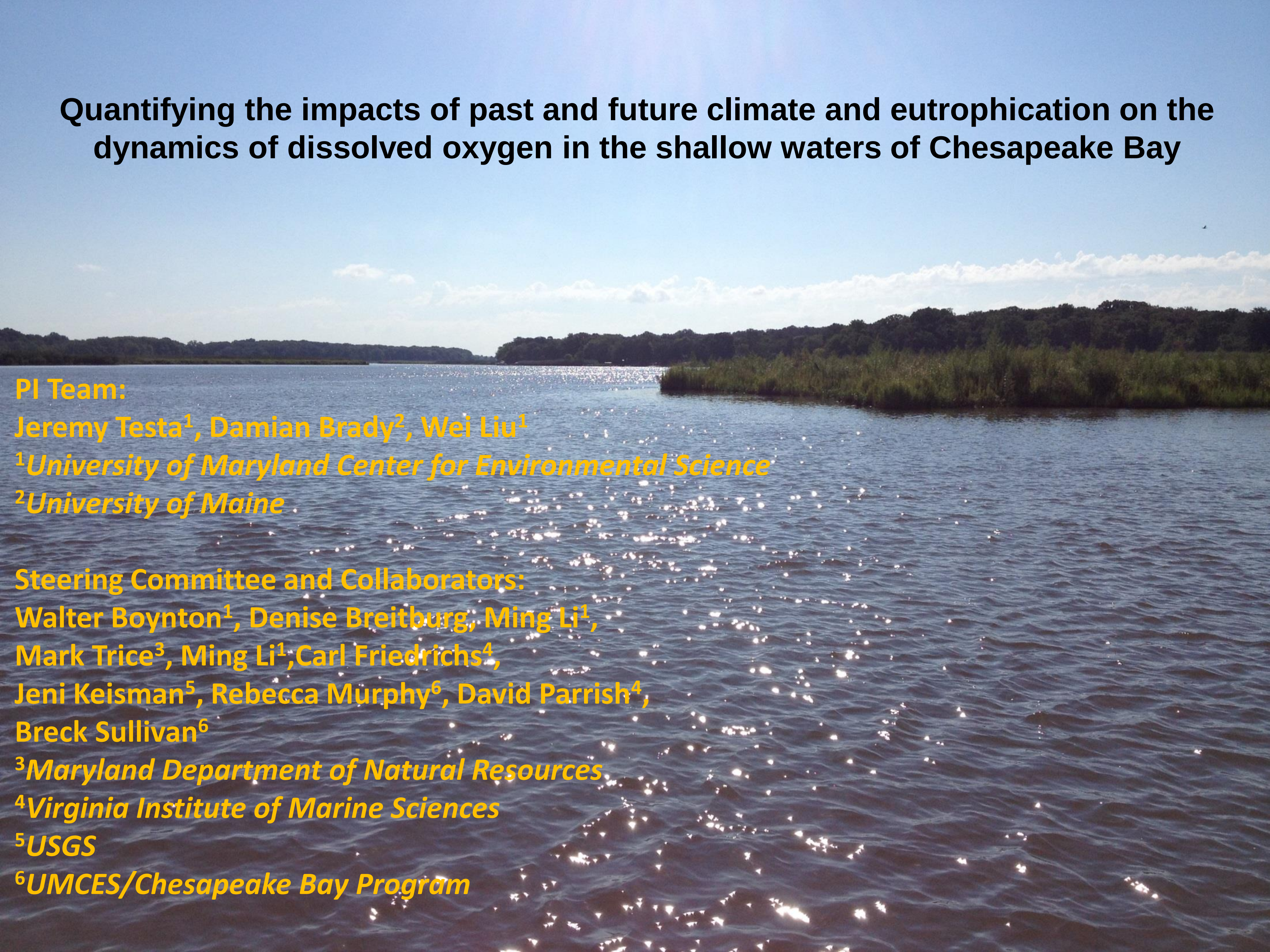
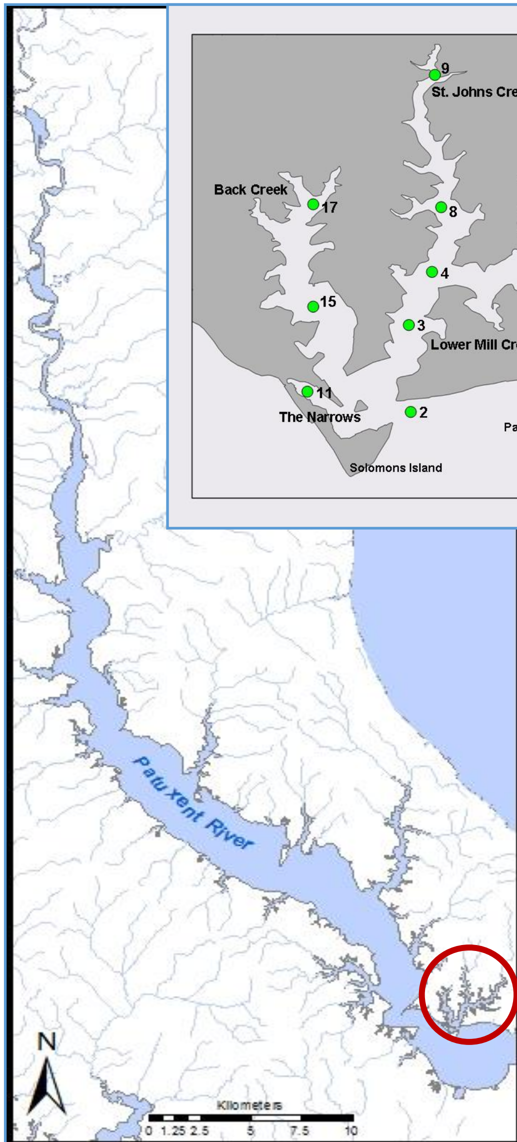


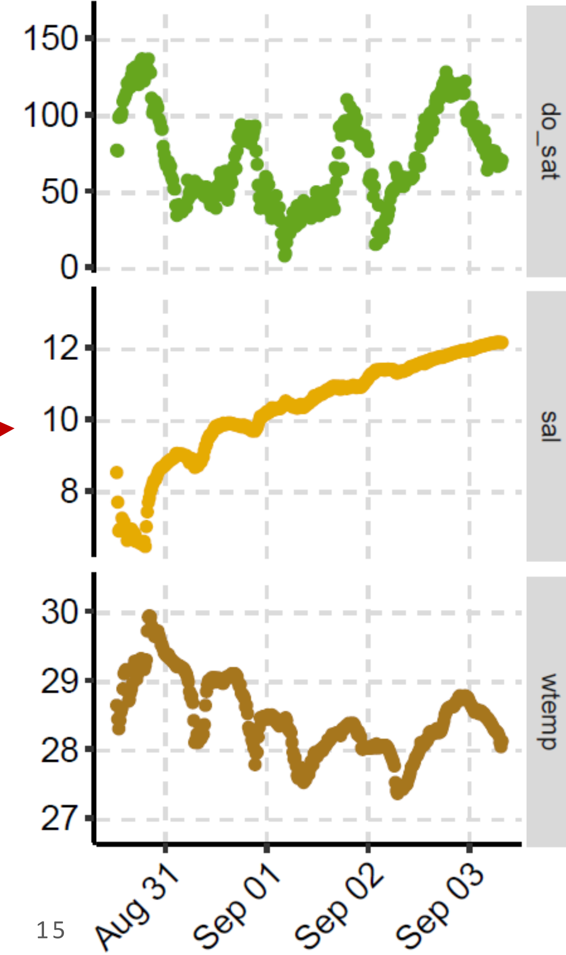
Quantifying the impacts of past and future climate and eutrophication on the dynamics of dissolved oxygen in the shallow waters of Chesapeake Bay

PI Team:
Jeremy Testa[1], Damian Brady[2], Wei Liu[1]
[1]*University of Maryland Center for Environmental Science*
[2]*University of Maine*

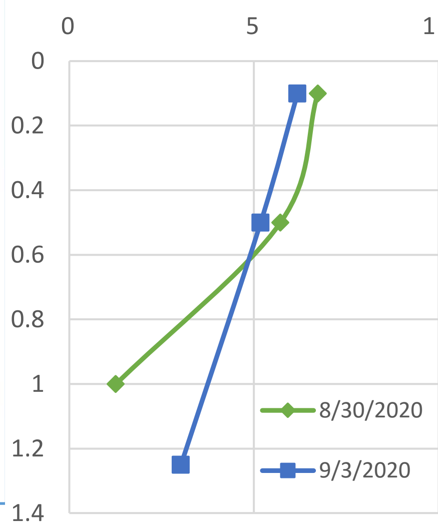
Steering Committee and Collaborators:
Walter Boynton[1], Denise Breitburg, Ming Li[1],
Mark Trice[3], Ming Li[1],Carl Friedrichs[4],
Jeni Keisman[5], Rebecca Murphy[6], David Parrish[4],
Breck Sullivan[6]
[3]*Maryland Department of Natural Resources*
[4]*Virginia Institute of Marine Sciences*
[5]*USGS*
[6]*UMCES/Chesapeake Bay Program*

Shallow Water Oxygen is a Challenging Problem

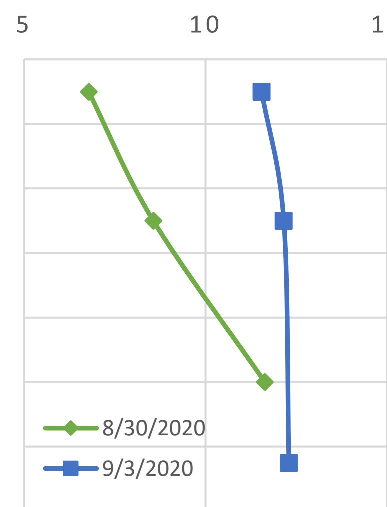




Dissolved O_2 (mg/L)

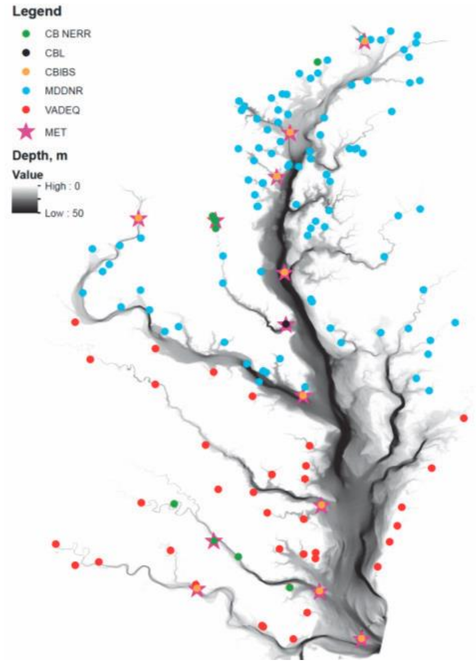


Salinity



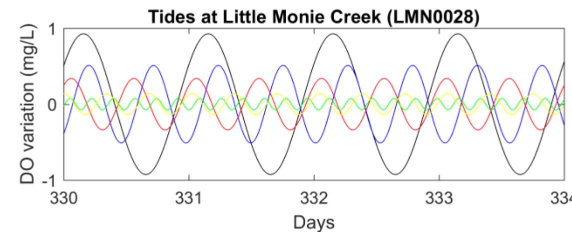
Schematic of Analysis Design

High-Frequency Oxygen Observations

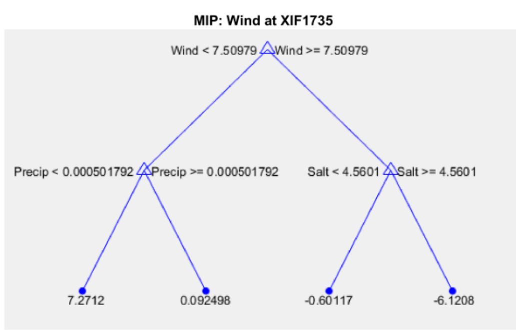


Decompose tidal contribution, isolate residual (biological?) contribution

$$C_{DO}(t) = \overline{C_{DO}} + \sum_{n=1}^{N} A_n \cos(\omega_n t - \theta_n) + R(t)$$

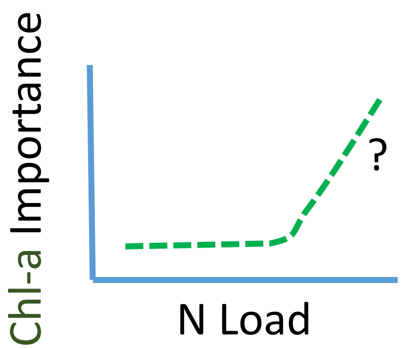


Use CART to link control variables to non-tidal DO variations

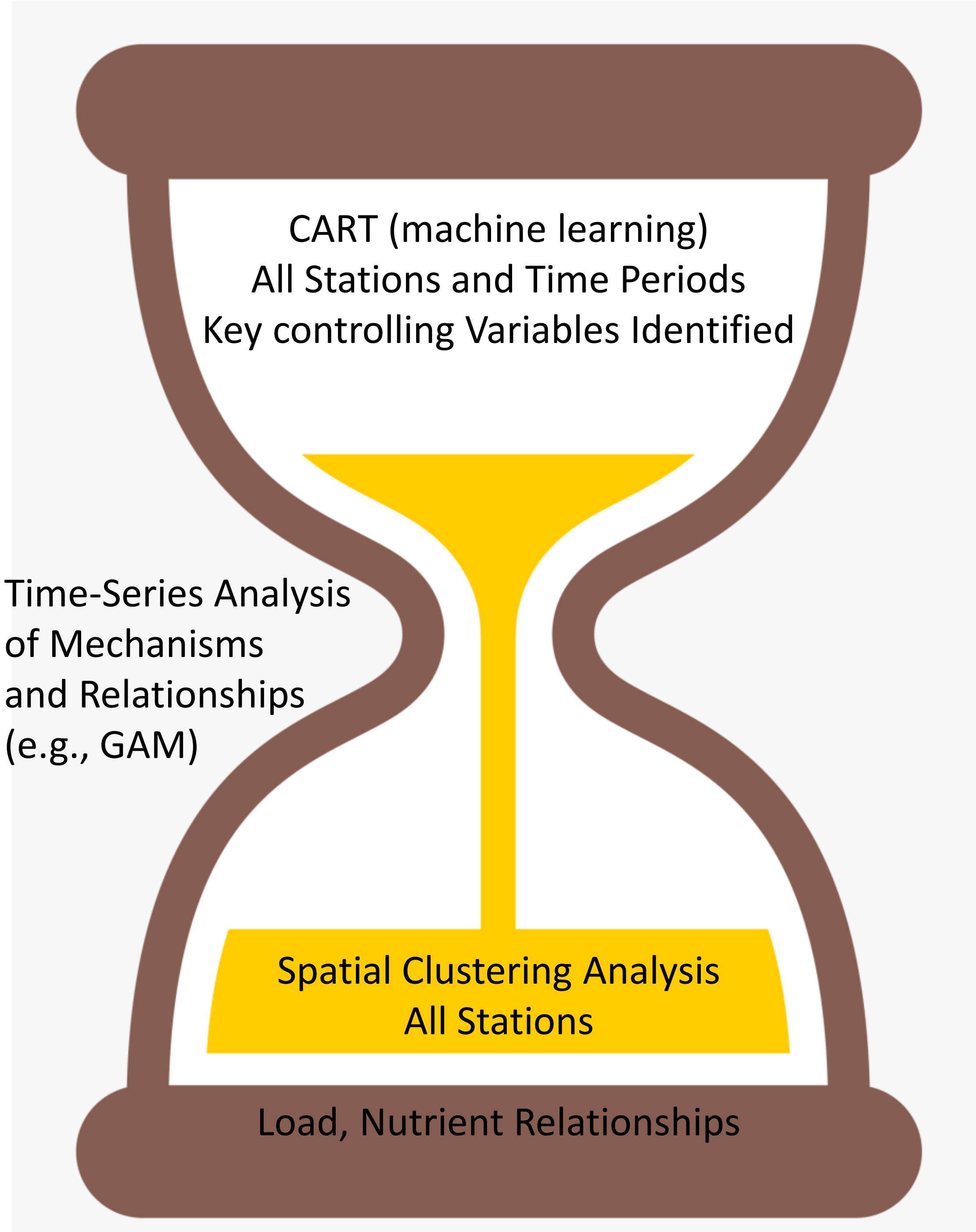


Temp
PAR
CHL-a
Turbidity
Salinity
Precip.
Wind

Associate local conditions (load, metabolism, physical setting) with DO variation



Hourglass Approach



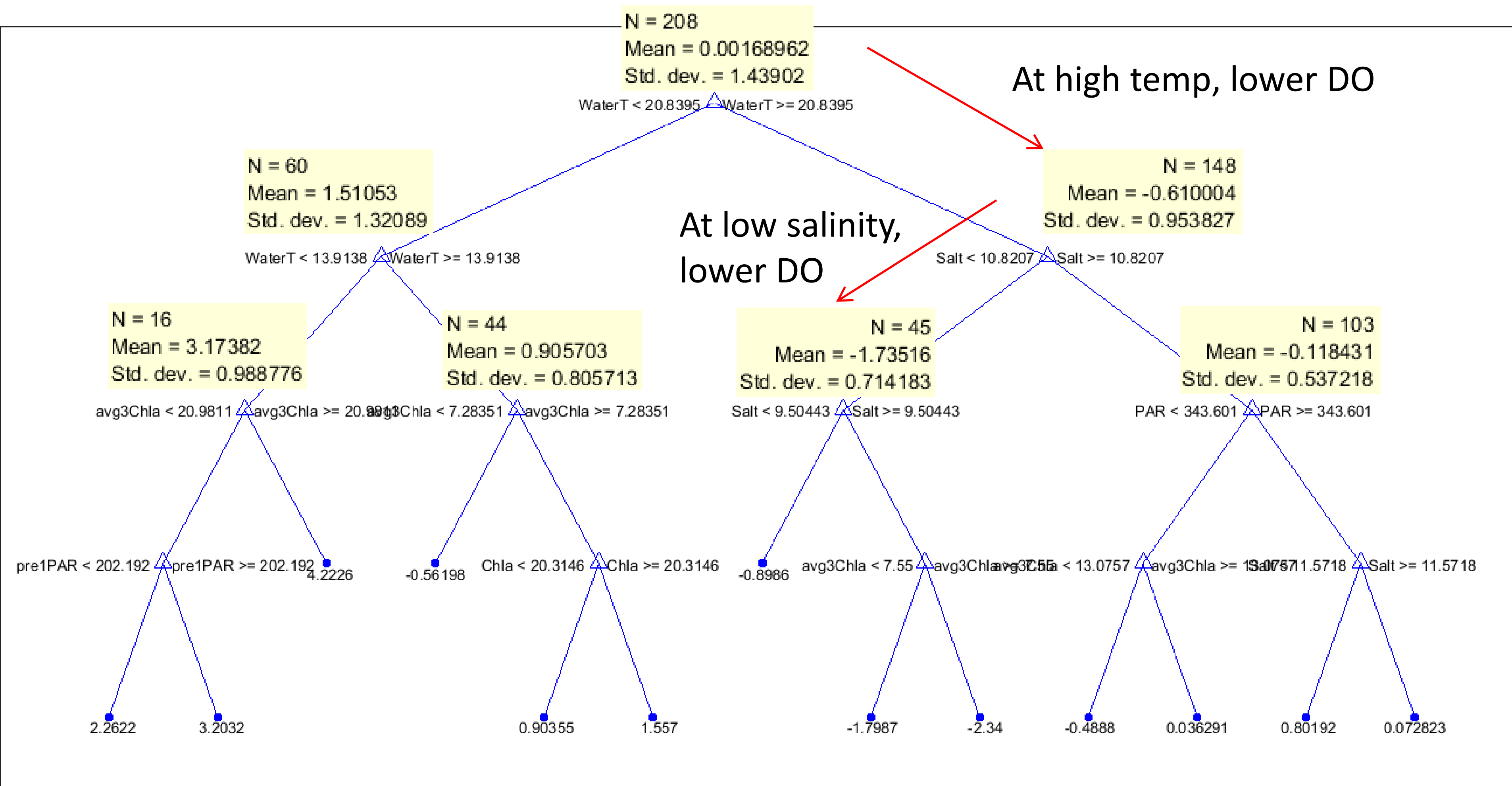
"Blind" Analysis of All Data

Verify Nature of Relationships, Identify Mechanisms

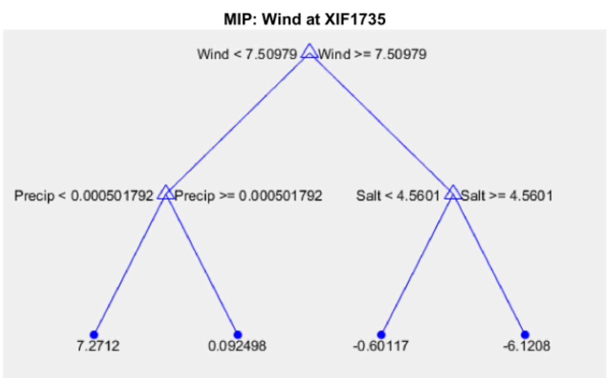
Explain Why Mechanism Important Across Space

CART to Discern Key Variables Driving Residual DO

Example: Regression Tree for ***DO residual*** (mg/L) at Little Monie Creek



Application of CART Across Stations



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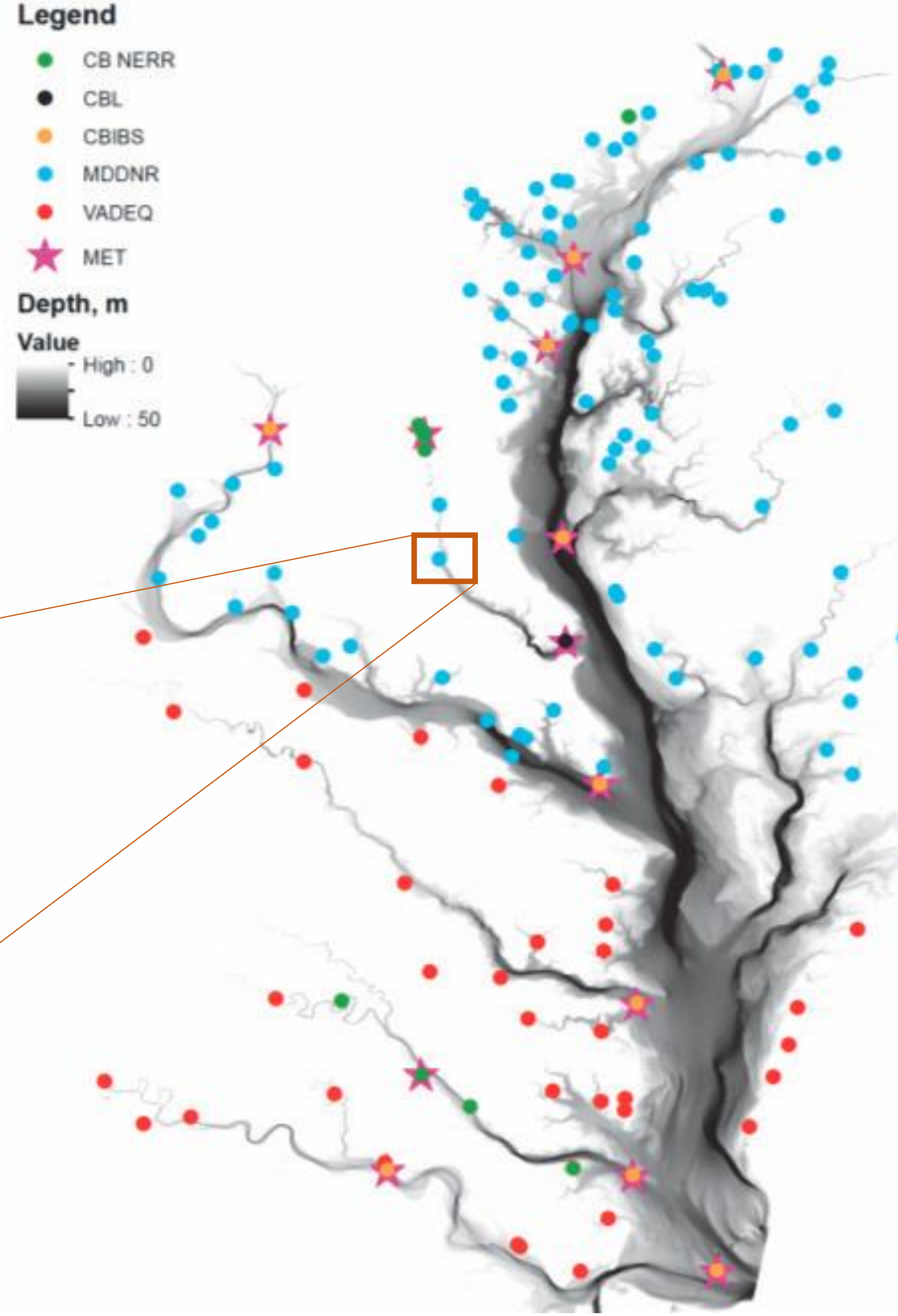
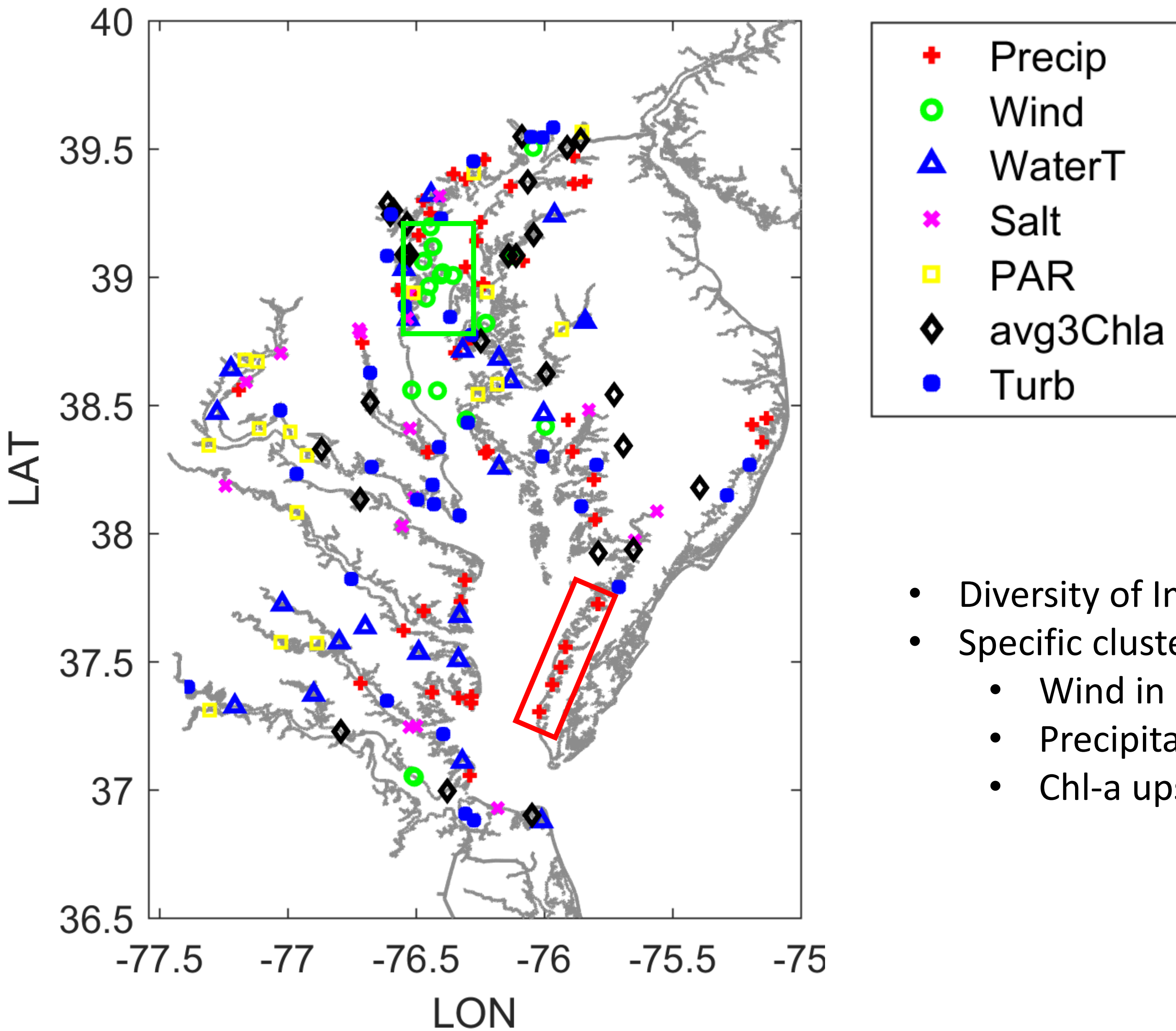
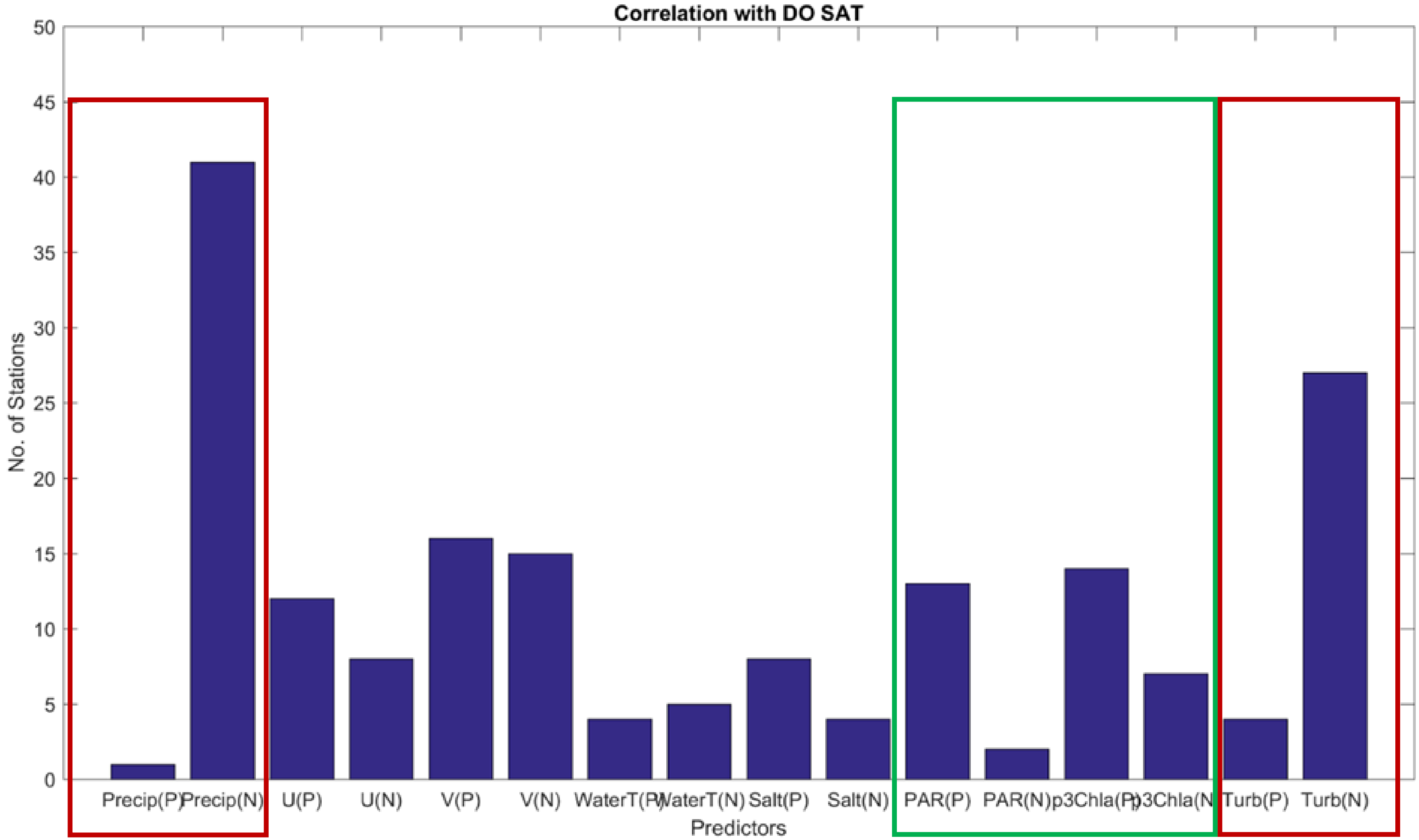


Most important predictor, by station



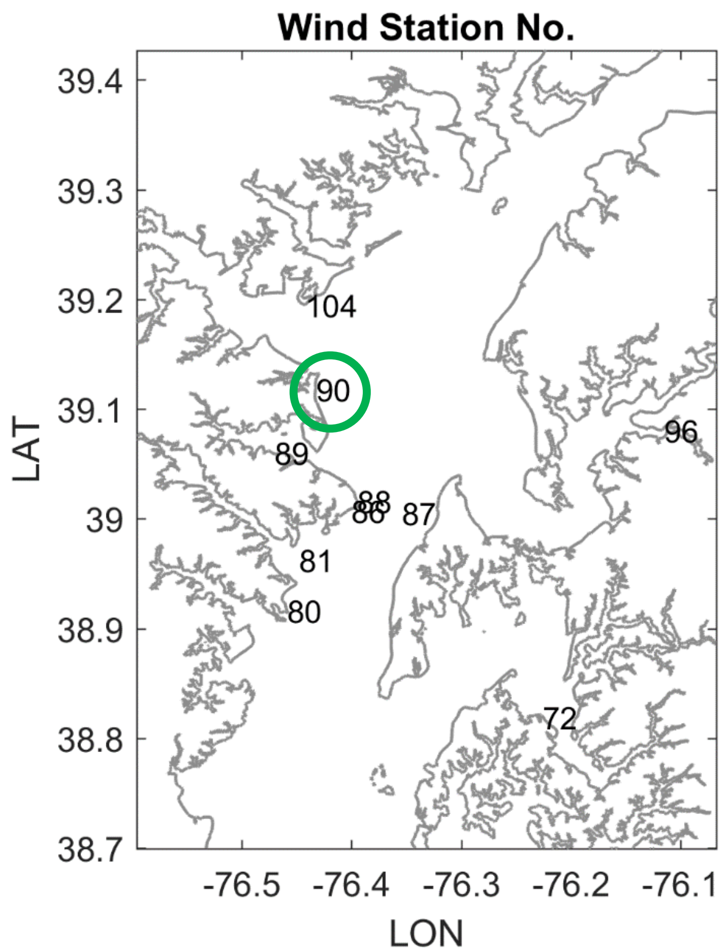
- Diversity of Important variables
- Specific clusters
  - Wind in upper mainstem
  - Precipitation in lower Bay ES
  - Chl-a upstream Baywide

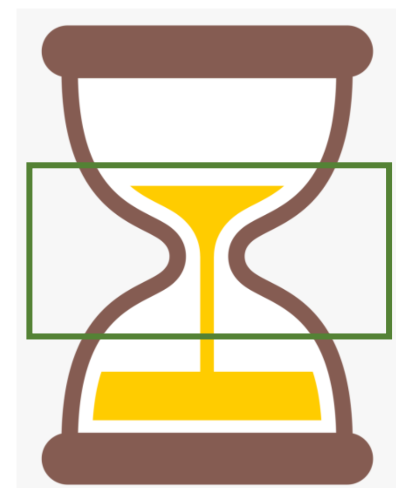
Frequency of most important predictor

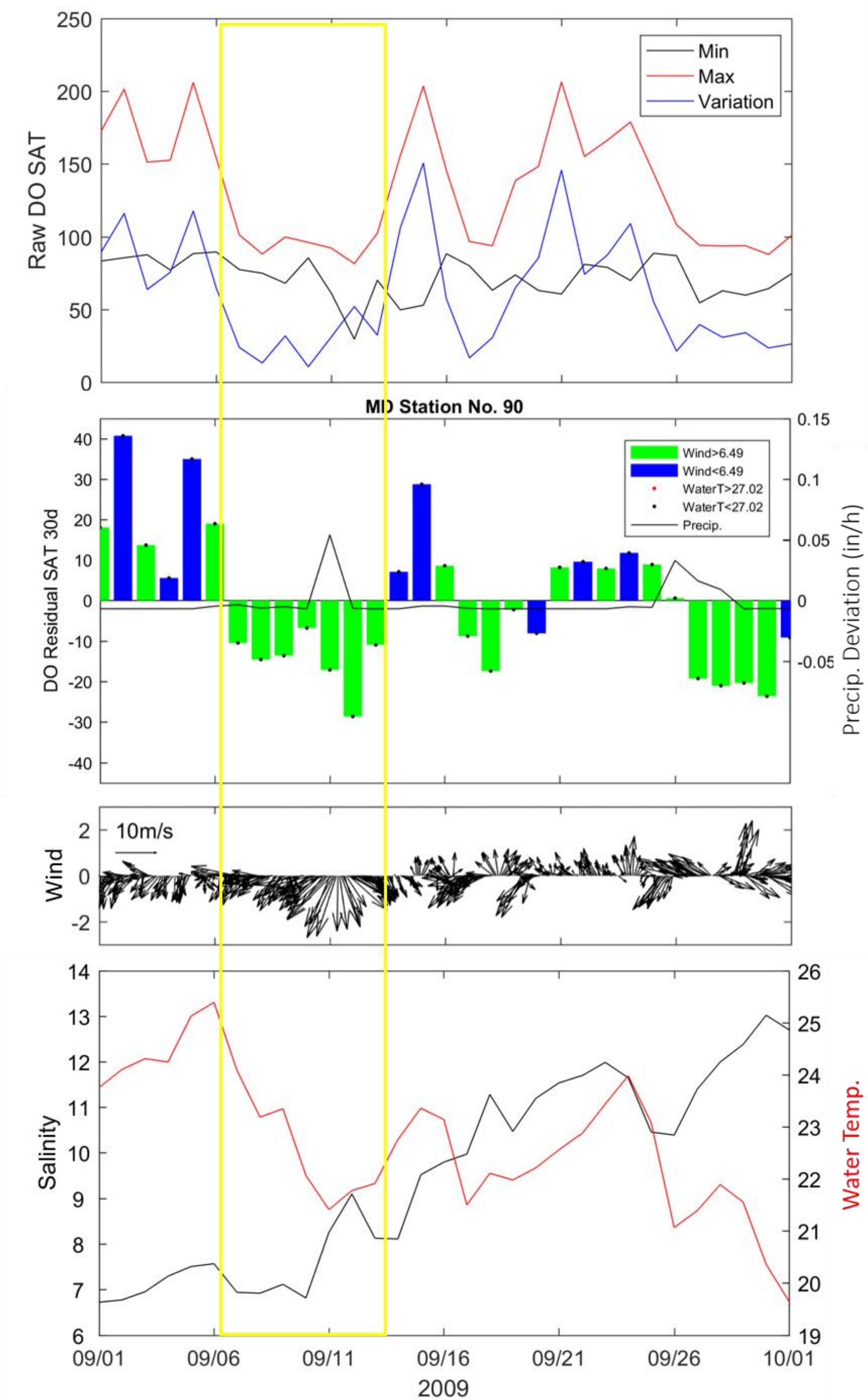


Time Series of sites with wind as MIP

How does wind impact DO?



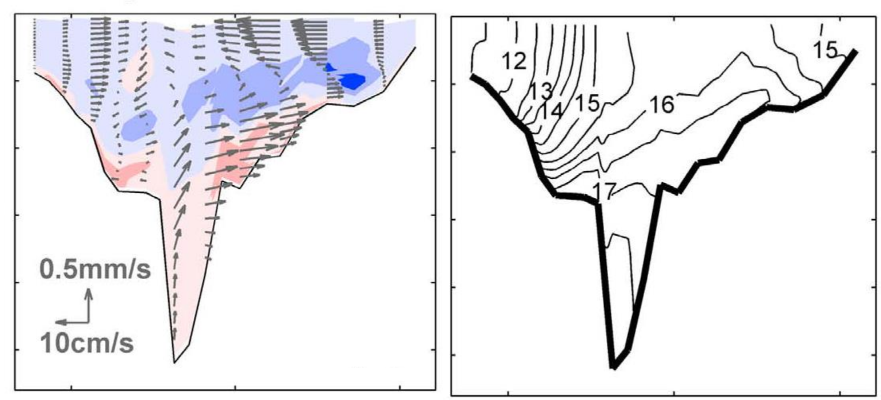




Primary Hypothesis: Wind coming from the north generates Ekman transport/counter-clock lateral circulation (looking upstream), which brings relatively salty water from the eastern shore to the western shore sites

Alternatives for lower do residual: (a) Wind transports upstream organic matter downstream. (b) Air-sea exchange (min and max ~100% saturation)

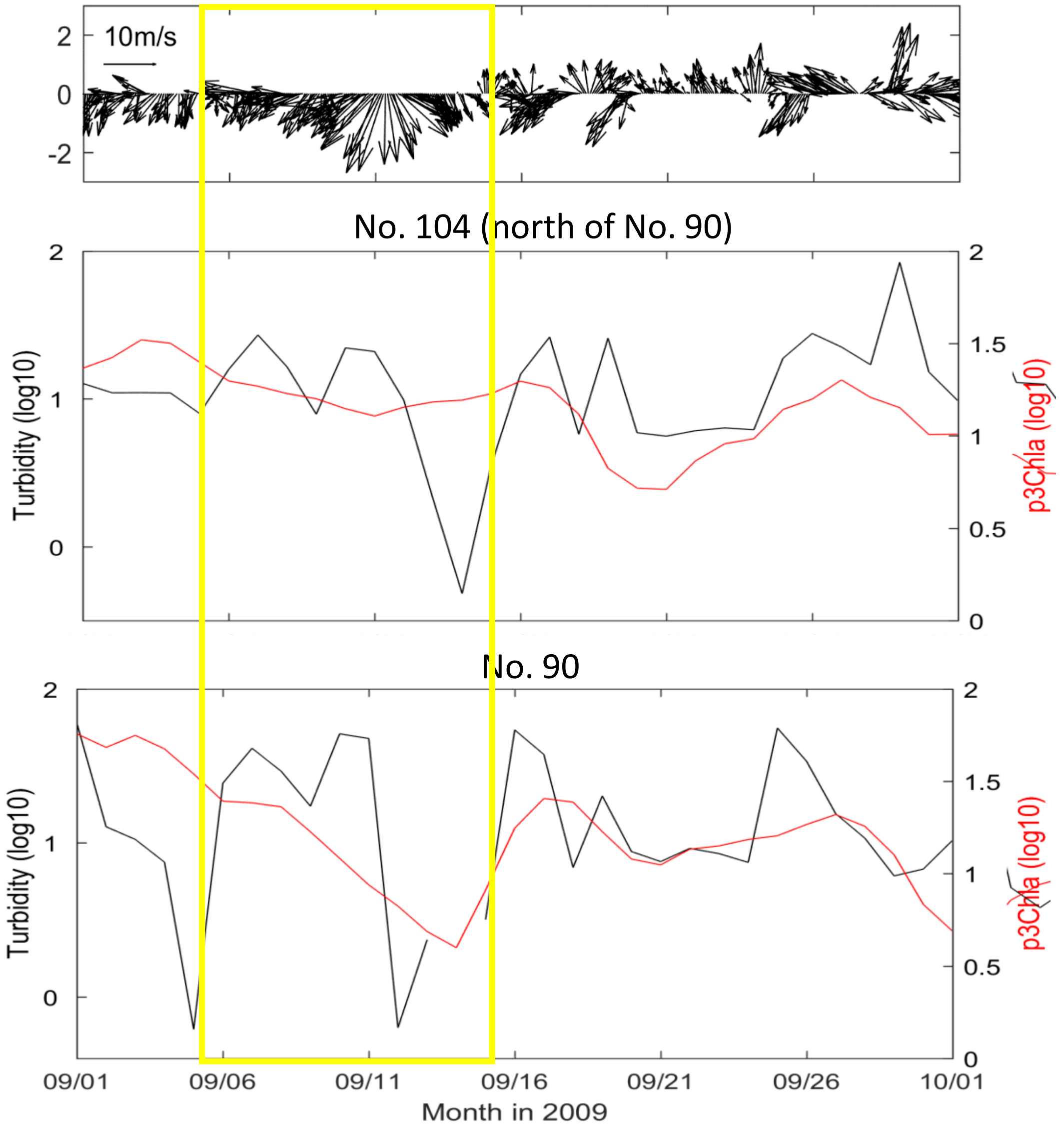
Wind coming from the north

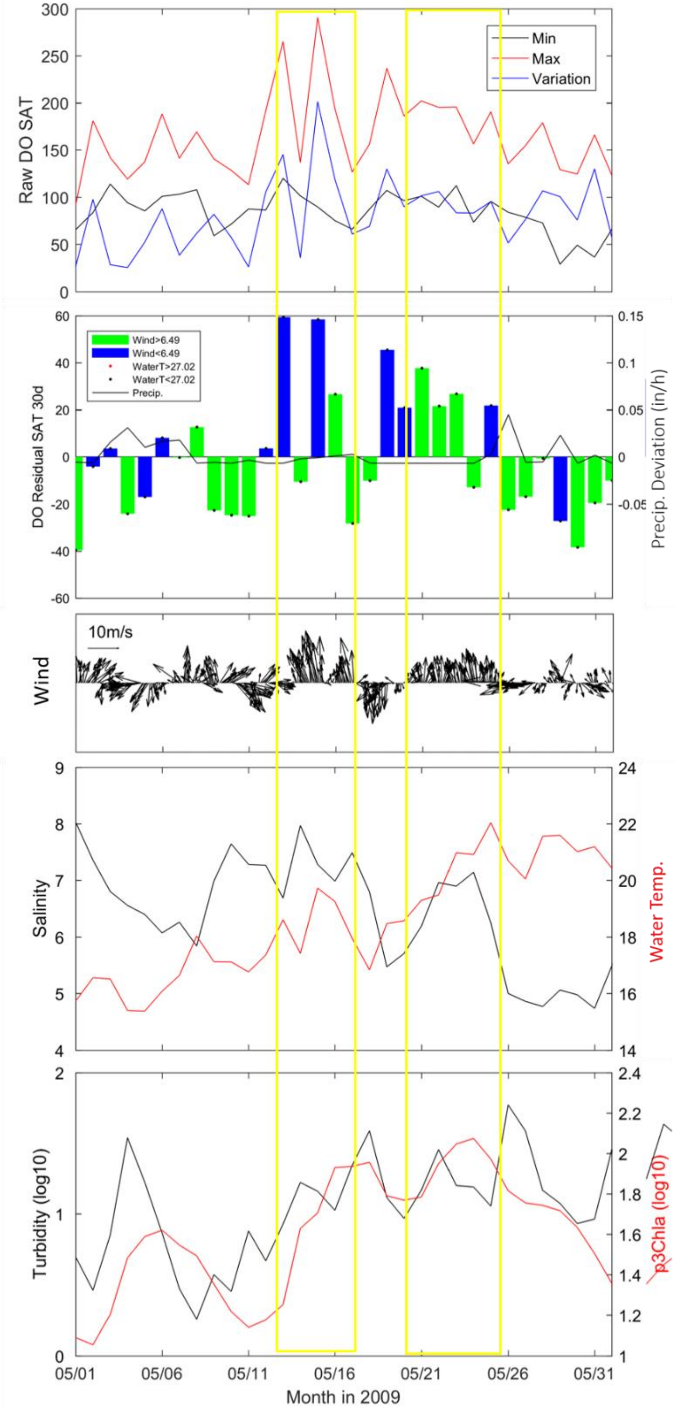


(Looking upstream)

Li&Li, 2012

Under strong North Wind, Chlorophyll-a declines and turbidity increases = lower DO

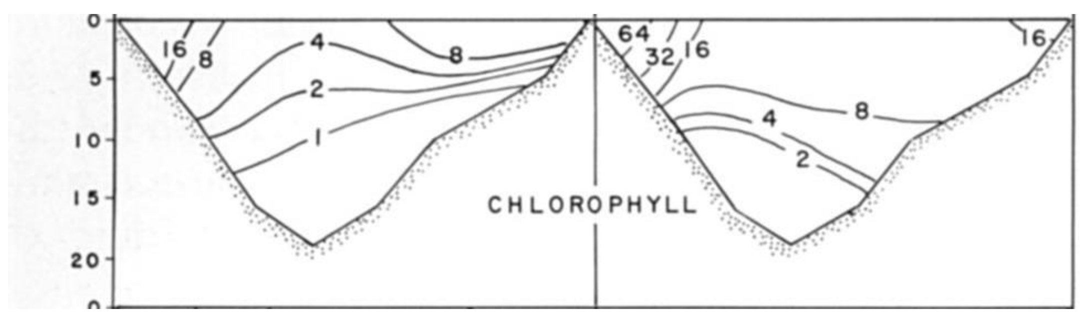




Primary Hypothesis: Wind from the south leads to the opposite effect: clockwise lateral circulation and upwelling in the western shore, which leads to salinity increase and higher DO SAT, due to mixing of nutrients to support blooms.

Previously reported in mainstem CB

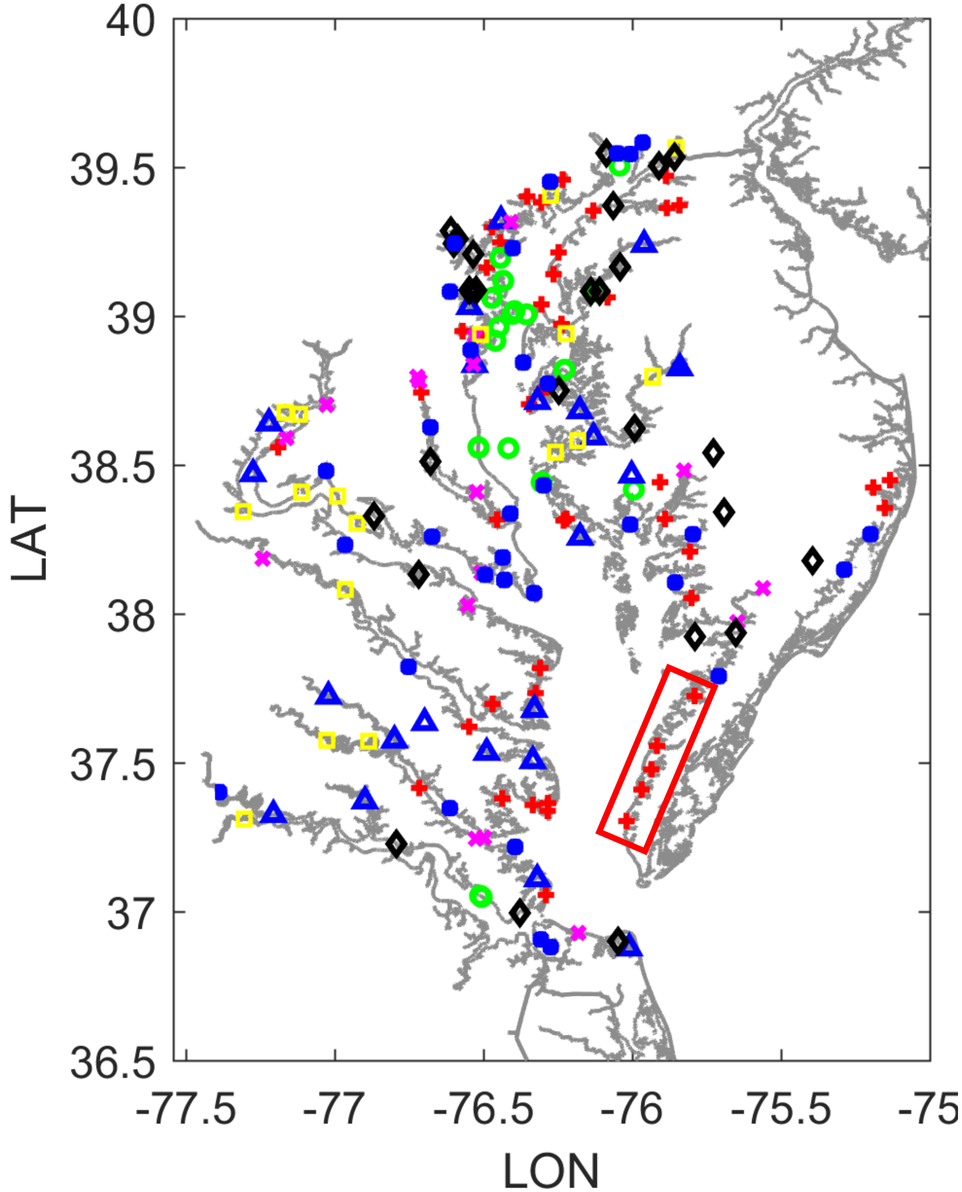
South Wind Event



Malone et al. 1986

How does precipitation effect DO?

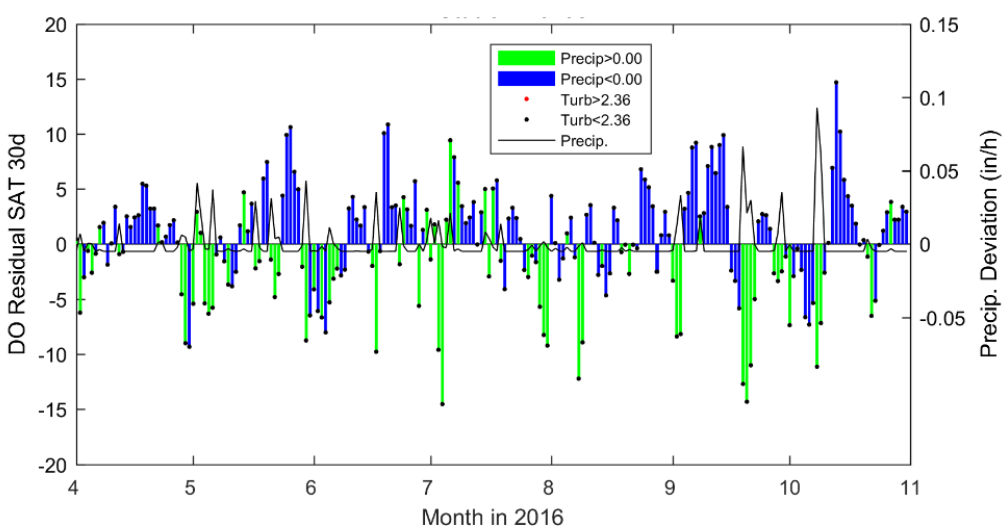
Eastern shore cluster with precipitation as MIP

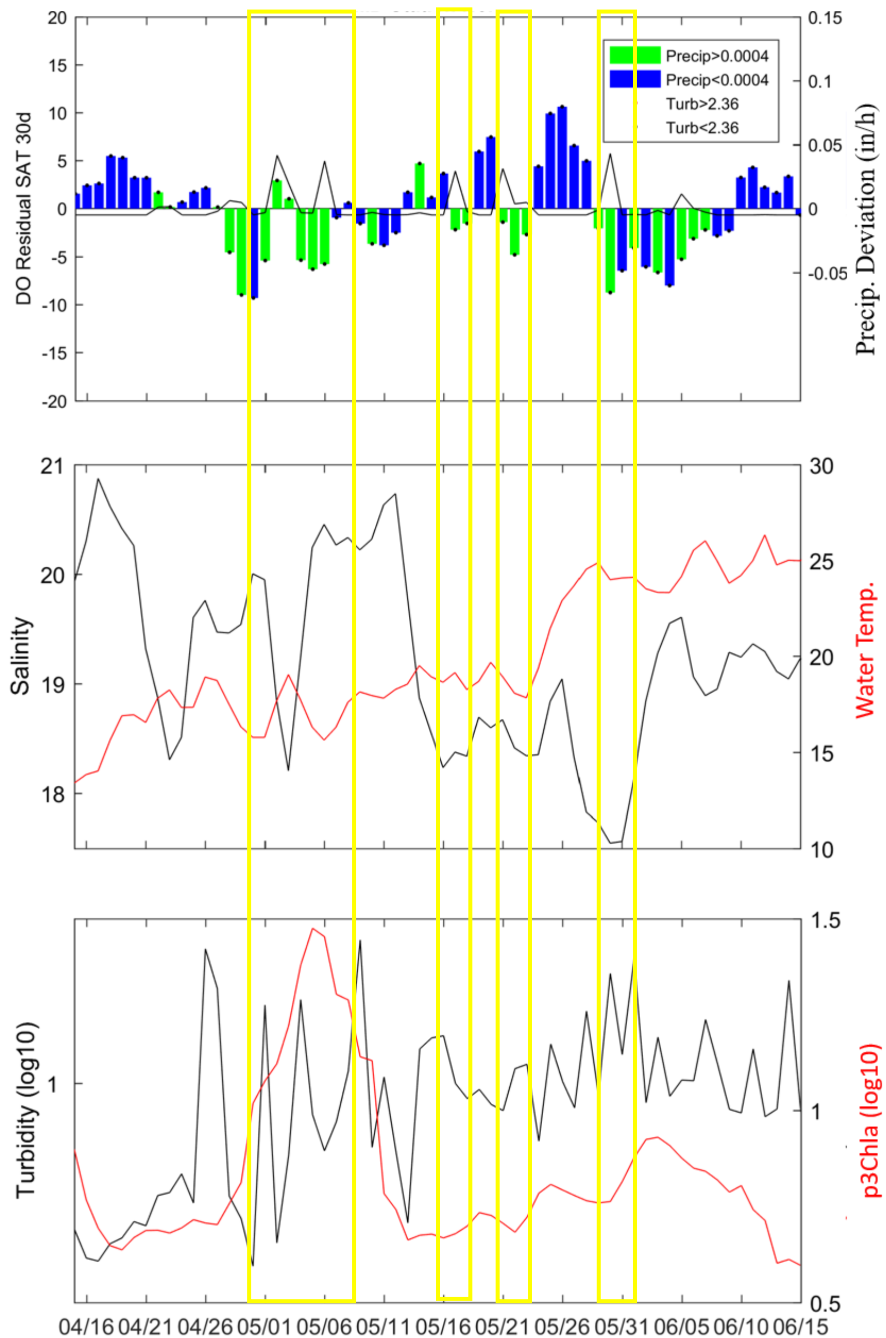


DOSAT is sensitive to precipitation change.

Precipitation divides positive/negative DO SAT.

Precip. Cluster Station No.	Split value of Precip. (cm/day)	Mean DOSAT above	Mean DOSAT below
VA 7	0.0366	-4.9282	1.4560
VA 12	0.1097	-3.8185	1.4318
VA 32	0.0244	-3.2516	1.7603
VA 34	2.0320e-05	-2.3140	1.8397
VA 35	0.1219	-3.6525	1.3514



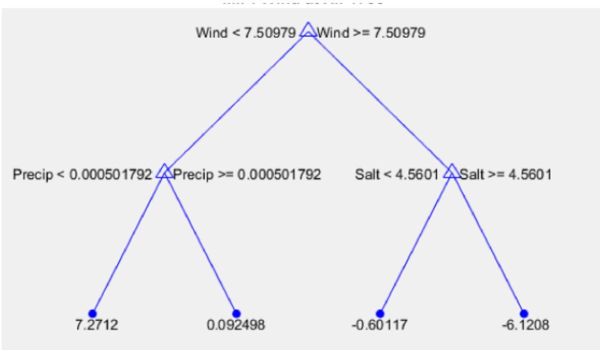


Primary Hypothesis: High precipitation events deliver nutrients into the rivers, leads to phytoplankton growth with increased Chla, then more respiration consumes DO, which eventually lead to low DO SAT.

Alternative: (a) Increasing water Temp. leads to the decreasing trend of DO SAT, (b) elevated flow leads to organic matter input (to increase respiration) and higer turbidity (to slow photosynthetic oxygen production)

CART to Explain Hypoxia Duration in Shallow Waters

Duration of hypoxia



Temp
PAR
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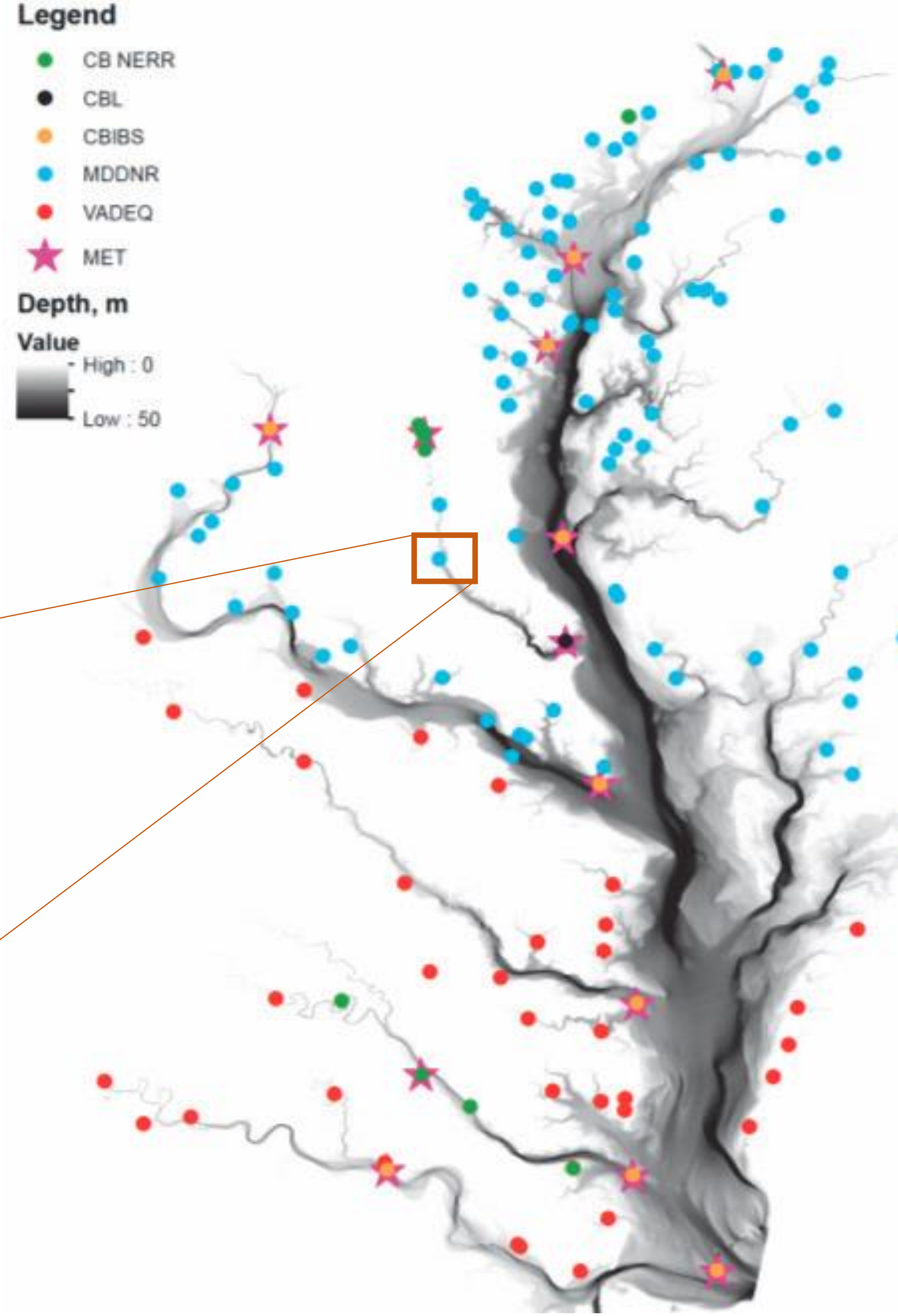
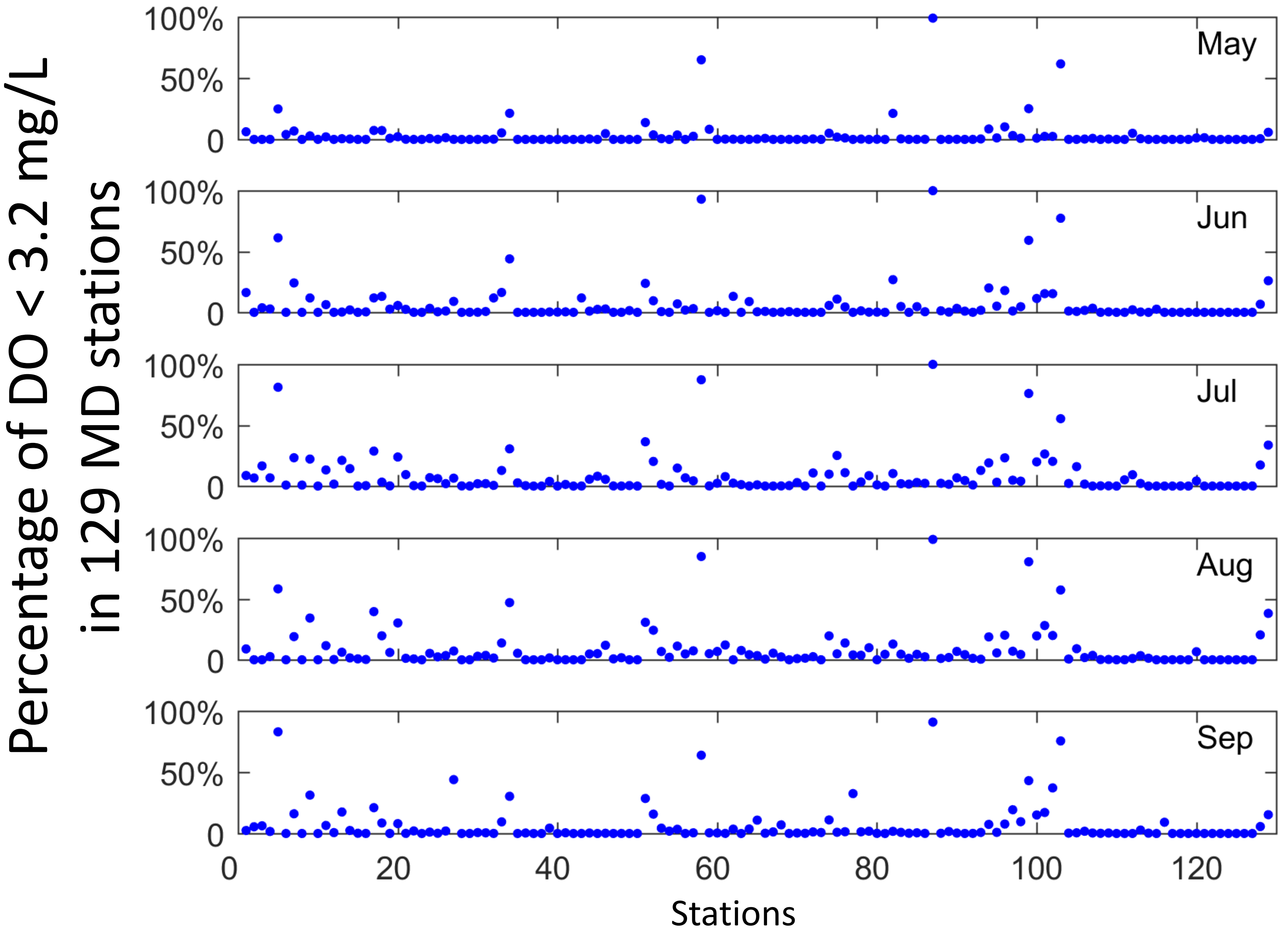
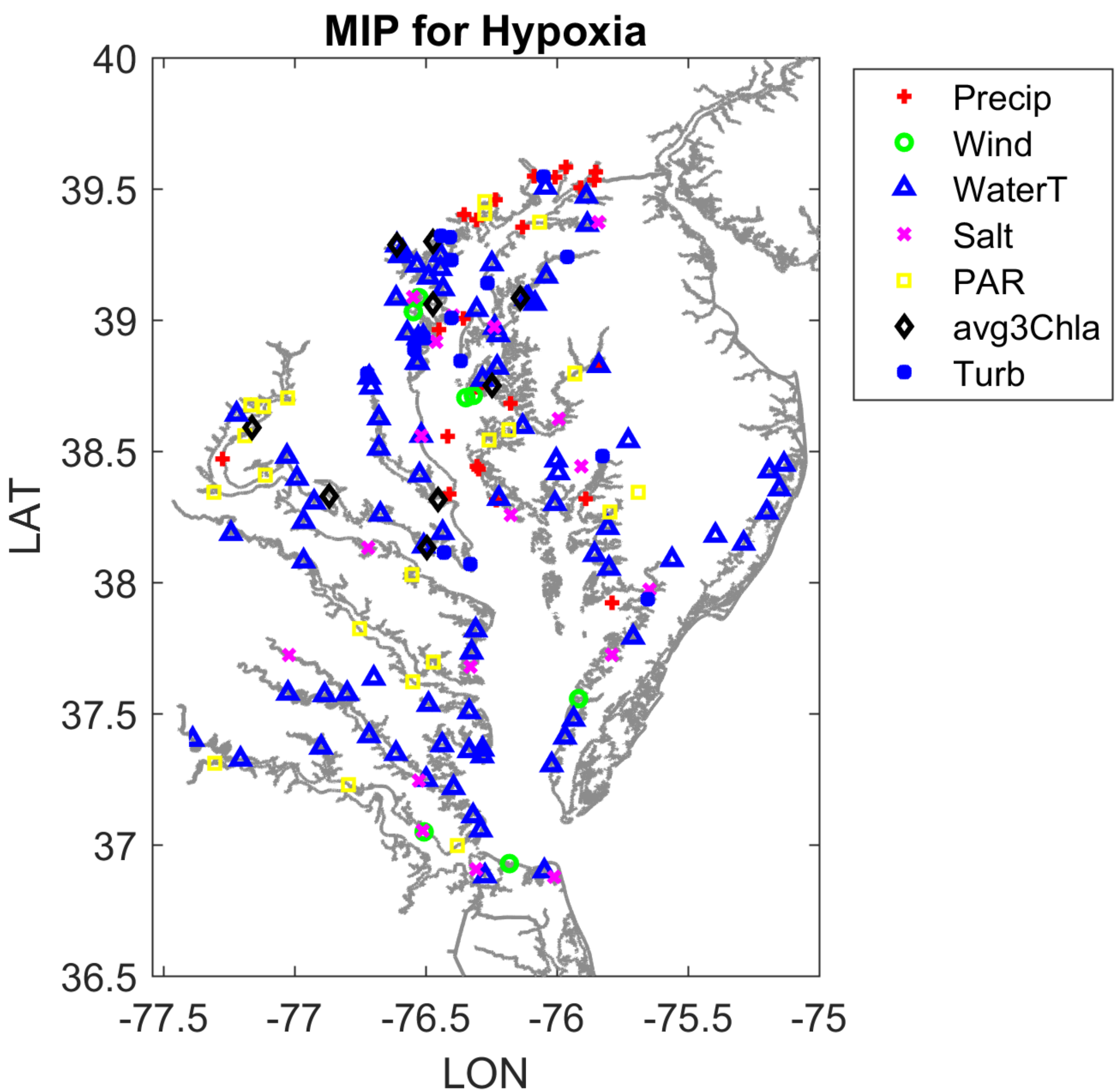


~Half of the MD stations experienced moderate hypoxia, DO < 3.2 mg/L

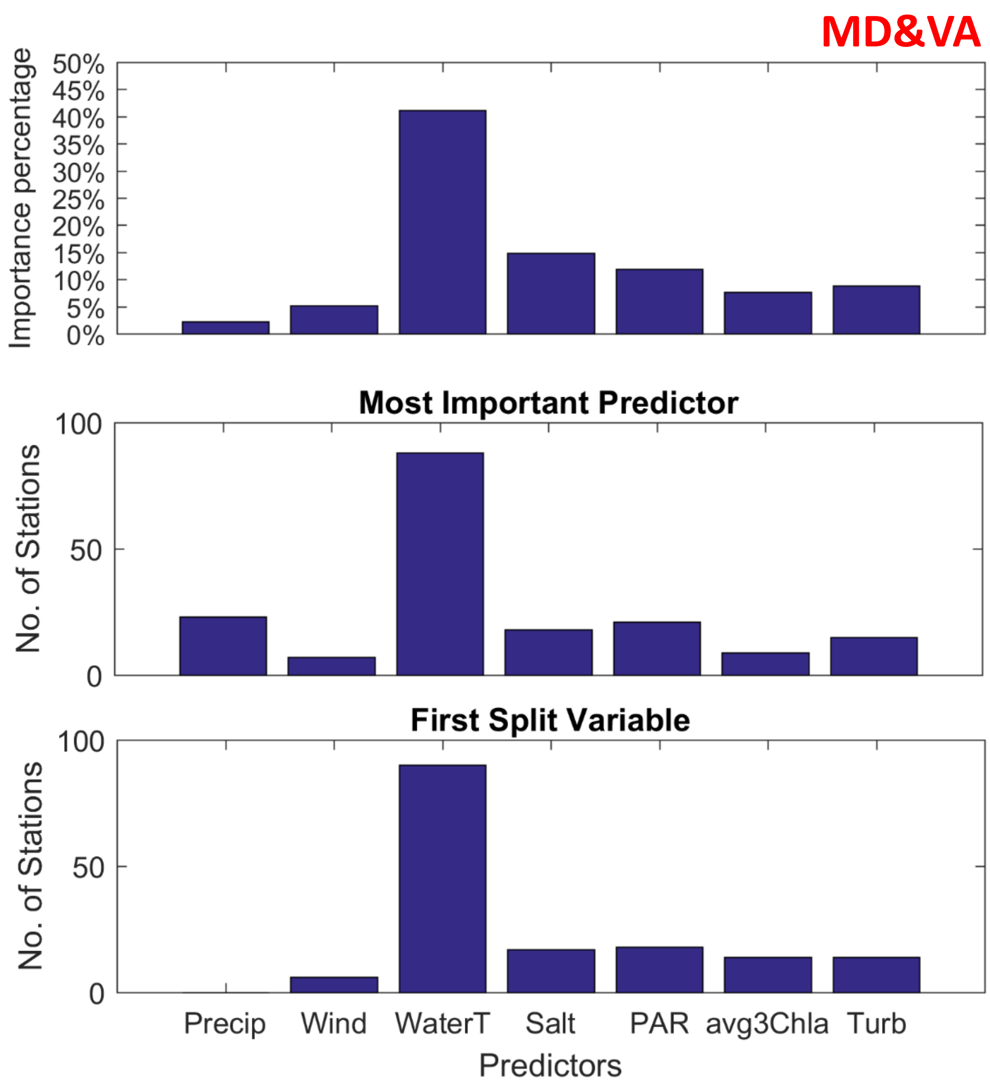


Water Temp. is dominant at most stations except some upper bay/river stations.

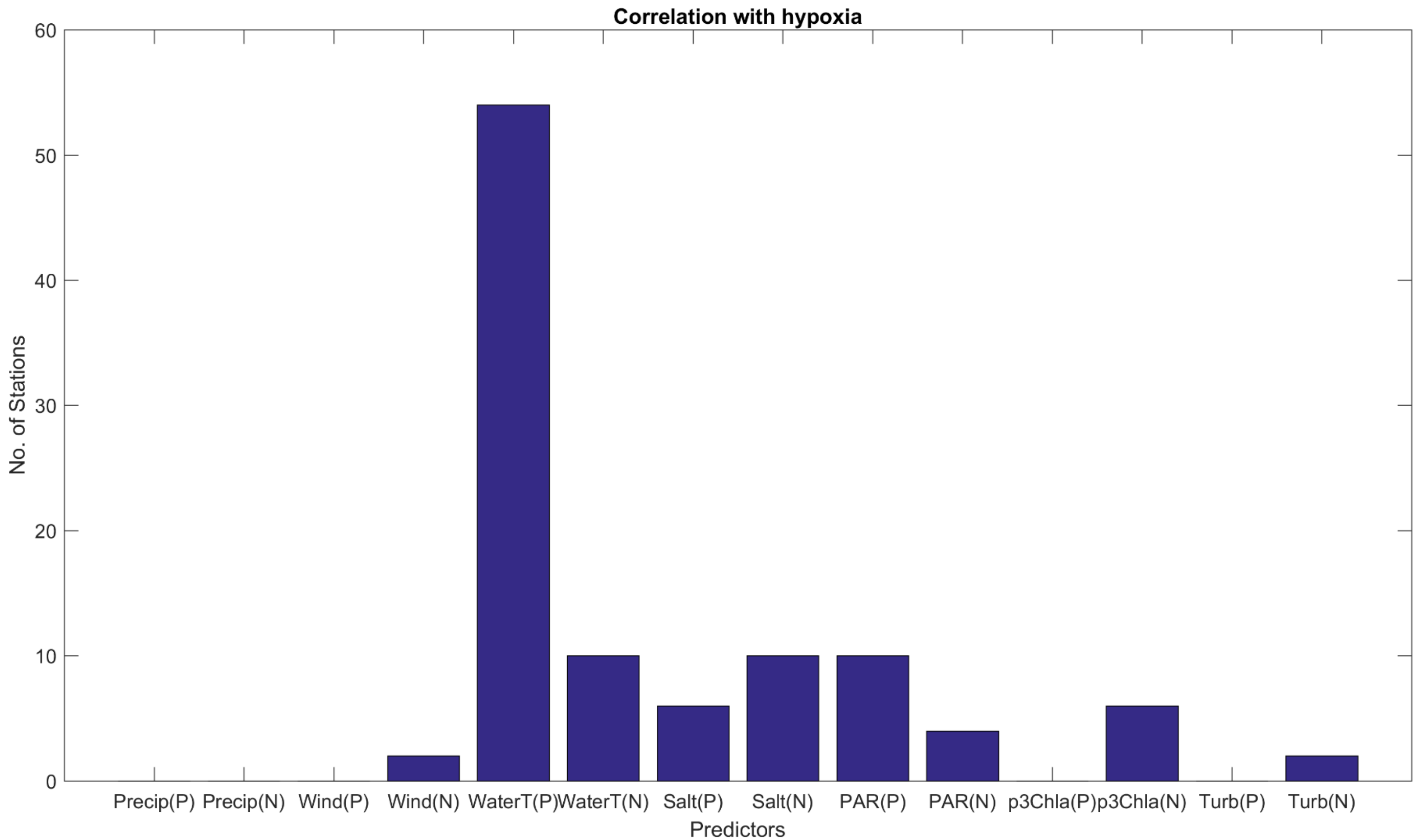


CART for hypoxia (<4.8 mg/L)

Water Temp. is the most important controller.
The 2nd and 3rd MIP are salinity and PAR for hypoxia.



As expected, higher water temp. leads to stronger hypoxia. Lower Chla connects with stronger hypoxia.



Conclusions to Date

- Diversity of controls on oxygen variability, regional similarities in controls
- Climate-relevant variables are key drivers of oxygen and hypoxia (Temp, precip)
- Chlorophyll-a effect may be both positive and negative for DO

Next Steps

- Connect CART analysis with discrete data (TSS, nutrients, loads, etc.)
- Use GAMs to Understand relationship and relative role of forcing variables (and to confirm cart results