Tidal Trends to evaluate water quality in the Chesapeake Bay

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Climate Resiliency Workgroup Call

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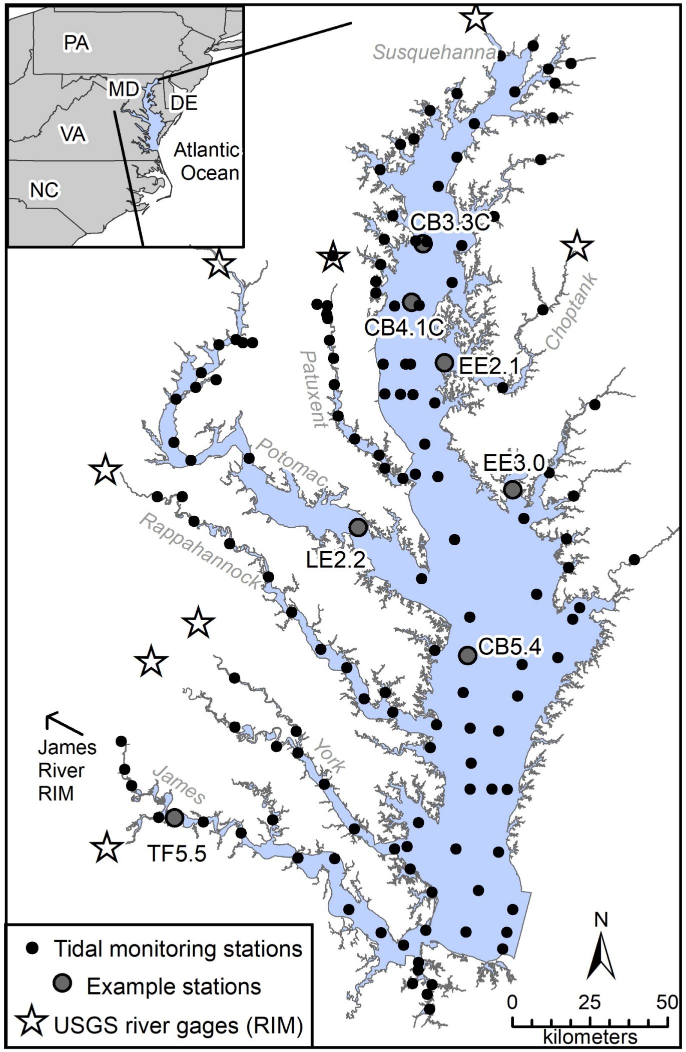
University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

Chesapeake Bay Program
Science. Restoration. Partnership.

Extensive long-term coordinated tidal water quality monitoring



- MDDNR, VADEQ and others have been sampling at 150+ stations since the 1980s 1-2 times/month
- Nutrients, chlorophyll-*a*, dissolved oxygen, secchi depth, salinity, temperature, and others, all measured at multiple depths

Matt Rath/Chesapeake Bay Program

Tidal Trends Analysis Collaboration

- Since the mid-1990s, coordinated trends efforts have existed as well between MD, VA, and CBP for:
  - Tracking change
  - Visual tool for management audiences
  - Identifying areas for further research
- Recent method revision to use Generalized Additive Models (GAMs)
- Tidal Trends Analysis Team: CBP, MDDNR, VADEQ, ODU, UMCES, USGS, statistical consultants

Approach: Generalized Additive Models (GAMs)

A response variable is modeled as the sum of multiple functions of explanatory variables

Water quality =
s(doy) + s(date) + Interaction(doy, date)

s = spline smooth functions
doy = day of year

Smoothly-varying non-linear "spline" functions

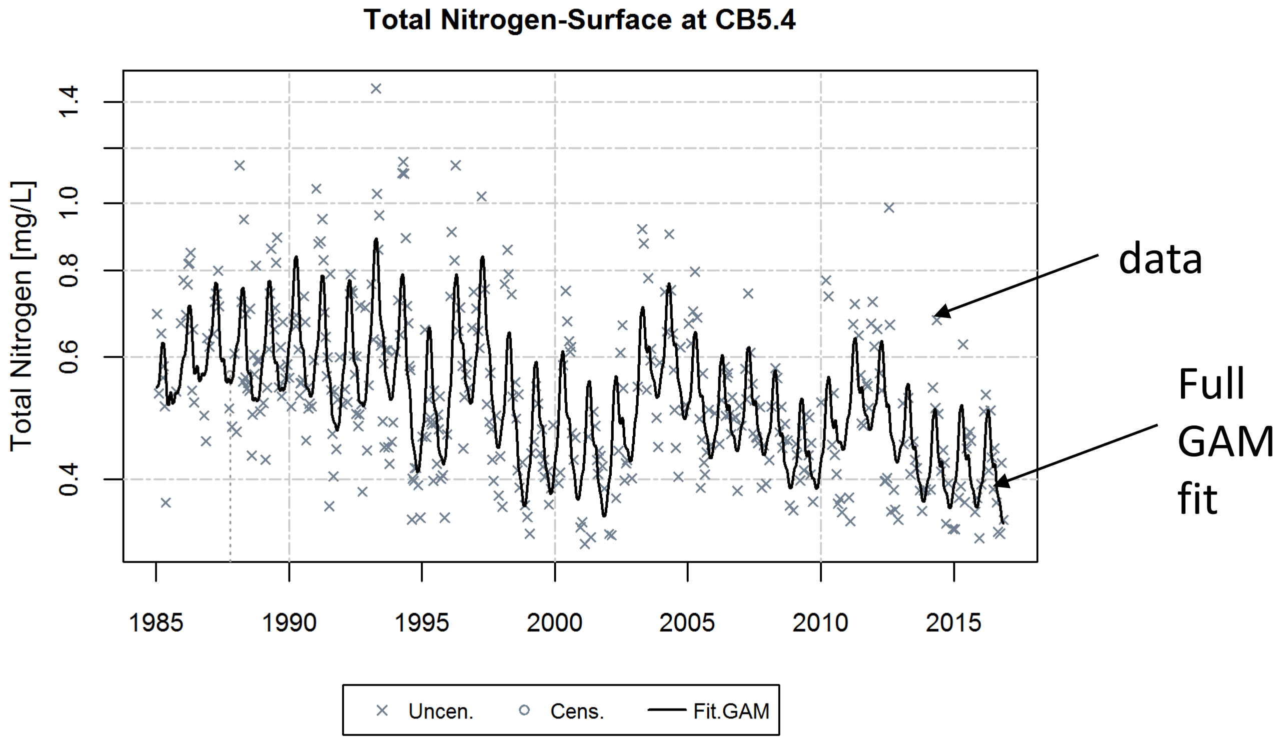
And multi-dimensional smooth functions

We're using: mgcv R package by Simon Wood: (https://cran.r-project.org/web/packages/mgcv/ mgcv.pdf) and through our separate R package 'baytrends'

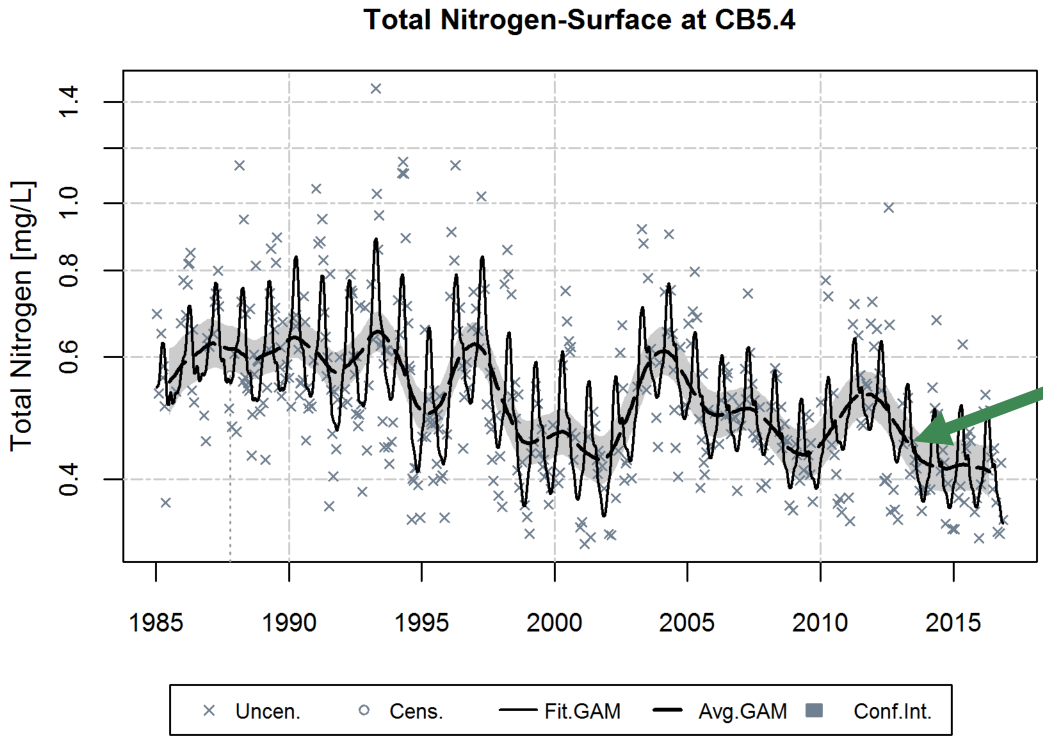
Murphy, R.R., Perry, E., Harcum, J. and Keisman, J. 2019. A Generalized Additive Model approach to evaluating water quality: Chesapeake Bay case study. Environmental Modelling and Software 118: 1-13. https://doi.org/10.1016/j.envsoft.2019.03.027

GAM Implementation

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

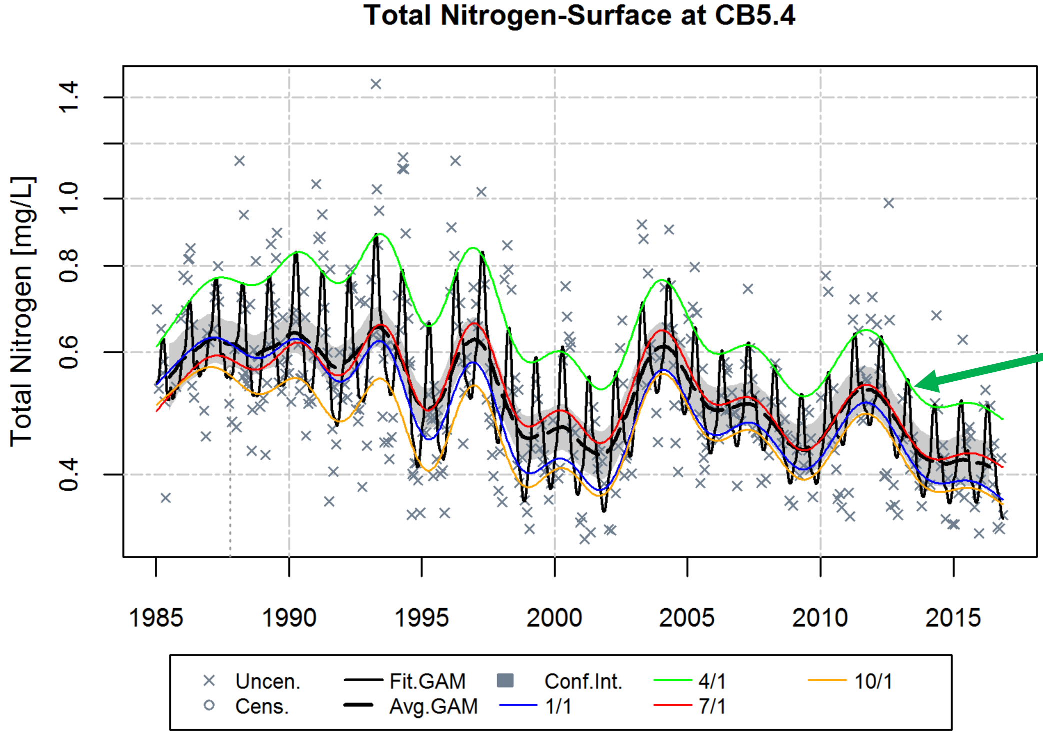


TN = s(doy) + s(date)+ interaction(doy,date)



Seasonal mean and 95% confidence interval on the mean

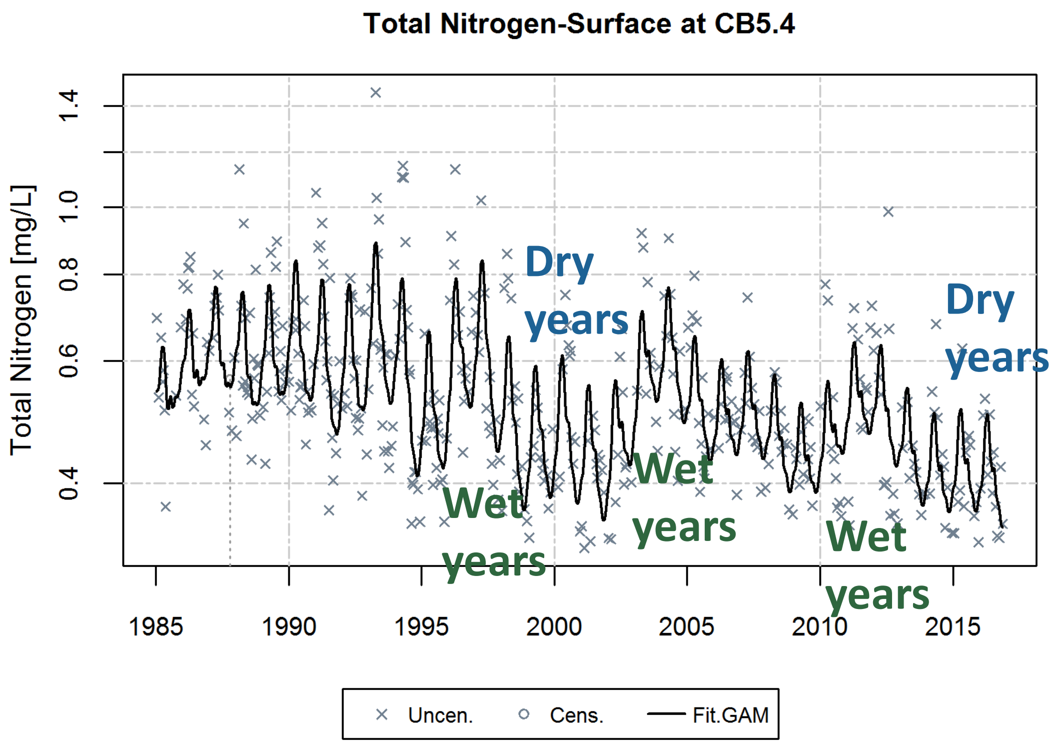
TN = s(doy) + s(date)+ interaction(doy,date)



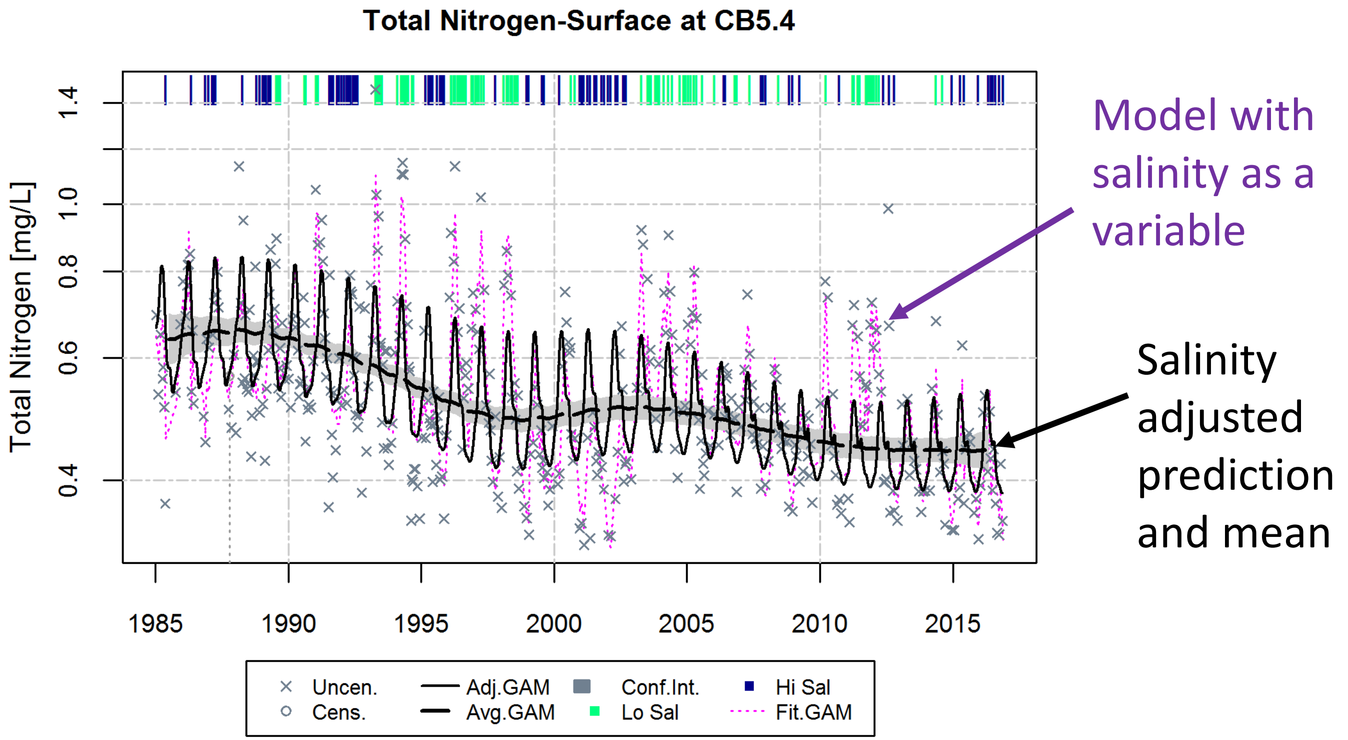
Mean prediction lines for 4 dates

- -April 1
- -July 1
- -Oct 1
- -Jan 1

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



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

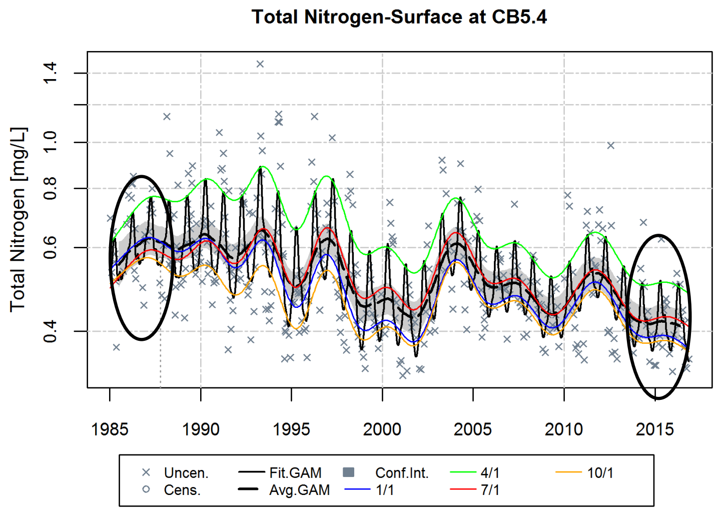


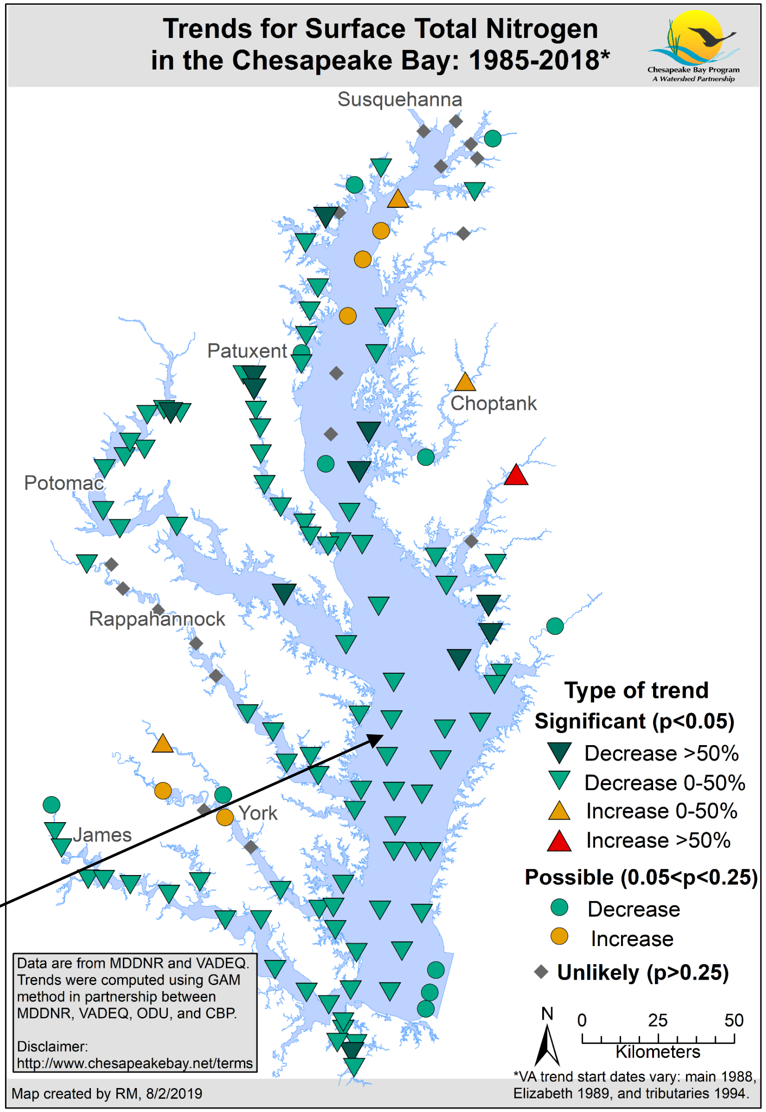
Annual trend products

- MDDNR and ODU/VADEQ fit GAMs like this for every station, surface & bottom:
  - Nutrients: Total Nitrogen, Dissolved Inorganic Nitrogen, Total Phosphorus, Orthophosphate
  - Chlorophyll-a, Dissolved Oxygen, Total Suspended Solids, Secchi Depth
  - Temperature, Salinity

Annual trend products

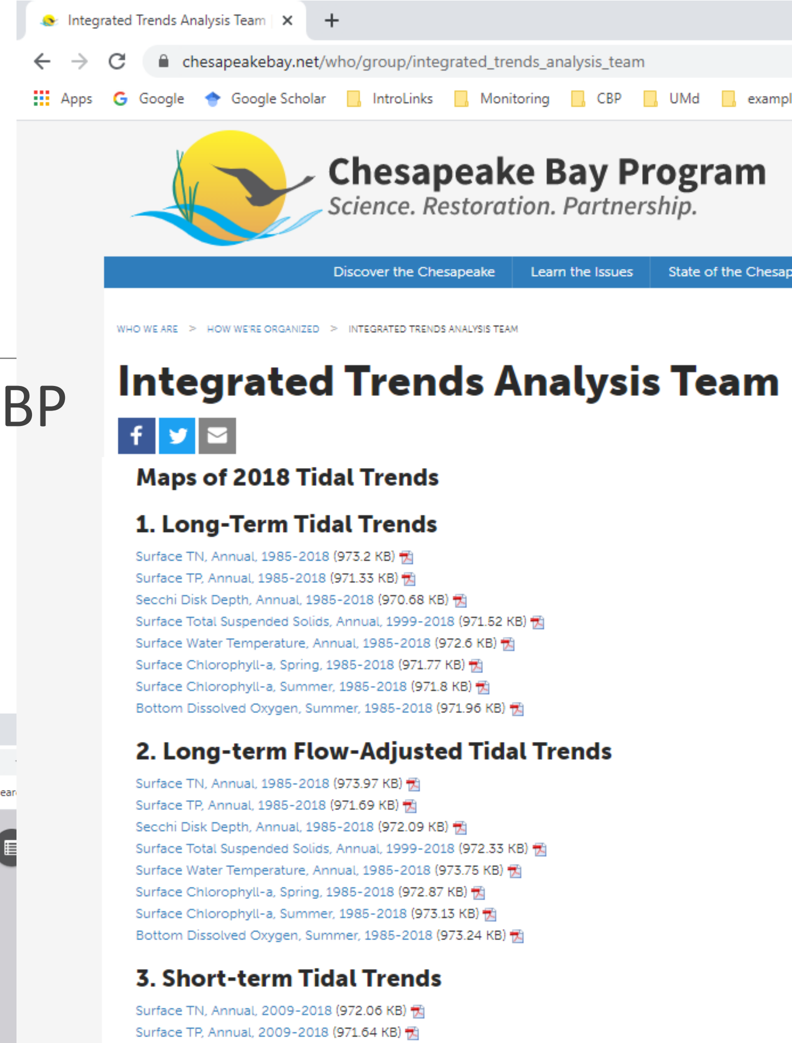
- Post-process analysis to compute change at each station for time periods and seasons
  - Long-term (ideally 1985-present)
  - Short-term (last 10 years)
  - Spring & Summer chlorophyll-a, summer bottom DO

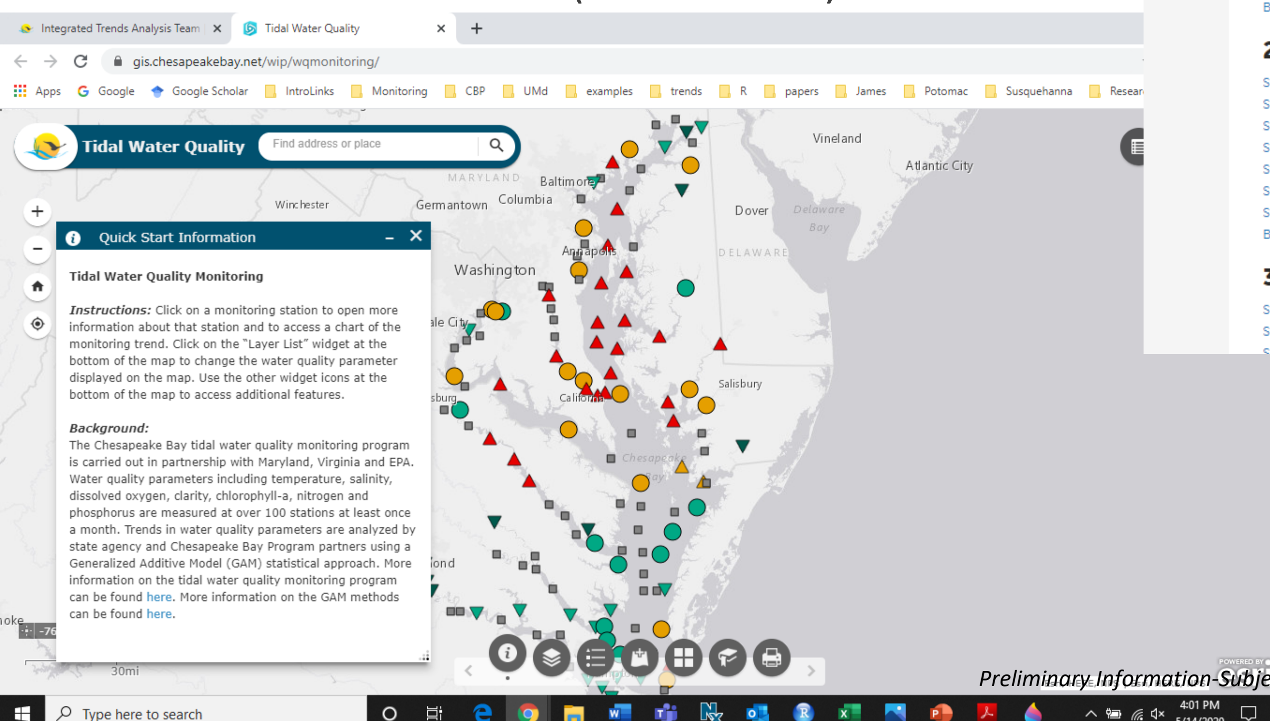




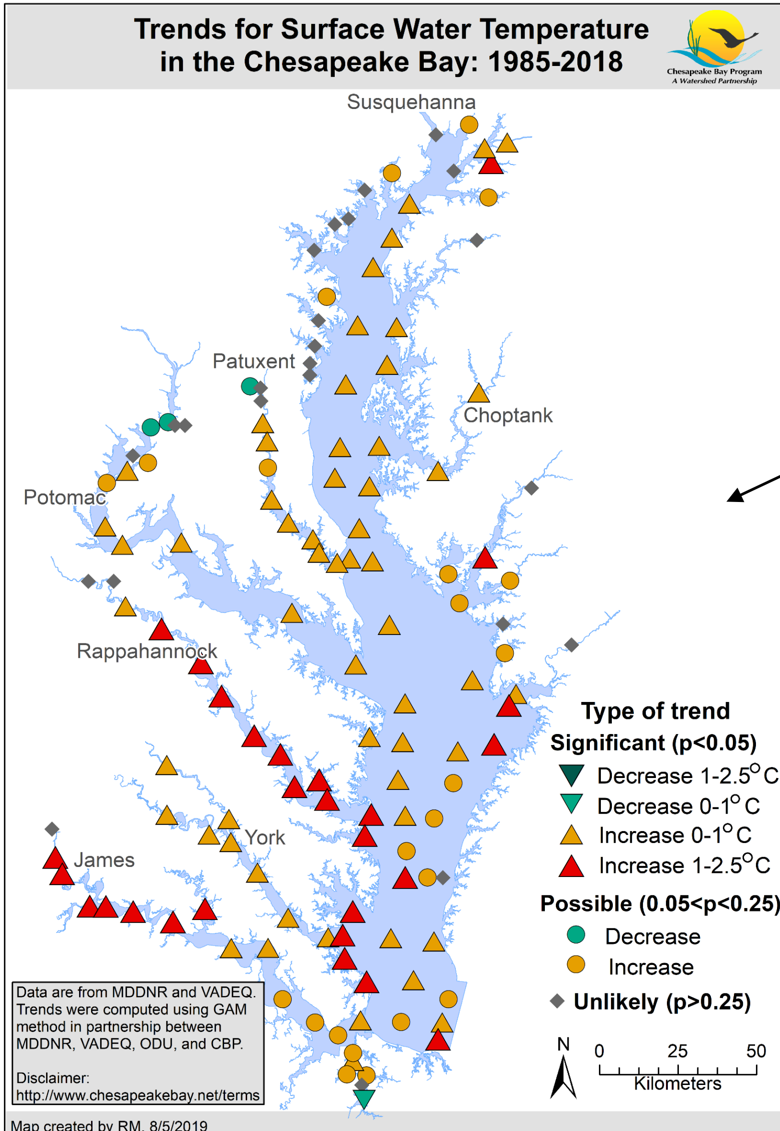
Annual trend products

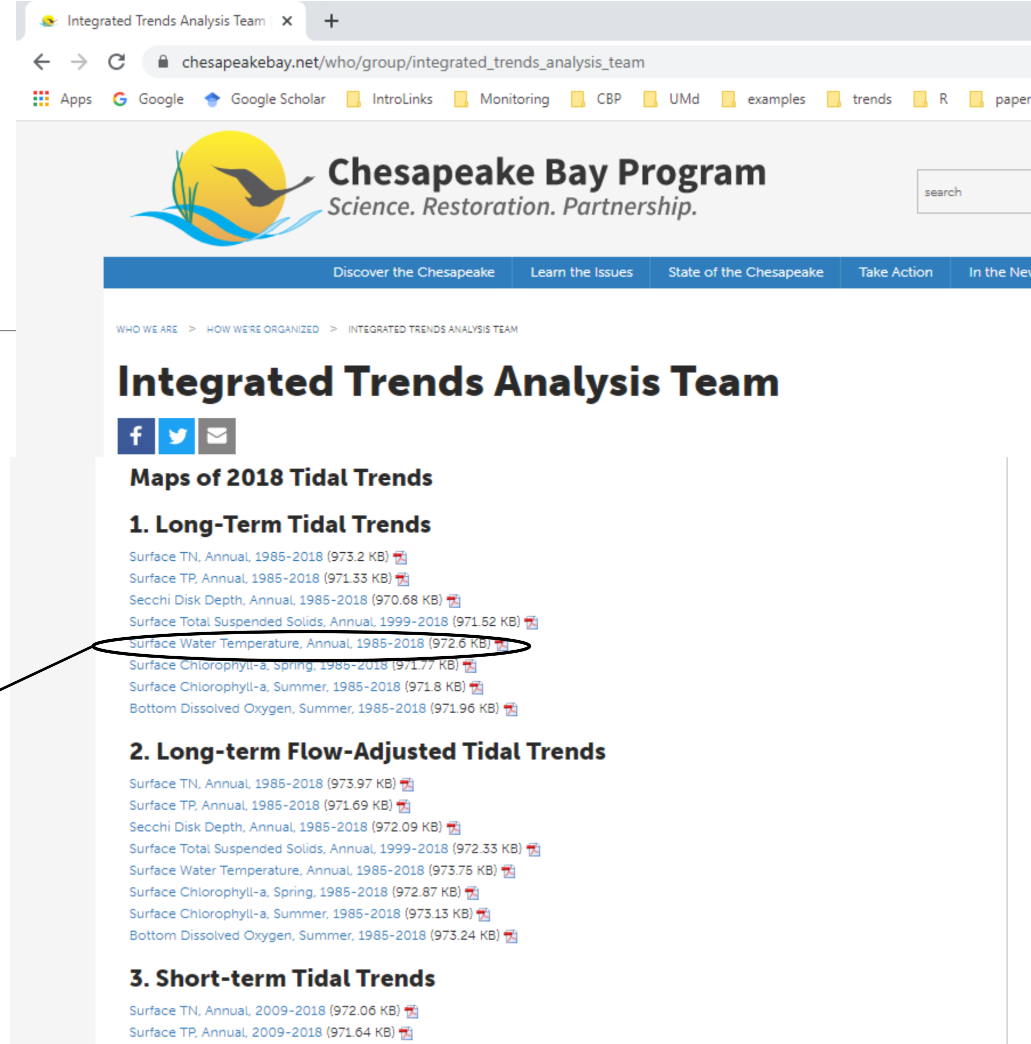
- Combined summaries generated at CBP
  - Maps
  - Graphics on data dashboard
  - Interactive mapping tool (available soon)
  - Basin summaries (in the works)



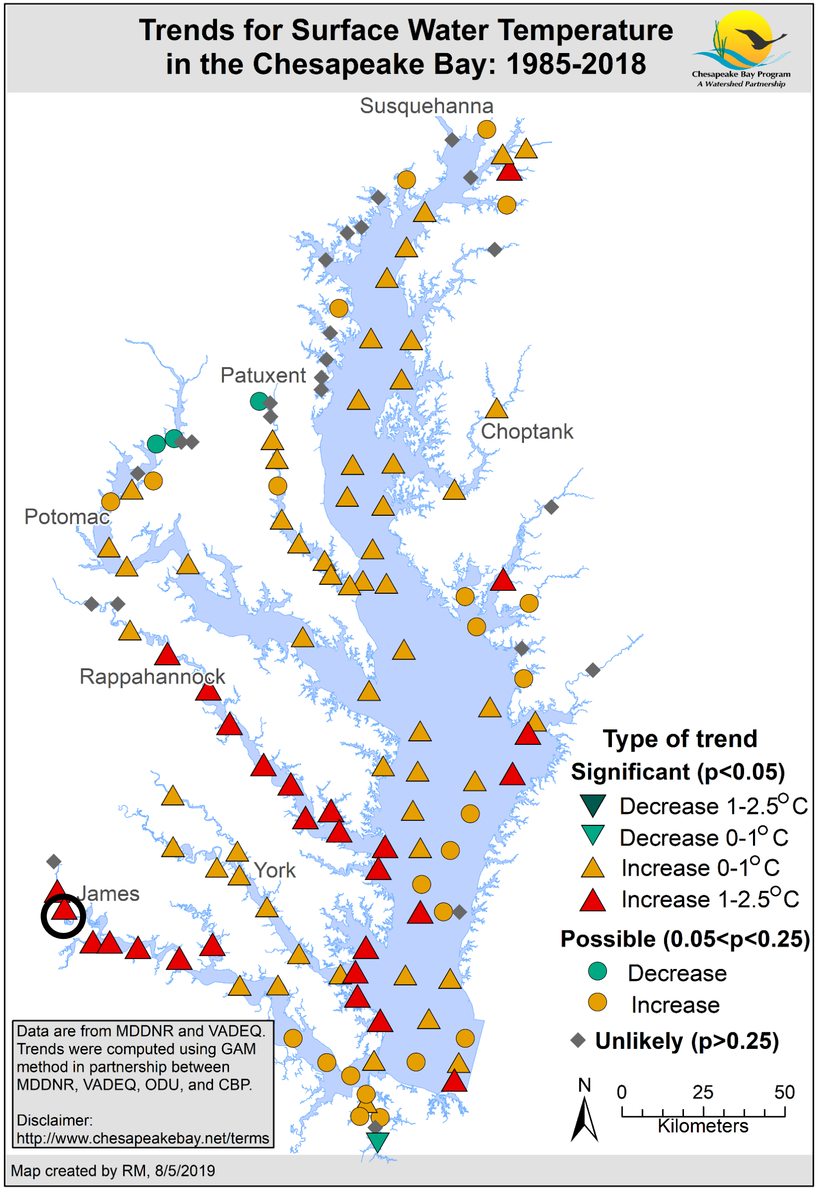


Annual trend products

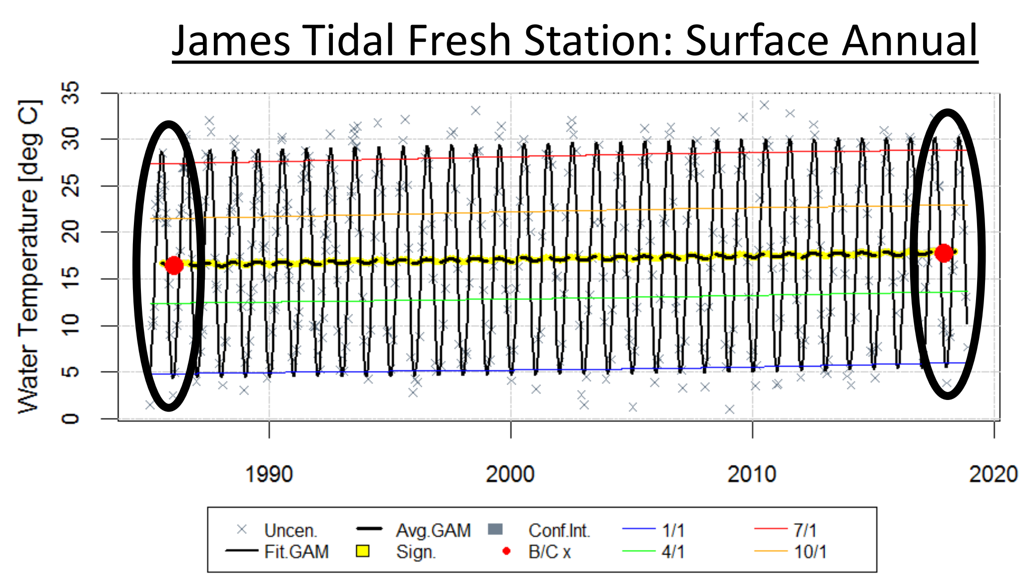




Can extract relevant info, such as:



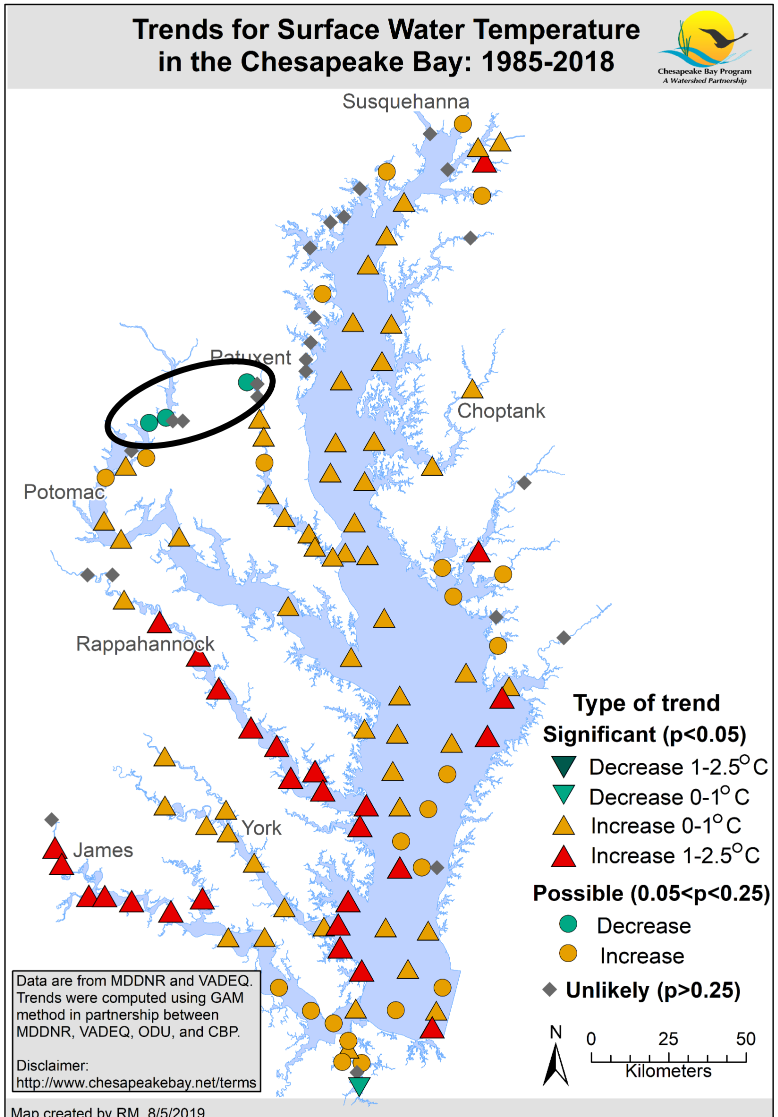
1. Detailed graphics of the data, model, and computed change

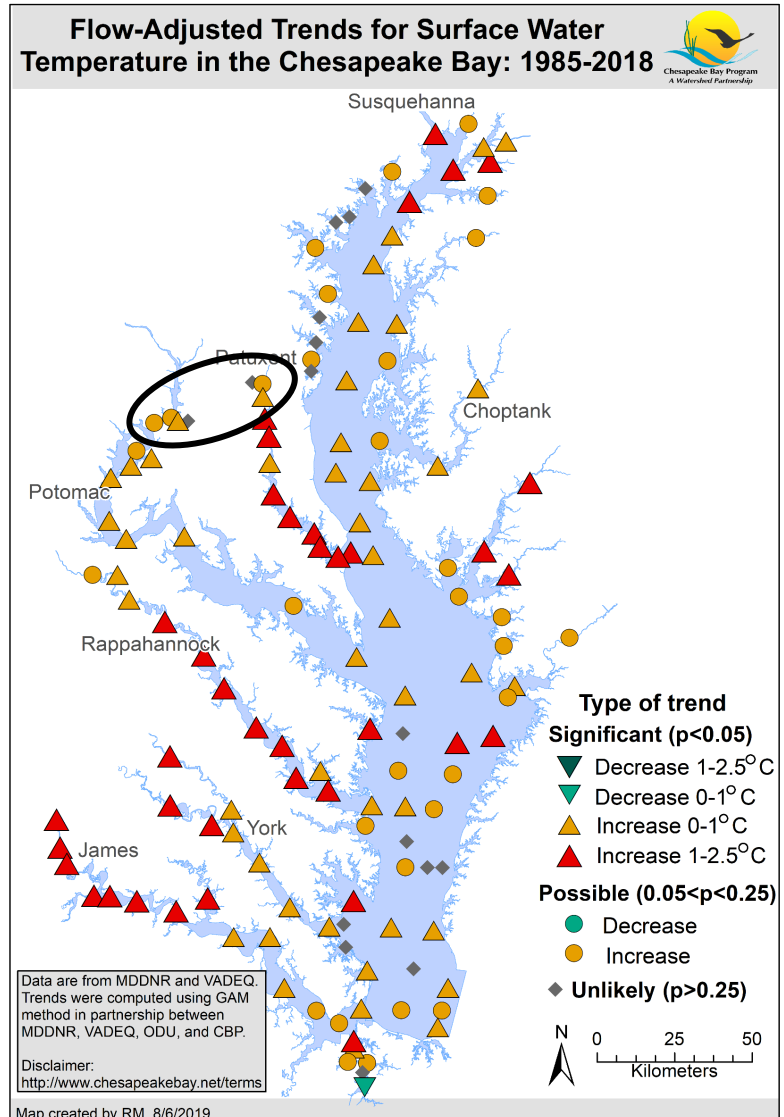


33 year change is: 1.3 C (2.4 F) increase (p<0.001)

Can extract relevant info, such as:

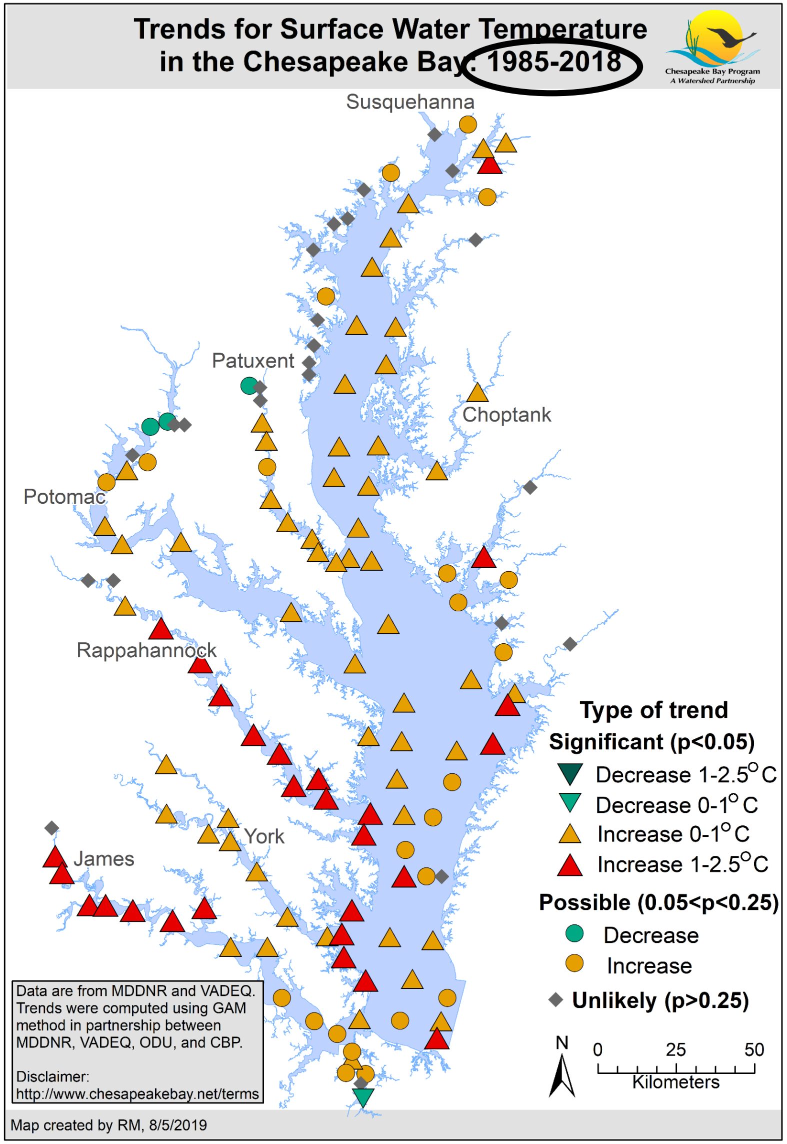
2. Estimates of change after accounting for flow variability

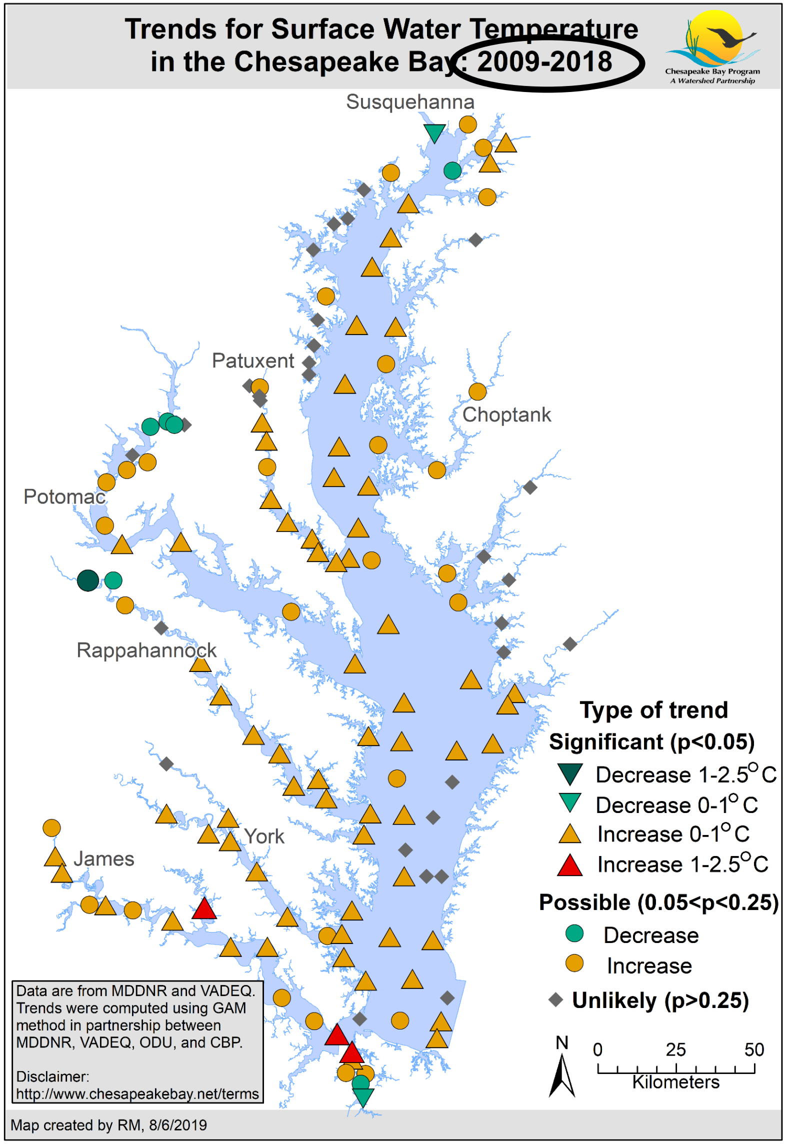




Can extract relevant info, such as:

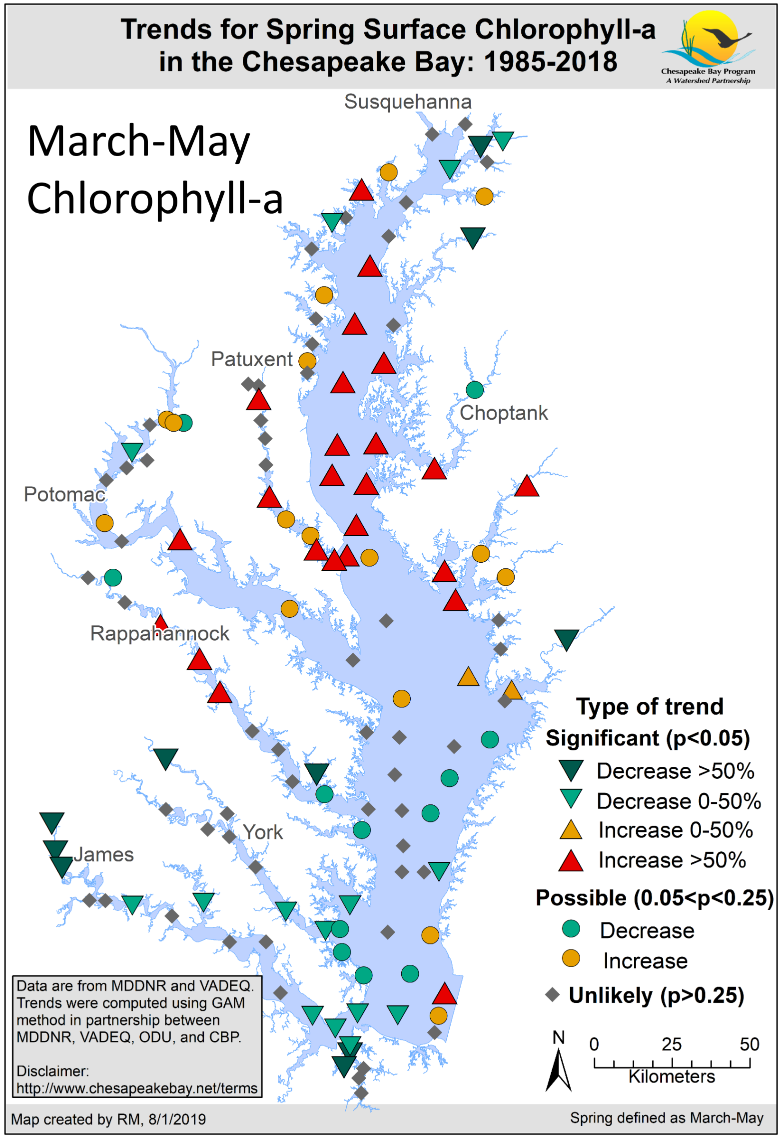
3. Shorter-term changes

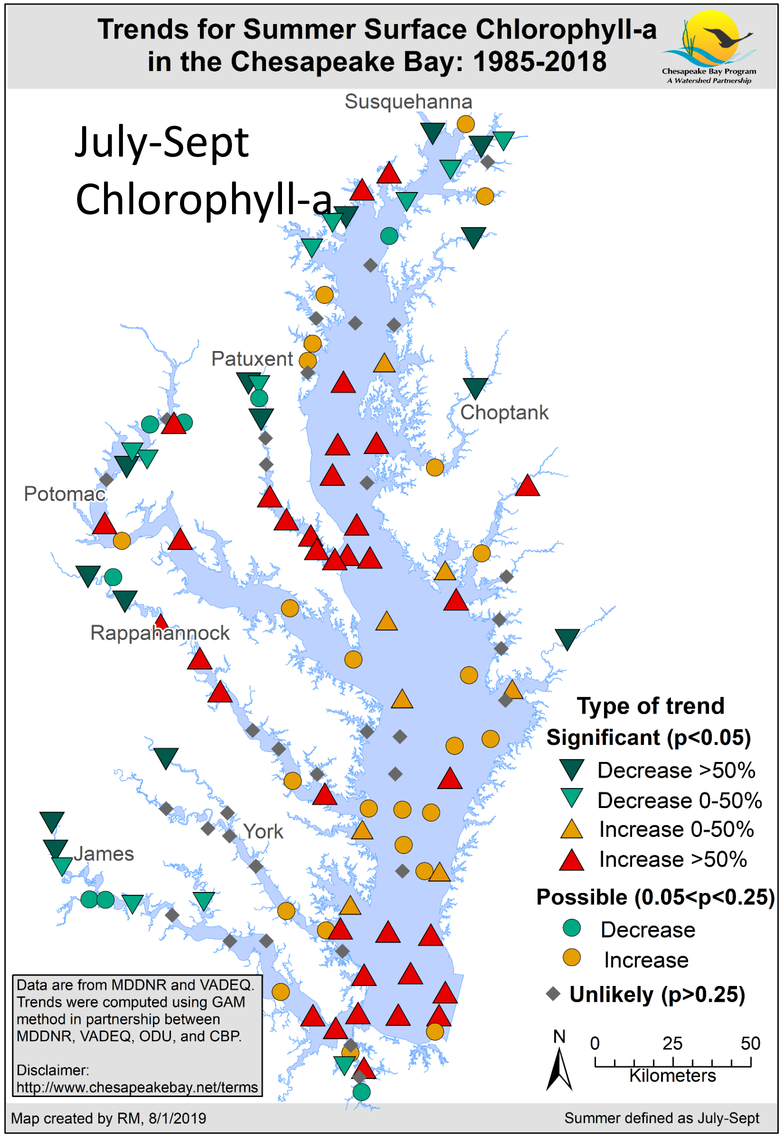




Can extract relevant info, such as:

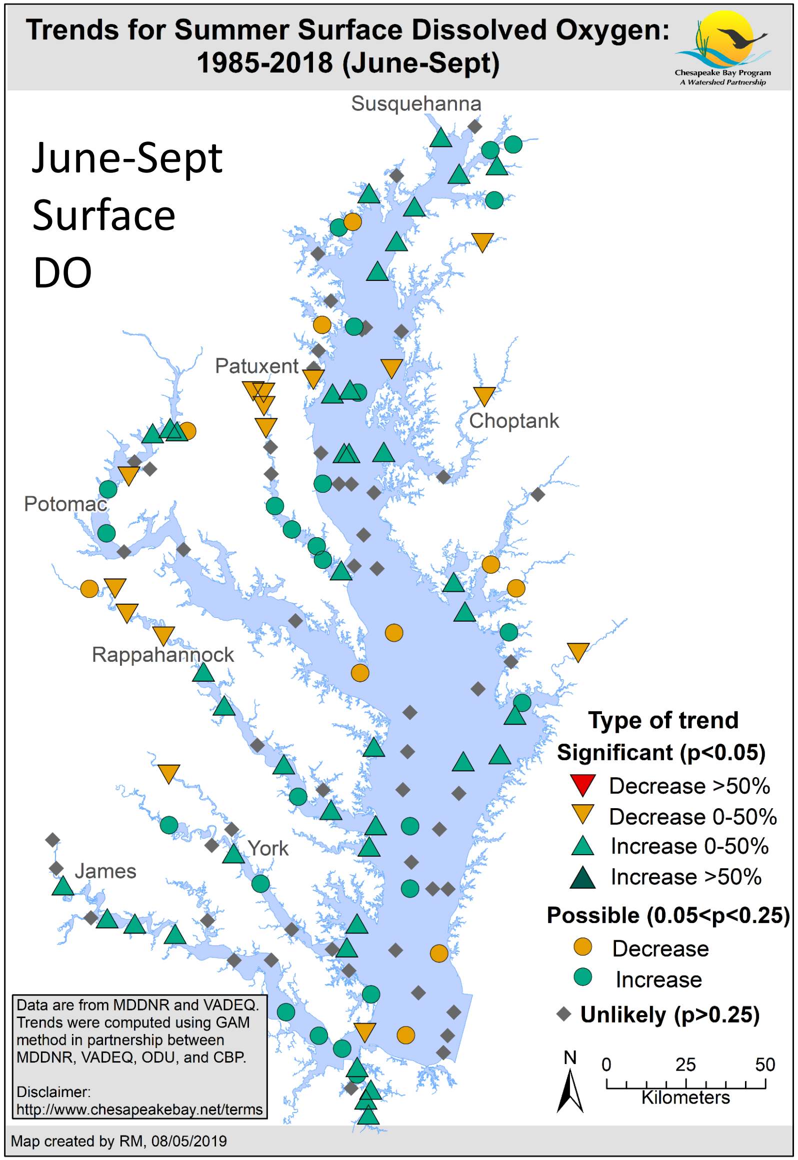
4. Changes for certain seasons

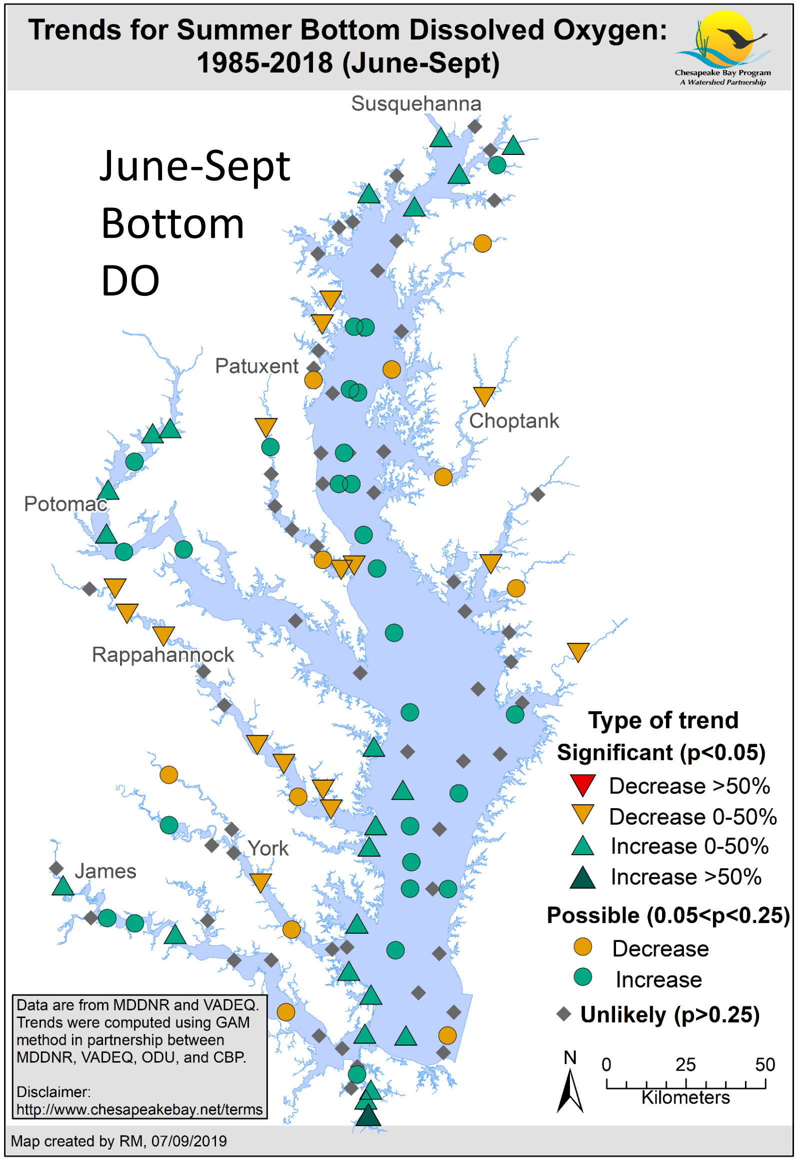




Can extract relevant info, such as:

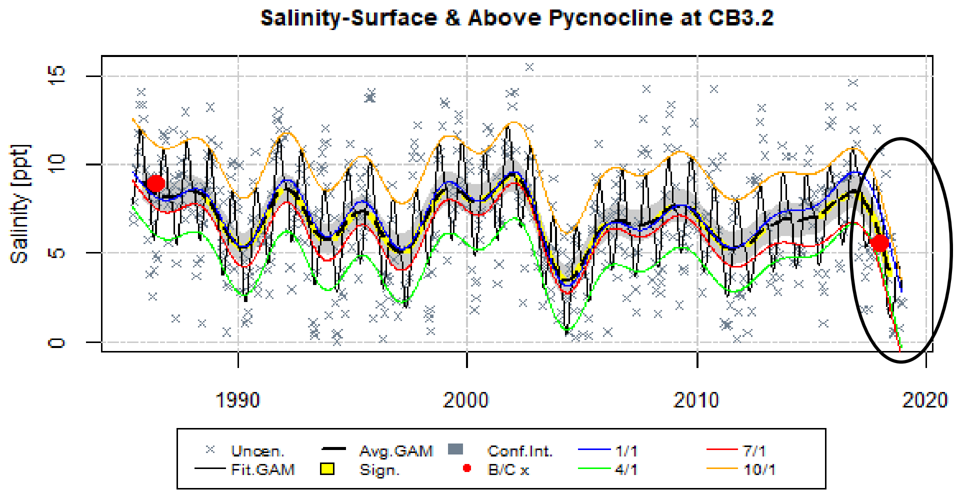
5. Depth comparison





Can extract relevant info, such as:

6. Graphics to examine flow impacts on salinity



Summary

- Multiple trend analysis products might be of interest to climate resiliency: water temperature, DO, chlorophyll-a, other water quality variables

- Long-term trends are currently being computed through 2019 at MDDNR and ODU, they are submitted to CBP in the summer and combined into various products by the fall

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

Tidal trends contributors:

- Jeni Keisman (USGS)
- Renee Karrh (MDDNR)
- Mike Lane (ODU)
- Elgin Perry
- Jon Harcum (Tetra Tech)
- Cindy Johnson and Amanda Shaver (VADEQ)

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