

Chesapeake Bay Tidal Trends Update

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*Integrated Trends Analysis Team lead: Jeni Keisman (USGS)
Trends run by Renee Karrh (MDDNR) and Mike Lane (ODU)*

STAR

May 27, 2021



Chesapeake Bay

Tidal Trends Stations

0 25 50
Kilometers

N

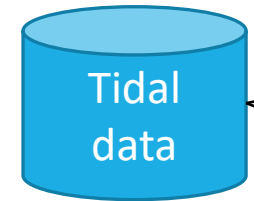
Extensive long-term coordinated
tidal monitoring

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



Matt Rath/Chesapeake Bay Program

Annual tidal trends/ change production



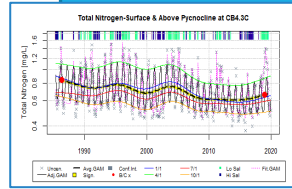
(Full set in
spring for
previous
year)

For MD:
Renee
Karrh
(MDDNR)

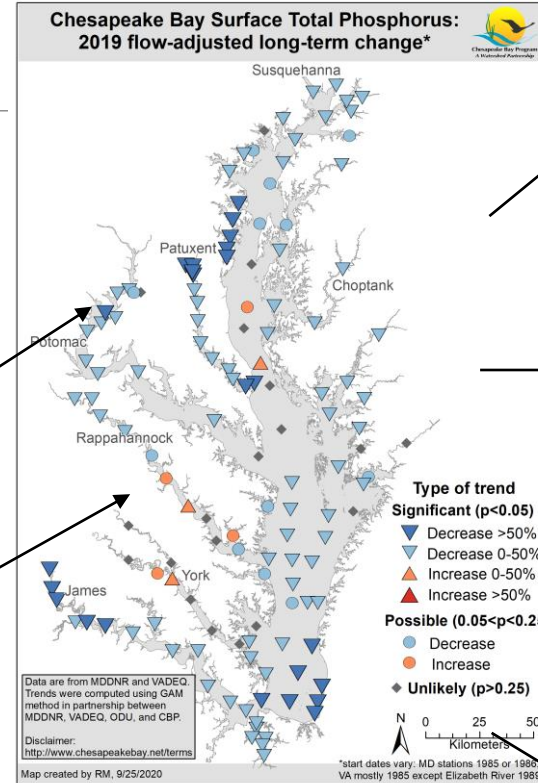
For VA:
Mike Lane
(ODU for
VADEQ)

'baytrends'
R package
to run
analysis

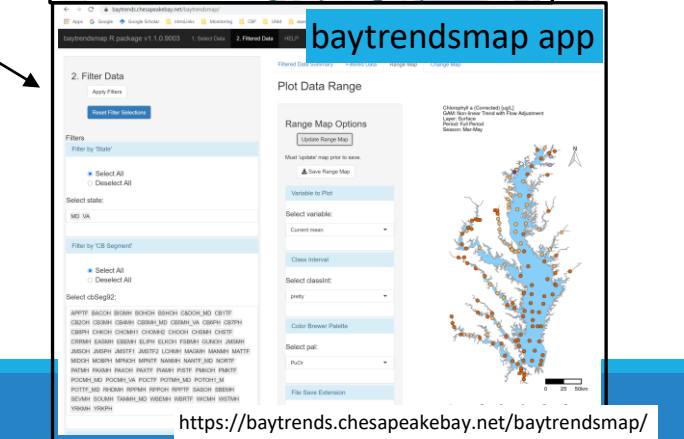
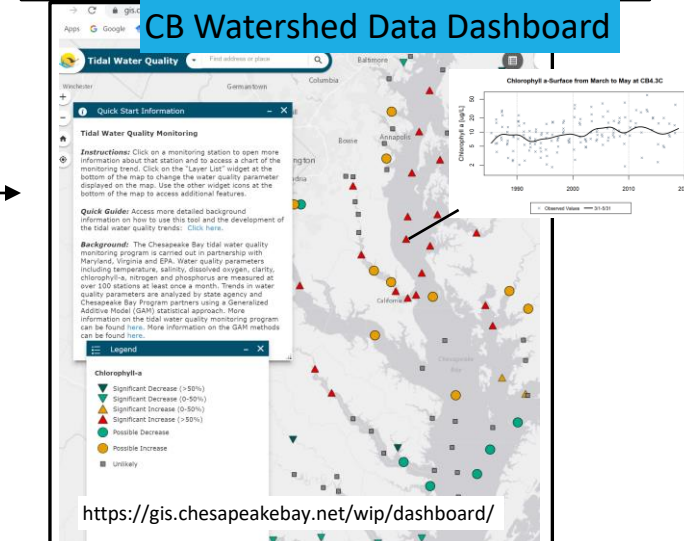
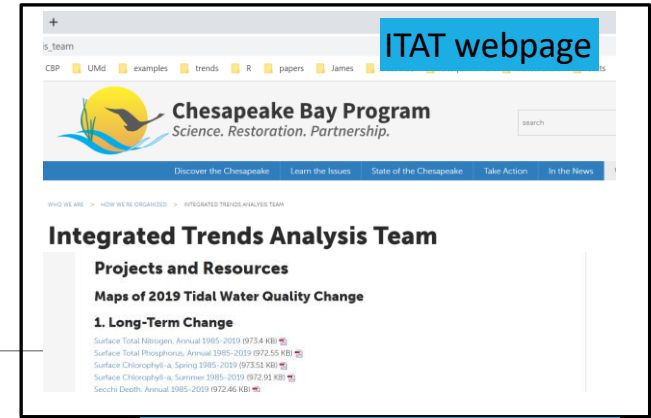
Development by:
Jon Harcum, Erik
Leppo (Tetra
Tech); Elgin Perry
(consultant); Jeni
Keisman (USGS)
Rebecca Murphy
(UMCES)



Submitted to CBP
& combined
(June)




(Made available during the fall, for
previous year)



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



Applicable to many of the outcomes:

- Fisheries and habitat
- SAV
- Water quality standards
- Climate change

Annual tidal trend results

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 - Temperature
- Capture the spatial and temporal dynamics:
 - Surface & bottom
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Water temperature

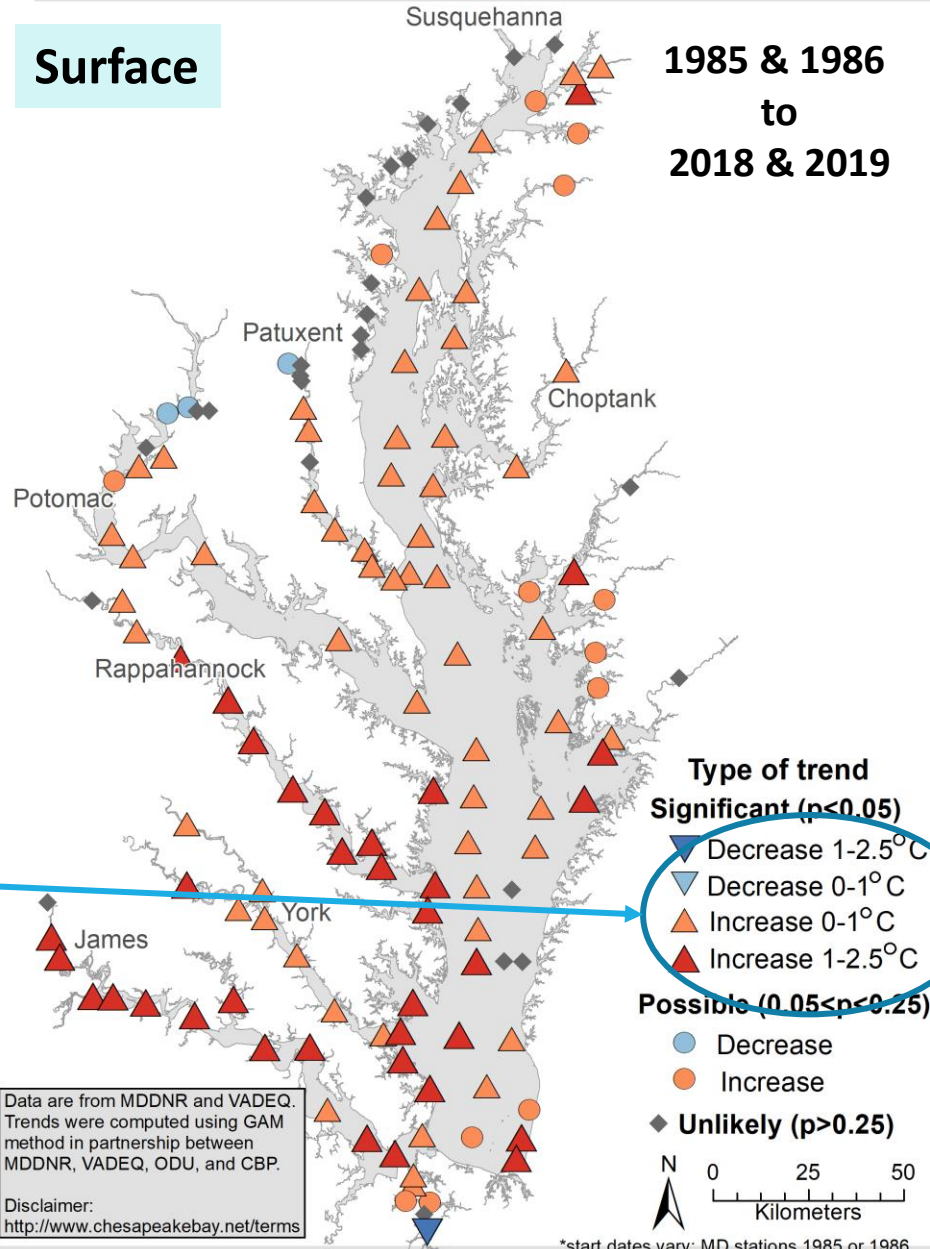
Water temp long-term

Chesapeake Bay Surface Water Temperature: 2019 long-term change*



Surface

1985 & 1986
to
2018 & 2019

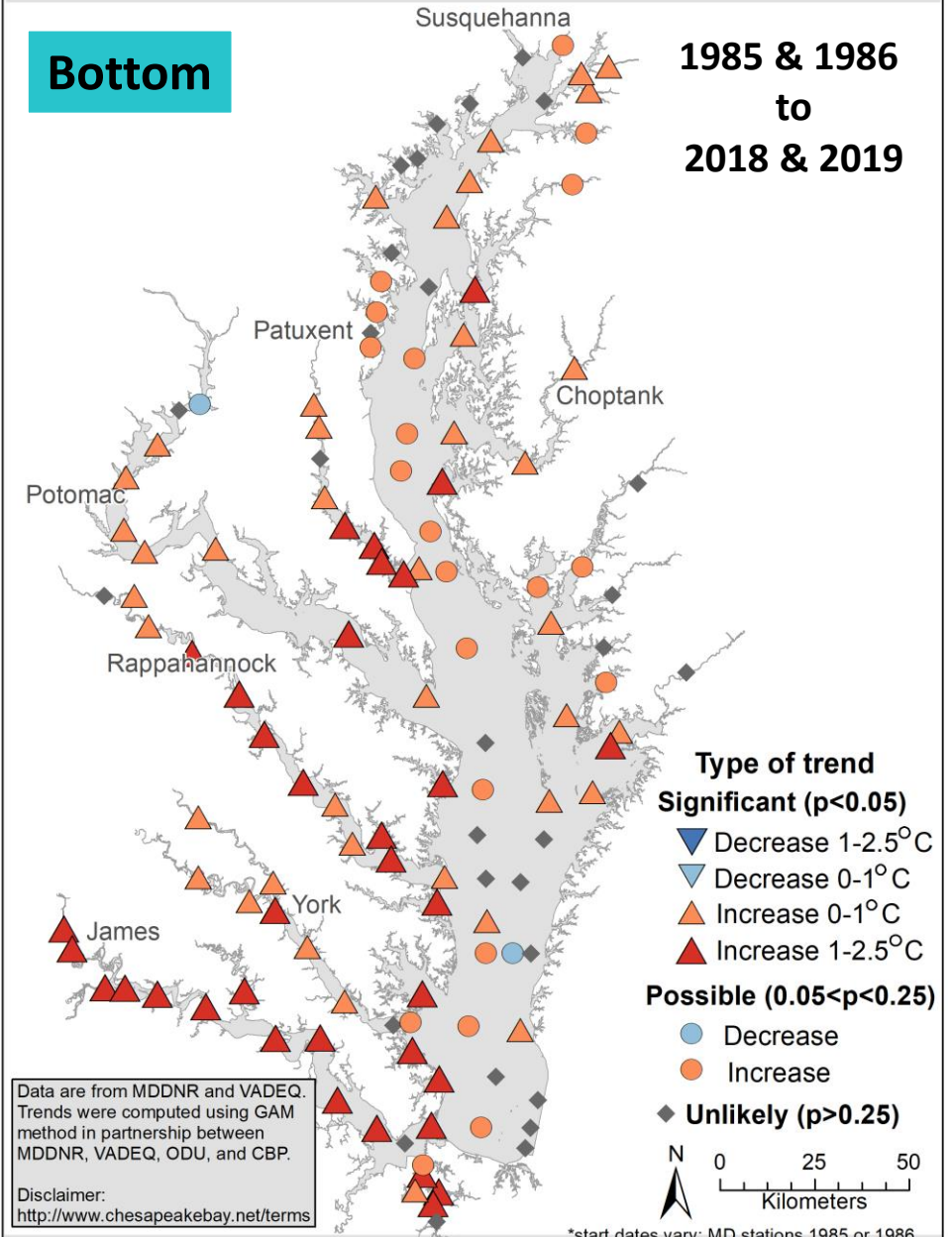


Chesapeake Bay Bottom Water Temperature: 2019 long-term change*



Bottom

1985 & 1986
to
2018 & 2019



These are for
the 34 years.

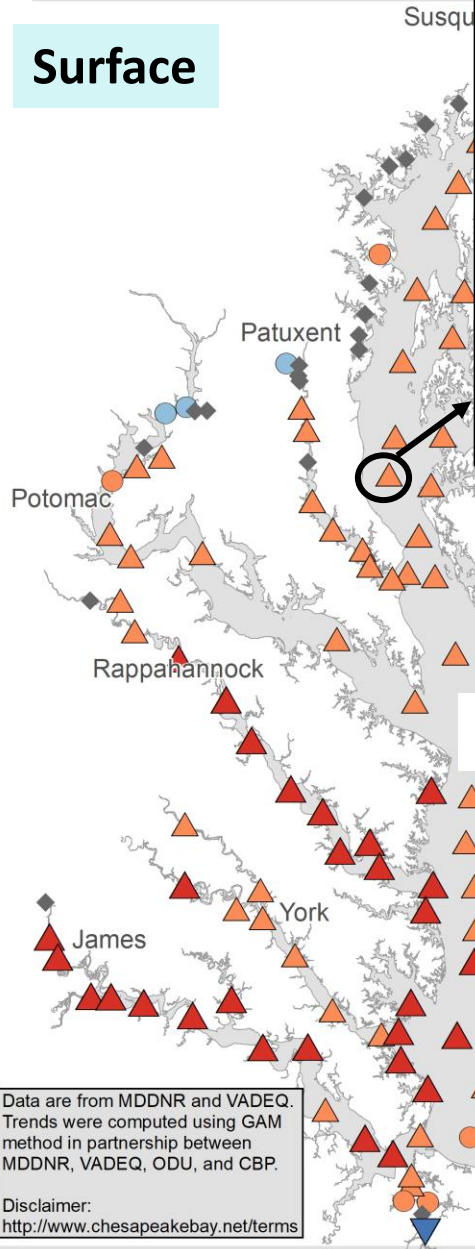
Per year, median
surface increase
= 0.024 C

Water temp long-term

Example surface change larger

Chesapeake Bay Surface Water Temperature: 2019 long-term trend*

Surface

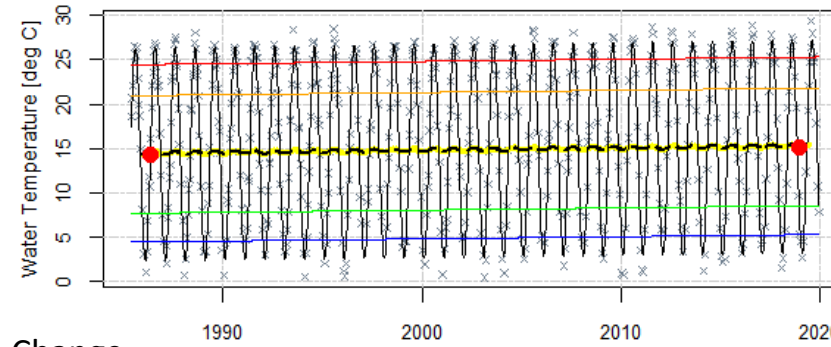


Data are from MDDNR and VADEQ. Trends were computed using GAM method in partnership between MDDNR, VADEQ, ODU, and CBP.

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

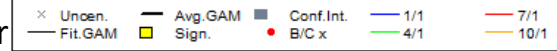
Map created by RM, 10/6/2020

Water Temperature-Surface & Above Pycnocline at CB4.3C



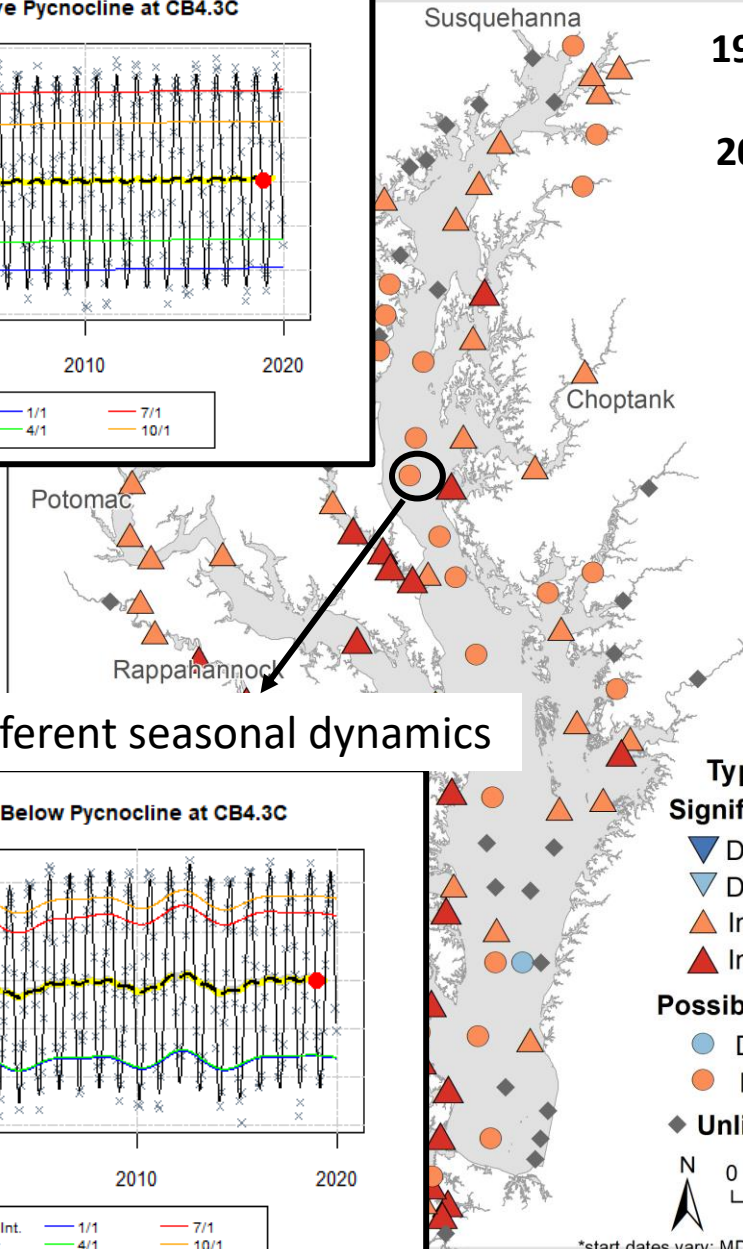
Change

= 0.024/yr



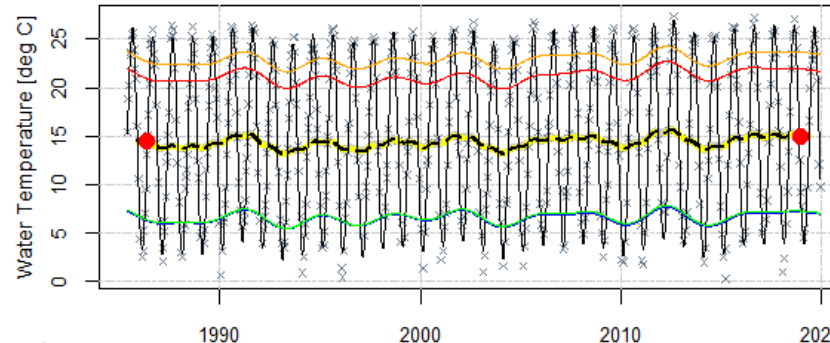
Chesapeake Bay Bottom Water Temperature: 2019 long-term trend*

1985 & 1986
to
2018 & 2019



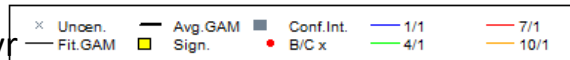
More wiggly, also slightly different seasonal dynamics

Water Temperature-Bottom & Below Pycnocline at CB4.3C



Change

= 0.014/yr



Type of trend

Significant ($p < 0.05$)

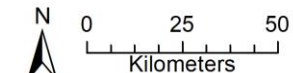
- Decrease 1-2.5°C (dark blue triangle)
- Decrease 0-1°C (light blue triangle)
- Increase 0-1°C (orange triangle)
- Increase 1-2.5°C (red triangle)

Possible ($0.05 < p < 0.25$)

- Decrease (light blue circle)
- Increase (orange circle)

Unlikely ($p > 0.25$)

- Unlikely (grey diamond)



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

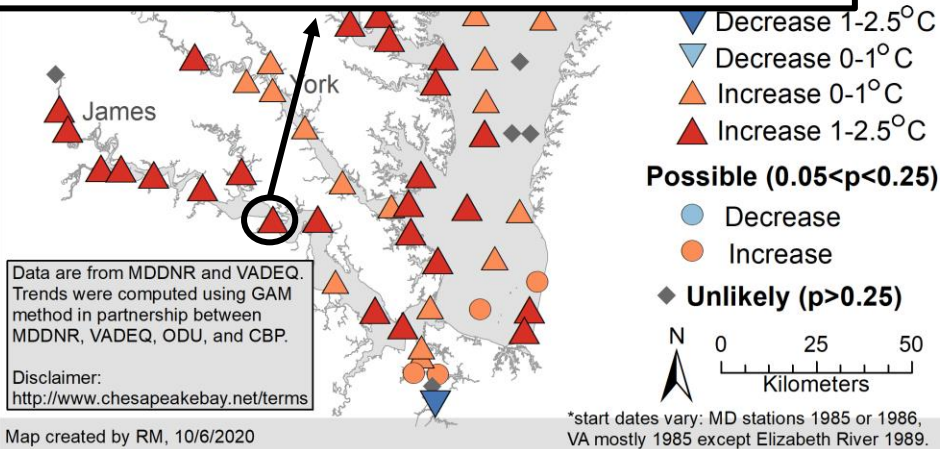
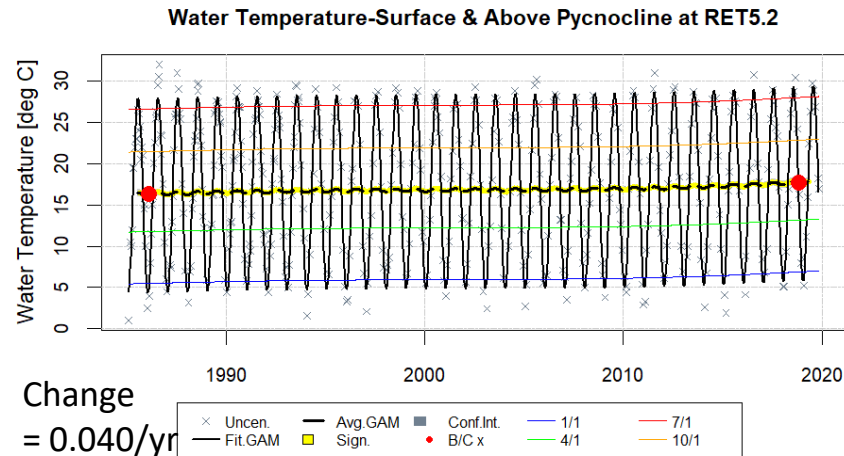
Water temp long-term

Chesapeake Bay Surface Water Temperature: 2019 long-term change*



Surface

Susquehanna 1985-2019

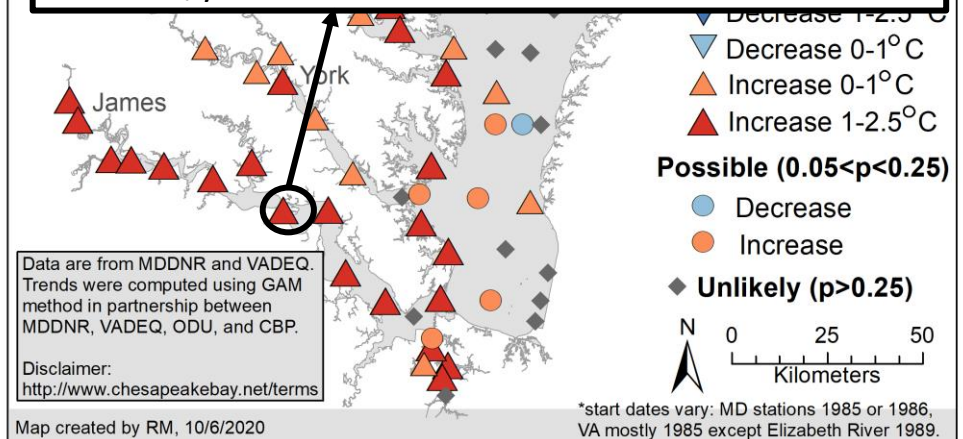
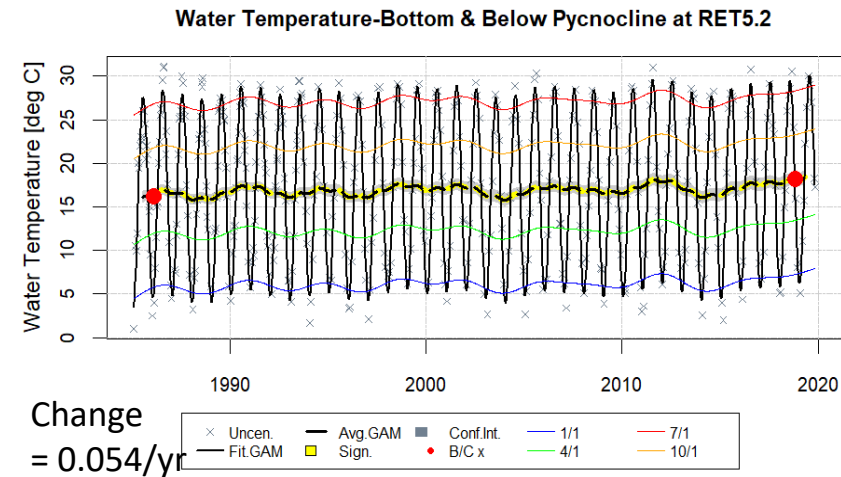


Chesapeake Bay Bottom Water Temperature: 2019 long-term change*



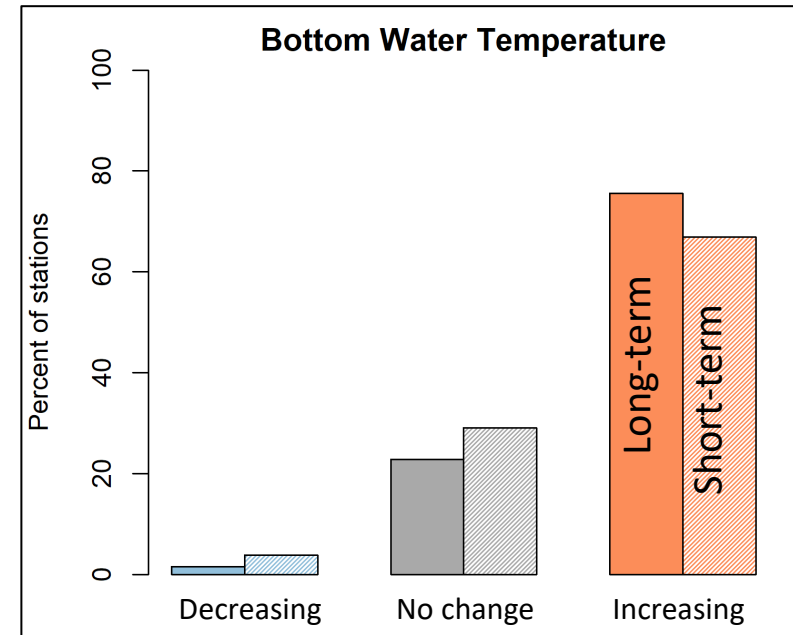
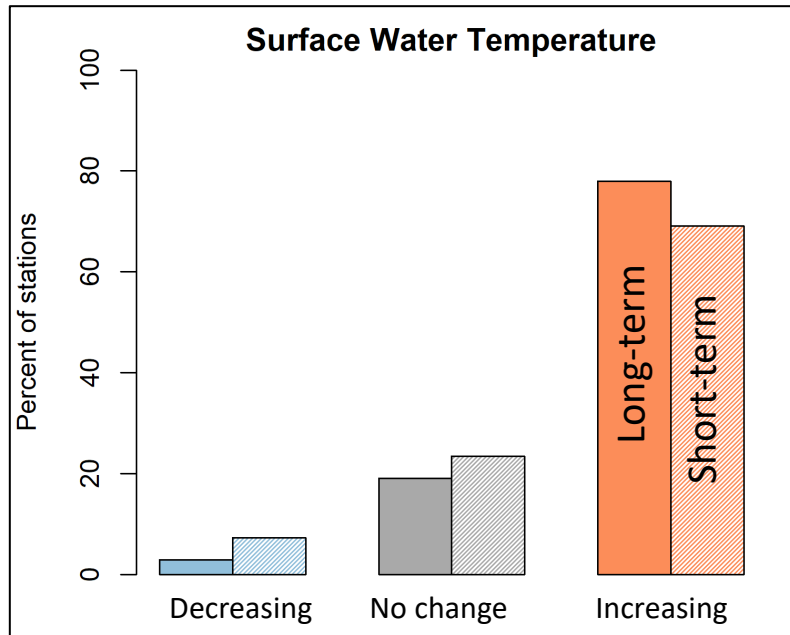
Bottom

Susquehanna 1985-2019



Example bottom change larger

Water temperature trend summary

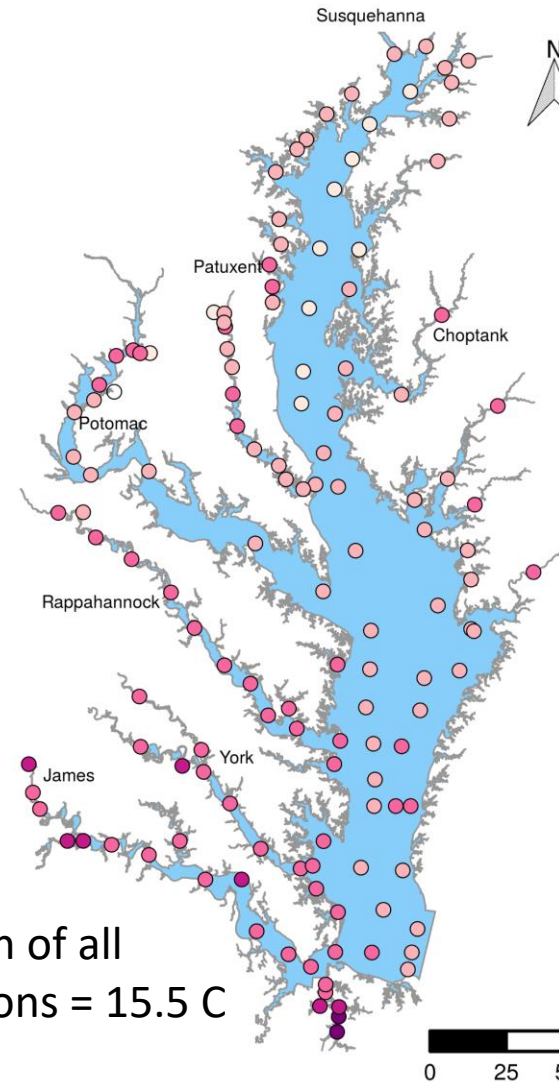


Other output possibly useful

- Can specify any period to generate an estimate of the mean for those dates
- These are annual, but could be output for a certain season
- Could combine these into baywide or regional averages, annual or certain season.

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

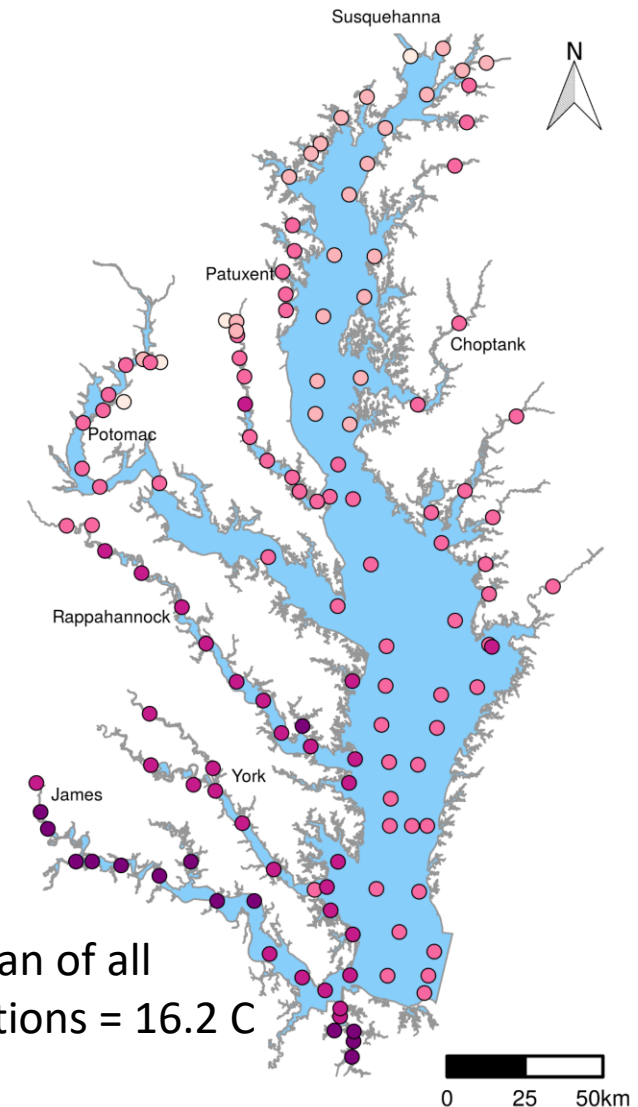
Surface water temp 1985-1986 mean



Mean of all
Stations = 15.5 C

Baseline mean
○ 13.5-14.5 ● 15.5-16.5 ● 17.5-18.5
● 14.5-15.5 ○ 16.5-17.5 ○ NA

Surface water temp 2018-2019 mean



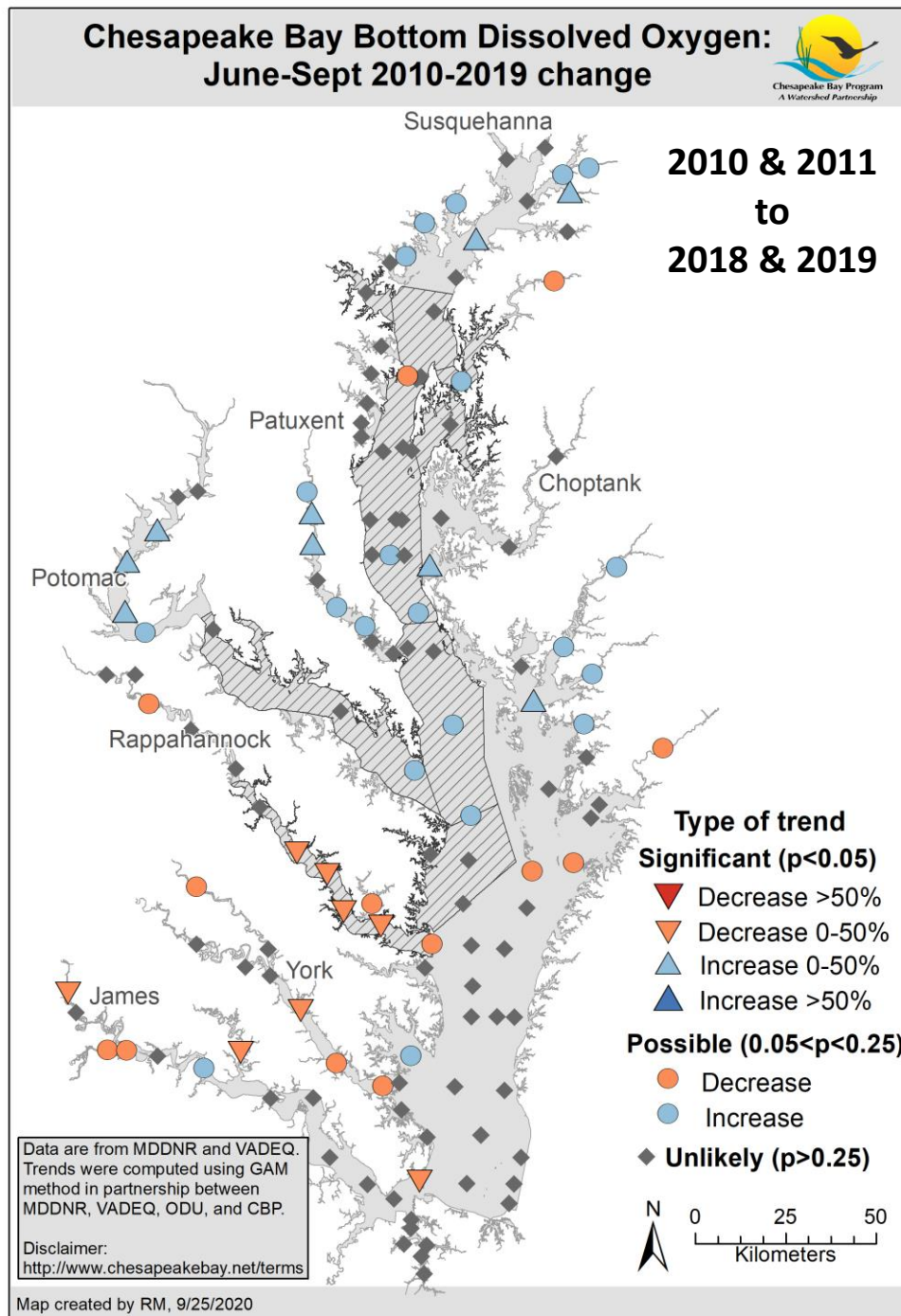
Mean of all
Stations = 16.2 C

Current mean
○ 13.5-14.5 ● 14.5-15.5 ● 15.5-16.5 ● 16.5-17.5 ● 17.5-18.5

Summer Bottom Dissolved Oxygen

Summer Bottom DO

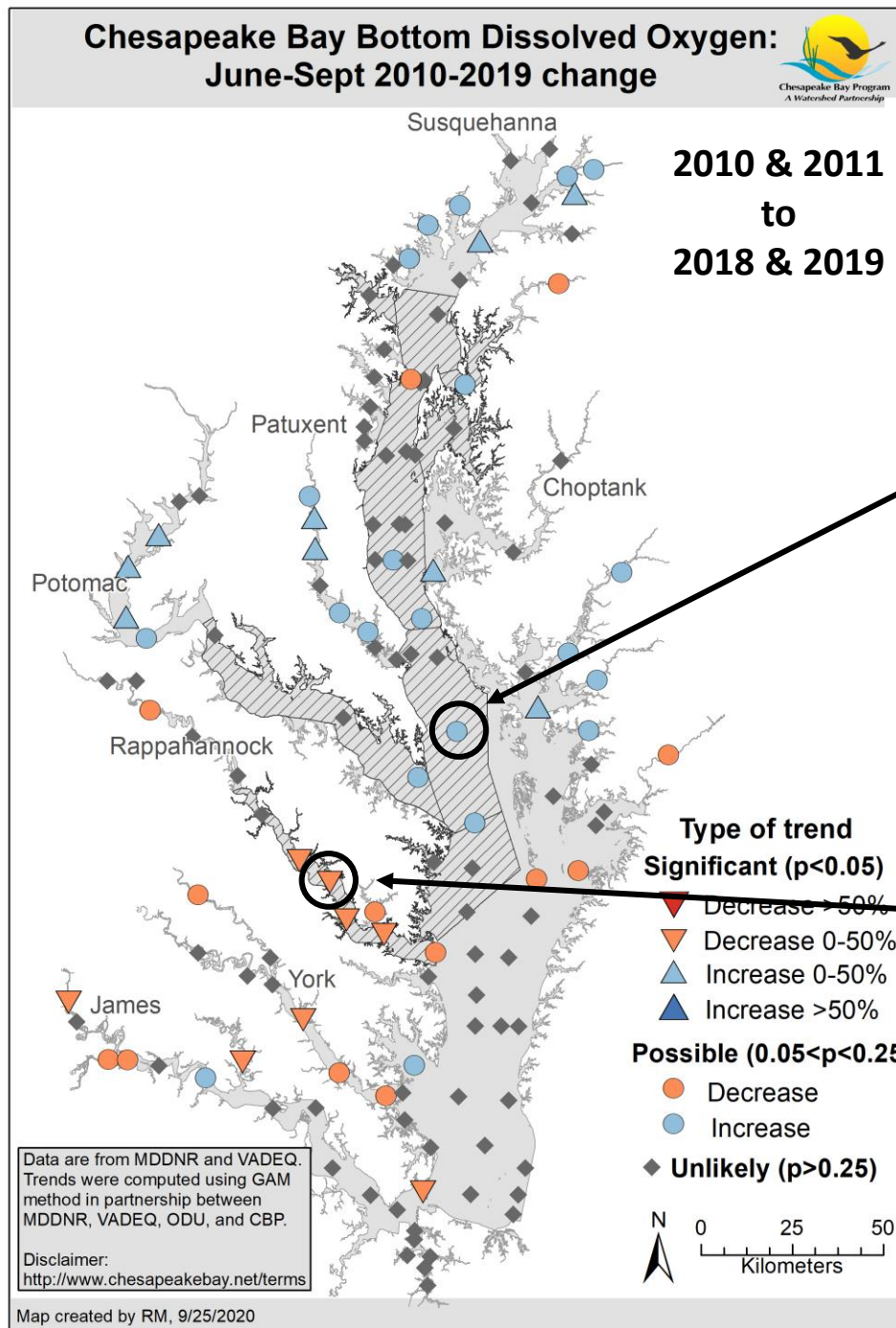
short-
term



- Depths vary greatly across the tidal waters.
- Very different forces are influential to bottom DO depending on mixing and depth.
- Deep channel segments with the summer criteria 1 mg/L are indicated with hatching.

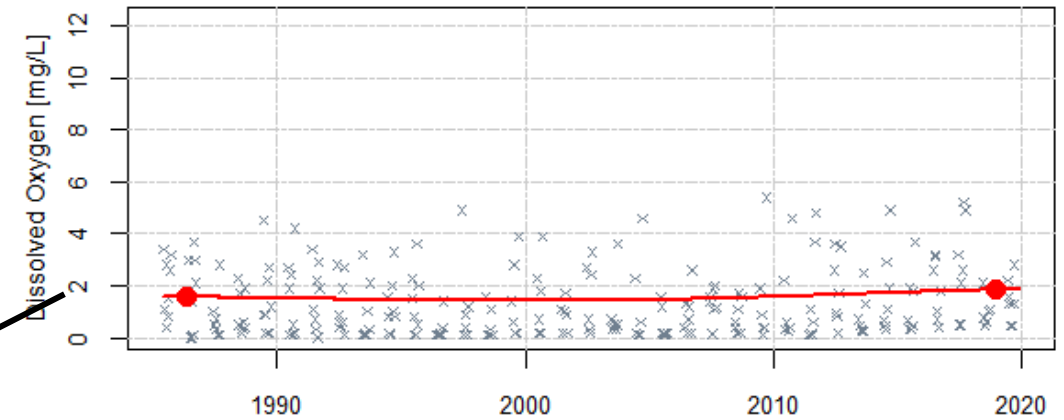
Summer Bottom DO

short-term



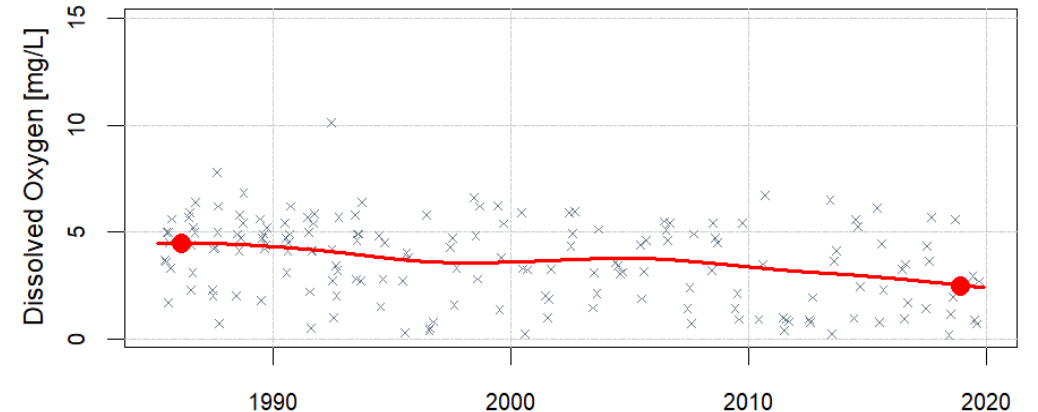
1. Small, but meaningful DO increase in deep mainstem in last 10 years.

Dissolved Oxygen-Bottom at CB5.2



2. Only deep channel segment with degradation is in Rappahannock. Can see it clearly in plots.

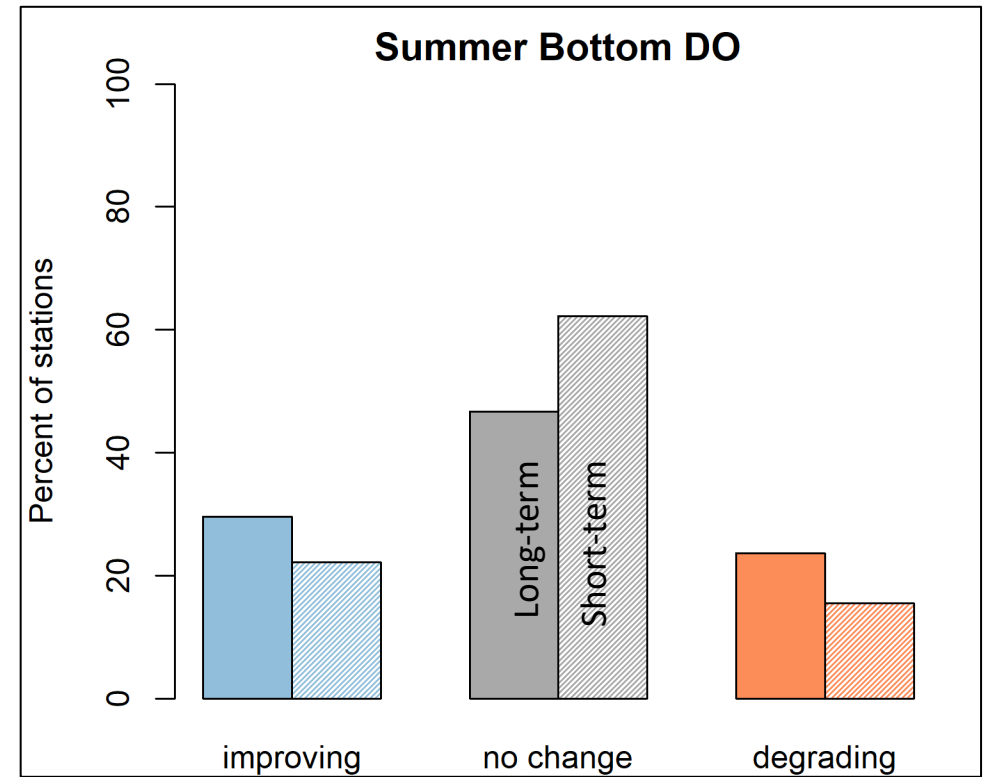
Dissolved Oxygen-Bottom at LE3.1



× Uncen. • B/C x — 6/1-9/30

DO summary

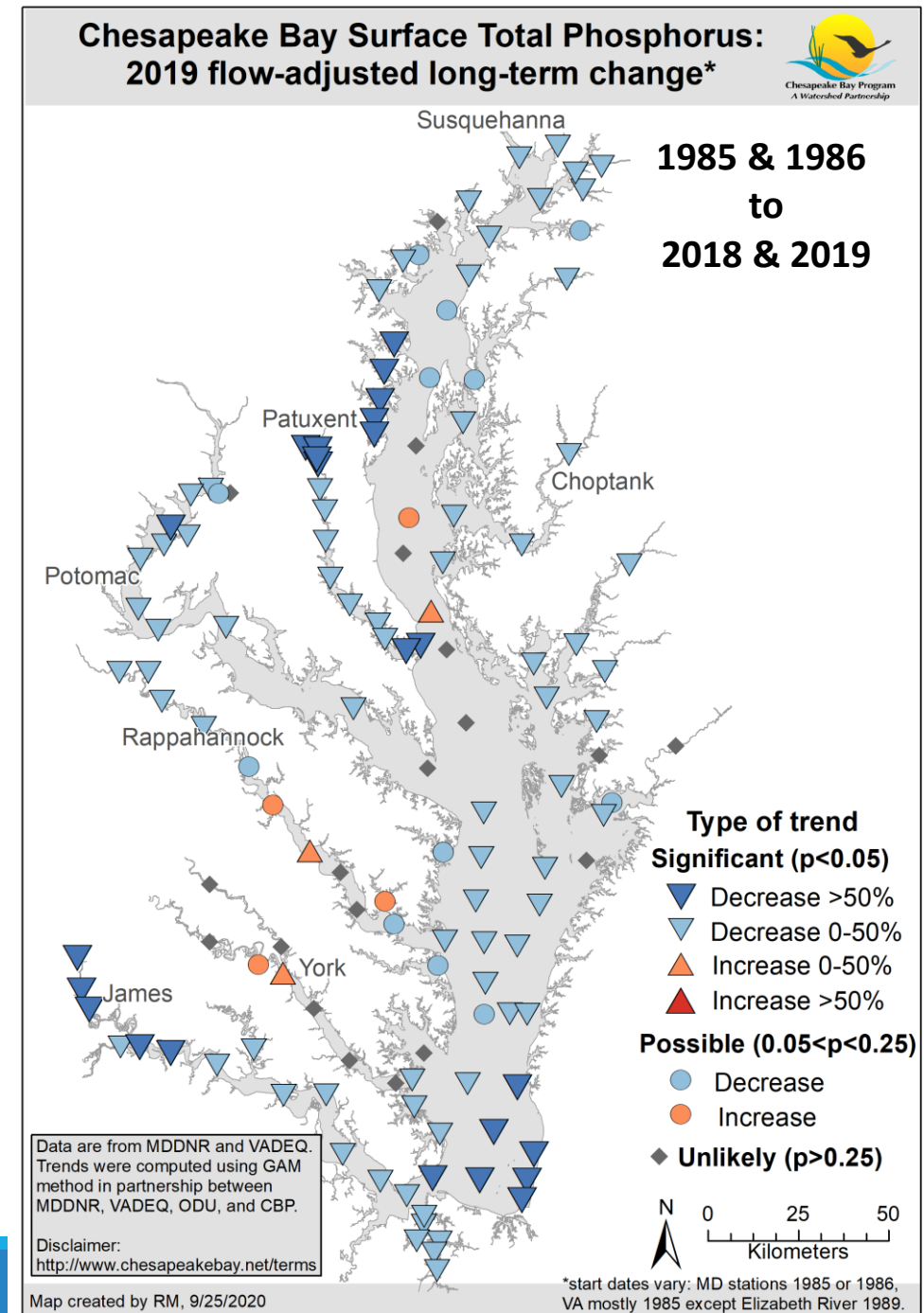
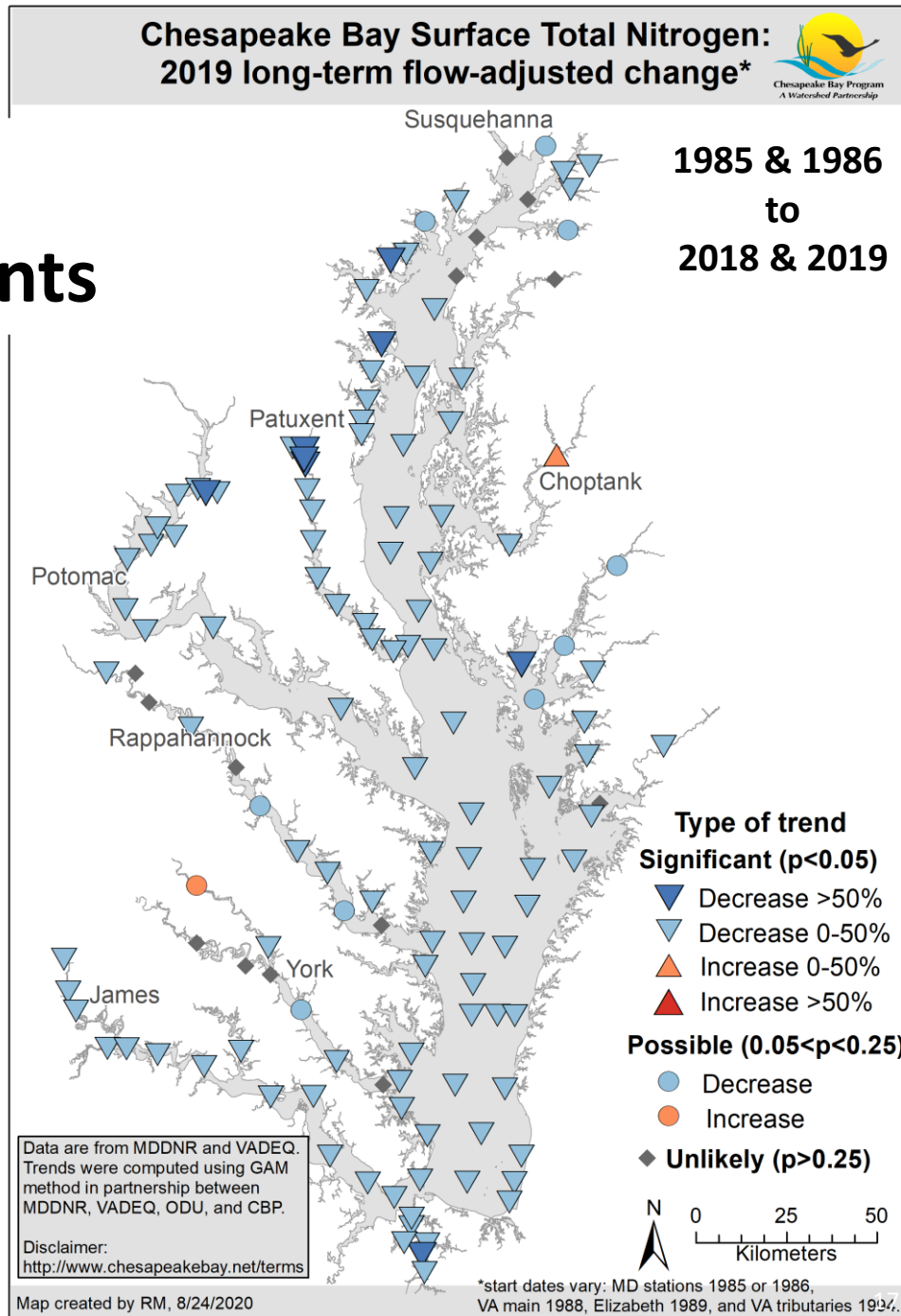
- A wide-variety of DO trends are likely due to different bottom conditions throughout the tidal waters.
- Most stations show no significant change over time.
- Notably, mainstem deep channel stations are slightly improving due to near-zero values not occurring as much anymore.



Total Nutrients

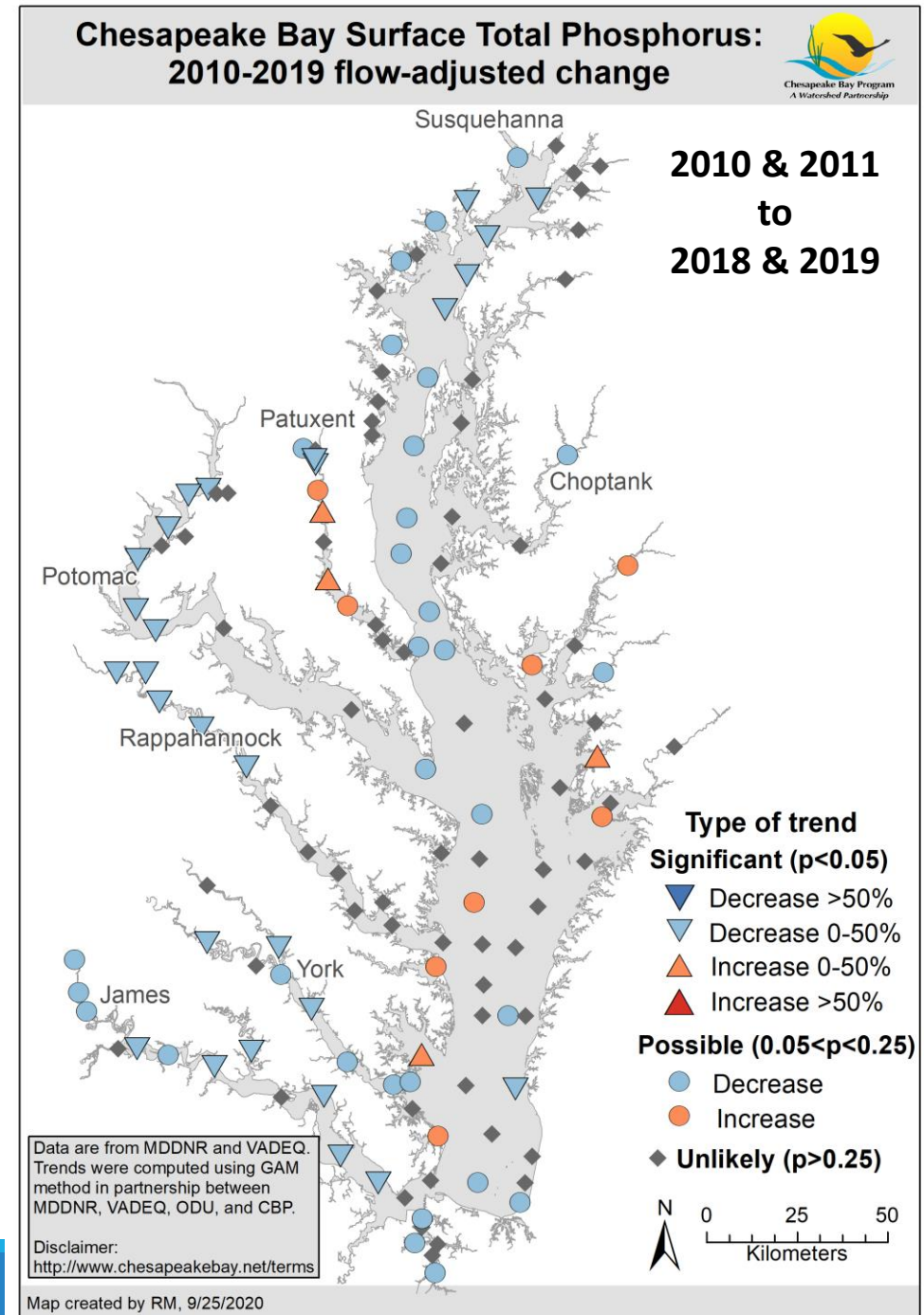
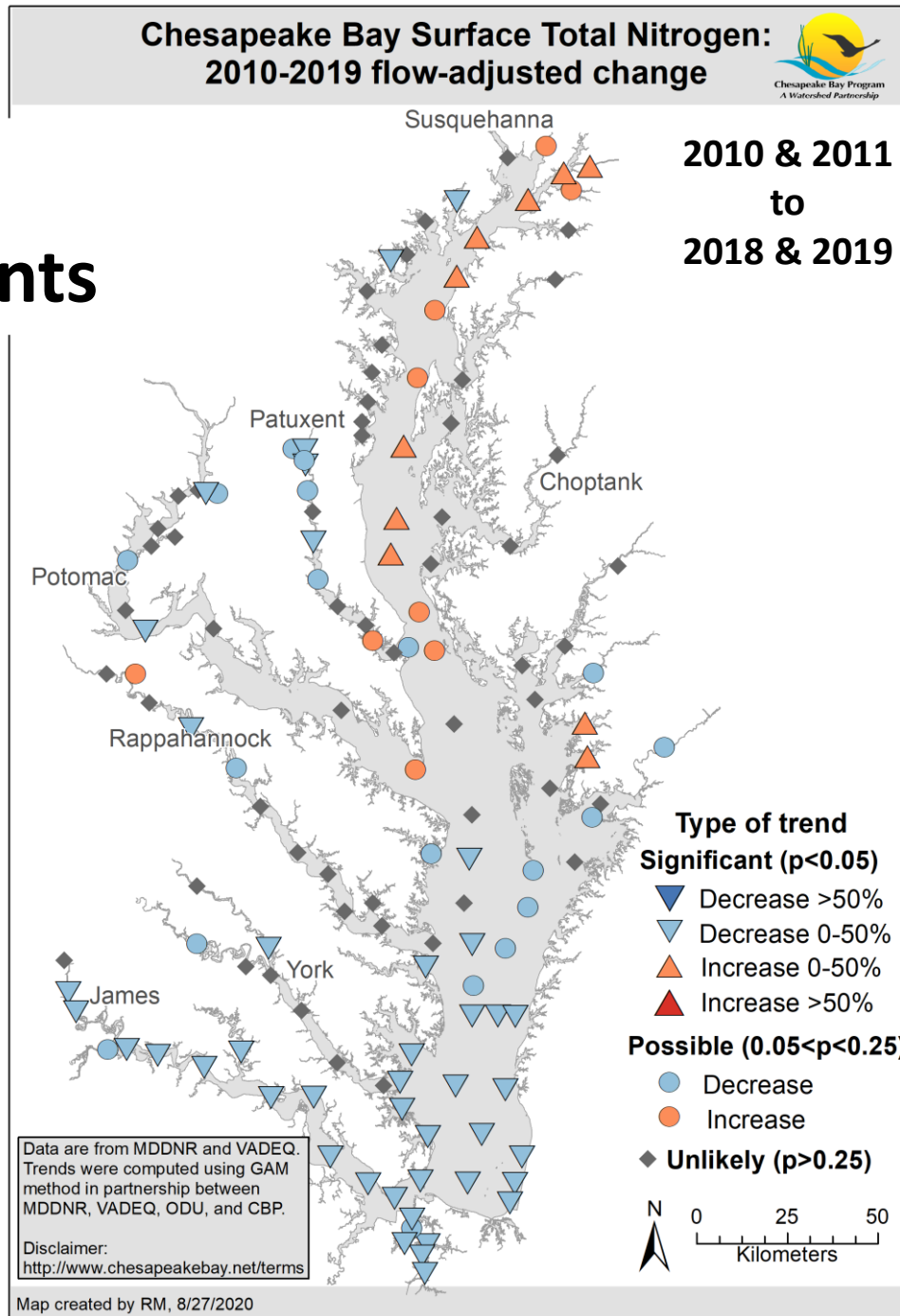
Total nutrients

long-
term



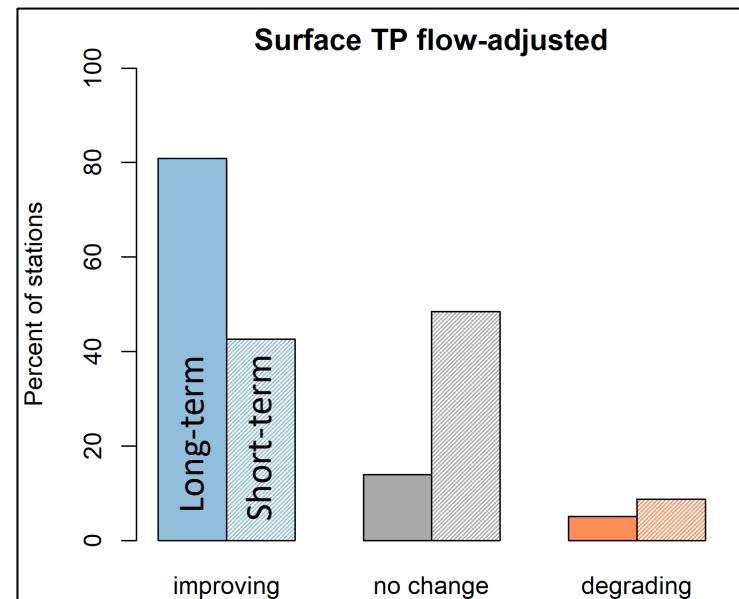
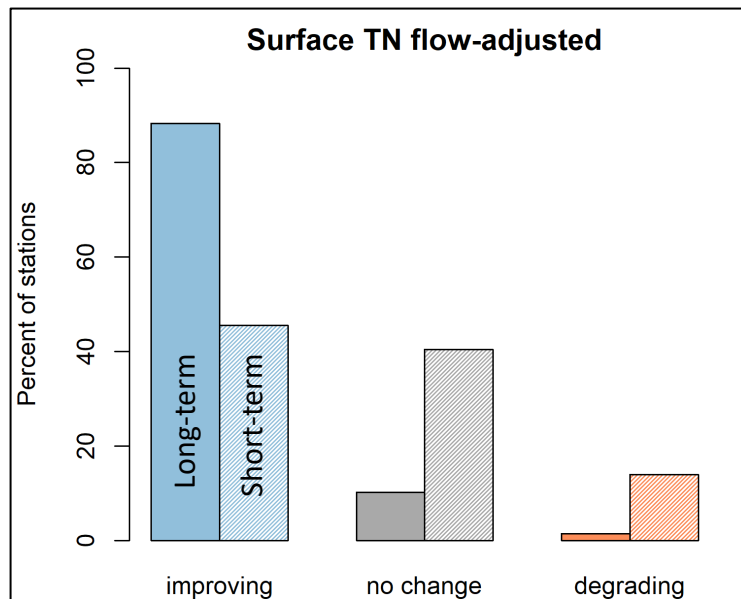
Total nutrients

short-
term



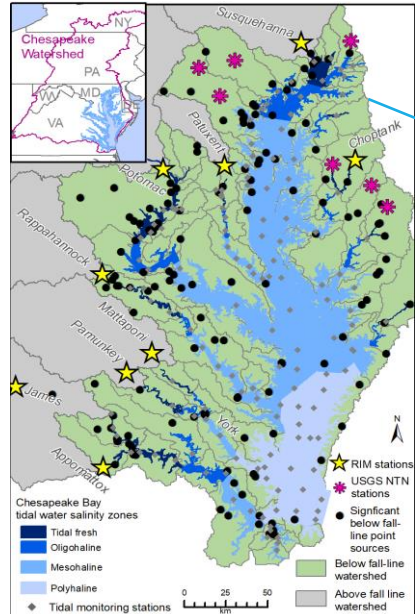
Total nutrients summary

- Long-term decreases at most stations (bottom is similar).
- Short-term changes are mixed with some plateauing of previously decreasing loads.

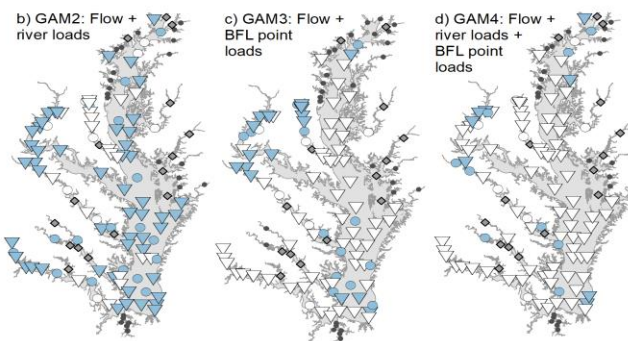


Using the results

Research explaining trends



Point vs. riverine
explanation of nutrient
trends



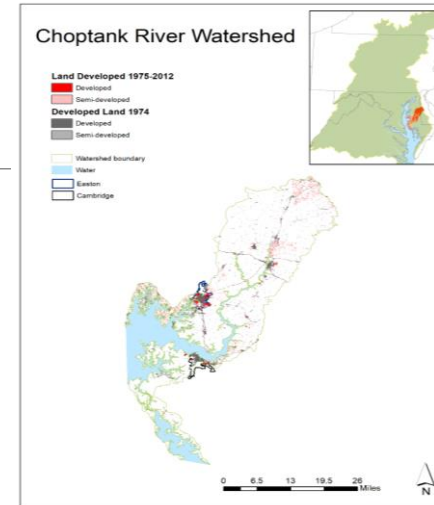
Trend after accounting for flow and load(s) (b, c, d):

- ▲ Strong decrease
- Possible decrease
- △ None, at station with strong decrease after accounting for flow only
- None, at station with possible decrease after accounting for flow only
- ◆ None
- Station not analyzed

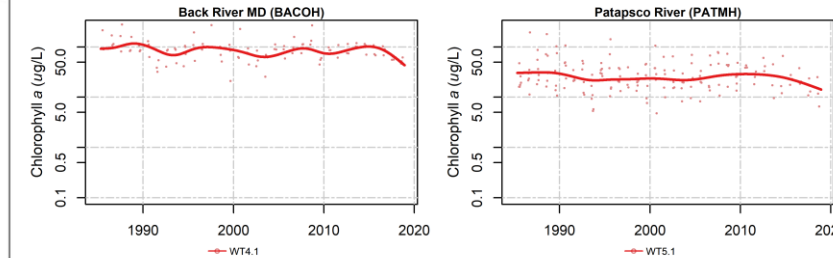
Murphy, Keisman, Perry, Harcum, Karrh, Lane, Zhang - in prep

Basin summaries

12 summaries documenting tidal
trends & watershed factors by region
→ *available online very soon*



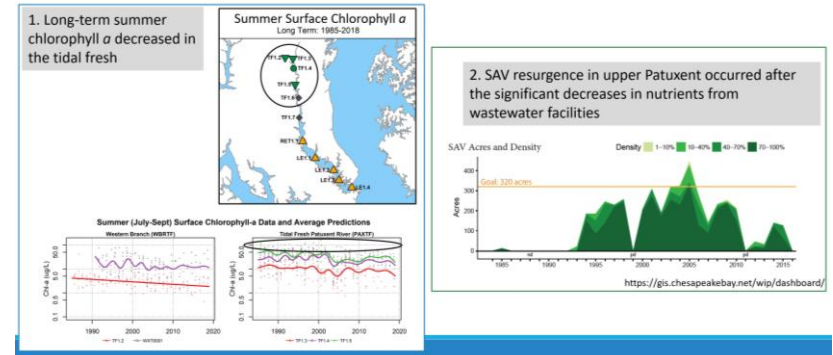
Summer (July-Sept) Surface Chlorophyll *a* Data and Average Predictions



<https://cast.chesapeakebay.net/Home/TMDLTracking#tributaryRptsSection>

Technical assistance to partners

Other improvements over the long-term:
Tidal fresh chlorophyll *a* & SAV



For MD Tech assistance meeting: May 17, 2021

Thank you

Tidal trends team:

- Jeni Keisman (USGS)
- Rebecca Murphy (UMCES/CBP)
- Elgin Perry
- Jon Harcum and Erik Leppo (Tetra Tech)
- Renee Karrh (MDDNR)
- Mike Lane (ODU)
- Cindy Johnson (VADEQ)

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