2022 Tidal Trends Summary

Rebecca Murphy (UMCES/CBP)

ITAT meeting, Oct. 25, 2023

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)

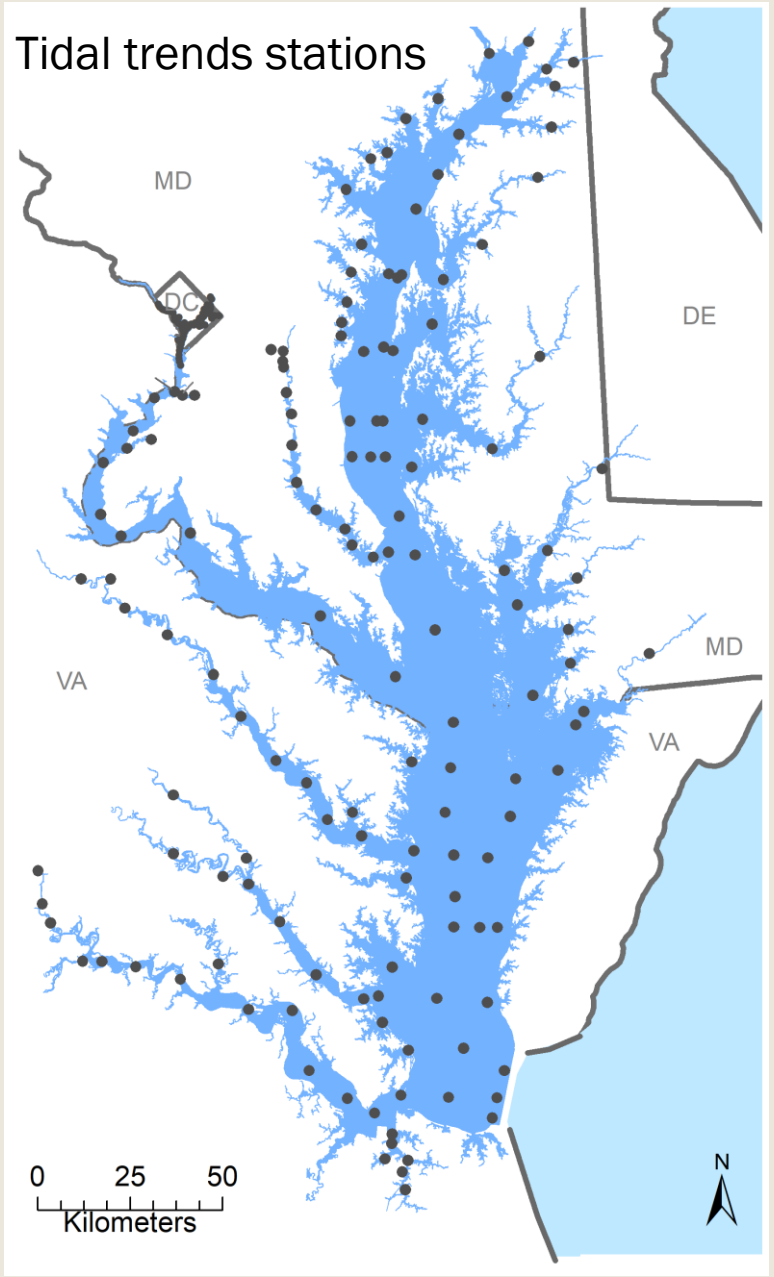
Data from: *DOEE, MDDNR, and VADEQ*

2022 Results

- Long-term (1980s-2022) and short-term (2013-2022) change:
  - *Total Nitrogen (TN)*
  - *Total Phosphorus (TP)*
  - *Water temperature*
  - *Secchi depth*
  - *Chlorophyll a*
  - *Dissolved Oxygen (DO)*
  - *Salinity*

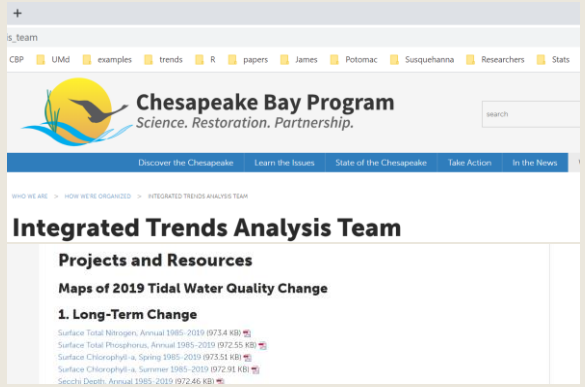
- 1999-2022 and short-term (2013-2022) change:
  - *Total Suspended Solids (TSS)*
  - *Dissolved Inorganic Nitrogen (DIN)*
  - *Orthophosphate (PO4)*

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



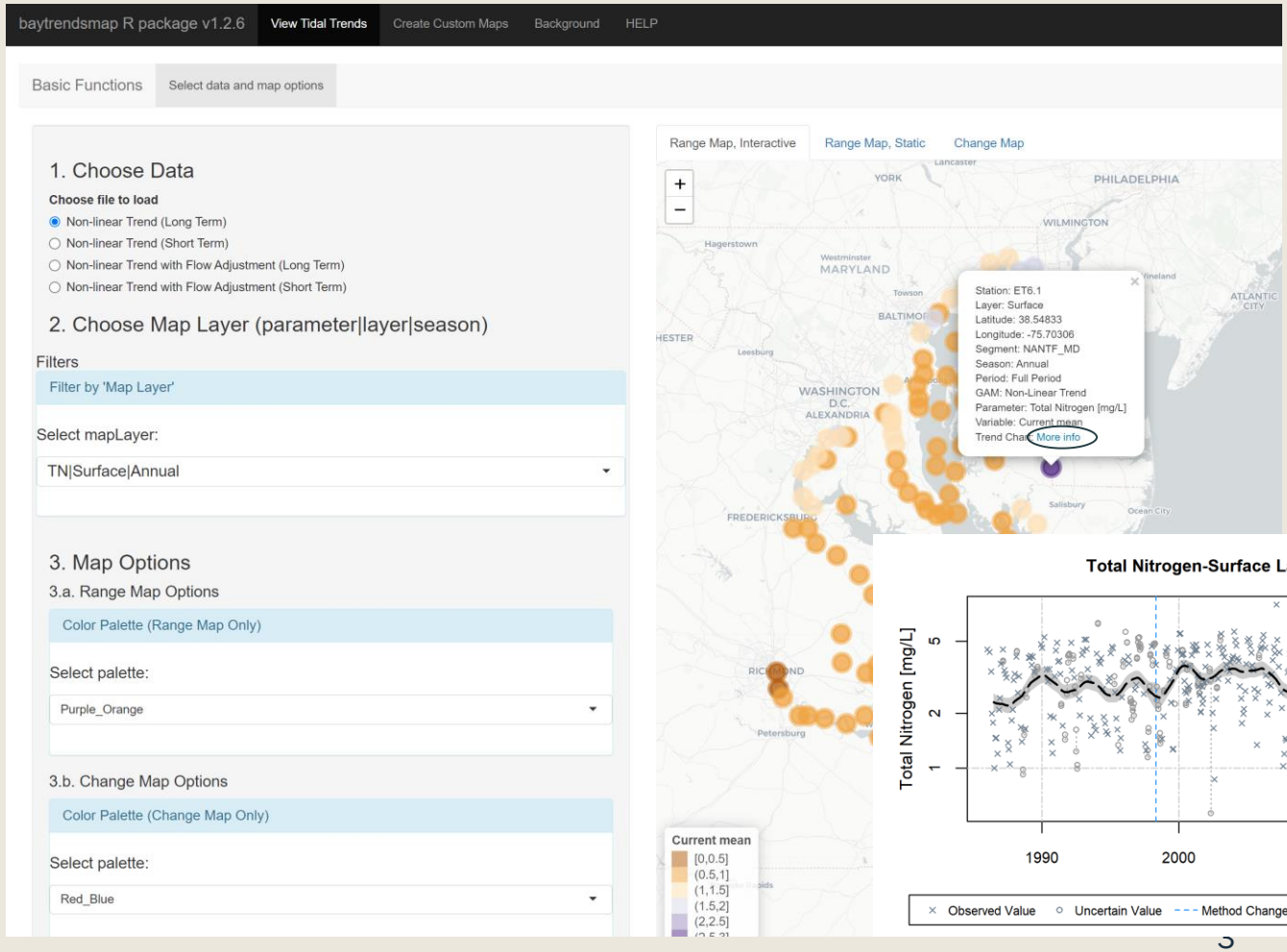
2022 Results

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



Thanks to Alex Gunnerson

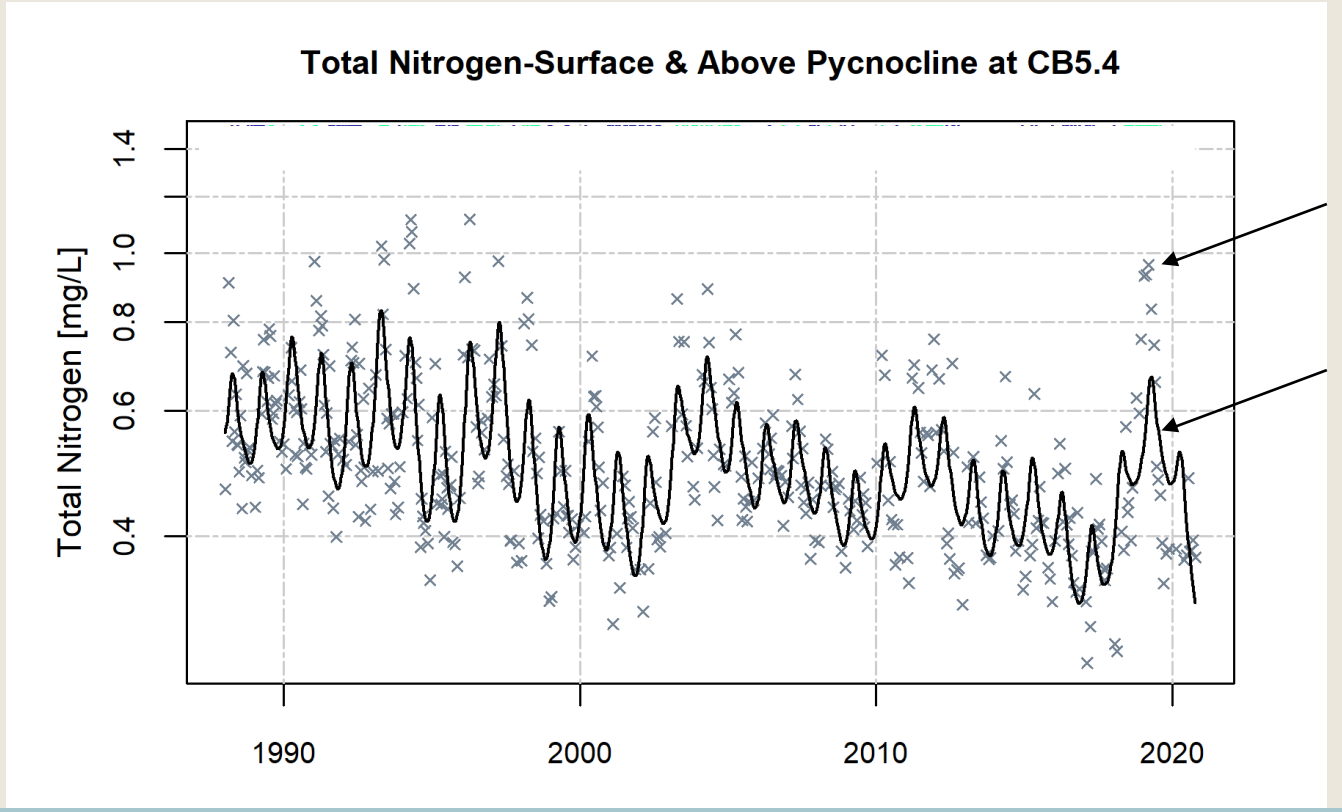
Baytrendsmap :
https://baytrends.chesapeakebay.net/baytrendsmap/



Thanks to Erik Leppo, John Massey, and CAST team

Generalized Additive Model (GAM) method review

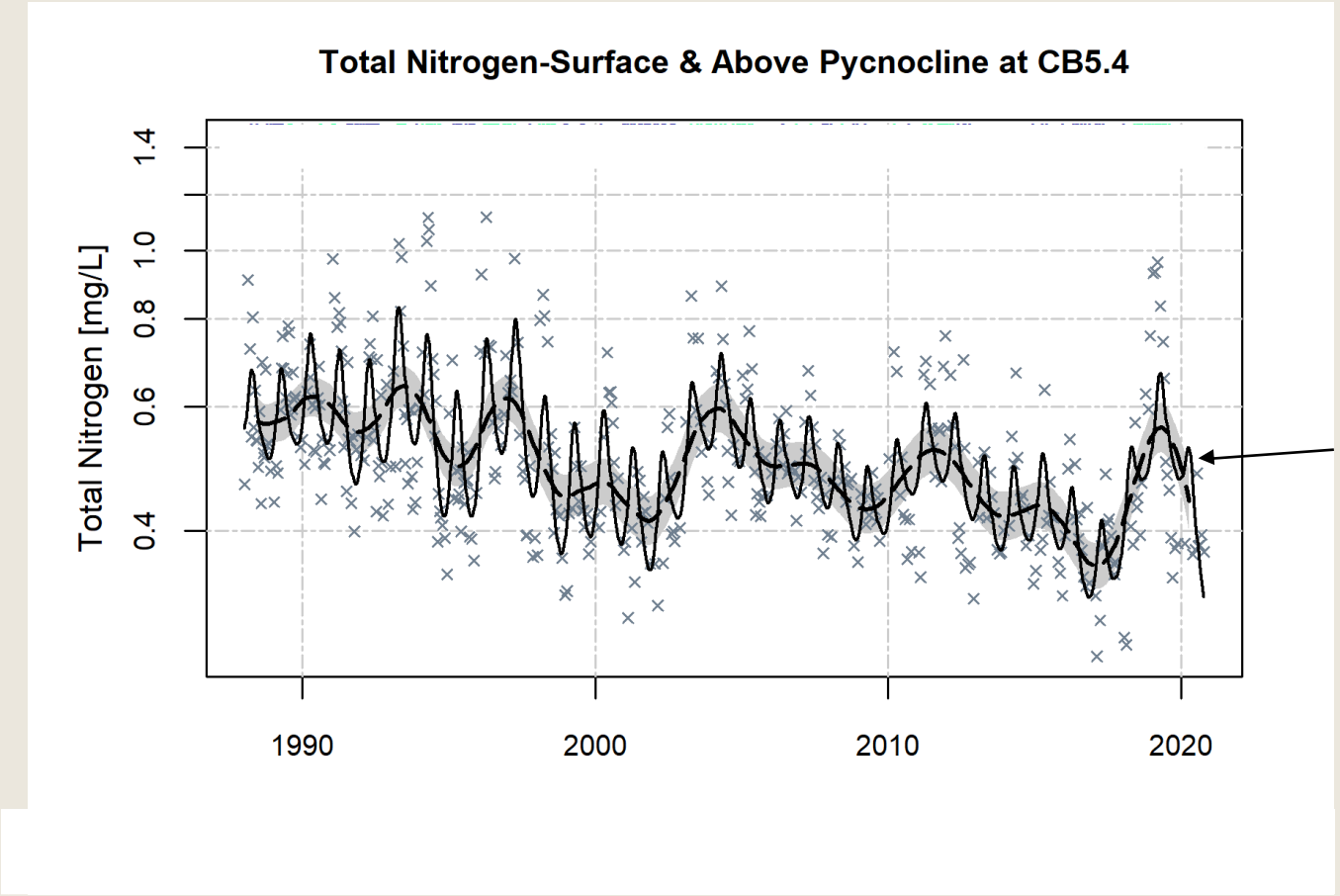
TN = s(doy) + s(date)+ interaction(doy,date)



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

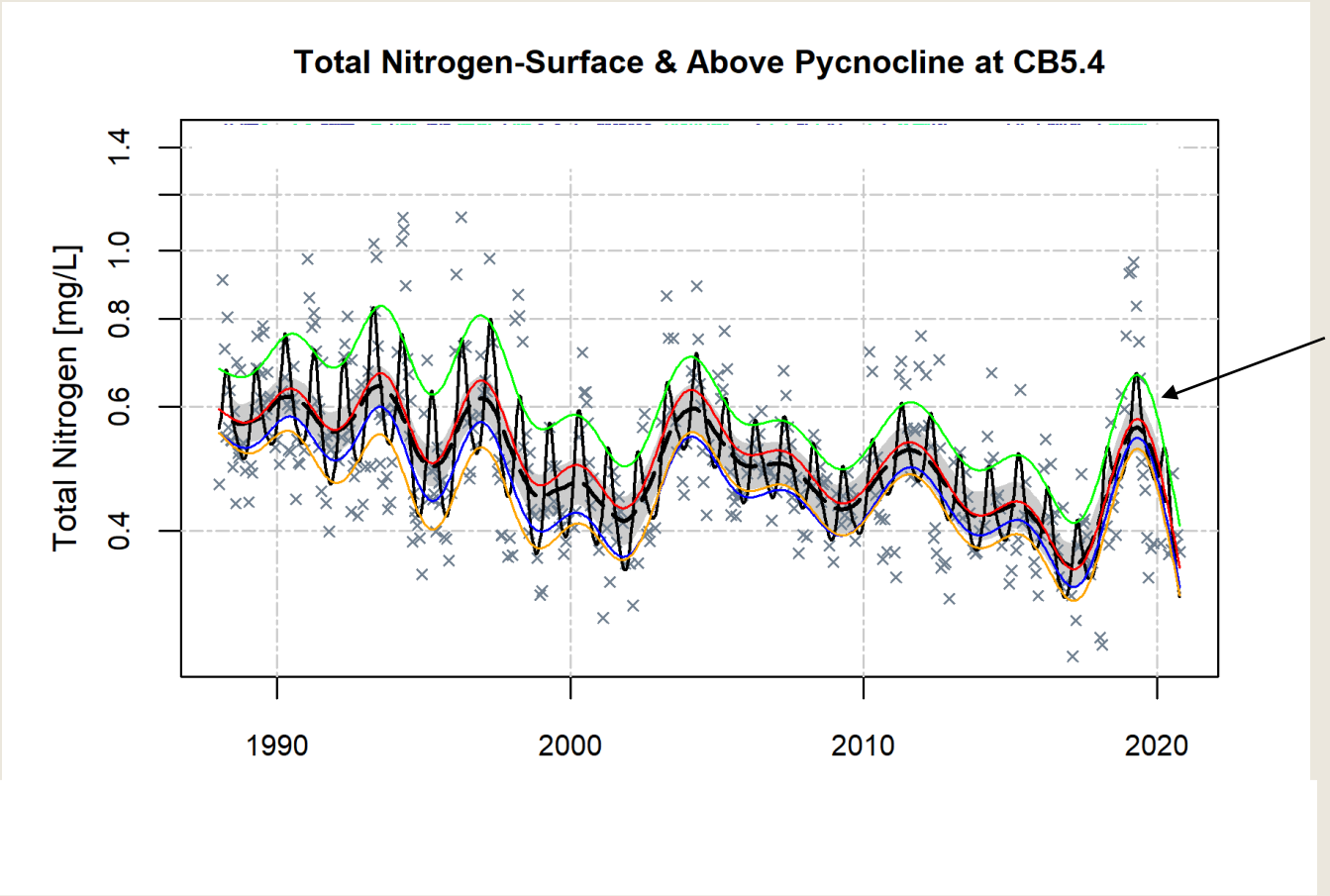
TN = s(doy) + s(date)+ interaction(doy,date)



Seasonal mean and 95% confidence interval on the mean

Tidal Trends/GAM method review

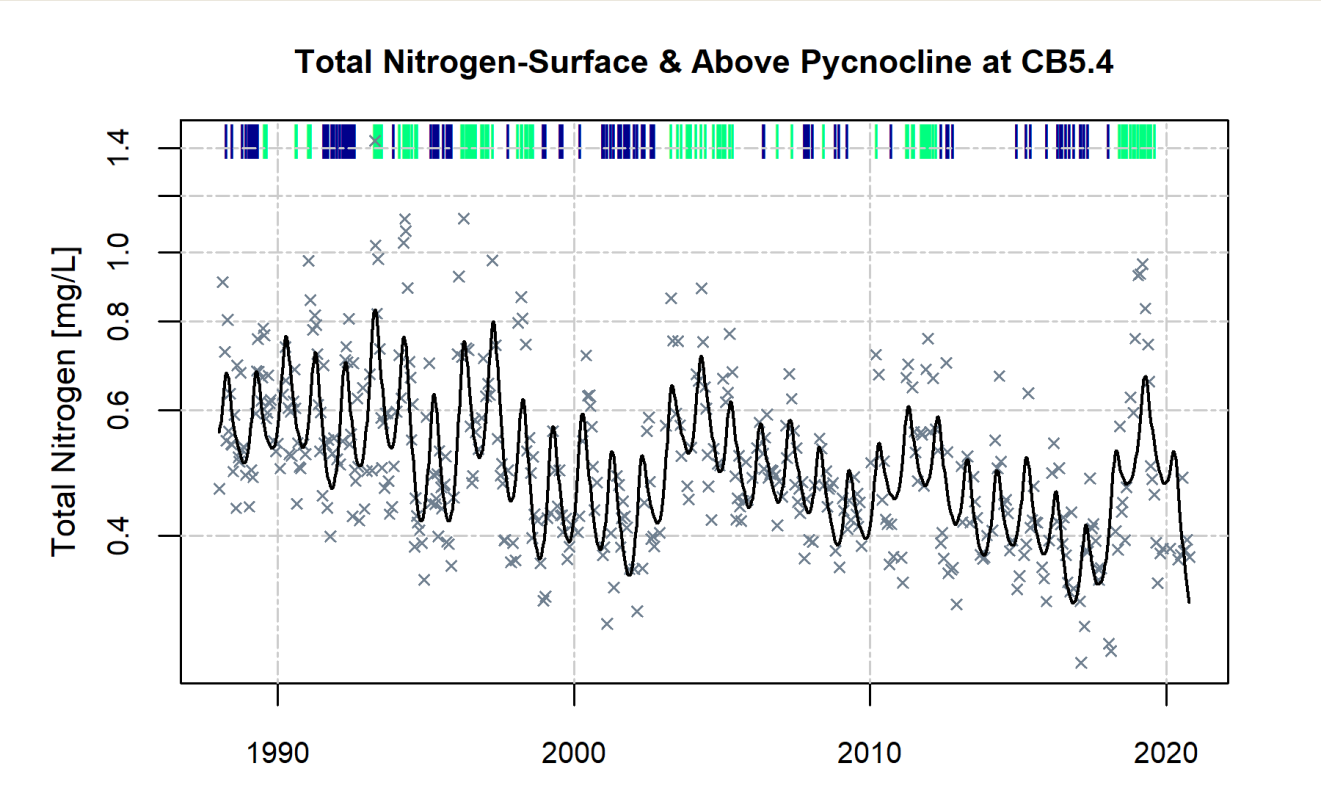
TN = s(doy) + s(date)+ interaction(doy,date)



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

Tidal Trends/GAM method review

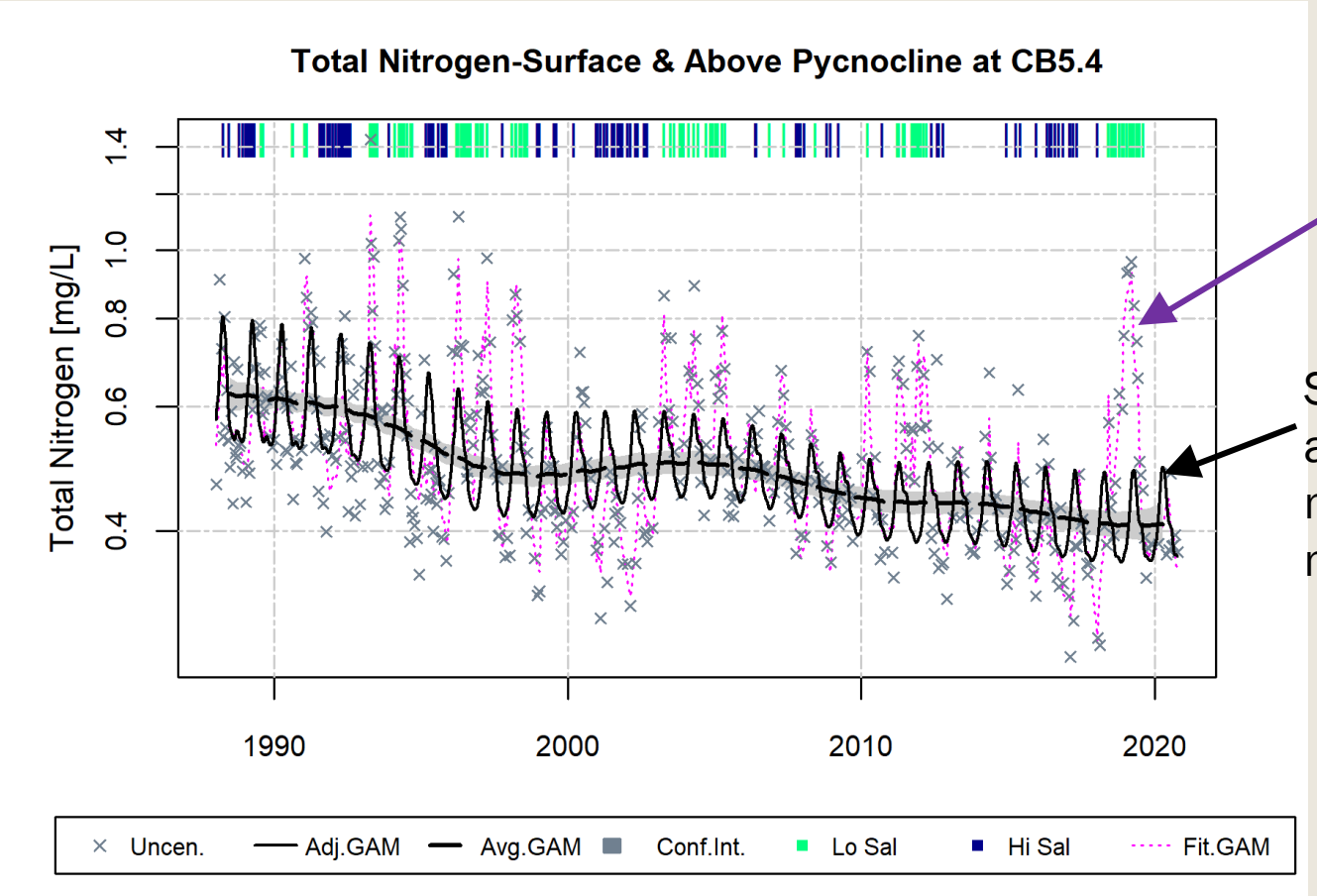
Is variability in river flow the cause of year-to-year fluctuations?



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)

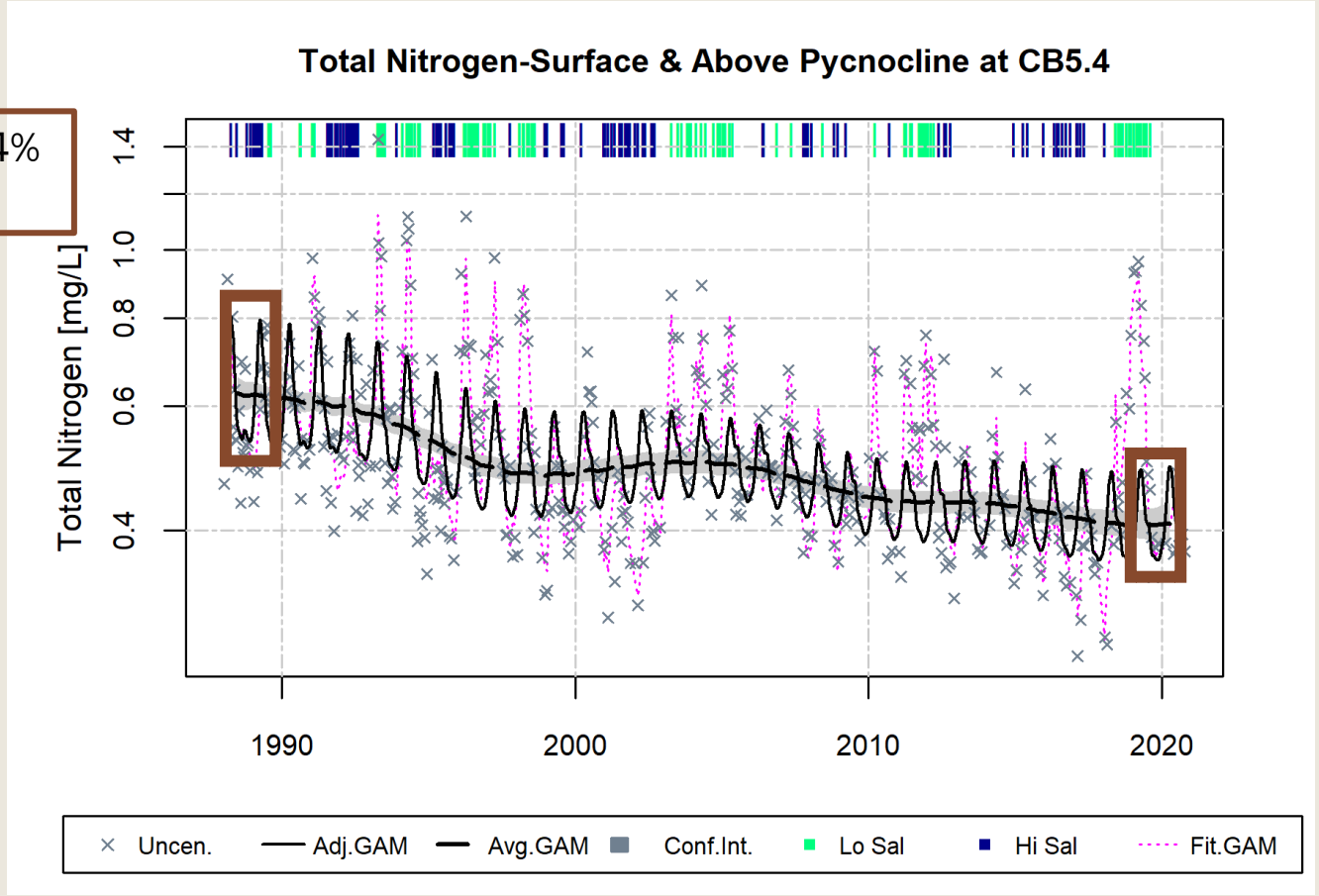


Model with salinity as a variable

Salinity adjusted model and mean

Tidal Trends/GAM method review

Percent change = -34%
p-value < 0.0001



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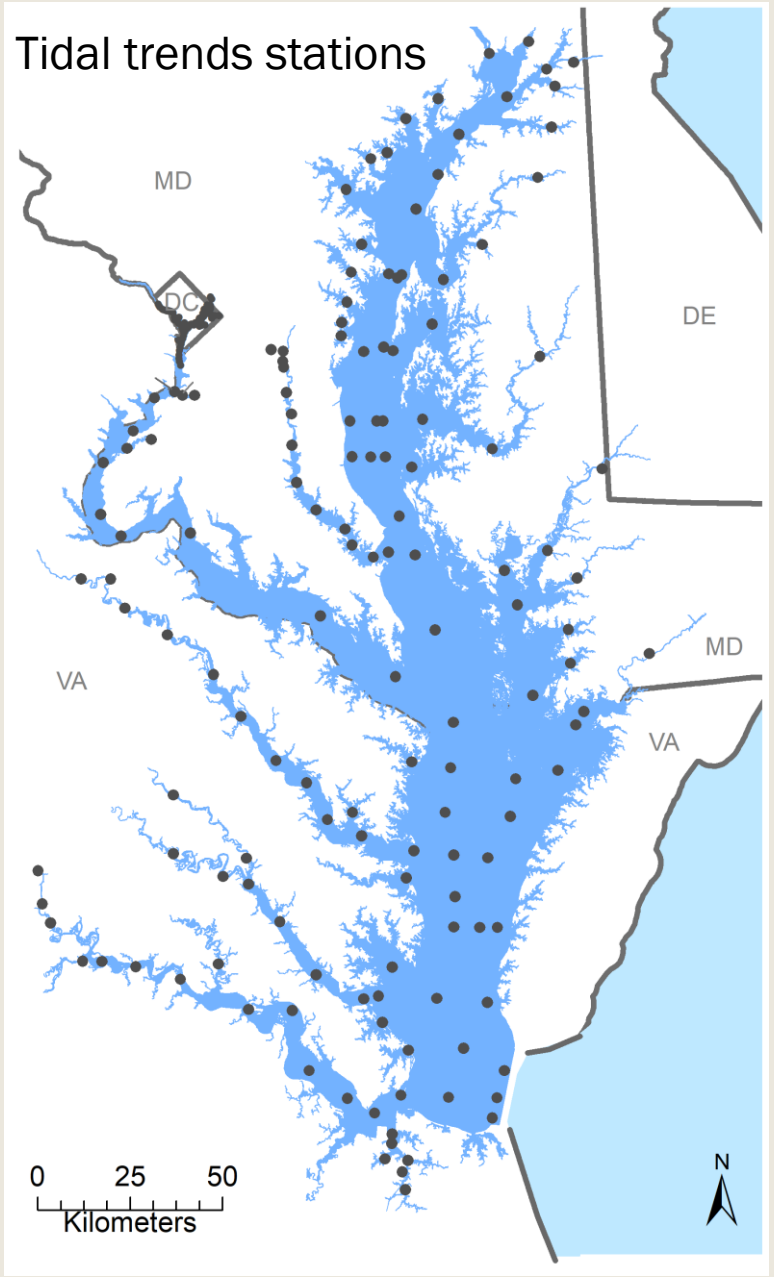
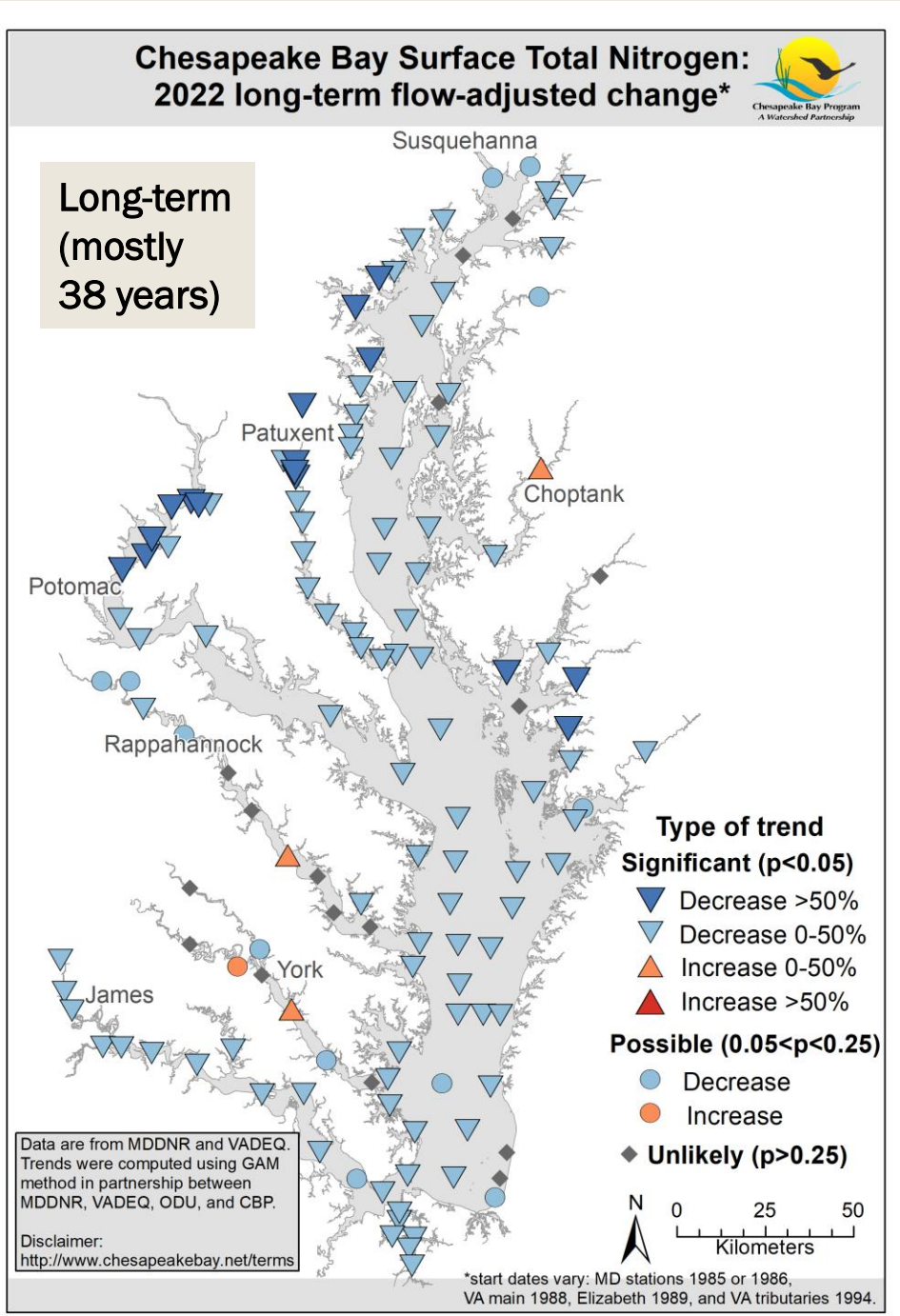
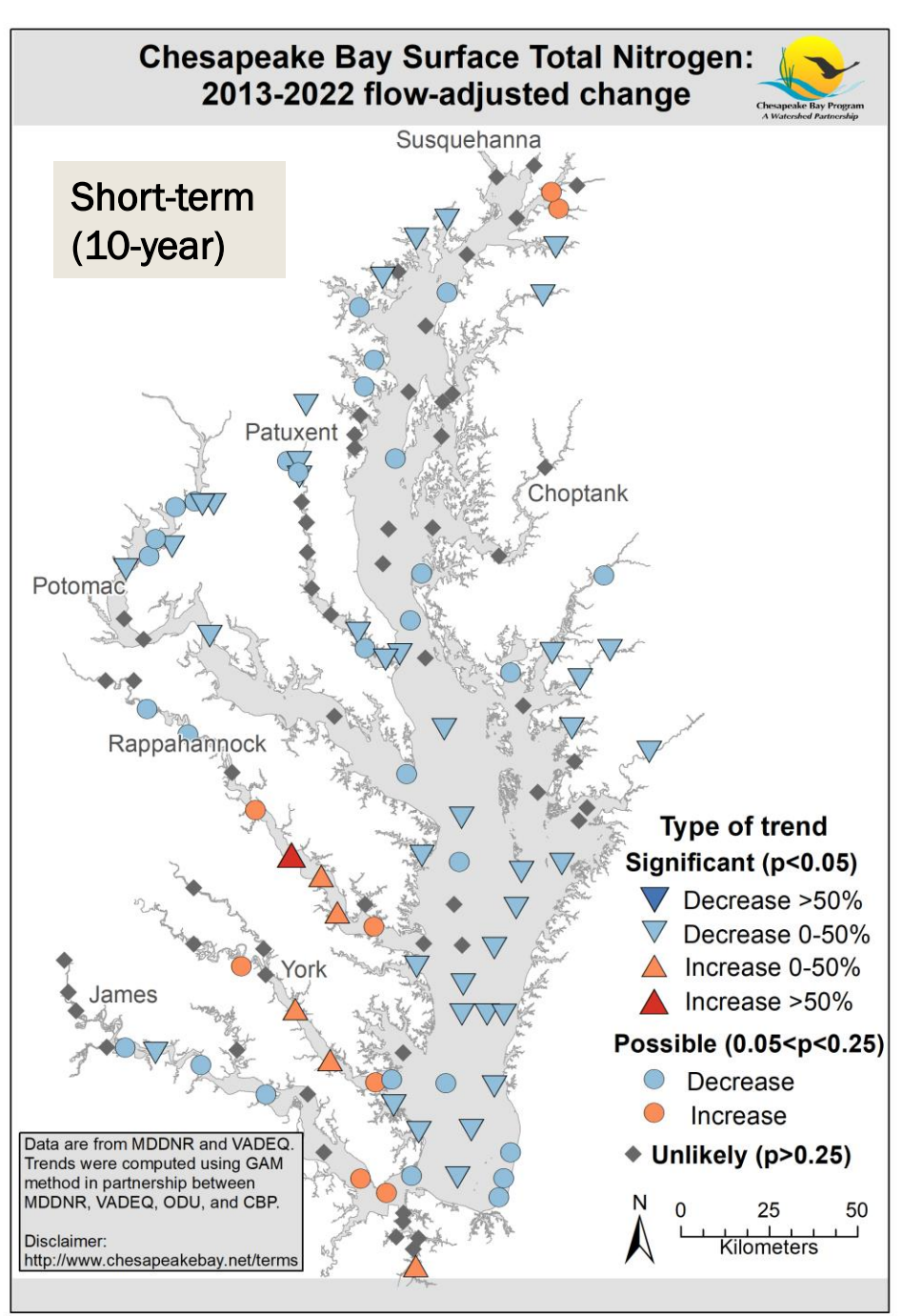


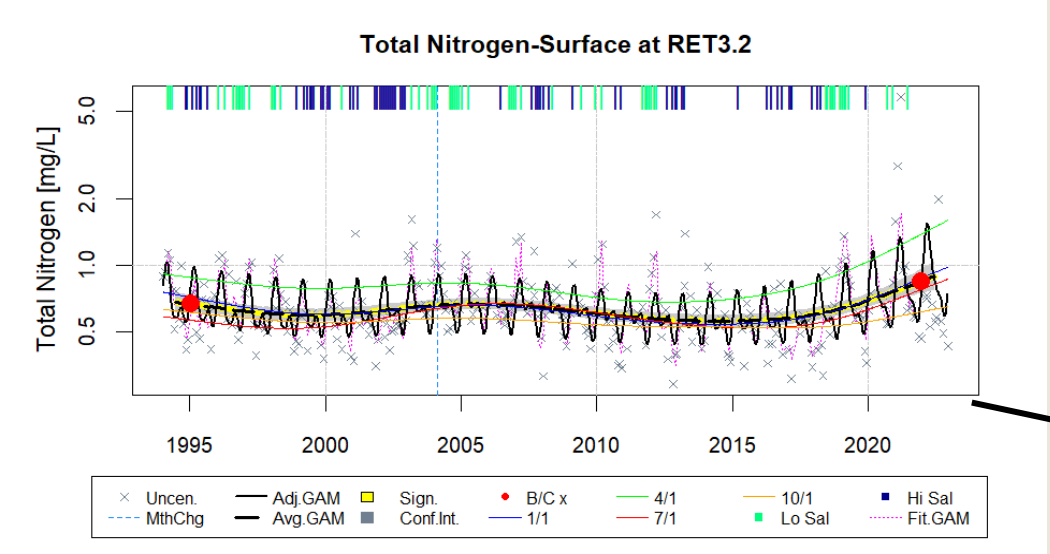
TN

Surface Flow-adjusted

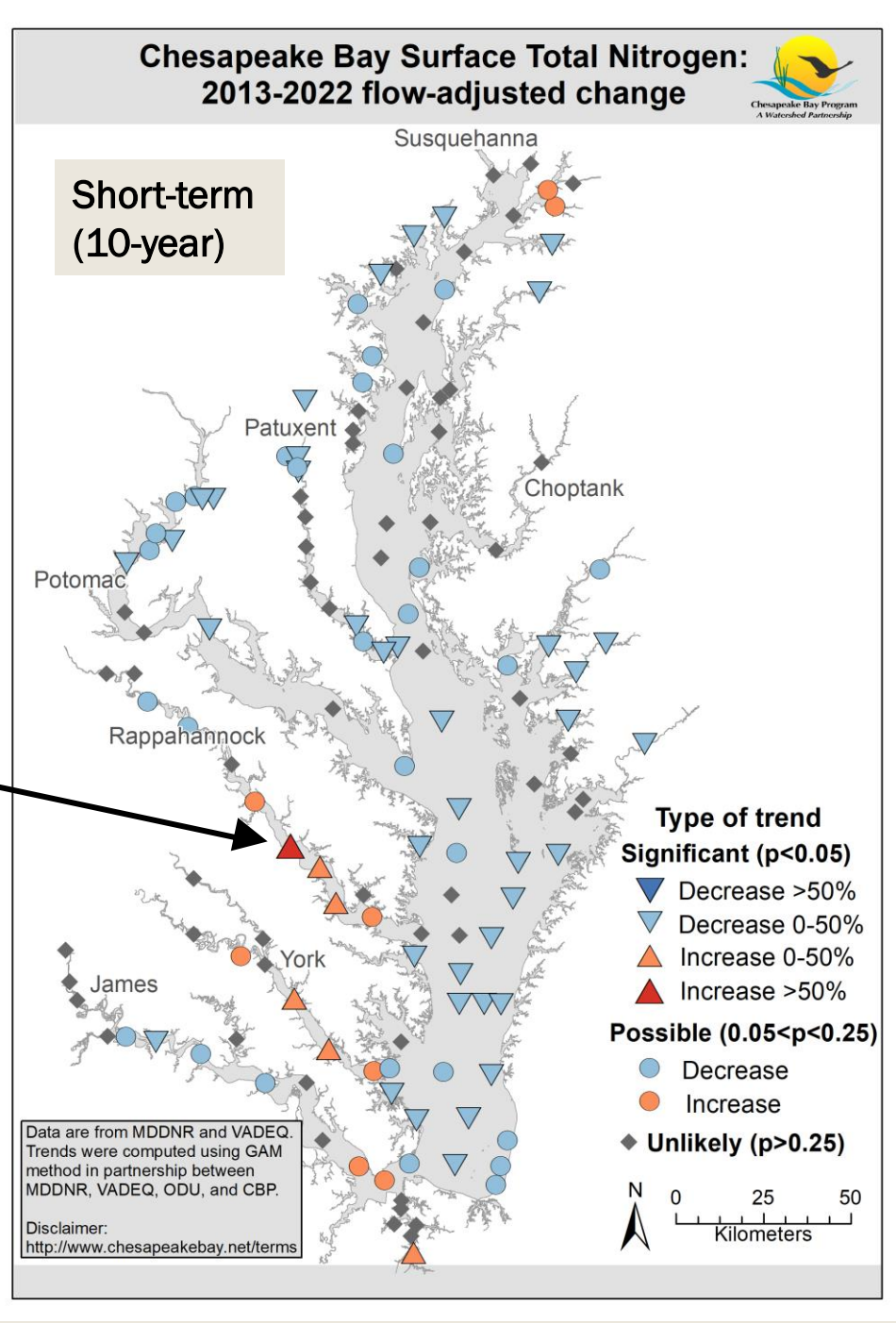




TN
Surface Example

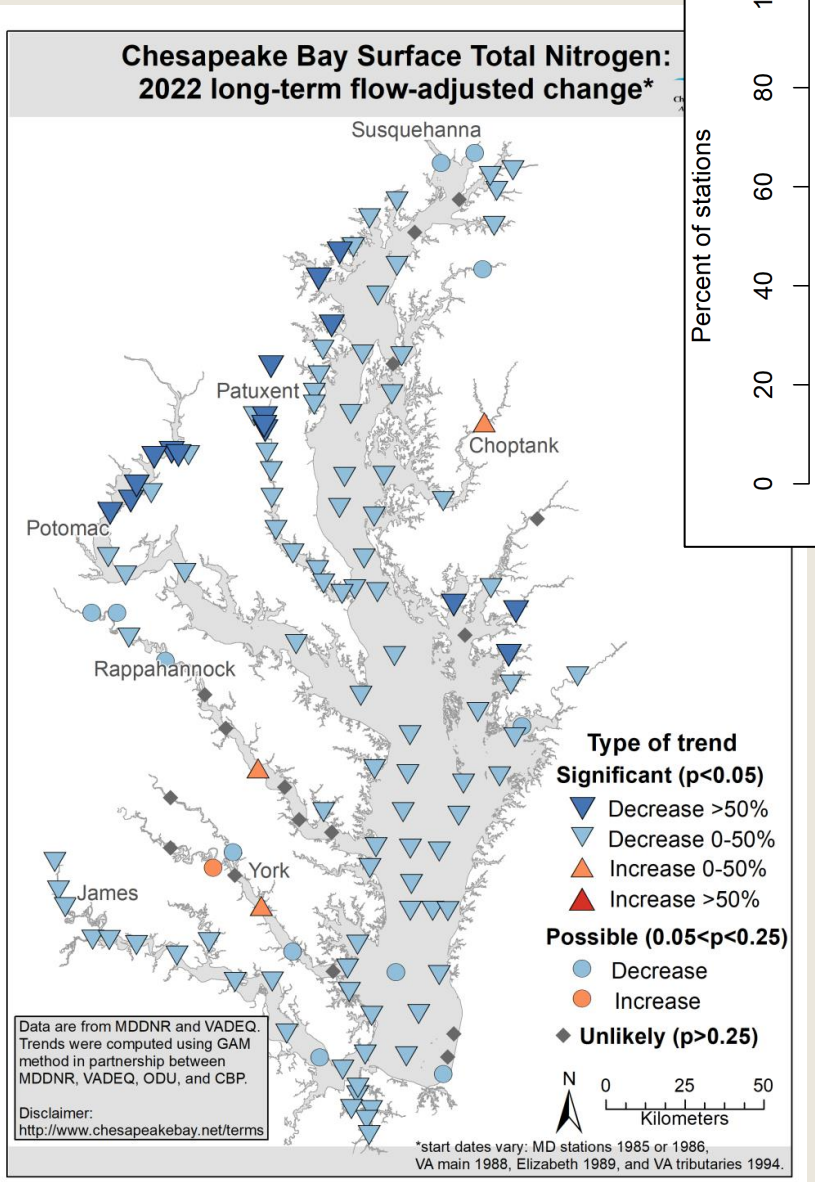


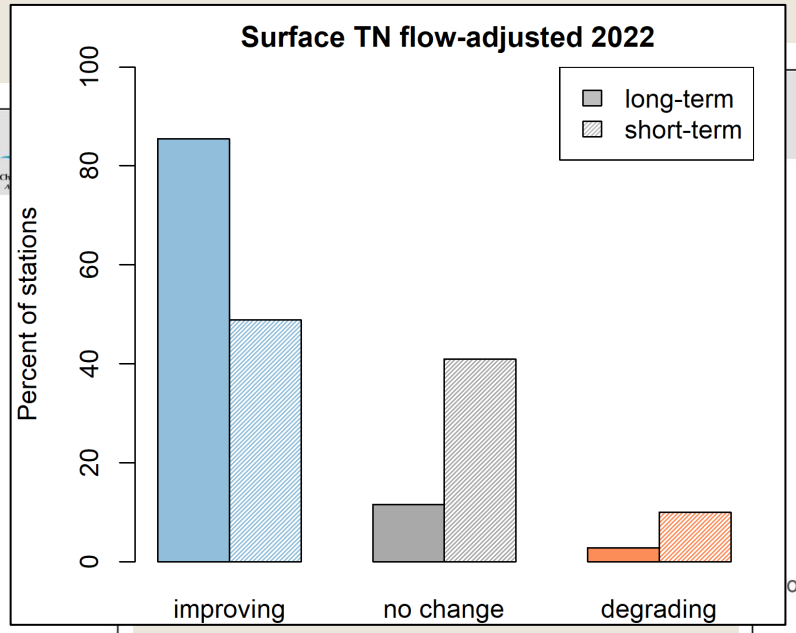
Example: The Rappahannock stations with short-term increases have fairly constant (and low) concentrations over the long-term with an upswing in the last few years.



TN

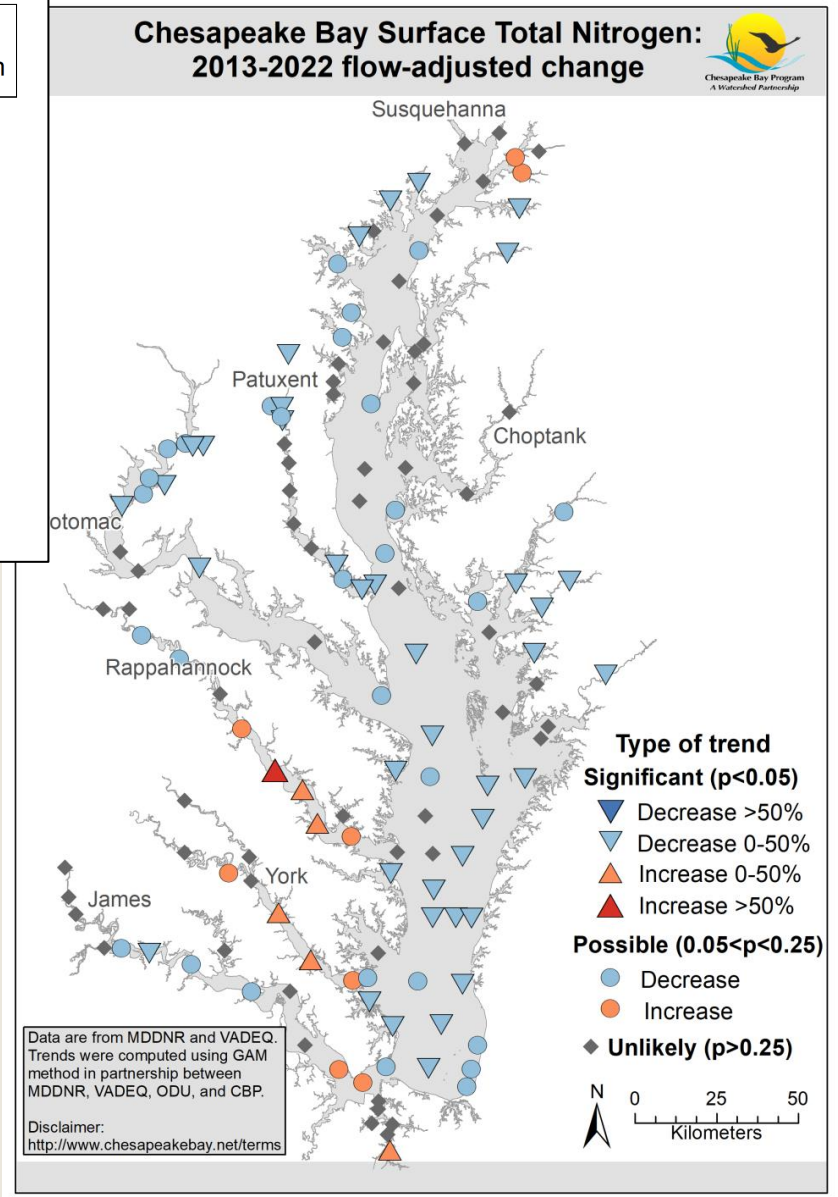
Surface Flow-adjusted





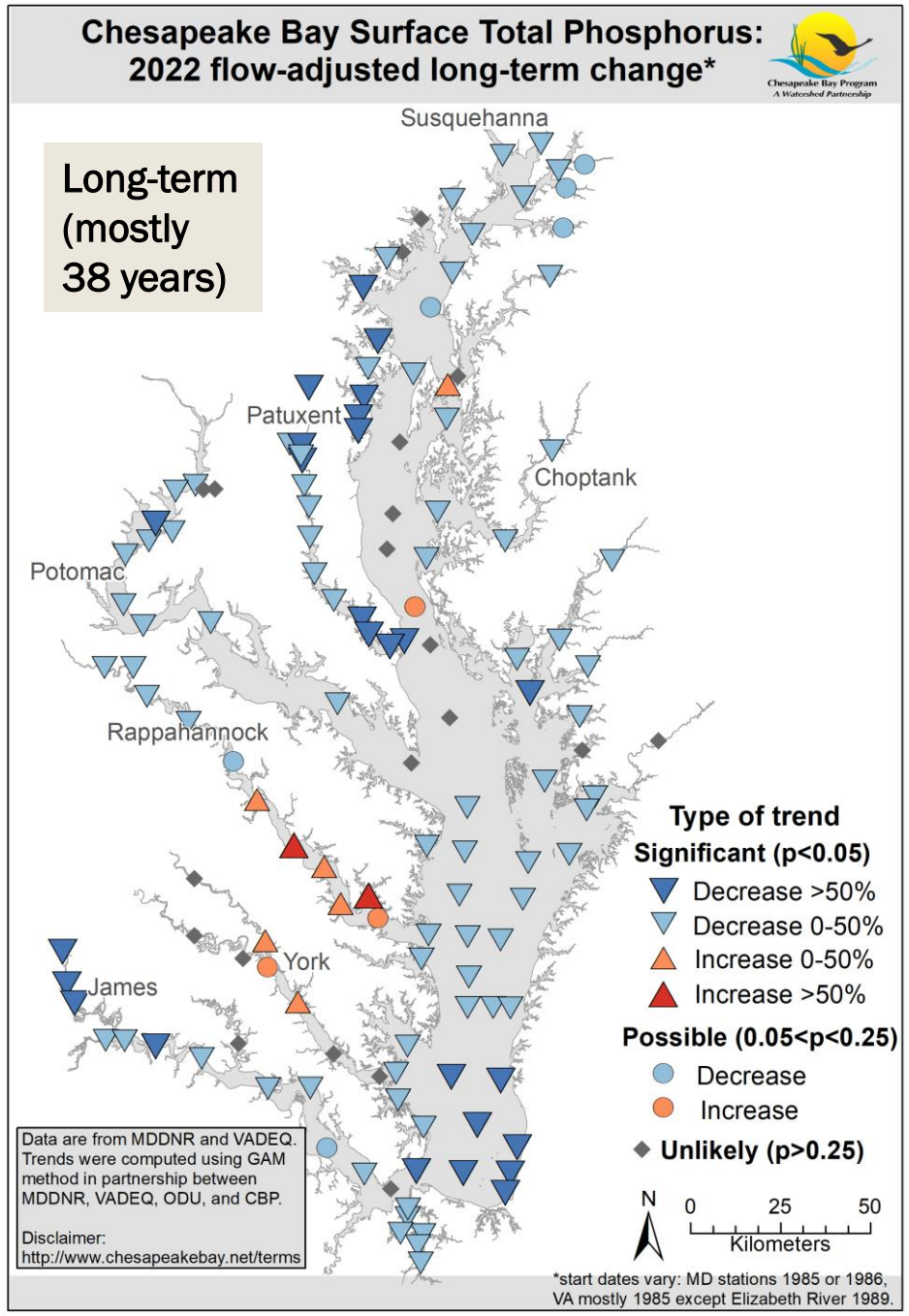
Summary for TN

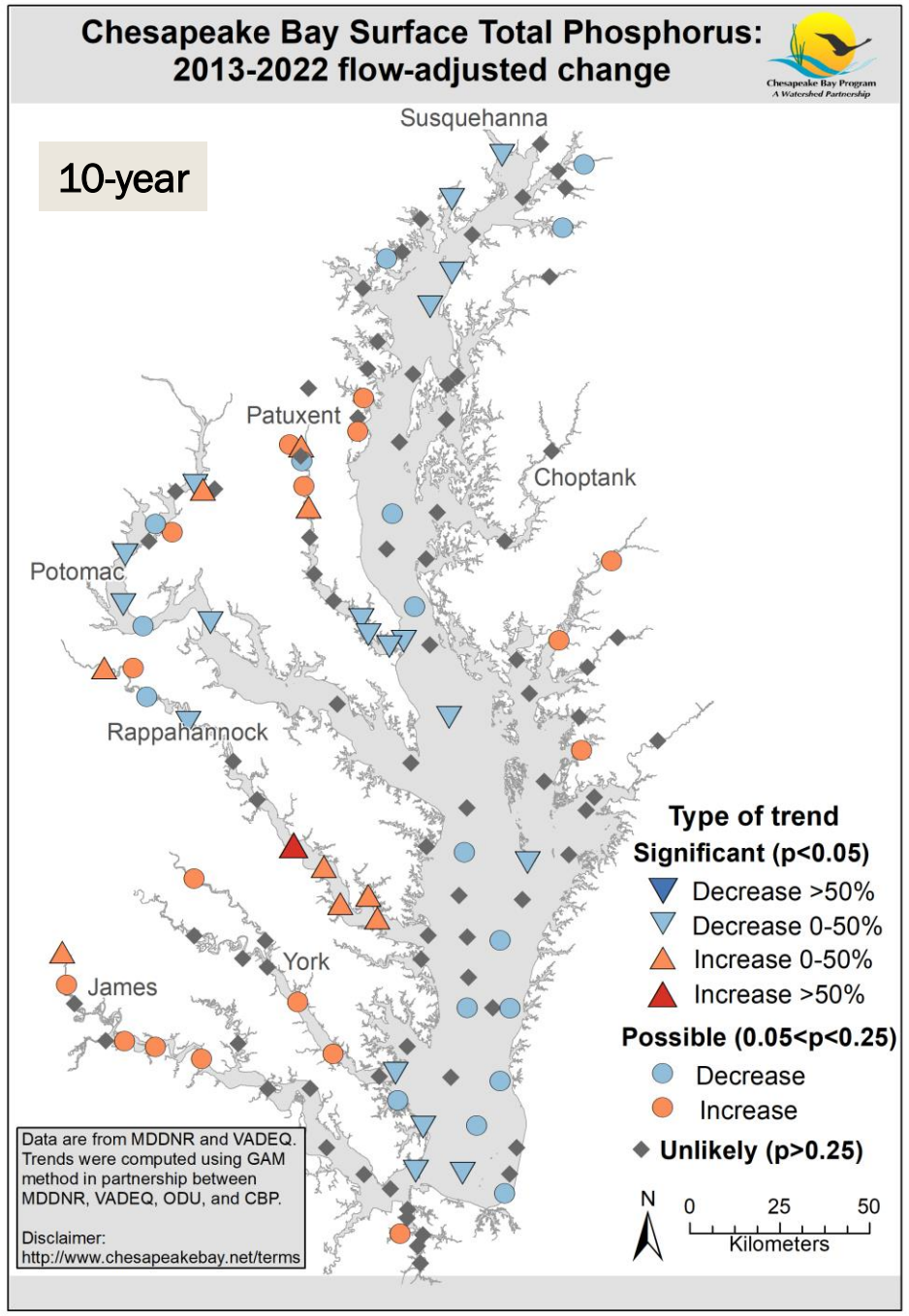
- Long-term trends decreasing at majority of stations (bottom is similar).
- Short-term trends are more mixed, but the largest group is improving.



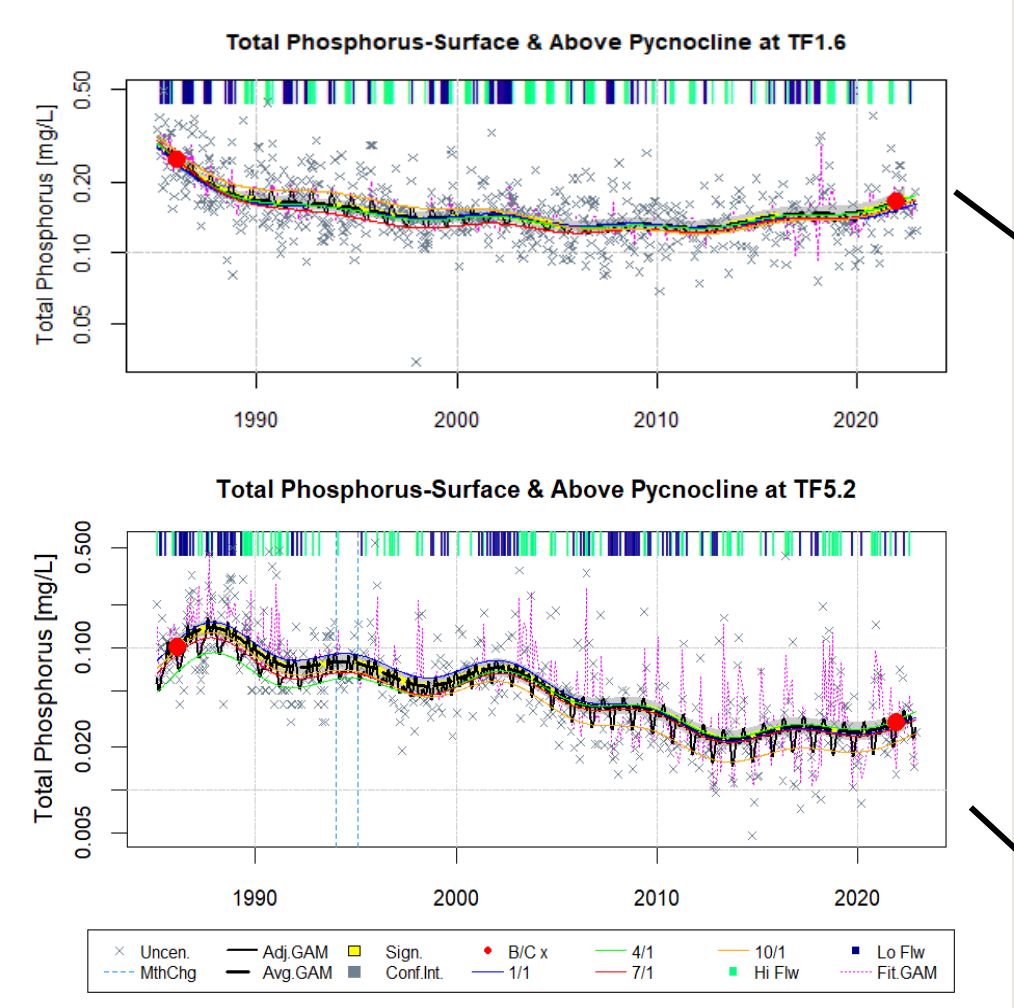
TP

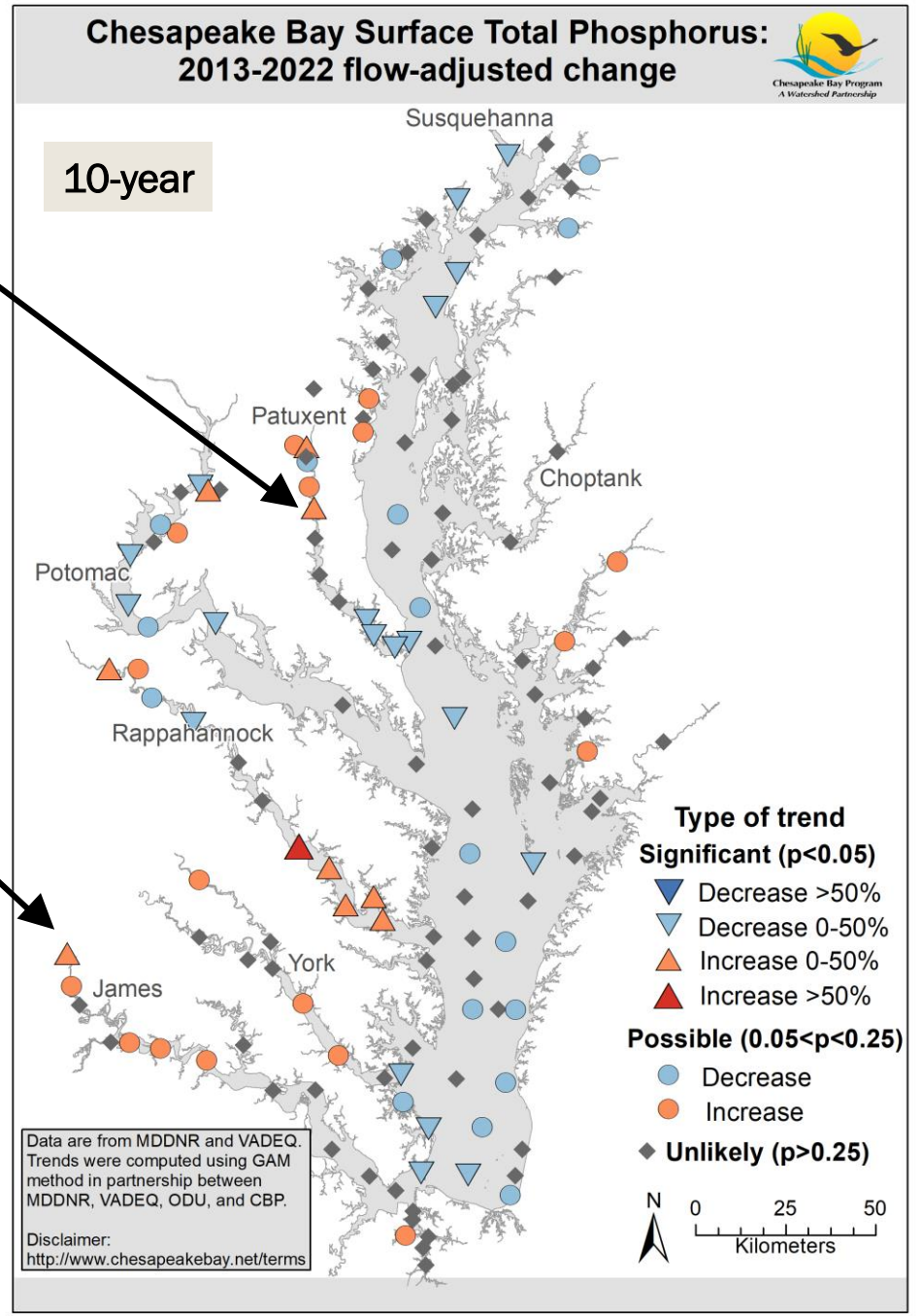
Surface Flow-adjusted





TP
Surface Examples

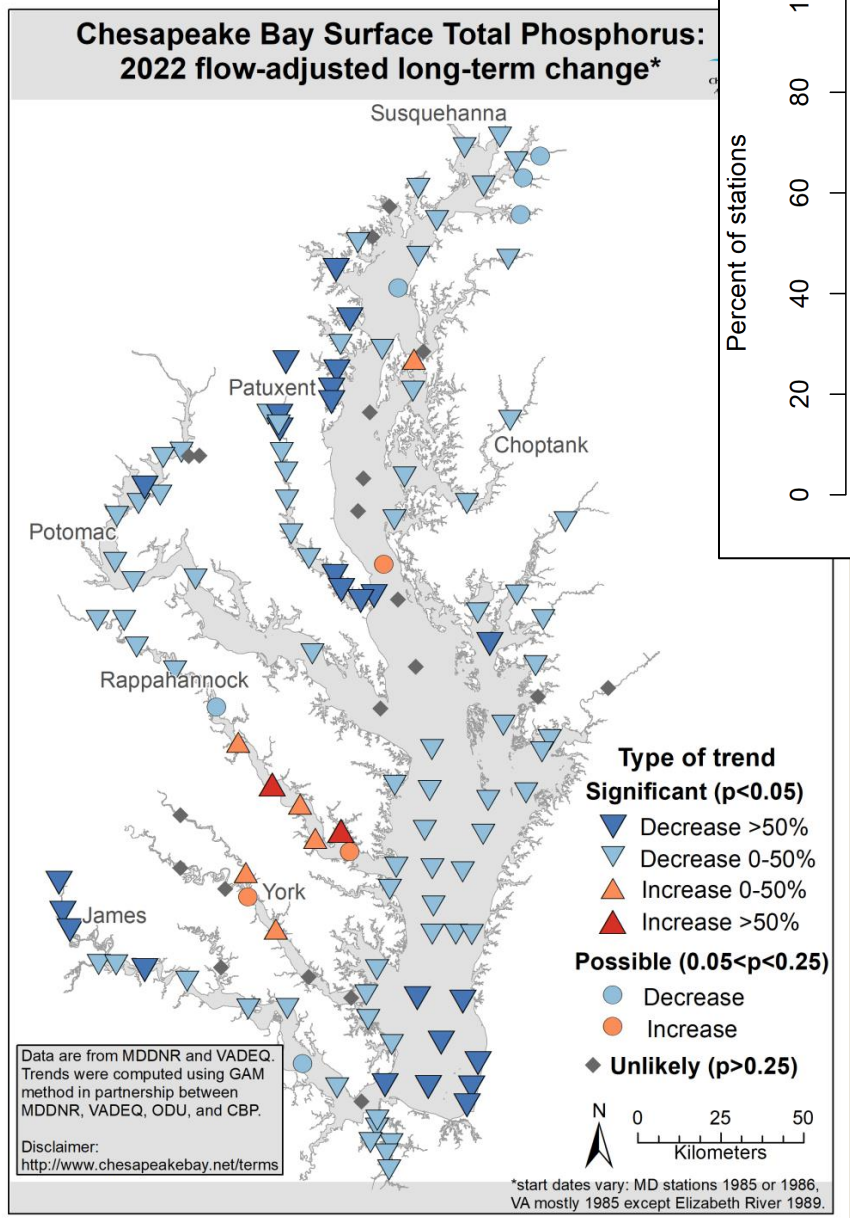


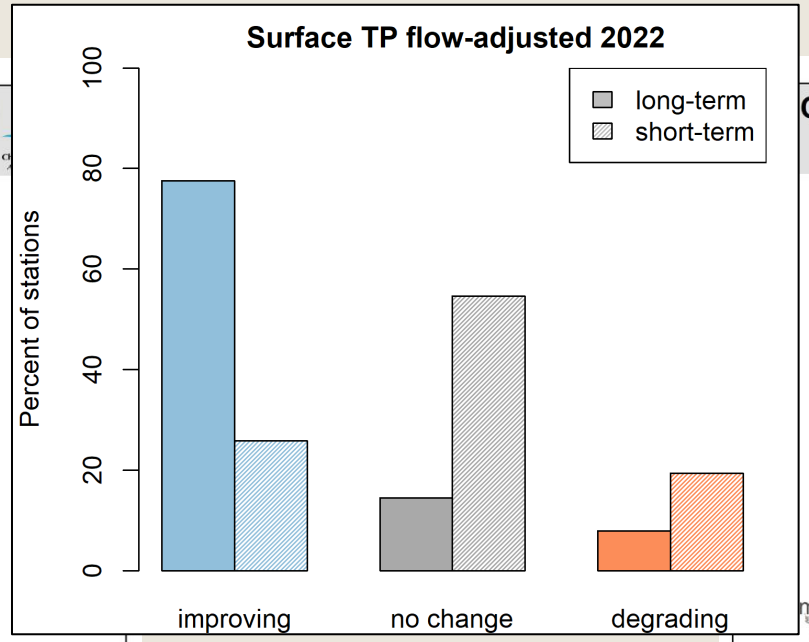


Example: Several of the trends that improve over the long-term but degrade over the short-term have large TP decreases in the 80s and smaller increases in the last decade.

TP

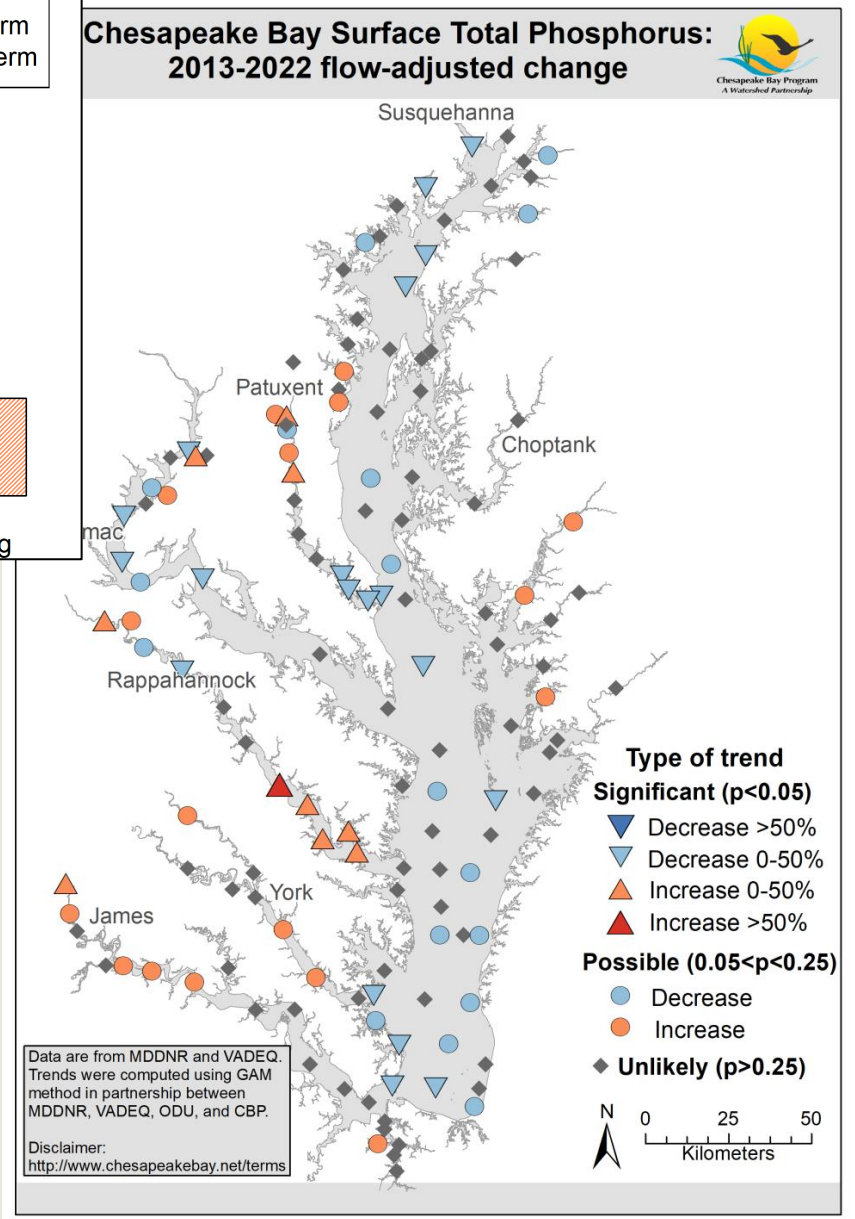
Surface Flow-adjusted





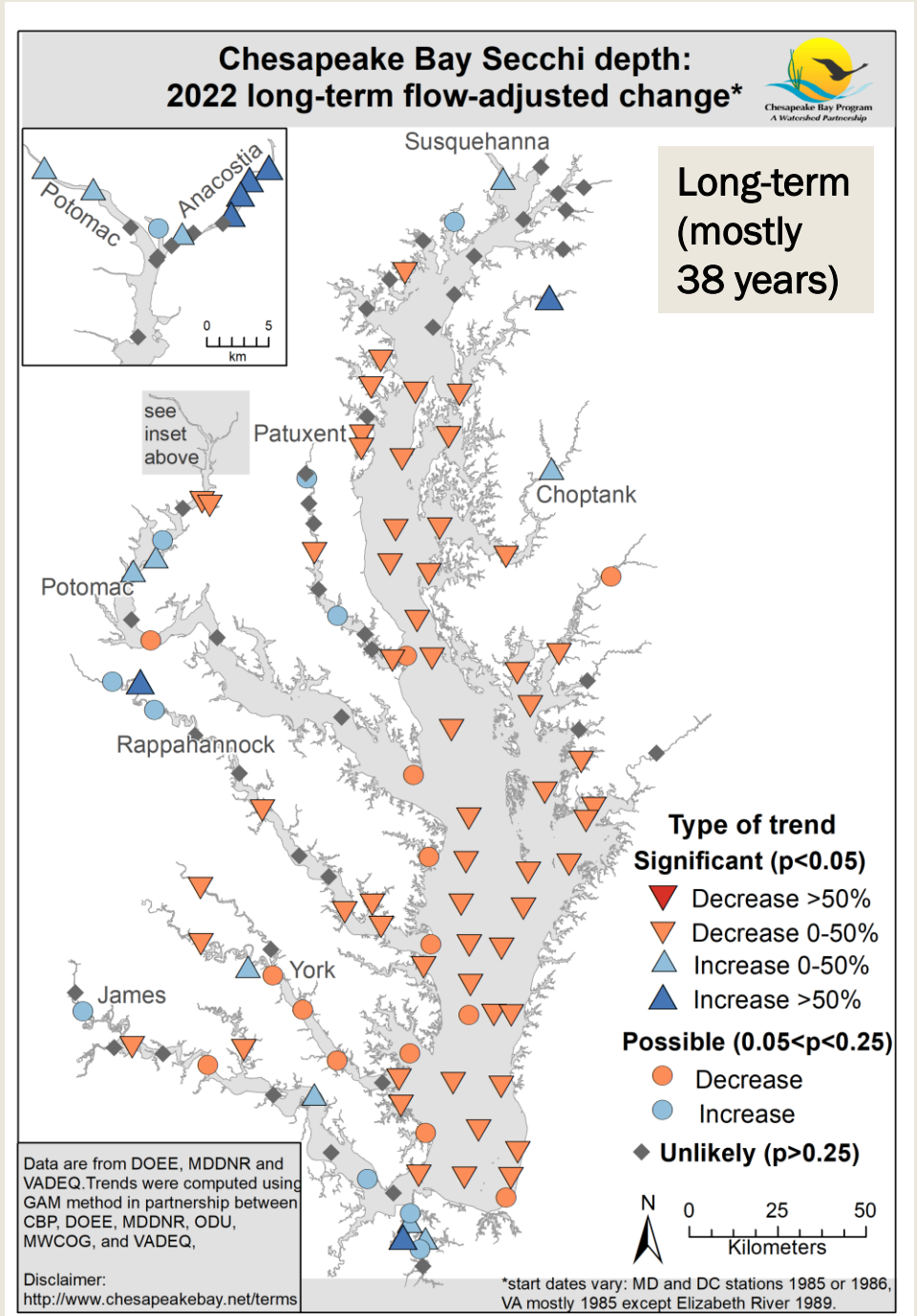
Summary for TP

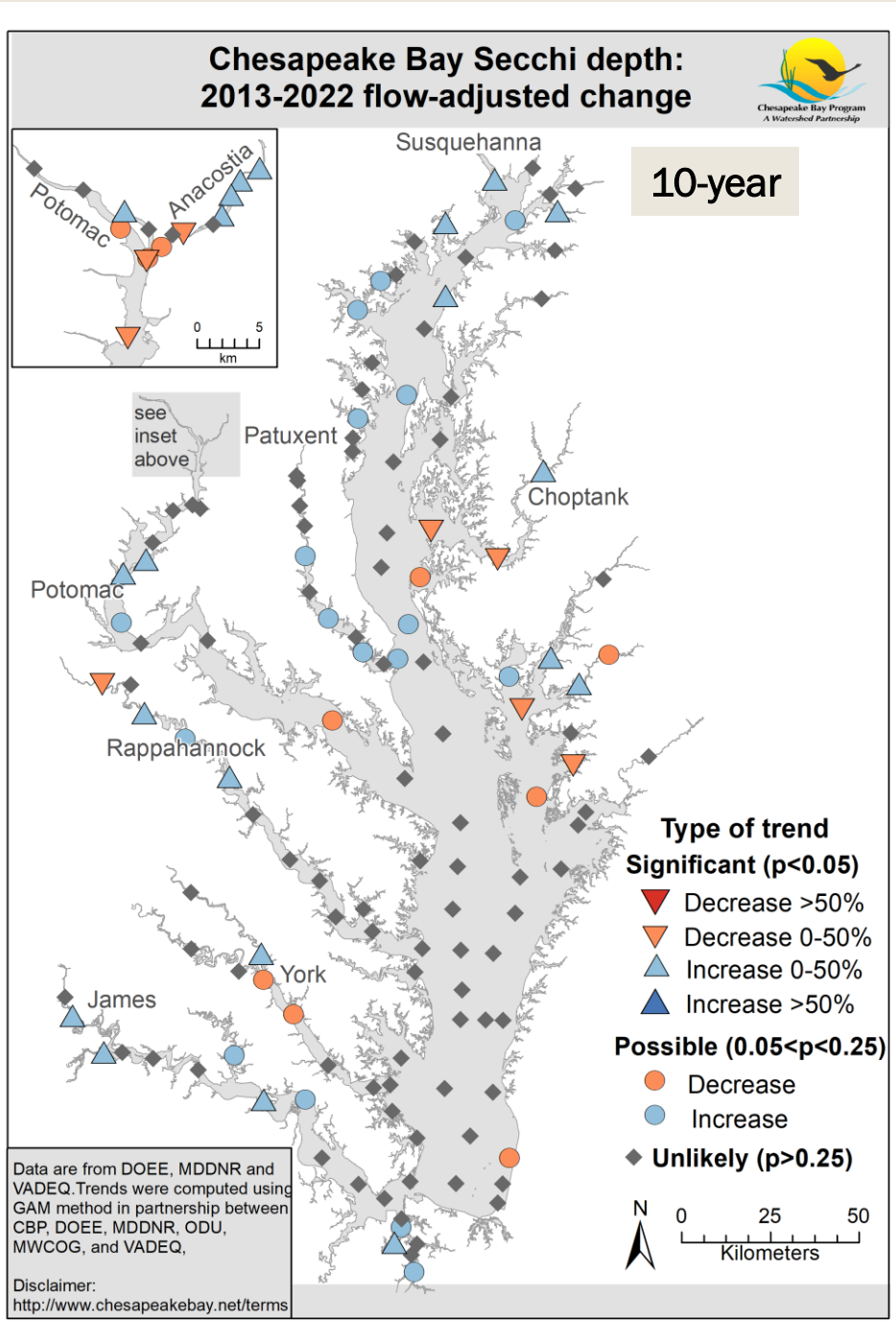
- Long-term trends decreasing at majority of stations (bottom is similar).
- Short-term is more mixed, with the largest group with no trend.



Secchi Depth

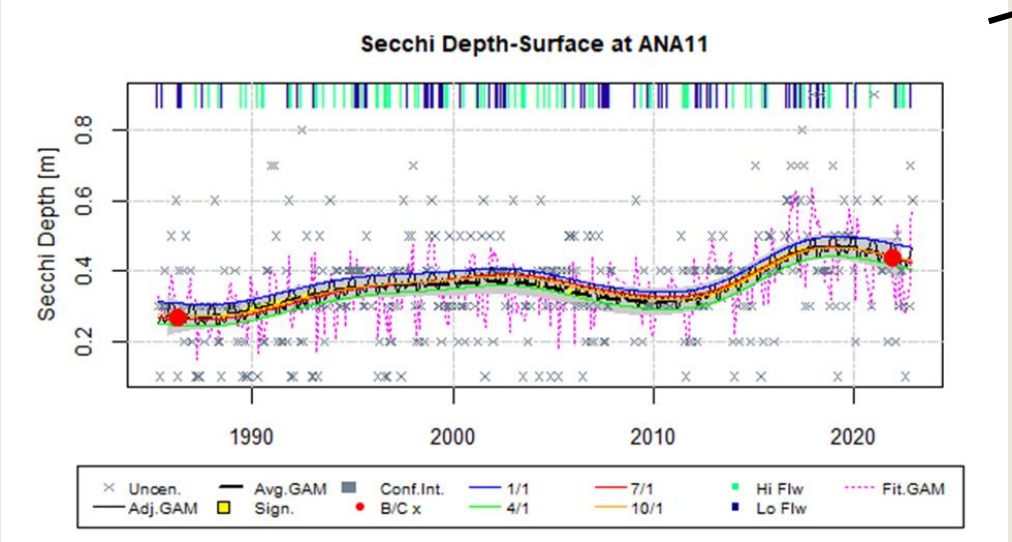
Flow-adjusted



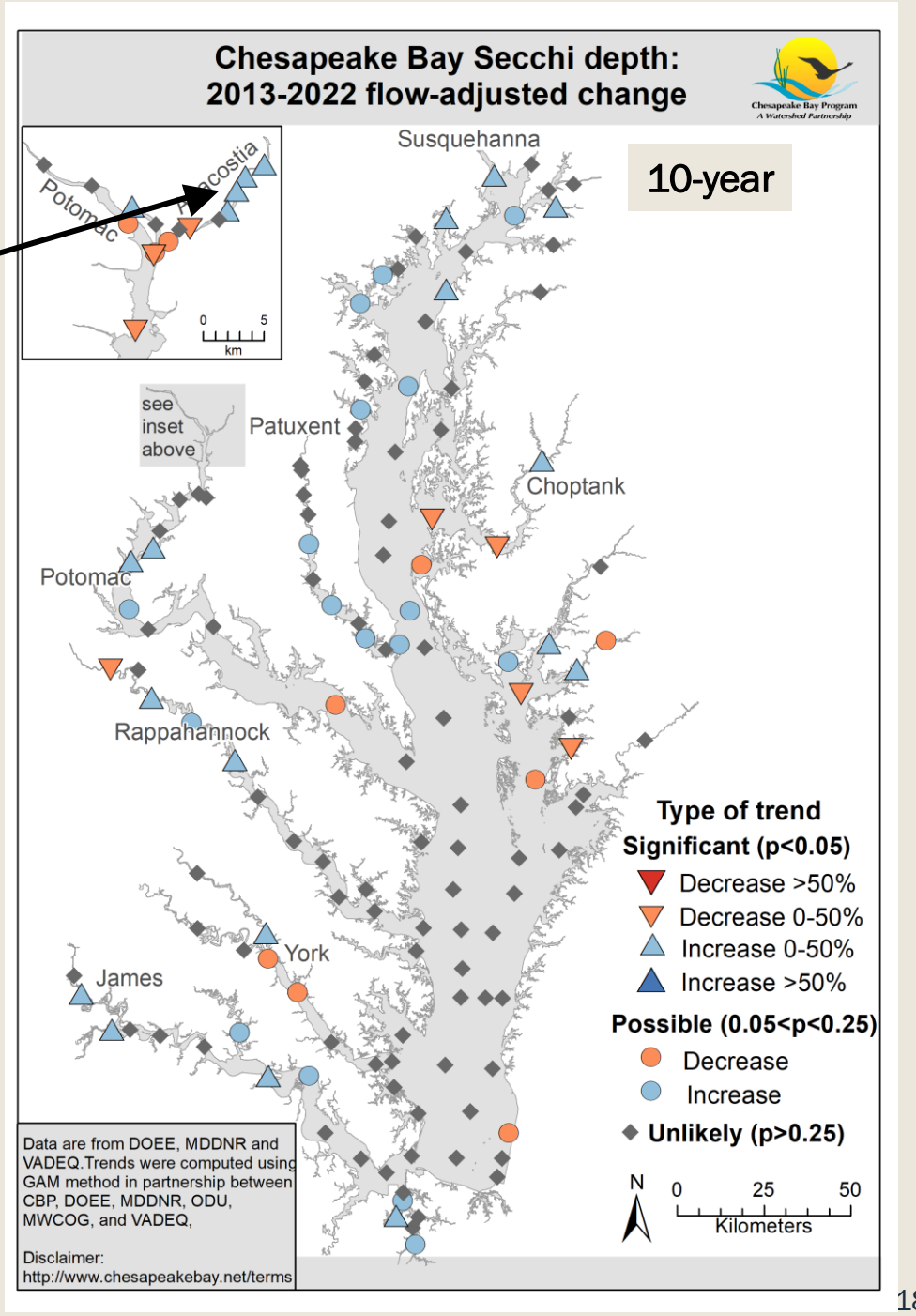


Secchi Depth

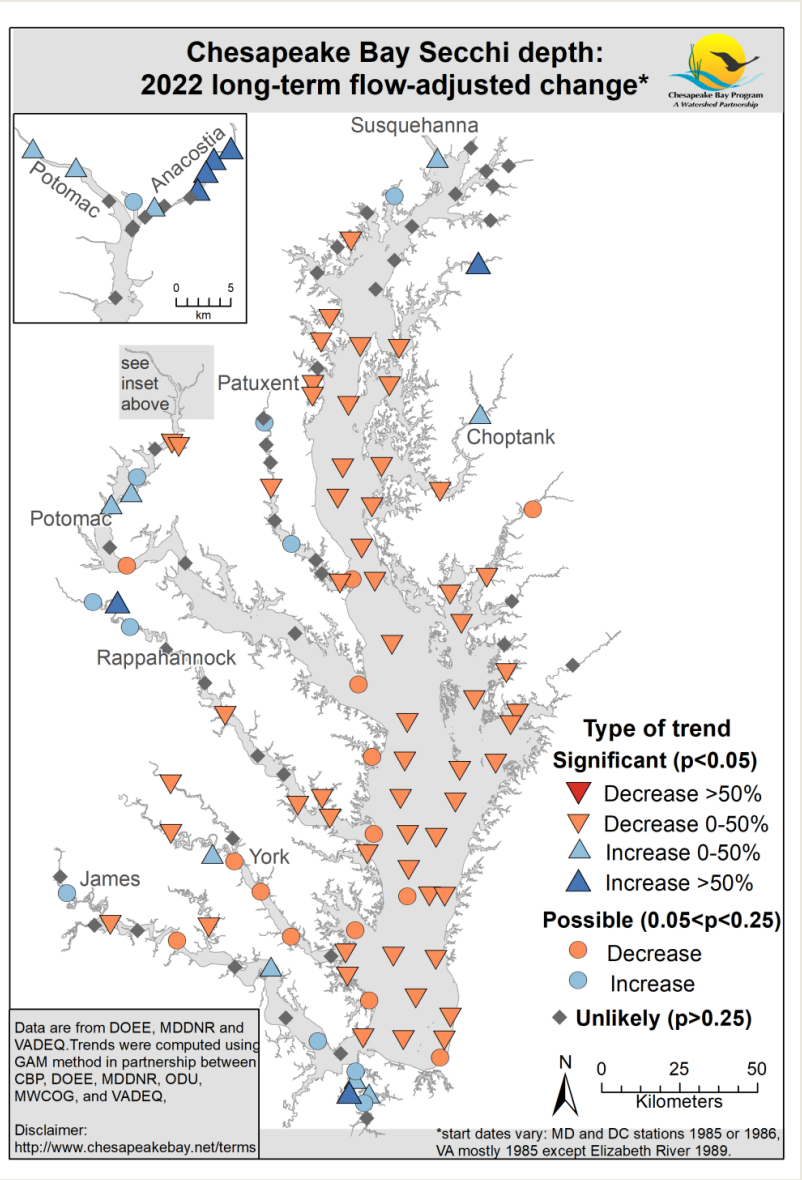
Example

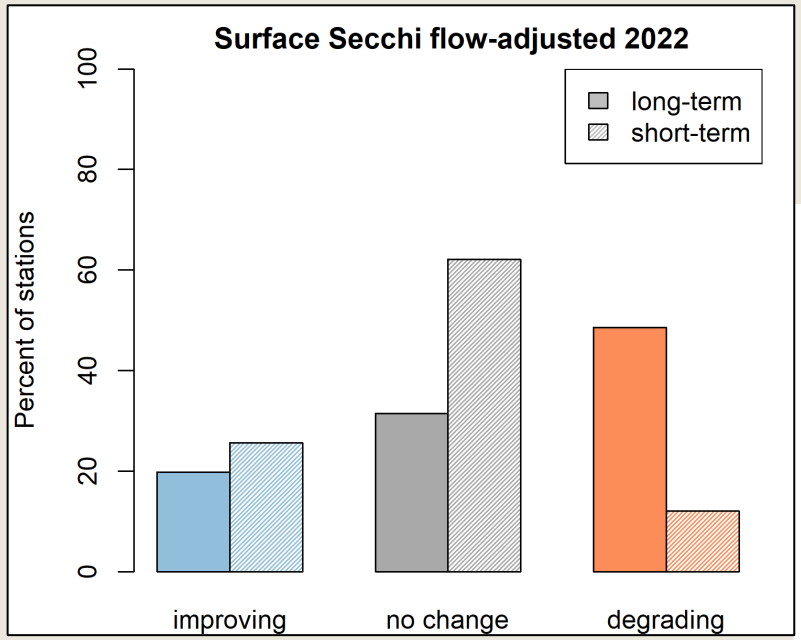


Example: Anacostia stations all show long-term gradual improvement. DOEE's Potomac stations also show long-term improvement with both rivers having mixed short-term trends.



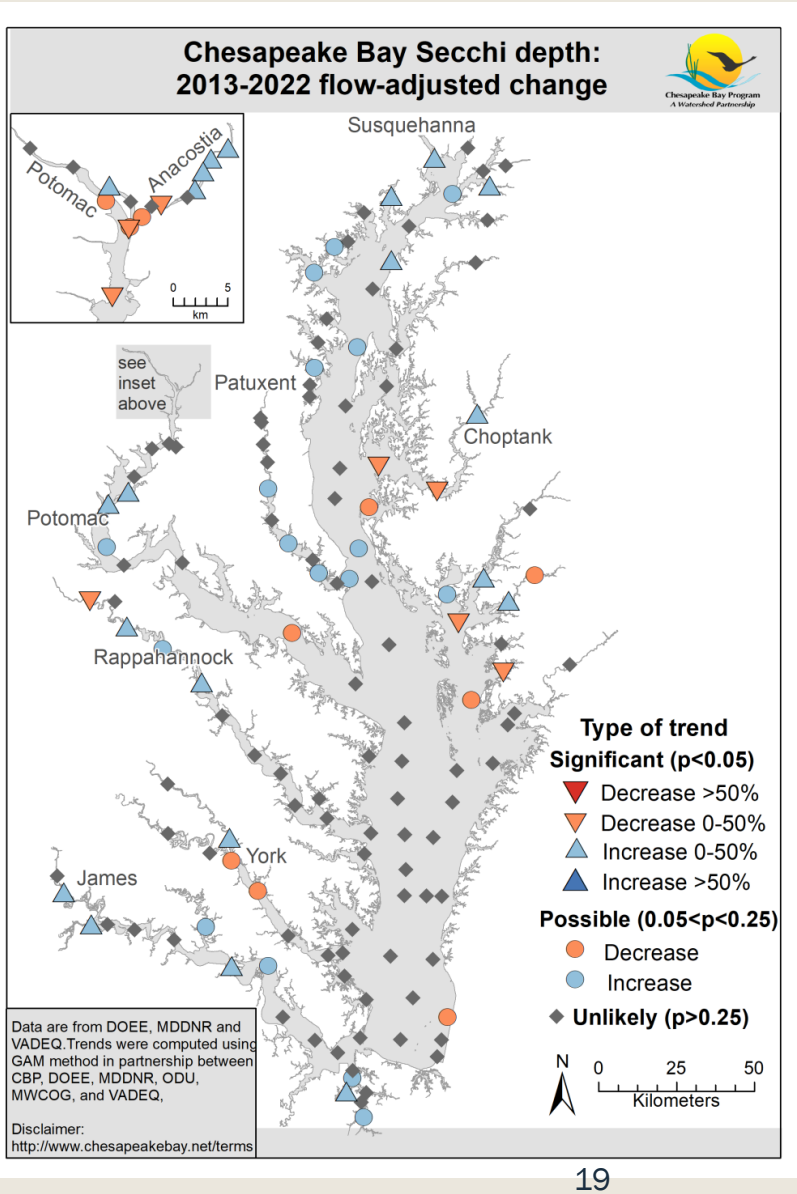
Secchi depth





Summary for Secchi

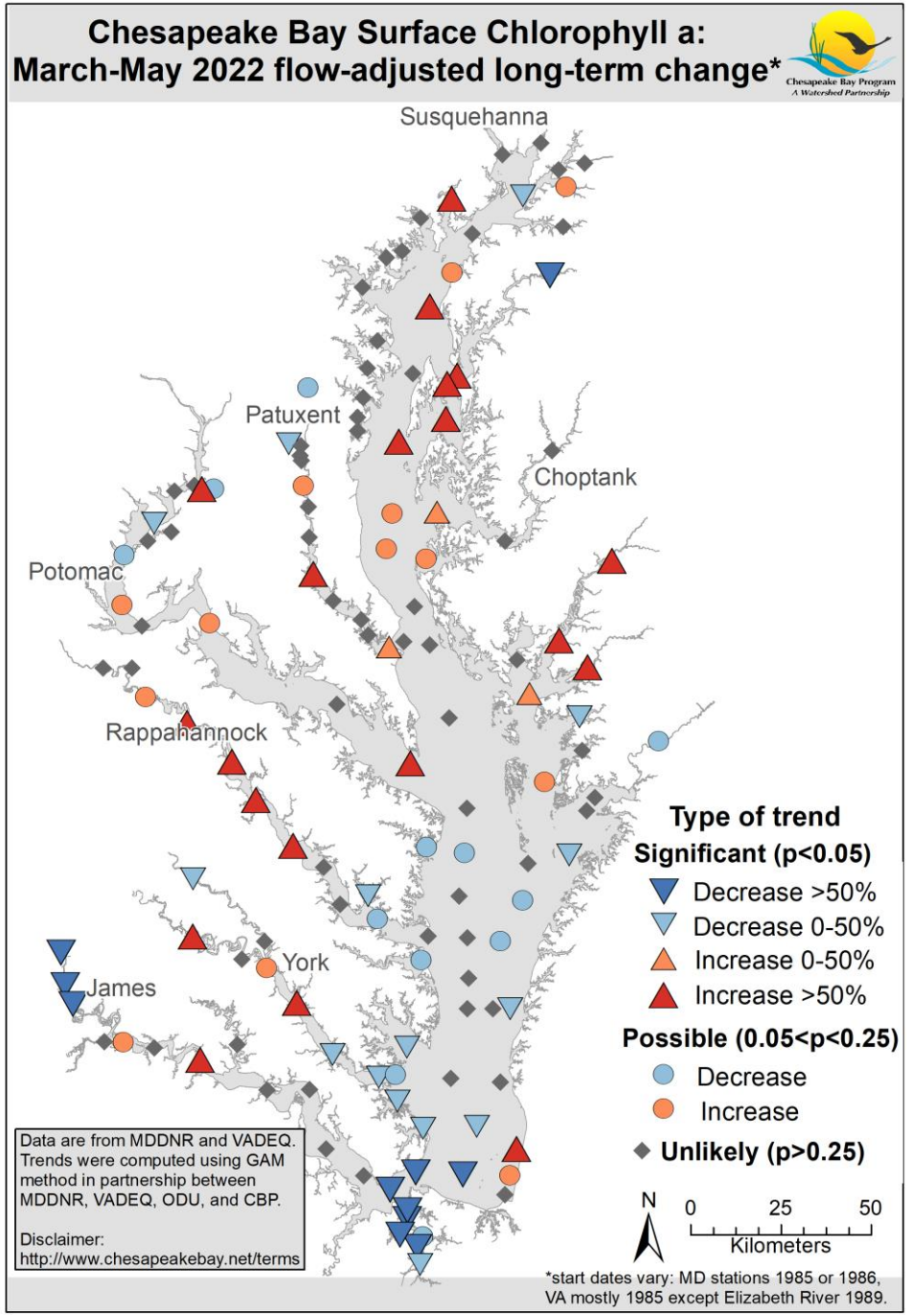
- Long-term degradation in Secchi depth is notable across many regions of the bay.
- But in last 10 years, there are more improvements than degradations.

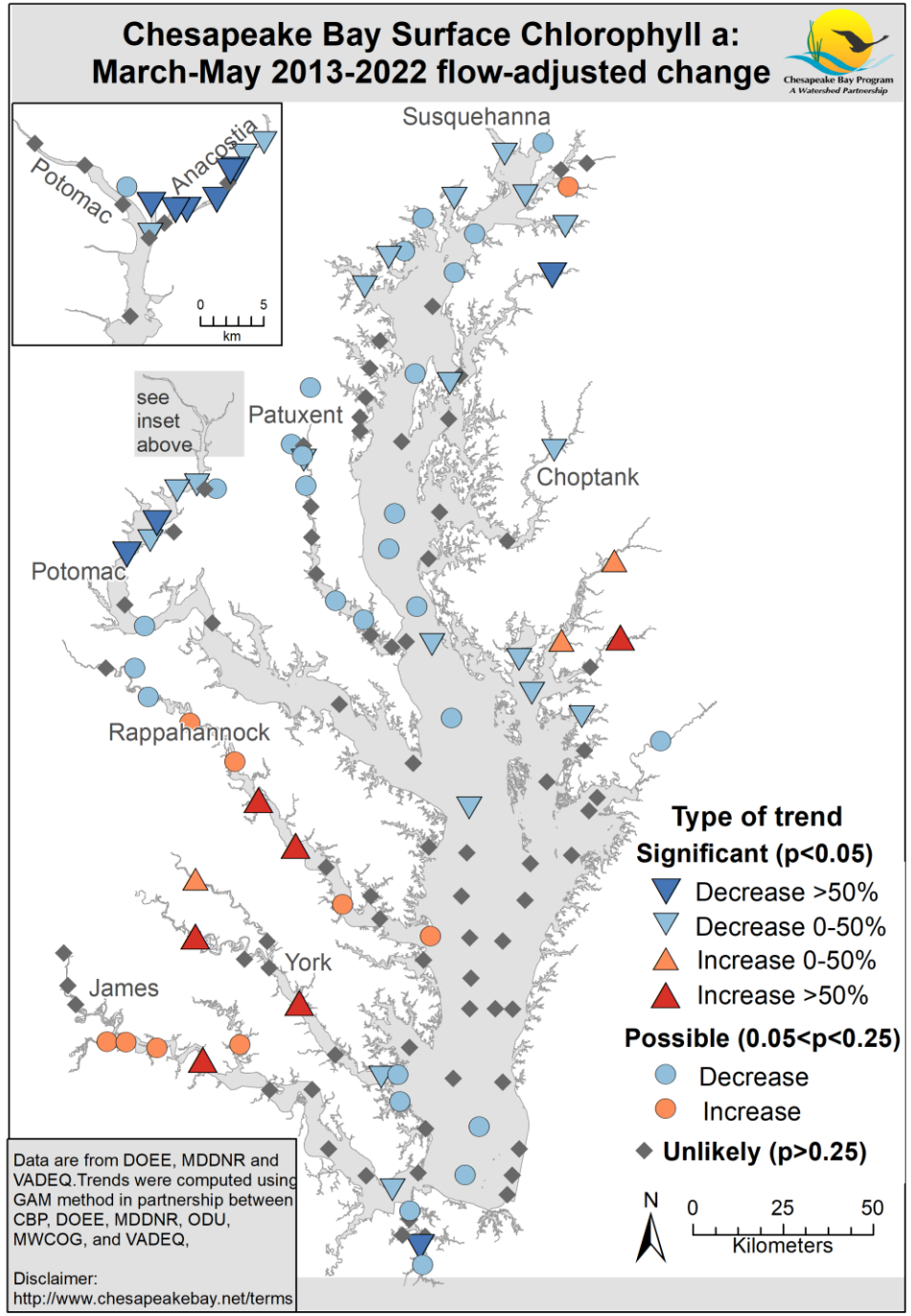


Spring Chlorophyll *a*

Surface

Flow-adjusted



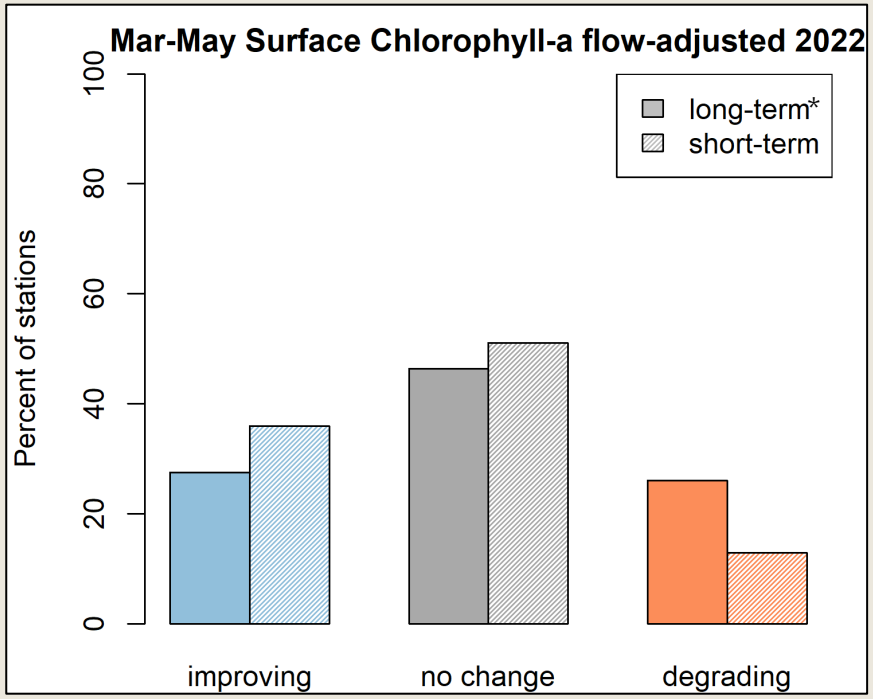


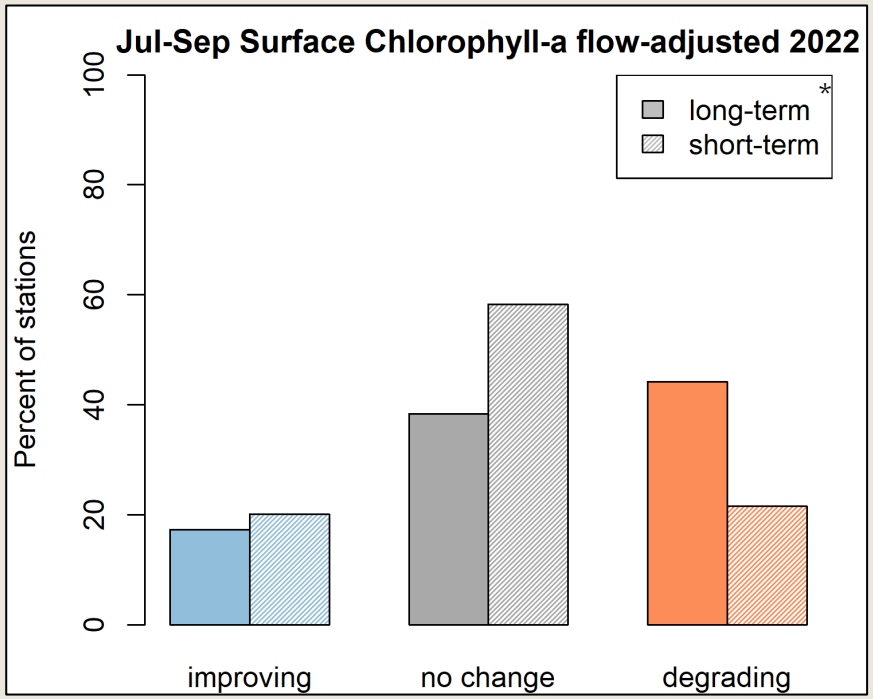
Summary

Chlorophyll *a*

Surface

Flow-adjusted

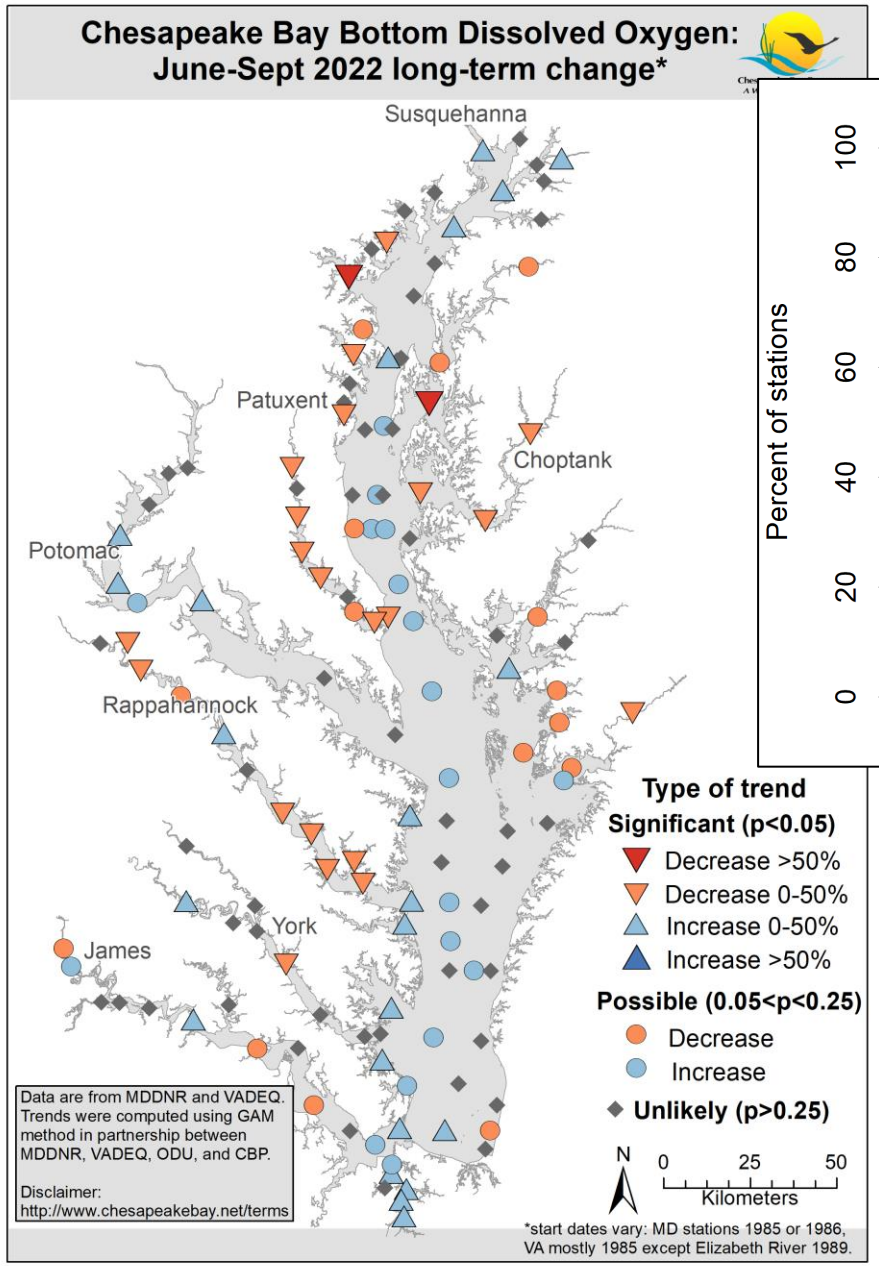


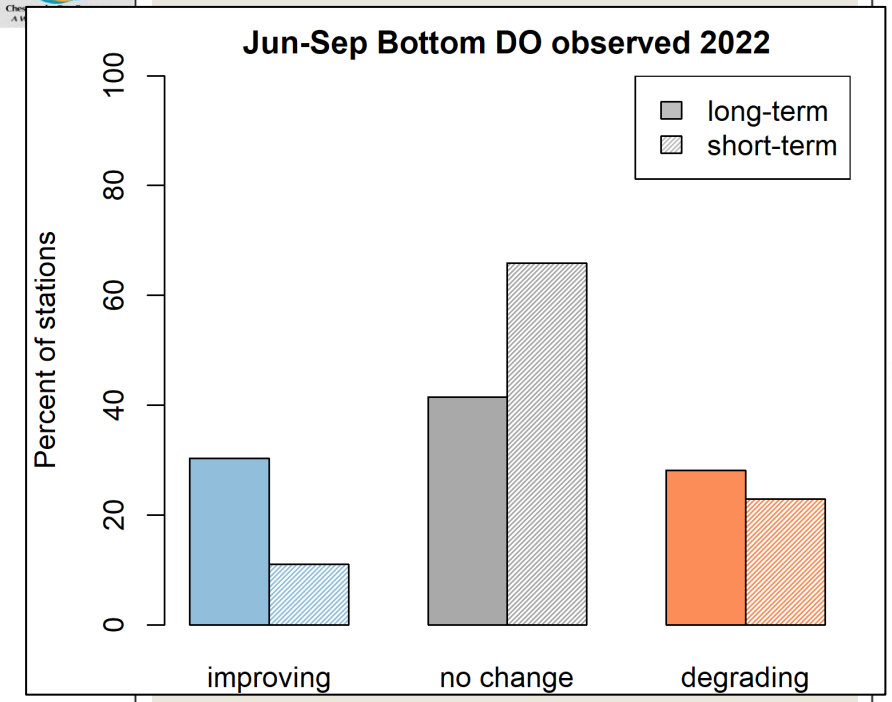


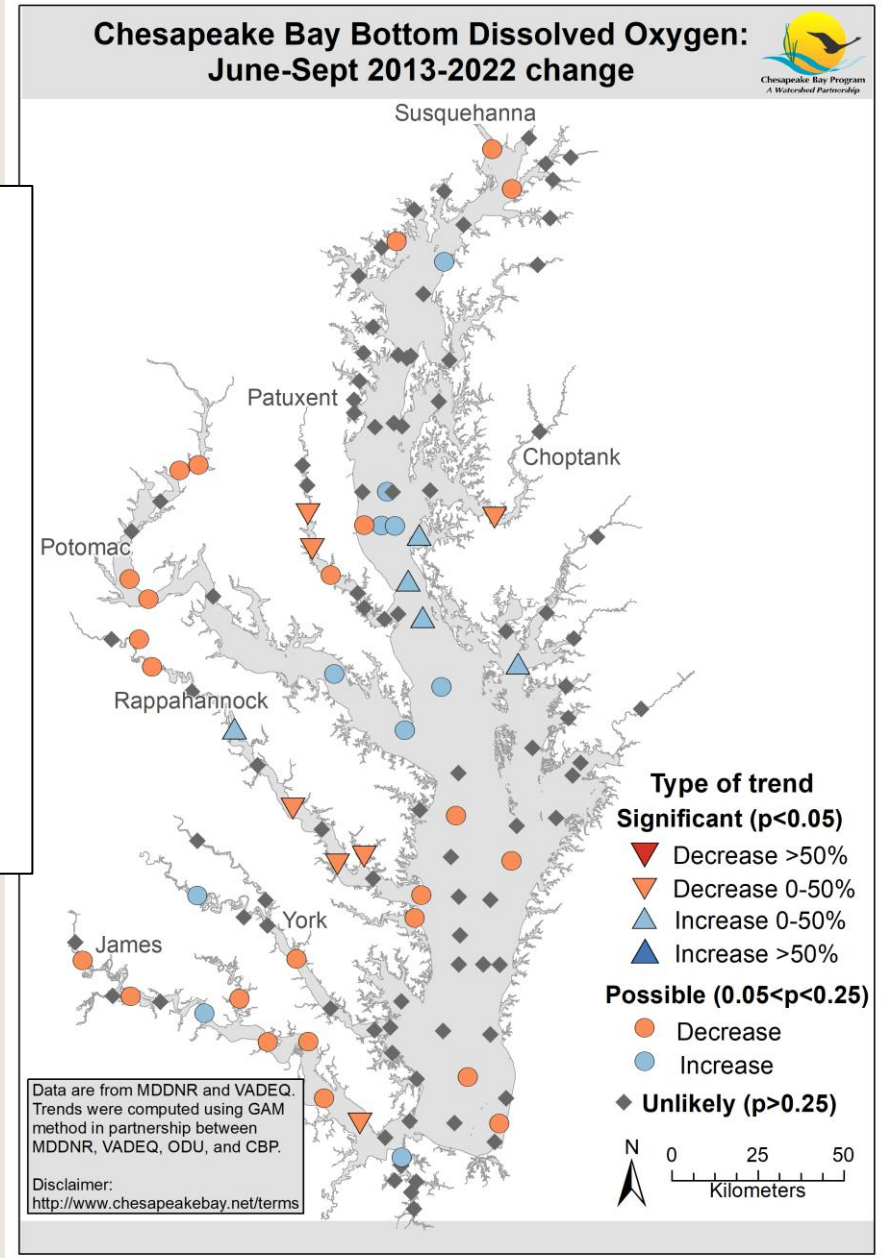
- In both seasons, trends have improved from the long- to short-term.
- Slightly better bay-wide trends in spring than summer.

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

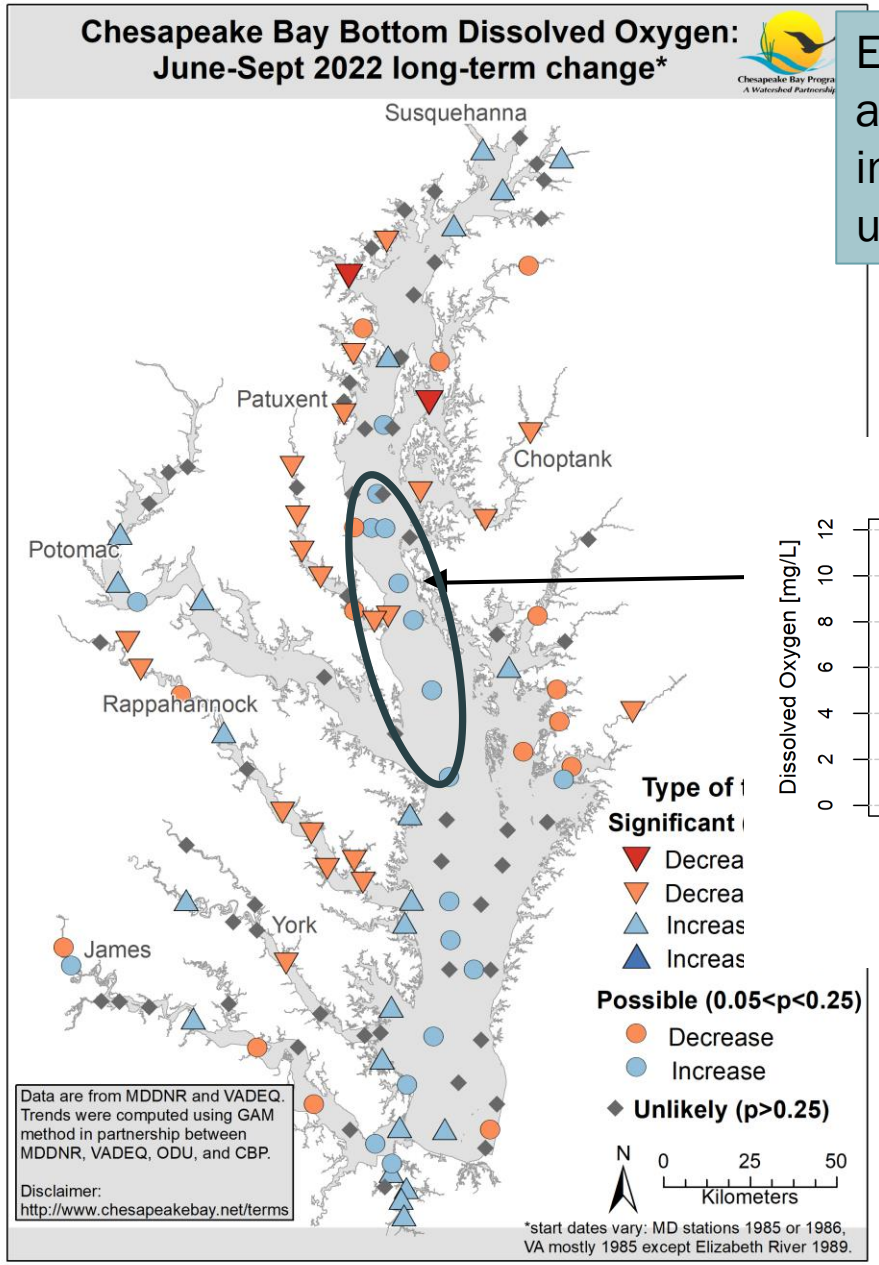
Bottom Summer DO



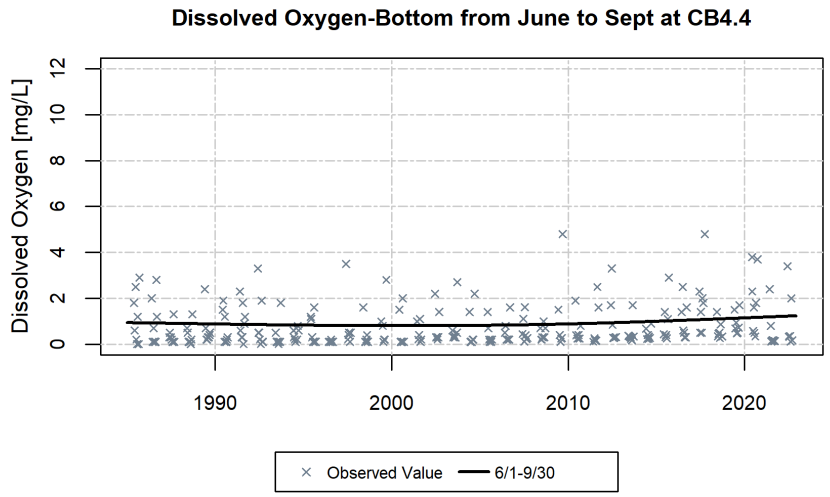


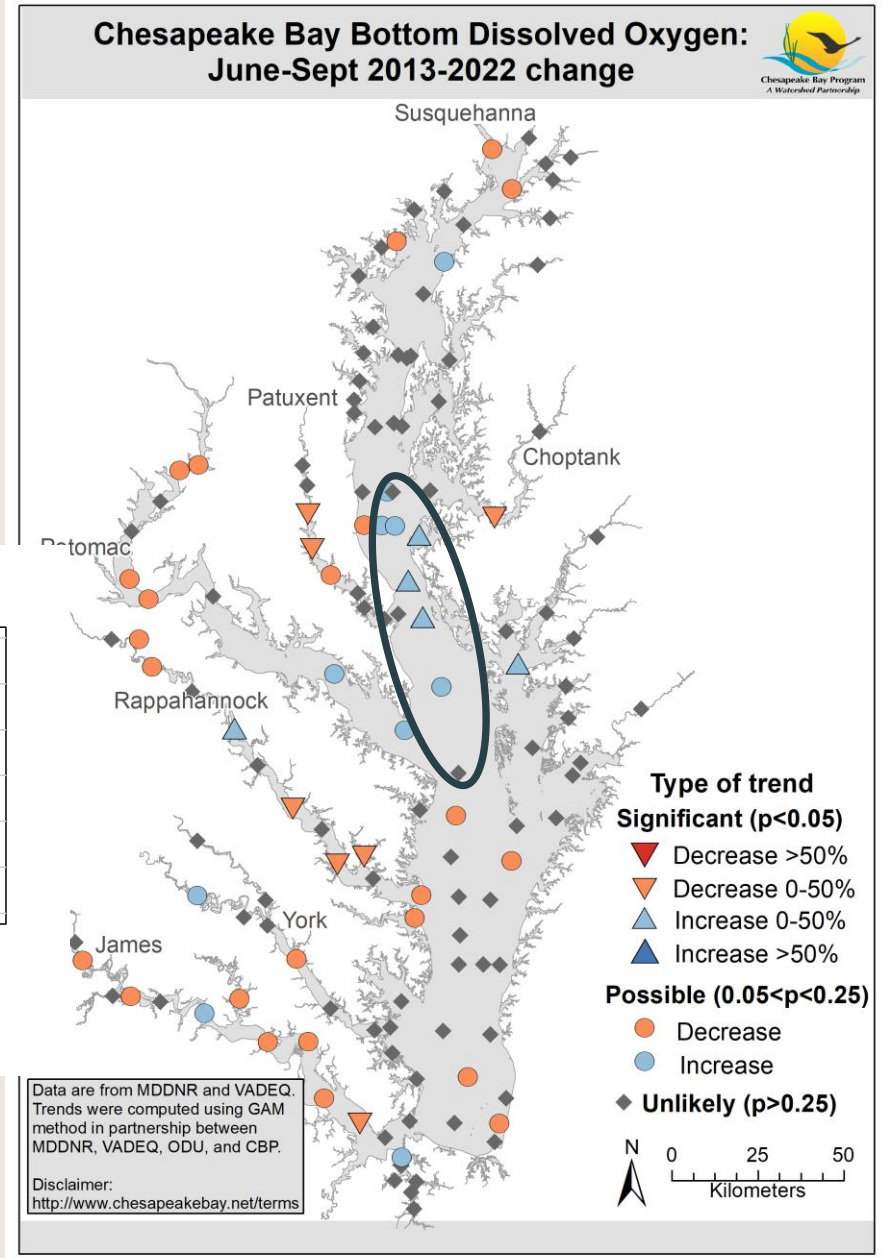


Bottom Summer DO

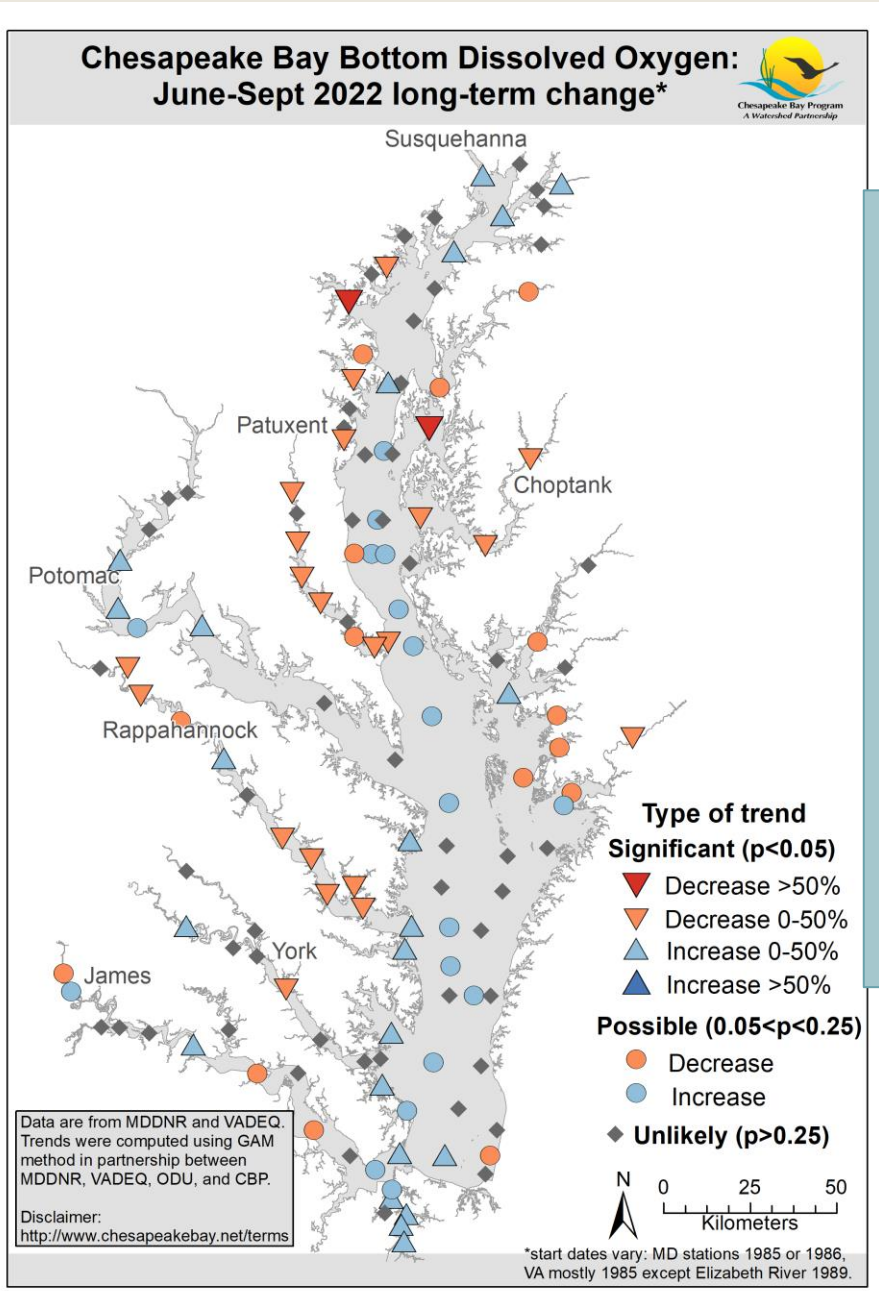


Example: Key areas in mainstem and nearby regions where increasing DO is starting to show up in the trends.

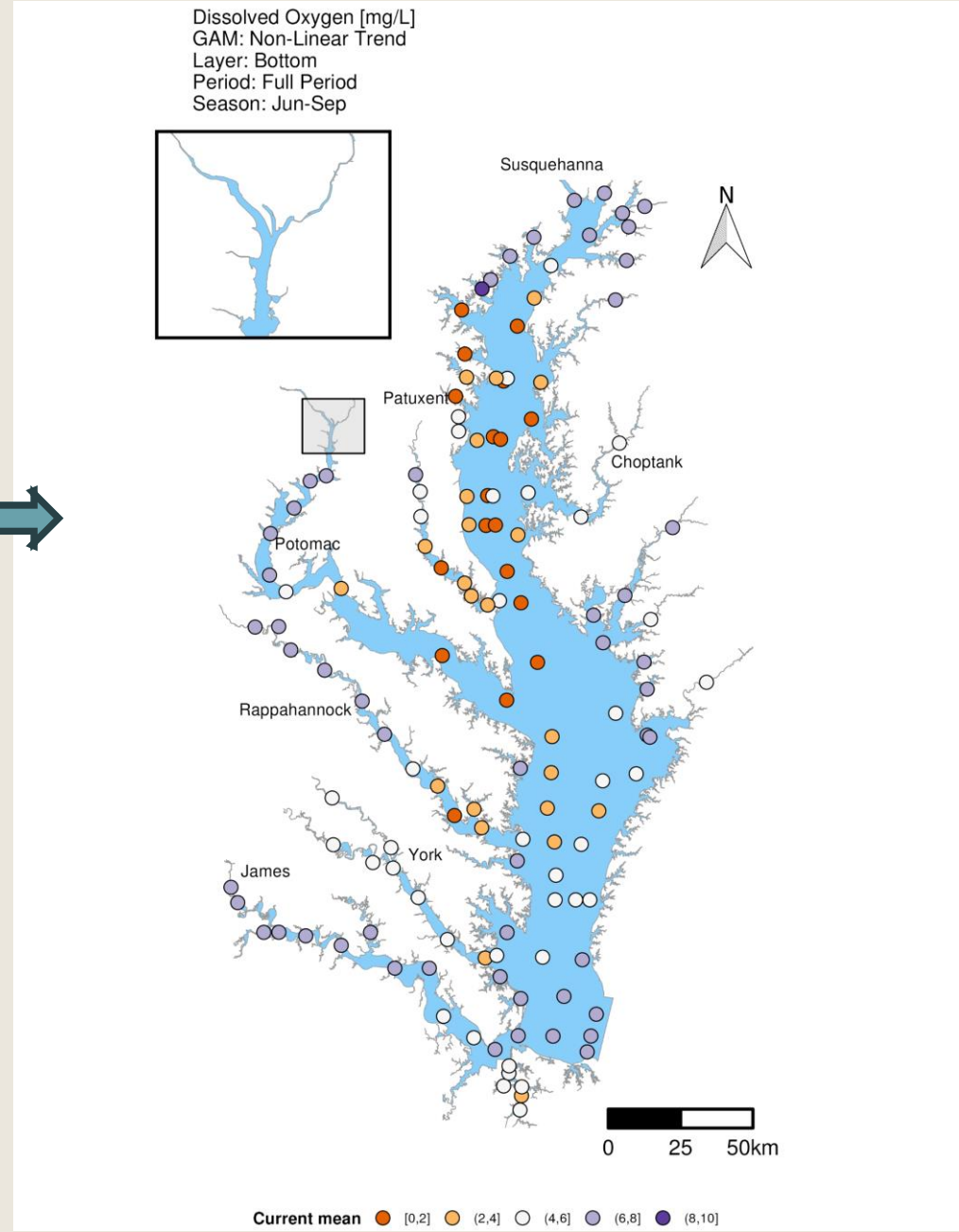




Combo conc & trend map ideas



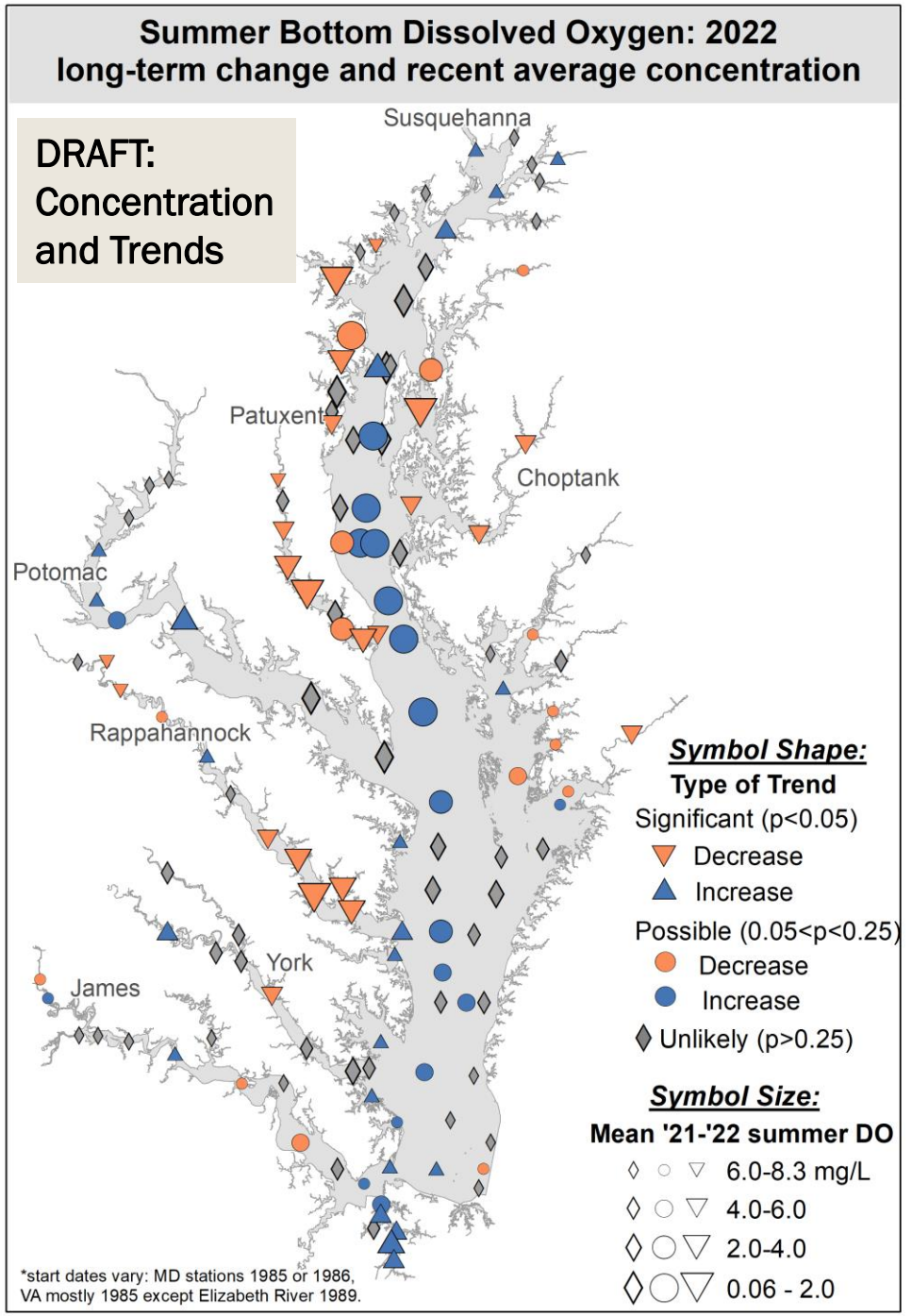
- We have separate maps on baytrendsmap that show the recent average concentrations
- Also, MDDNR already does status & trends on their website with symbols like: ▲■



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

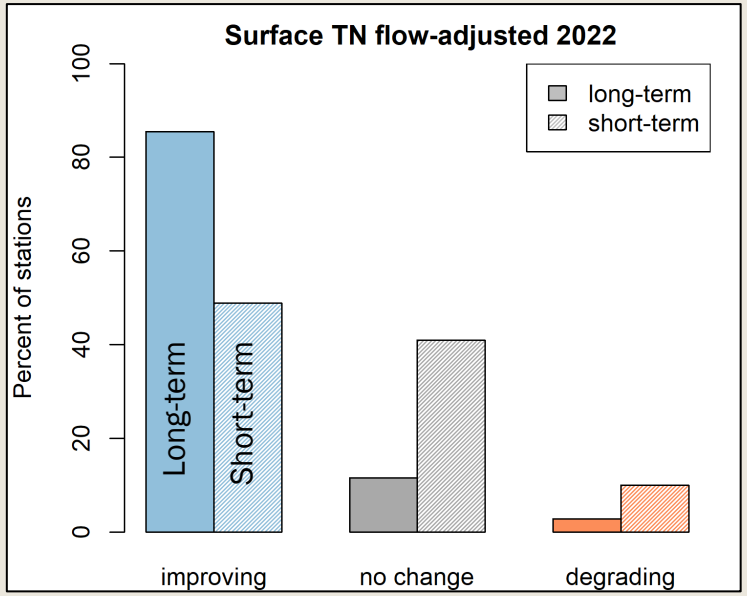
Combo conc & trend map ideas

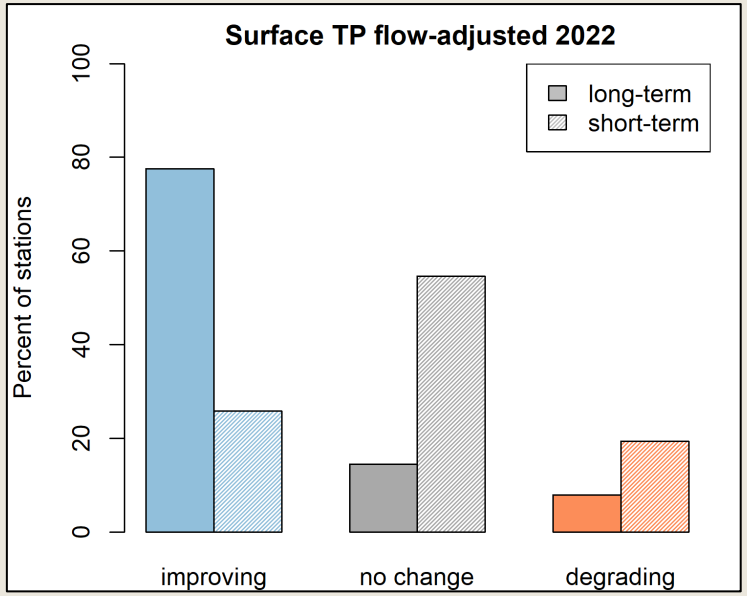
- One baywide idea: Scale size of symbols by average 2021-2022 concentration
- For DO, larger symbols are smaller summer bottom DO

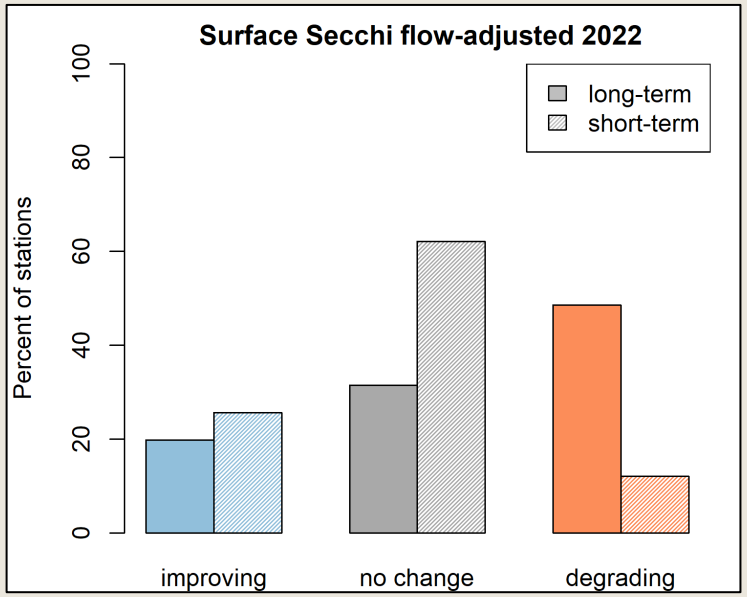


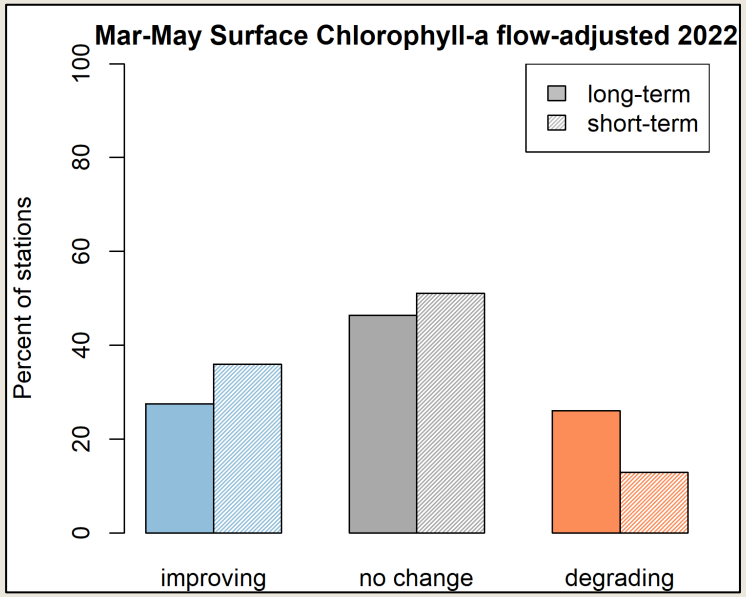
2022 Summary

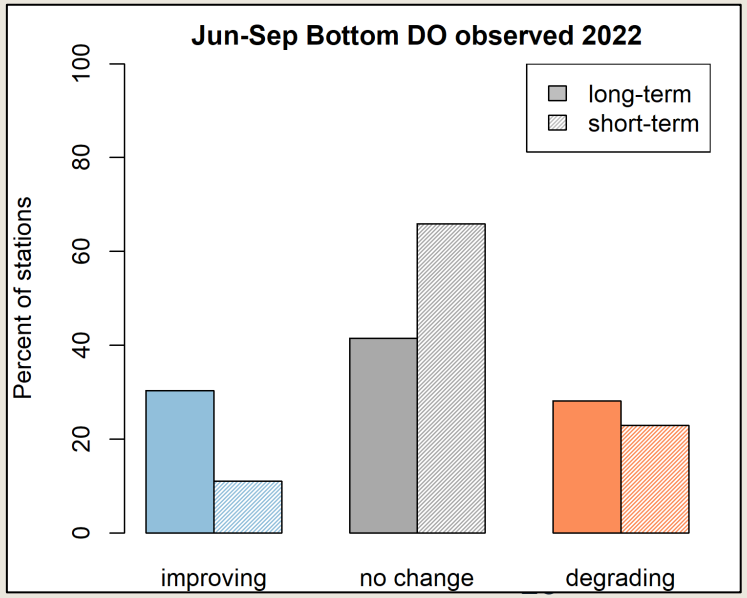
- Nutrient trends mostly improving over the long-term with some leveling-out over the short-term.
- The number of stations with degrading conditions have decreased over the short-term for Secchi, chlorophyll *a,* and DO.
- Overall patterns consistent with last few years.











Acknowledgements

- 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 and Karl Berger (MWCOG);*
  - *Breck Sullivan (USGS), Alex Gunnerson (CRC)*
- Baytrends/GAM implementation and updates: Jeni Keisman (USGS); Elgin Perry; Jon Harcum and Erik Leppo (Tetra Tech)

Summer Chlorophyll *a*

Surface

Flow-adjusted