Summary of 2019 tidal water quality trends and visualization tool

CBP's Integrated Trends Analysis Team (ITAT)

Dec. 14, 2020, STAC meeting

Rebecca Murphy (UMCES at CBP), Jeni Keisman (USGS),

Erik Leppo and Jon Harcum (Tetra Tech)

Annual tidal trends/ change production

Tidal WQ data

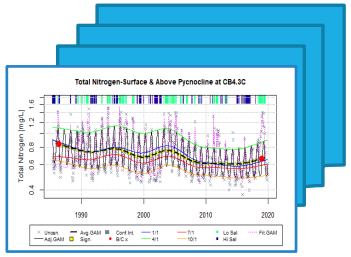
(Full set in spring for previous year)

For MD: Renee Karrh (MDDNR)

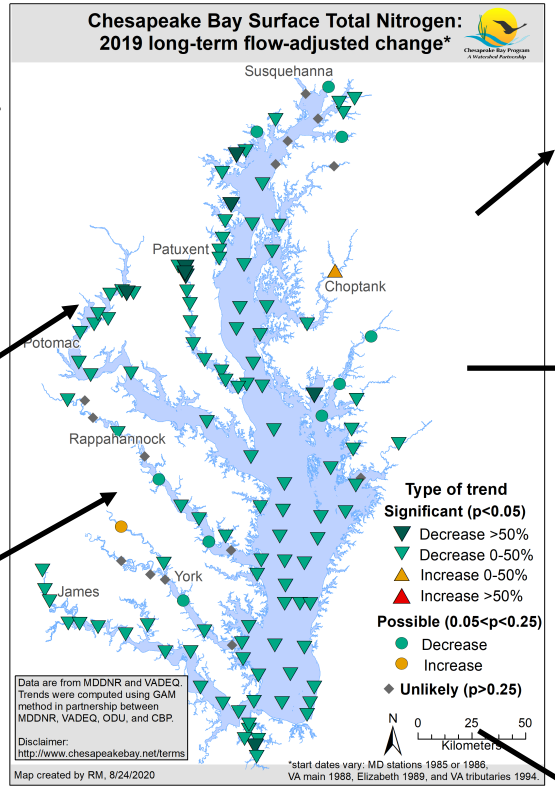
For VA: Mike Lane (ODU for VADEQ)

'baytrends' R package to run GAMs

Development by: Jon Harcum, Erik Leppo (Tetra Tech); Elgin Perry (consultant); Jeni Keisman (USGS) Rebecca Murphy (UMCES)

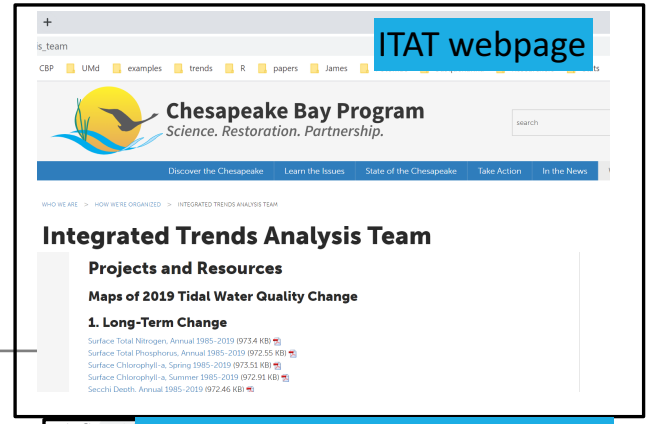


Submitted to CBP & combined *(June)*

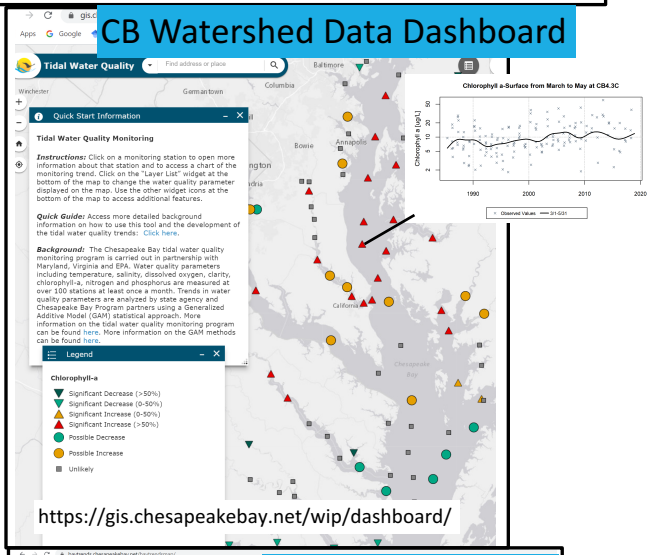


(Made available during the fall, for previous year)

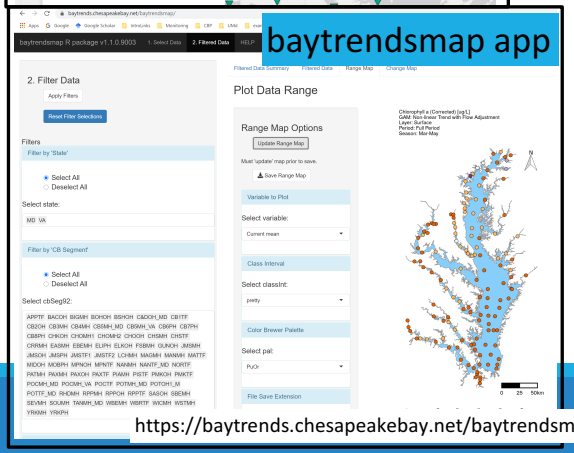
ITAT webpage



CB Watershed Data Dashboard



baytrendsmap app



Approach

A Generalized Additive Model (GAM) represents a constituent of interest as the sum of multiple smooth functions of explanatory variables

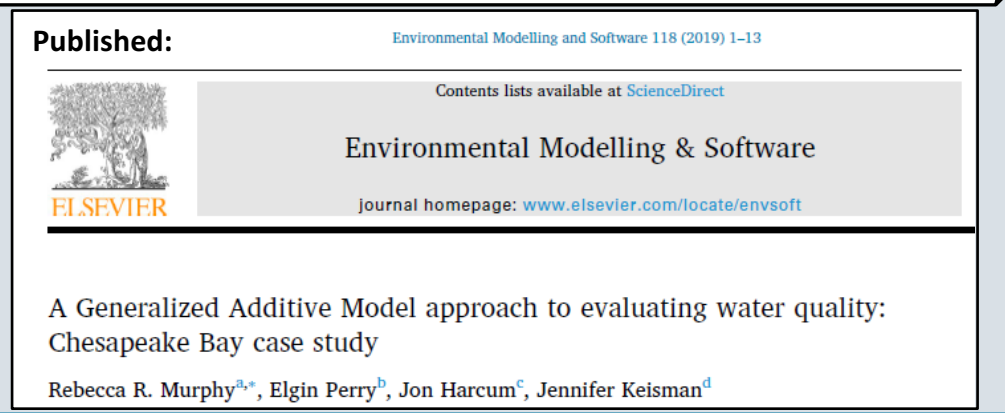
Our implementation:

'baytrends' R package to run GAMs

Available on CRAN: https://CRAN.R-project.org/package=baytrends

STAC Review:
Ellis, Du, Friedrichs, Lyubchich. 2016. Scientific and Technical Advisory Committee Review of the Generalized Additive Model (GAM) Approach for Water Quality Trends in Tidal Waters. STAC Publication Number 17-001, Edgewater, MD. 22 pp.

Published:



- Fit multiple GAMs to each data set (e.g., Surface TN at CB3.3C).
- Features include nonlinear or linear change, seasonal cycle, and relationship to flow or salinity.
- Post-process to compute mean change over any time/season.

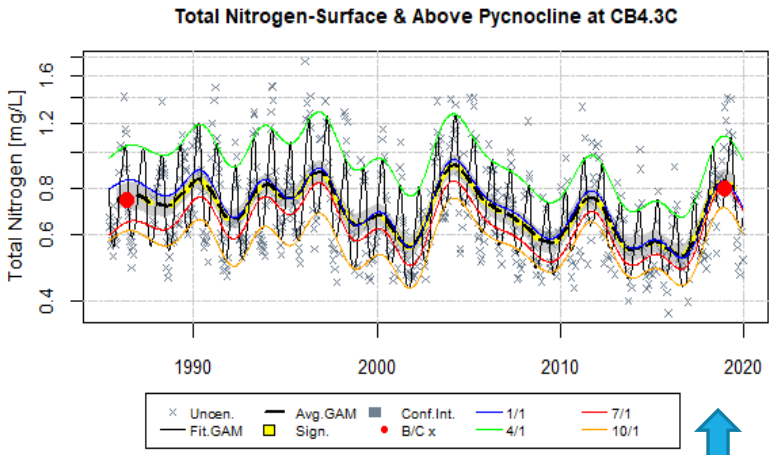
2019 results sets

Long-term (1980s-2019) and short-term (2010-2019) change:

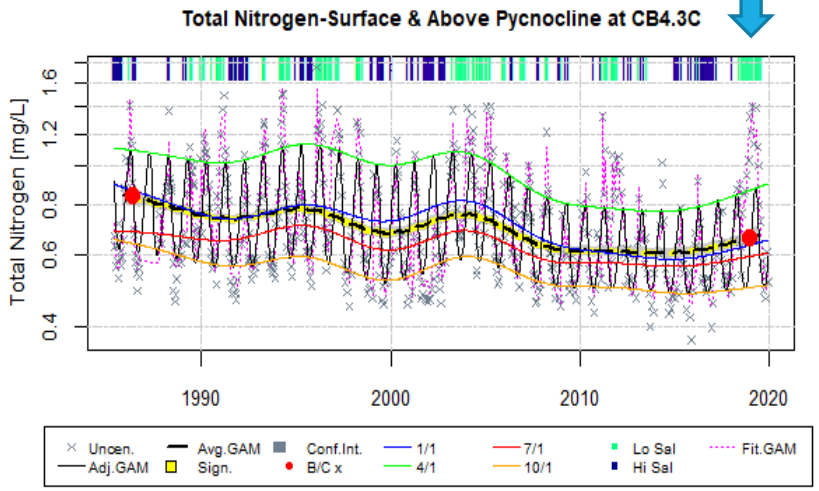
- Total nitrogen, total phosphorus (annual; surface & bottom)
- Water temp, salinity (annual; surface & bottom)
- Secchi depth (annual & Apr-Oct)
- Chlorophyll-a (spring & summer; surface & bottom)
- Dissolved oxygen (summer; surface & bottom)

1999-2019 and short-term (2010-2019) change :

- TSS, DIN, PO4 (annual; surface & bottom)



For each of these, both observed/non-adjusted results and Flow- or salinity-adjusted results are generated



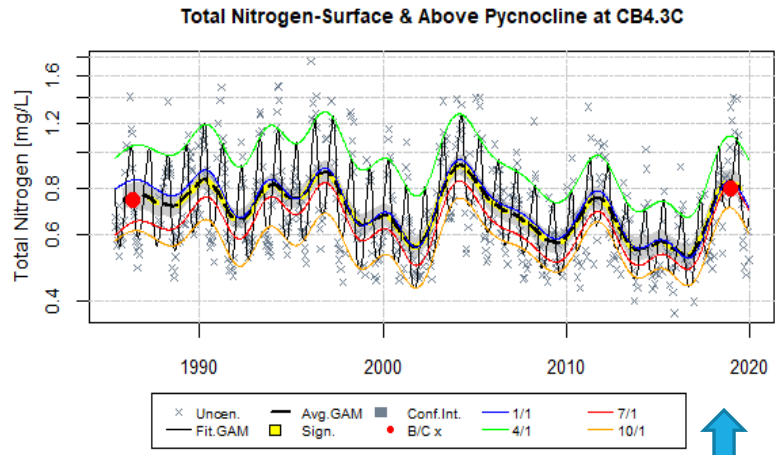
2019 results sets

Long-term (1980s-2019) and short-term (2010-2019) change:

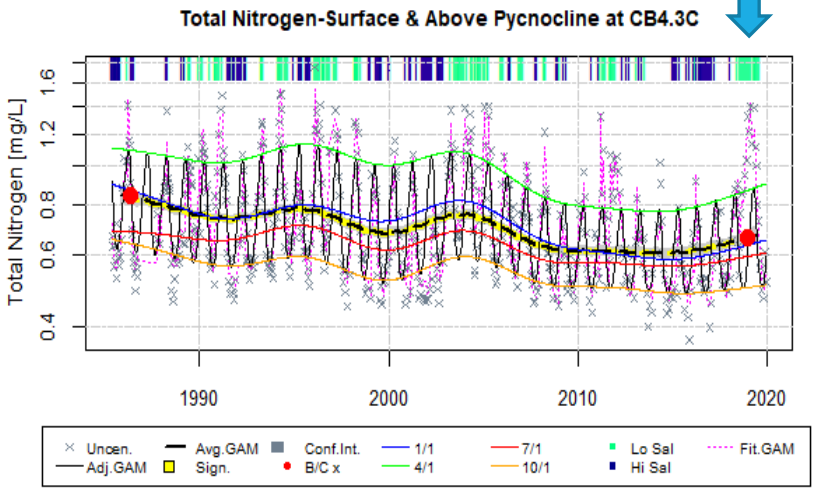
- Total nitrogen, total phosphorus (annual; surface & bottom)
- Water temp, salinity (annual; surface & bottom)
- Secchi depth (annual & SAV season)
- Chlorophyll-a (spring & summer; surface & bottom)
- Dissolved oxygen (summer; bottom & surface)

1999-2019, and short-term (2010-2019) change :

- TSS, DIN, PO4 (annual; surface & bottom)



For each of these, both <u>observed/non-adjusted results</u> and <u>Flow- or salinity-adjusted results</u> are generated



Total monitored flow into tidal waters

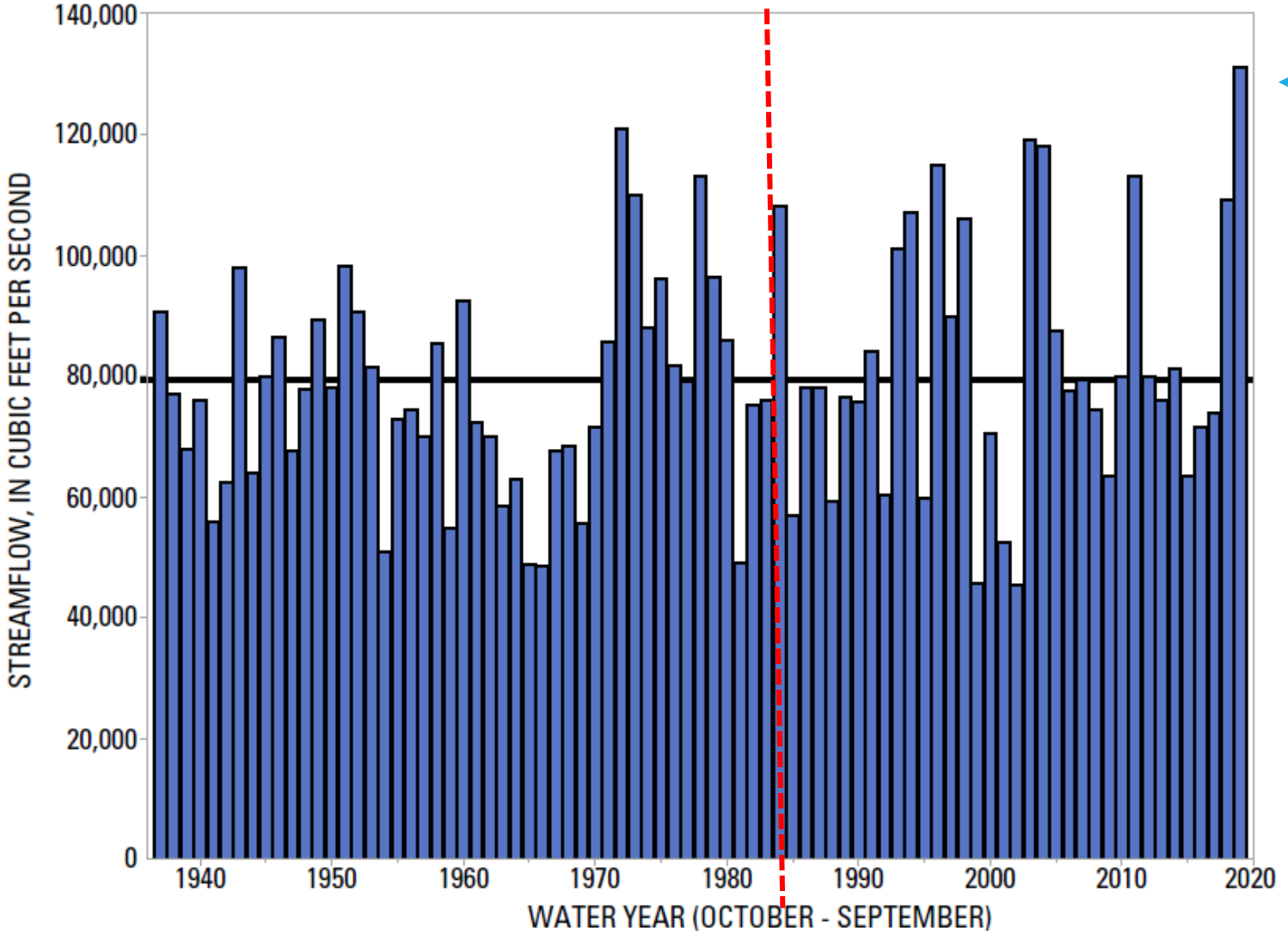


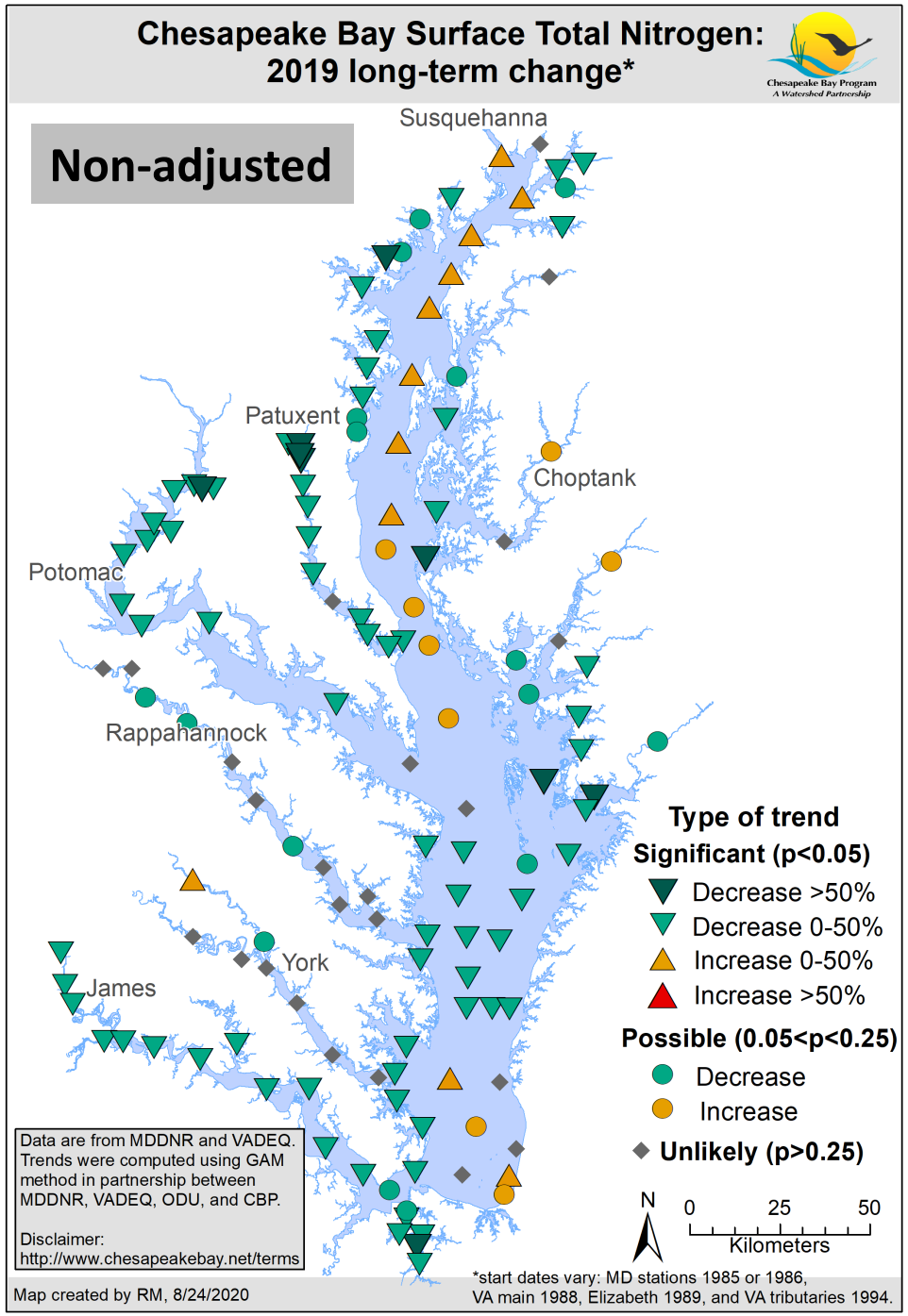
Figure 2. Estimated annual-mean streamflow entering Chesapeake Bay. Black line represents the average annual-mean streamflow of 79,423 cubic feet per second.

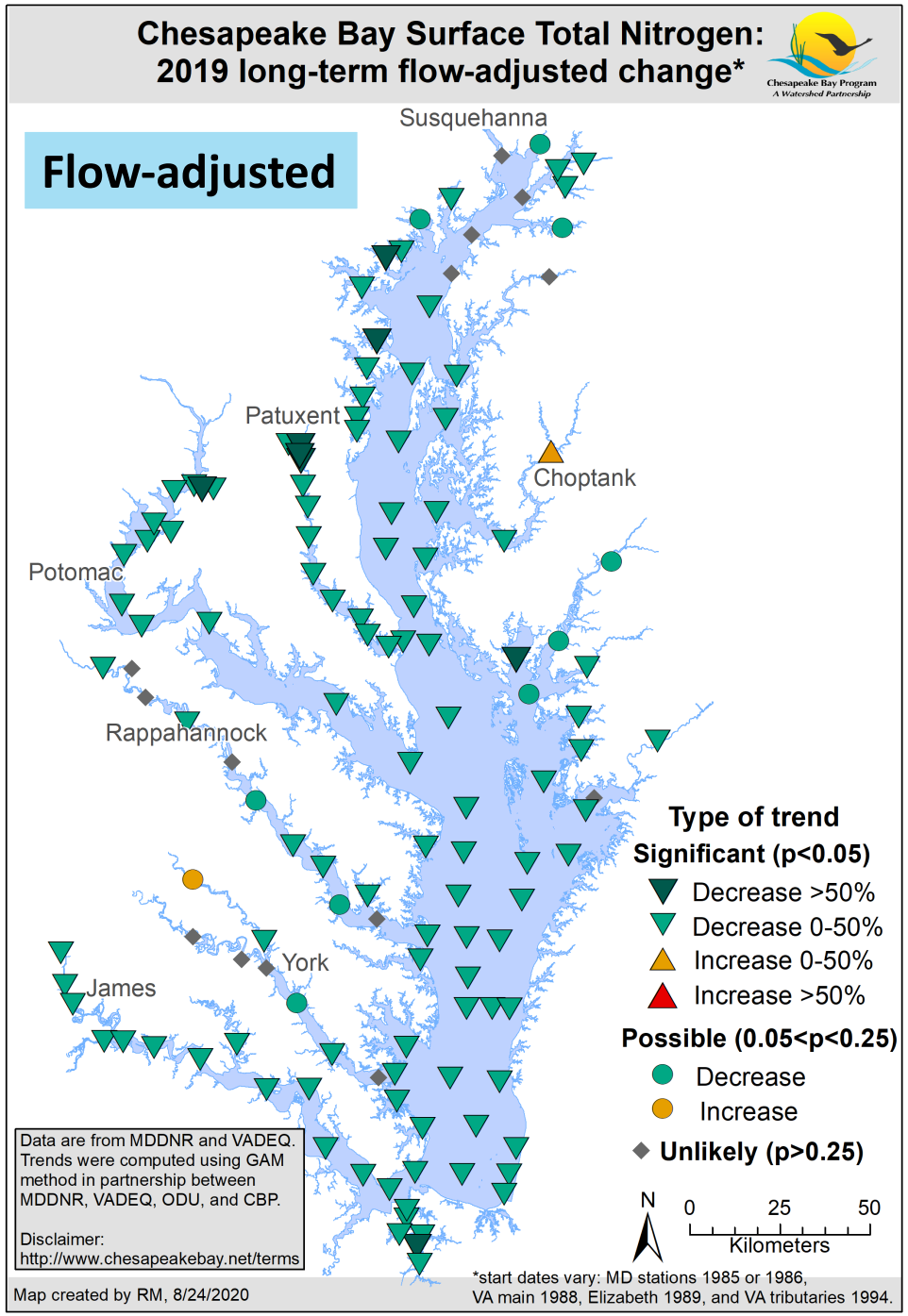
Note:
2019 highest in this record. 2018 very high too.

Moyer and Blomquist 2020. https://doi.org/10.5066/P9VG459V.

TN

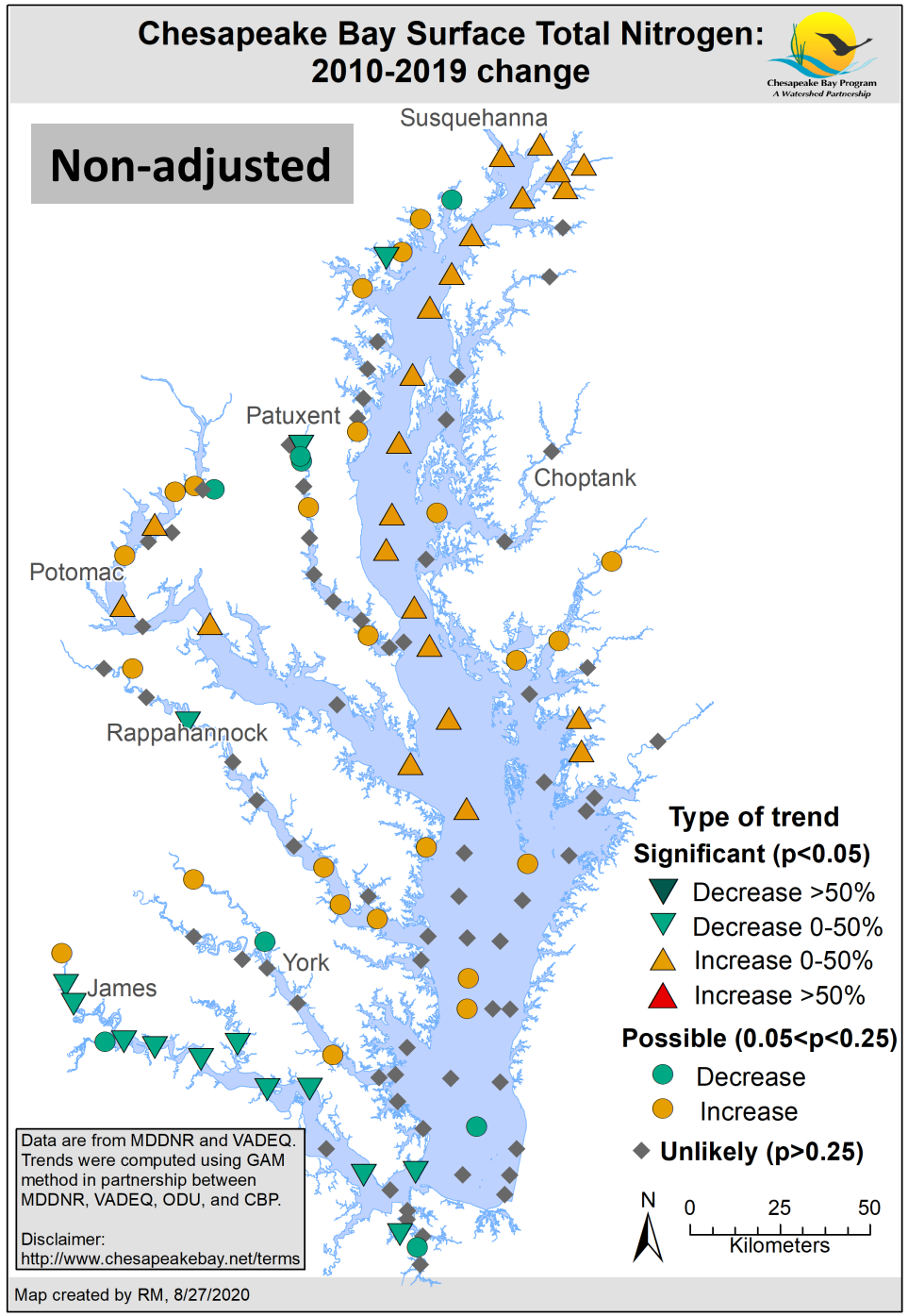
long-term

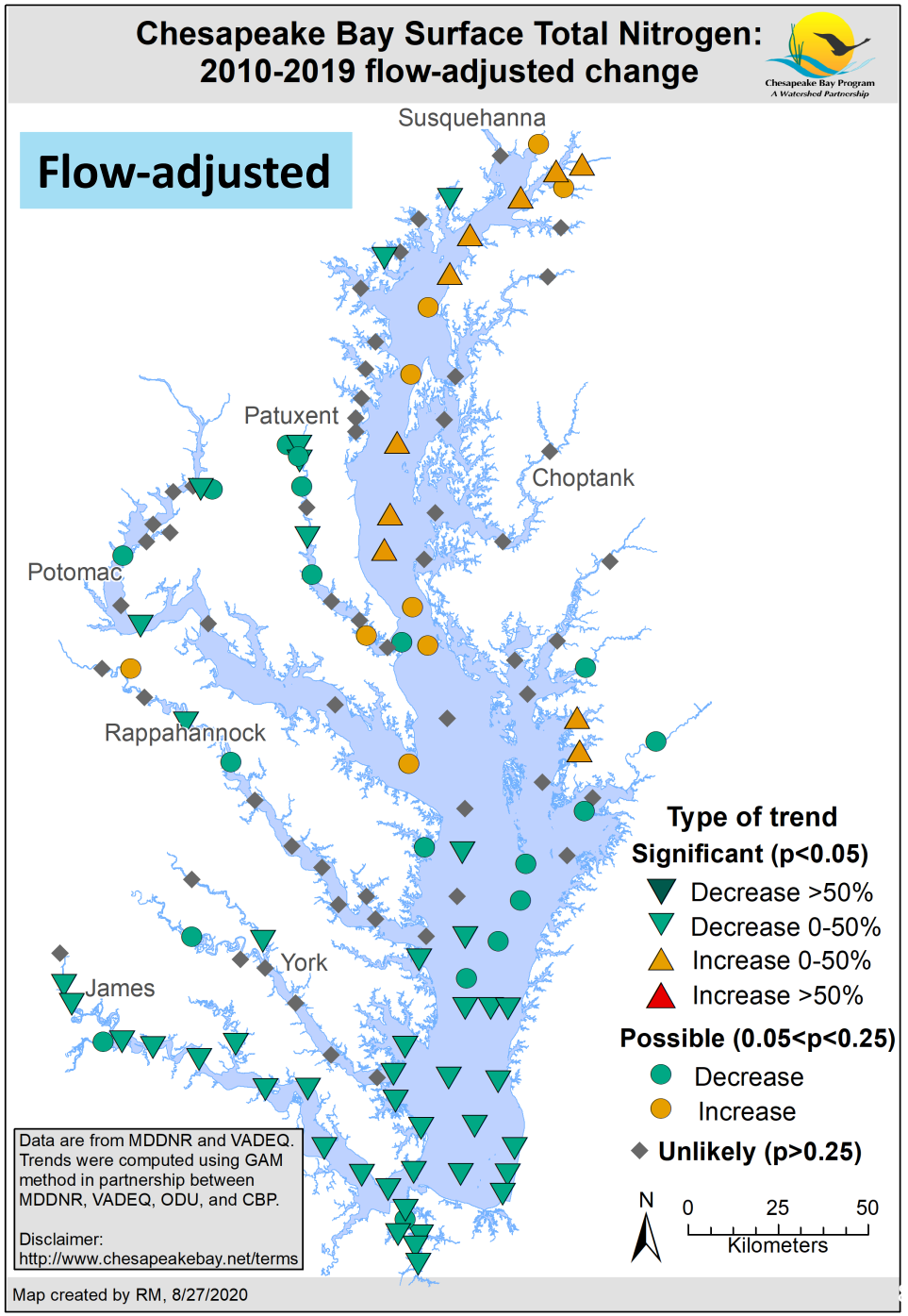

Chesapeake Bay Surface Total Nitrogen:
2019 long-term change*
Chesapeake Bay Program
A Watershed Partnership
Non-adjusted
Susquehanna
Patuxent
Choptank
Potomac
Rappahannock
York
James
Type of trend
Significant (p<0.05)
Decrease >50%
Decrease 0-50%
Increase 0-50%
Increase >50%
Possible (0.05<p<0.25)
Decrease
Increase
Unlikely (p>0.25)
N
0
25
50
Kilometers
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
Map created by RM, 8/24/2020
*start dates vary: MD stations 1985 or 1986,
VA main 1988, Elizabeth 1989, and VA tributaries 1994.


Chesapeake Bay Surface Total Nitrogen:
2019 long-term flow-adjusted change*
Chesapeake Bay Program
A Watershed Partnership
Flow-adjusted
Susquehanna
Patuxent
Choptank
Potomac
Rappahannock
York
James
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)
N
0
25
50
Kilometers
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
Map created by RM, 8/24/2020
*start dates vary: MD stations 1985 or 1986,
VA main 1988, Elizabeth 1989, and VA tributaries 1994.

TN

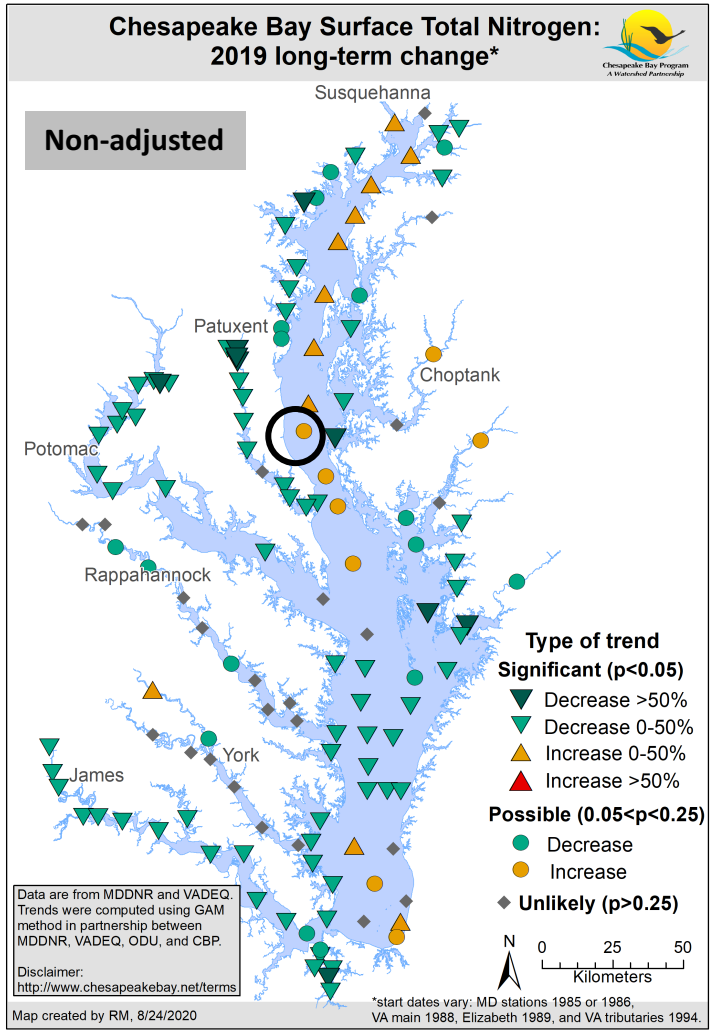
short-term

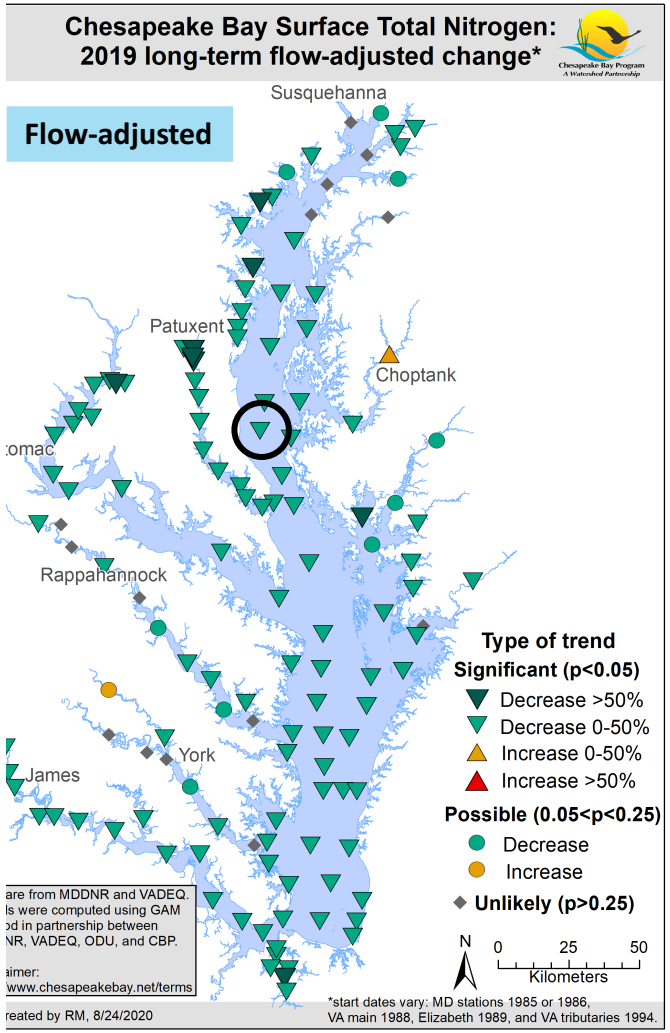


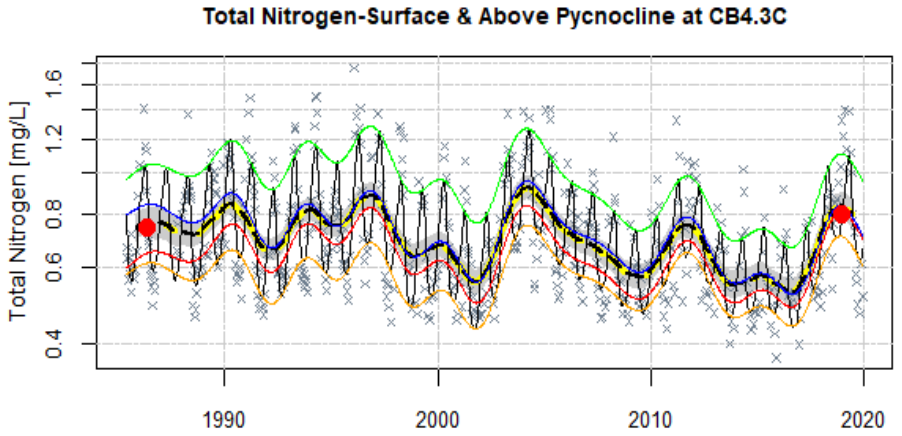


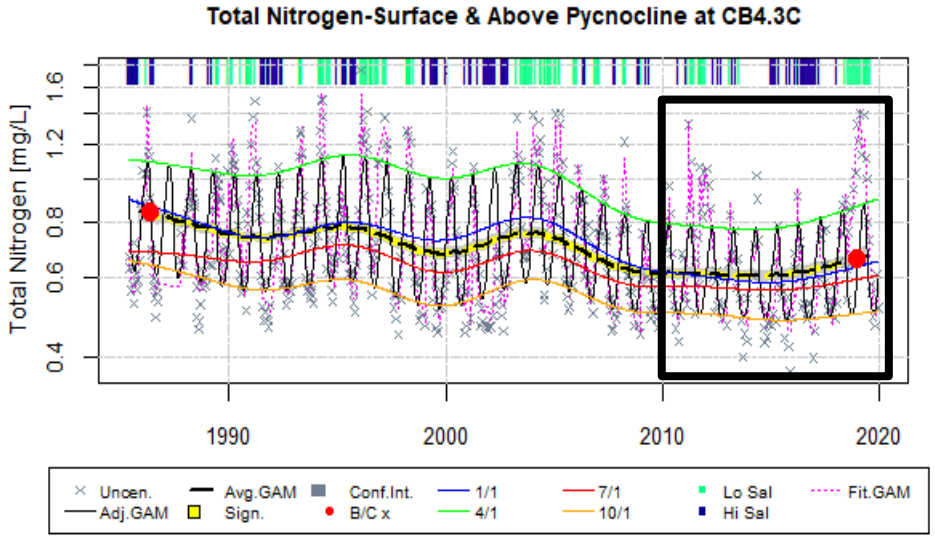
TN

long-term





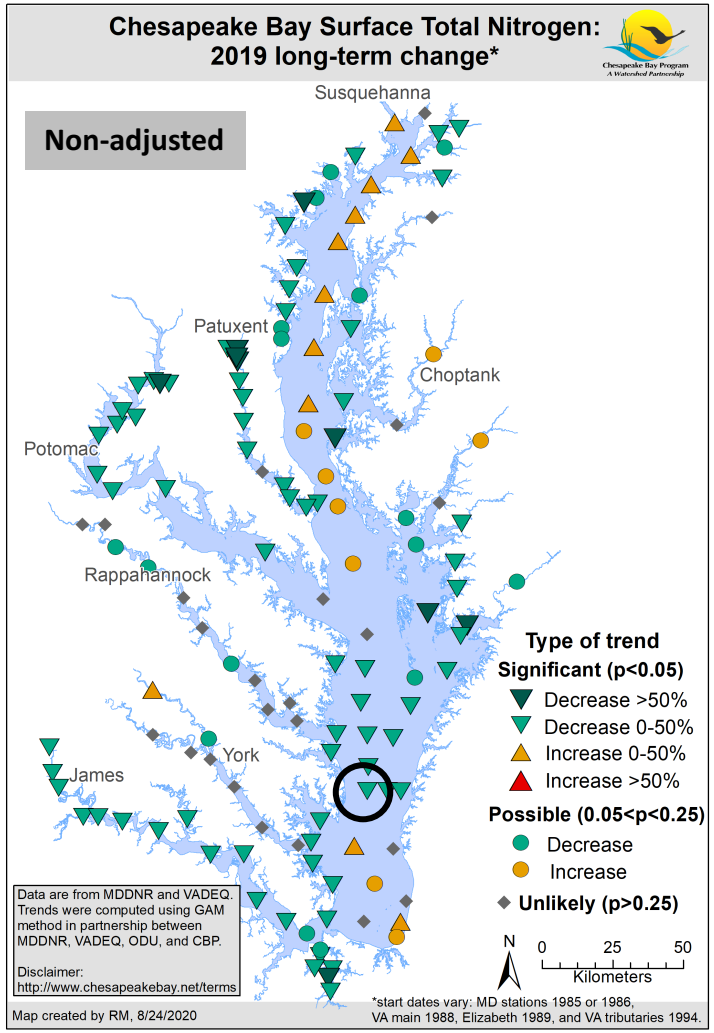


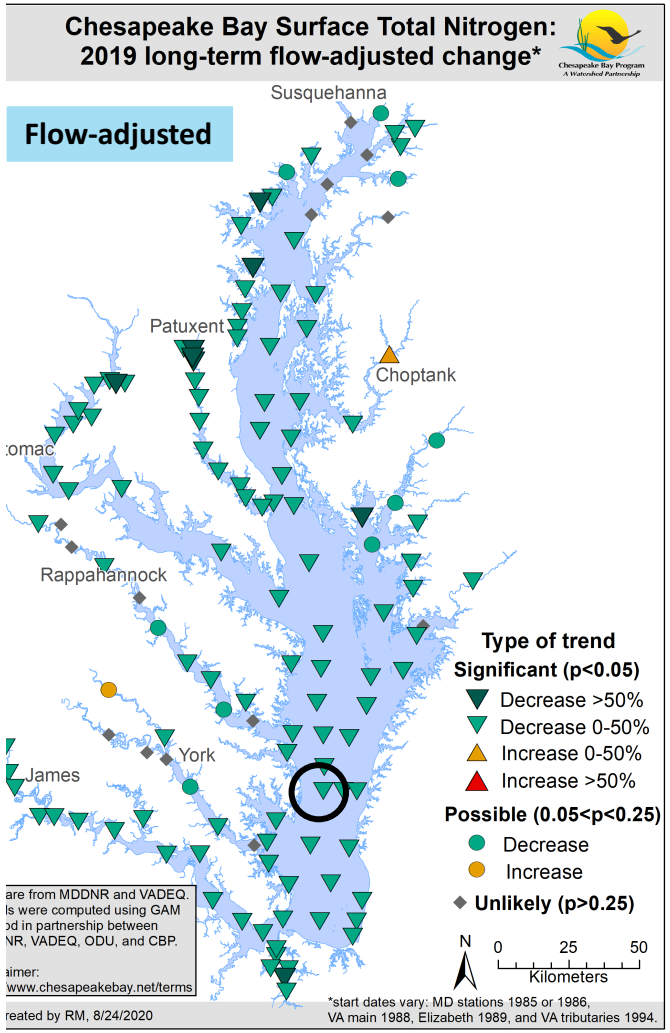


1. Entire upper half of mainstem shows increase before flow-adjustment.

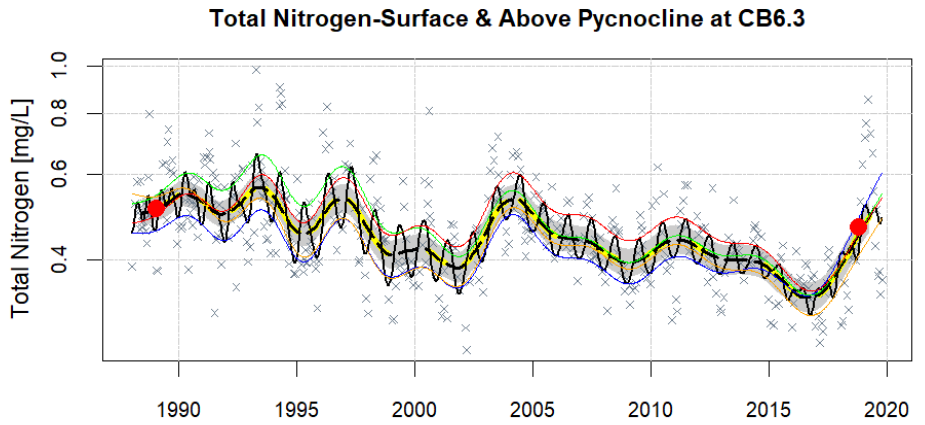
TN

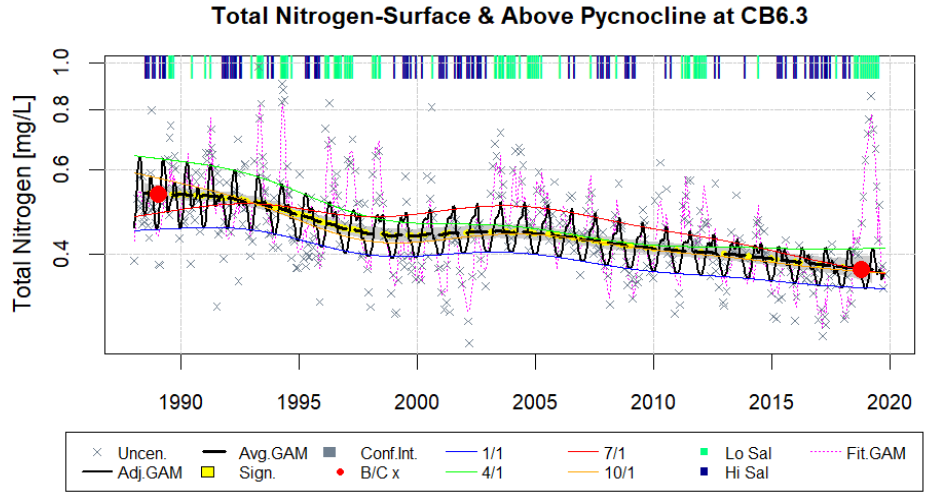
long-term





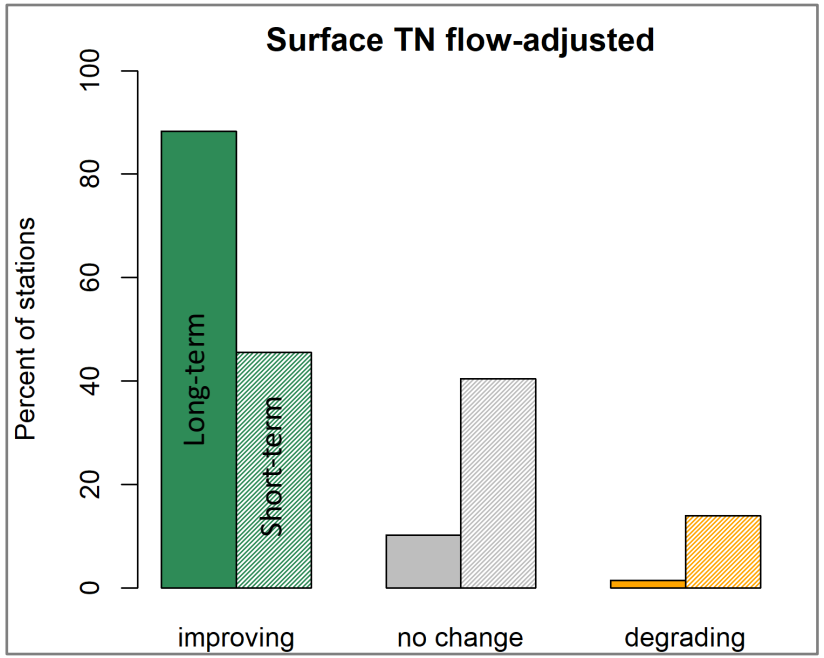
2. Impact of wet years is still seen at the VA mainstem stations, but the TN decrease gets more substantial.





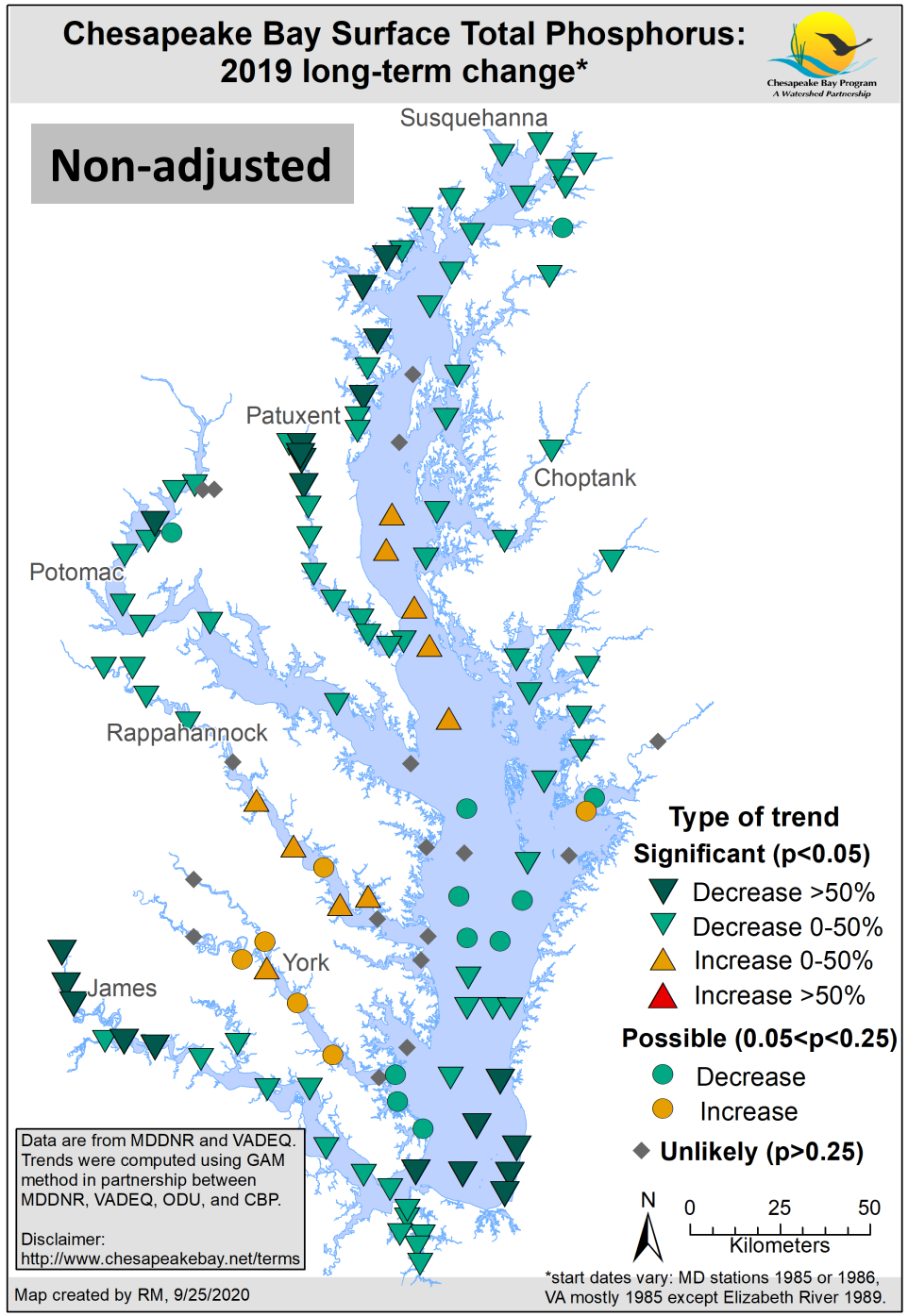
TN initial reactions

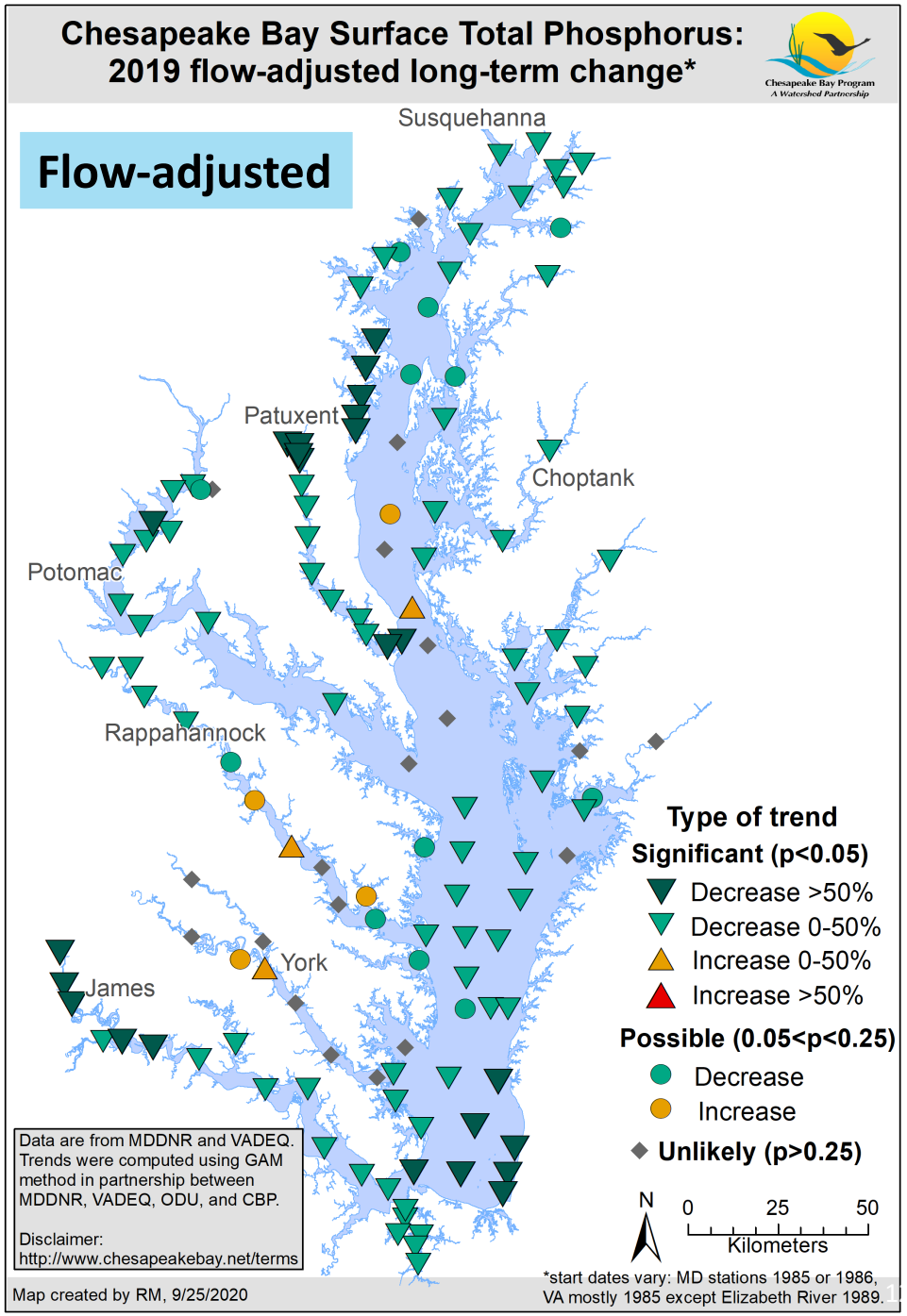
- Long-term decreases at most stations (bottom is similar).
- Short-term changes are mixed, possibly some flow impacts that are not accounted for with adjustment.
- Only long-term increases that are not due to wet year: stations in the Mattaponi and Choptank TF show gradual increases.



TP

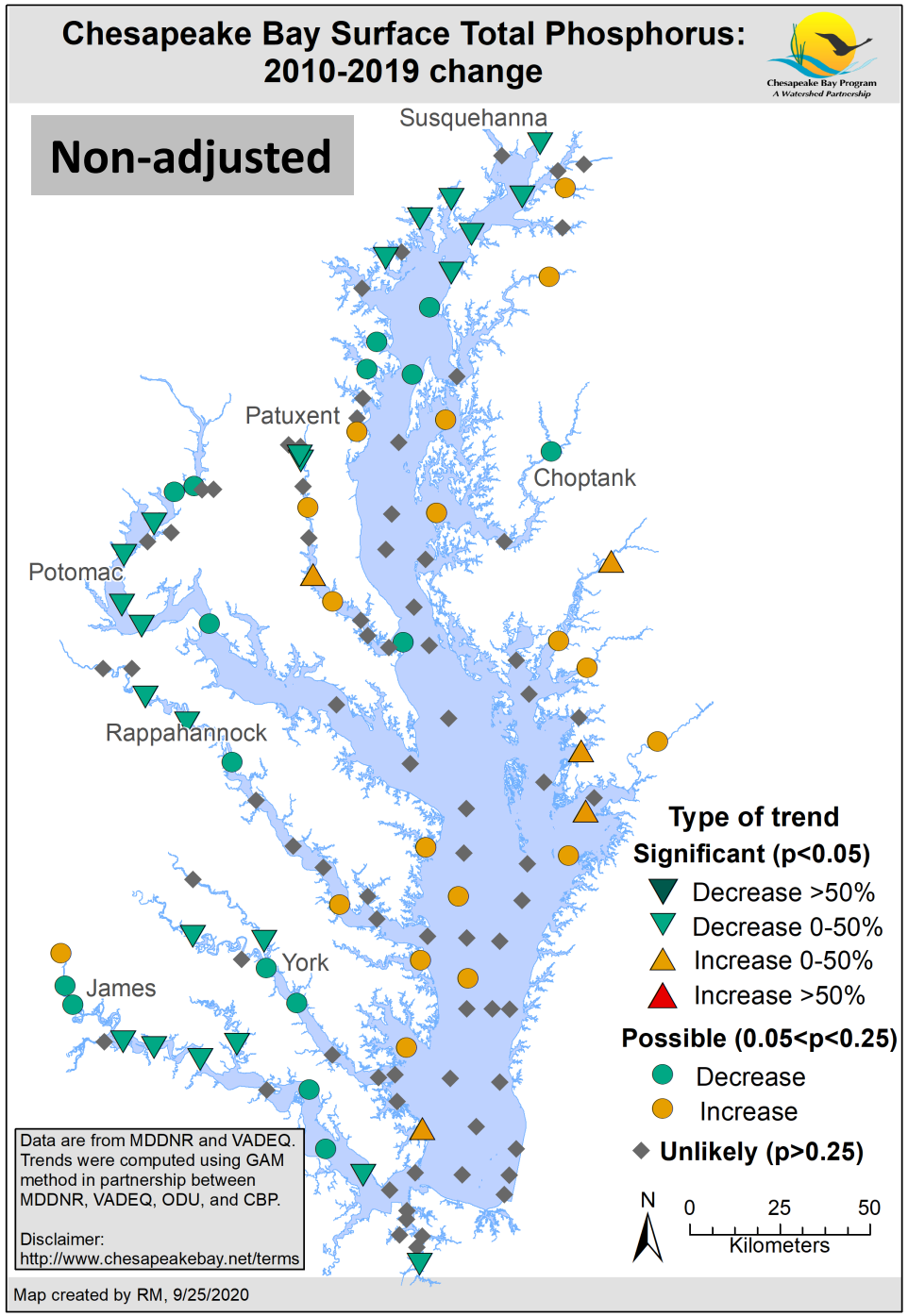
long-term

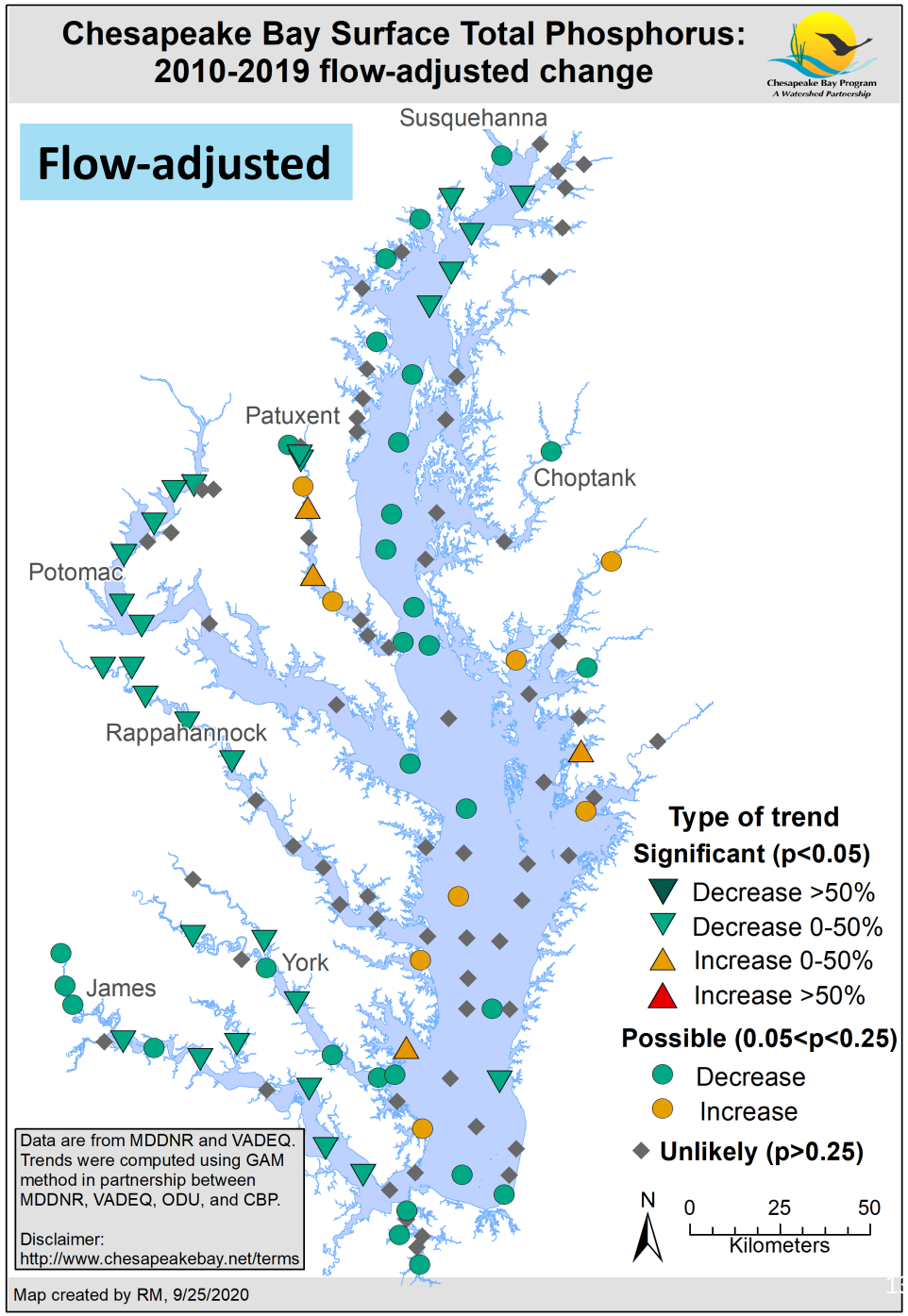

Chesapeake Bay Surface Total Phosphorus:
2019 long-term change*
Chesapeake Bay Program
A Watershed Partnership
Non-adjusted
Susquehanna
Patuxent
Choptank
Potomac
Rappahannock
York
James
Type of trend
Significant (p<0.05)
Decrease >50%
Decrease 0-50%
Increase 0-50%
Increase >50%
Possible (0.05<p<0.25)
Decrease
Increase
Unlikely (p>0.25)
N
0
25
50
Kilometers
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
Map created by RM, 9/25/2020
*start dates vary: MD stations 1985 or 1986, VA mostly 1985 except Elizabeth River 1989.


Chesapeake Bay Surface Total Phosphorus:
2019 flow-adjusted long-term change*
Chesapeake Bay Program
A Watershed Partnership
Flow-adjusted
Susquehanna
Patuxent
Choptank
Potomac
Rappahannock
York
James
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)
N
0
25
50
Kilometers
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
Map created by RM, 9/25/2020
*start dates vary: MD stations 1985 or 1986, VA mostly 1985 except Elizabeth River 1989.

TP

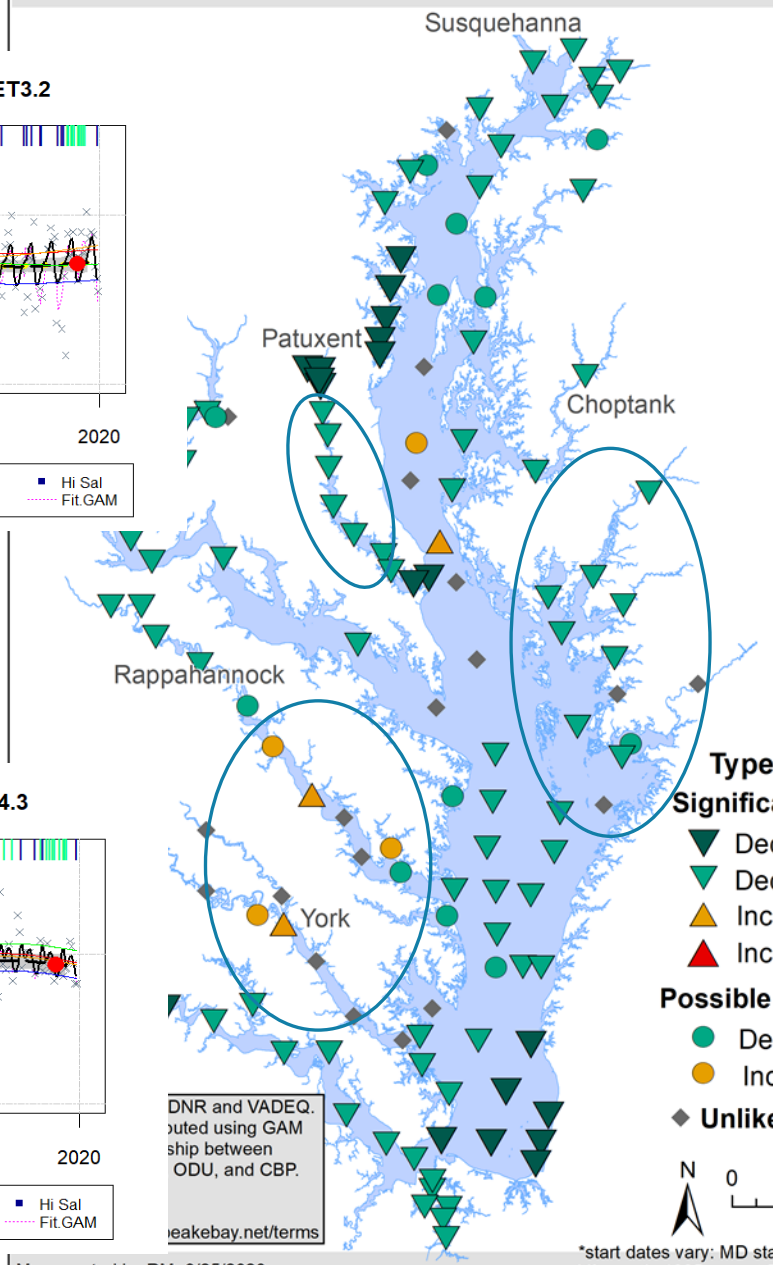
short-term



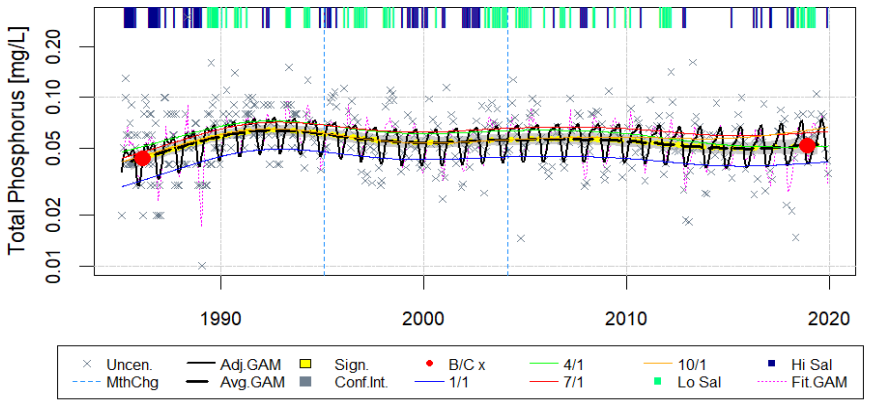


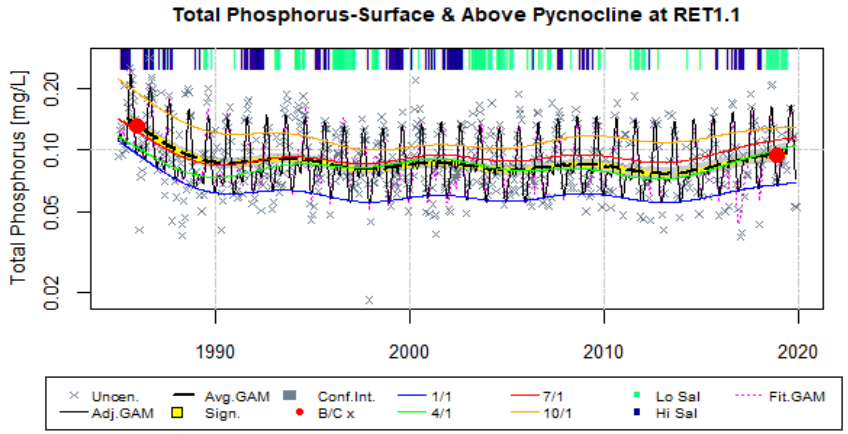
TP

Chesapeake Bay Surface Total Phosphorus: 2019 flow-adjusted long-term change*



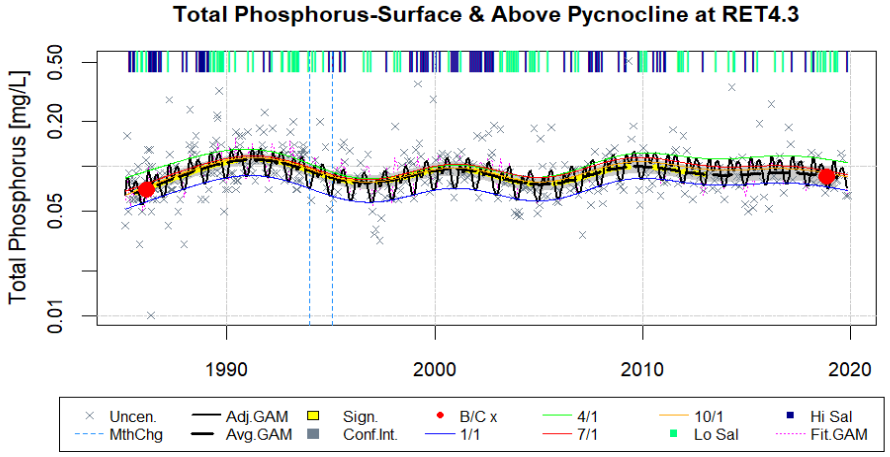
2. Patuxent OH&MH: Long term ↓, Short term ↑ →

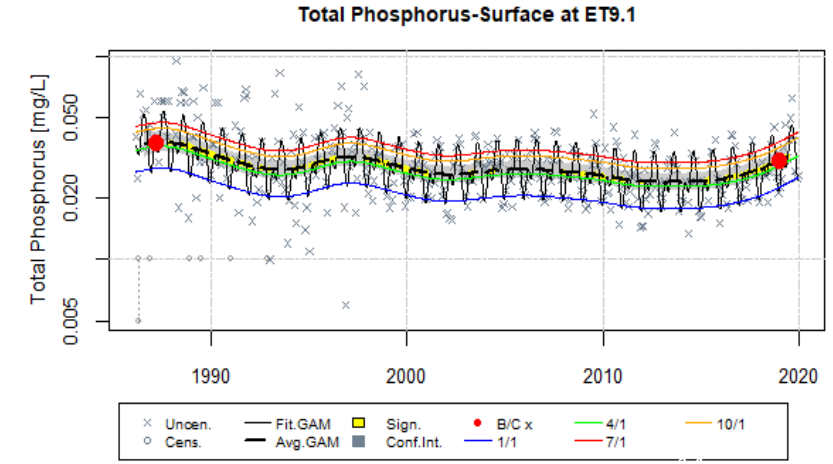




1. Rapp & York MH: Long term →, Short term ↑ ↓ →

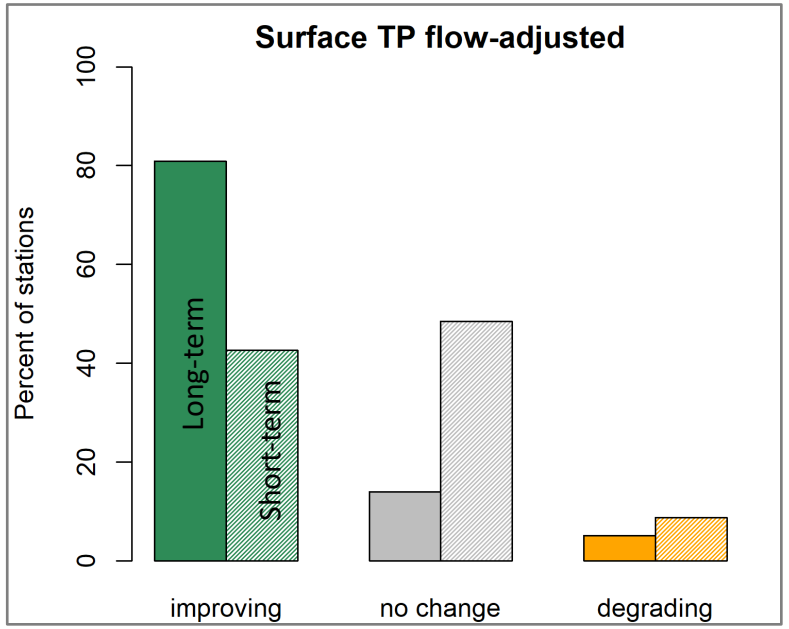
3. Lower Eastern shore: Long term ↓, Short term ↑ →





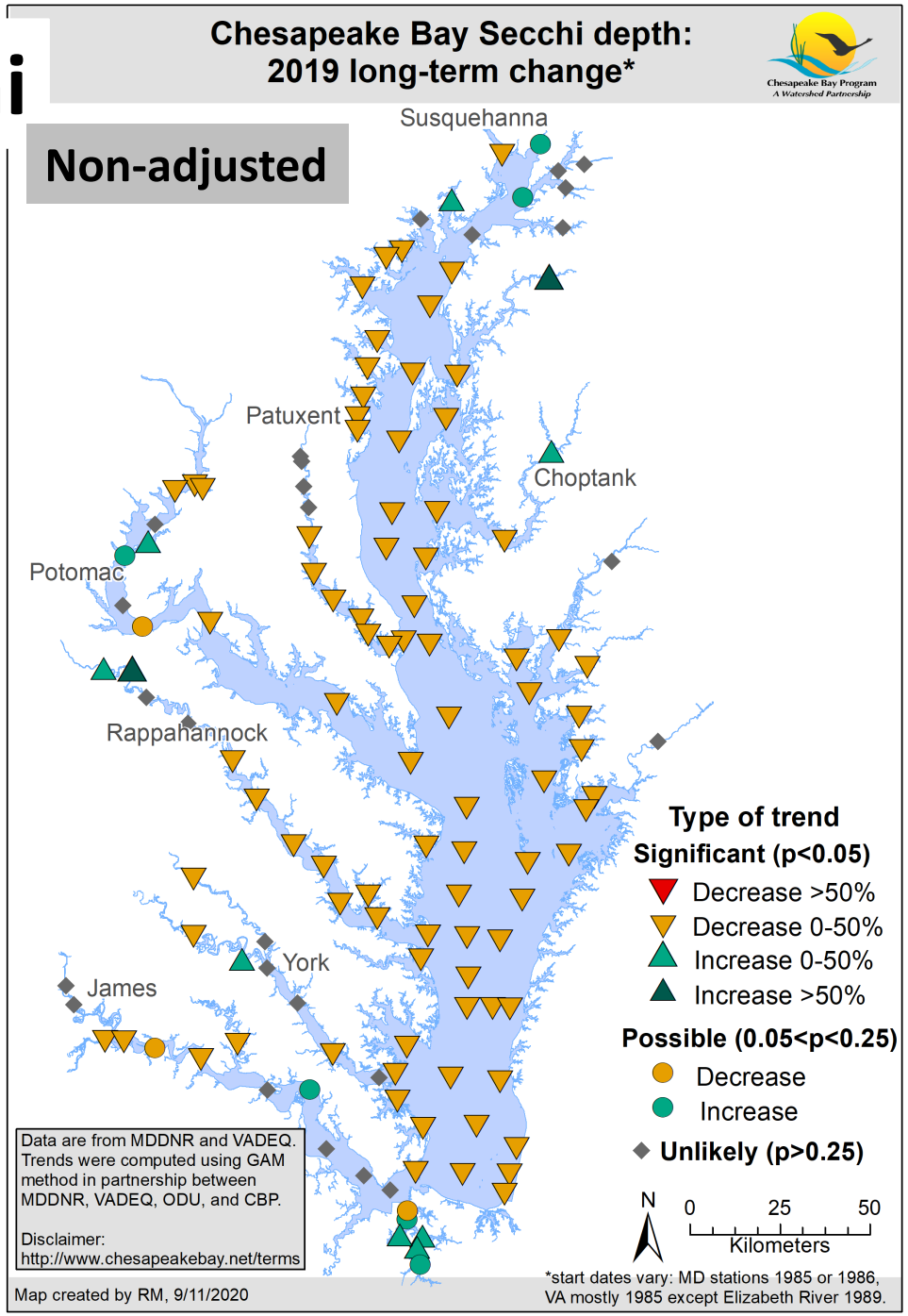
TP initial reactions

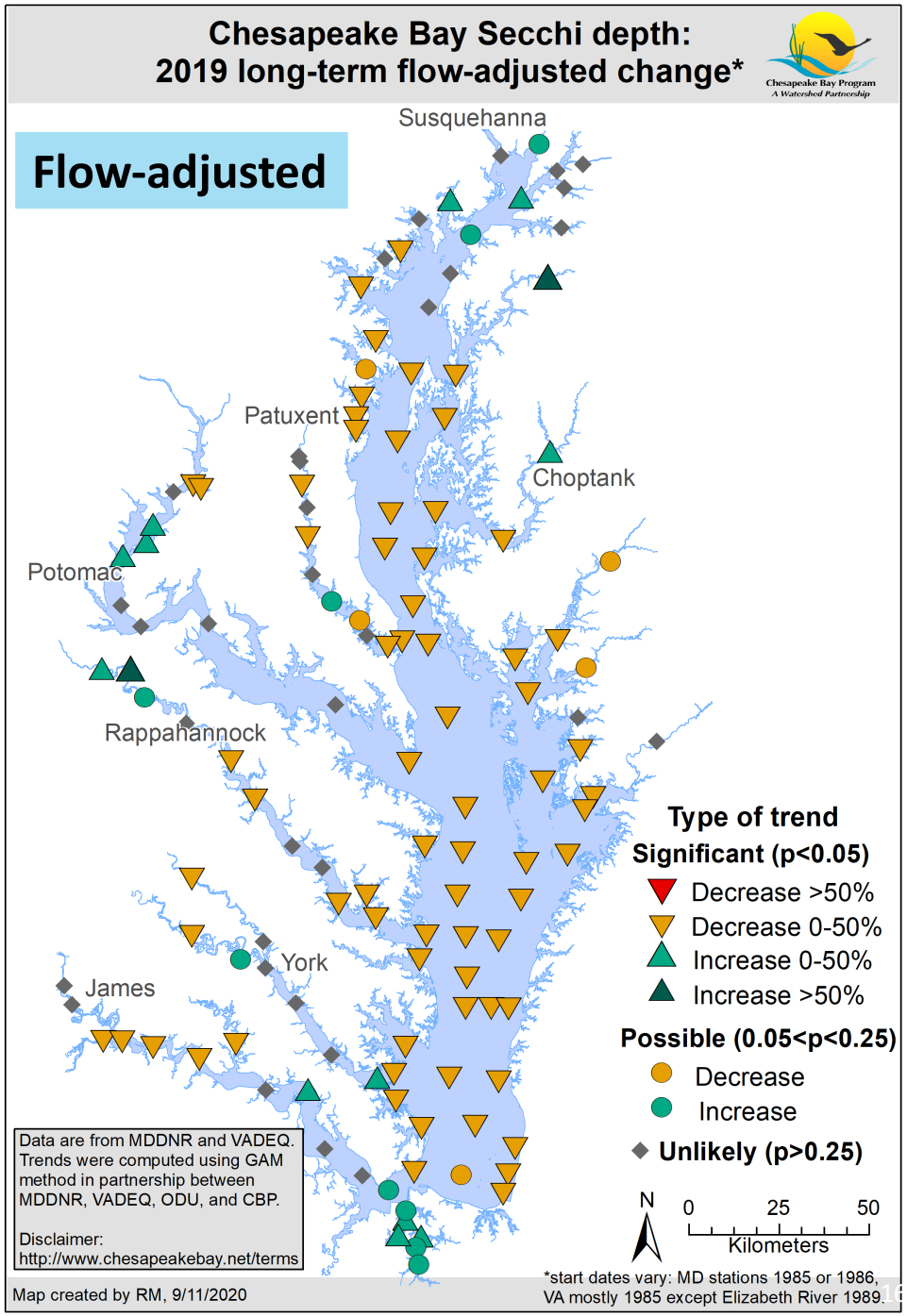
- Long-term TP is decreasing at most of the stations, but short-term changes are more mixed.
- Long-term, the 1980s decrease in TP drives the downward changes in many places.



Secchi

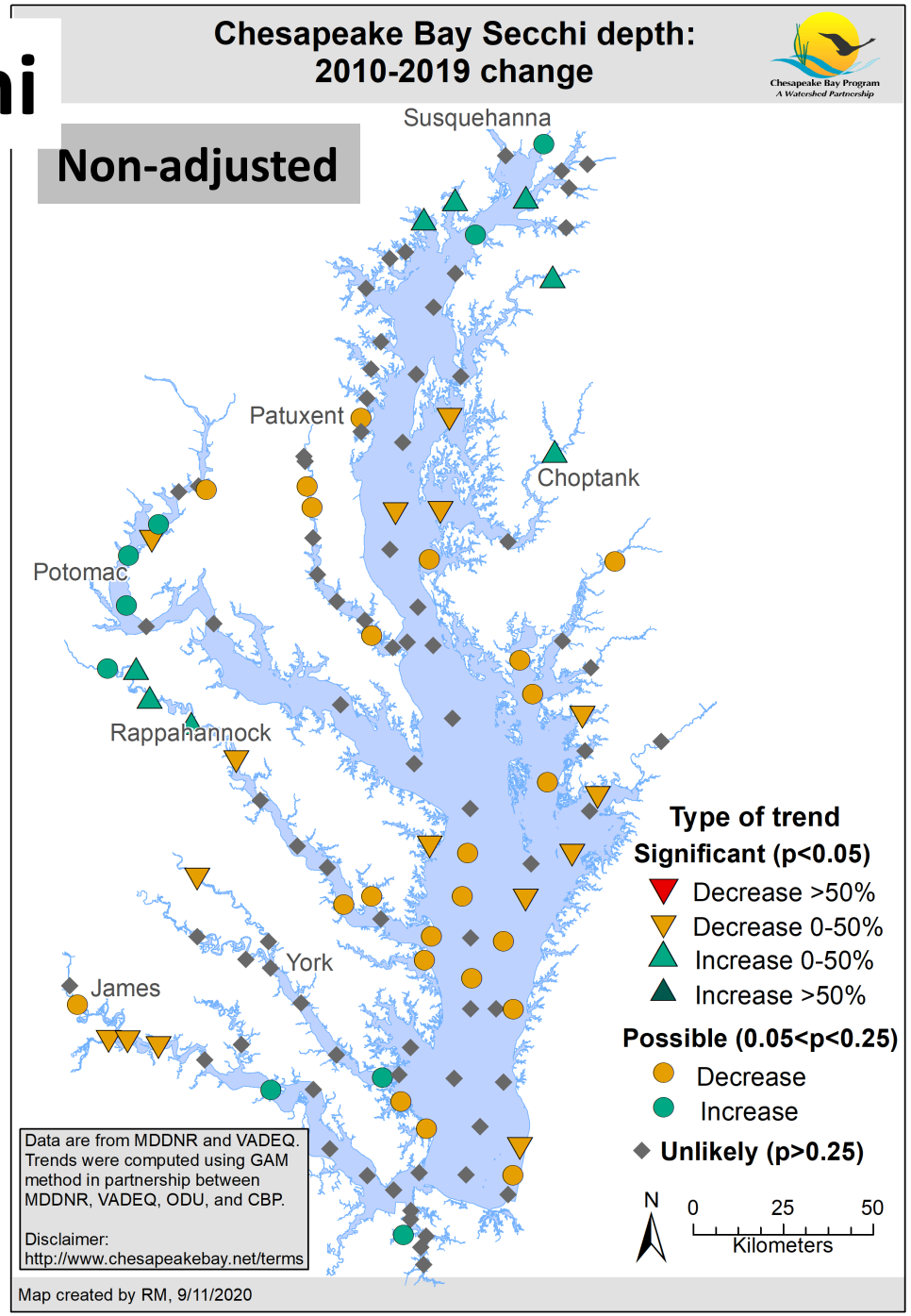
long-term

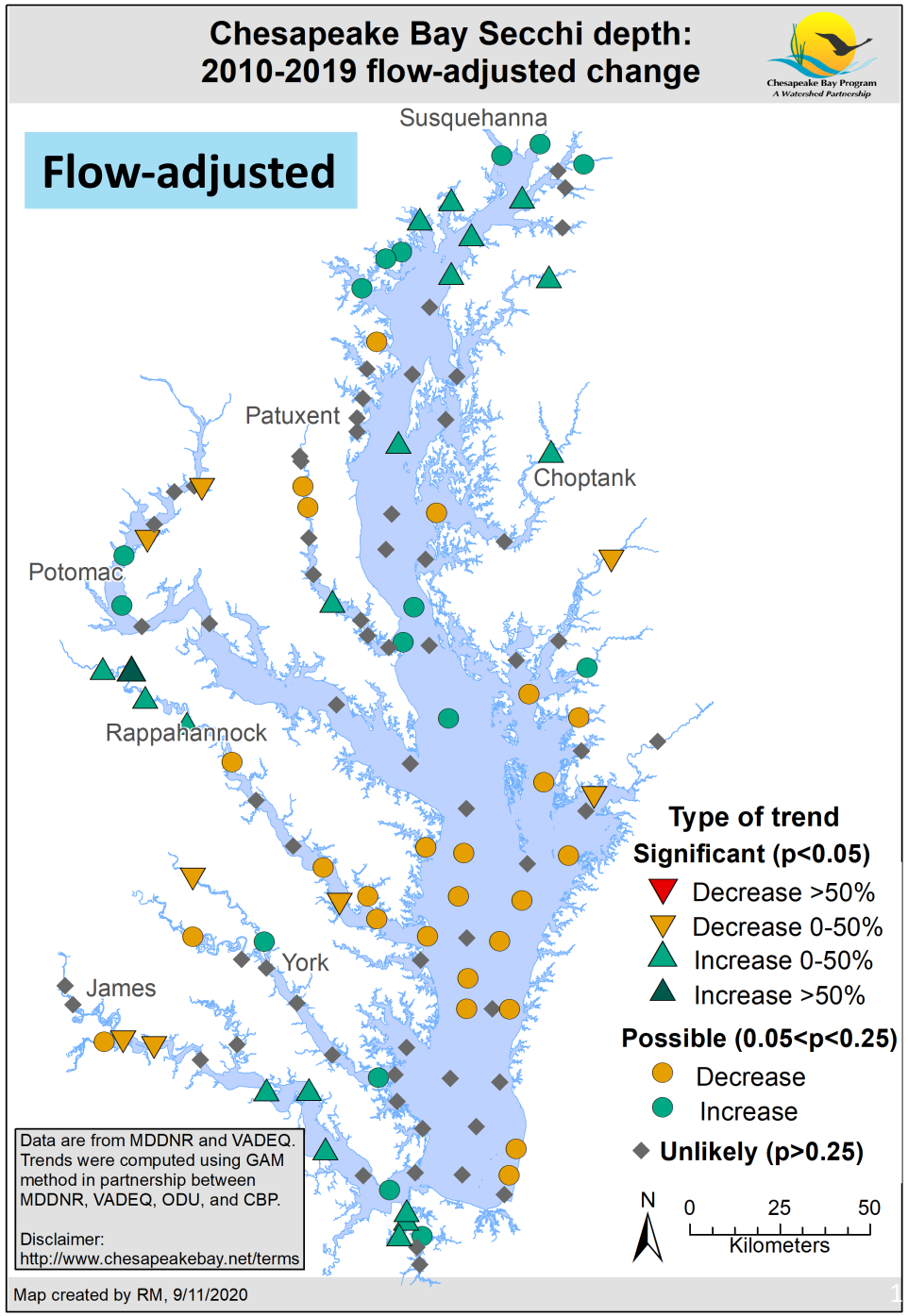




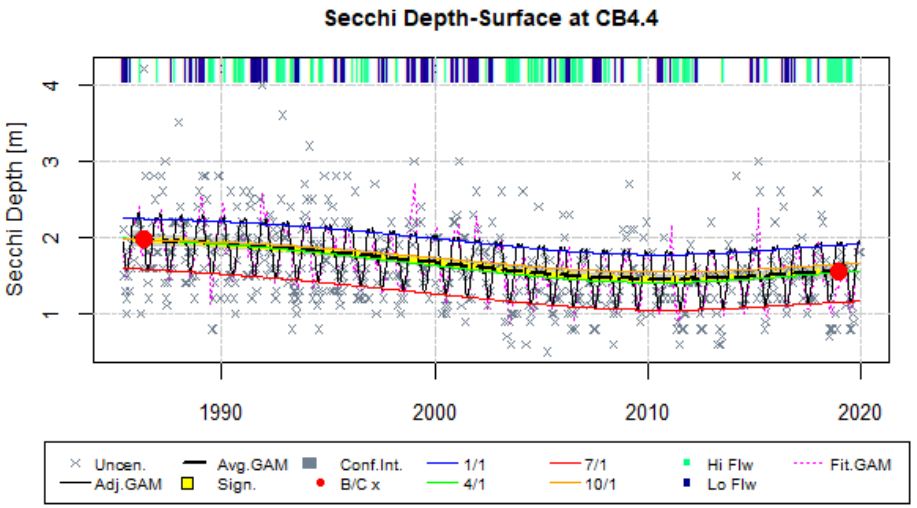
Secchi

short-term

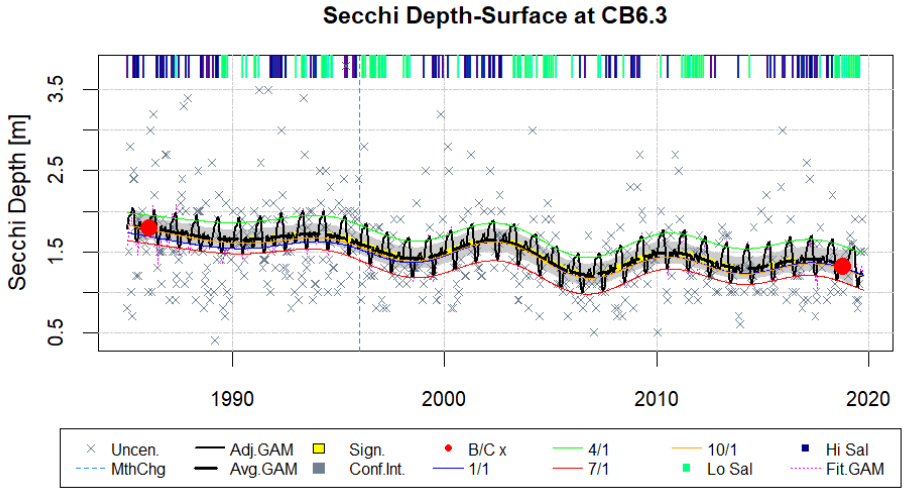


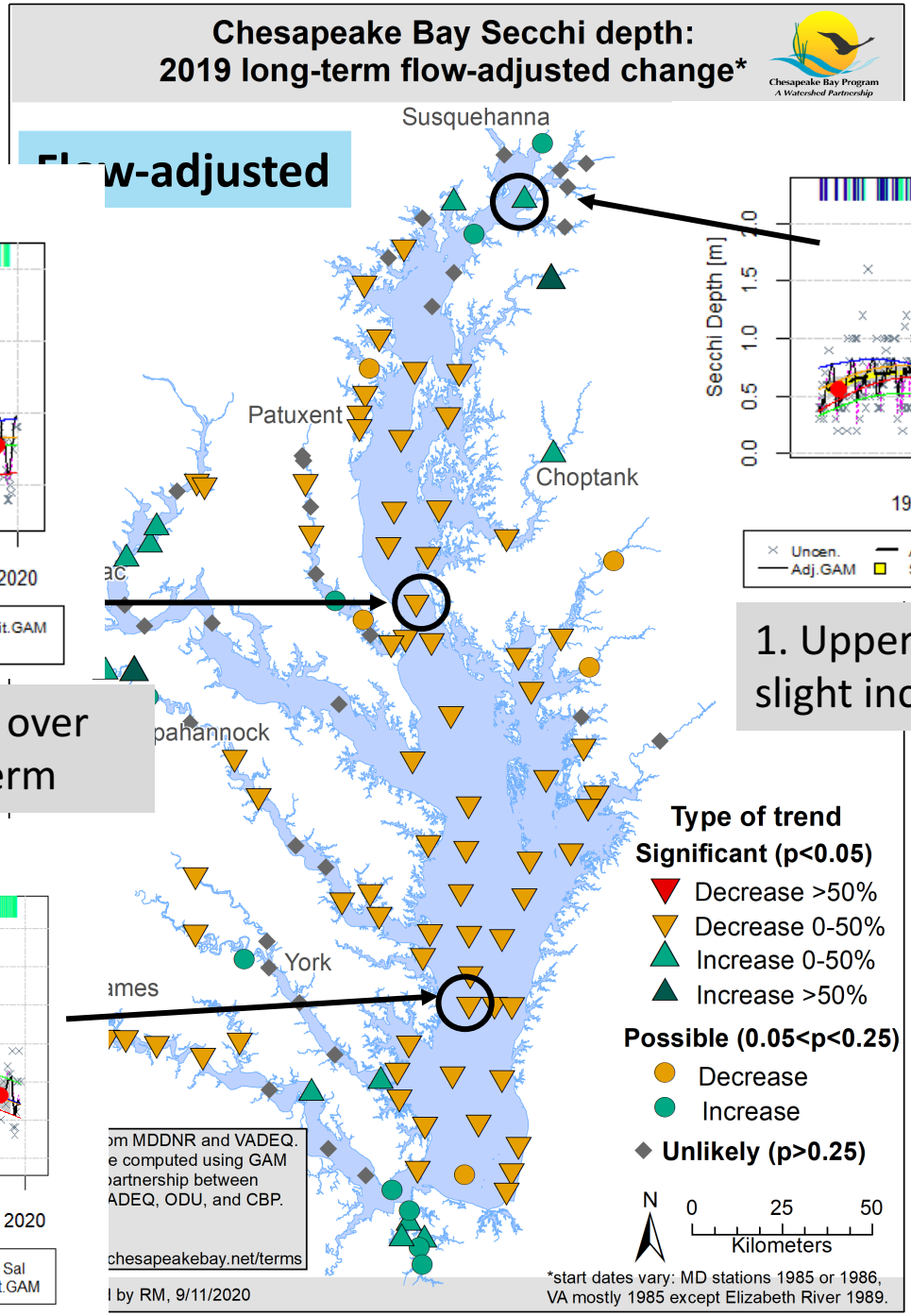


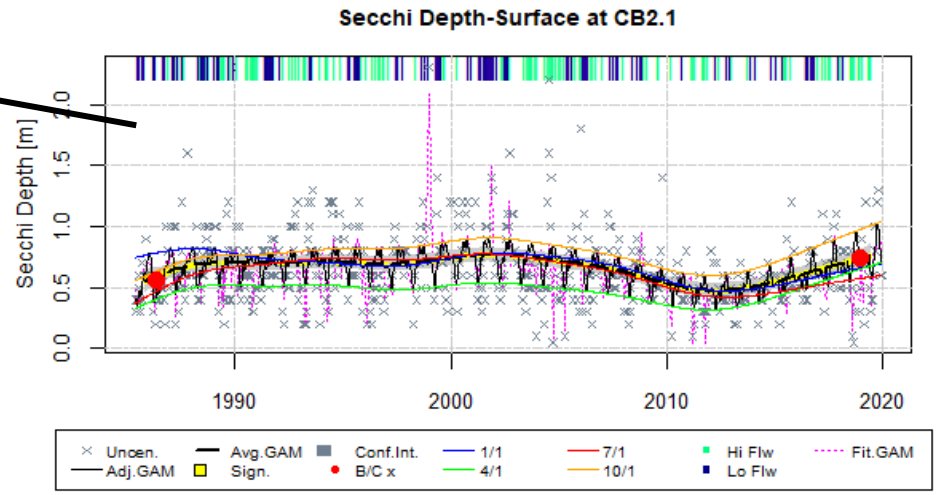
Secchi: Mainstem mix



2. Mid- and lower-mainstem all decrease over long-term, but are fairly flat over short-term



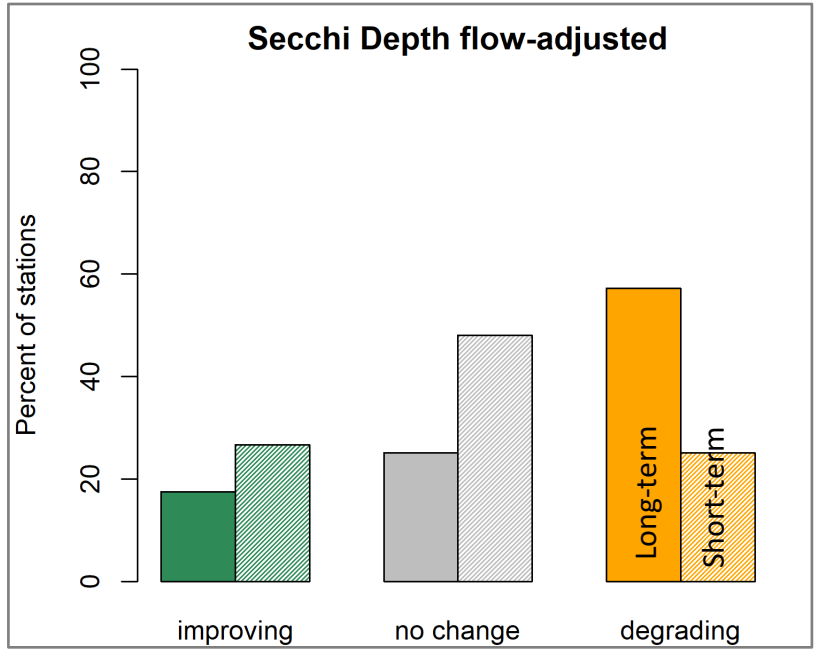




1. Upper bay fairly flat over long-term, and slight increase recently

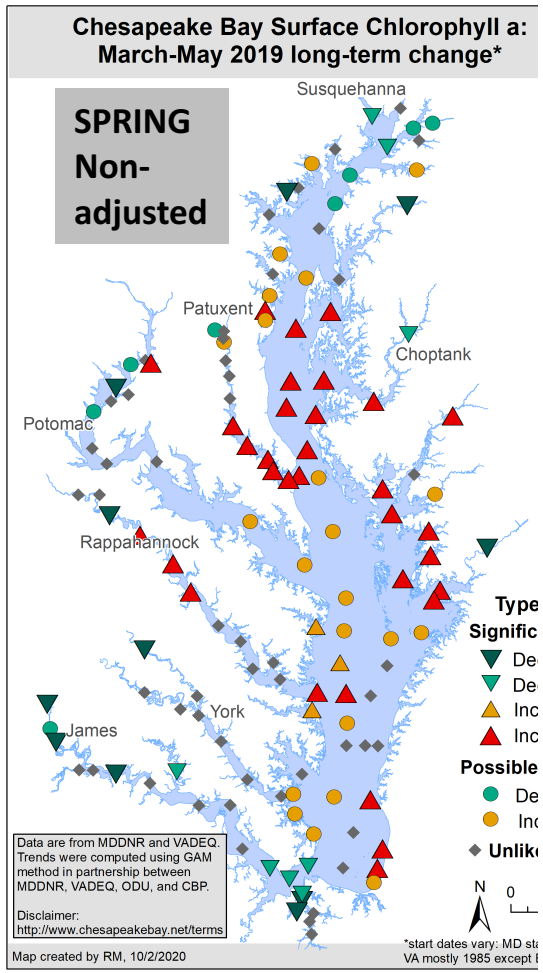
Secchi initial reactions

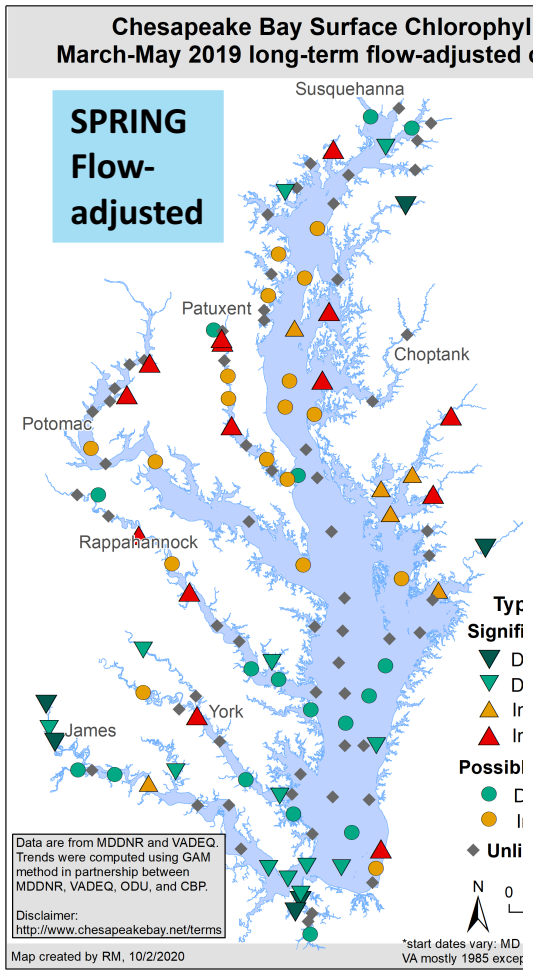
- Long-term degradation of Secchi at many stations is most obvious take-away.
- Shorter-term, the number of degradations is much lower, and there are even slightly more improvements than degradations (flow-adjusted).
- The diverse set of GAM fits over time suggests to me many different factors at play depending on location.

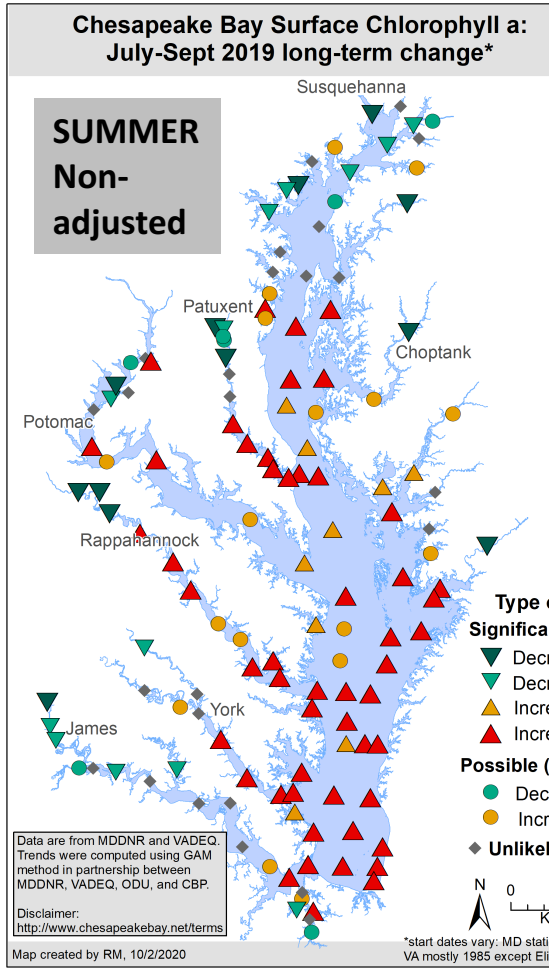


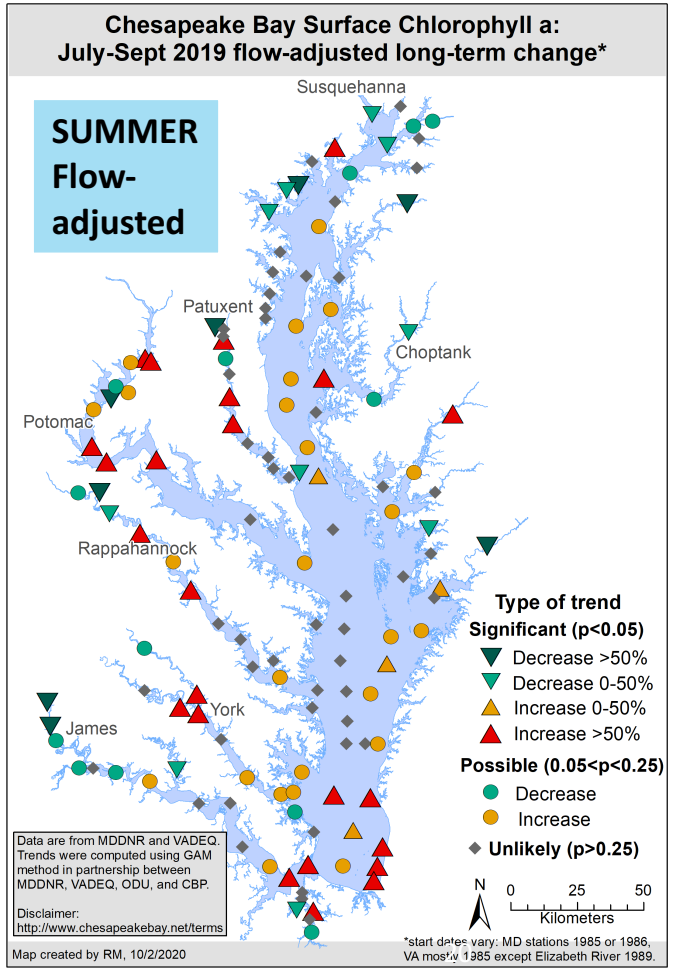
Chlorophyll-a

long-term



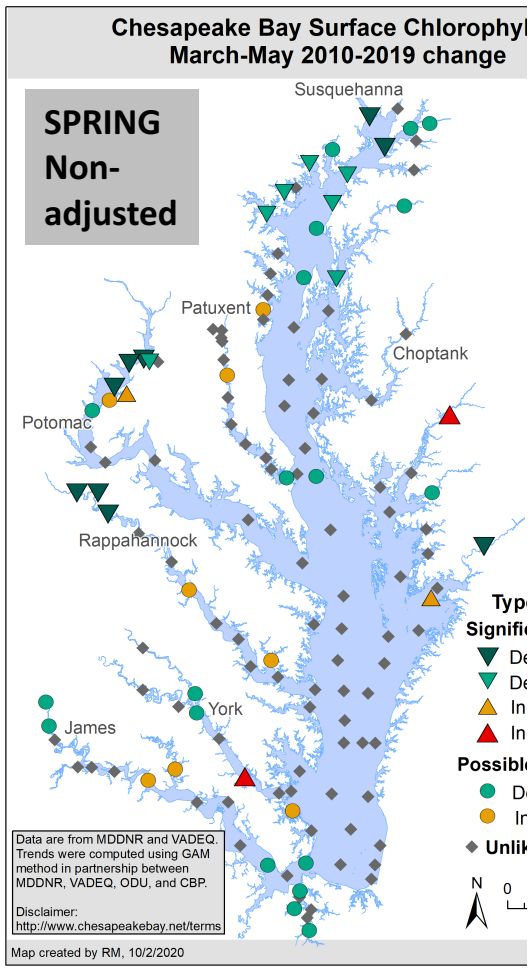


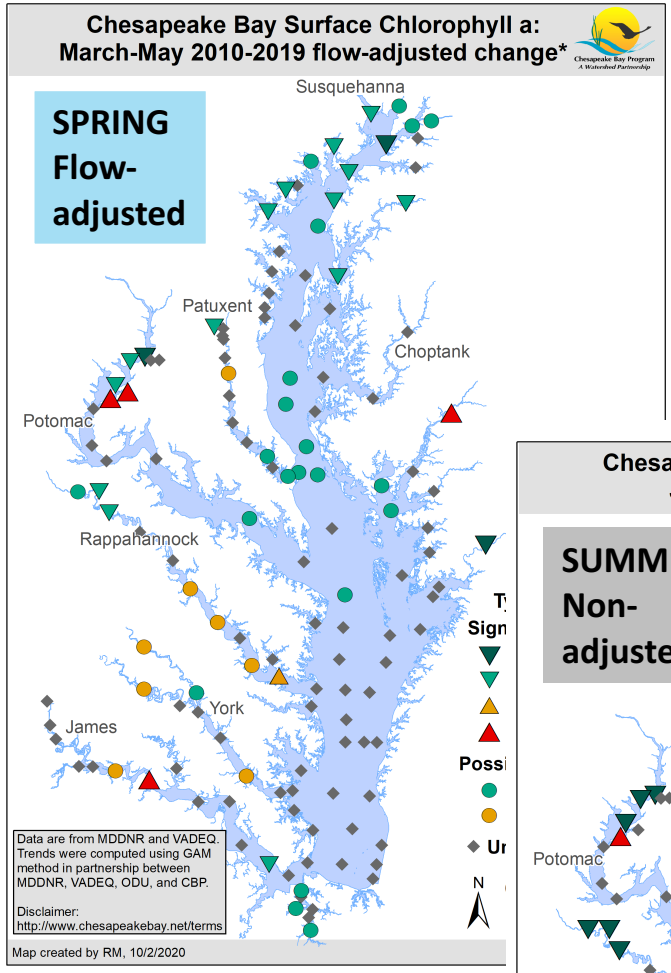


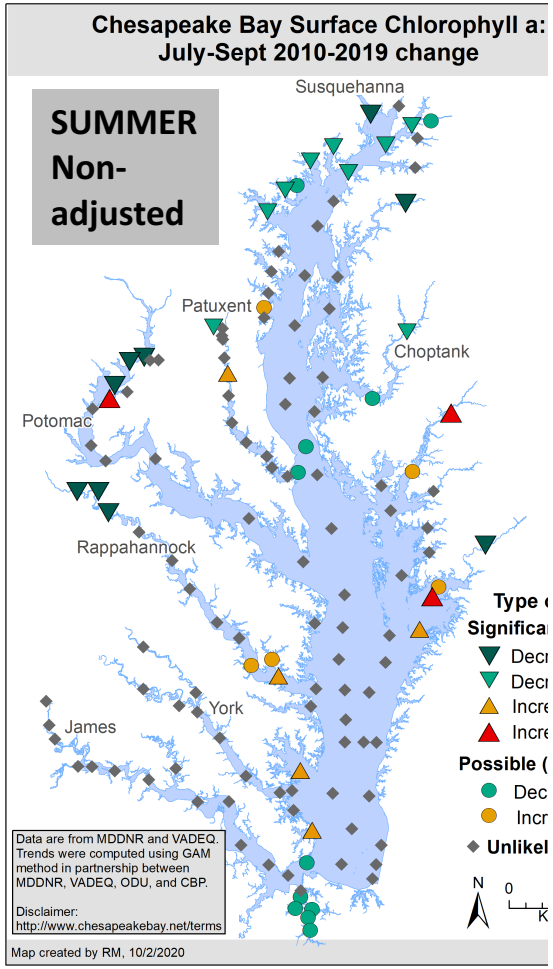


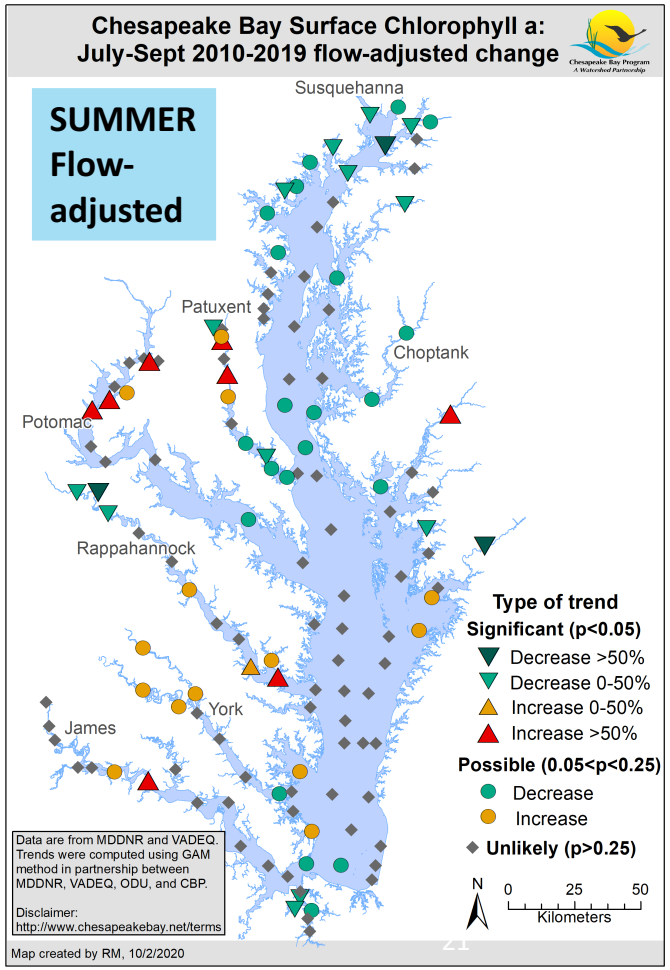
Chlorophyll-a

short-term



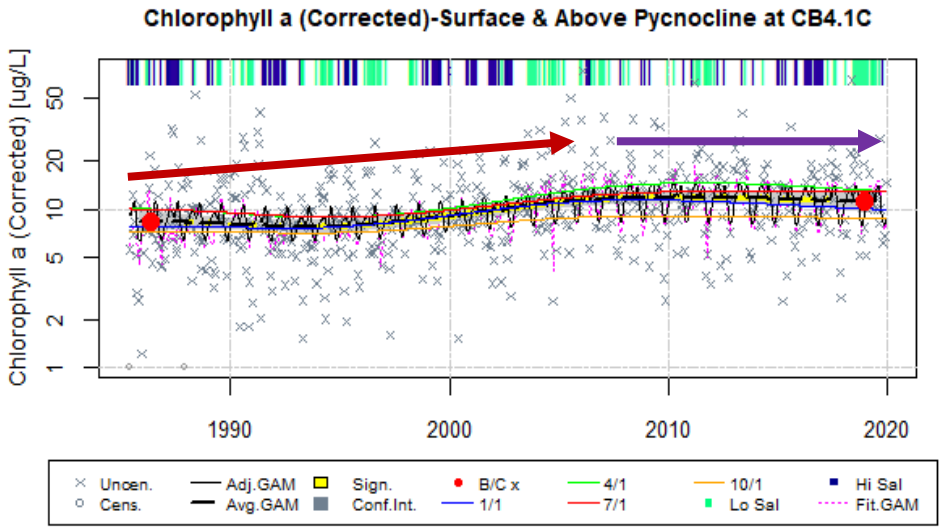




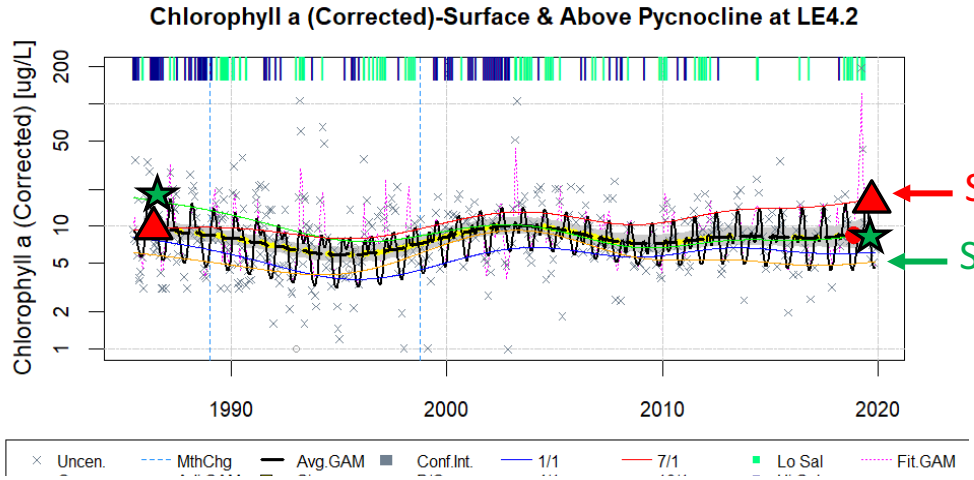


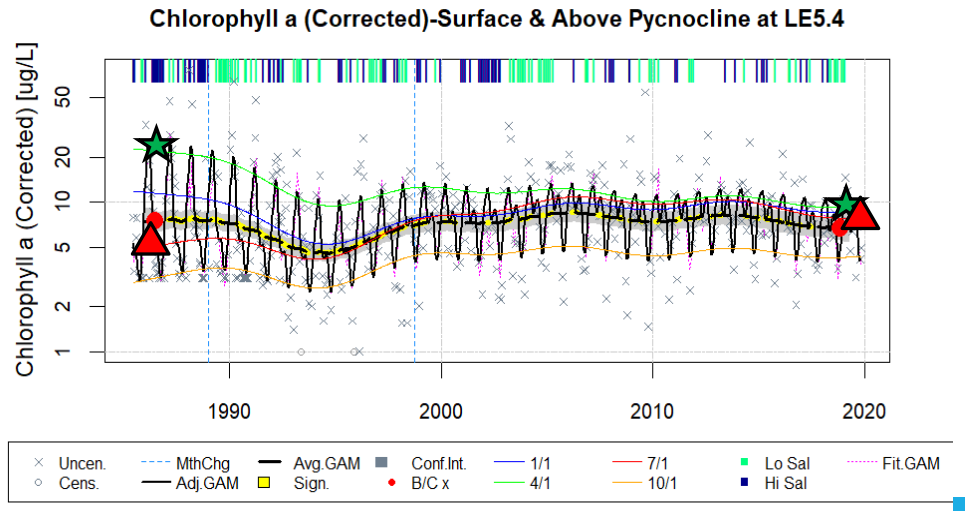
Chlorophyll-a

1. Long-term maps show many degrading locations. But over the last 10-years, many of these turn to “no change.”



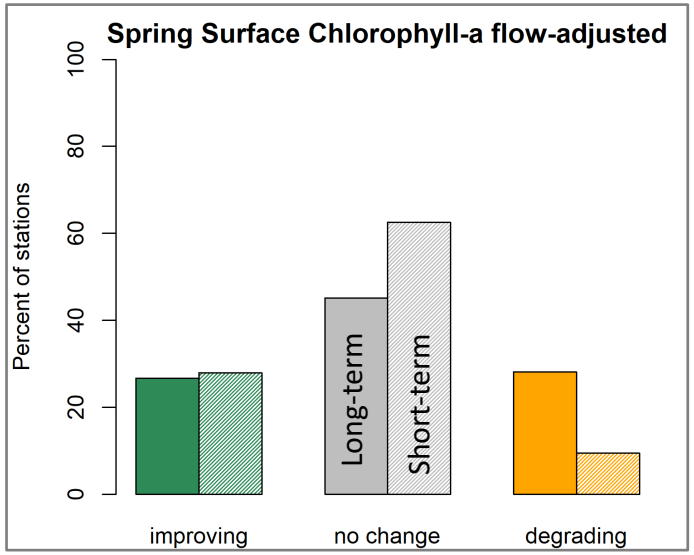
2. The polyhaline segments are the ones where we see the largest consistent difference in long-term change between the spring and summer.

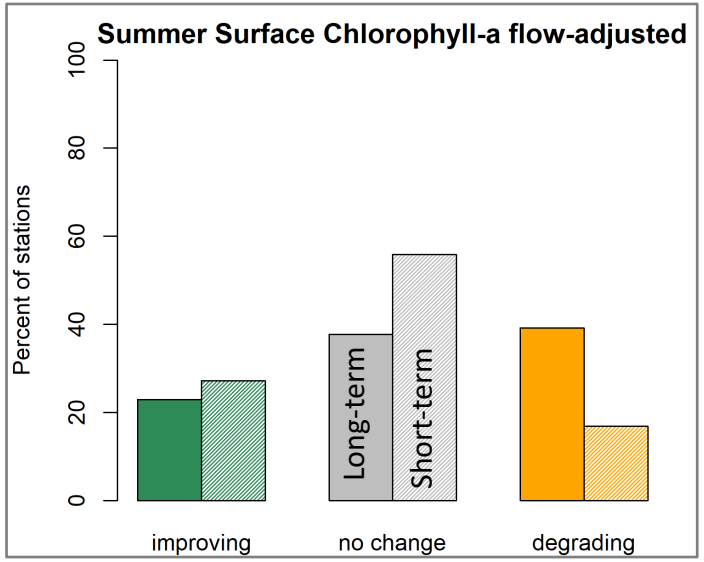




Chlorophyll-a initial reactions

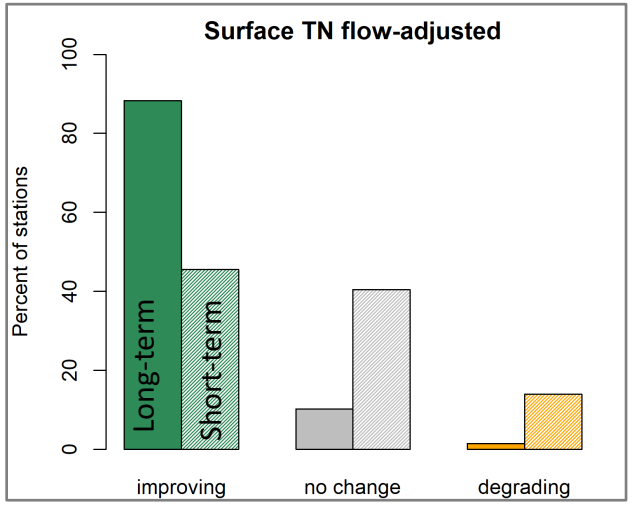
- Short-term chlorophyll-a has leveled out at many stations, turning degrading long-term changes into no change in the short-term.
- Like Secchi, patterns differ greatly by region.

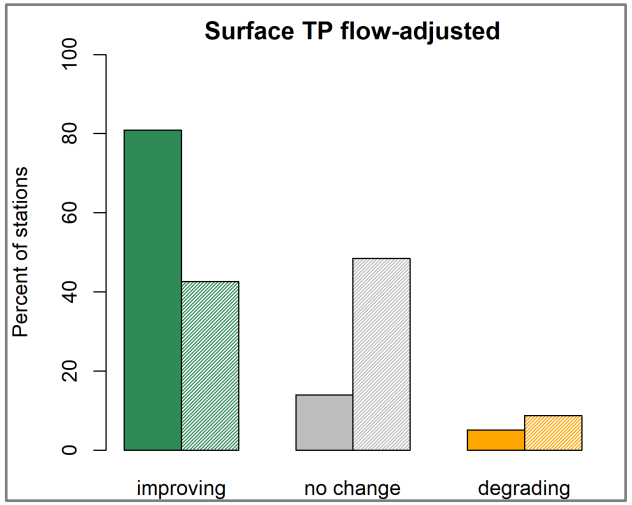


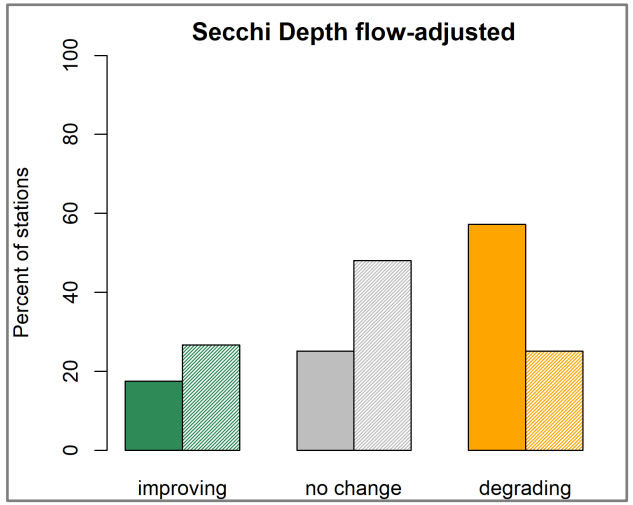


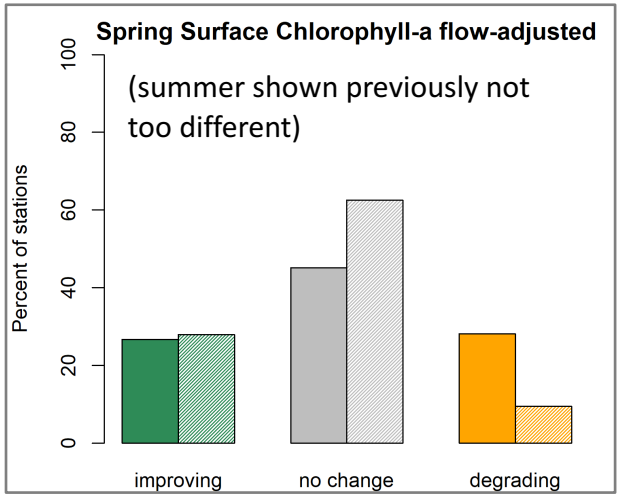
2019 Summary

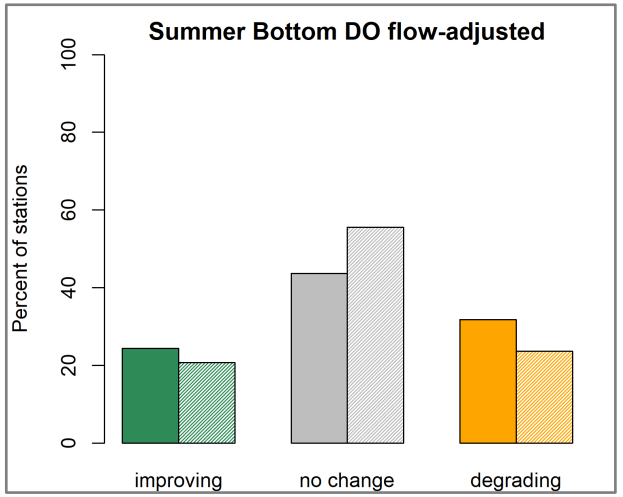
- Two very wet years influenced observed changes, but can be mostly accounted for with flow-adjustment.
- Nutrient concentrations improved mostly over the long-term, although slower rate of improvement lately.
- Some promise in reduced number of degrading stations over the short-term for Secchi, chlorophyll-a and DO.











Deeper investigations

- Currently:
  - Linking TN and TP tidal patterns to watershed nutrient loads and BFL point source loads (Murphy et al. in prep manuscript)
  - Our team is exploring how the GAM results group spatially (Elgin Perry leading)
  - Our team has used these results in combination with SEM to explore chlorophyll-a patterns in the Patuxent (Jon Harcum and Diane Allen lead, Tetra Tech)
  - Tributary reports will summarize these results by location in combination with watershed and other information (Potomac release soon, Jeni Keisman lead)
- Published studies investigating/comparing changes observed with these results:
  - Changes in nutrient limitation patterns were compared to dissolve nutrient GAMs: Zhang et al. 2021. Water Research 188.
  - Examined Secchi changes compared to kd for water clarity: Keisman et al. 2019 STAC Publication 19-004
  - Explored changing seasonality of chl-a and N: Testa et al. 2018. Frontiers in Marine Science 5:114.