

2020 Tidal Trends Summary

Rebecca Murphy (UMCES/CBP)

With results run by Renee Karrh (MDDNR) and Mike Lane (ODU)

ITAT meeting

Nov 19, 2021

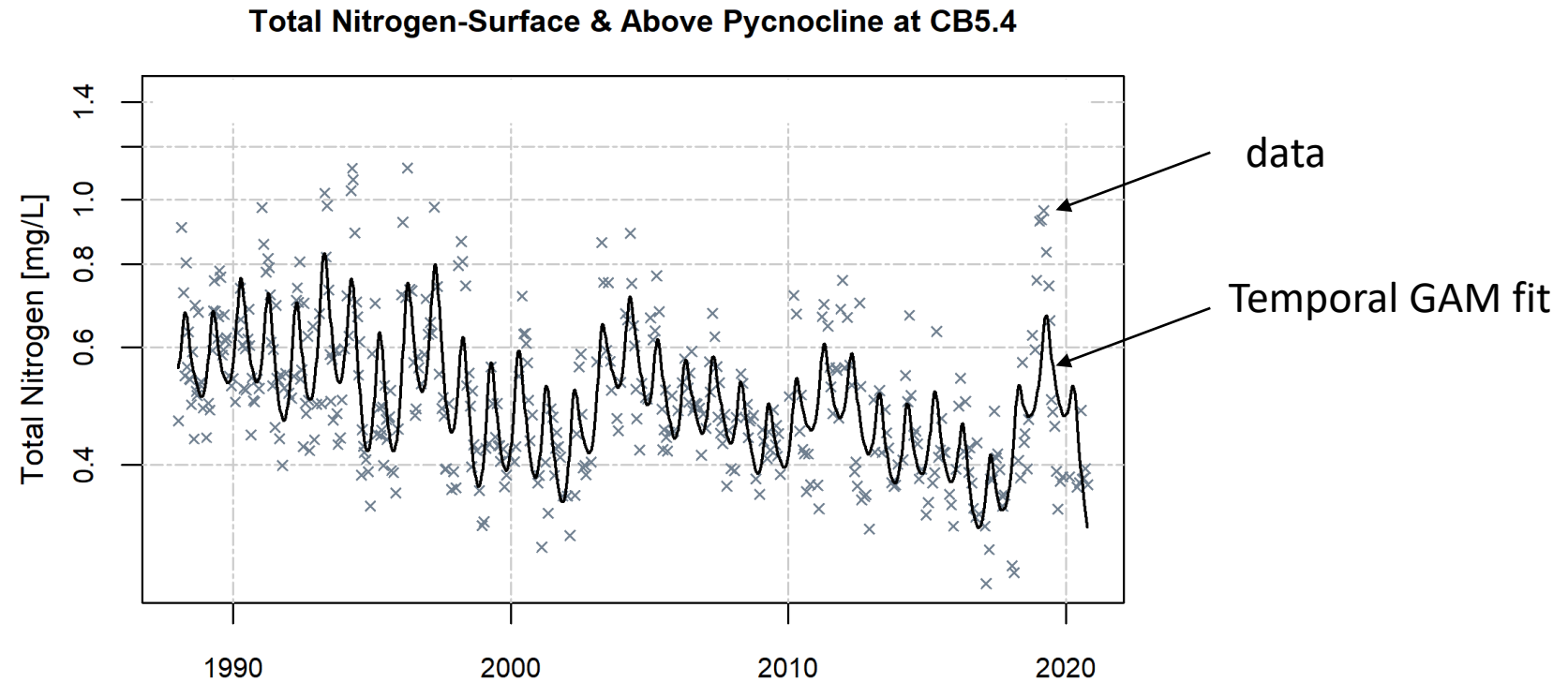
2020 Tidal Trend Results

- Long-term (1980s-2020) and short-term (2011-2020) change:
 - Annual surface & bottom TN, TP, water temp, salinity
 - Annual Secchi depth
 - Spring & summer, surface & bottom: Chlorophyll *a*
 - Summer surface & bottom DO
- 1999-2020 and short-term (2011-2020) change :
 - Annual surface & bottom TSS, DIN, PO₄

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

Tidal Trends/GAM* method review

$$\text{TN} = s(\text{doy}) + s(\text{date}) + \text{interaction}(\text{doy}, \text{date})$$

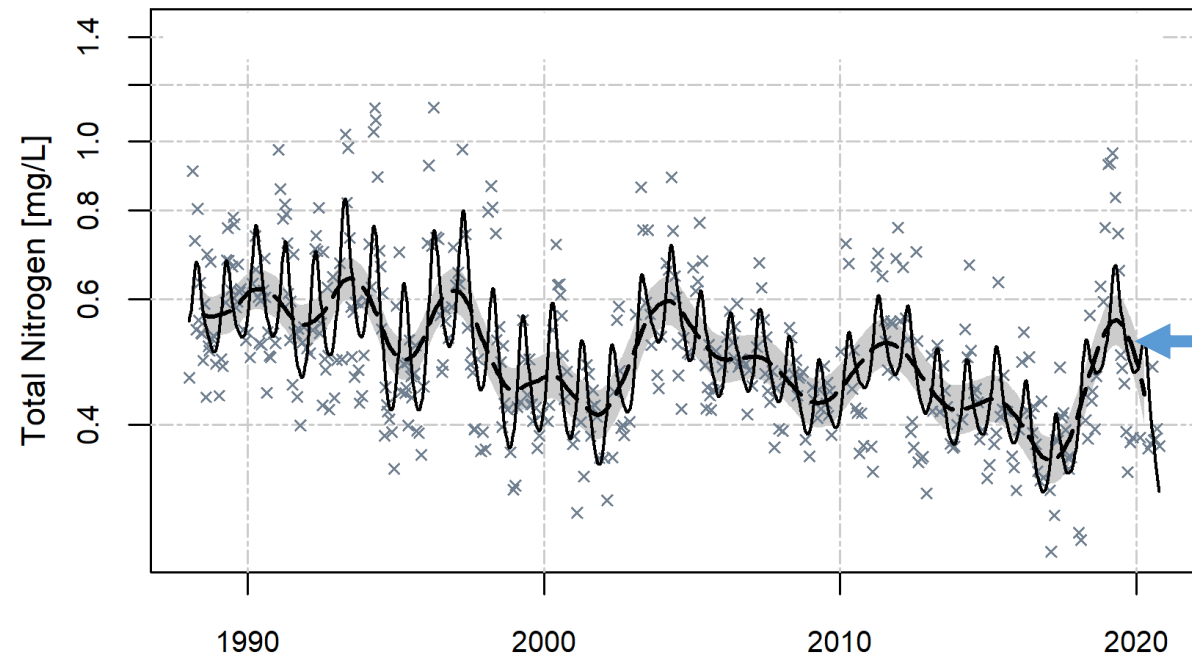


*Generalized Additive Models

Tidal Trends/GAM method review

$$\text{TN} = \text{s}(\text{doy}) + \text{s}(\text{date}) + \text{interaction}(\text{doy}, \text{date})$$

Total Nitrogen-Surface & Above Pycnocline at CB5.4

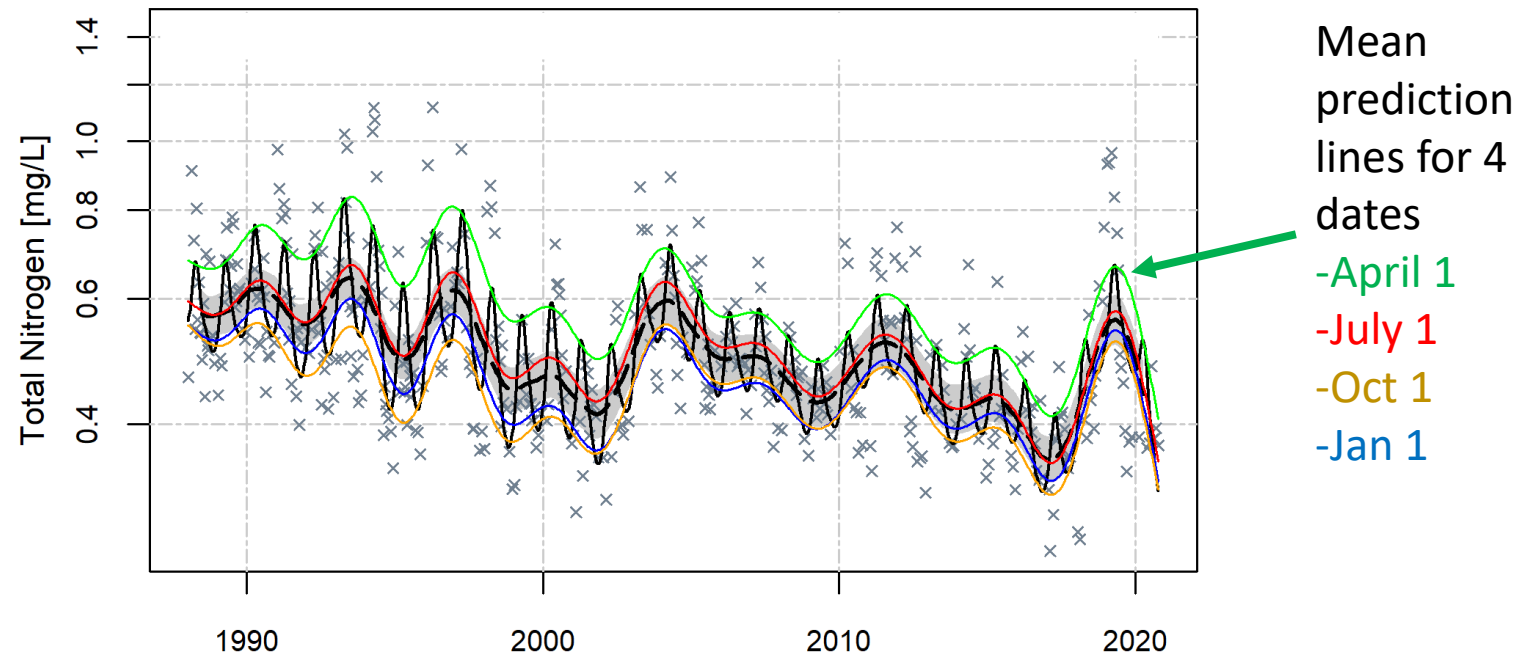


Seasonal
mean and
95%
confidence
interval on
the mean

Tidal Trends/GAM method review

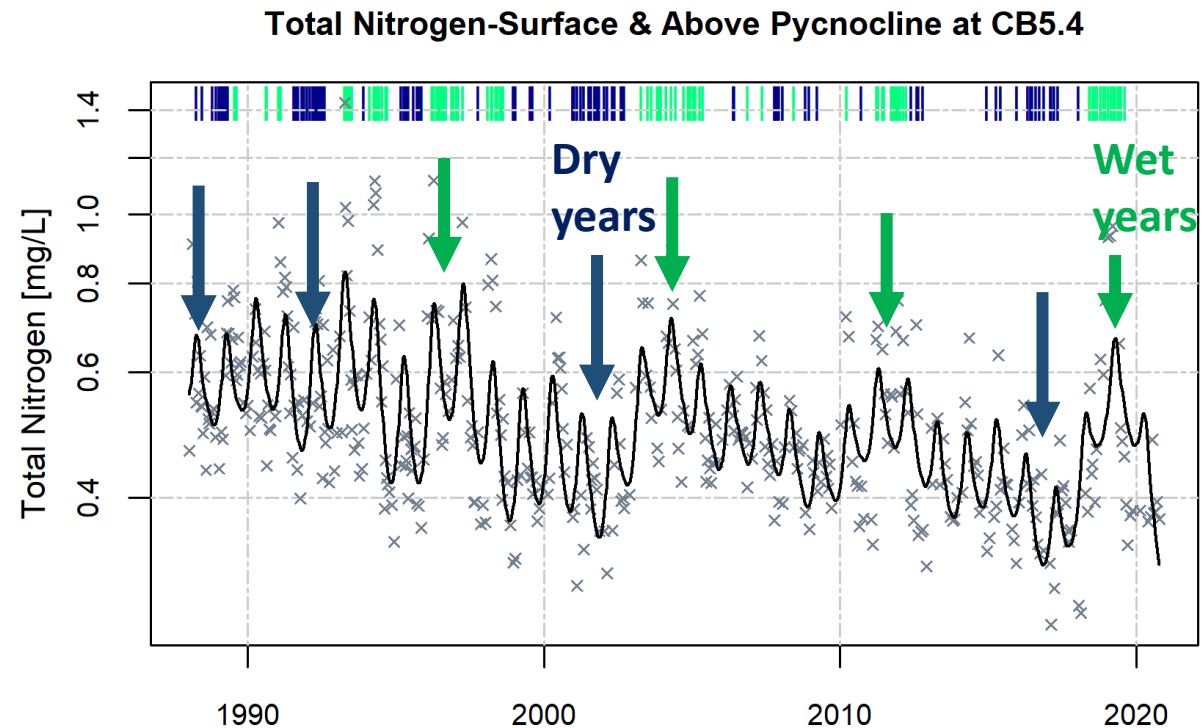
$$\text{TN} = s(\text{doy}) + s(\text{date}) + \text{interaction}(\text{doy}, \text{date})$$

Total Nitrogen-Surface & Above Pycnocline at CB5.4



Tidal Trends/GAM method review

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

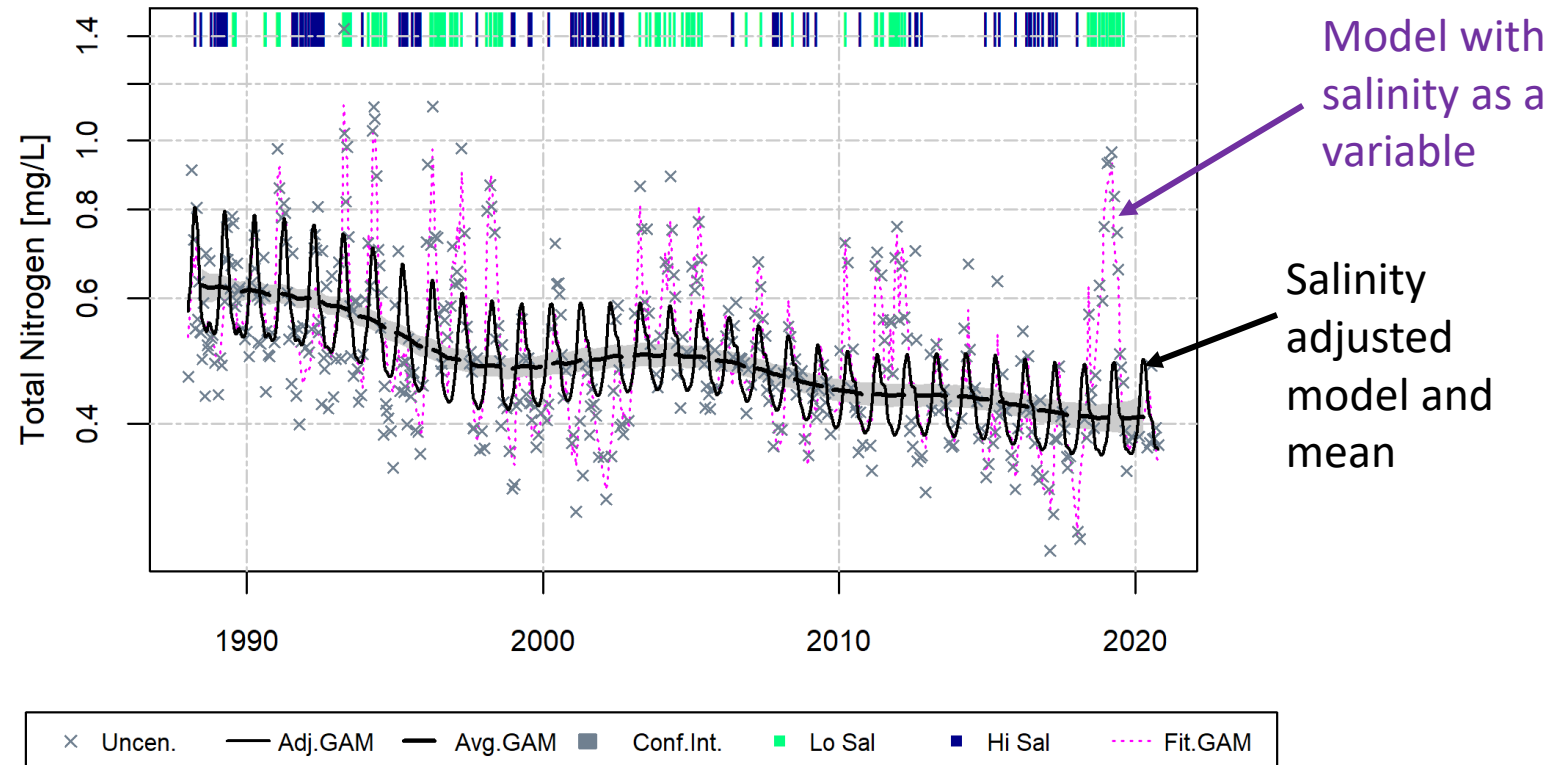


Approach: Include upstream flow or local salinity in the model, depending on location of analysis.

Tidal Trends/GAM method review

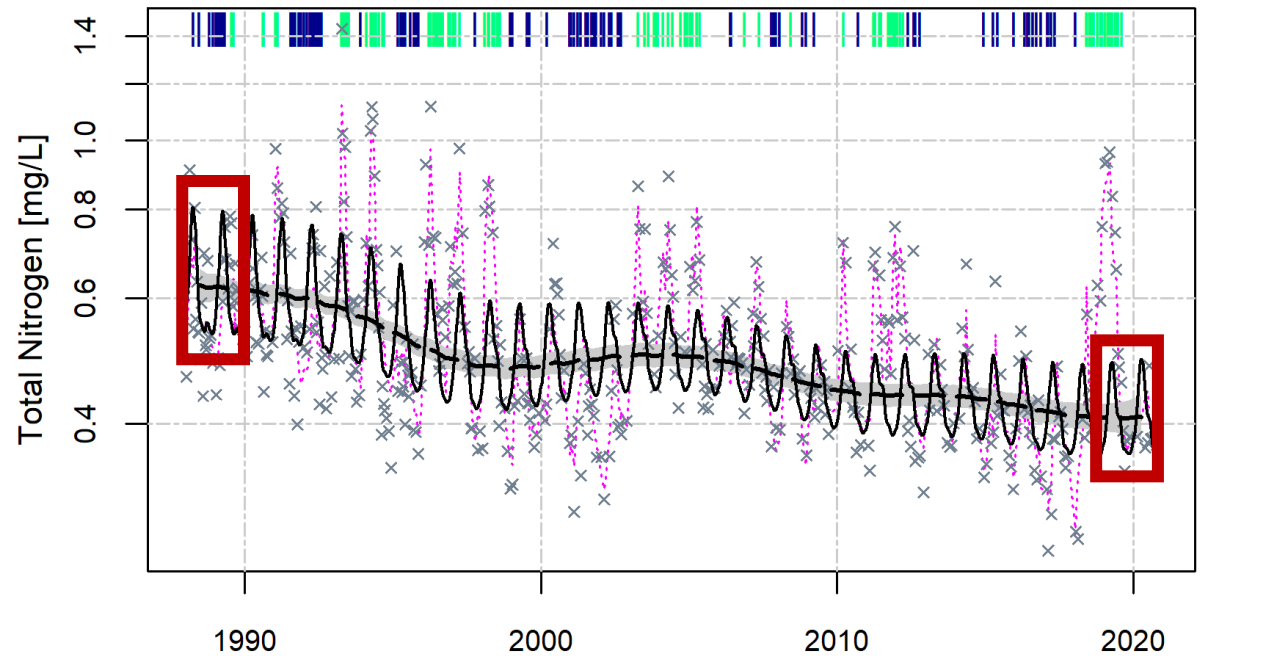
$$\text{TN} = s(\text{doy}) + s(\text{date}) + \text{interaction}(\text{doy}, \text{date}) \\ + s(\text{flw_sal}) + \text{interaction}(\text{flw_sal}, \text{doy}) + \text{interaction}(\text{flw_sal}, \text{date}) + \text{interaction}(\text{flw_sal}, \text{doy}, \text{date})$$

Total Nitrogen-Surface & Above Pycnocline at CB5.4



Tidal Trends/GAM method review

Total Nitrogen-Surface & Above Pycnocline at CB5.4

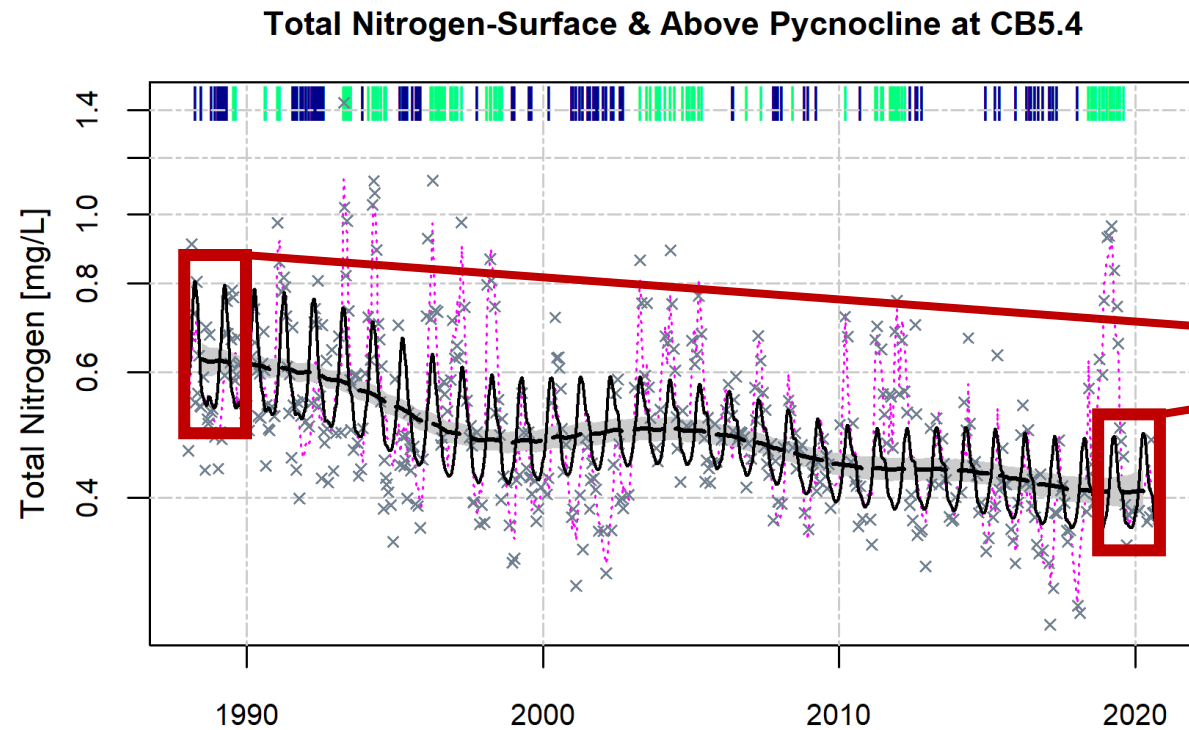


Percent change = -34%
p-value < 0.0001

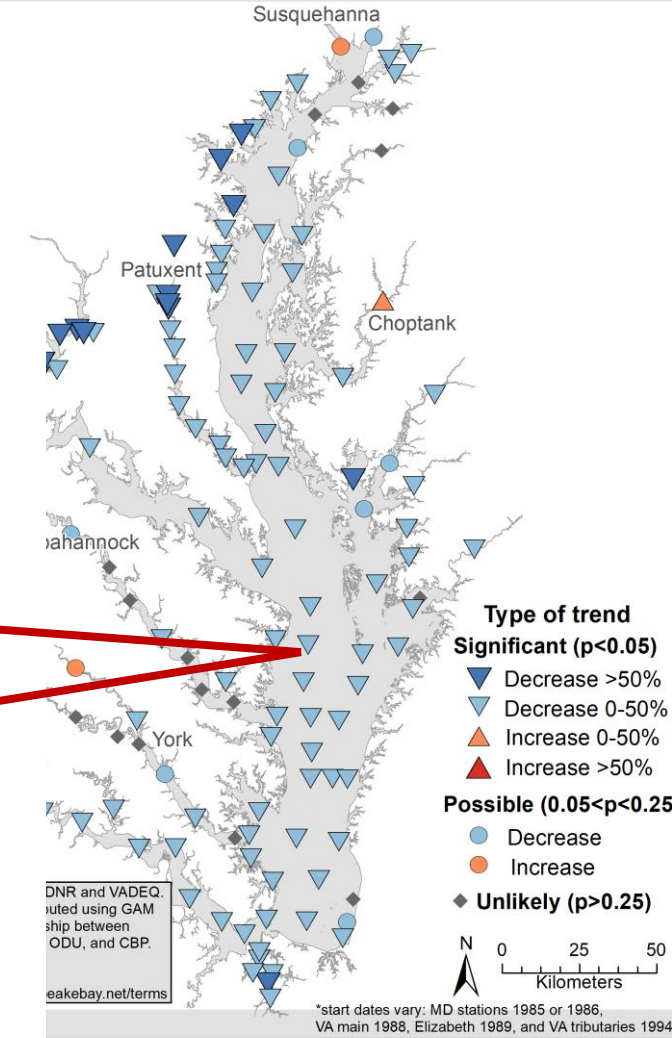


Tidal Trends/GAM method

Chesapeake Bay Surface Total Nitrogen: 2020 long-term flow-adjusted change*

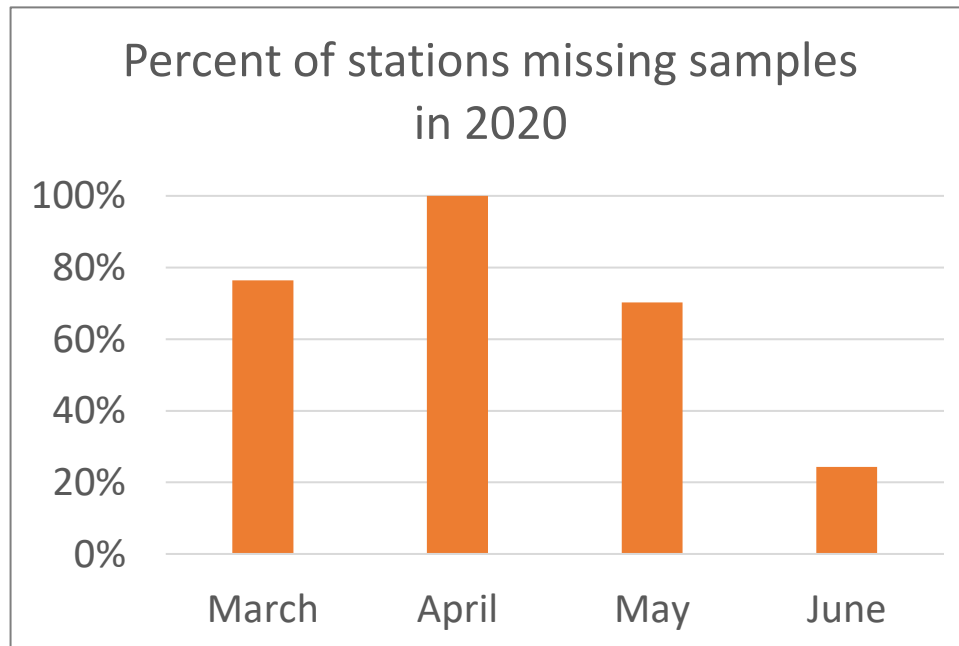


Percent change = -34%
p-value < 0.0001



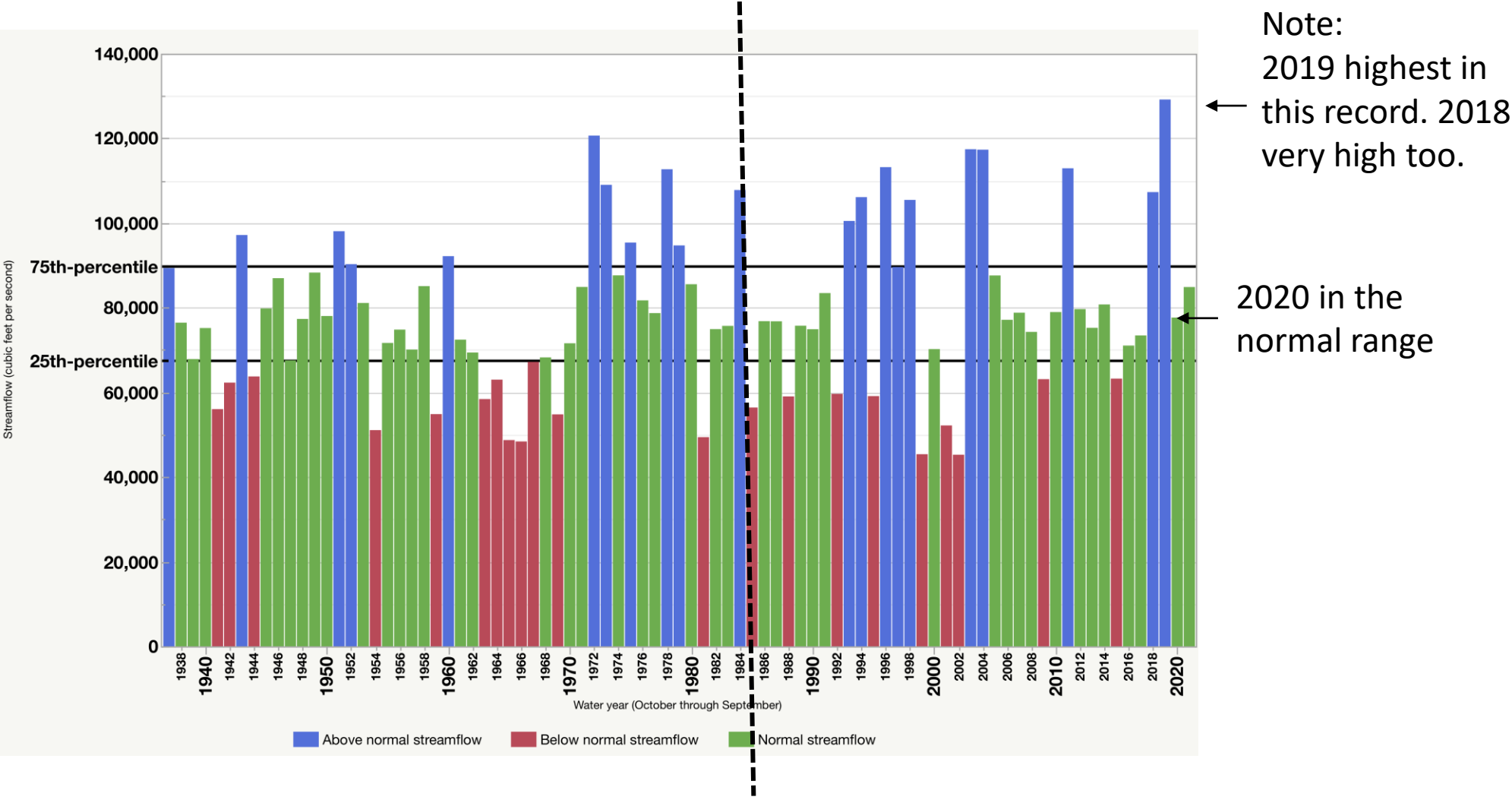
× Uncen. — Adj.GAM - - Avg.GAM ■ Conf.Int. ■ Lo Sal ■ Hi Sal - - - Fit.GAM

Sampling loss due to COVID in 2020



- Jon Harcum (Tetra Tech) did some testing using data ending in 2019 and simulated the sample removal to gauge the impact.
- Results showed little difference to our trend conclusions with the missing data.
- The biggest differences are for TN and spring chlorophyll, which would be expected. But still ~80% of the trend conclusions for those two are the same and most of the changes are in and out of the “possible trend” category.
- This is due to the rich data record we have for 30+ years. The GAMs could “borrow” that information to provide reasonable estimates. ***With more missing data performance would very likely get worse.***

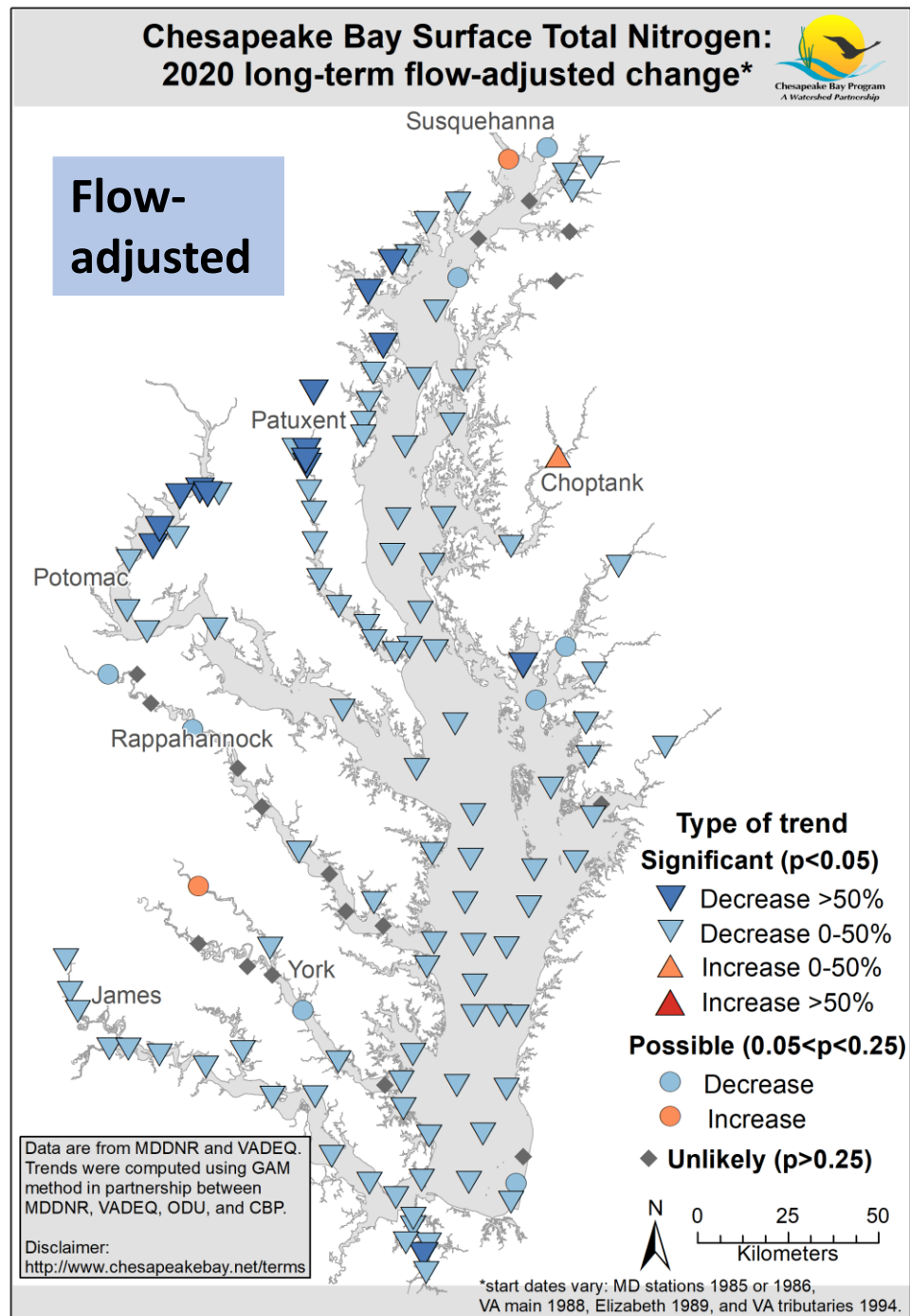
Total monitored flow into tidal waters



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

TN

Surface
Long-term



TN

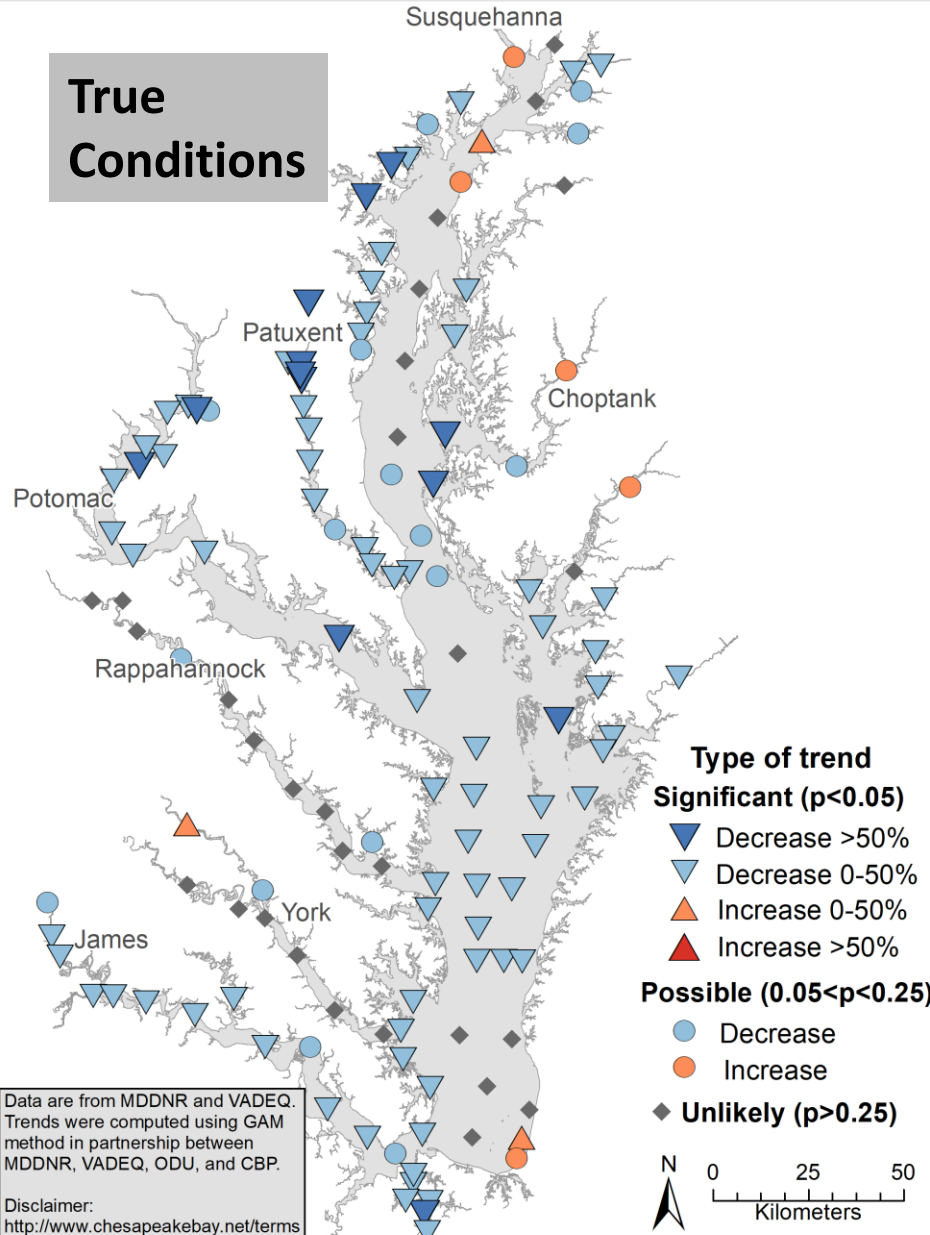
Surface

Long-term

Chesapeake Bay Surface Total Nitrogen: 2020 long-term change*



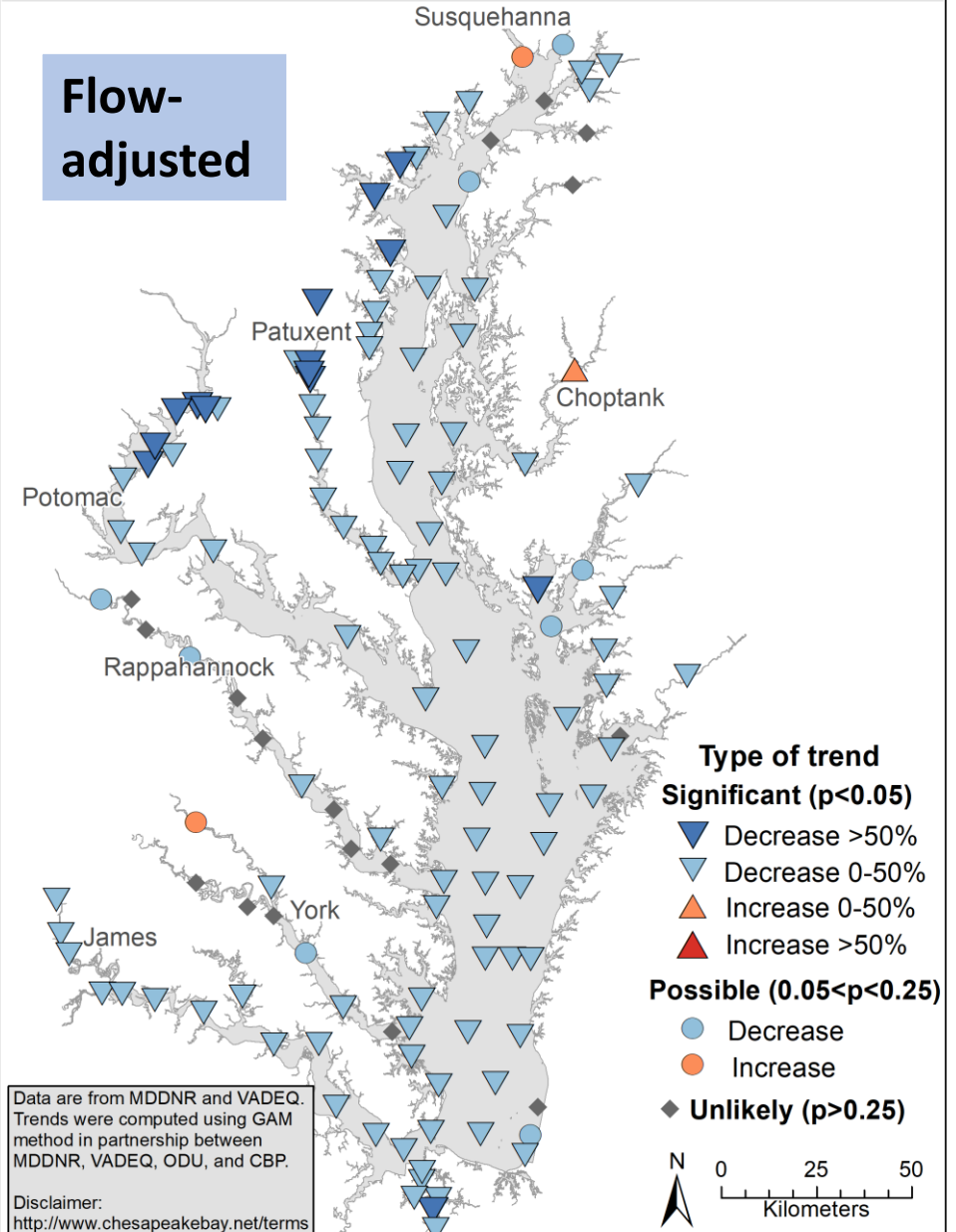
**True
Conditions**



Chesapeake Bay Surface Total Nitrogen: 2020 long-term flow-adjusted change*



**Flow-
adjusted**



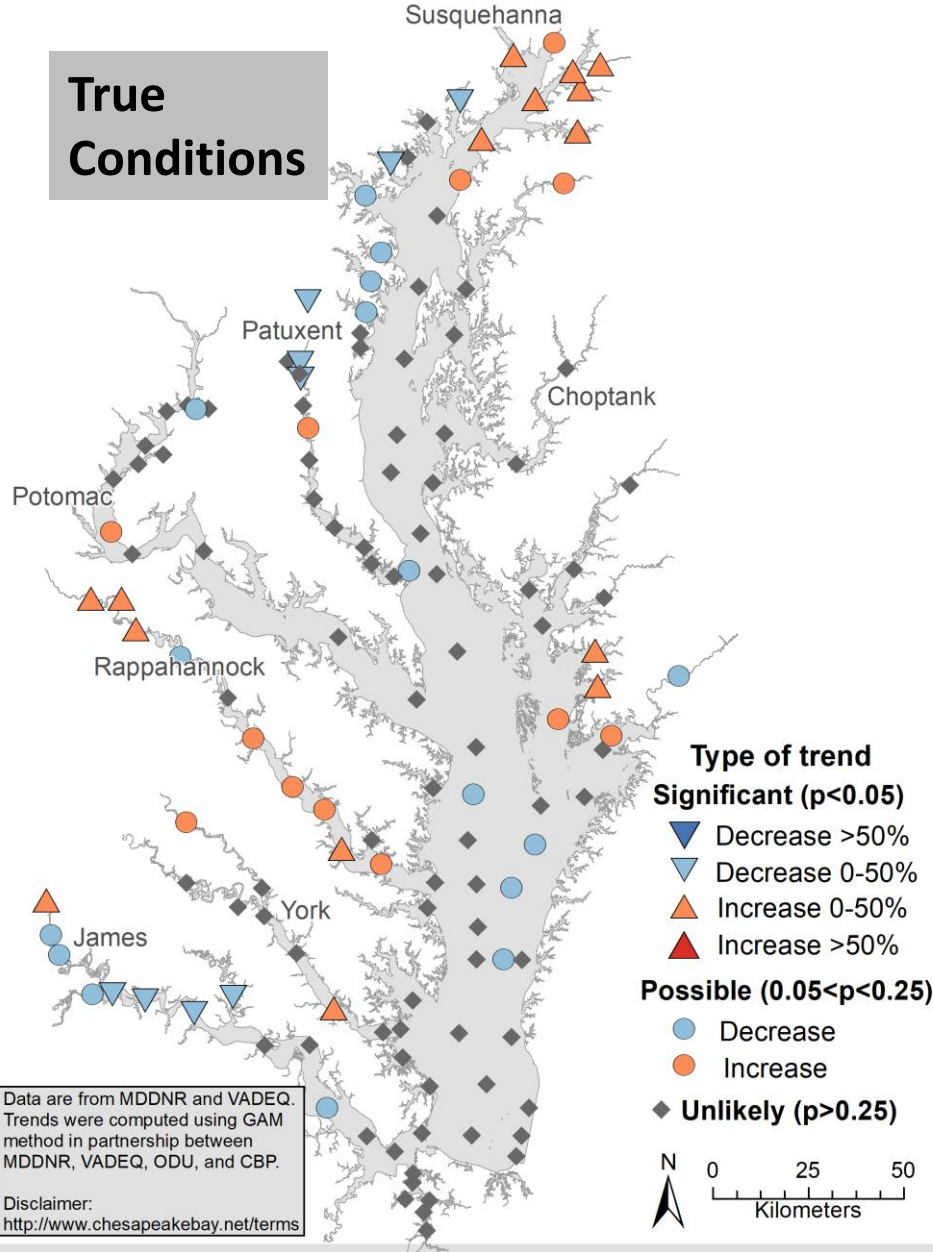
TN

Surface Short-term

Chesapeake Bay Surface Total Nitrogen: 2011-2020 change*



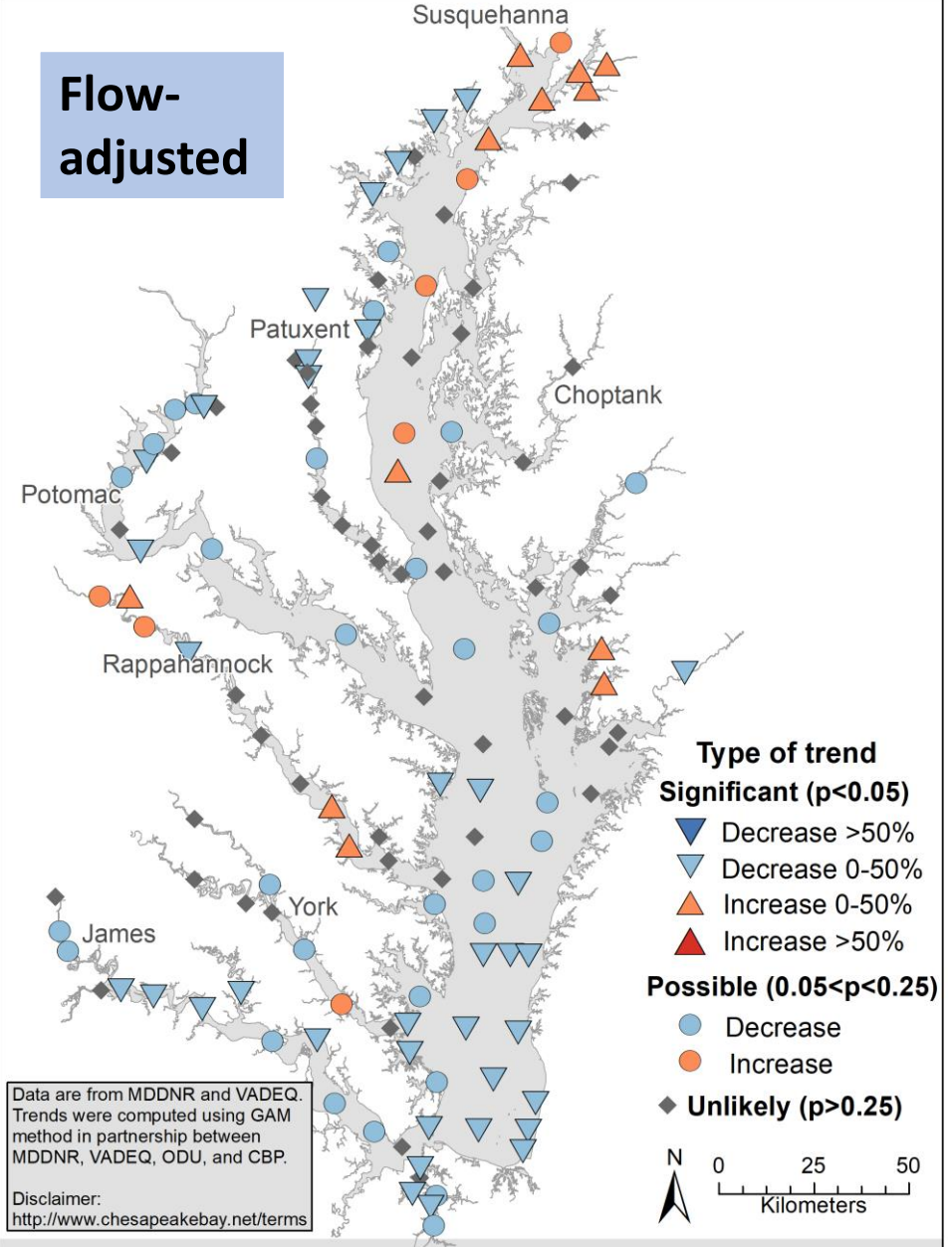
True Conditions



Chesapeake Bay Surface Total Nitrogen: 2011-2020 flow-adjusted change*

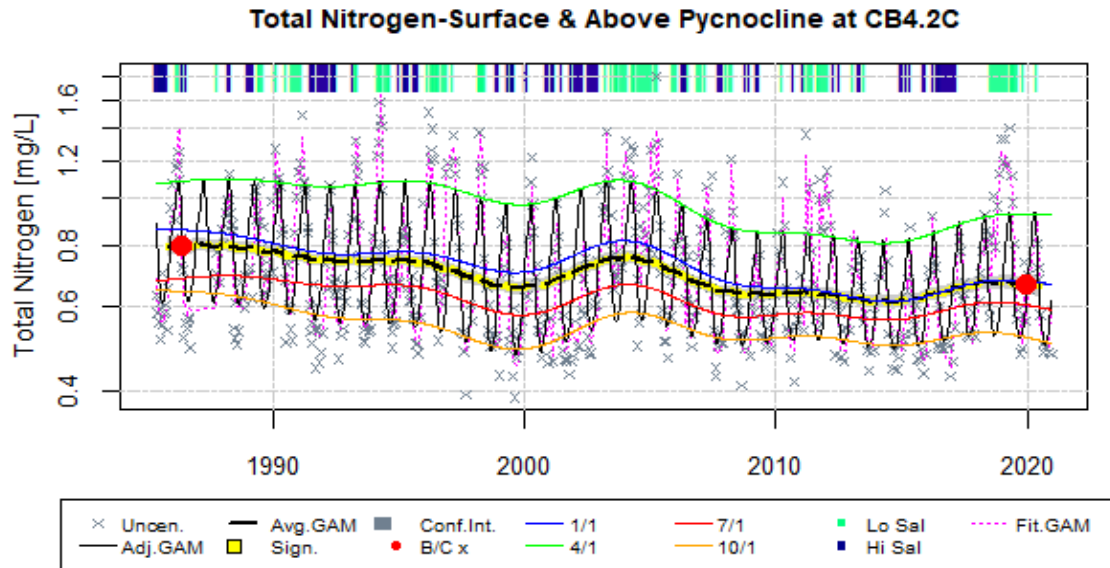


Flow-adjusted



TN

Surface Example

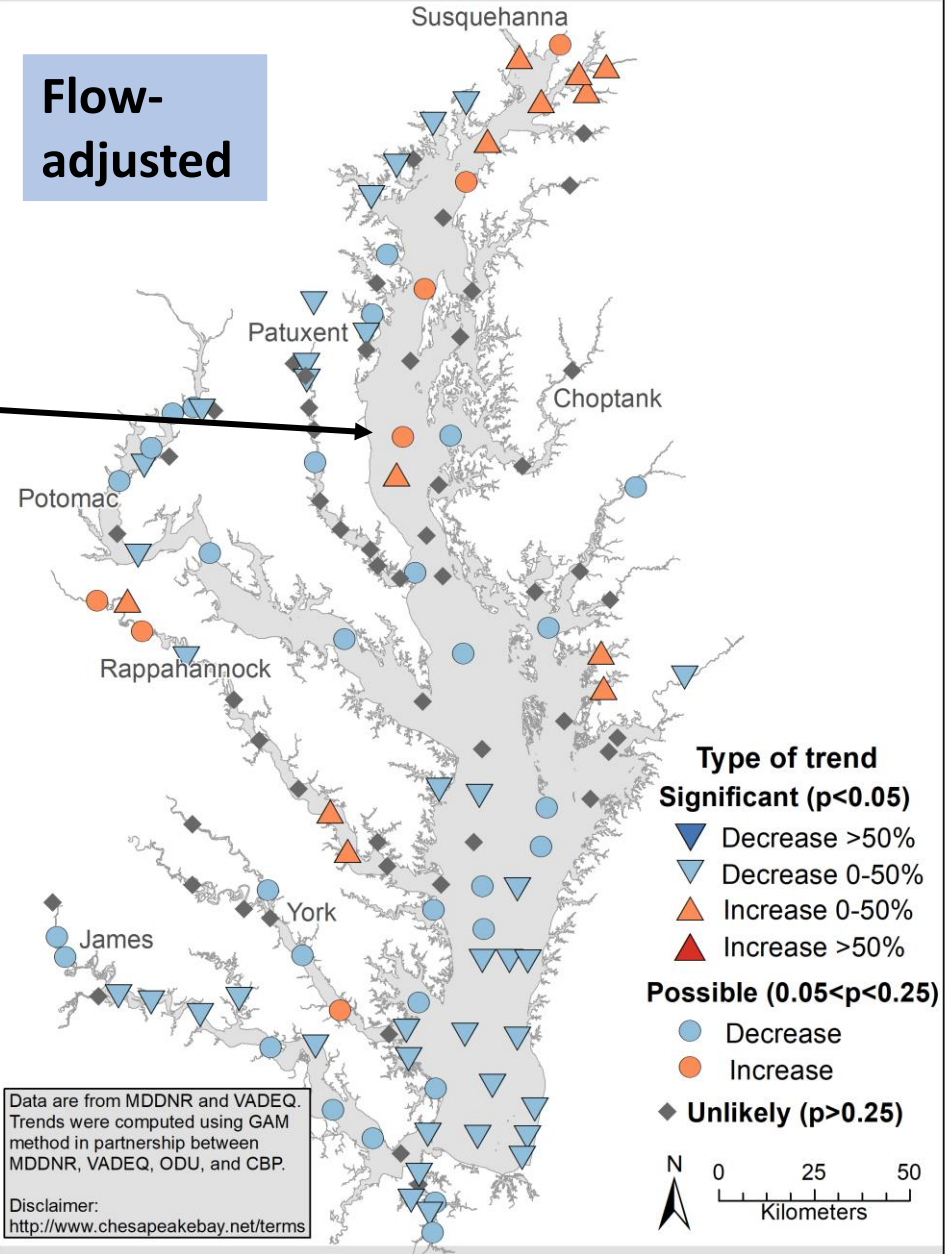


Example: A station with long-term improvement but slight increase at the end of the record.

Chesapeake Bay Surface Total Nitrogen: 2011-2020 flow-adjusted change*

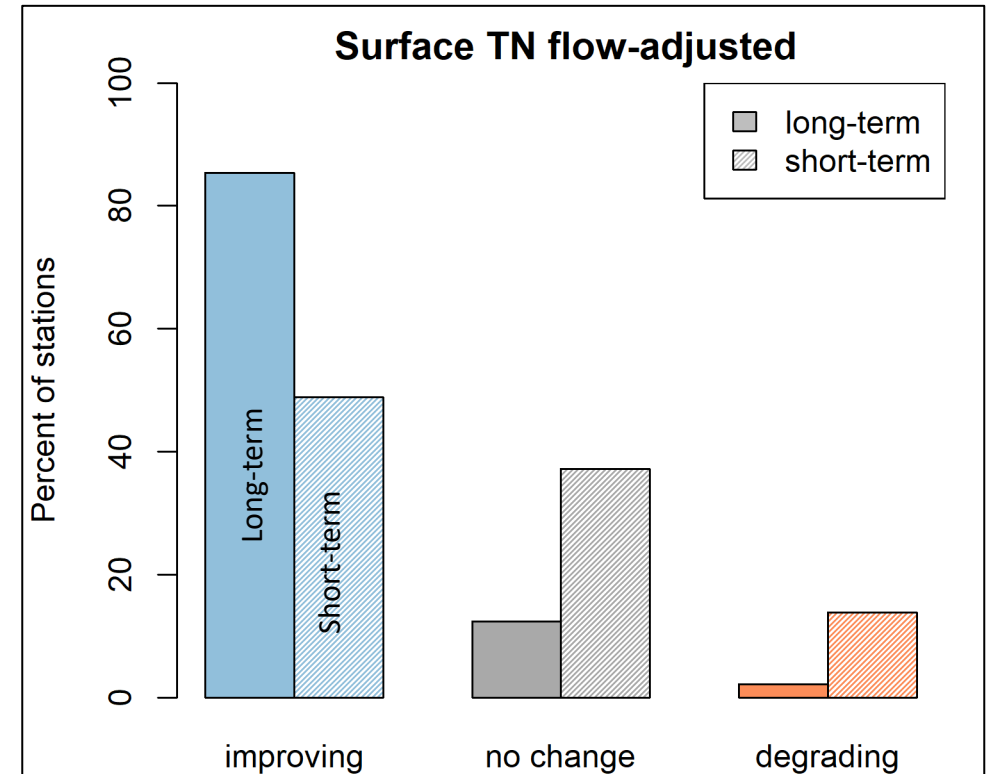


Flow-adjusted



TN summary

- Long-term trends decreasing at majority of stations (bottom is similar).
- Short-term trends are more mixed.



TP

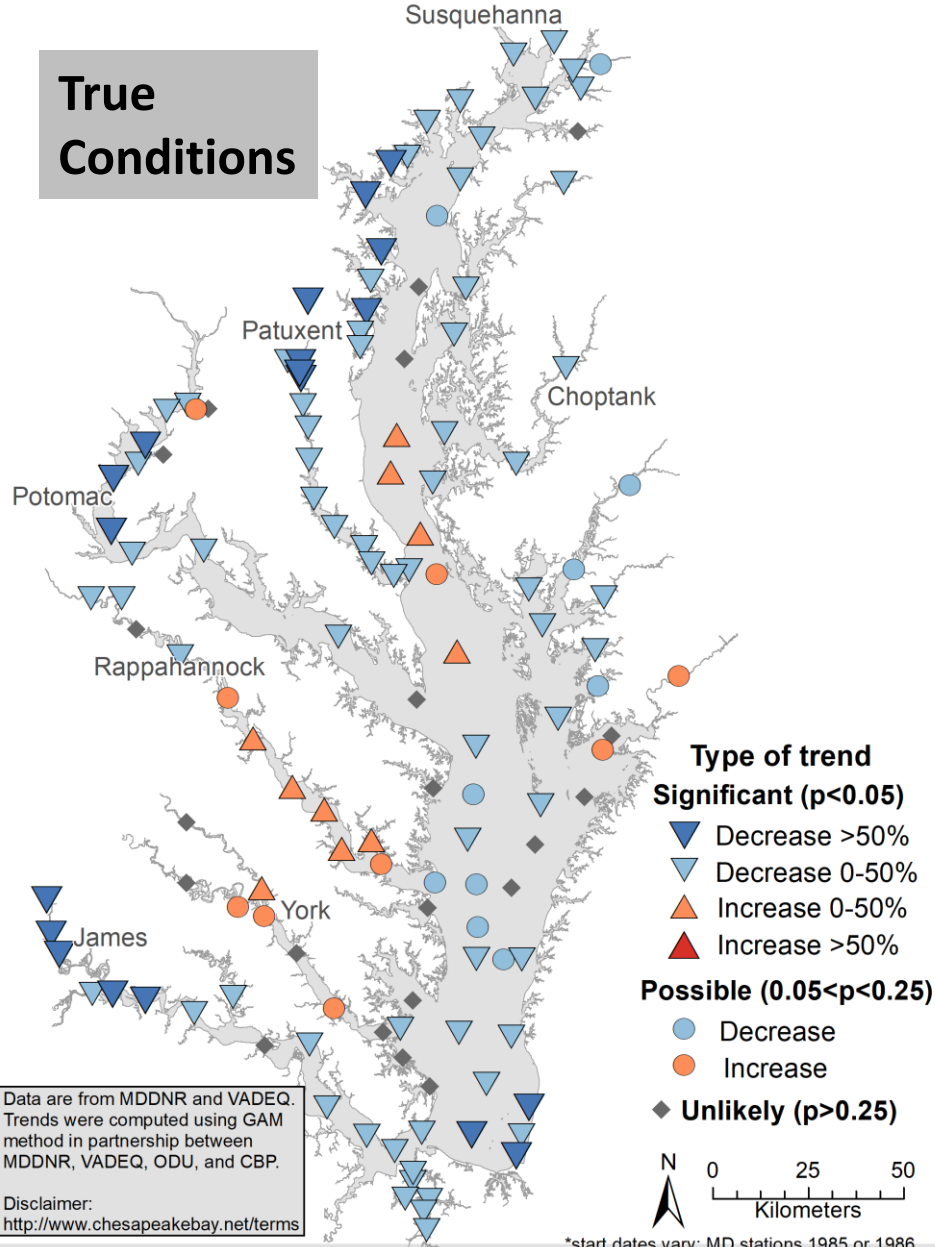
Surface

Long-term

Chesapeake Bay Surface Total Phosphorus: 2020 long-term change*



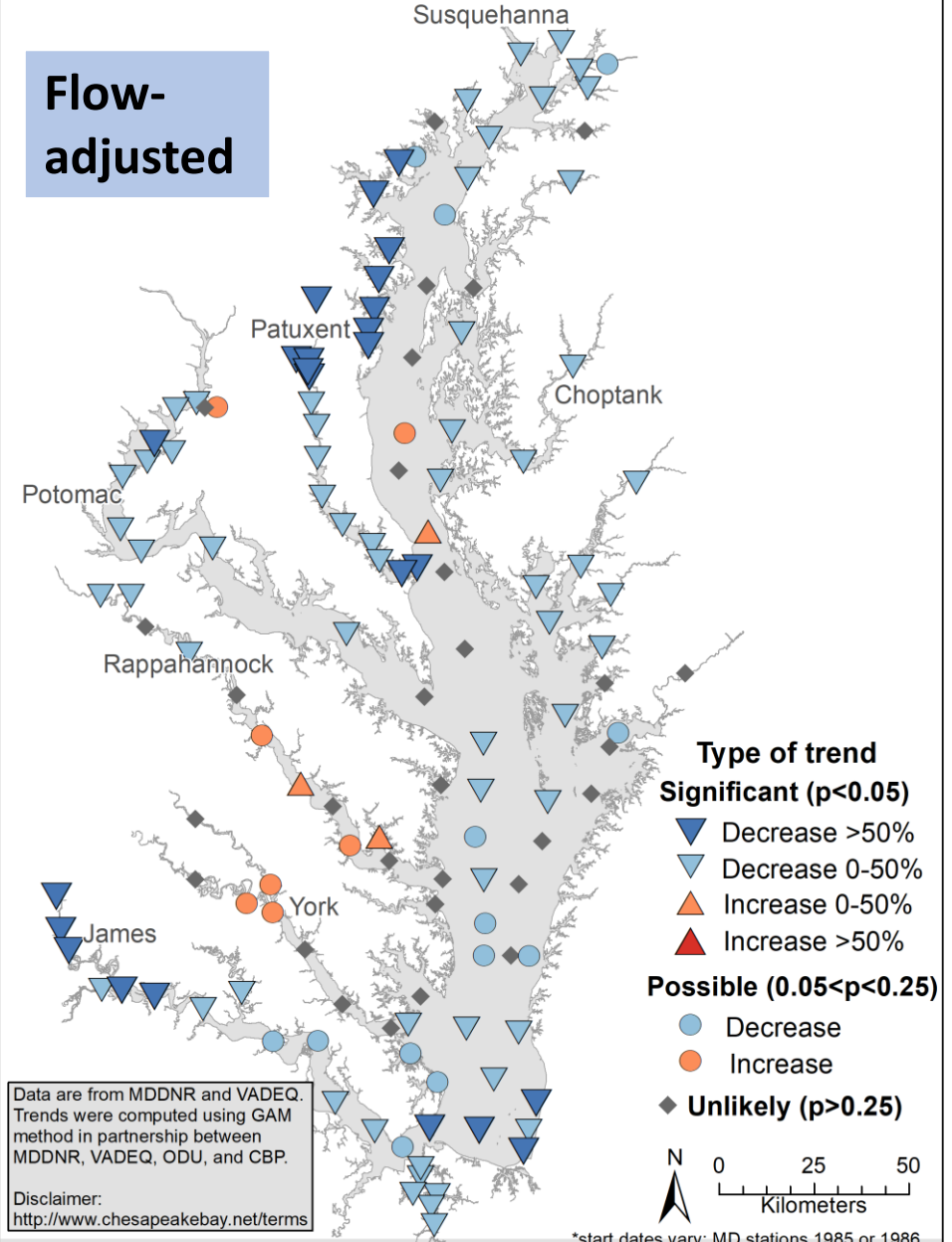
**True
Conditions**



Chesapeake Bay Surface Total Phosphorus: 2020 flow-adjusted long-term change*



**Flow-
adjusted**



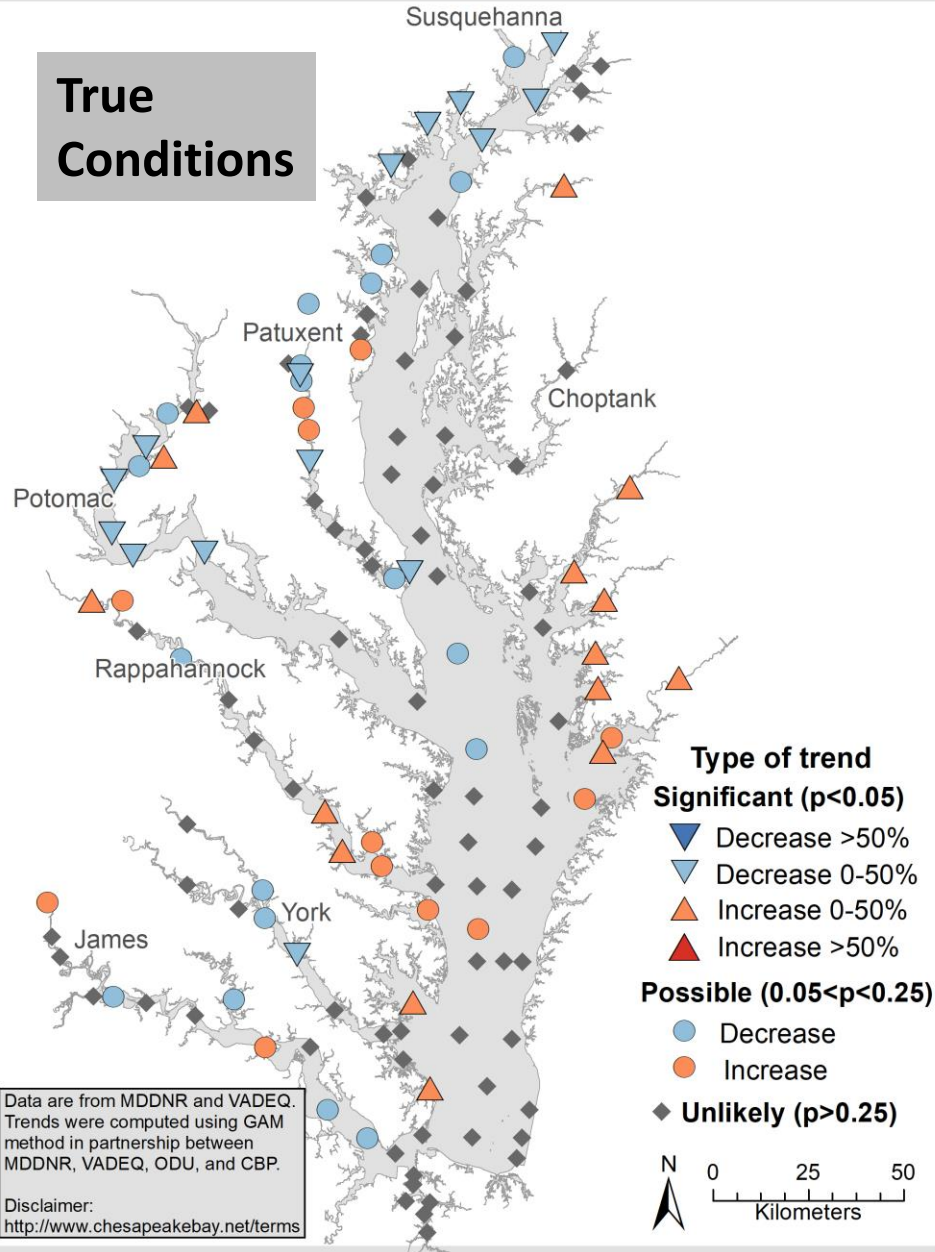
TP

Surface
Short-term

Chesapeake Bay Surface Total Phosphorus: 2011-2020 change



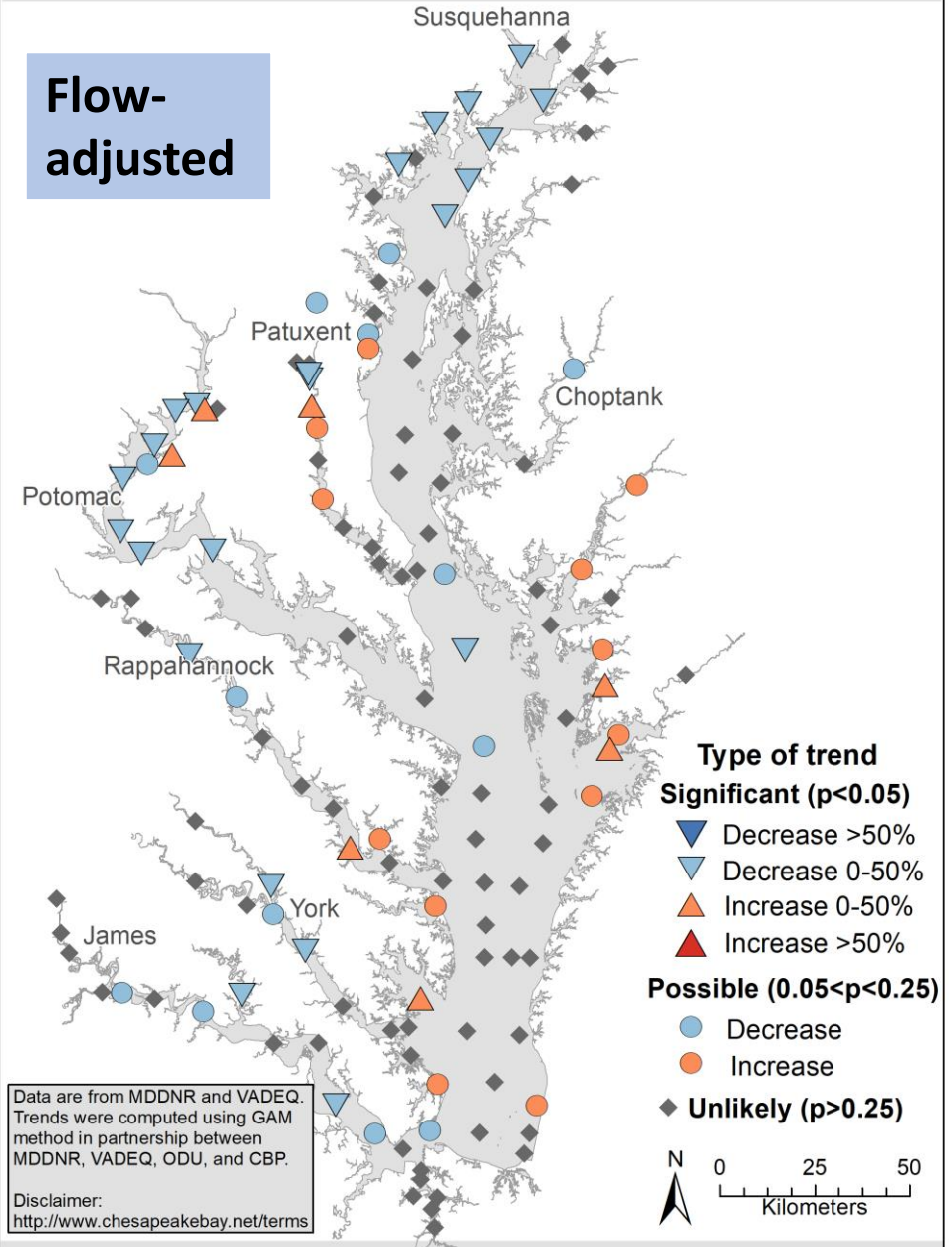
True
Conditions



Chesapeake Bay Surface Total Phosphorus: 2011-2020 flow-adjusted change

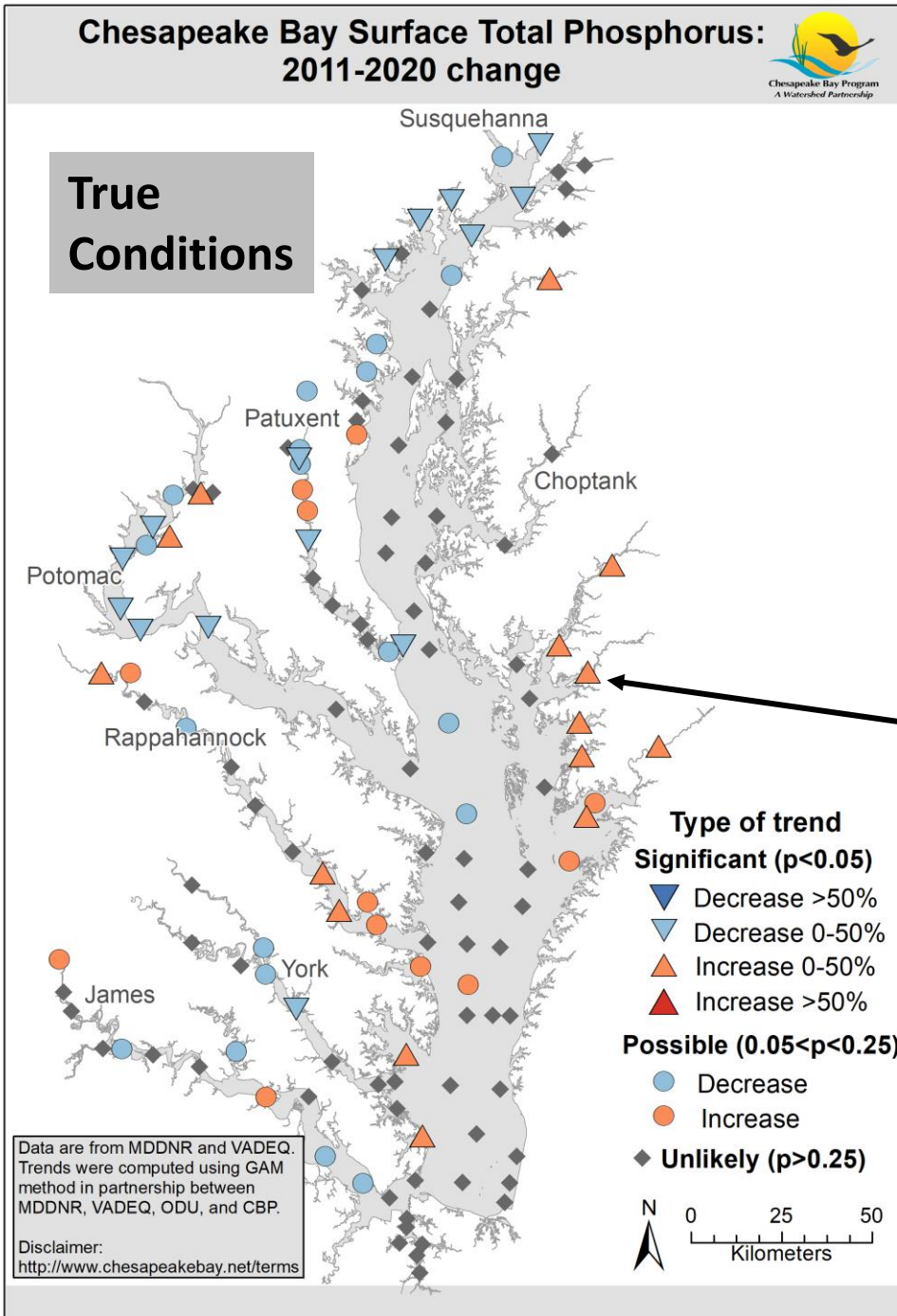


Flow-
adjusted

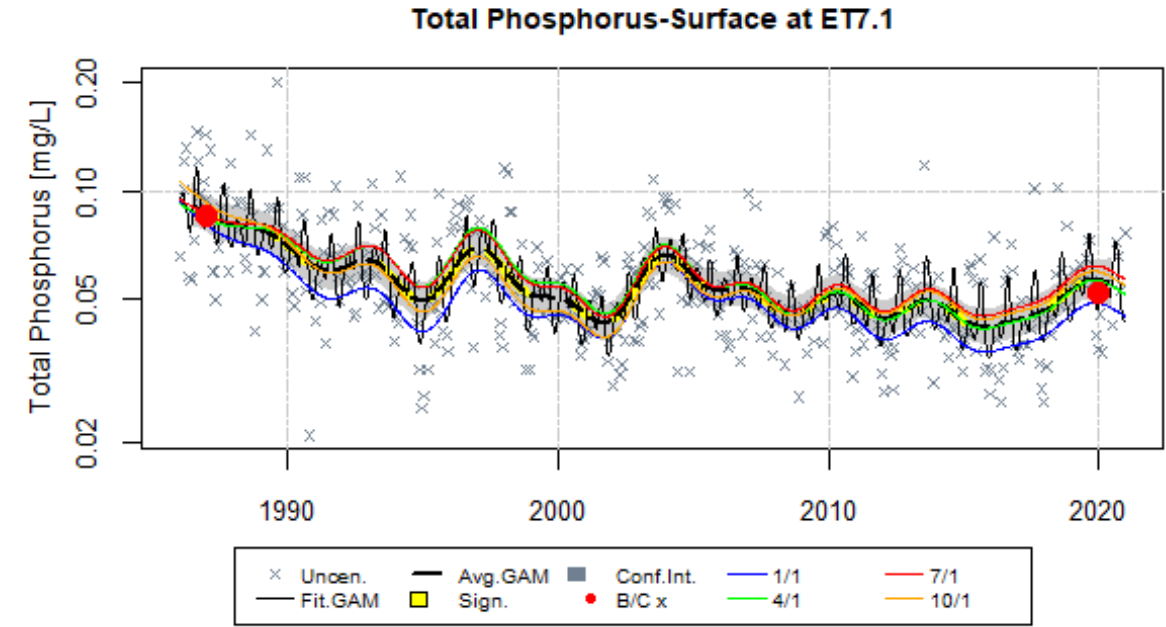


TP

Surface Example

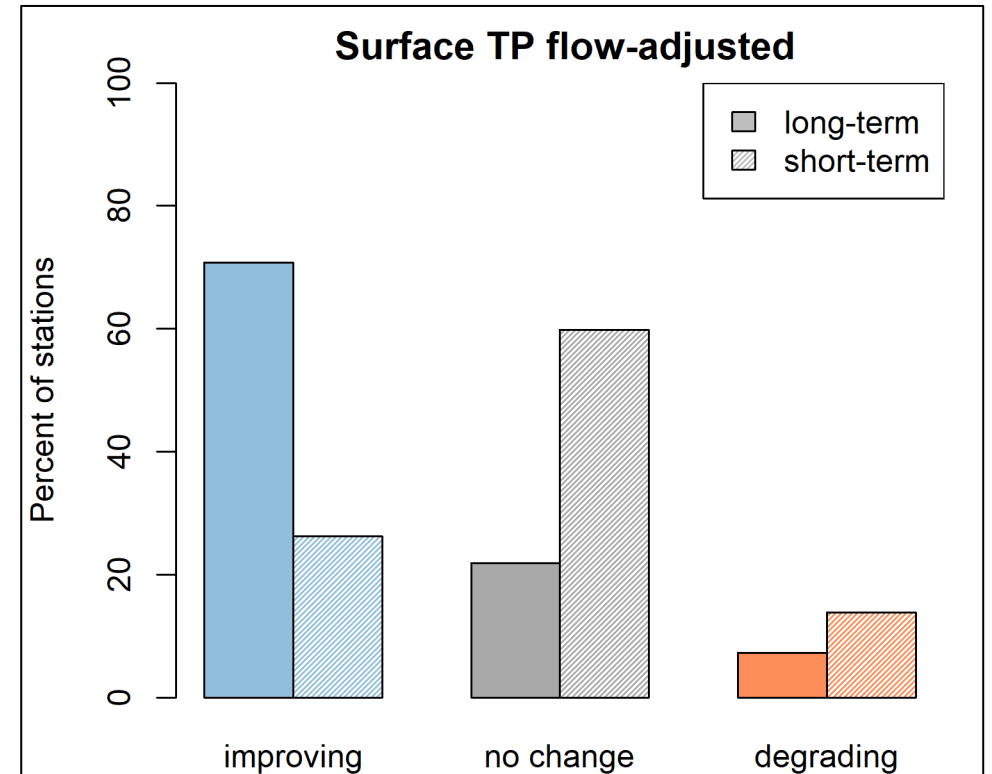


Example: Long-term decrease due to reductions at the beginning of the record, and either plateau or some slight increases in the short-term.



TP summary

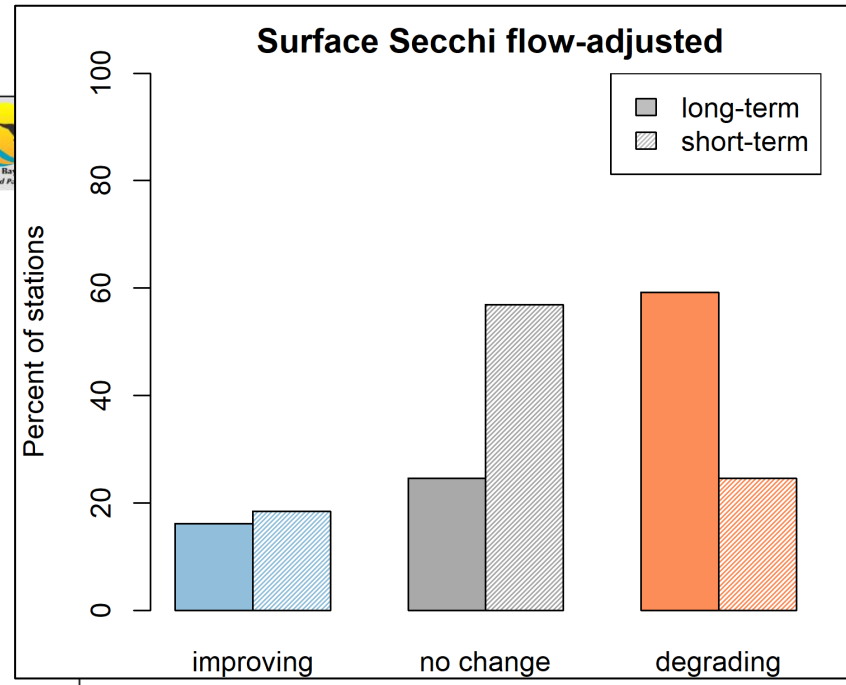
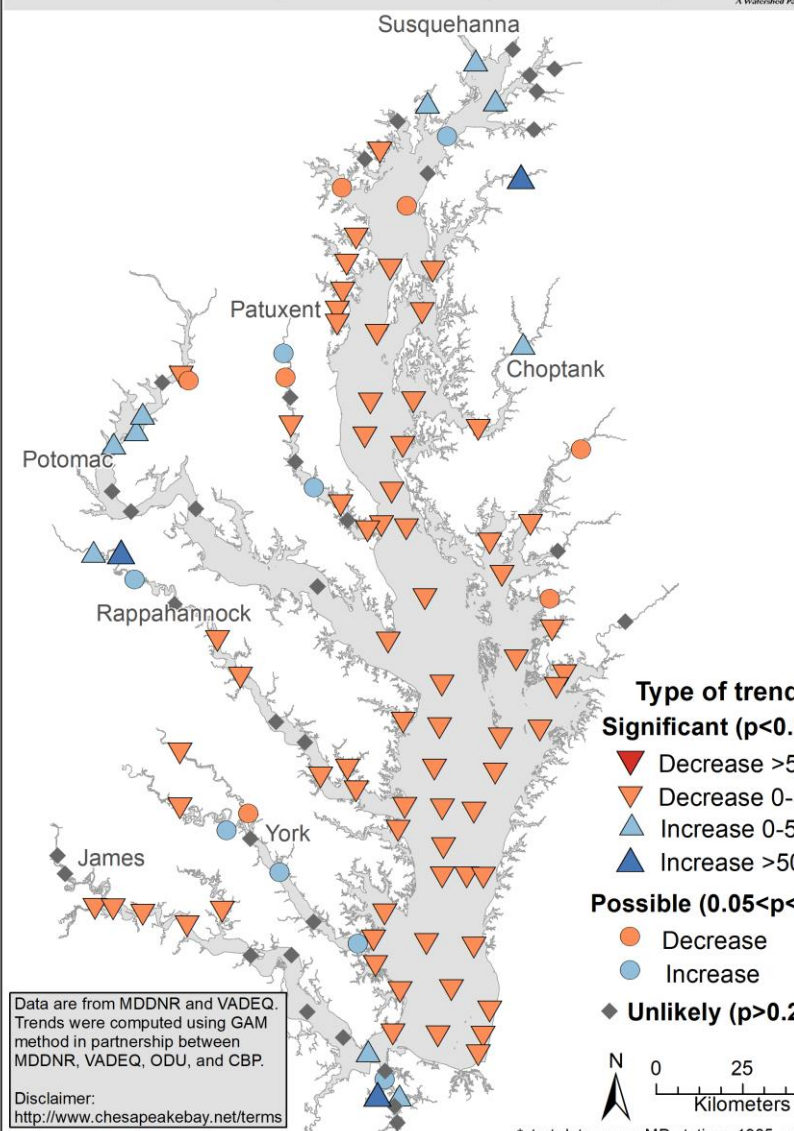
- Long-term trends decreasing at majority of stations (bottom is similar).
- Short-term improvements reduced by more than half, with many more regions showing “no change” over the short-term



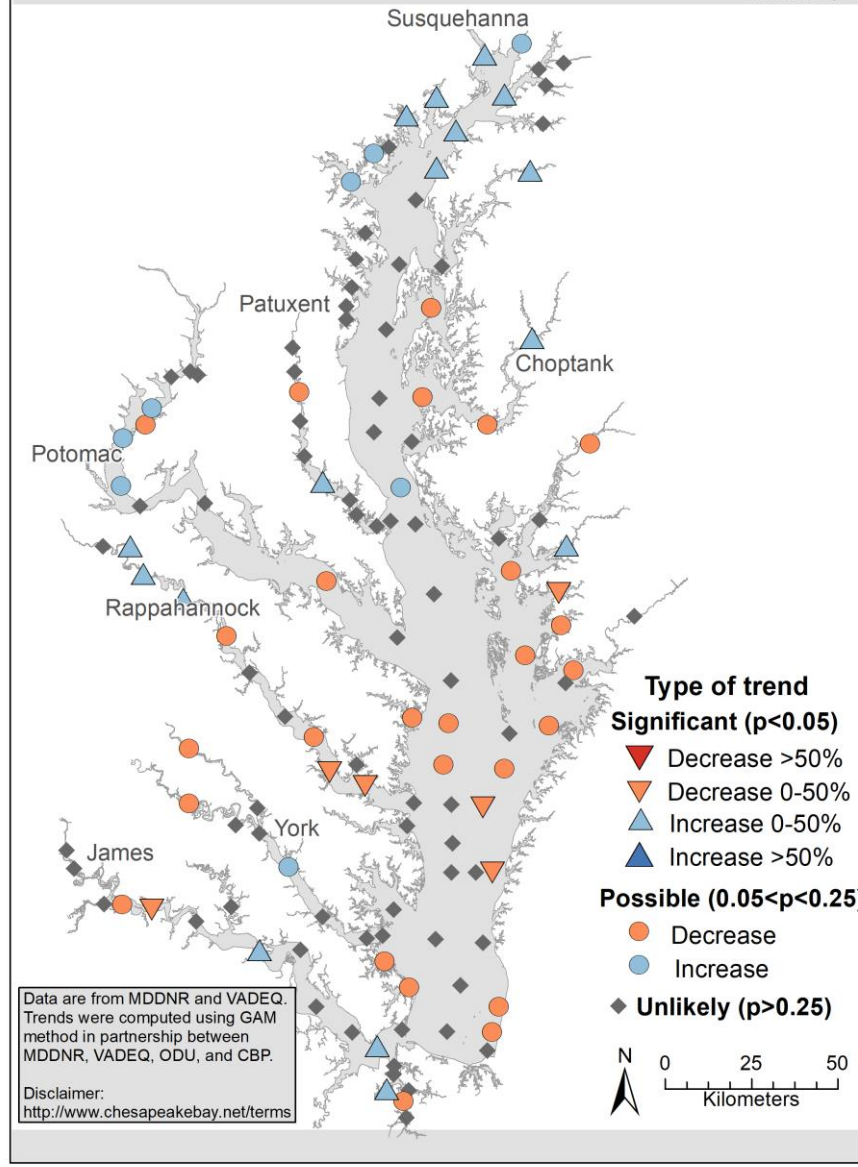
Secchi depth



Chesapeake Bay Secchi depth: 2020 long-term flow-adjusted change*



Chesapeake Bay Secchi depth: 2011-2020 flow-adjusted change



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

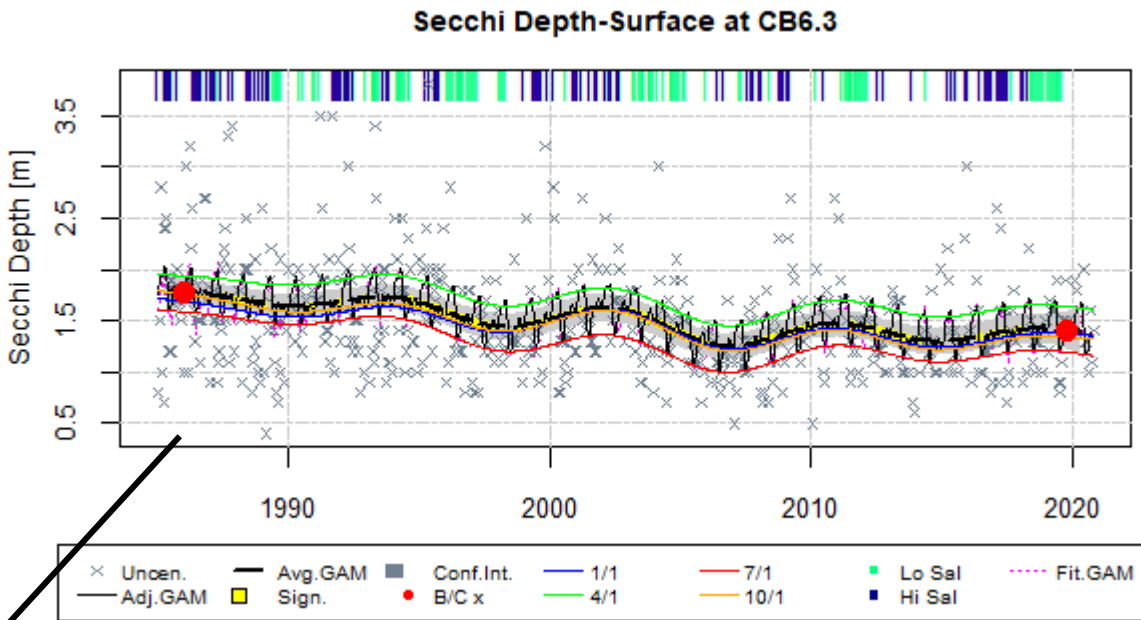
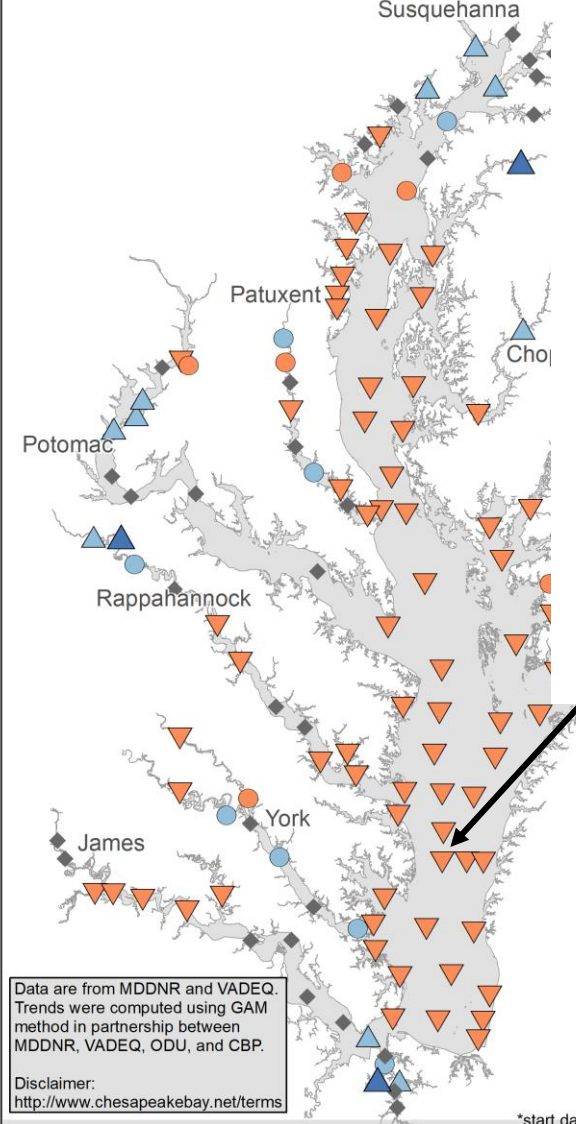
Secchi depth

Example: Long-term degradations have leveled off (or changed direction) over short-term.

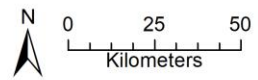
Chesapeake Bay Secchi depth: 2011-2020 flow-adjusted change



Chesapeake Bay Secchi depth: 2020 long-term flow-adjusted change*

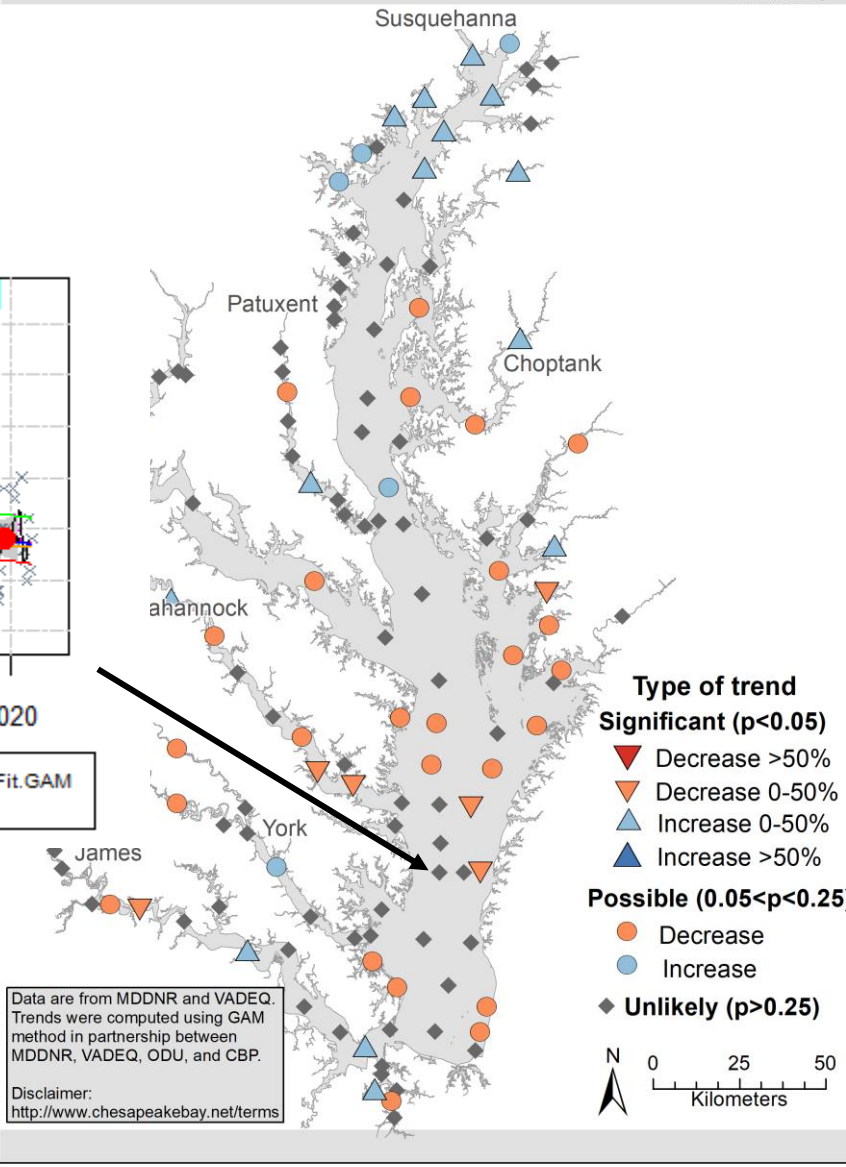


- Significant ($p < 0.05$)**
- ▼ Decrease >50%
 - ▽ Decrease 0-50%
 - ▲ Increase 0-50%
 - ▲ Increase >50%
- Possible ($0.05 < p < 0.25$)**
- Decrease
 - Increase
- Unlikely ($p > 0.25$)**
- ◆ Unlikely ($p > 0.25$)



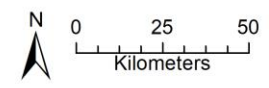
Data are from MDDNR and VADEQ. Trends were computed using GAM method in partnership between MDDNR, VADEQ, ODU, and CBP.
Disclaimer: <http://www.chesapeakebay.net/terms>

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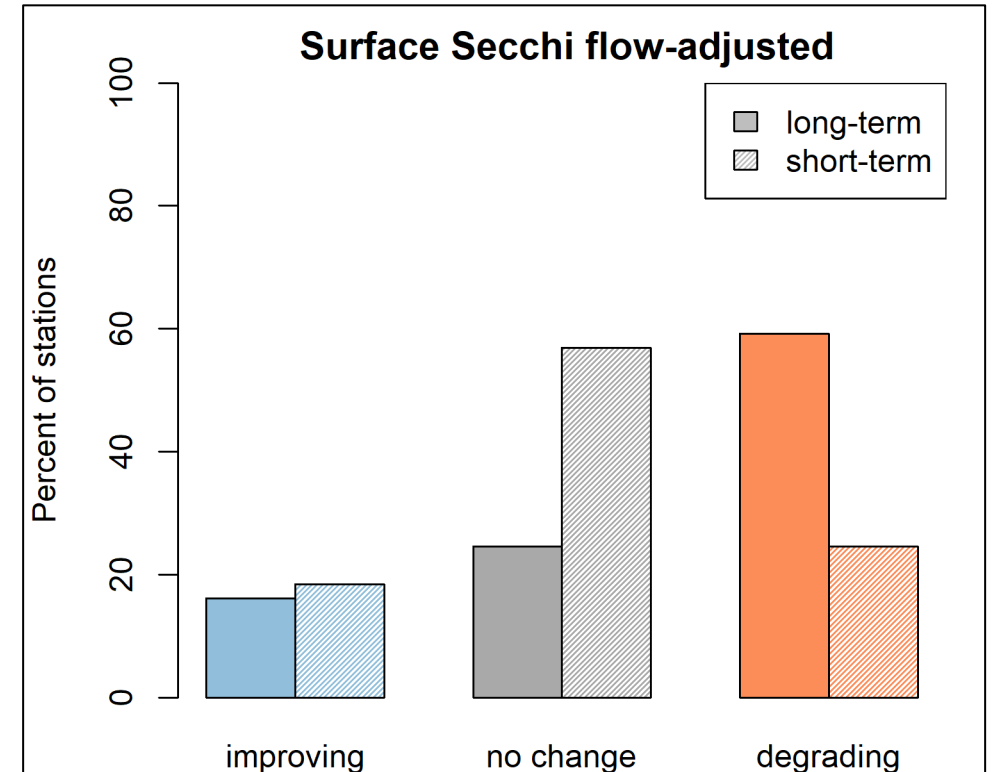
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- Type of trend**
- Significant ($p < 0.05$)**
- ▼ Decrease >50%
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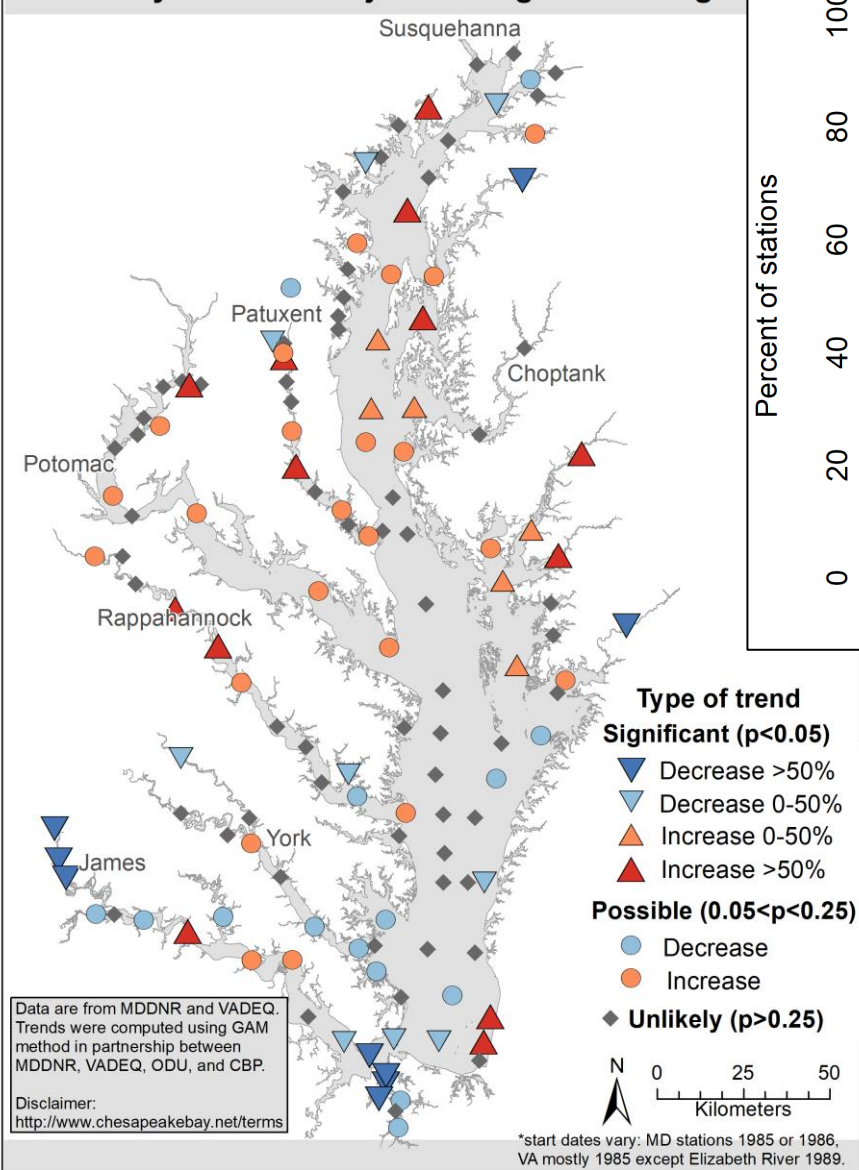
Secchi depth summary

- 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.

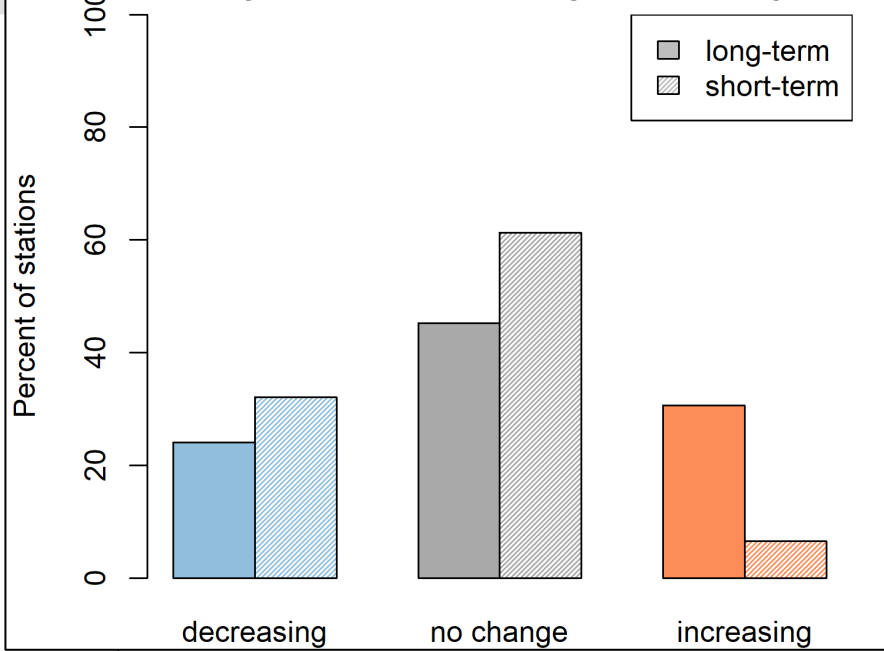


Spring Surface Chlorophyll *a*

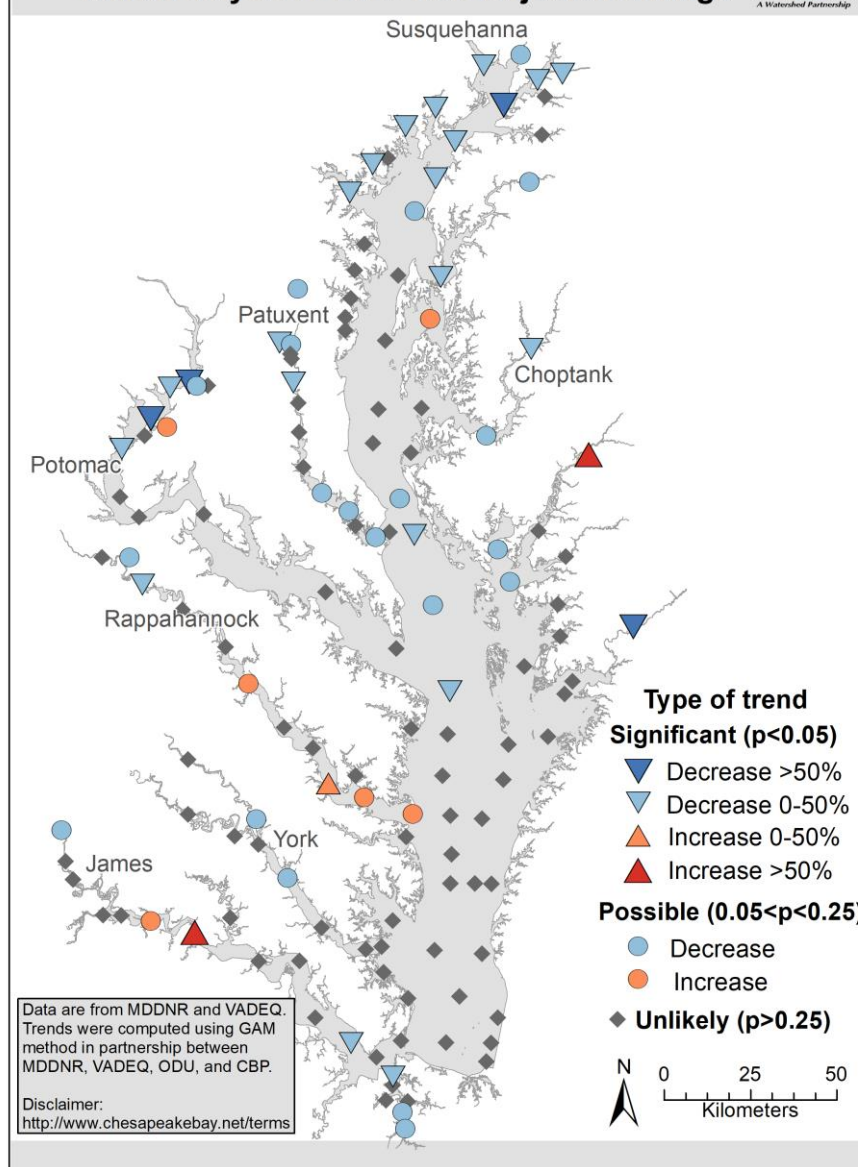
Chesapeake Bay Surface Chlorophyll *a*:
March-May 2020 flow-adjusted long-term change*



Mar-May Surface Chlorophyll-*a* flow-adjusted



Chesapeake Bay Surface Chlorophyll *a*:
March-May 2011-2020 flow-adjusted change

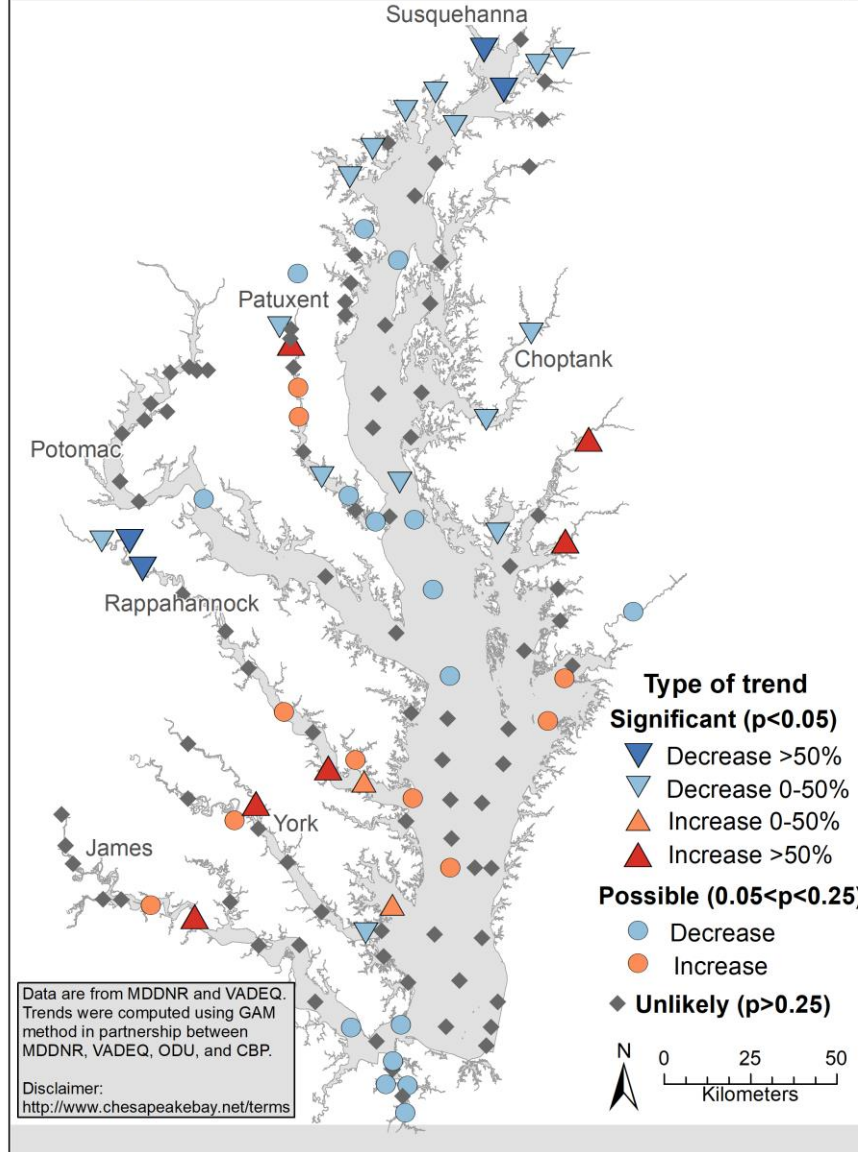
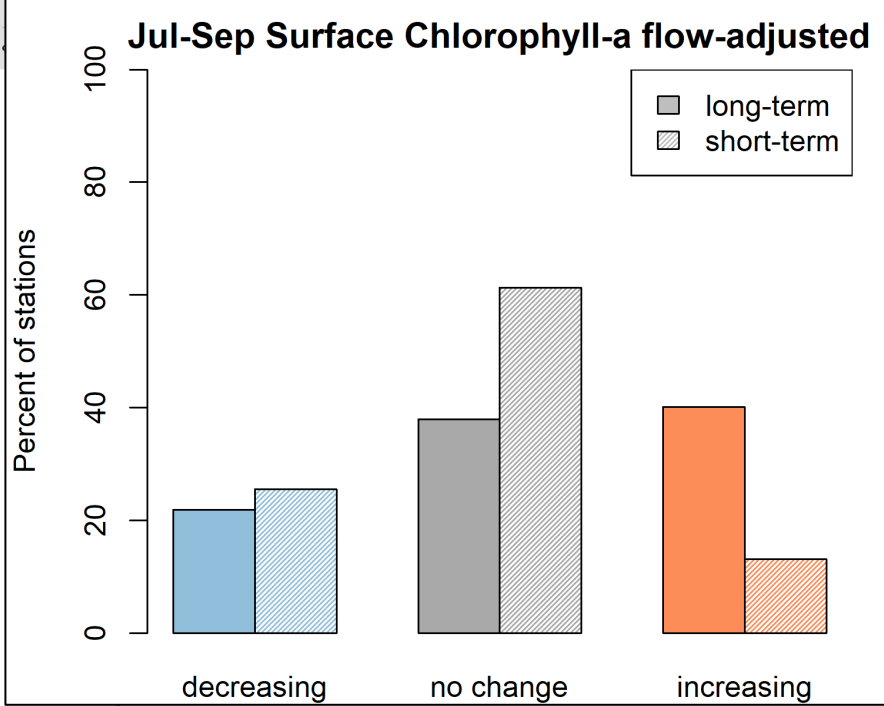
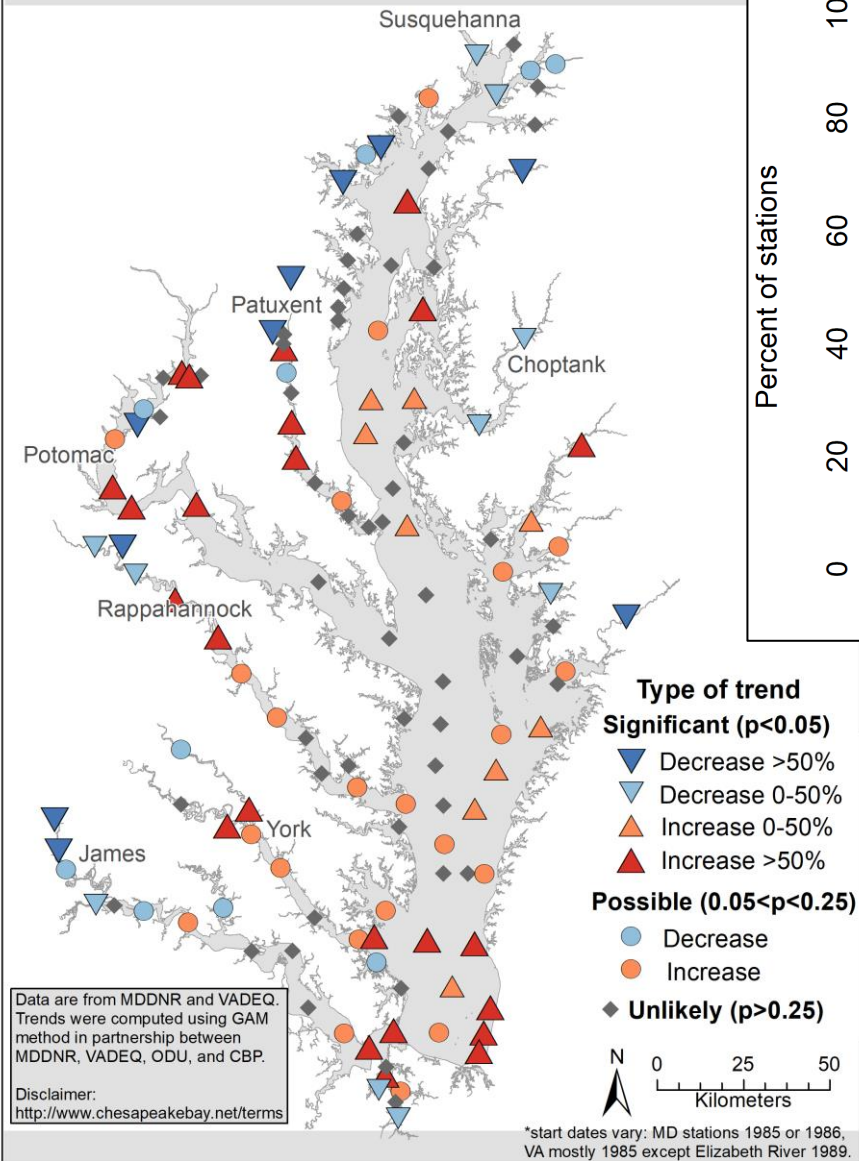


Summer Surface Chlorophyll *a*



Chesapeake Bay Surface Chlorophyll *a*: July-Sept 2011-2020 flow-adjusted change

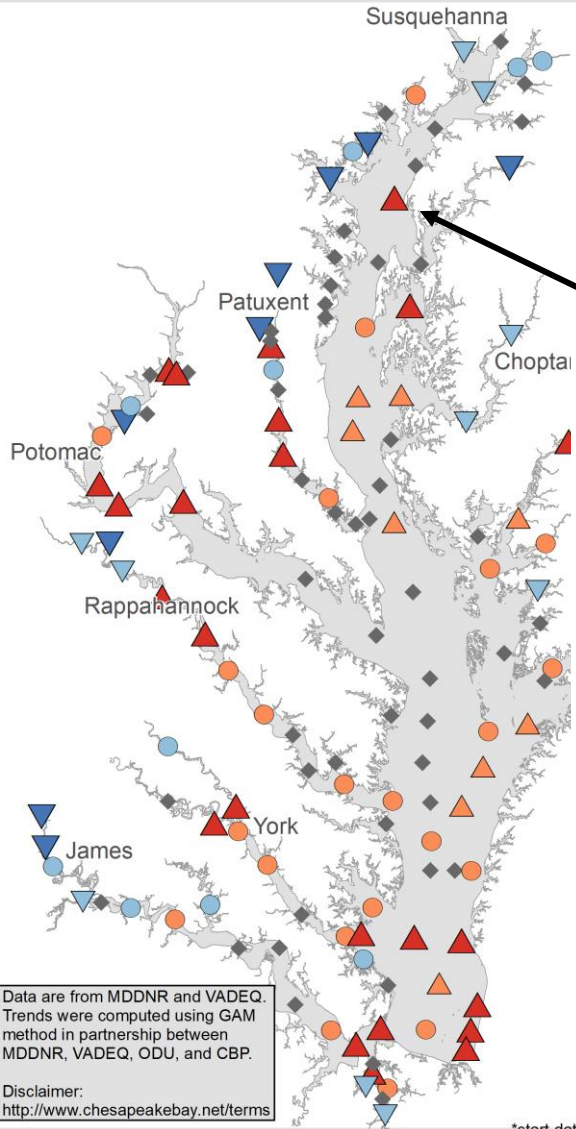
Chesapeake Bay Surface Chlorophyll *a*: July-Sept 2020 long-term flow-adjusted change*



Summer Surface Chlorophyll *a*



Chesapeake Bay Surface Chlorophyll *a*: July-Sept 2020 long-term flow-adjusted change*



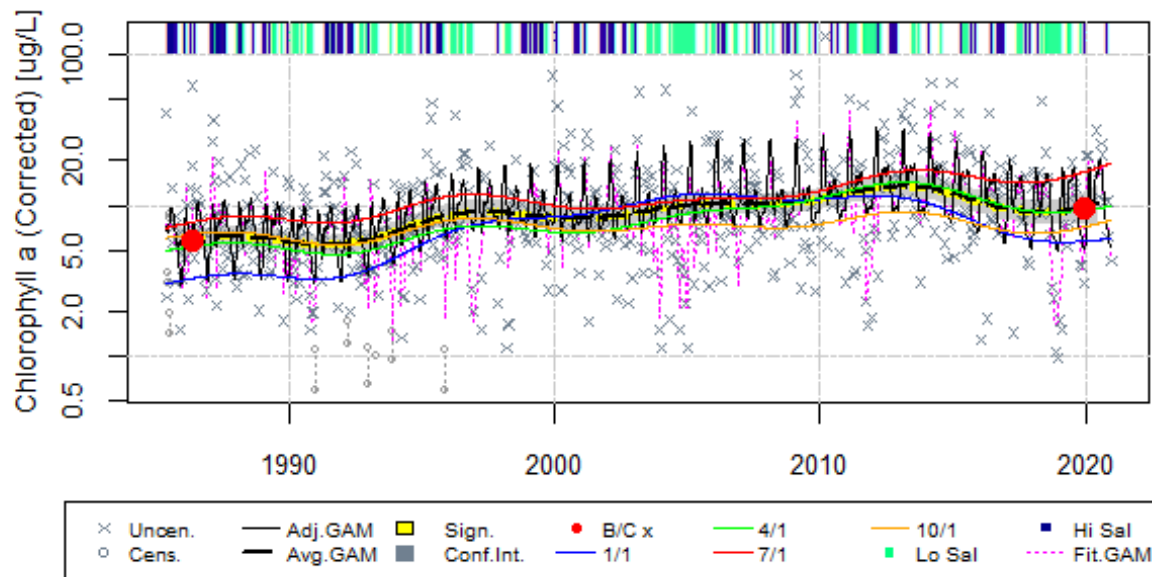
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Example: Long-term degradations have leveled off (or changed direction) over short-term.

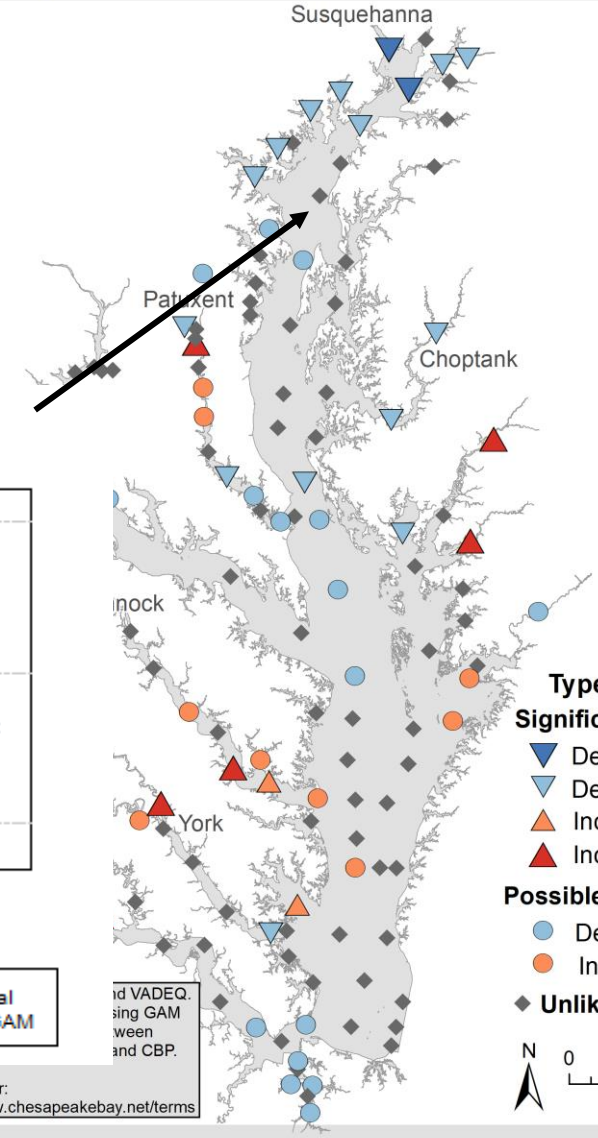
Chlorophyll *a* (Corrected)-Surface & Above Pycnocline at CB3.2



× Uncen. — Adj.GAM ■ Sign. ● B/C x — 4/1 — 10/1 ■ Hi Sal
 ○ Cens. — Avg.GAM ■ Conf.Int. — 1/1 — 7/1 ■ Lo Sal ■ Fit.GAM

● Increase
 ◆ Unlikely ($p > 0.25$)

Chesapeake Bay Surface Chlorophyll *a*: July-Sept 2011-2020 flow-adjusted change



Type of trend

Significant ($p < 0.05$)

- ▼ Decrease >50%
- ▽ Decrease 0-50%
- ▲ Increase 0-50%
- ▲ Increase >50%

Possible ($0.05 < p < 0.25$)

- Decrease
- Increase

◆ Unlikely ($p > 0.25$)

and VADEQ using GAM between and CBP.

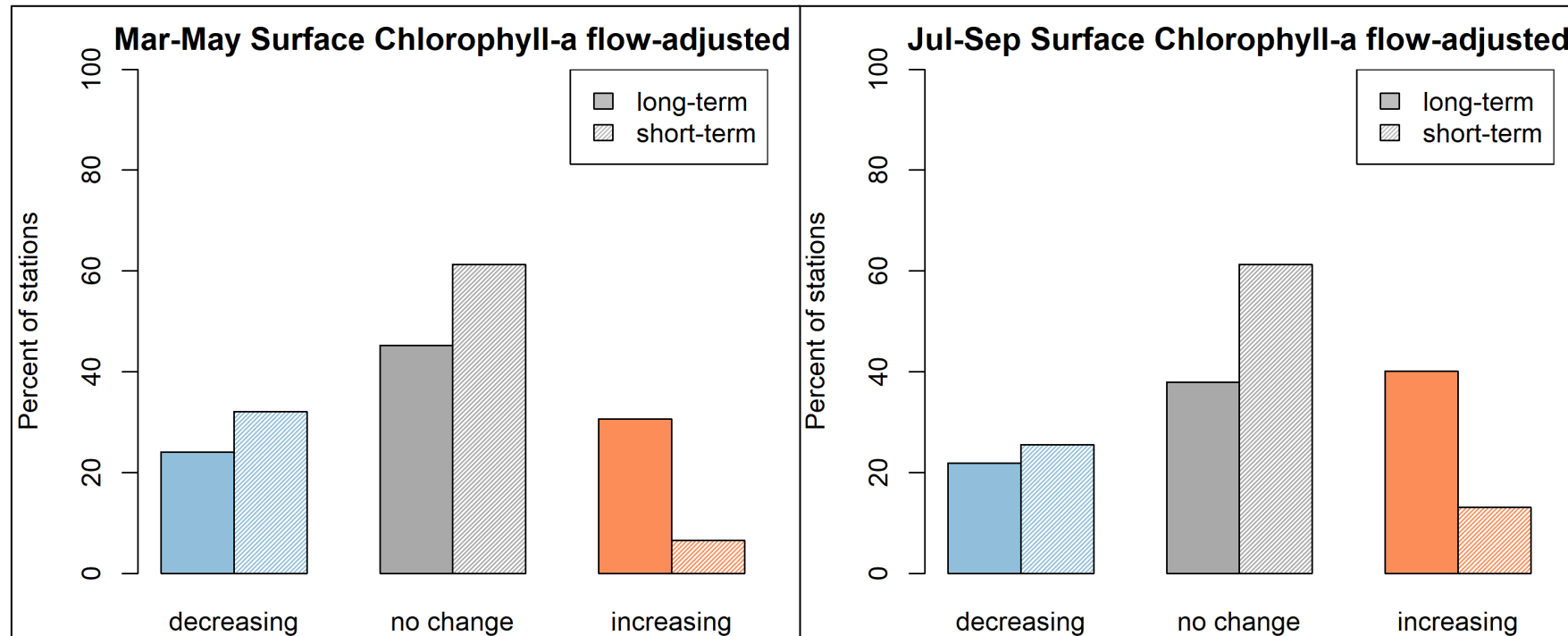
Disclaimer: <http://www.chesapeakebay.net/terms>

N
 0 25 50
 Kilometers

Many degradations have leveled off

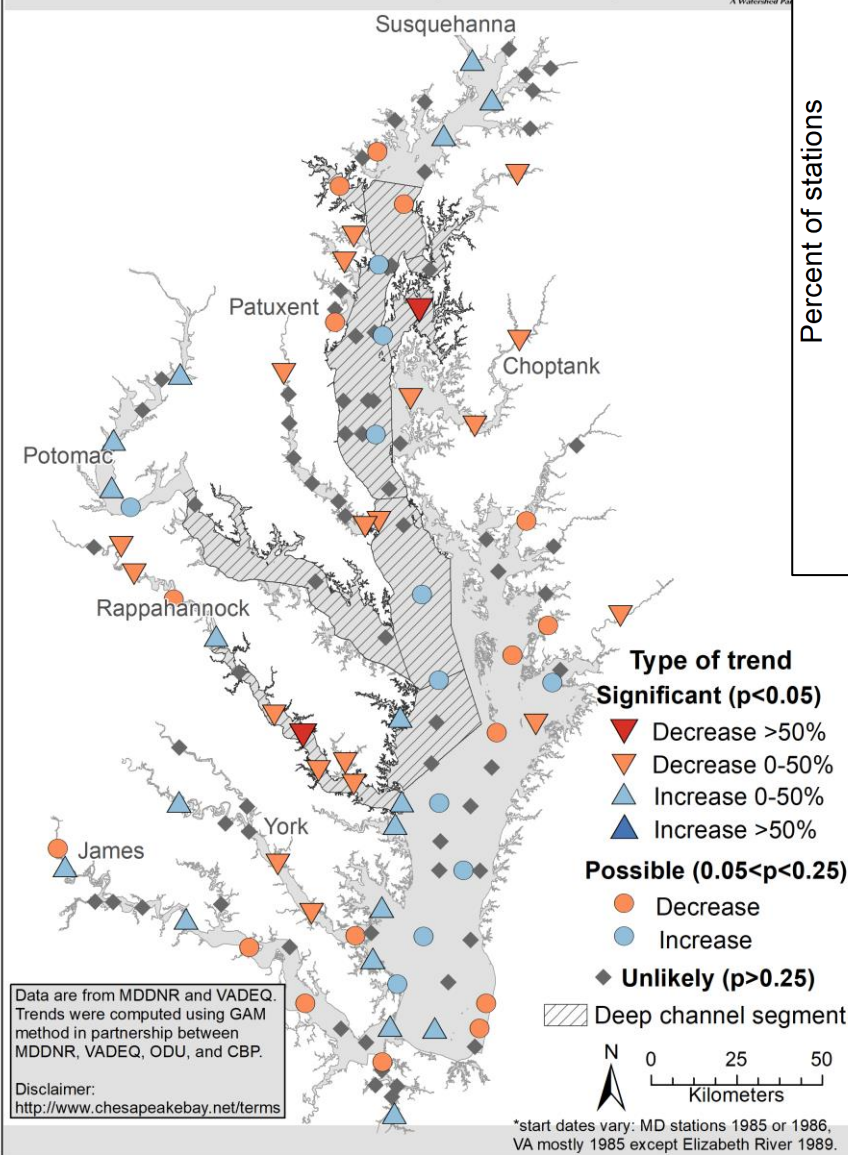
Chlorophyll *a* summary

- In both seasons, conditions have improved from the long- to short-term.

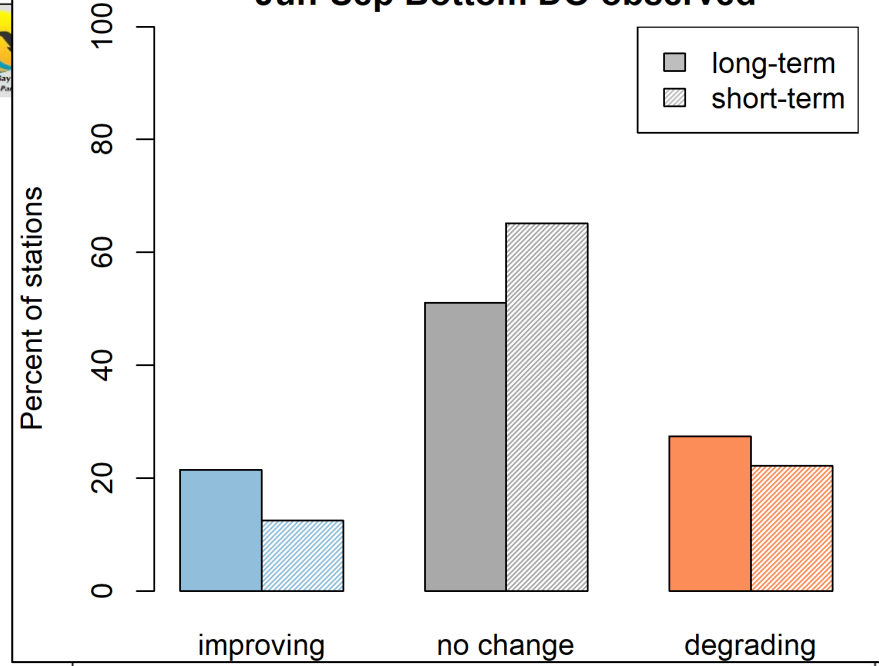


Bottom Summer DO

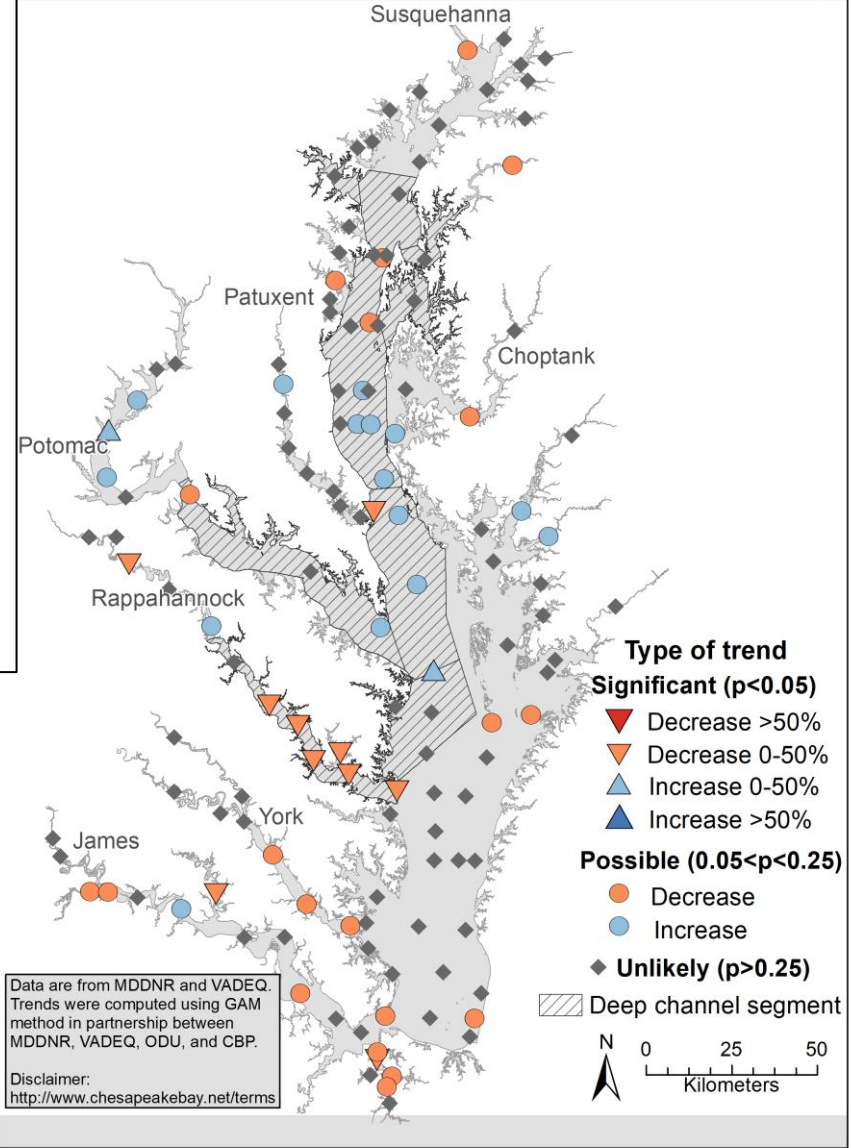
Chesapeake Bay Bottom Dissolved Oxygen: June-Sept 2020 long-term change*



Jun-Sep Bottom DO observed



Chesapeake Bay Bottom Dissolved Oxygen: June-Sept 2011-2020 change

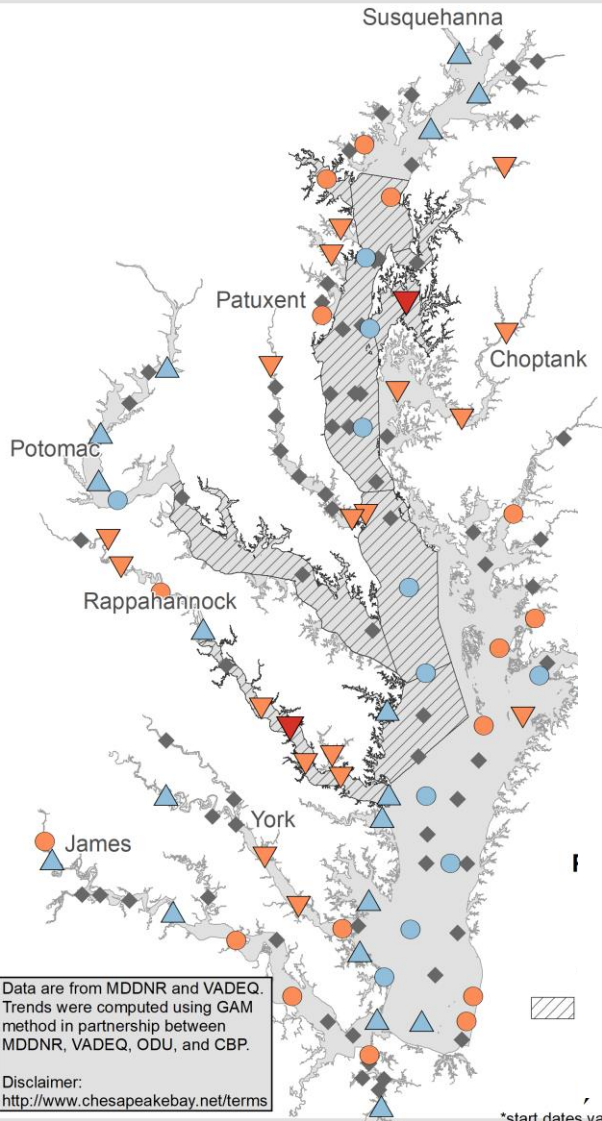


Bottom Summer DO

Chesapeake Bay Bottom Dissolved Oxygen:
June-Sept 2011-2020 change



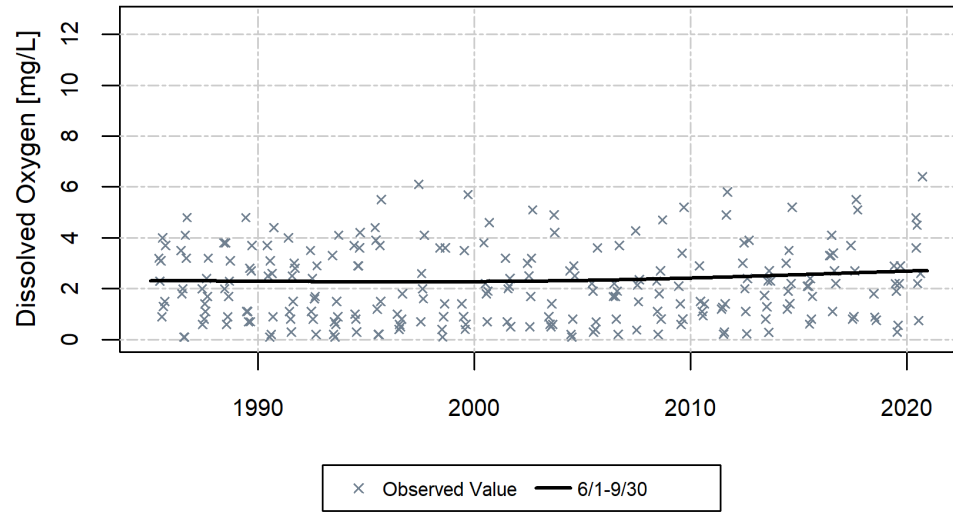
Chesapeake Bay Bottom Dissolved Oxygen June-Sept 2020 long-term change*



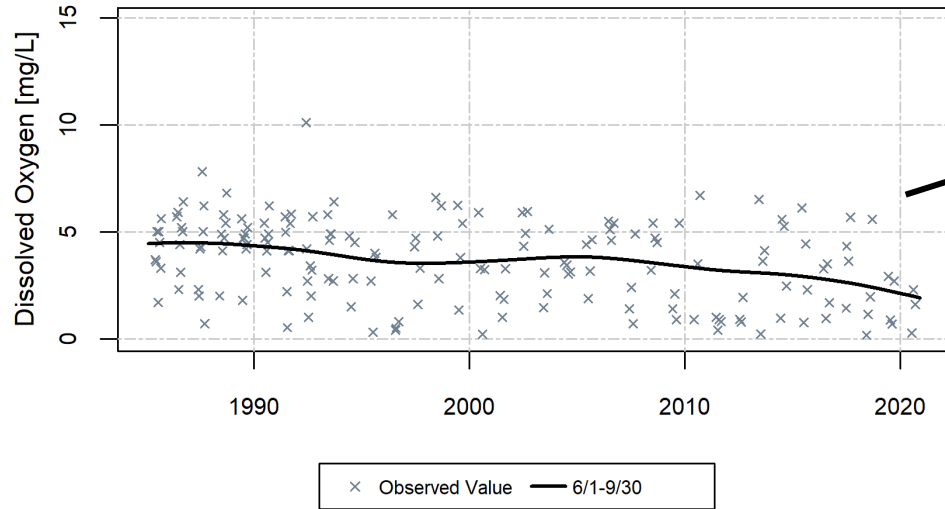
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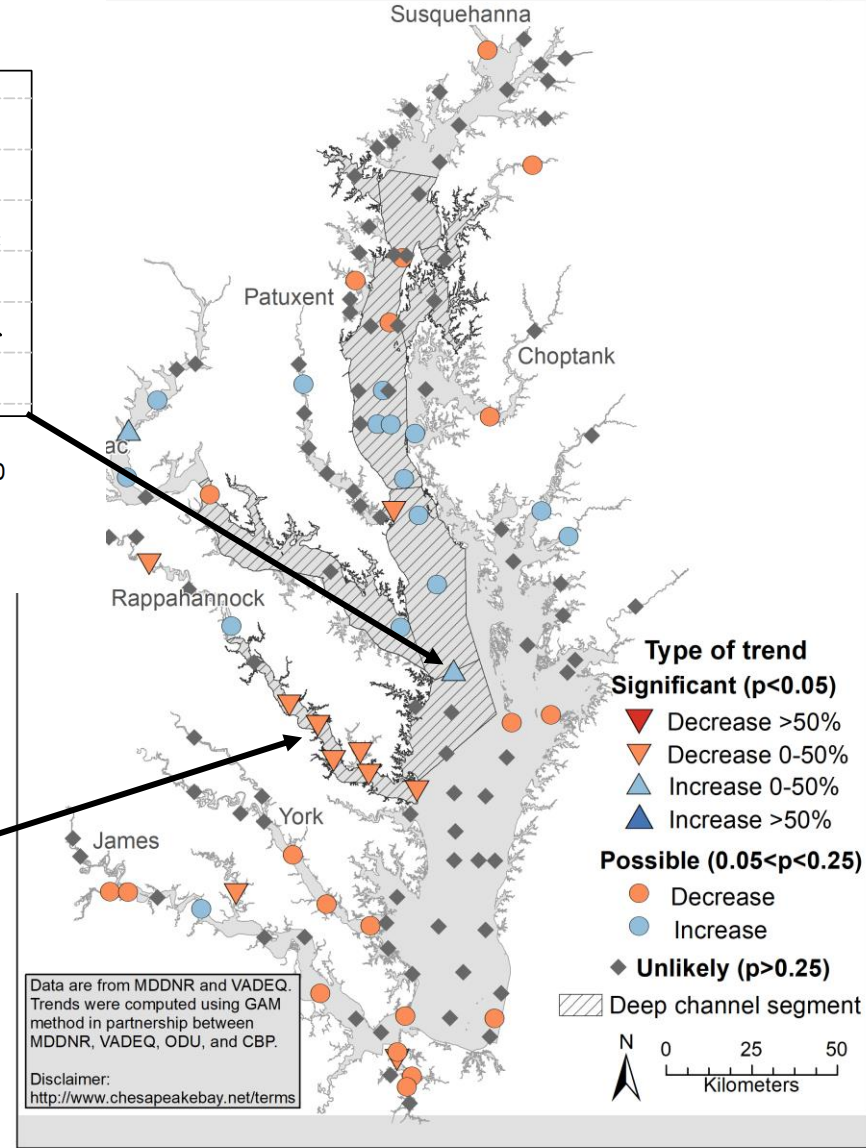
Dissolved Oxygen-Bottom from June to Sept at CB5.3



Dissolved Oxygen-Bottom from June to Sept at LE3.1



Data are from MDDNR and VADEQ. Trends were computed using GAM method in partnership between MDDNR, VADEQ, ODU, and CBP.
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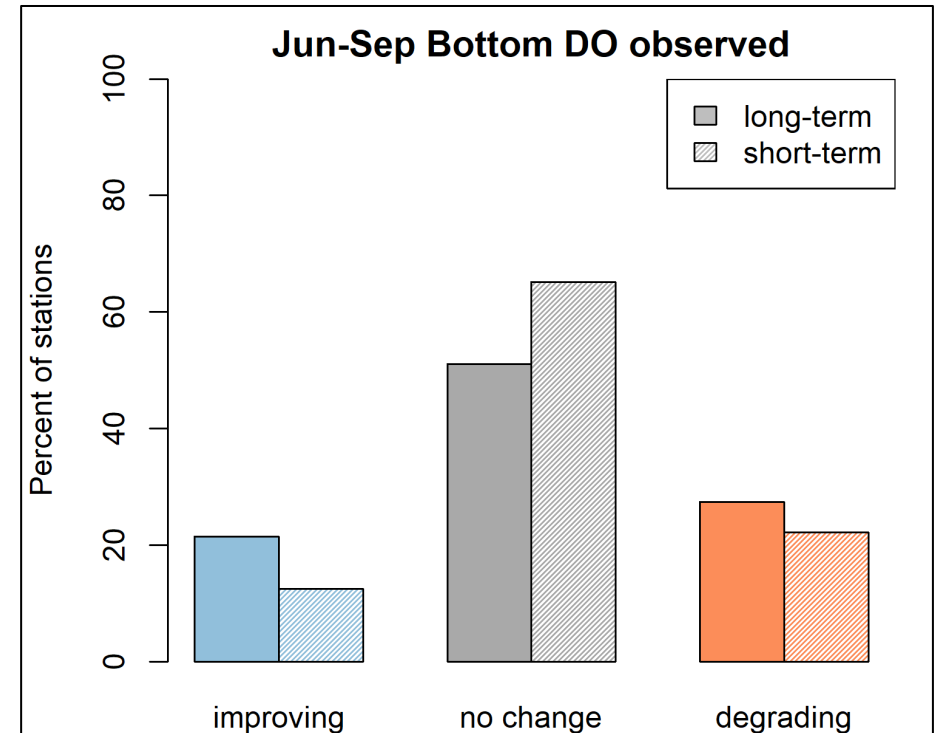


Type of trend
Significant ($p < 0.05$)
 ▼ Decrease >50%
 ▽ Decrease 0-50%
 ▲ Increase 0-50%
 ▲ Increase >50%
Possible ($0.05 < p < 0.25$)
 ○ Decrease
 ○ Increase
Unlikely ($p > 0.25$)
 ◆
 ▨ Deep channel segment

0 25 50
Kilometers

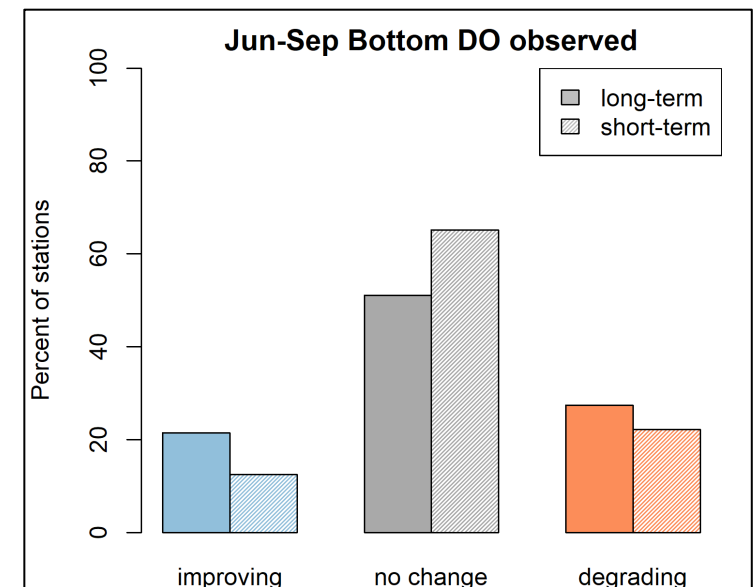
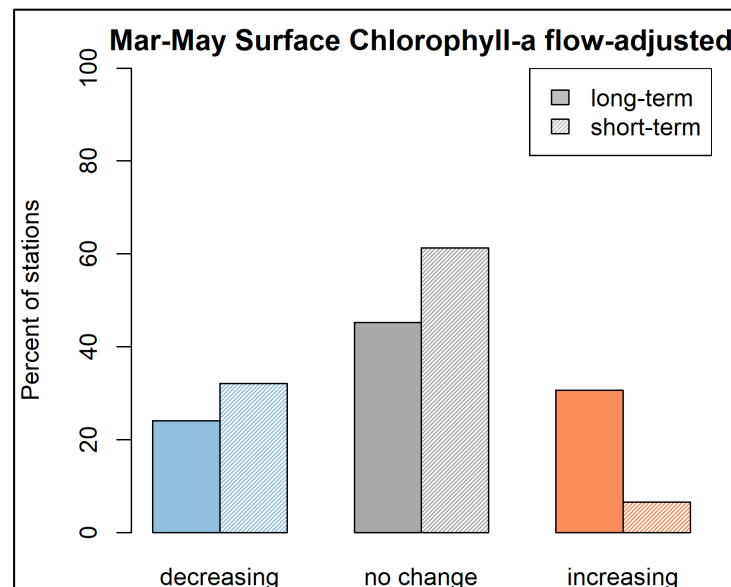
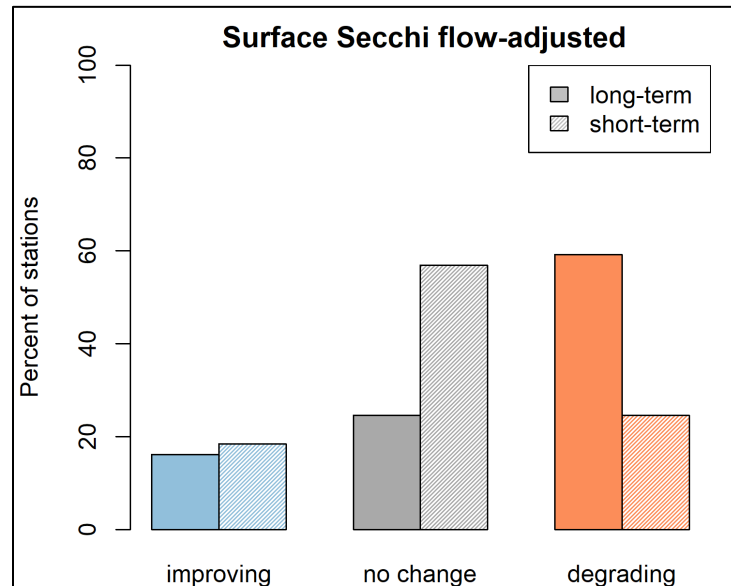
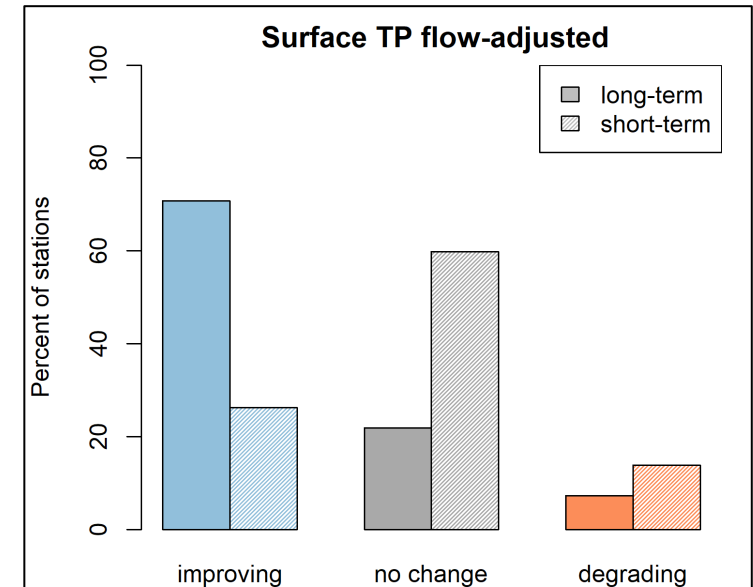
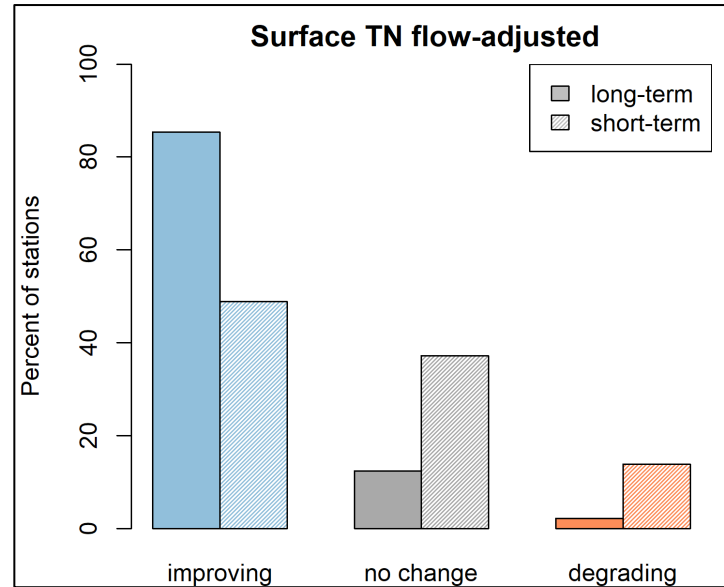
Dissolved oxygen summary

- Changes are gradual – but mainstem deep DO is improving.
- Overall baywide there are still more degradations than improvements.



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.



Accessing 2020 Tidal Trends

- ITAT webpage
 - 2020 maps are available (thanks, Alex!).
 - https://www.chesapeakebay.net/who/group/integrated_trends_analysis_team



Soon to come:

- Baytrendsmap via CAST
 - Will get a combination results file uploaded to baytrendsmap website for users to interact with on their own.
 - <https://cast.chesapeakebay.net/TrendsOverTime>
- Chesapeake Bay Watershed Data Dashboard (Beta)
 - Includes maps and static graphs of simplified results.
 - <https://gis.chesapeakebay.net/wip/dashboard/>

Integrated Trends Analysis Team | x +

chesapeakebay.net/who/group/integrated_trends_analysis_team

Chesapeake Bay Program
Science. Restoration. Partnership.

Discover the Chesapeake | Learn the Issues | State of the Chesapeake

Projects and Resources

Maps of 2020 Tidal Water Quality Change

1. Long-Term Change

- Surface Total Nitrogen, Annual 1985-2020 (462.47 KB)
- Surface Total Phosphorus, Annual 1985-2020 (470.11 KB)
- Surface Chlorophyll-a, Spring 1985-2020 (466.4 KB)
- Surface Chlorophyll-a, Summer 1985-2020 (488.69 KB)
- Secchi Depth, Annual 1985-2020 (449.67 KB)
- Surface Total Suspended Solids, Annual 1999-2020 (444.54 KB)
- Surface Water Temperature, Annual 1985-2020 (482.07 KB)
- Bottom Dissolved Oxygen, Summer 1985-2020 (467.25 KB)

2. Long-Term Flow-Adjusted Change

- Surface Total Nitrogen, Flow-Adjusted, Annual 1985-2020 (464.53 KB)
- Surface Total Phosphorus, Flow-Adjusted, Annual 1985-2020 (463.86 KB)
- Surface Chlorophyll-a, Flow-Adjusted, Spring 1985-2020 (453.73 KB)
- Surface Chlorophyll-a, Flow-Adjusted, Summer 1985-2020 (464.17 KB)
- Secchi Depth, Flow-Adjusted, Annual 1985-2020 (452.02 KB)
- Surface Total Suspended Solids, Flow-Adjusted, Annual 1999-2020 (442.16 KB)
- Surface Water Temperature, Flow-Adjusted, Annual 1985-2020 (485.2 KB)
- Bottom Dissolved Oxygen, Flow-Adjusted, Summer 1985-2020 (476.98 KB)

