# 2021 Tidal Trends Summary

Rebecca Murphy (UMCES/CBP)

With results generated by Mukhtar Ibrahim (MWCOG), Renee Karrh (MDDNR) and Mike Lane (ODU)

Data from DOEE, MDDNR, and VADEQ

ITAT meeting

Oct. 26, 2022

# 2021 Tidal Trend Results

- Long-term (1980s-2021) and short-term (2012-2021) change:
  - Annual surface & bottom TN, TP, water temperature, salinity
  - Annual & SAV season Secchi depth
  - Spring & summer, surface & bottom: Chlorophyll *a*
  - Summer surface & bottom DO
- 1999-2021 and short-term (2012-2021) change :
  - Annual surface & bottom TSS, DIN, PO4

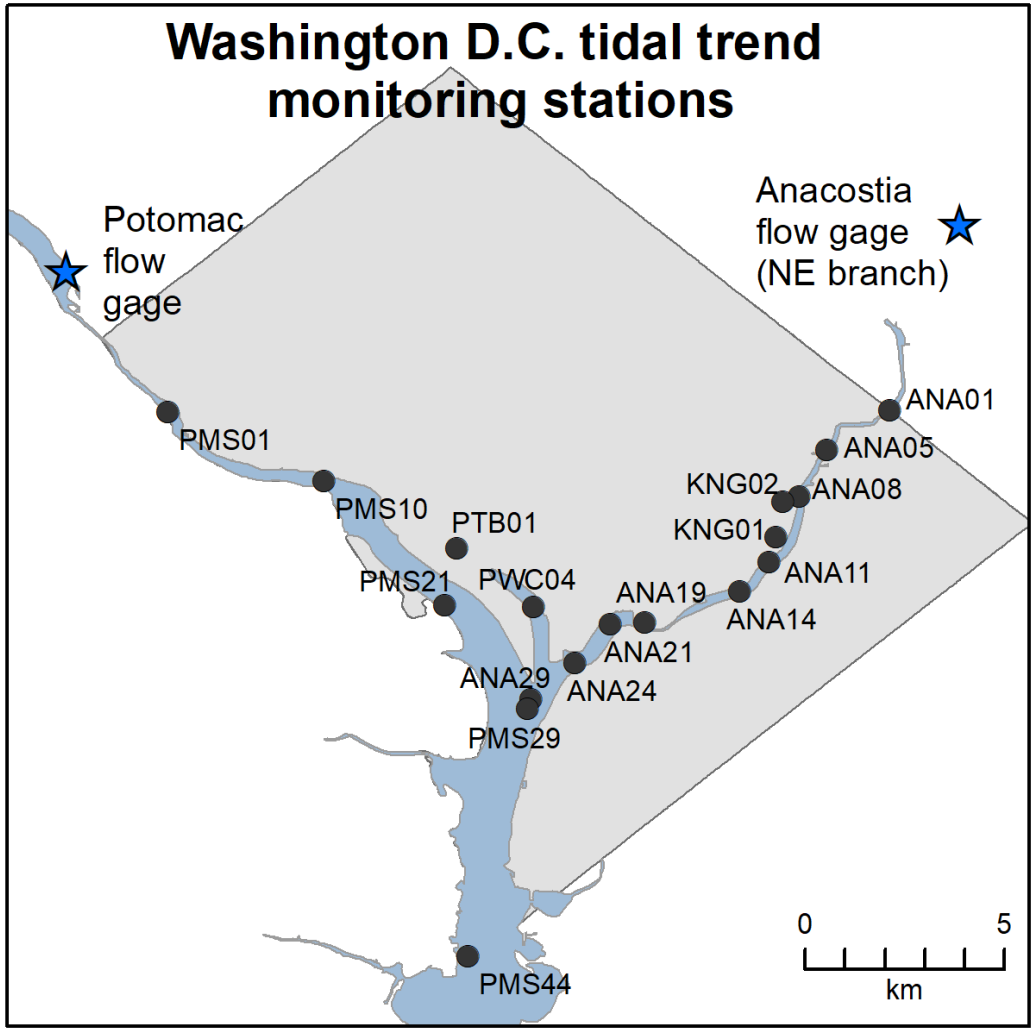
x2 → (a) Observed conditions, and (b) flow- or salinity-adjusted conditions

# *New this year:* Addition of Washington D.C. tidal trends

- Team effort:
  - Efeturi Oghenekaro, Blessing Edje and George Onyullo from DOEE – *provided data, guidance, testing & DOEE approval*
  - Mukhtar Ibrahim and Karl Berger from MWCOG – *ran baytrends, tested options, finalized the results*
  - Breck Sullivan, Alex Gunnerson, and myself from CBP – *training, maps*

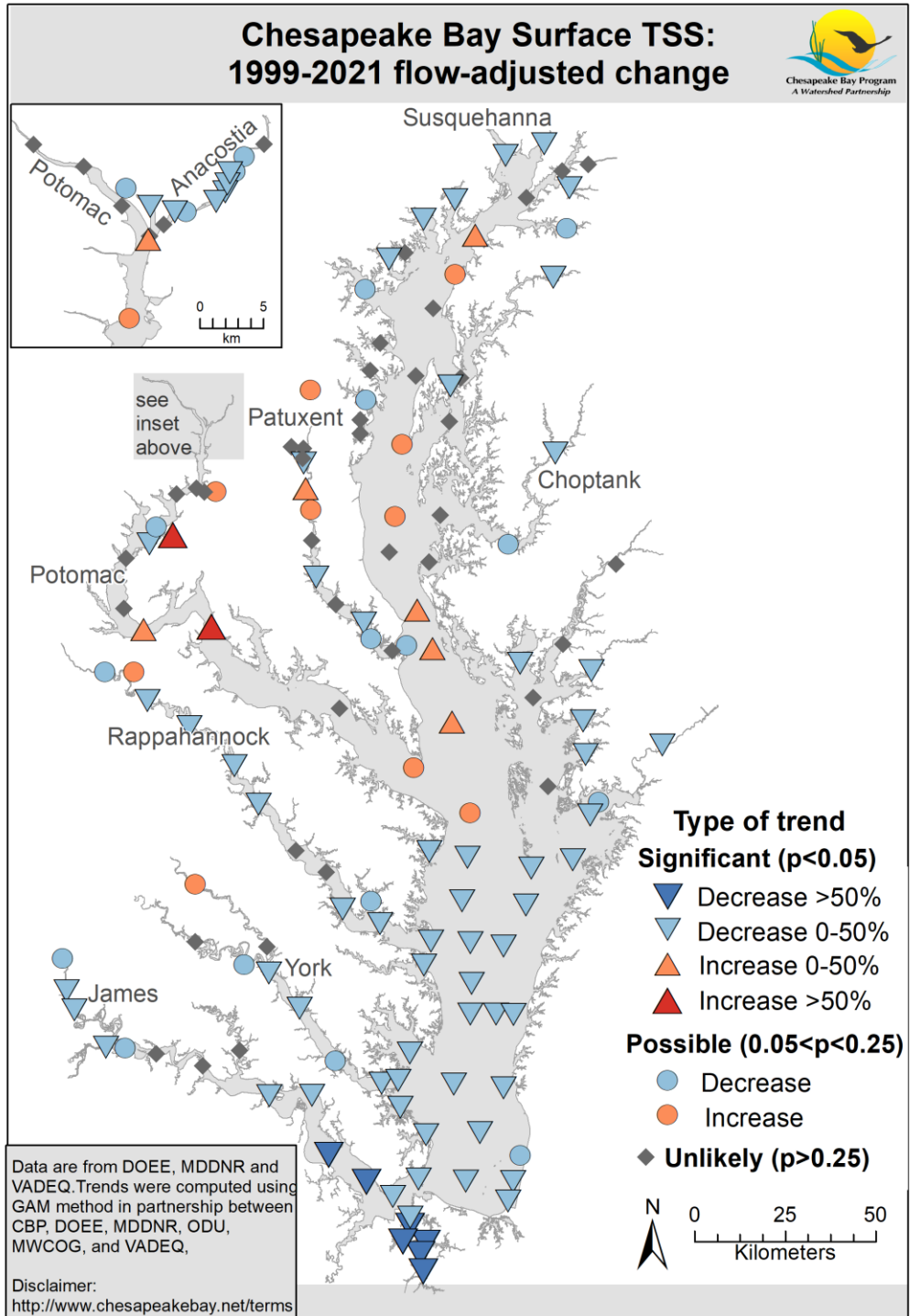
- Parameters & time periods for 18 stations
  - Annual Secchi depth
  - Spring & summer, surface Chlorophyll *a*
  - Summer surface DO
  - Annual surface TSS & PO4
  - Annual surface DIN – for graphs only

- Flow adjustment: Used either Potomac USGS gage or NE Branch Anacostia



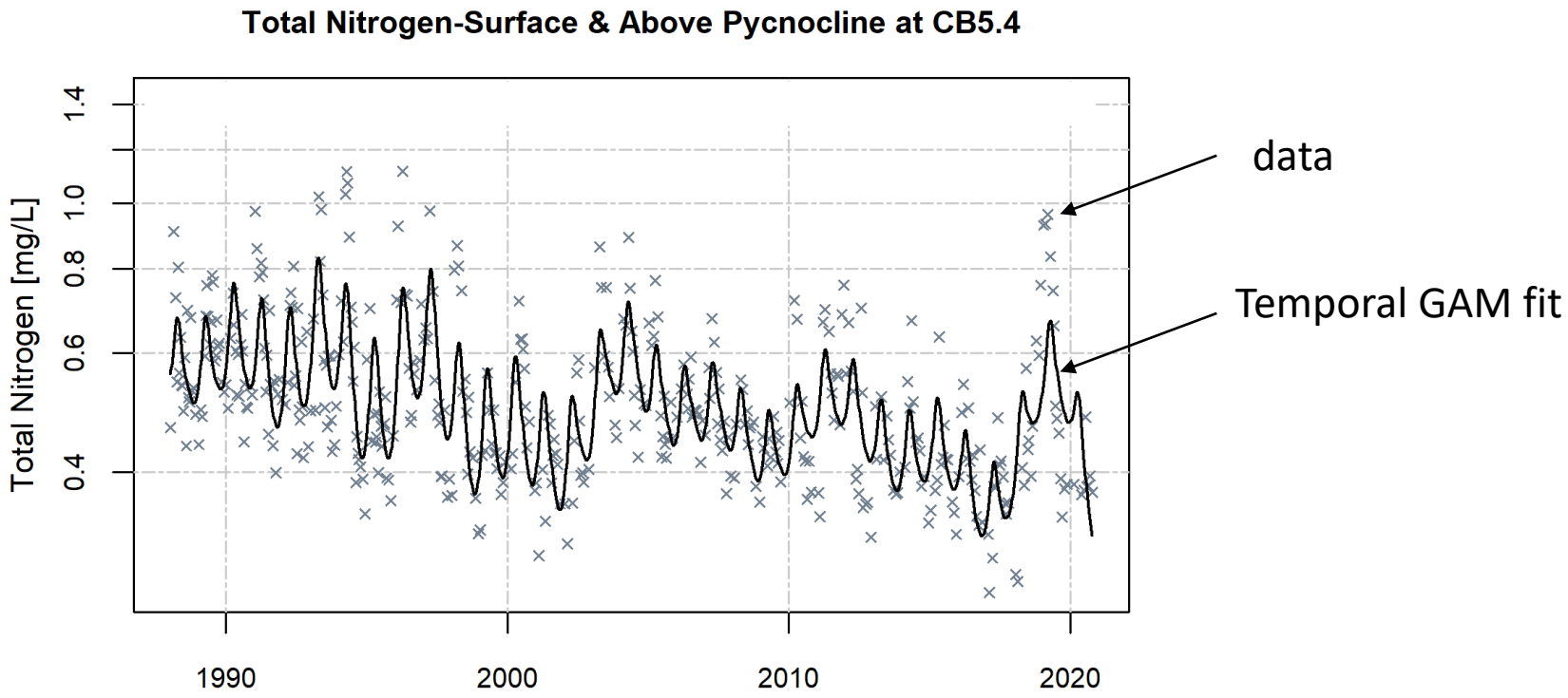
# Washington D.C. stations

- Results presented on the applicable maps for this year
- Future work could include:
  - Additional parameters,
  - Analysis of the results with the team, and
  - Inclusion in Potomac Tributary Report during next revision.



# Tidal Trends/GAM* method review

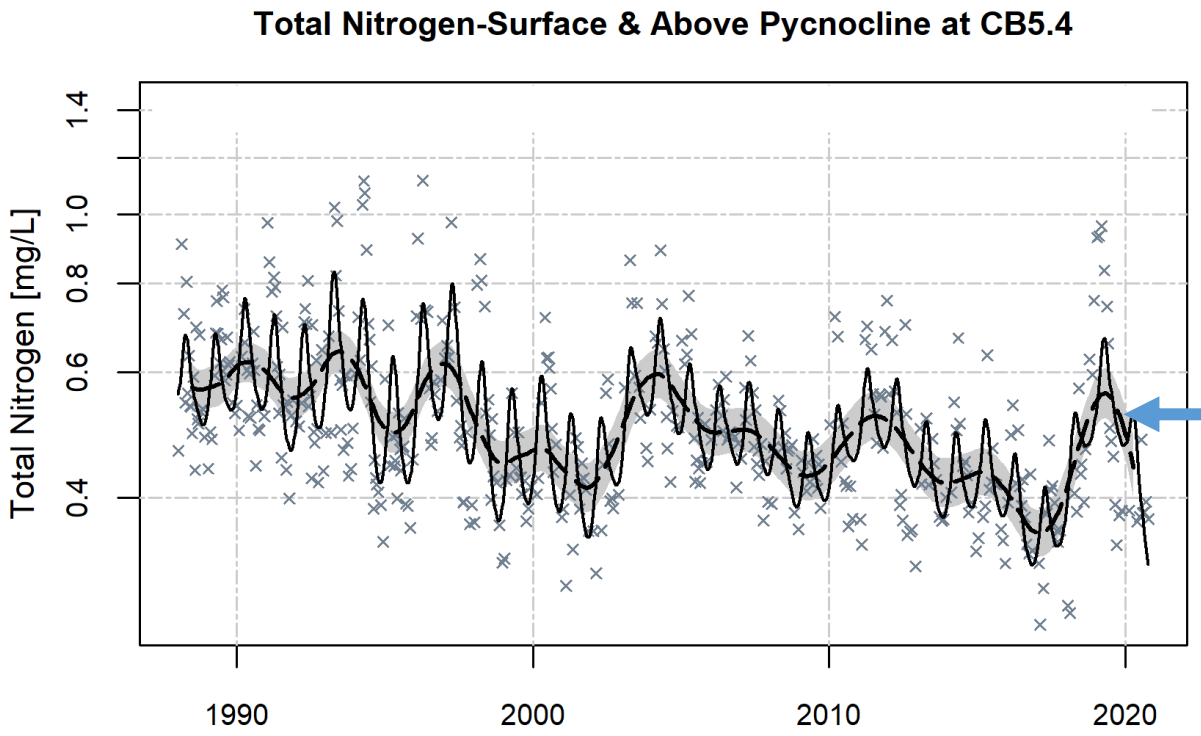
TN = s(doy) + s(date)+ interaction(doy,date)




*Generalized Additive Models

# Tidal Trends/GAM method review

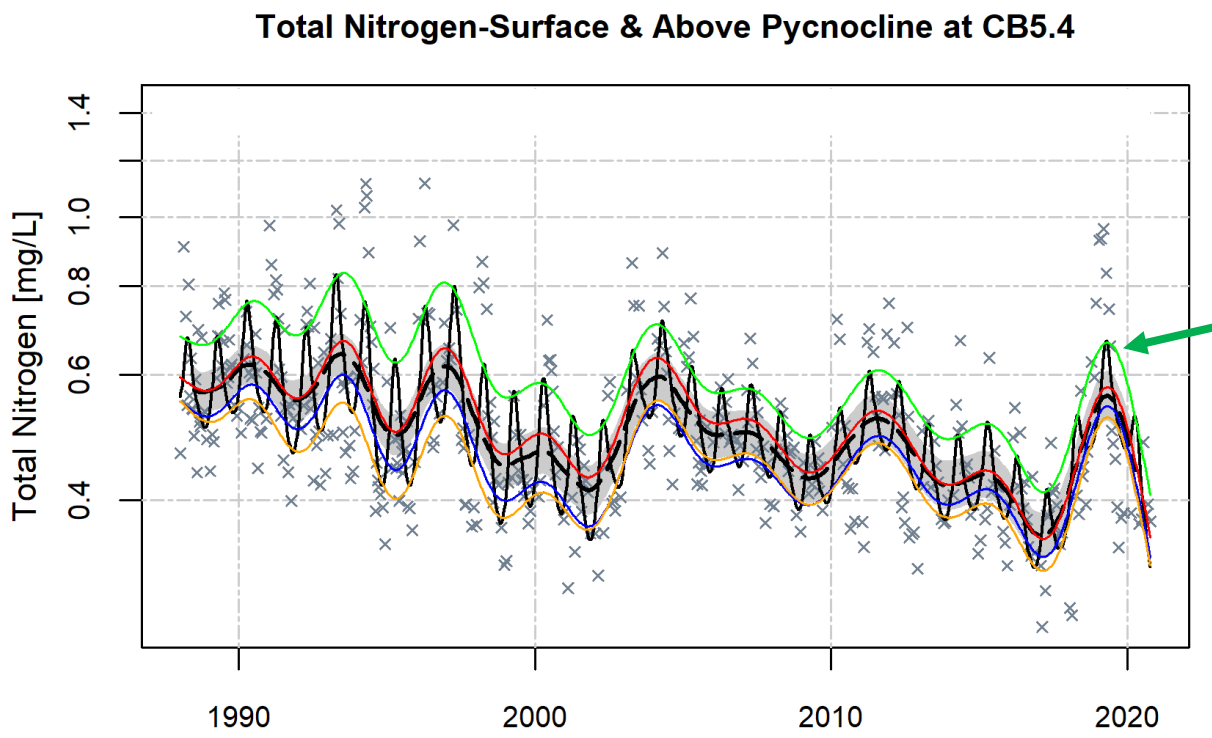
TN = s(doy) + s(date)+ interaction(doy,date)




Seasonal mean and 95% confidence interval on the mean

# Tidal Trends/GAM method review

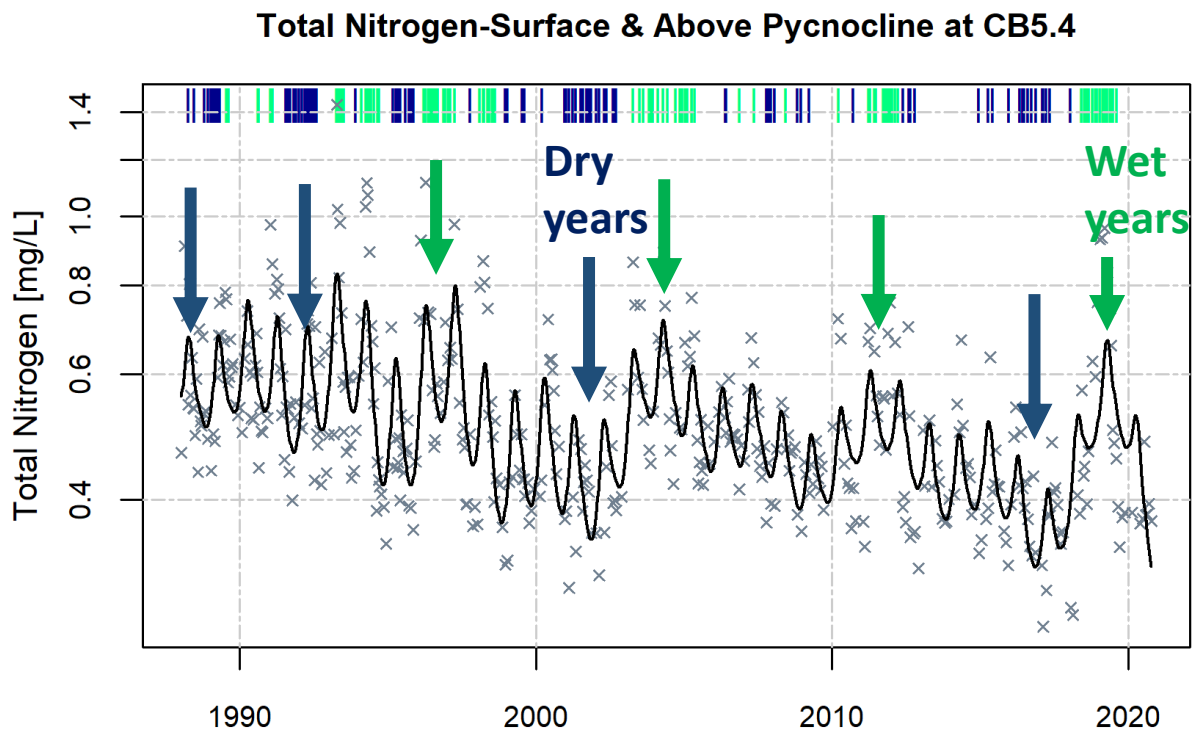
TN = s(doy) + s(date)+ interaction(doy,date)




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

# Tidal Trends/GAM method review

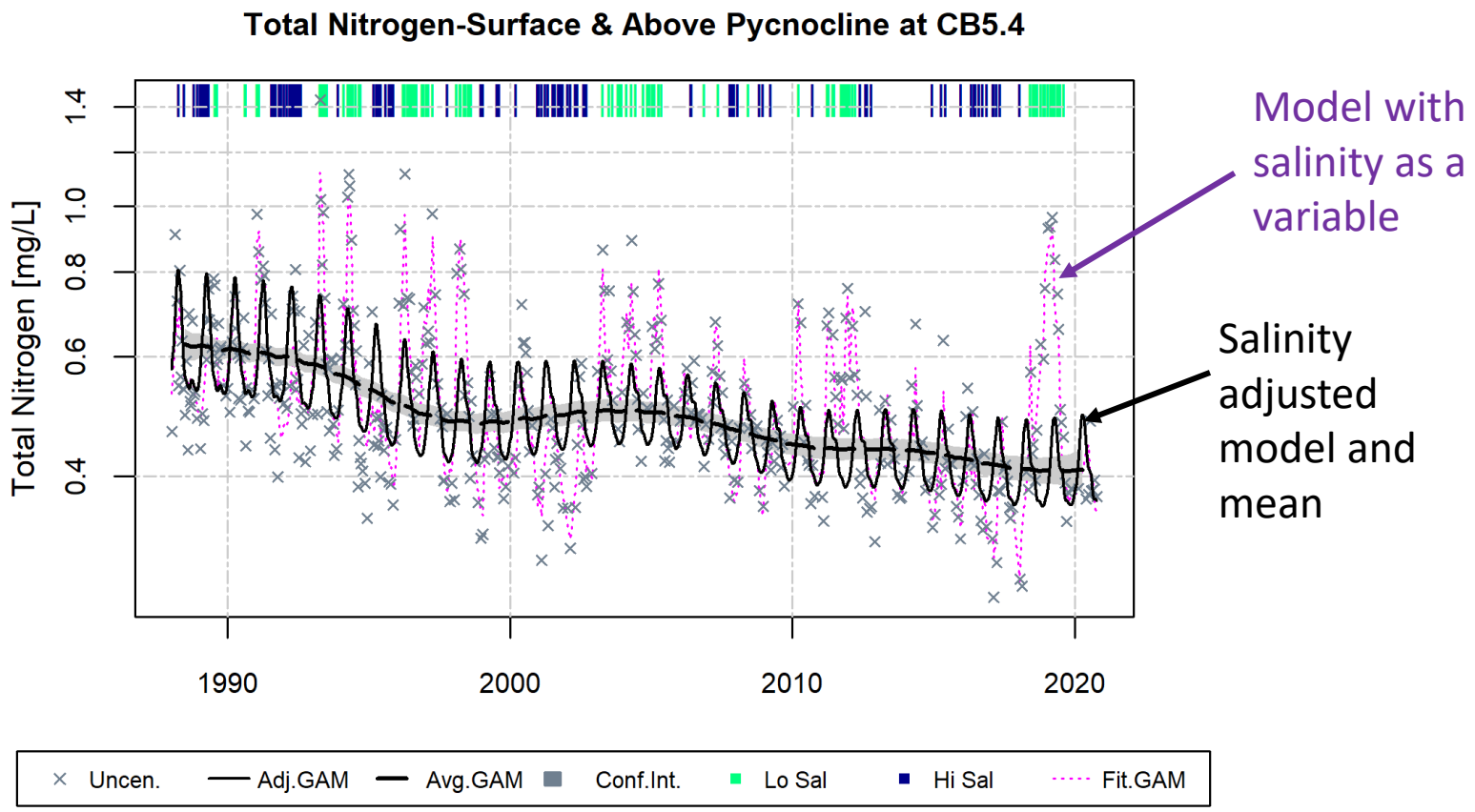
Is variability in river flow the cause of year-to-year fluctuations?




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)

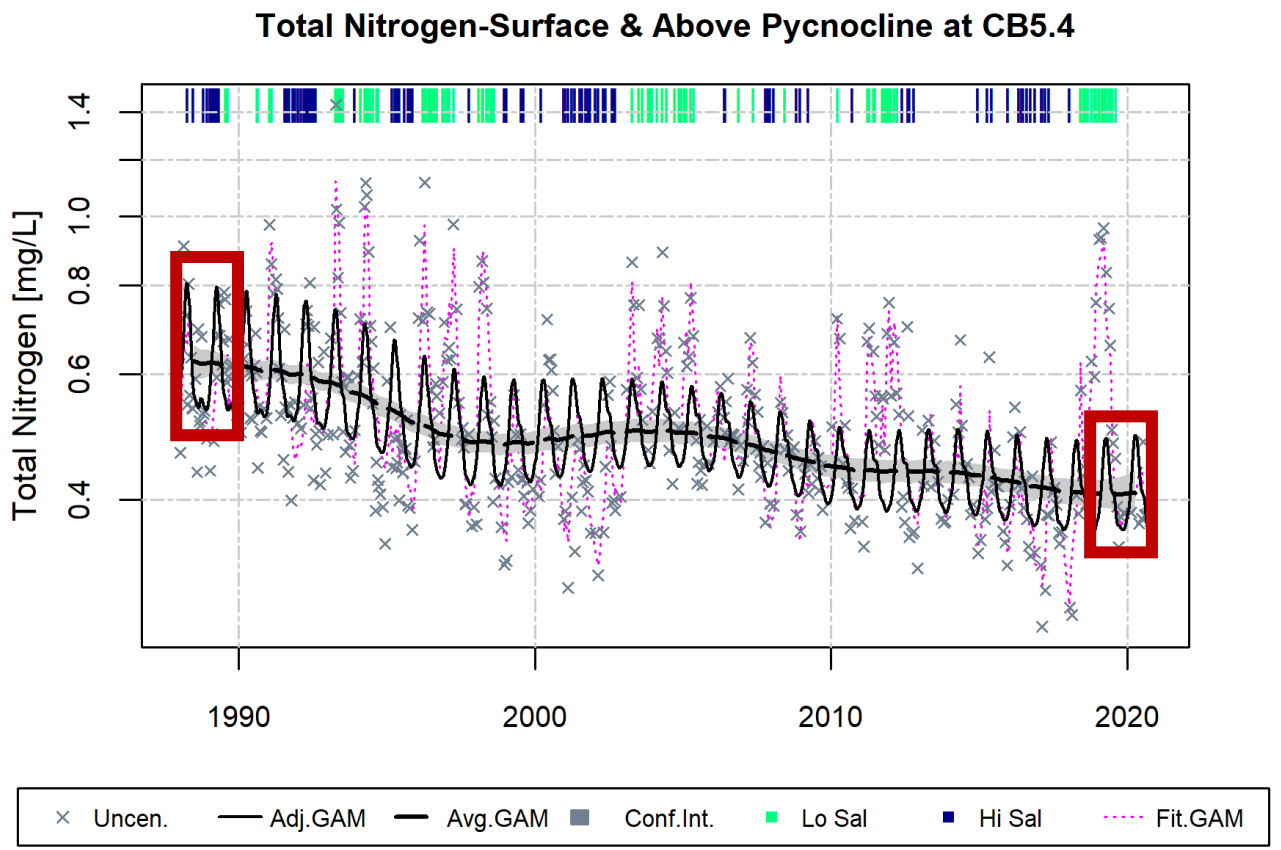



Model with salinity as a variable

Salinity adjusted model and mean

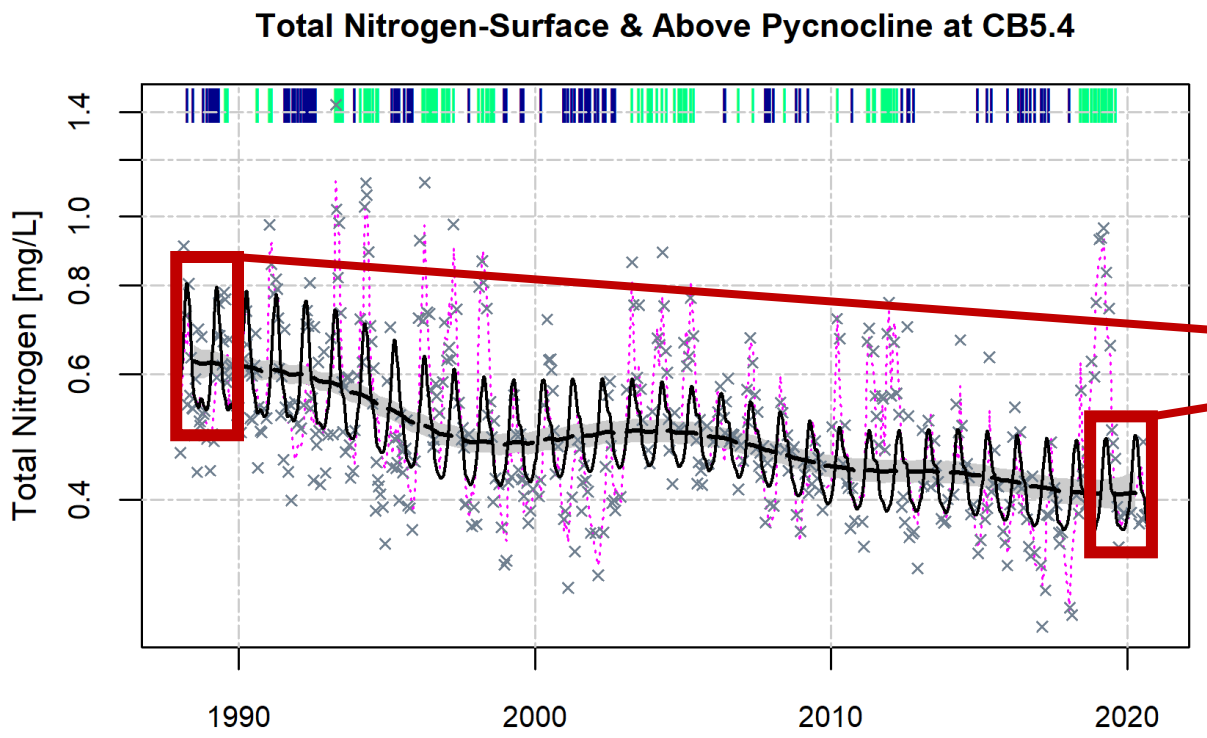
# Tidal Trends/GAM method review

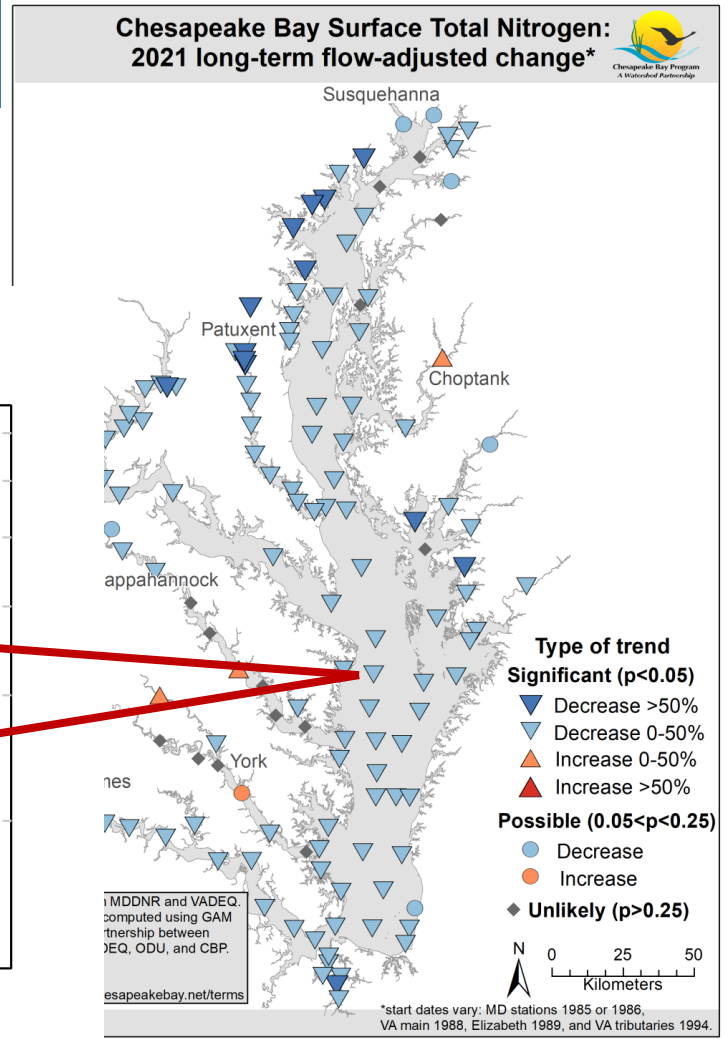
Percent change = -34%
p-value < 0.0001



# Tidal Trends/GAM method

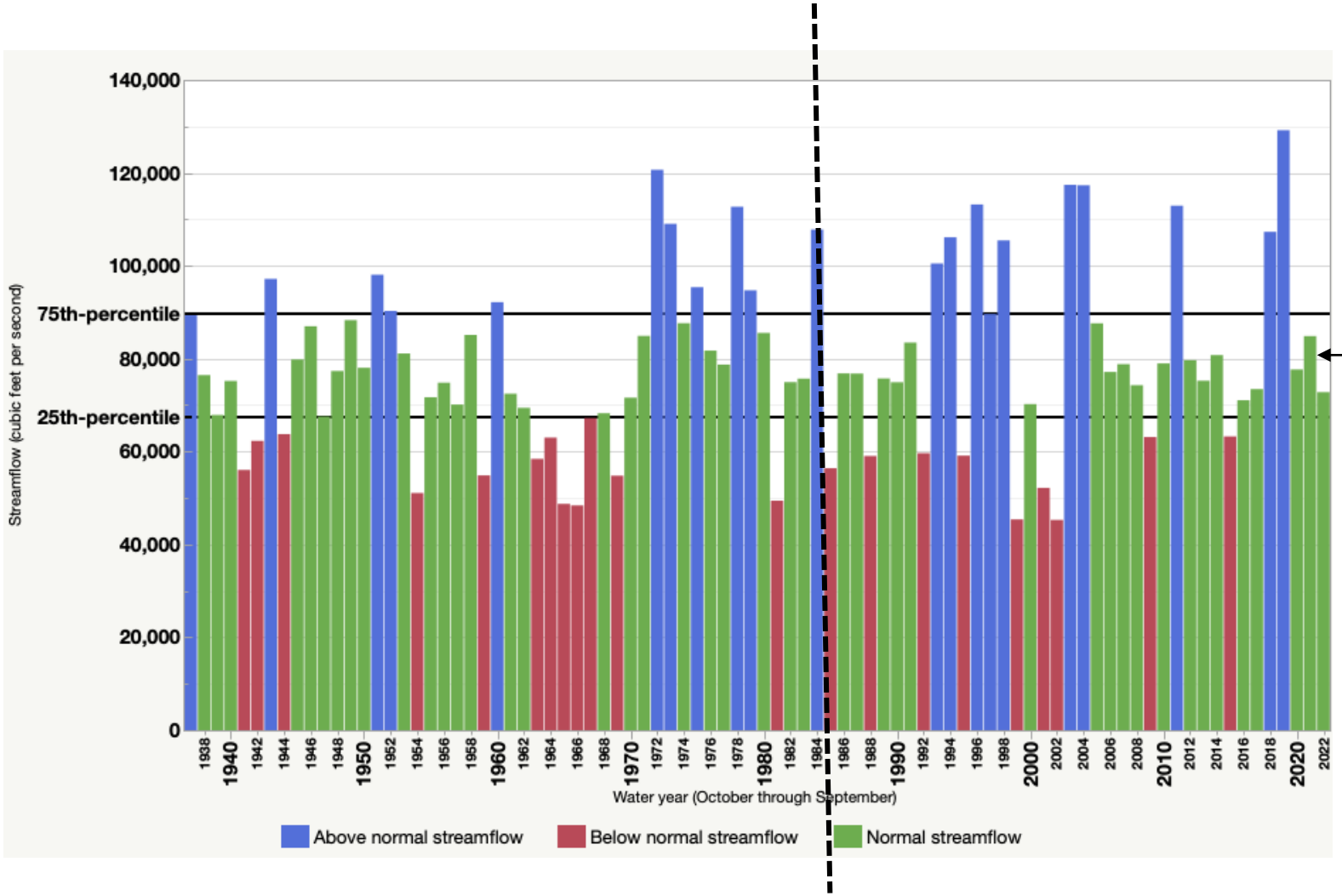
Percent change = -34%
p-value < 0.0001




Note graph is 2020, but result is the same for this station.

# Total monitored flow into tidal waters




2021 in the normal range

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

# 2021 Tidal Trend Results

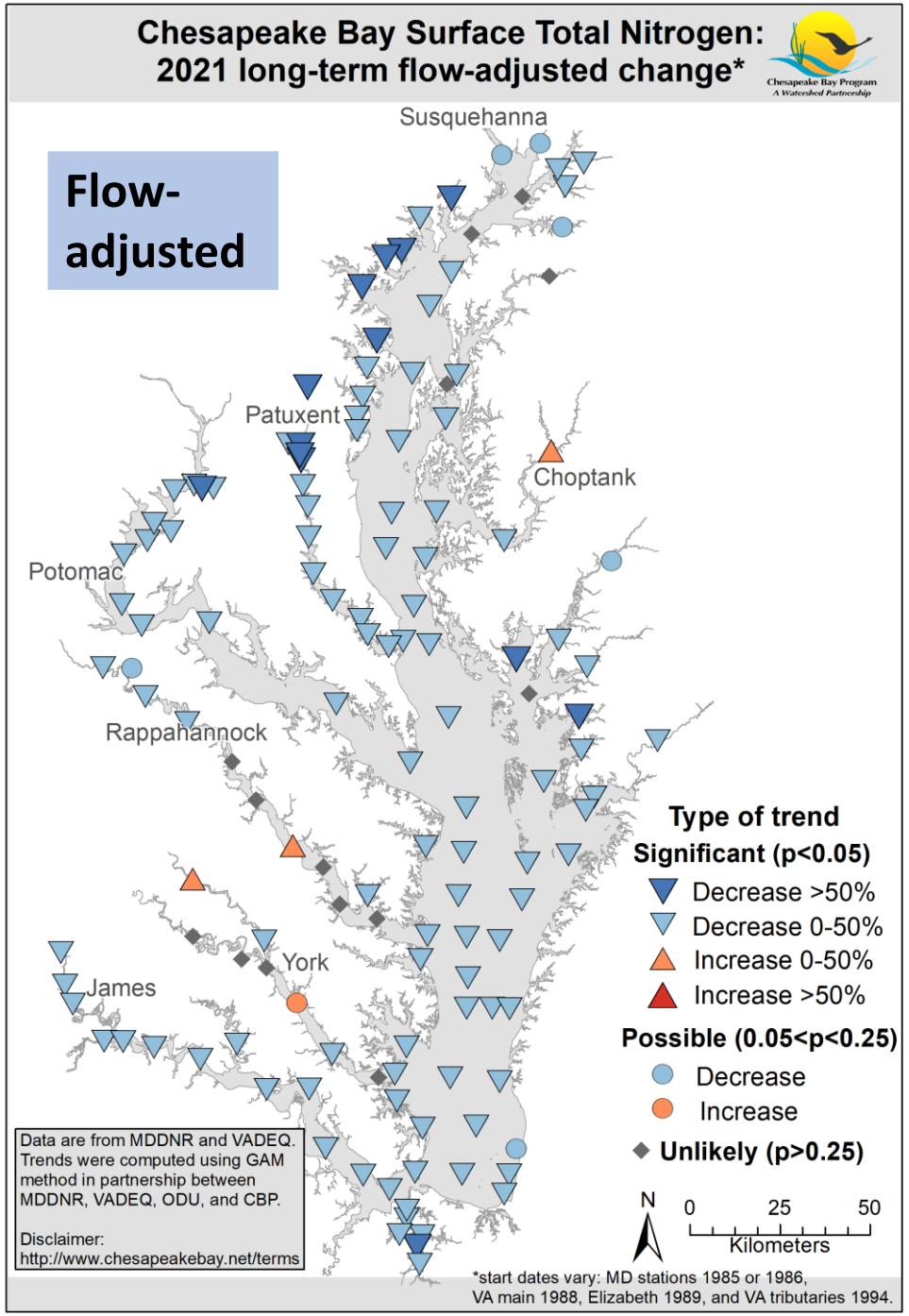
- Long-term (1980s-2021) and short-term (2012-2021) change:
  - Annual surface & bottom TN, TP, water temperature, salinity
  - Annual Secchi depth
  - Spring & summer, surface & bottom: Chlorophyll *a*
  - Summer surface & bottom DO
- 1999-2021 and short-term (2012-2021) change :
  - Annual surface & bottom TSS, DIN, PO4

x2 → (a) Observed conditions, and (b) flow- or salinity-adjusted conditions

# TN

## Surface

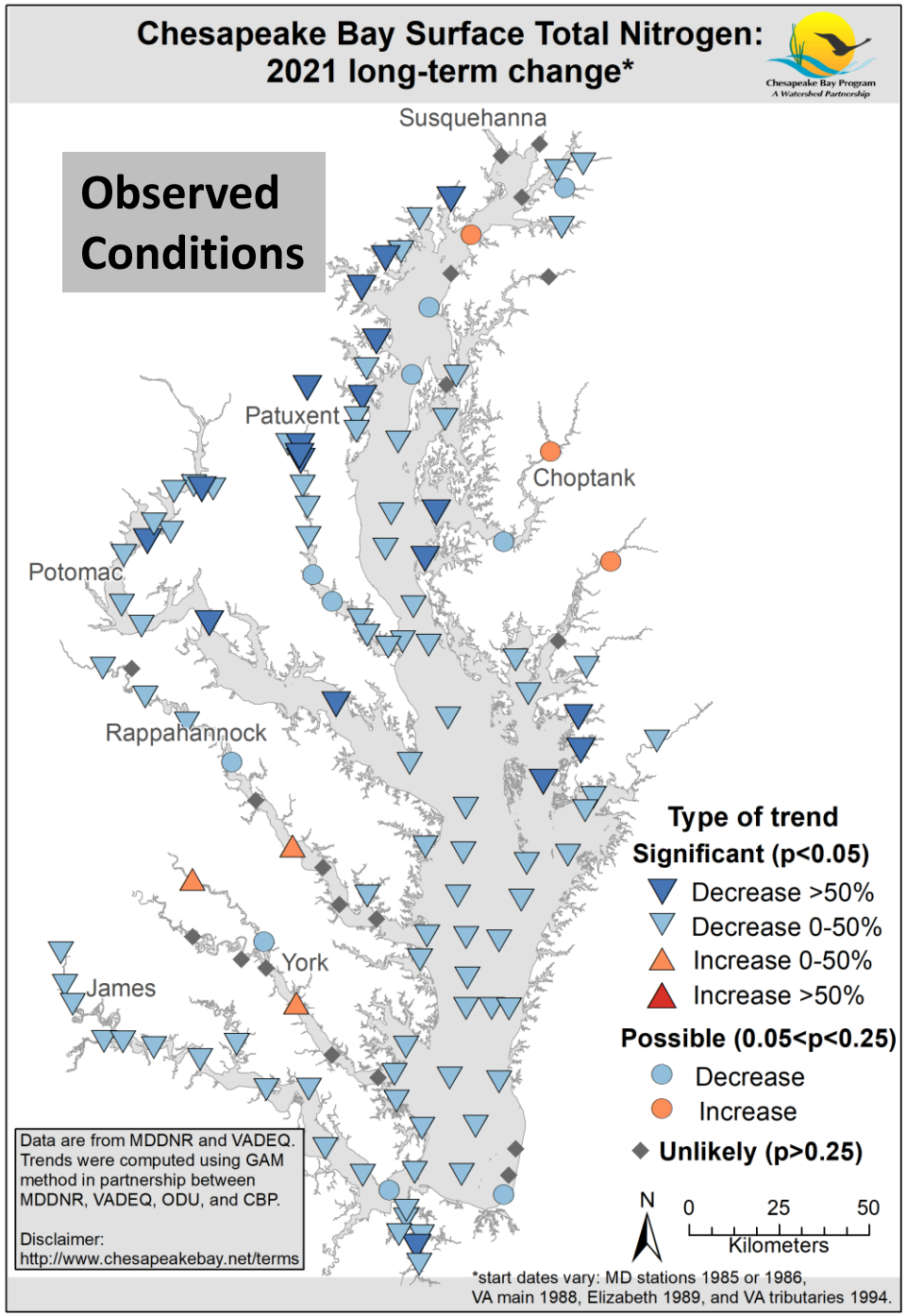
## Long-term

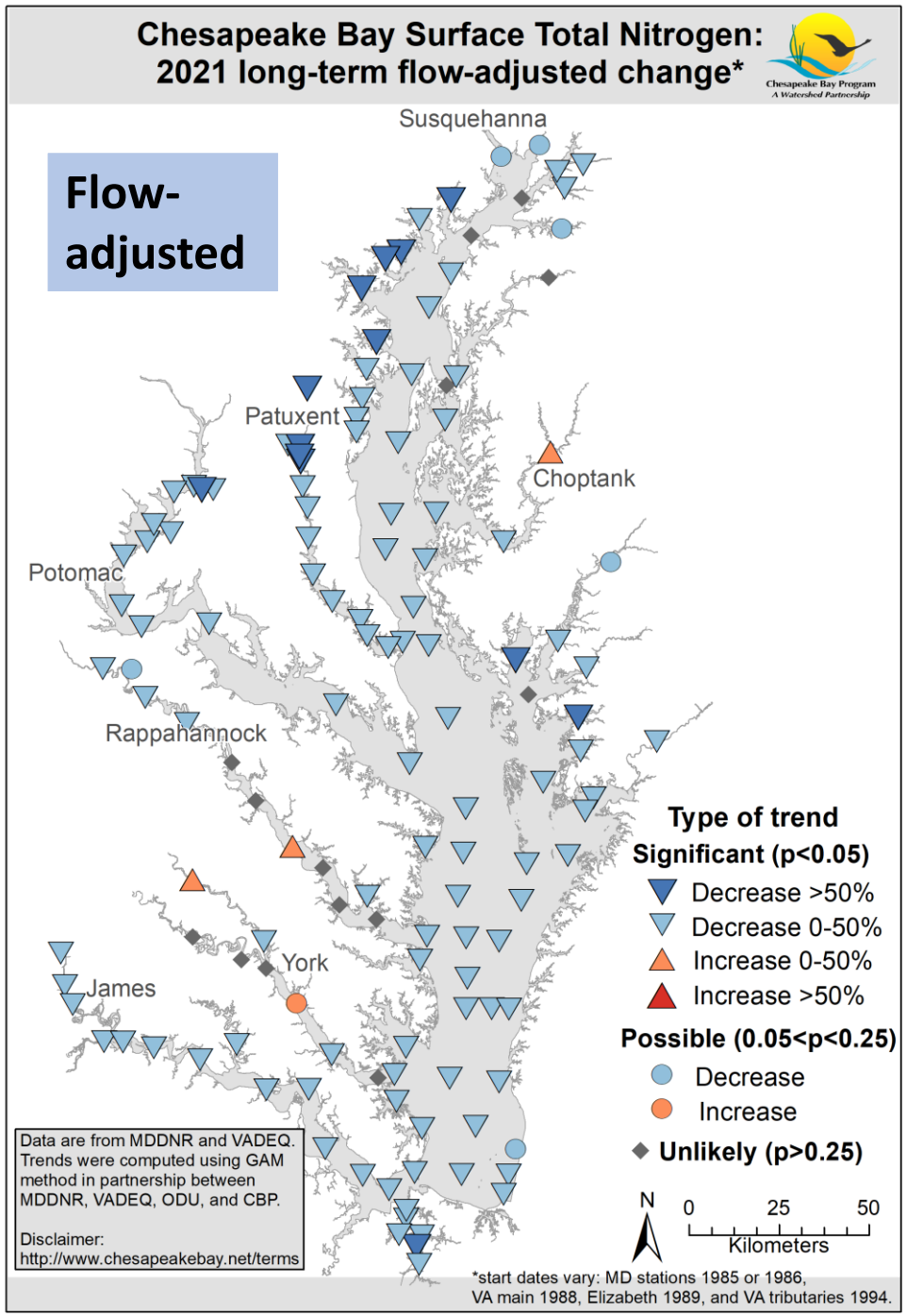


# TN

## Surface

## Long-term

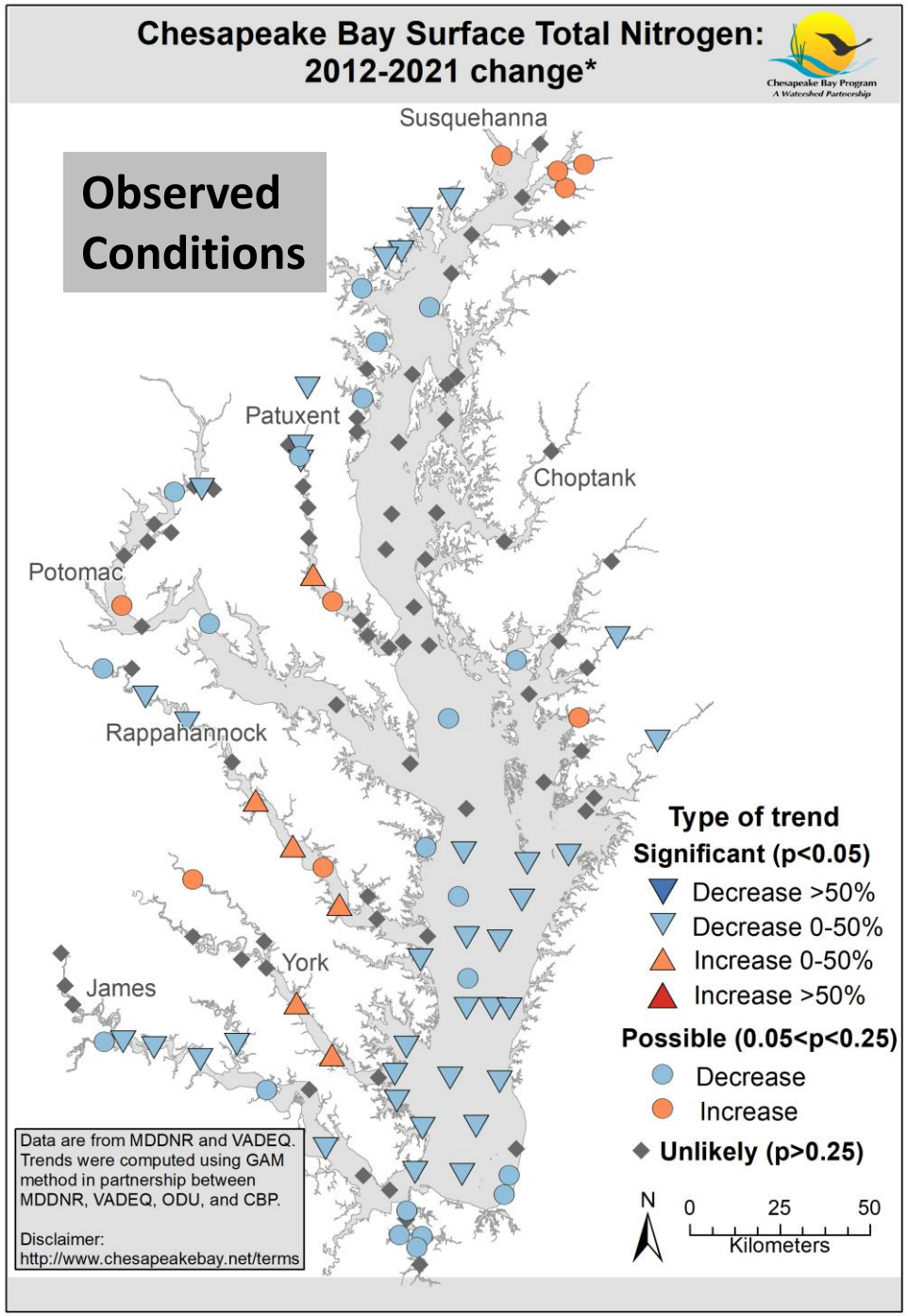


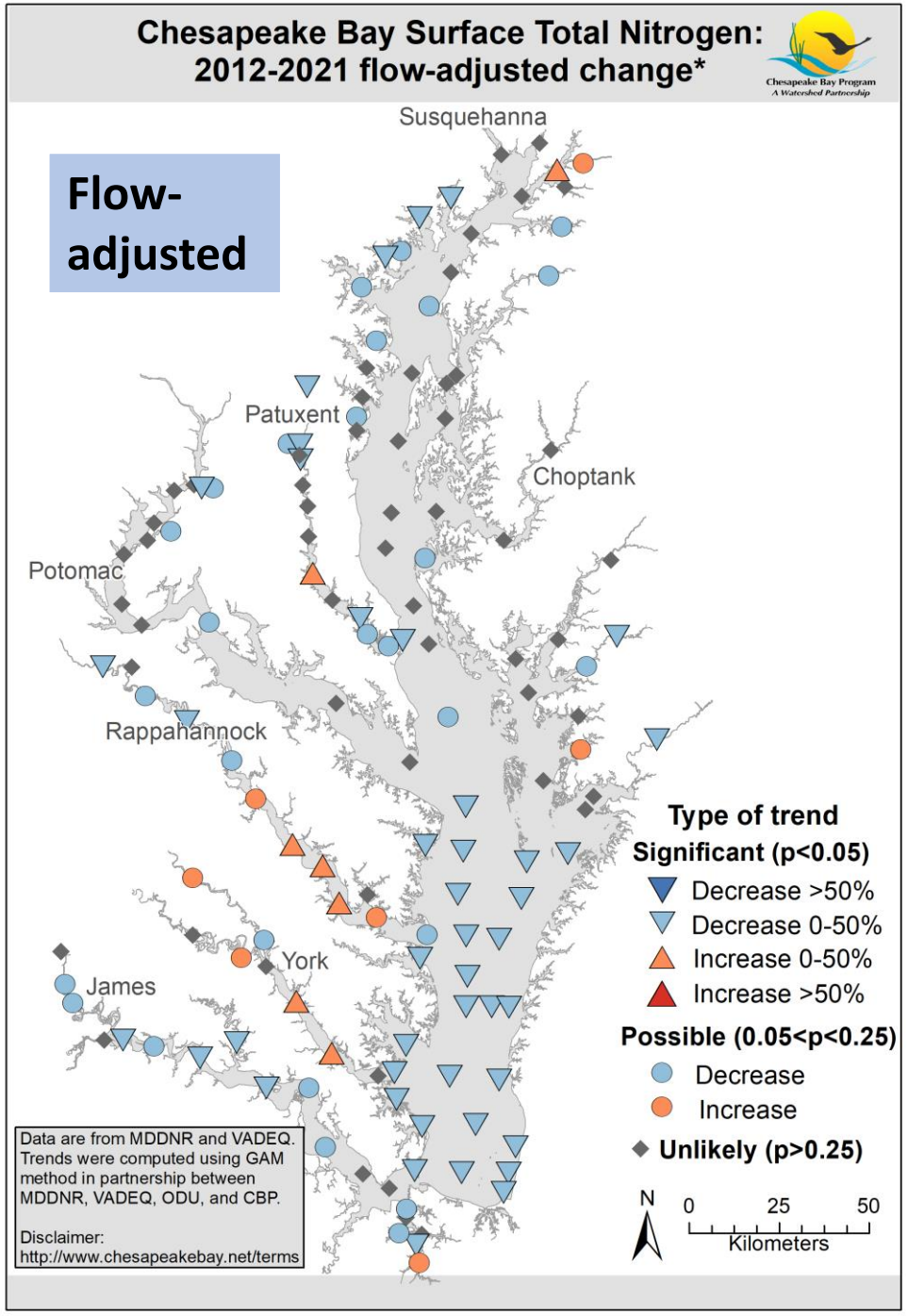



# TN

## Surface

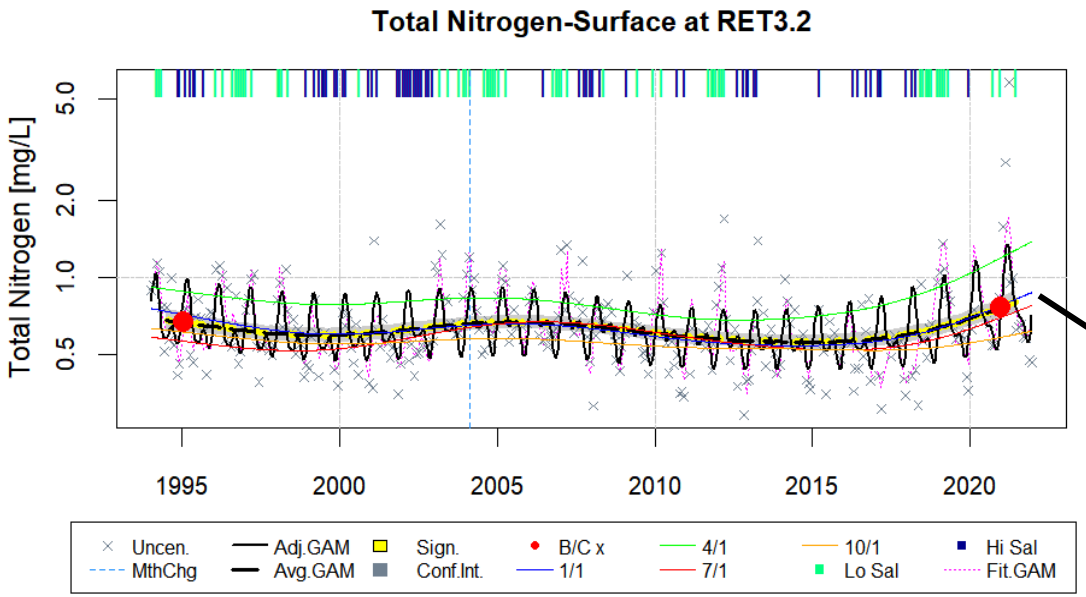
## Short-term



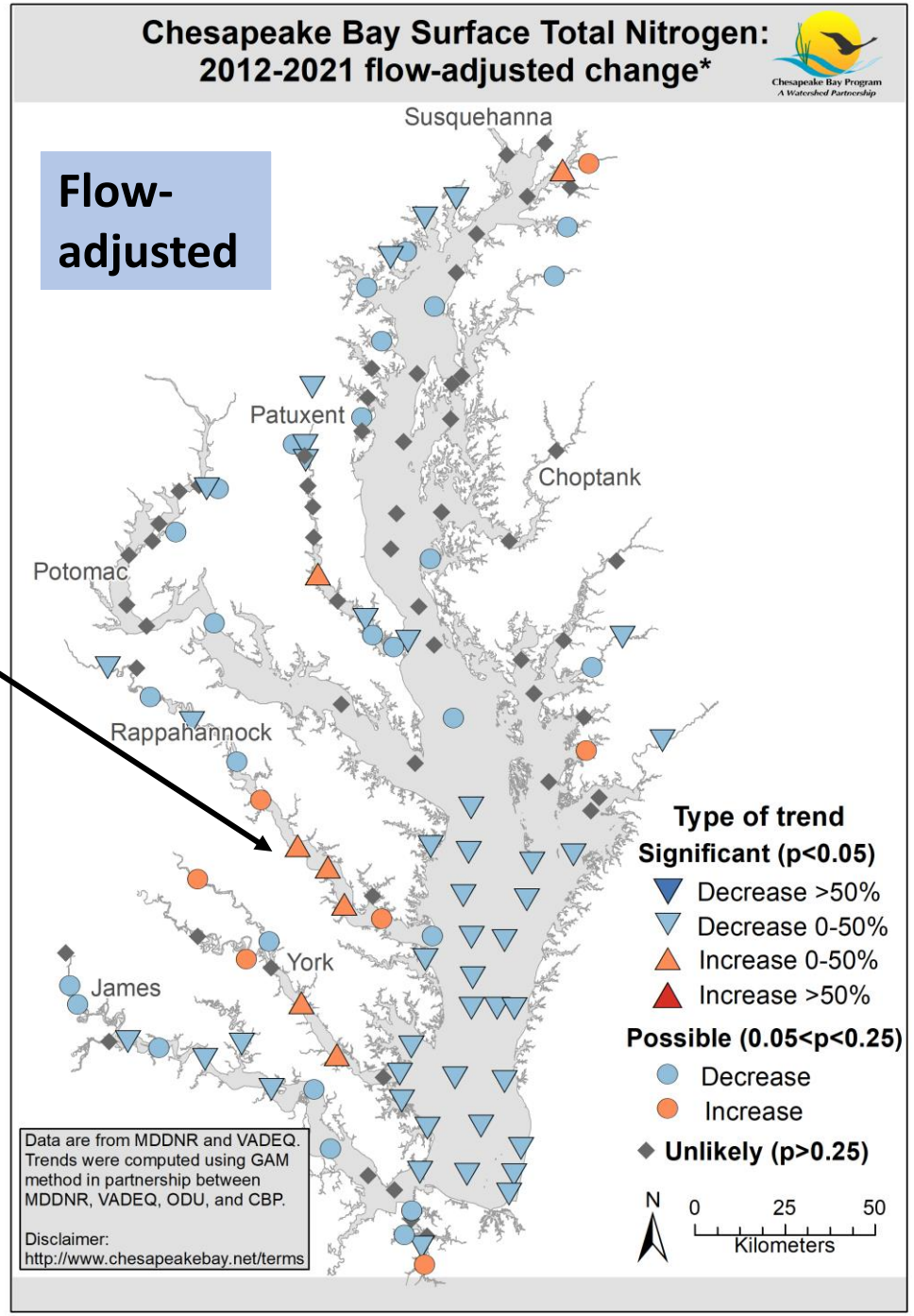



# TN

## Surface Example

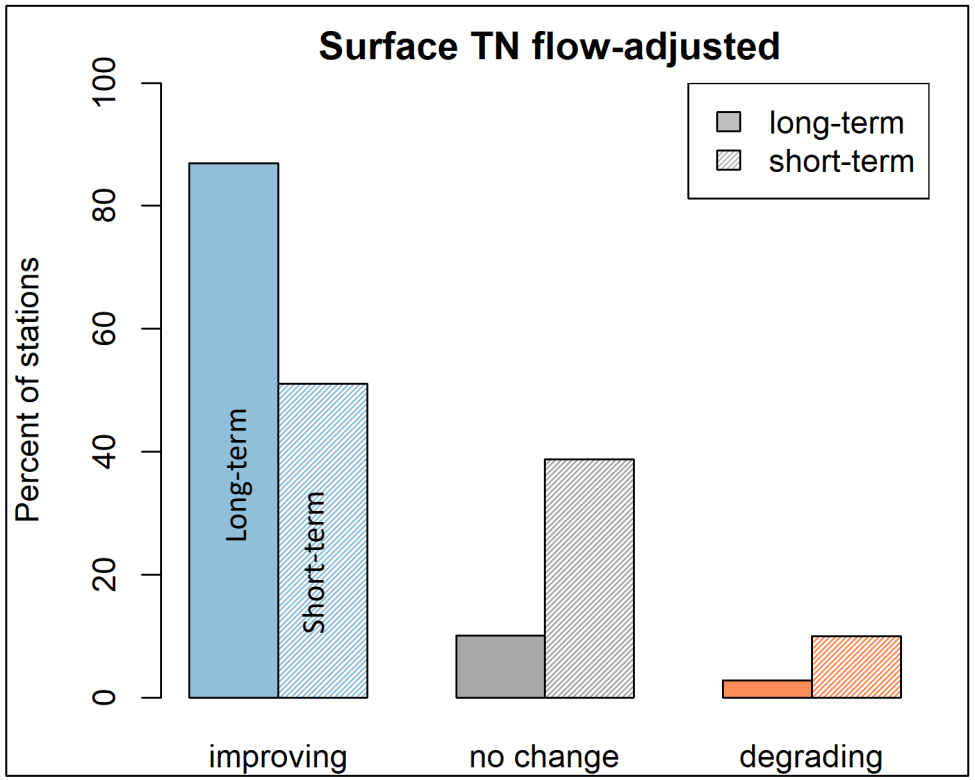



Example: The Rappahannock stations with short-term increases have fairly constant concentrations over the long-term with an upswing in the last few years.



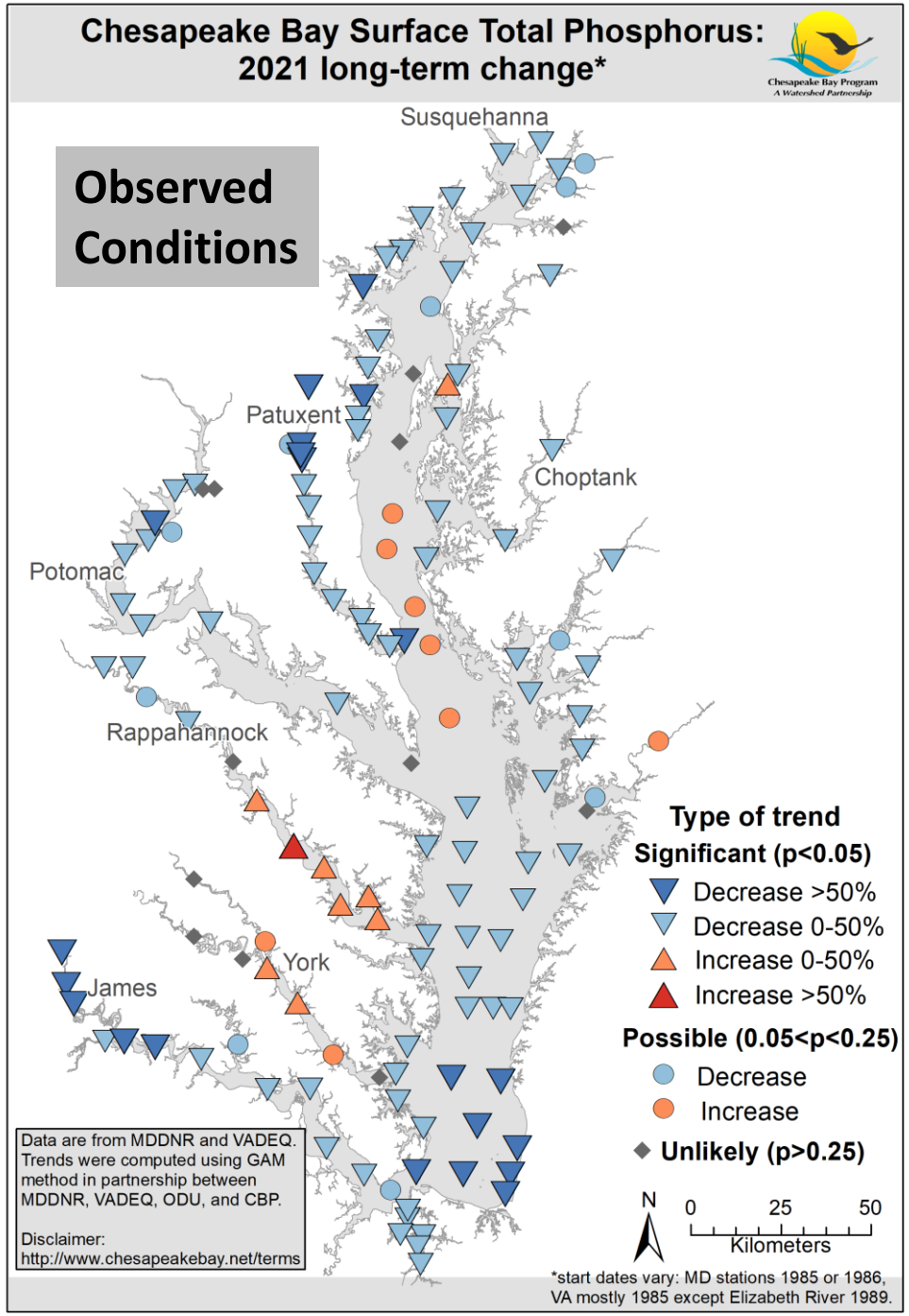
# TN summary

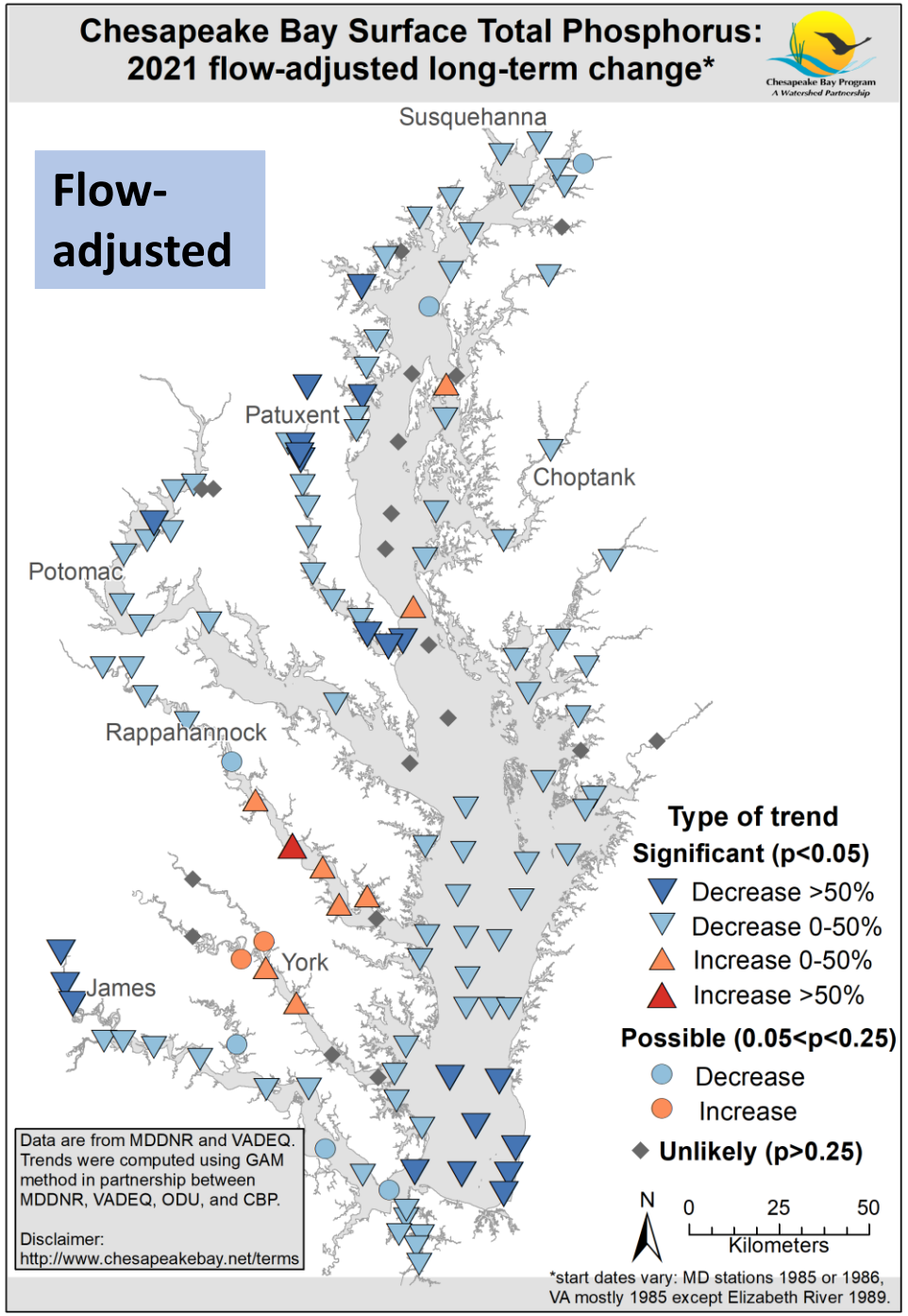
- Long-term trends decreasing at majority of stations (bottom is similar).
- Short-term trends are more mixed, but the largest group is improving.



# TP

## Surface Long-term

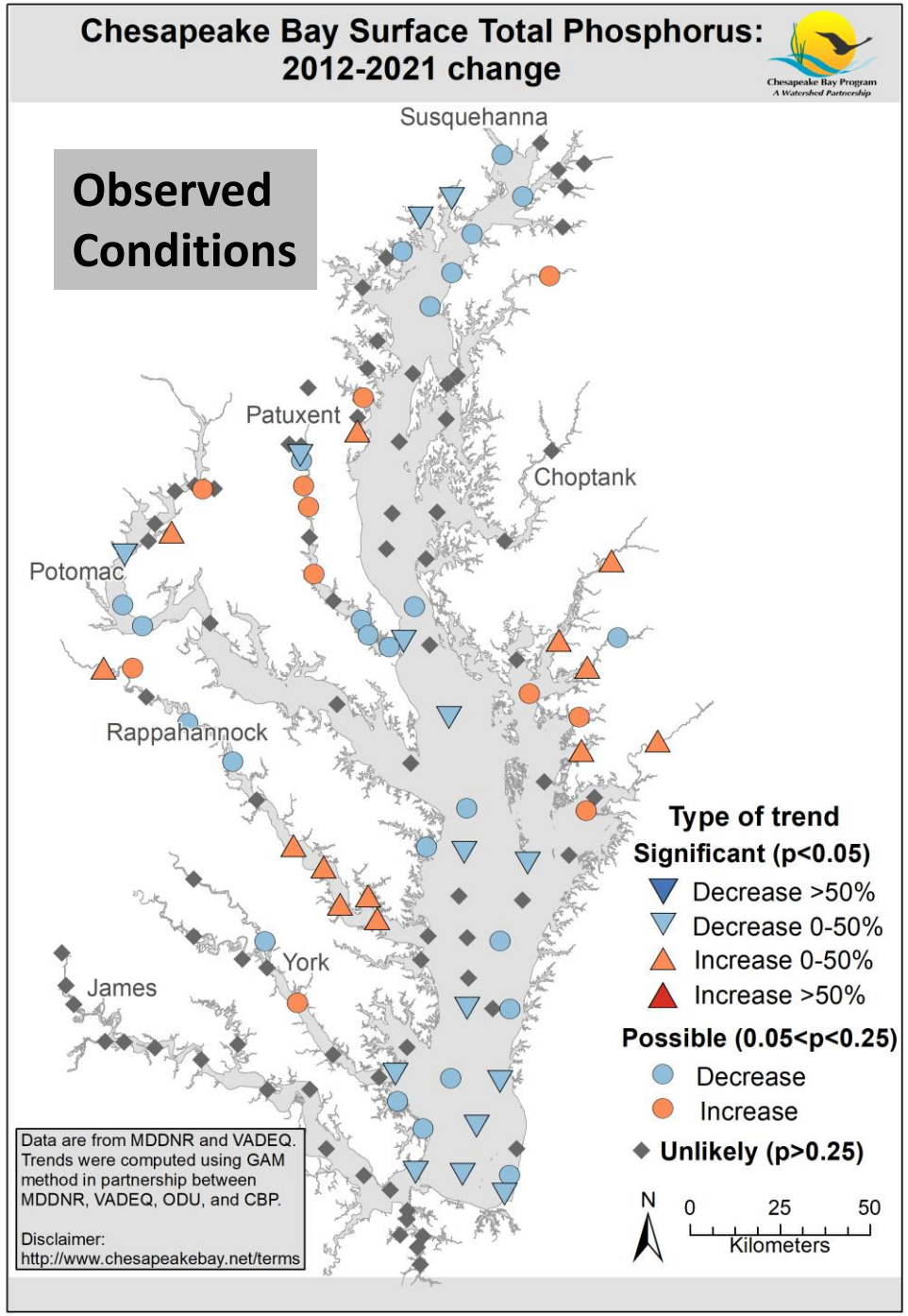


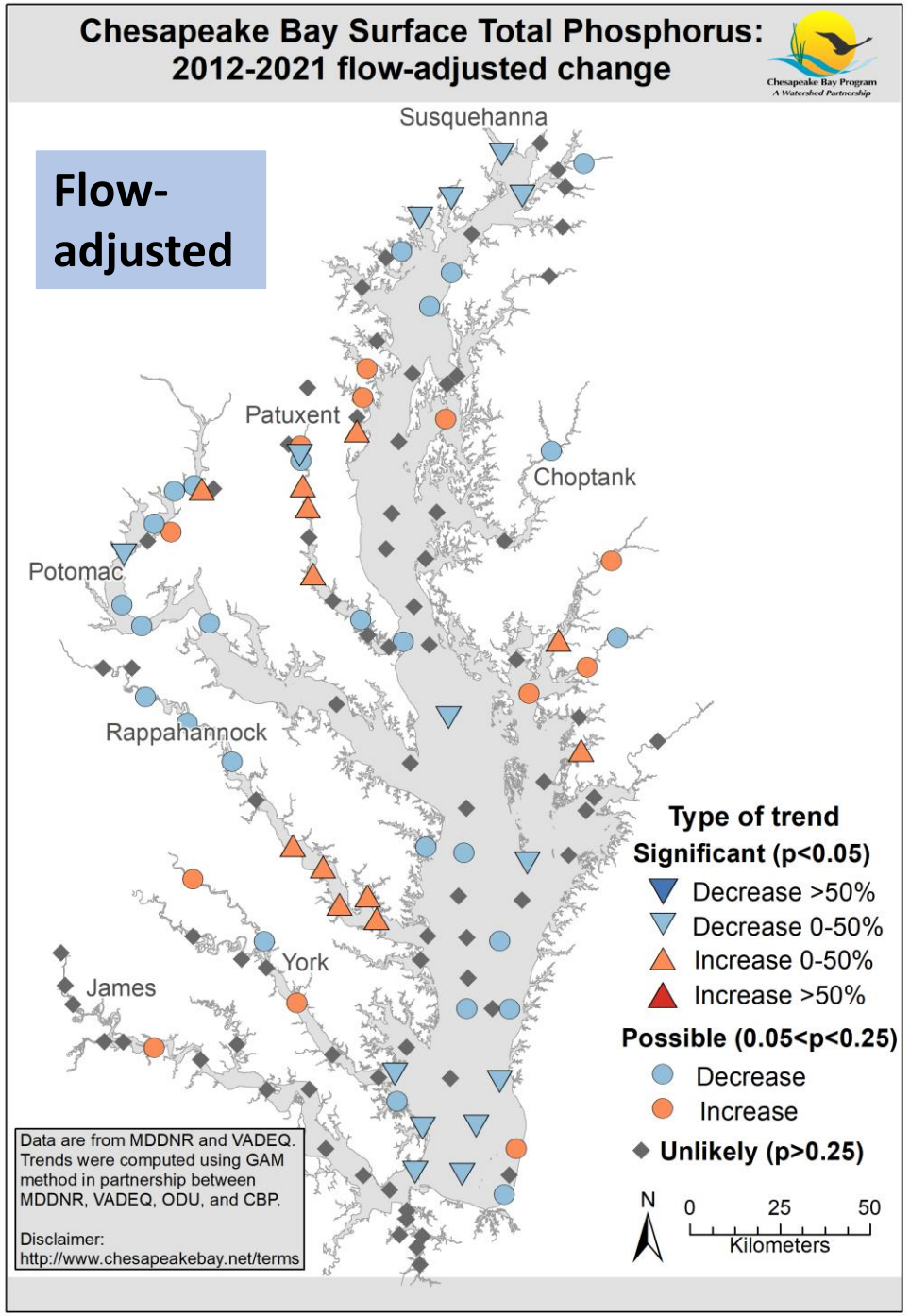



# TP

## Surface

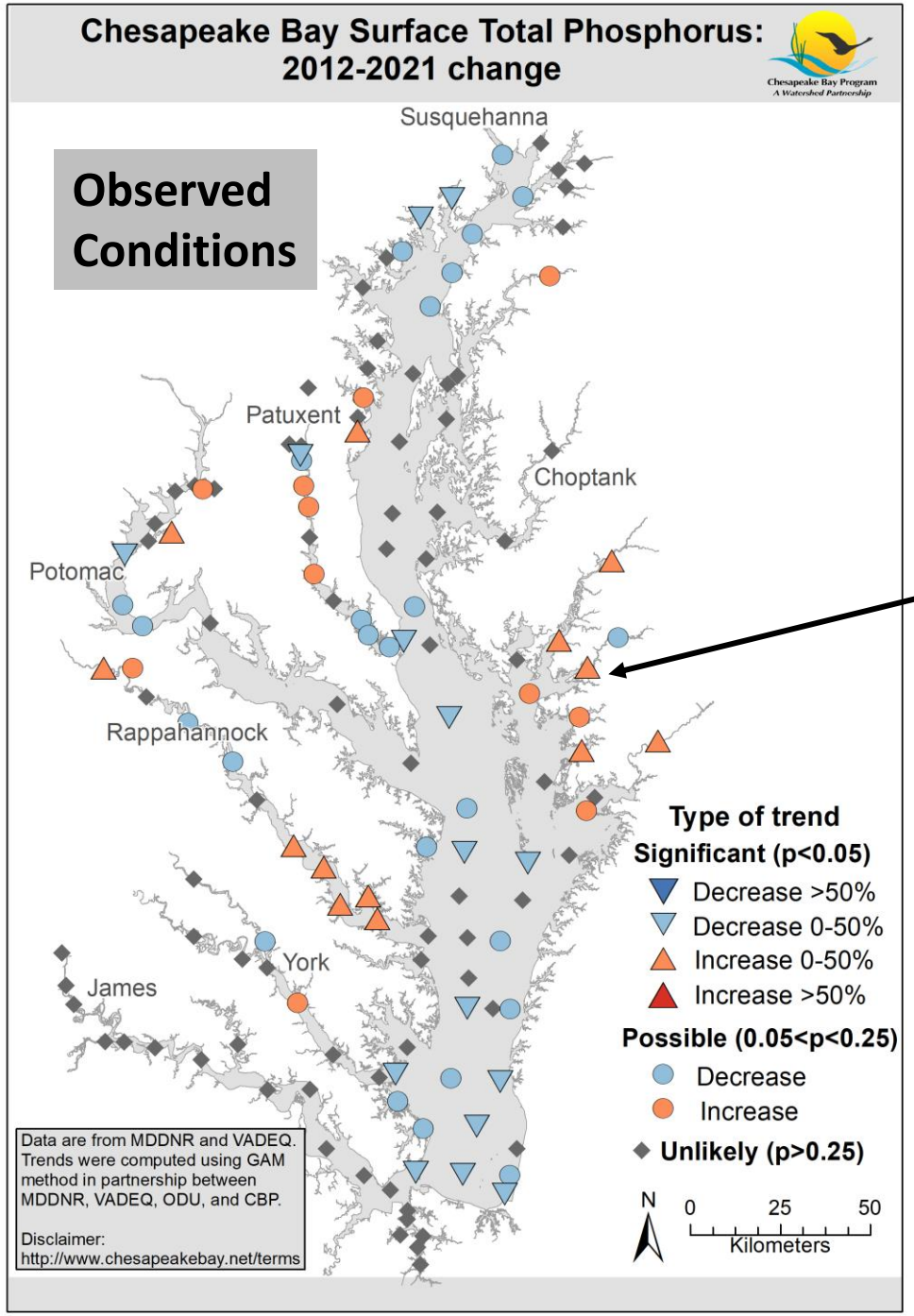
## Short-term



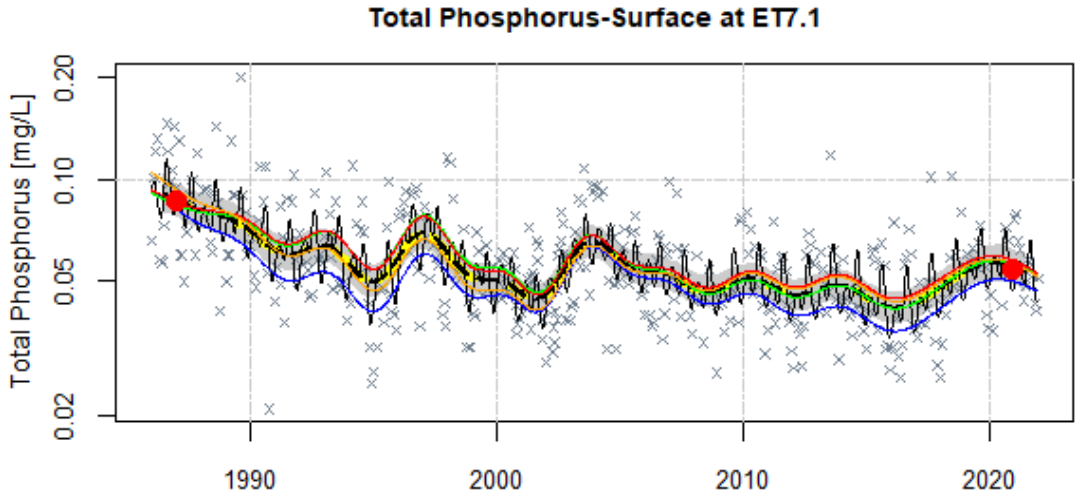



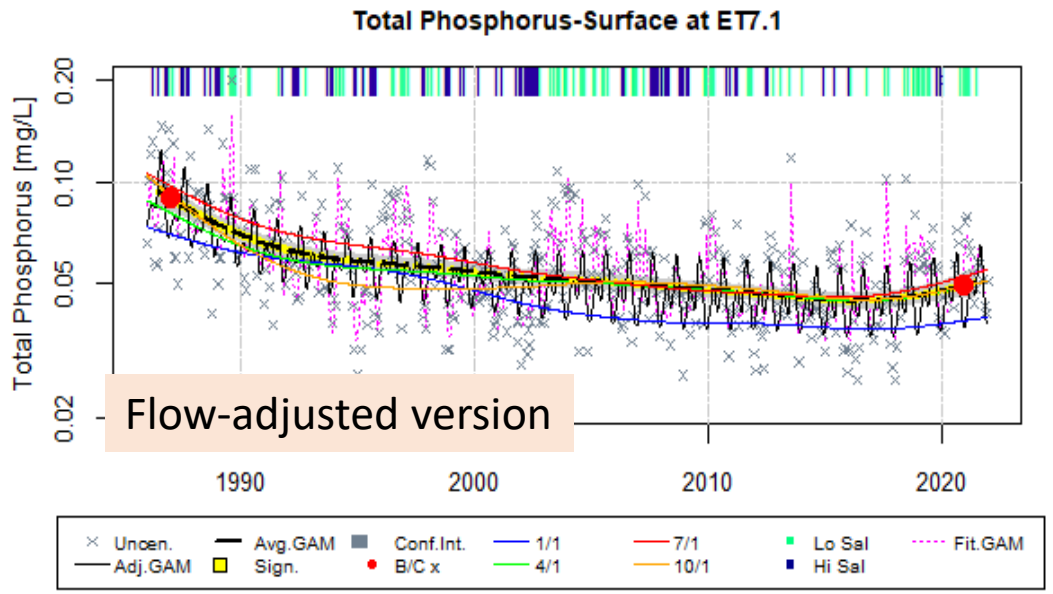
# TP

## Surface Example




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.

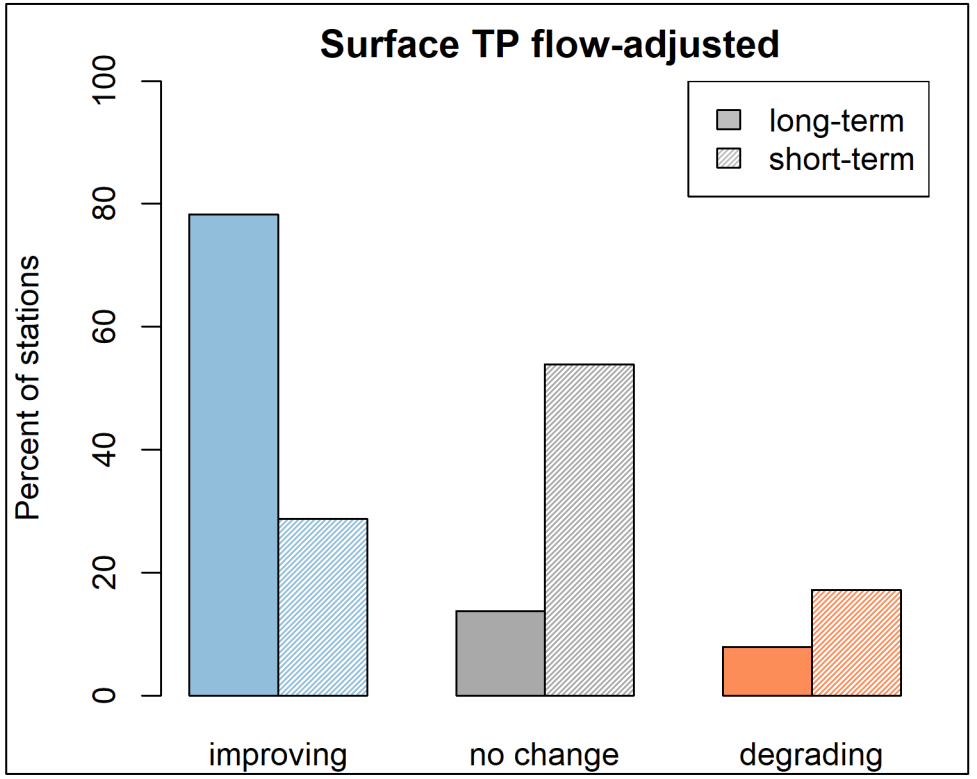


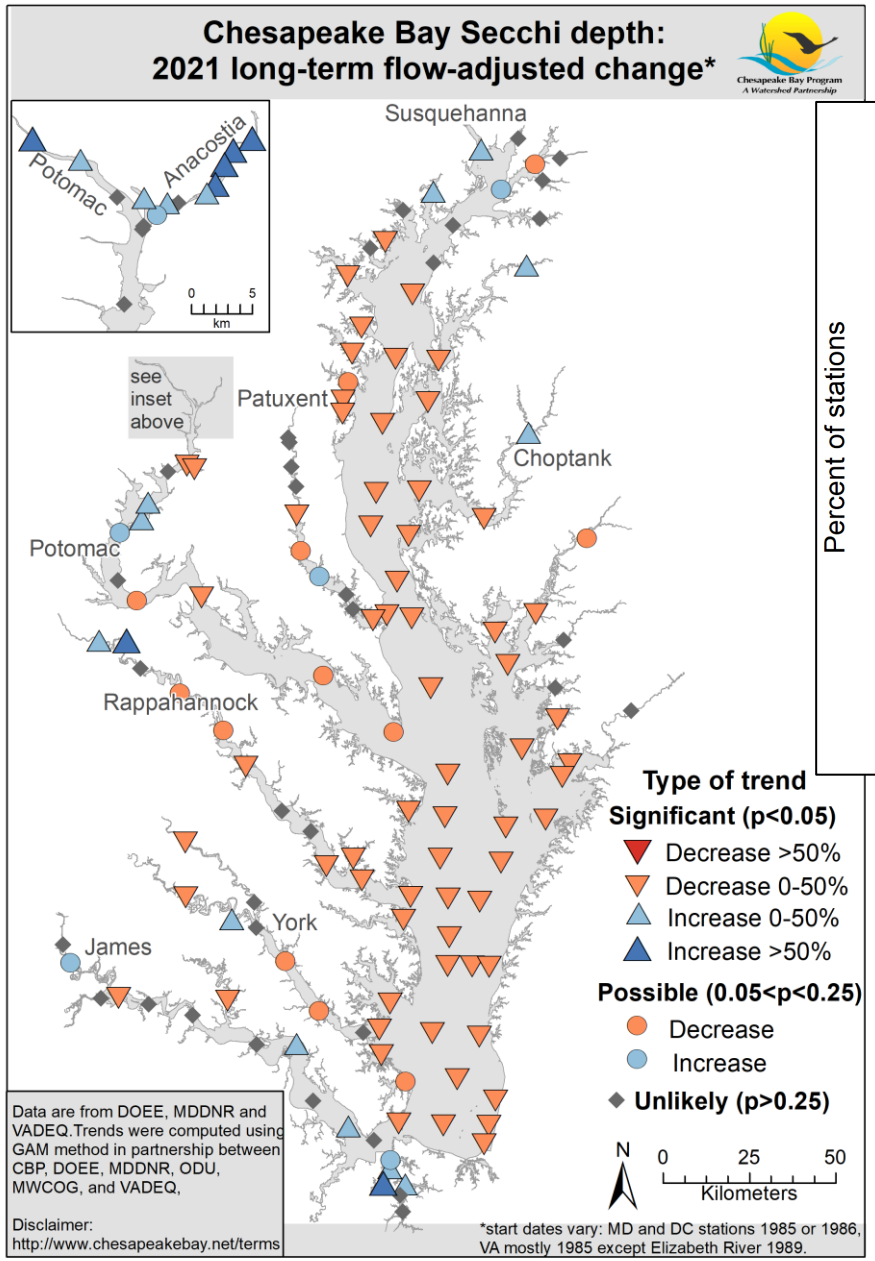

Flow-adjusted version

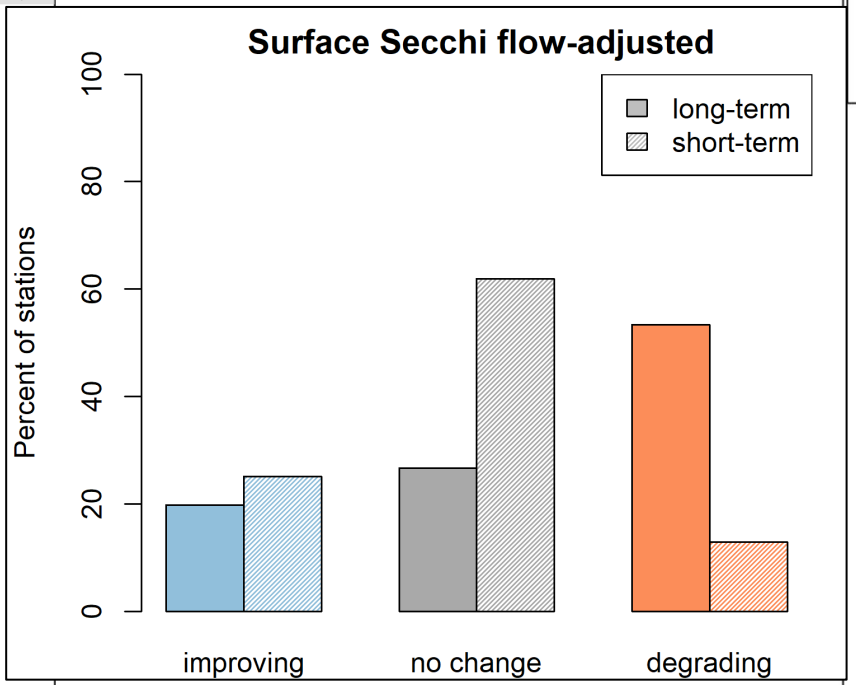
# TP summary

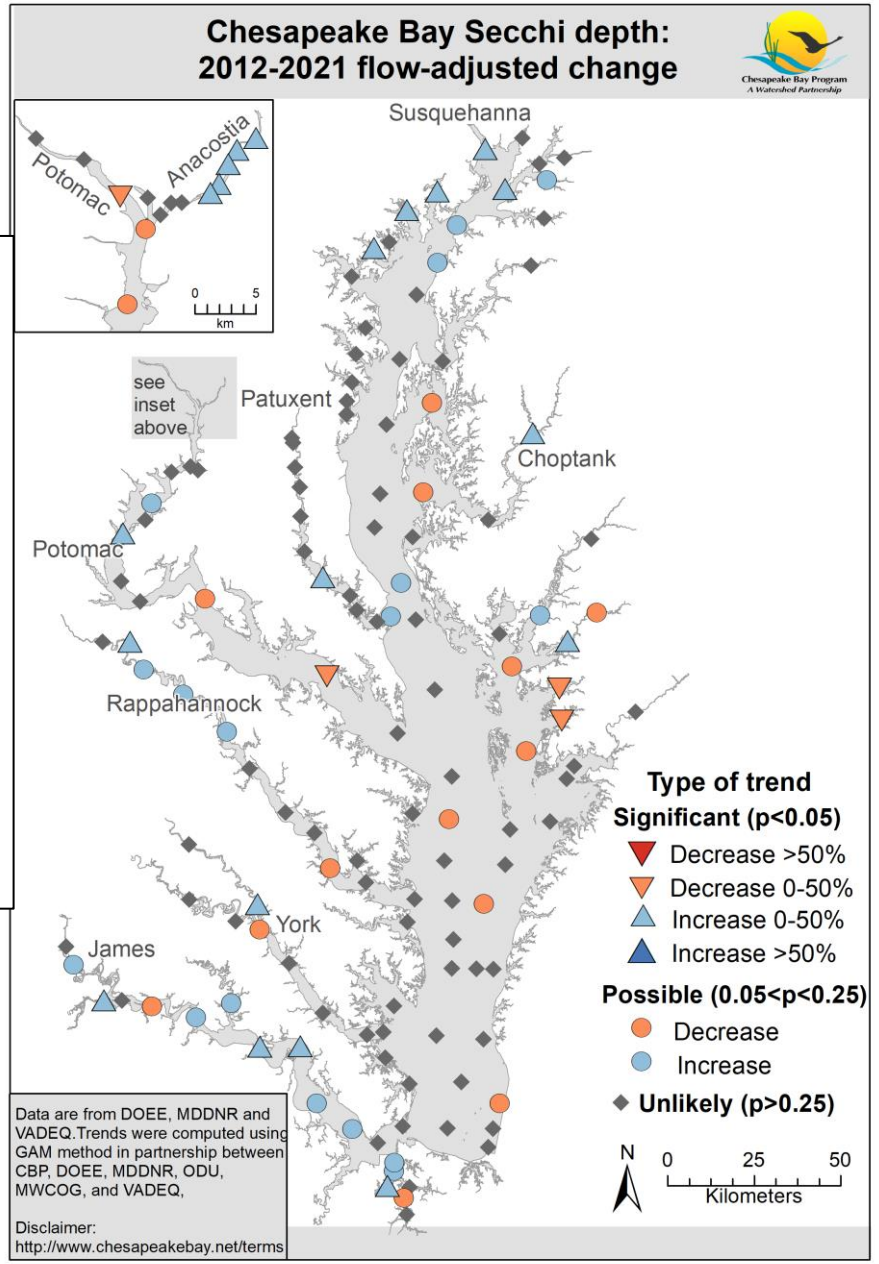
- Long-term trends decreasing at majority of stations (bottom is similar).
- Short-term improvements reduced by more than half, with many more regions showing “no change” over the short-term.



# Secchi depth

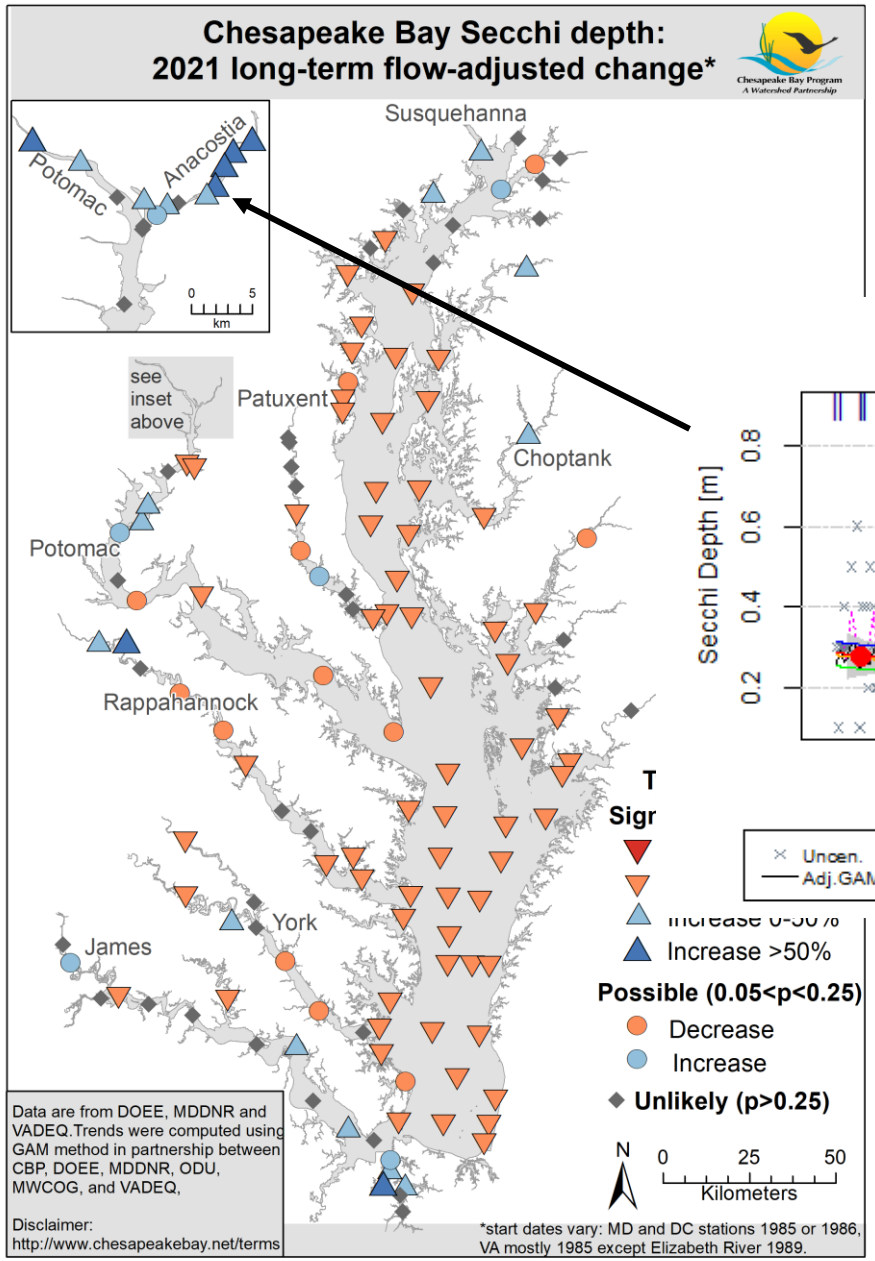


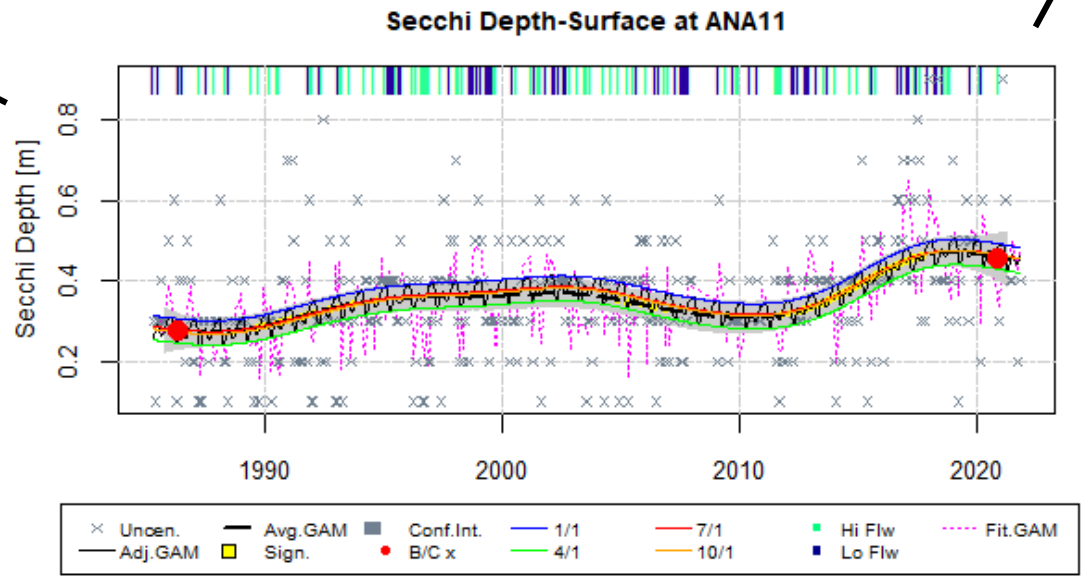



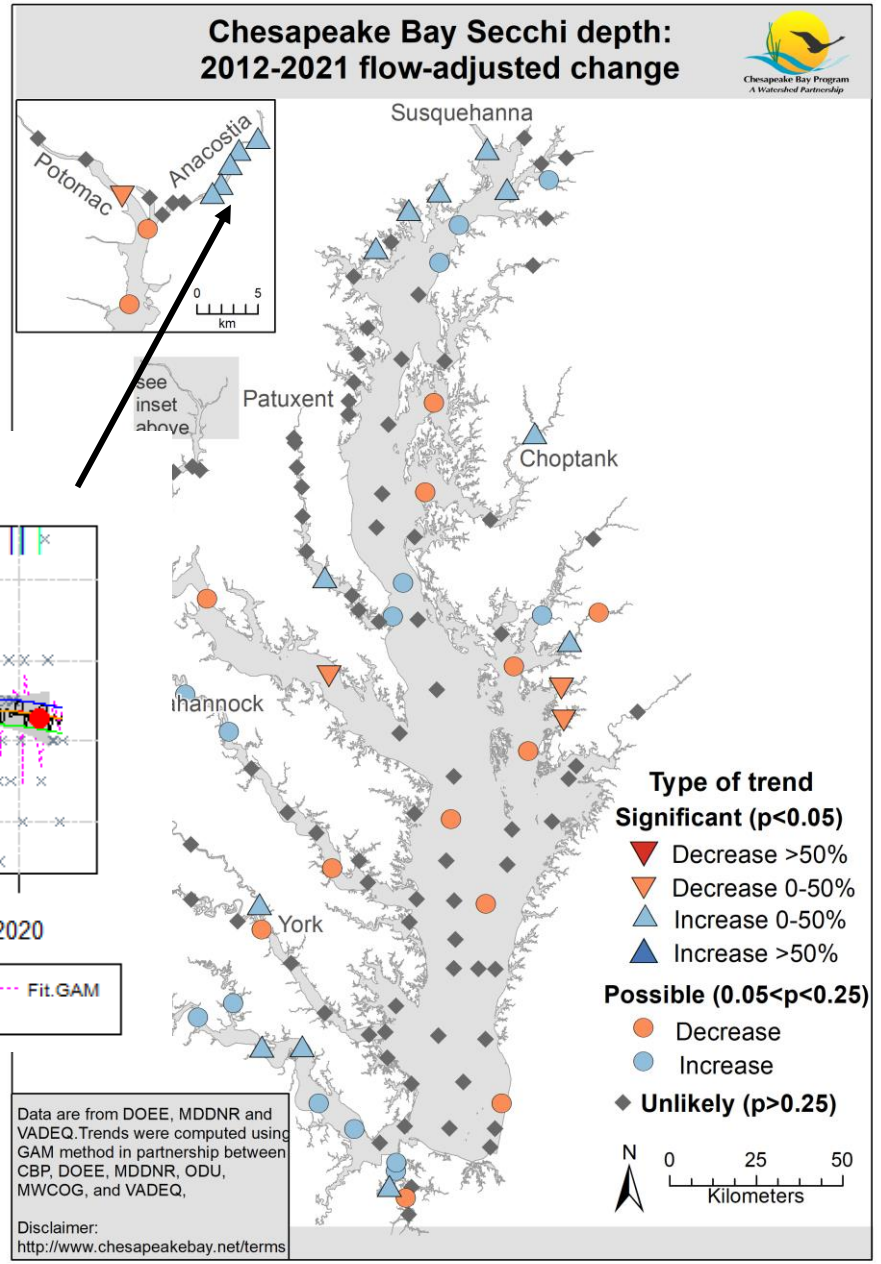



# Secchi depth

Example: Anacostia stations all show long-term gradual improvement followed by even more improvement in the recent decade. DOEE's Potomac stations also show long-term improvement with plateau recently.

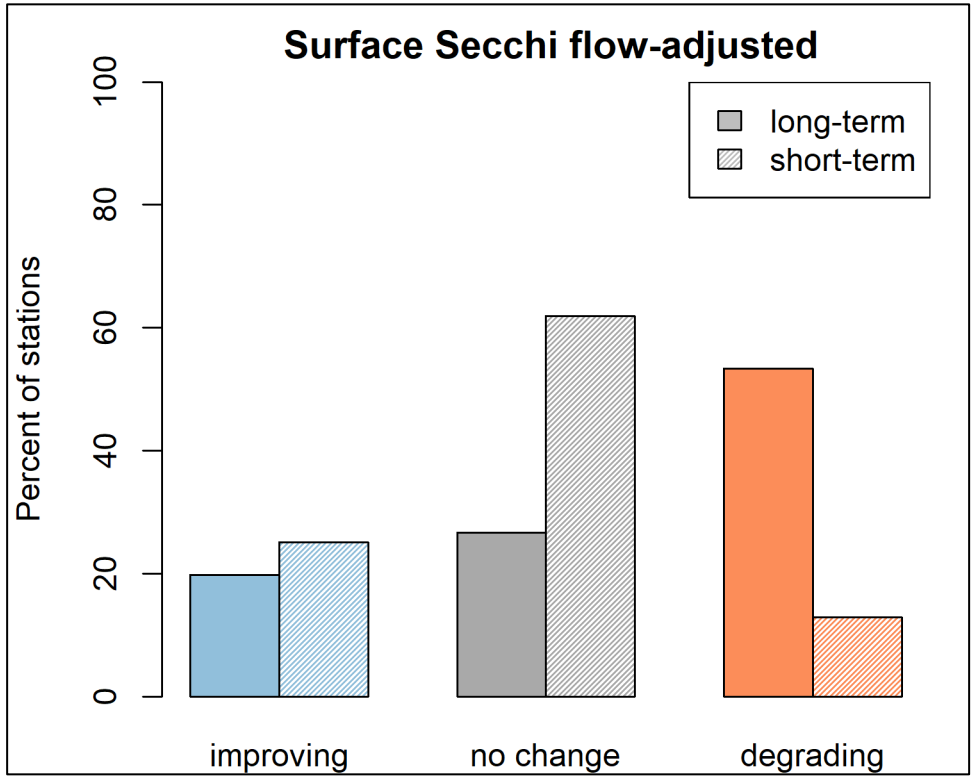


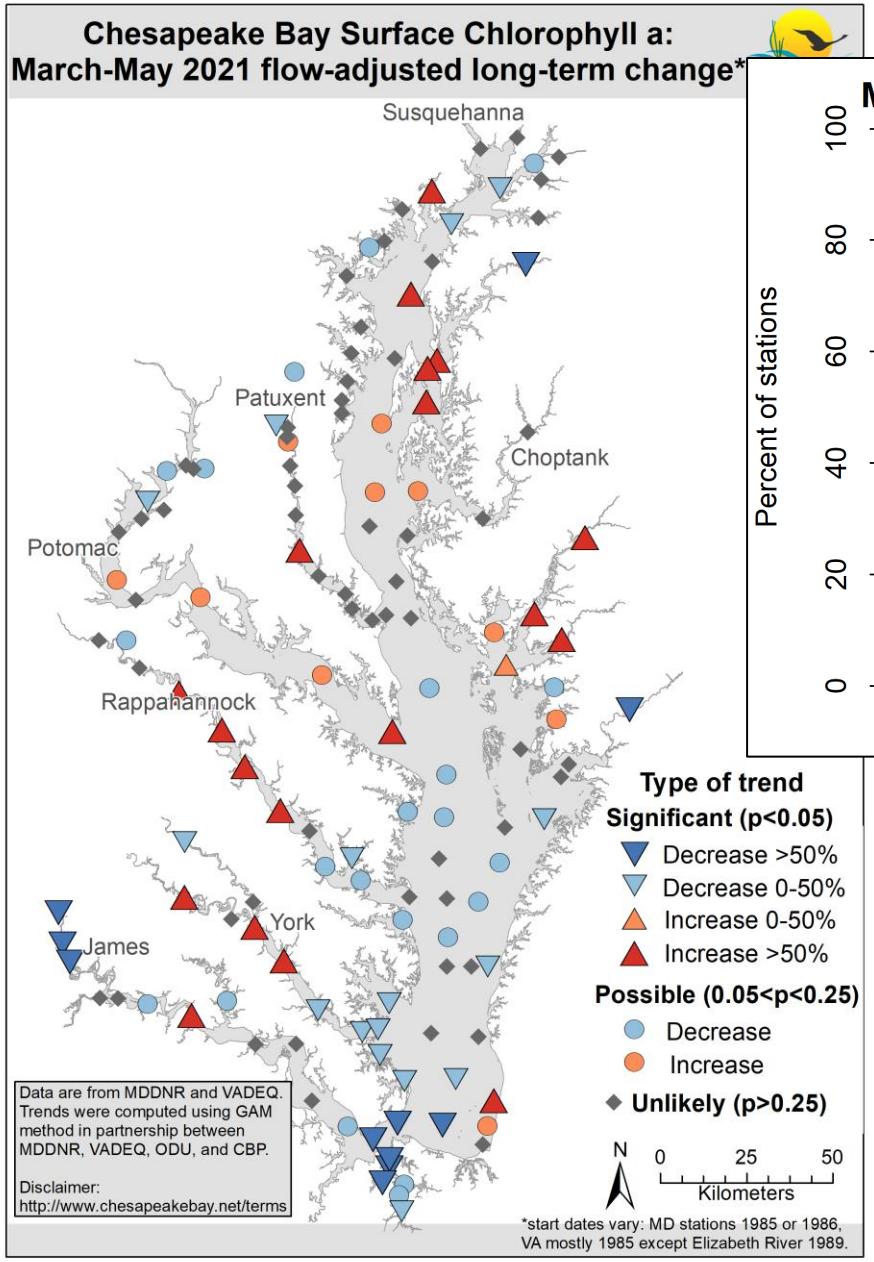



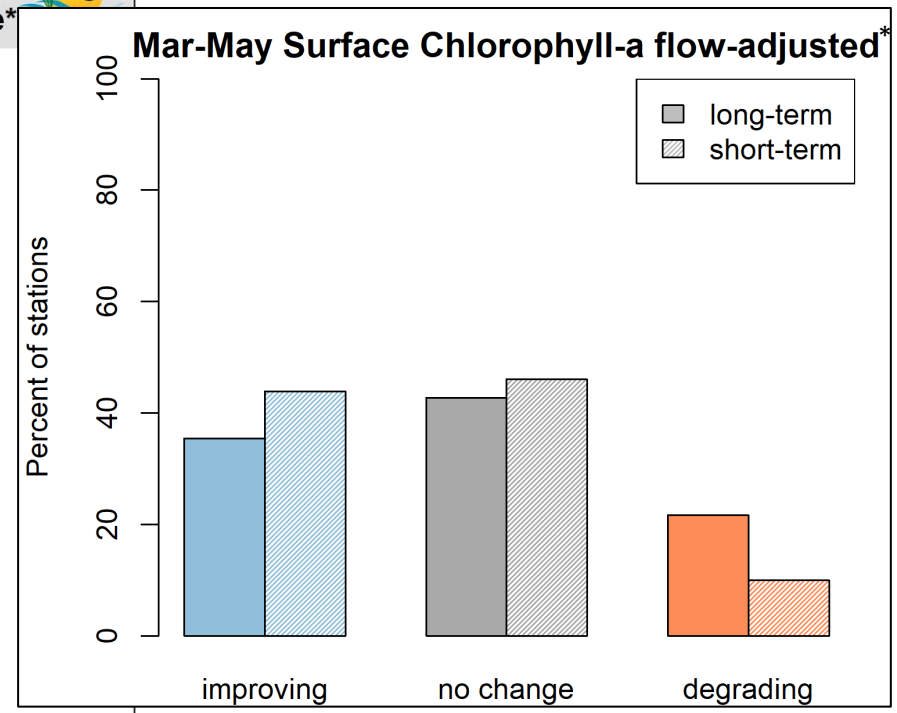
# Secchi depth summary

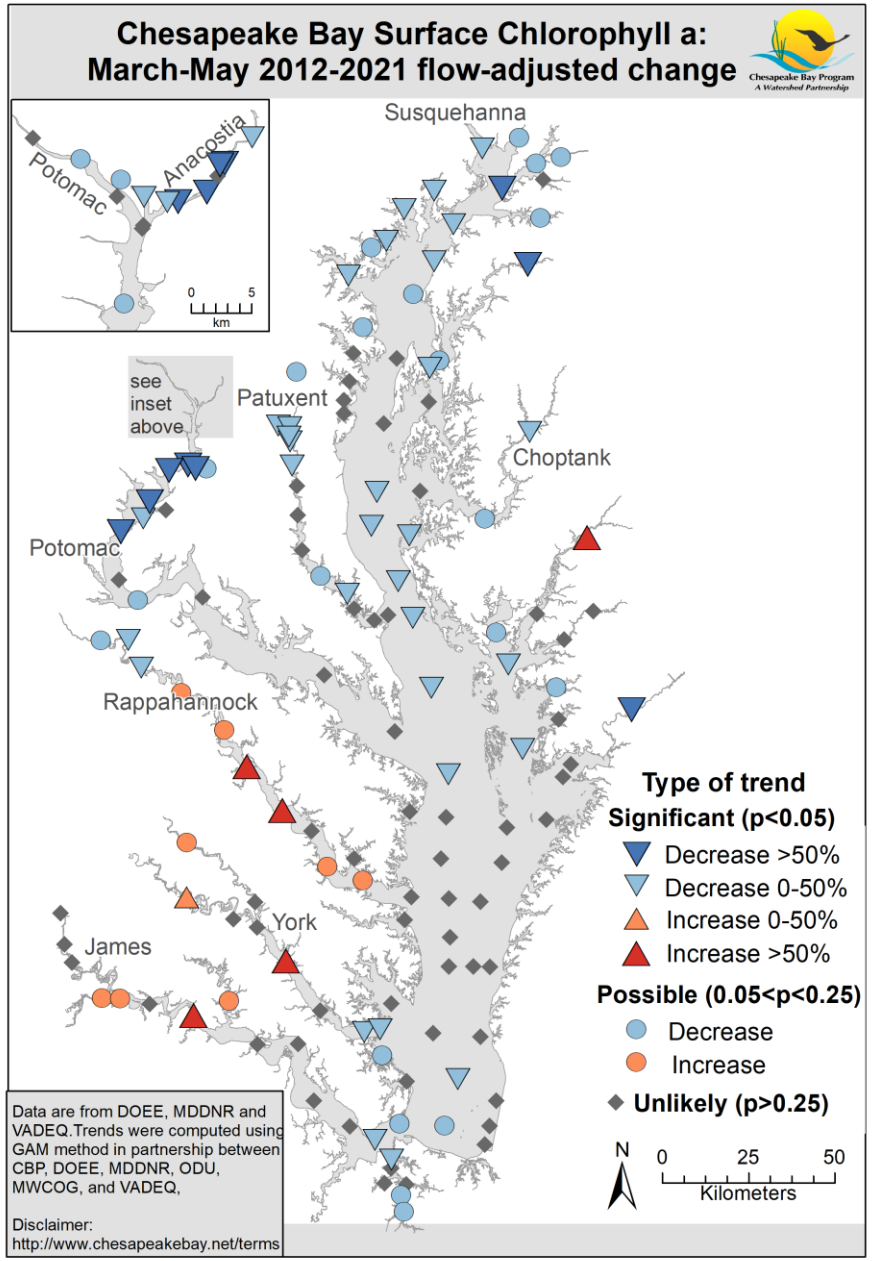
- More than half of the long-term degradations have turned to “no change” for the last 10 years.
- Stations with long- and short-term improvements are fairly consistent.



# Spring Surface Chlorophyll *a*



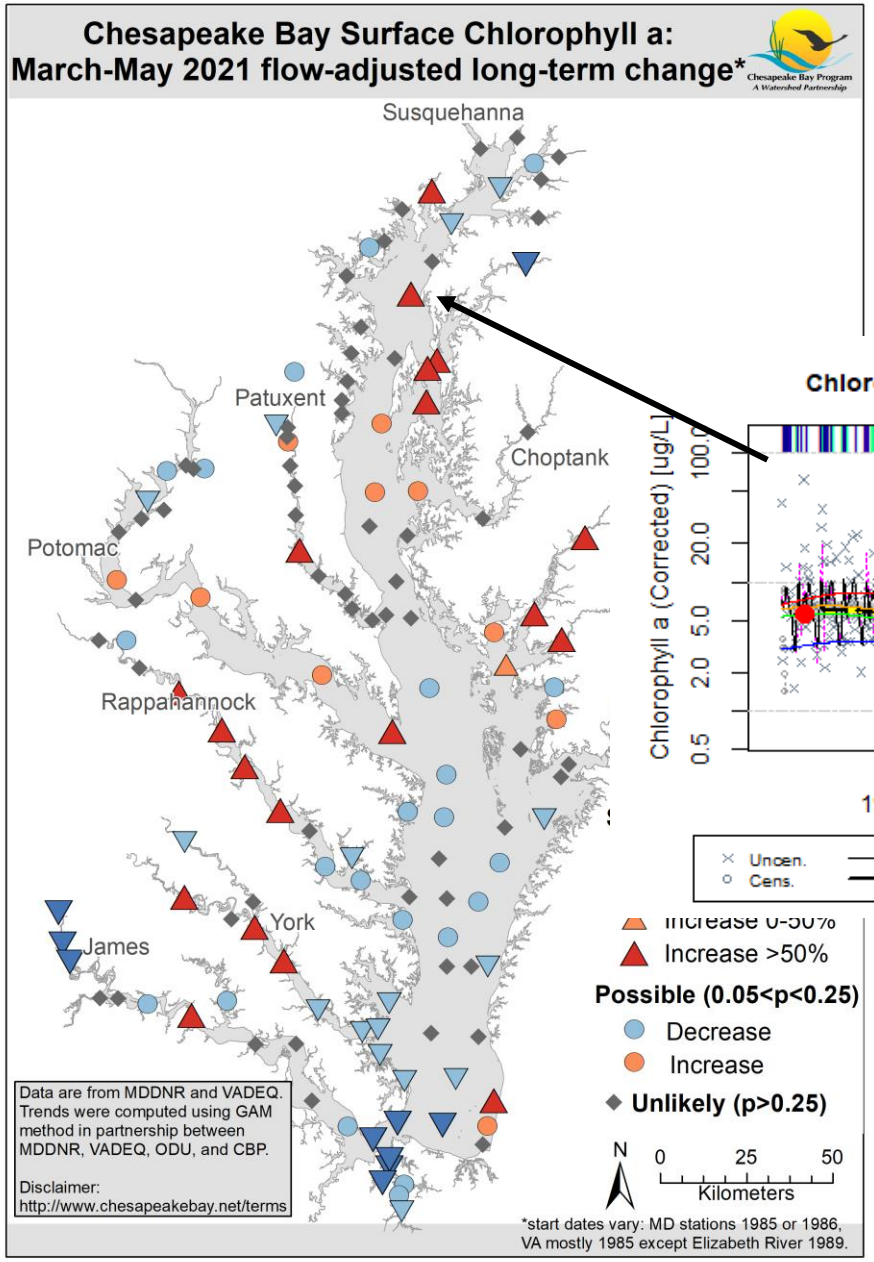



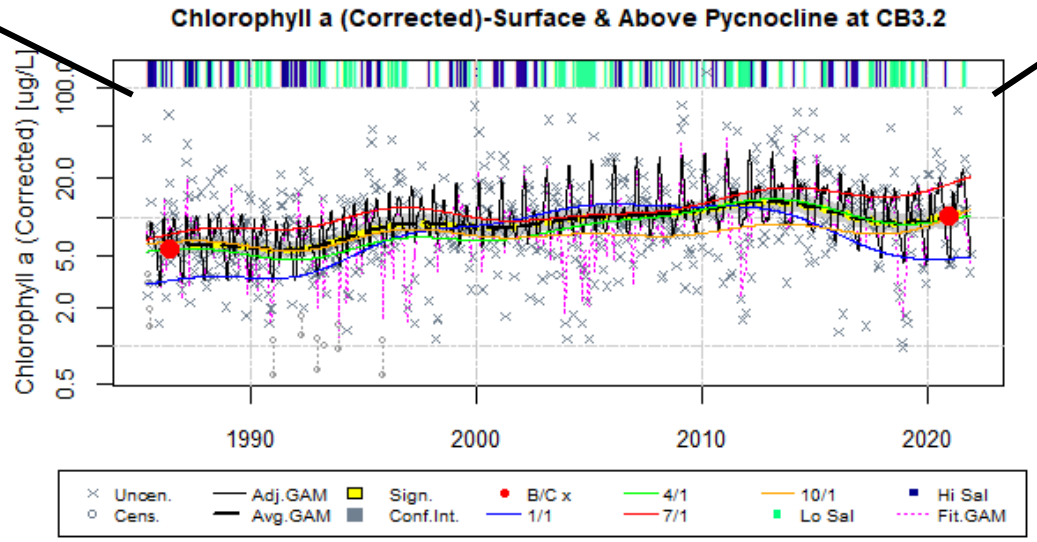


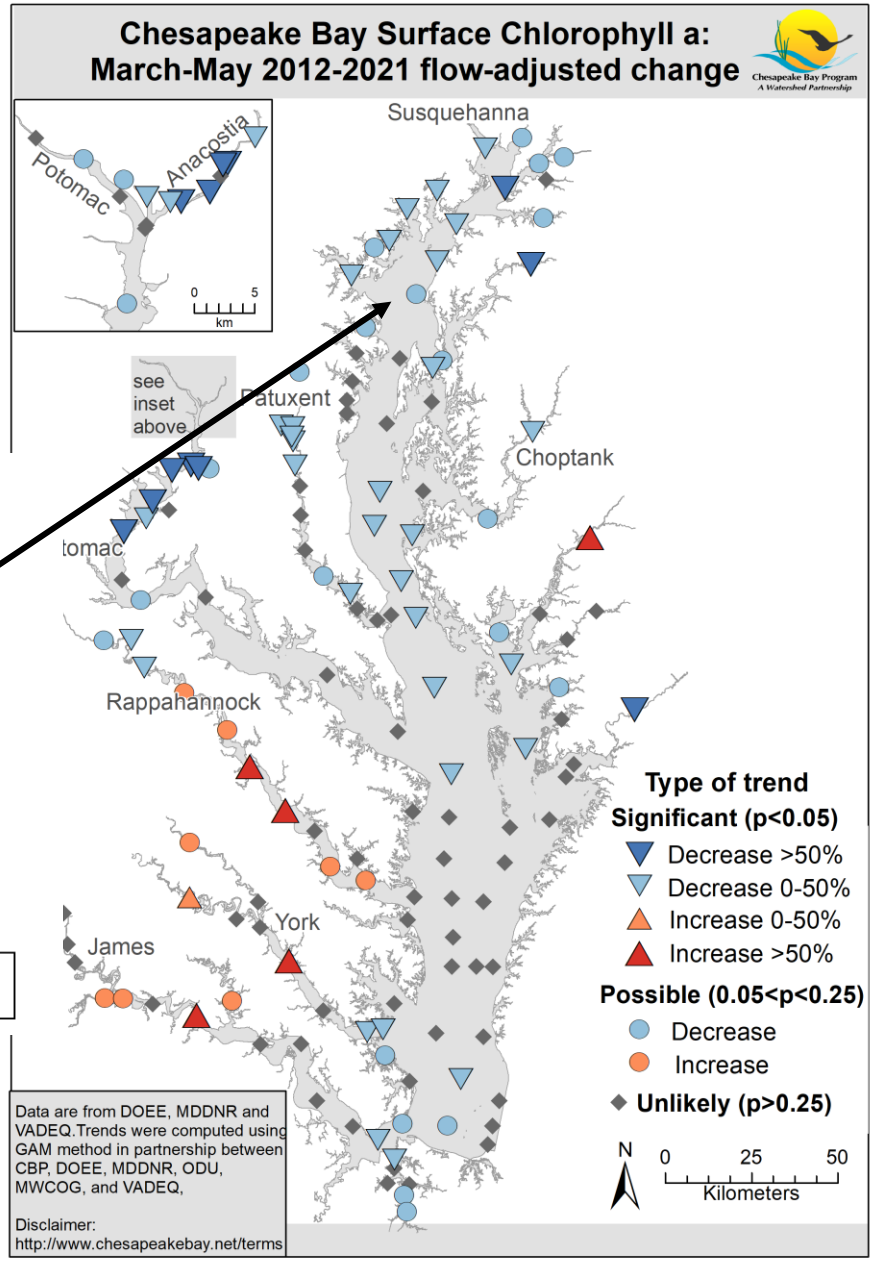

*Note: Bar chart does not include Washington D.C. stations since they are only short-term

# Spring Surface Chlorophyll *a*




Example: Long-term increases in some regions have plateaued or decreased in the spring for the short-term.

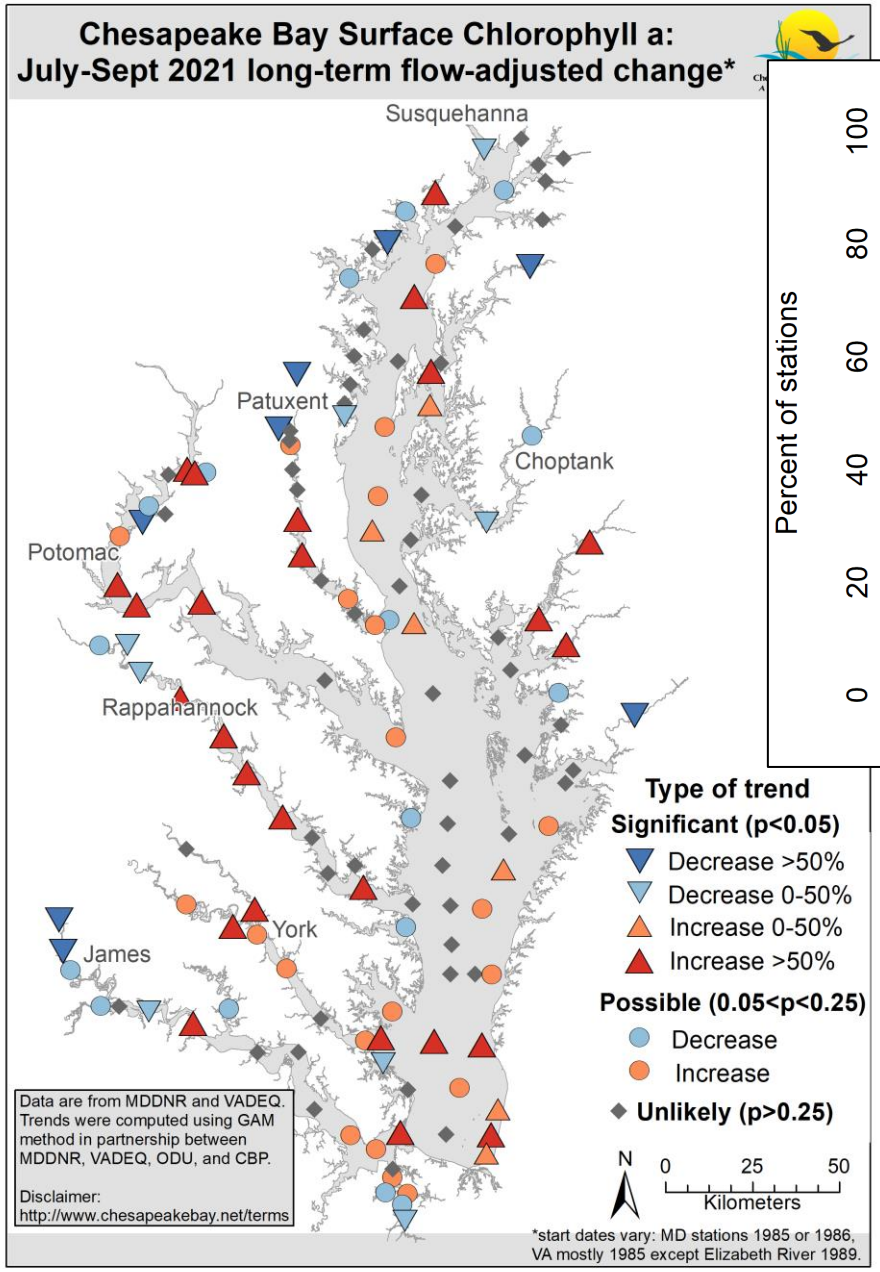


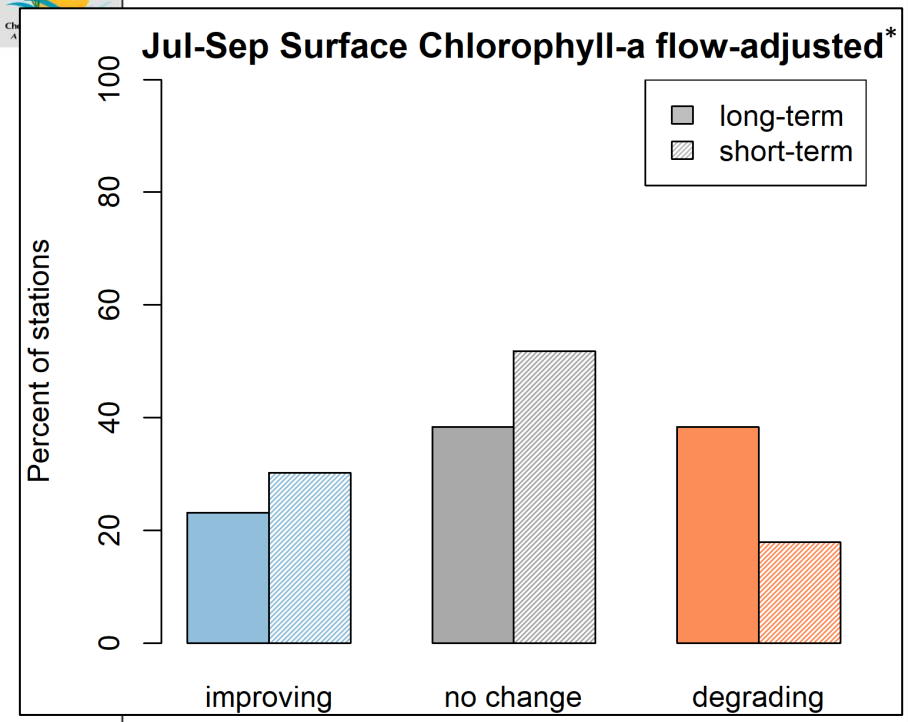



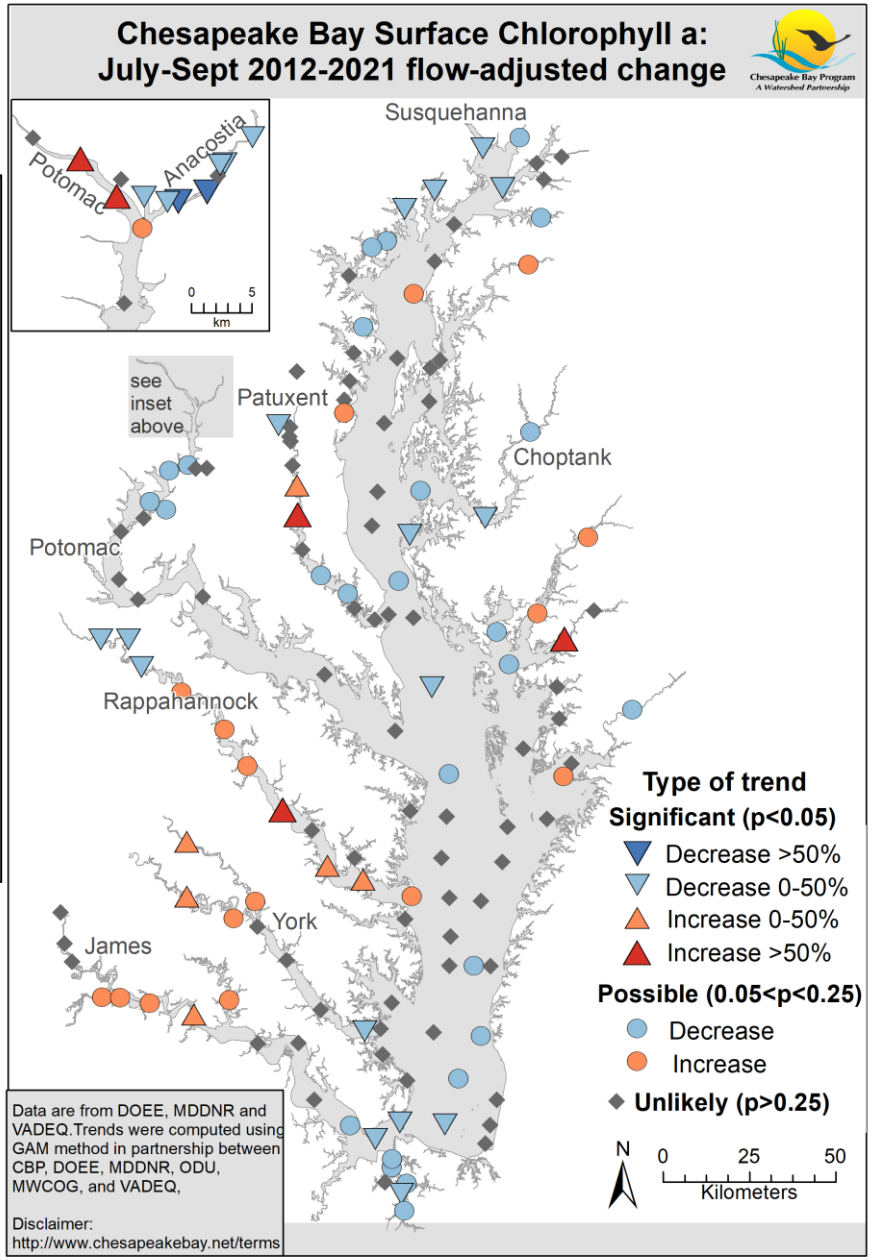



*Note: Bar chart does not include Washington D.C. stations since they are only short-term

# Summer Surface Chlorophyll *a*



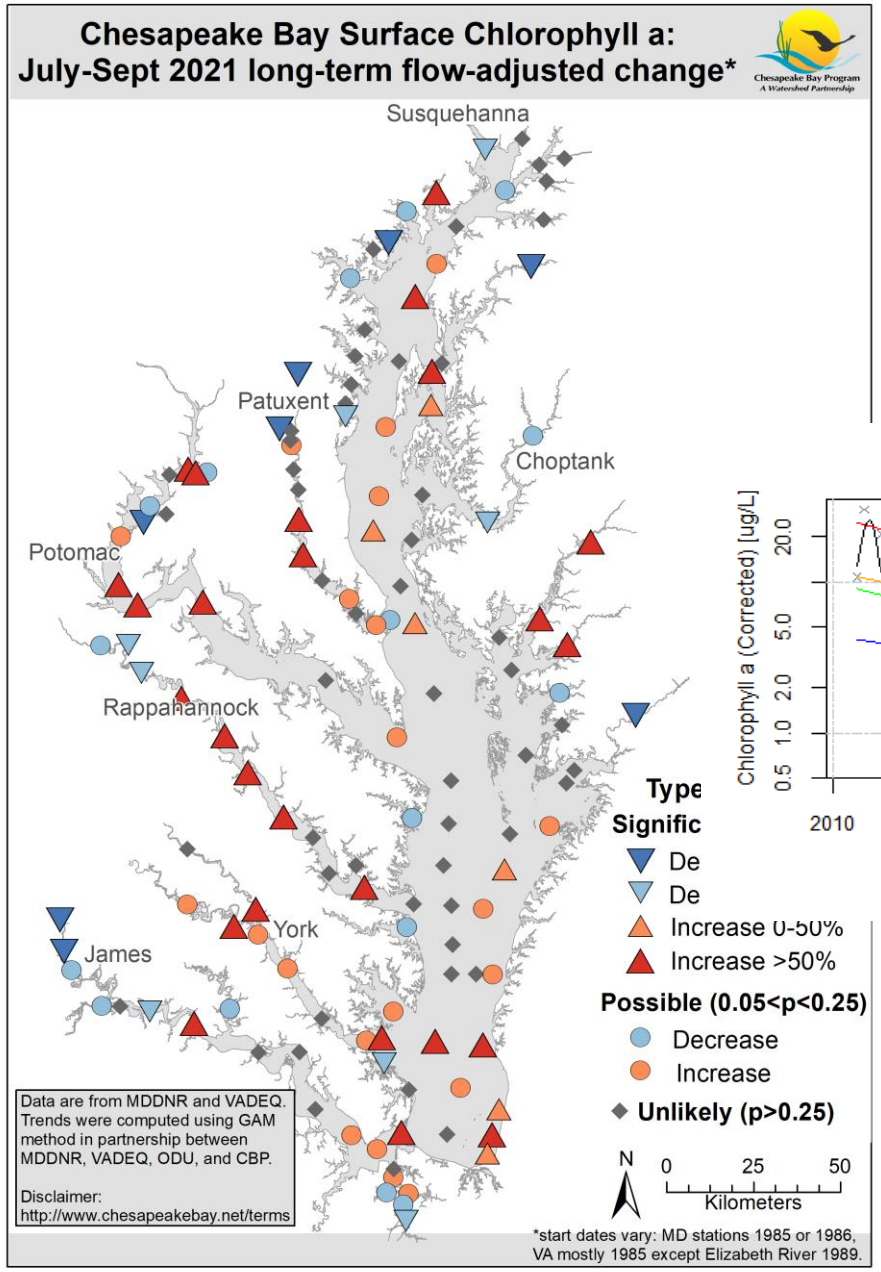



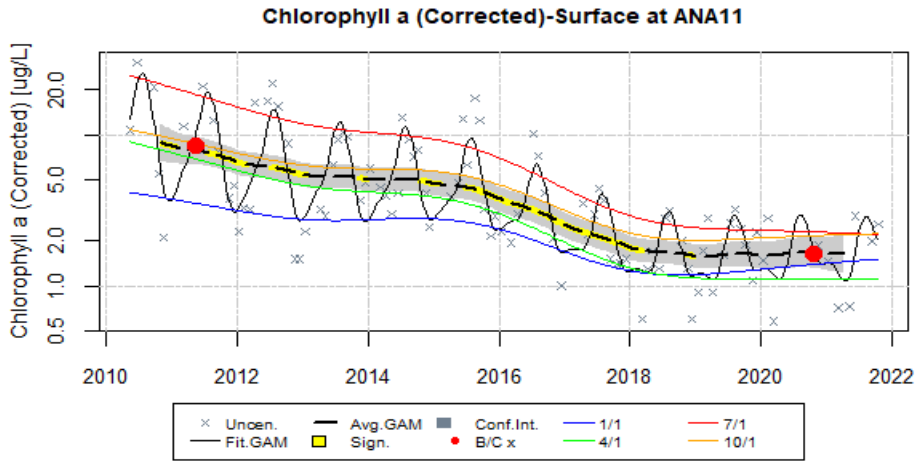


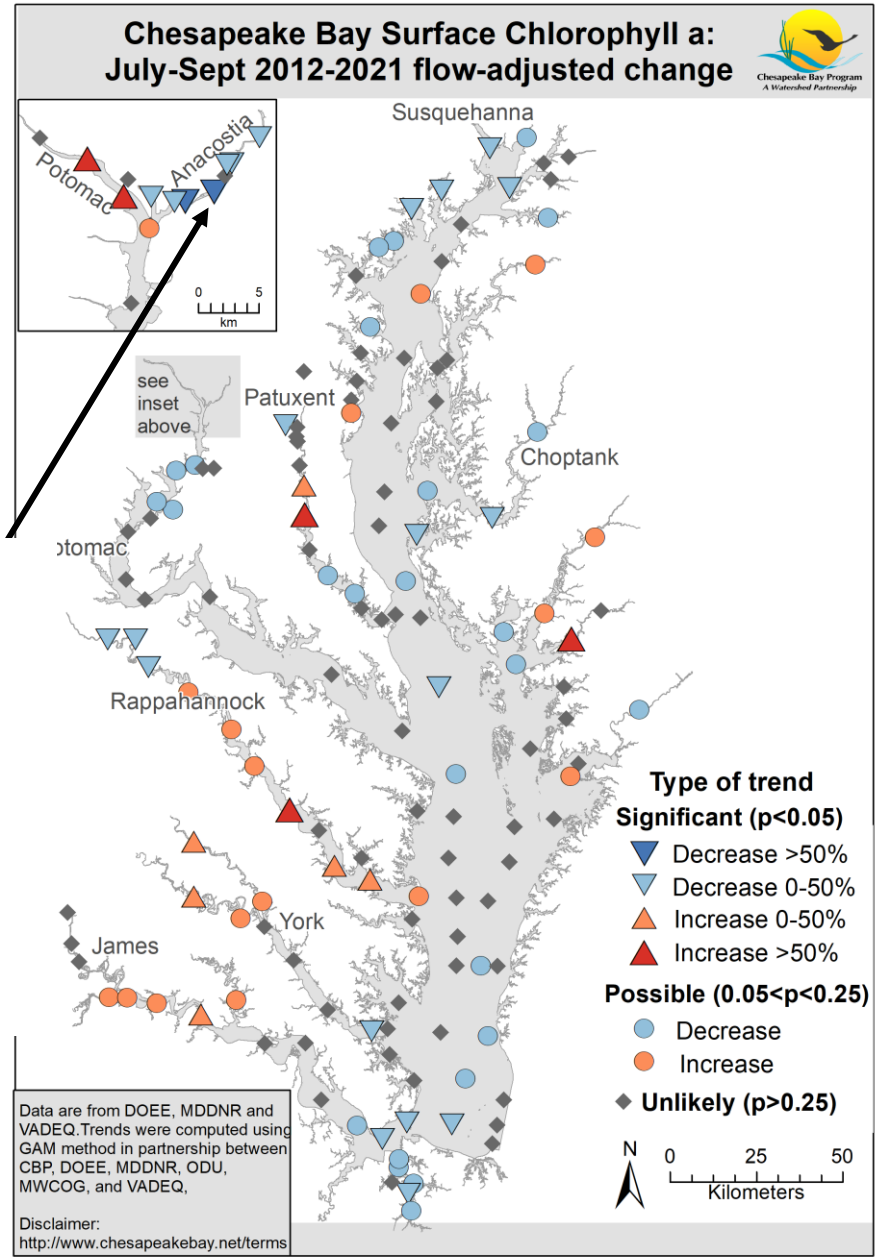

*Note: Bar chart does not include Washington D.C. stations since they are only short-term

# Summer Surface Chlorophyll *a*



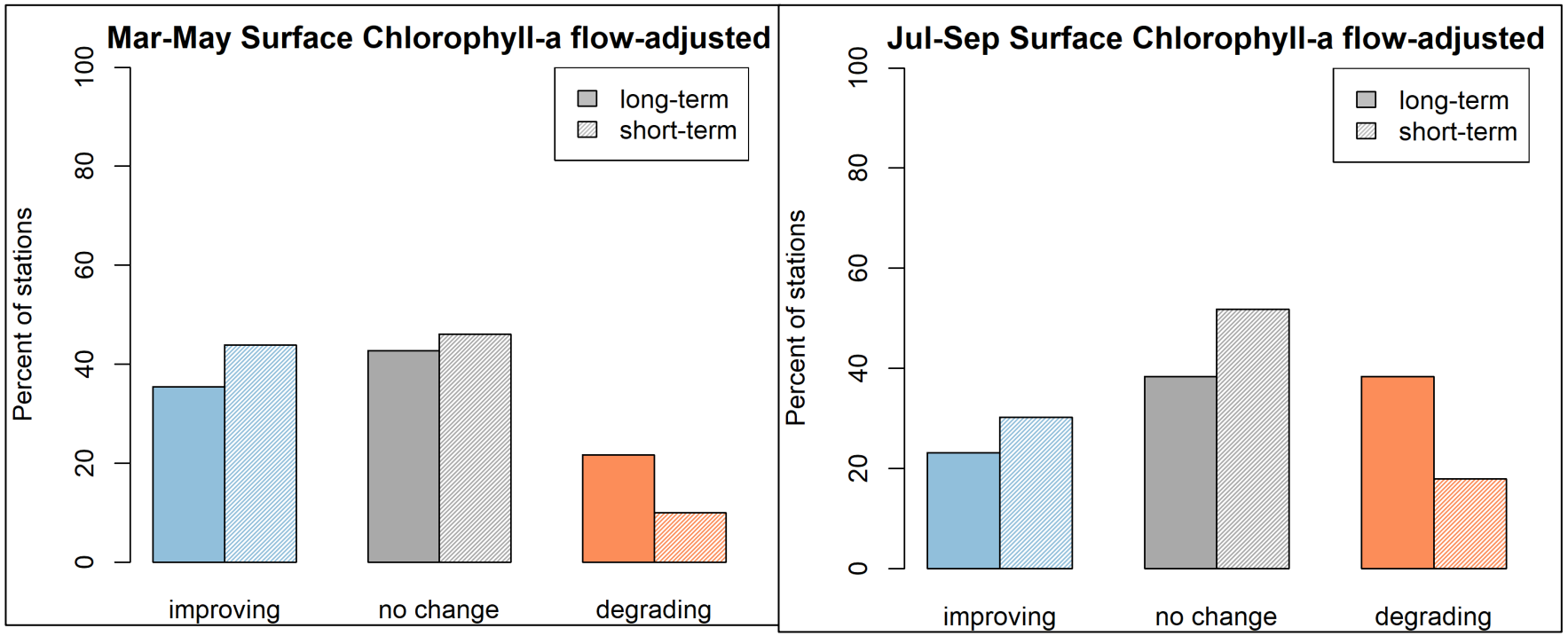

Example: Same station (different length of record) as Secchi. Shows the clarity improvement likely linked to phytoplankton.



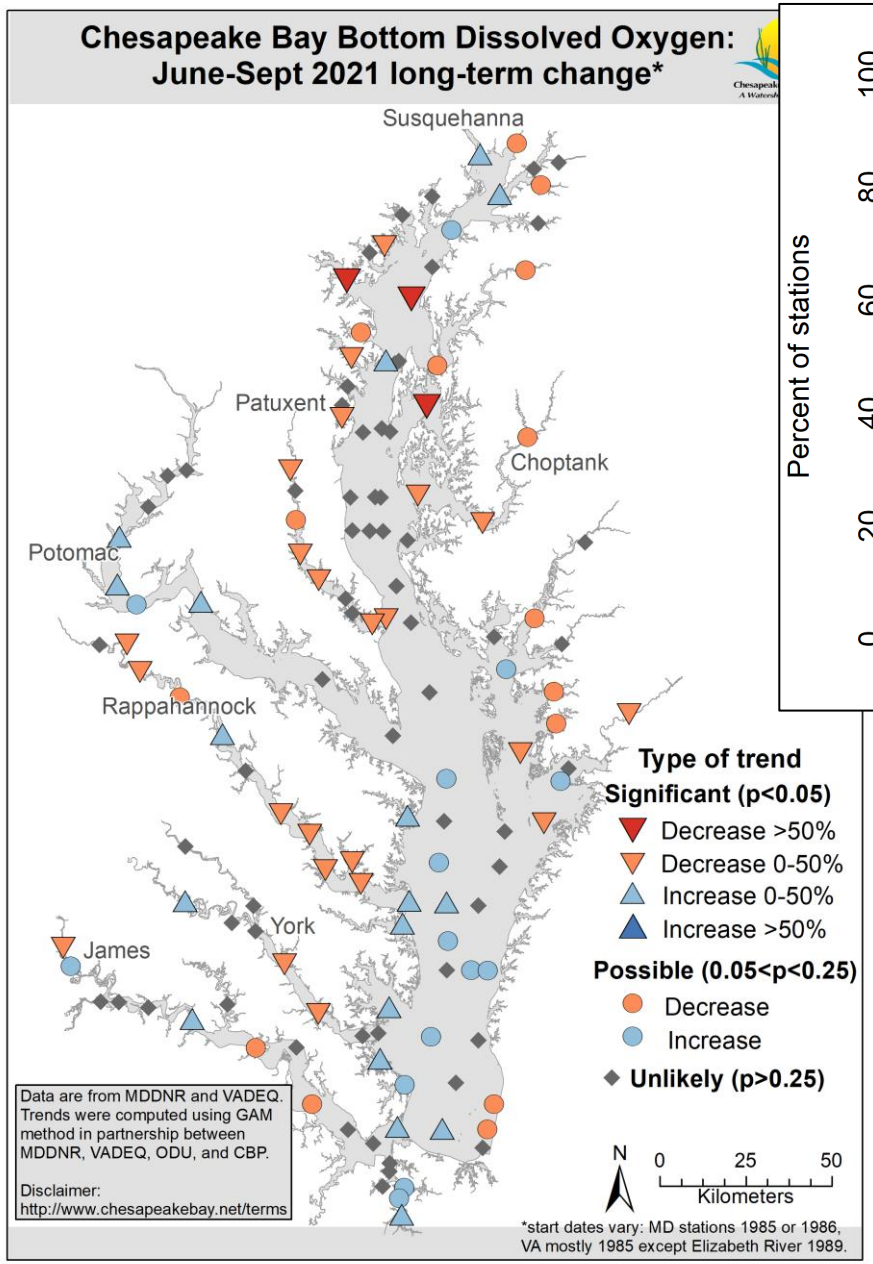



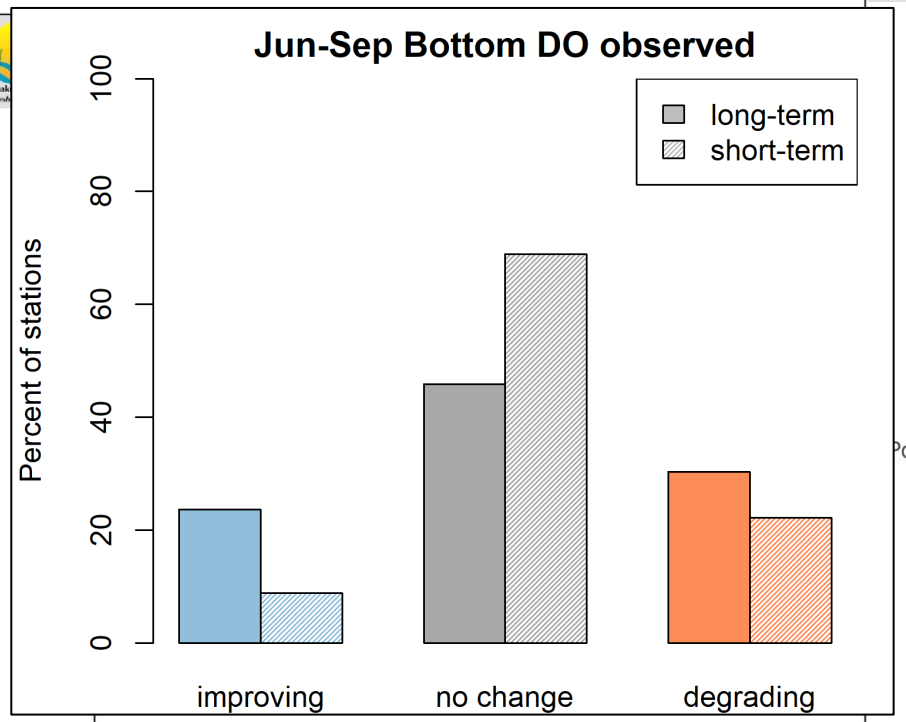
# Chlorophyll *a* summary

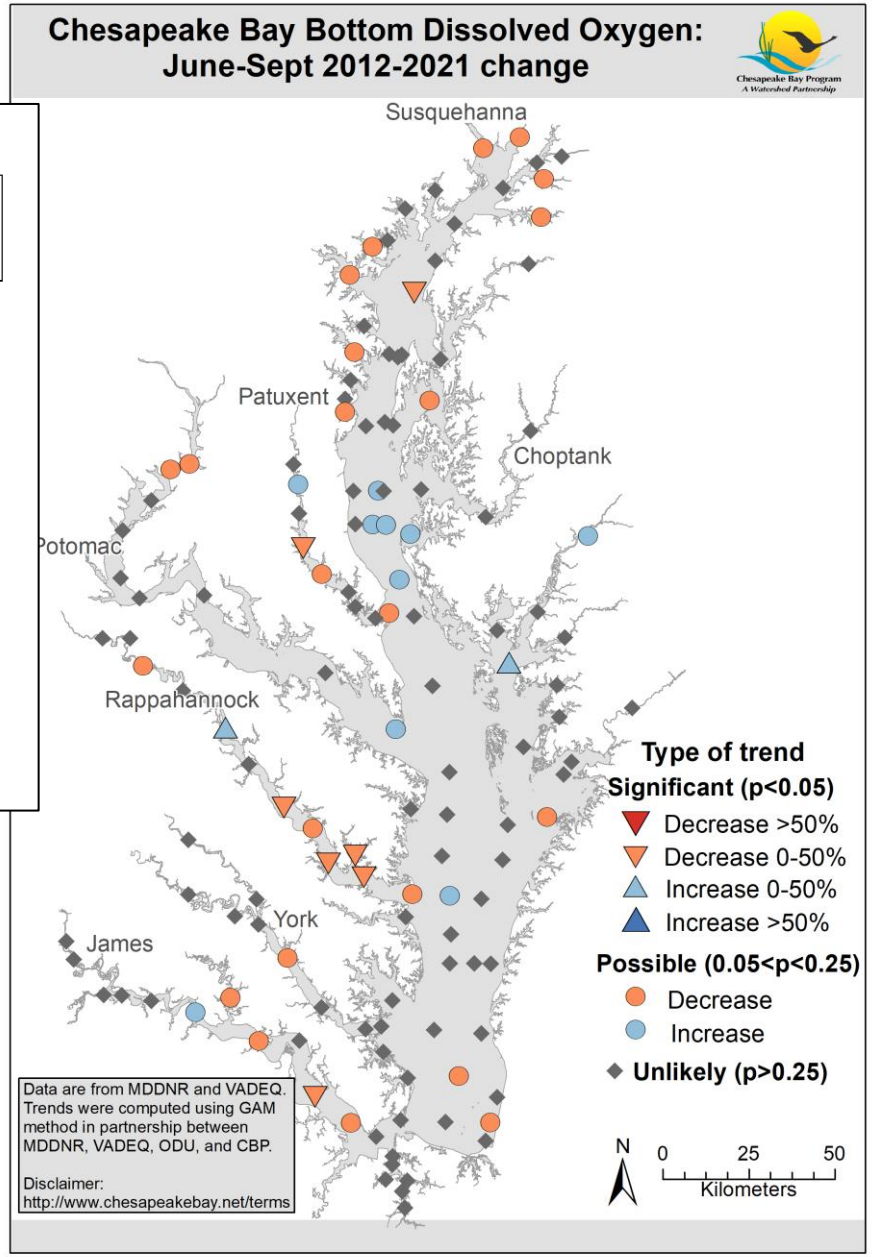
- In both seasons, conditions have improved from the long- to short-term.
- Slightly better bay-wide trends in spring than summer.



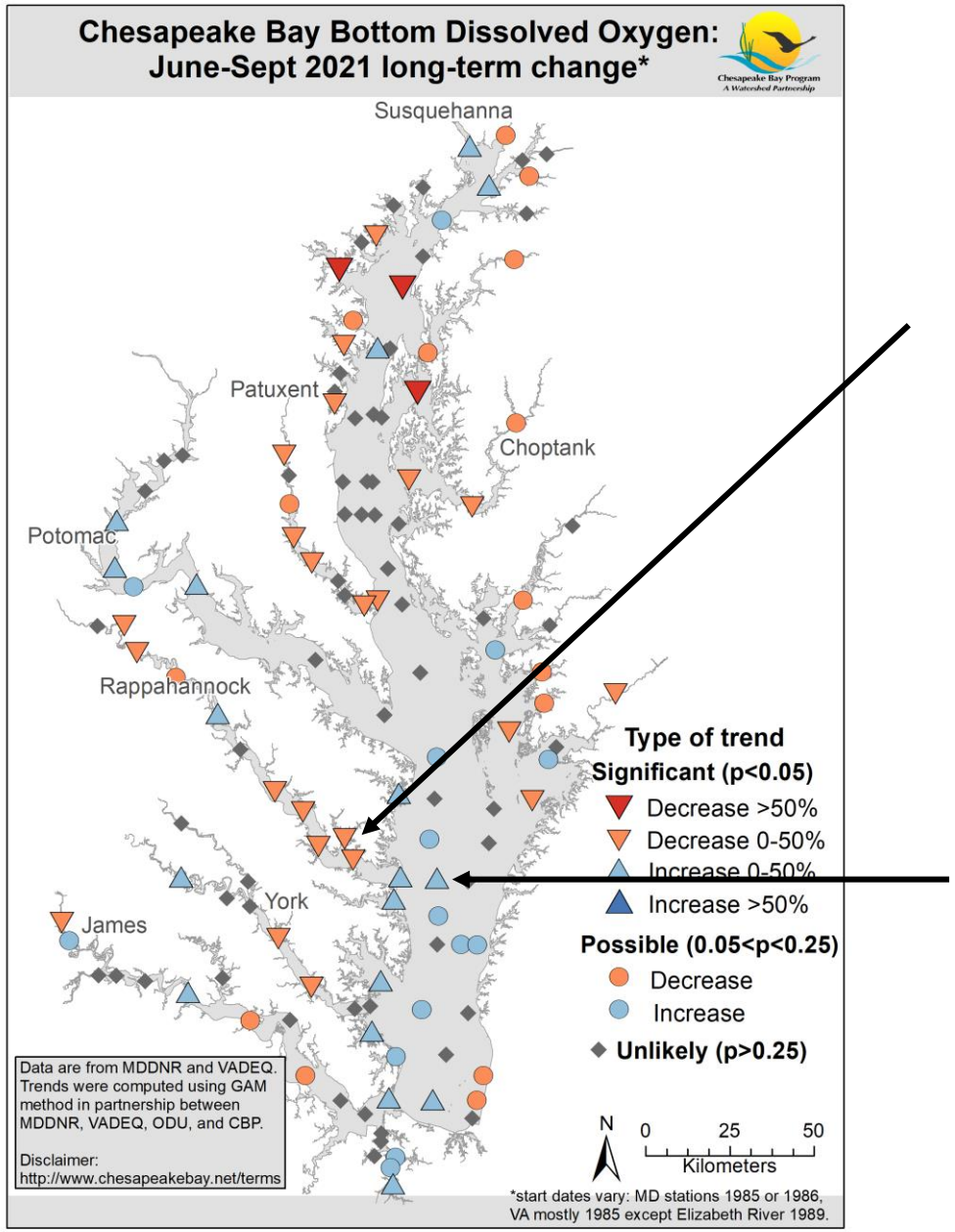
# Bottom Summer DO

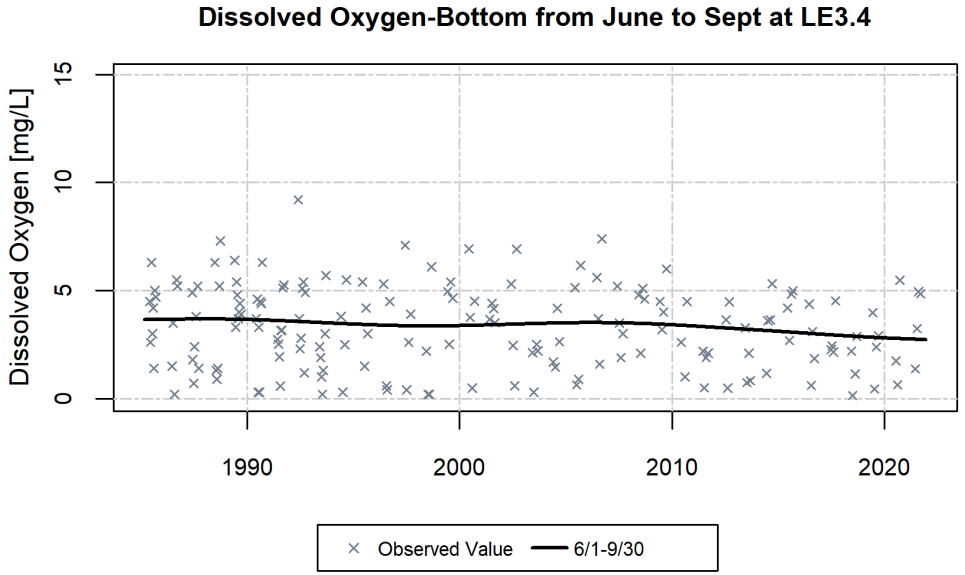


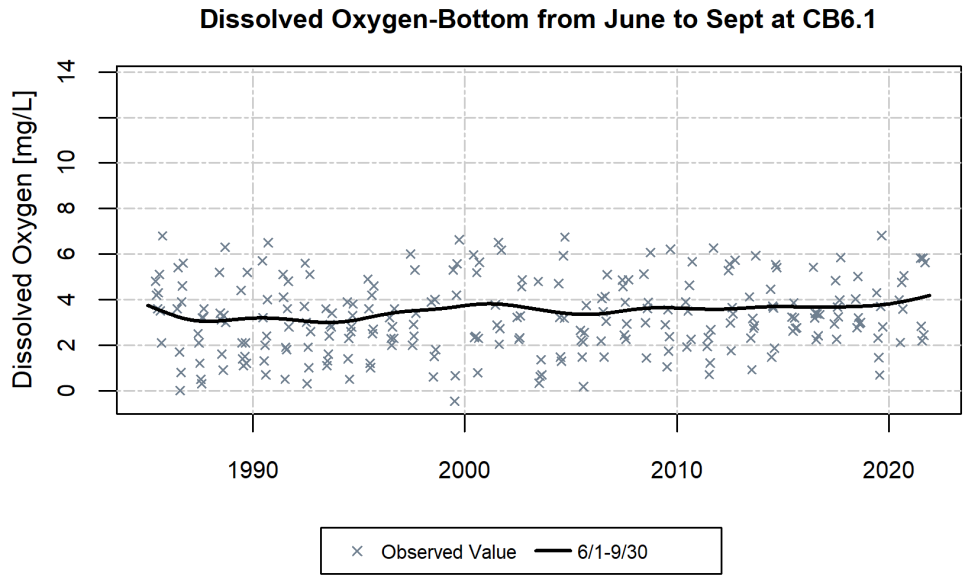



# Bottom Summer DO



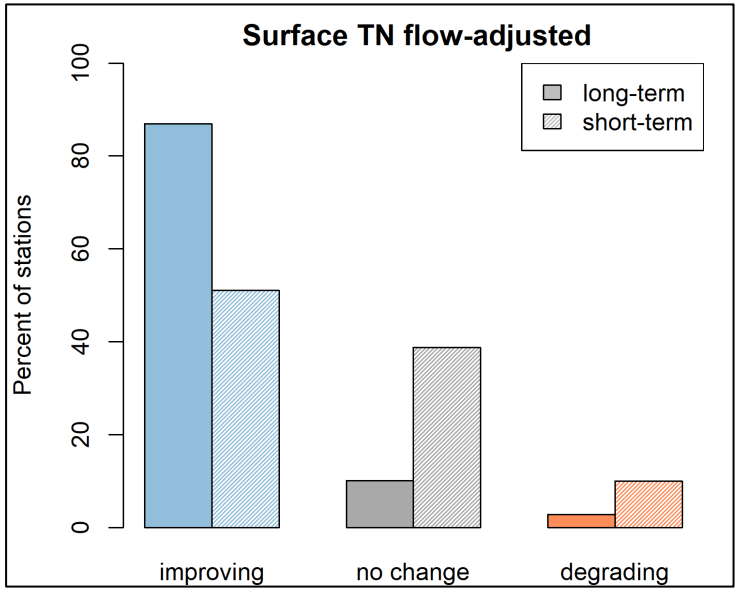



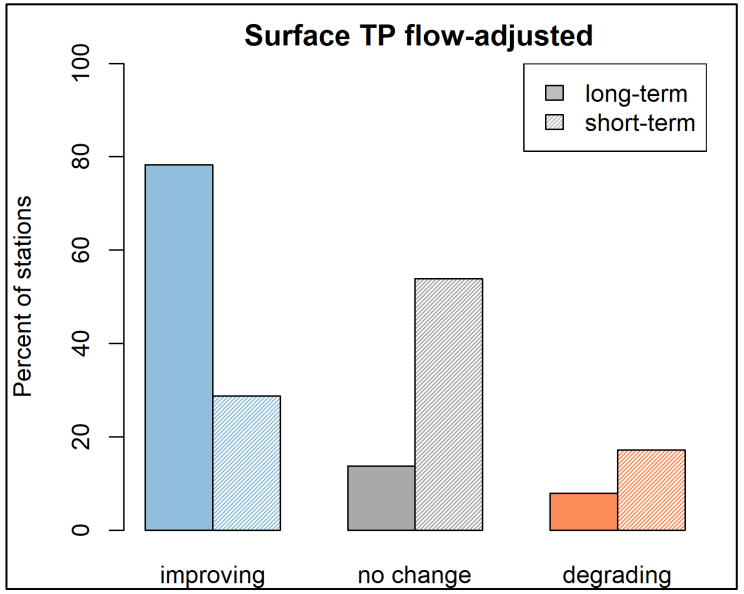



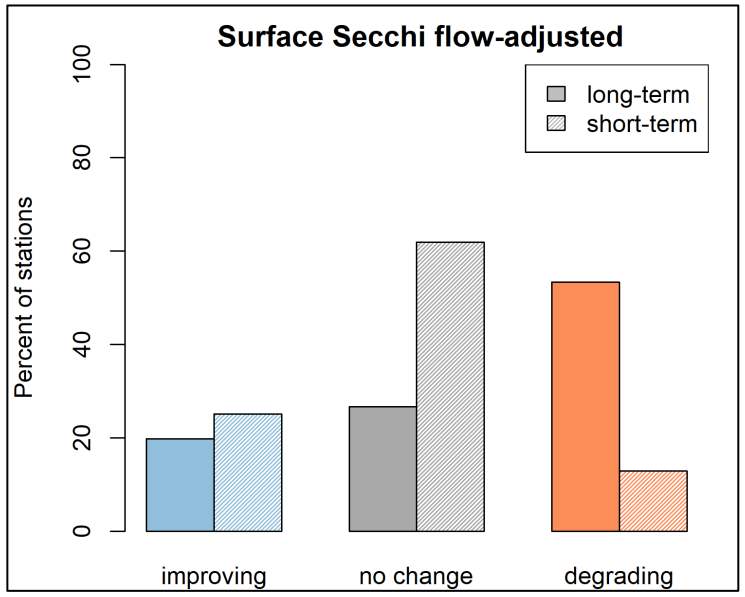

Example: Bottom summer oxygen trends.

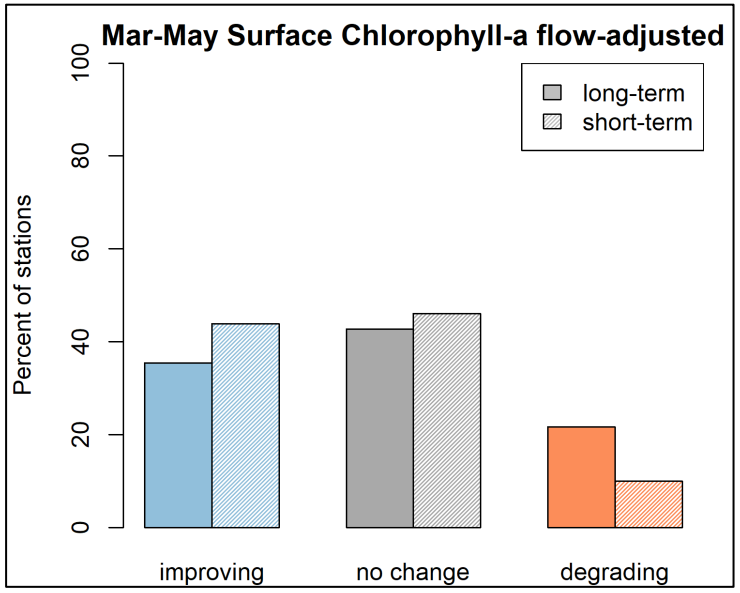
# 2021 Summary

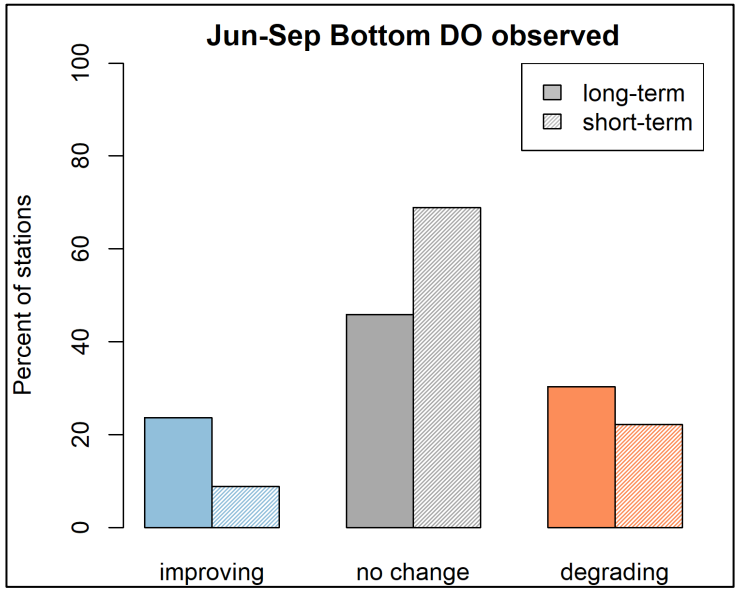
- Overall patterns consistent with last year. (more TP and chla improvements)
- Nutrient trends mostly improving over the long-term with some leveling-out over the short-term.
- Fewer degrading short-term trends than long-term for Secchi, chlorophyll *a* and DO.



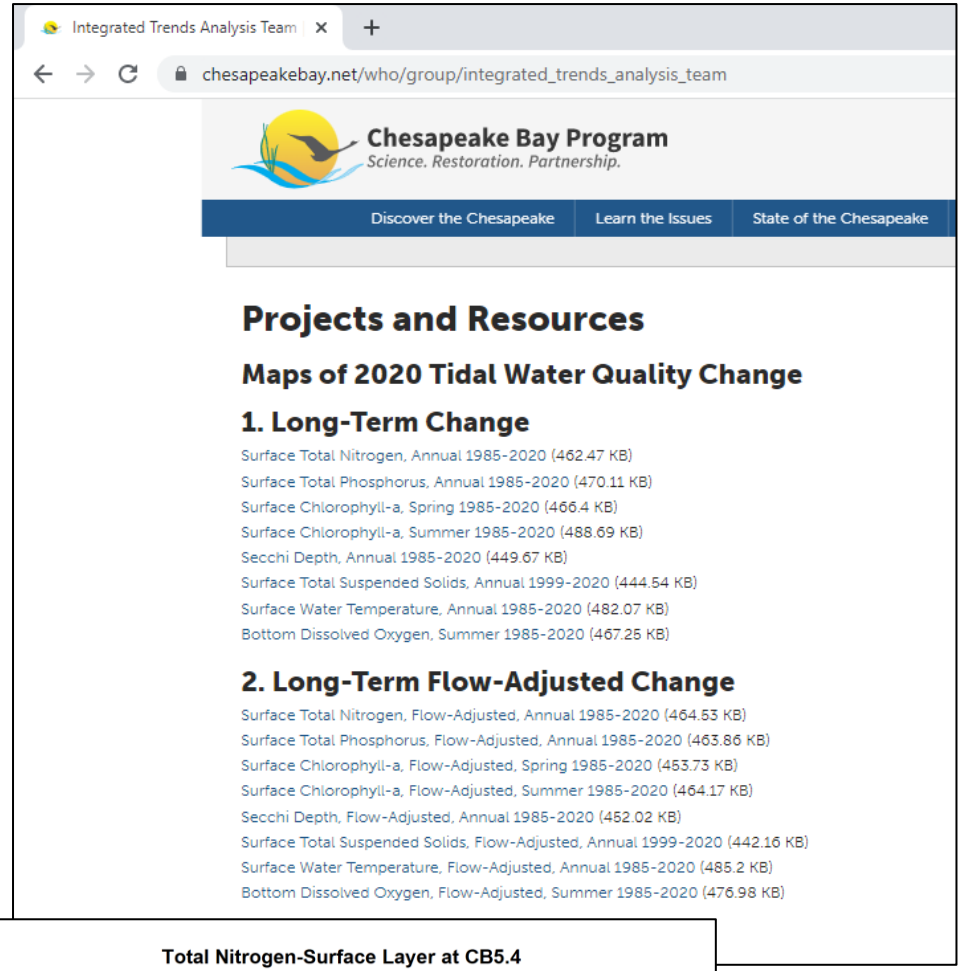



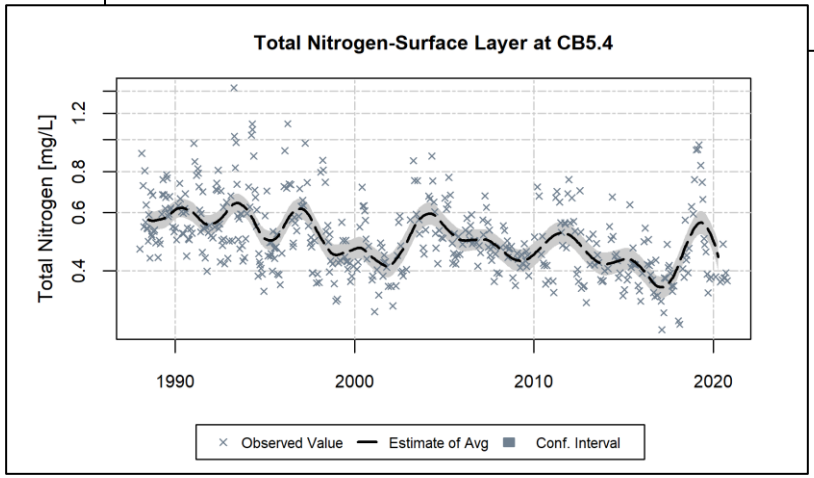



# Accessing 2021 Tidal Trends – updates to occur soon

- ITAT webpage
  - https://www.chesapeakebay.net/who/group/integrated_trends_analysis_team
- Baytrendsmap
  - https://cast.chesapeakebay.net/TrendsOverTime
- Chesapeake Bay Watershed Data Dashboard (Beta) – 2020 just updated recently
  - Includes maps and static graphs of simplified results.
  - https://gis.chesapeakebay.net/wip/dashboard/



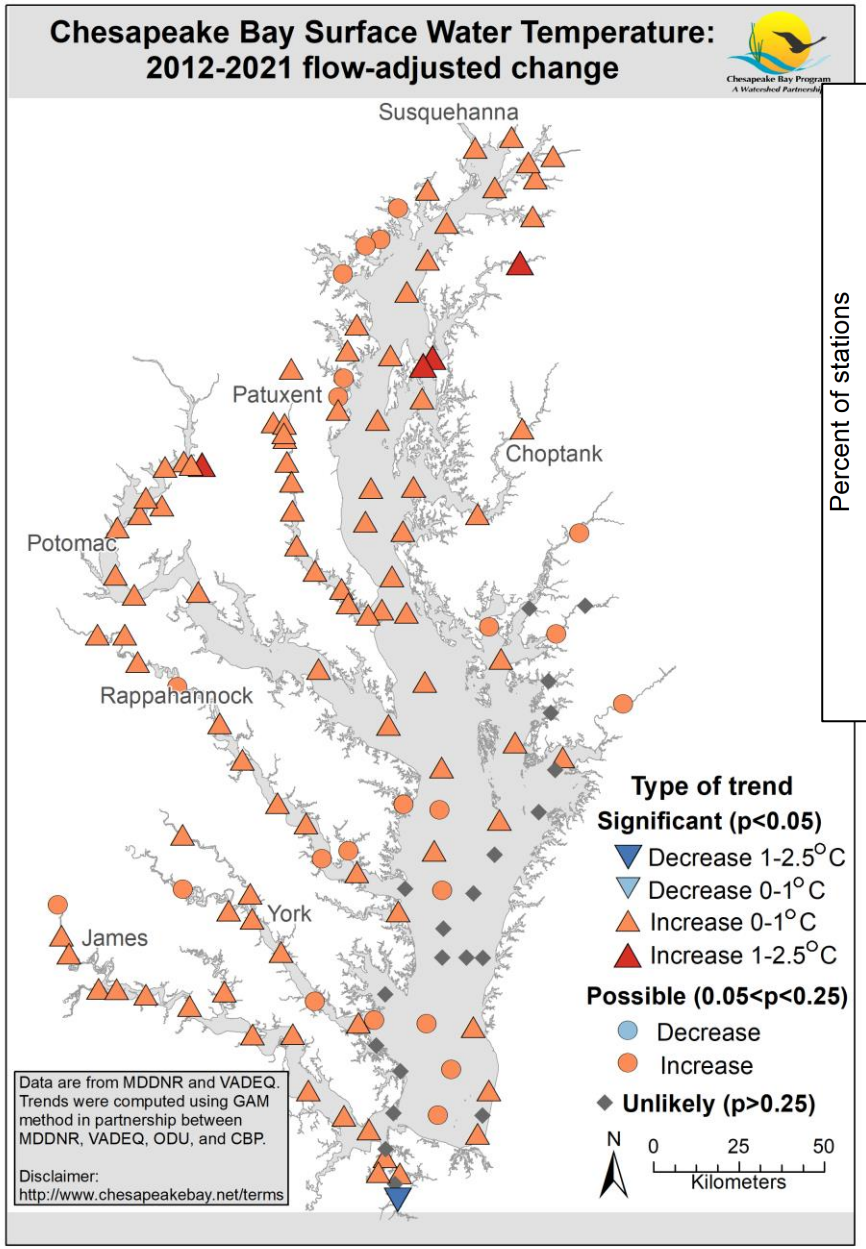



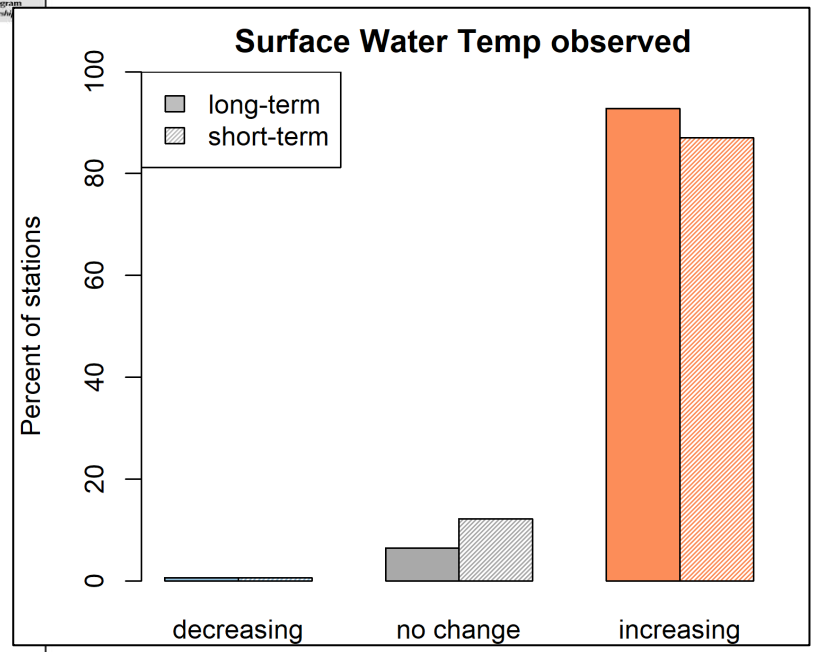
# Acknowledgements

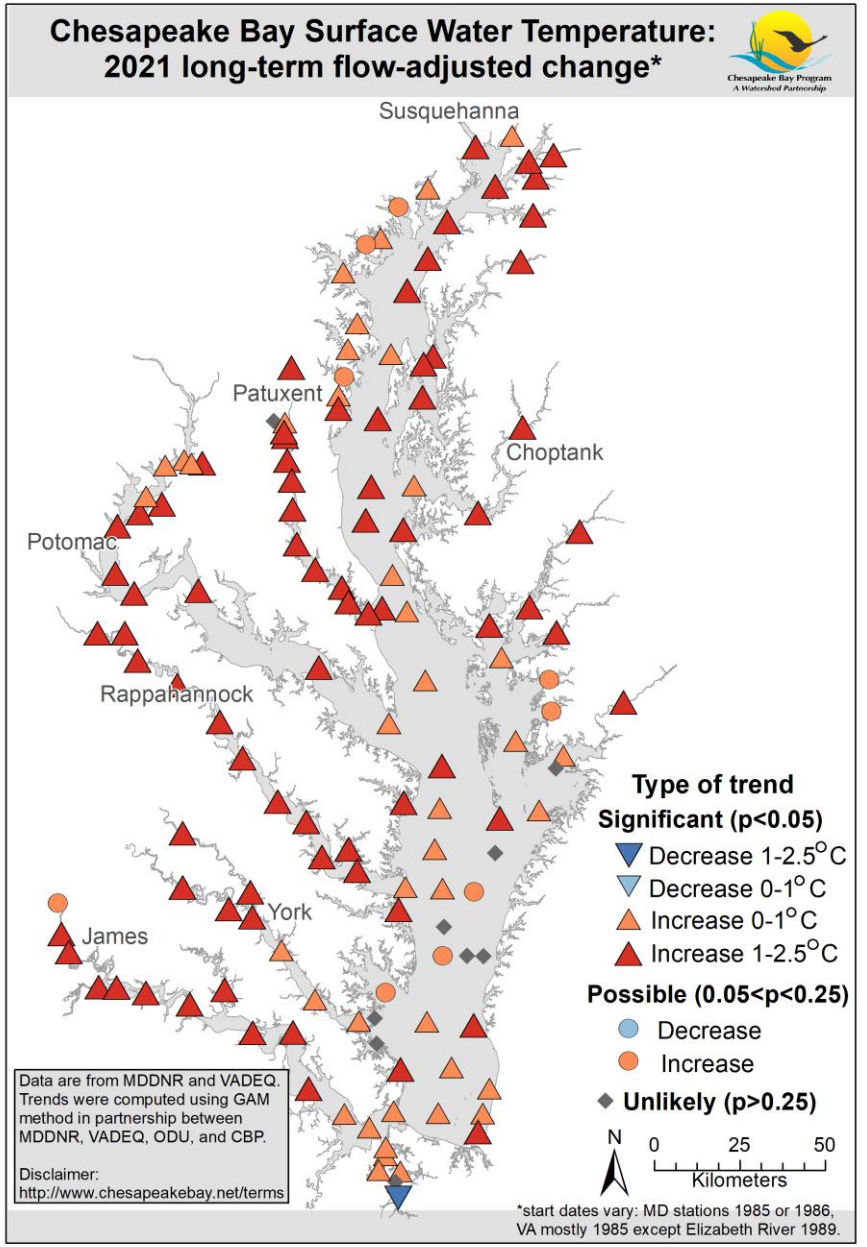

- Data collection through MDDNR, VADEQ, DOEE
- Elgin Perry, Jon Harcum (Tetra Tech), and Jeni Keisman (USGS) for method development
- Contributing to this year's results:
  - Renee Karrh (MDDNR);
  - Mike Lane (ODU) and Cindy Johnson (VADEQ);
  - Efeturi Oghenekaro, Blessing Edje and George Onyullo (DOEE); Mukhtar Ibrahim and Karl Berger (MWCOG);
  - Breck Sullivan (USGS), Alex Gunnerson (CRC)

# extras

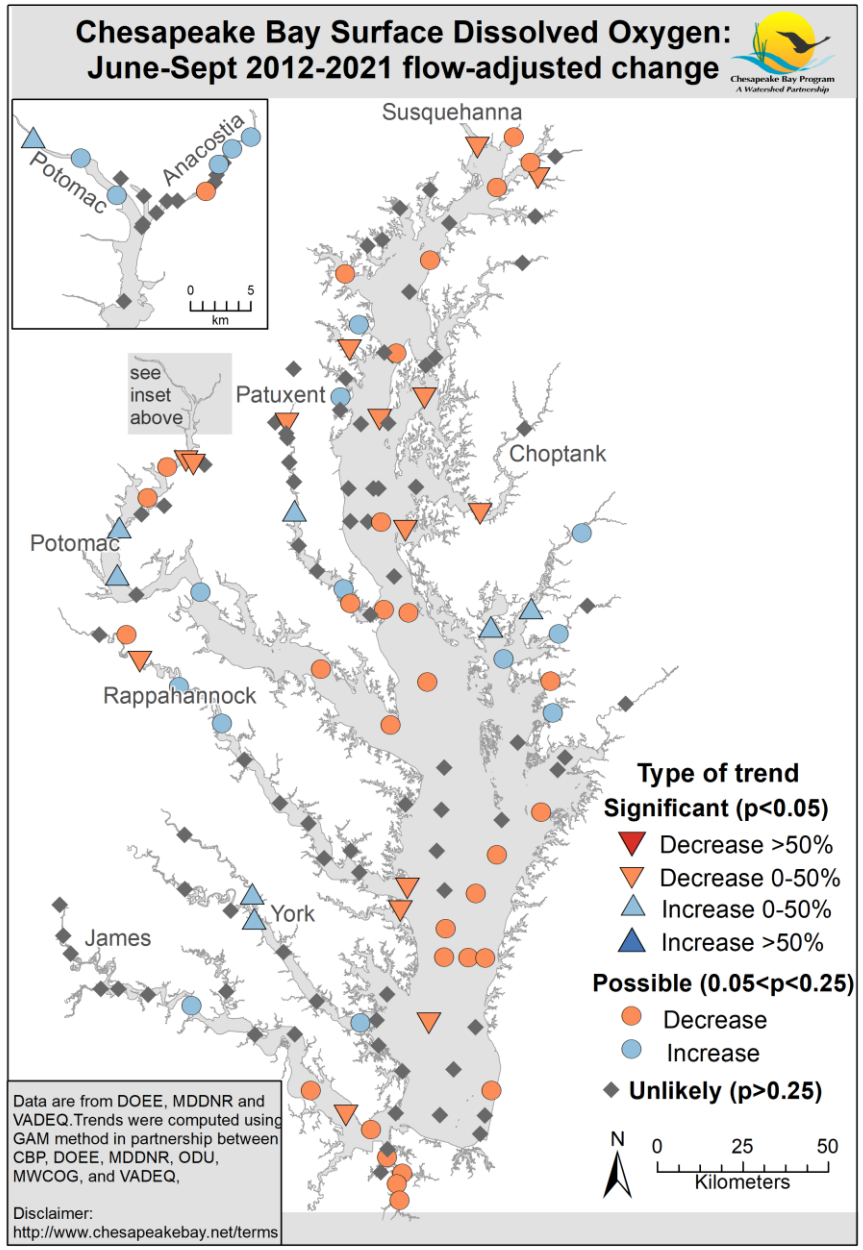
# Surface Water Temperature

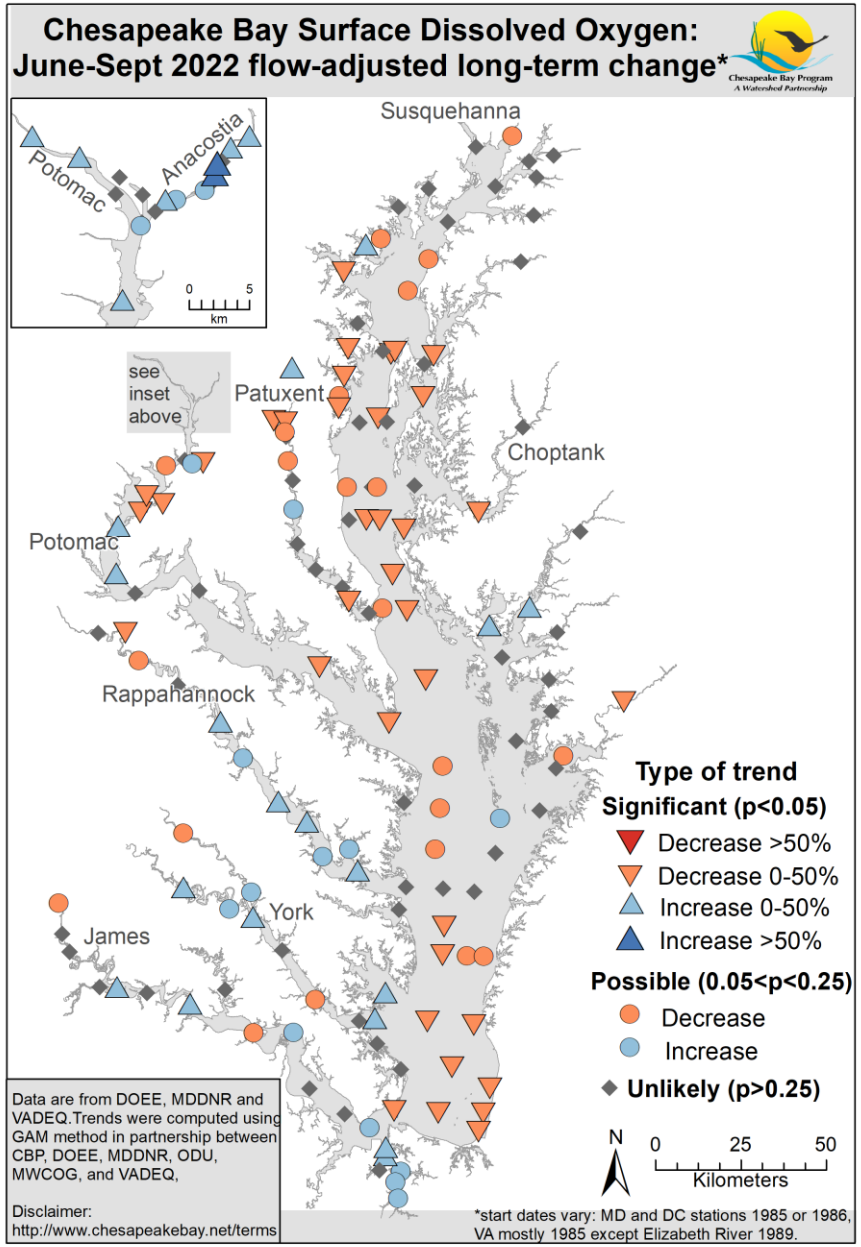


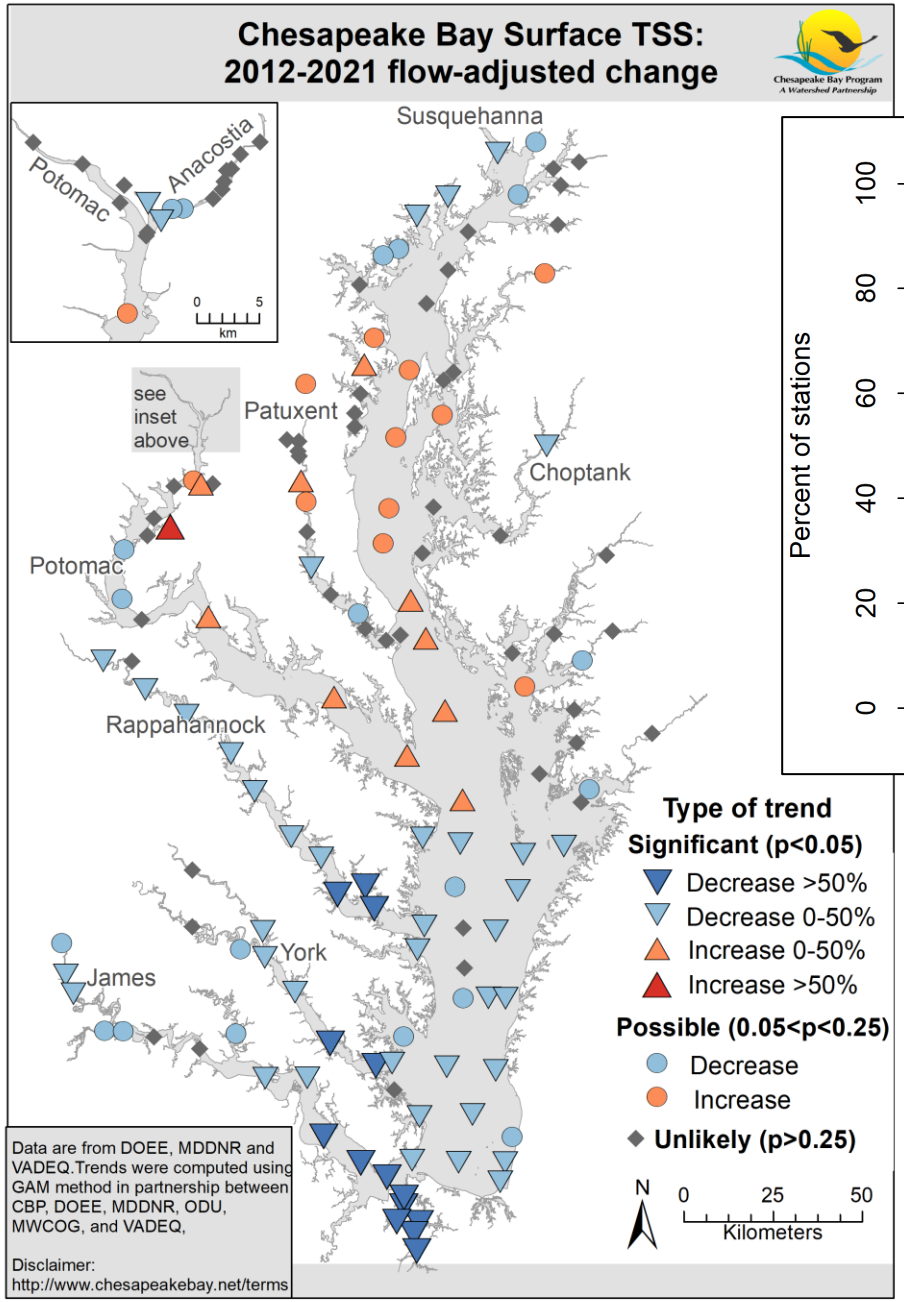



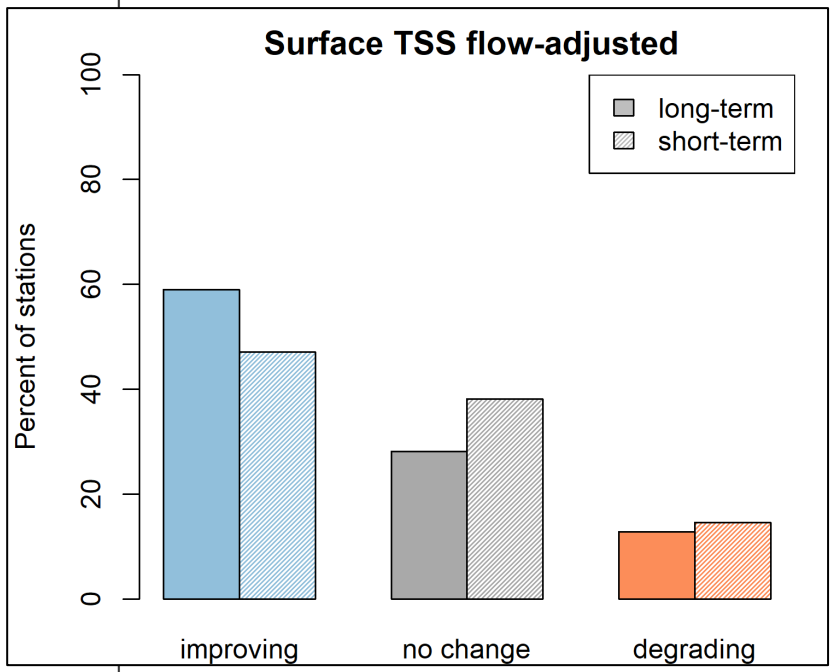
# Surface Dissolved Oxygen

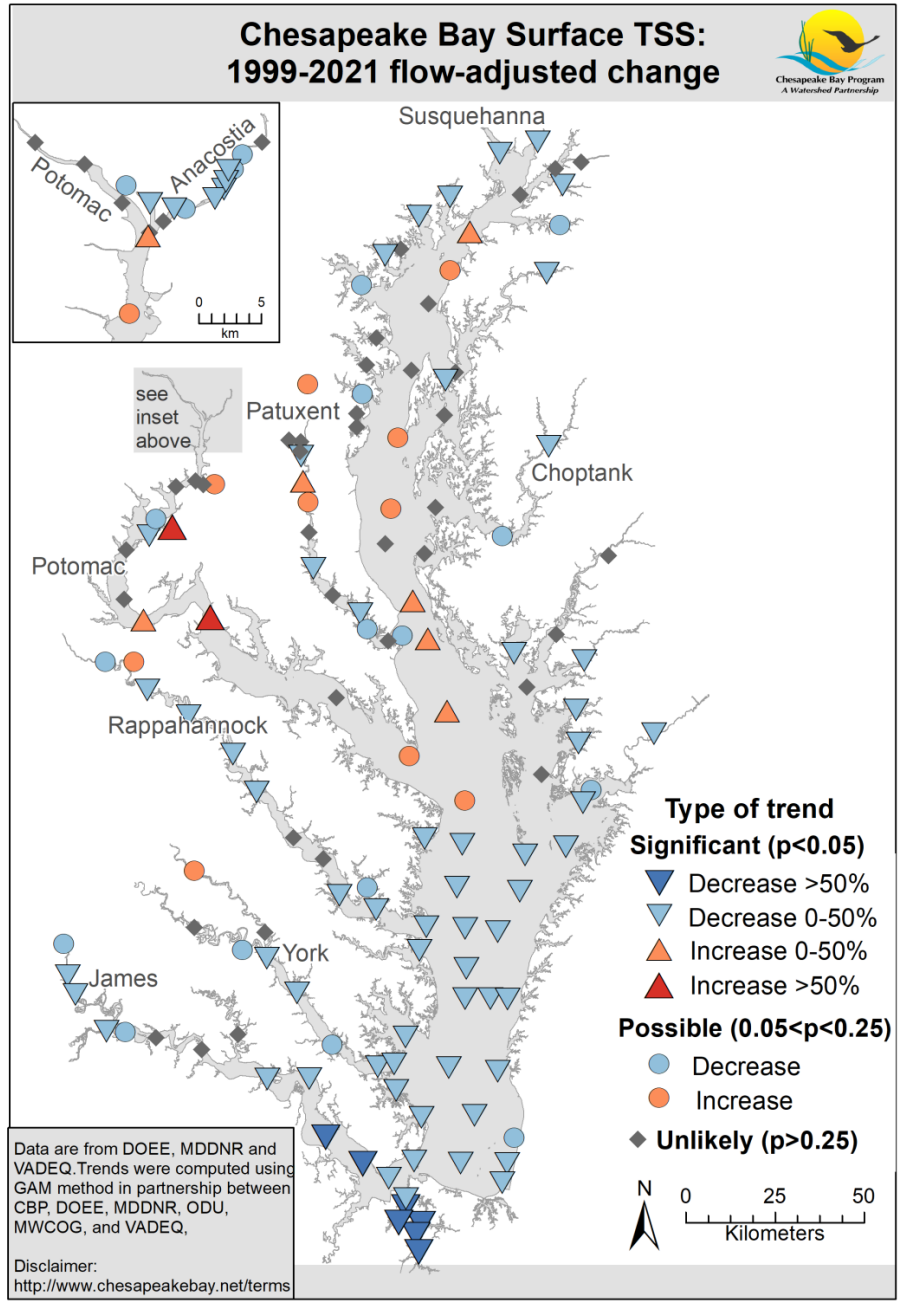


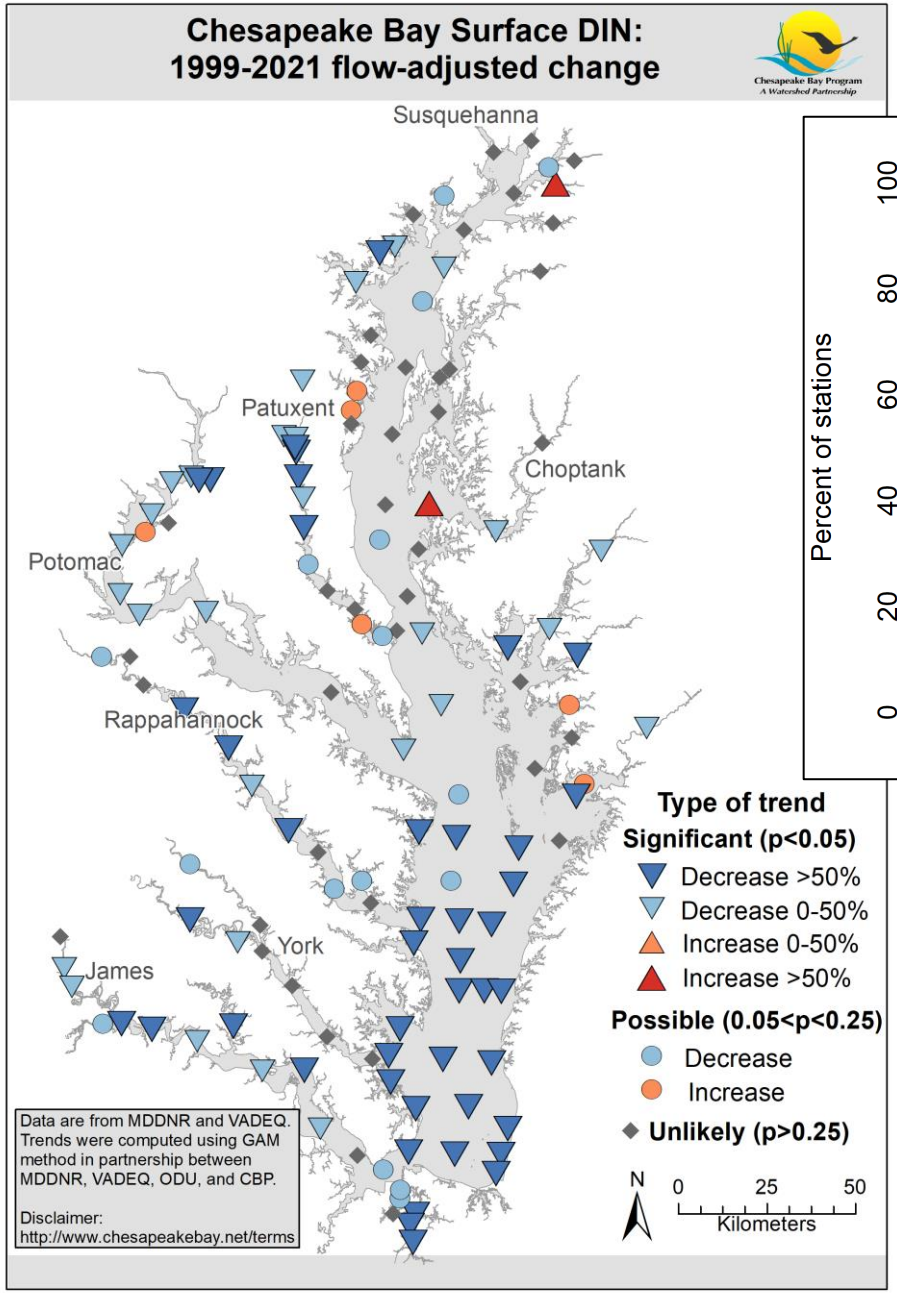
# Surface TSS (1999 analysis start)

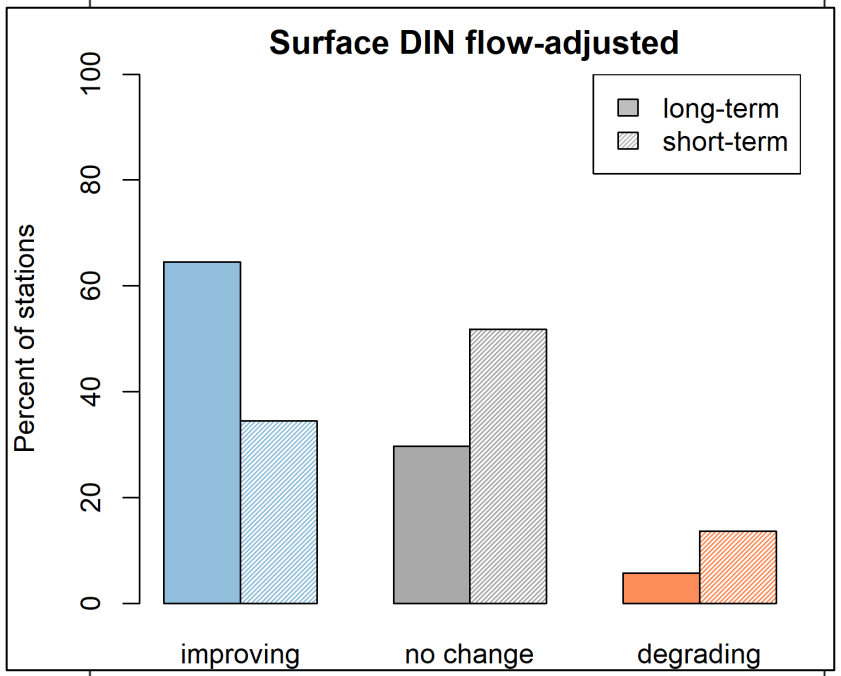


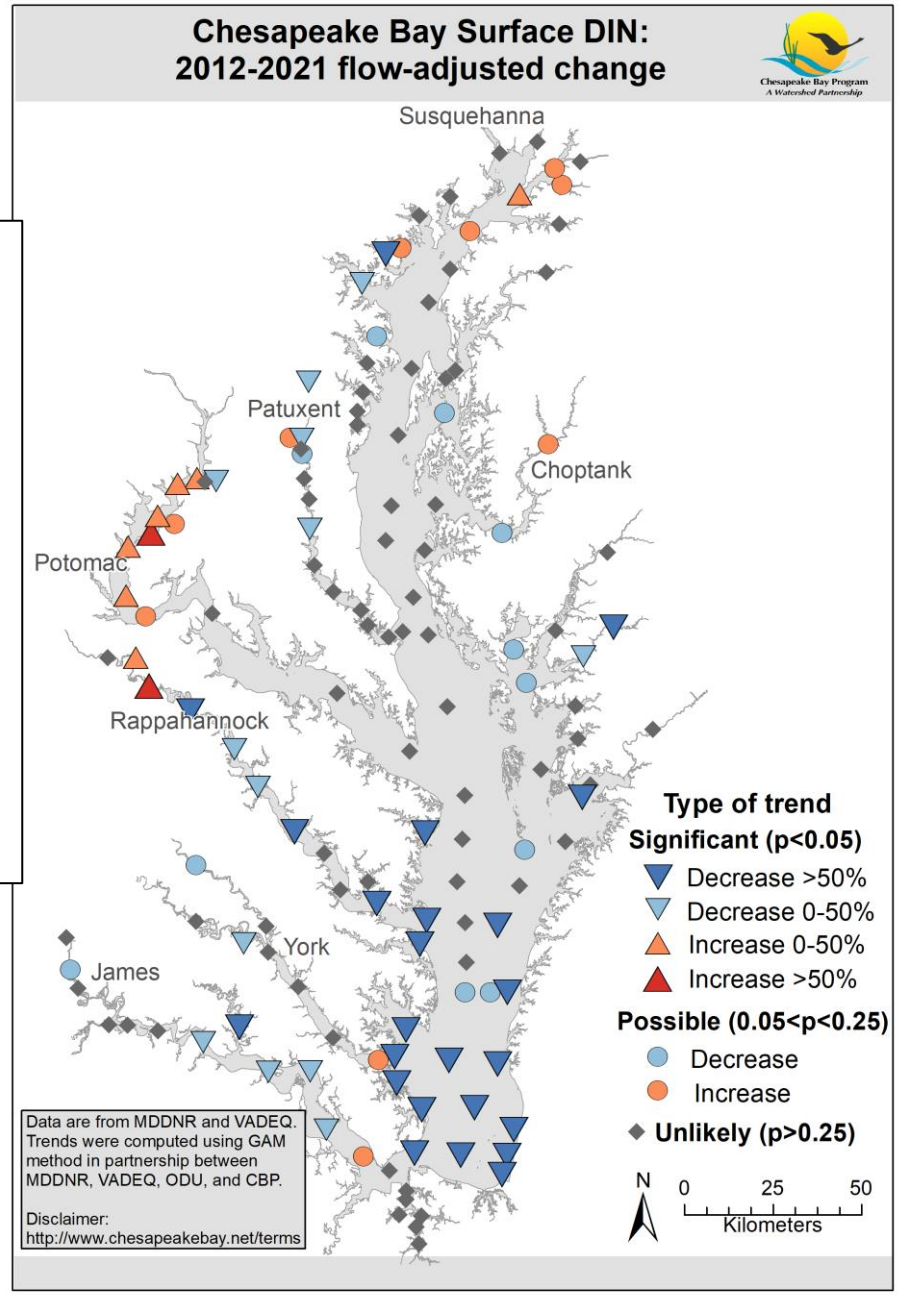



# Surface DIN (1999 analysis start)

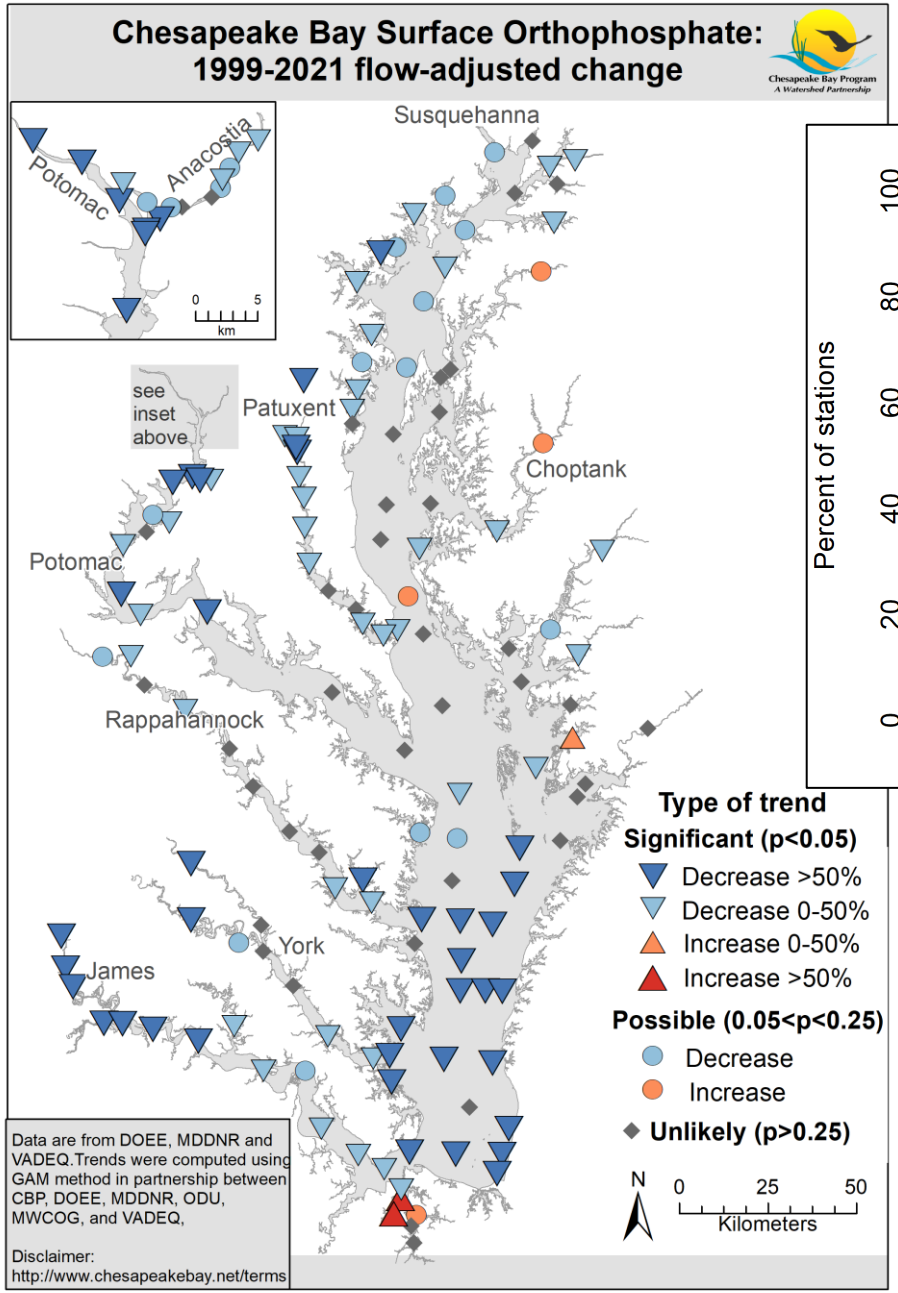


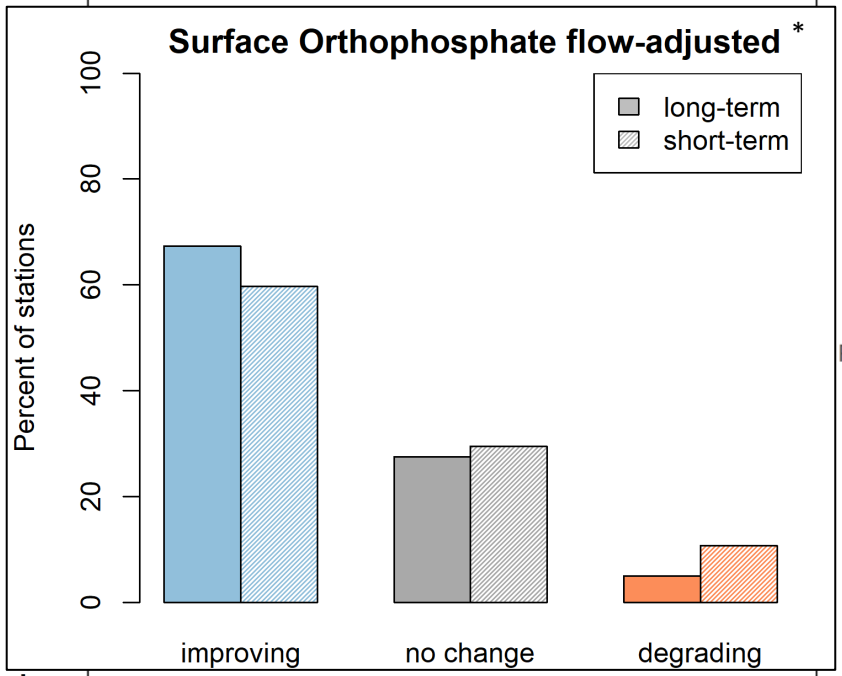



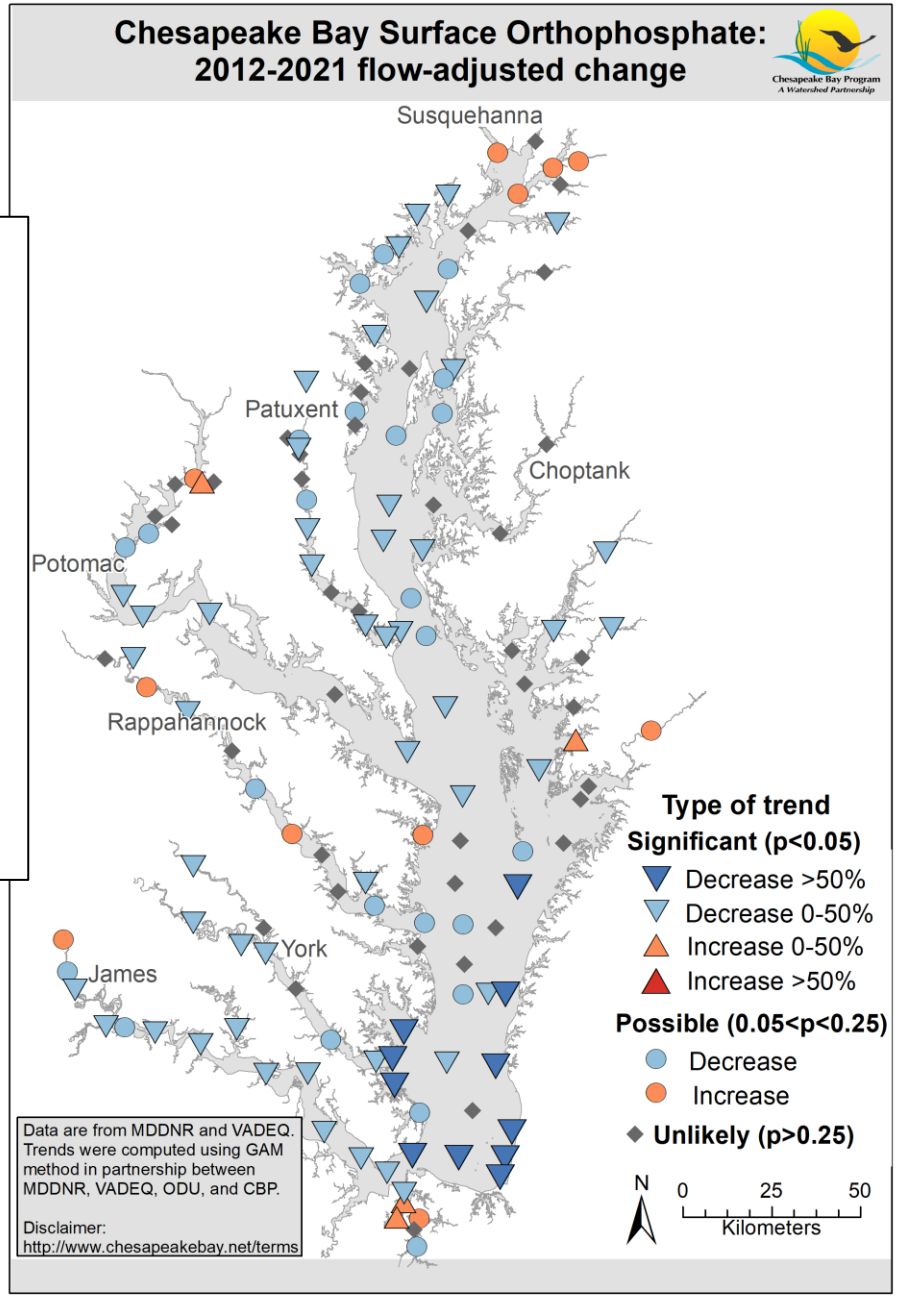




← Keep in mind not the same start year at TN

# Surface PO4 (1999 analysis start)




← Keep in mind not the same start year at TP

*Note: Bar chart does not include Washington D.C. stations since they are only short-term

# 2020 Summary

- Overall patterns consistent with last year.
- Nutrient trends mostly improving over the long-term with some leveling-out over the short-term.
- Fewer degrading short-term trends than long-term for Secchi, chlorophyll *a* and DO.