

2024 Tidal Trends Summary

Rebecca Murphy (UMCES/CBP)

STAR meeting, Dec. 18, 2025

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)

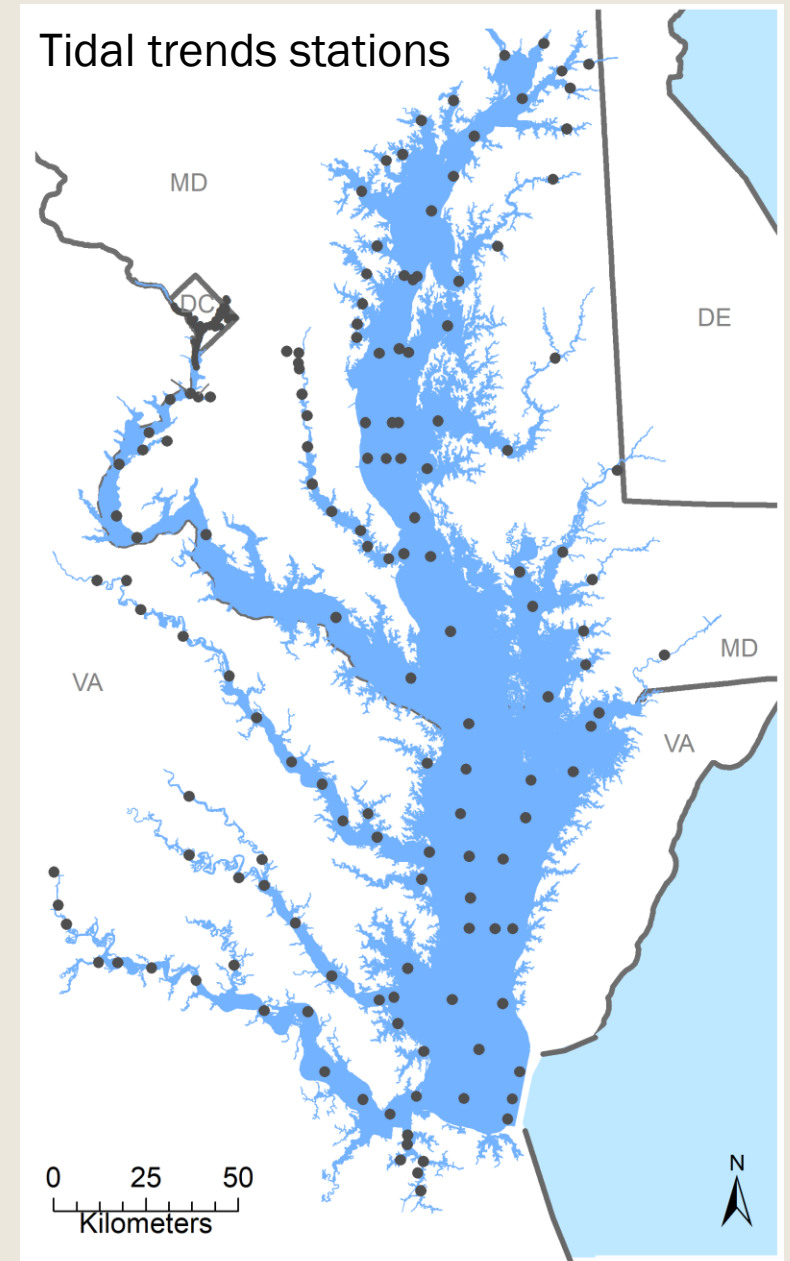
Data from: *DOEE, MDDNR, and VADEQ*



What are the tidal trends?

- Short- and long-term changes, or trends, at about 150 monitoring stations across the Chesapeake Bay mainstem and tidal tributaries for multiple water quality parameters including nutrients, clarity, oxygen, and temperature.
- Uses a nonlinear smoothing function* approach to account for seasonal influences, variations in flow or salinity, and changes in methods.
 - See *Murphy et al., 2019* for more details.
- Successful partnership collaboration to generate consistent, comparable trend results across MD, VA, and DC tidal waters.

* Generalized Additive Models (GAMs)

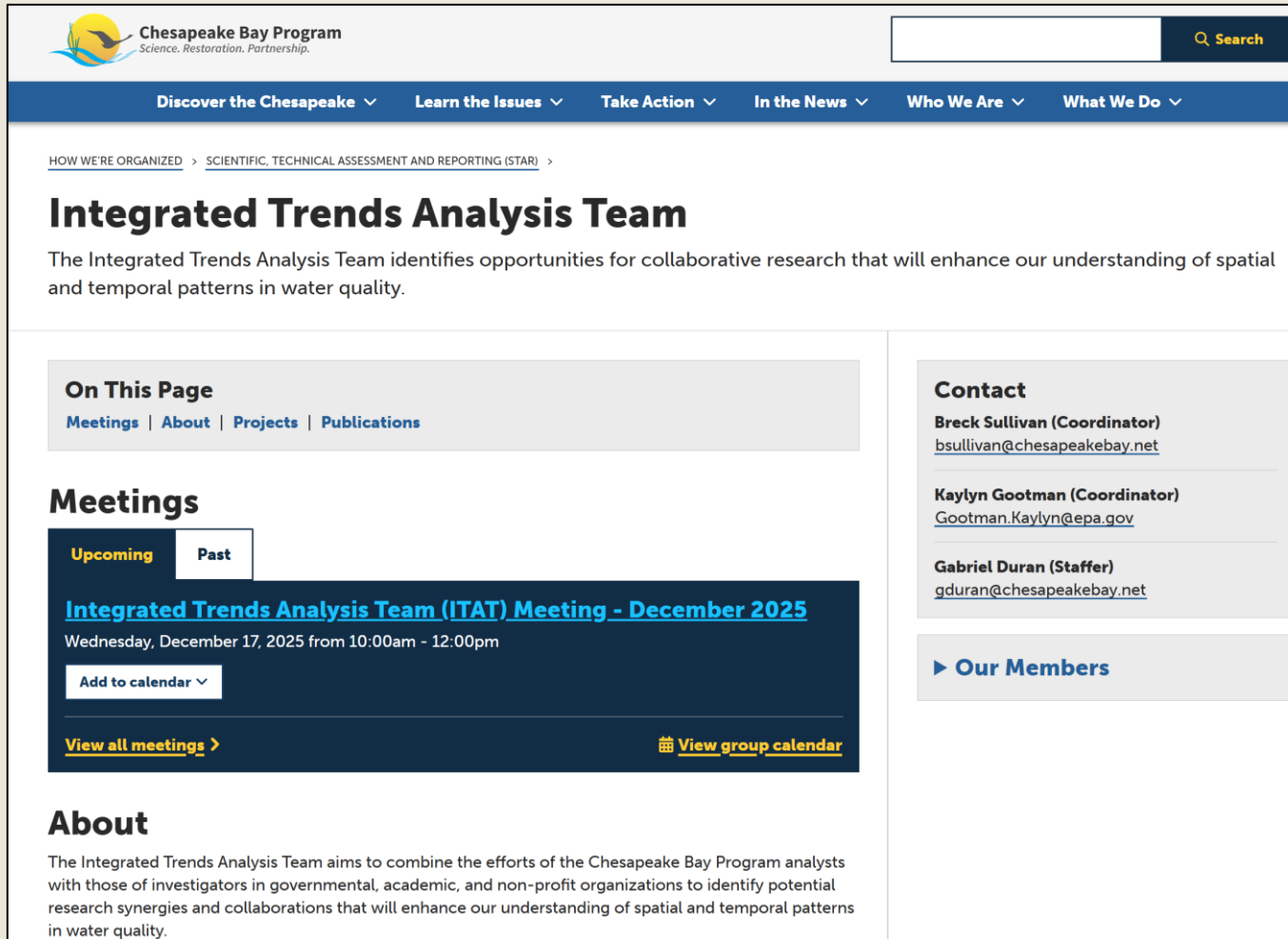


Annual collaborative effort between partners



Integrated Trends Analysis Team

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



The screenshot shows the website for the Integrated Trends Analysis Team (ITAT) under the Chesapeake Bay Program. The header includes the program logo and navigation links: Discover the Chesapeake, Learn the Issues, Take Action, In the News, Who We Are, and What We Do. A search bar is also present. The main content area is titled 'Integrated Trends Analysis Team' and describes the team's mission to enhance understanding of spatial and temporal patterns in water quality. Below this, there is a section 'On This Page' with links to Meetings, About, Projects, and Publications. The 'Meetings' section is active, showing an 'Upcoming' tab and a list of meetings, including the 'Integrated Trends Analysis Team (ITAT) Meeting - December 2025' on Wednesday, December 17, 2025, from 10:00am to 12:00pm. There is a button to 'Add to calendar' and a link to 'View all meetings'. A 'View group calendar' link is also present. The 'About' section describes the team's goal to combine efforts of Chesapeake Bay Program analysts with those of investigators in governmental, academic, and non-profit organizations. A 'Contact' section lists three individuals: Breck Sullivan (Coordinator), Kaylyn Gootman (Coordinator), and Gabriel Duran (Staffer), each with their email address. A link to 'Our Members' is also provided.

Chesapeake Bay Program
Science. Restoration. Partnership.

Discover the Chesapeake ▾ Learn the Issues ▾ Take Action ▾ In the News ▾ Who We Are ▾ What We Do ▾

HOW WE'RE ORGANIZED > SCIENTIFIC, TECHNICAL ASSESSMENT AND REPORTING (STAR) >

Integrated Trends Analysis Team

The Integrated Trends Analysis Team identifies opportunities for collaborative research that will enhance our understanding of spatial and temporal patterns in water quality.

On This Page
[Meetings](#) | [About](#) | [Projects](#) | [Publications](#)

Meetings

Upcoming | Past

[Integrated Trends Analysis Team \(ITAT\) Meeting - December 2025](#)
Wednesday, December 17, 2025 from 10:00am - 12:00pm
[Add to calendar ▾](#)

[View all meetings >](#) [View group calendar](#)

About

The Integrated Trends Analysis Team aims to combine the efforts of the Chesapeake Bay Program analysts with those of investigators in governmental, academic, and non-profit organizations to identify potential research synergies and collaborations that will enhance our understanding of spatial and temporal patterns in water quality.

Contact

Breck Sullivan (Coordinator)
bsullivan@chesapeakebay.net

Kaylyn Gootman (Coordinator)
Gootman.Kaylyn@epa.gov

Gabriel Duran (Staffer)
gduran@chesapeakebay.net

[► Our Members](#)

- Gather to identify the broad scope of on-going work related to trends and patterns of water quality in the Chesapeake watershed and estuary.
- Discover previously un-identified linkages among the ongoing research activities of participating individuals and organizations.
- Develop a standard set of analysis tools that can be applied in any relevant ecosystem within the Chesapeake watershed and estuary.
- Foster increased collaboration and awareness of ongoing research.
- Provide a forum for bringing findings to the broader Chesapeake Bay management community.

2024 Results

ITAT webpage:

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

Thanks to
Gabriel Duran

CAST webpage/Trends over time:
<https://cast.chesapeakebay.net/EstuaryTrends>

Water Quality Variable	Improving	No Change
Dissolved Oxygen (summer, bottom layer)	13%	55%
Secchi Depth (annual)	39%	54%
Chlorophyll-a (spring, surface layer)	22%	60%
Total Nitrogen (annual, surface layer)		

Thanks to Raj Bojja and Megan Thyne

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)*

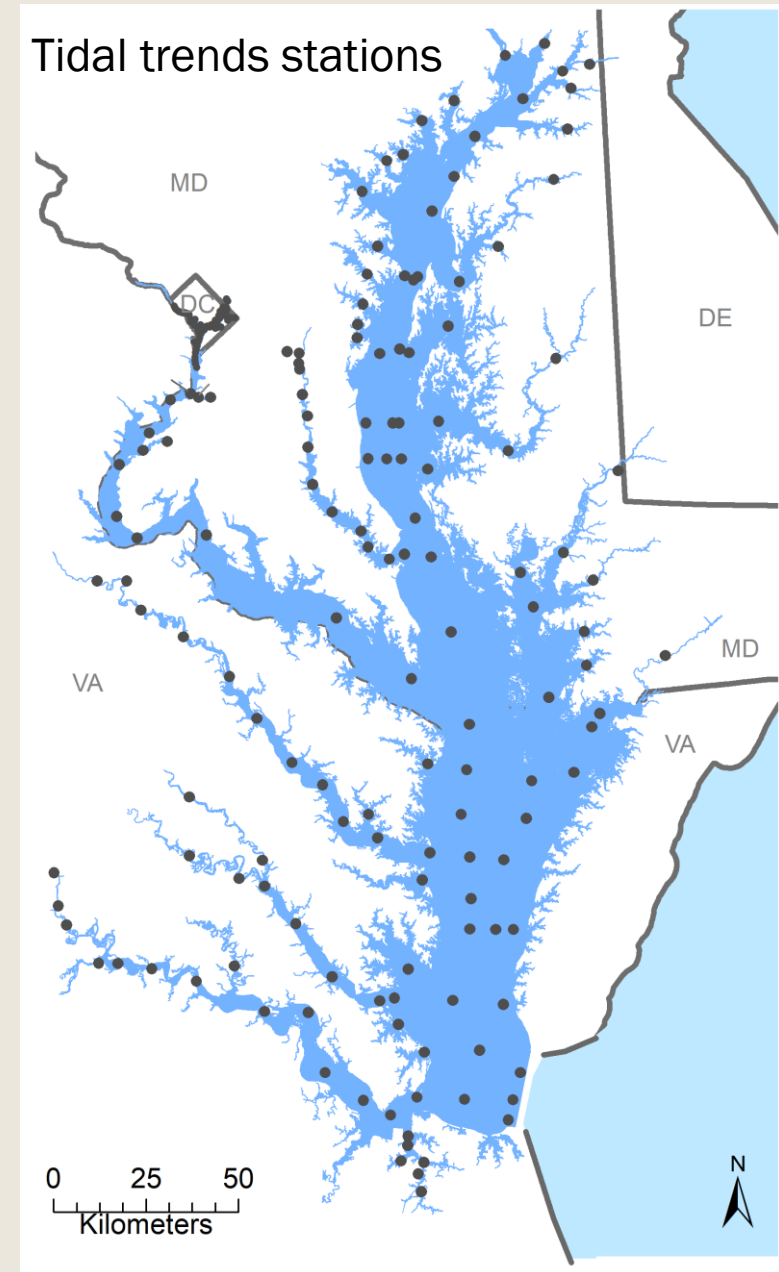
40 year trends!

- 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*



2024 Results

- Long-term (1980s-2024) and short-term (2015-2024) change:

- *Total Nitrogen (TN)*
- *Total Phosphorus (TP)*
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- *Chlorophyll a*
- *Water temperature*
- *Dissolved Oxygen (DO)*

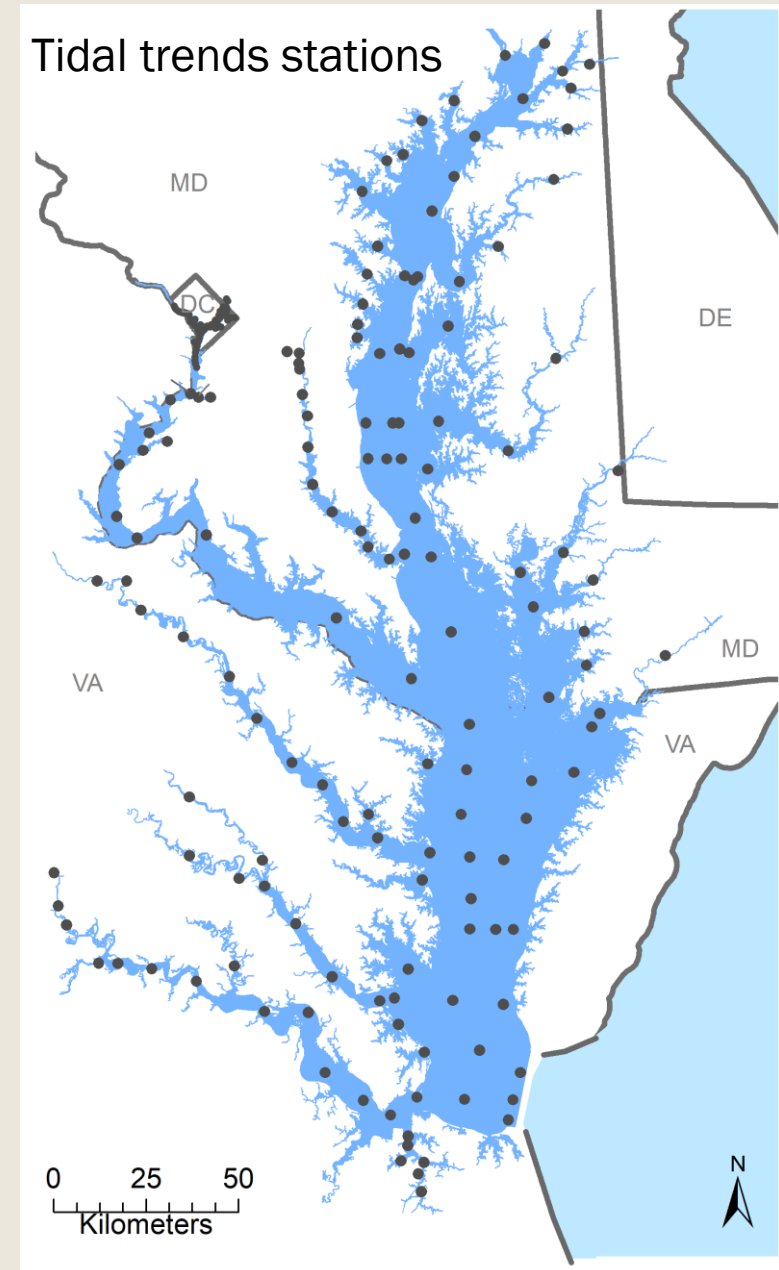
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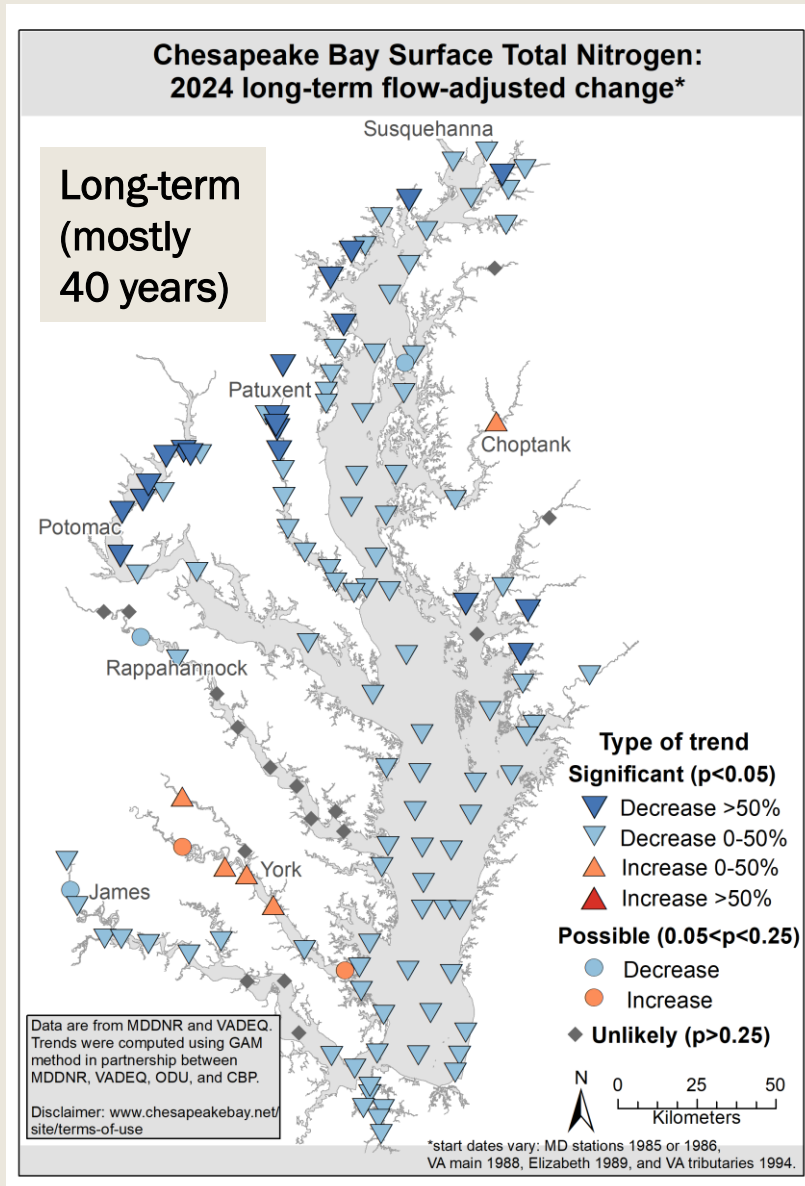
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- *Observed conditions, and flow- or salinity-adjusted conditions*

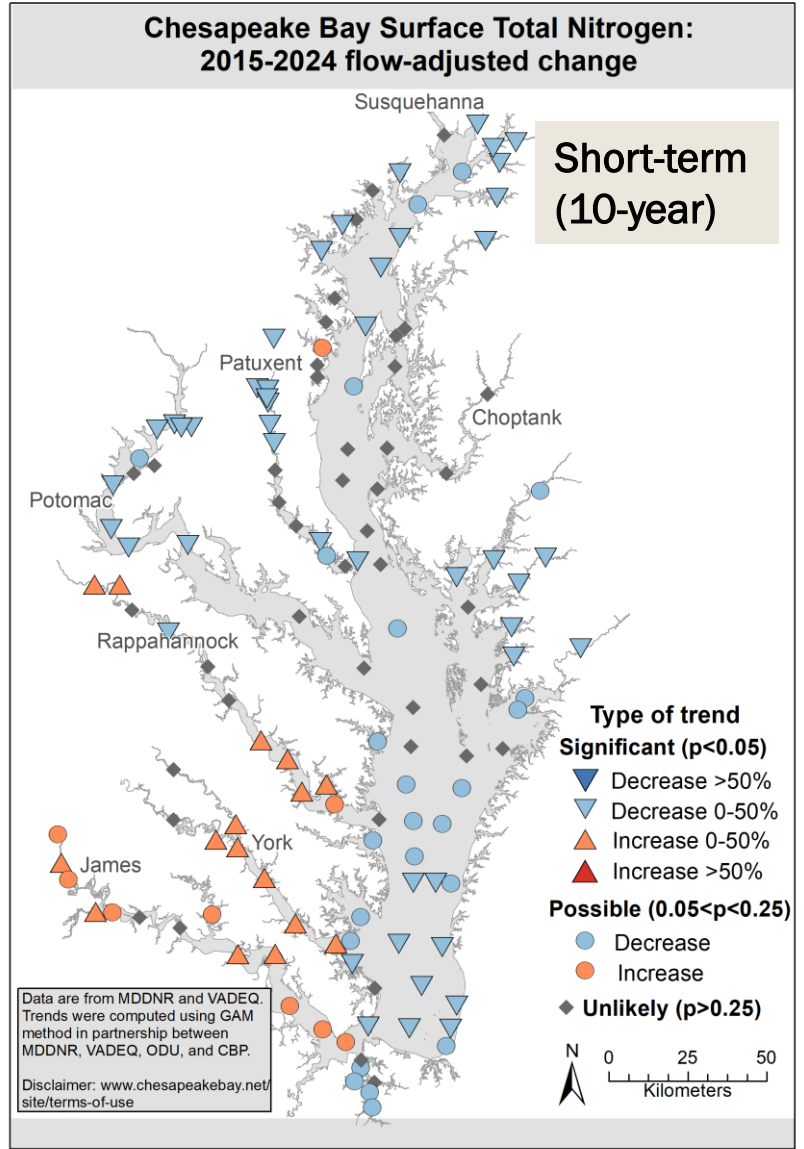
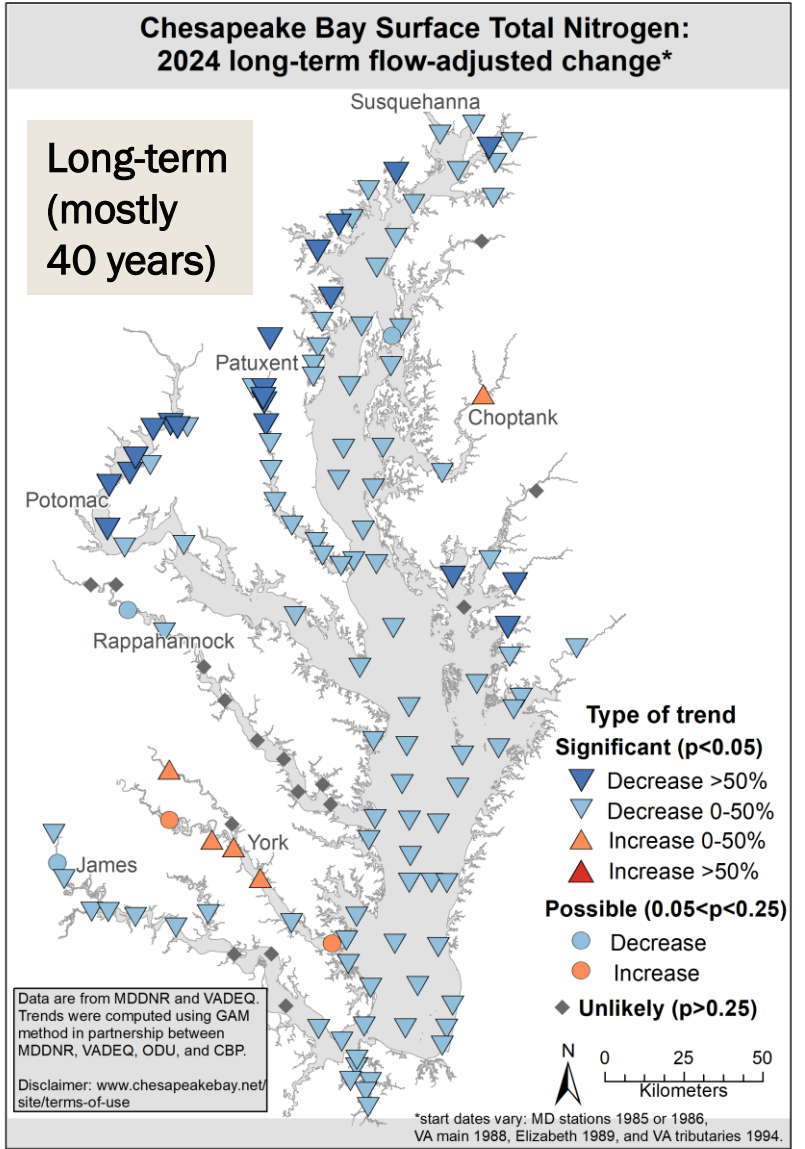


Surface Flow- adjusted

Surface Flow- adjusted

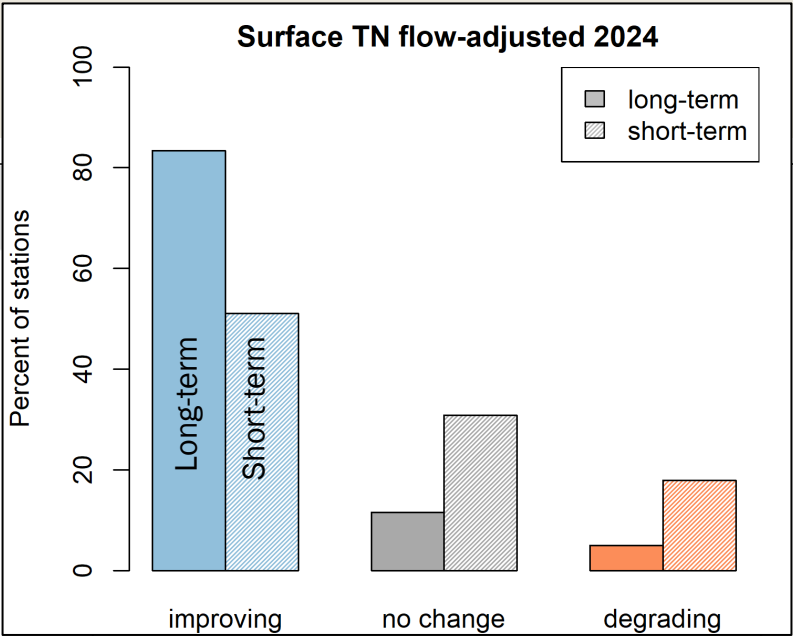
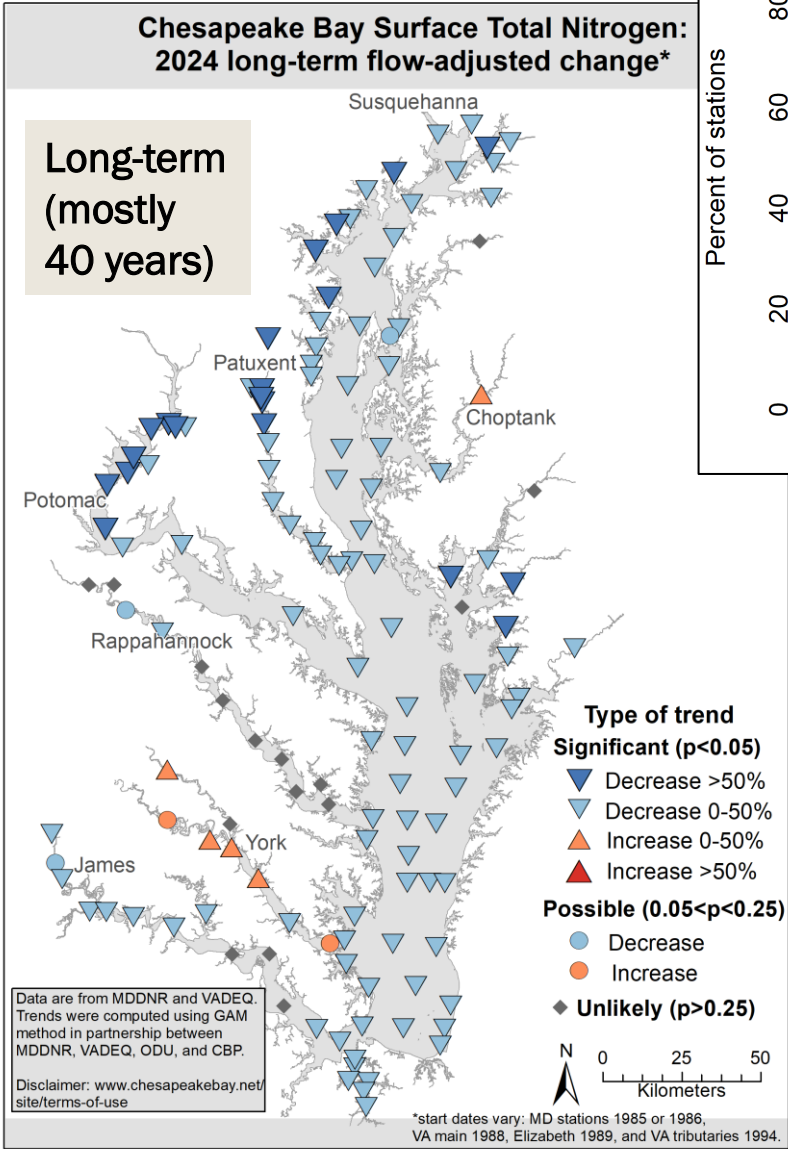


TN
Surface
Flow-
adjusted



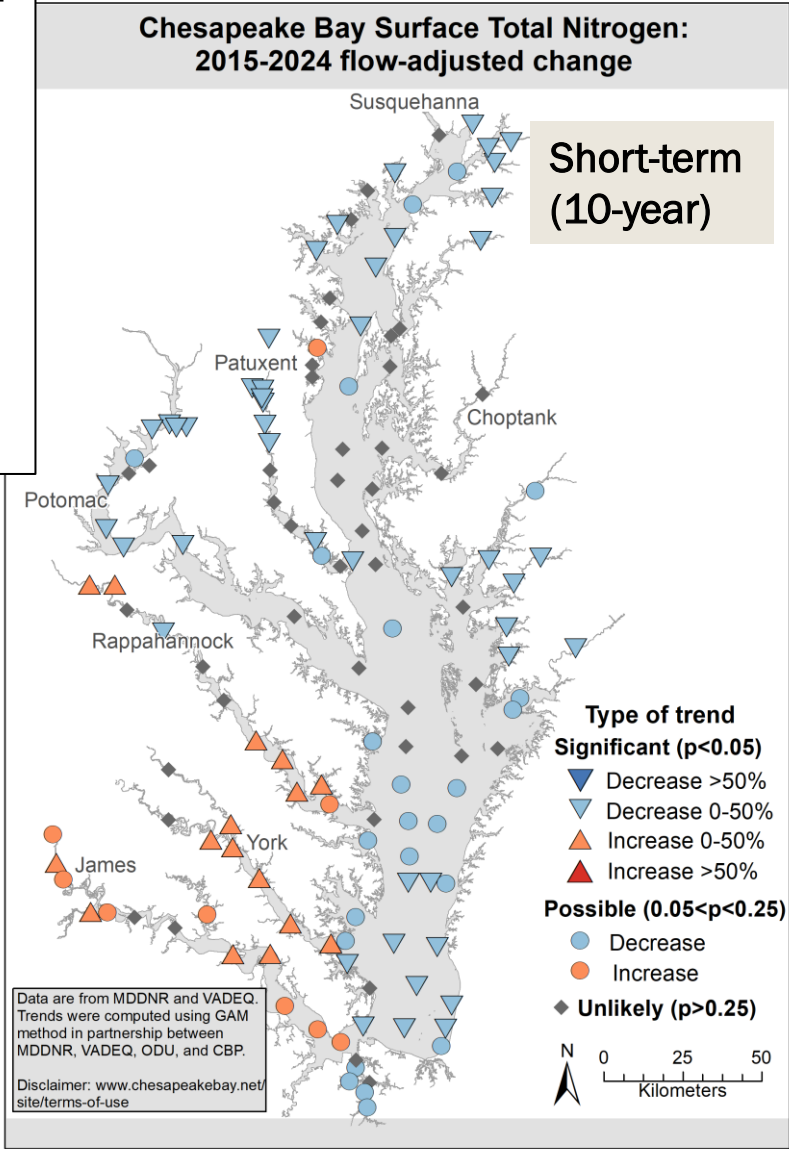
TN

Surface Flow-adjusted



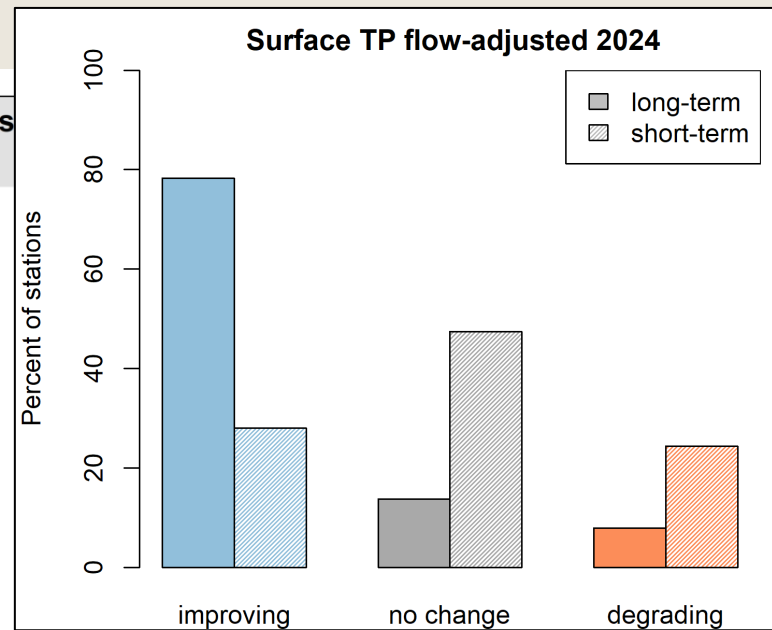
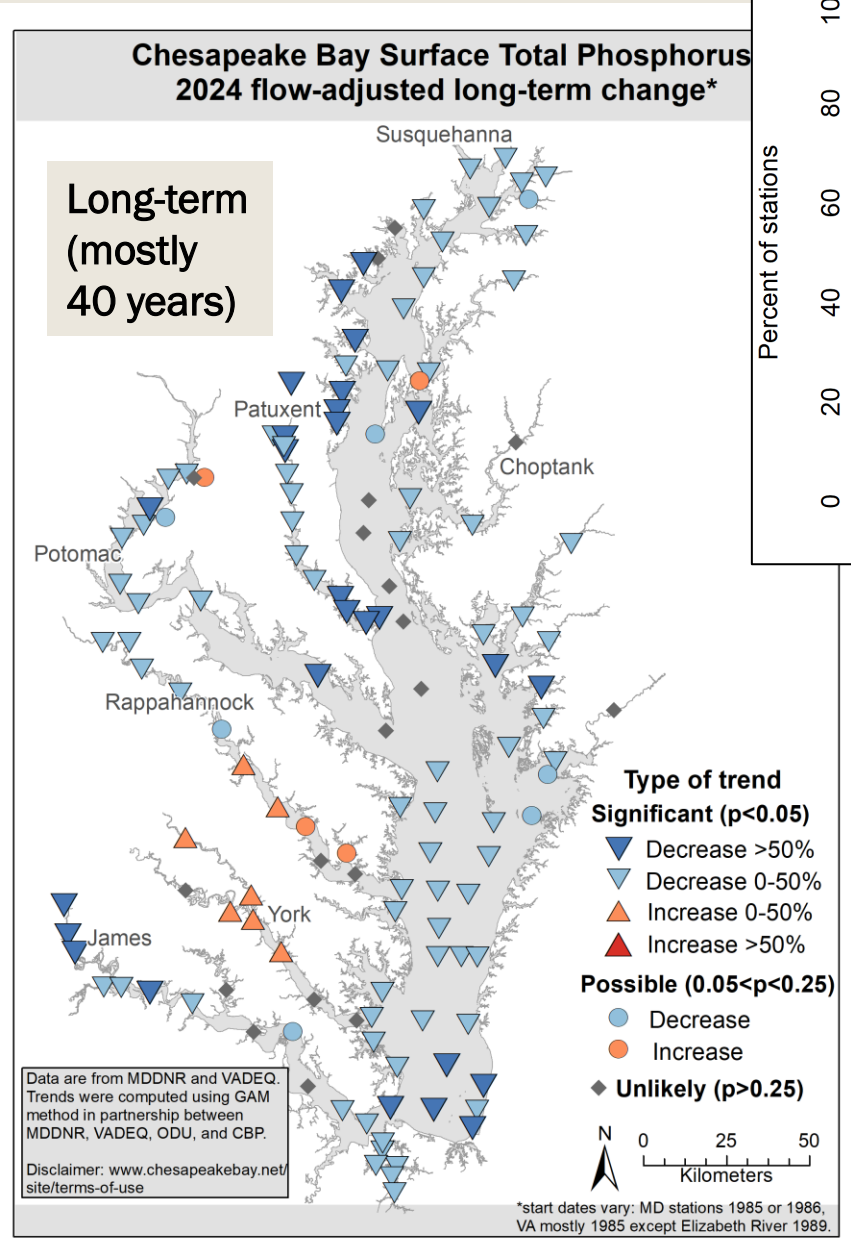
Summary for TN

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



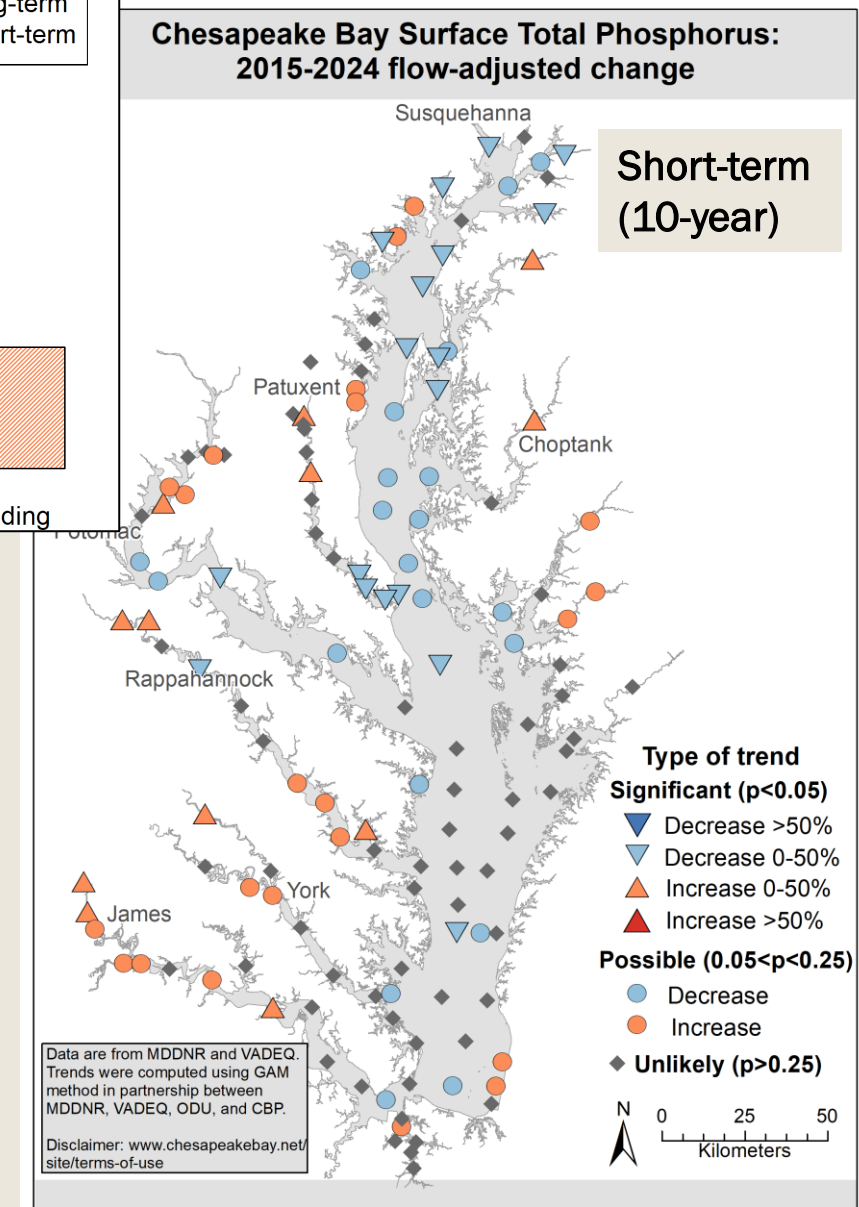
TP

Surface Flow- adjusted



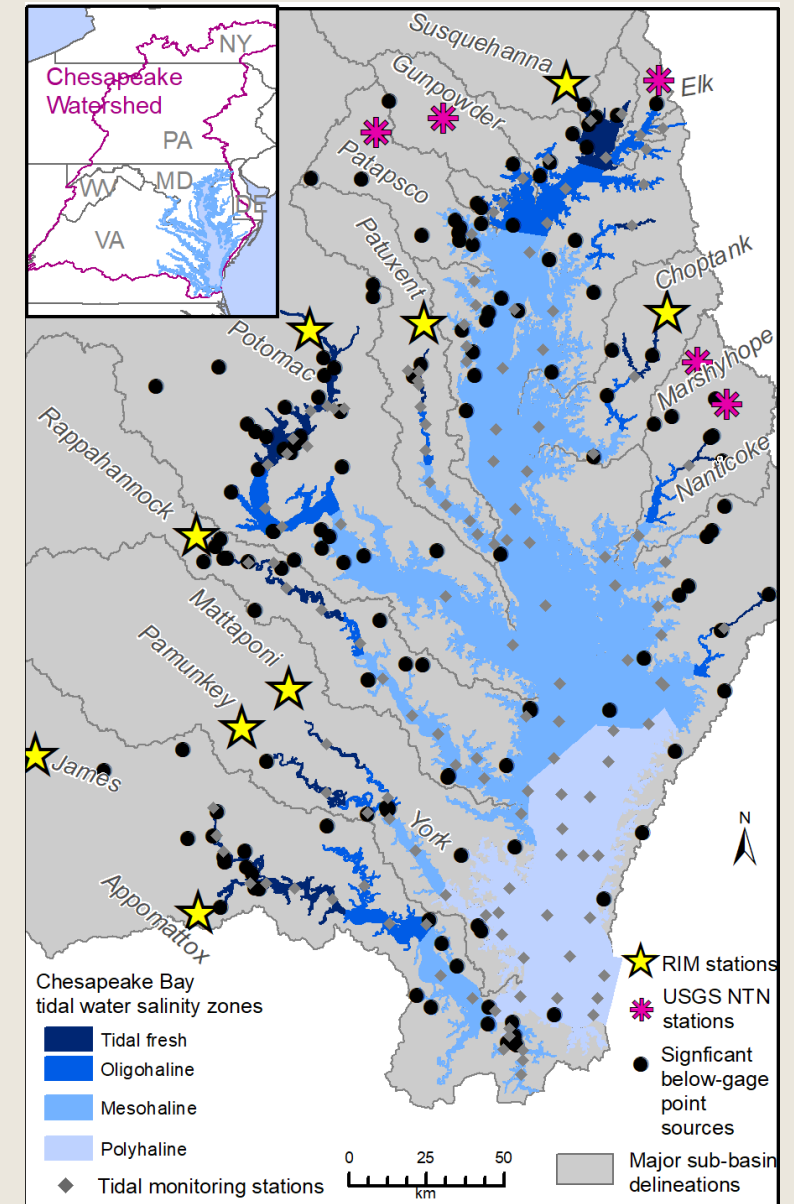
Summary for TP

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



Comparison to watershed loads

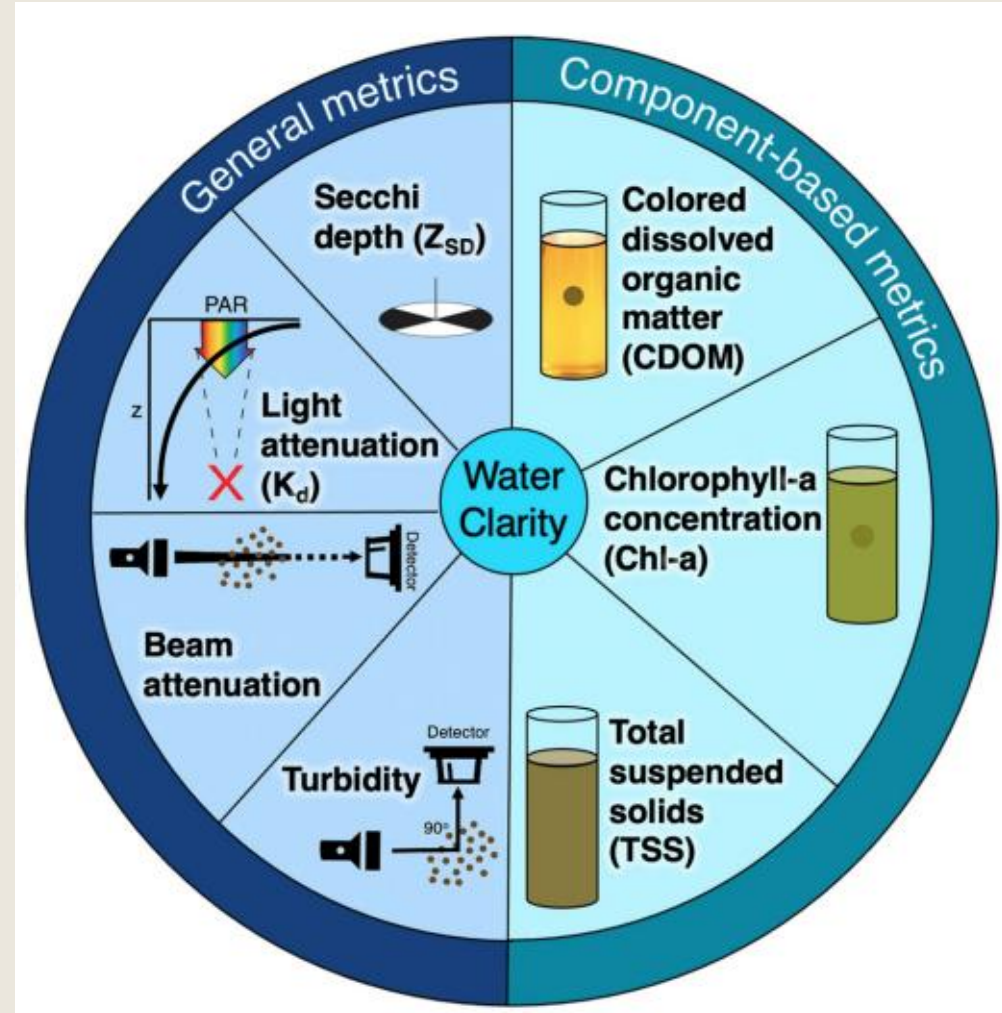
- Jimmy Webber will show some comparison next.
- ITAT & NTN conversations yesterday.
- Previous analysis provided insights as well. ➡



Murphy et al. 2021 "Nutrient Improvements in Chesapeake Bay: Direct Effect of Load Reductions and Implications for Coastal Management"
<https://doi.org/10.1021/acs.est.1c05388>

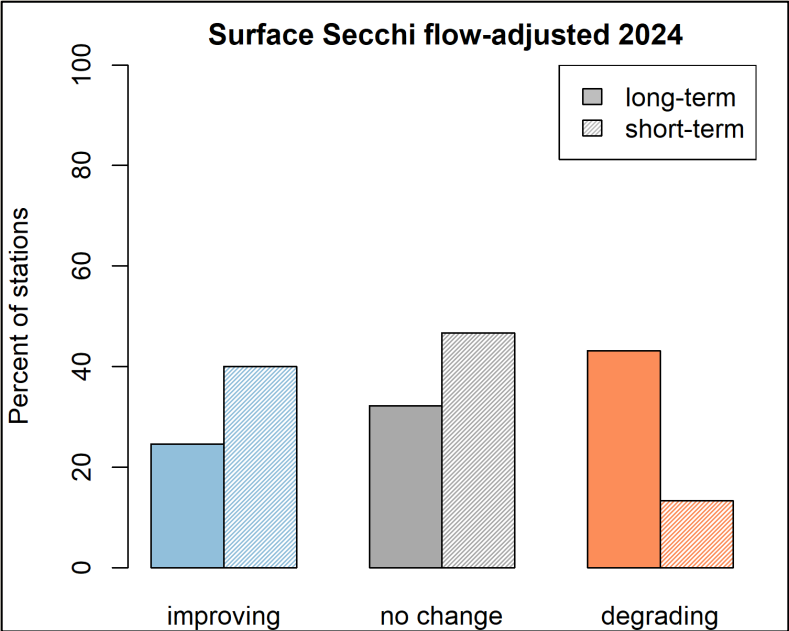
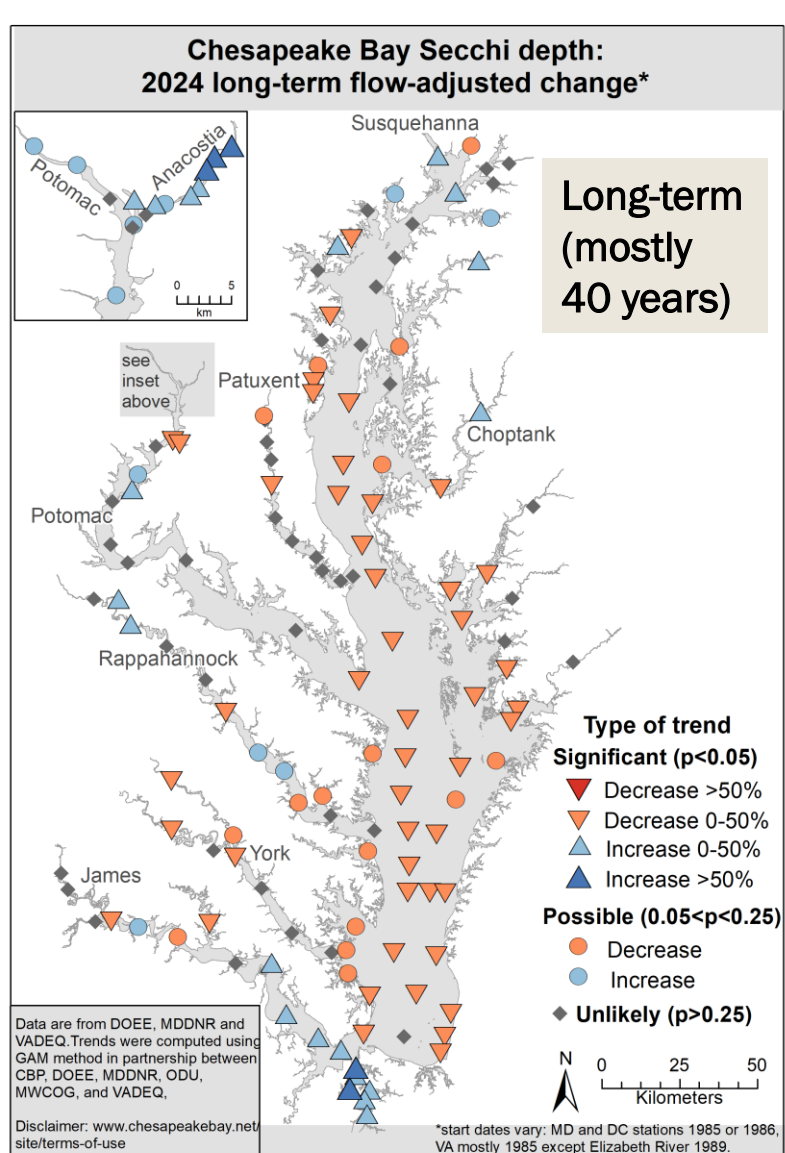
Multiple ways to consider water clarity

- Next trends = Secchi Depth
 - *Transparency and visibility*
 - *Long term data available for historical comparison*
 - *Community science and engagement opportunities*



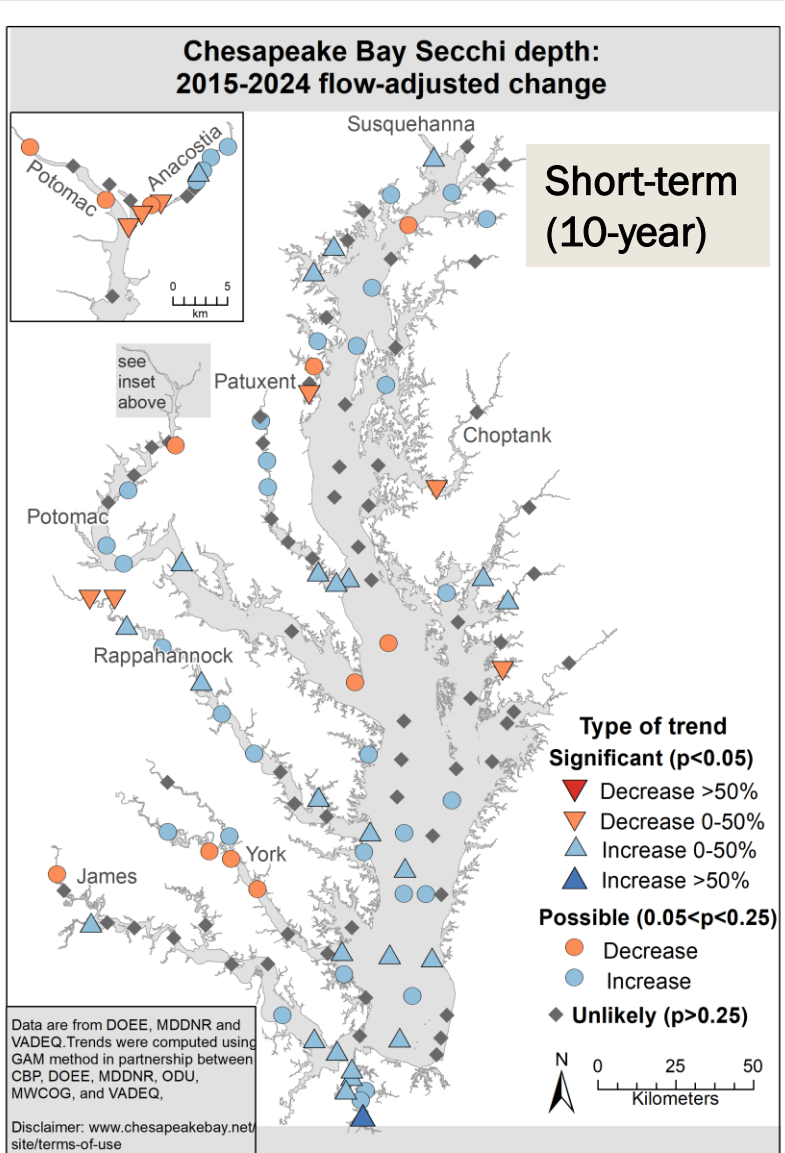
Sources: Turner et al., 2022; IAN UMCES media library

Secchi depth



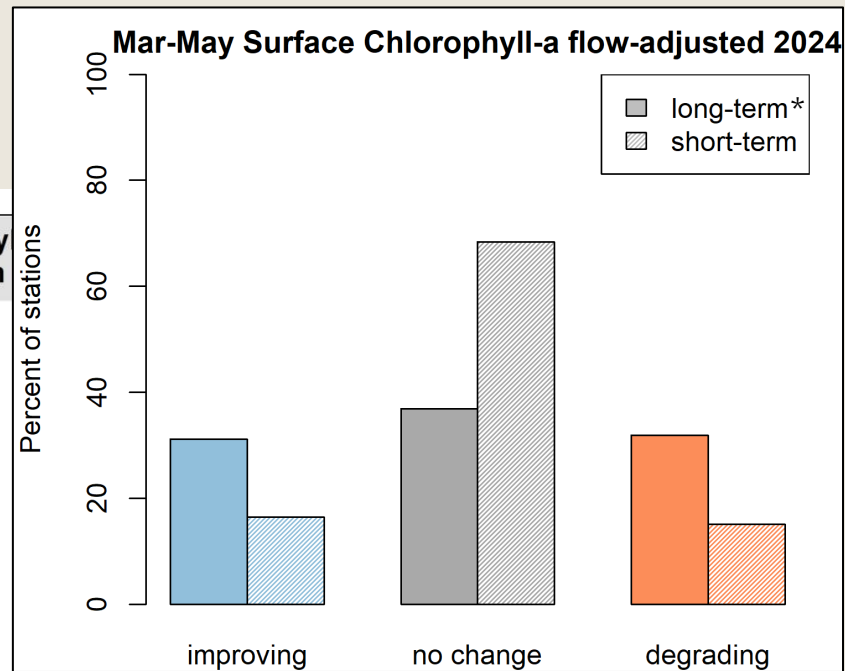
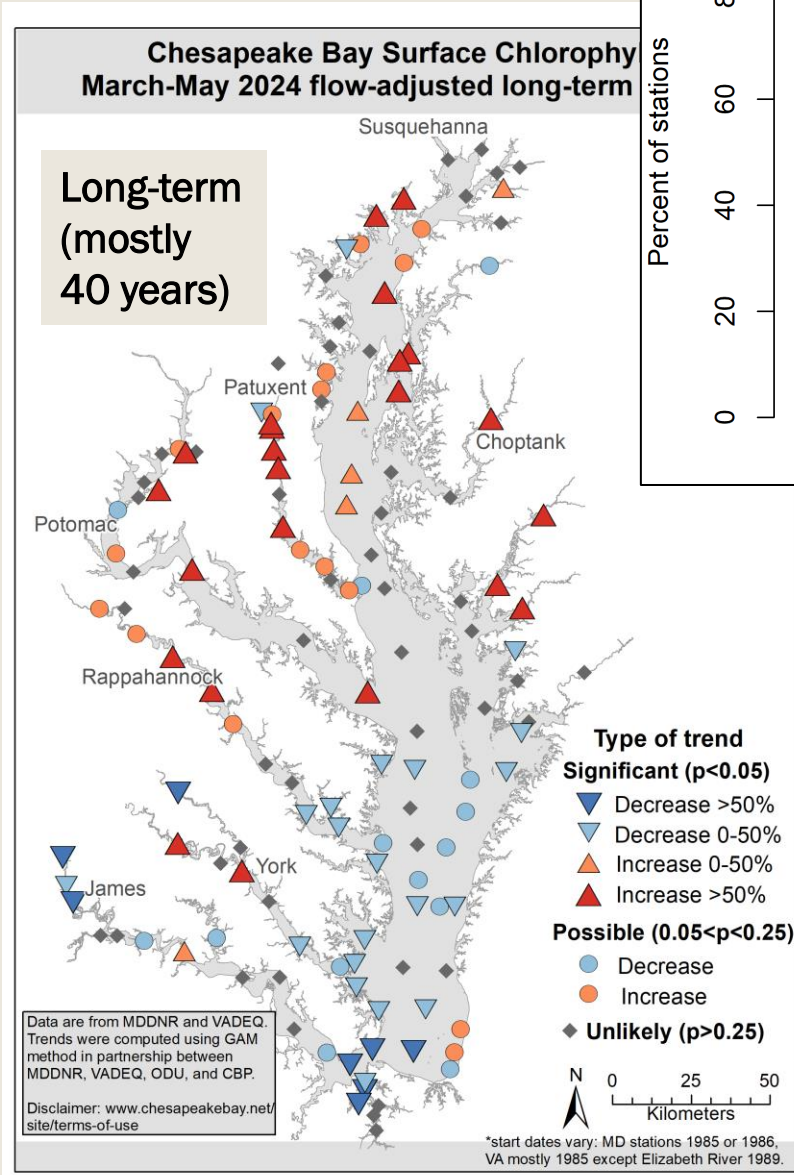
Summary for Secchi

- 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.
- These patterns were analyzed recently by Turner et al. 2025: <https://doi.org/10.1146/annurev-marine-040224-120528>



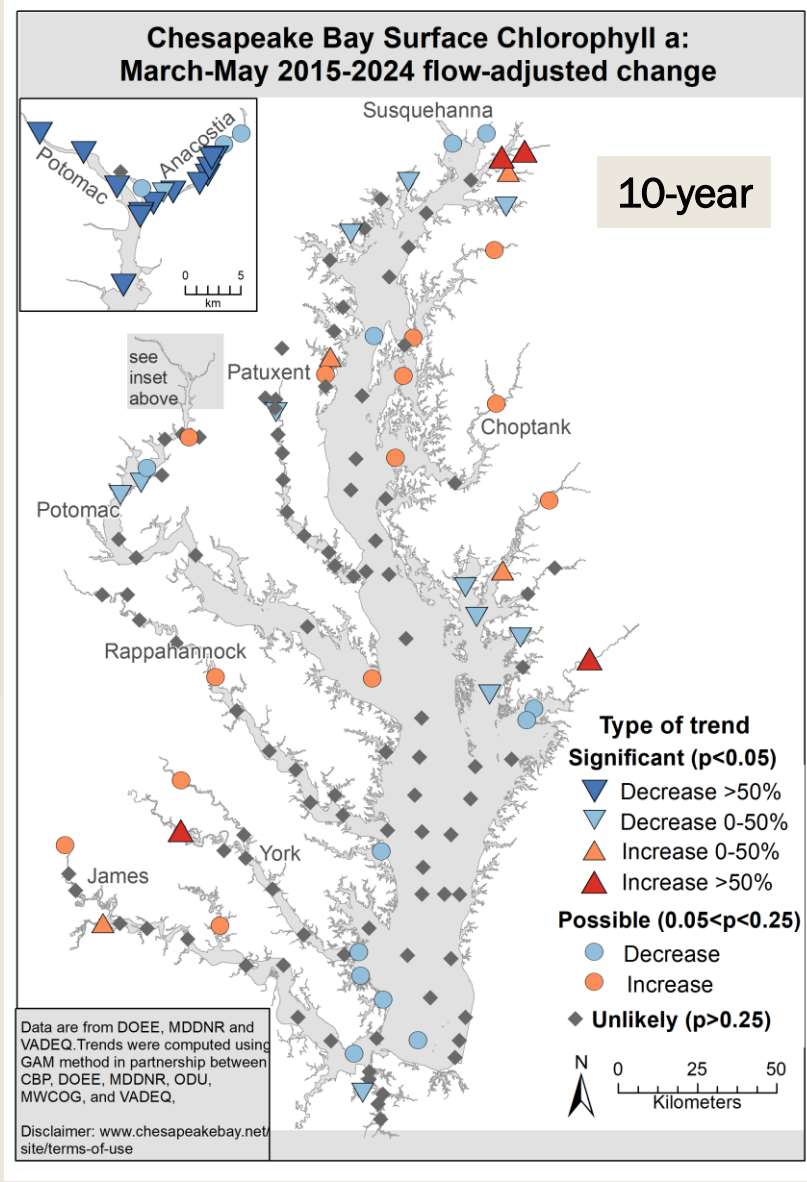
Spring Chlorophyll a

Surface
Flow-adjusted



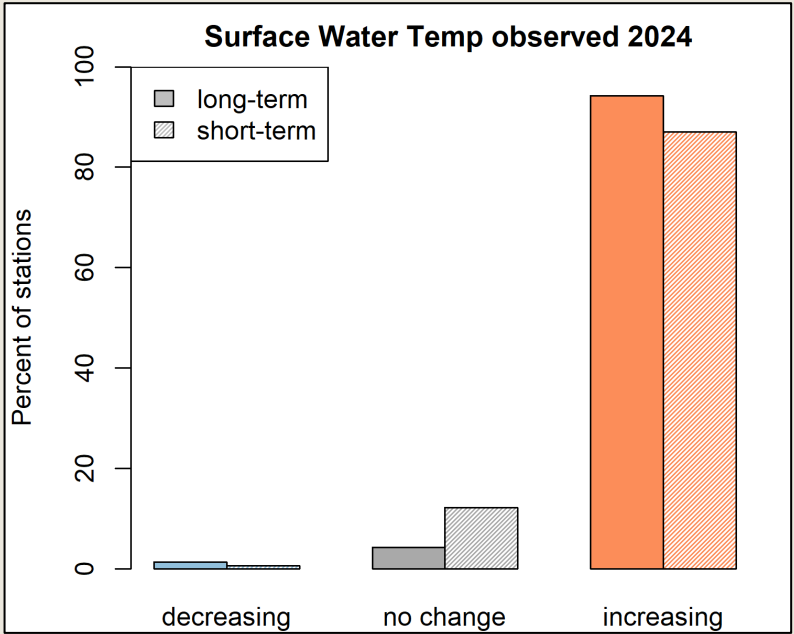
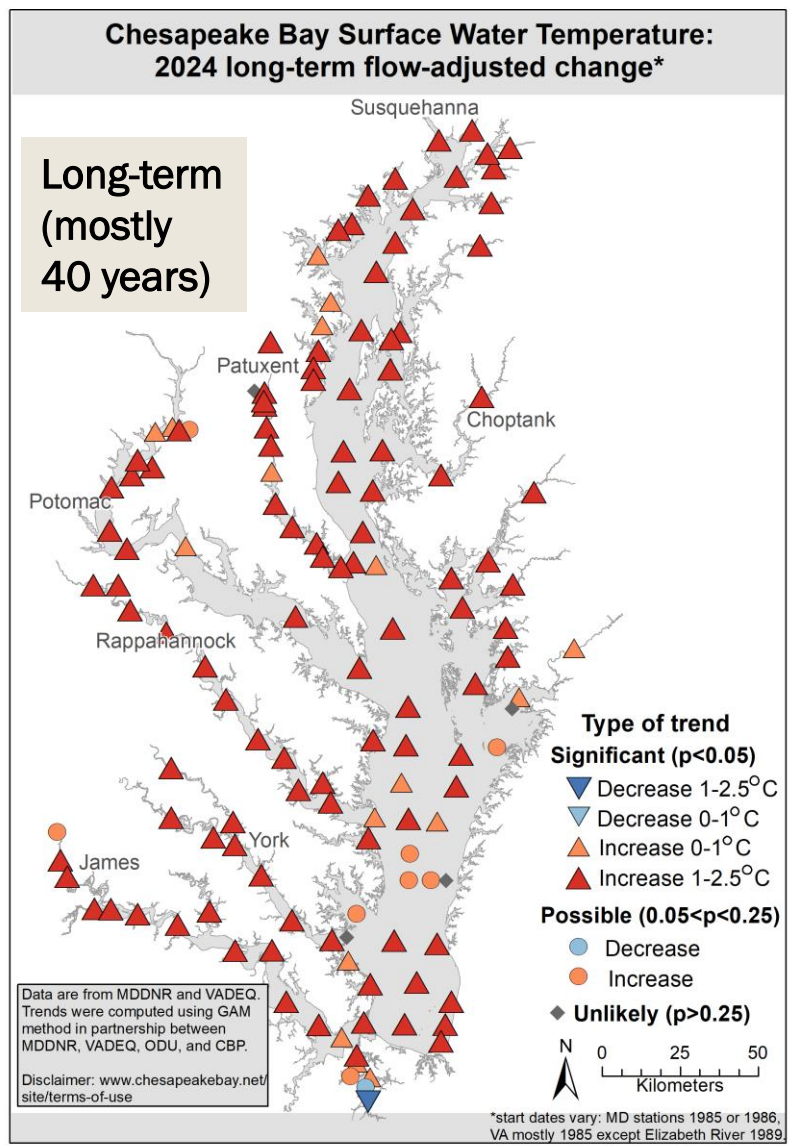
Summary for Chlorophyll

- A large mixture of trend types for chlorophyll a.
- The summer trends are similar.



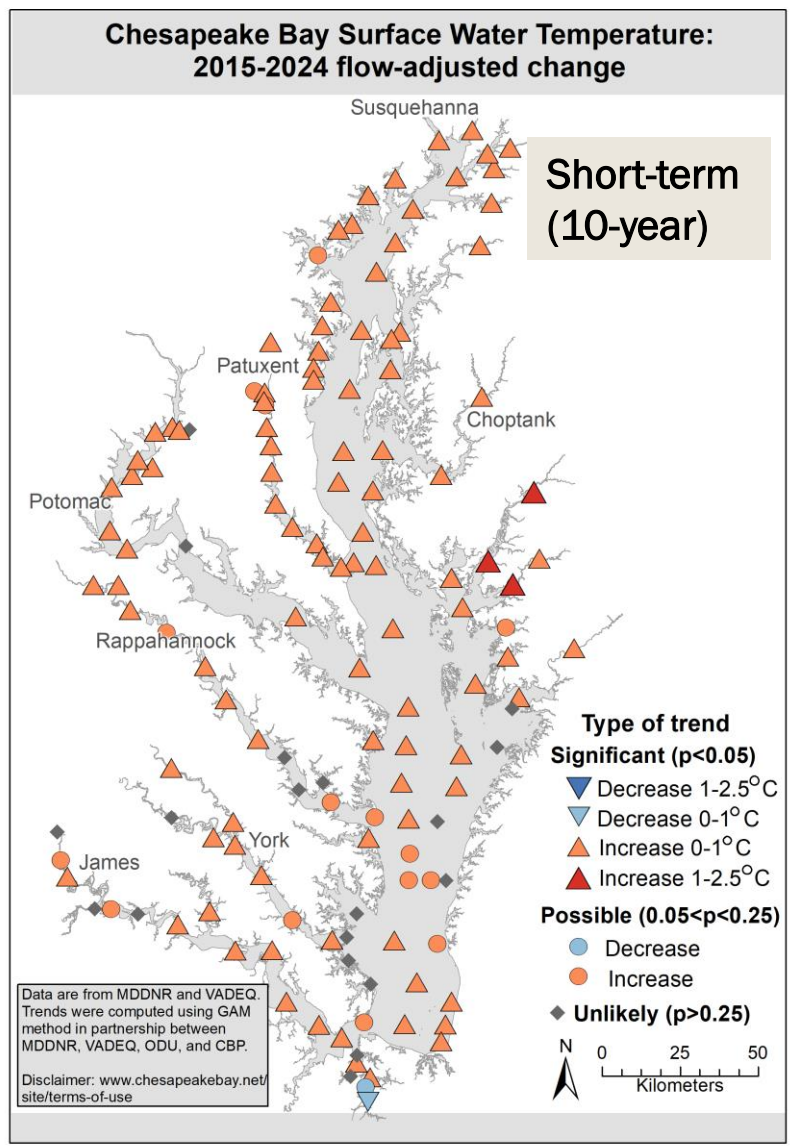
*Bar chart does not include DC trends since we don't have them for both long and short-term.

Water Temperature

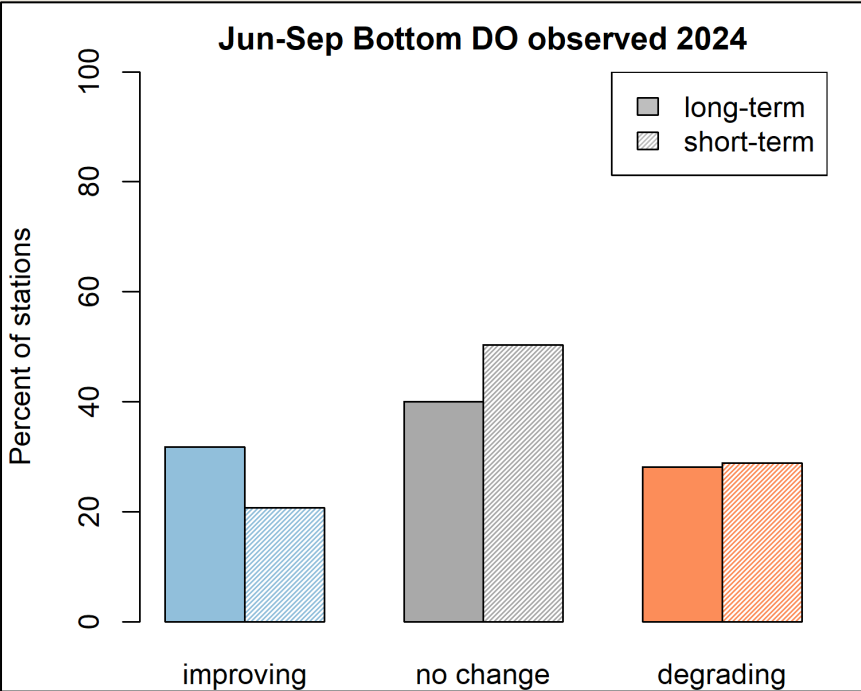
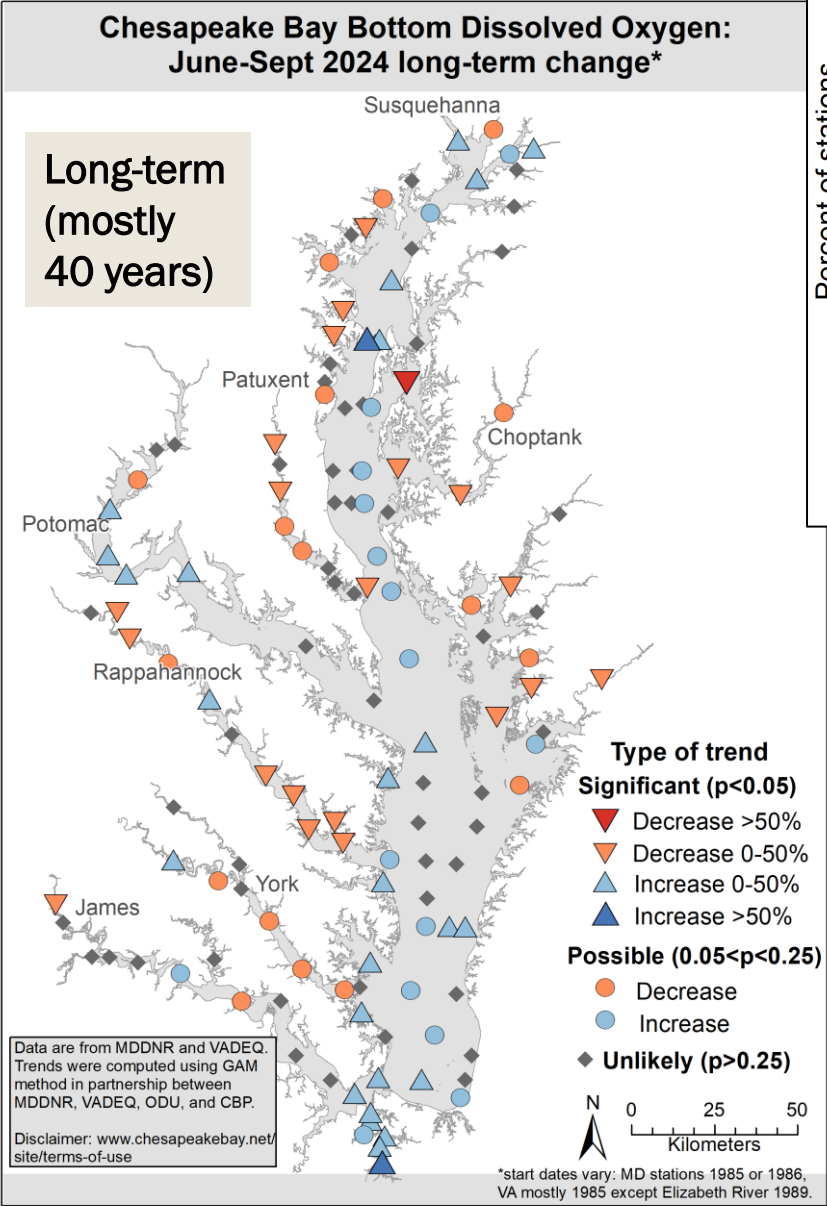


Summary for water temperature

- 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.

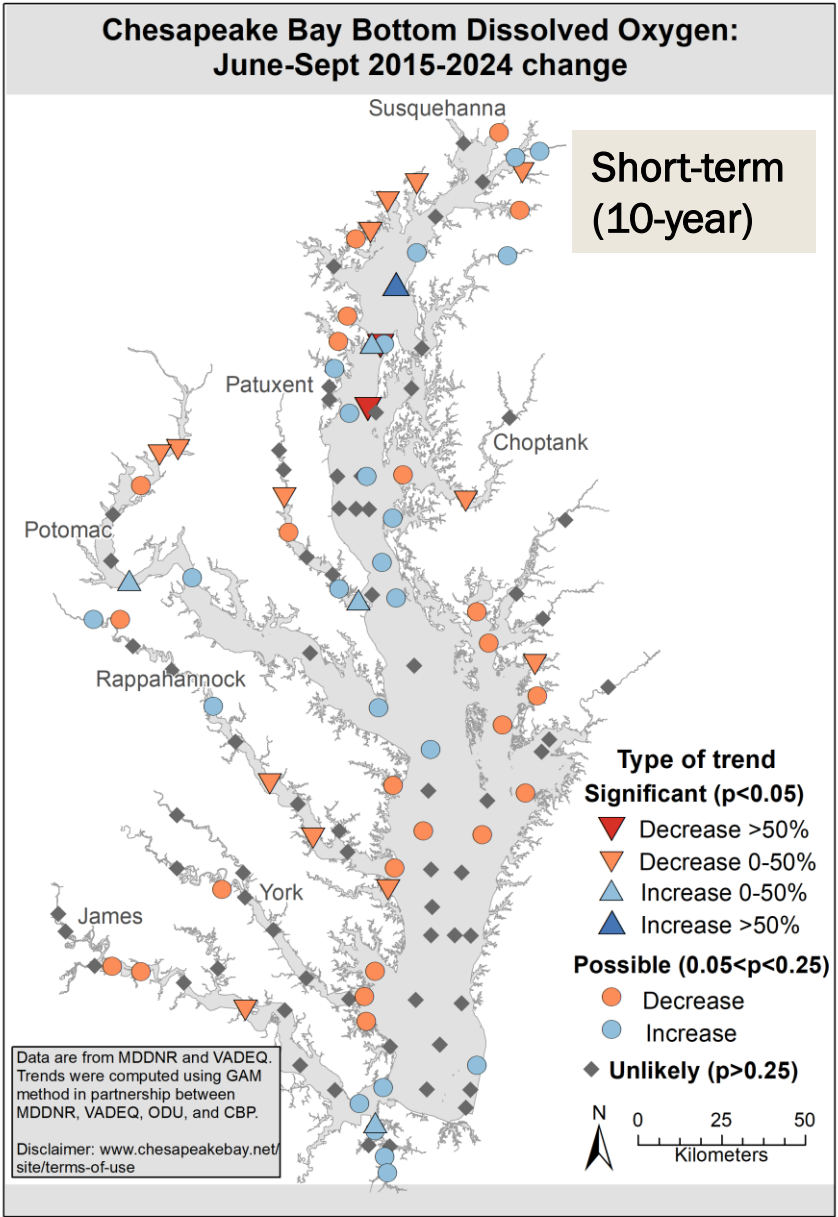


Bottom Summer DO



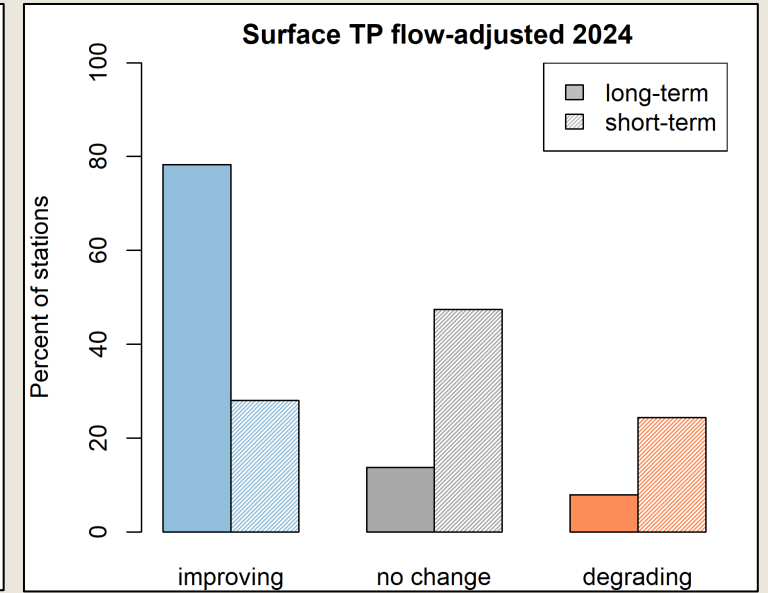
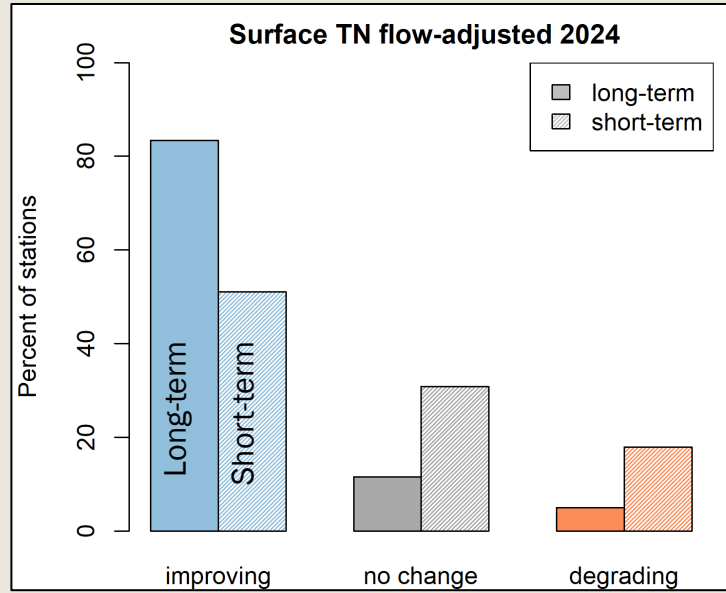
Summary for DO

- 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.
- Consistent with criteria-based analysis, Zhang et al. 2024 <https://doi.org/10.1016/j.scitotenv.2024.177617>



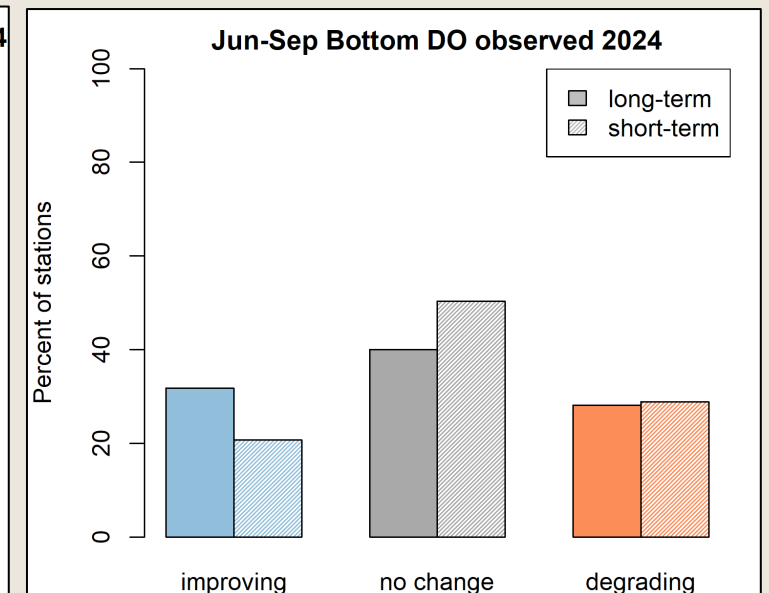
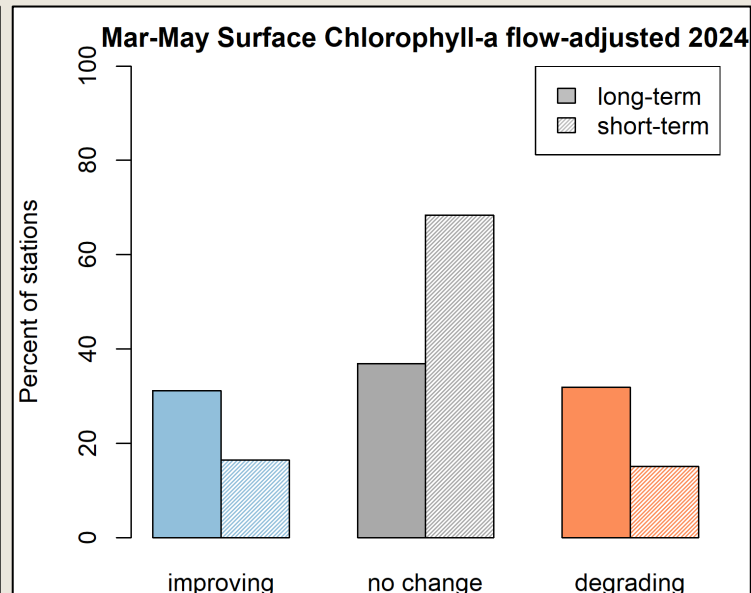
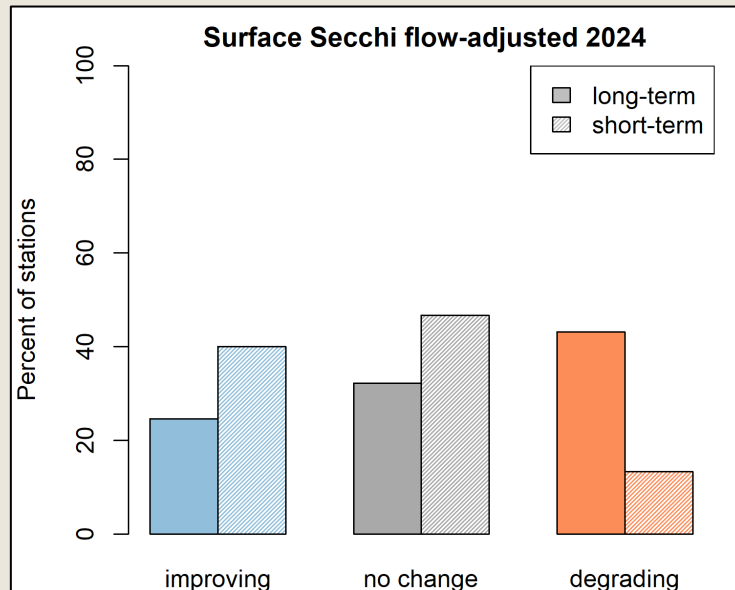
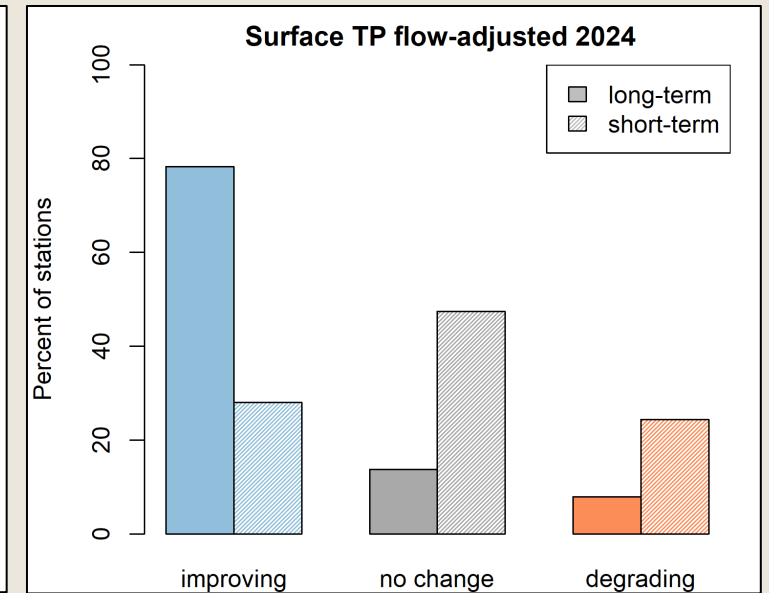
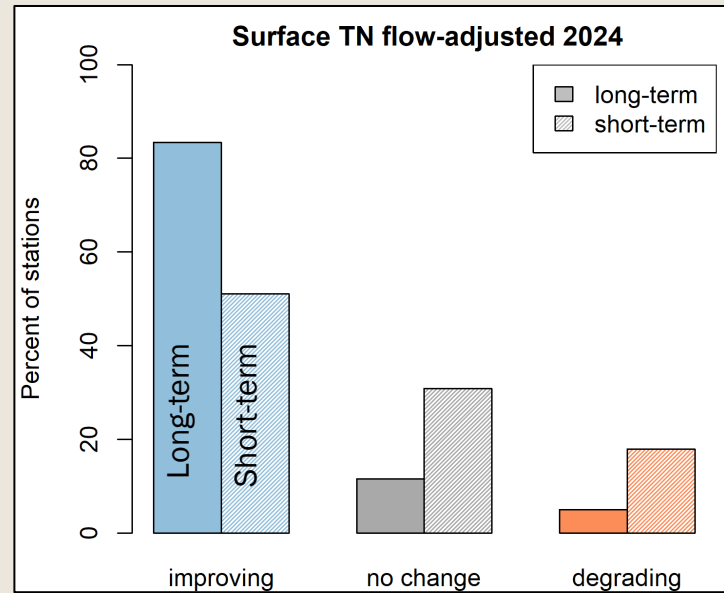
2024 Summary

- Nutrient trends mostly improving over the long-term with some leveling-out over the short-term.



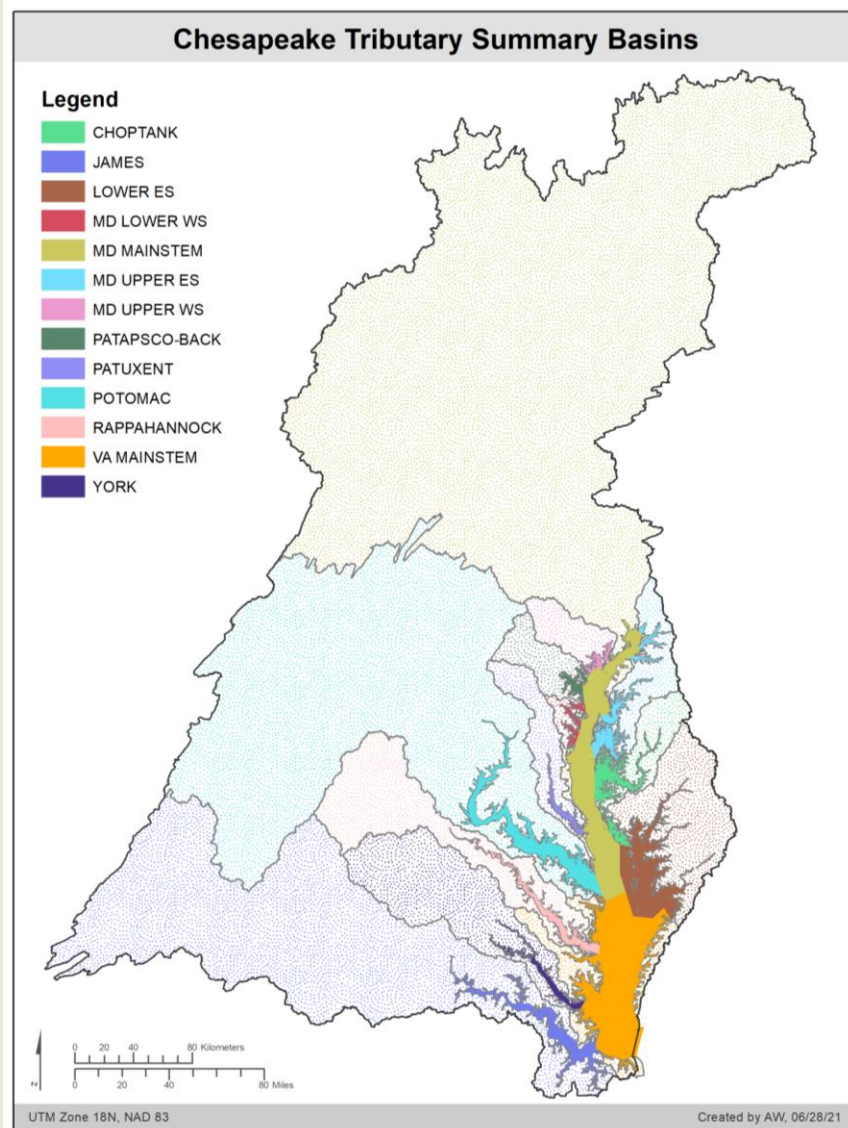
2024 Summary

- Nutrient trends mostly improving over the long-term with some leveling-out over the short-term.
- The number of stations with degrading conditions have decreased over the short-term for Secchi and chlorophyll a, while DO has different patterns in deeper vs. tributary waters.
- Overall patterns consistent with last few years.



For region-specific information: Tributary Summaries

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



Online Story
Maps

PDF
documents

Potomac Tributary Summary:
A summary of trends in tidal water quality and
associated factors, 1985-2022.

August 19, 2025

Prepared for the Chesapeake Bay Program (CBP) Partnership by the CBP
Integrated Trends Analysis Team (ITAT)



Chesapeake Bay Program
Science. Restoration. Partnership.



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:

- *Renee Karrh (MDDNR); Mike Lane (ODU) and Cindy Johnson (VADEQ);*
- *Efeturi Oghenekaro, Blessing Edje and George Onyullo (DOEE); Mukhtar Ibrahim (MWCOC);*
- *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>

Contact Information and References

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

Trend-related references cited here:

- Murphy et al. 2019. “A Generalized Additive Model approach to evaluating water quality: Chesapeake Bay case study.” Environmental Modelling & Software 118. <https://doi.org/10.1016/j.envsoft.2019.03.027>
- Murphy et al. 2021. “Nutrient Improvements in Chesapeake Bay: Direct Effect of Load Reductions and Implications for Coastal Management.” Environmental Science and Technology 56(1). <https://doi.org/10.1021/acs.est.1c05388>
- Turner et al. 2025. “Chesapeake Bay Water Clarity: Challenges and Successes.” Annual Review of Marine Science 18. <https://doi.org/10.1146/annurev-marine-040224-120528>
- Zhang et al. 2024. “Dissolved oxygen criteria attainment in Chesapeake Bay: where has it improved since 1985?” Science of the Total Environment 957 <https://doi.org/10.1016/j.scitotenv.2024.177617>

extras

Comparison to watershed loads (USGS RIM Trends)

		RIM Monitoring Station	Long term: 1985 - 2024			Short term: 2015 - 2024		
			TN	TP	SS	TN	TP	SS
Maryland	RIM stations	SUSQ	-31.2%	-4.6%	+21.5%	-12.4%	-22.8%	-24.8%
		CHOP	-2.5%	+77.4%	-34.3%	-4.5%	+20.2%	-7.5%
		PATX	-69.5%	-66.8%	-44.0%	-21.0%	-5.5%	-4.5%
		POTO	-18.4%	-24.3%	-41.7%	-7.6%	-1.0%	+13.1%
Virginia	RIM stations	RAPP	-15.6%	+31.2%	+50.0%	+7.3%	+7.6%	+1.7%
		MATT	-6.4%	+6.4%	+8.6%	+1.7%	+8.9%	+26.9%
		PAM	-1.3%	+59.2%	+36.3%	-3.9%	+1.0%	-9.9%
		JAMC	-8.0%	-22.1%	+40.3%	+11.2%	+25.8%	+20.9%
		APPO	+6.4%	+99.5%	+44.2%	+5.4%	+23.4%	+38.9%
Trend Direction			Improving	Degrading	No trend			

- Similar long and short-term patterns in nontidal and tidal tributaries.
- TN: more improving long-term than short-term.
- TP: More mixed conditions than TN, with the same tributaries showing increasing trends.

From Jimmy Webber, USGS