2024 Tidal Trends Summary

Rebecca Murphy (UMCES/CBP)

LGAC, June 4, 2026

Contributing to this year's results:

Renee Karrh (MDDNR); Mike Lane (ODU) and Cindy Johnson (VADEQ);
Efeturi Oghenekaro, Blessing Edje and George Onyullo (DOEE); Mukhtar Ibrahim (MWCOG);
Breck Sullivan (USGS), Kaylyn Gootman (EPA) and Gabriel Duran (CRC)

R package for analysis maintained by:

Erik Leppo and Jon Harcum (Tetra Tech)

Data from: *DOEE, MDDNR, and VADEQ*

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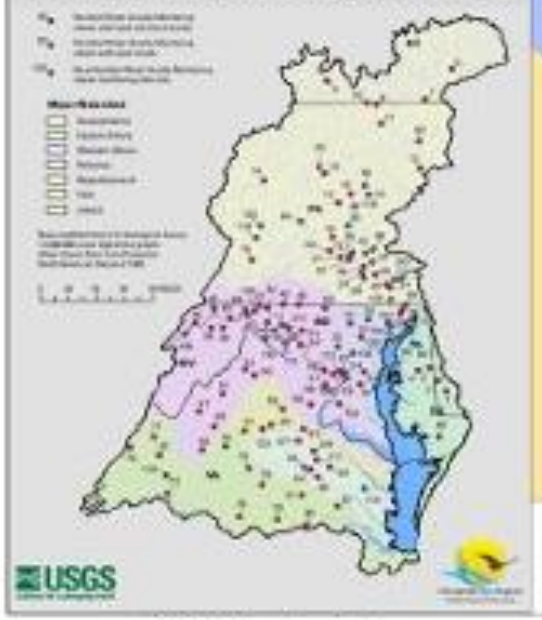
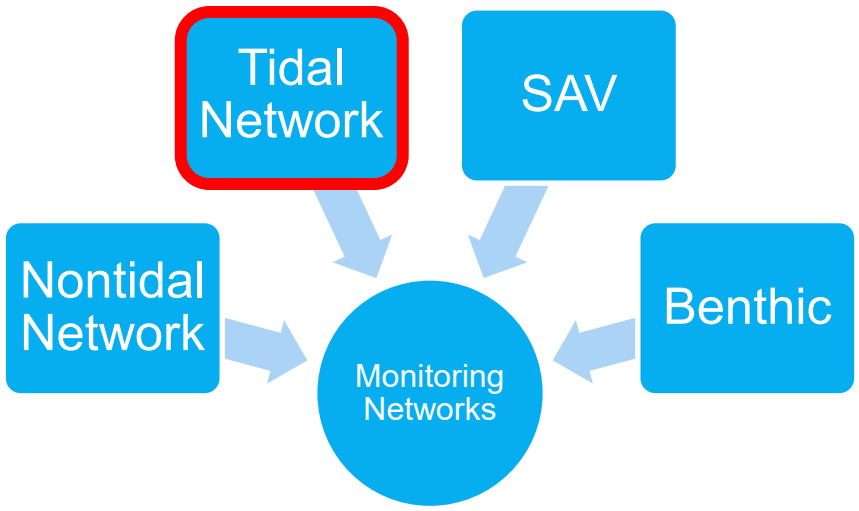
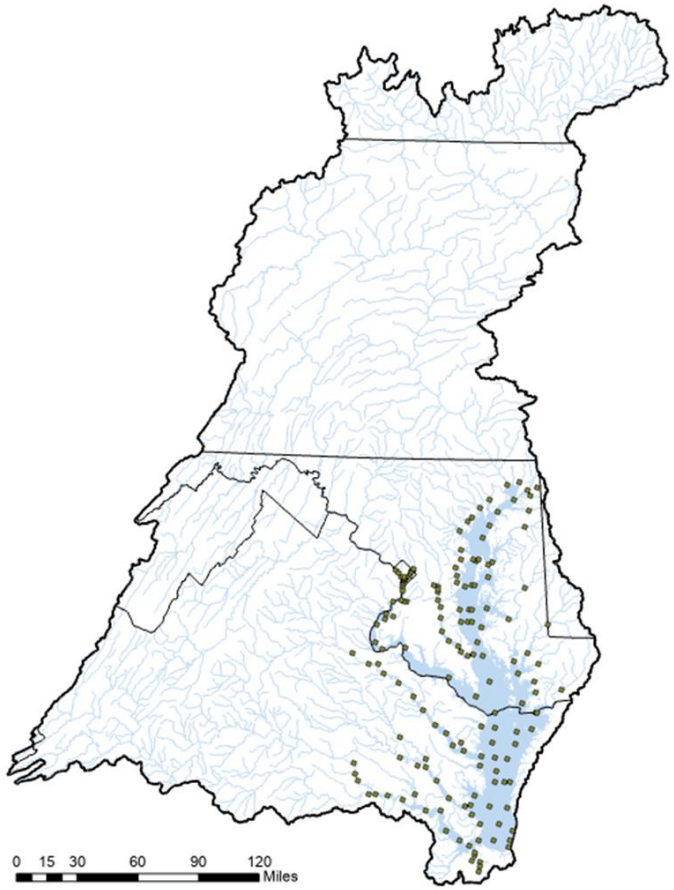
Traditional networks

CBP Partnership Monitoring Networks: Annual Monitoring

Water Quality		Living Resources	
Nontidal Monitoring Network	Tidal Monitoring Network	SAV Monitoring Network	Benthic Monitoring Network
			
123 stations	156 stations	181 flight lines	250 sites
			

CBP Partnership Monitoring Networks





Tidal Network

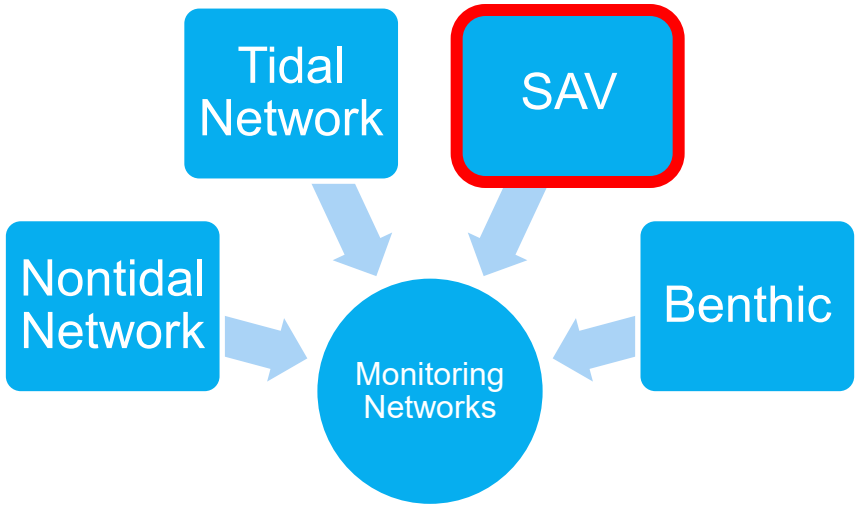
- 156 stations (discrete samples)
- Locations within 92 CB segments
- Cruises (VA DEQ and MD DNR)
- Continuous monitoring
  - Buoys and vertical arrays (NOAA)
- 117e, state, federal, commission, academic partners; includes 1:1 match

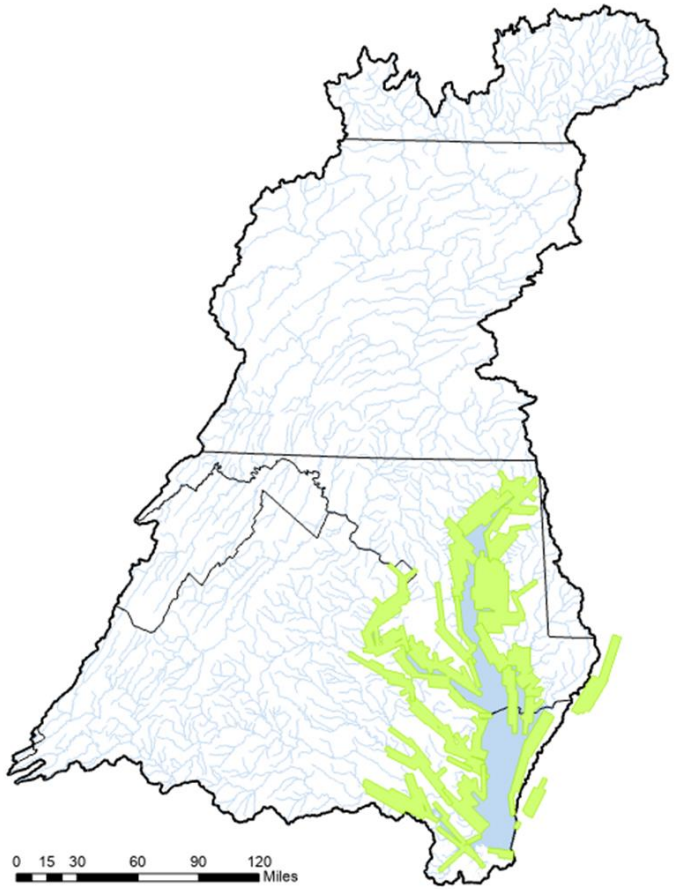
What do we get?

- Annual status and trends
- Continuous monitoring
- New vertical arrays
- DO, temperature, salinity, clarity
- Nitrogen, Phosphorus, CHL-a, TSS
- “Big data” management
- Advanced statistical analyses

From Kaylyn Gootman, EPA/CBP

CBP Partnership Monitoring Networks





SAV

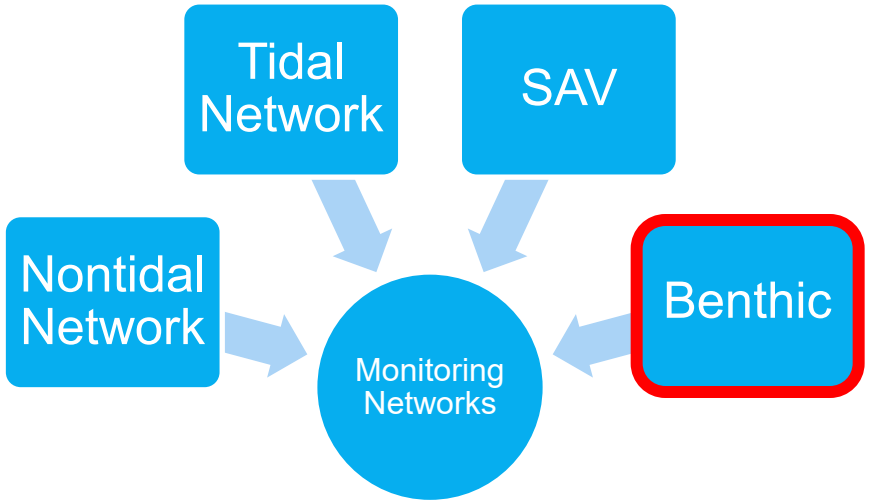
- 188 flight lines → 19 SAV areas
- Annual Bay-wide SAV monitoring via aerial survey conducted by VIMS
- ODU developing AI methods with satellite imagery
- CBPO, VIMS match, VA Legislature, VA Coastal Zone Management Program, MDE, MD DNR

What do we get?

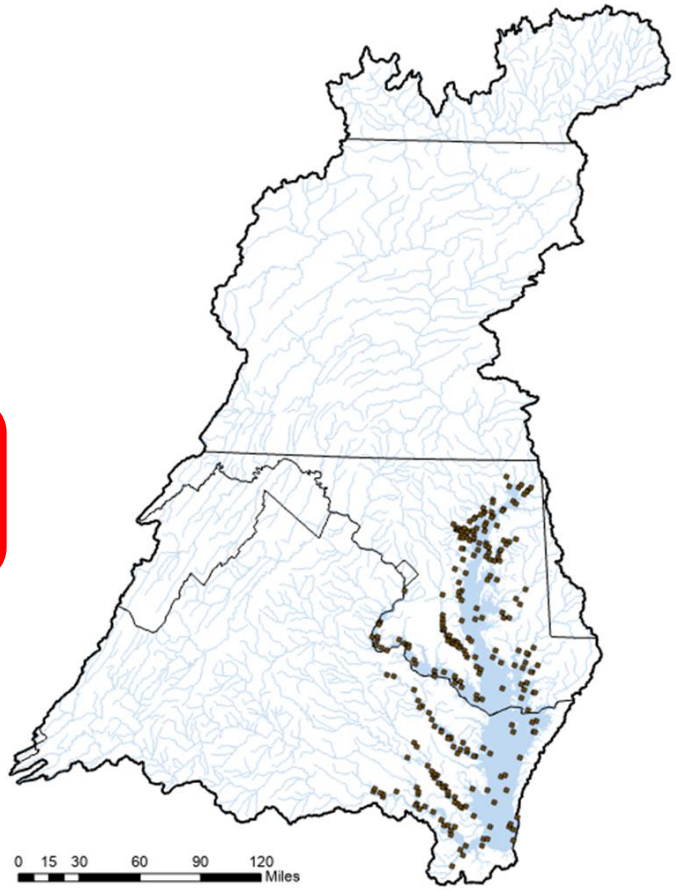
- SAV delineation
- A volunteer-based ground survey program, Chesapeake Bay SAV Watchers, supplements the aerial survey with data on more specific species and habitat

From Kaylyn Gootman, EPA/CBP

CBP Partnership Monitoring Networks



**Benthic refers to anything related to or occurring at the bottom of a body of water. Monitoring include surveying the animals and plants that live on or in the tidal waters bottom zone.*



Benthic (Tidal)

- 250 Sites
- Fixed-site monitoring sampling Probability-based sampling effort (~200 random sites)
- Summer season monitoring (July 15th through September 30th)
- MD DNR, VA DEQ, CBPO

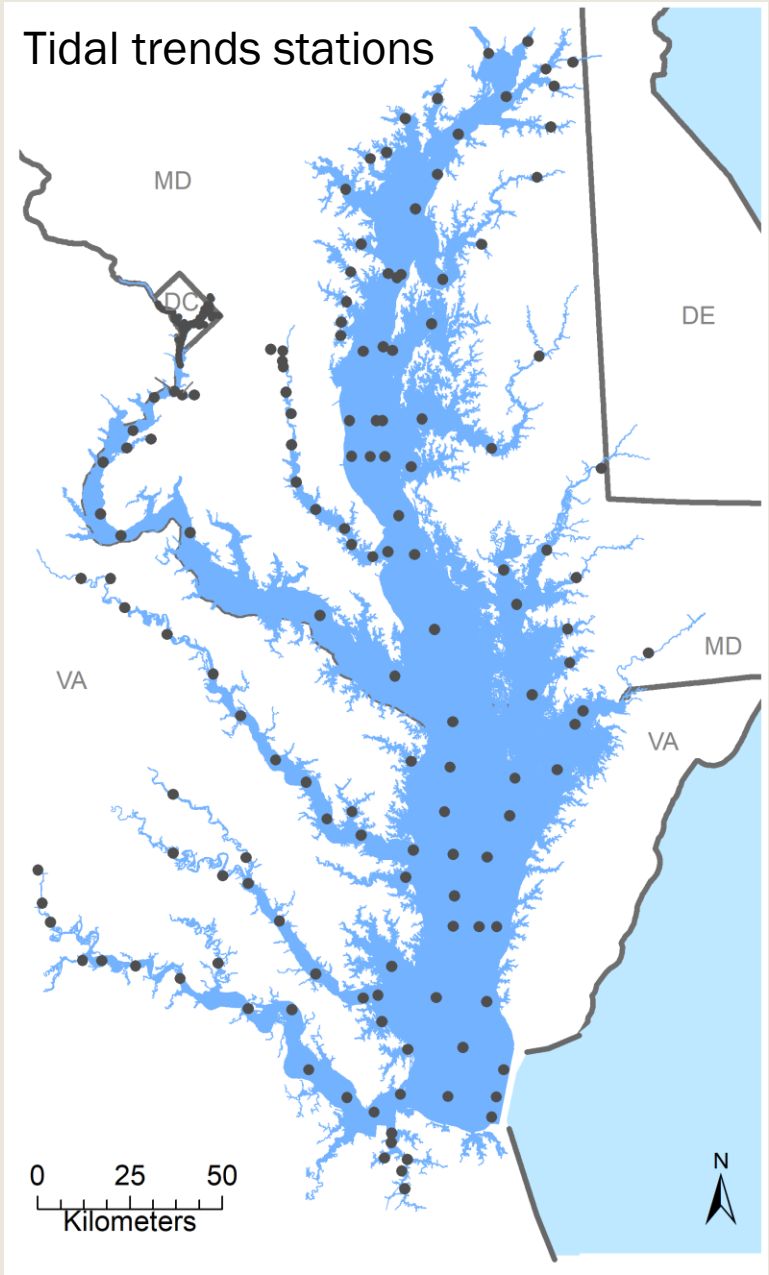
What do we get?

- Living resource monitoring
- Benthic condition trends
- Index to develop an index to estimate MD and VA benthic communities meeting/failing CBP restoration goals

From Kaylyn Gootman, EPA/CBP

What are the tidal trends?

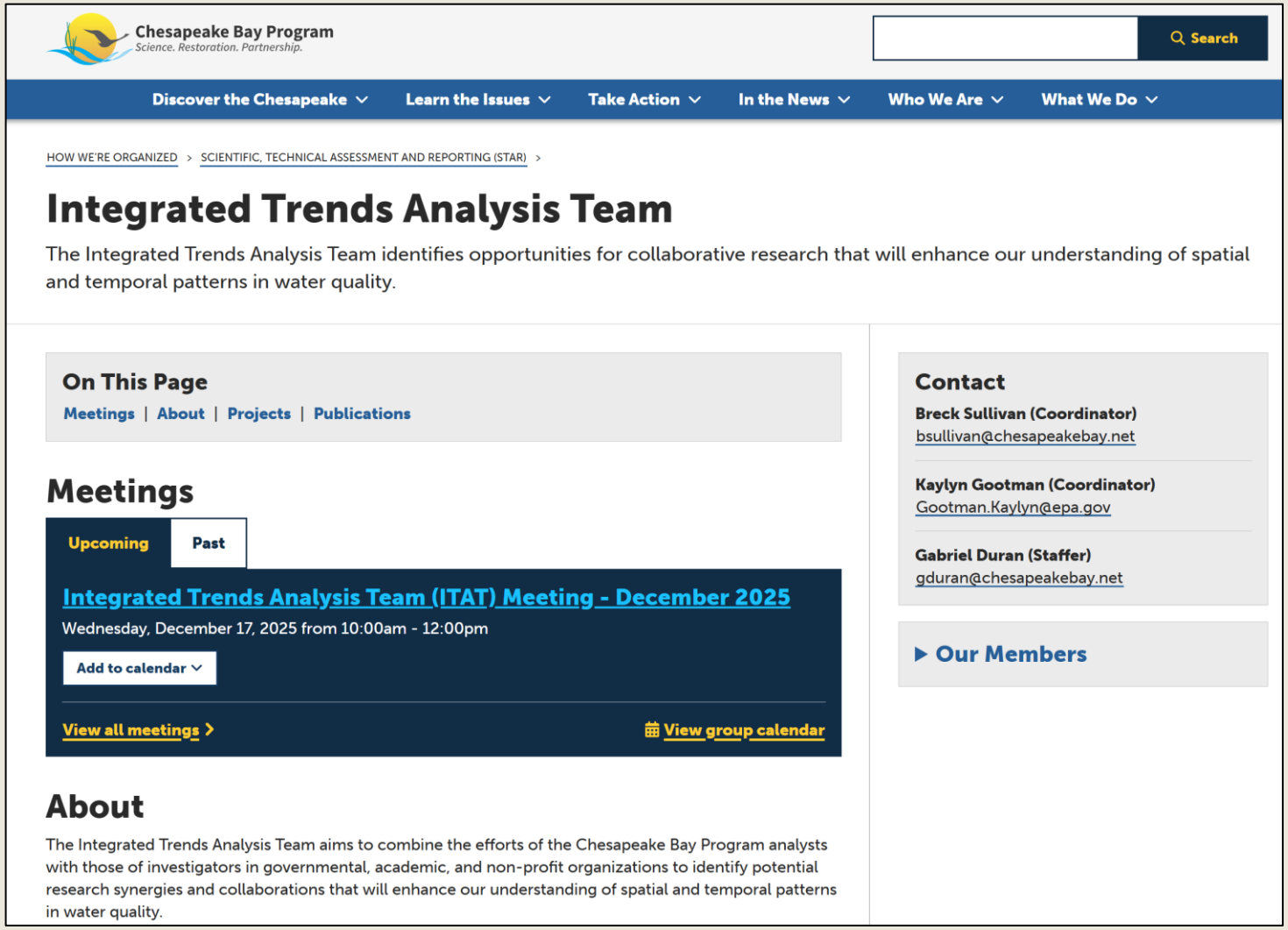
- Short- and long-term changes, or trends, at the ~150 tidal network stations for multiple water quality parameters including nutrients, clarity, oxygen, and temperature.
- Uses a nonlinear statistical approach to account for seasonal influences, variations in flow or salinity, and changes in methods.
- Successful partnership collaboration to generate consistent, comparable trend results across MD, VA, and DC tidal waters.



Annual collaborative effort between partners

Integrated Trends Analysis Team

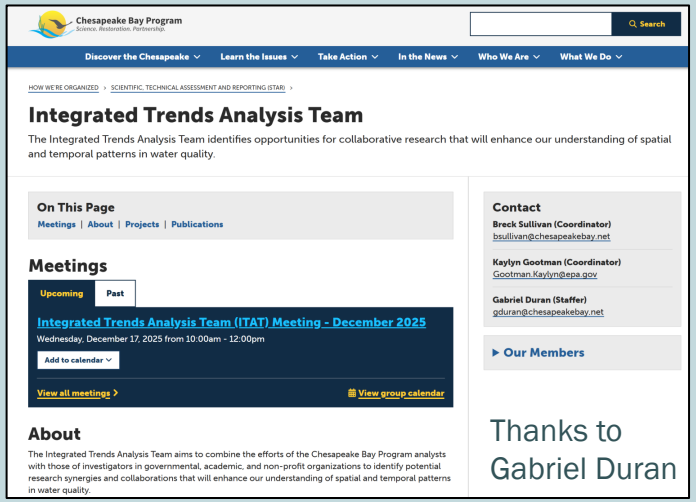
https://www.chesapeakebay.net/who/group/integrated_trends_analysis_team



Where to find the trends

ITAT webpage:

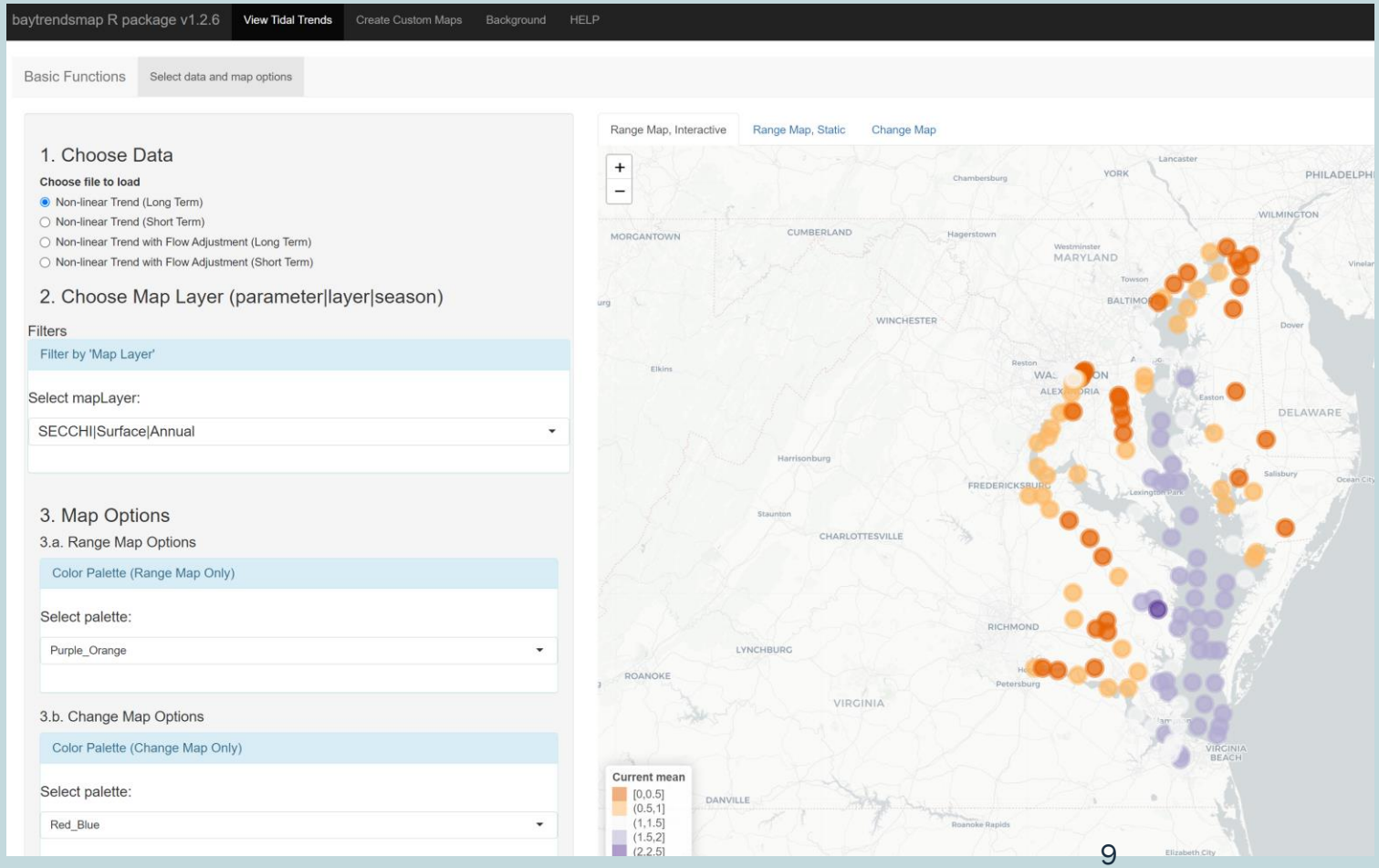
https://www.chesapeakebay.net/who/group/integrated-trends-analysis-team



Thanks to Gabriel Duran

Baytrendsmap :

https://baytrends.chesapeakebay.net/baytrendsmap/



Thanks to Erik Leppo and John Massey

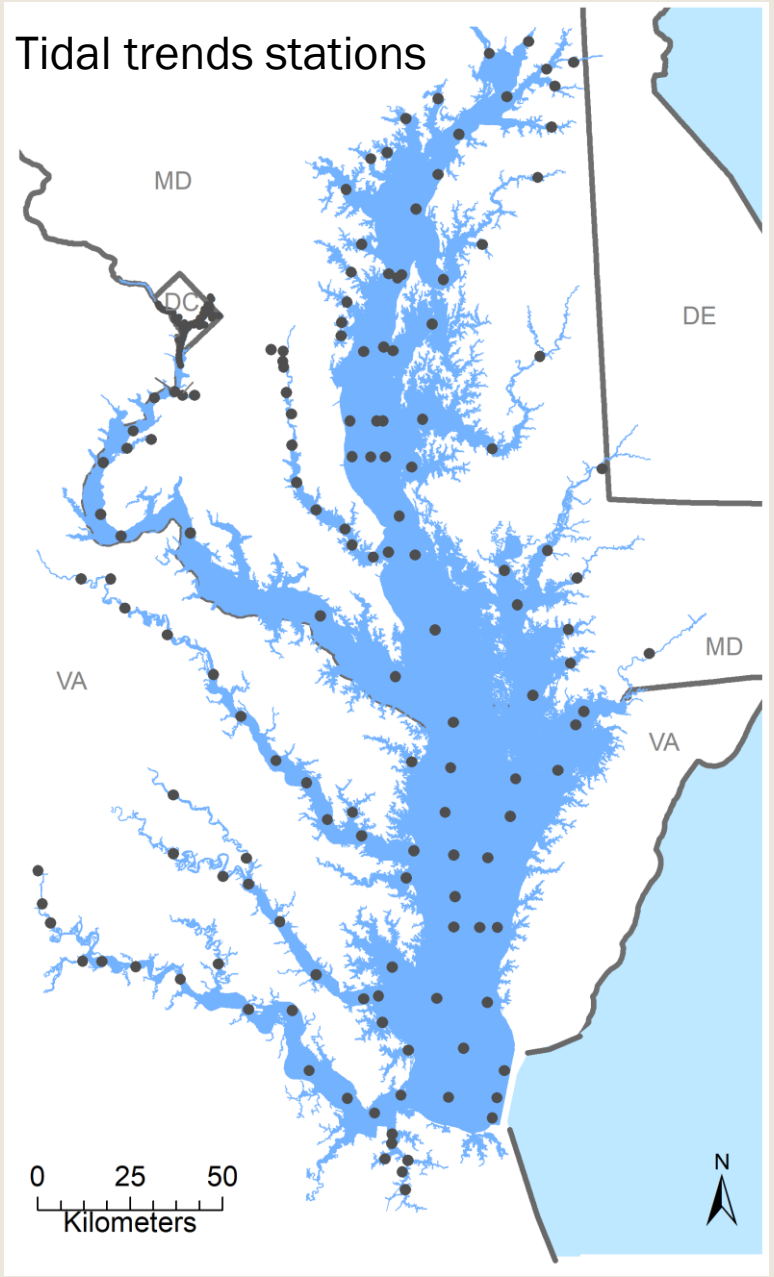
2024 Results

- Long-term (1980s-2024) and short-term (2015-2024) change:
  - *Total Nitrogen (TN)*
  - *Total Phosphorus (TP)*
  - *Secchi depth*
  - *Chlorophyll a*
  - *Water temperature*
  - *Dissolved Oxygen (DO)*

40 year trends!

- 1999-2024 and short-term (2015-2024) change:
  - *Total Suspended Solids (TSS)*
  - *Dissolved Inorganic Nitrogen (DIN)*
  - *Orthophosphate (PO4)*

- Multiple views of each parameter:
  - *Surface & Bottom*
  - *Chla, Secchi, DO: different seasons*
  - *Observed conditions, and flow- or salinity-adjusted conditions*



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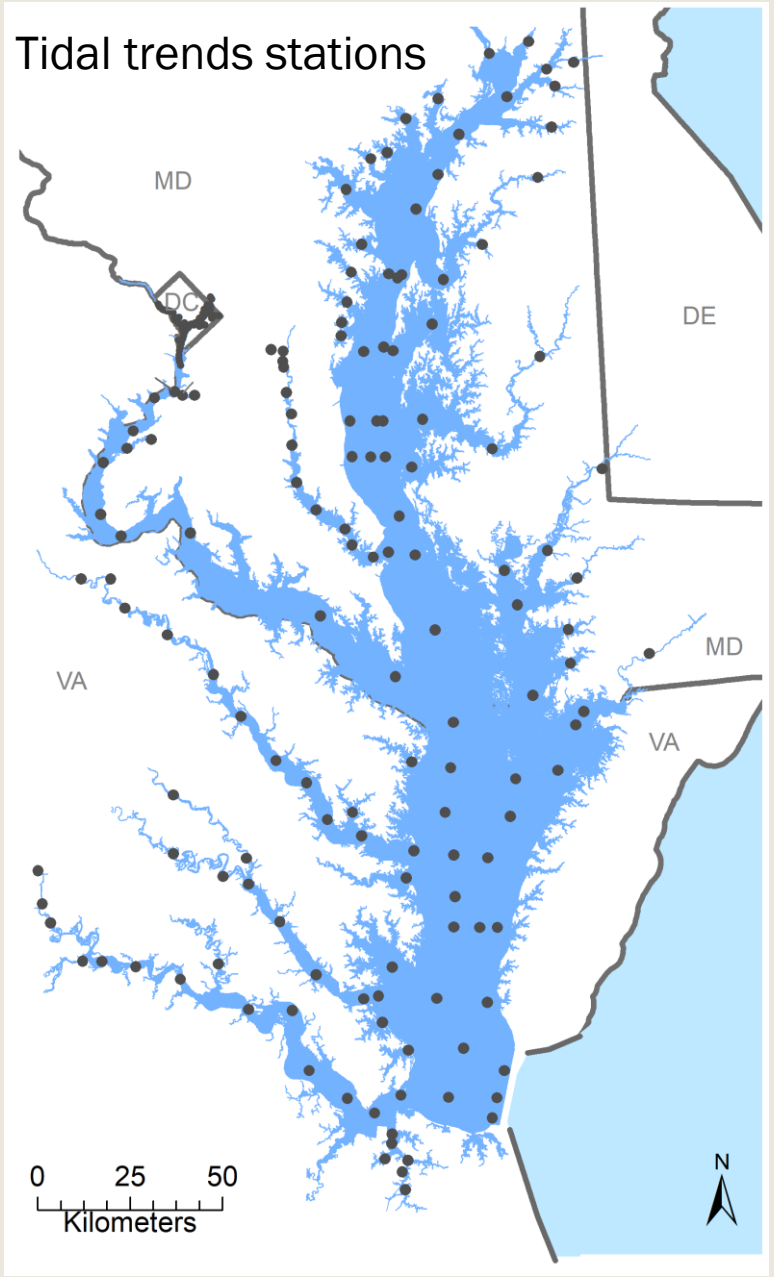
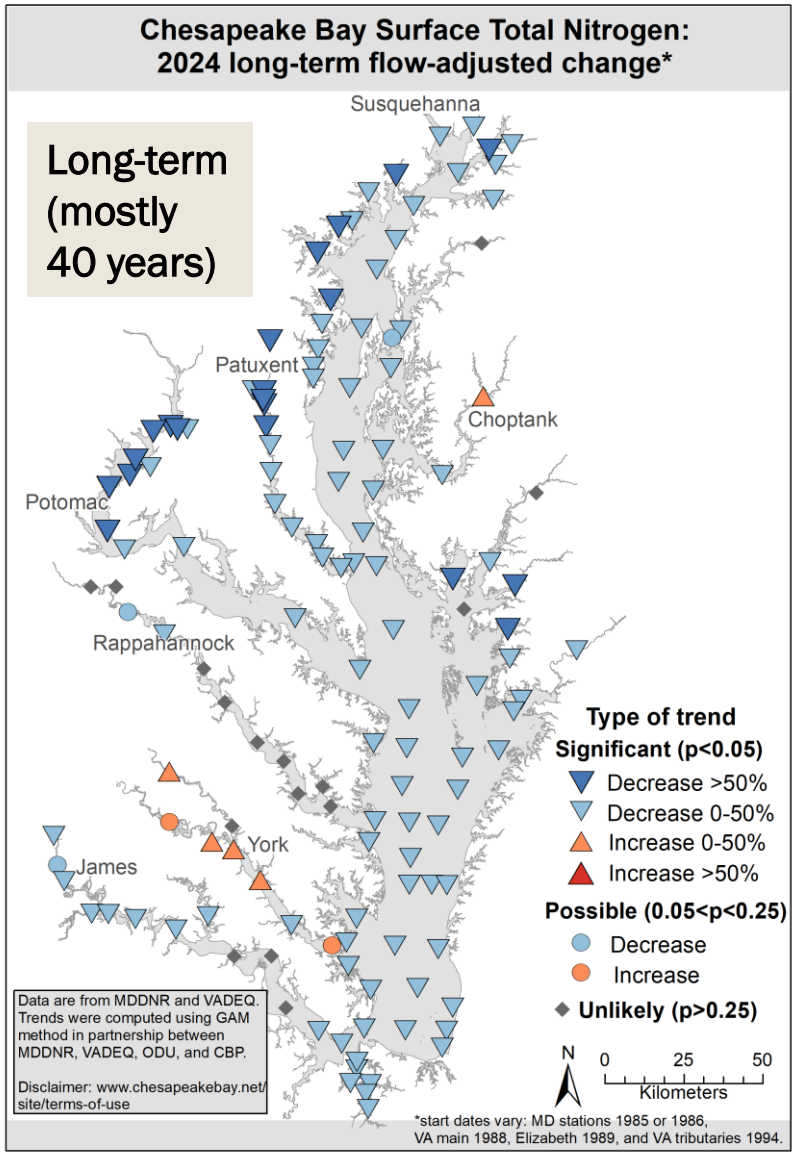


Total Nitrogen



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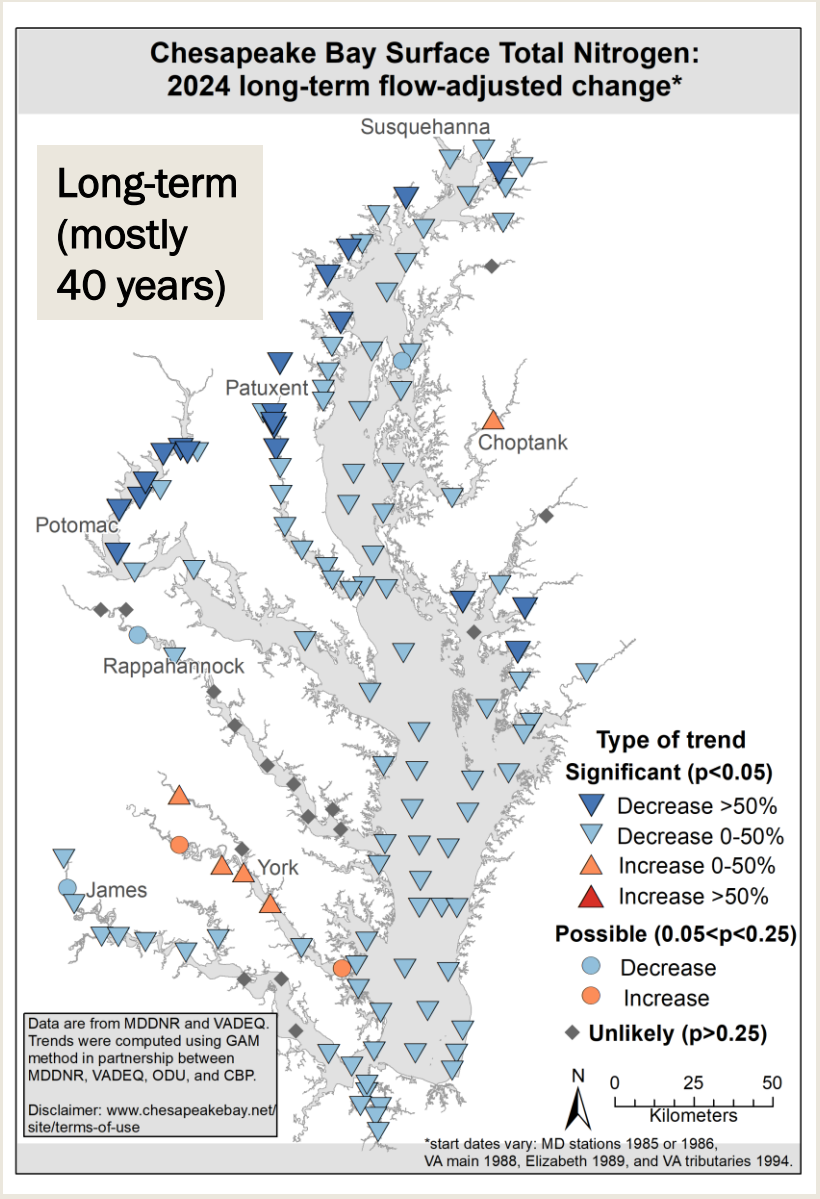

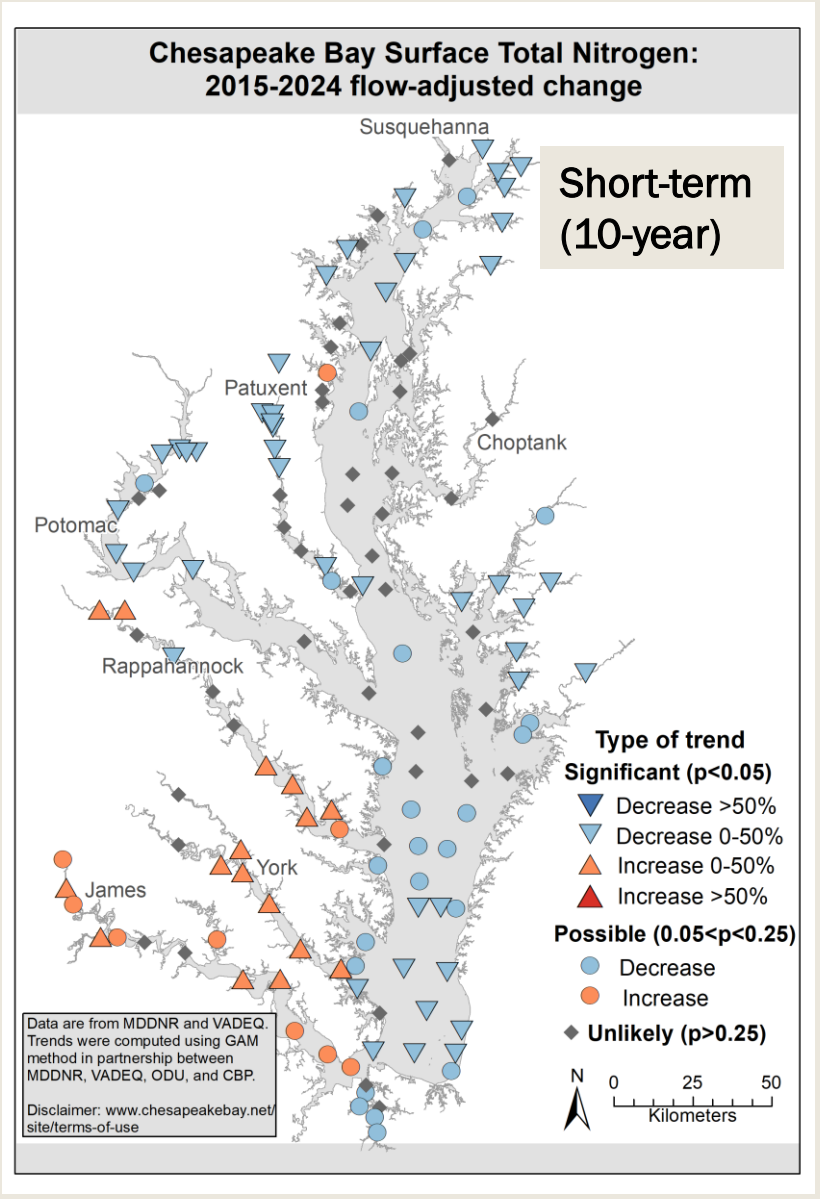

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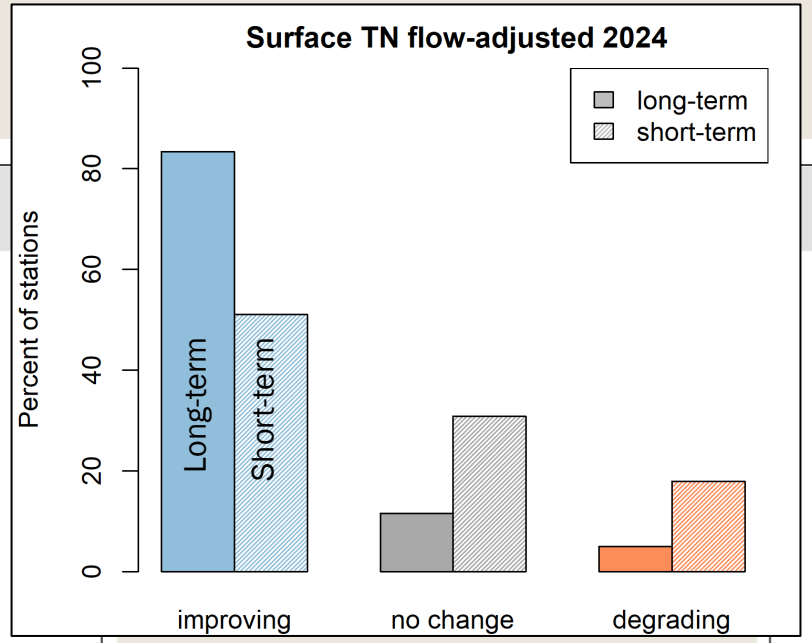
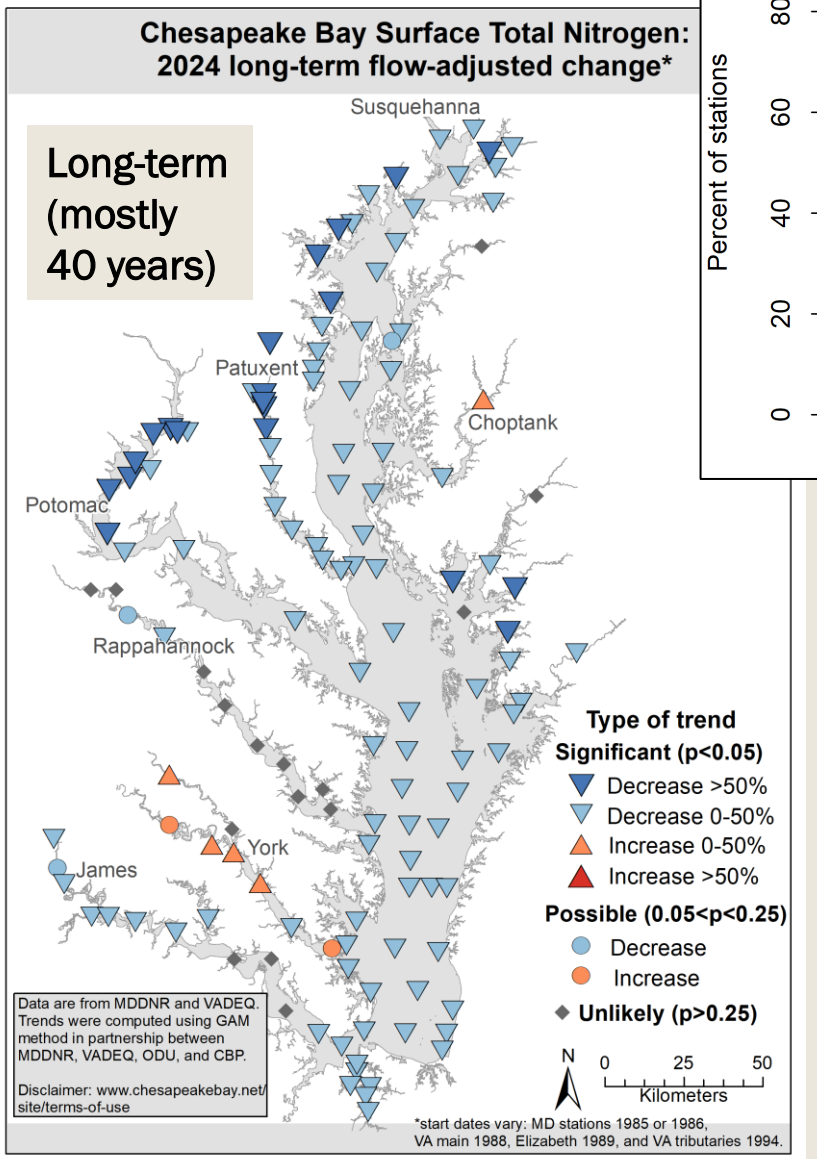
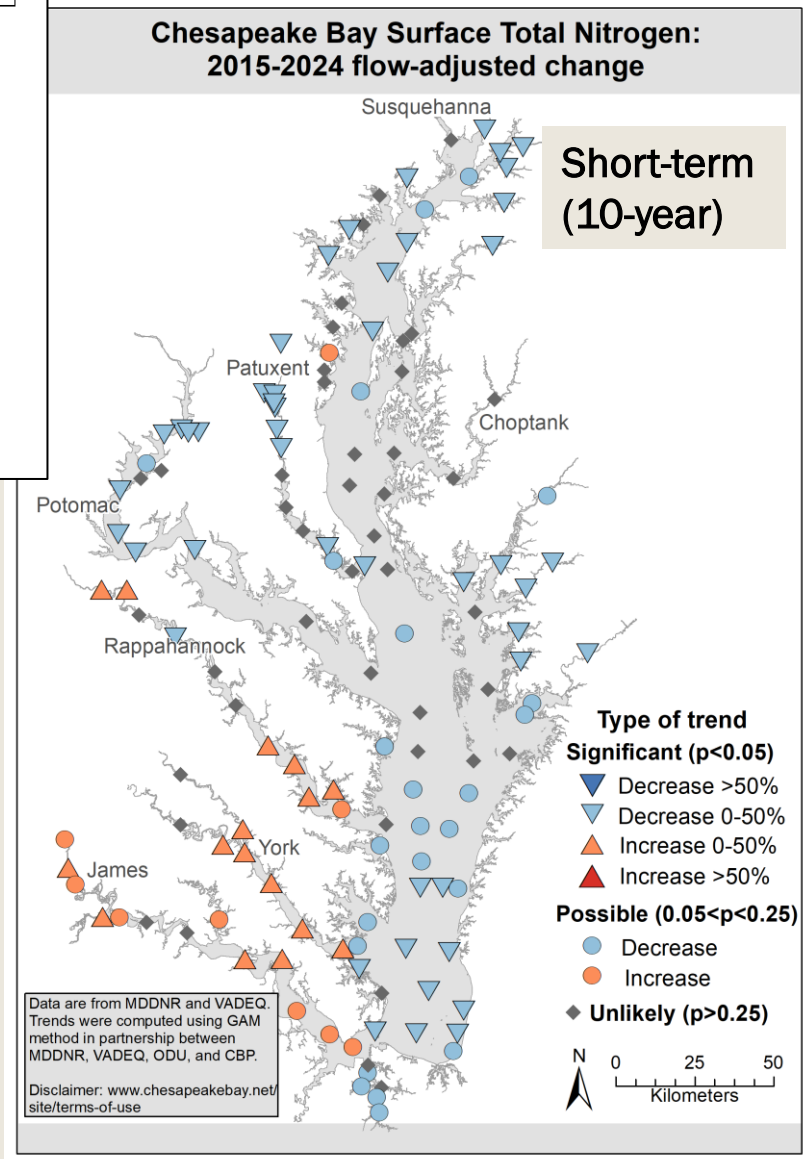


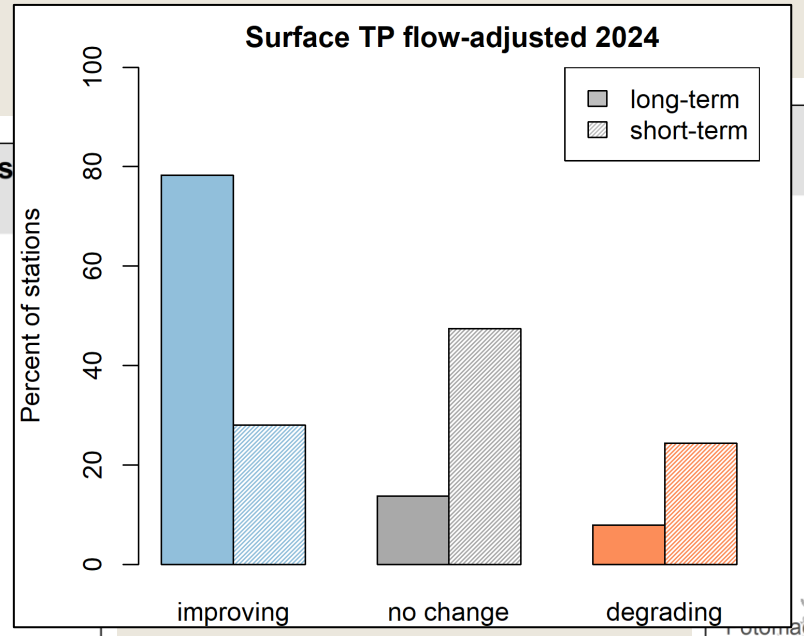


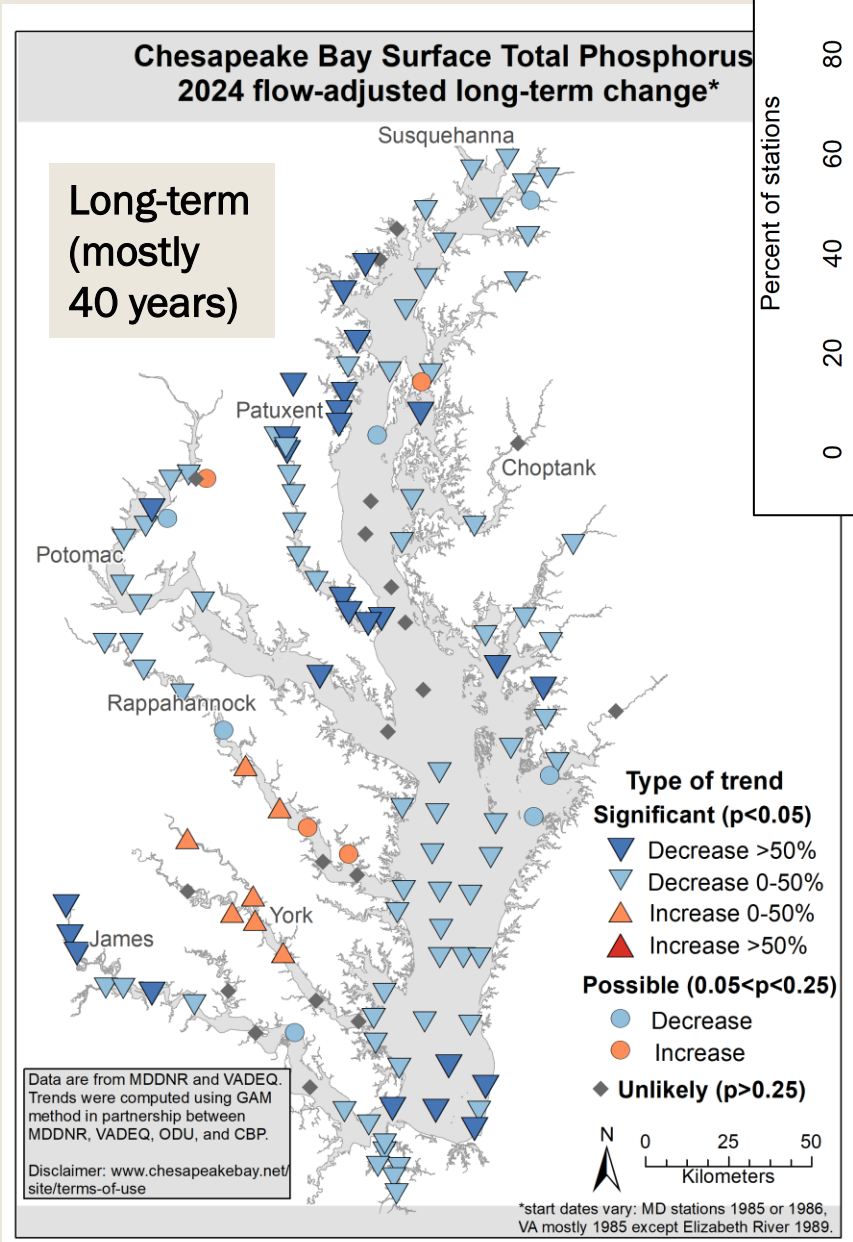


Summary for TN

- Long-term trends decreasing at majority of stations.
- Short-term trends are more mixed, but the largest group is improving.

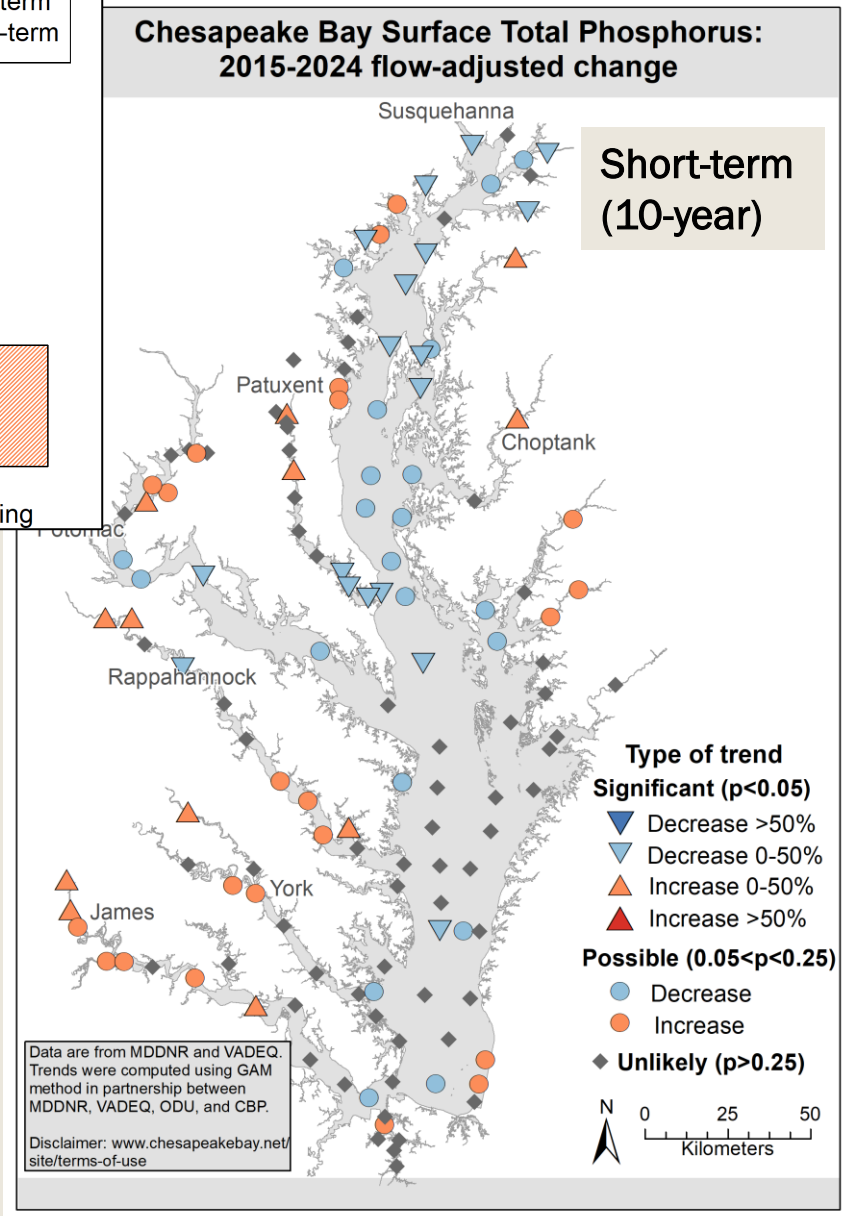
Total Phosphorus





Summary for TP

- Long-term trends decreasing at majority of stations.
- Short-term is more mixed, with the largest group with no trend.



Watershed loads likely explain some tidal trends

Watershed Area

- RIM Watershed
- Chesapeake Bay

RIM Trend[1]: Load
2015 – 2024
Flow Normalized

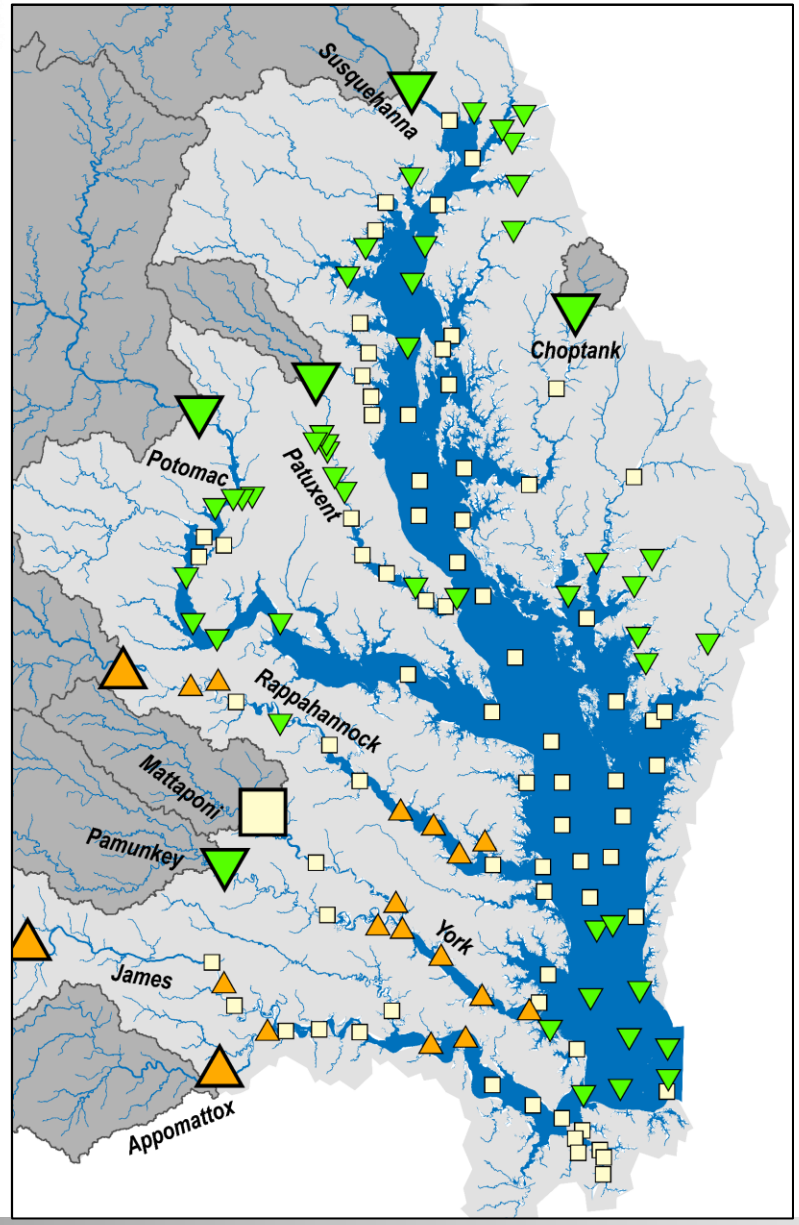
- Increase
- Decrease
- No Trend

Tidal Trend: Surface Concentration
2015/16 – 2023/24
Non-linear with Flow Adjustment

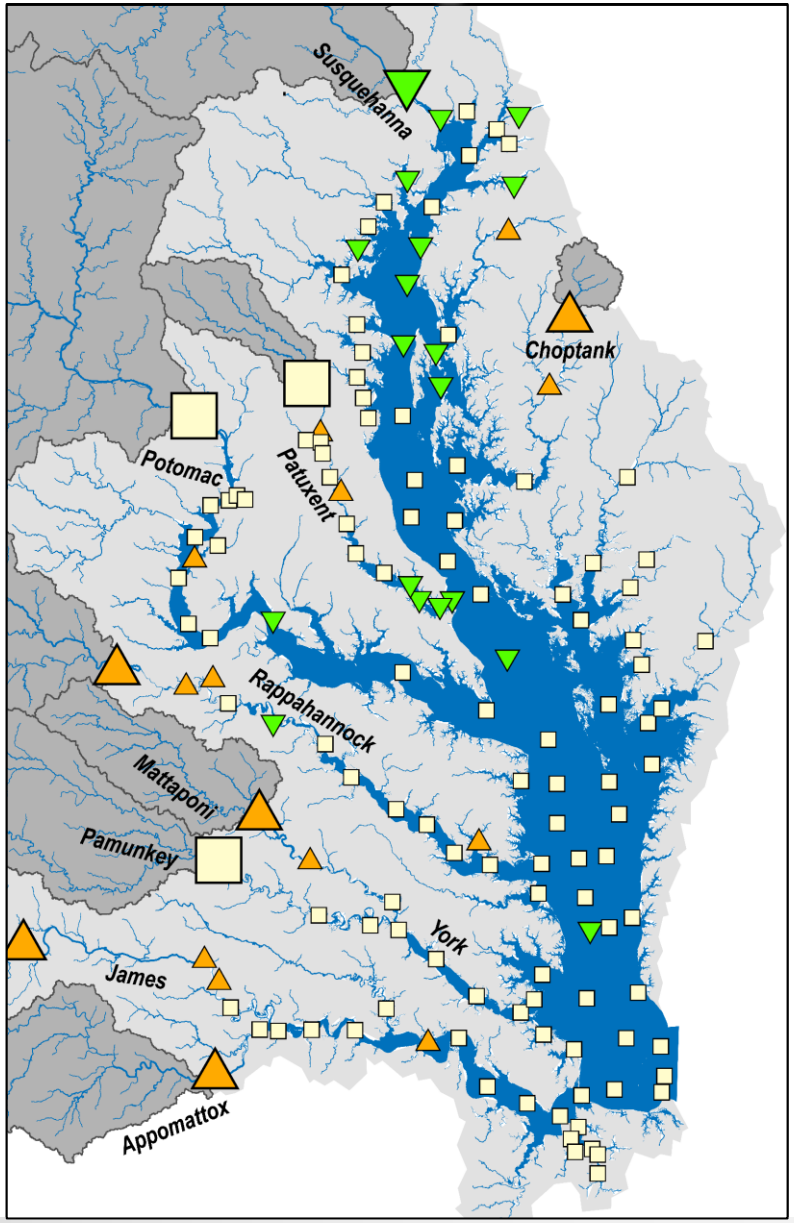
- Significant increase
- Significant decrease
- Possible or unlikely change

From Jimmy Webber, USGS

Total Nitrogen



Total Phosphorus



USGS science for a changing world

[1]Nontidal trends: https://www.usgs.gov/centers/chesapeake-bay-activities/science/chesapeake-bay-water-quality-loads-and-trends

Some of the other water quality variables of concern

Clarity: Secchi Depth

Visibility and light for underwater grasses

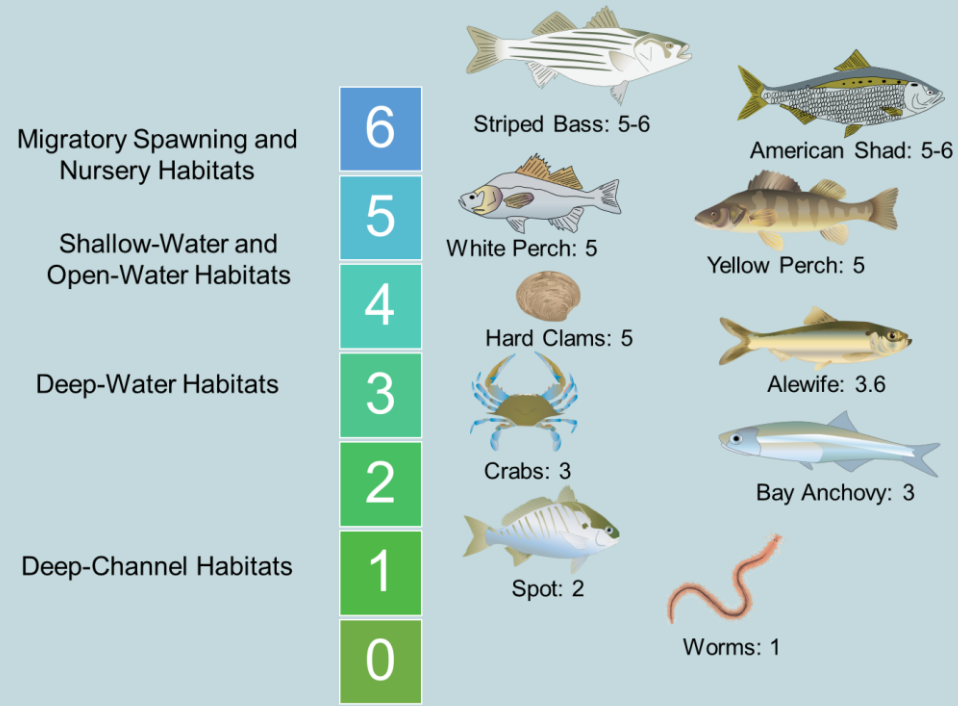
Matt Rath/Chesapeake Bay Program

Water Temperature

Impacts habitat suitability and amount of dissolved oxygen the water can hold

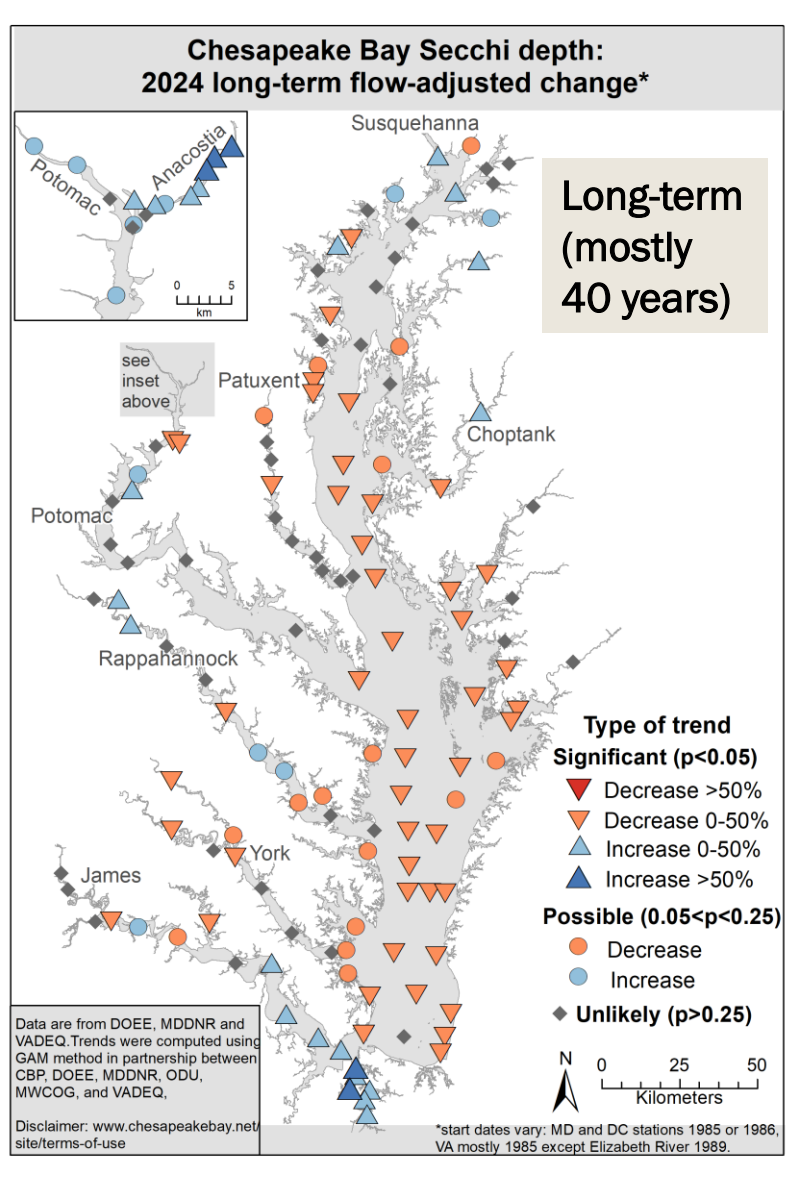
Dissolved Oxygen:

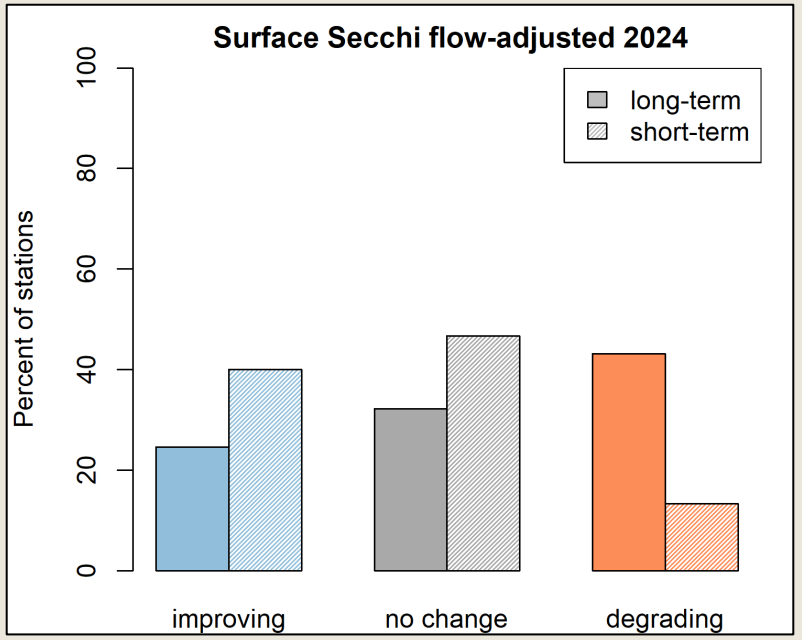
Different levels of concern for different species life stages and habitat



Based on EPA (2003). *EPA 903-R-03-002*

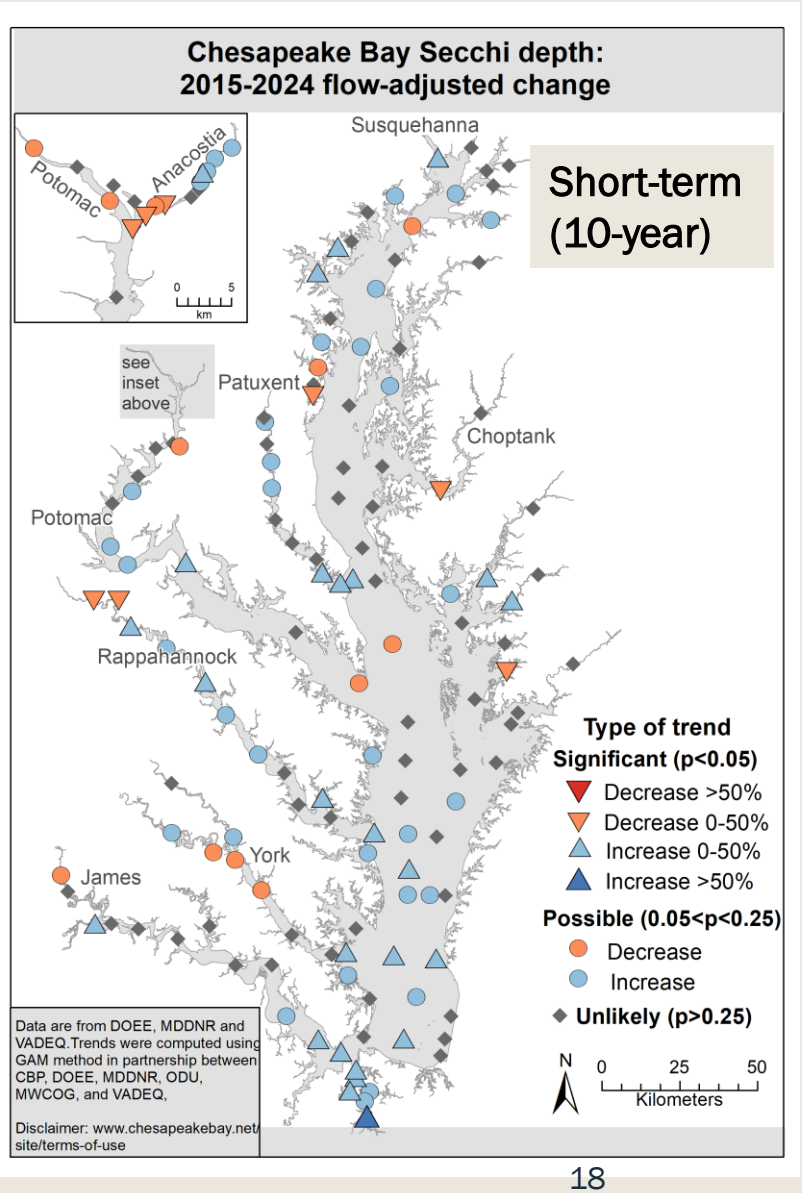
Secchi depth



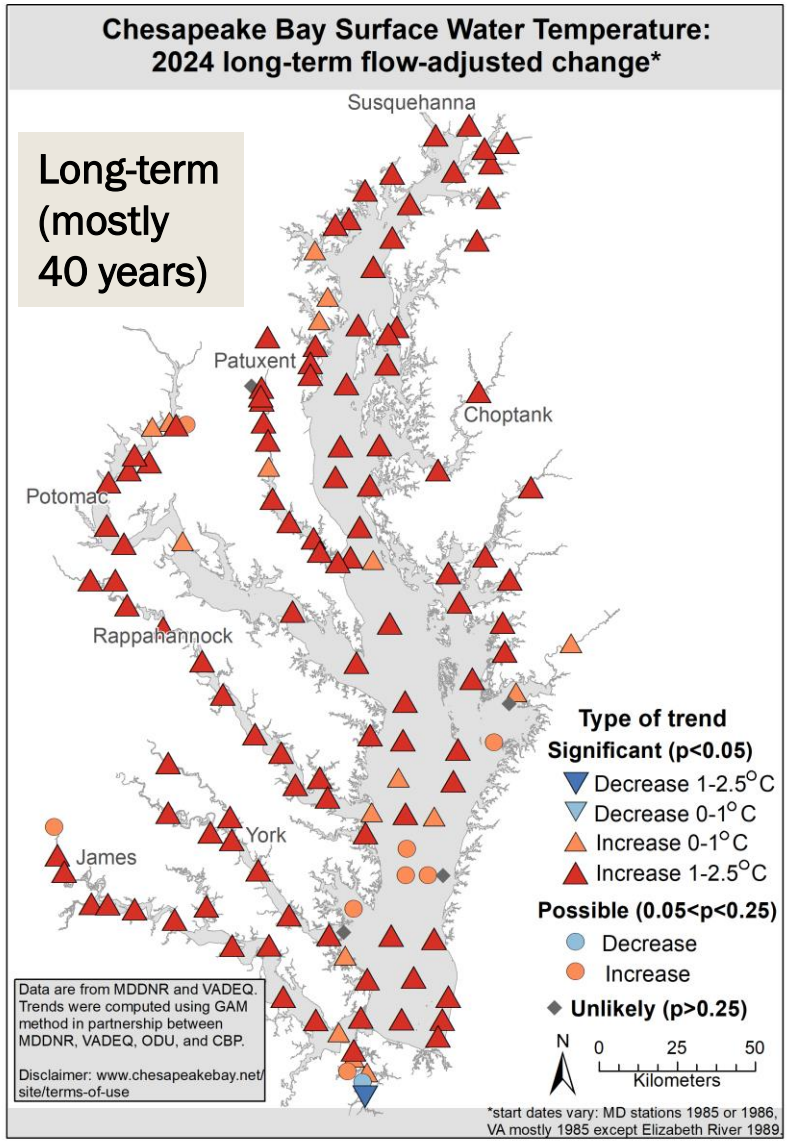


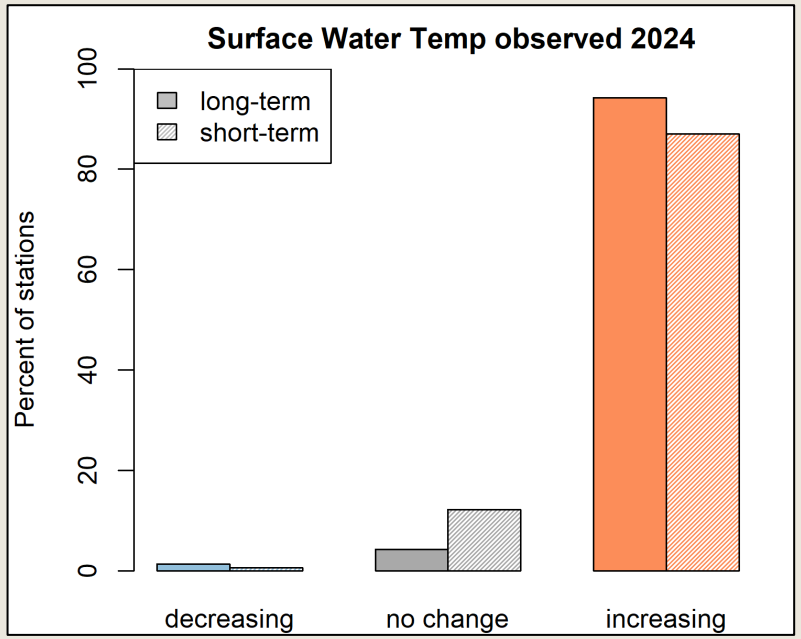
Summary for Secchi

- Long-term degradation in Secchi depth is notable across many regions of the bay.
- But in last 10 years, there are more improvements than degradations.



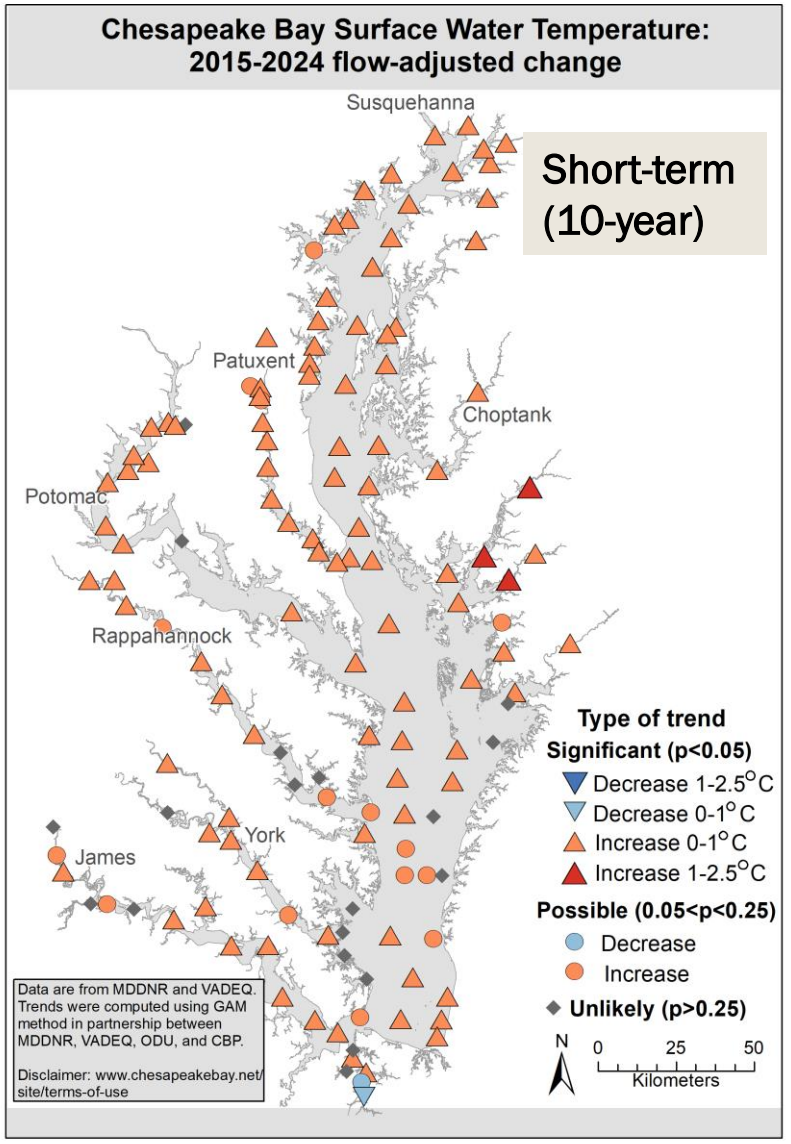
Water Temperature



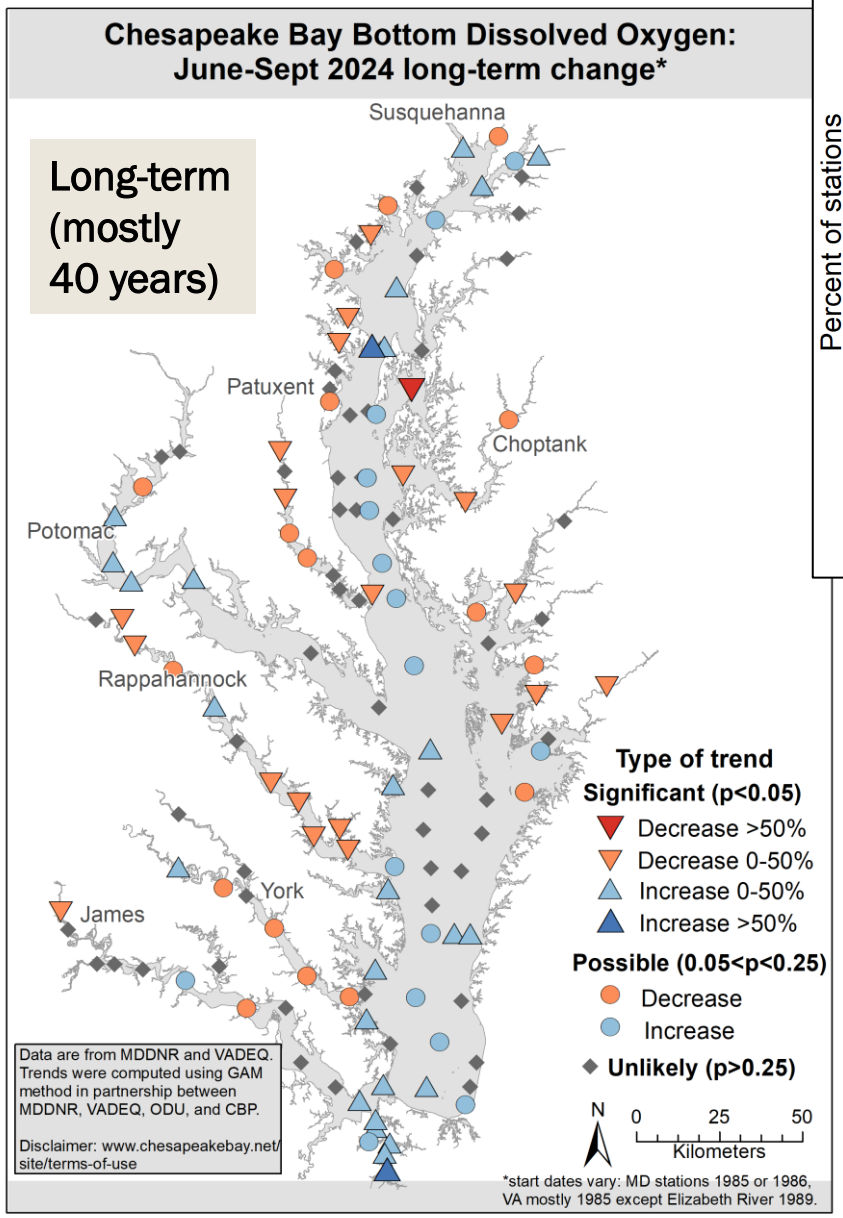


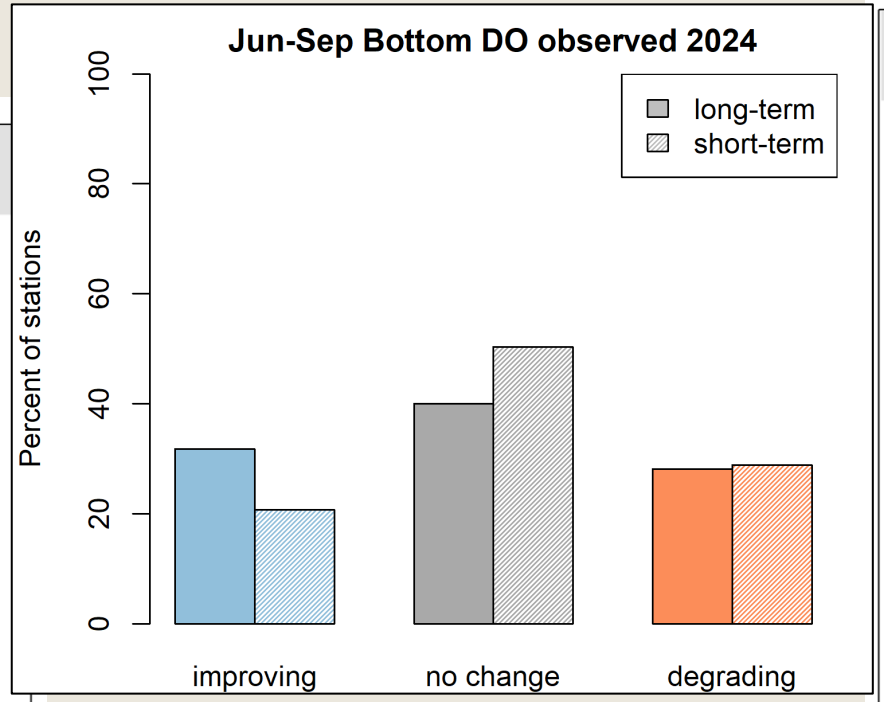
Summary for water temperature

- Water temperature is increasing across the entire tidal waters, both in the long- and short-term
- Water temperature can impact water quality and habitat in many ways.



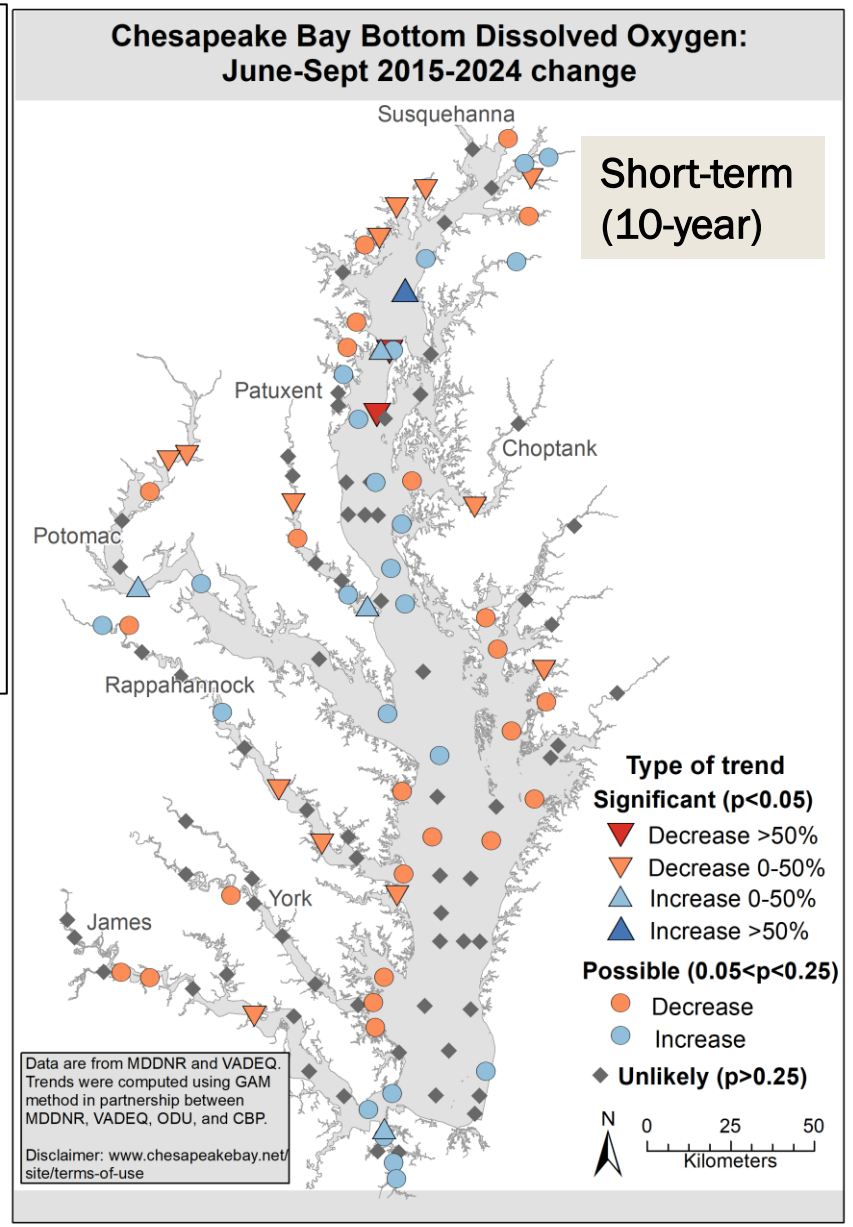
Bottom Summer DO





Summary for DO

- Bottom DO conditions vary widely across these stations due to depth and mixing.
- Improving conditions are observed in some of the deepest waters, while mixed trends exist elsewhere.

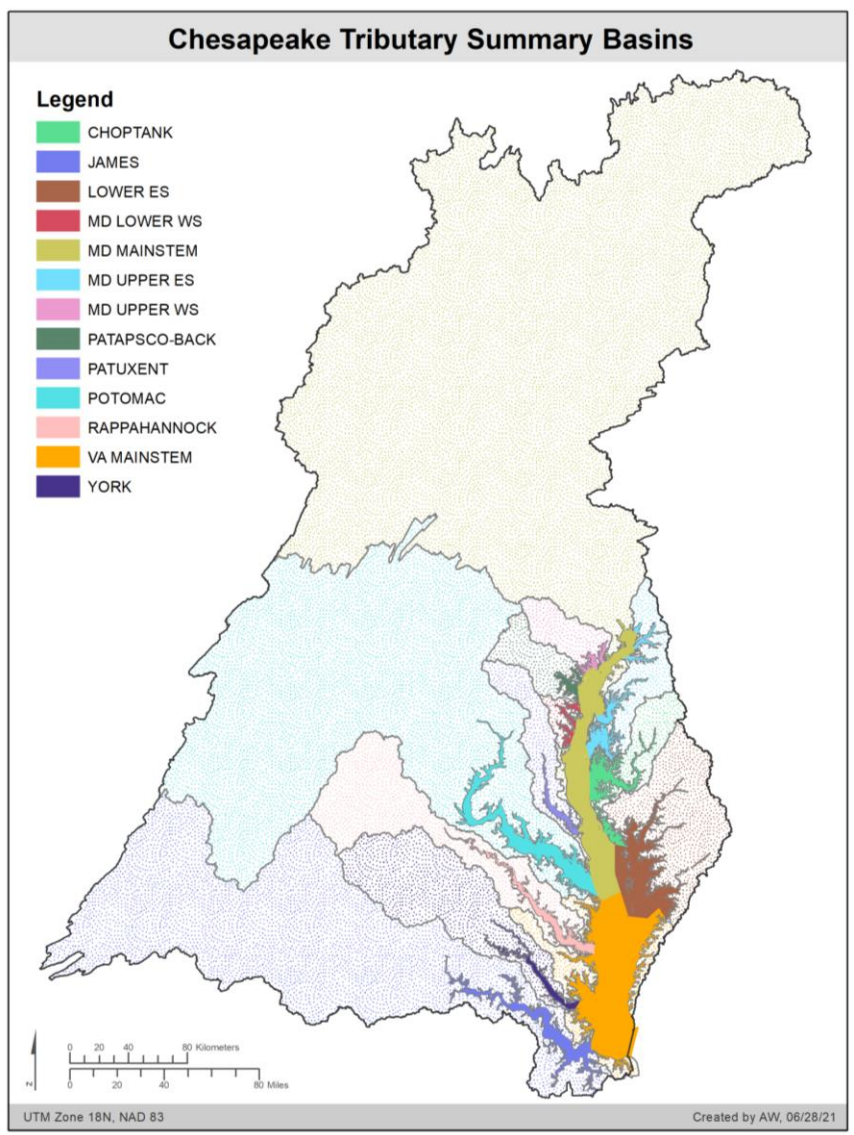


Tidal Trends Summary

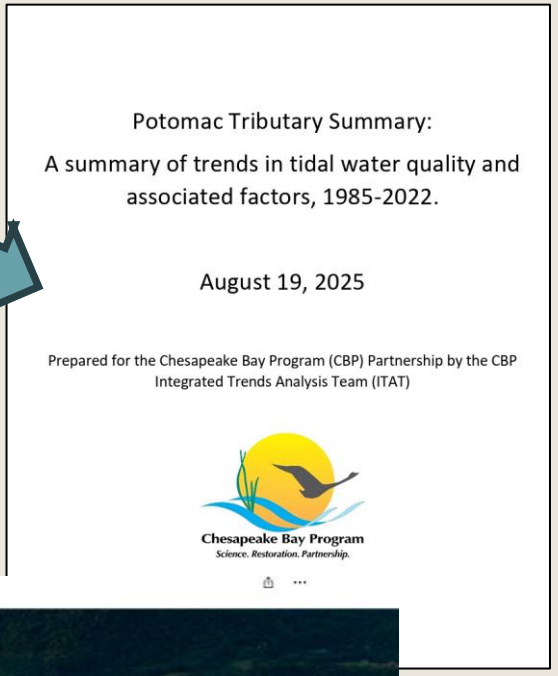
- Nutrient trends mostly improving over the long-term with some leveling-out over the short-term.
  - *Estuary response is generally consistent with the watershed.*
- Temperature increases bay-wide.
- Response variables have a variety of trends likely due to these differing influences from climate, nutrients, and in-estuary processing.

For region-specific information: Tributary Summaries

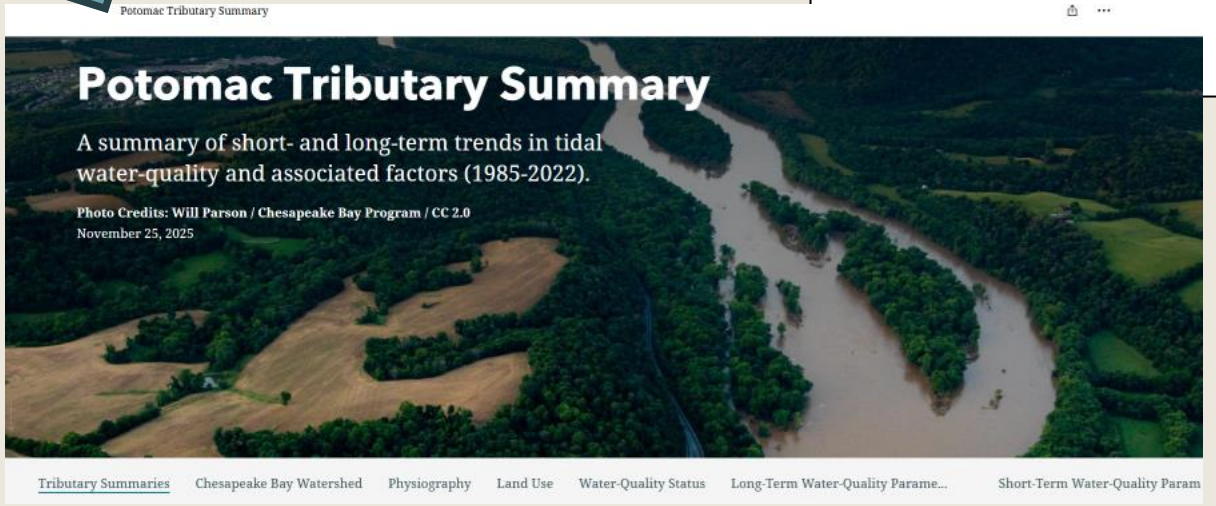
https://www.chesapeakebay.net/projects/tributary-summaries1



PDF documents



Online Story Maps



Contact Information

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- **ITAT Staffer:** Gabriel Duran, Chesapeake Research Consortium: gduran@chesapeakebay.net
- **ITAT Co-coordinator:** Breck Sullivan, USGS: bsullivan@chesapeakebay.net
- **ITAT Co-coordinator:** Kaylyn Gootman, EPA: gootman.kaylyn@epa.gov

Chesapeake Bay Program
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Acknowledgements and links

- ITAT Projects Page: https://www.chesapeakebay.net/who/projects-archive/integrated-trends-analysis-team
- Baytrendsmap: https://baytrends.chesapeakebay.net/baytrendsmap/
- CAST link with trends: https://cast.chesapeakebay.net/Home/TMDLTracking#tributaryRptsSection

- Contributing to this year's results:
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  - *Breck Sullivan (USGS), Kaylyn Gootman (EPA) and Gabriel Duran (CRC)*
- Baytrends and baytrendsmap maintenance: Jon Harcum and Erik Leppo (Tetra Tech)
- And no trends are possible without data collection from DOEE, MDDNR, and VADEQ teams!

More info on trends approach:

- baytrends: Long Term Water Quality Trend Analysis. R package version 2.0.12. https://cran.r-project.org/web/packages/baytrends/index.html
- Murphy, R.R., E. Perry, J. Harcum, and J. Keisman. 2019. https://doi.org/10.1016/j.envsoft.2019.03.027