2023 Tidal Trends Summary

Rebecca Murphy (UMCES/CBP)

ITAT meeting, Oct. 23, 2024

Trend results generated by: *Renee Karrh (MDDNR for MD), Mike Lane (ODU for VA) and Mukhtar Ibrahim (COG for DC)*

R package for analysis maintained by:
Erik Leppo and Jon Harcum (Tetra Tech)

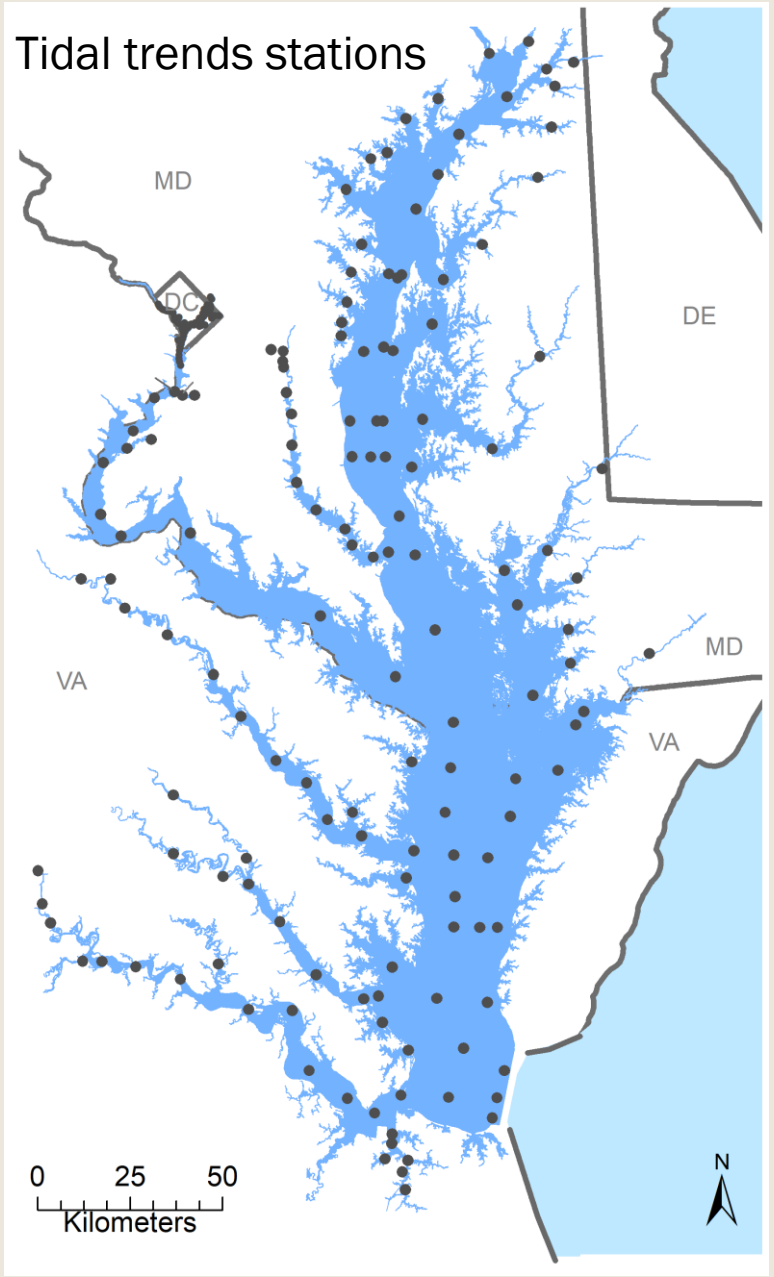
Data from: *DOEE, MDDNR, and VADEQ*

2023 Results

- Long-term (1980s-2023) and short-term (2014-2023) change:
  - *Total Nitrogen (TN)*
  - *Total Phosphorus (TP)*
  - *Secchi depth*
  - *Chlorophyll a*
  - *Water temperature*
  - *Dissolved Oxygen (DO)*

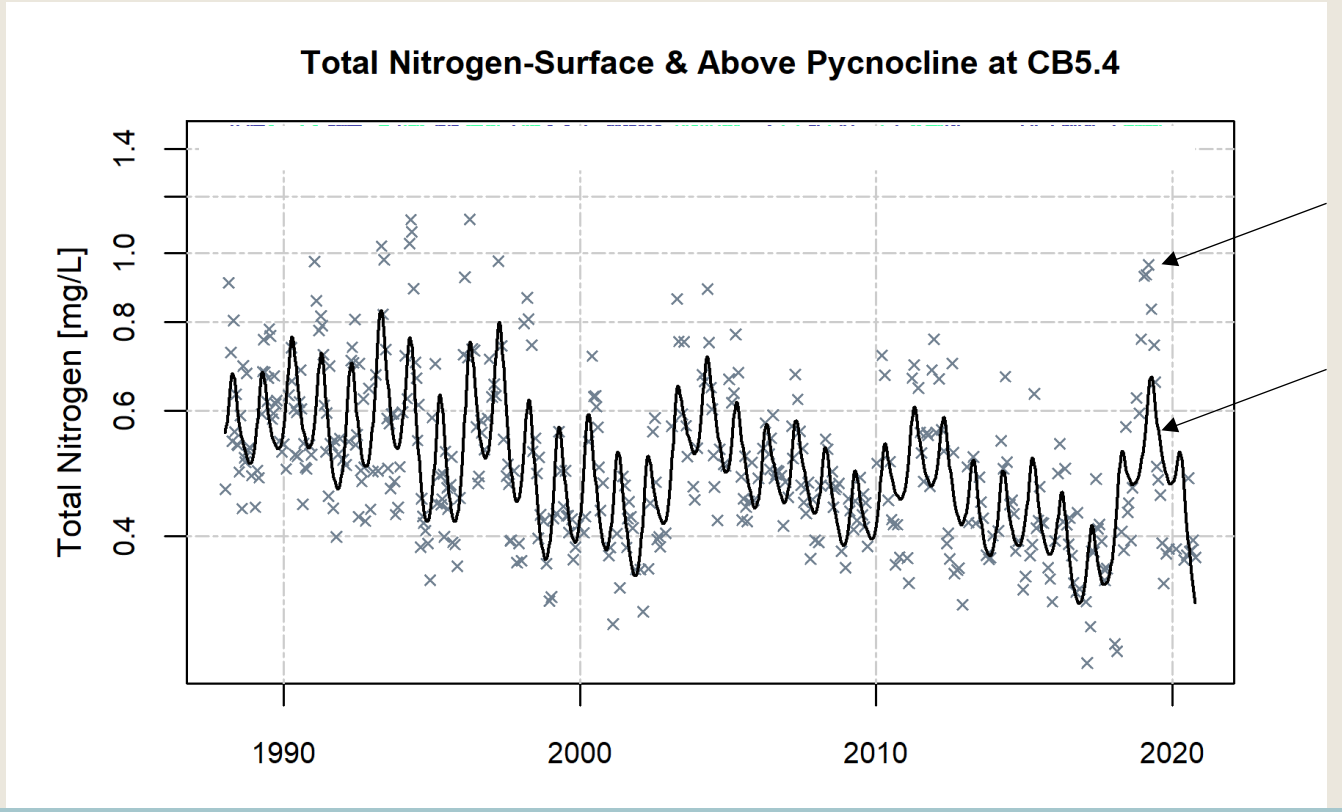
- 1999-2023 and short-term (2014-2023) change:
  - *Total Suspended Solids (TSS)*
  - *Dissolved Inorganic Nitrogen (DIN)*
  - *Orthophosphate (PO4)*

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



Generalized Additive Model (GAM) method review

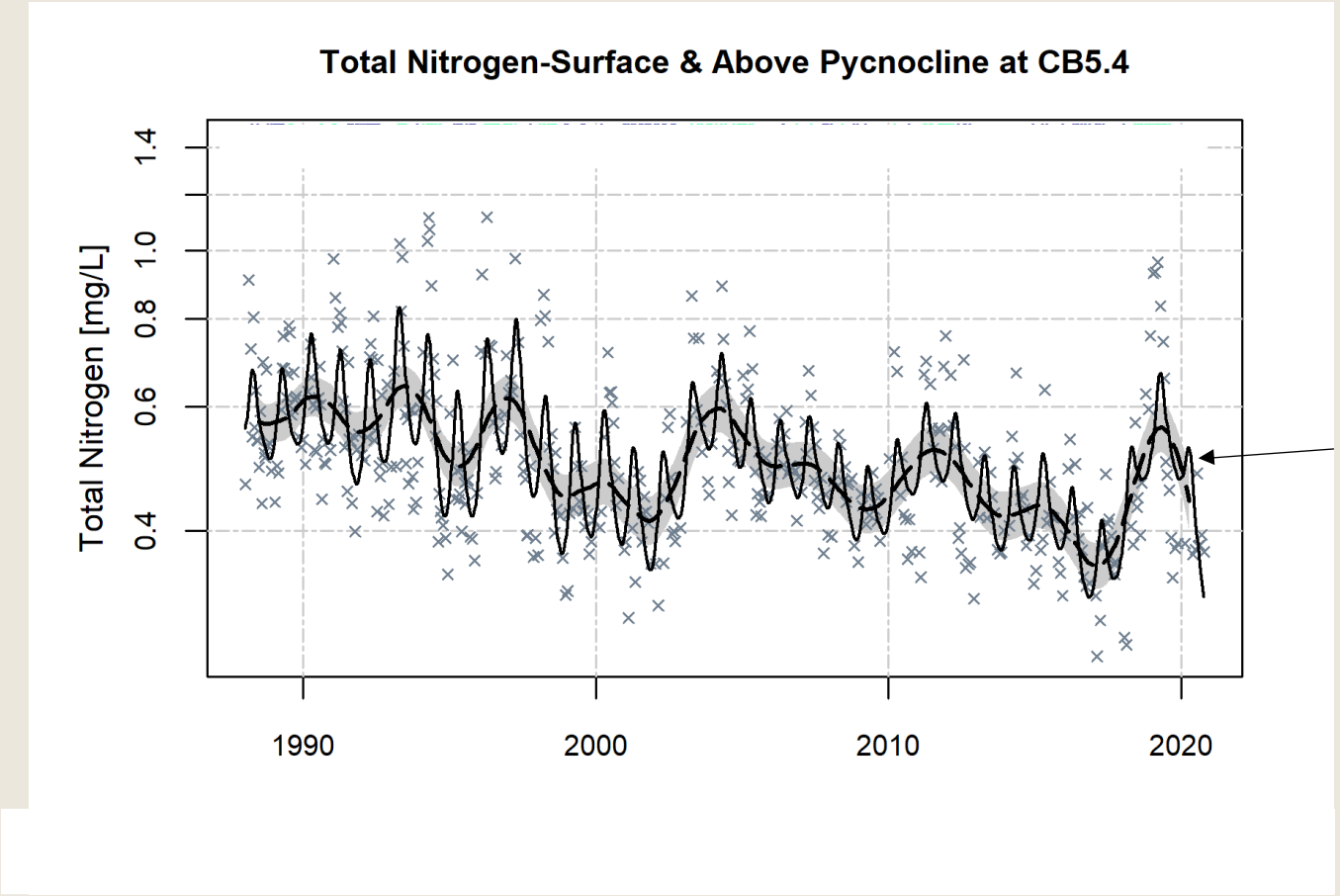
TN = s(doy) + s(date)+ interaction(doy,date)



Method documented: Murphy et al. 2019. *Environ. Modelling Software* 118: 1-13. https://doi.org/10.1016/j.envsoft.2019.03.027.
Implemented with R package baytrends: https://cran.r-project.org/web/packages/baytrends/index.html

Tidal Trends/GAM method review

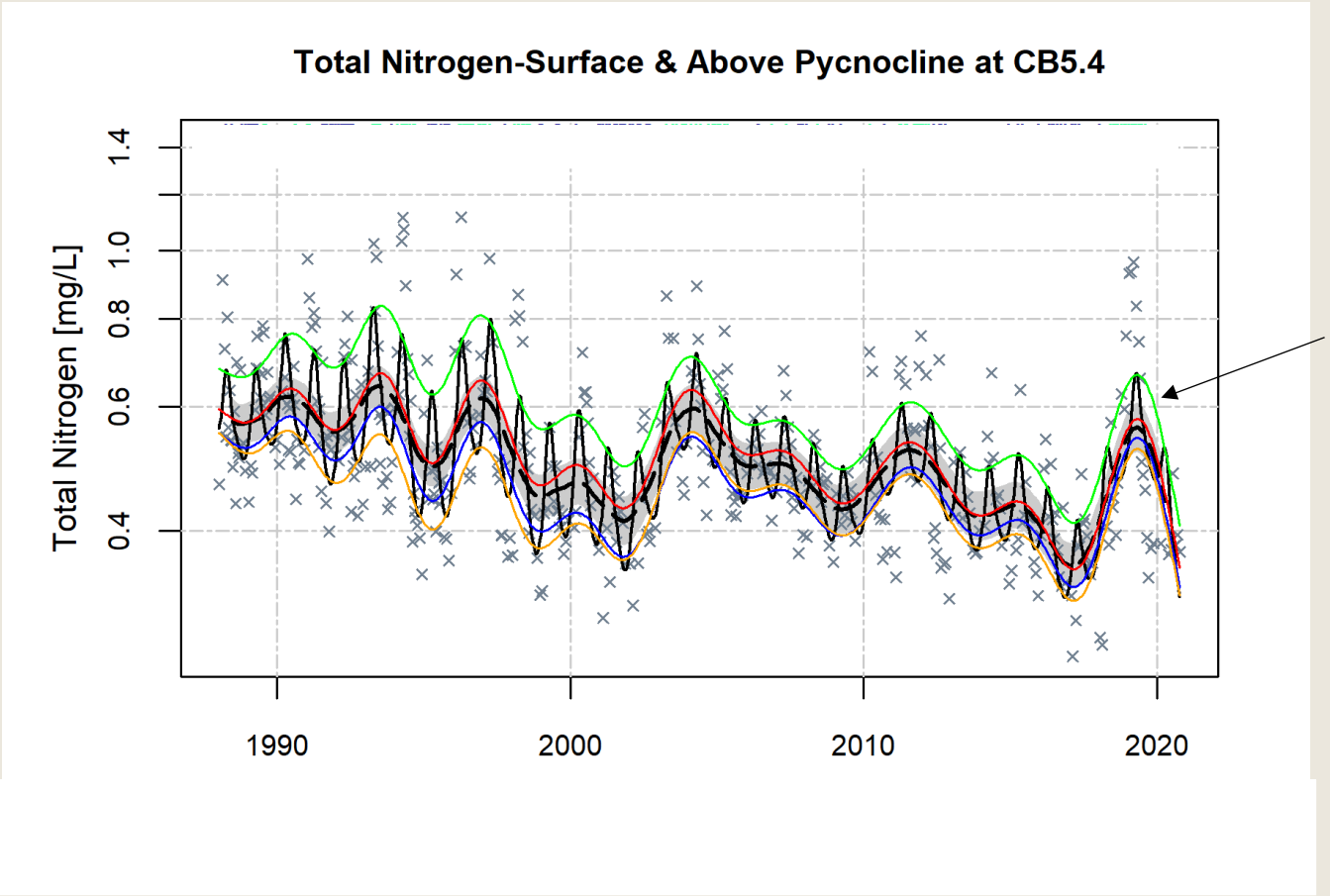
TN = s(doy) + s(date)+ interaction(doy,date)



Seasonal mean and 95% confidence interval on the mean

Tidal Trends/GAM method review

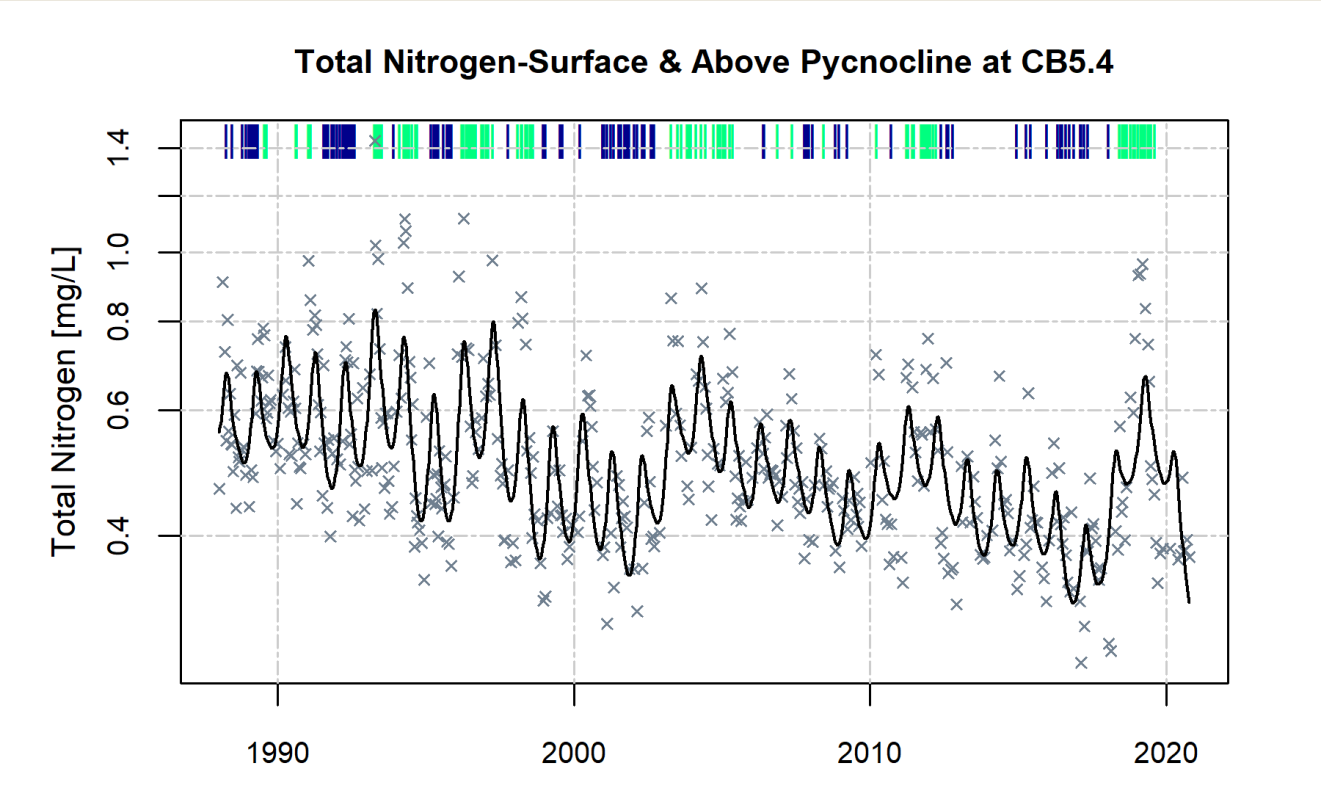
TN = s(doy) + s(date)+ interaction(doy,date)



Mean prediction lines for 4 dates
-April 1
-July 1
-Oct 1
-Jan 1

Tidal Trends/GAM method review

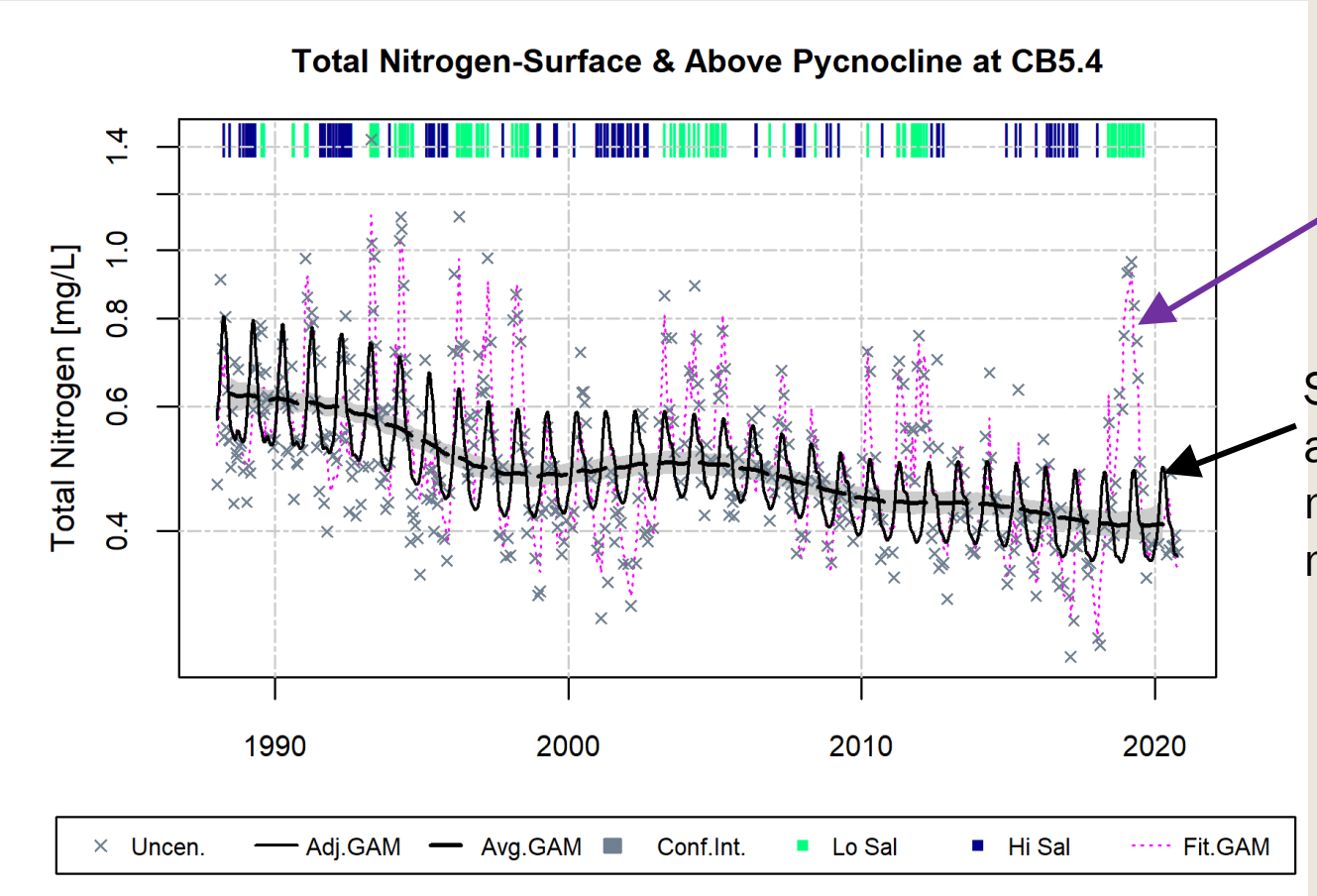
Is variability in river flow the cause of year-to-year fluctuations?



Approach: Include upstream flow or local salinity in the model, depending on location of analysis.

Tidal Trends/GAM method review

TN = s(doy) + s(date)+ interaction(doy,date)
+ s(flw_sal) + interaction(flw_sal,doy) + interaction(flw_sal,date) + interaction(flw_sal,doy,date)

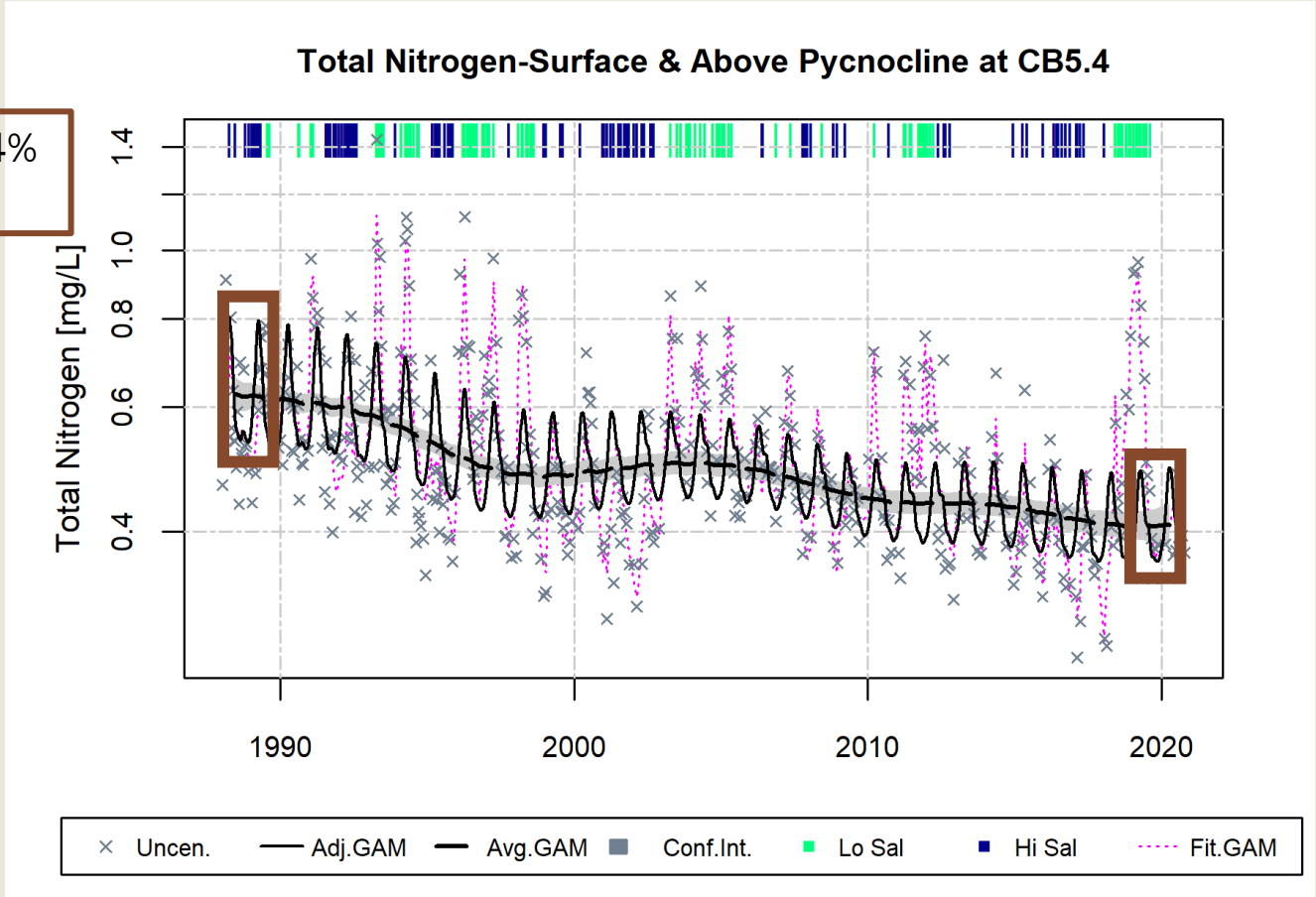


Model with salinity as a variable

Salinity adjusted model and mean

Tidal Trends/GAM method review

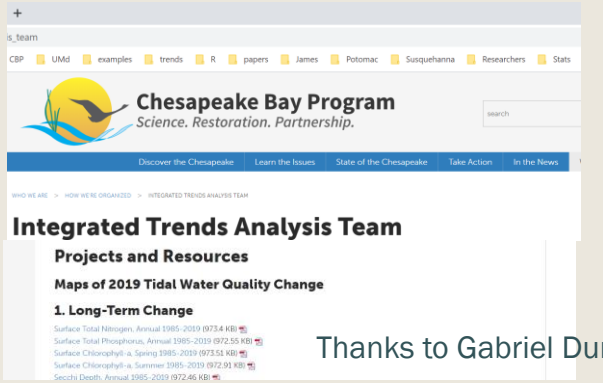
Percent change = -34%
p-value < 0.0001



2023 Results

ITAT webpage:

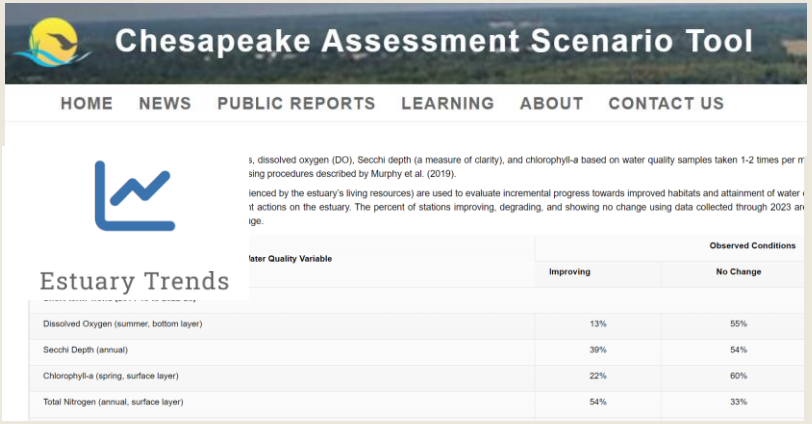
https://www.chesapeakebay.net/who/group/integrated-trends-analysis-team



Thanks to Gabriel Duran

CAST webpage/Trends over time:

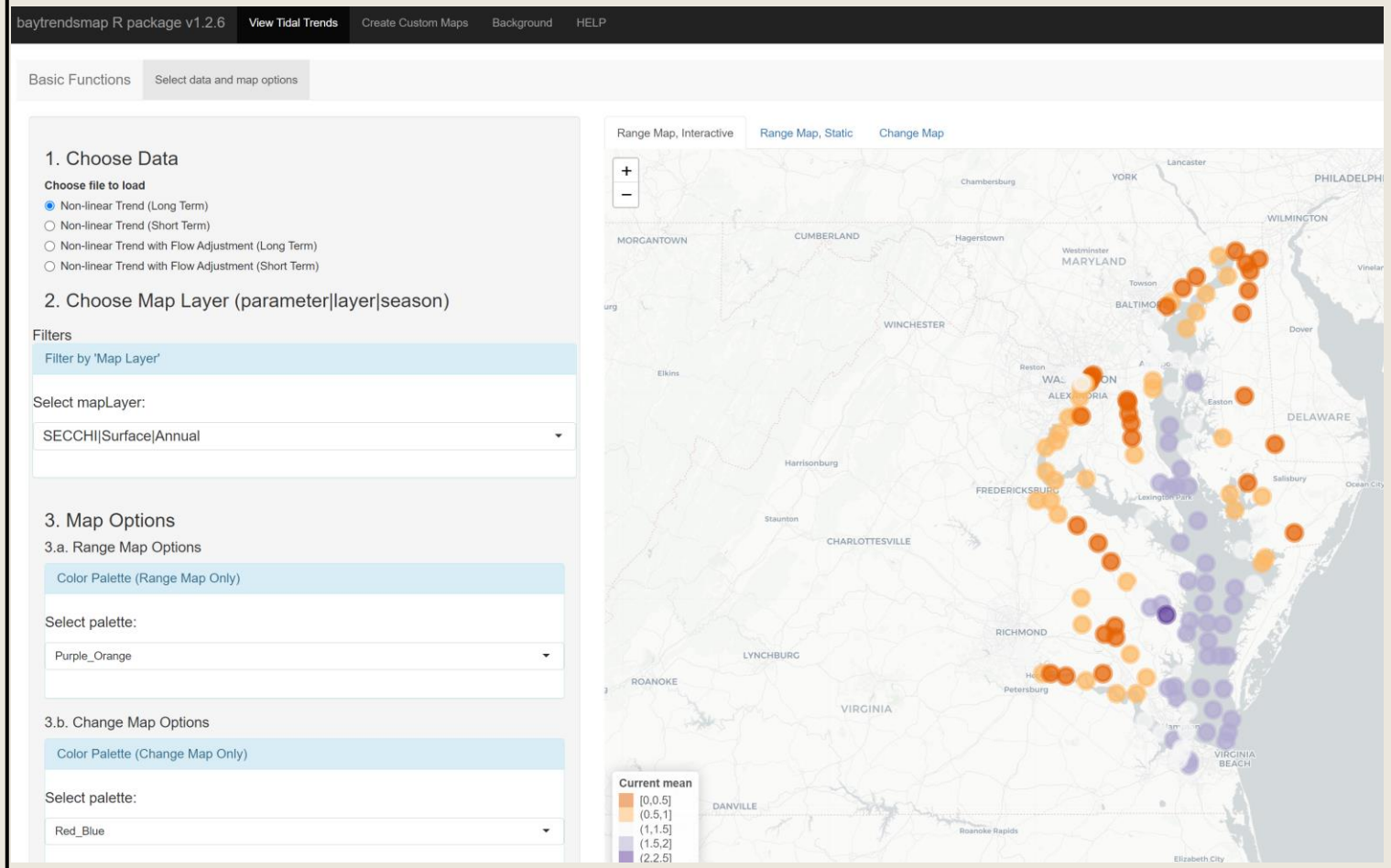
https://cast.chesapeakebay.net/EstuaryTrends



Thanks to Helen Golimowski and Olivia Devereux

Baytrendsmap :

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



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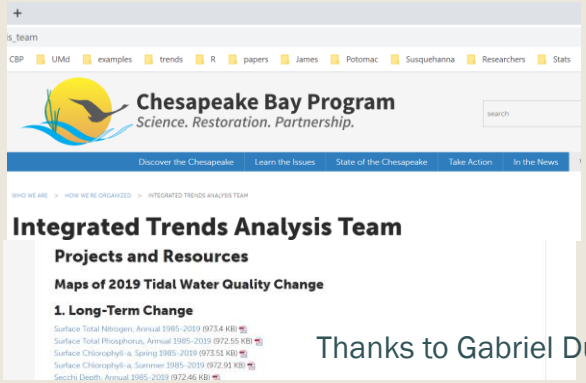

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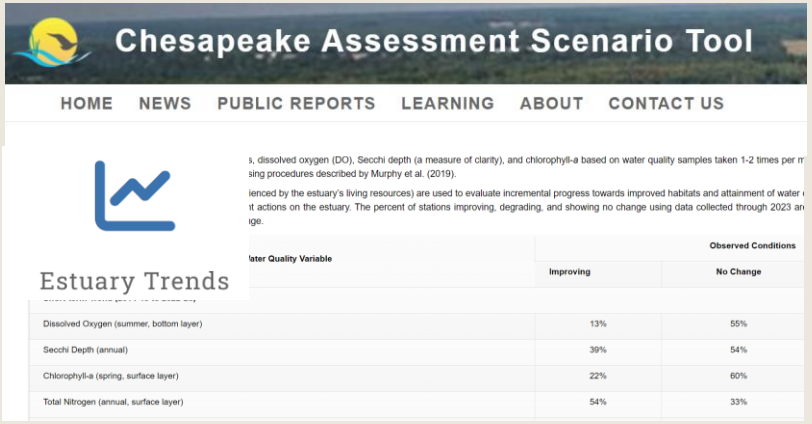

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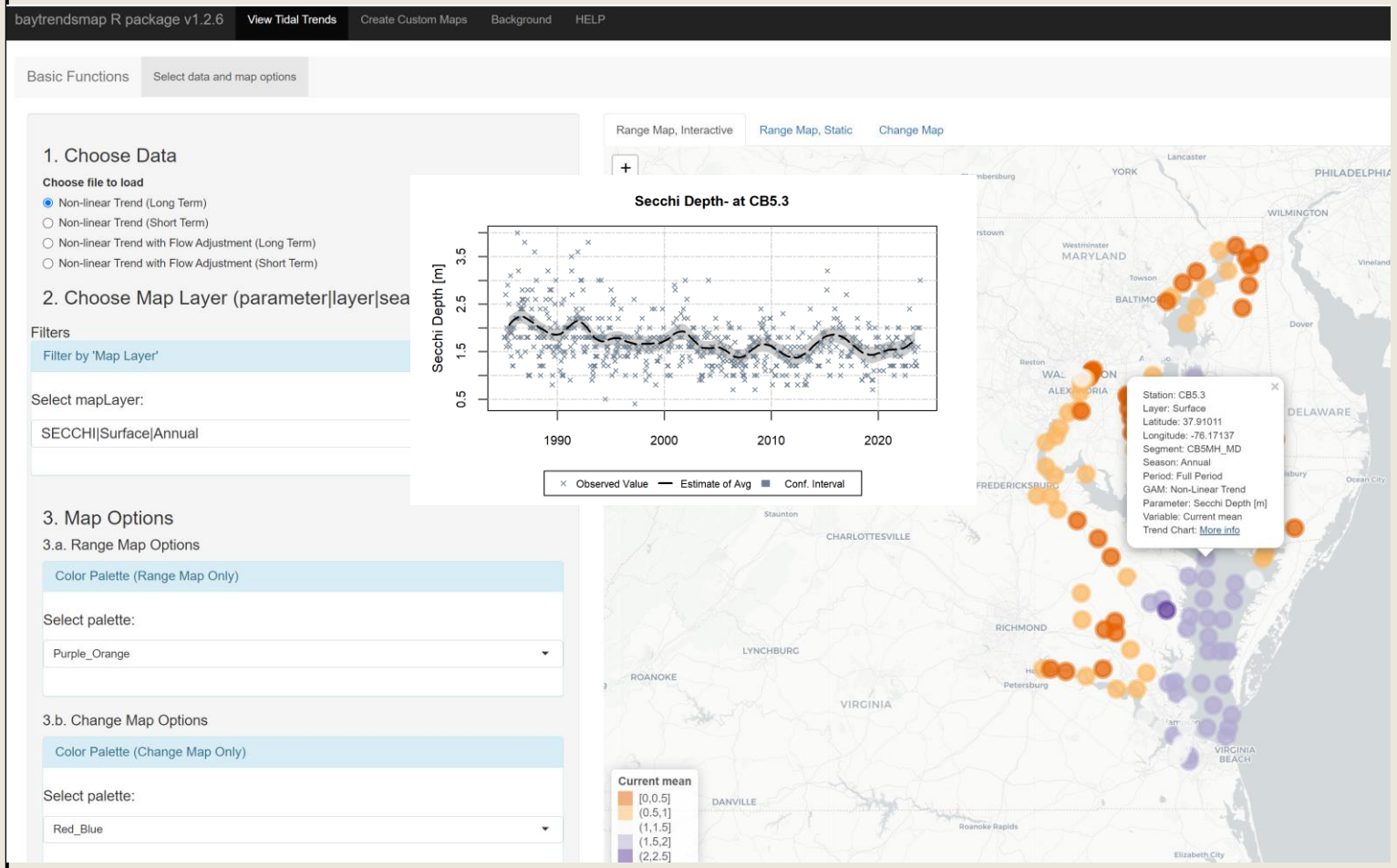

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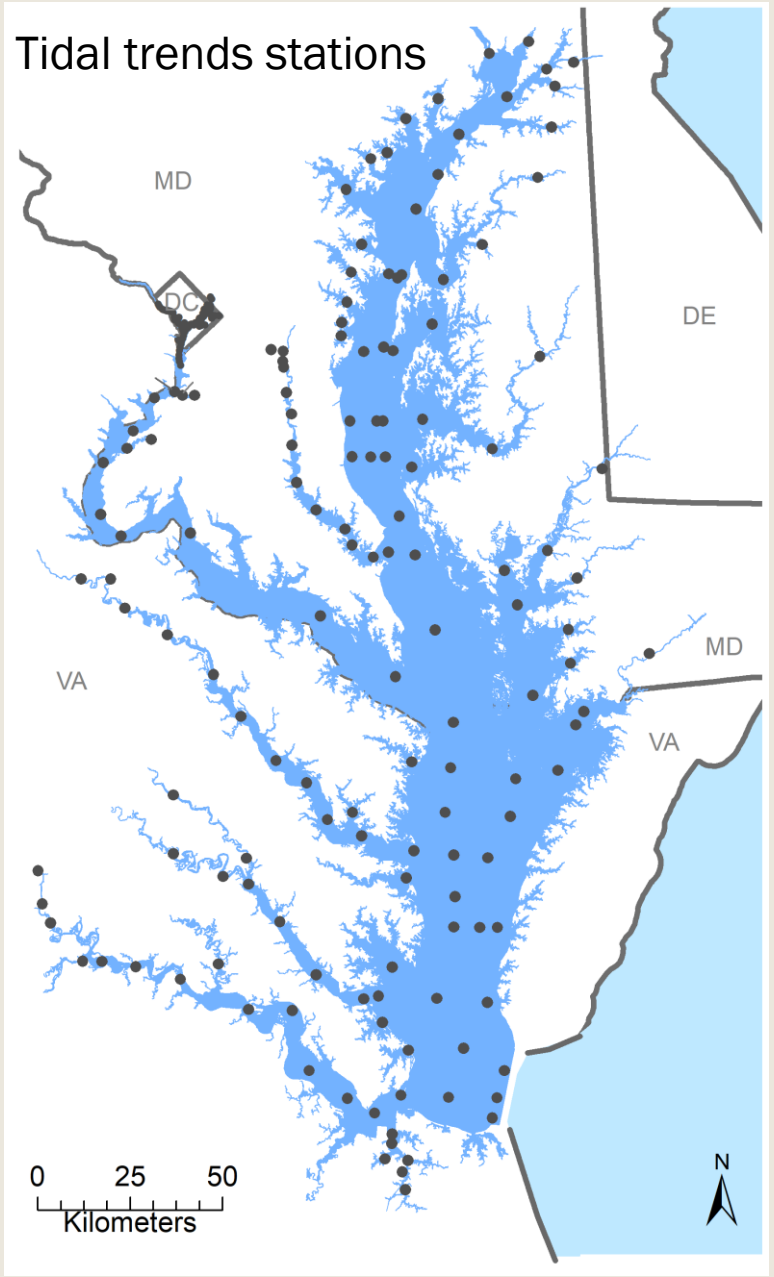
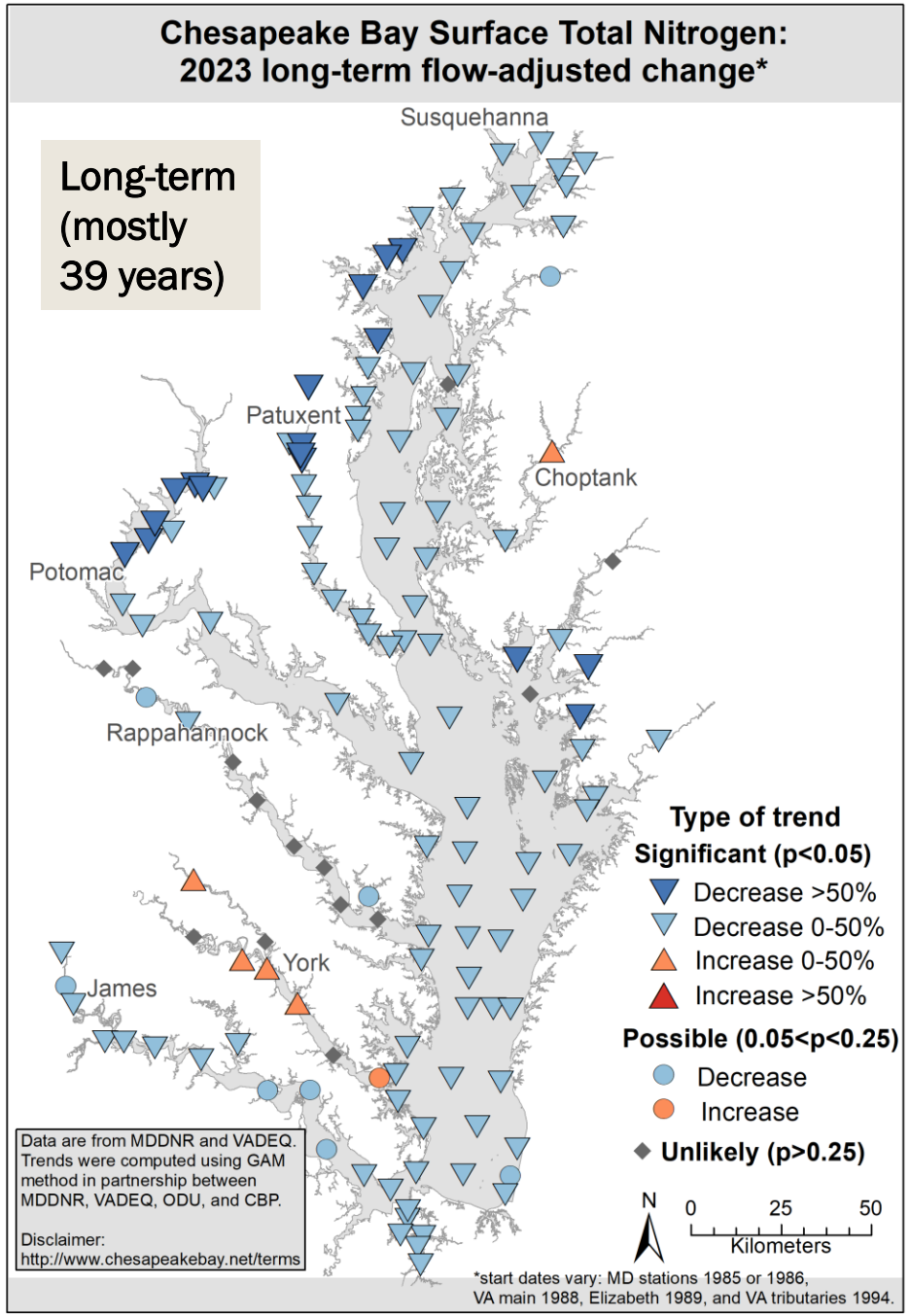
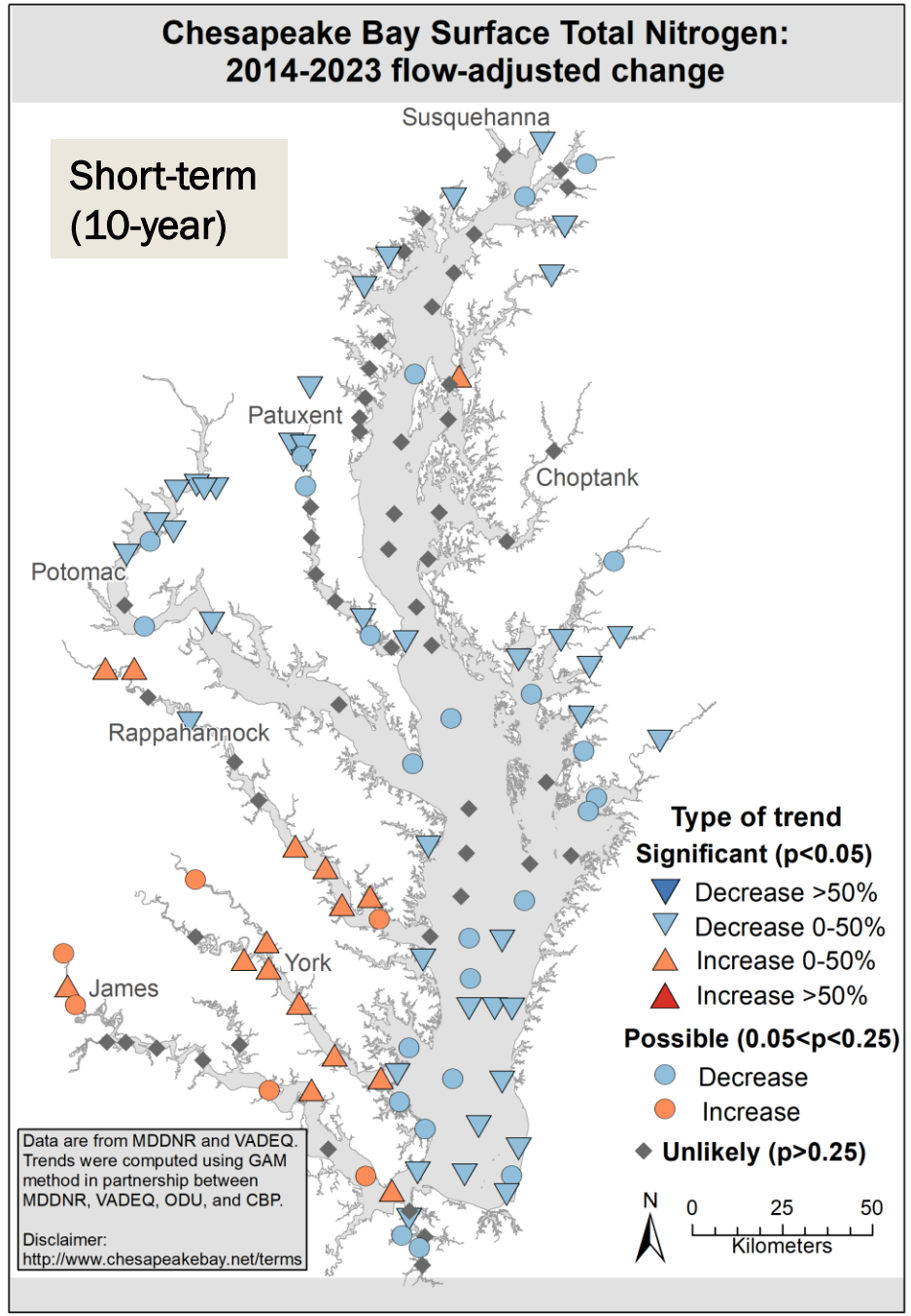


TN

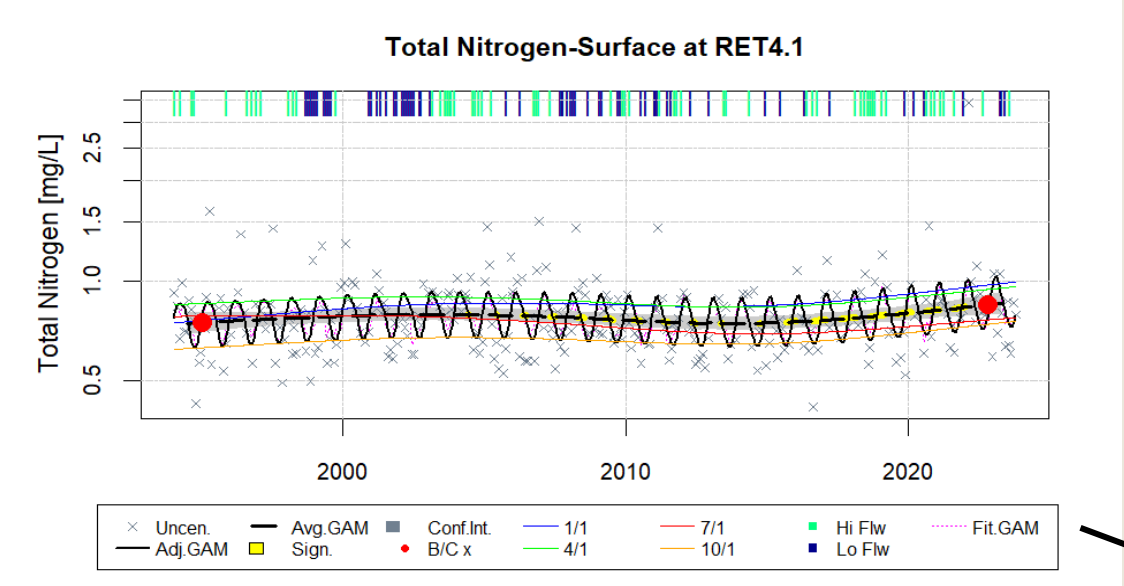
Surface Flow-adjusted



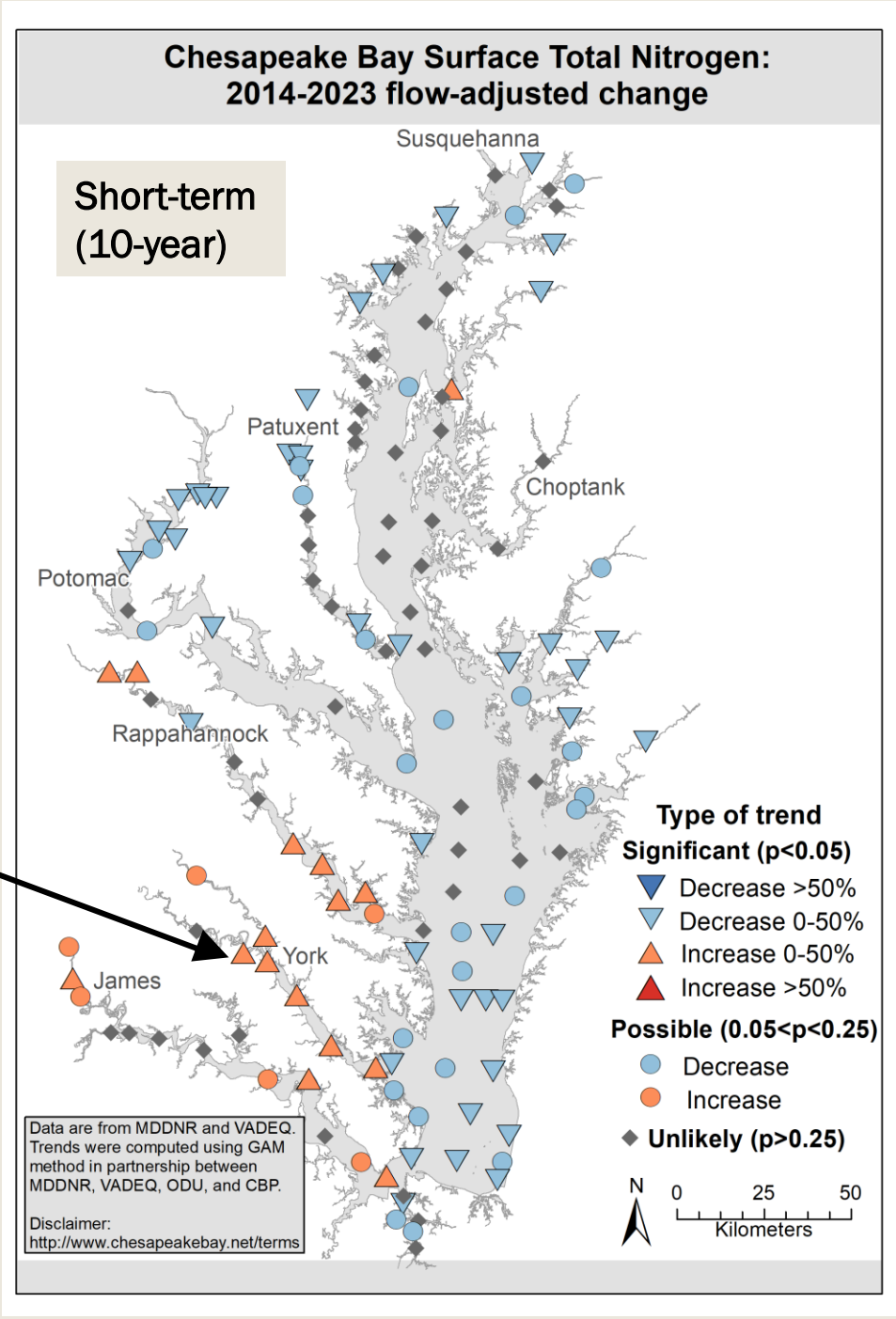


TN

Surface Example

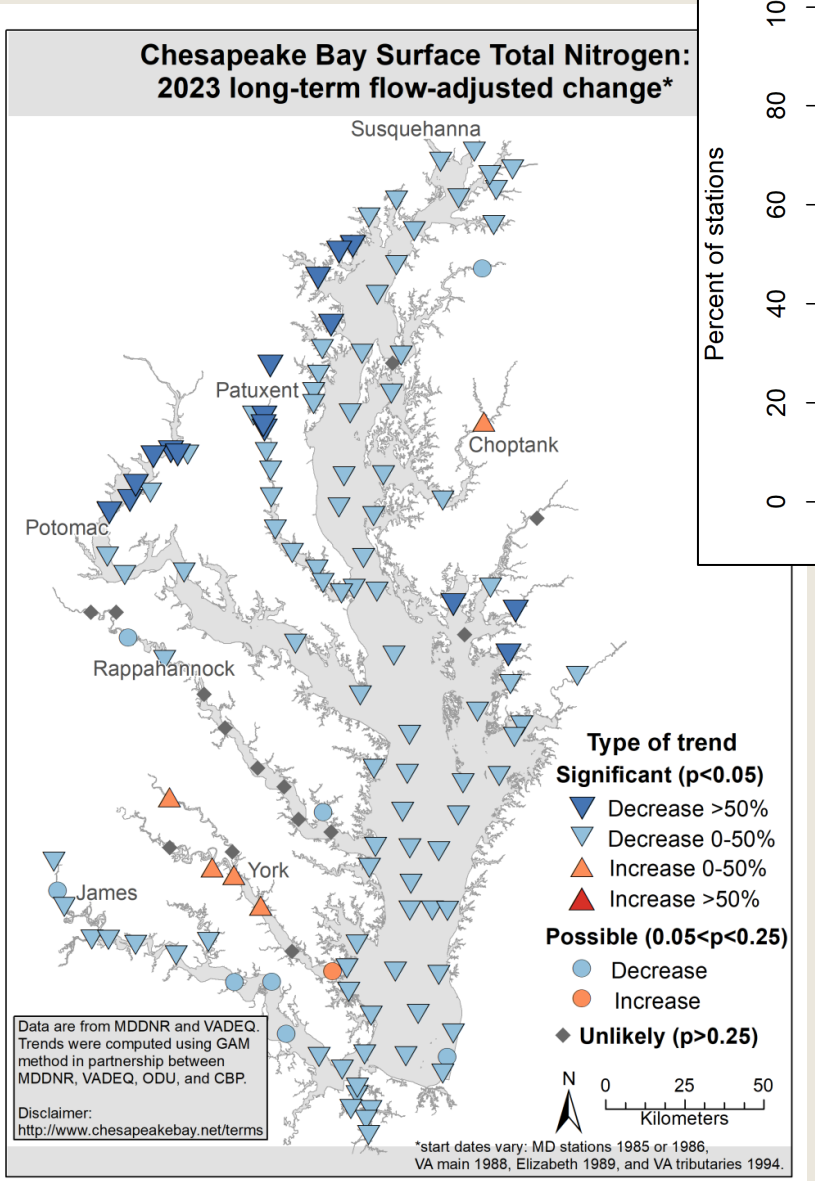


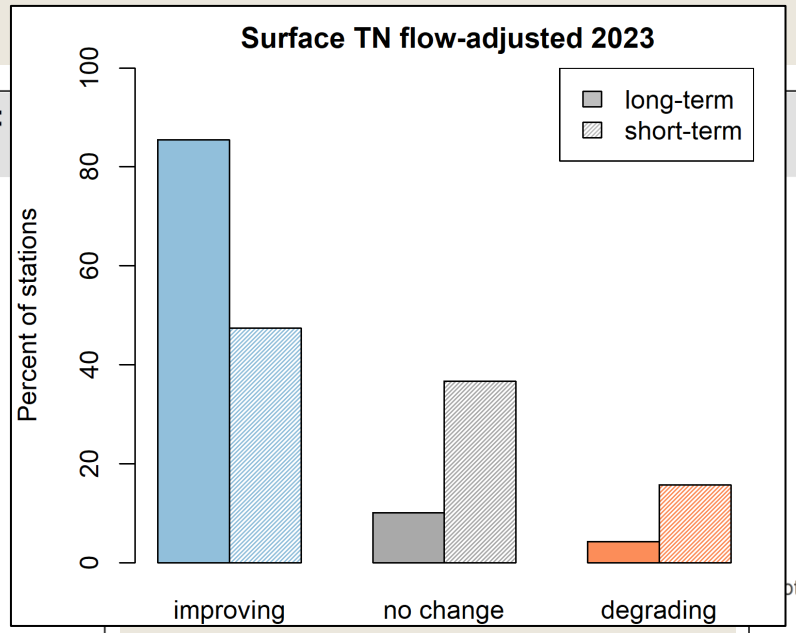
Example: The York tributary stations with short-term increases have fairly low concentrations over the long-term with an upswing in the last few years.



TN

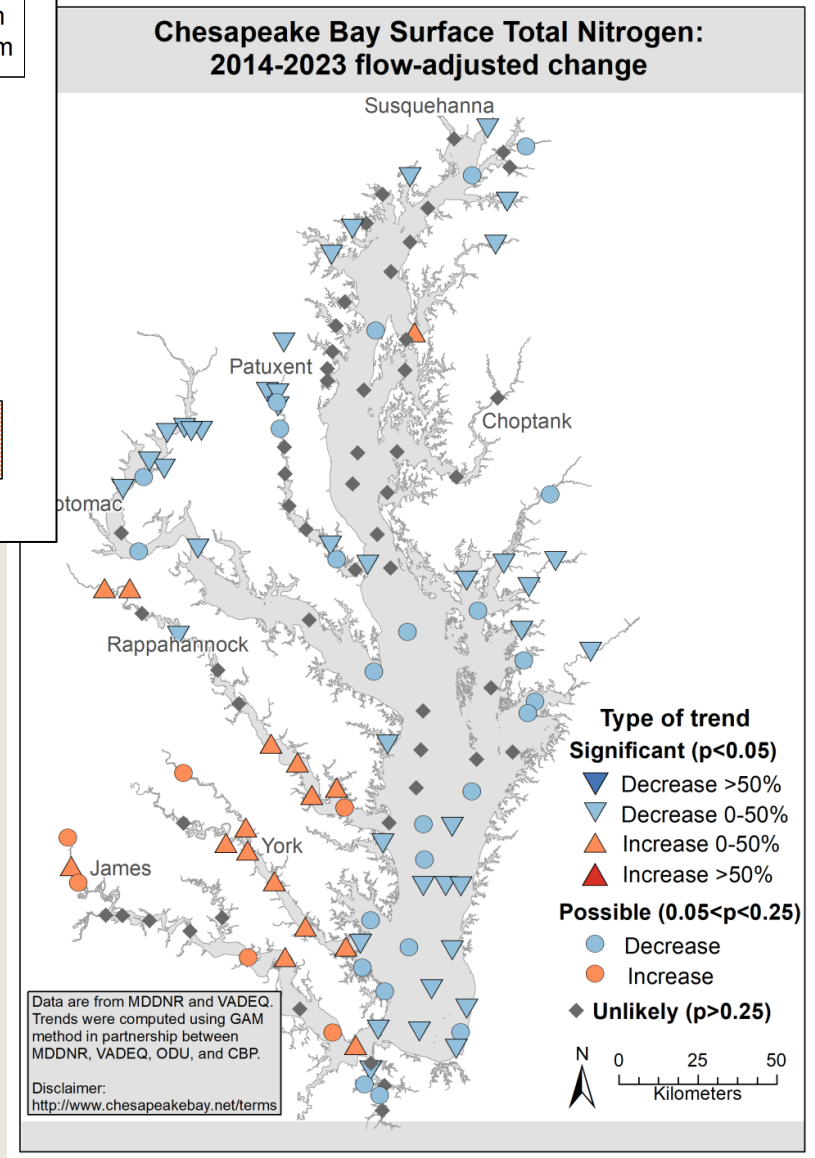
Surface Flow-adjusted





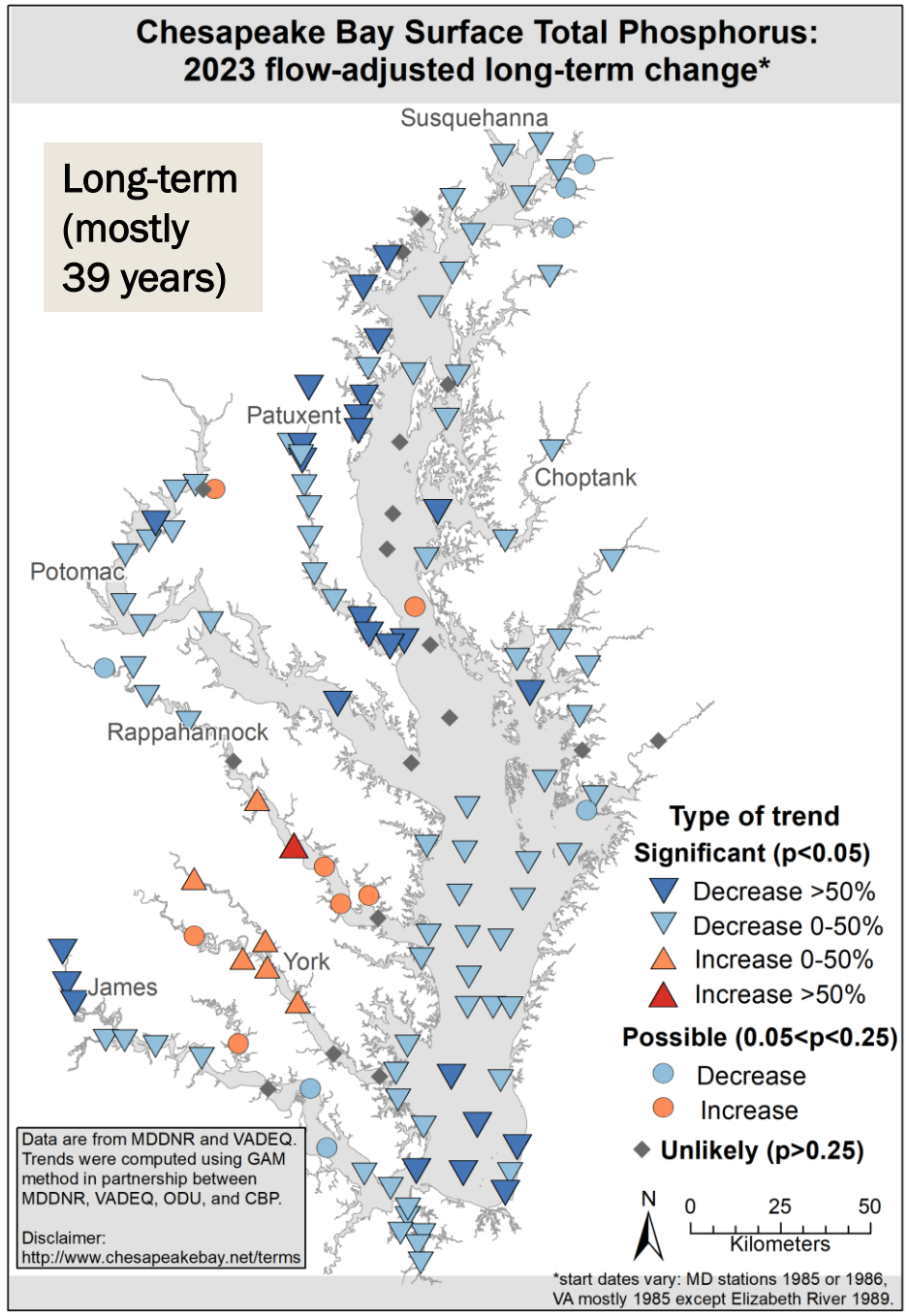
Summary for TN

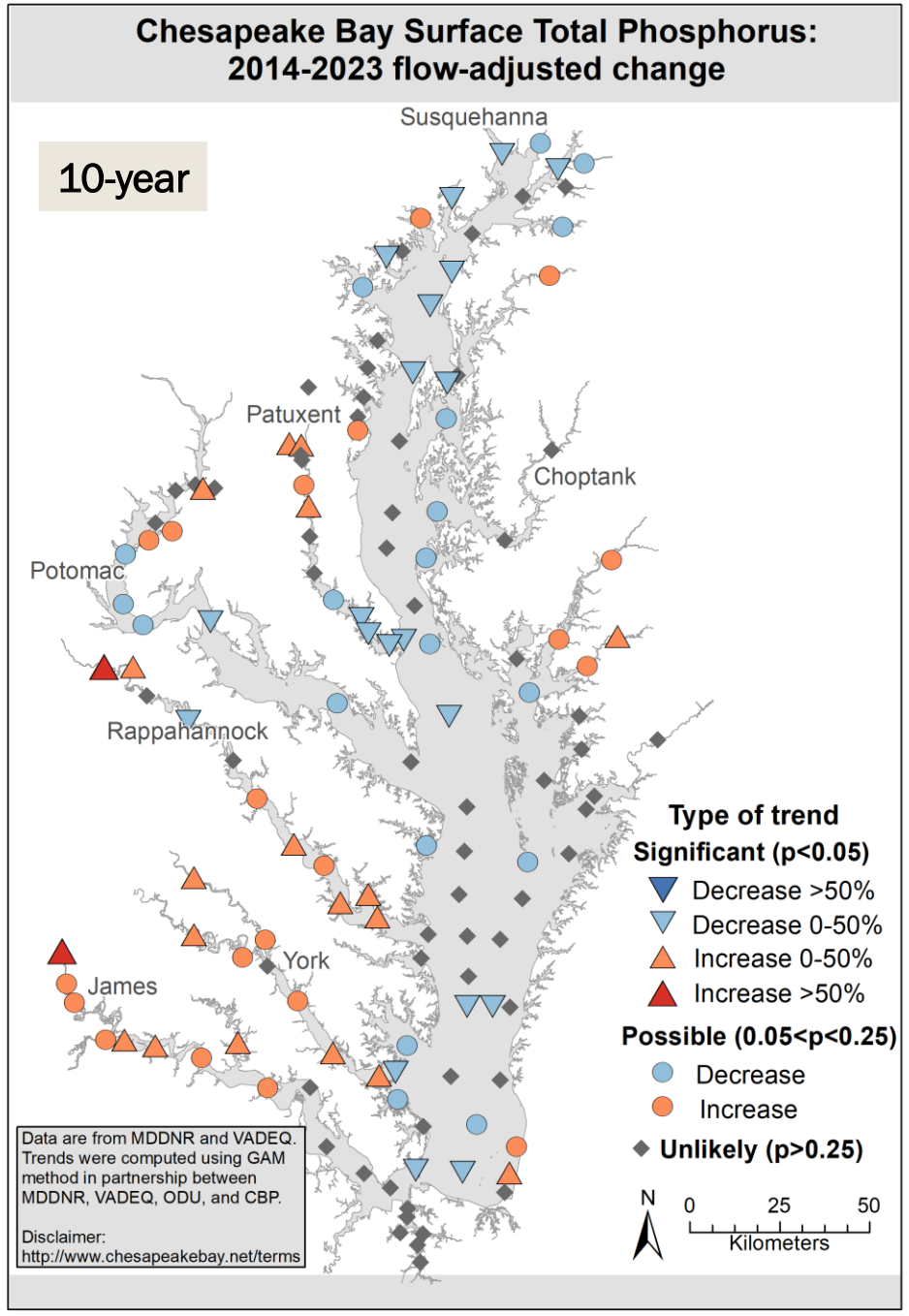
- Long-term trends decreasing at majority of stations (bottom is similar).
- Short-term trends are more mixed, but the largest group is improving.



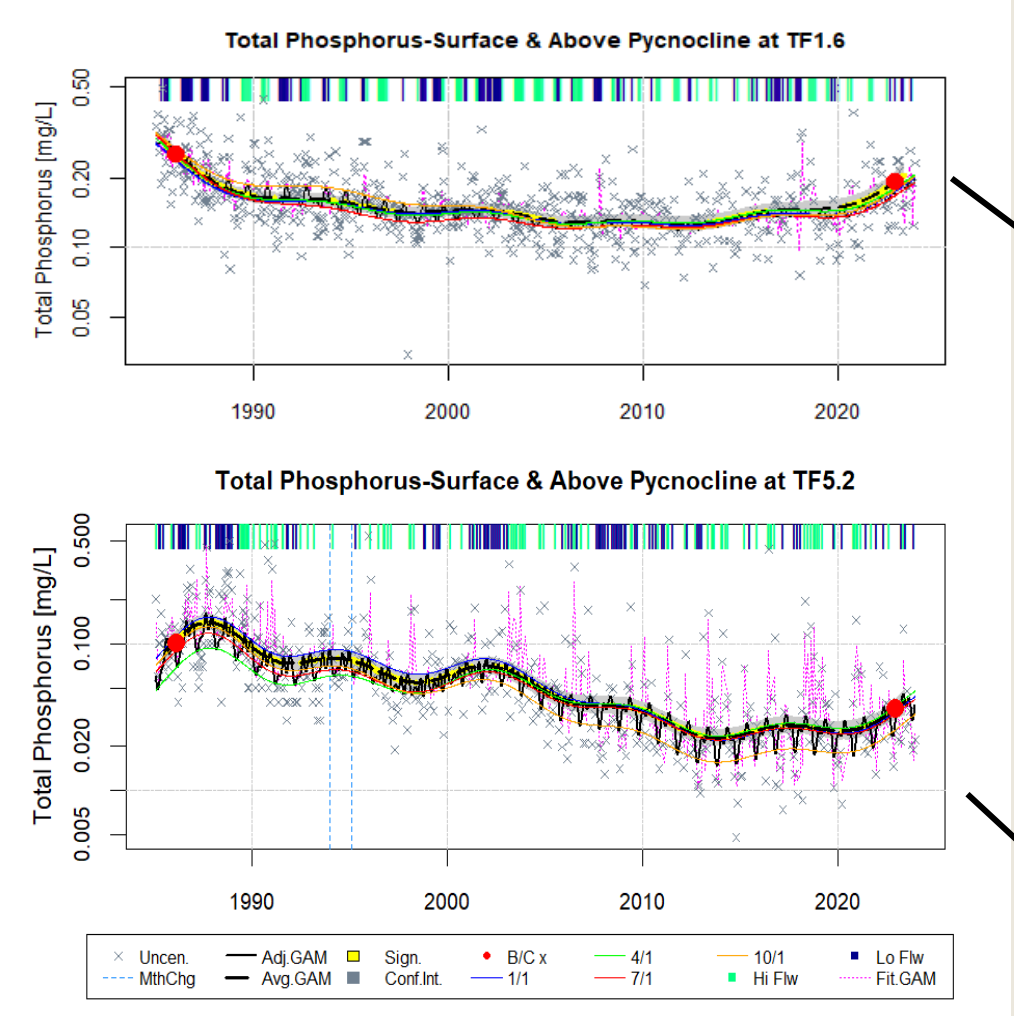
TP

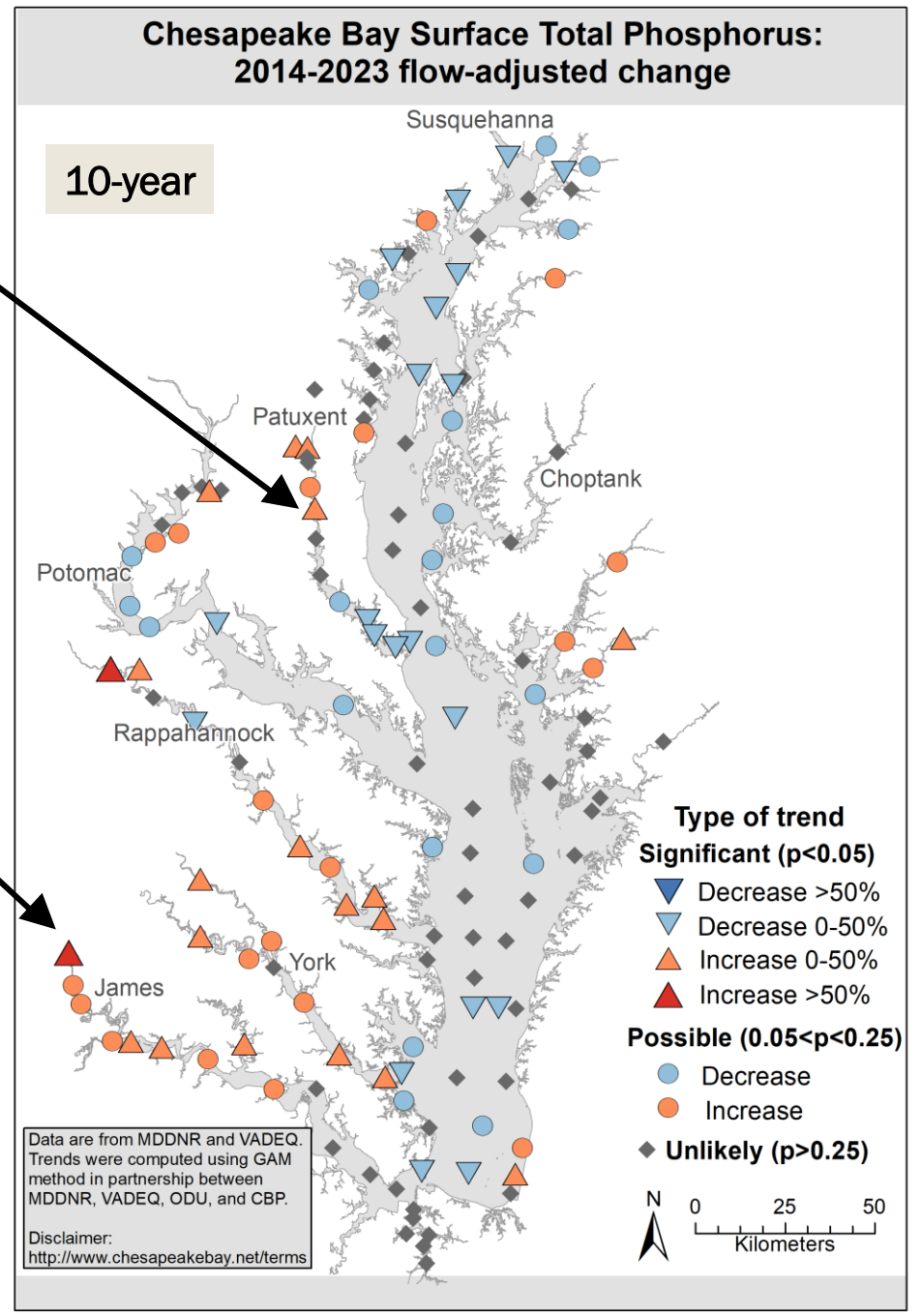
Surface Flow-adjusted





TP
Surface Examples

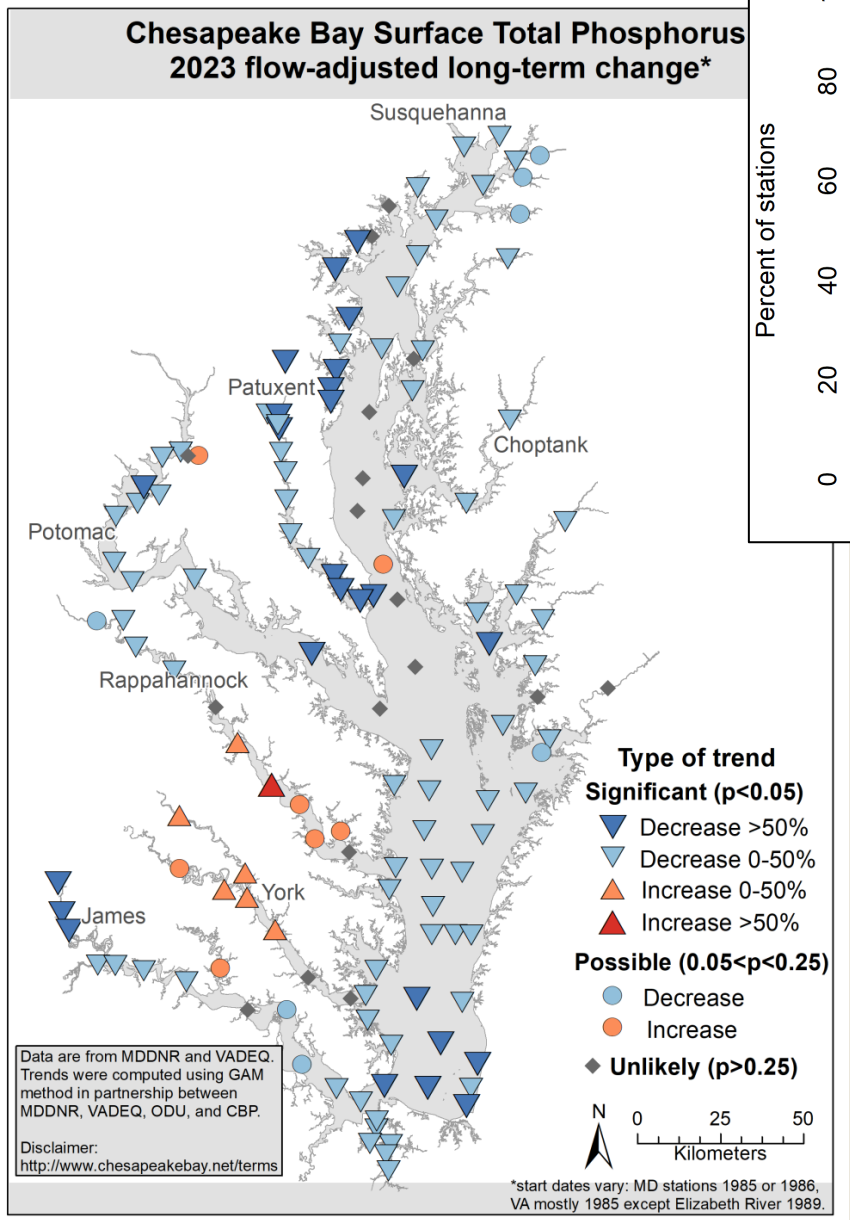


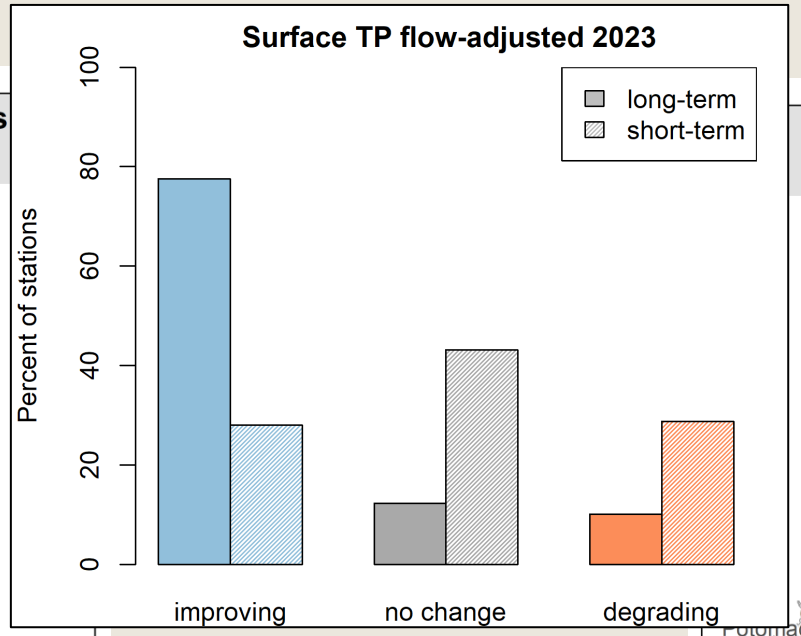


Example: Several of the trends that improve over the long-term but degrade over the short-term have large TP decreases in the 80s and smaller increases in the last decade.

TP

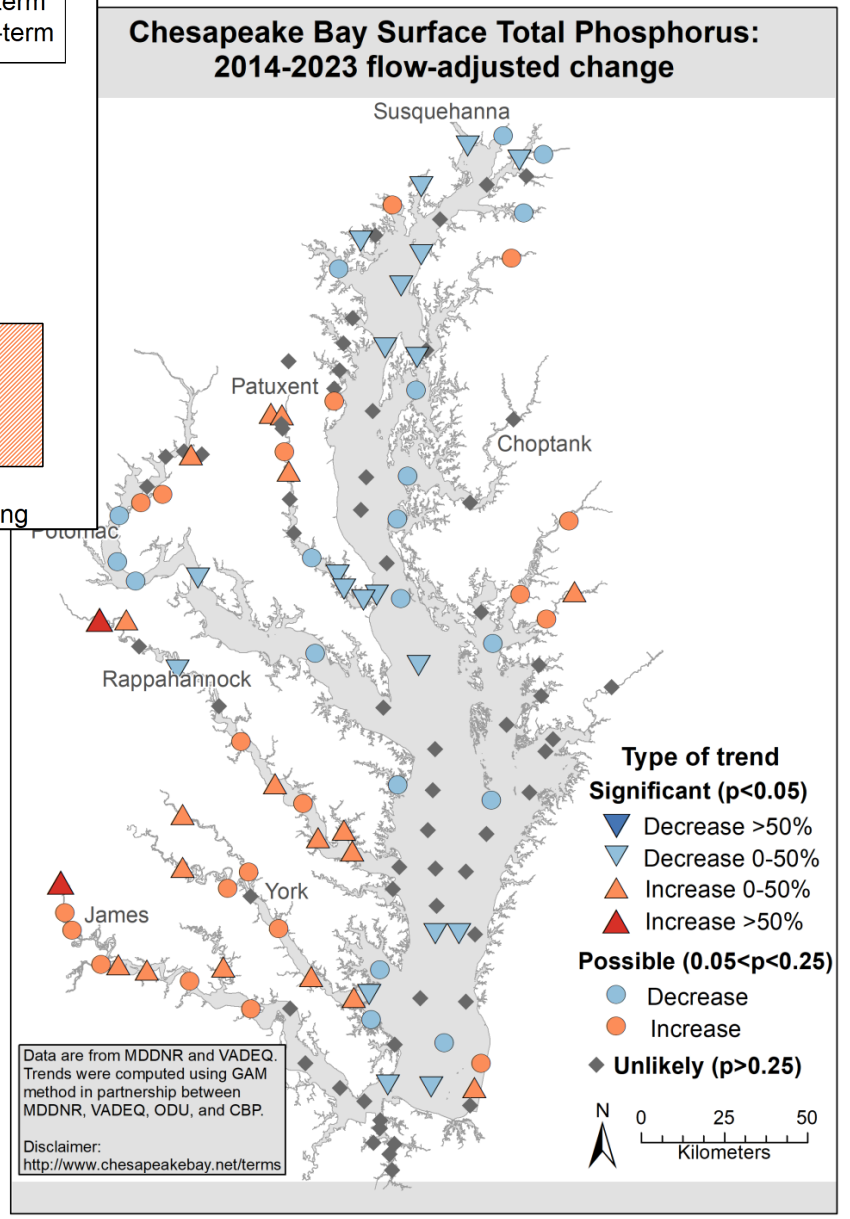
Surface Flow-adjusted





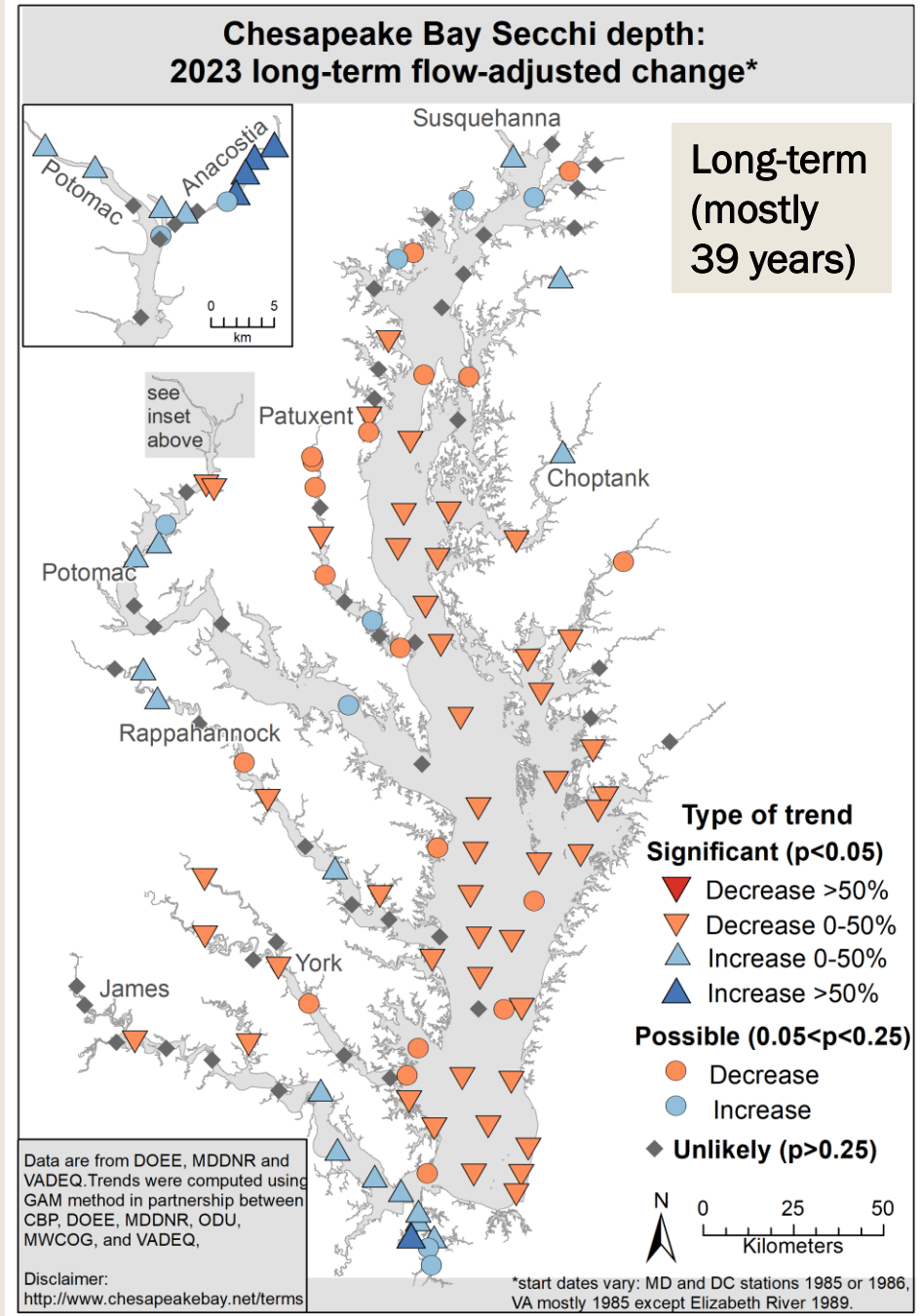
Summary for TP

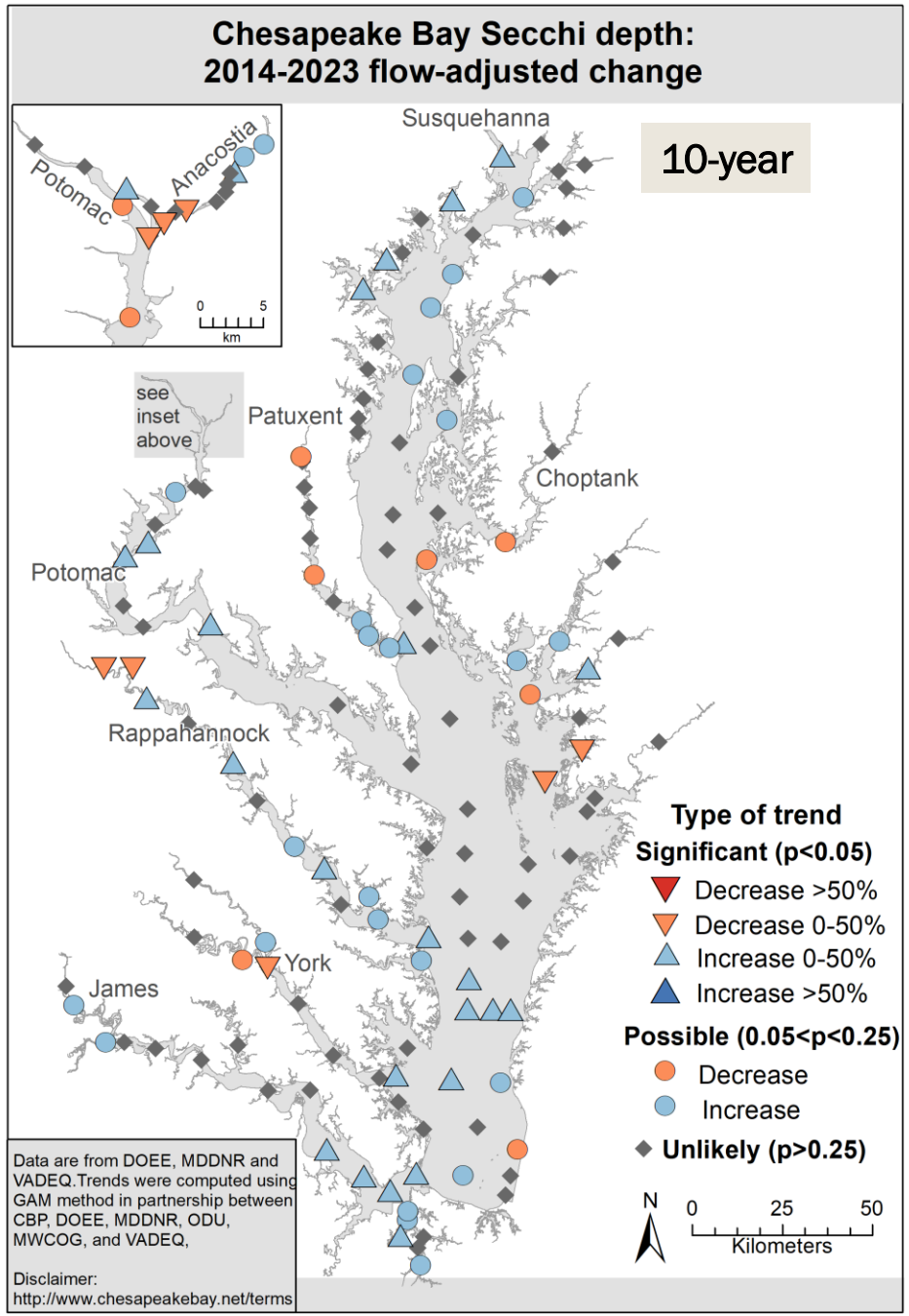
- Long-term trends decreasing at majority of stations (bottom is similar).
- Short-term is more mixed, with the largest group with no trend.



Secchi Depth

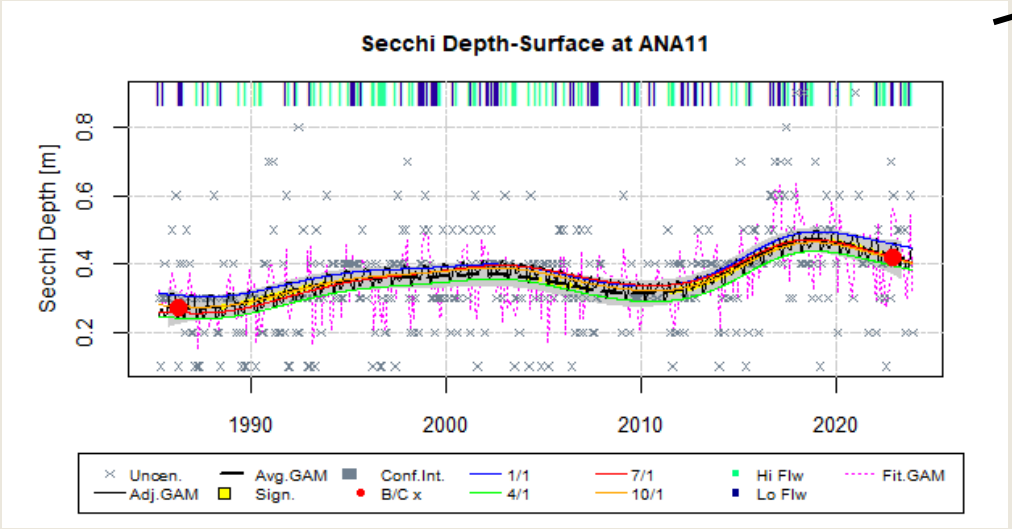
Flow-adjusted



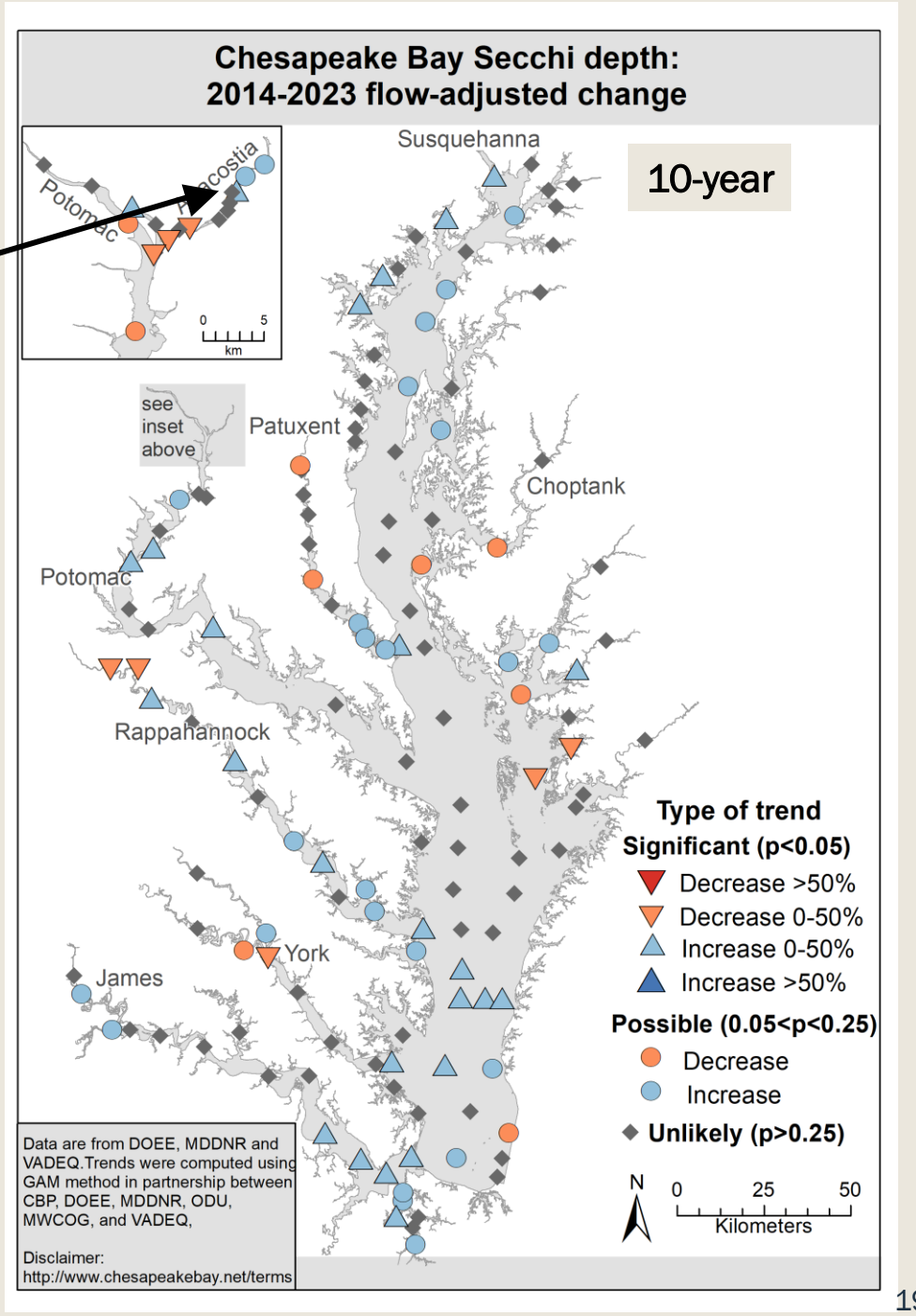


Secchi Depth

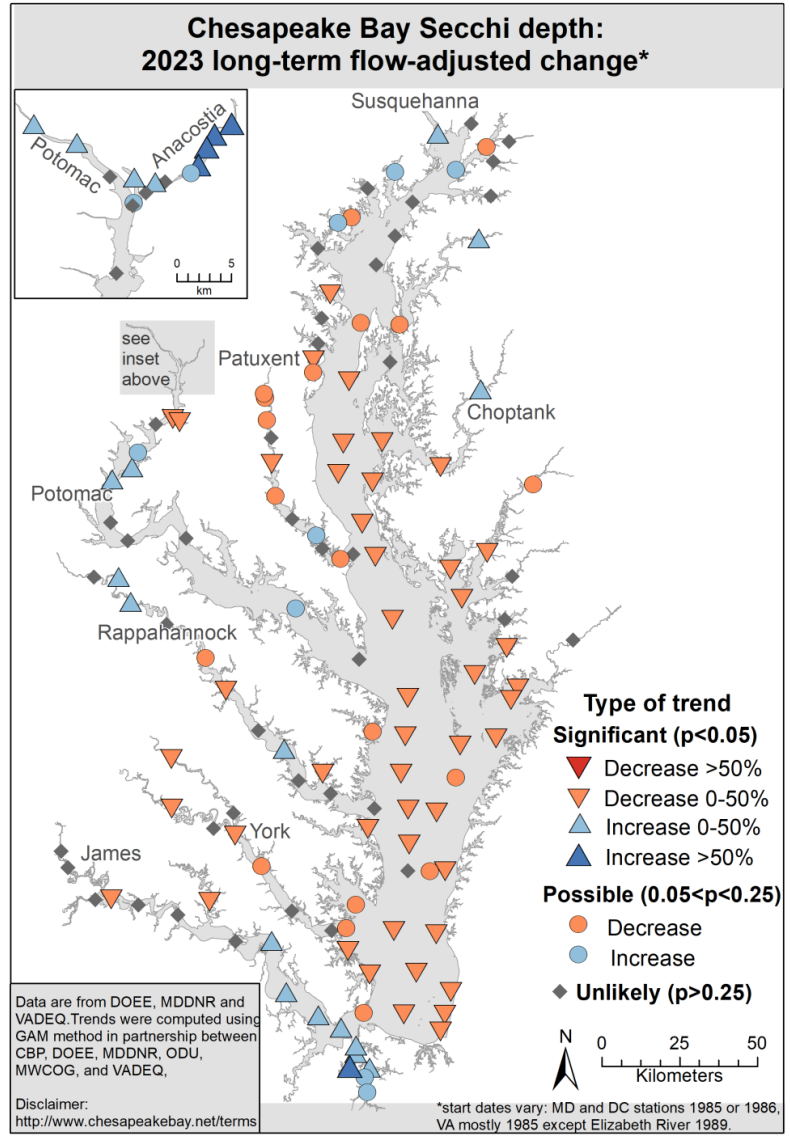
Example

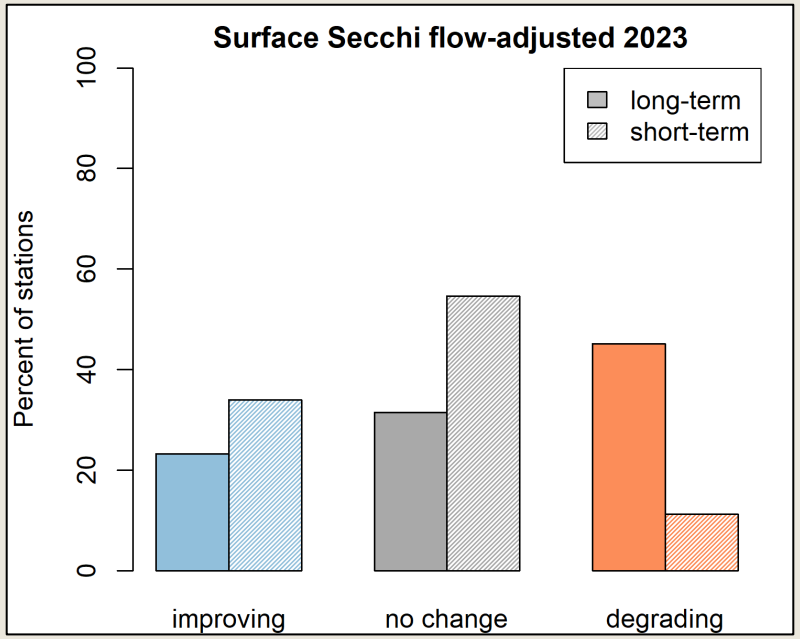


Example: Anacostia stations all show long-term gradual improvement. DOEE's Potomac stations also show long-term improvement with both rivers having mixed short-term trends.



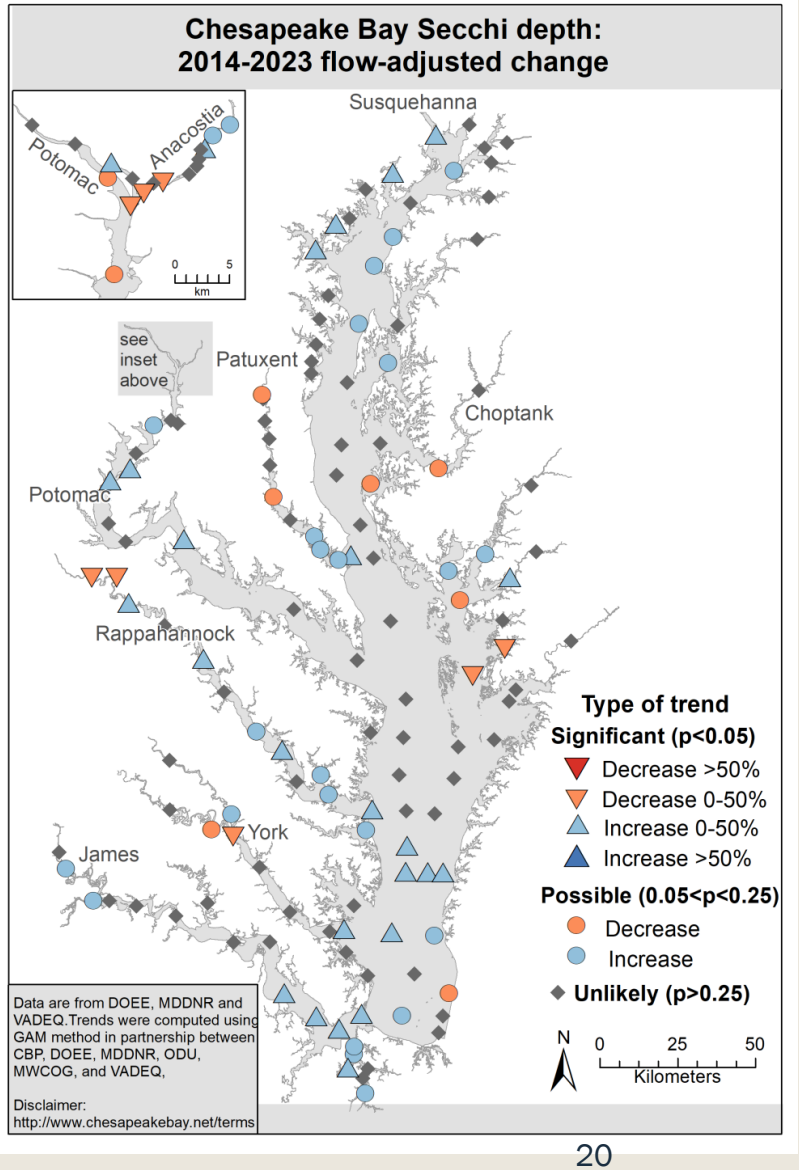
Secchi depth





Summary for Secchi

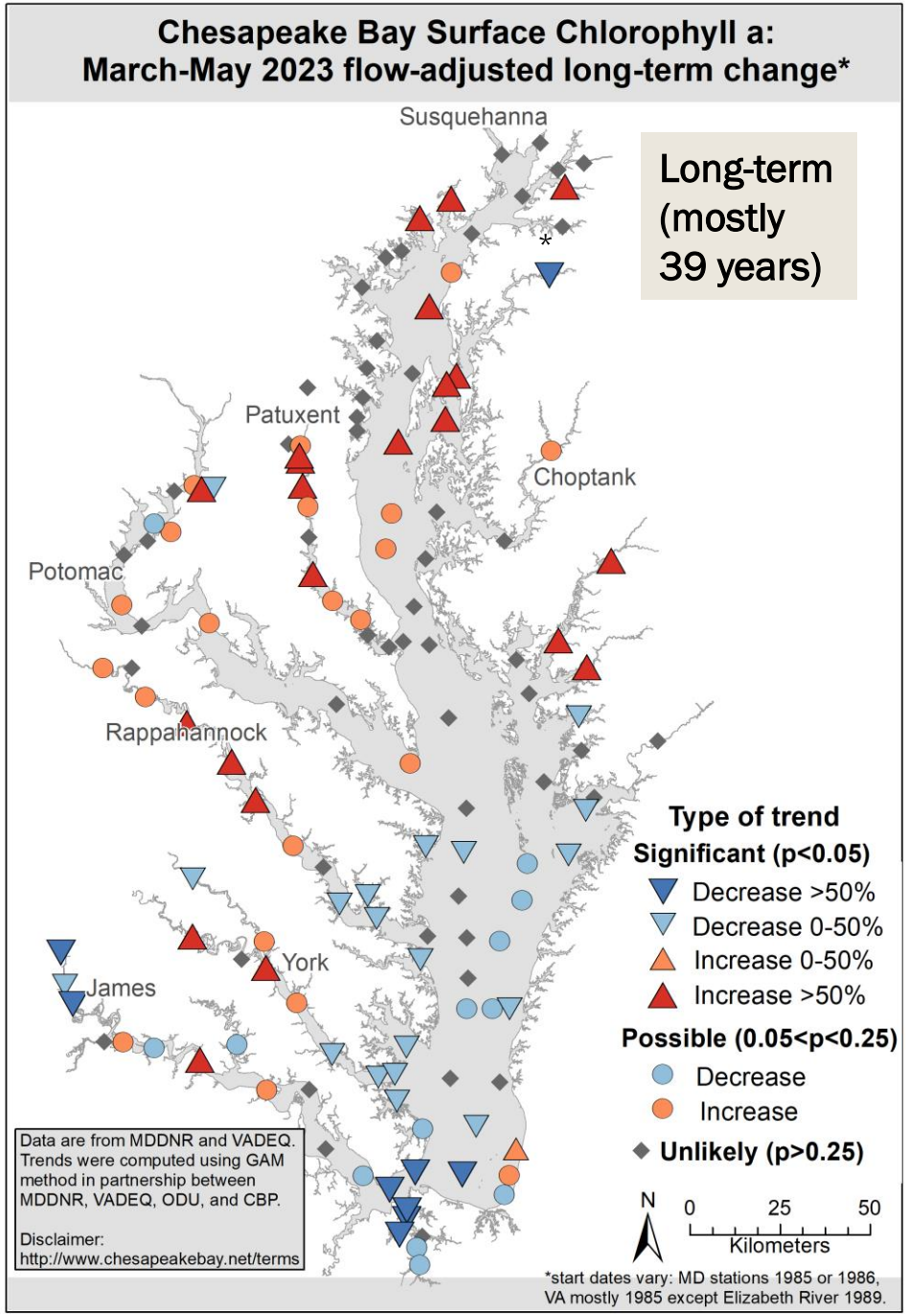
- Long-term degradation in Secchi depth is notable across many regions of the bay.
- But in last 10 years, there are more improvements than degradations.

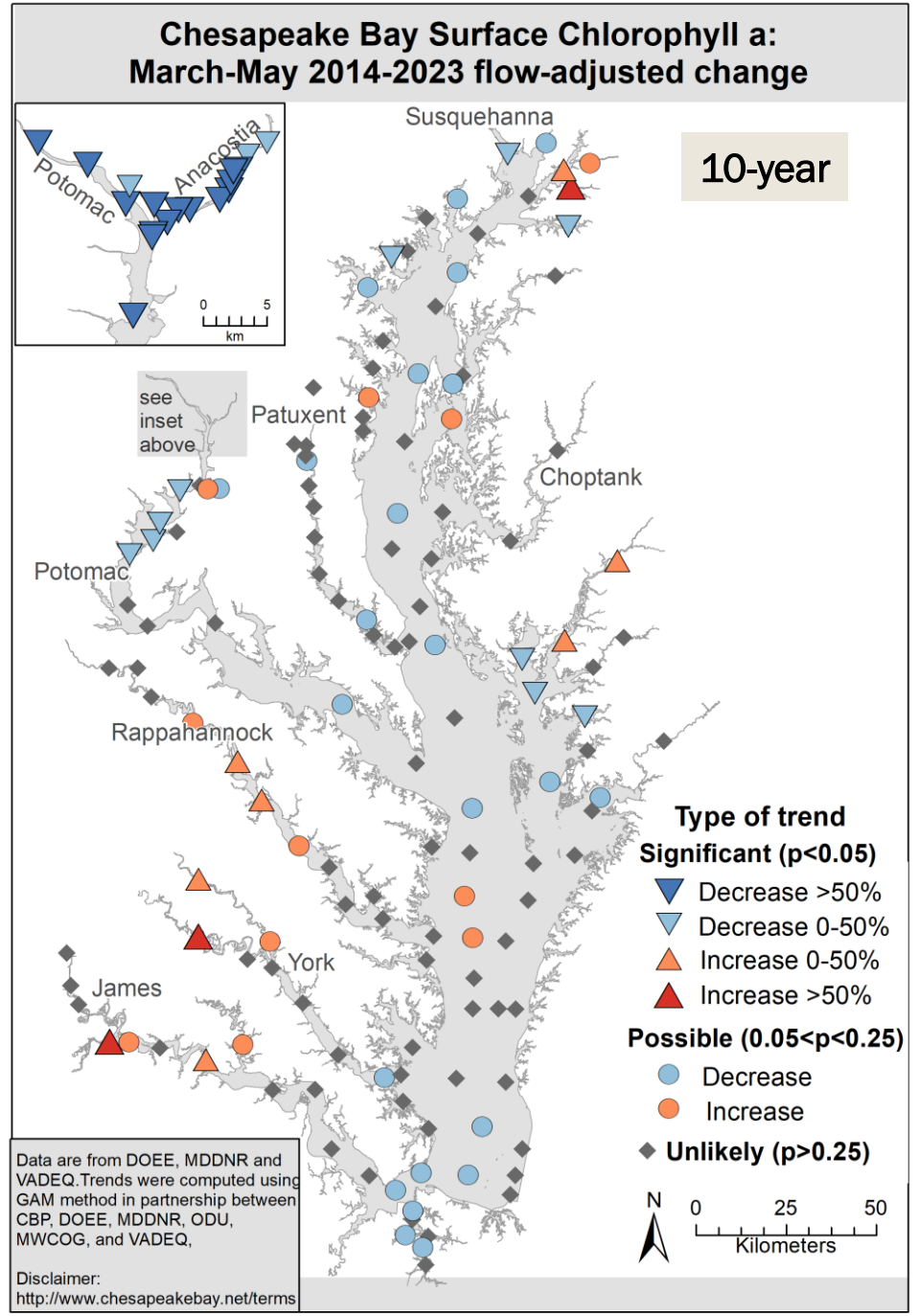


Spring Chlorophyll *a*

Surface

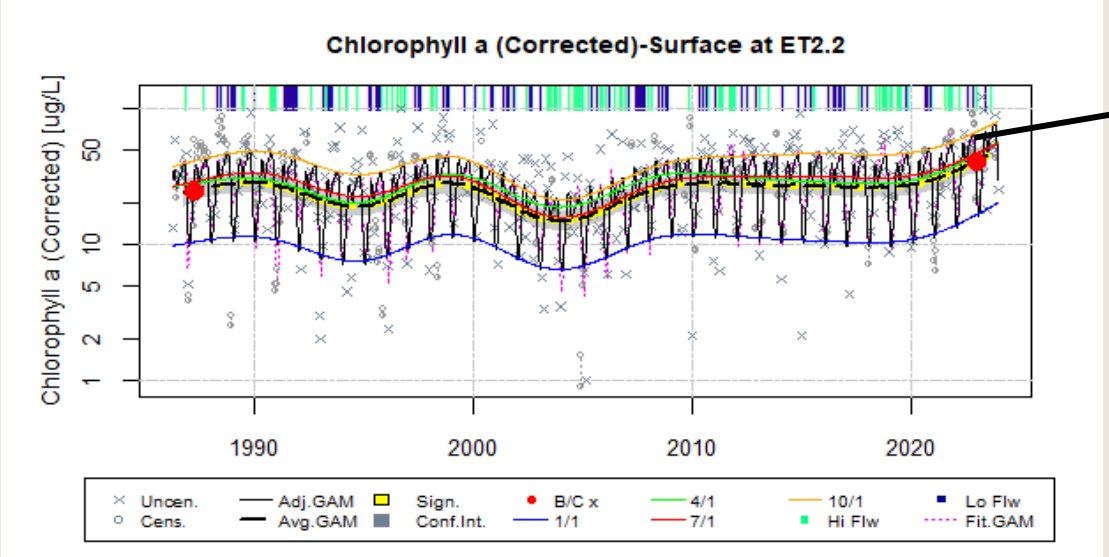
Flow-adjusted

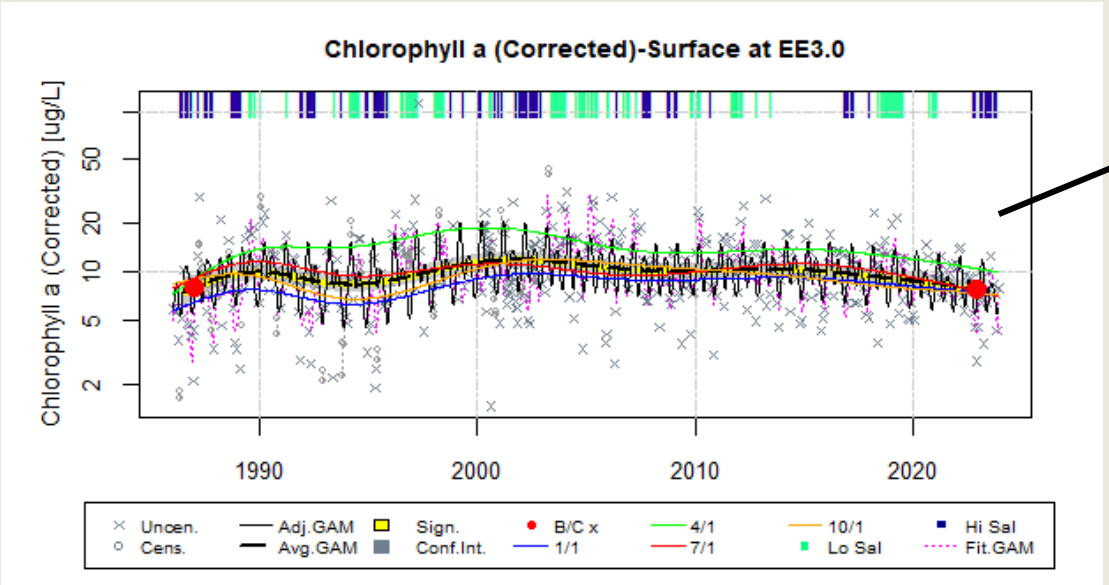


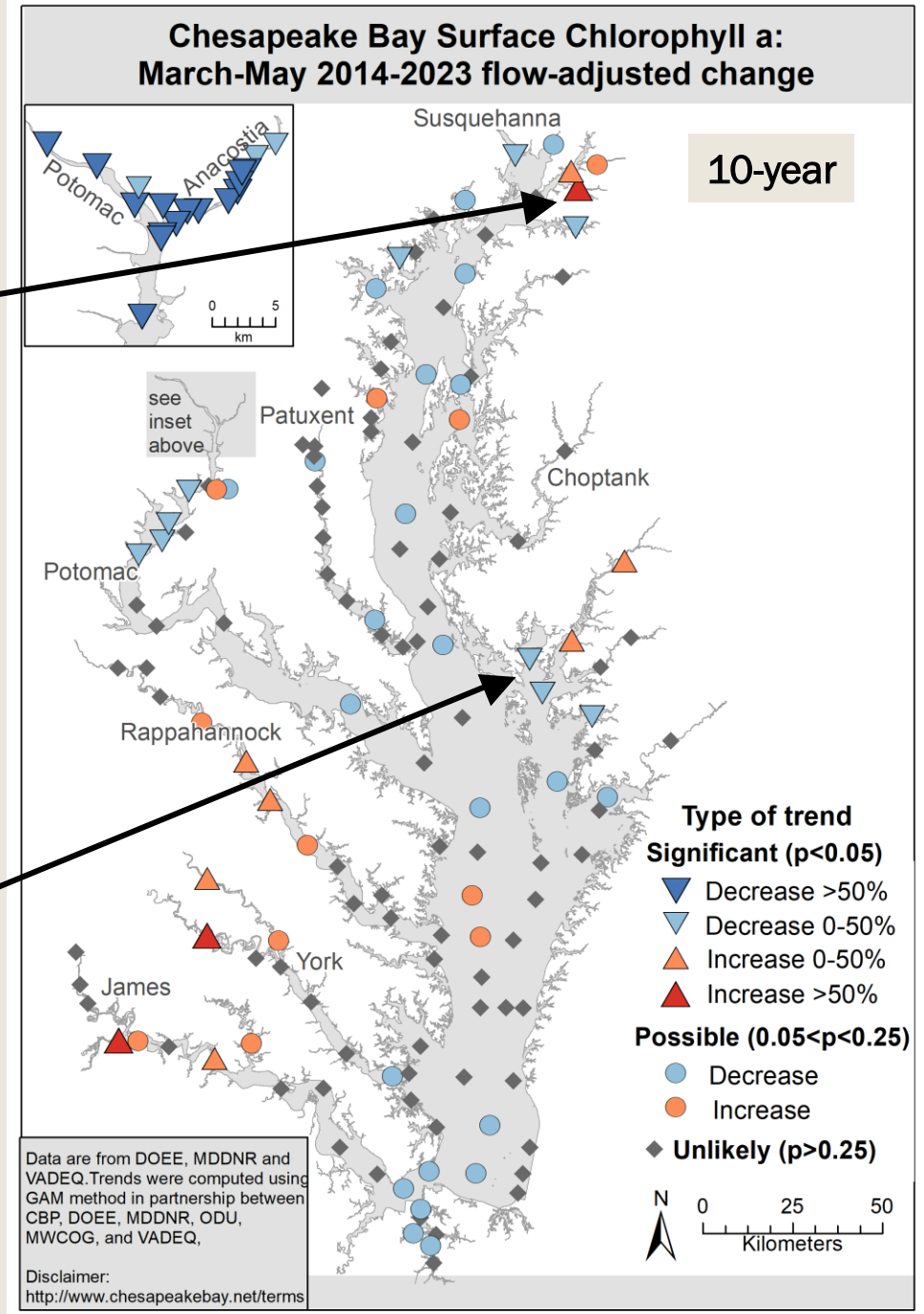


Spring Chlorophyll *a*

Surface Examples





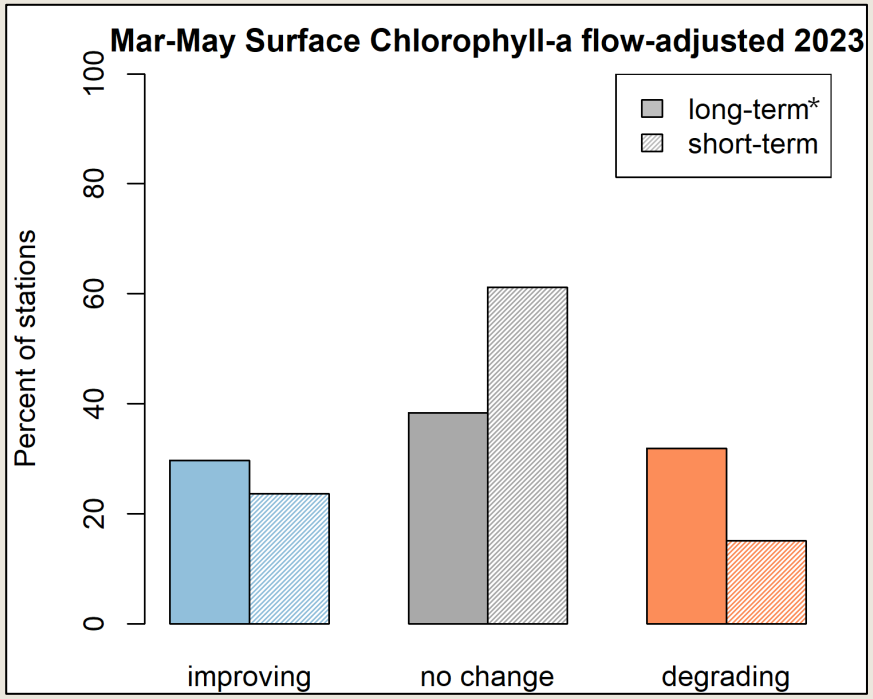


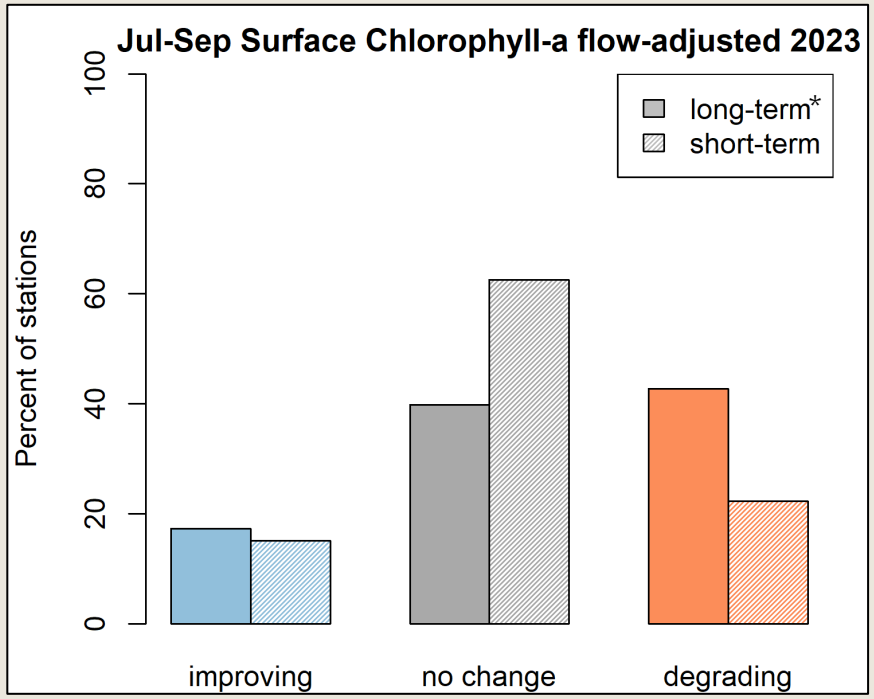
Summary

Chlorophyll *a*

Surface

Flow-adjusted





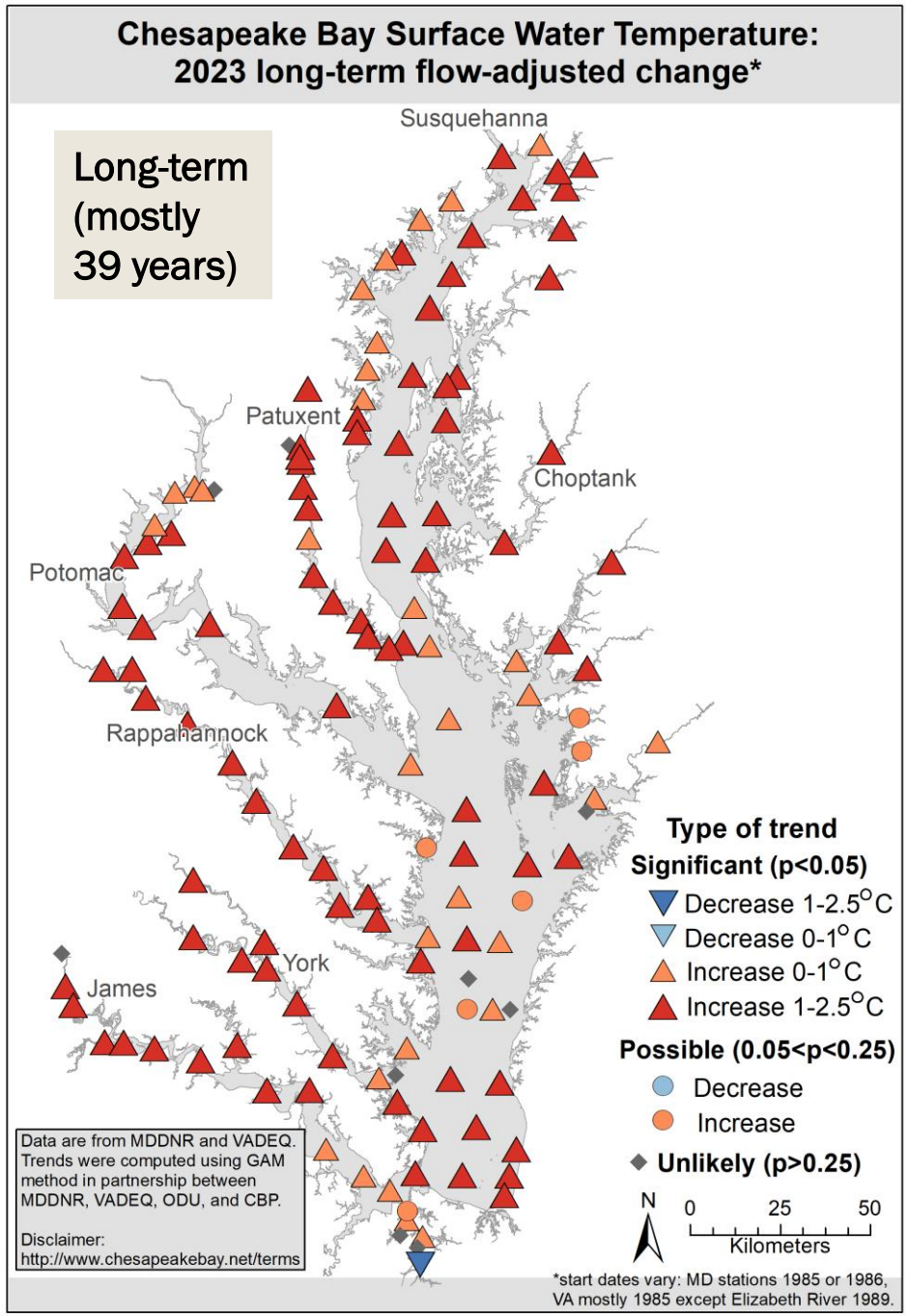
- In both seasons, this is a large mixture of trend types for chlorophyll *a*.
- There are slightly better bay-wide trends in spring than summer.

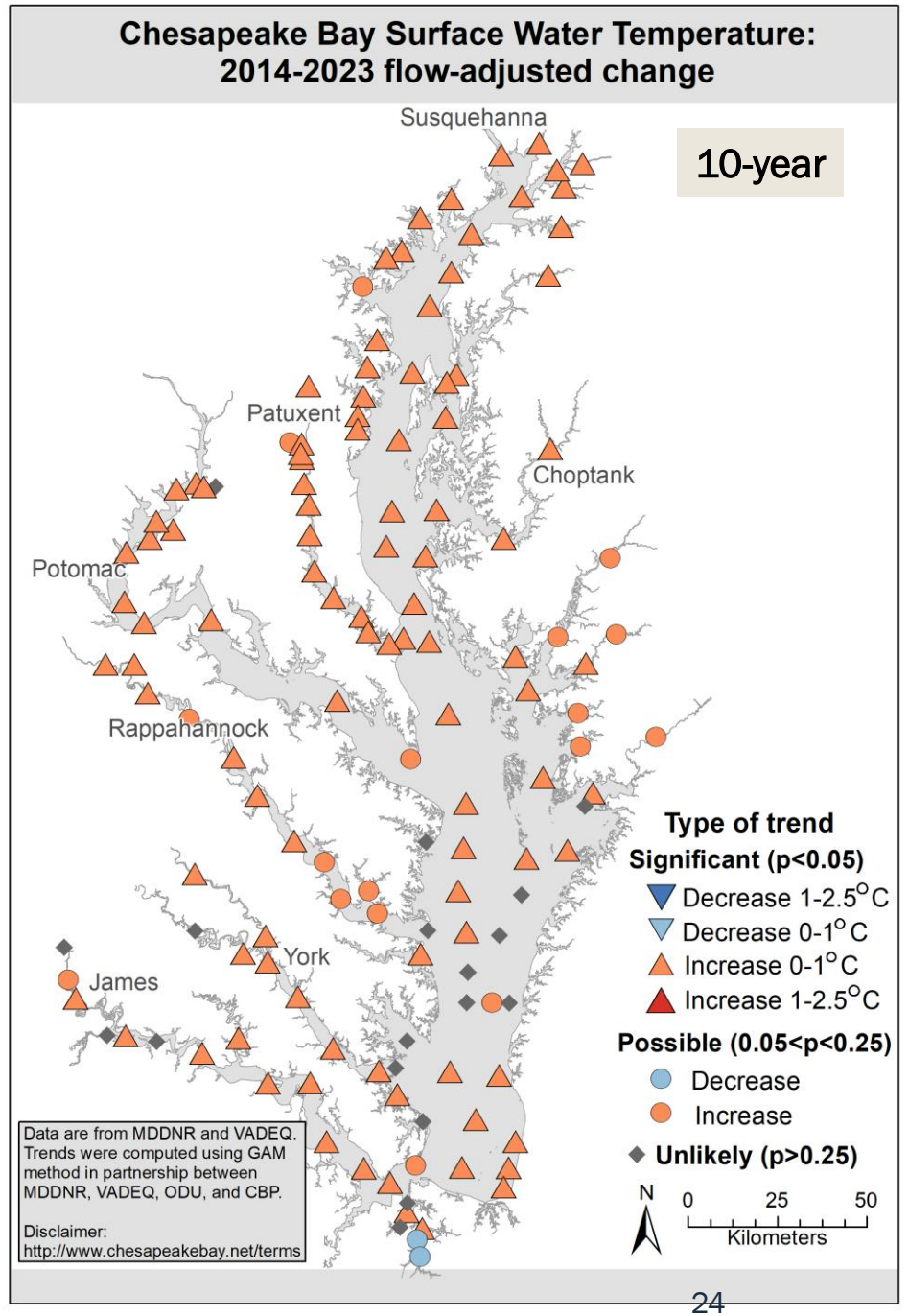
*Note: Bar charts do not include Washington D.C. stations since DC is only short-term

Water Temperature

Surface

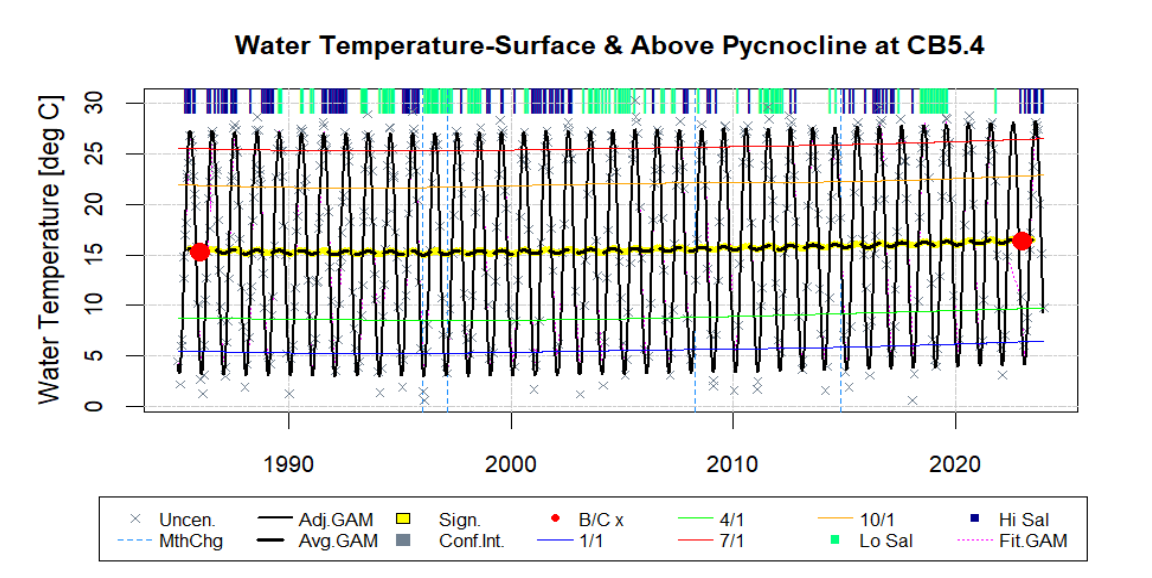
Flow-adjusted



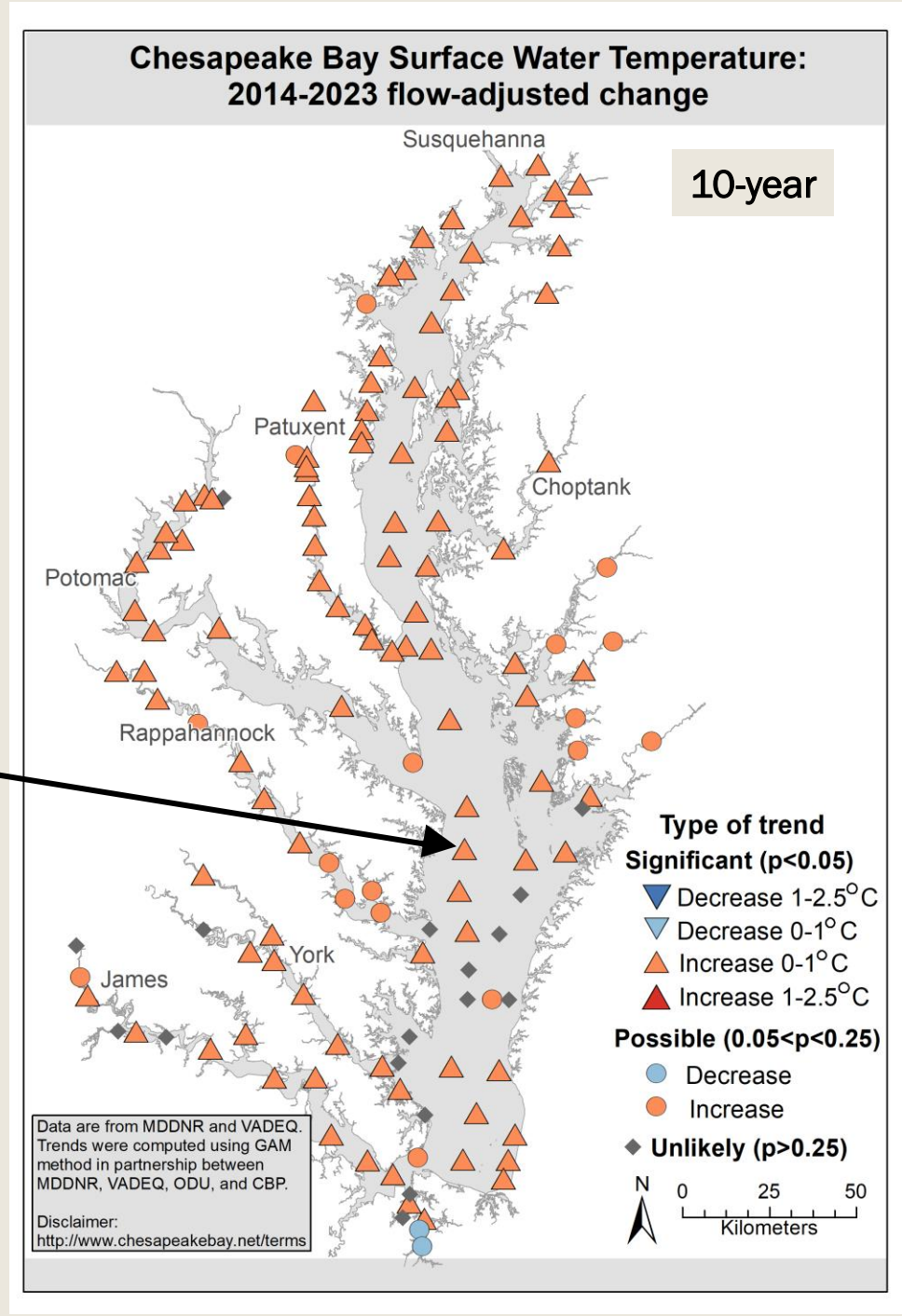


Water Temperature

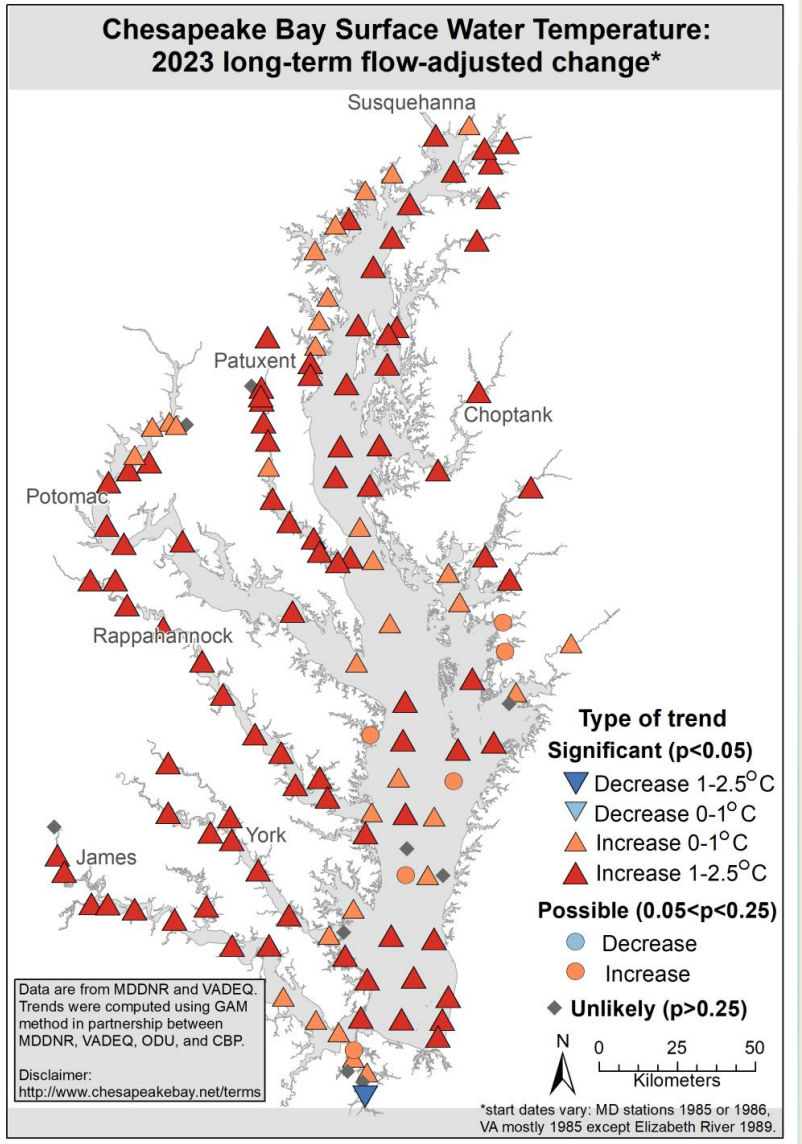
Surface Example

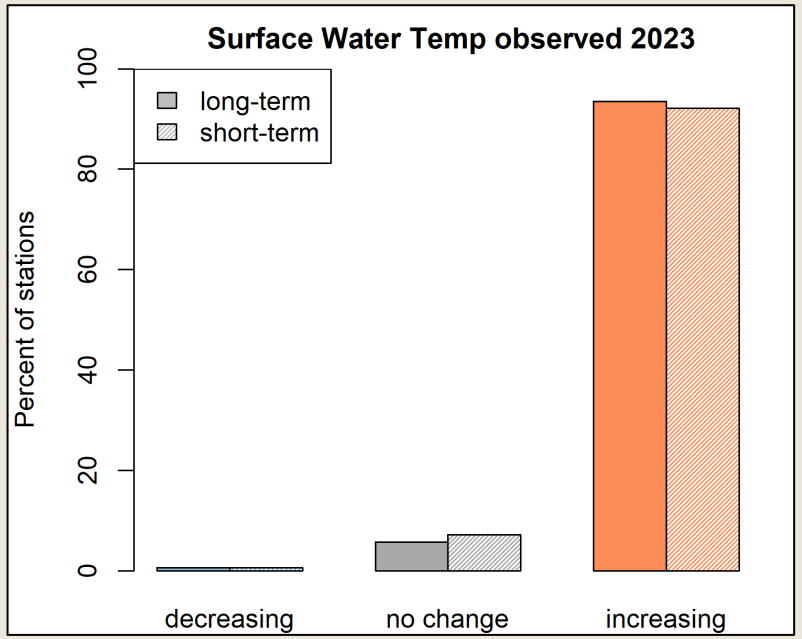


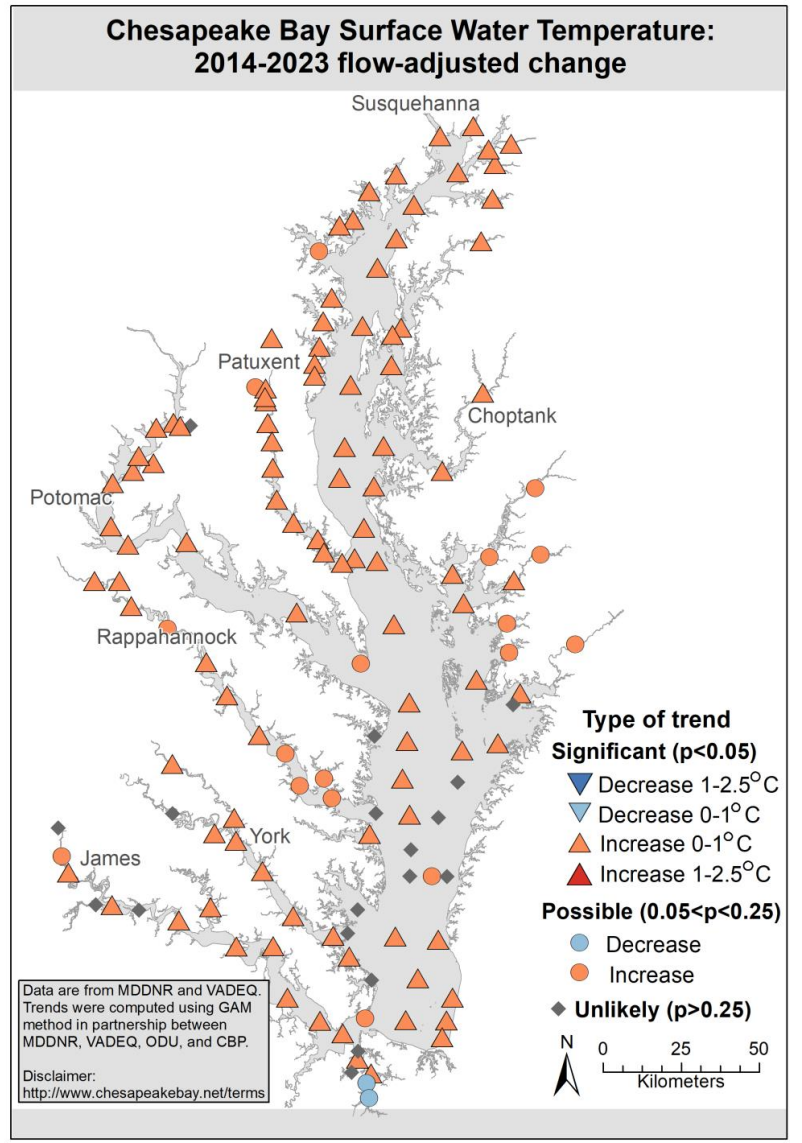
Example: Water temperature values vary a lot throughout the year, but consistently we see a mean increase.



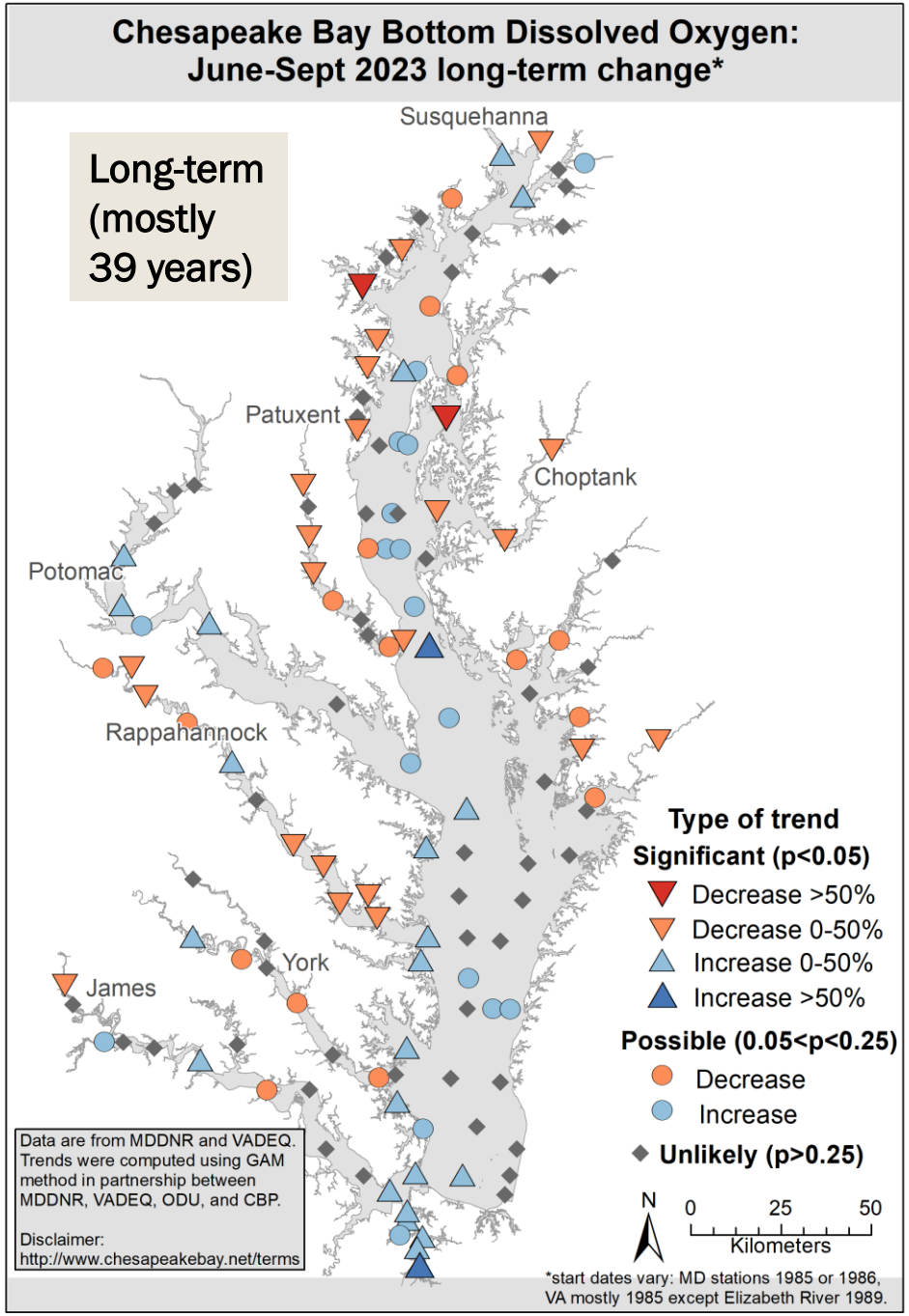
Water Temperature

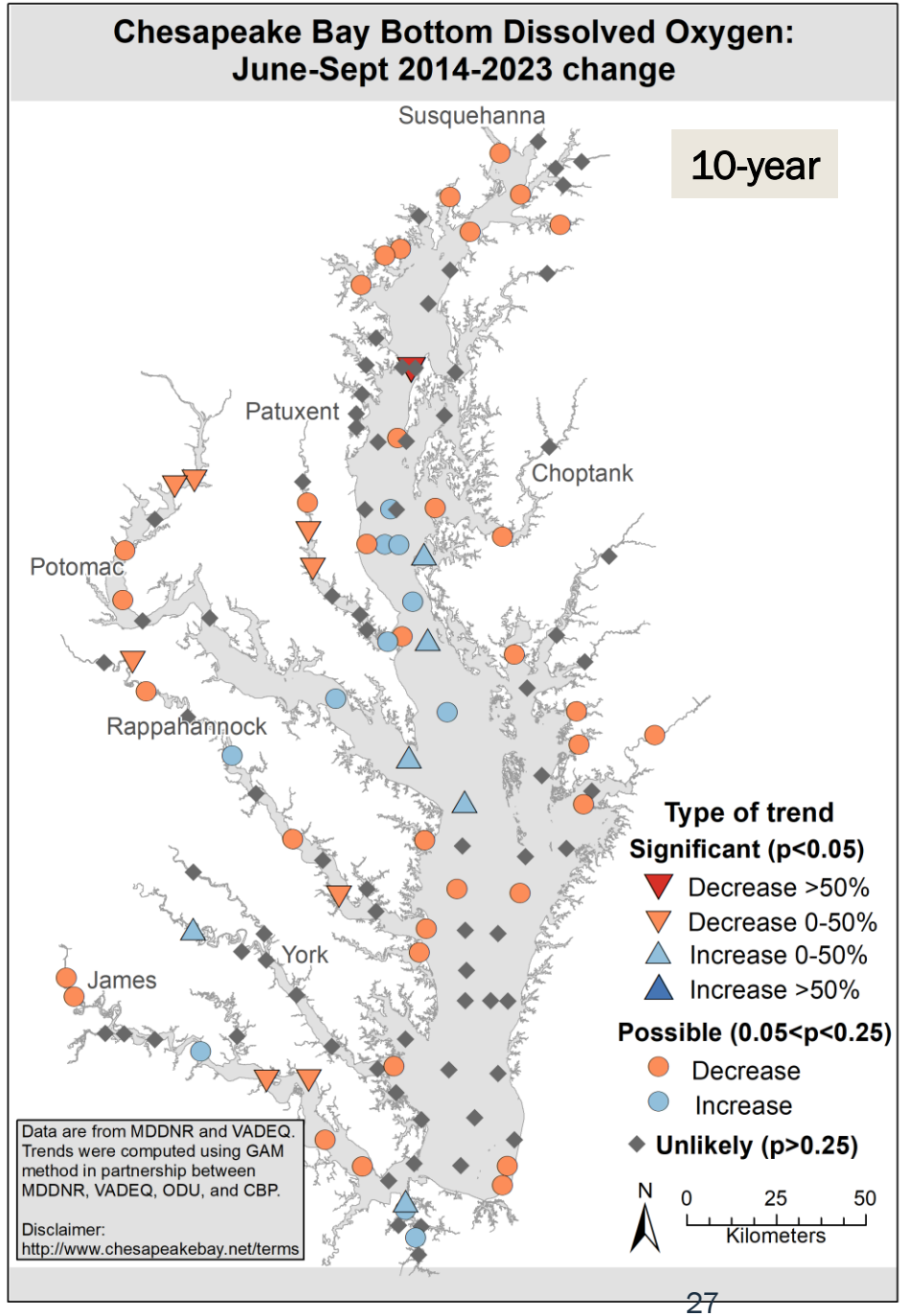




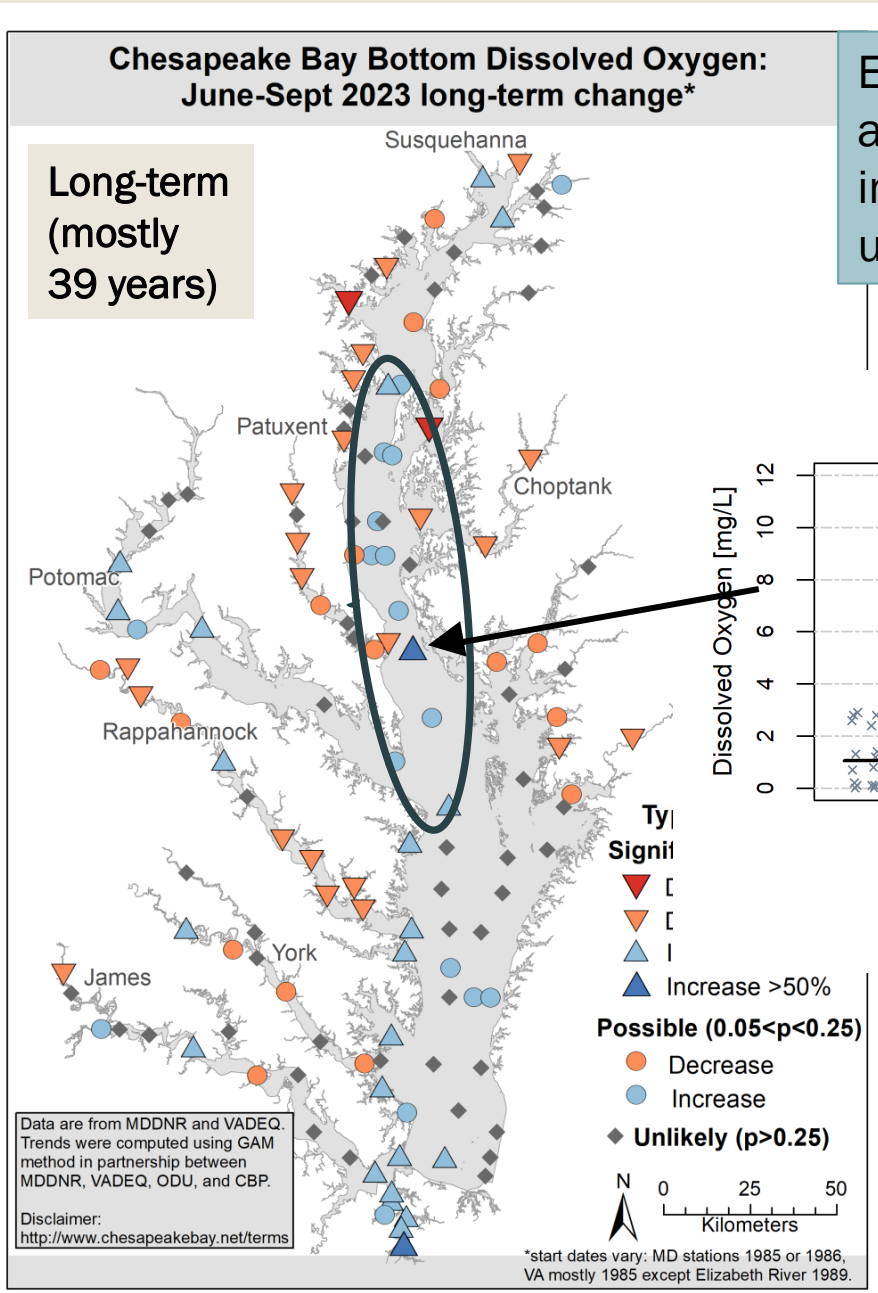


Bottom Summer DO

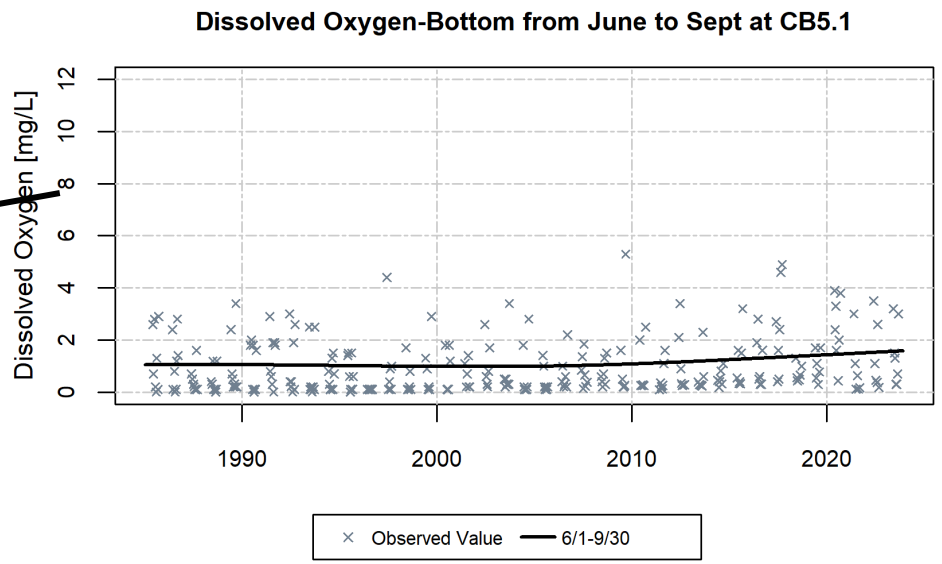


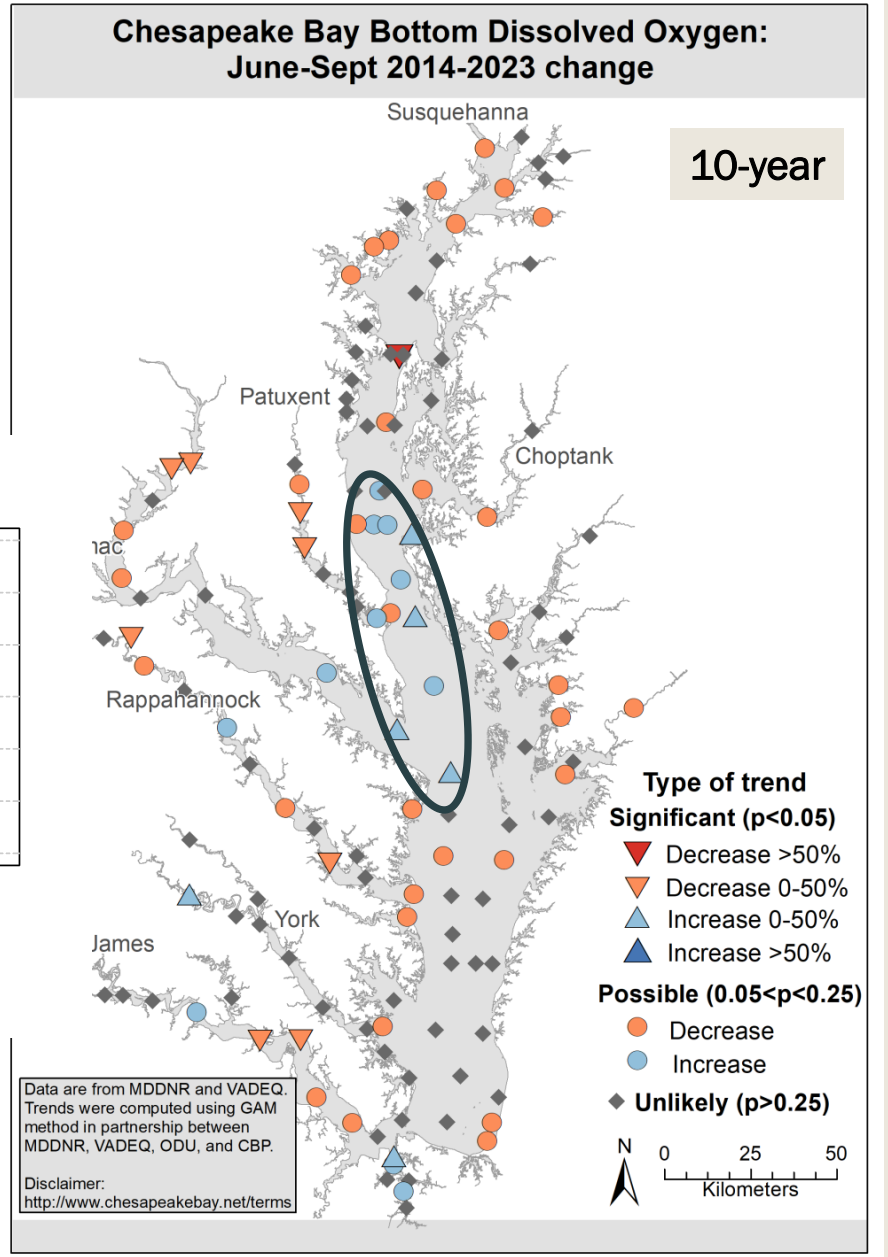


Bottom Summer DO

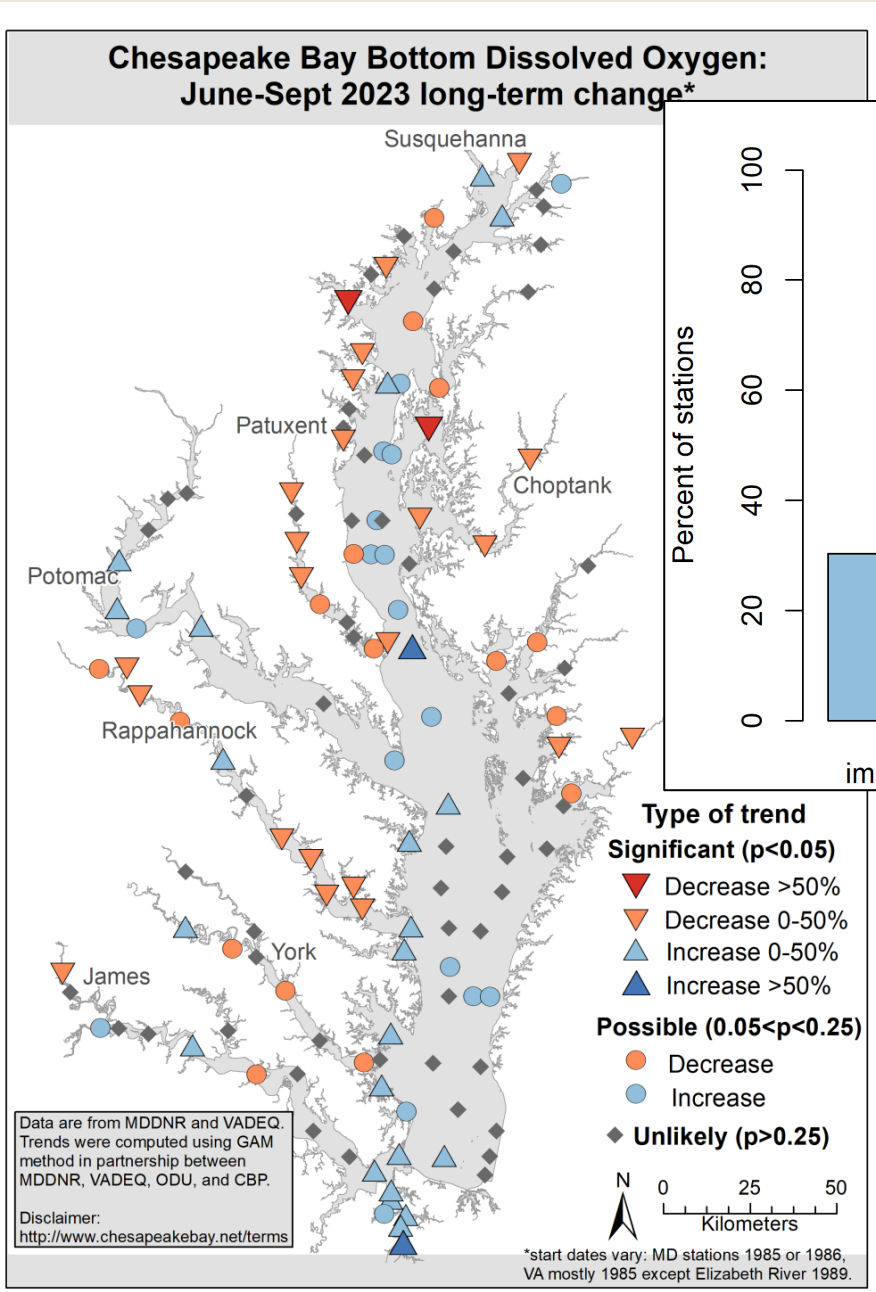


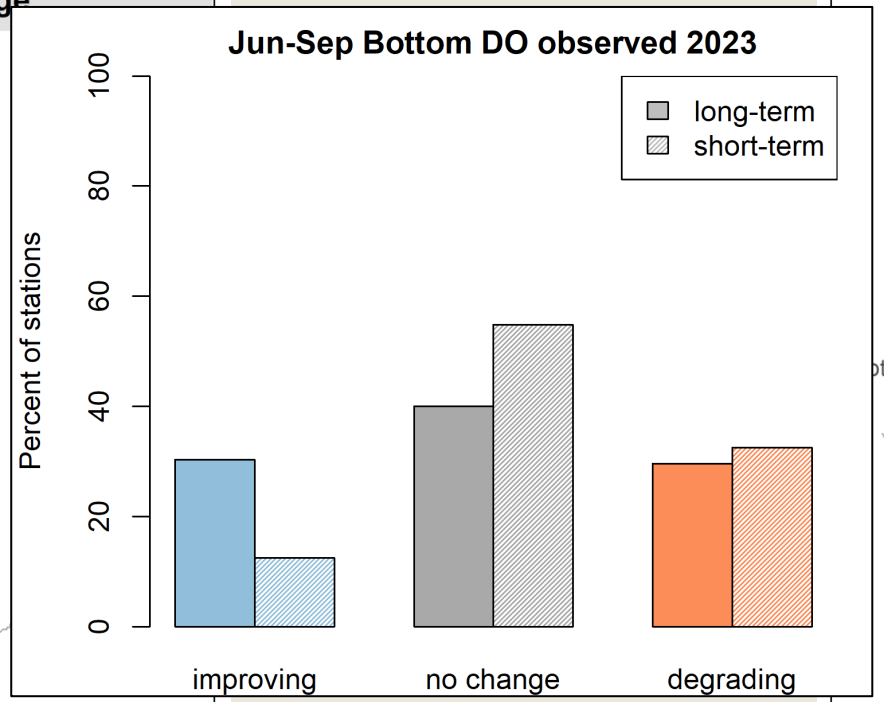
Example: Key areas in mainstem and nearby regions where increasing DO is starting to show up in the trends.

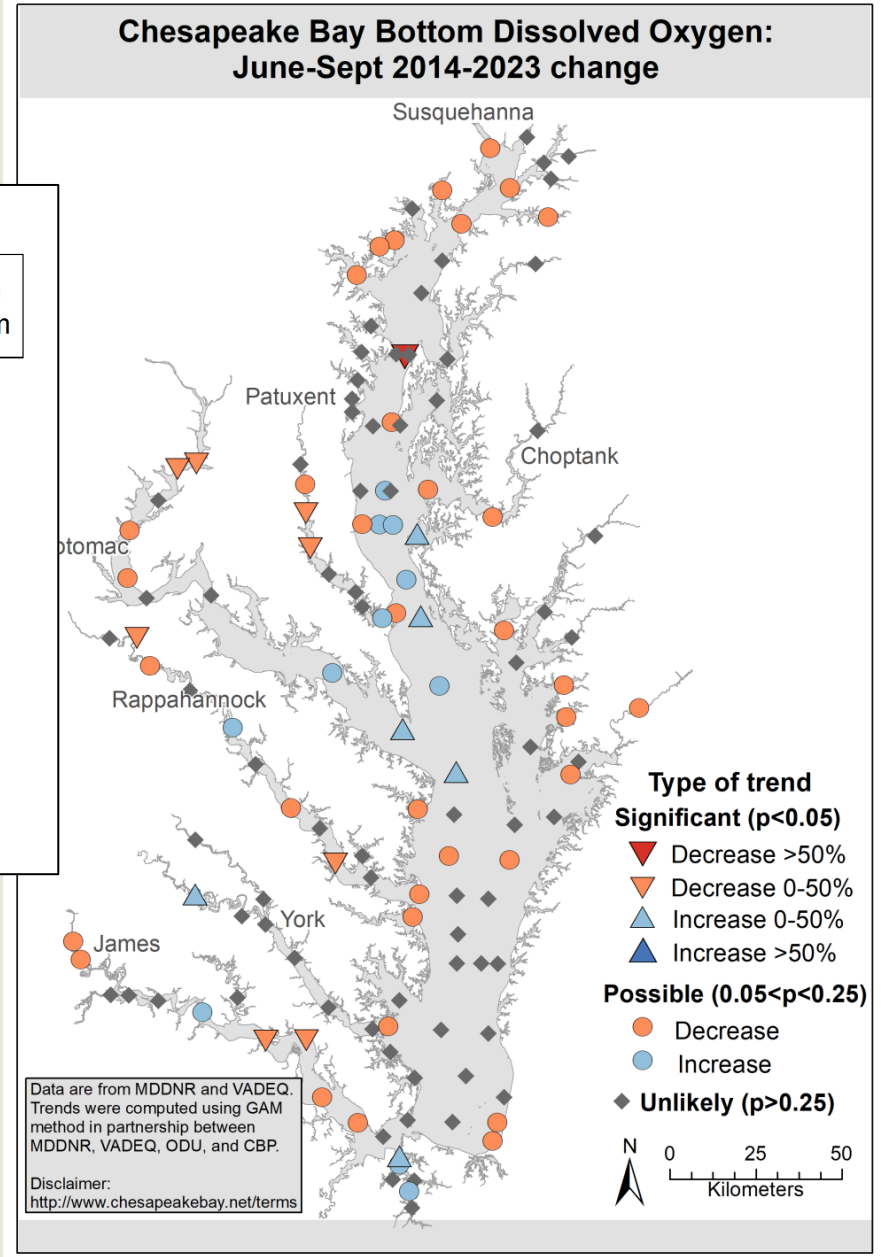




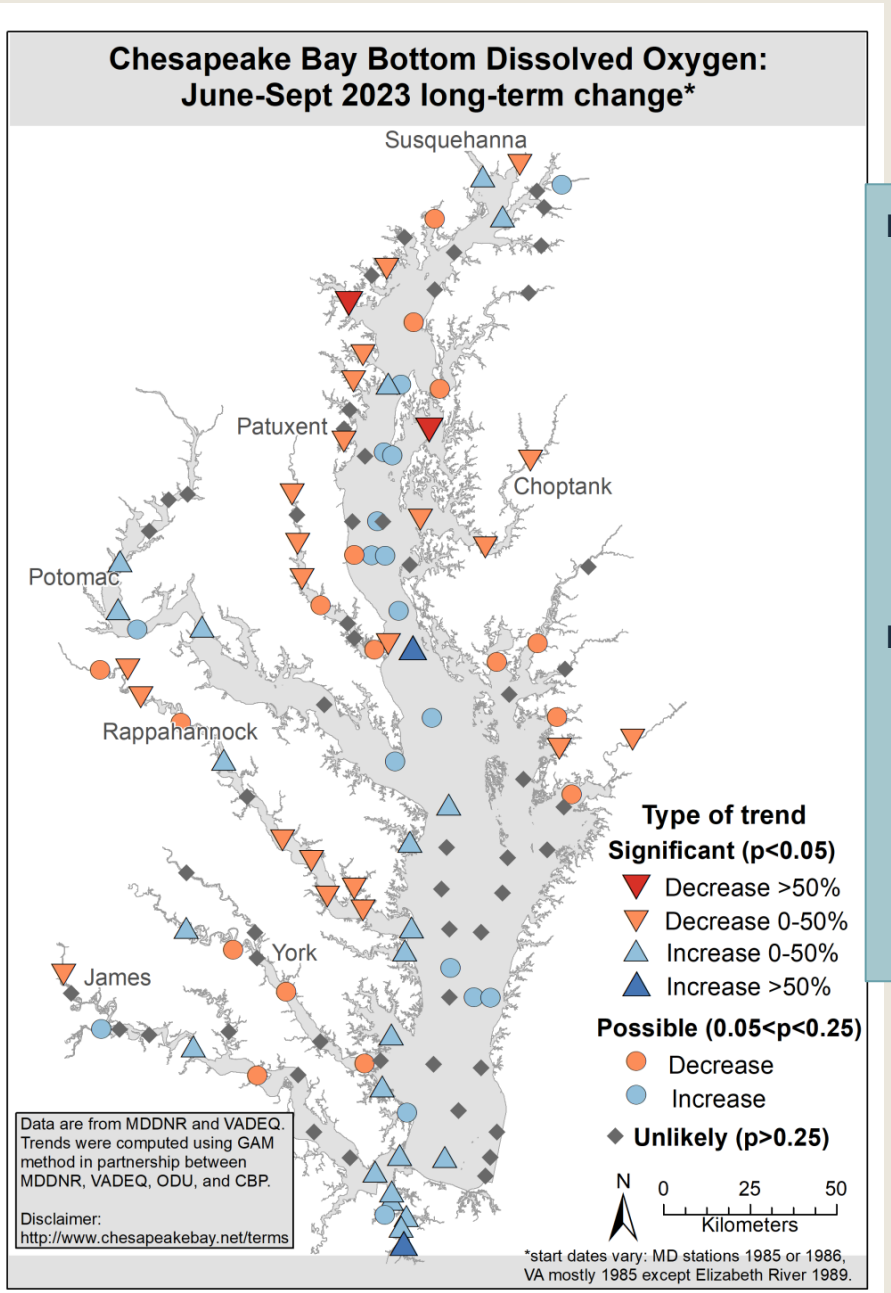
Bottom Summer DO



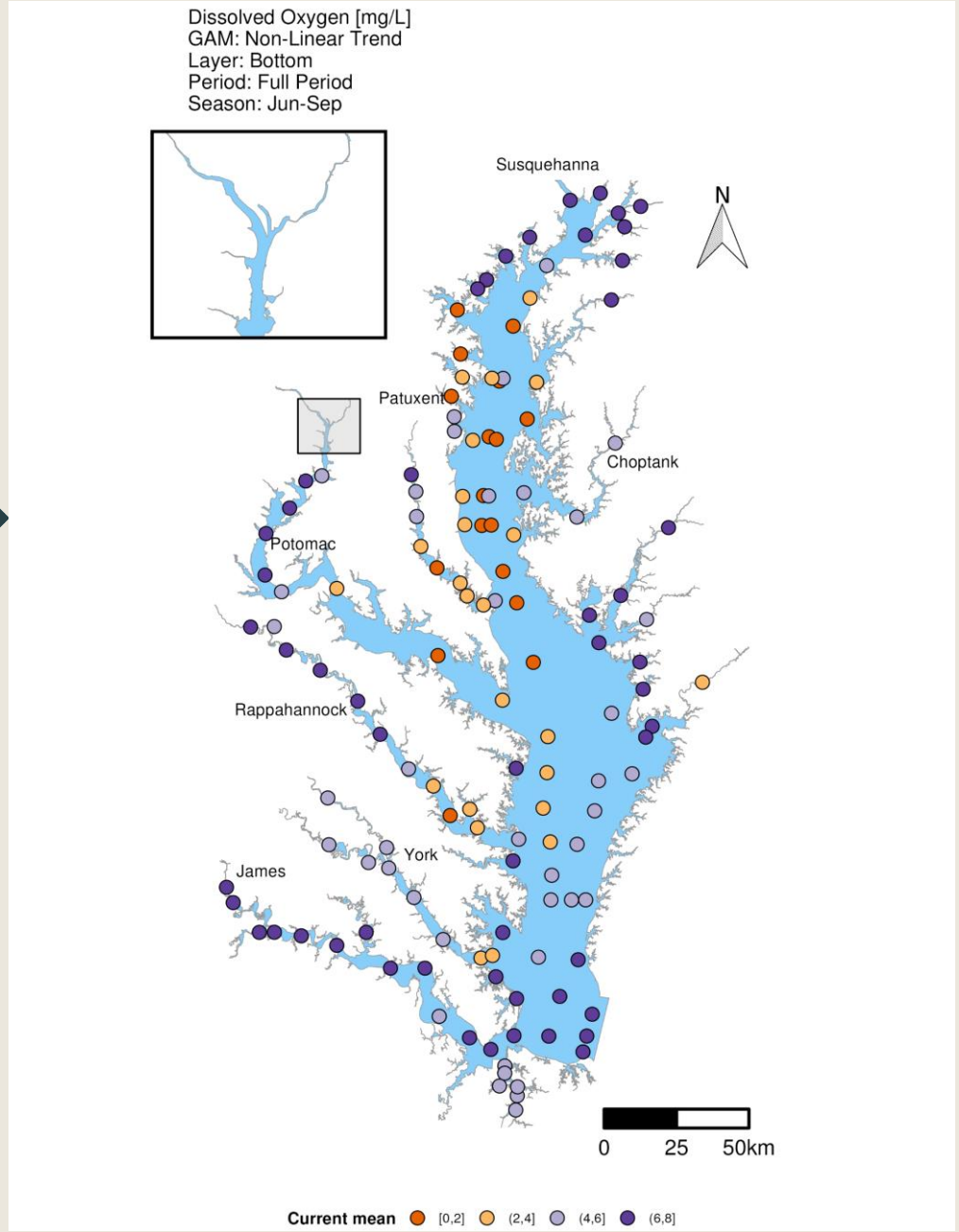




Combo conc & trend map ideas



- We have separate maps on baytrendsmap that show the recent average concentrations
- Also, MDDNR already does status & trends on their website with symbols like: ▲

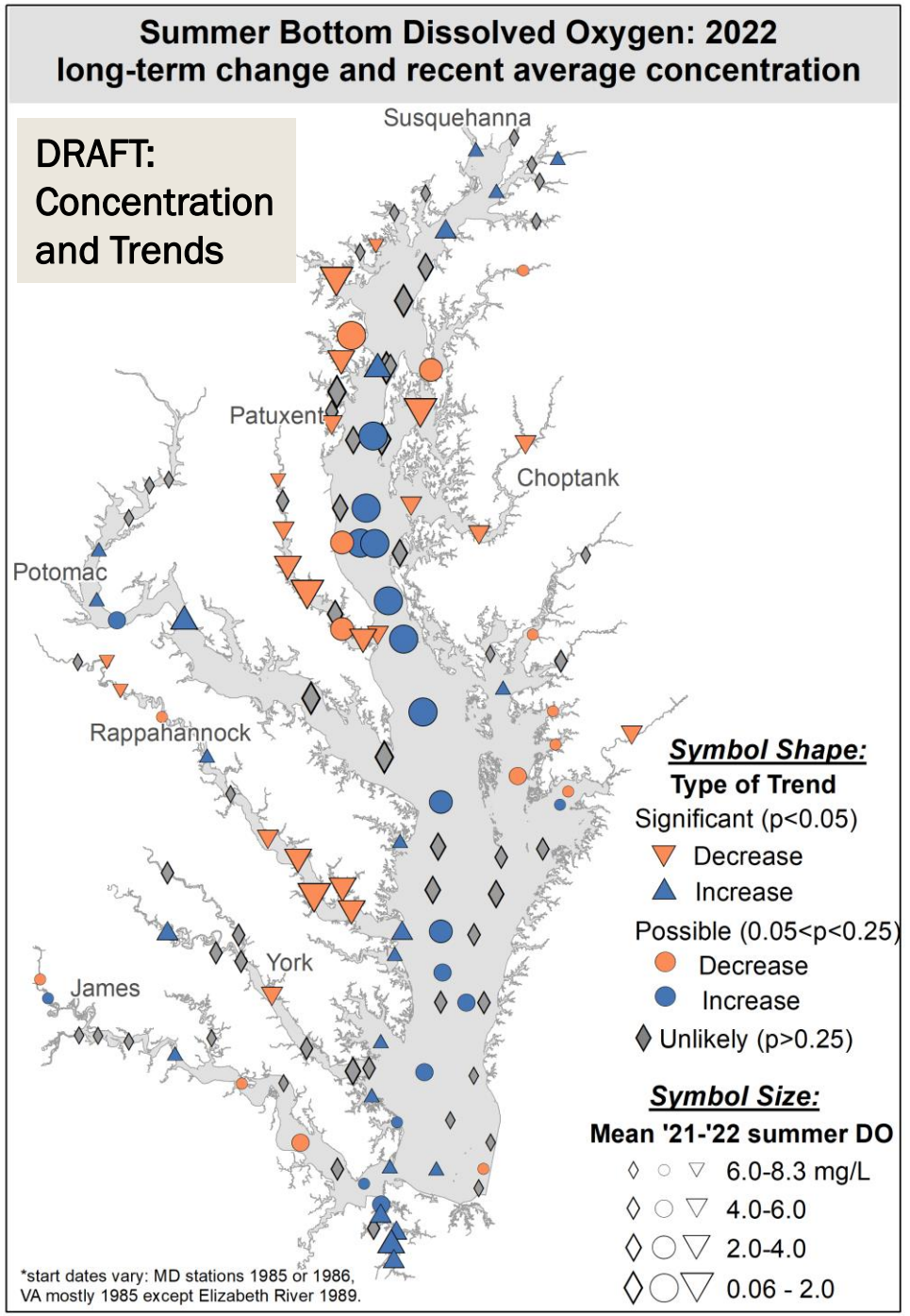


https://baytrends.chesapeakebay.net/baytrendsmap/

Combo conc & trend map ideas

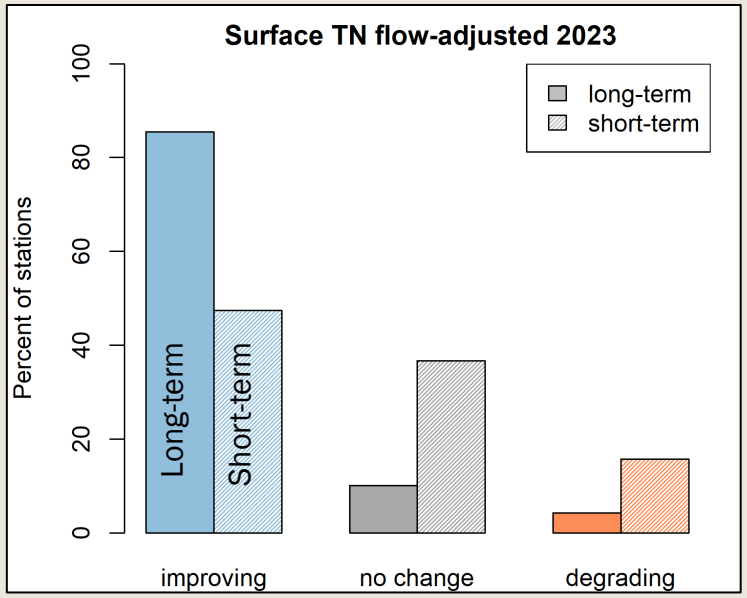
Note: this is from last year, for 2022

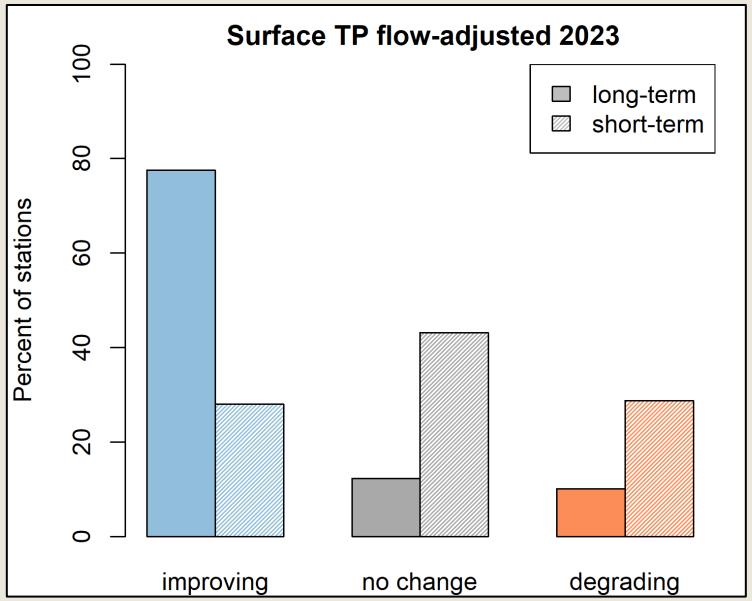
- One baywide idea: Scale size of symbols by average 2021-2022 concentration
- For DO, larger symbols are smaller summer bottom DO

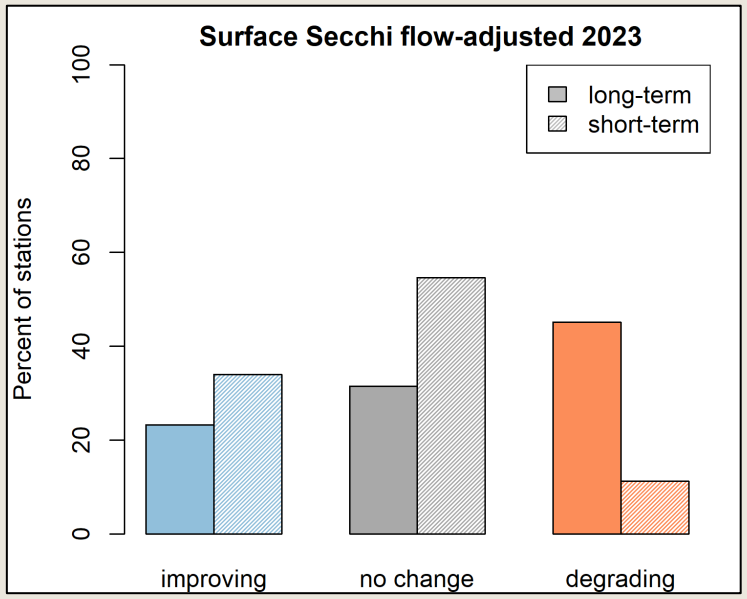


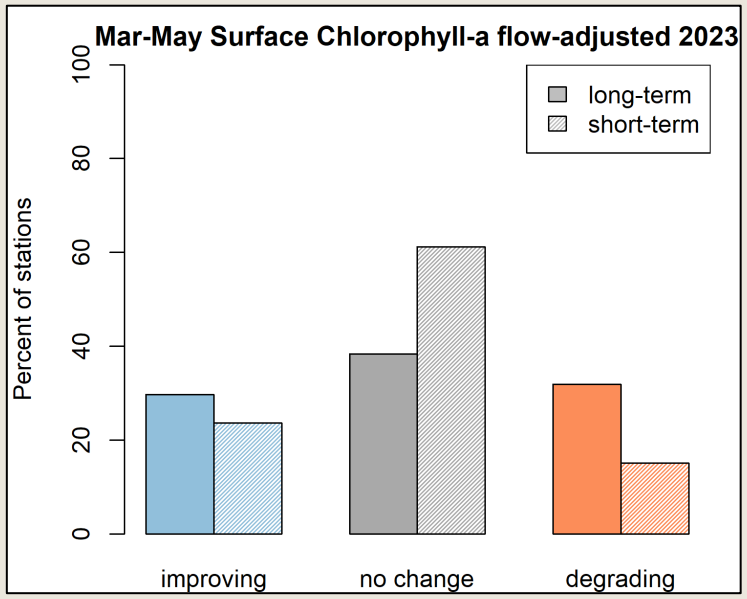
2023 Summary

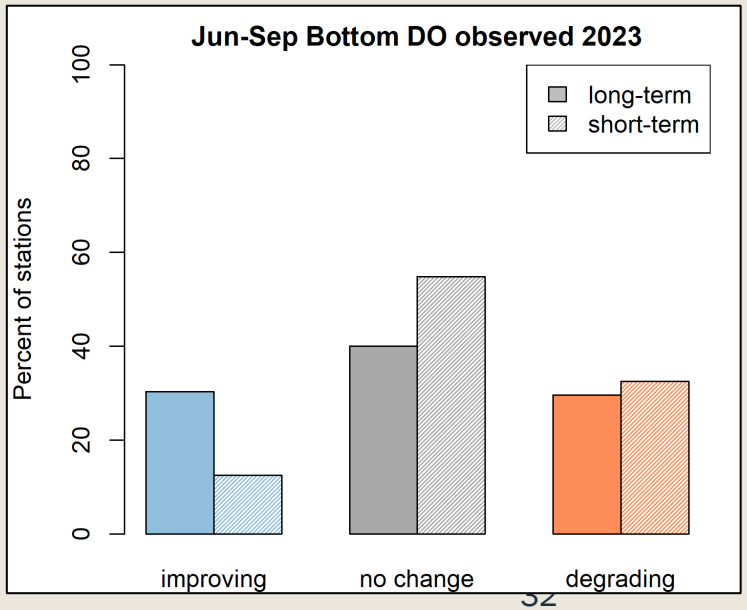
- Nutrient trends mostly improving over the long-term with some leveling-out over the short-term.
- The number of stations with degrading conditions have decreased over the short-term for Secchi and chlorophyll *a,* while DO has different patterns in deeper vs. tributary waters.
- Overall patterns consistent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











Acknowledgements

- Contributing to this year's results:
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  - *Efeturi Oghenekaro, Blessing Edje and George Onyullo (DOEE); Mukhtar Ibrahim (MWCOG);*
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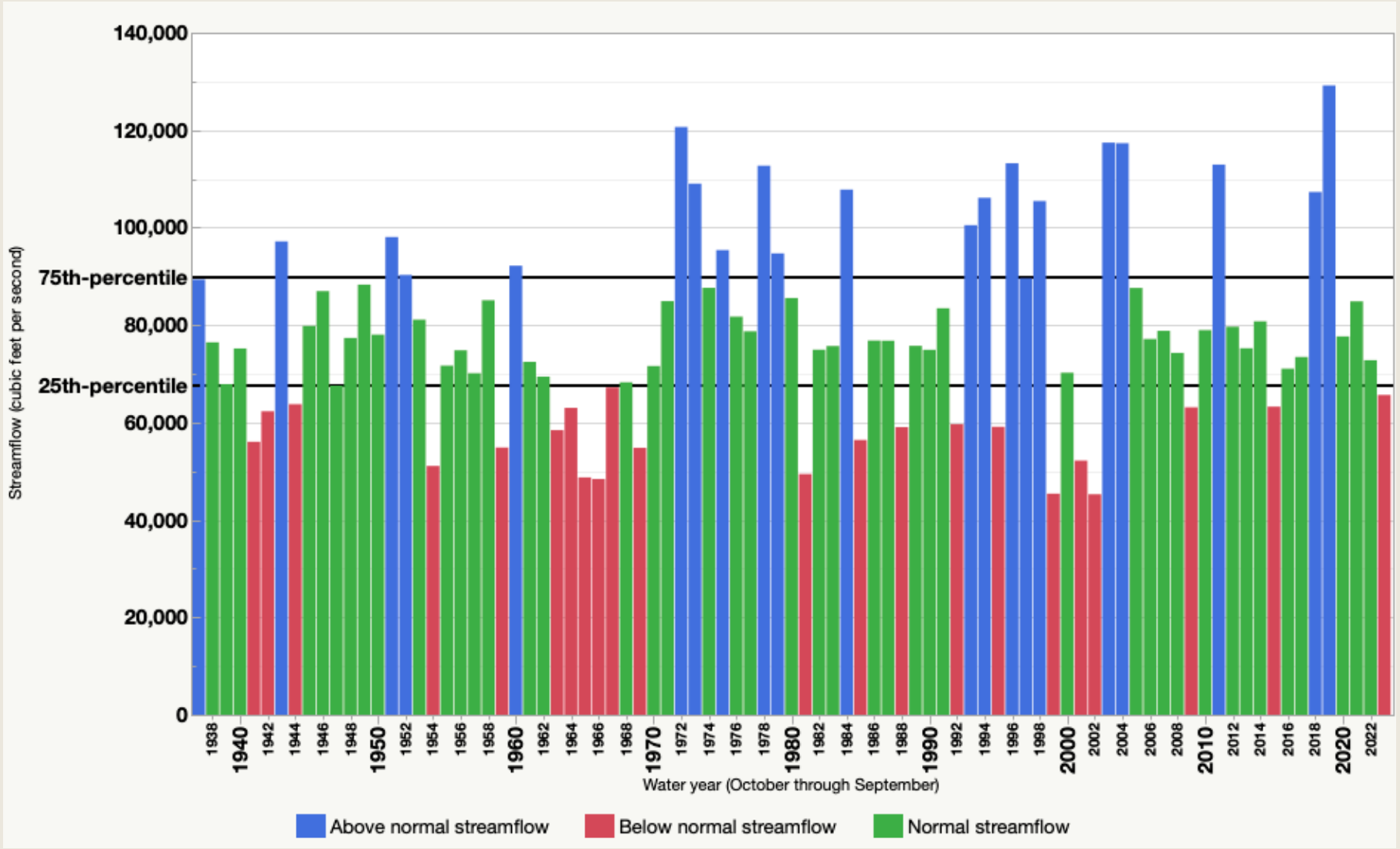
- Baytrends and baytrendsmap maintenance: Jon Harcum and Erik Leppo (Tetra Tech)
- Thanks to the CAST and CBP support (Olivia Devereaux, Helen Golimowski, Mike Mallonee, and John Massey).
- And no trends are possible without data collection from DOEE, MDDNR, and VADEQ teams!

More info on GAM approach development and the R package:

- 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

extras

Total monitored flow into tidal waters



← 2022 in the normal range, 2023 slightly below normal

https://www.usgs.gov/media/images/estimated-annual-mean-streamflow-entering-chesapeake-bay