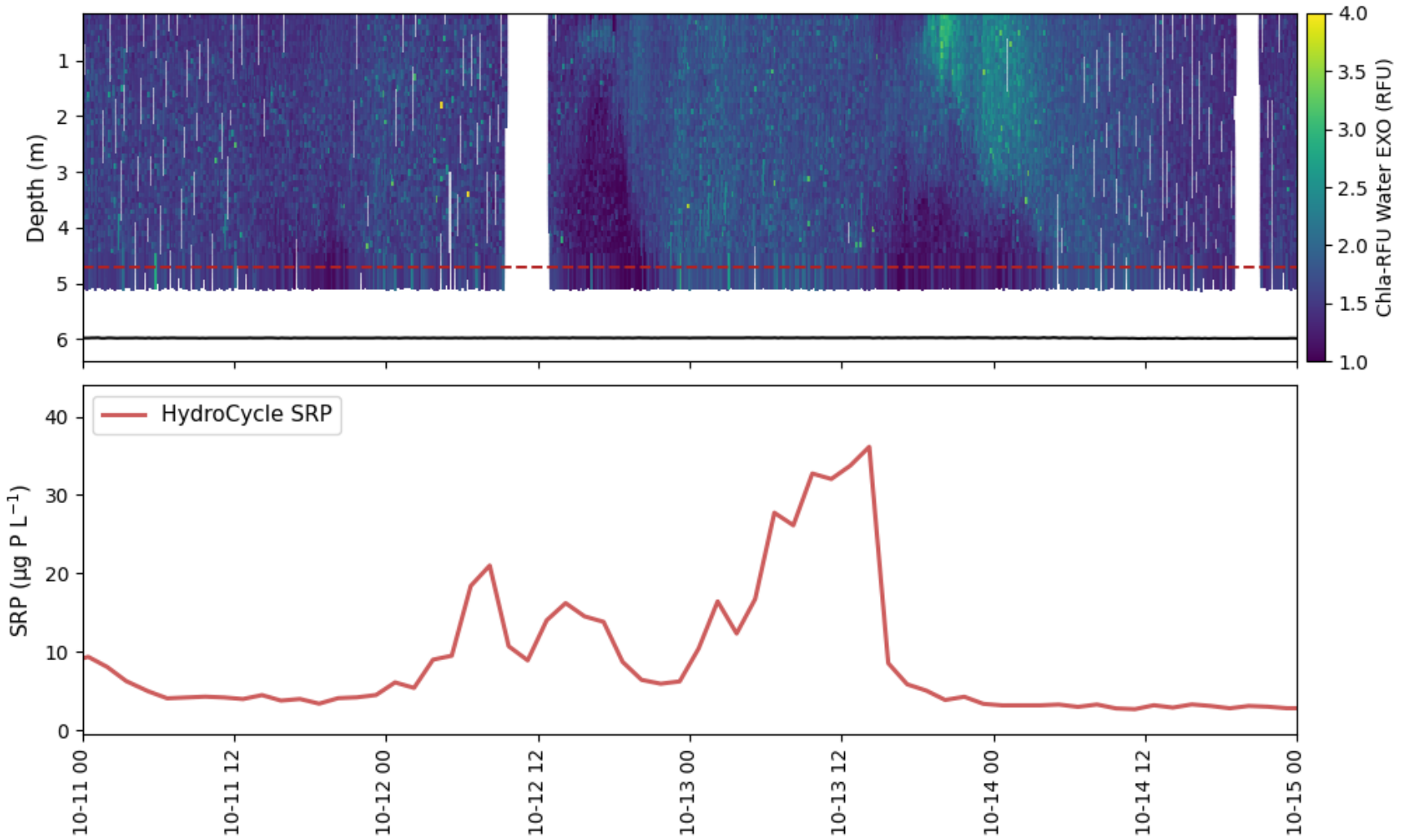

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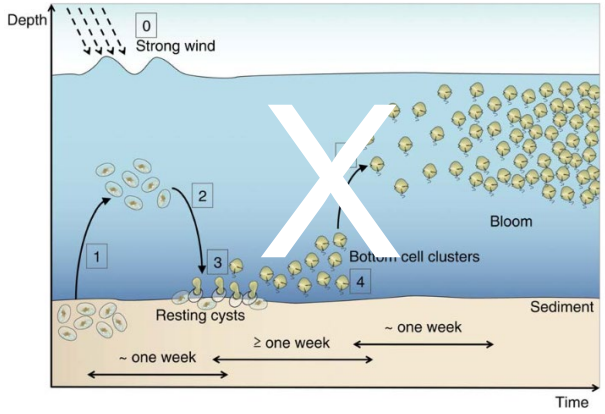

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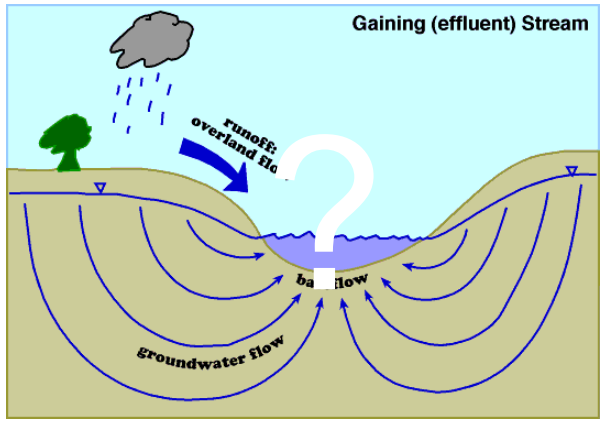
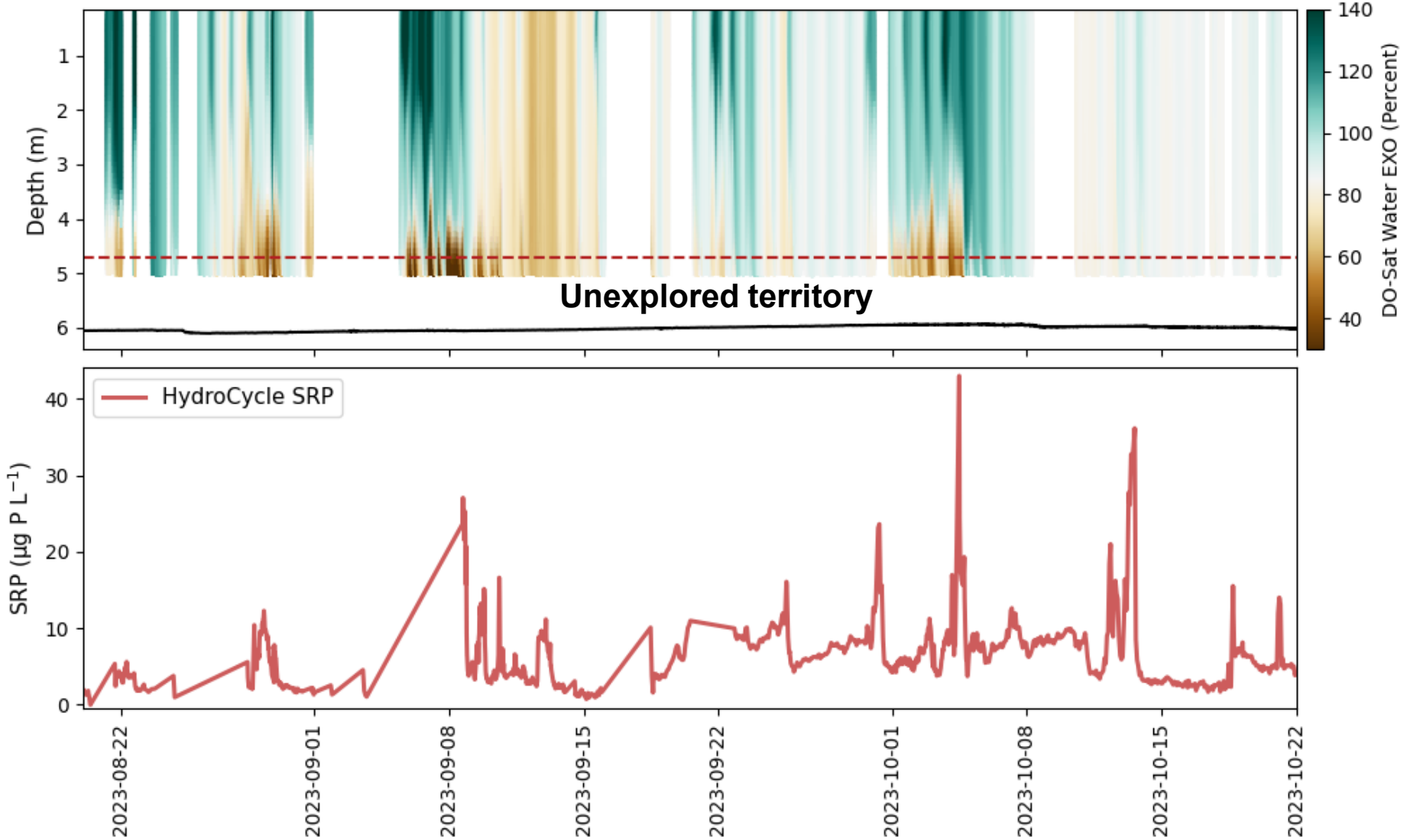
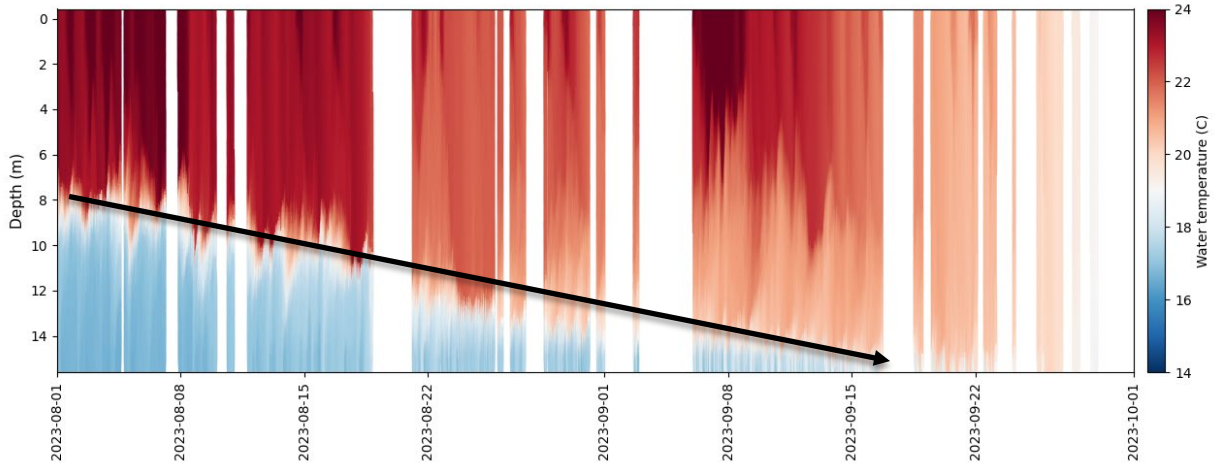
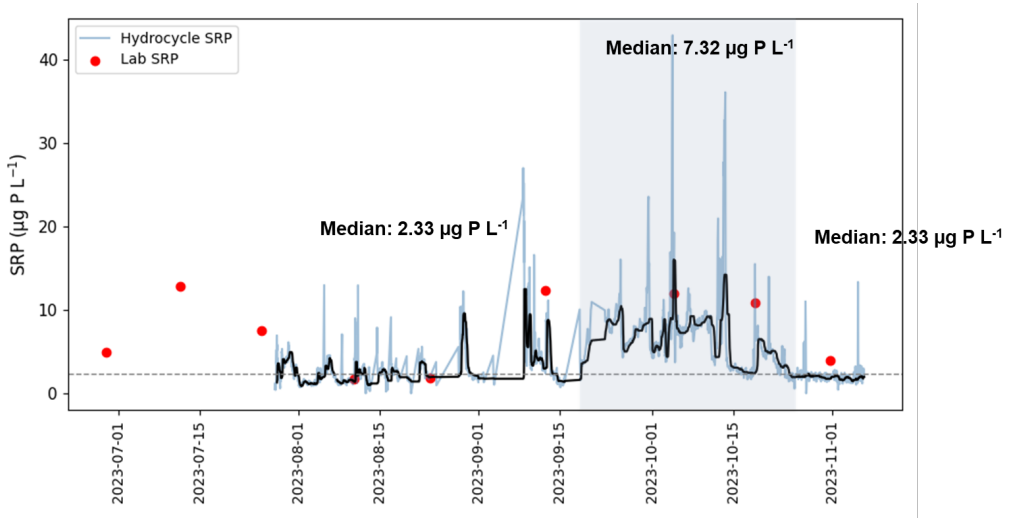


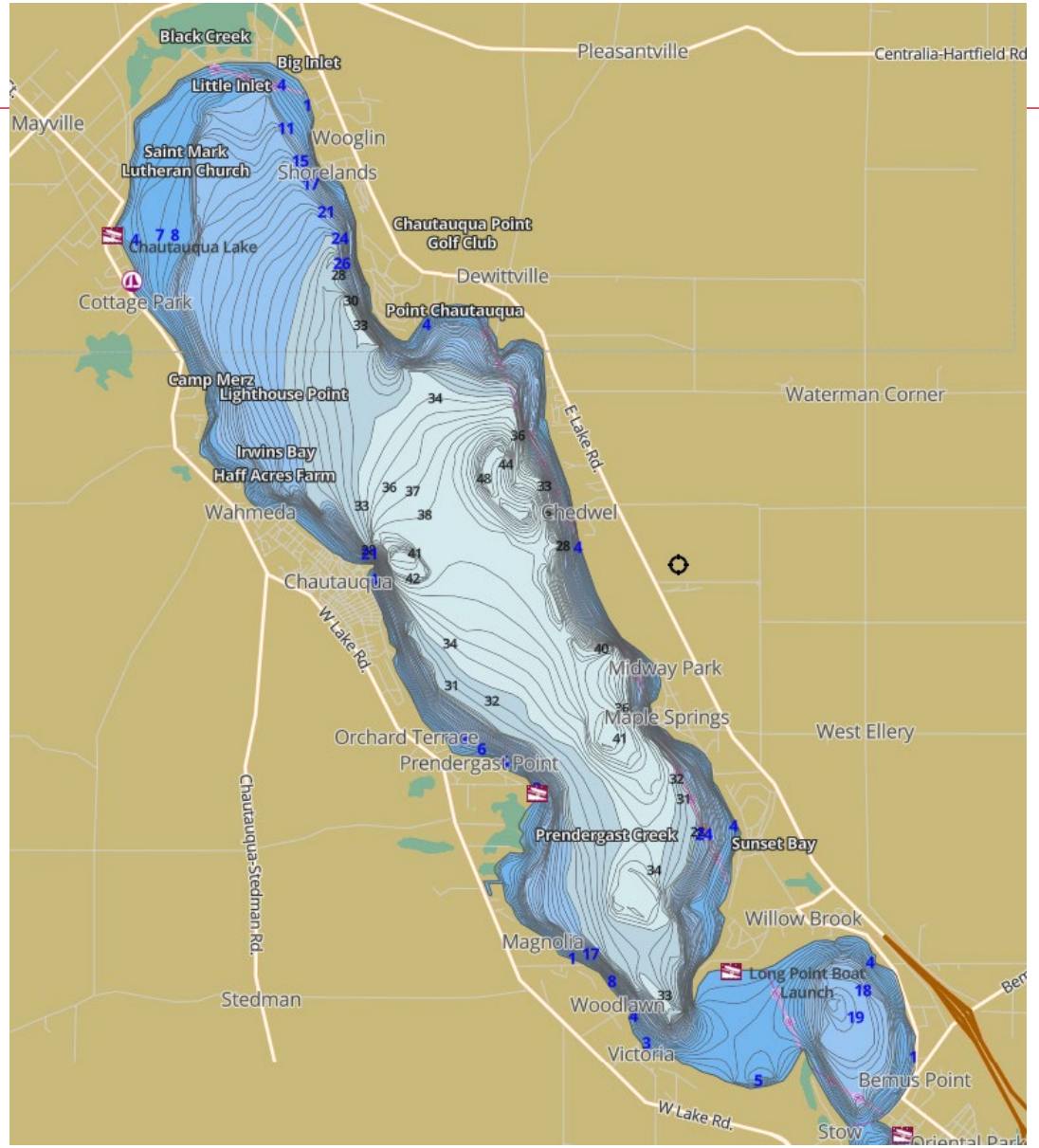
Spikes - Reductive dissolution



Fall increase – North Basin turnover







Fall increase – Macrophyte dieback/senescence

- Seasonal dieback of macrophytes can lead to substantial release of P back into the water column
- Timing of P increase is coincident with likely dieback in CHQ lake
- Need better understanding of species present and lifecycles

Chautauqua Lake Macrophyte Management Strategy, 2017

Conclusion

Main Findings

- Successful deployment strategy
- Internal loading is likely a significant source of P in the south basin of Chautauqua Lake
- Strong evidence for reductive dissolution
- Evidence for other sources of internal/external loading as well

Future Work

- Integrating some additional sensor data into analysis
- Incorporation of tributary station data
- Additional deployments

Acknowledgements

The Jefferson Project at Lake George

Organizations

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Chautauqua Lake & Watershed Management Alliance

Chautauqua Institution

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IBM Research

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LGA Lake George Association