Progress in Open-Water DO Analysis using Shallow Water Data

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Modeling Workgroup Meeting

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Motivation:

CBP climate change scenarios predict more negative impacts on summer dissolved oxygen (DO) concentrations in Open and Shallow Water areas than in Deep Water, but it is still under investigation how well the estuarine model is capturing Open and Shallow response to rising air temperatures.

Rationale:

We can gain some insight into the estuarine model climate change predictions by analyzing the shallow water monitoring data and comparing patterns in temperature and DO to nearby long-term monitoring stations.

Shallow Water (SW) Question:

CBP climate change scenarios predict that DO in “shallow” waters (~1-3m total depth to bottom) will be more impacted than Open Water. ***Are the monitoring data showing evidence of this effect?***

Approach:

1. Evaluate whether the frequency of DO and percent DO saturation criteria violation has increased at a select set of shallow water monitoring stations over the period of record.

2. Investigate how water temperature change relates to DO criteria violation concentration in shallow waters.

3. Compare temperature and DO trends in shallow water monitoring data to nearby long-term monitoring stations.

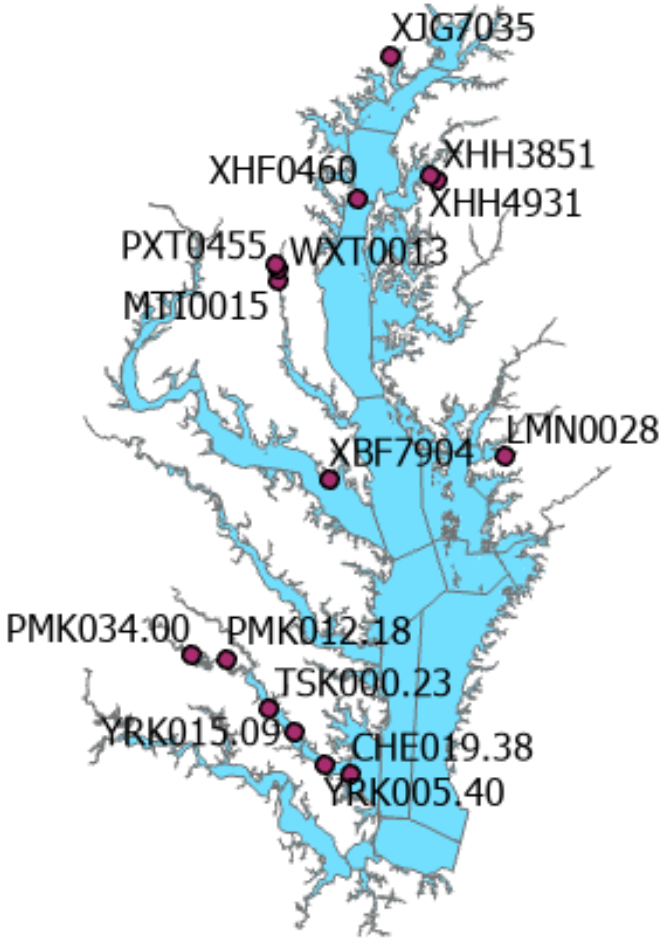
Shallow Water Stations

MD Stations

- **Chester River**
  - XHH3851: 2005 – 2017
  - XHH4931: 2006 – 2016
- **Jug Bay**
  - WXT0013: 2003 – 2019
  - PXT0455: 2003 – 2019
  - MTI0015: 2003 – 2019
- **Wicomico River**
  - LMN0028: 2006 - 2019
- **Potomac River**
  - XBF7904: 2006 - 2019
- **Sandy Point**
  - XHF0460: 2004 - 2019
- **Bush River**
  - XJG7035: 2003 - 2019

VA Stations

- **York River**
  - CHEO19.38: 2006 - 2019
  - TSK000.23: 2005 -2019
  - YRK005.40: 2005 -2019
  - YRK015.09: 2005 -2019
- **Pamunkey River**
  - PMK012.18: 2005 -2019
  - PMK034.00: 2005 -2019



MD data collected by MDDNR continuous monitoring program: http://eyesonthebay.dnr.maryland.gov/contmon/ContinuousMonitoring.cfm
VA data from CBNERR: http://vecos.vims.edu/

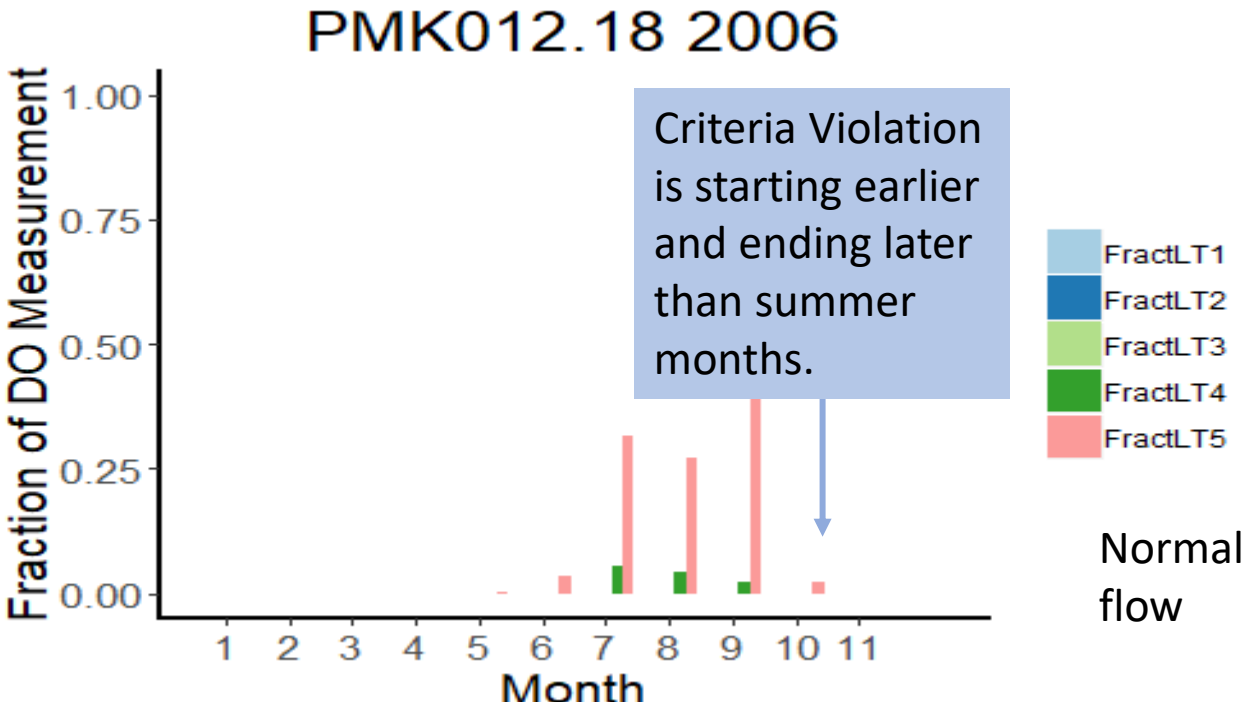
Shallow Water Data

Calibration Data

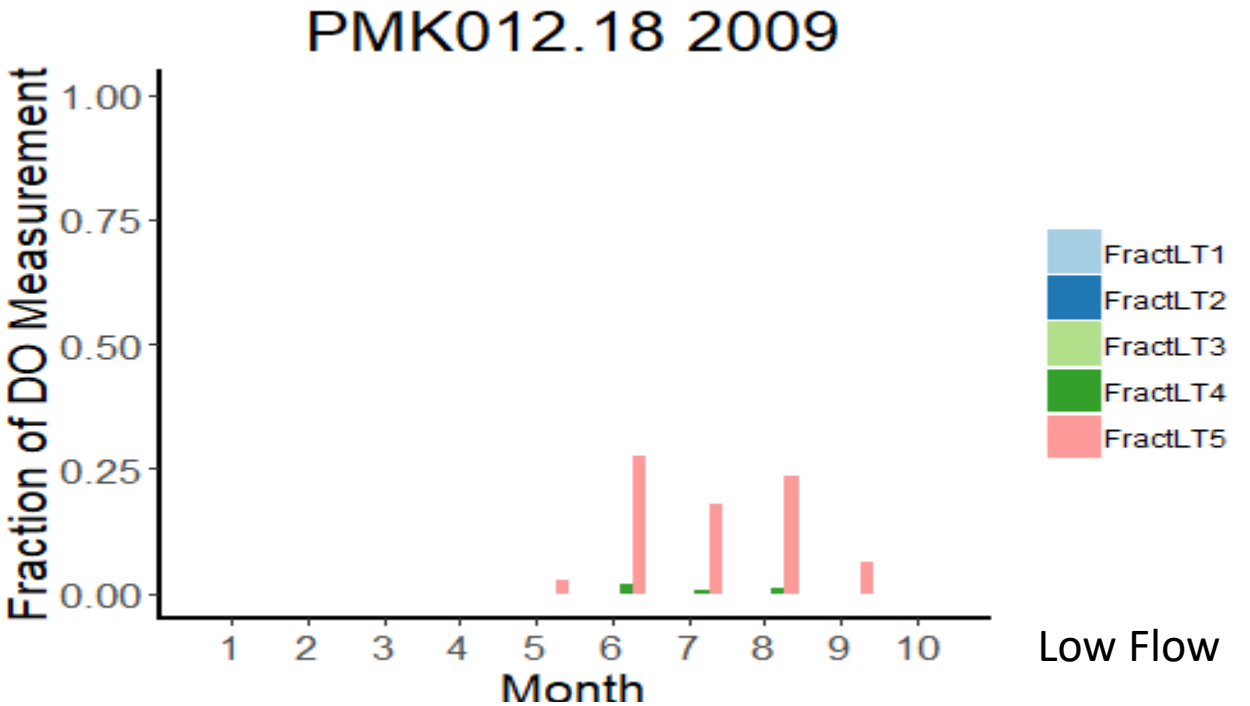
- Collected once or twice a month
- Used in Approach #2 & #3
- Parameters
  - DO (mg/L)
  - WTMEP (° C)

High Frequency

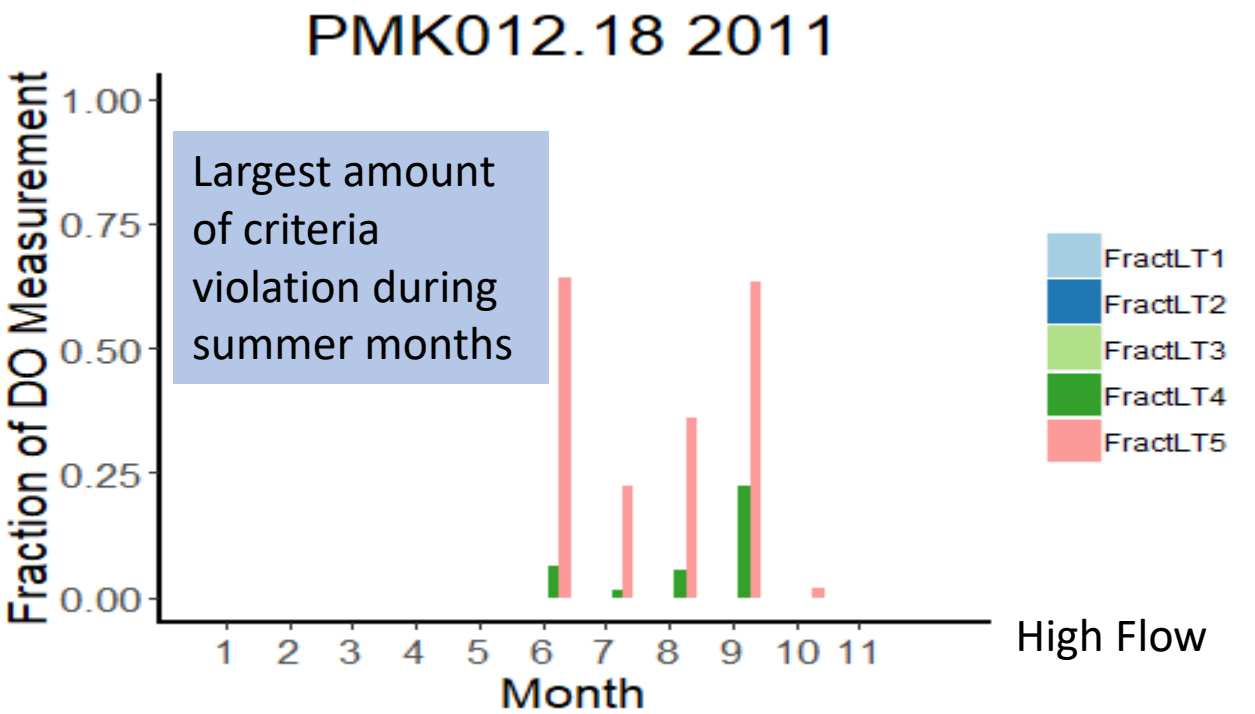
- Continuous data collected every 15 minutes
- Used in Approach #1
- Parameters
  - DO (mg/L)
  - DO Saturation (%)



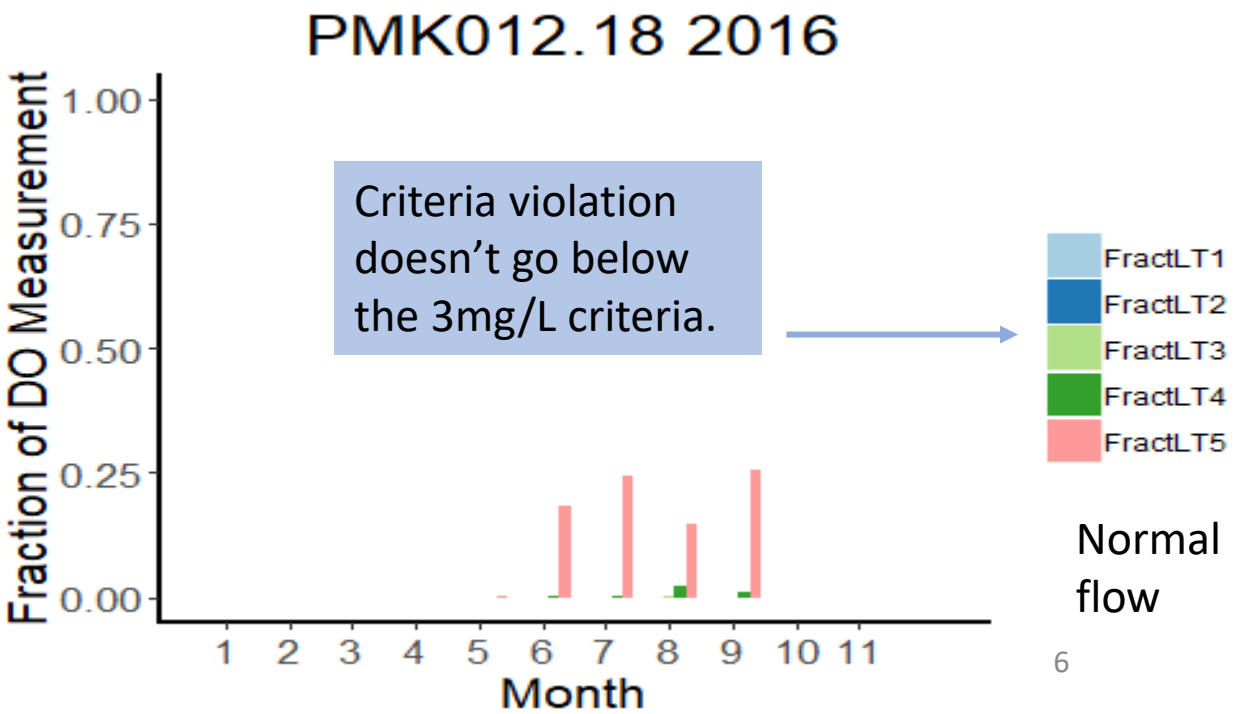
Normal flow



Low Flow

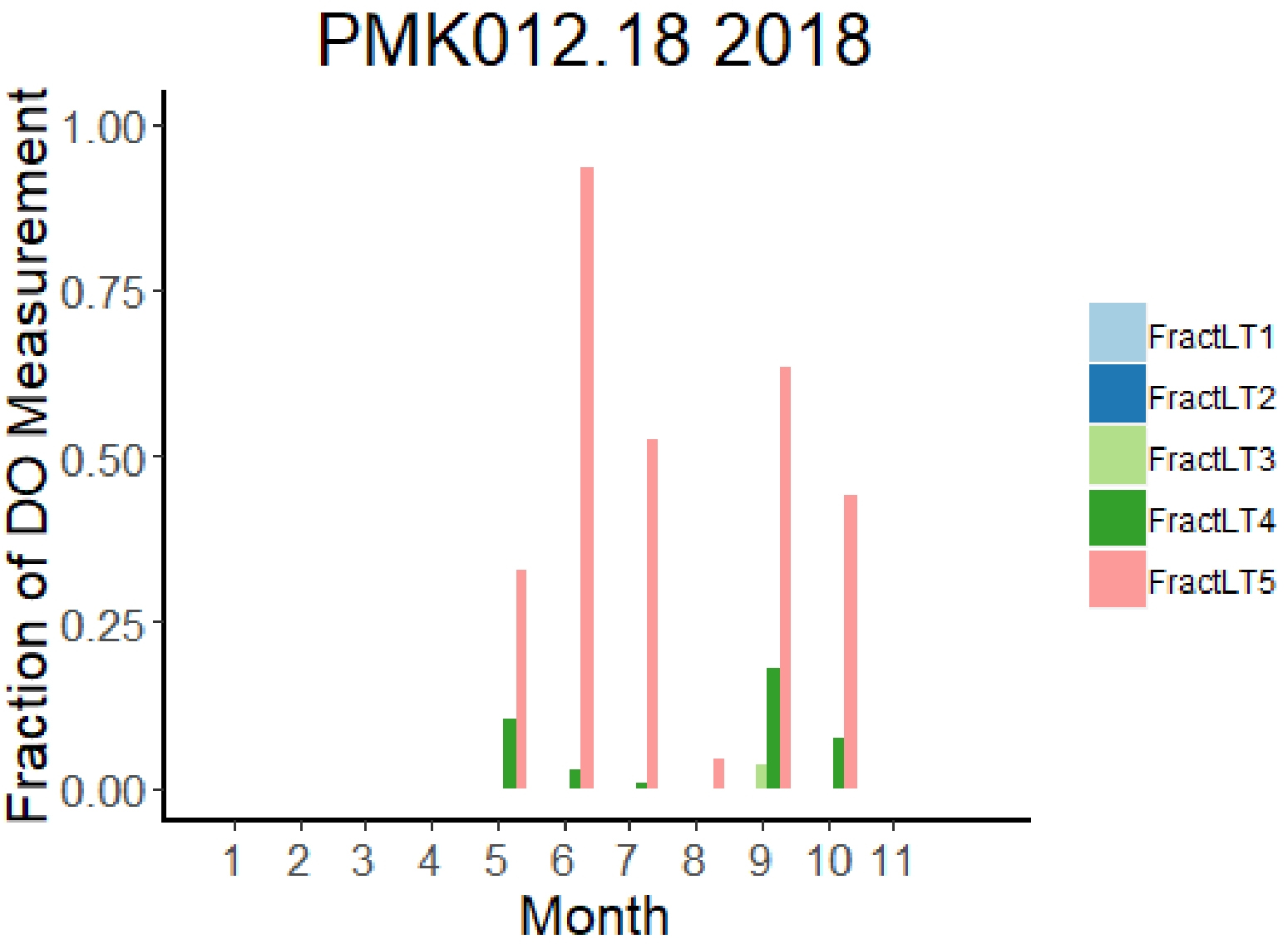


High Flow



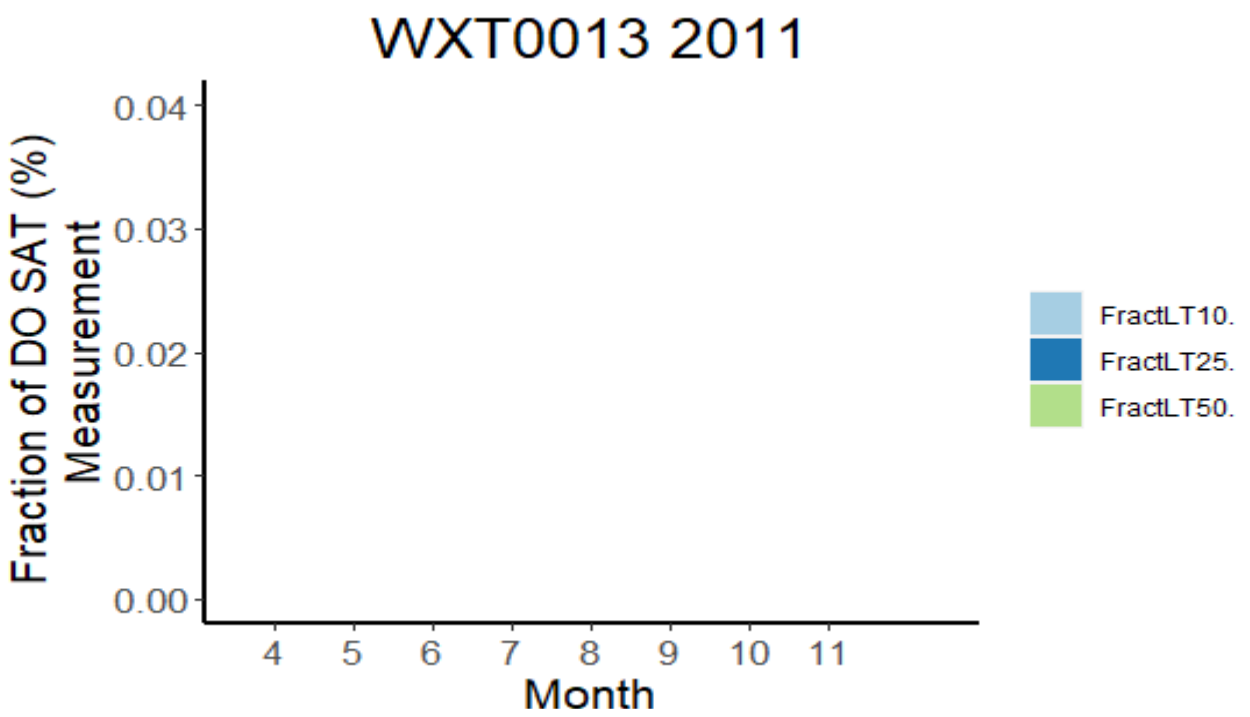
Normal flow

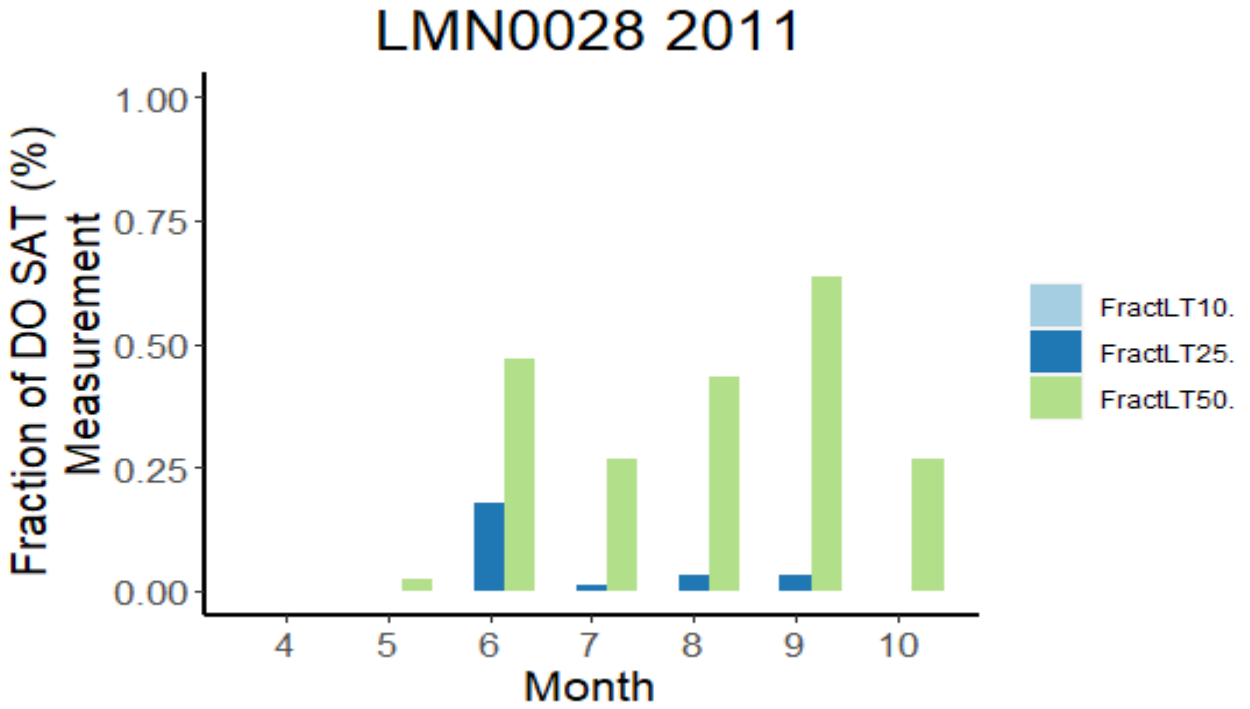
For VA stations: Large spike in criteria violation in 2018.



Approach #1: Evaluate whether the frequency of DO and percent DO saturation criteria violation has increased at a select set of shallow water monitoring stations over the period of record.

- Frequency graphs for DO SAT (%) are similar to the DO graphs
- Next steps include fitting statistical models to frequencies over time to identify any change



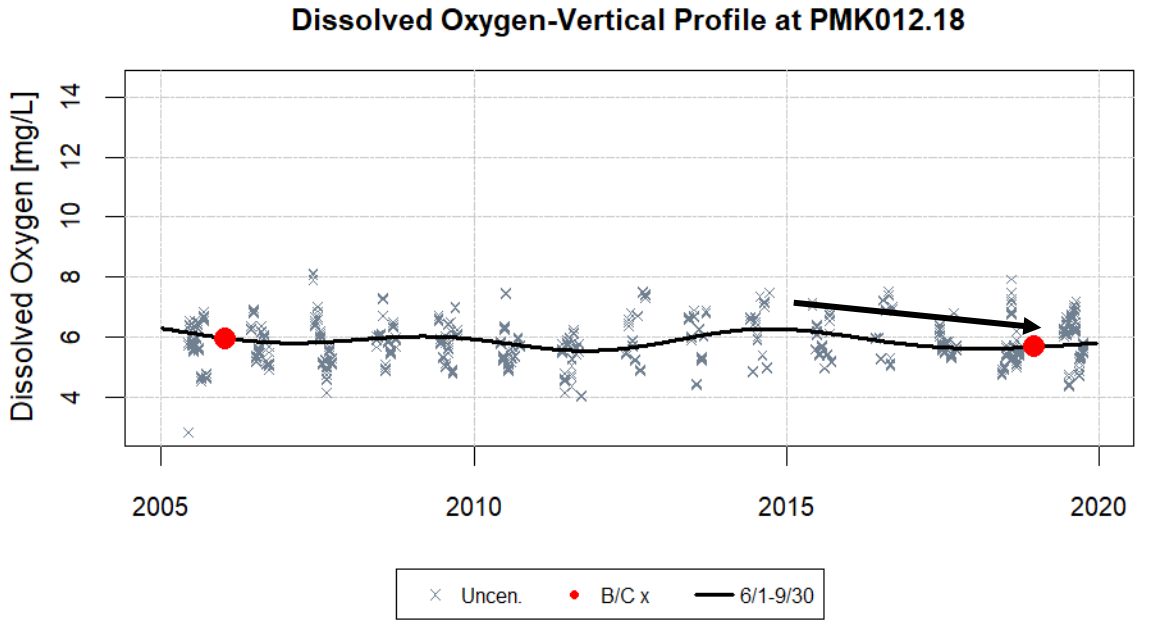


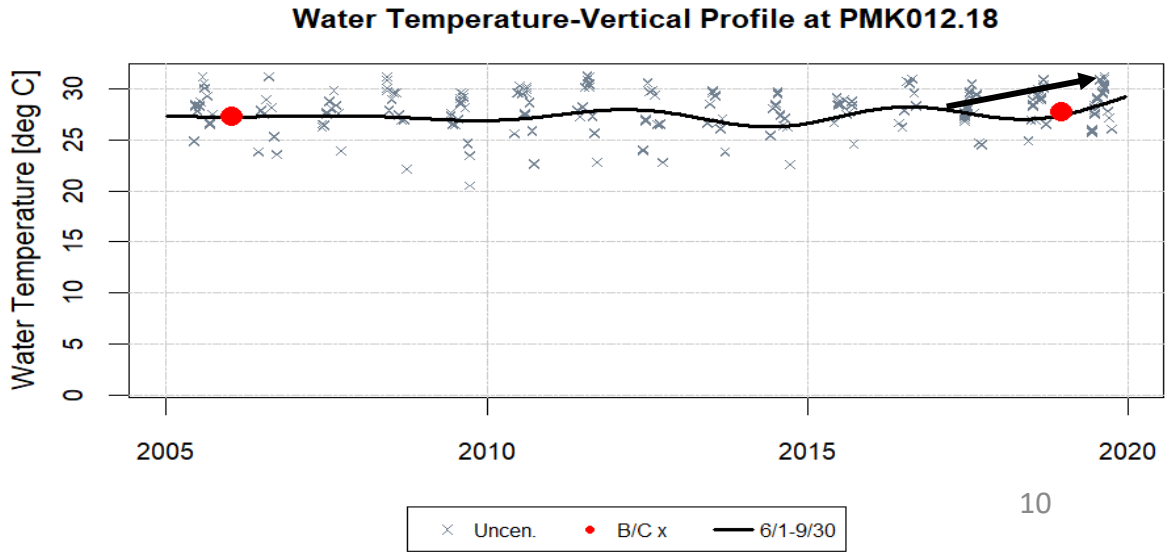
Approach #1: Summary

- With the high frequency data, the largest amount of criteria violation is during summer months
- Criteria violation can start as early as April and end as late as October for some stations
- Eastern Shore stations seem to have more criteria violation than western shore stations
- Future evaluation is under way of temporal patterns

Approach #2: Investigate how water temperature change relates to DO criteria violation in shallow waters.

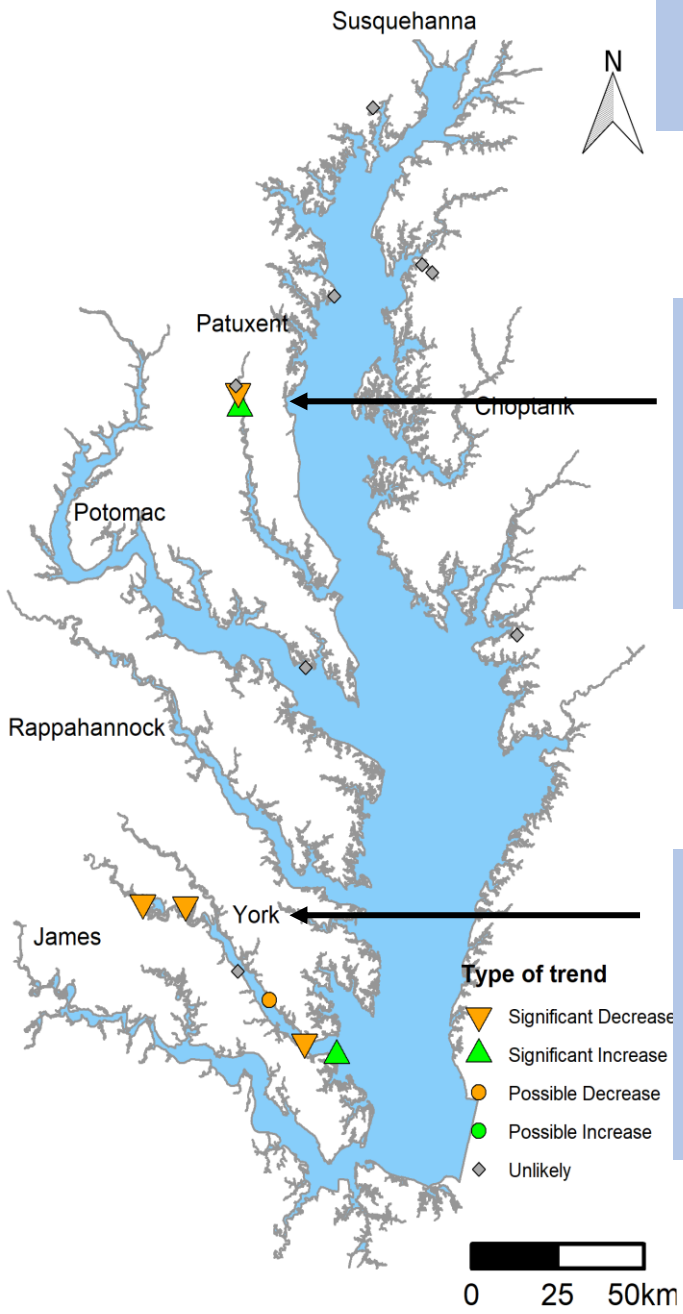
- Fitted GAMs to ConMon calibration data during the summer months.
  - Graphs shows AVG summer GAM result
- In this example, the VA Pamunkey River station had a significant decreasing trend over time for DO.
- The Pamunkey River station had a significant increasing trend over time for water temp.





Approach #2: Investigate how water temperature change relates to DO criteria violation in shallow waters.

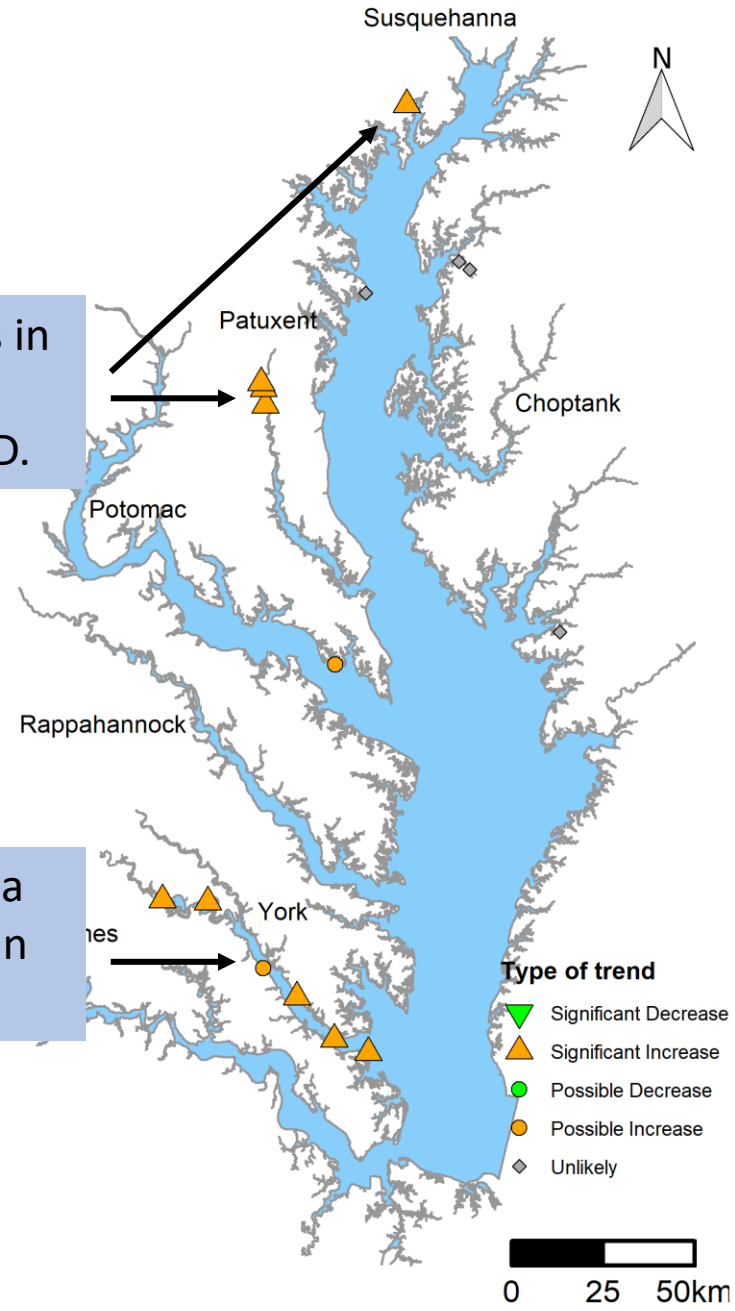
Shallow Water DO Trends



Only one MD station has a significant DO decrease. One station has a significant DO increase.

Three VA stations have a significant DO decrease while one station has a significant increase.

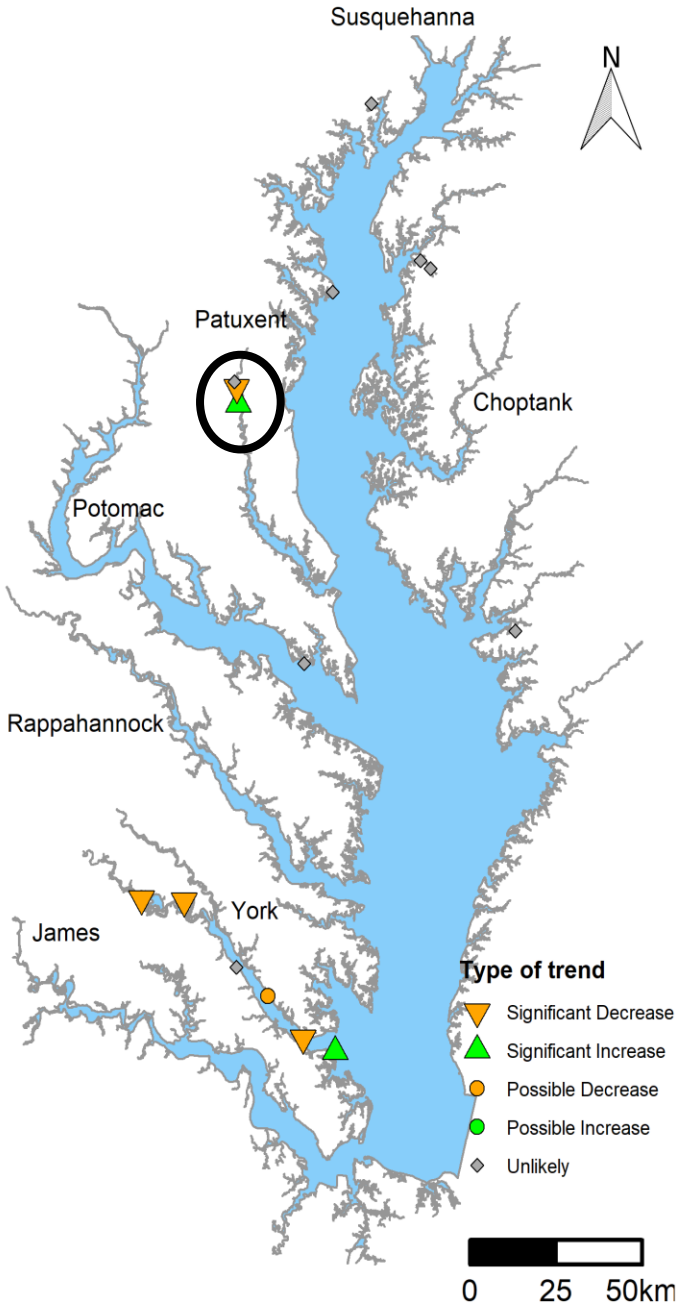
Shallow water WTEMP Trends

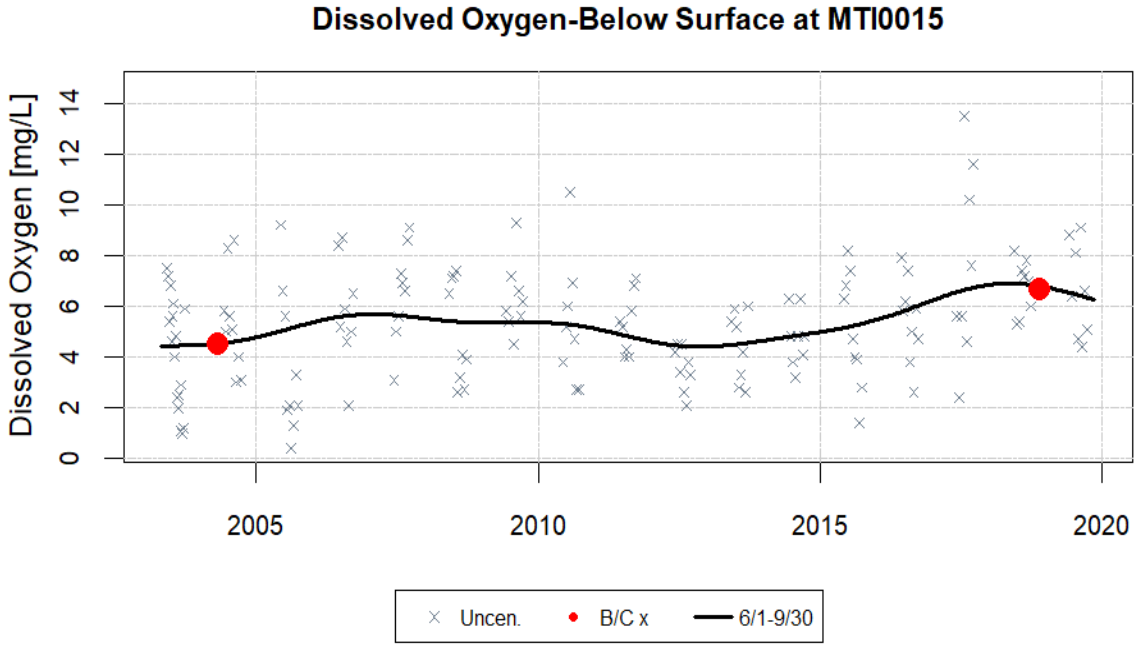


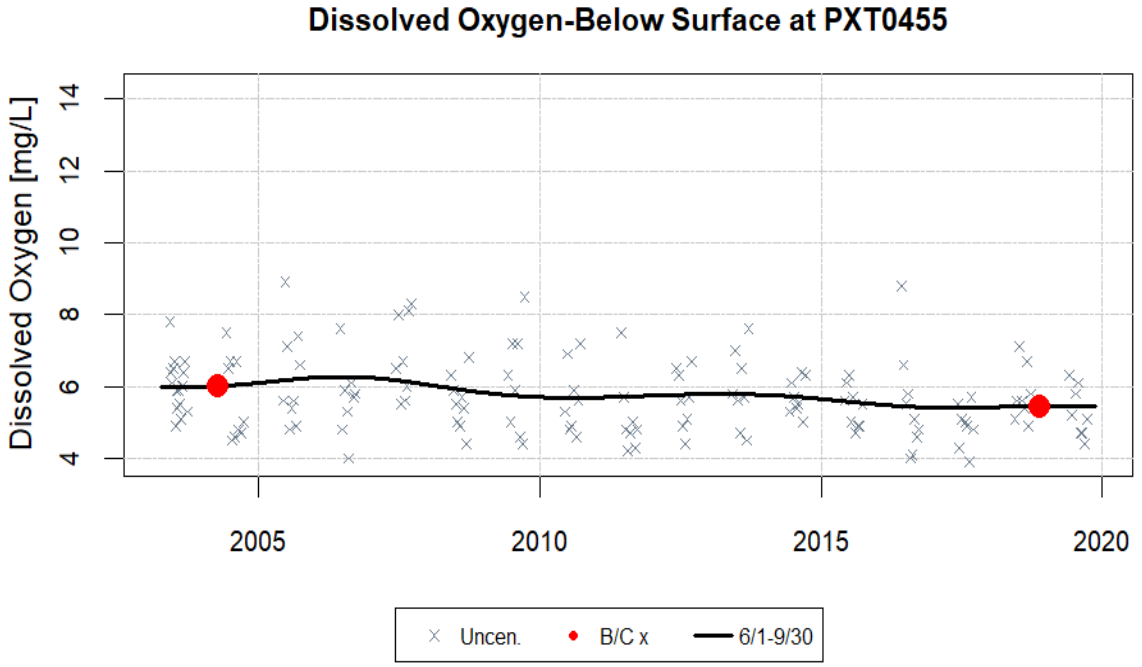
Significant increases in WTEMP only on western shore of MD.

All VA stations have a significant increase in WTEMP except one.

Shallow Water DO Trends

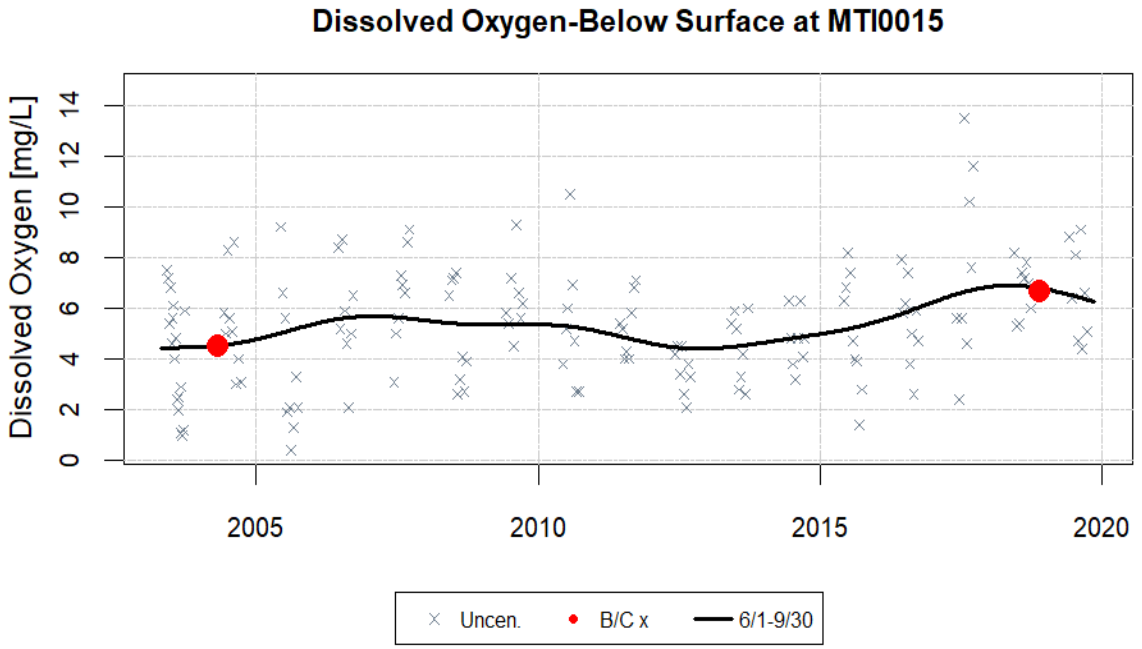






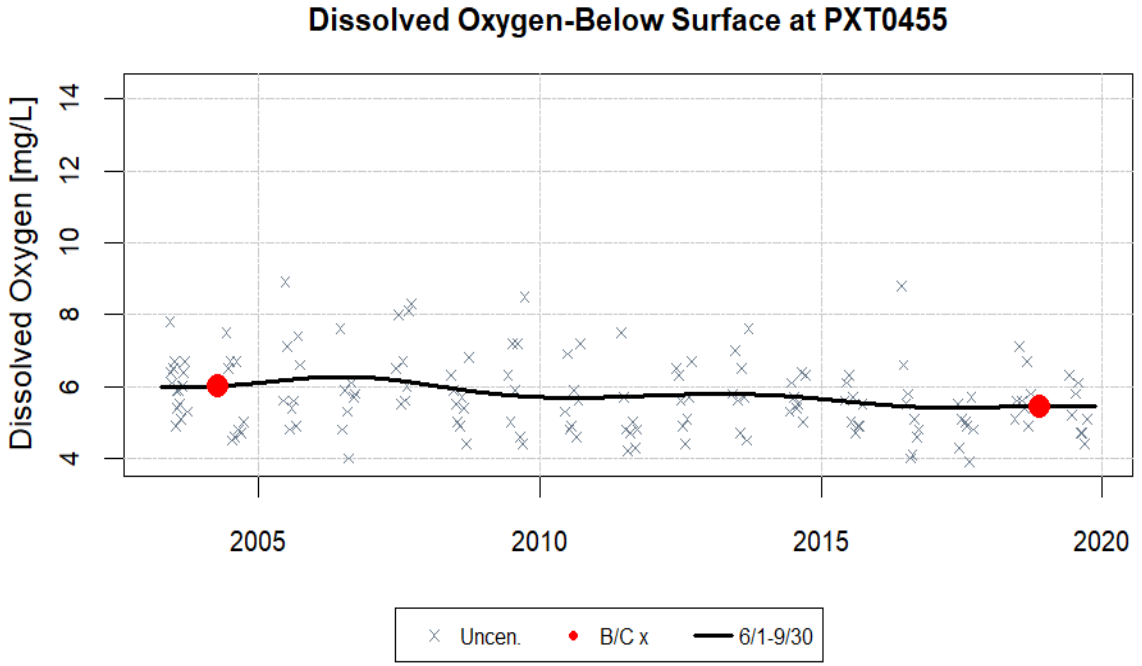
MTI0015:

- 17-year change is: 46.75% increase (p<0.0001)
- Beginning DO Level ≈ 4.5 mg/L
- End DO Level ≈ 6.6 mg/L



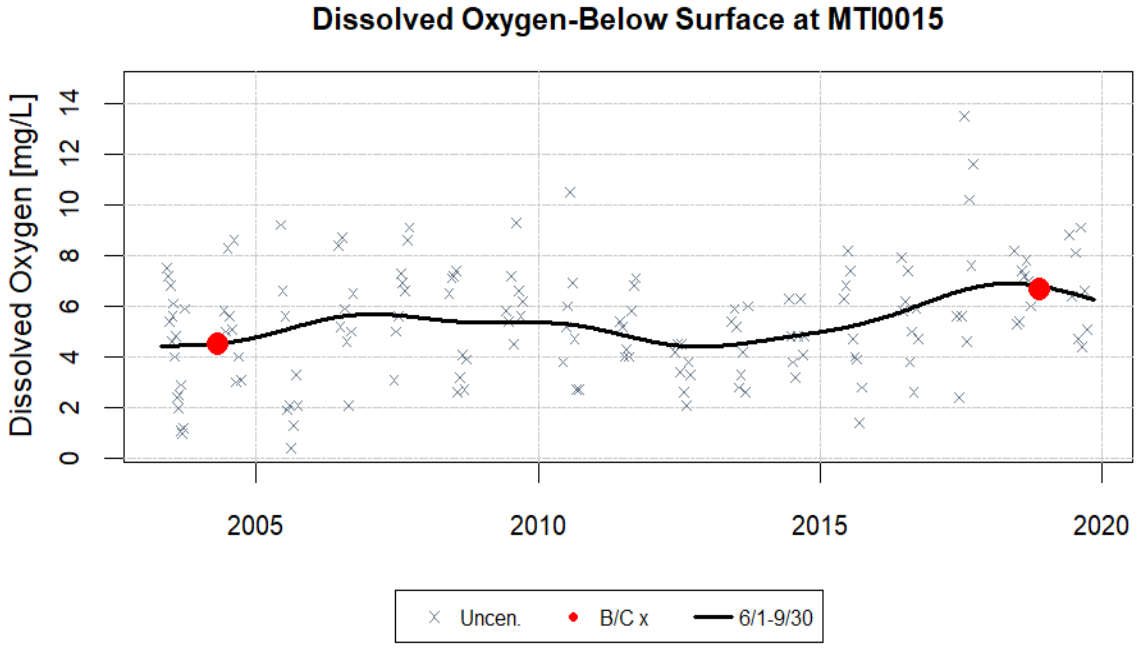
PXT0455:

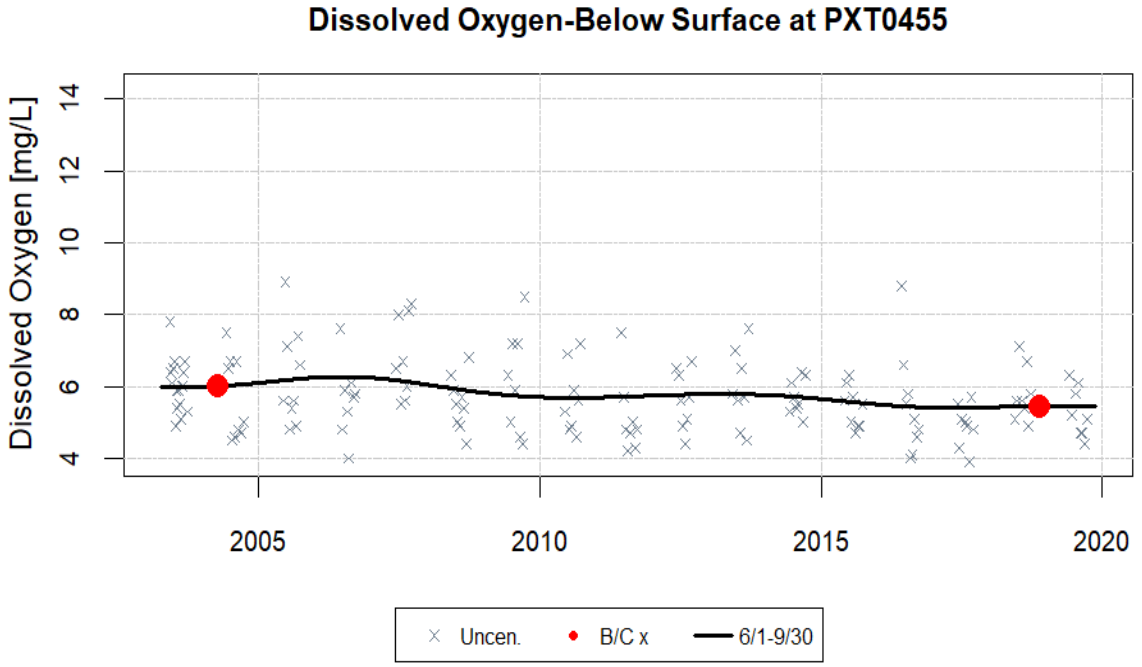
- 17-year change is: 9.55% decrease (p<0.0150)
- Beginning DO Level ≈ 6 mg/L
- End DO Level ≈ 5.4 mg/L



Overview:

- Majority of change in DO levels happened from 2015 – 2019.
- Close shallow water stations with very different long-term trends, but similar current summer DO levels.
- Could nearshore watershed characteristics be driving these differences or residence time?
- Similar comparison possible for stations at mouth of York River (not shown)





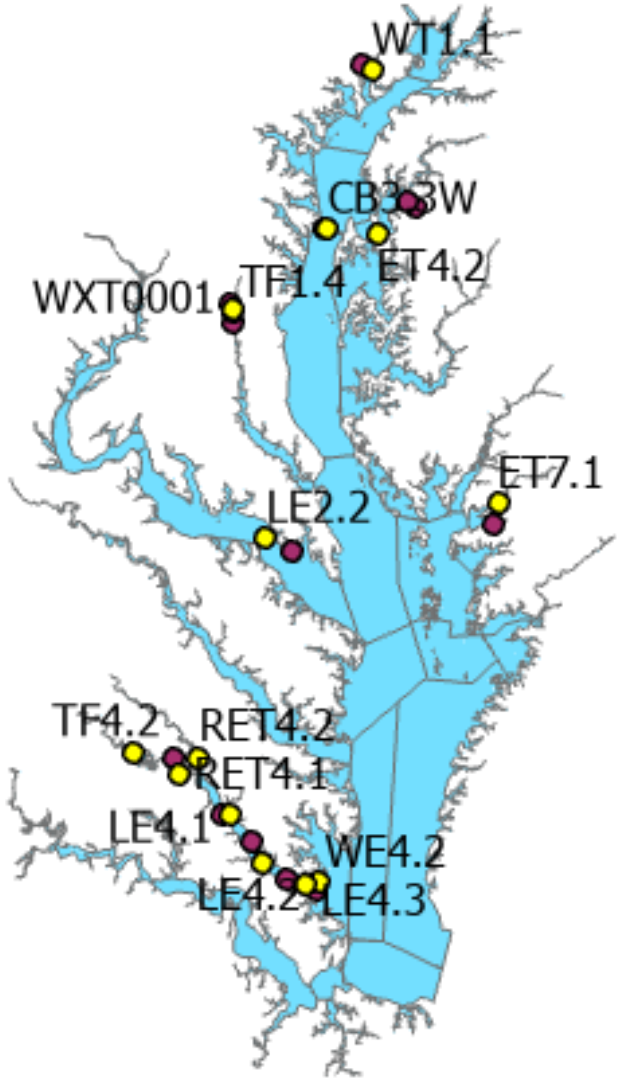
Approach #2: Summary

- With the calibration data and looking at trends over time,
  - Most VA stations have a decreasing DO trend with a coinciding increasing trend in water temp.
  - There were no observed trends in water temp or DO at the eastern shore MD stations for the period of record.
  - While water temp is significantly increasing on the Western shore of MD, there is not a coinciding decrease in DO at those stations.
  - Two pairs of adjacent stations show opposite DO trends, but same water temp trends. These locations will be investigated further for possible factors.

Approach #3: Compare temperature and DO in shallow water monitoring data to nearby long-term monitoring stations.

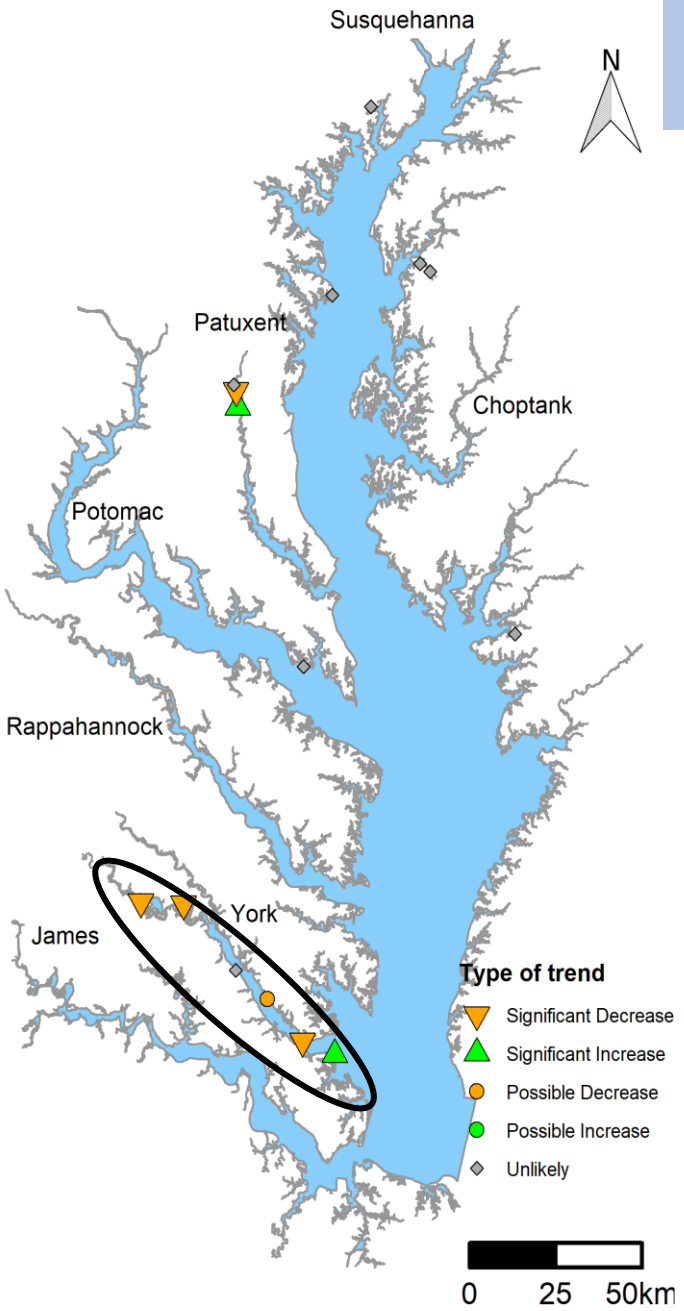
Long-term Monitoring Stations

Shallow Water Station	State	Long-Term Station
XHH3851	MD	ET4.2
XHH4931	MD	ET4.2
WXT0013	MD	WXT0001
PXT0455	MD	WXT0001
MTI0015	MD	TF1.4
LMN0028	MD	ET7.1
XBF7904	MD	LE2.2
XHF0460	MD	CB3.3W
XJG7035	MD	WT1.1
CHE019.38	VA	WE4.2
TSK000.23	VA	LE4.1
YRK005.40	VA	LE4.3
YRK015.09	VA	LE4.2
PMK012.18	VA	RET4.1
PMK034.00	VA	TF4.2



Shallow Water DO Trends

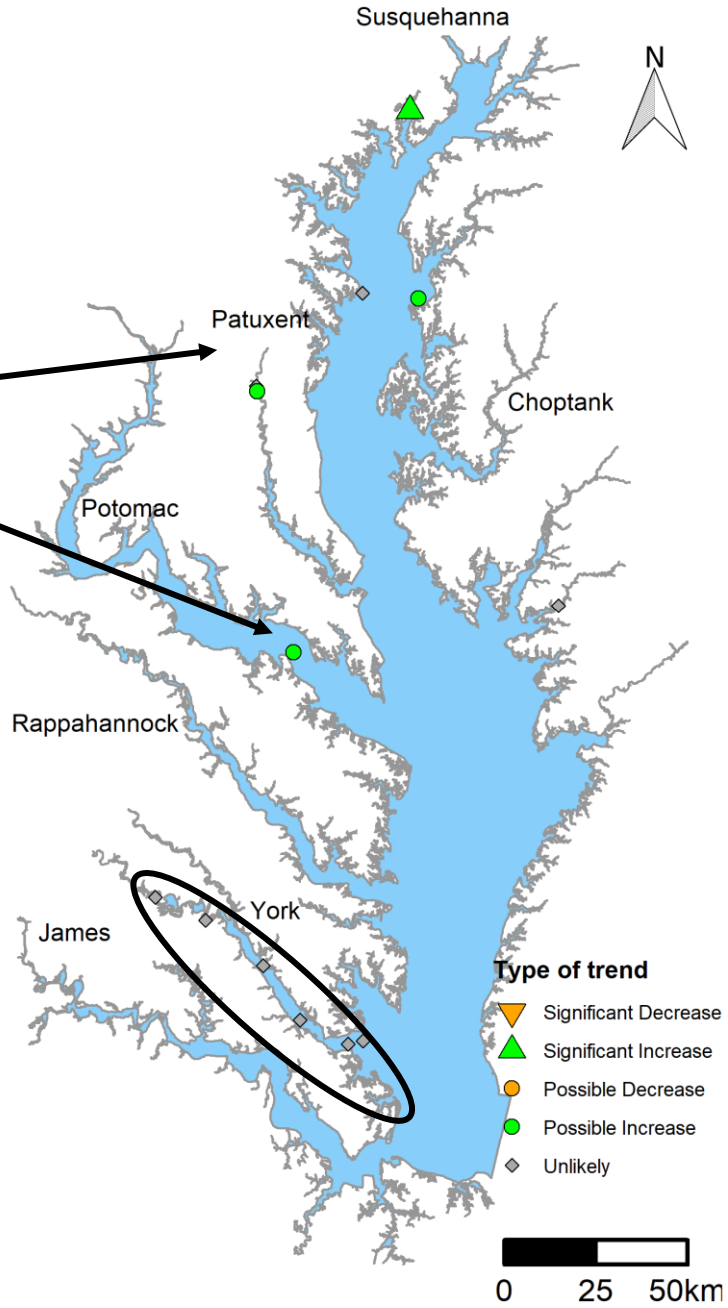
Approach #3: Compare temperature & DO in shallow water monitoring data to nearby long-term monitoring stations.



More possible increases in DO for MD long-term stations than shown for the shallow water stations.

VA long-term stations are unlikely to have a trend while multiple VA shallow water stations have a significant decrease in DO and one has a significant increase.

Long-term Monitoring DO Trends



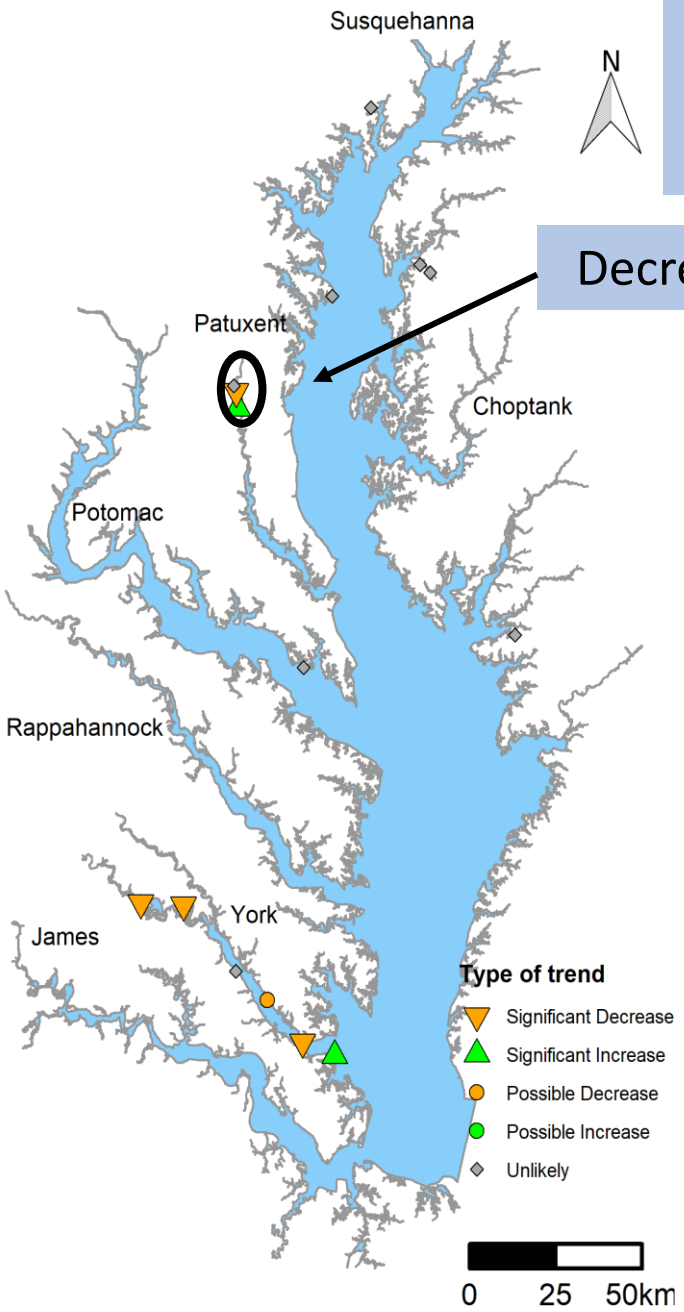
Shallow Water DO Trends

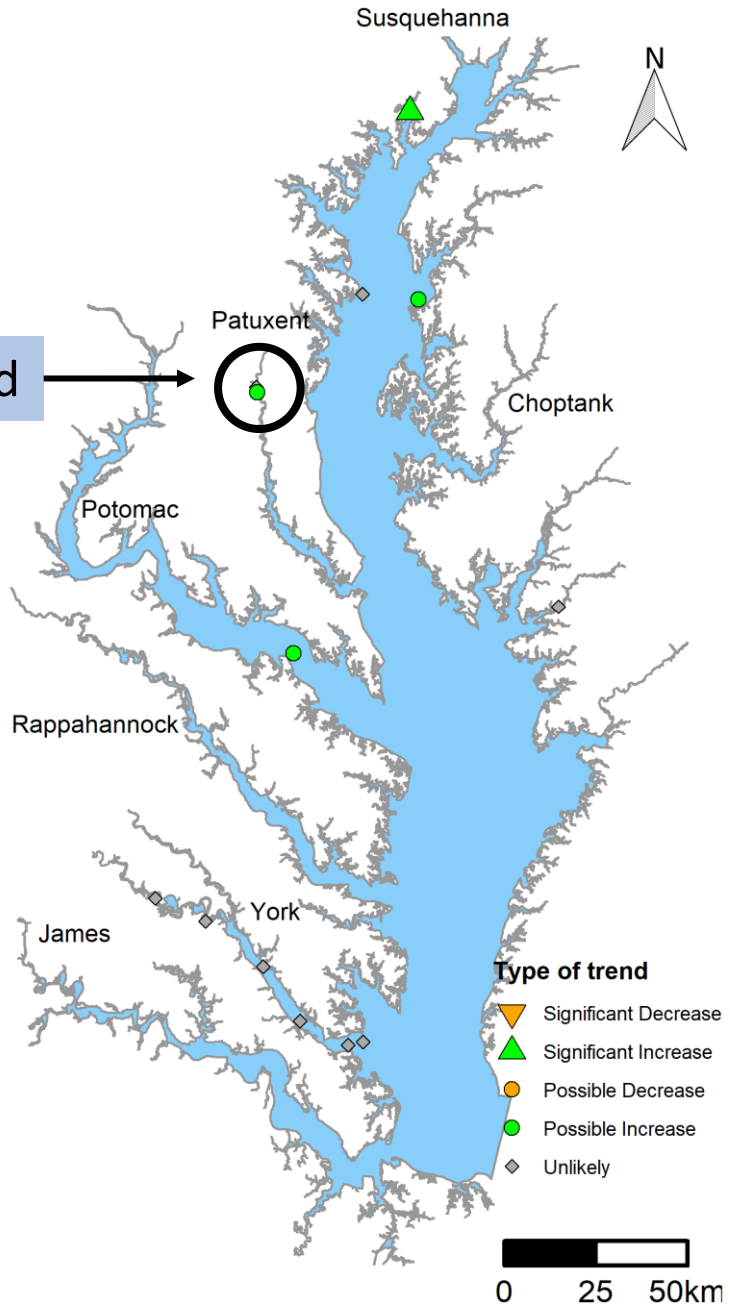
Long-term Monitoring DO Trends

Approach #3: Compare temperature & DO trends in shallow water monitoring data to nearby long-term monitoring stations.

Decreasing Shallow Water Trend

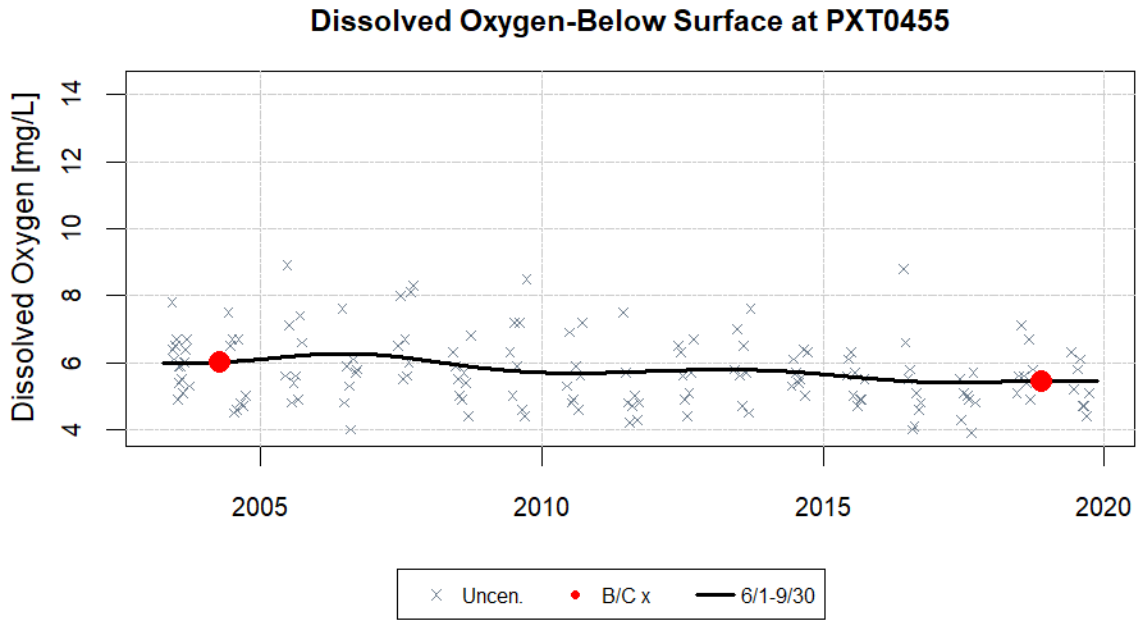
Unlikely Long-term Trend





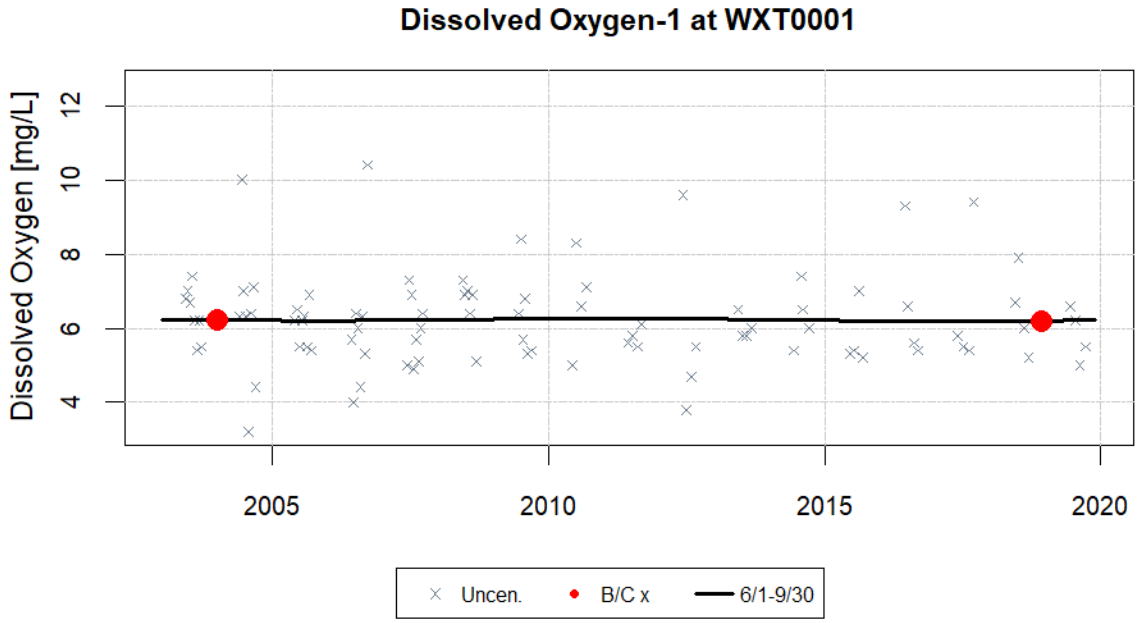
Shallow Water Station PXT0455:

- 17-year change is: 9.71% decrease (p = 0.016)
- Beginning DO Level ≈ 5.95 mg/L
- End DO Level ≈ 5.37 mg/L



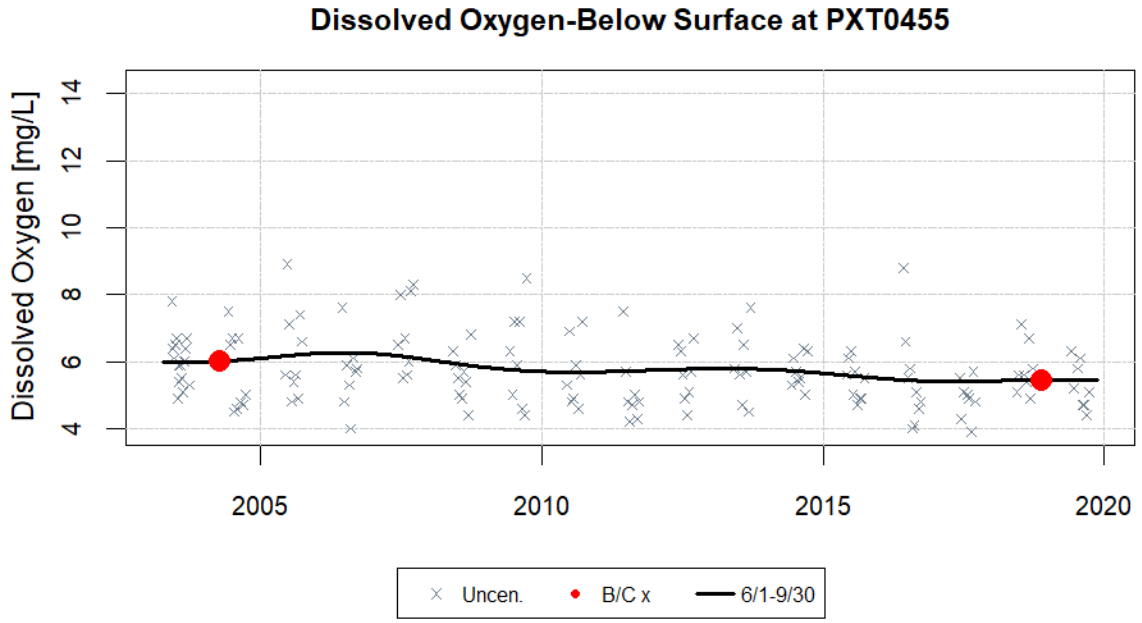
Long-term Monitoring Station WXT0001:

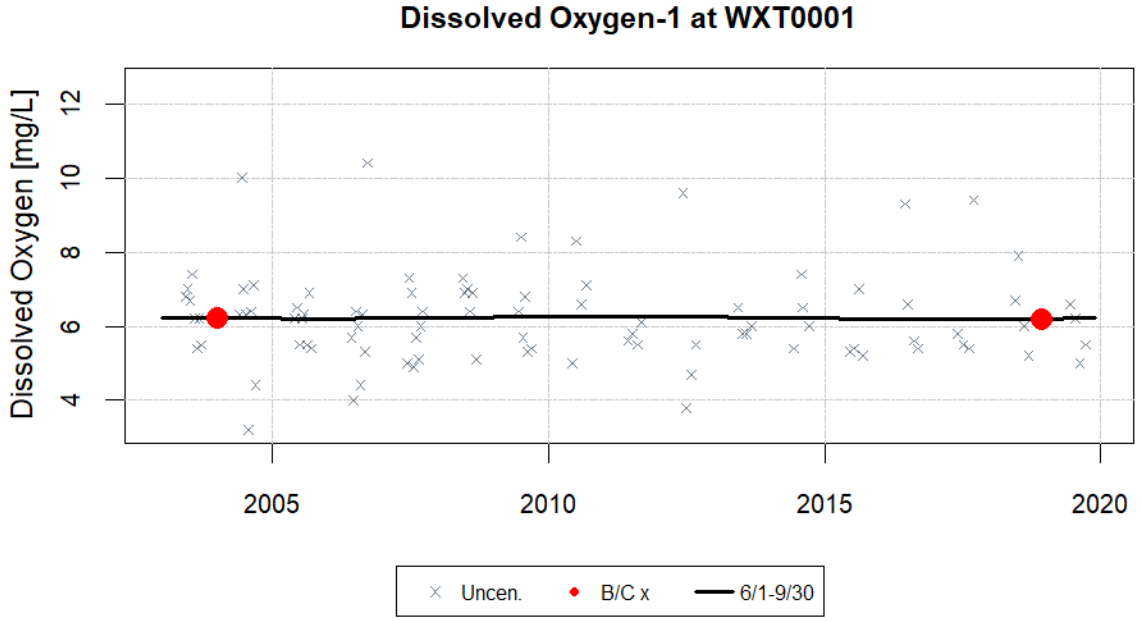
- 17-year change is: 0.21% decrease (p = 0.95)
- Beginning DO Level ≈ 6.18 mg/L
- End DO Level ≈ 6.17 mg/L



Overview:

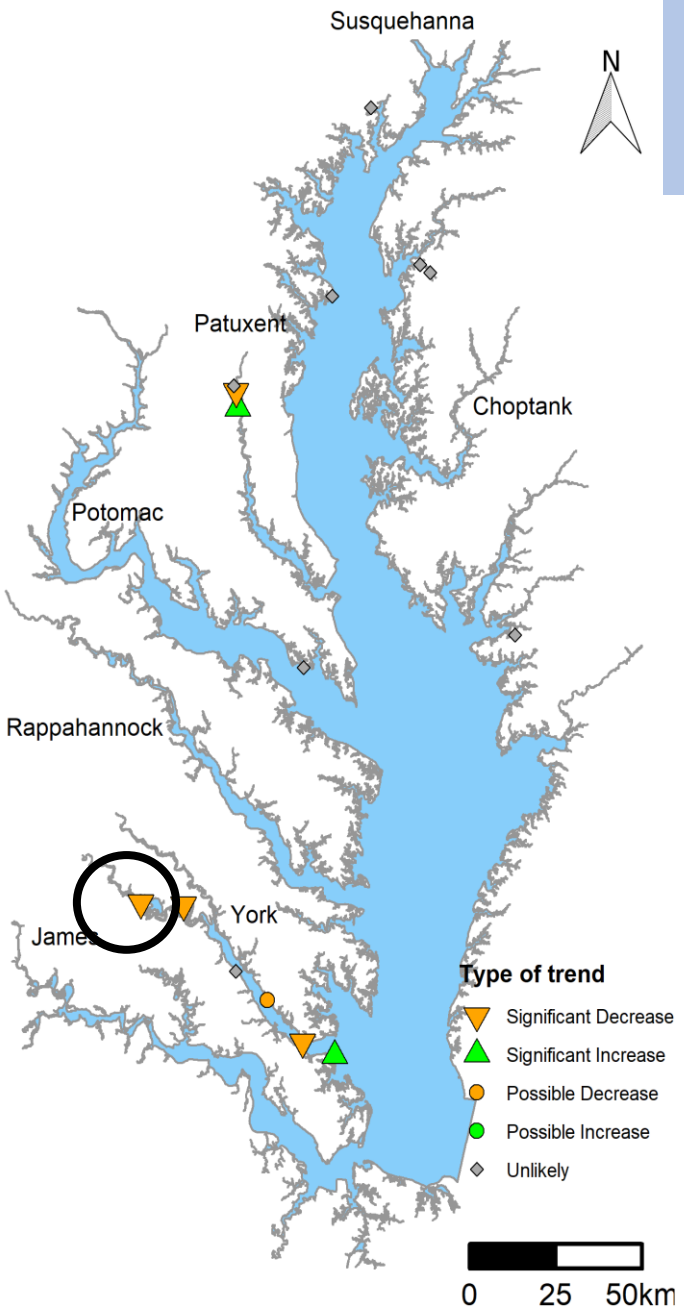
- Shallow water station has a decreasing trend vs the unlikely trend for the long-term station, but the decreasing change is not that large (B = 5.95 mg/L vs C = 5.37 mg/L).
- Throughout the period of record the DO measurements are not very different.
- The most change for the shallow water station happens at the end of the period of record



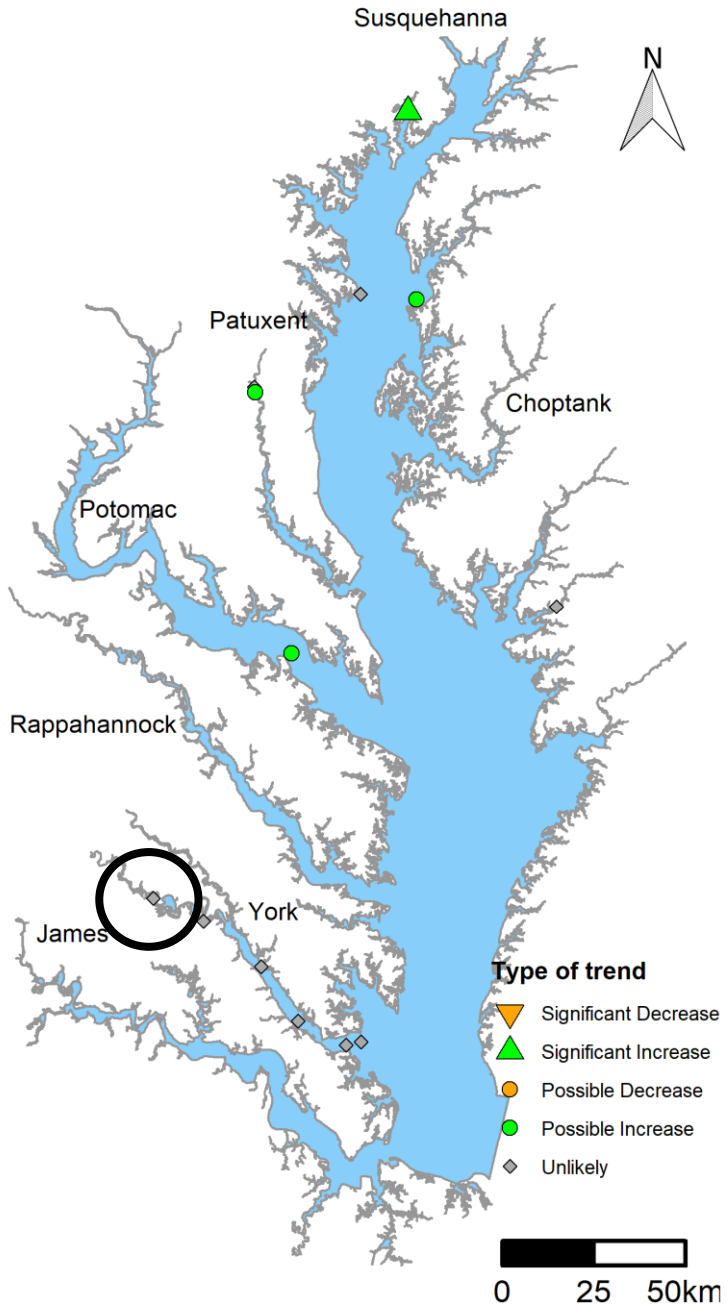


Approach #3: Compare temperature & DO trends in shallow water monitoring data to nearby long-term monitoring stations.

Shallow Water DO Trends

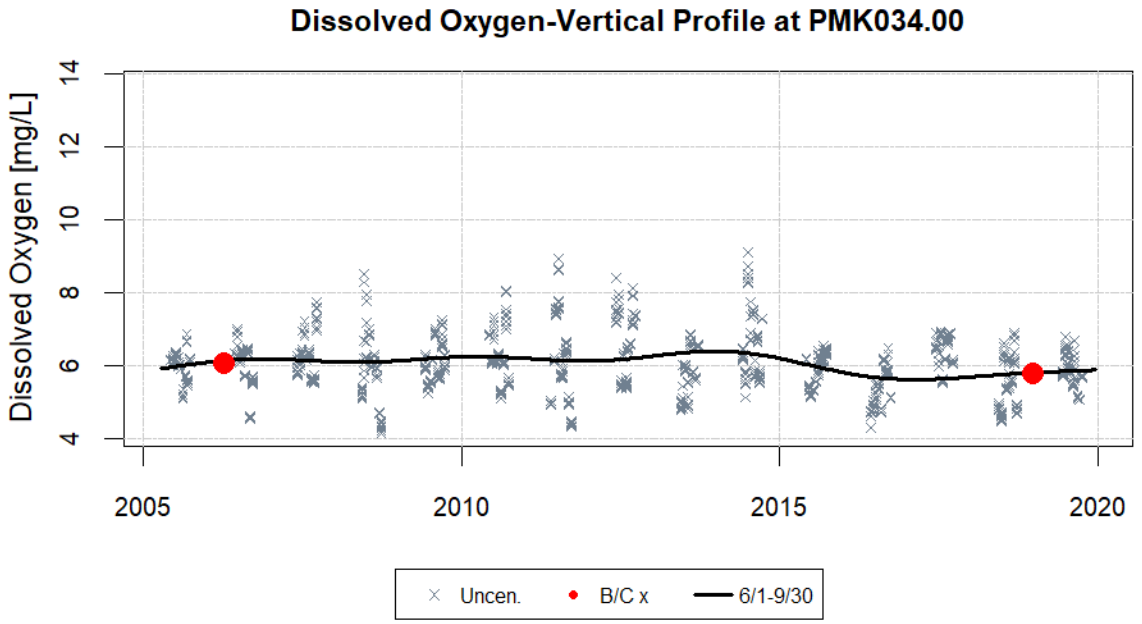


Long-term Monitoring DO Trends



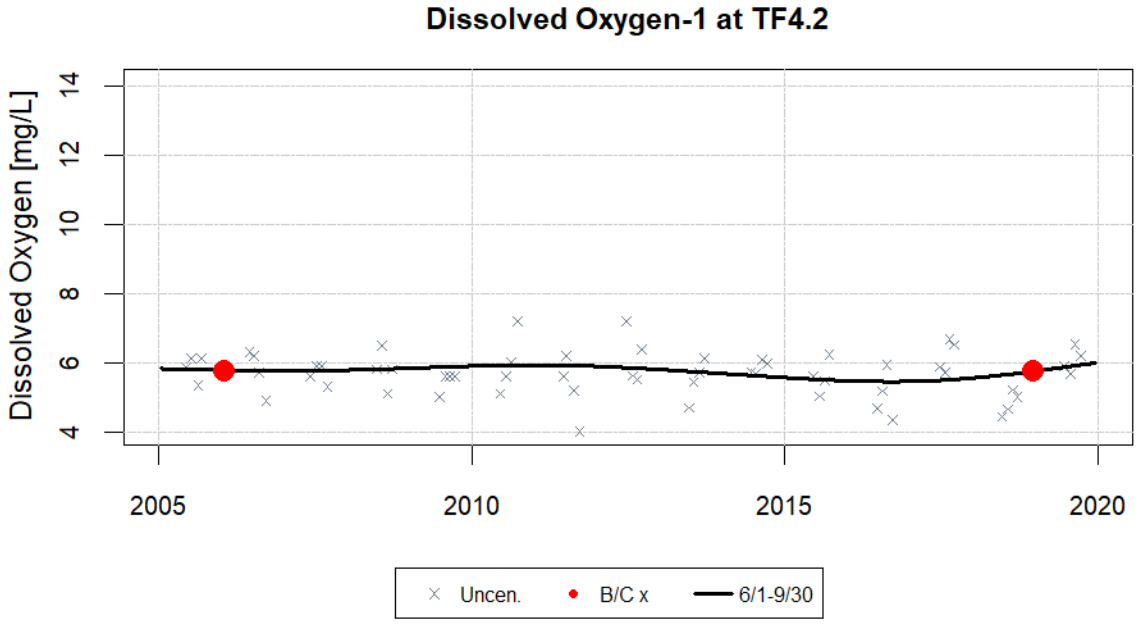
Shallow Water Station PMK034.00:

- 17-year change is: 4.69% decrease (p = 0.0004)
- Beginning DO Level ≈ 6.07 mg/L
- End DO Level ≈ 5.73 mg/L



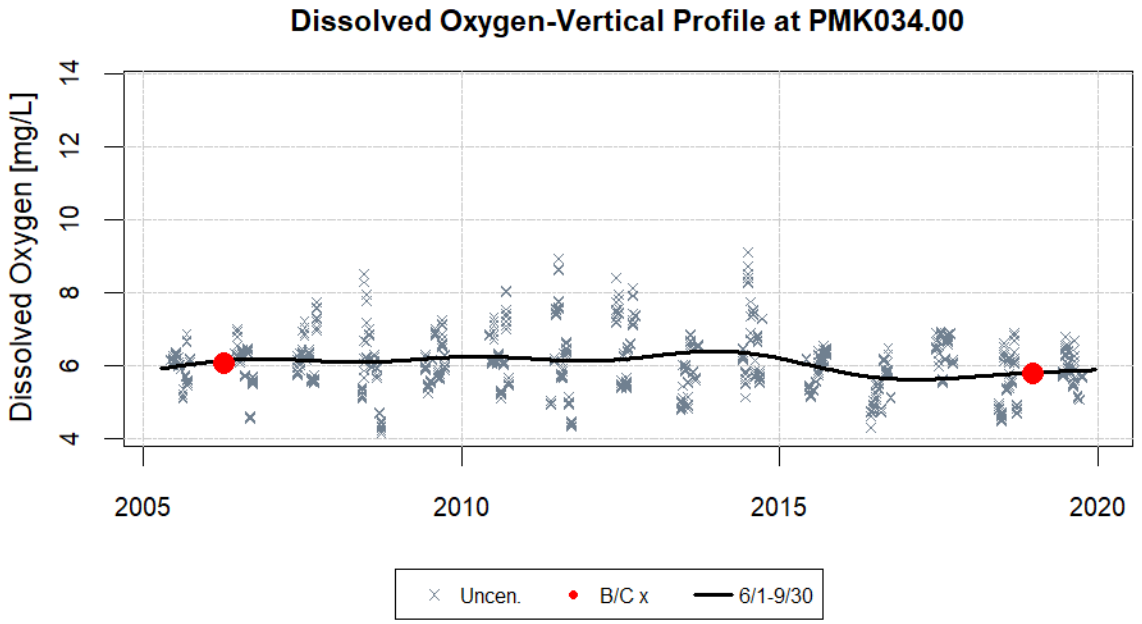
Long-term Monitoring Station TF4.2:

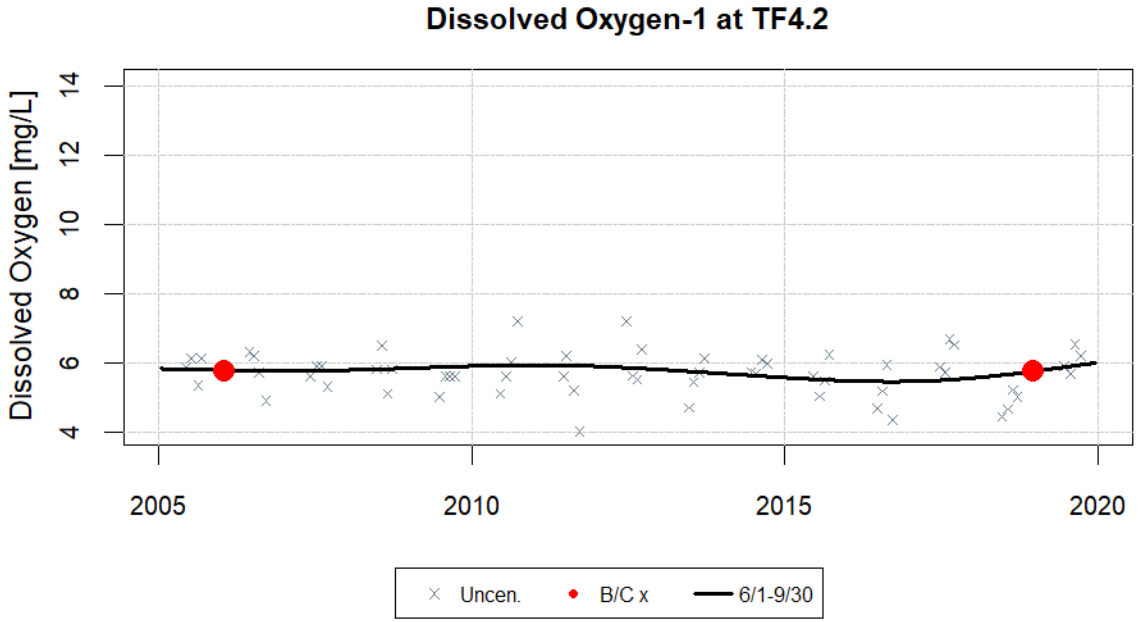
- 17-year change is: 0.11% decrease (p = 0.98)
- Beginning DO Level ≈ 5.74 mg/L
- End DO Level ≈ 5.73 mg/L



Overview:

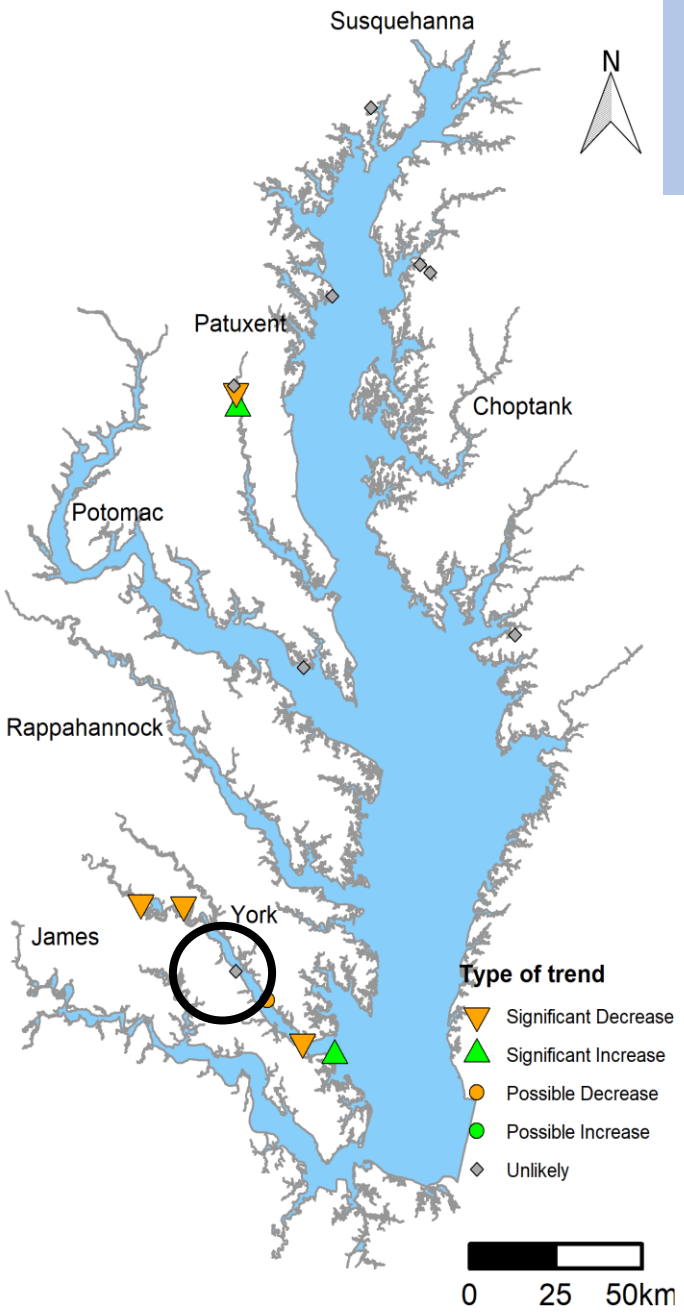
- Shallow water station shows a significant decreasing trend compared to the long-term, but there is not drastic decrease (4.69%).
  - This attribute occurs at multiple VA stations.
- Both stations have the same current summer DO measurement.



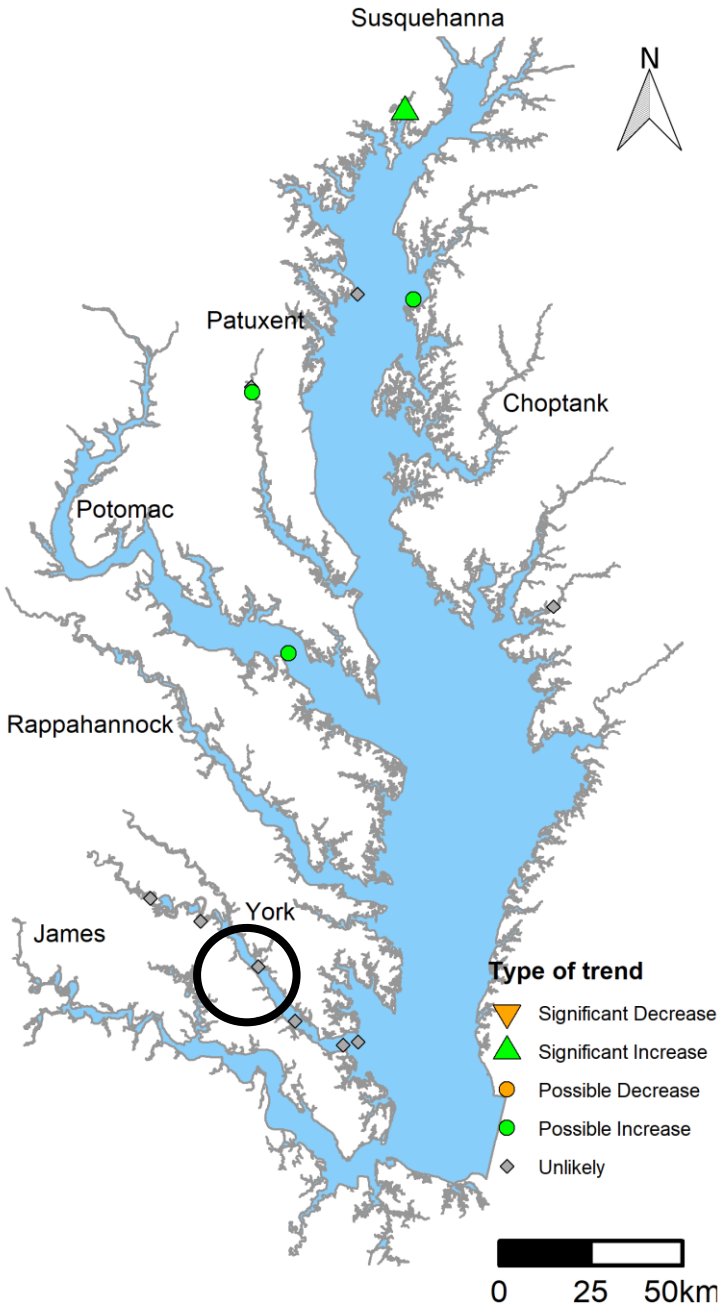


Approach #3: Compare temperature & DO trends in shallow water monitoring data to nearby long-term monitoring stations.

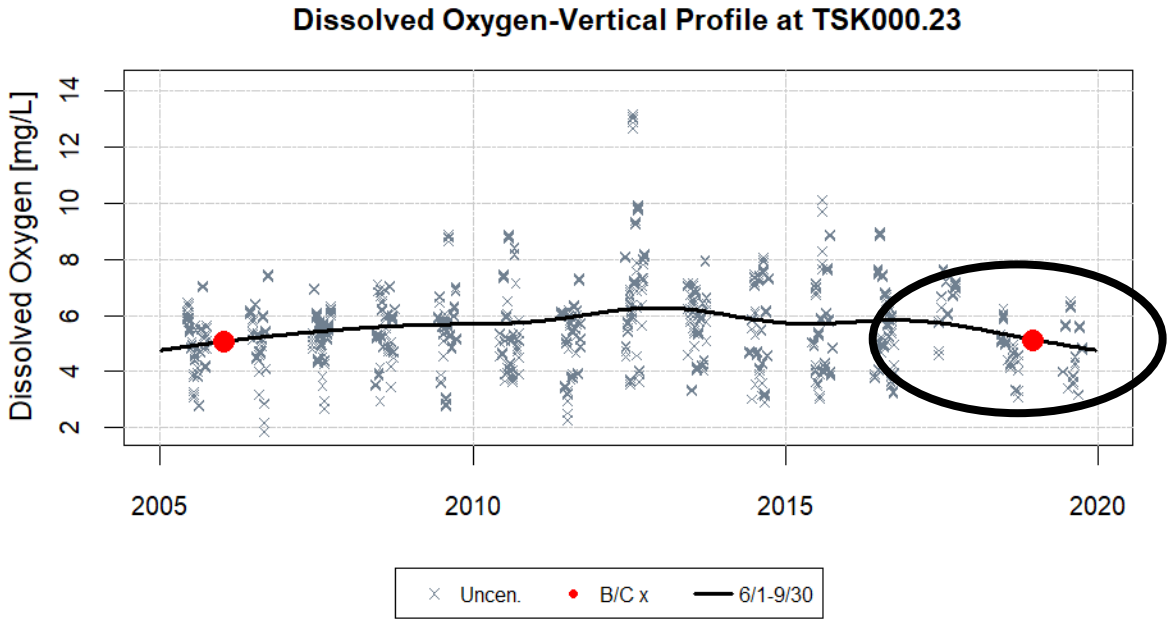
Shallow Water DO Trends

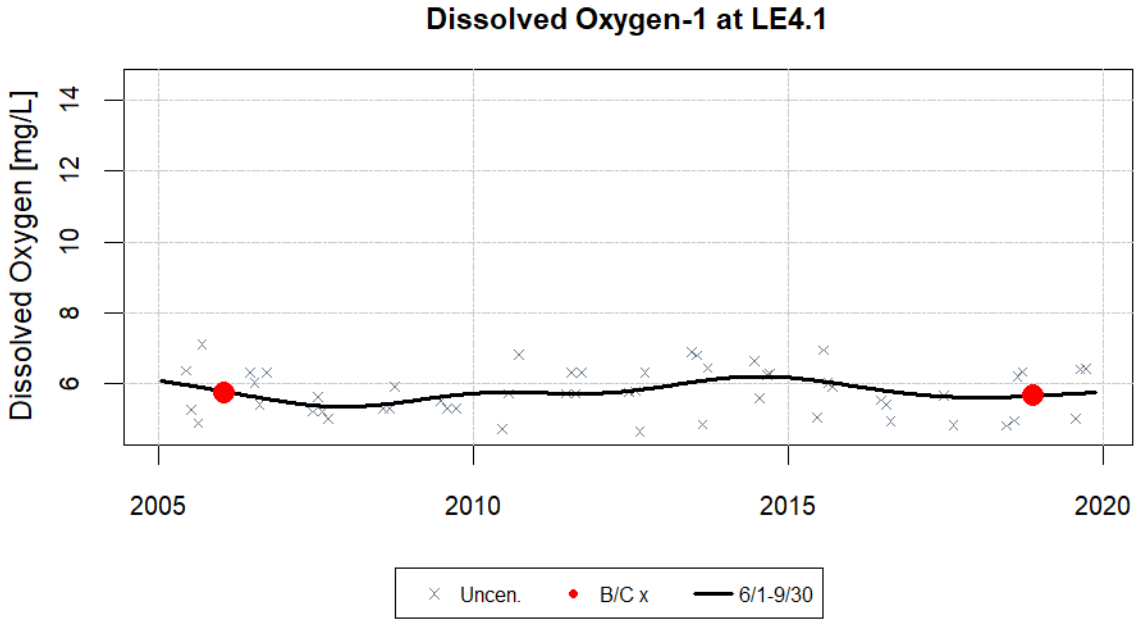


Long-term Monitoring DO Trends



- While both stations show an unlikely decreasing or increasing trend, the GAM fit for the shallow water station again shows a decrease towards the end of the period of record.

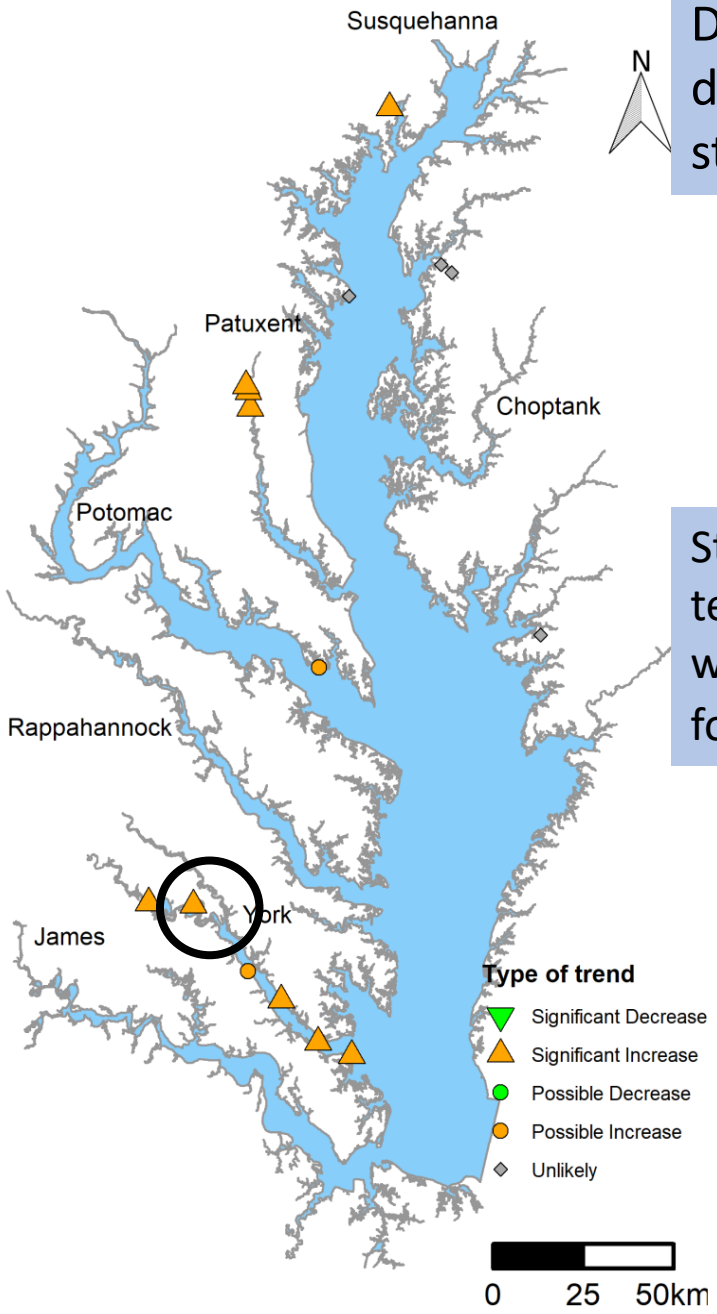




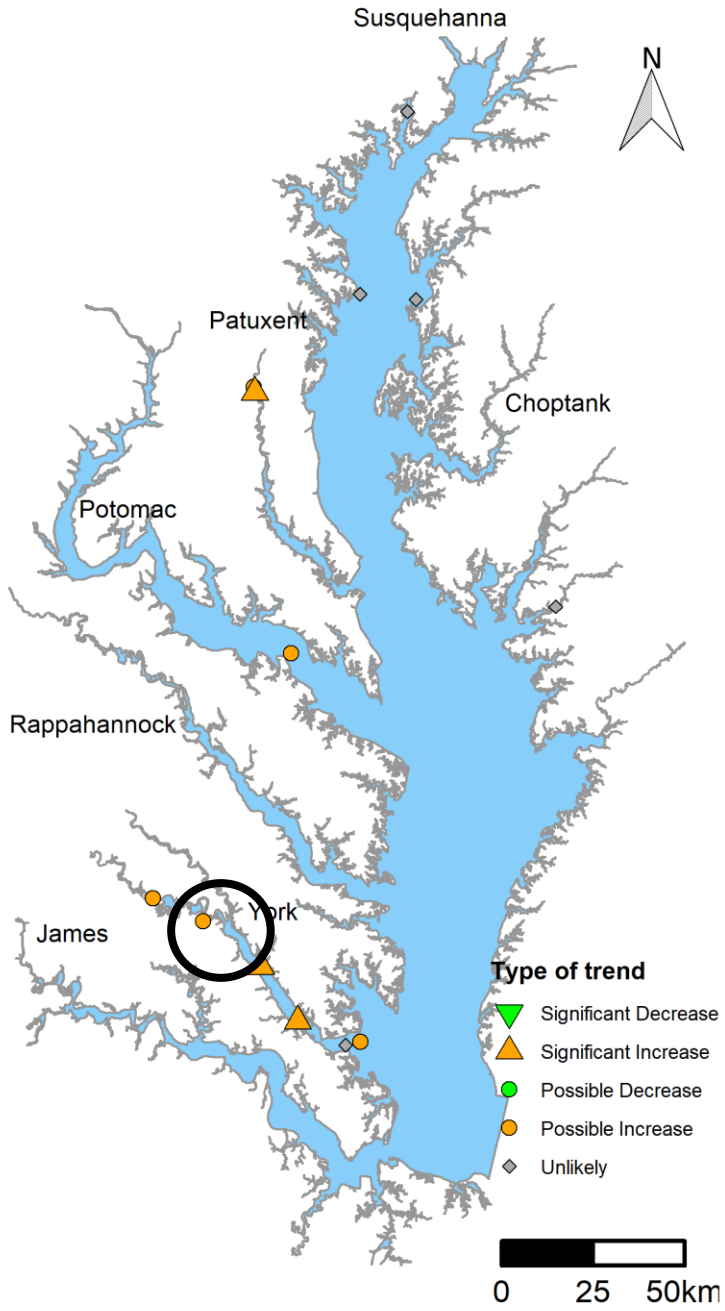
Approach #3: Compare temperature & DO trends in shallow water monitoring data to nearby long-term monitoring stations.

Stations for both shallow water and long-term are increasing, but a few more shallow water stations are significantly increasing for water temp.

Shallow water WTEMP Trends

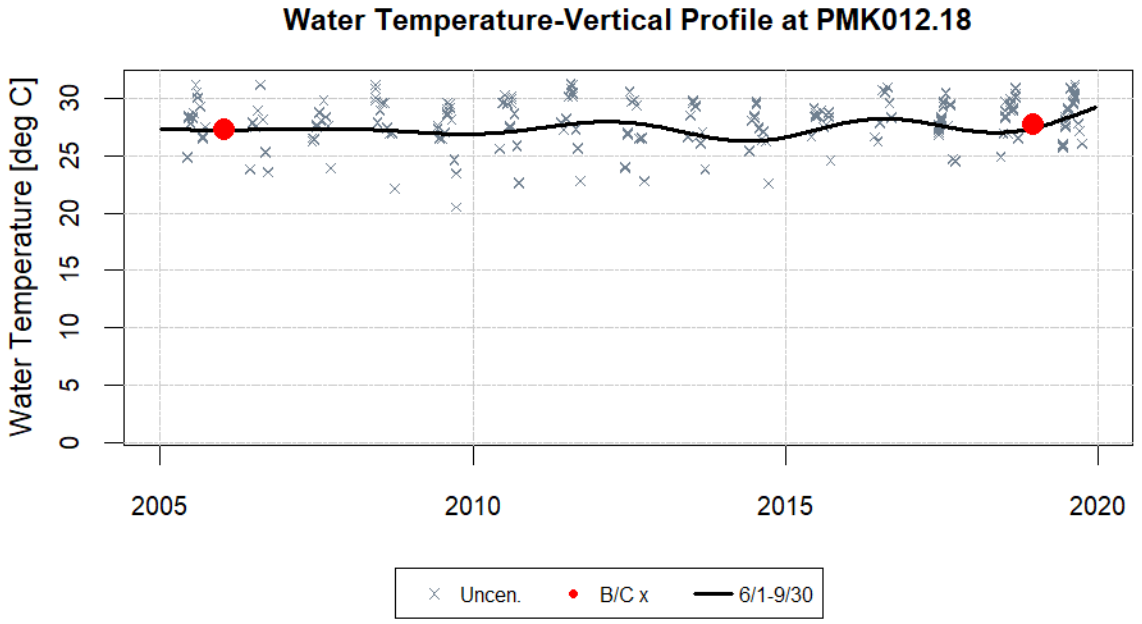


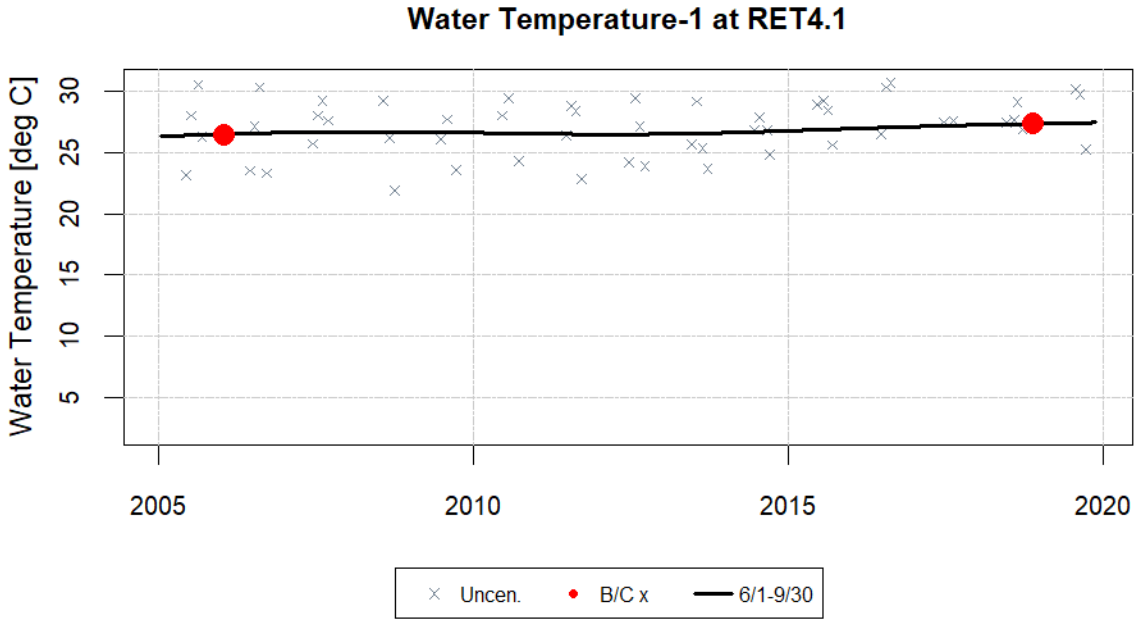
Long-term Monitoring WTEMP Trends



Overview:

- Most shallow water stations have a significant increase while the long-term has possible increase. The difference in increase between the two stations are not drastic in both states, and they have similar current summer water temp levels.
- At some stations in MD, the shallow water temp is significantly increasing over the period of record by the current summer water temp is still lower than long-term current summer water temp.





Approach #3: Summary

- When comparing the trends in shallow water stations to near by long-term monitoring stations,
  - There are mores shallow water stations with significant or possible decreasing DO trends than with the long-term stations.
    - There is not a drastic decrease in DO for most of the shallow water stations compared to the long-term monitoring stations

Will shallow water be more impacted than open water?

- The impact is not universal! It changes depending on state and within the state.
- The trends show more differences when comparing VA shallow water stations to VA long-term than for all MD stations.
- MD Eastern Shore stations have a lower DO then the Western Shore stations, but they show no trends over the period of record.
- More change is occurring for DO and water temp in the most recent years for the shallow water stations, but this doesn't always mean a worse measurement.
- If a shallow water station is more impacted compared to a long-term monitoring station, the difference is not drastic.

Are shallow water monitoring stations more impacted due to rising water temperatures?

- Rising water temperatures may be one factor.
  - Significant decreases in shallow water temp are only seen on the western shores of MD and in VA while there are not as many significant decreases shown in the long-term monitoring stations (over the time period analyzed).
  - The increasing difference between shallow water and long-term water temperature are not drastic.

- When looking at nearby shallow water stations within a state, both stations could have a significant increase in water temp but opposing DO trends.
  - Could nearshore watershed characteristics be driving these differences?

Next Steps

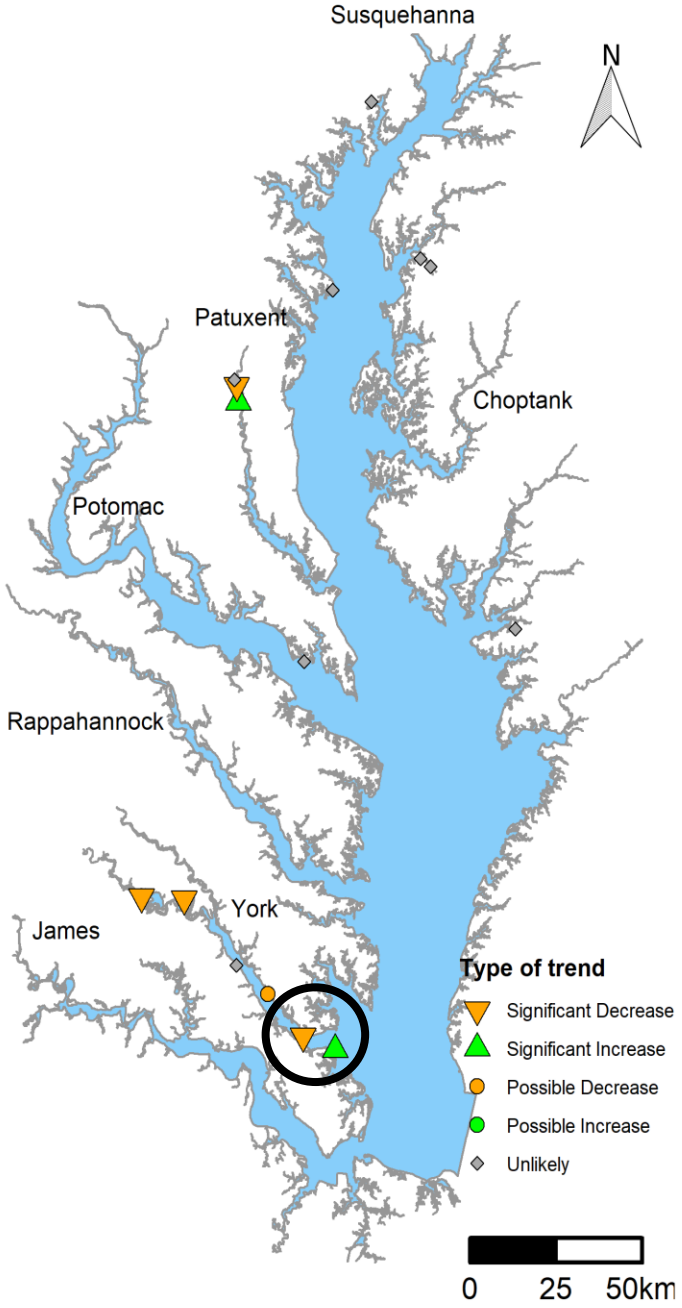
- Fit temporal GAM models to criteria violations over time at select stations
- Gain knowledge of general watershed characteristic for each station starting with nearby stations showing opposing trends
- Look into different drivers
  - Shoreline characteristics
  - Development
  - Precipitation
- Align work with Jeremy to help pinpoint some drivers

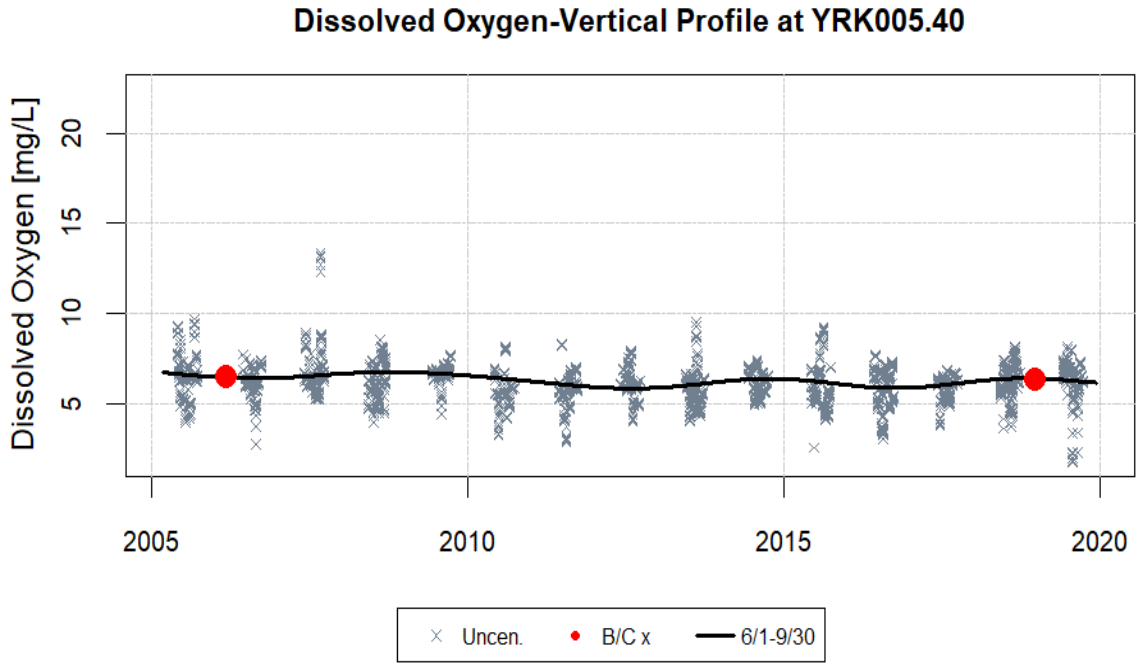
Questions?

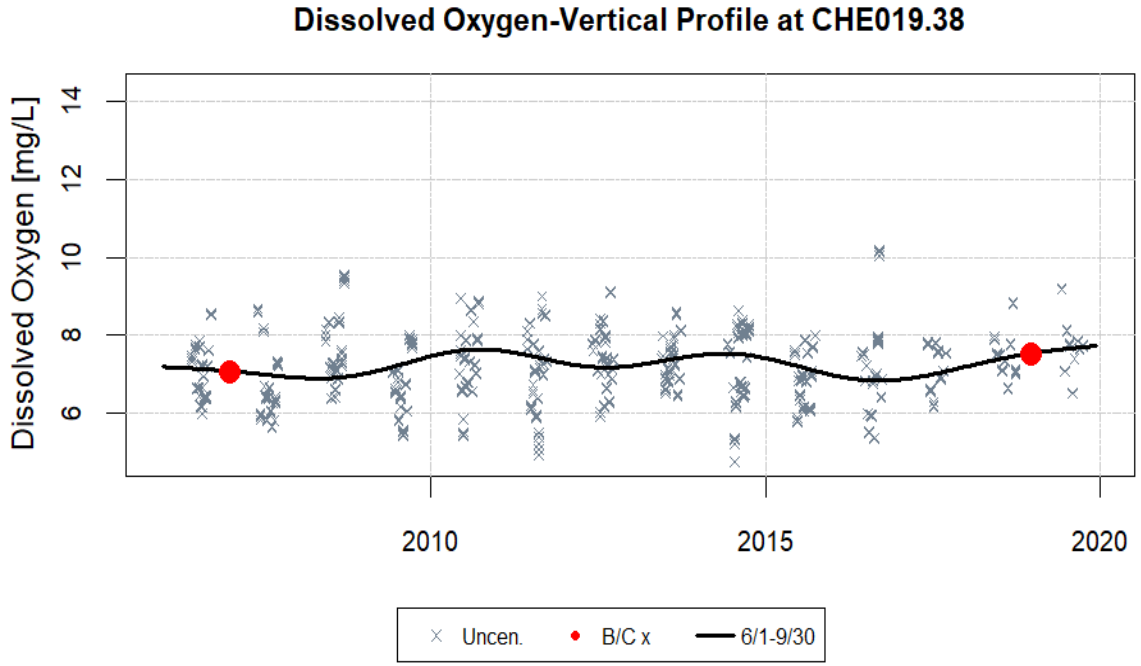
Thank you to Mark Trice and Dave Parrish!

Extra Slides

Shallow Water DO Trends

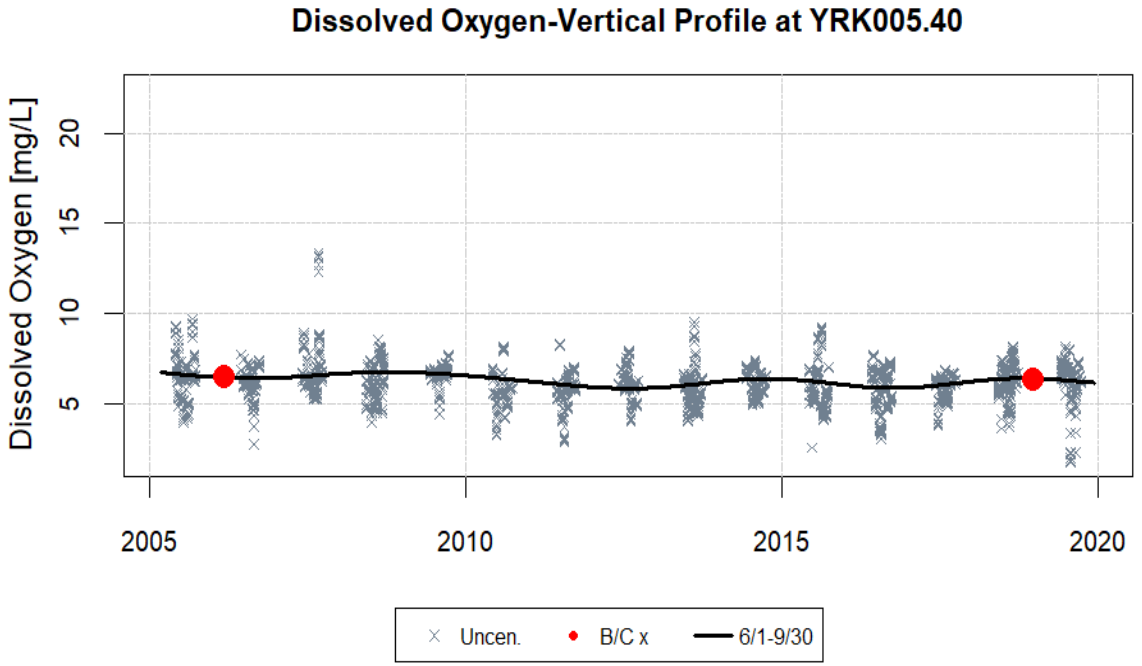






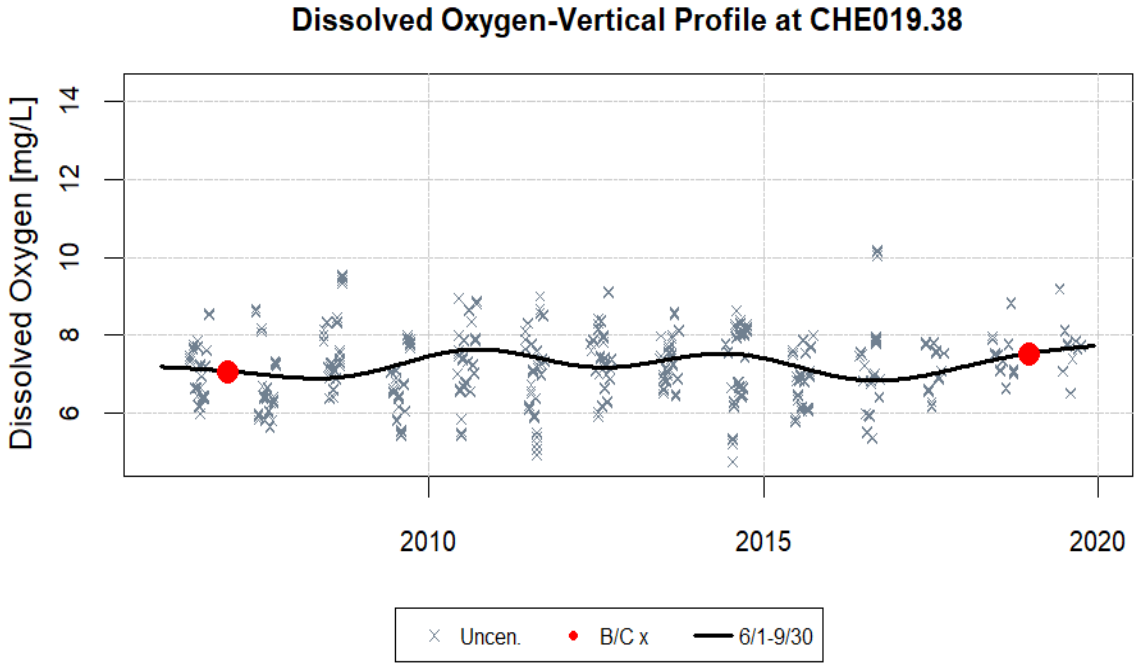
YRK005.40:

- 17-year change is: 2.99% decrease (p = 0.0033)
- Beginning DO Level ≈ 6.5 mg/L
- End DO Level ≈ 6.3 mg/L



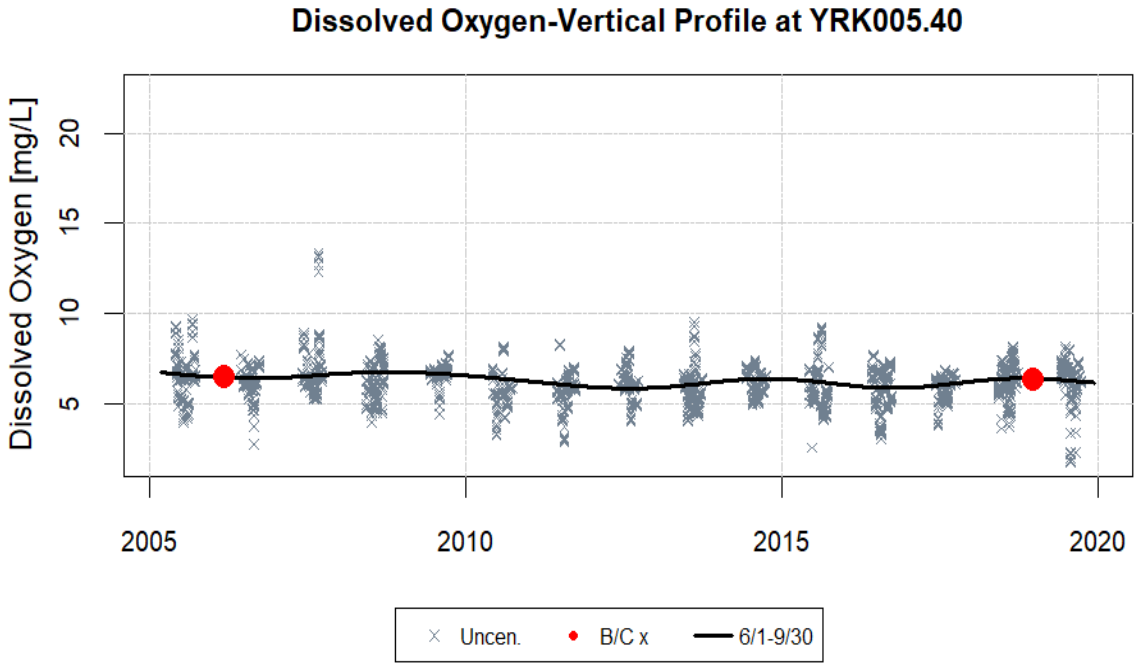
CHE019.38:

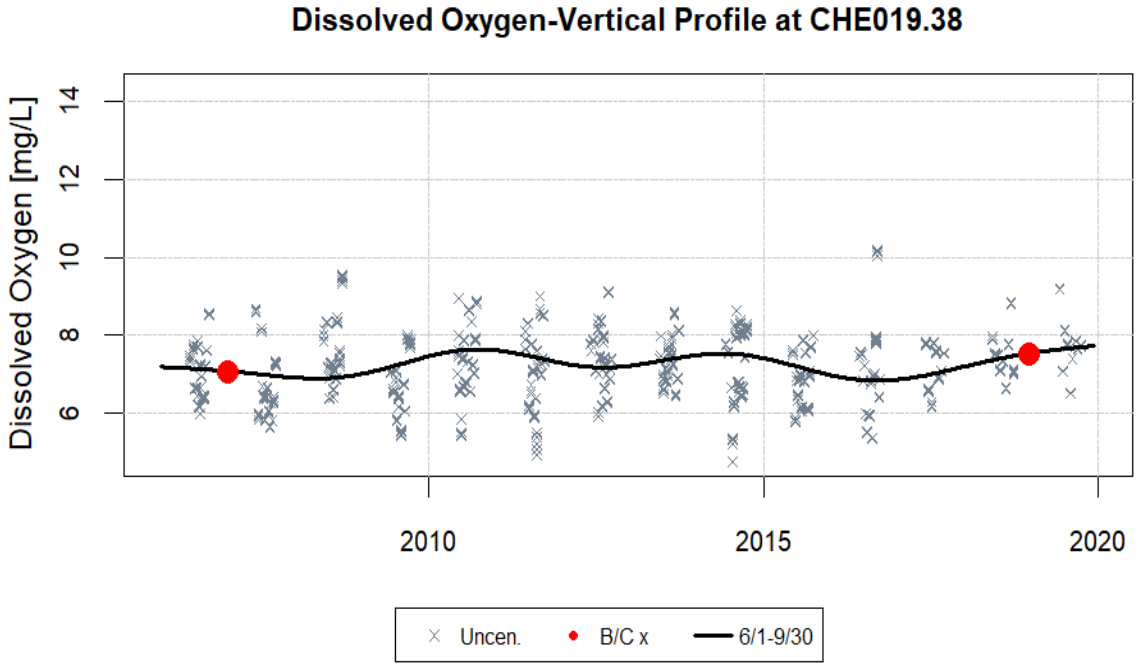
- 17-year change is: 6.4% increase (p <0.0001)
- Beginning DO Level ≈ 7 mg/L
- End DO Level ≈ 7.5 mg/L



Overview:

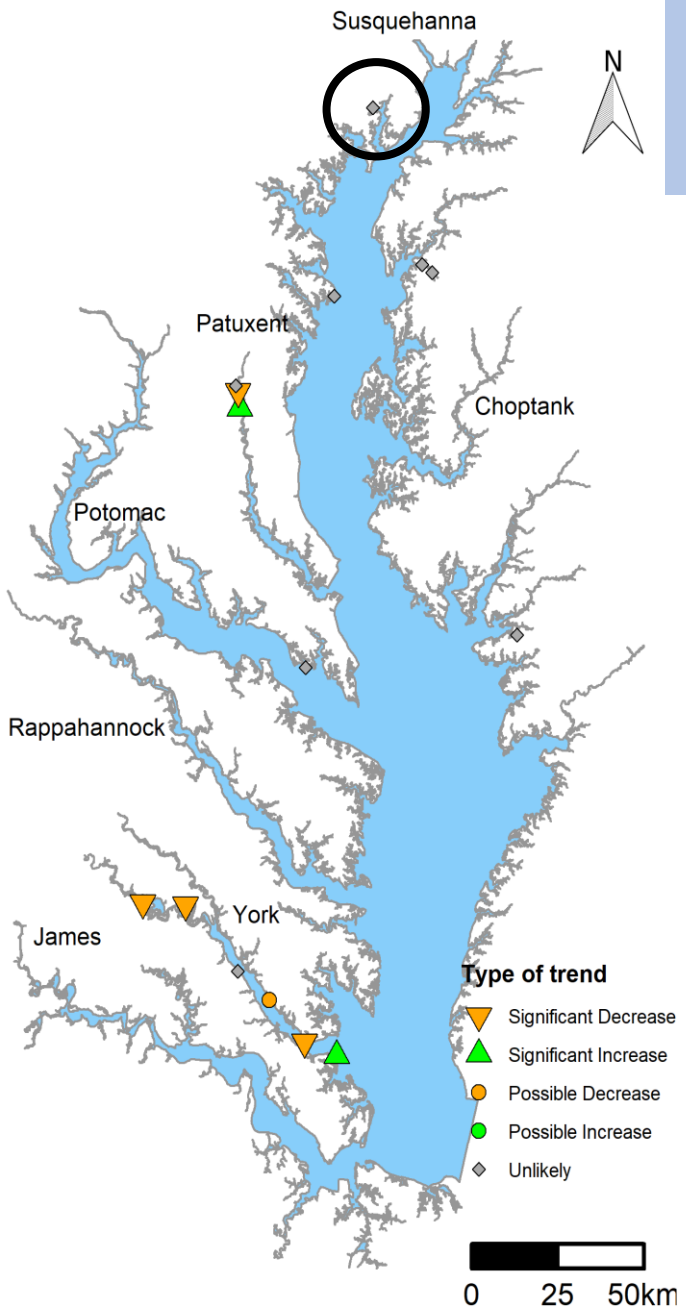
- Substantial change for CHE019.38 happened from 2015 – 2019.
- Close shallow water stations where one is consistently increasing over the period of record while the other one is slightly decreasing. Current summer DO levels are different but above criteria violation.
- Could nearshore watershed characteristics be driving these differences?



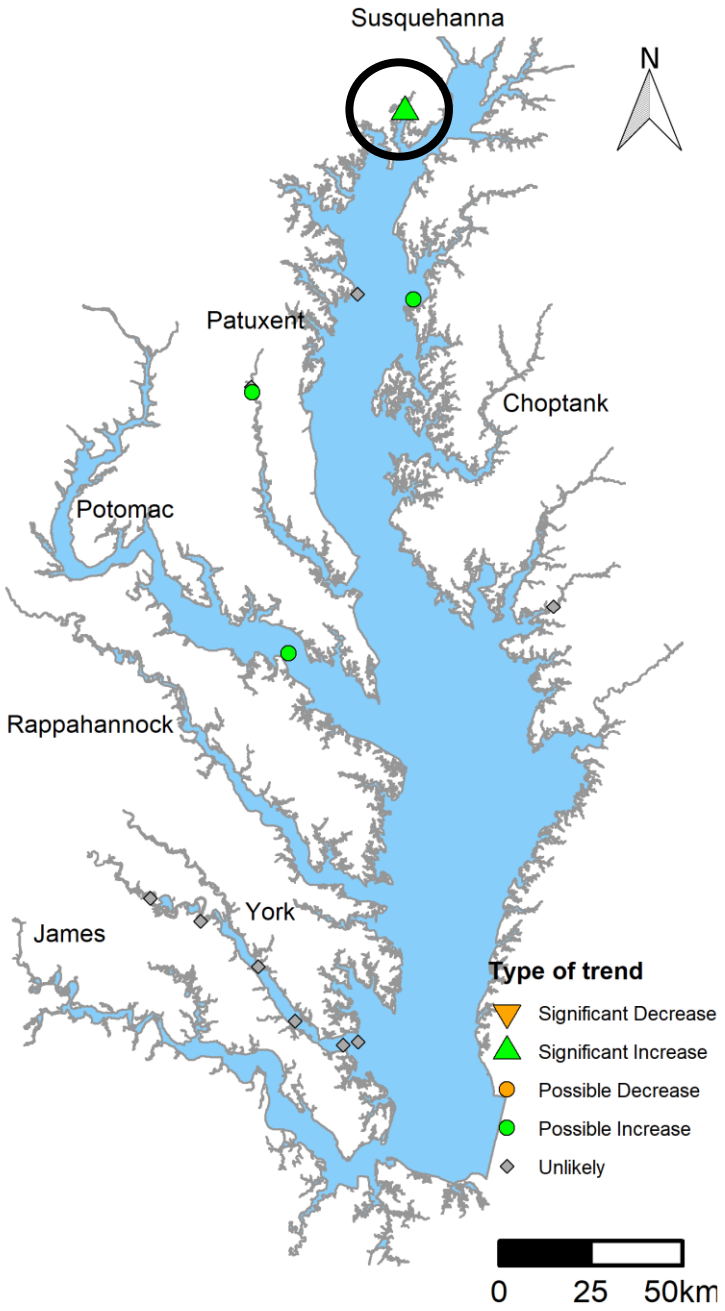


Approach #3: Compare temperature, DO, and DO saturation trends in shallow water monitoring data to nearby long-term monitoring stations.

Shallow Water DO Trends

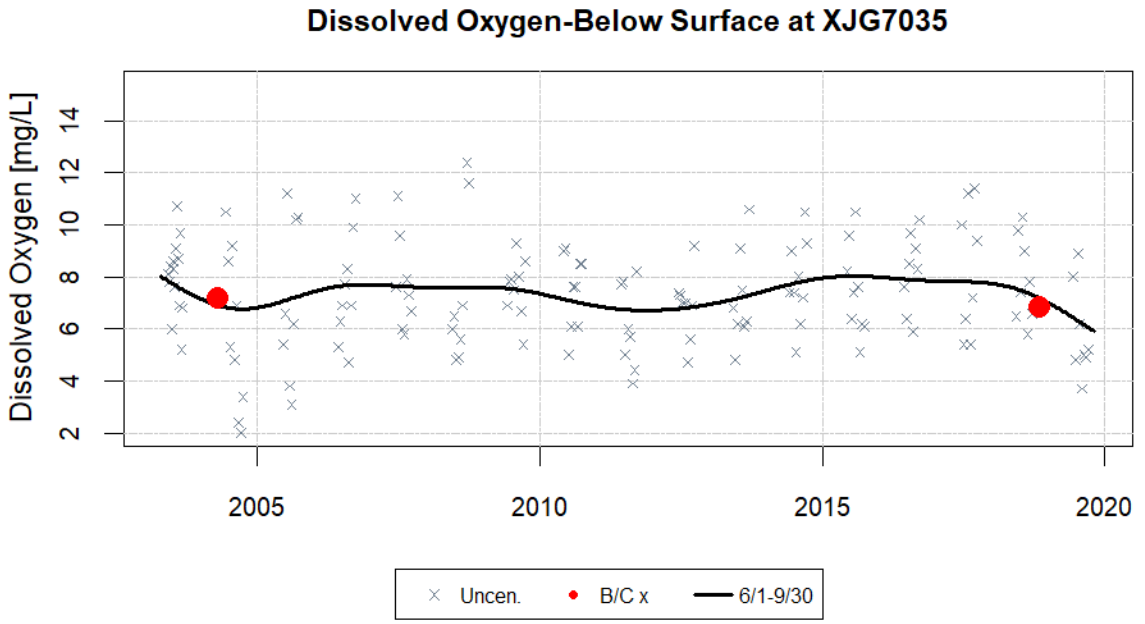


Long-term Monitoring DO Trends



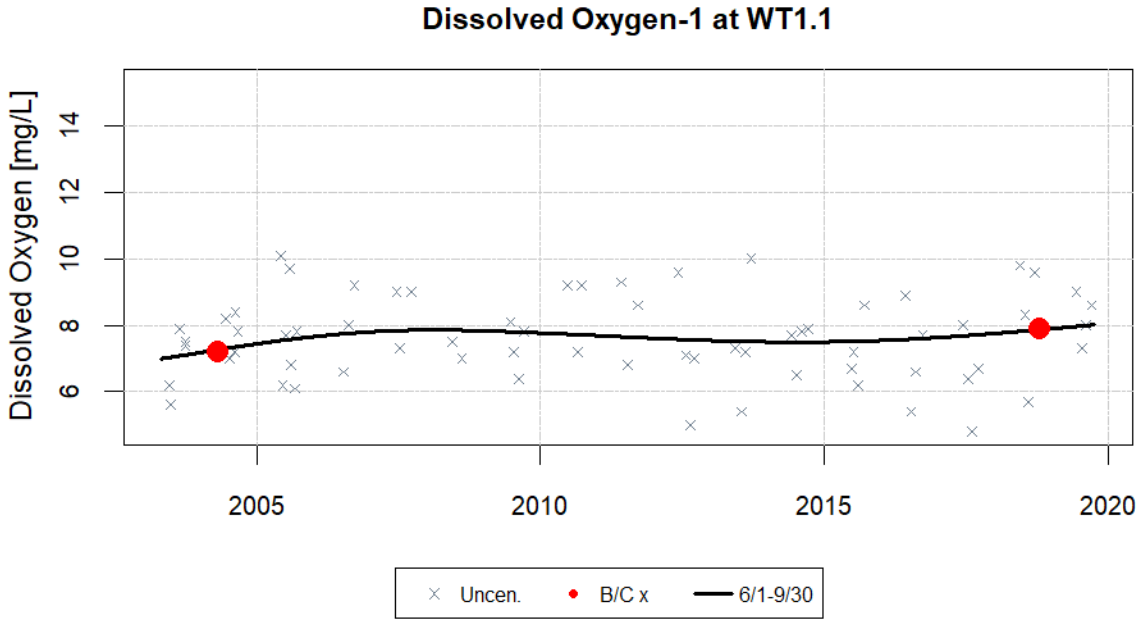
Shallow Water Station XJG7035:

- 17-year change is: 5.23% decrease (p = 0.321)
- Beginning DO Level ≈ 7 mg/L
- End DO Level ≈ 6.8 mg/L



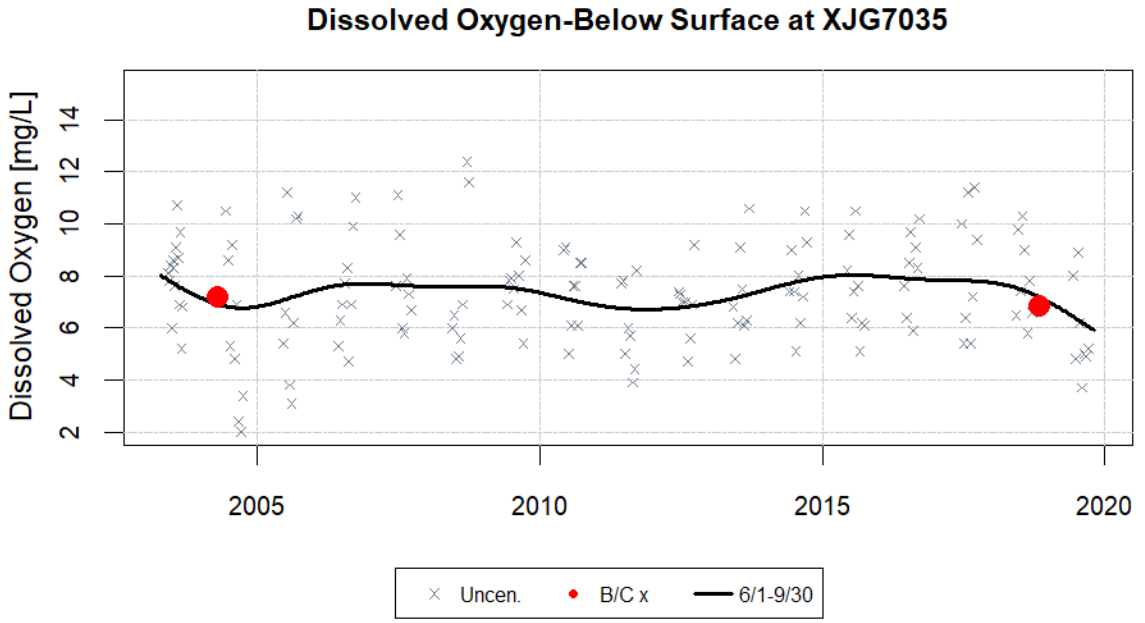
Long-term Monitoring Station WT1.1:

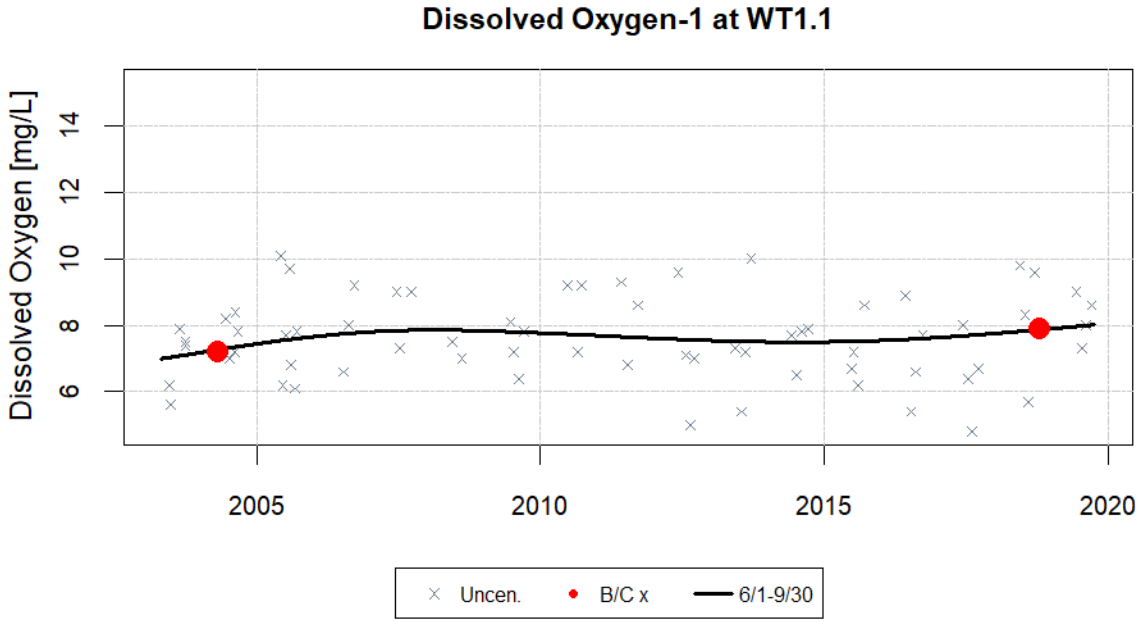
- 17-year change is: 9.9% increase (p = 0.0359)
- Beginning DO Level ≈ 7.1 mg/L
- End DO Level ≈ 7.8 mg/L



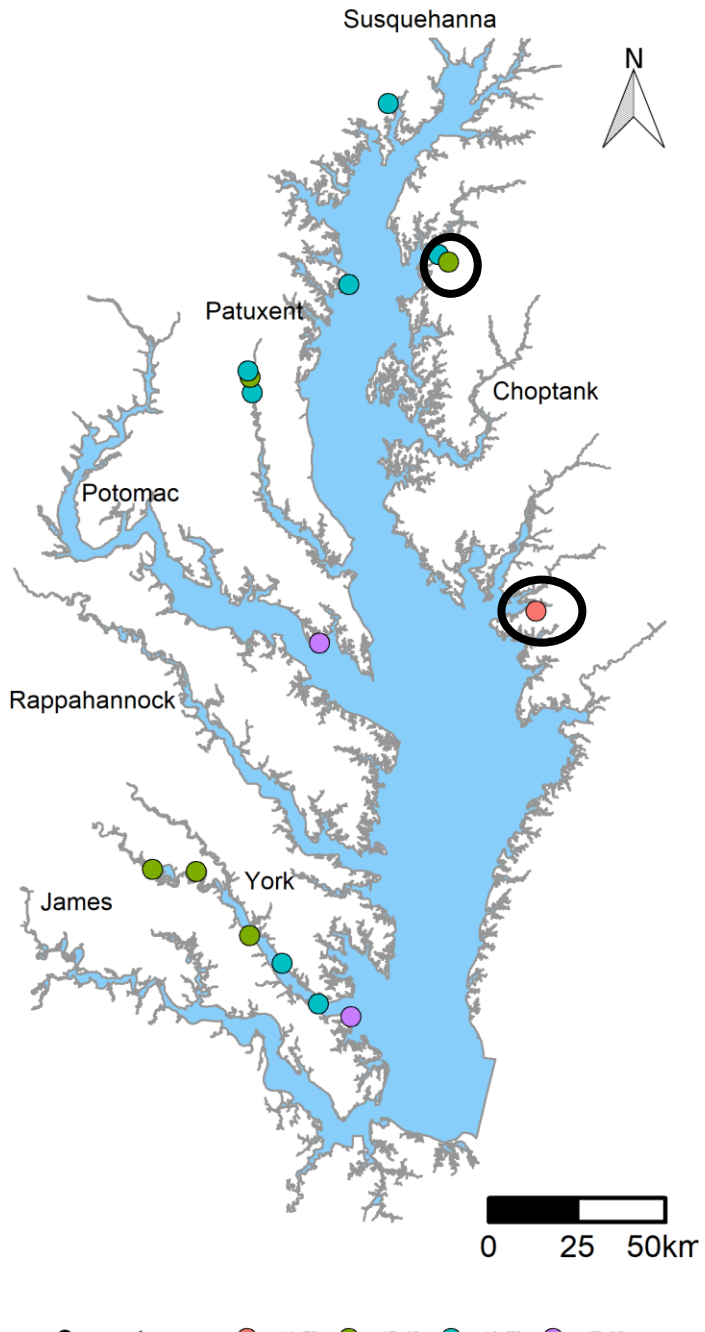
Overview:

- While the shallow water station is unlikely to have an increasing or decreasing trend, again the GAM fit is showing a decrease in DO levels during last few years.
- The long-term monitoring station is increasing throughout the period of record and has a higher current summer DO level (7.8 vs 6.8).





Shallow Water DO (mg/L): Last Two Years Averaged



Question: Does the MD Eastern Shore Shallow Water stations have lower DO levels vs the MD Western Shore stations?

Most MD stations have lower DO levels on Eastern Shore vs Western Shore.

These stations have a little lower current summer DO measurement compared to the long-term monitoring stations, but this is not consistent with all the other stations.

Long-term Monitoring DO (mg/L): Last Two Years Averaged