

2024 Tidal Trends Summary

Rebecca Murphy (UMCES/CBP)

WQGIT meeting, Dec. 15, 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)

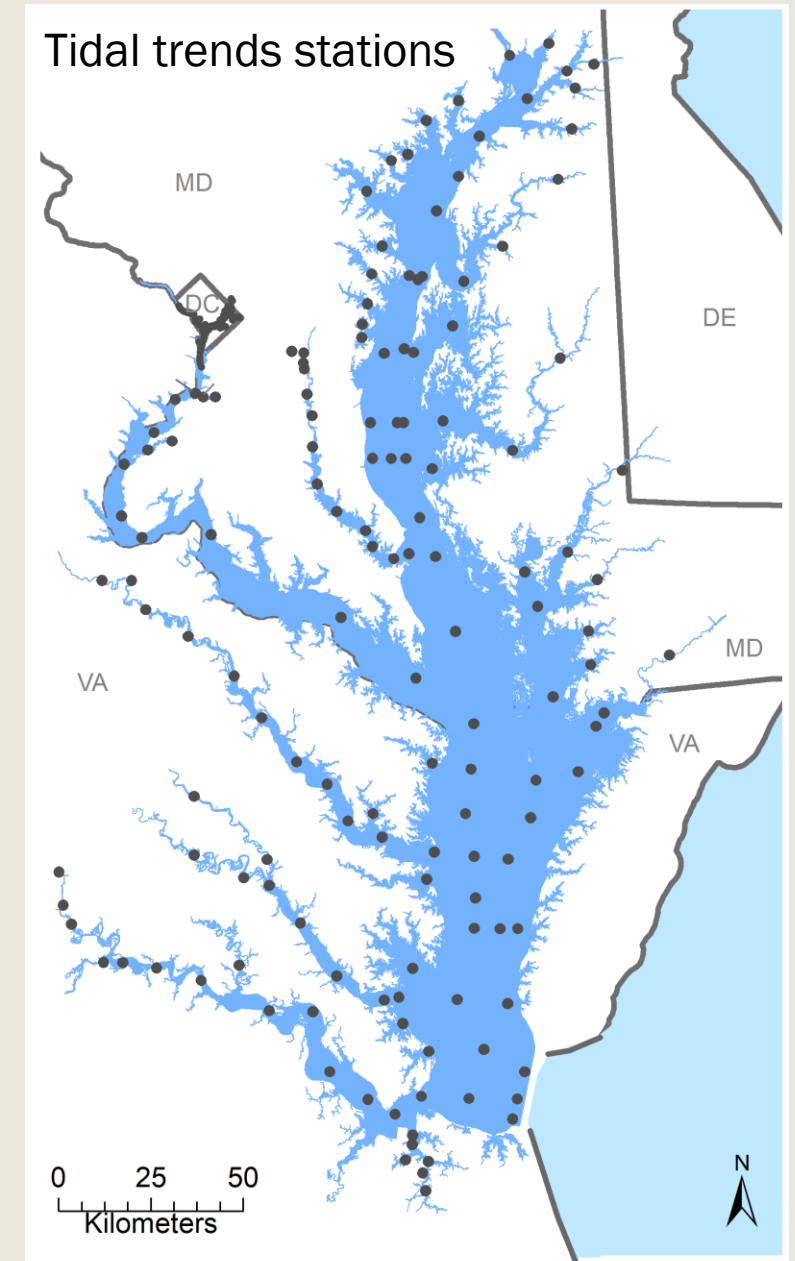
Data from: *DOEE, MDDNR, and VADEQ*



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

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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.

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Meetings

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[Integrated Trends Analysis Team \(ITAT\) Meeting - December 2025](#)

Wednesday, December 17, 2025 from 10:00am - 12:00pm

Add to calendar ▾

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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)
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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>

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Gabriel Duran (Staffer)
gduran@chesapeakebay.net
Our Members

Thanks to
Gabriel Duran

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

Chesapeake Assessment Scenario Tool

HOME NEWS PUBLIC REPORTS LEARNING ABOUT CONTACT US

Estuary Trends

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/>

baytrendsmap R package v1.2.6 View Tidal Trends Create Custom Maps Background HELP

Basic Functions Select data and map options

1. Choose Data
Choose file to load
☒ Non-linear Trend (Long Term)
☐ Non-linear Trend (Short Term)
☐ Non-linear Trend with Flow Adjustment (Long Term)
☐ Non-linear Trend with Flow Adjustment (Short Term)

2. Choose Map Layer (parameter|layer|season)

Filters
Filter by 'Map Layer'

Select mapLayer:
SECCHI|Surface|Annual

3. Map Options
3.a. Range Map Options
Color Palette (Range Map Only)
Select palette:
Purple_Orange

3.b. Change Map Options
Color Palette (Change Map Only)
Select palette:
Red_Blue

Range Map, Interactive Range Map, Static Change Map

Current mean
[0,0.5]
(0.5,1]
(1,1.5]
(1.5,2]
(2,2.5]

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)*

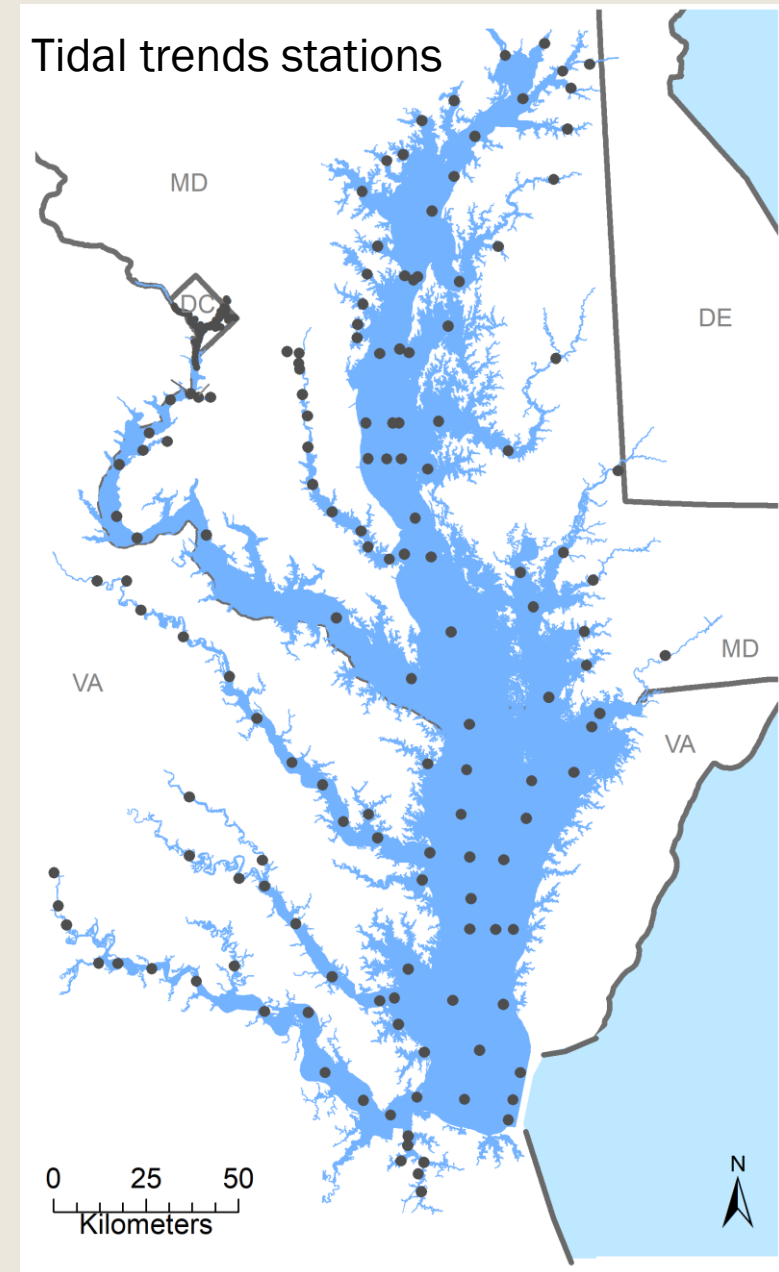
40 year trends!

- 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:

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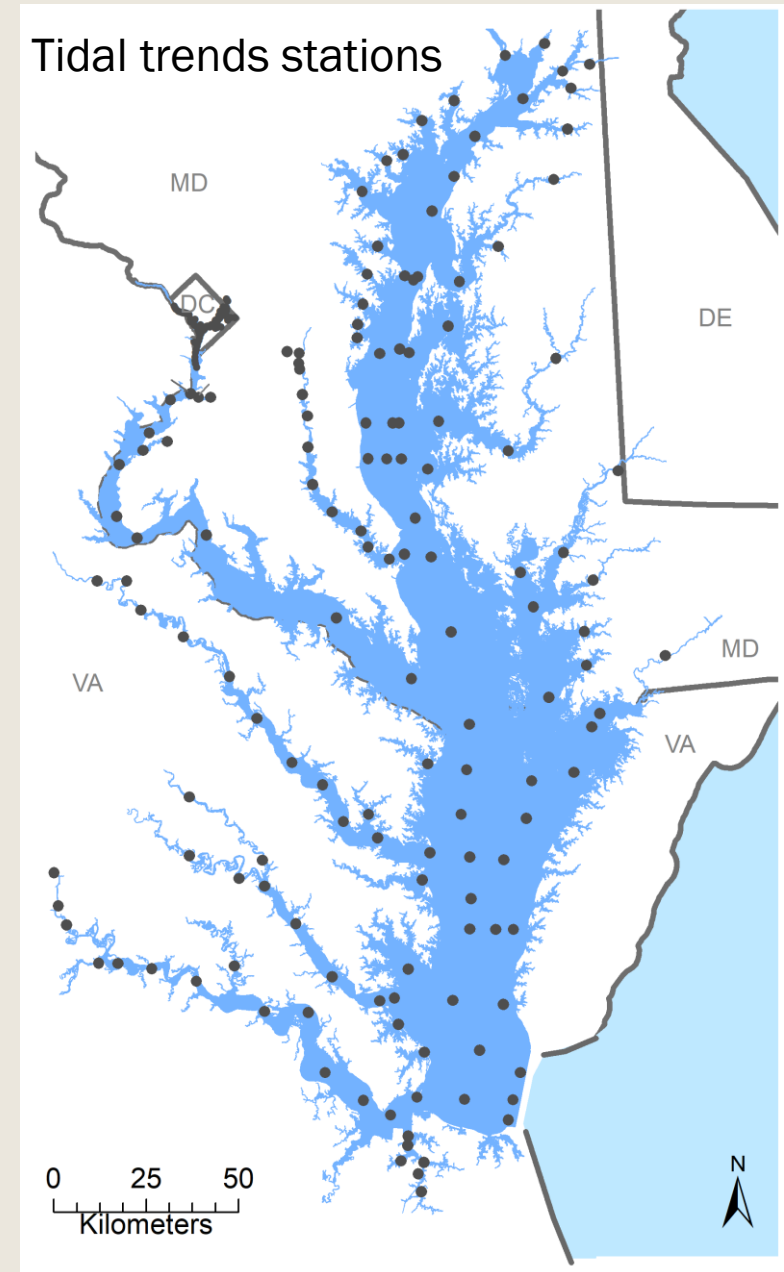
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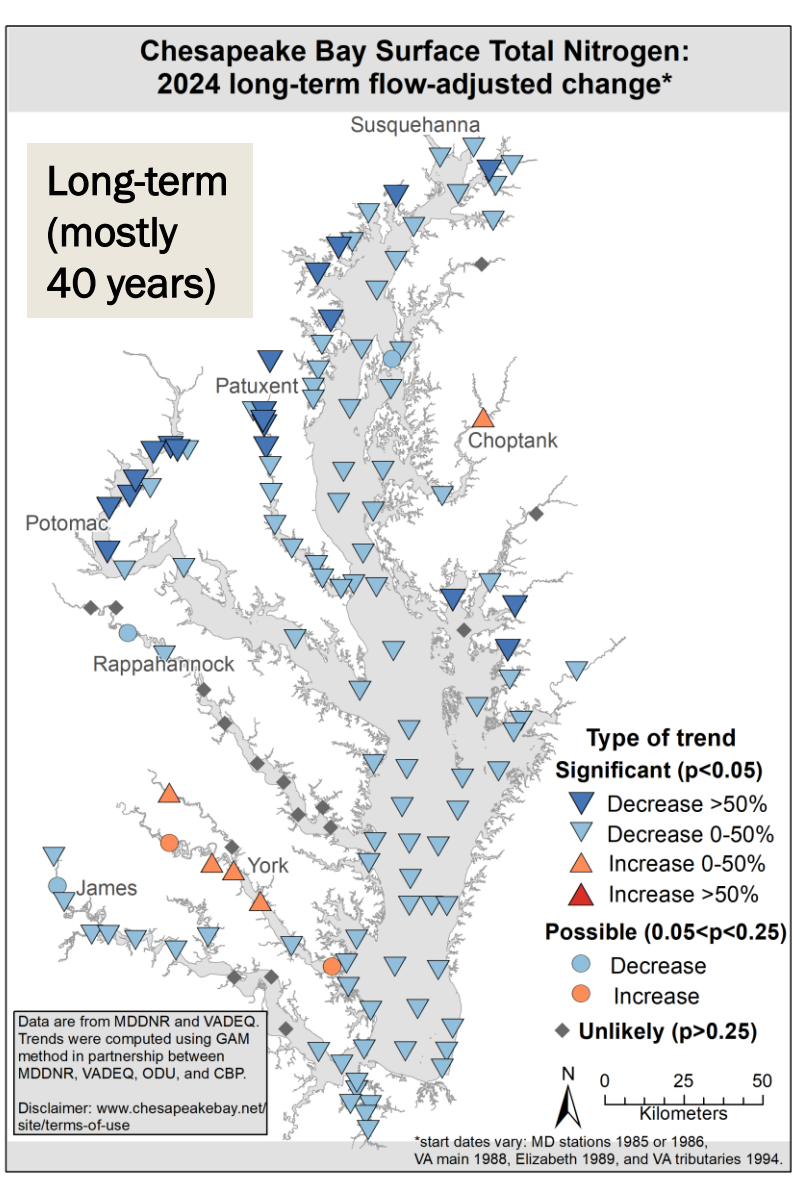
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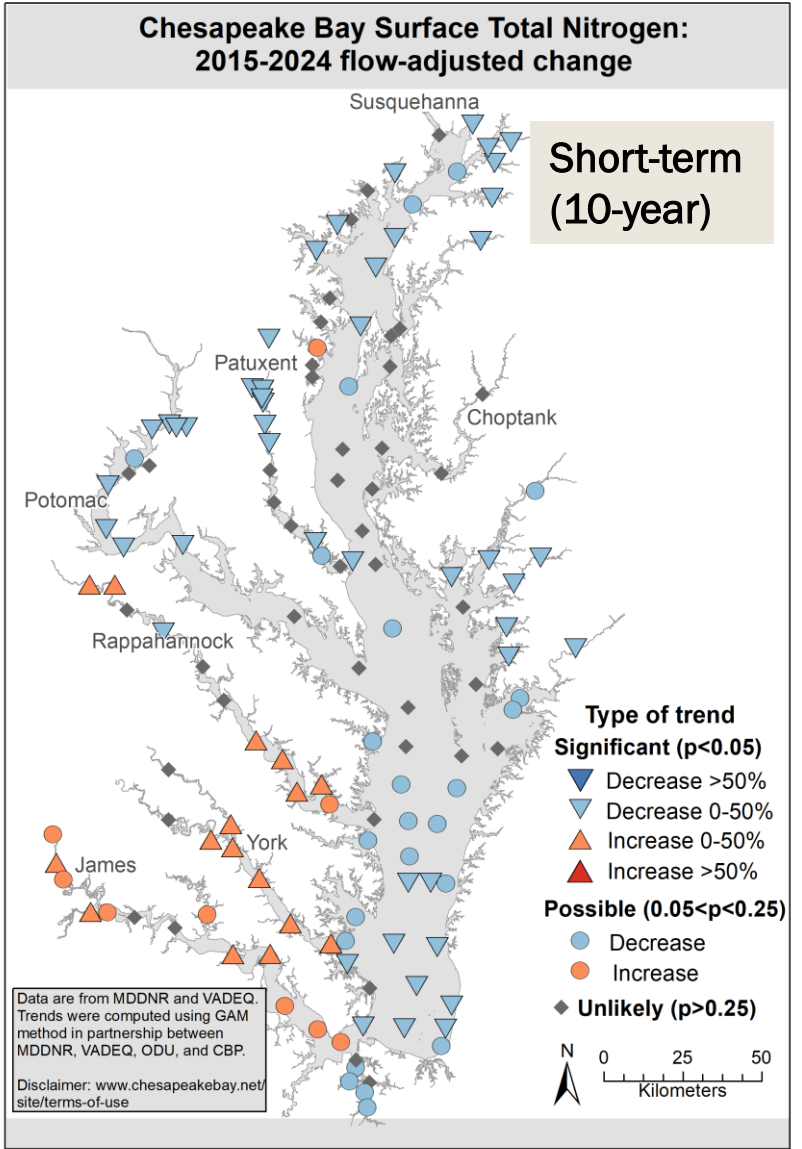
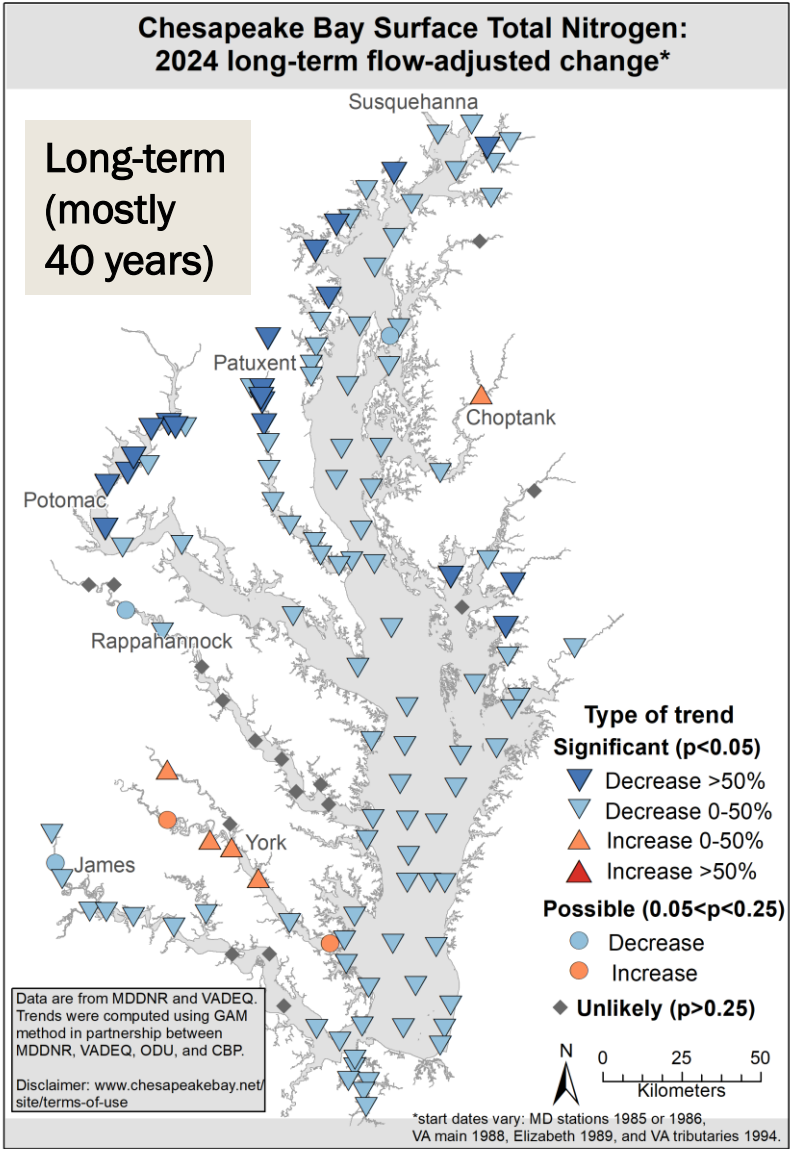
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- *Chla, Secchi, DO: different seasons*
- *Observed conditions, and flow- or salinity-adjusted conditions*



TN
Surface
Flow-
adjusted

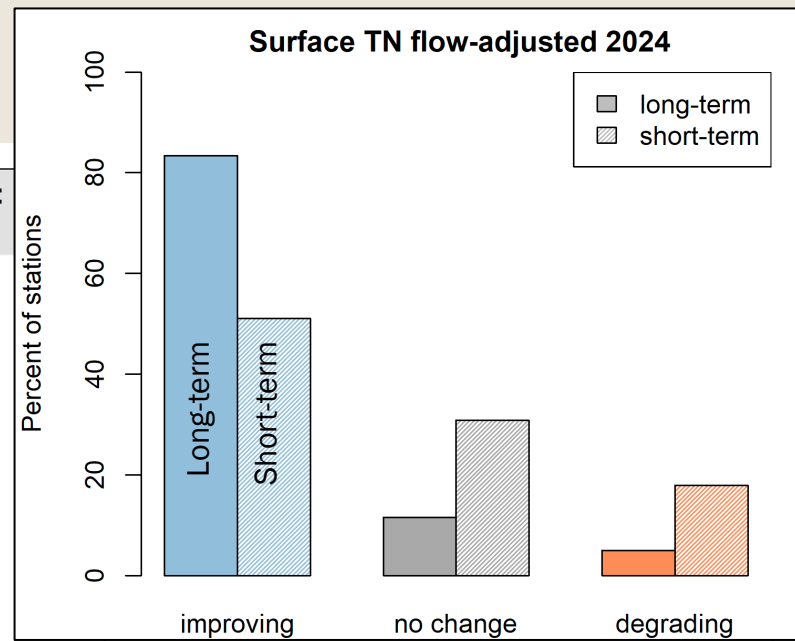
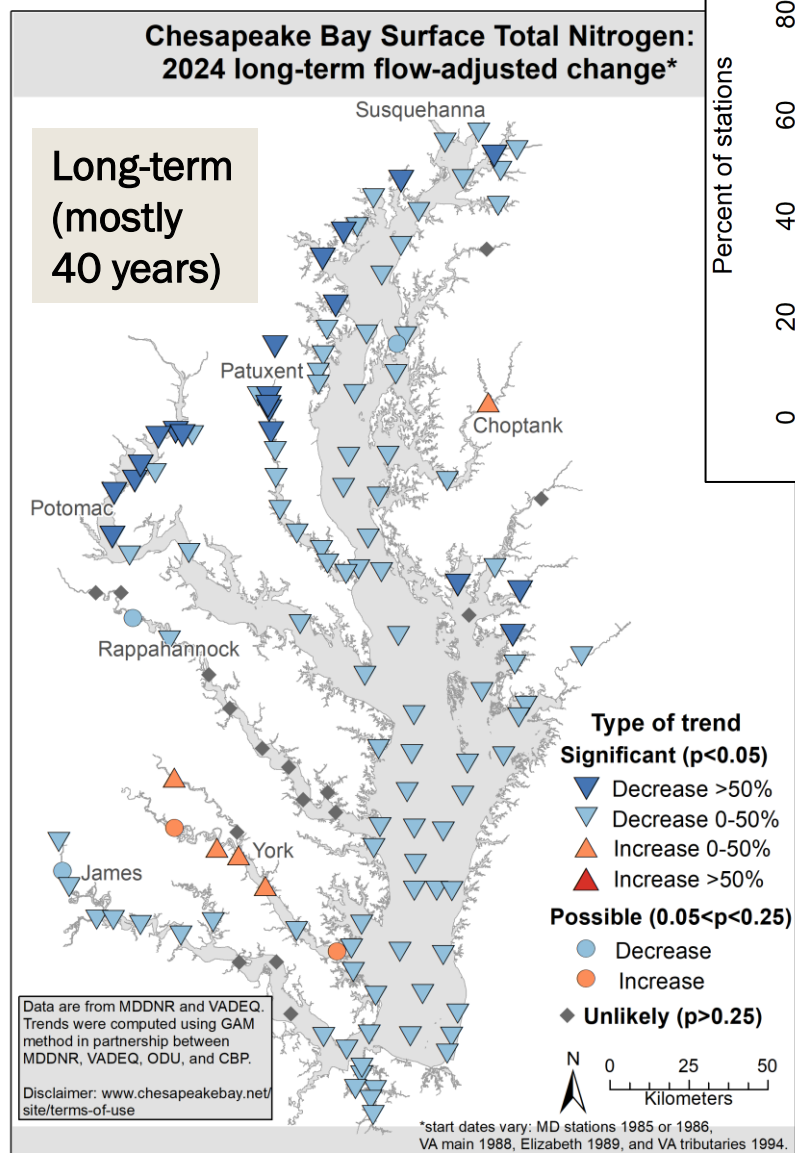


TN
Surface
Flow-
adjusted



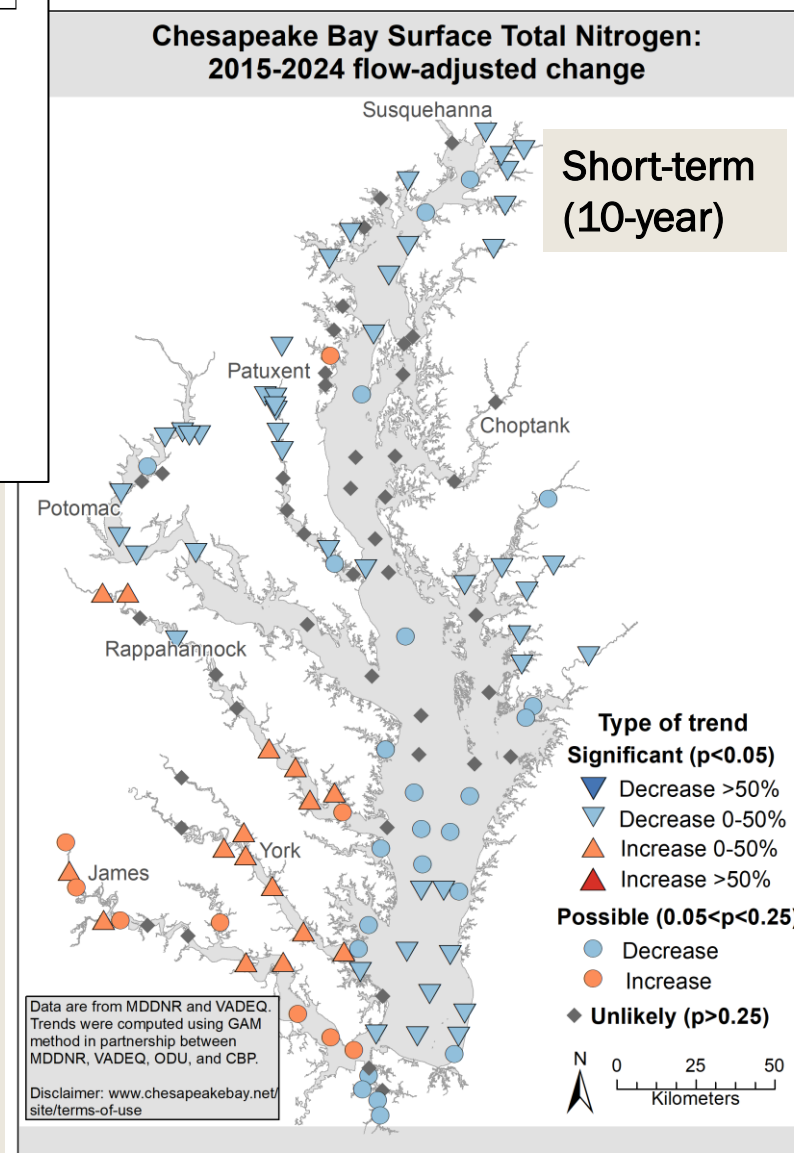
TN

Surface Flow- adjusted



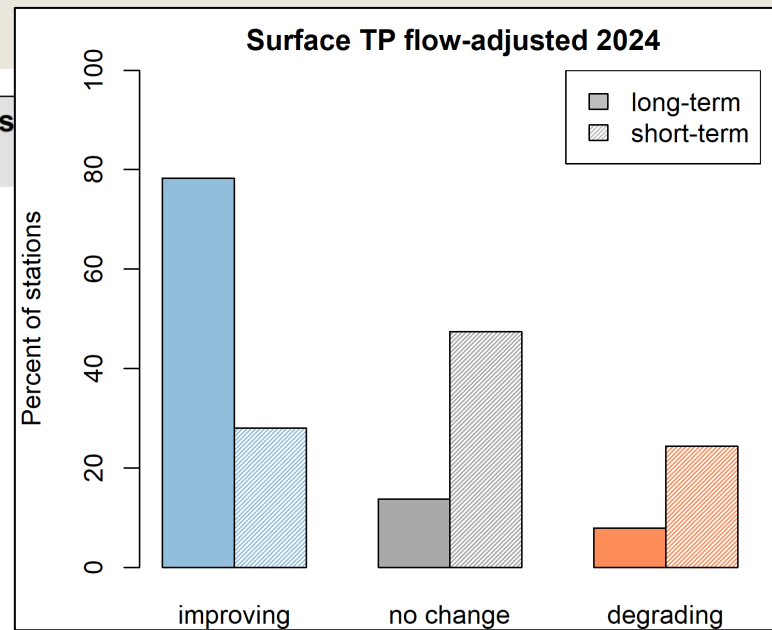
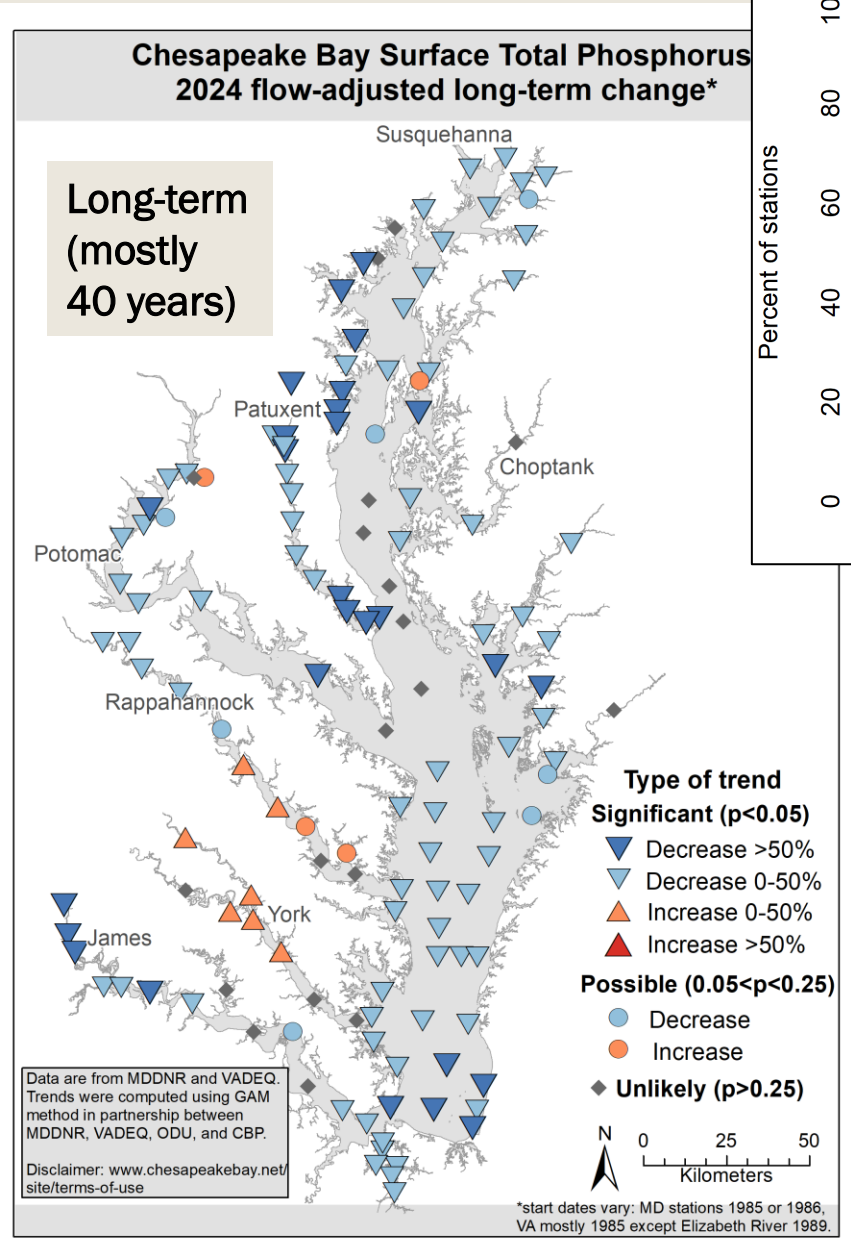
Summary for TN

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



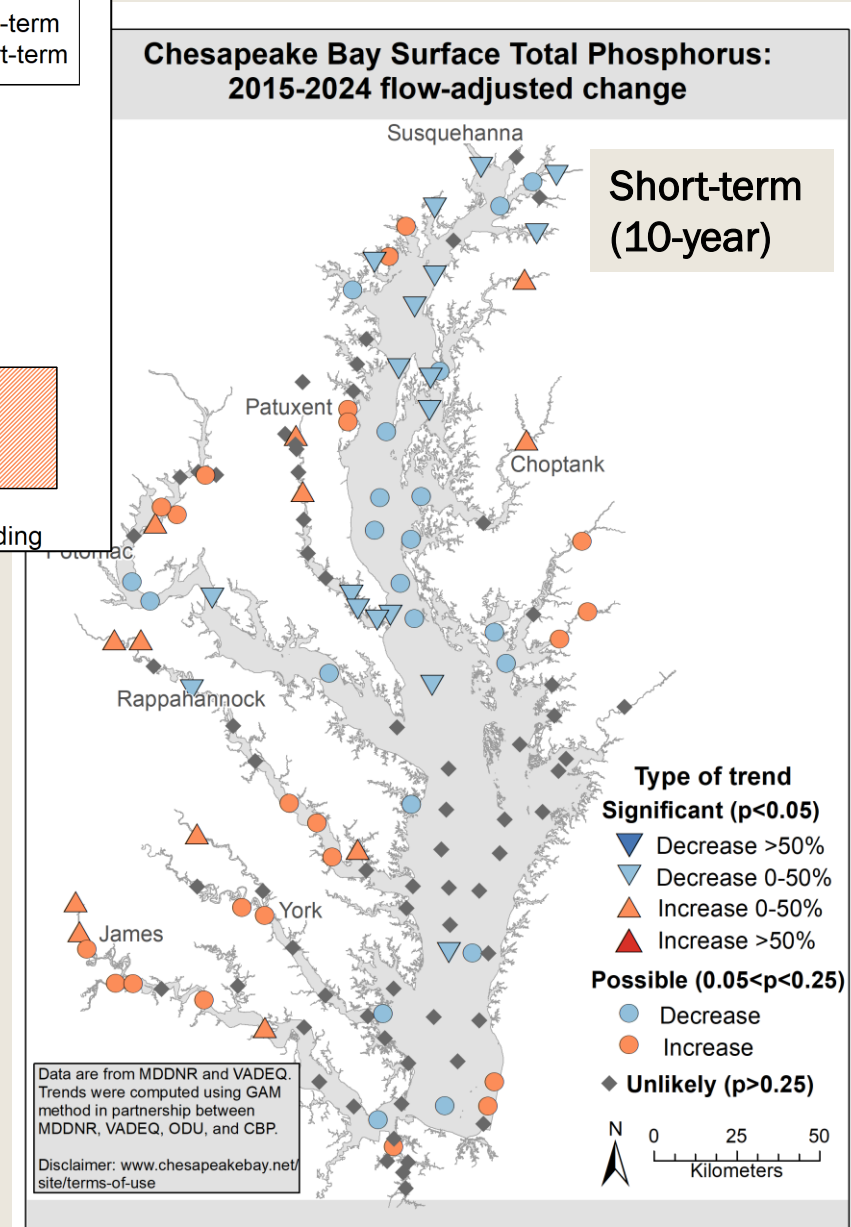
TP

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 (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%

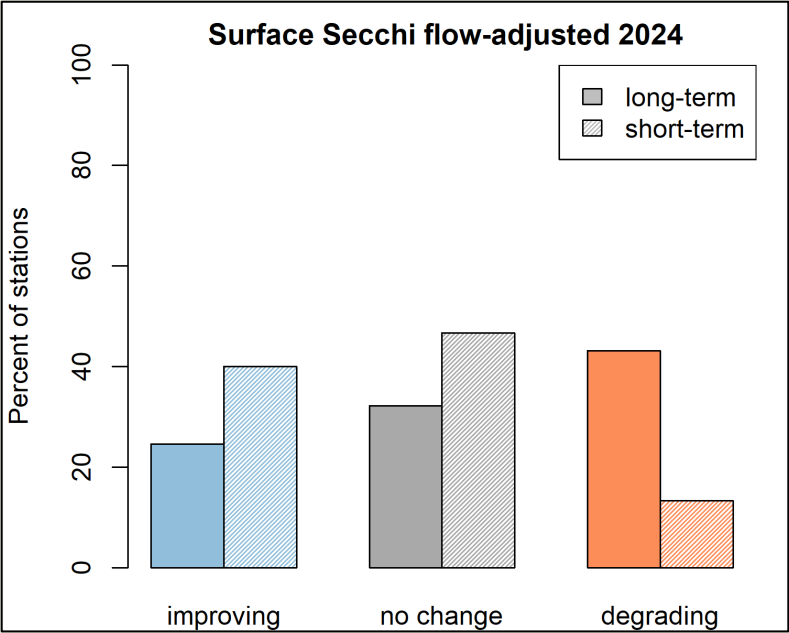
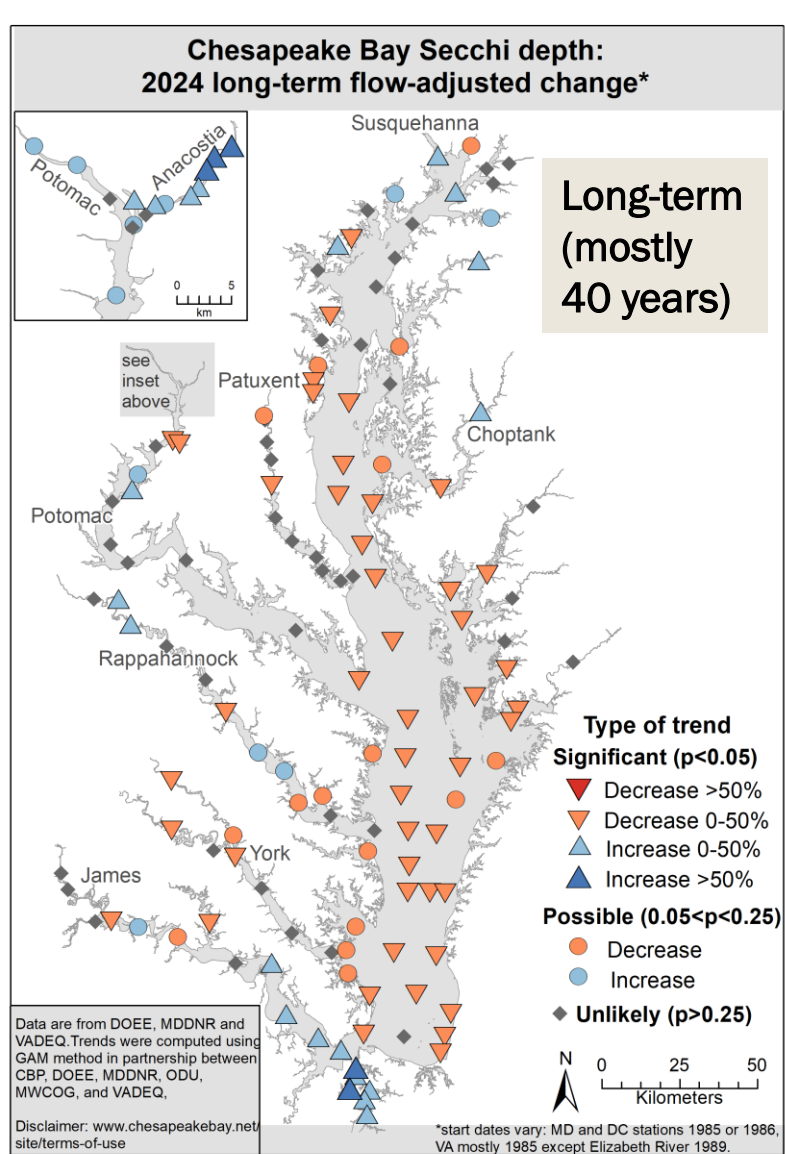
Trend Direction Improving Degrading No trend

- 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

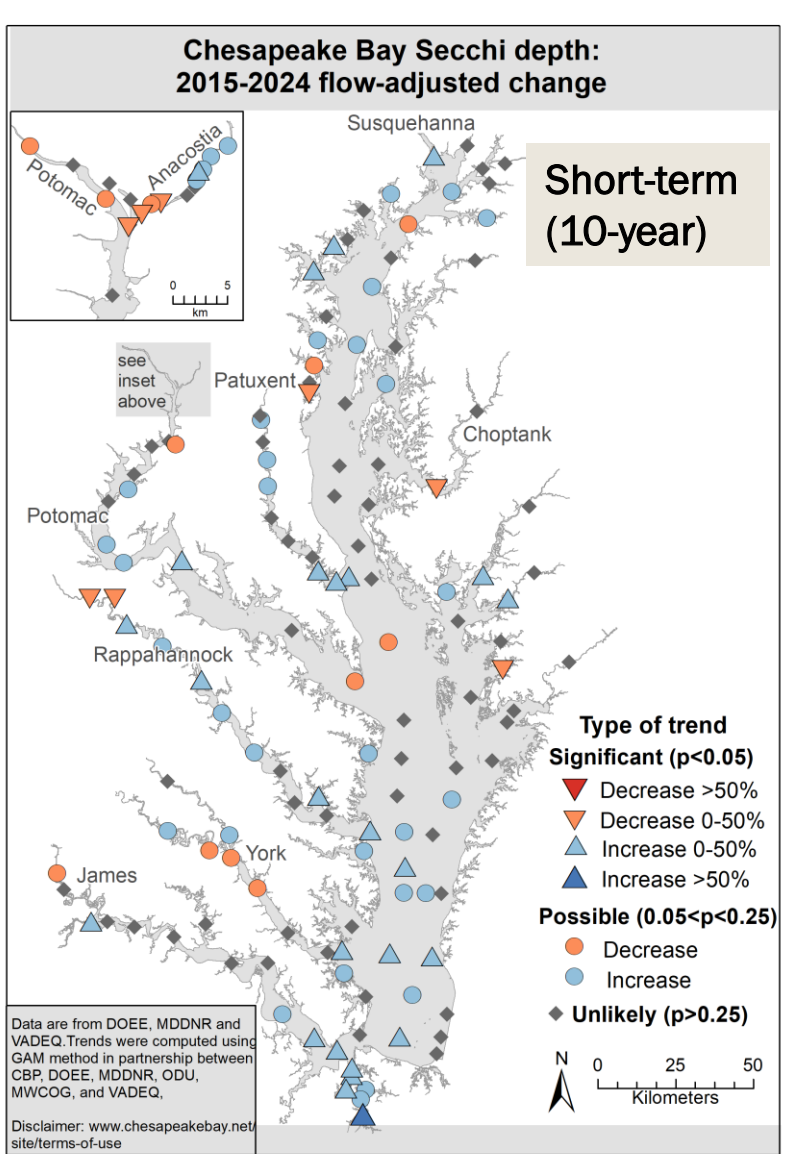
See also: Murphy et al. 2021 "Nutrient Improvements in Chesapeake Bay: Direct Effect of Load Reductions and Implications for Coastal Management" <https://pubs.acs.org/doi/10.1021/acs.est.1c05388>

Secchi depth



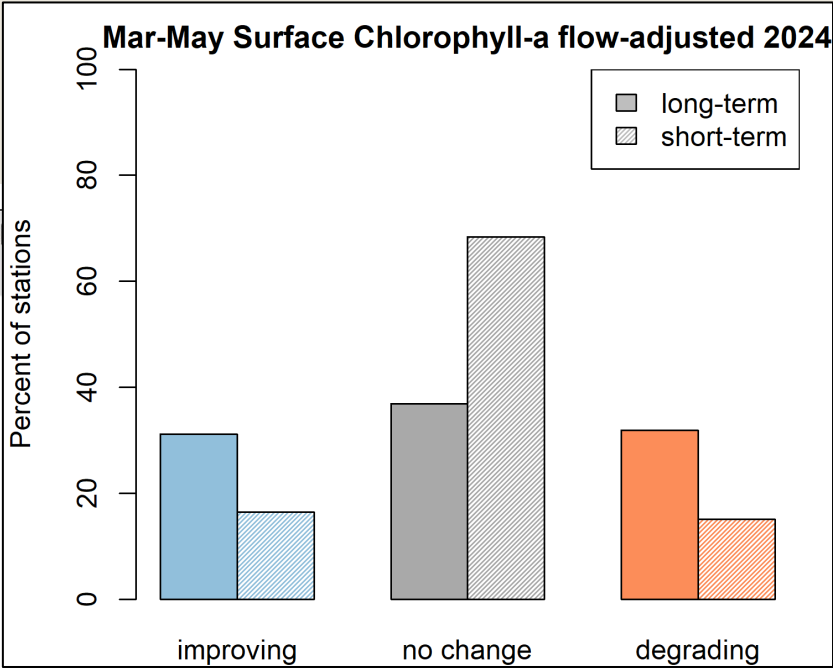
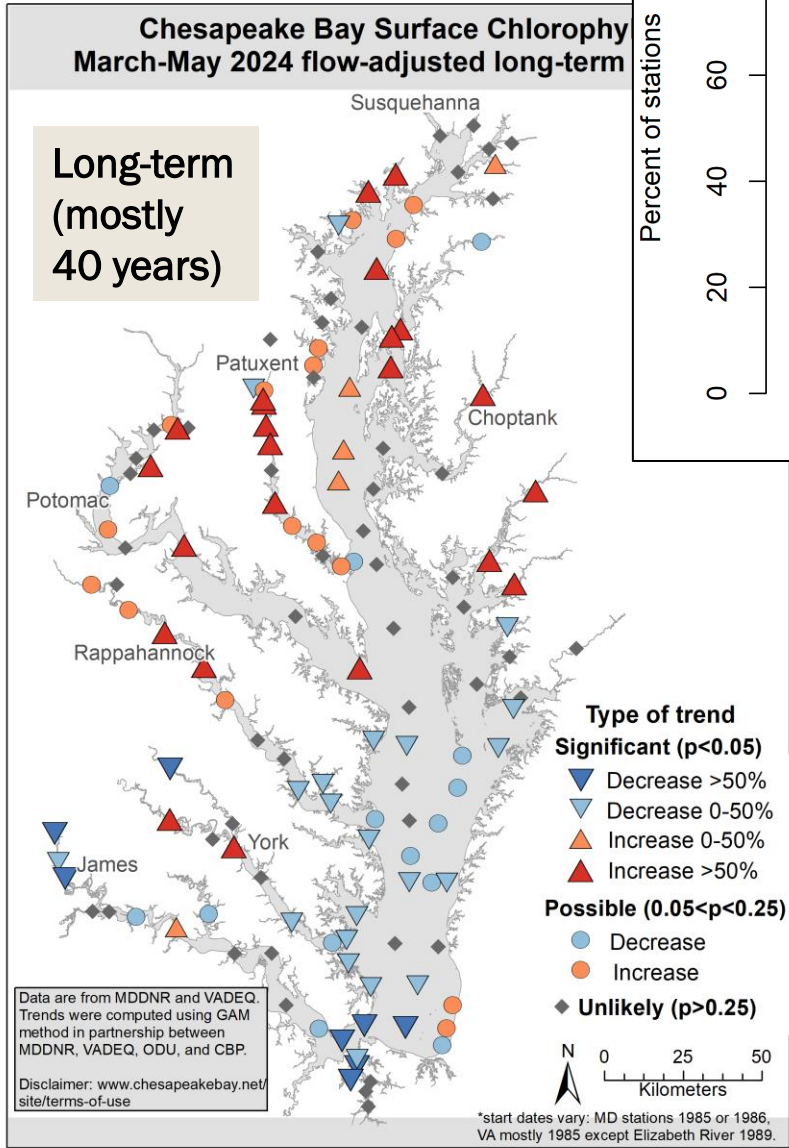
Summary for Secchi

- 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.



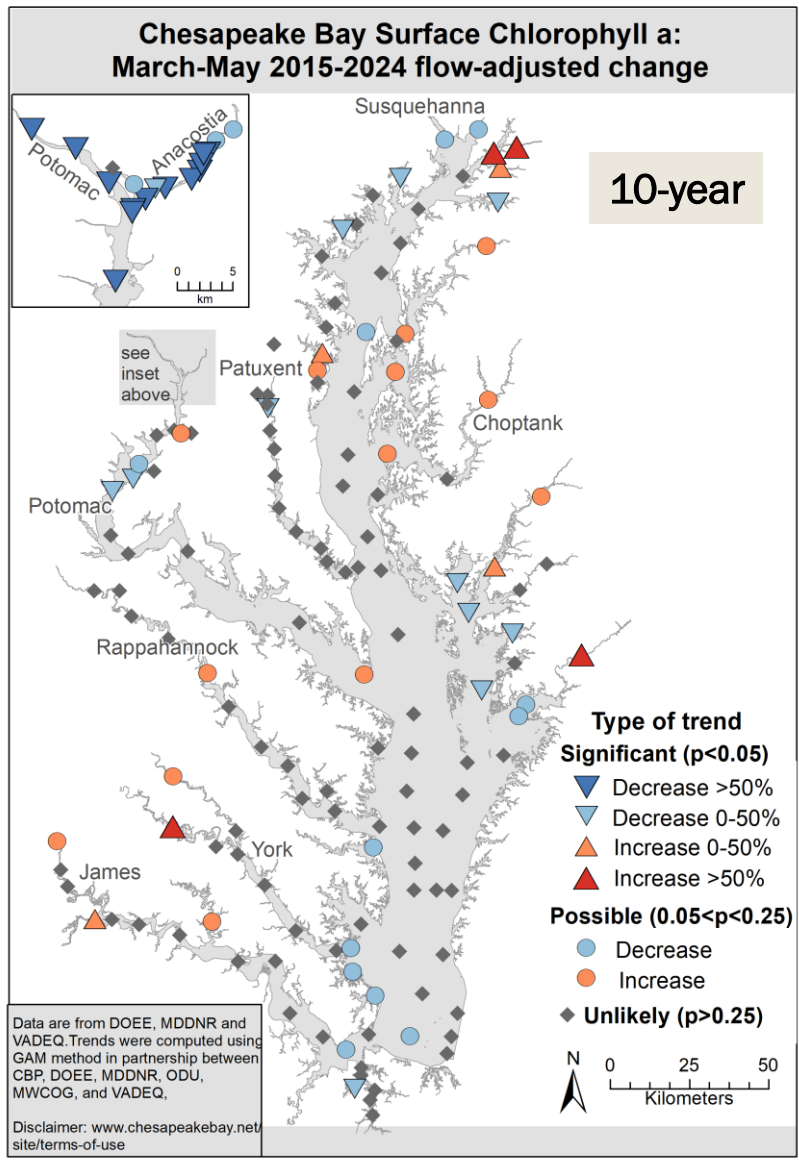
Spring Chlorophyll a

Surface Flow-adjusted

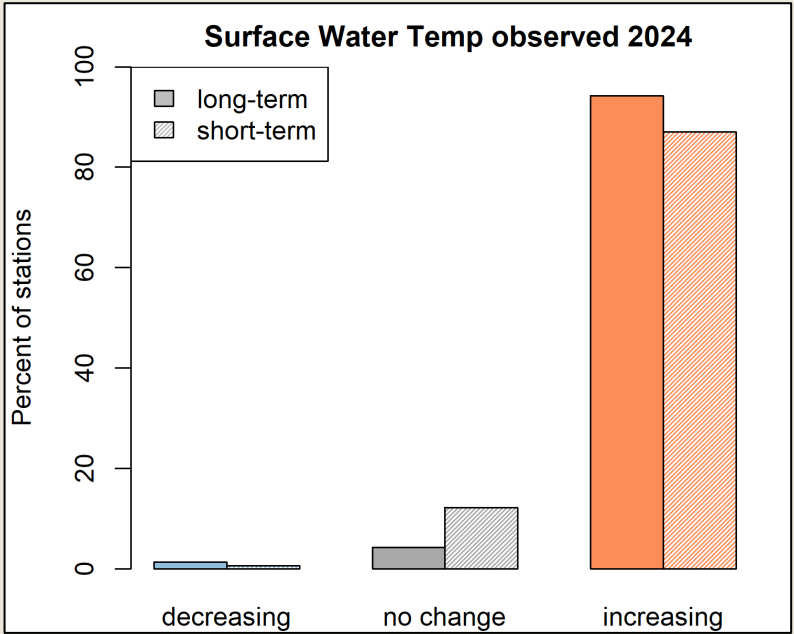
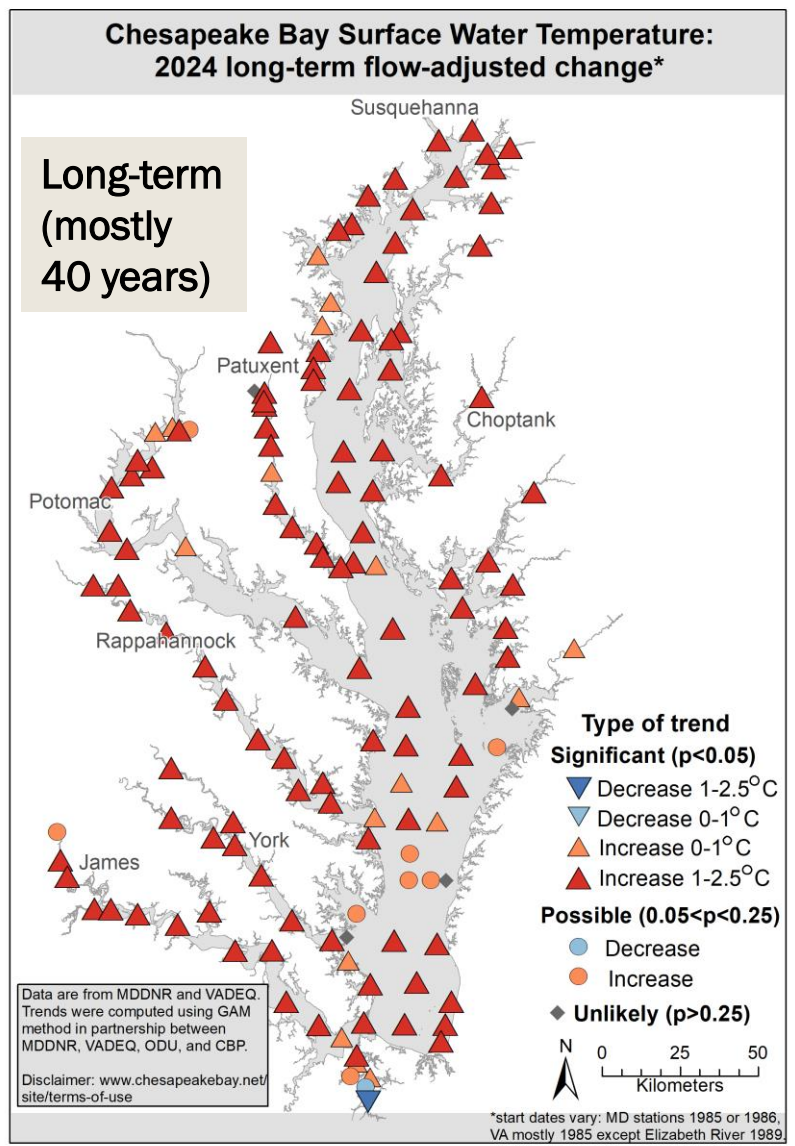


Summary for Chlorophyll

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

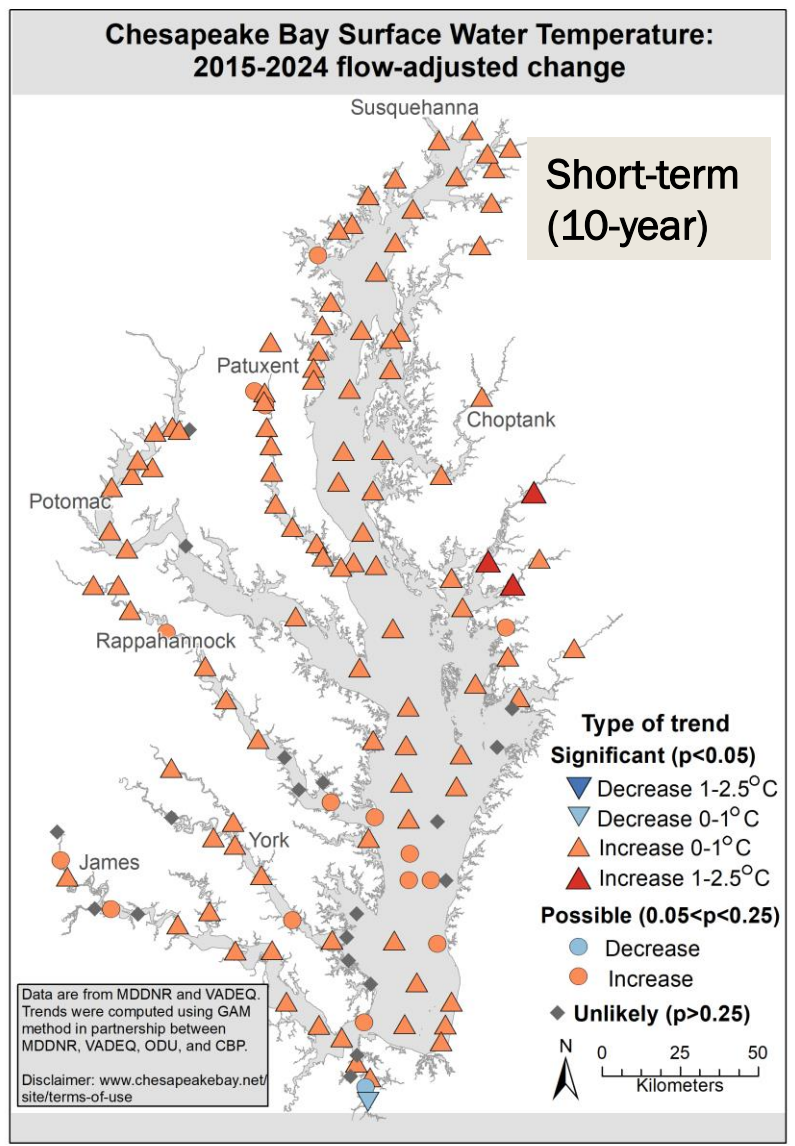


Water Temperature

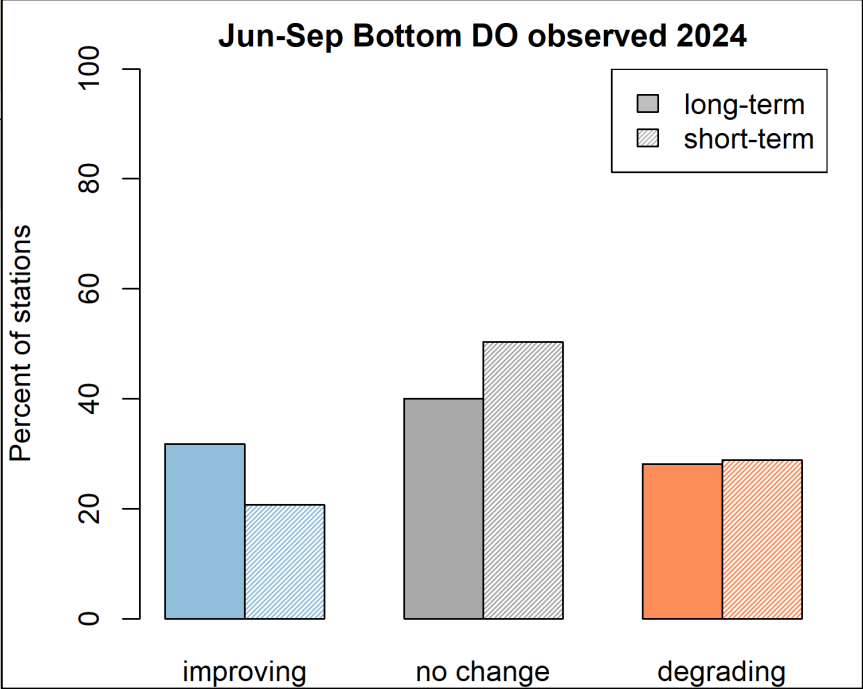
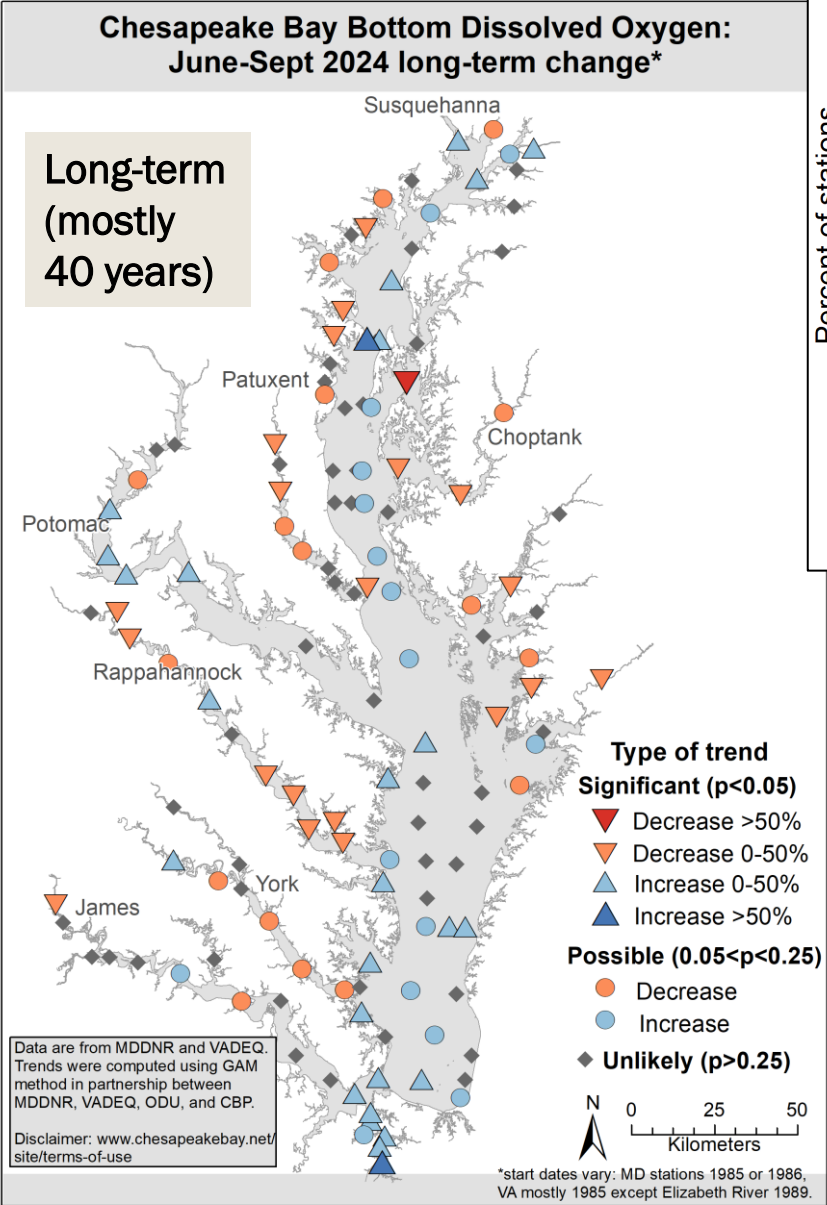


Summary for water temperature

- 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.

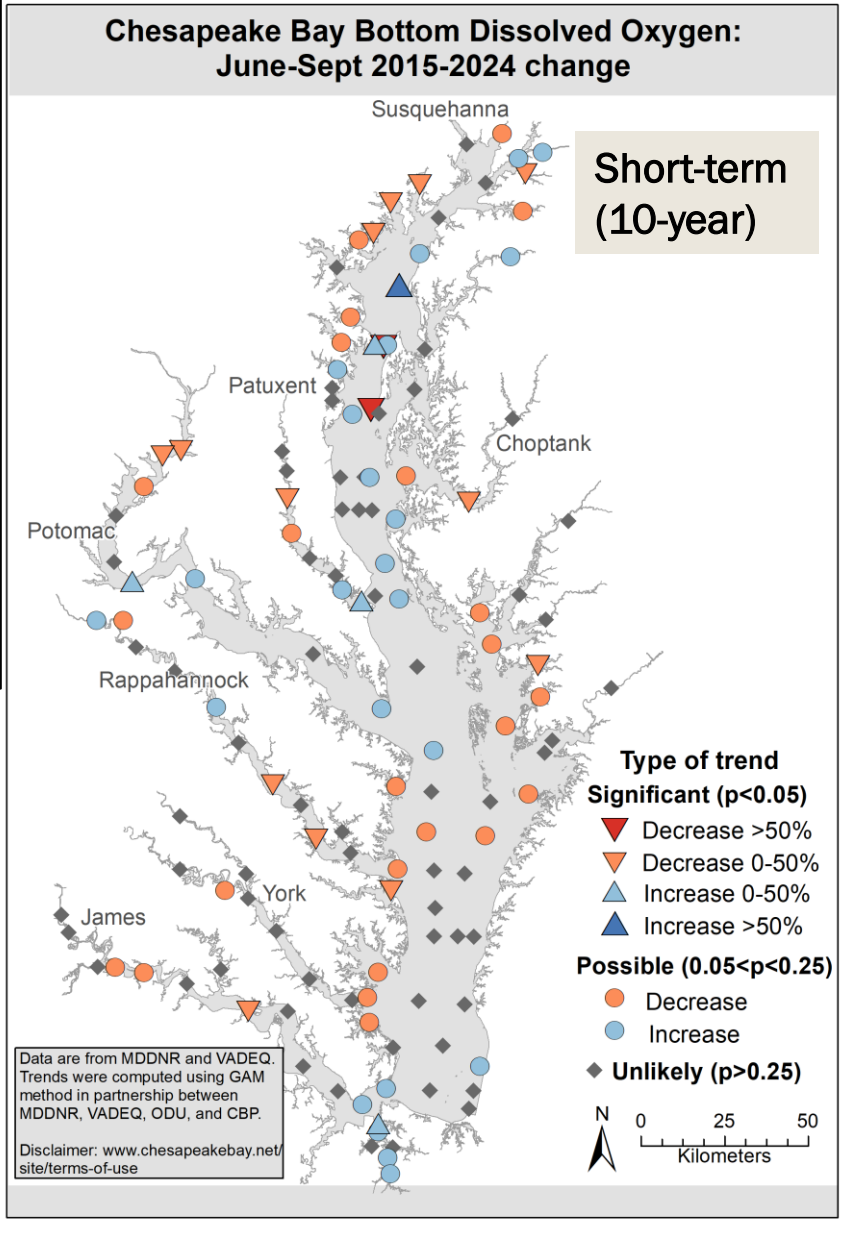


Bottom Summer DO



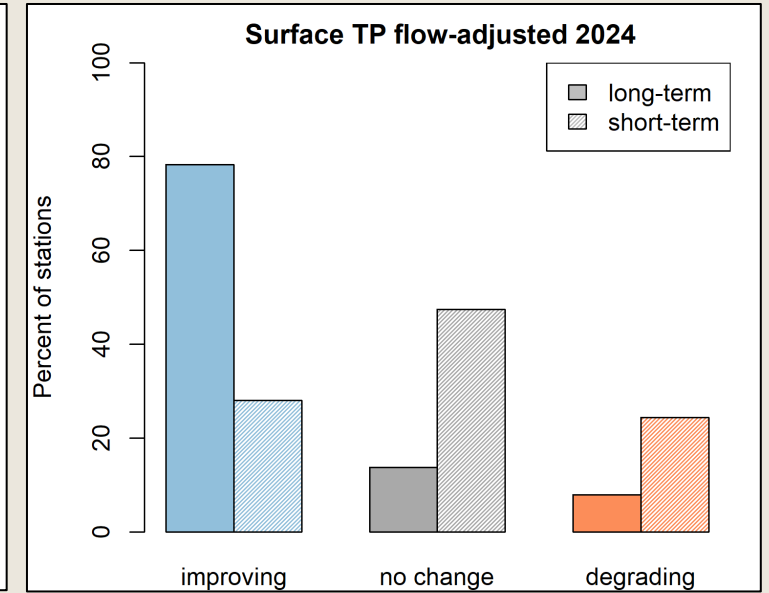
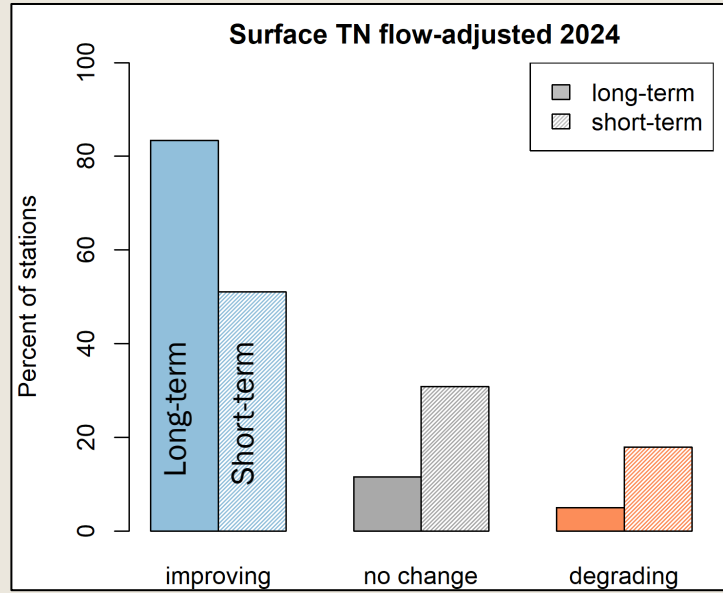
Summary for DO

- 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.



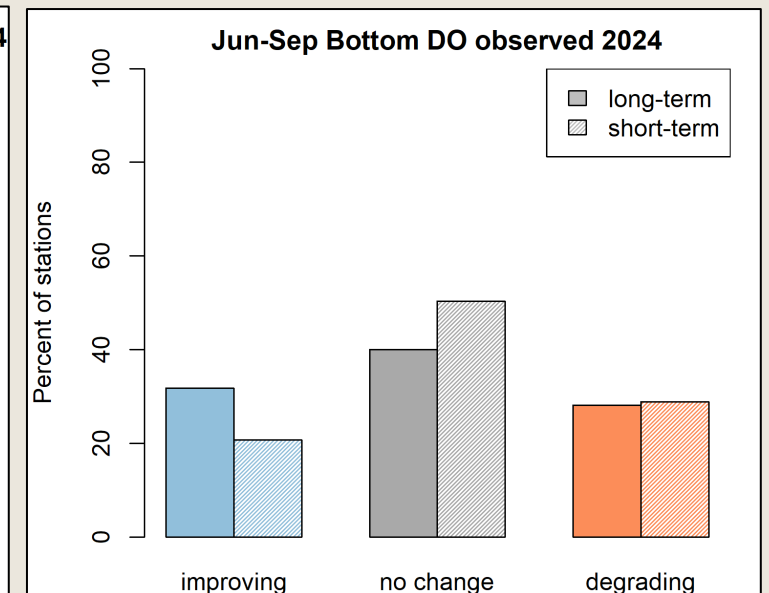
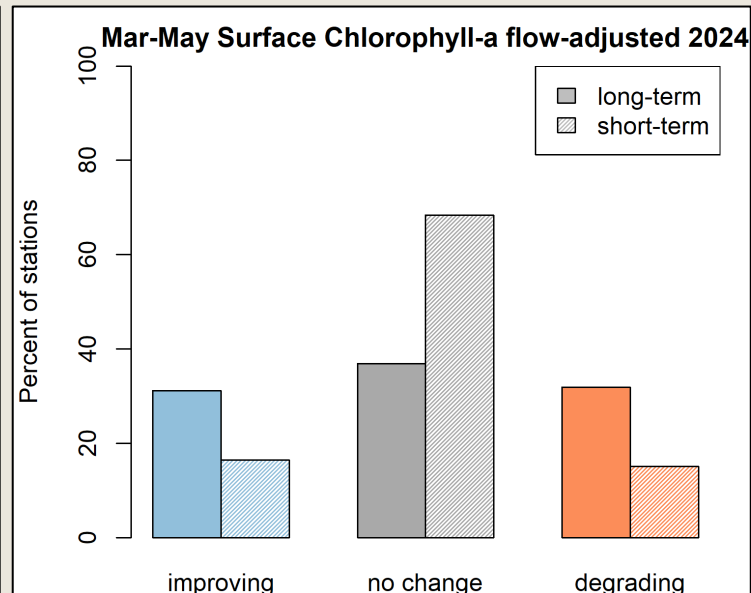
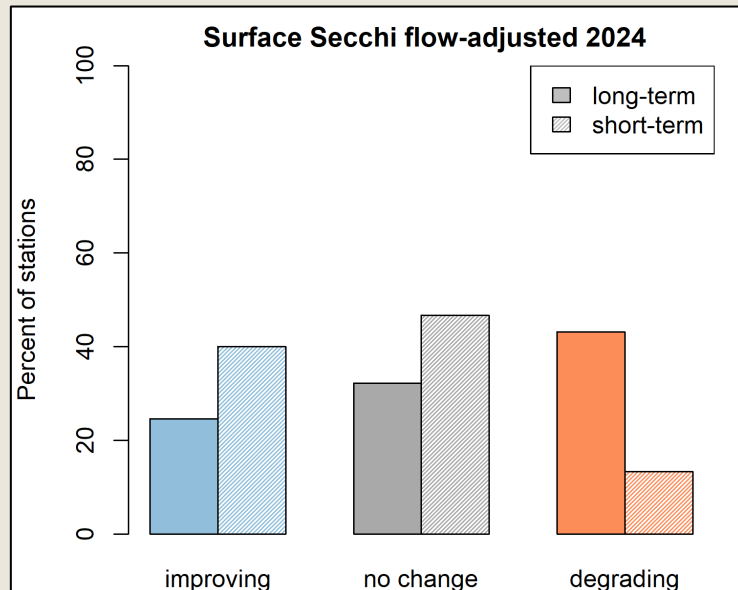
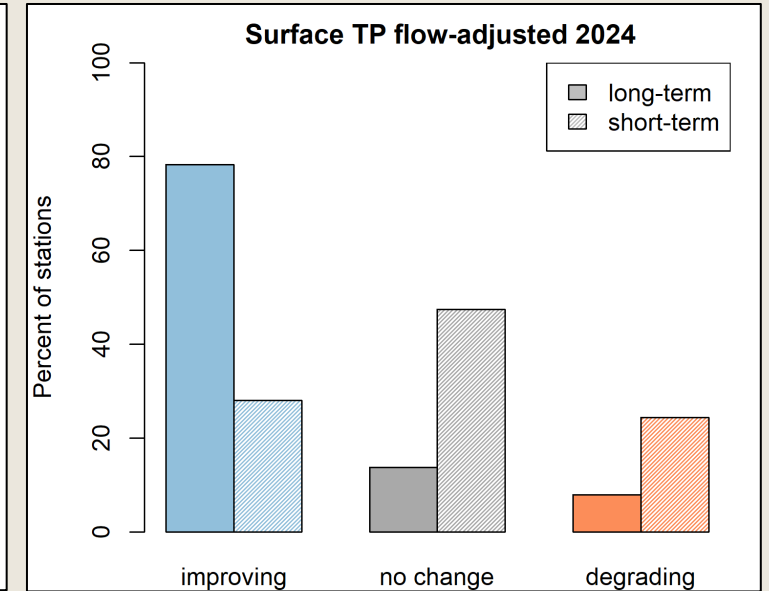
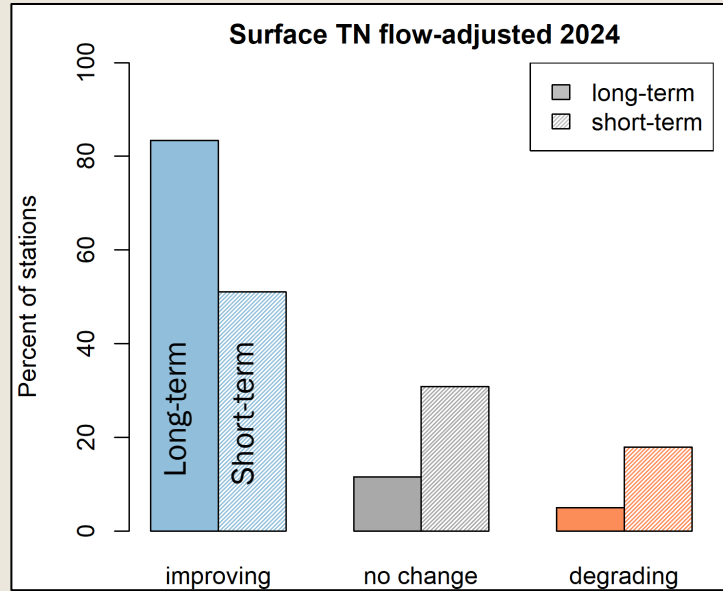
2024 Summary

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



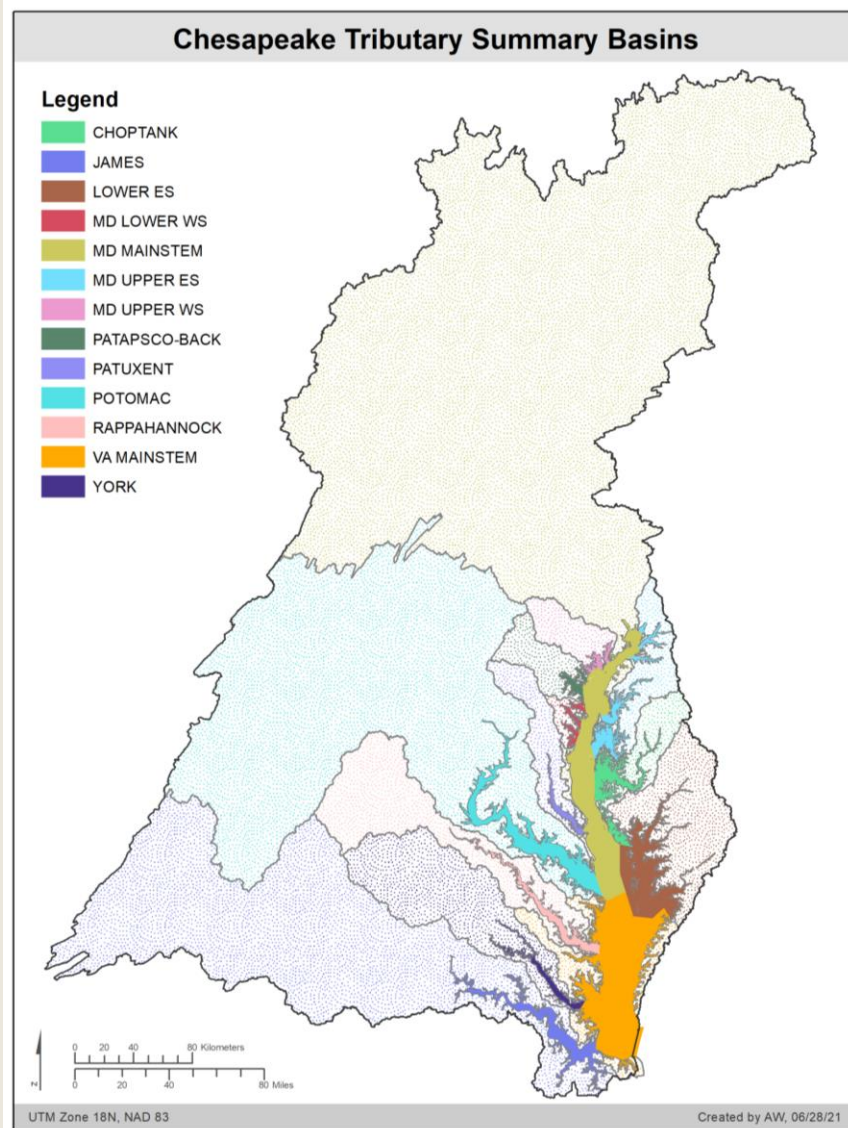
2024 Summary

- 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>

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- **ITAT Co-coordinator:** Kaylyn Gootman, EPA:
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