

2021 Tidal Trends Summary

STAR, Nov. 17, 2022

Rebecca Murphy

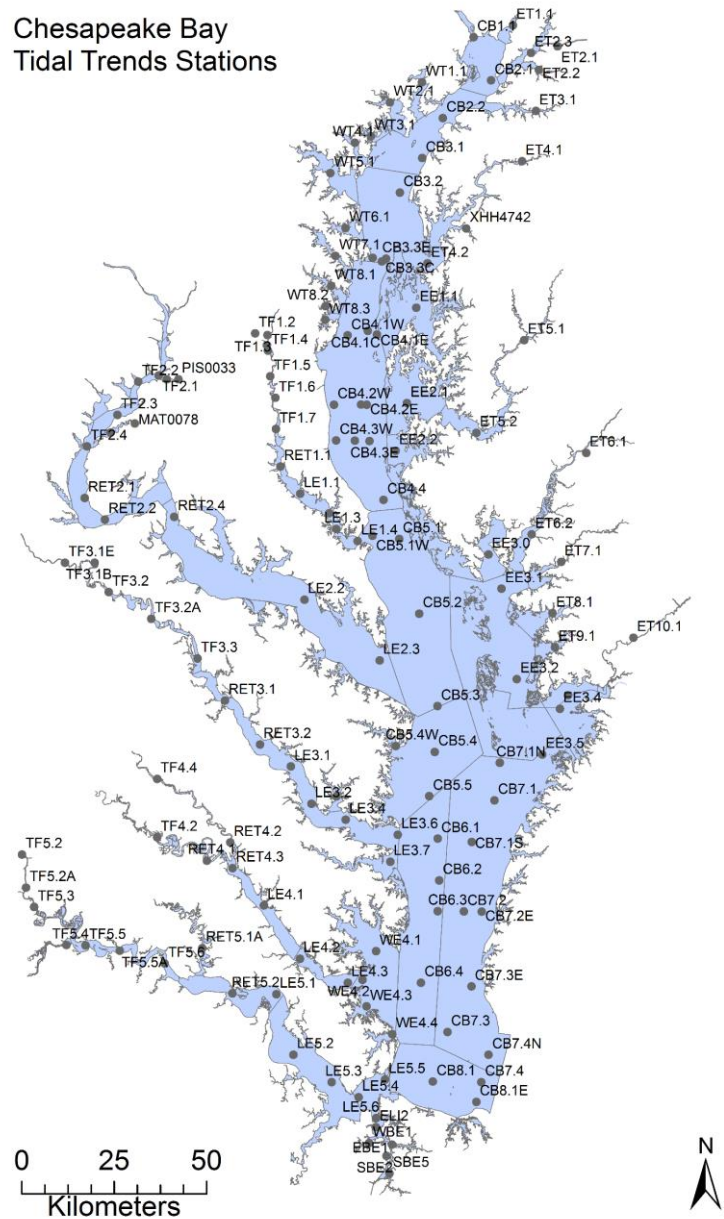
University of Maryland Center for Environmental Science,
Chesapeake Bay Program Office

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

Baytrendsmap development by: Erik Leppo and Jon Harcum (Tetra Tech)

Data from: DOEE, MDDNR, and VADEQ

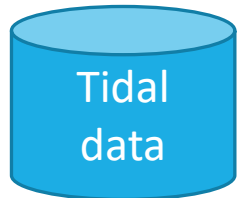
Chesapeake Bay
Tidal Trends Stations



Extensive long-term coordinated tidal monitoring

- MDDNR, VADEQ, DOEE 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 other parameters at multiple depths
- Long-standing coordinated effort to analyze trends in these data between the partners

Annual tidal trends/ change production

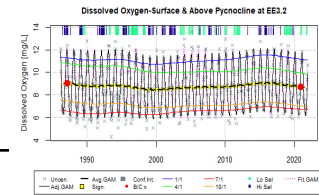


Tidal data

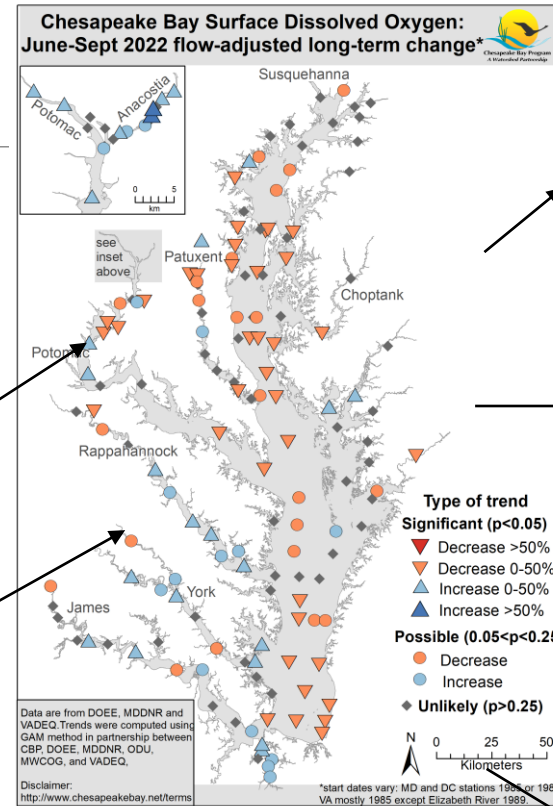
(Full set in spring for previous year)

'baytrends'
R package
to run
analysis

ODU, MDDNR, COG



Submitted to CBP
& combined
(June)



(Made available during the fall, for previous year)

Annual tidal trend results

- Multiple parameters at every station:
 - Nutrients: Total Nitrogen, Dissolved Inorganic Nitrogen, Total Phosphorus, Orthophosphate
 - Secchi Depth, Chlorophyll a , Dissolved Oxygen, Total Suspended Solids
 - Temperature
- Capture the spatial and temporal dynamics:
 - Surface & bottom
 - Observed conditions & flow-adjusted
- Post-process analysis possible for time periods and seasons:
 - Long-term (ideally 1985-present)
 - Short-term (last 10 years)
 - Spring & summer chlorophyll- a , summer bottom DO

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

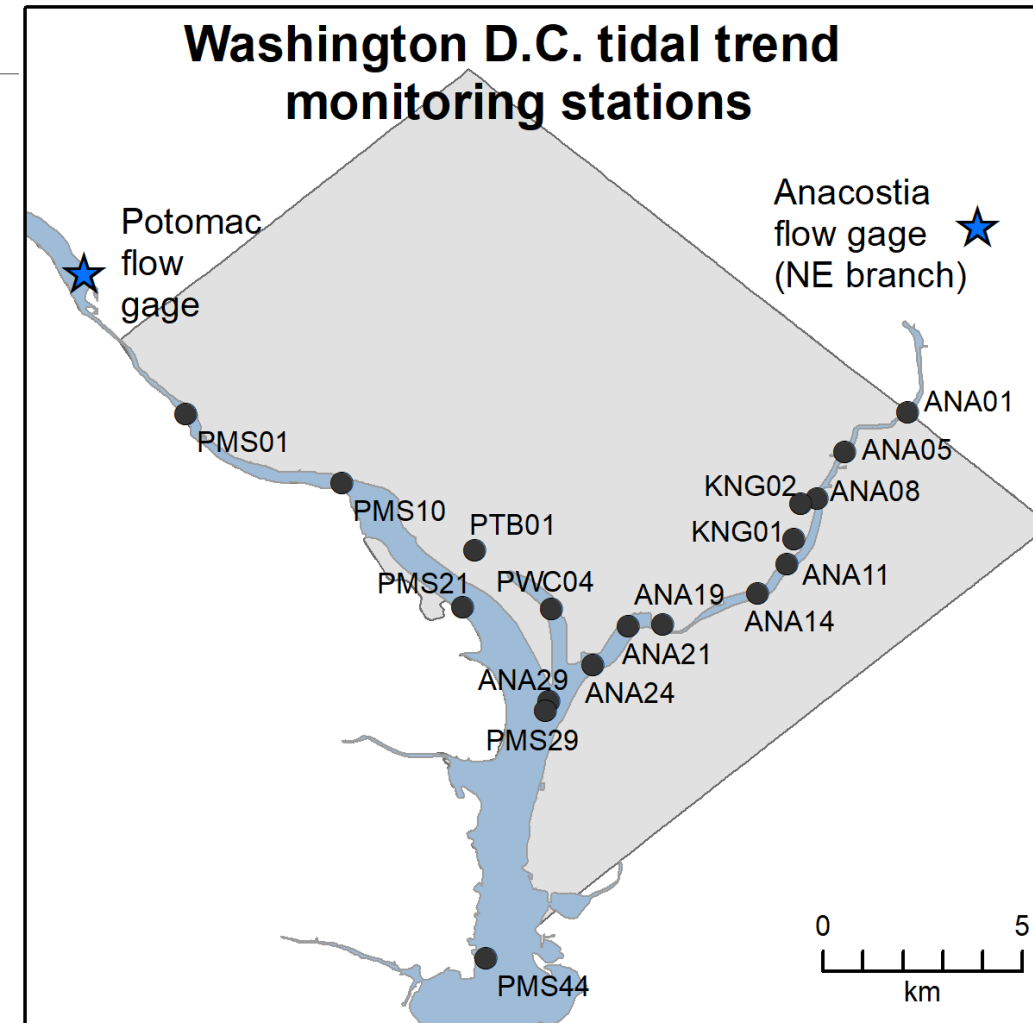
Team effort:

- Efeturi Oghenekaro, Blessing Edje and George Onyullo from DOEE
- Mukhtar Ibrahim and Karl Berger from MWCOG
- Breck Sullivan, Alex Gunnerson, and myself from CBP

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

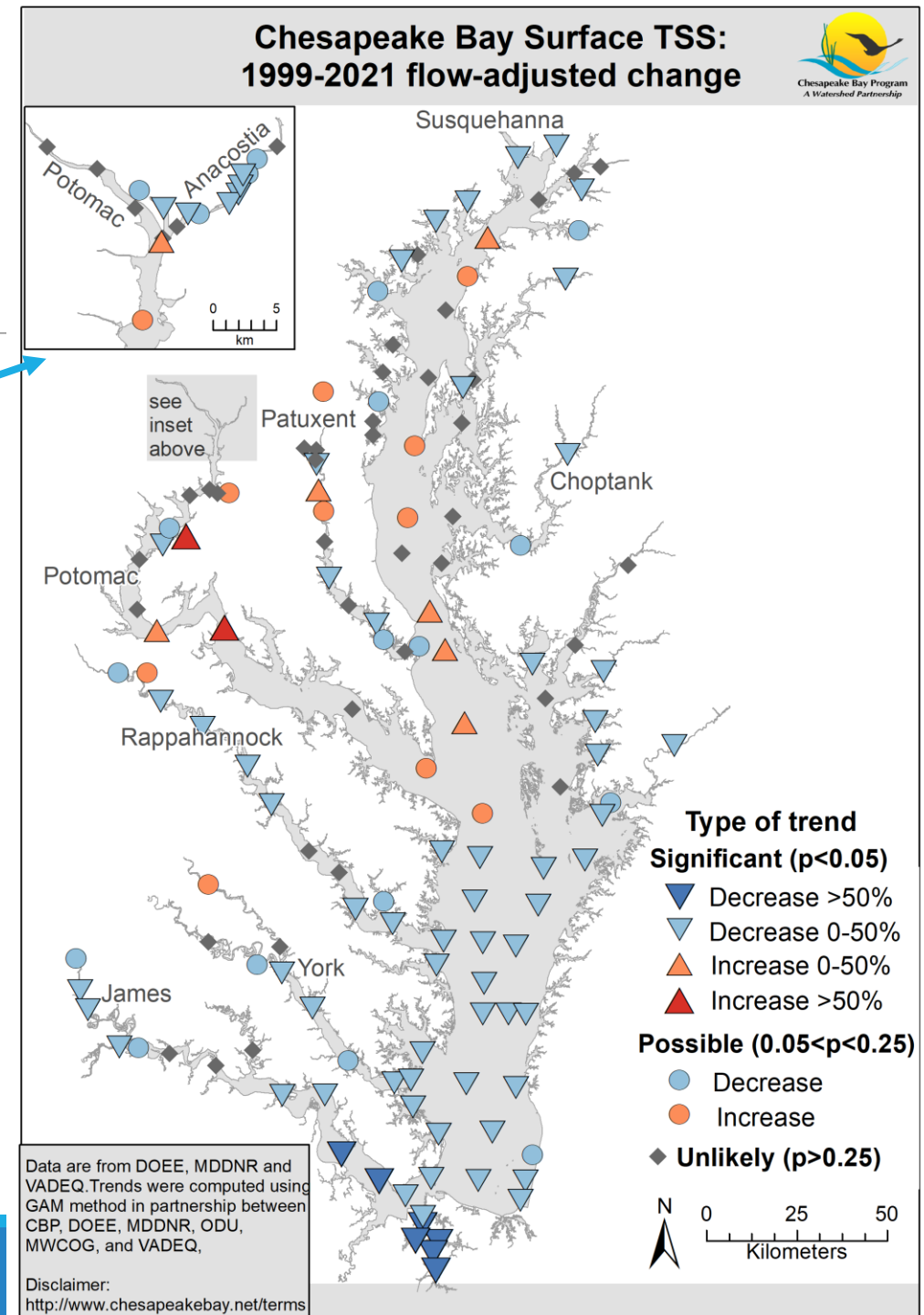


Washington D.C. stations

Results are 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.



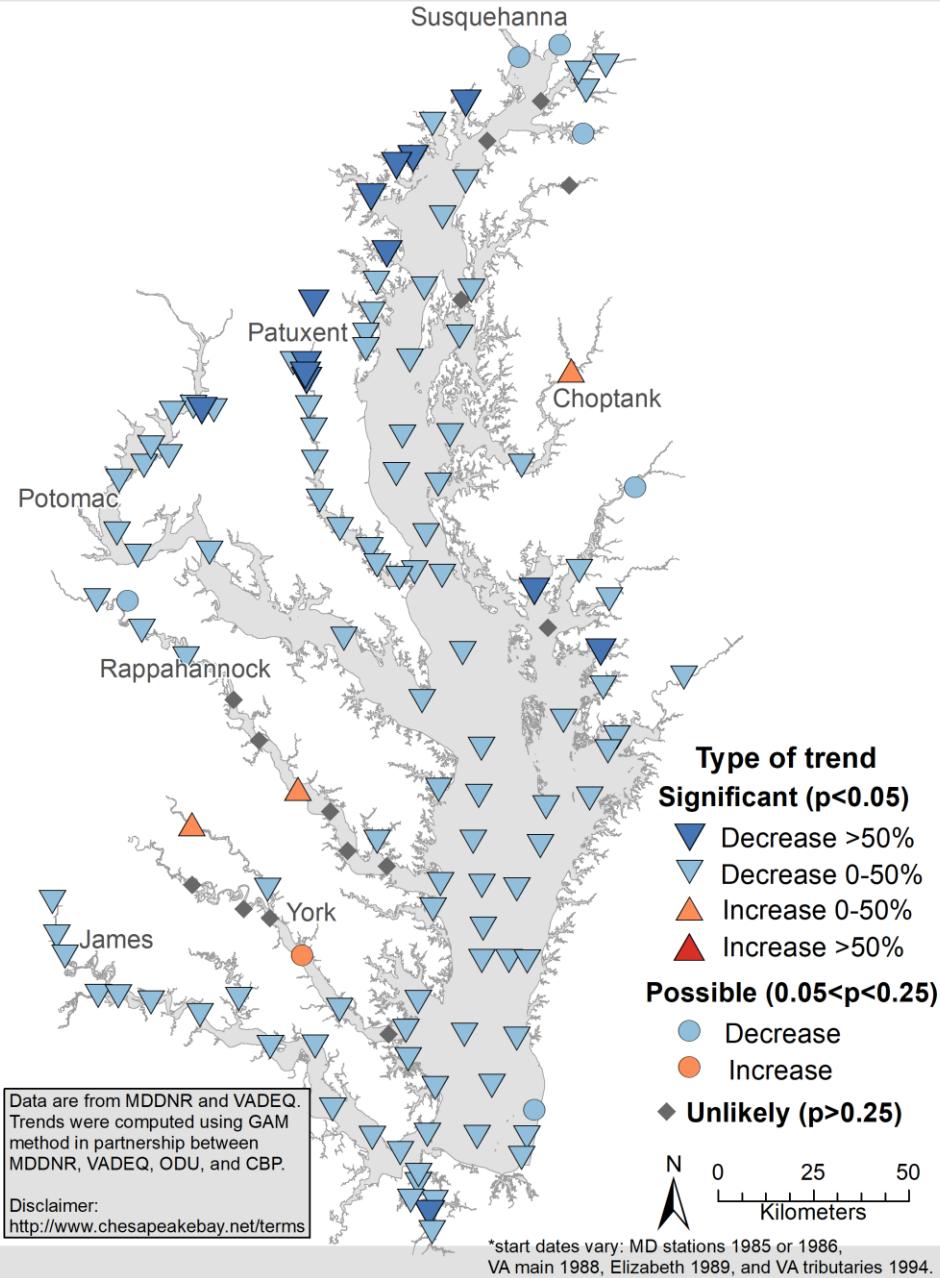
Annual tidal trend results

- Multiple parameters at every station:
 - Nutrients: Total Nitrogen, Dissolved Inorganic Nitrogen, Total Phosphorus, Orthophosphate
 - Secchi Depth, Chlorophyll a , Dissolved Oxygen, Total Suspended Solids
 - Temperature
- Capture the spatial and temporal dynamics:
 - Surface & bottom
 - Observed conditions & flow-adjusted
- Post-process analysis possible for time periods and seasons:
 - Long-term (ideally 1985-present)
 - Short-term (last 10 years)
 - Spring & summer chlorophyll- a , summer bottom DO

Total Nitrogen

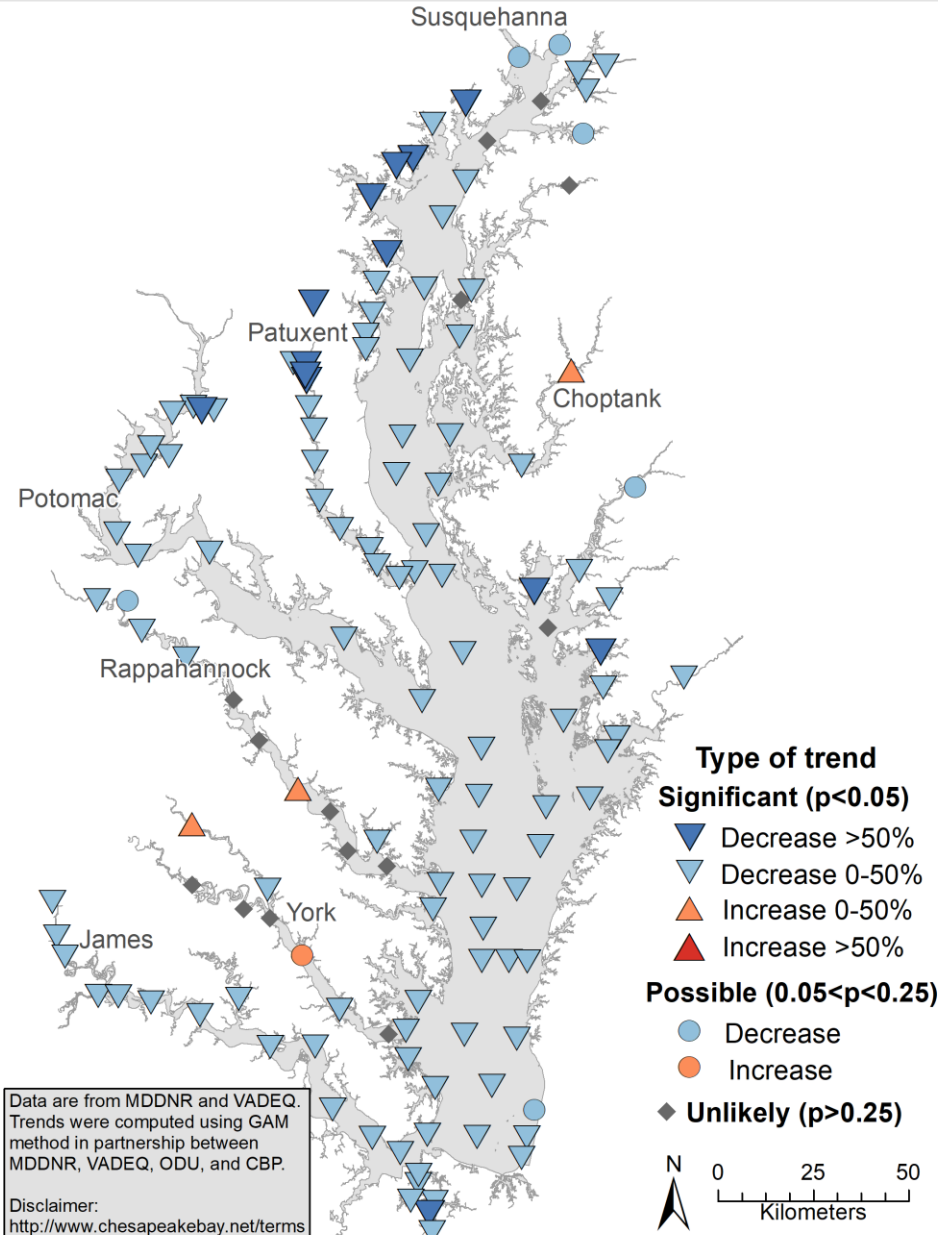
TN

Chesapeake Bay Surface Total Nitrogen: 2021 long-term flow-adjusted change*

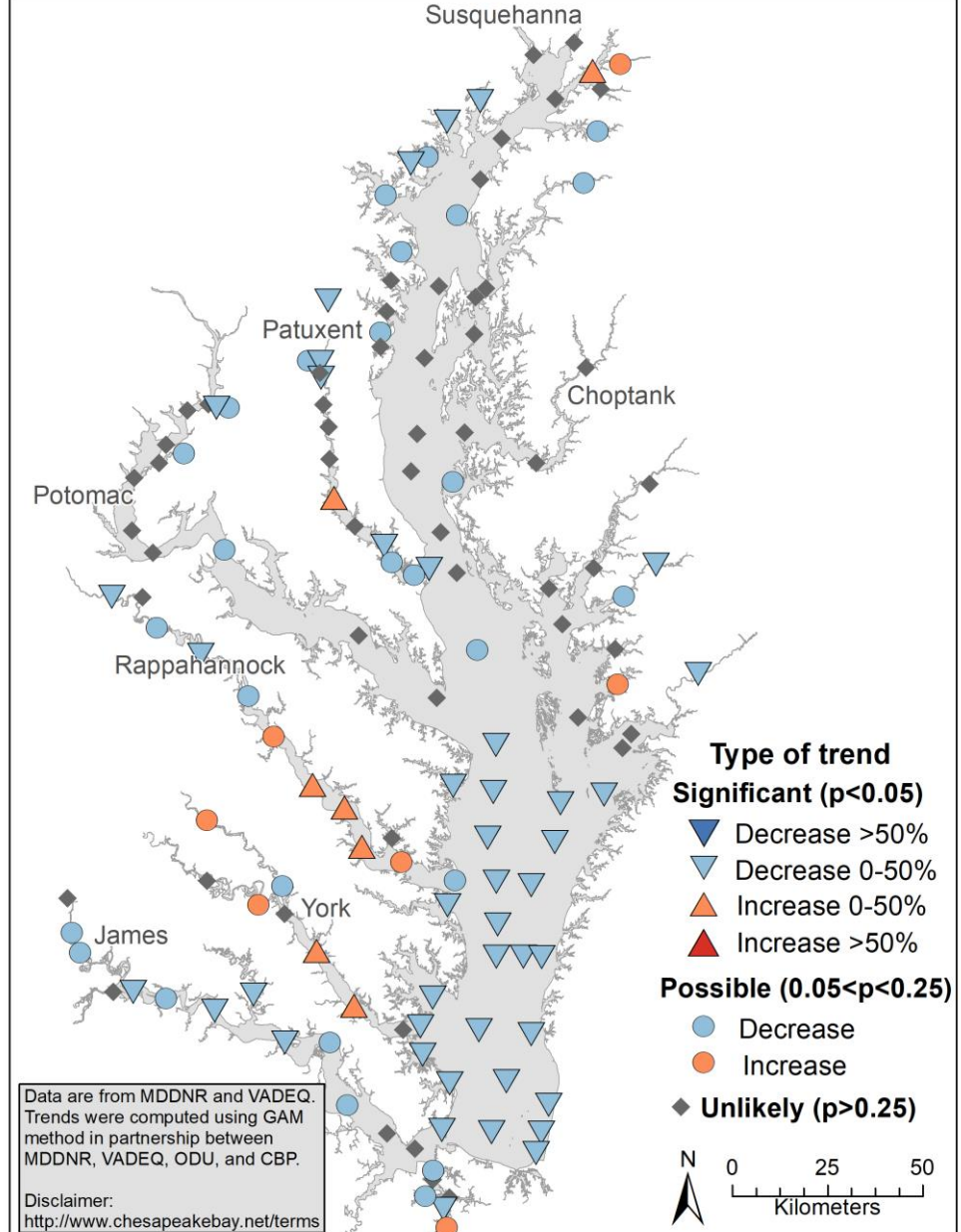


TN

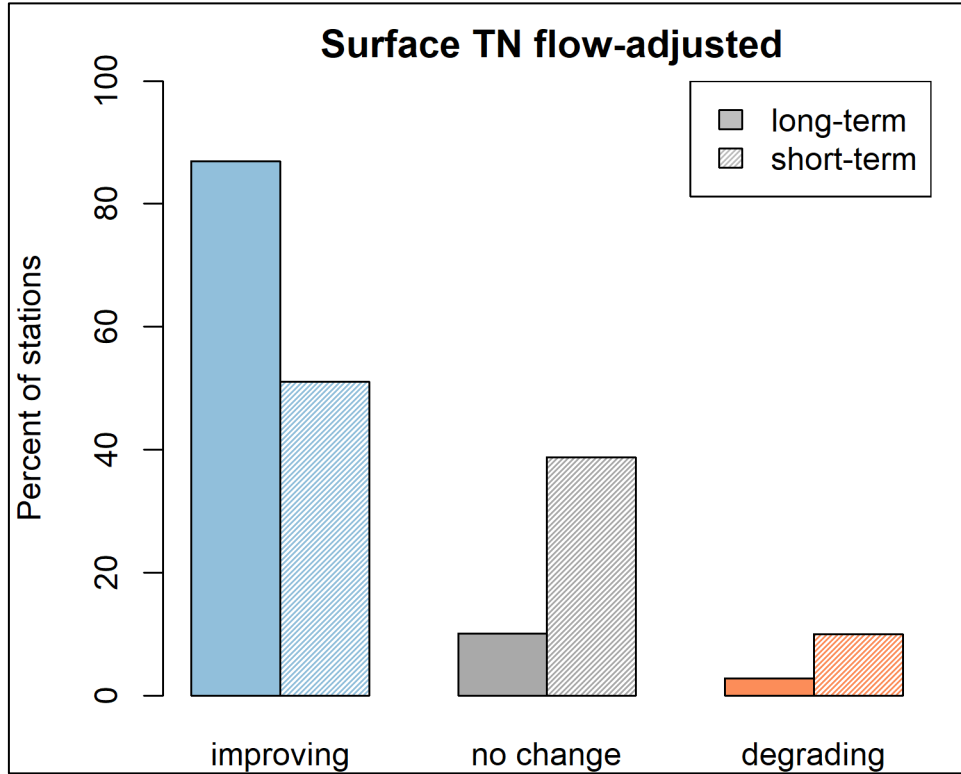
Chesapeake Bay Surface Total Nitrogen: 2021 long-term flow-adjusted change*



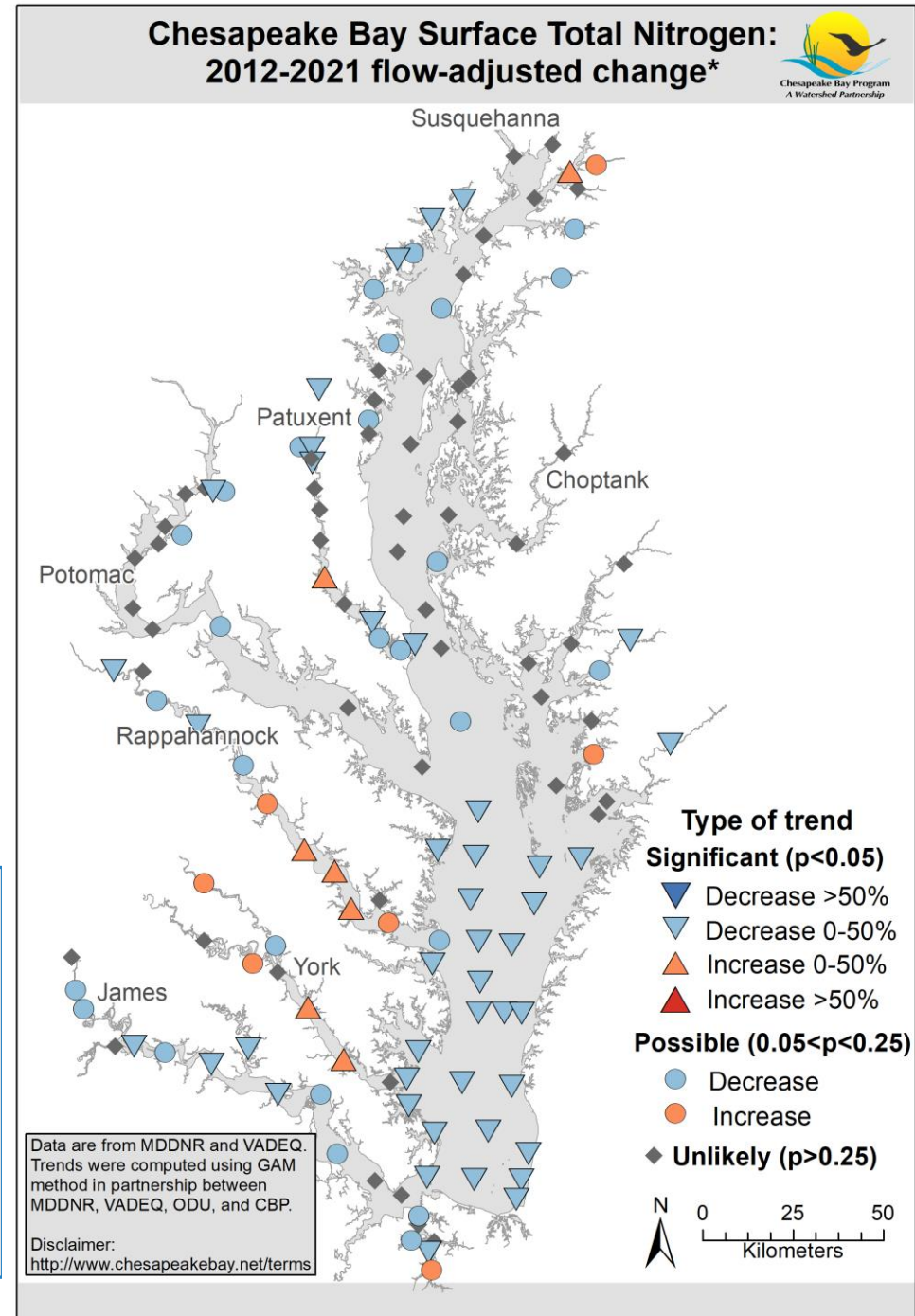
Chesapeake Bay Surface Total Nitrogen: 2012-2021 flow-adjusted change*



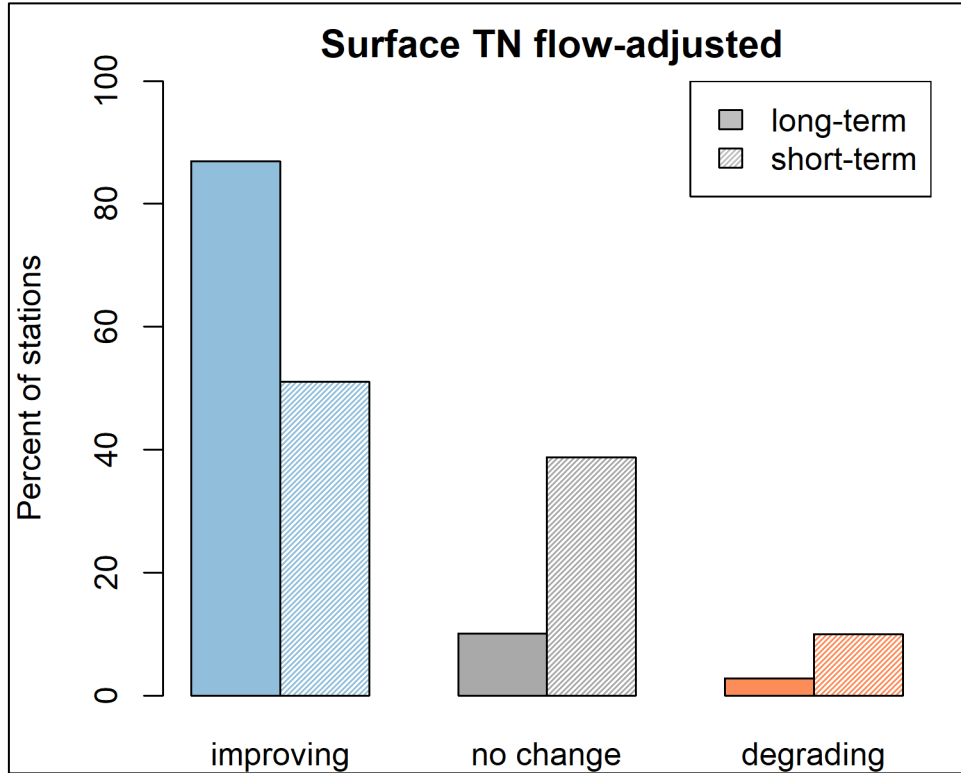
TN



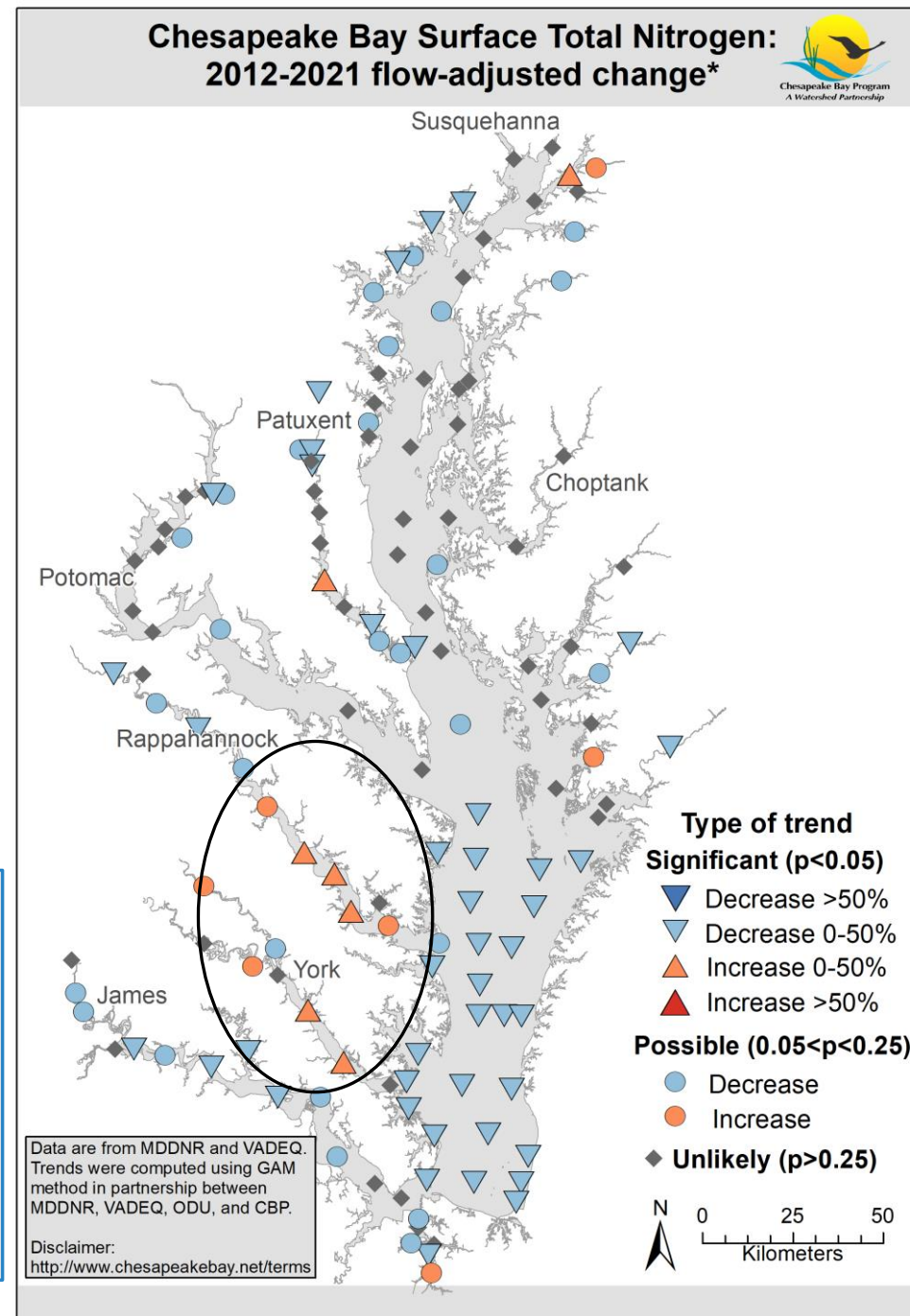
- Total nutrients (TN and TP) are decreasing over the long-term at most the tidal stations.
- Over short-term, concentration at some stations have plateaued or started to increase.



TN

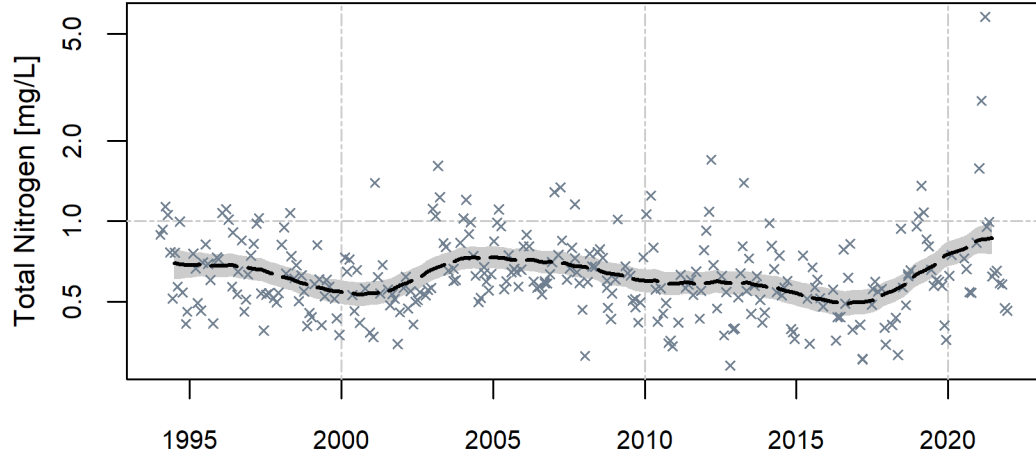


- Total nutrients (TN and TP) are decreasing over the long-term at most the tidal stations.
- Over short-term, concentration at some stations have plateaued or started to increase.
- With these type of results, we use our baytrendmap tool to explore the results:
<https://baytrends.chesapeakebay.net/baytrendsmap/>

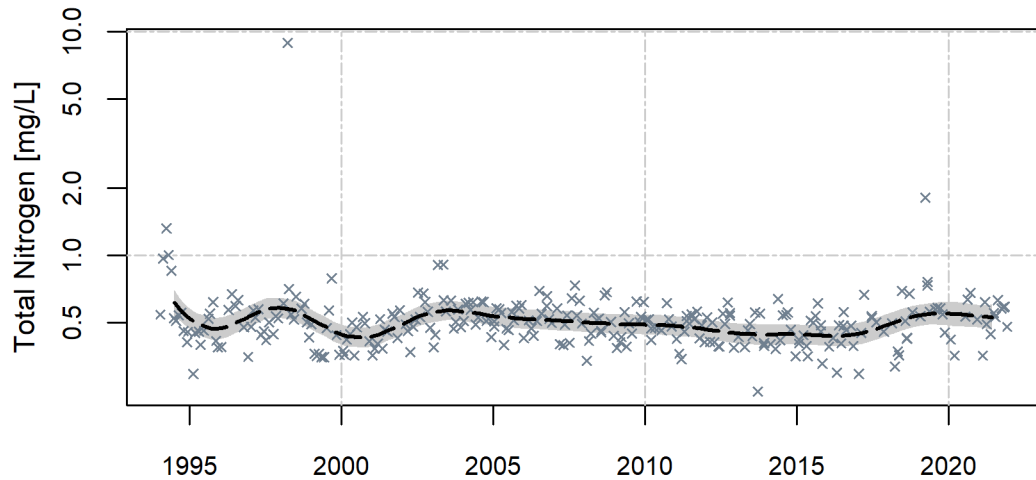


TN

Total Nitrogen-Surface Layer at RET3.2

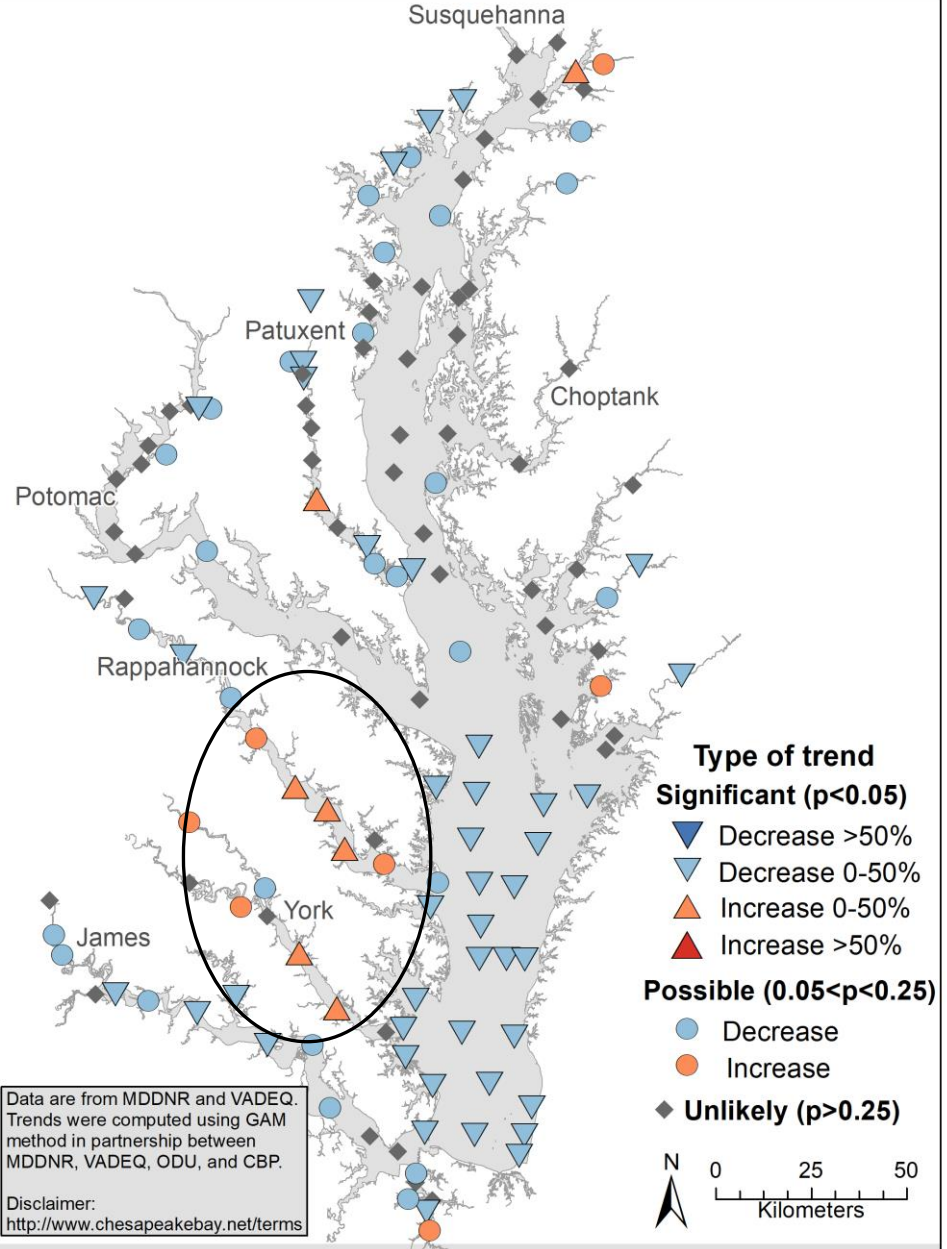


Total Nitrogen-Surface Layer at LE4.2



x Observed Value — Estimate of Avg ■ Conf. Interval

Chesapeake Bay Surface Total Nitrogen: 2012-2021 flow-adjusted change*



Secchi Disk Depth

Secchi depth

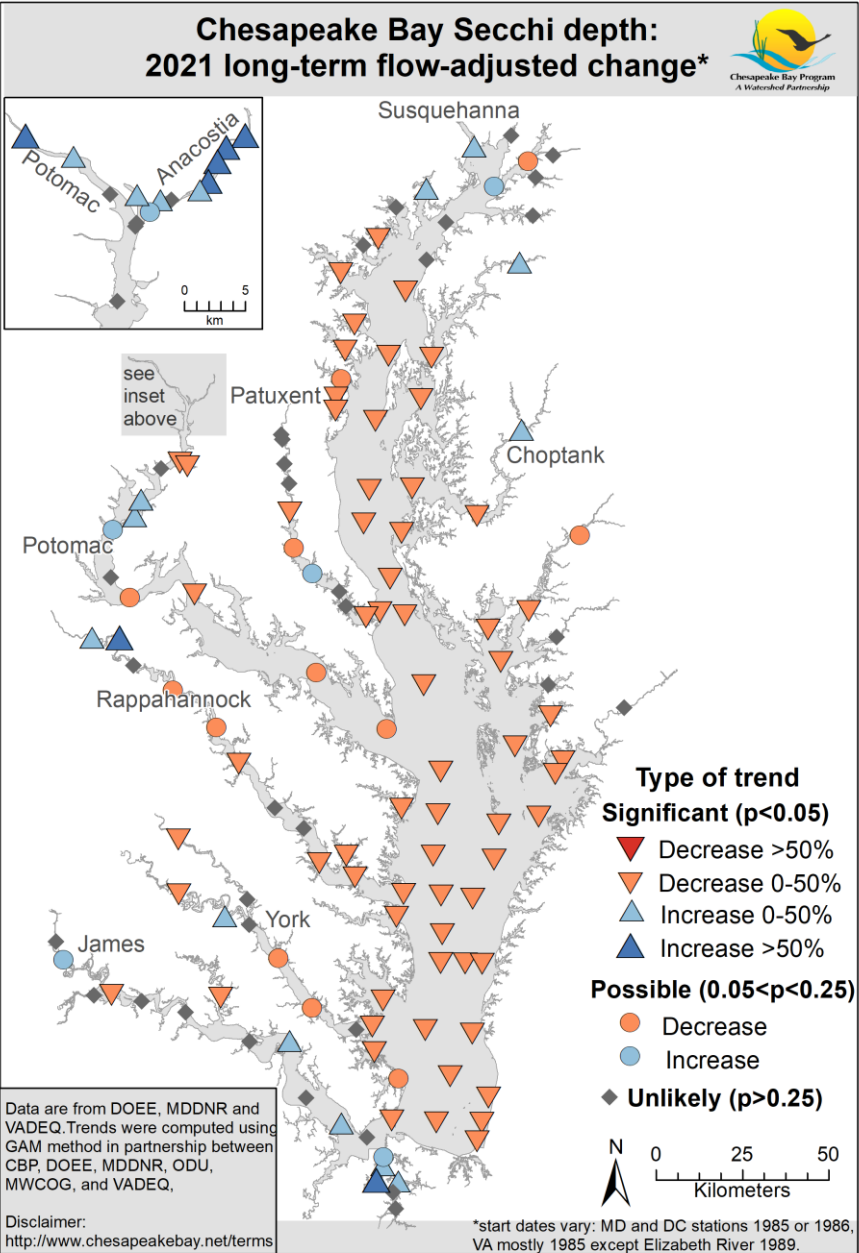
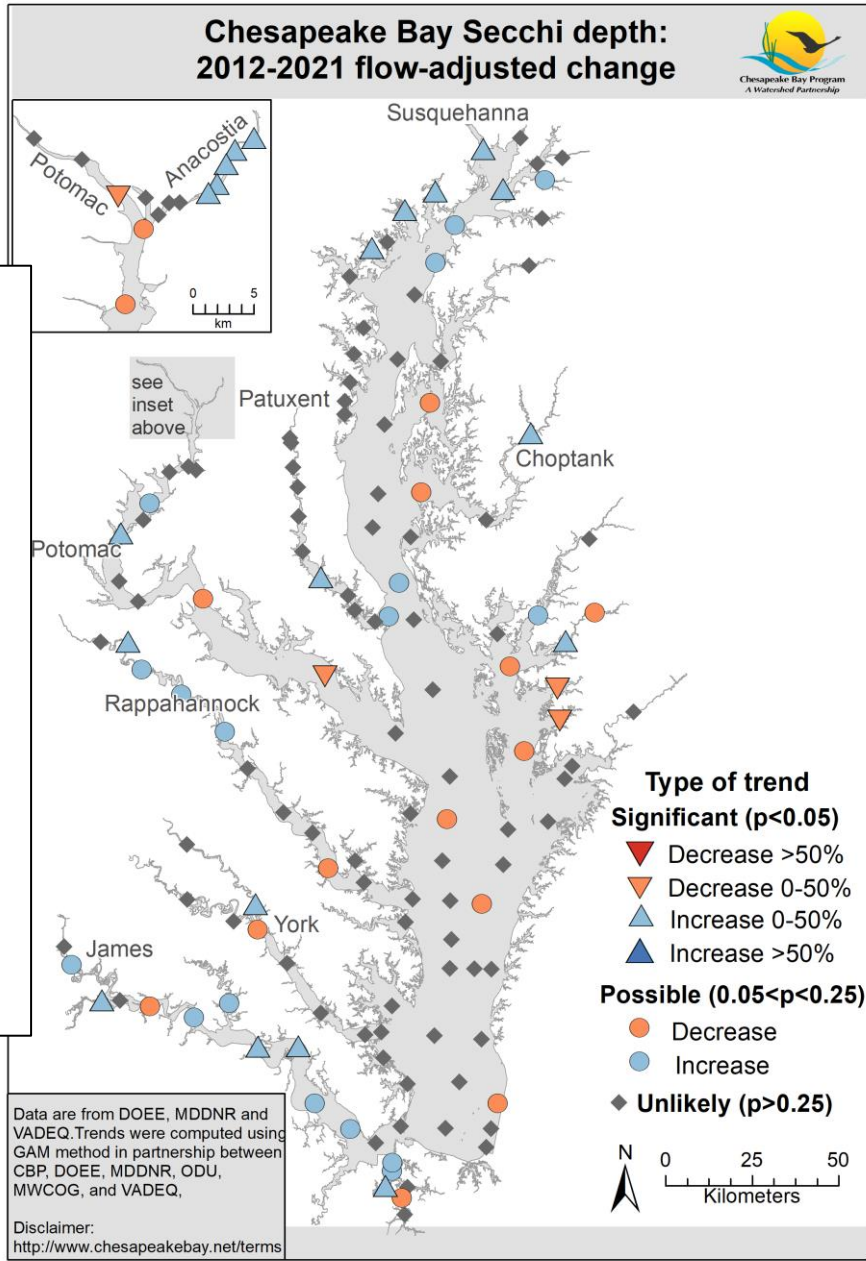
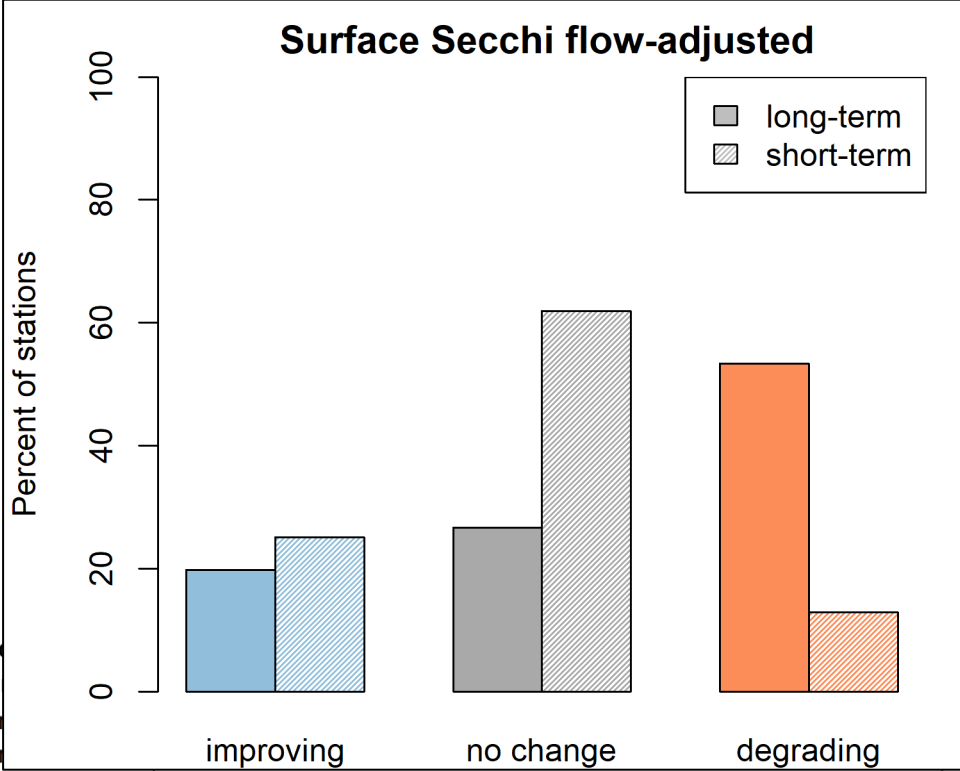
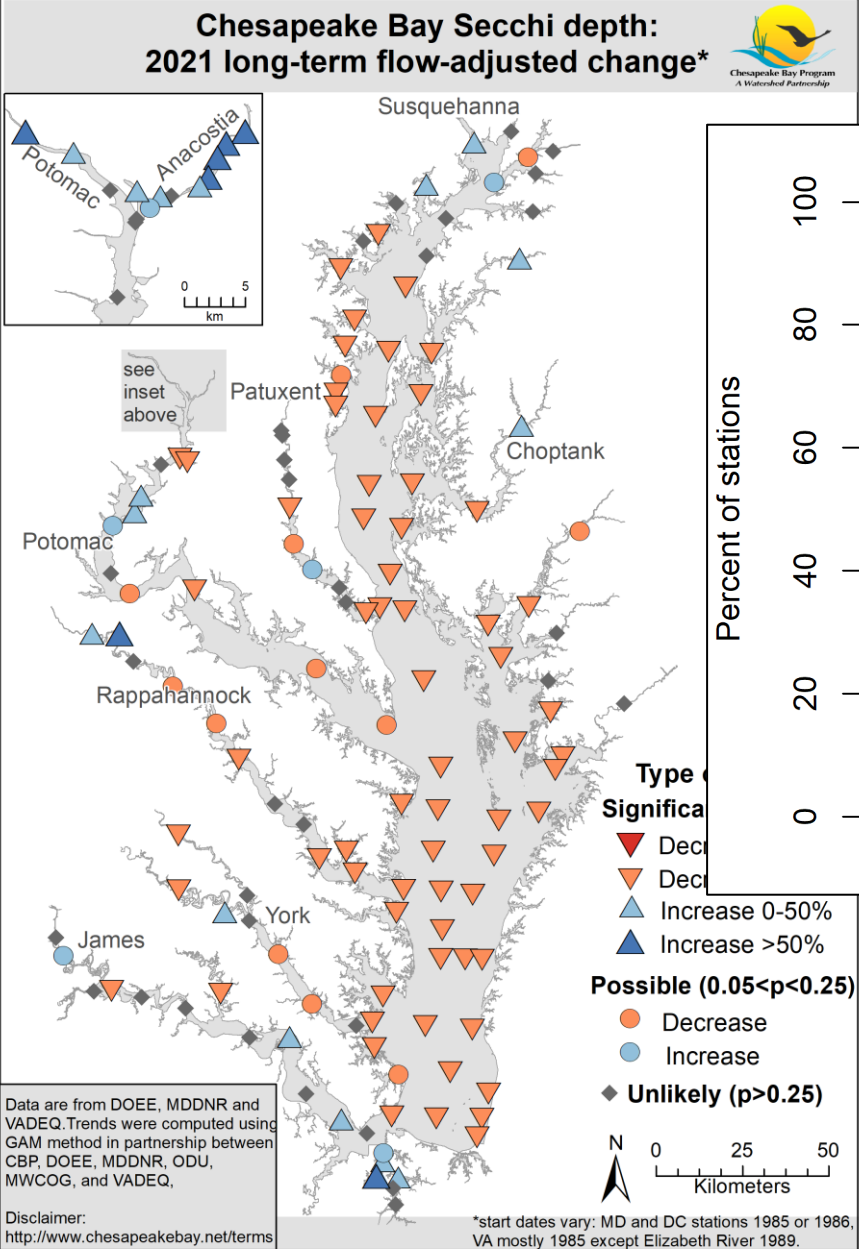


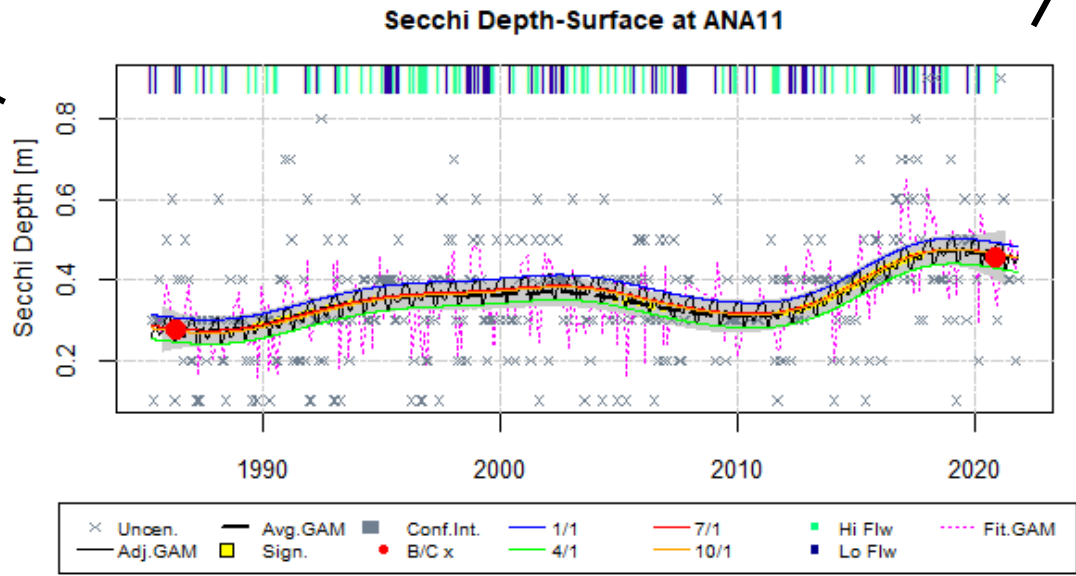
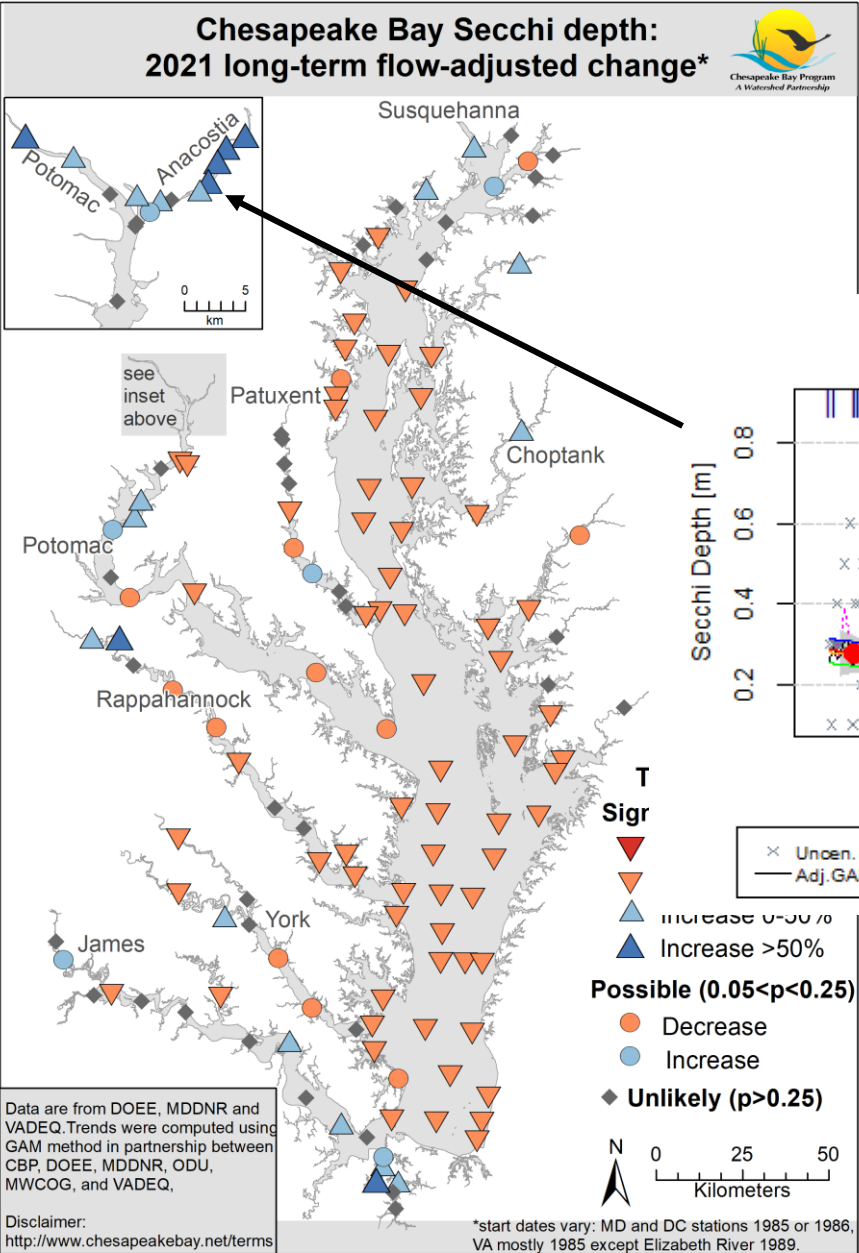
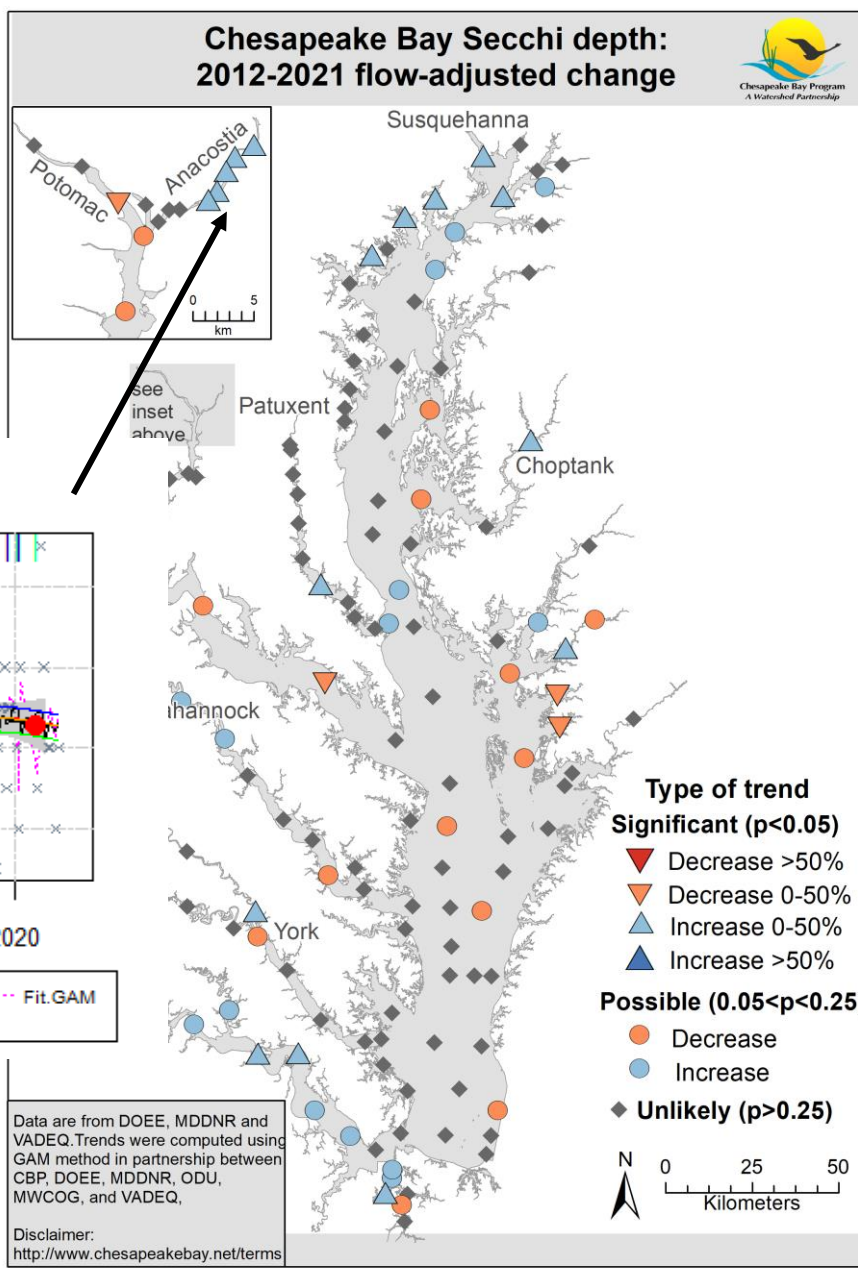
Photo by: Matt Rath/Chesapeake Bay Program

Secchi depth



Secchi depth

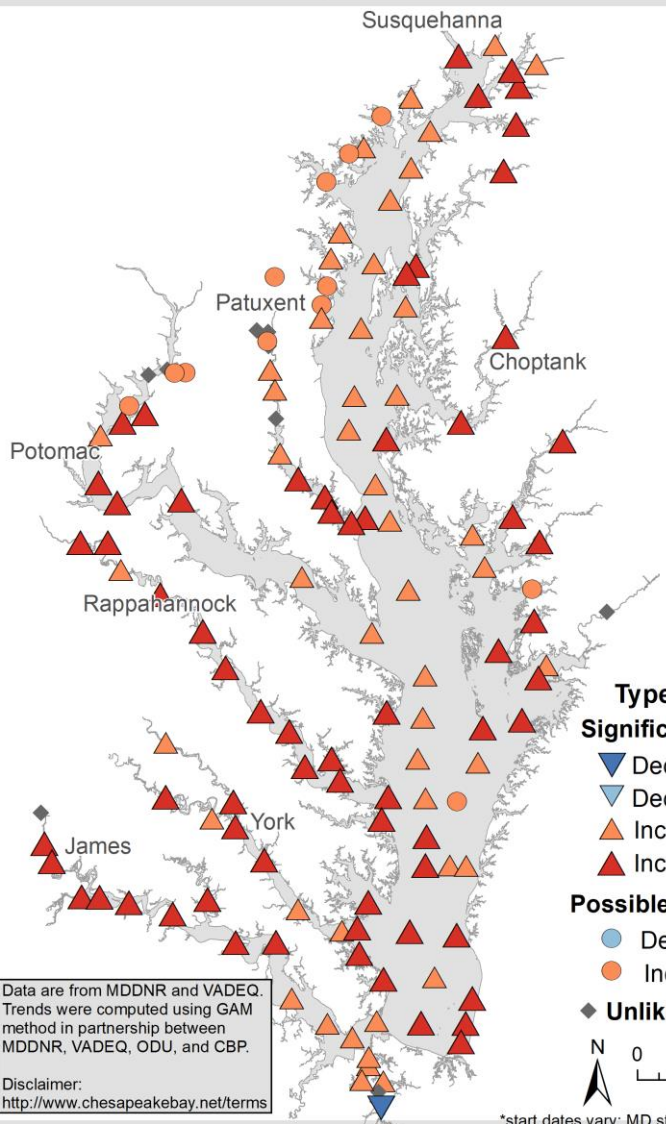
Example: Anacostia stations all show long-term gradual improvement followed by even more improvement in the recent decade. DOEE's Potomac stations also show long-term improvement with plateau recently.



Surface Water Temperature

Surface Water Temperature

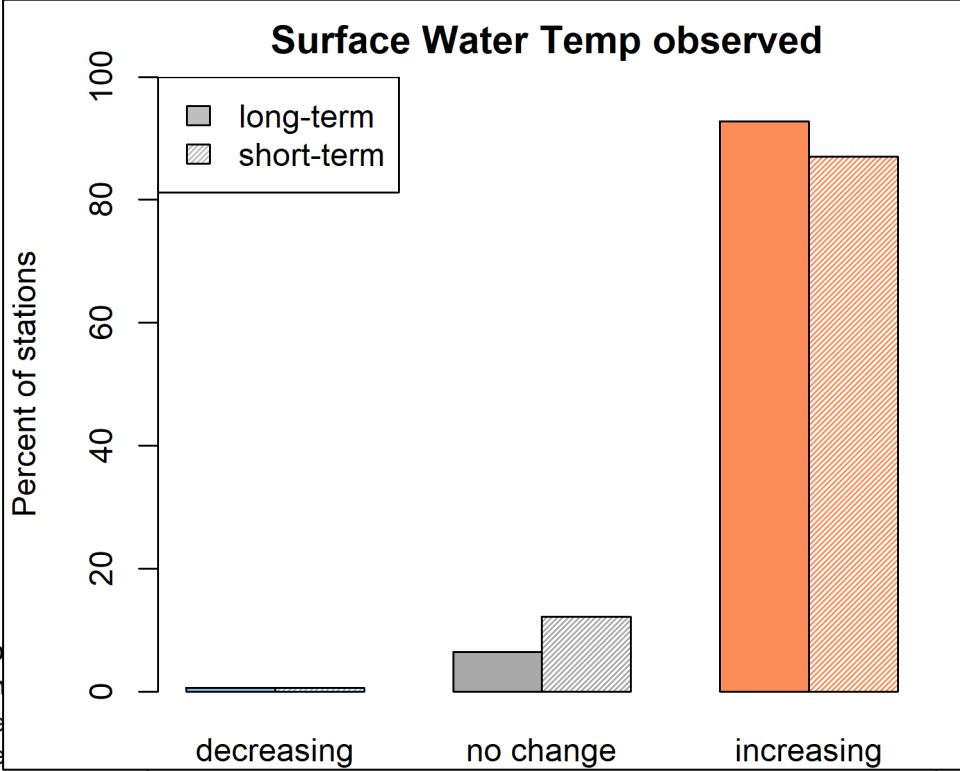
Chesapeake Bay Surface Water Temperature:
2021 long-term change*



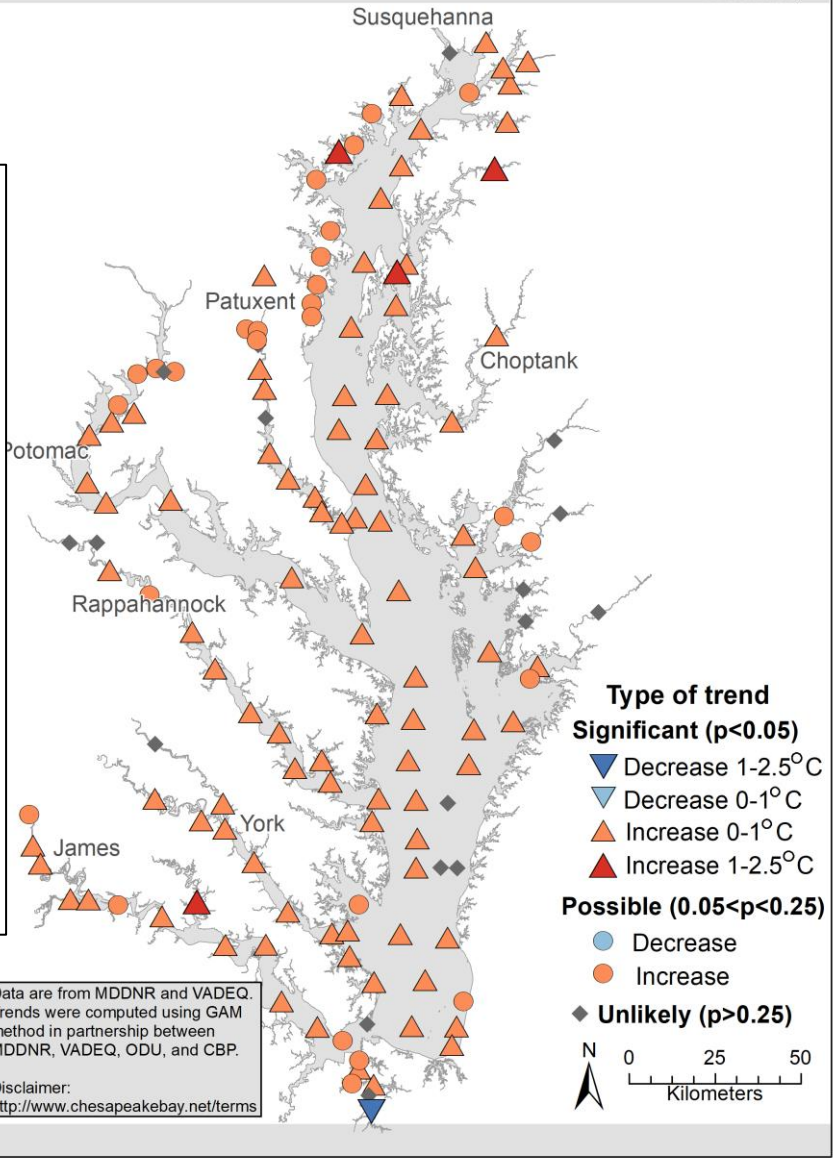
Data are from MDDNR and VADEQ. Trends were computed using GAM method in partnership between MDDNR, VADEQ, ODU, and CBP.
Disclaimer:
<http://www.chesapeakebay.net/terms>

*start dates vary: MD stations 1985 or 1986, VA mostly 1985 except Elizabeth River 1989.

Surface Water Temp observed



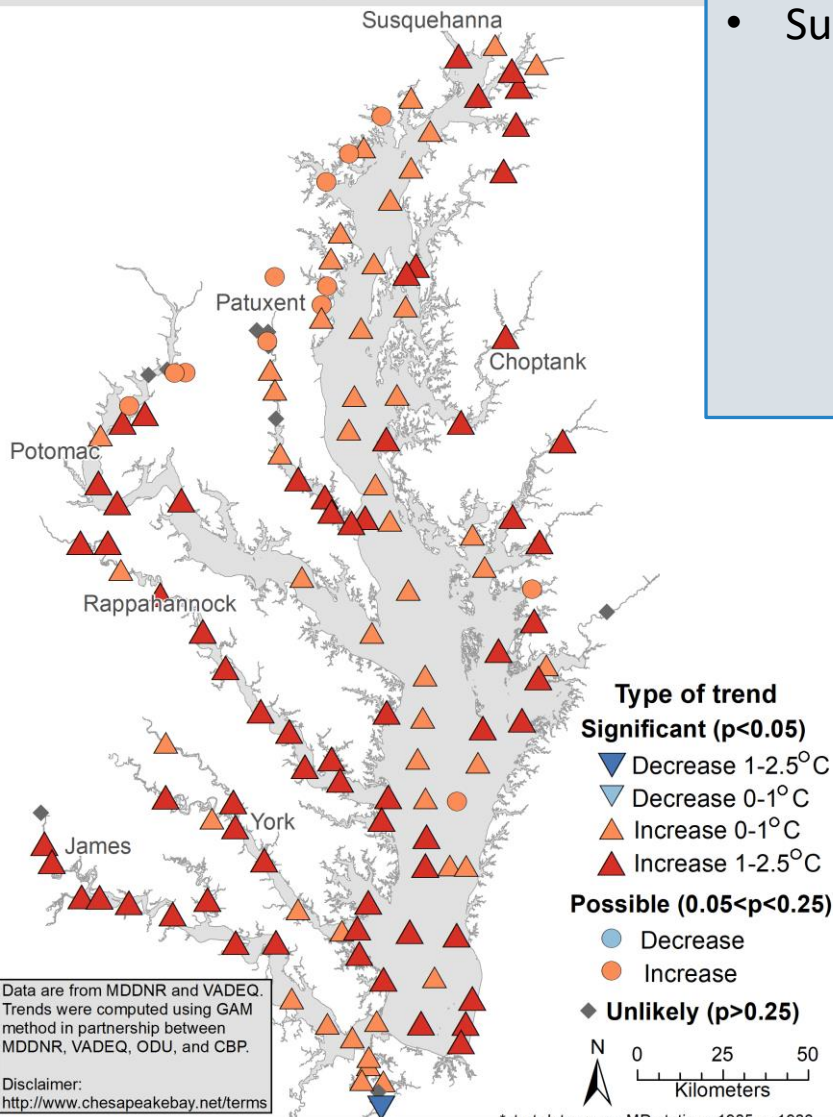
Chesapeake Bay Surface Water Temperature:
2012-2021 change



Data are from MDDNR and VADEQ. Trends were computed using GAM method in partnership between MDDNR, VADEQ, ODU, and CBP.
Disclaimer:
<http://www.chesapeakebay.net/terms>

Surface Water Temperature

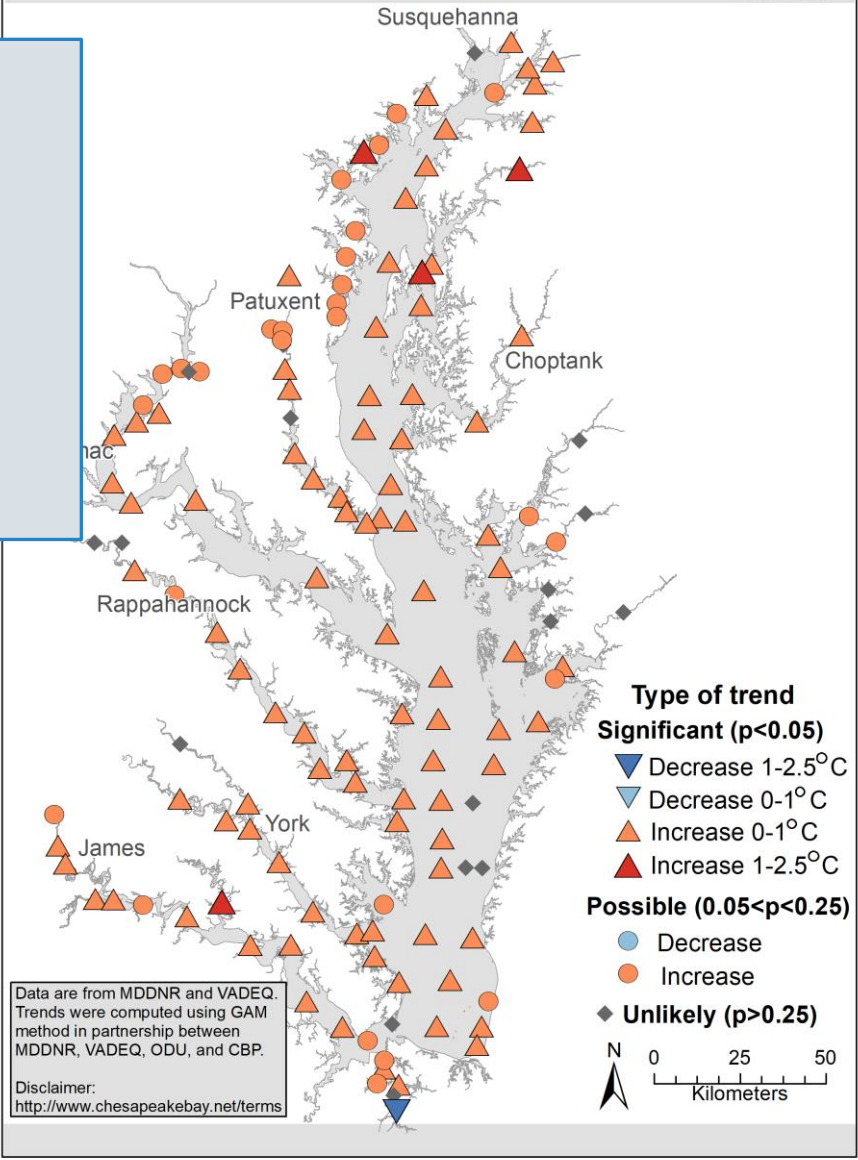
Chesapeake Bay Surface Water Temperature: 2021 long-term change*



Readily available outputs for temperature:

- Surface and bottom changes by station.

Chesapeake Bay Surface Water Temperature: 2012-2021 change

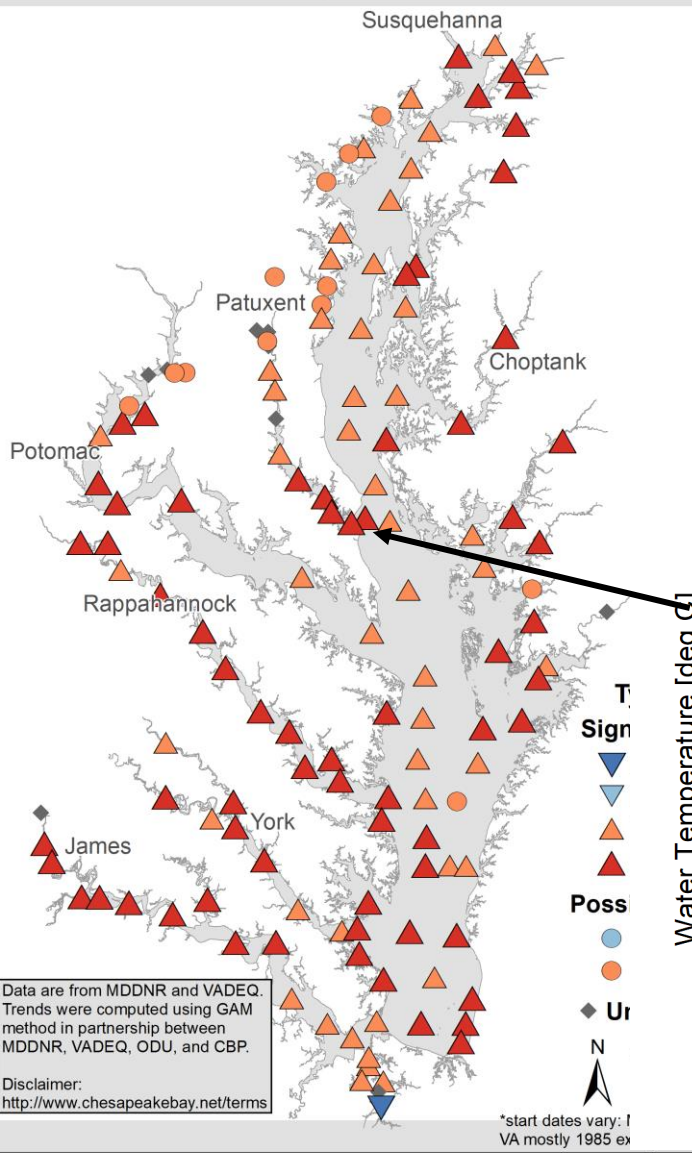


Data are from MDDNR and VADEQ. Trends were computed using GAM method in partnership between MDDNR, VADEQ, ODU, and CBP.
Disclaimer: <http://www.chesapeakebay.net/terms>

*start dates vary: MD stations 1985 or 1986, VA mostly 1985 except Elizabeth River 1989.

Surface Water Temperature

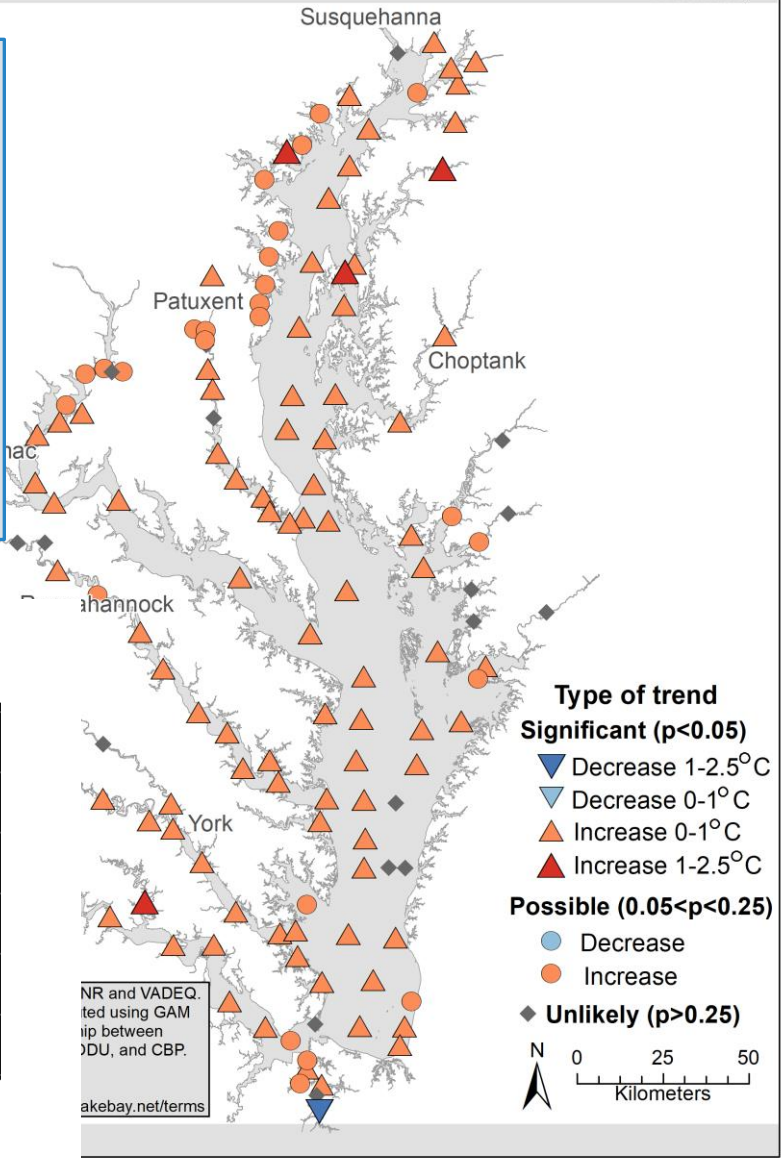
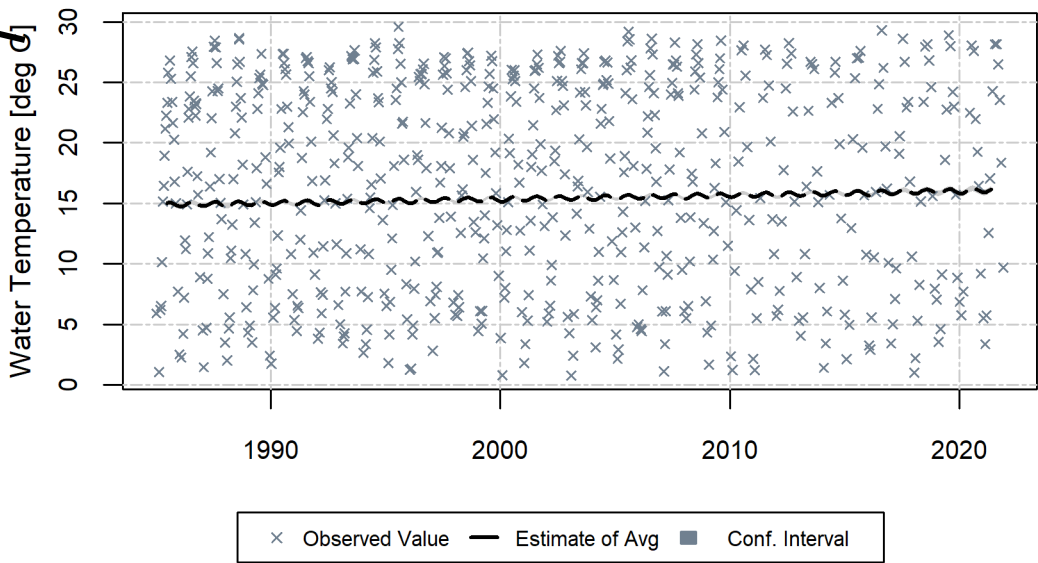
Chesapeake Bay Surface Water Temperature: 2021 long-term change*



Readily available outputs for temperature:

- Surface and bottom changes by station.
- Graphs of the long-term patterns.

Water Temperature-Surface Layer at LE1.4

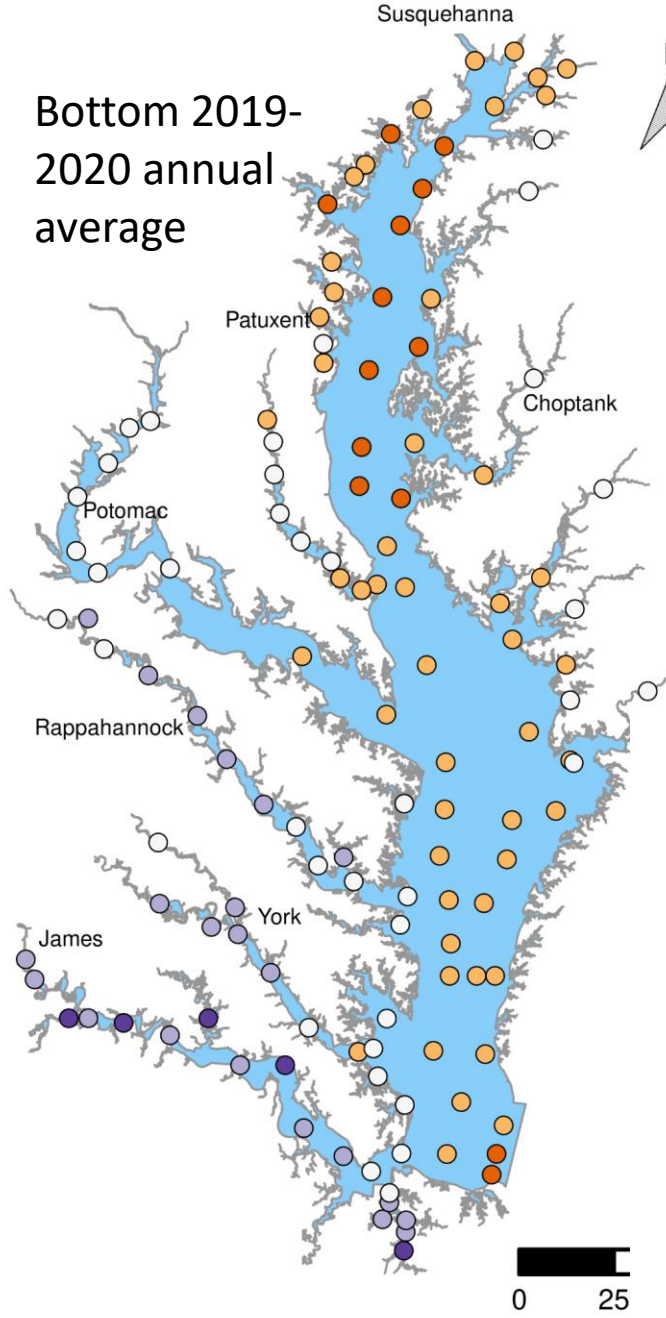


Data are from MDDNR and VADEQ. Trends were computed using GAM method in partnership between MDDNR, VADEQ, ODU, and CBP.
Disclaimer: <http://www.chesapeakebay.net/terms>

*start dates vary: MD mostly 1985 ex

x Observed Value — Estimate of Avg ■ Conf. Interval

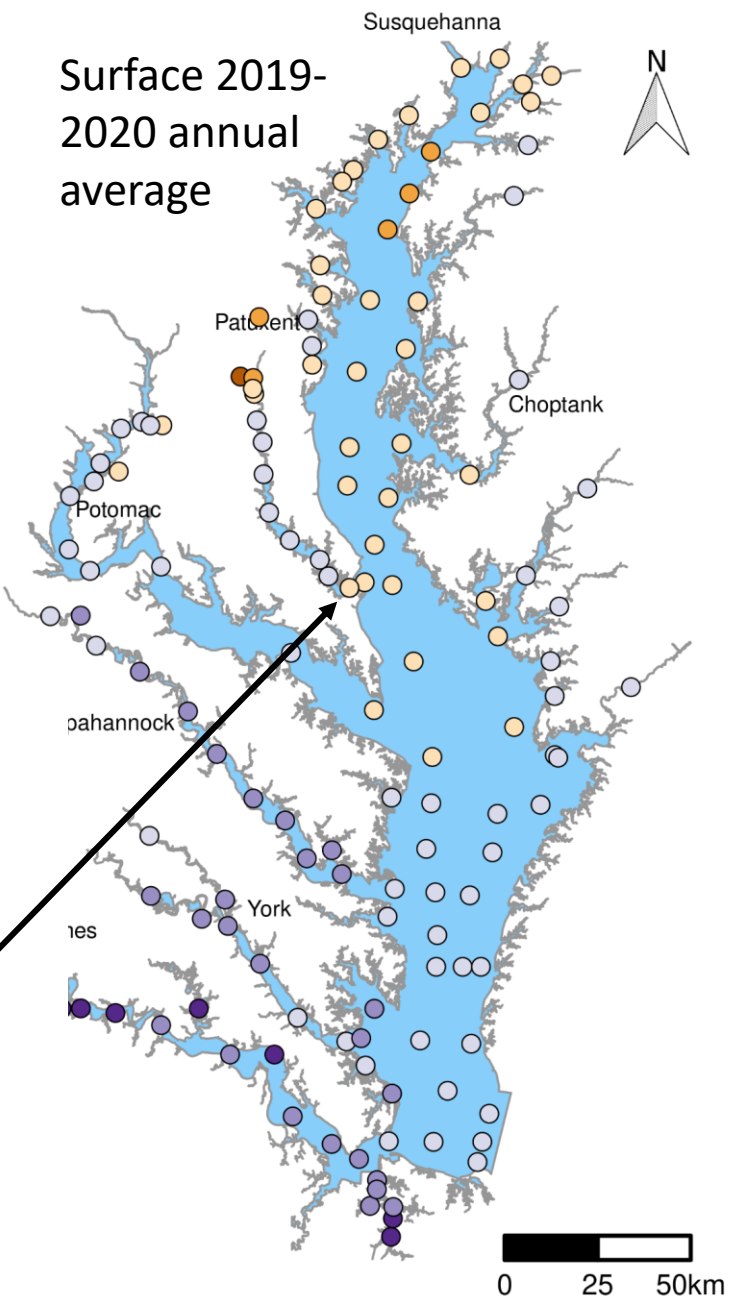
Bottom 2019-2020 annual average



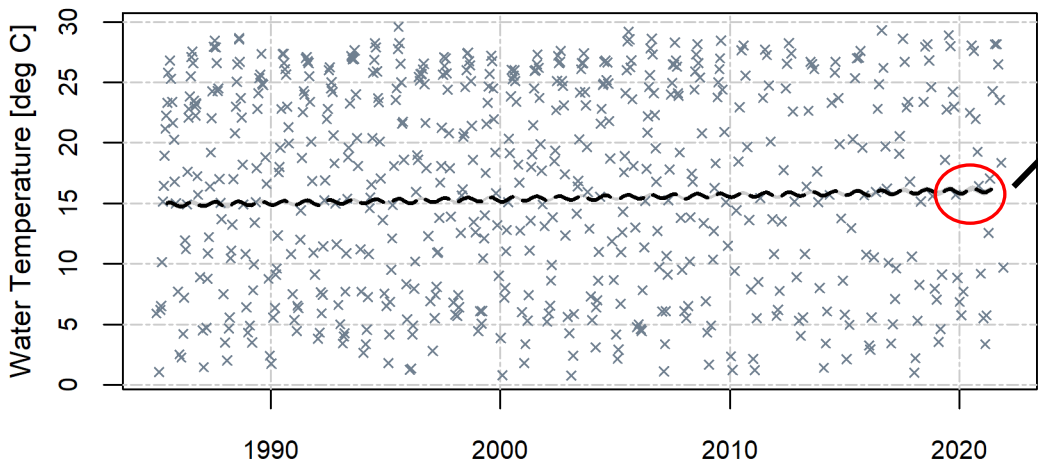
Readily available outputs for temperature:

- Surface and bottom changes by station.
- Graphs of the long-term patterns.
- Current (last 2 years) and mid-1980s average temperatures by station.

Surface 2019-2020 annual average



Water Temperature-Surface Layer at LE1.4



x Observed Value - Estimate of Avg ■ Conf. Interval

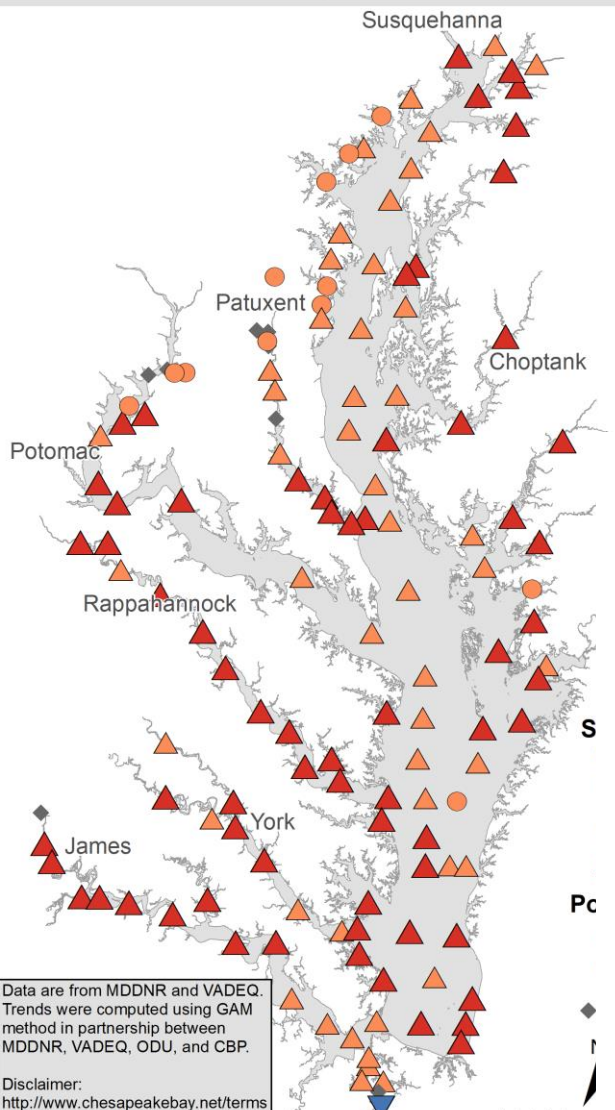
Current mean ● [14,15] ● (15,16) ○ (16,17) ● (17,18) ● (18,19)

Current mean ● [13,14] ● (15,16) ● (17,18) ● (14,15) ● (16,17) ● (18,19)

Maps from: <https://baytrends.chesapeakebay.net/baytrendsmap/>

Surface Water Temperature

Chesapeake Bay Surface Water Temperature: 2021 long-term change*



Data are from MDDNR and VADEQ. Trends were computed using GAM method in partnership between MDDNR, VADEQ, ODU, and CBP.
Disclaimer: <http://www.chesapeakebay.net/terms>

*start dates vary: MD stations 1985 or 1986, VA mostly 1985 except Elizabeth River 1989.

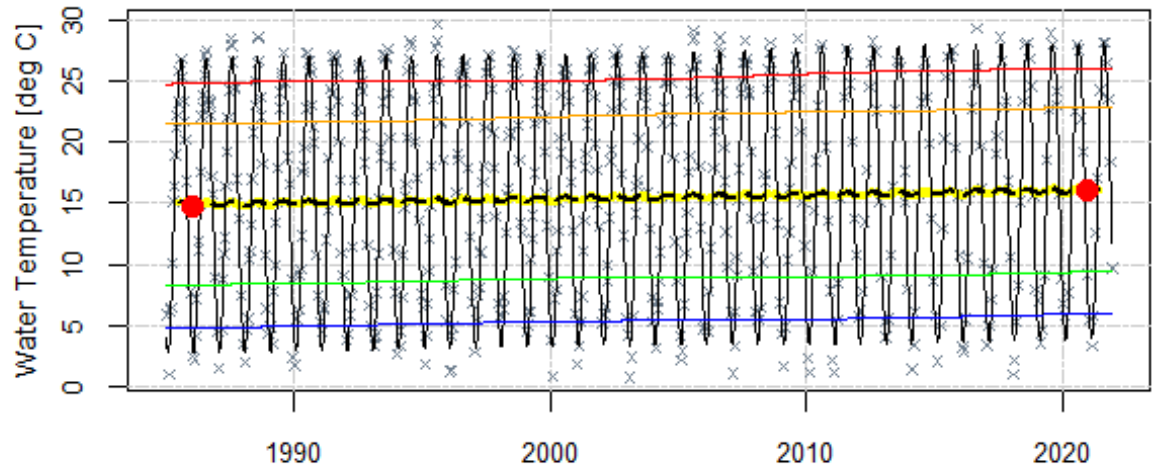
Readily available outputs for temperature:

- Surface and bottom changes by station
- Graphs of the long-term patterns.
- Current (last 2 years) and mid-1980s average temperatures by station.

With just a few more steps:

- Any of this info by season or month.

Water Temperature-Surface & Above Pycnocline at LE1.4



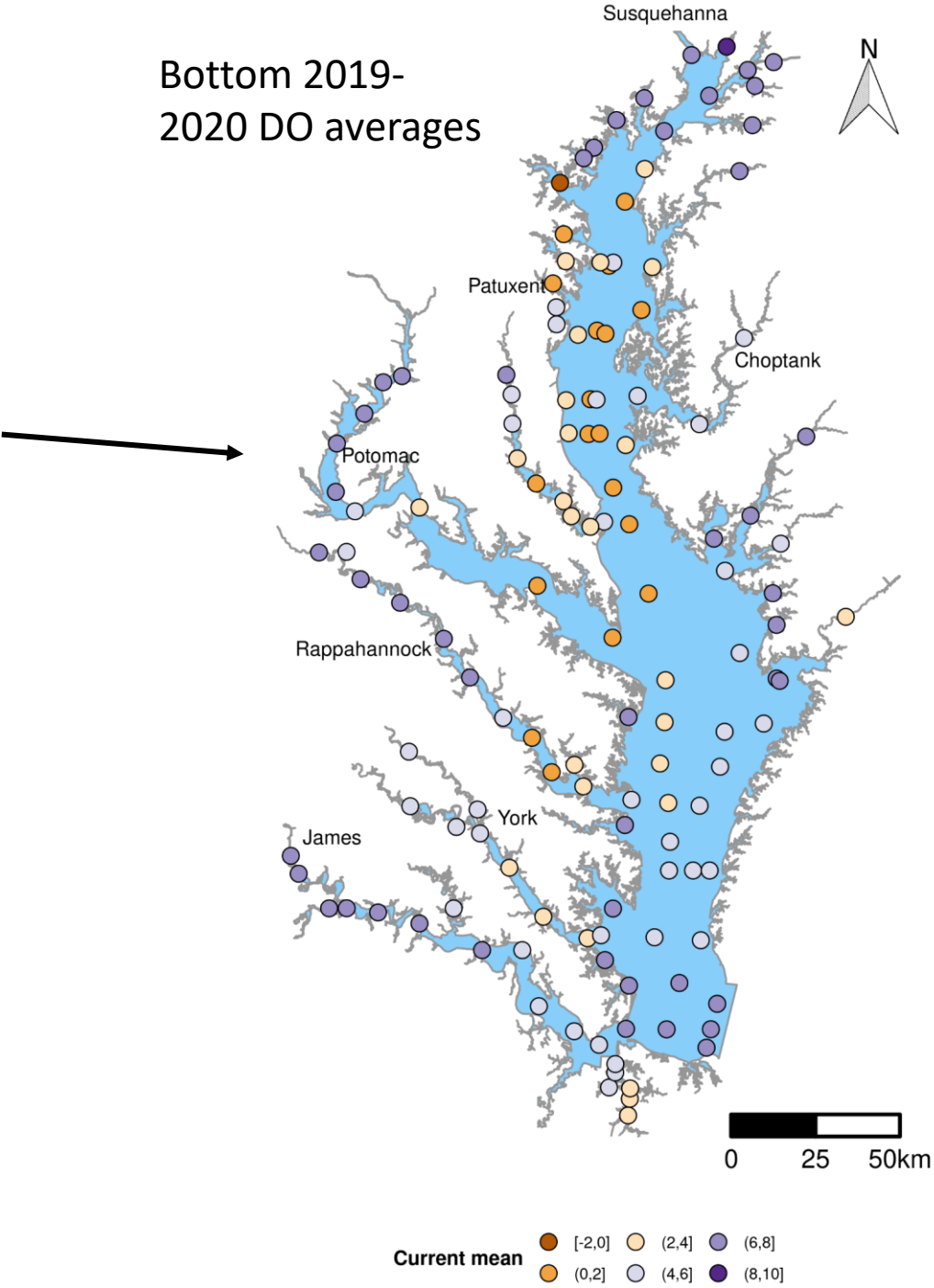
× Uncen.	— Avg. GAM	■ Conf. Int.	— 1/1	— 7/1
— Fit. GAM	■ Sign.	• B/C x	— 4/1	— 10/1

Summer Bottom Dissolved Oxygen

Bottom Summer DO

- Bottom DO varies greatly by depth, and hence by station

Bottom 2019-2020 DO averages



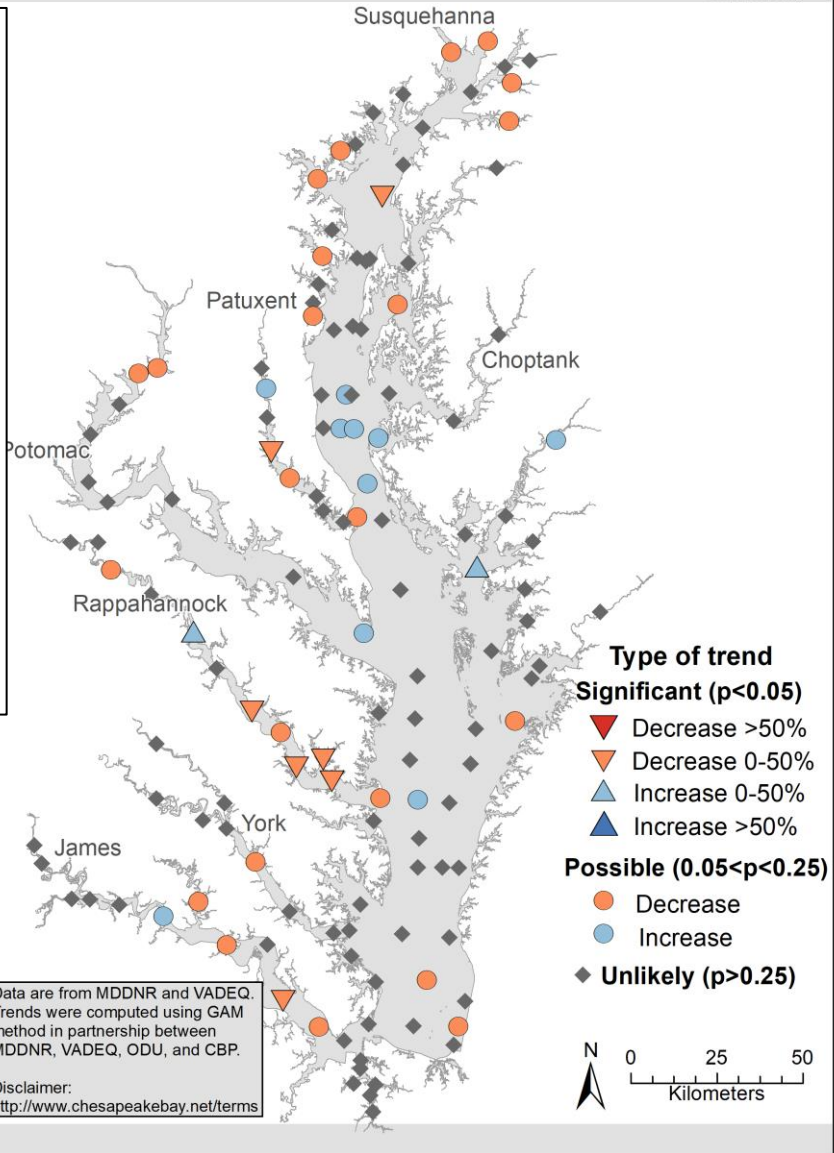
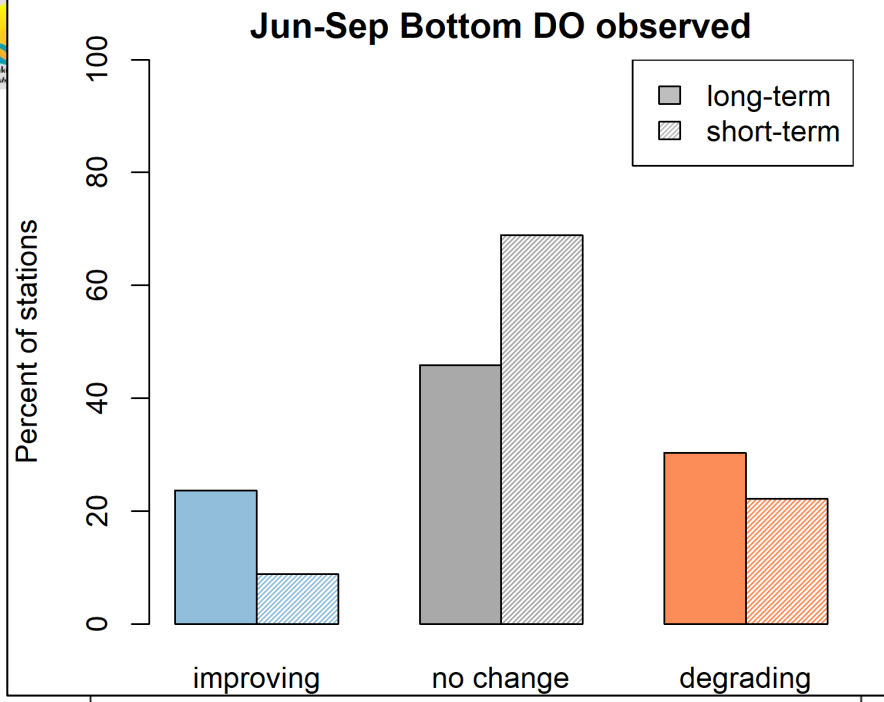
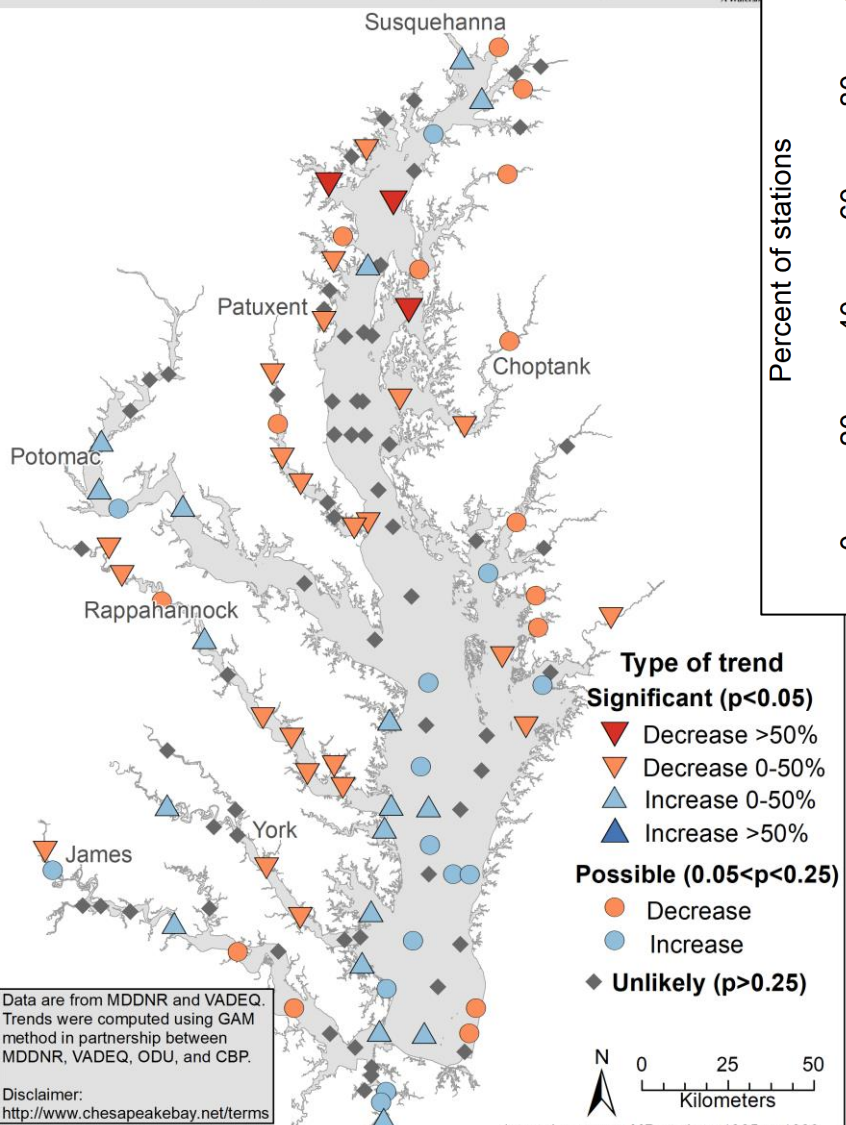
Map from: <https://baytrends.chesapeakebay.net/baytrendsmap/>

Bottom Summer DO

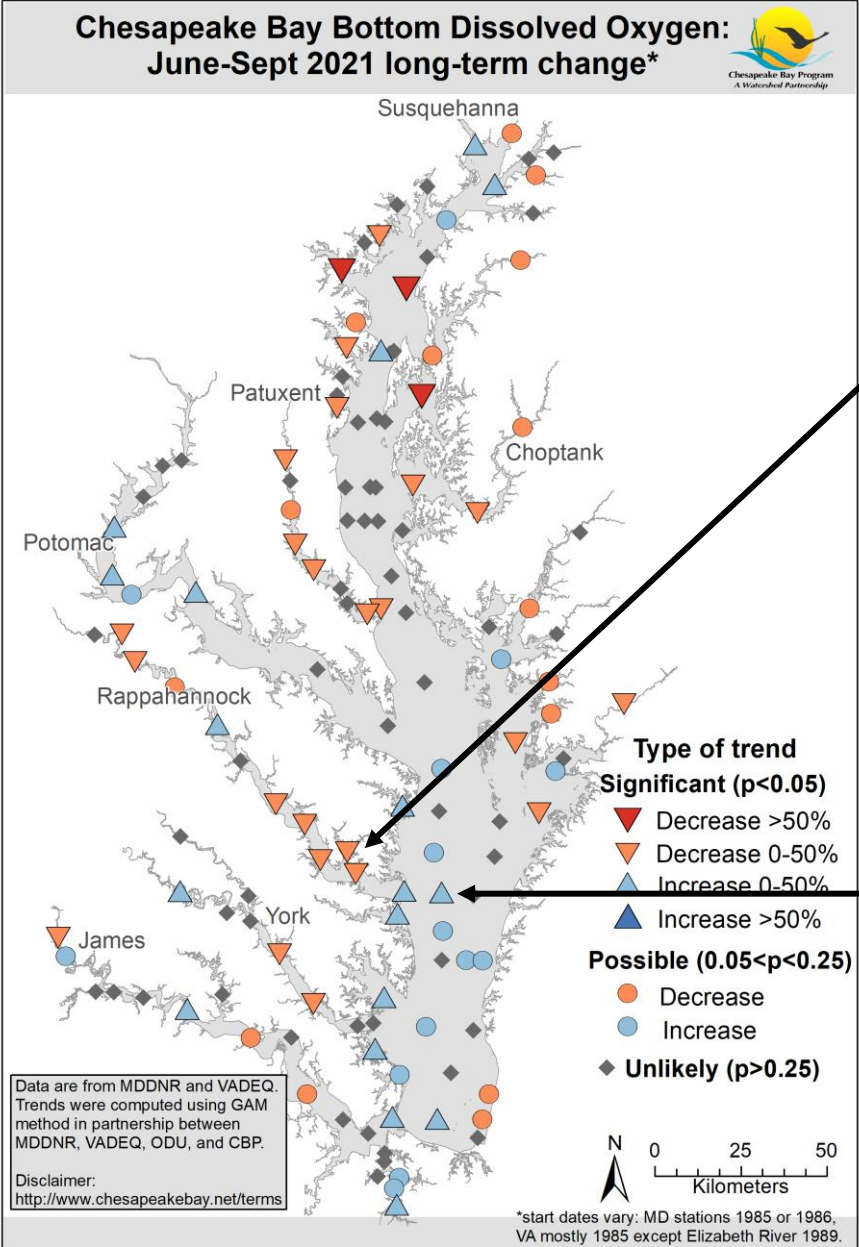
Chesapeake Bay Bottom Dissolved Oxygen: June-Sept 2012-2021 change



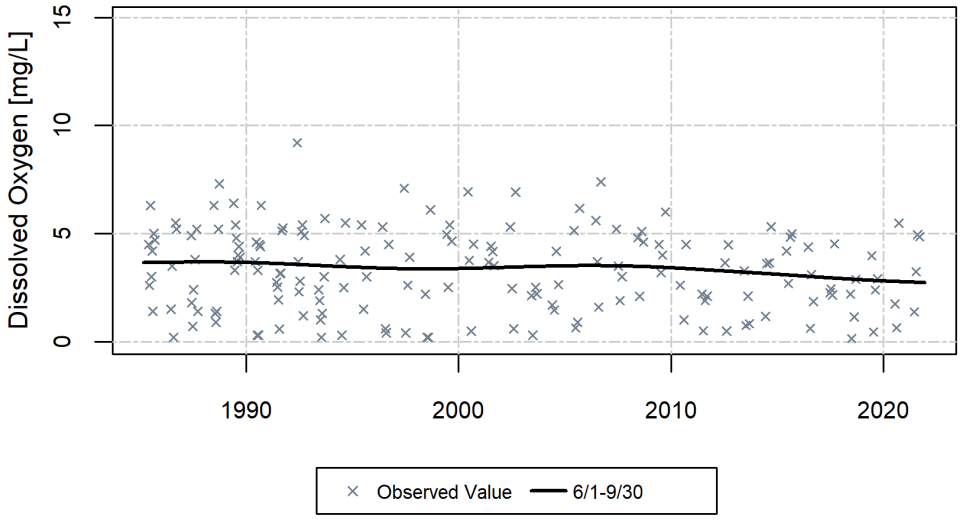
Chesapeake Bay Bottom Dissolved Oxygen: June-Sept 2021 long-term change*



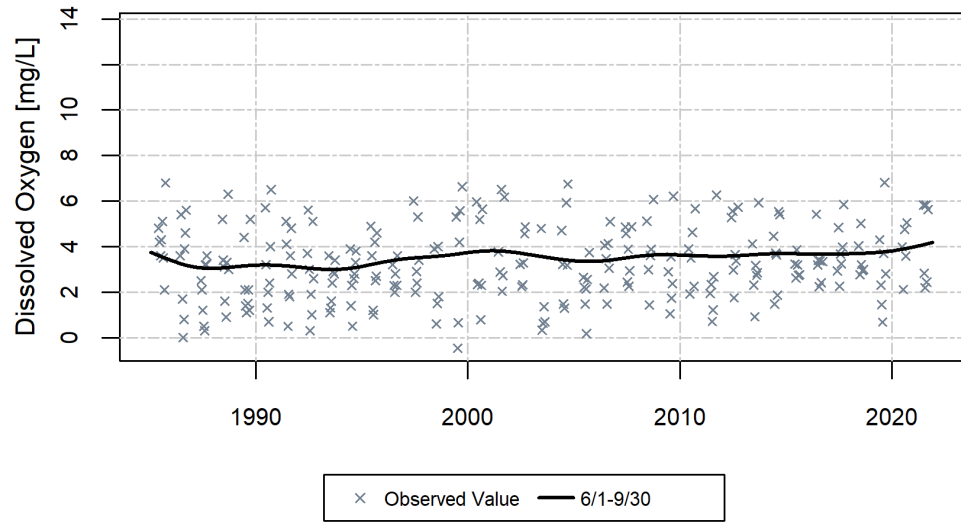
Bottom Summer DO



Dissolved Oxygen-Bottom from June to Sept at LE3.4



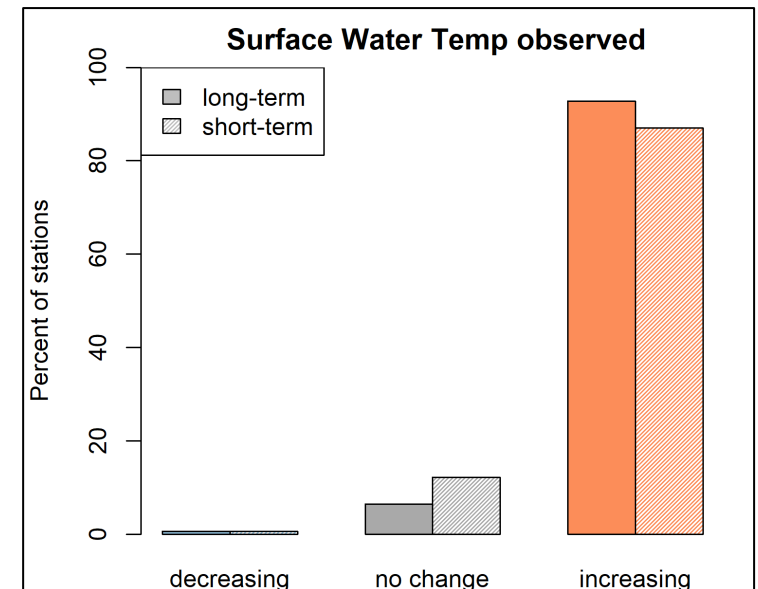
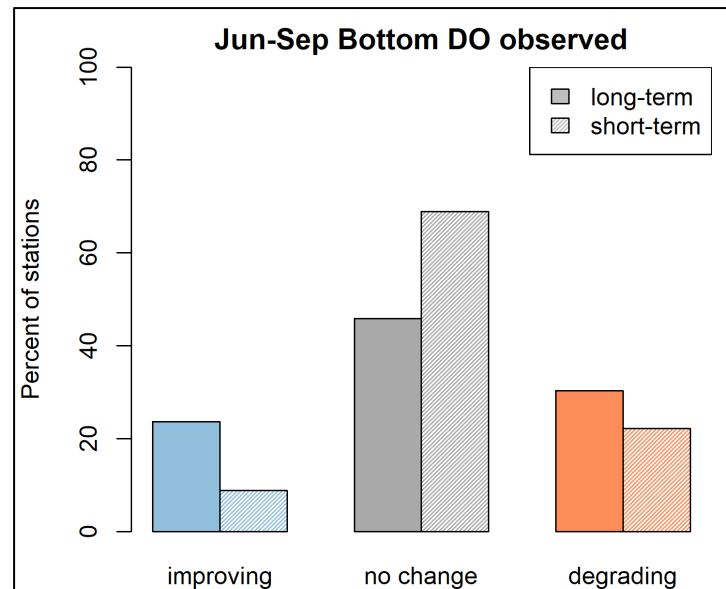
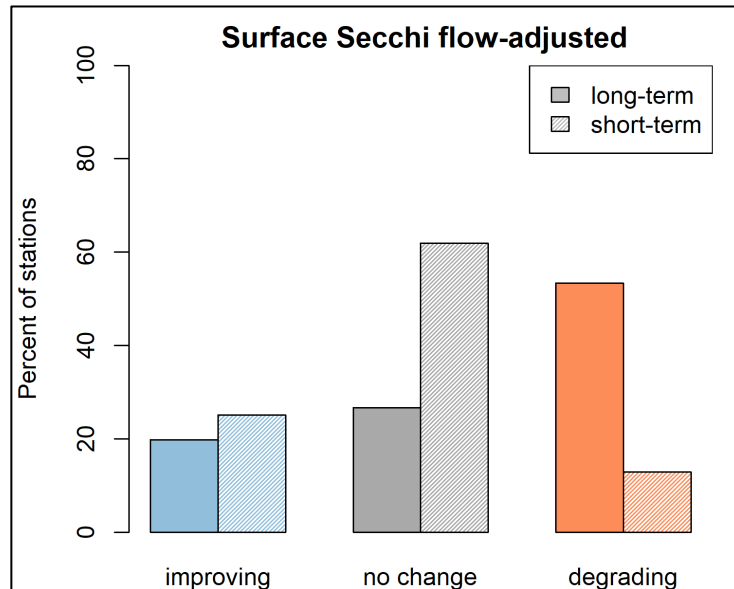
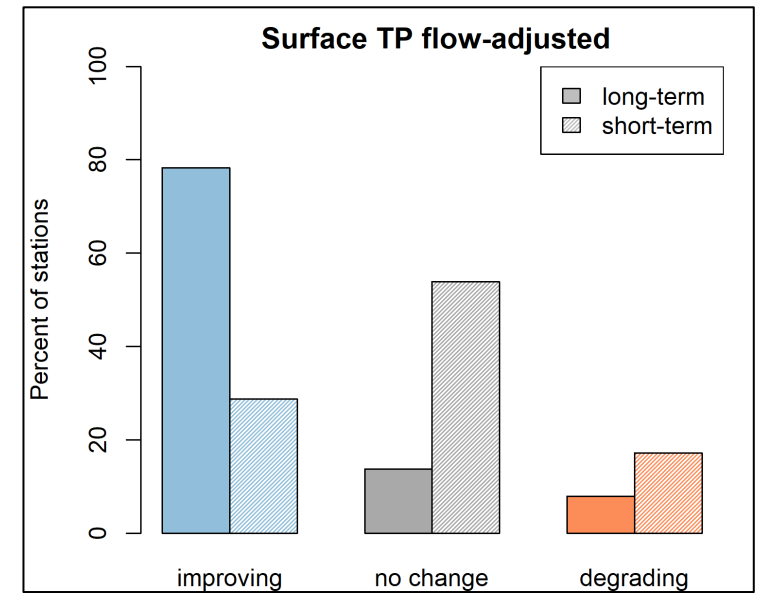
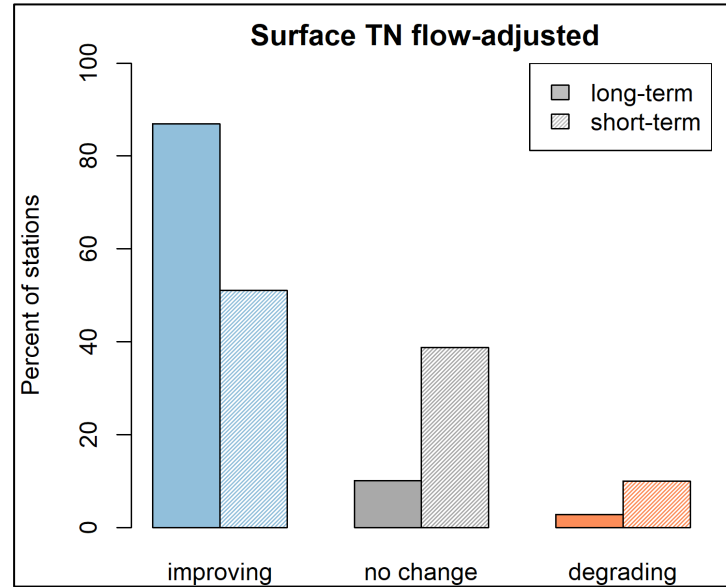
Dissolved Oxygen-Bottom from June to Sept at CB6.1



Example: Bottom summer oxygen trends in deep Rappahannock compared to nearby mainstem.

2021 Summary

- Overall patterns consistent with last year.
- Nutrient trends mostly improving over the long-term with some leveling-out over the short-term.
- Secchi and DO are mixed, but both have an increasing number of stations with “no change” in recent years.
- Water temperature is increasing.



Access

ITAT webpage:

Static maps and summary document

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

The screenshot shows the Chesapeake Bay Program website. The header includes the logo and navigation links: "Discover the Chesapeake", "Learn the Issues", "State of the Chesapeake", "Take Action", and "In the News". The main content area is titled "Integrated Trends Analysis Team" and "Maps of 2020 Tidal Water Quality Change". It lists various water quality parameters and their long-term changes for 2021, such as Total Nitrogen Surface Annual Long-Term Change 2021 (467.547 KB) and Dissolved Oxygen Bottom Summer Long-Term Change 2021 (456.576 KB). The page is organized into sections for "1. Long-Term Change" and "2. Long-Term Flow-Adjusted Change".

baytrendsmap app: Web tool to map the trends, current concentrations, and zoom in on regions
<https://baytrends.chesapeakebay.net/baytrendsmap/>

The screenshot shows the baytrendsmap web application interface. The top navigation bar includes "baytrendsmap R package v1.2.3", "View Tidal Trends", "Create Custom Maps", "Background", and "HELP". The main interface is divided into two columns. The left column contains configuration options: "1. Choose Data" (with radio buttons for "Non-linear Trend (Long Term)", "Non-linear Trend (Short Term)", "Non-linear Trend with Flow Adjustment (Long Term)", and "Non-linear Trend with Flow Adjustment (Short Term)"), "2. Choose Map Layer (parameter|layer|season)" (with a dropdown menu showing "DO|Bottom|Jun-Sep"), "3. Map Options" (with sub-sections for "3.a. Range Map Options" and "3.b. Change Map Options", each with a "Color Palette" dropdown menu). The right column displays a map of the Chesapeake Bay with a legend for "Dissolved Oxygen [mg/L]" and "Type of change". The legend includes "Significant Decrease" (red triangle), "Significant Increase" (blue triangle), "Possible Decrease" (red circle), "Possible Increase" (blue circle), and "Unlikely" (grey diamond). A scale bar indicates 0, 25, and 50 km. The map shows various tributaries labeled, including Susquehanna, Patuxent, Choptank, Potomac, Rappahannock, York, and James.

Acknowledgements

- States & DC: Renee Karrh (MDDNR), Mike Lane (ODU), Cindy Johnson (VADEQ), Efeturi Oghenekaro, Blessing Edje and George Onyullo (DOEE), Mukhtar Ibrahim and Karl Berger (COG)
- Consultants: Elgin Perry (independent), Jon Harcum and Erik Leppo (Tetra Tech)
- CBP office: Breck Sullivan (USGS), Alex Gunnerson (CRC), Rebecca Murphy (UMCES, rmurphy@chesapeakebay.net)