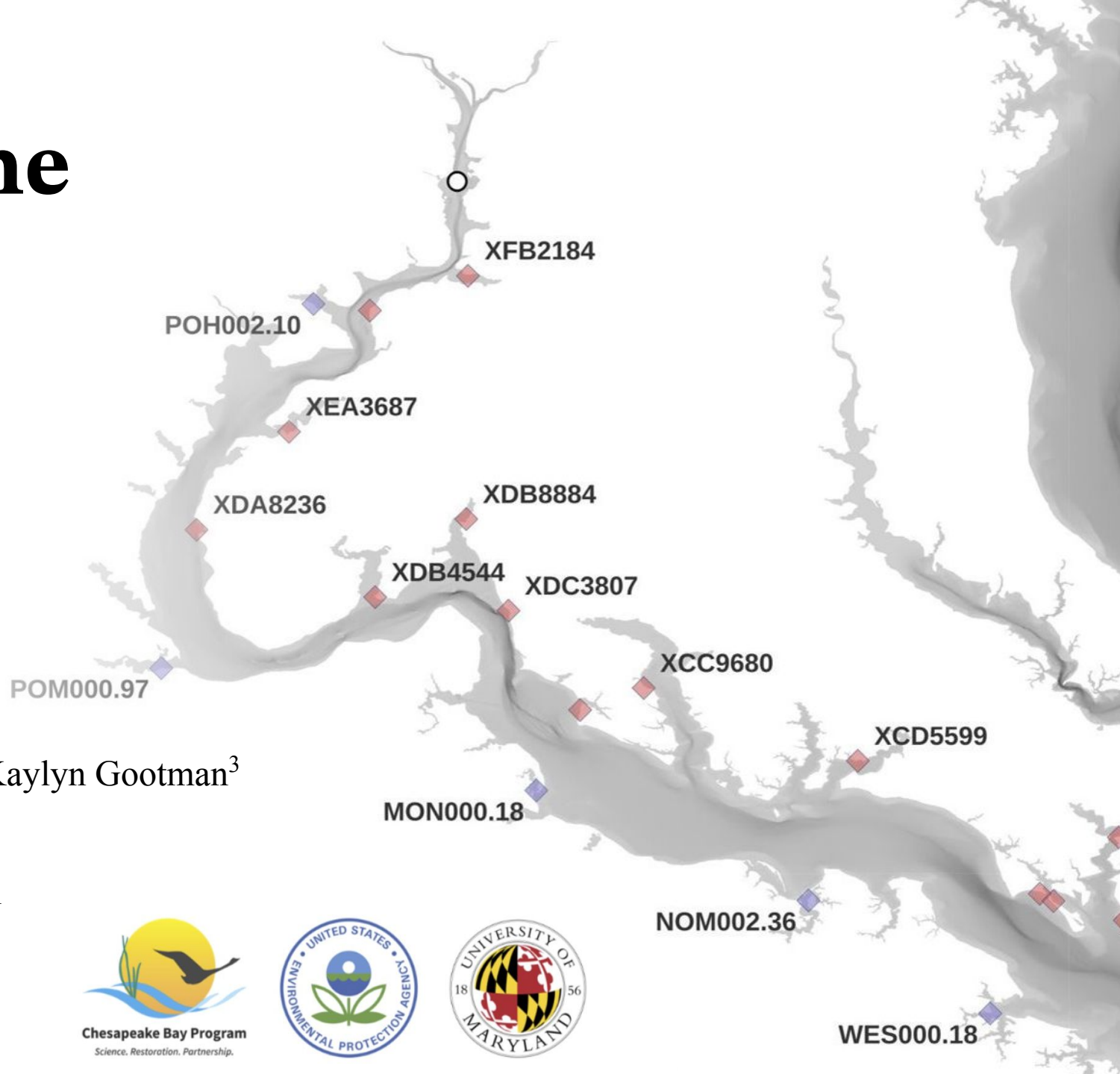
Water quality variability along the salinity gradient: insights from high-frequency monitoring in the Chesapeake Bay



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[4] Oak Ridge Institute for Science and Education, Oak Ridge, TN

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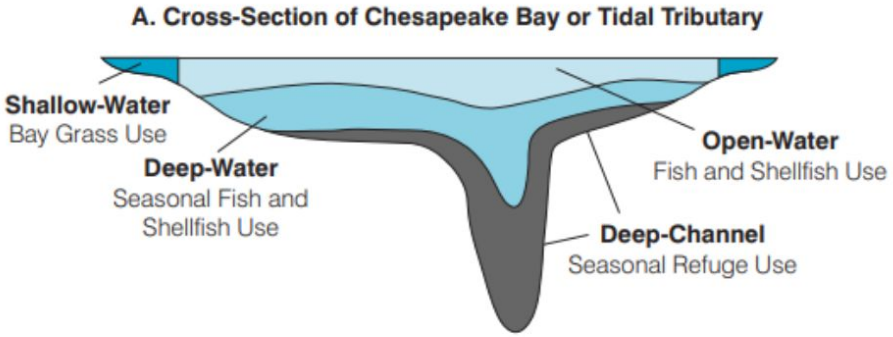
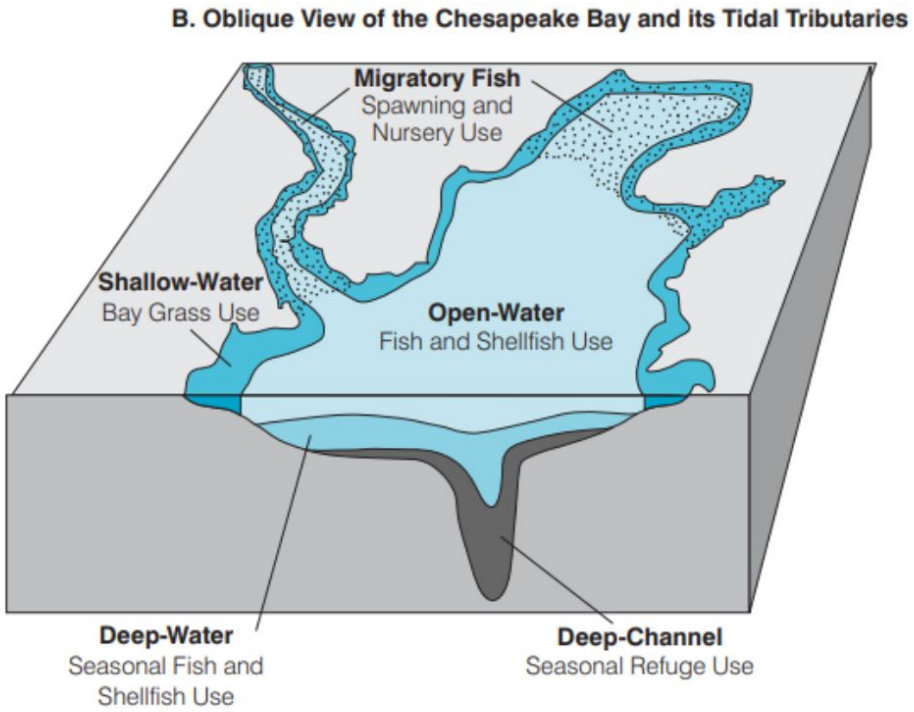
CBP Goals: Water Quality in Shallow Water and Criteria Assessment at High Spatial and Temporal Resolution





Instantaneous minimum $\geq$ 3.2 mg liter^{-1}

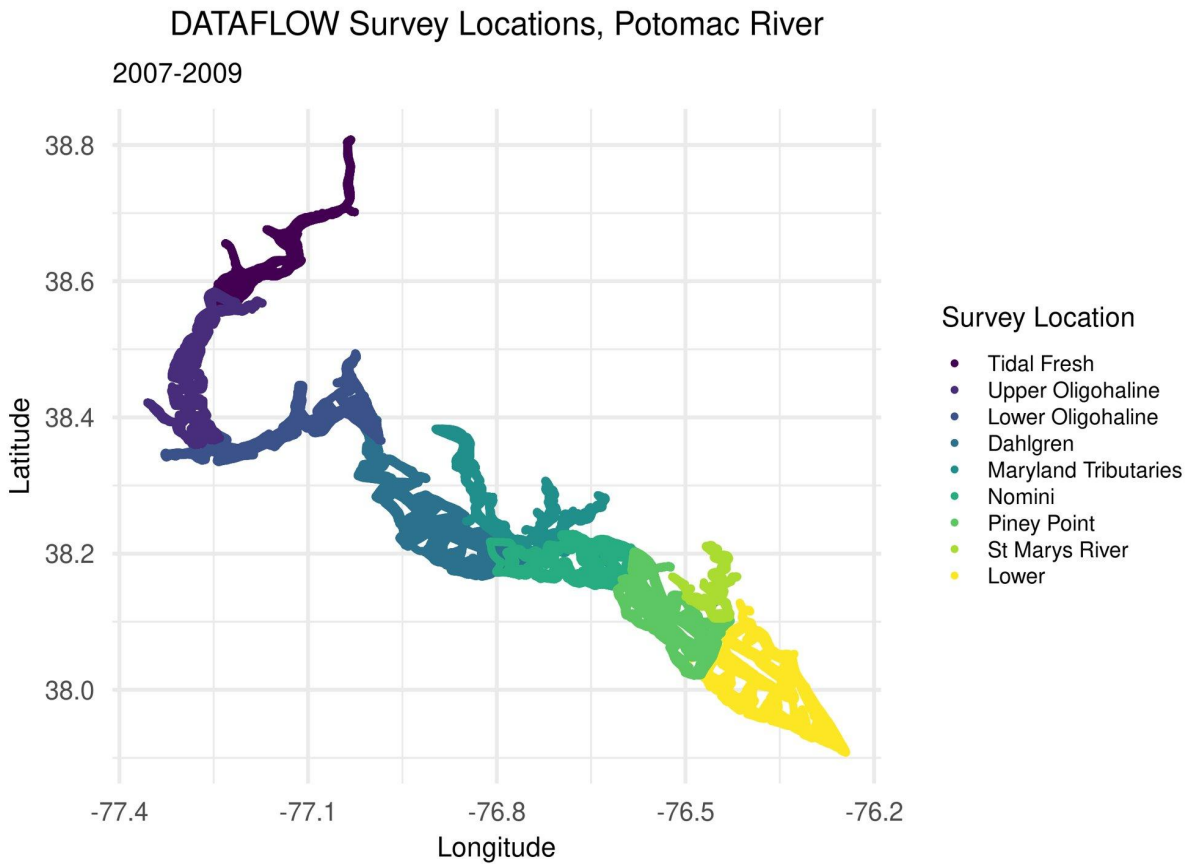
Table 1. Chesapeake Bay dissolved oxygen criteria.

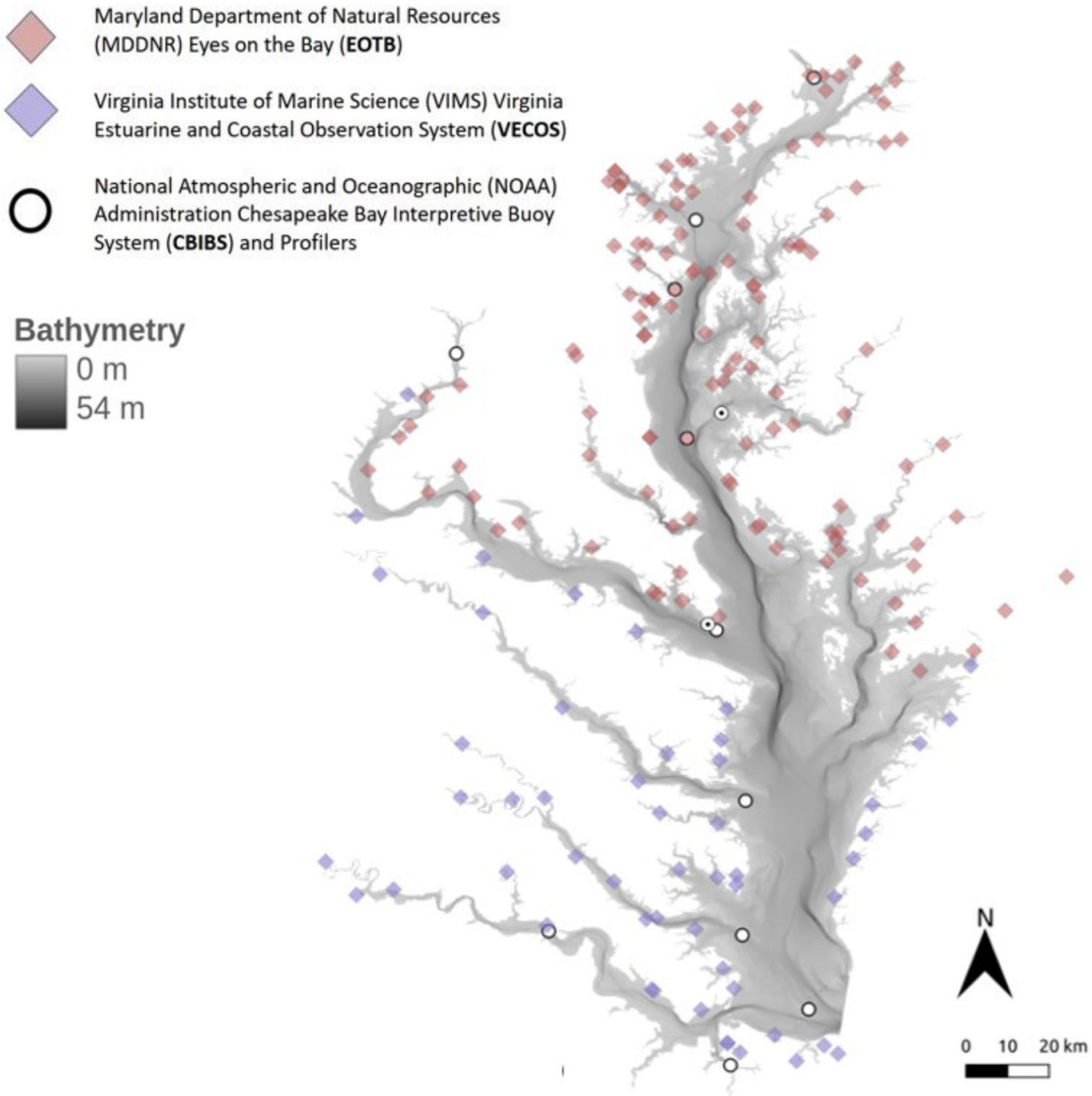
Designated Use	Criteria Concentration/Duration	Protection Provided	Temporal Application
Migratory fish spawning and nursery use	7-day mean $\geq$ 6 mg liter^{-1} (tidal habitats with 0-0.5 ppt salinity)	Survival/growth of larval/juvenile tidal-fresh resident fish; protective of threatened/endangered species.	February 1 - May 31
	Instantaneous minimum $\geq$ 5 mg liter^{-1}	Survival and growth of larval/juvenile migratory fish; protective of threatened/endangered species.	
	Open-water fish and shellfish designated use criteria apply		June 1 - January 31
Shallow-water bay grass use	Open-water fish and shellfish designated use criteria apply		Year-round
Open-water fish and shellfish use	30-day mean $\geq$ 5.5 mg liter^{-1} (tidal habitats with 0-0.5 ppt salinity)	Growth of tidal-fresh juvenile and adult fish; protective of threatened/endangered species.	Year-round
	30-day mean $\geq$ 5 mg liter^{-1} (tidal habitats with >0.5 ppt salinity)	Growth of larval, juvenile and adult fish and shellfish; protective of threatened/endangered species.	
	7-day mean $\geq$ 4 mg liter^{-1}	Survival of open-water fish larvae.	
	Instantaneous minimum $\geq$ 3.2 mg liter^{-1}	Survival of threatened/endangered sturgeon species.[1]	
Deep-water seasonal fish and shellfish use	30-day mean $\geq$ 3 mg liter^{-1}	Survival and recruitment of bay anchovy eggs and larvae.	June 1 - September 30
	1-day mean $\geq$ 2.3 mg liter^{-1}	Survival of open-water juvenile and adult fish.	
	Instantaneous minimum $\geq$ 1.7 mg liter^{-1}	Survival of bay anchovy eggs and larvae.	
	Open-water fish and shellfish designated-use criteria apply		October 1 - May 31
Deep-channel seasonal refuge use	Instantaneous minimum $\geq$ 1 mg liter^{-1}	Survival of bottom-dwelling worms and clams.	June 1 - September 30
	Open-water fish and shellfish designated use criteria apply		October 1 - May 31

[1] At temperatures considered stressful to shortnose sturgeon (>29°C), dissolved oxygen concentrations above an instantaneous minimum of 4.3 mg liter^{-1} will protect survival of this listed sturgeon species.

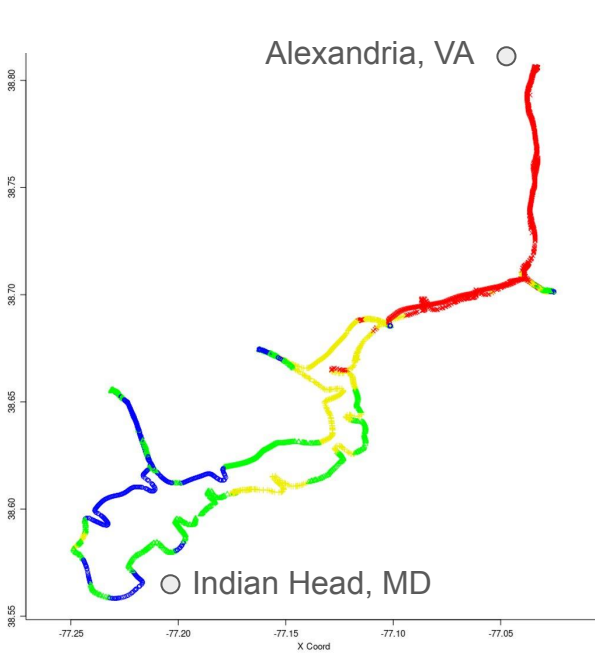
(US EPA 2003)

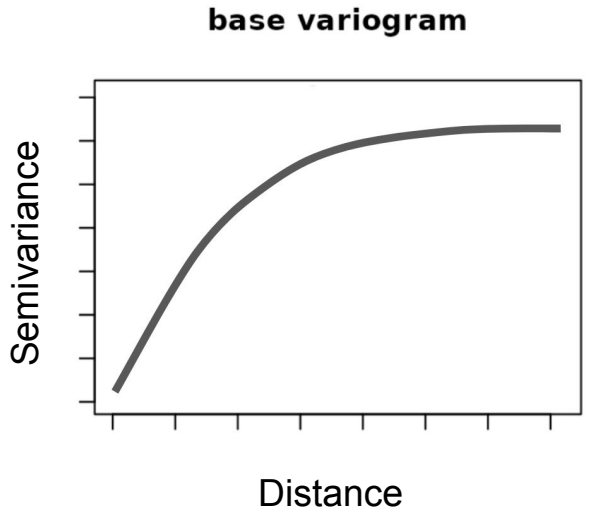
CBP Goals: Utilizing ConMon & DATAFLOW Data

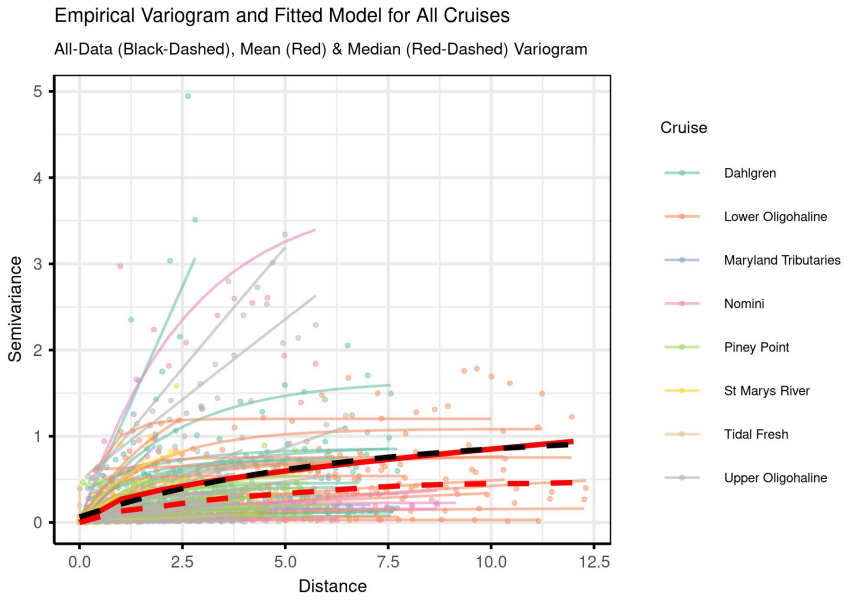




CBP Goals: Quantifying High-resolution Water Quality Variance Across Space
DATAFLOW Data & the 4D Interpolator





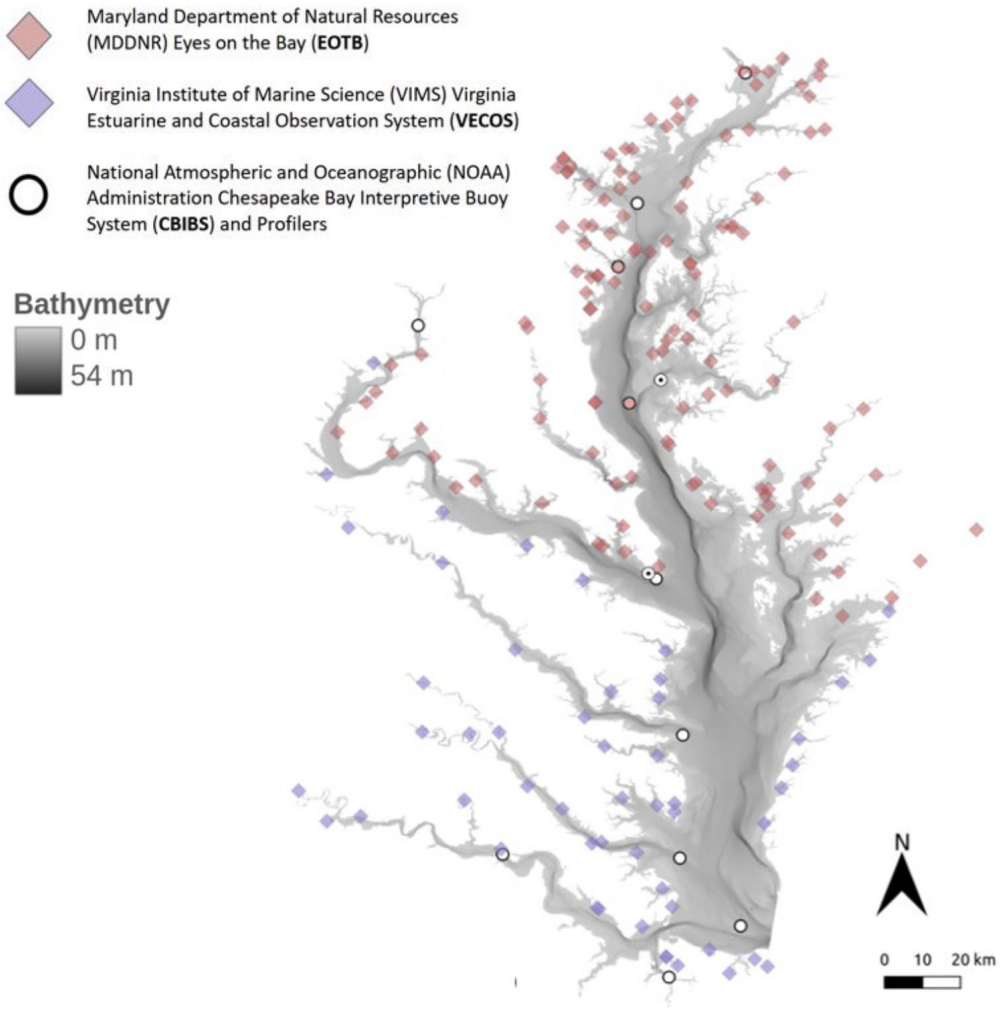


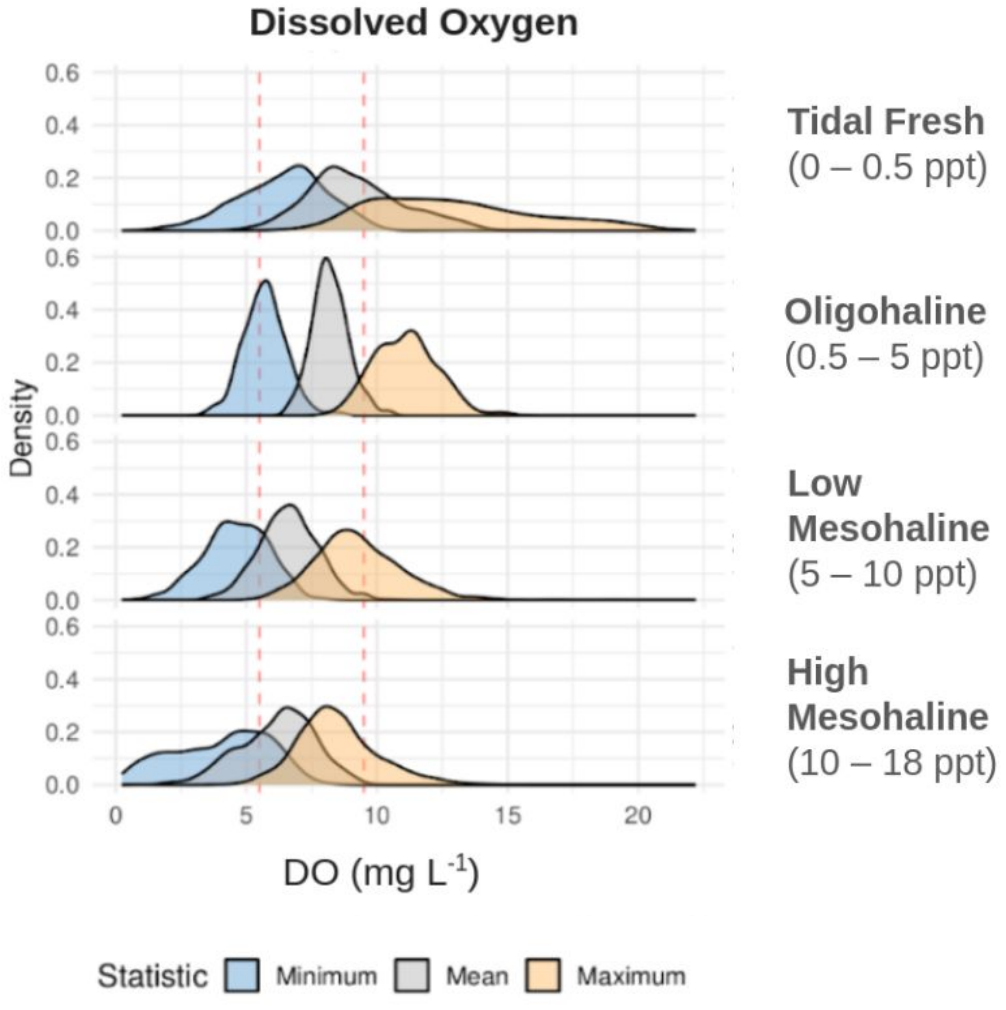
CBP 4D Interpolator

(Rebecca Murphy, Breck Sullivan, Jon Harcum, Elgin Perry, and others)

CBP Goals: Quantifying High-resolution Water Quality Variance in Time and Across the Salinity Gradient

ConMon Data



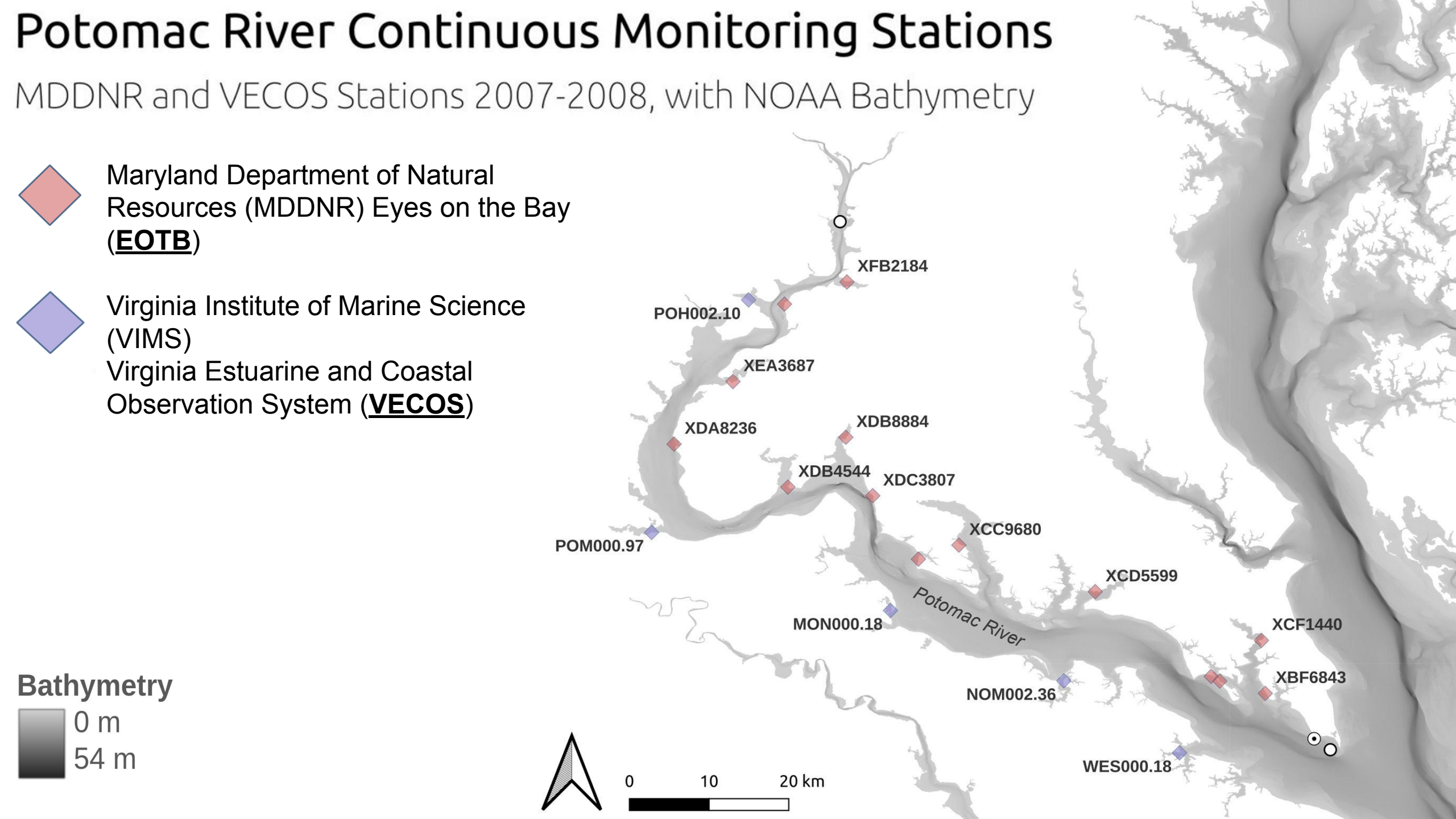


Potomac River Continuous Monitoring Stations

MDDNR and VECOS Stations 2007-2008, with NOAA Bathymetry

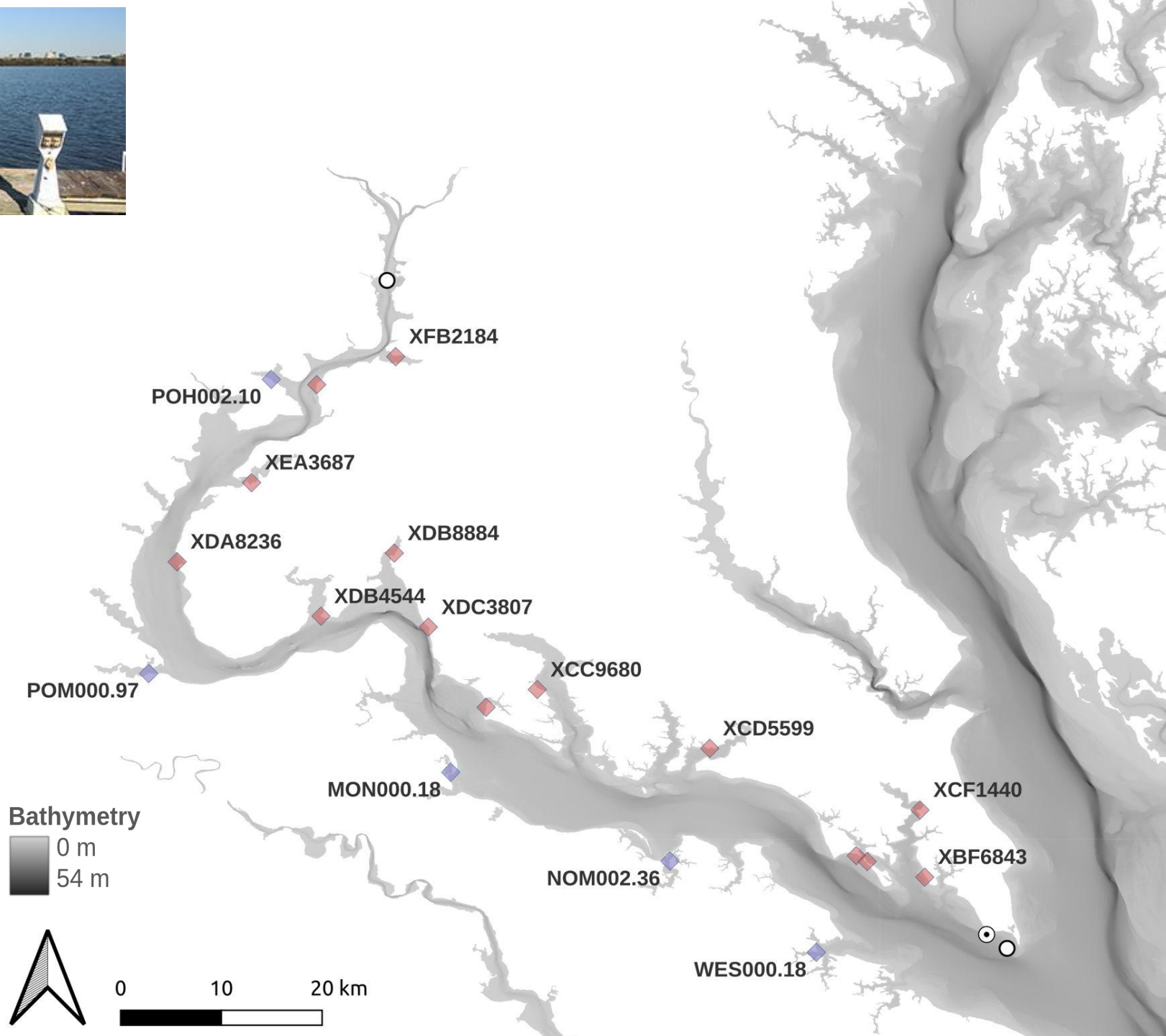
Maryland Department of Natural Resources (MDDNR) Eyes on the Bay (**EOTB**)

Virginia Institute of Marine Science (VIMS)
Virginia Estuarine and Coastal Observation System (**VECOS**)

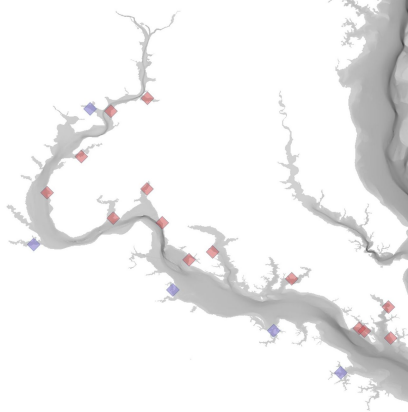


Dissolved Oxygen
Chlorophyll-a
Turbidity
Temperature
Salinity
Depth

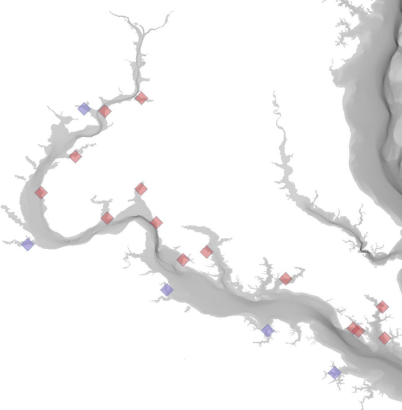
2024-04-12

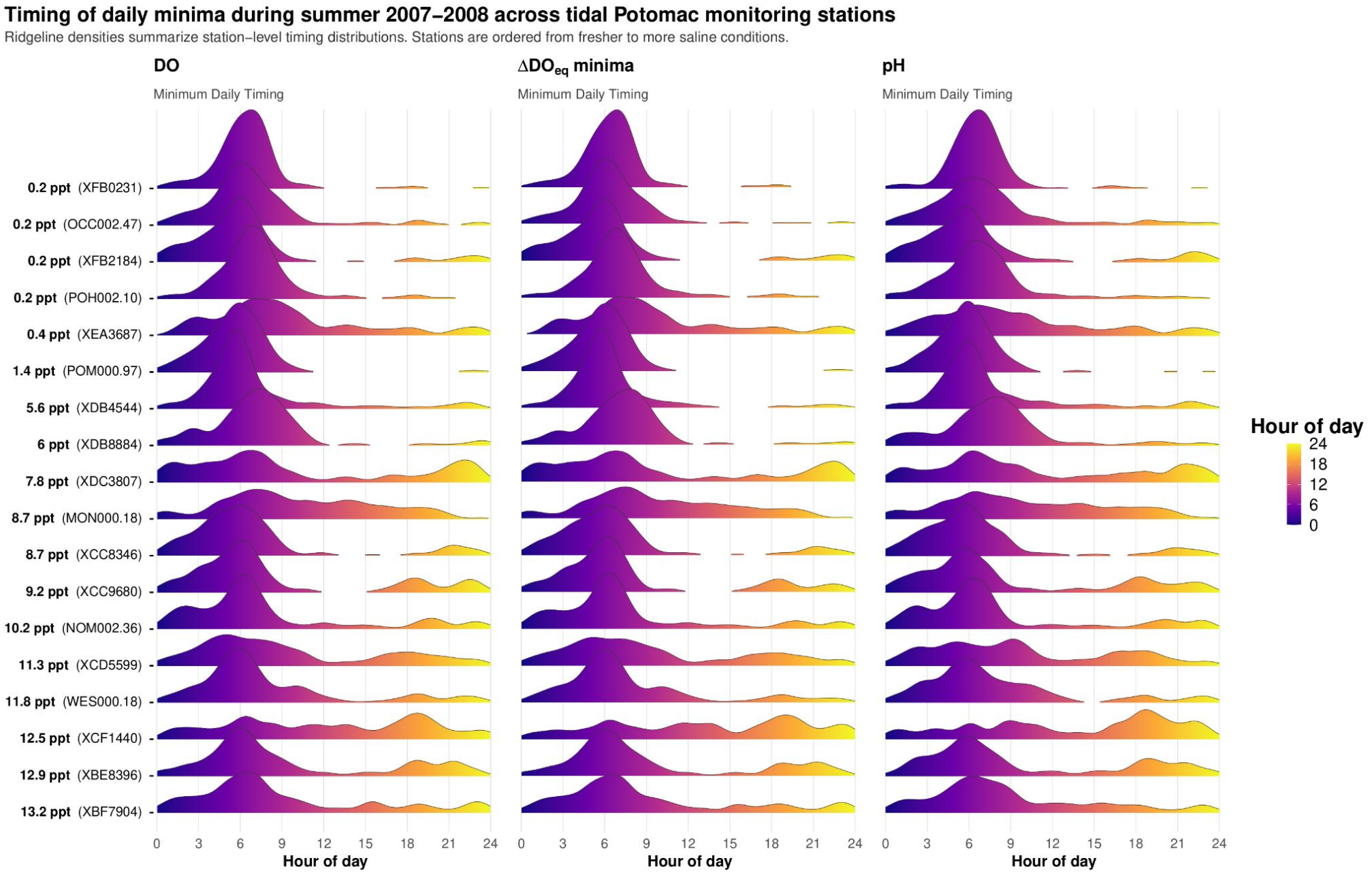


Distributions of Summertime DO, pH, and ΔDO_{eq} Across the Salinity Gradient



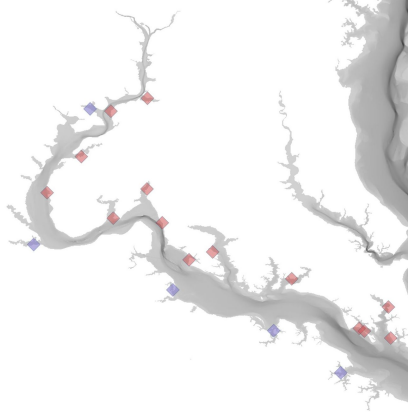
Diel Timing of DO and pH Extremes

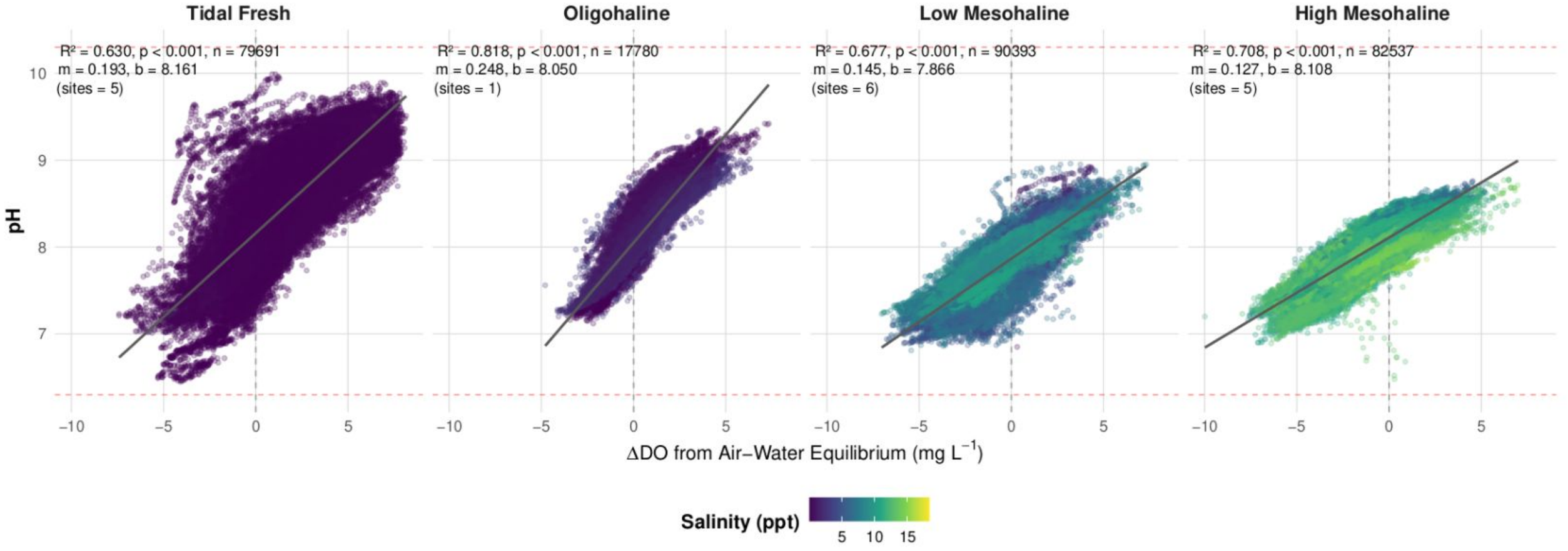




Continuous DO_{eq} and pH Relationships Across Salinity Zones in the Potomac Estuary Case Study Period

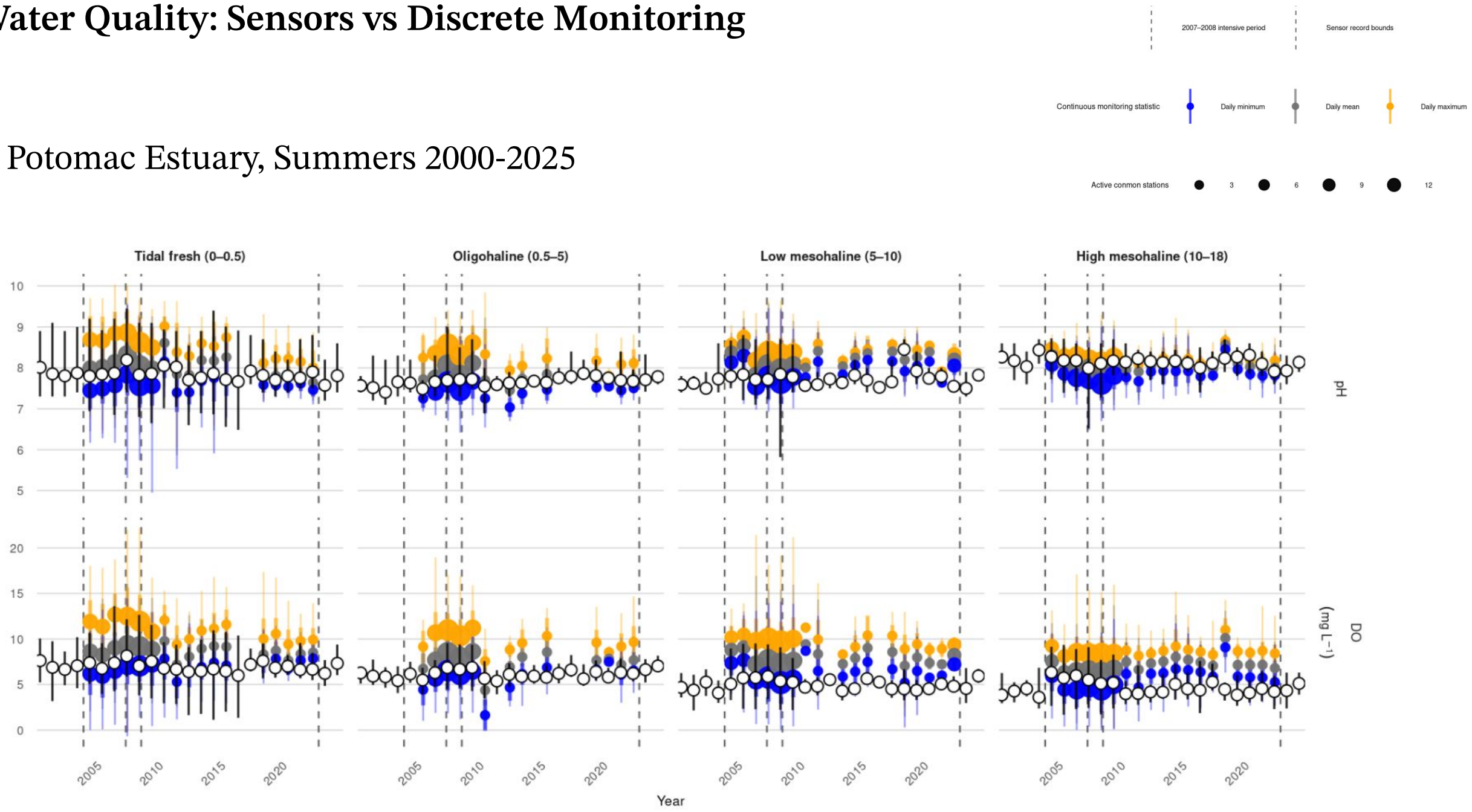
15m Observations, Summers 2007-2008





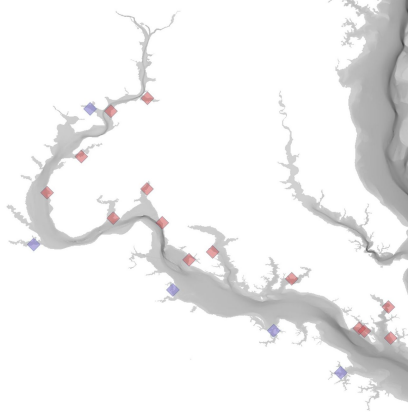
Water Quality: Sensors vs Discrete Monitoring

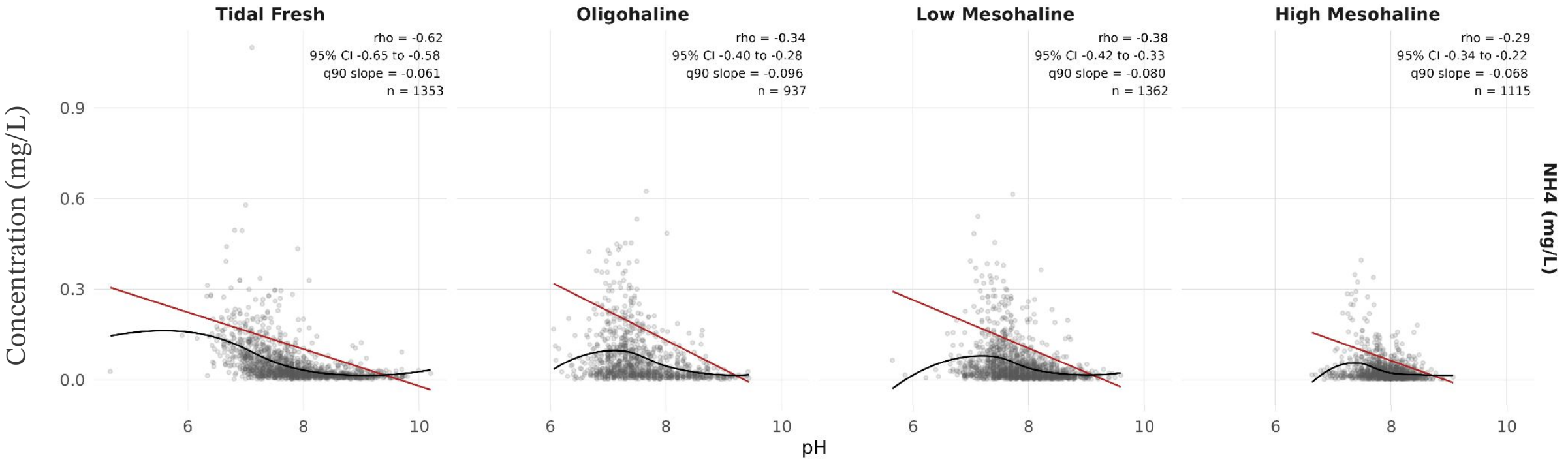
Potomac Estuary, Summers 2000-2025



DO, pH and Nutrient Control

Potomac Estuary, CBP Discrete Data, Summers 2000-2025





Black line = loess smoother; red line = 0.9 quantile regression.
Zone assignment from concurrent sample salinity; BS layer nutrient analyses use co-located shallow-water discrete samples.

How this project leveraged public data and supported CBP goals

CBP Need	Dataset	Findings
Quantify high-frequency water quality variability through time, especially in shallow water habitats	Continuous Monitoring (ConMon) 15-minute DO, pH, salinity, temperature observations	***Identified low-oxygen and high-pH extremes*** in shallow water habitats
Understand how water quality, especially extremes relevant to criteria violations, varies across the estuarine gradient	Continuous Monitoring (ConMon) 15-minute DO, pH, salinity, temperature observations	Explored how ***the frequency and magnitude of DO and pH extremes differ among salinity zones***
Explore how discrete monitoring observations compare to full diel range	Continuous Monitoring (ConMon) 15-minute DO, pH, salinity, temperature observations & CBP discrete WQ data	Compared discrete sampling to full diel distributions, finding ***high-end DO and pH values least represented by discrete monitoring***
Better understand the drivers and potential impacts of water quality extrema	Continuous Monitoring (ConMon) 15-minute DO, pH, salinity, temperature observations & CBP discrete WQ data	Showed ***strong coupling between dissolved oxygen and pH*** across salinity zones, document frequent high pH events and explore possible relevance to nutrient concentrations
Support spatial interpolation and capturing variance in 4D project	DATAFLOW surveys sub 5-minute DO, pH, salinity, temperature observations during boat cruises	Preliminary analysis of ***water quality variance by distance supporting the development of the 4D interpolator***

Thank you!
Questions?

Thank you to CBP for allowing me to conduct this research, which has been an invaluable learning and professional development opportunity, and an incredible part of my graduate research and education

Special thank you to Rebecca Murphy, John Harcum, Elgin Perry and Breck Sullivan of the 4D interpolator team, and thanks to everyone at the Chesapeake Bay Program. Thank you to MDDNR, VECOS and all other public data providers

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