Potomac River: Tidal Water Quality and Criteria Attainment Trends

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With key inputs from:
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MWCOG meeting
Washington D.C.
June 18, 2018

[1]UMCES at CBP; [2]USGS; [3]MDDNR; [4]EPA at CBP

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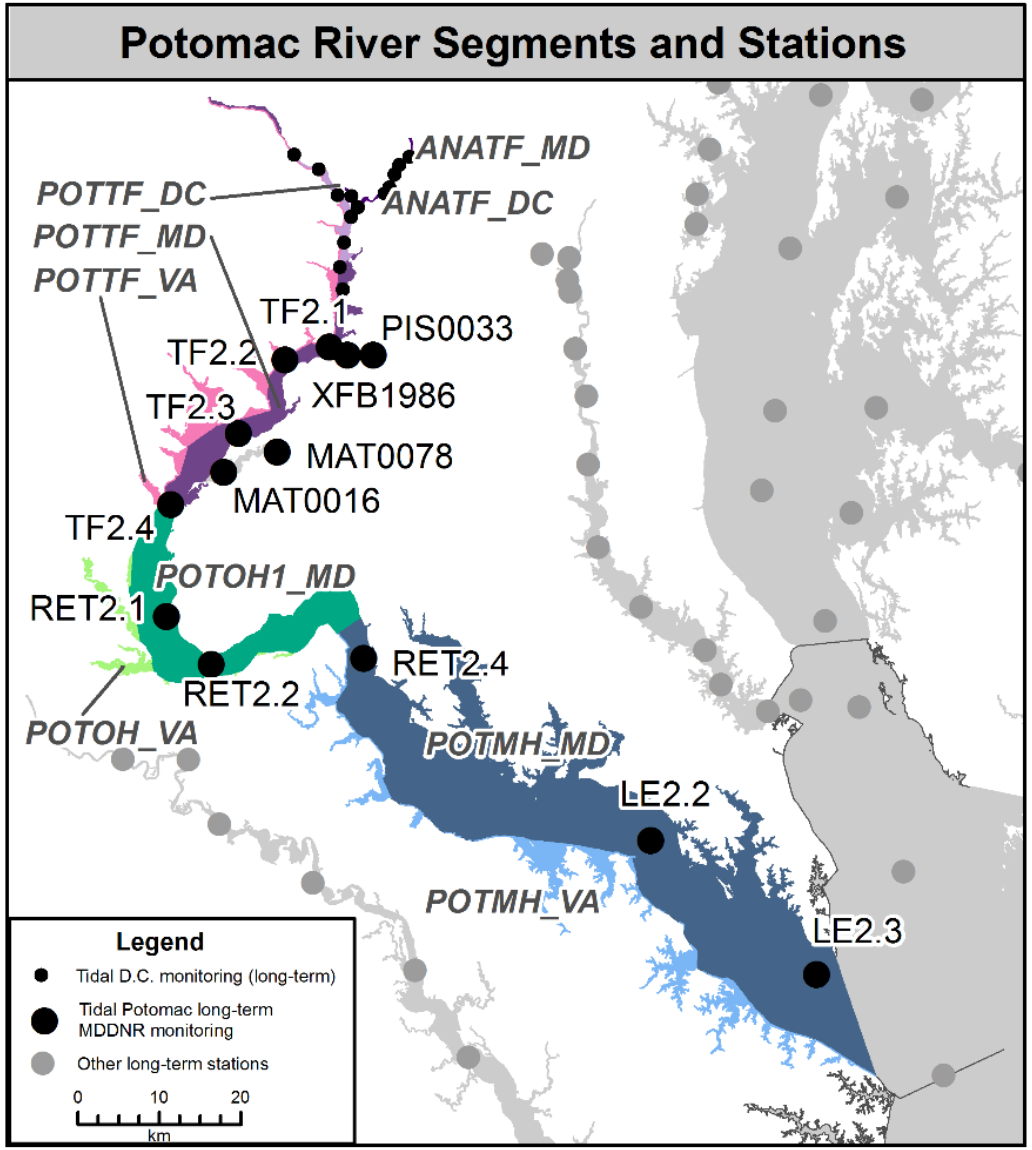
Overview: questions

1. What are the trends and status of water quality criteria attainment in the Potomac?
2. Are we seeing the same rate of improvement in deep water/deep channel DO in the lower Potomac and the mainstem?
3. How is attainment status linked to DO and other water quality parameter trends?
4. What can the tidal trends tell us about nutrient reductions?



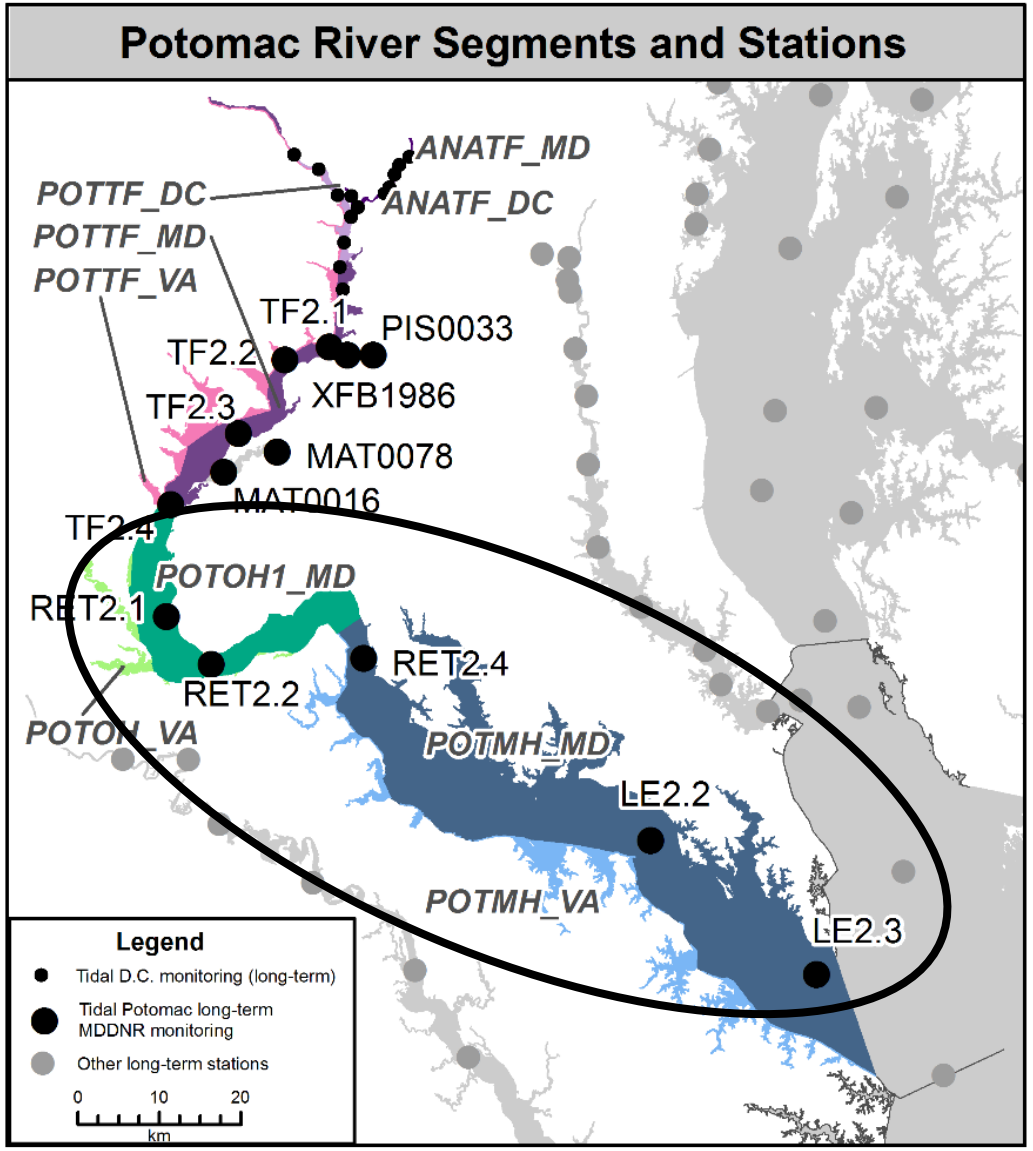
Overview: Organization

1. Lower and Middle Potomac
   - Comparison to mainstem water quality criteria patterns
   - Examination of water quality trends
   - Consider system dynamics

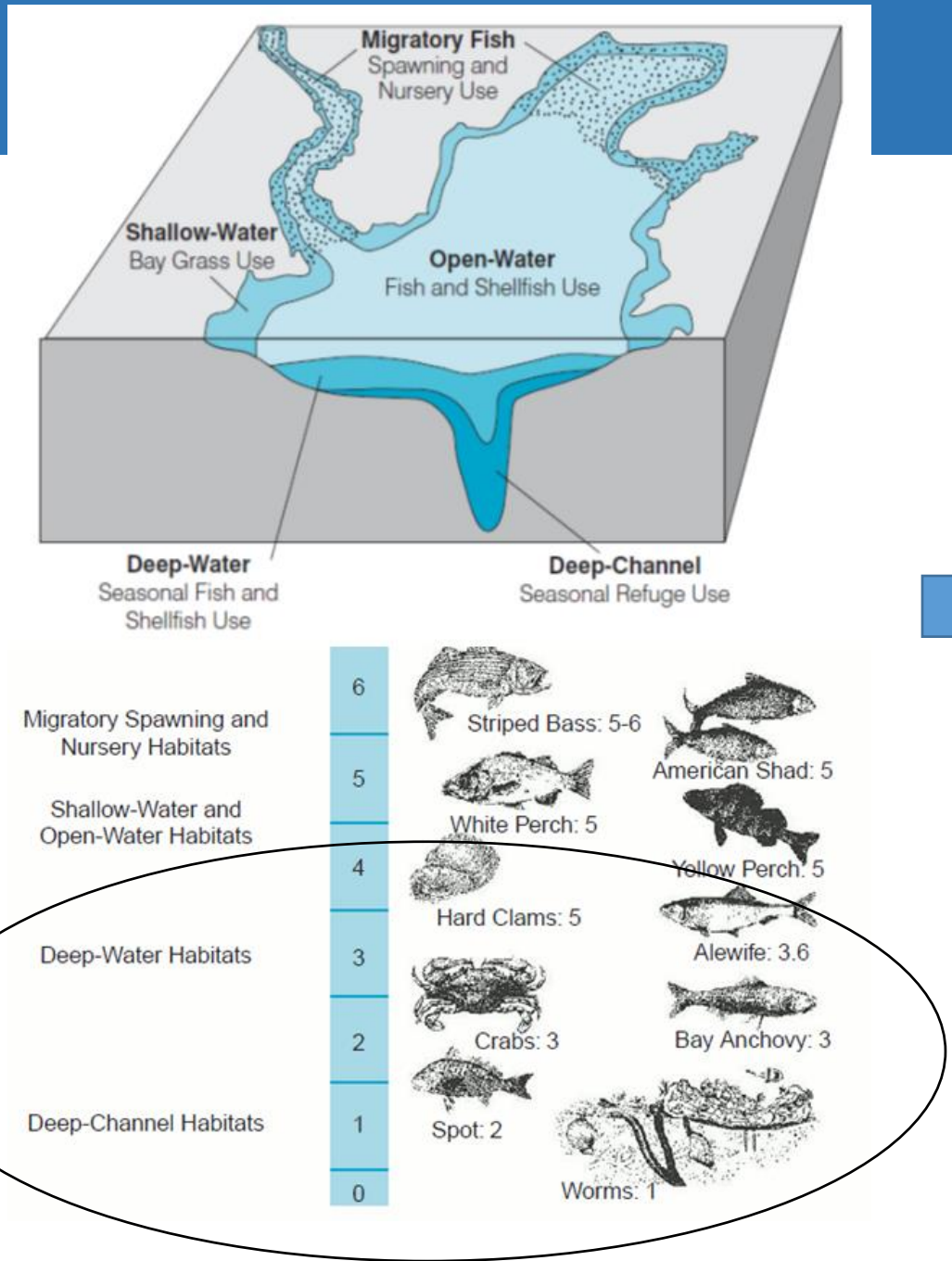
2. Upper Estuary (briefly)
   - Anacostia and Potomac-DC quick look at the data

3. Consider nutrient sources (briefly)

1. Lower and Middle Potomac



Designated Uses with DO requirements



Evaluate with monitoring data spatially and temporally combined to determine if conditions are met over 3 year periods

USEPA 2003 and 2004

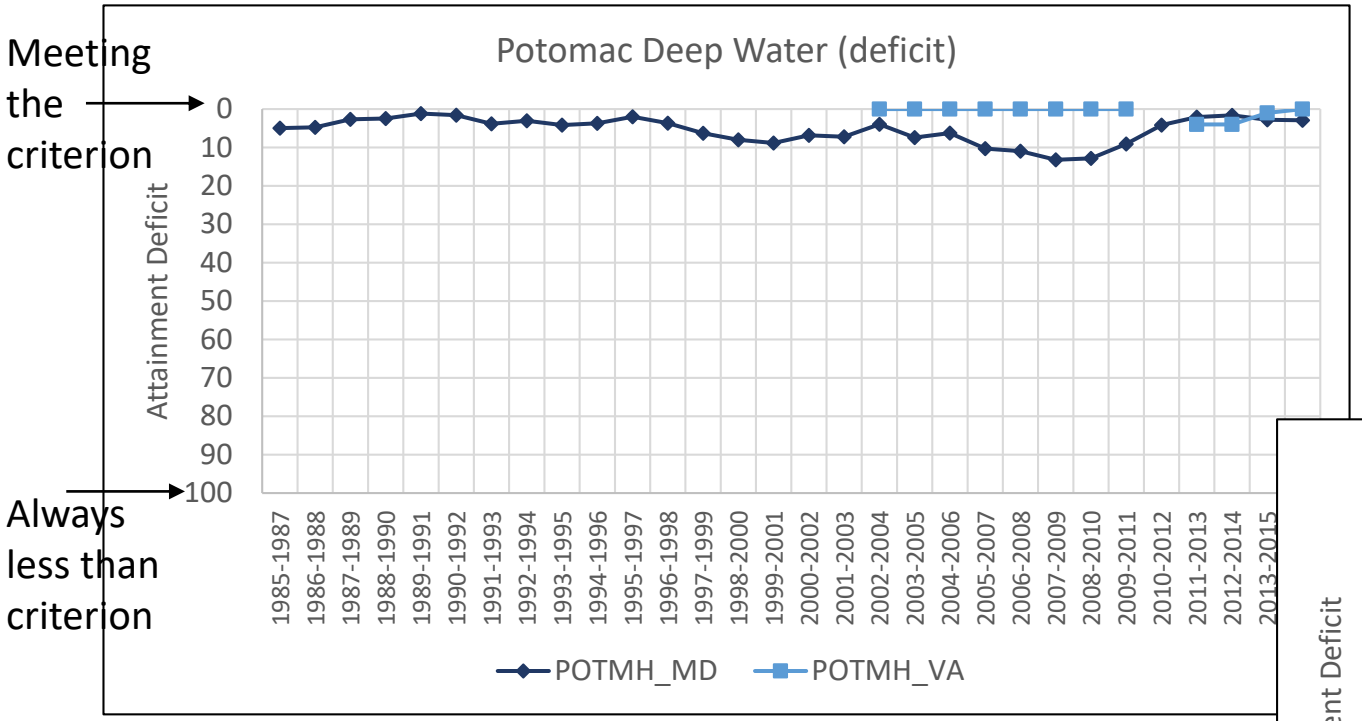
Potomac and Nearby Mainstem: Deep Water and Deep Channel

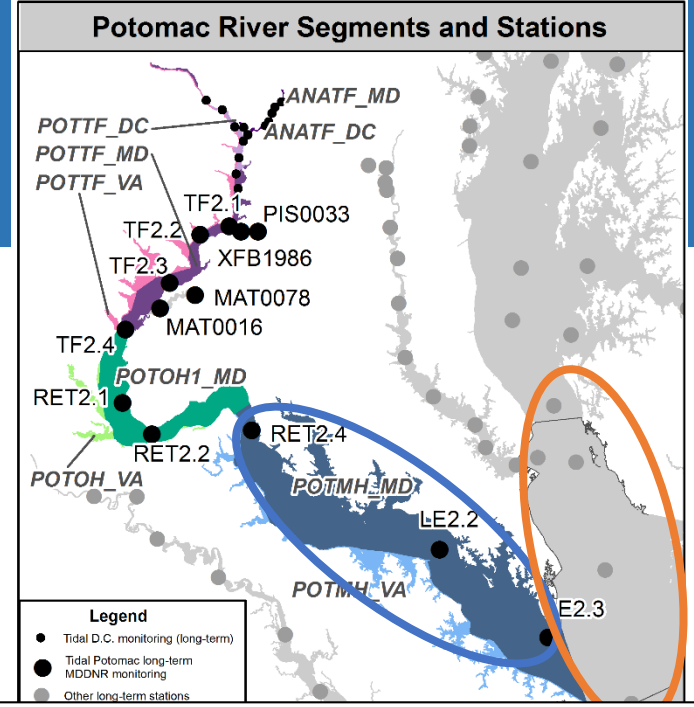
For 3-year periods, indicates if criteria was met (green shaded) or not met (blank)

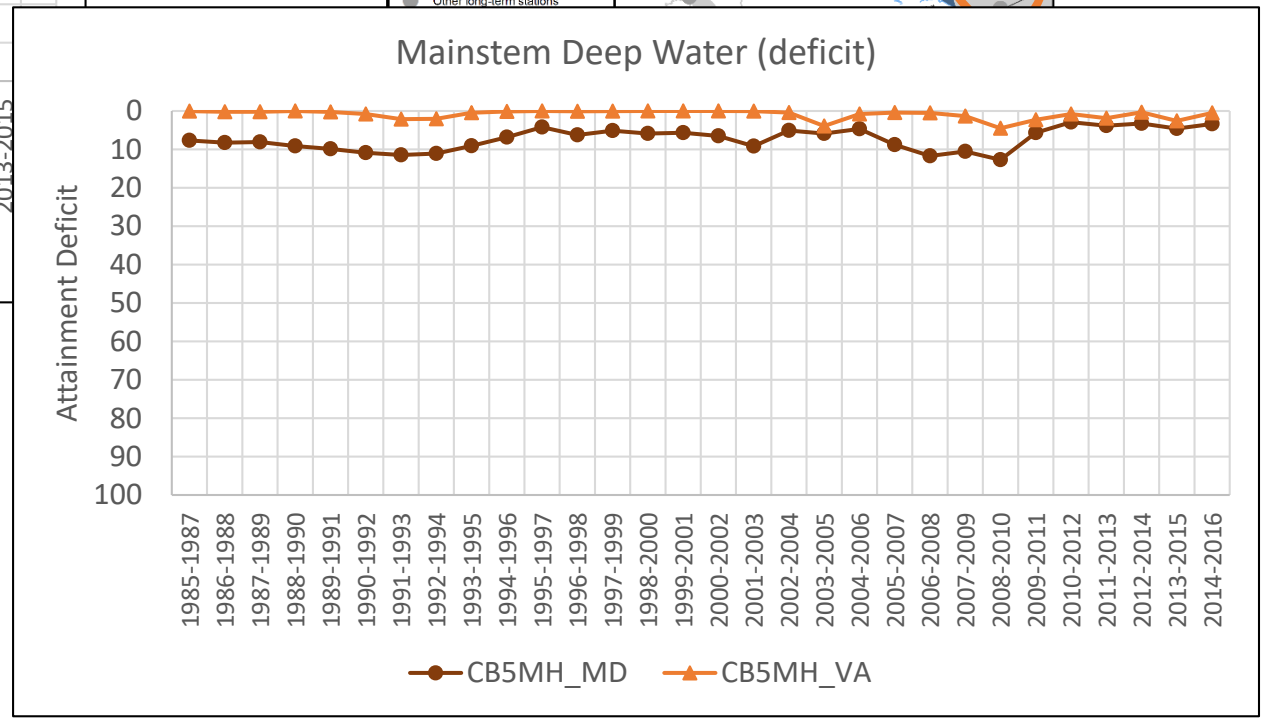
	DU	Segment	1985-1987	1986-1988	1987-1989	1988-1990	1989-1991	1990-1992	1991-1993	1992-1994	1993-1995	1994-1996	1995-1997	1996-1998	1997-1999	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016
Summer 30-day mean	Deep Water	POTMH_MD																													
		POTMH_VA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND								ND				
		CB5MH_MD																													
		CB5MH_VA																													
Summer instantaneous	Deep Channel	POTMH_MD																													
		POTMH_VA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND						ND	ND	ND	ND	ND
		CB5MH_MD																													
		CB5MH_VA																													

- The MD segments have never met these criteria over the record.
- But hard to compare and assess progress this way.
- We'll dig in with another metric →

“Attainment deficit” for Deep Water



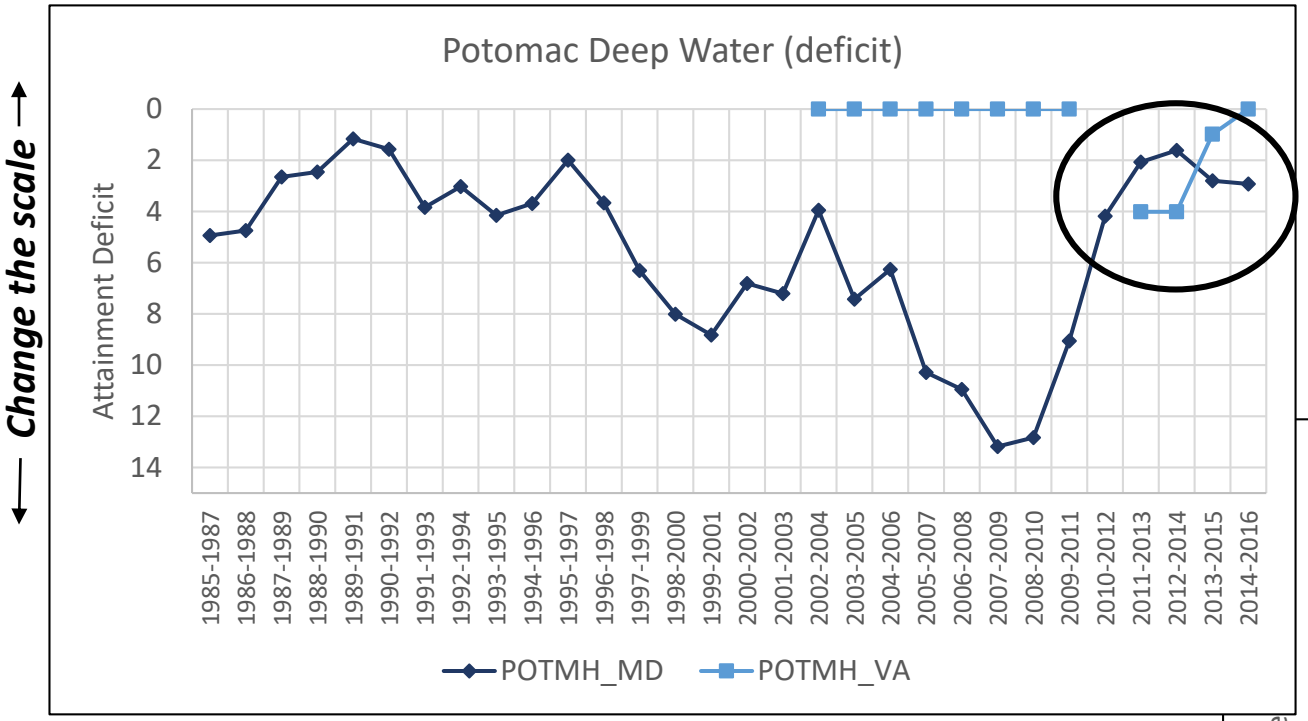




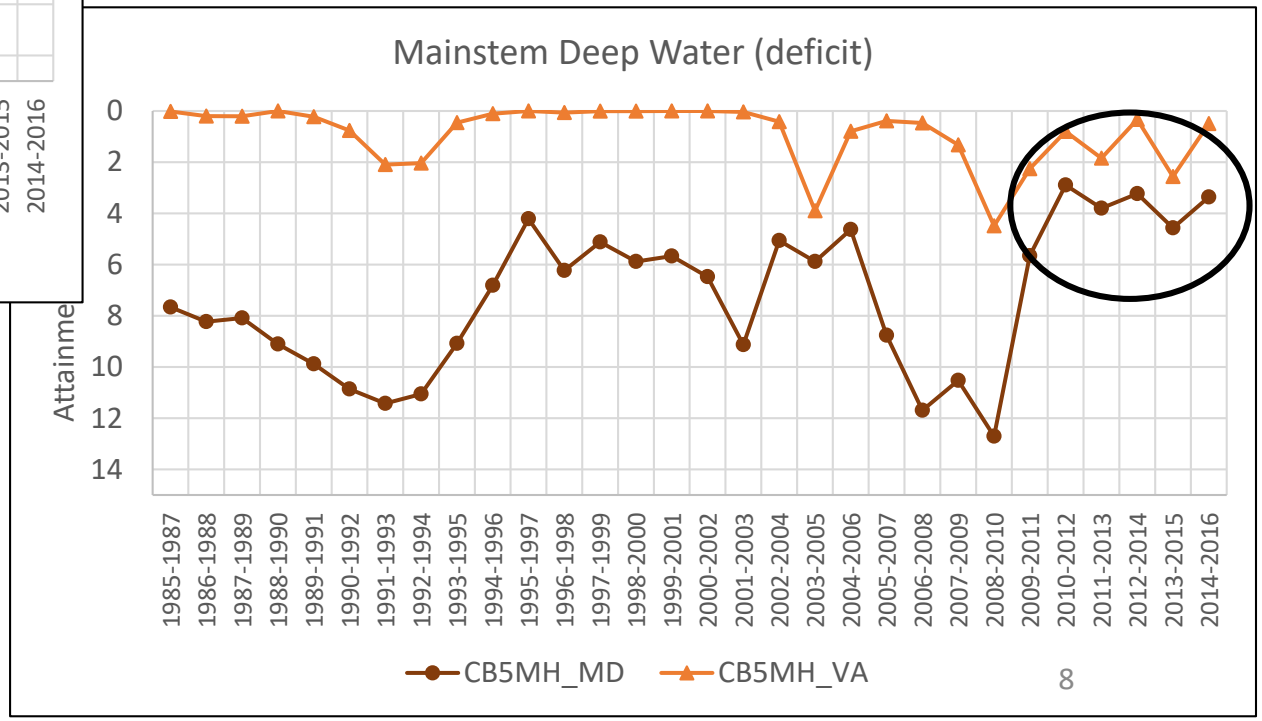
Attainment Deficit: Is the percent of space and time for the assessment that is not meeting the minimum acceptable DO criterion

Attainment deficit computed by Qian Zhang, UMCES

“Attainment deficit” for Deep Water



See a lot of variability over time. But in last 5-6 periods, both Potomac and MD mainstem show similar improvements.



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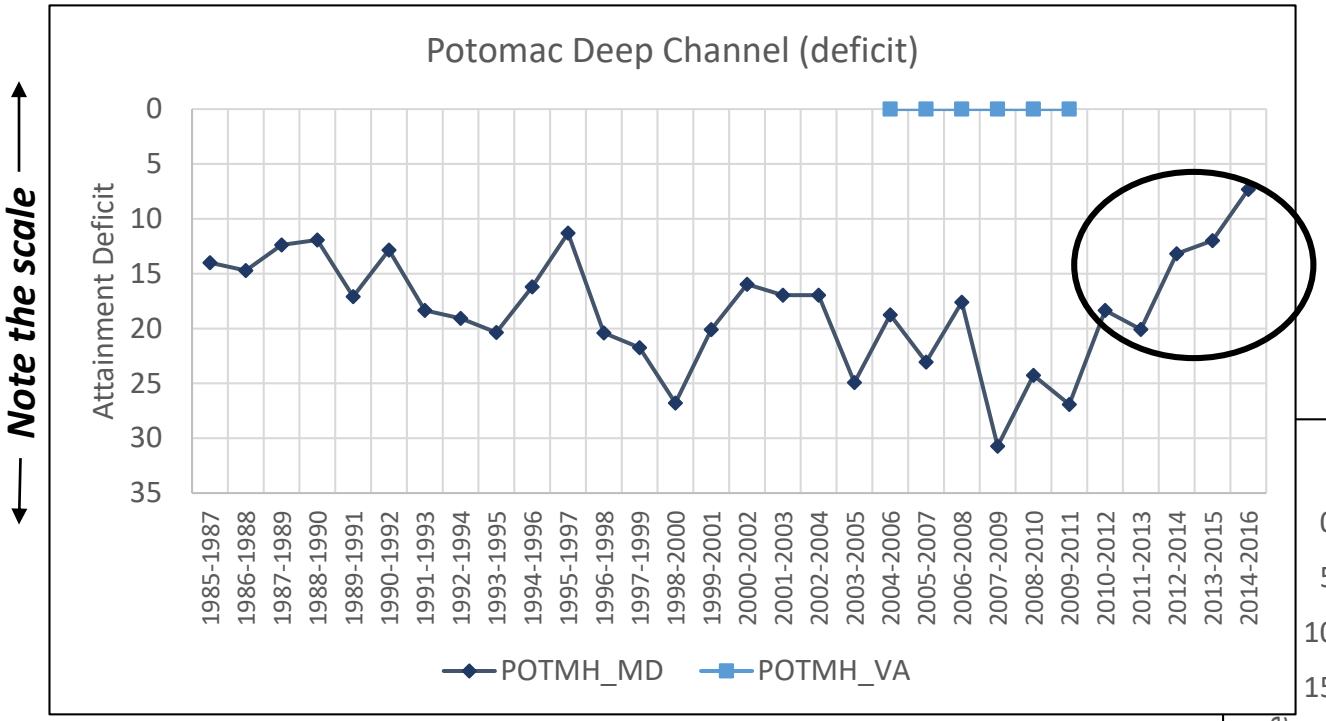
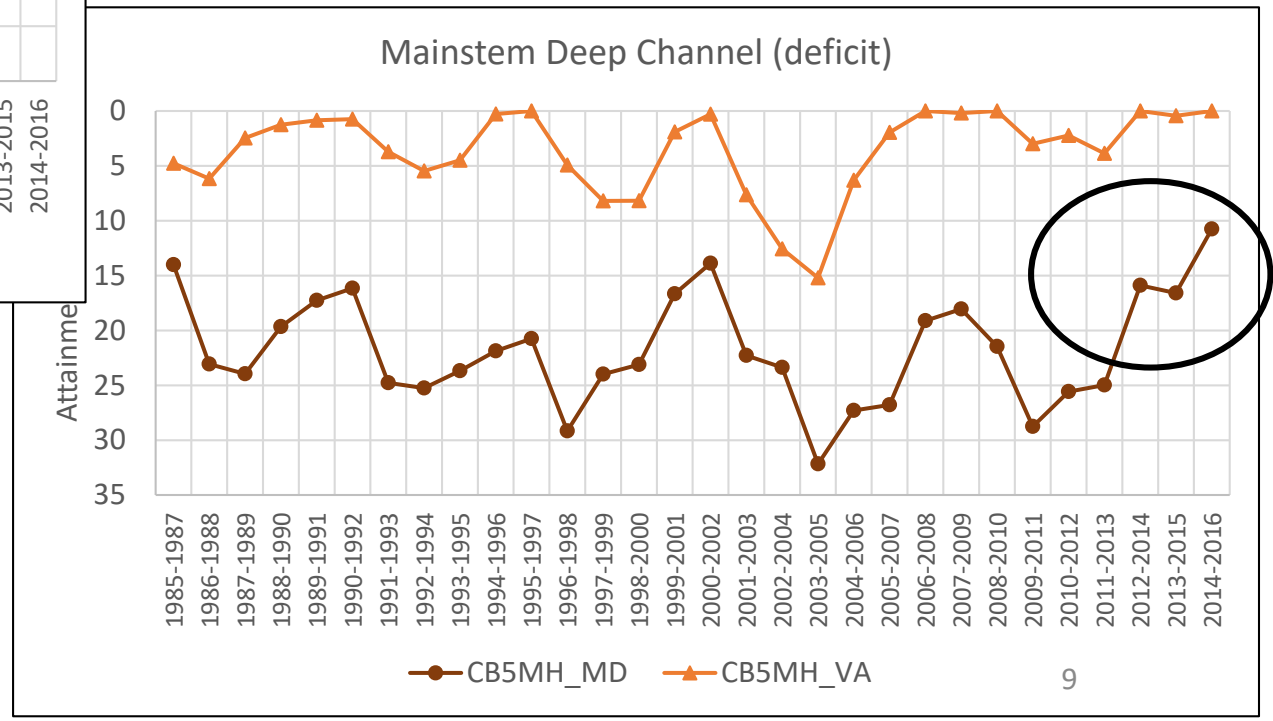
“Attainment deficit” for Deep Channel



Note the scale

Same finding for Deep Channel – improvements in last few periods.



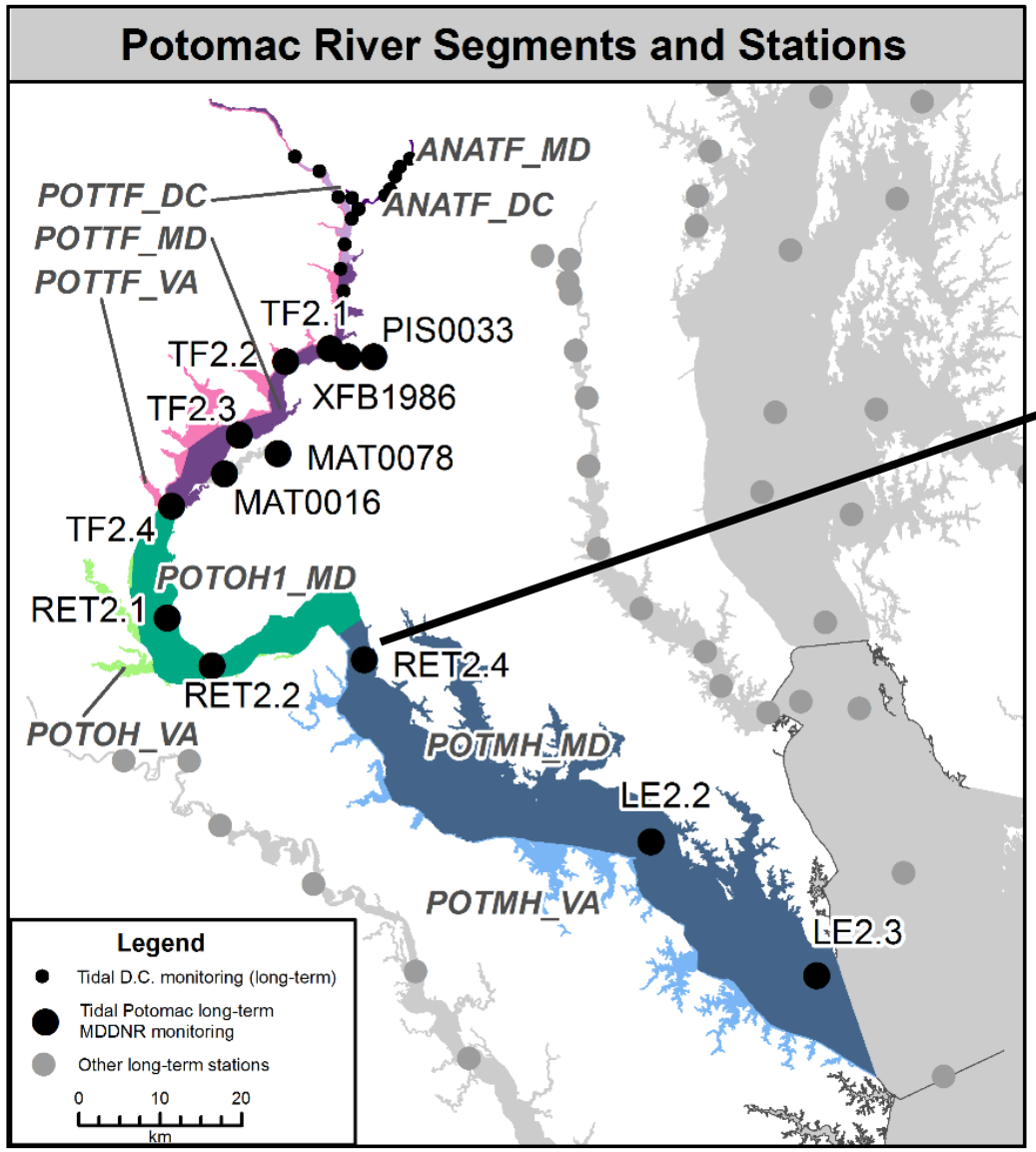
Attainment deficit computed by Qian Zhang, UMCES

Summary: Deep water and deep channel criteria

- Historically the Lower Potomac and mainstem segments had different patterns.
- But recent improvements are similar in both Potomac and mainstem.

→ *Link to the data to unravel why and what to expect:*

Examine the data



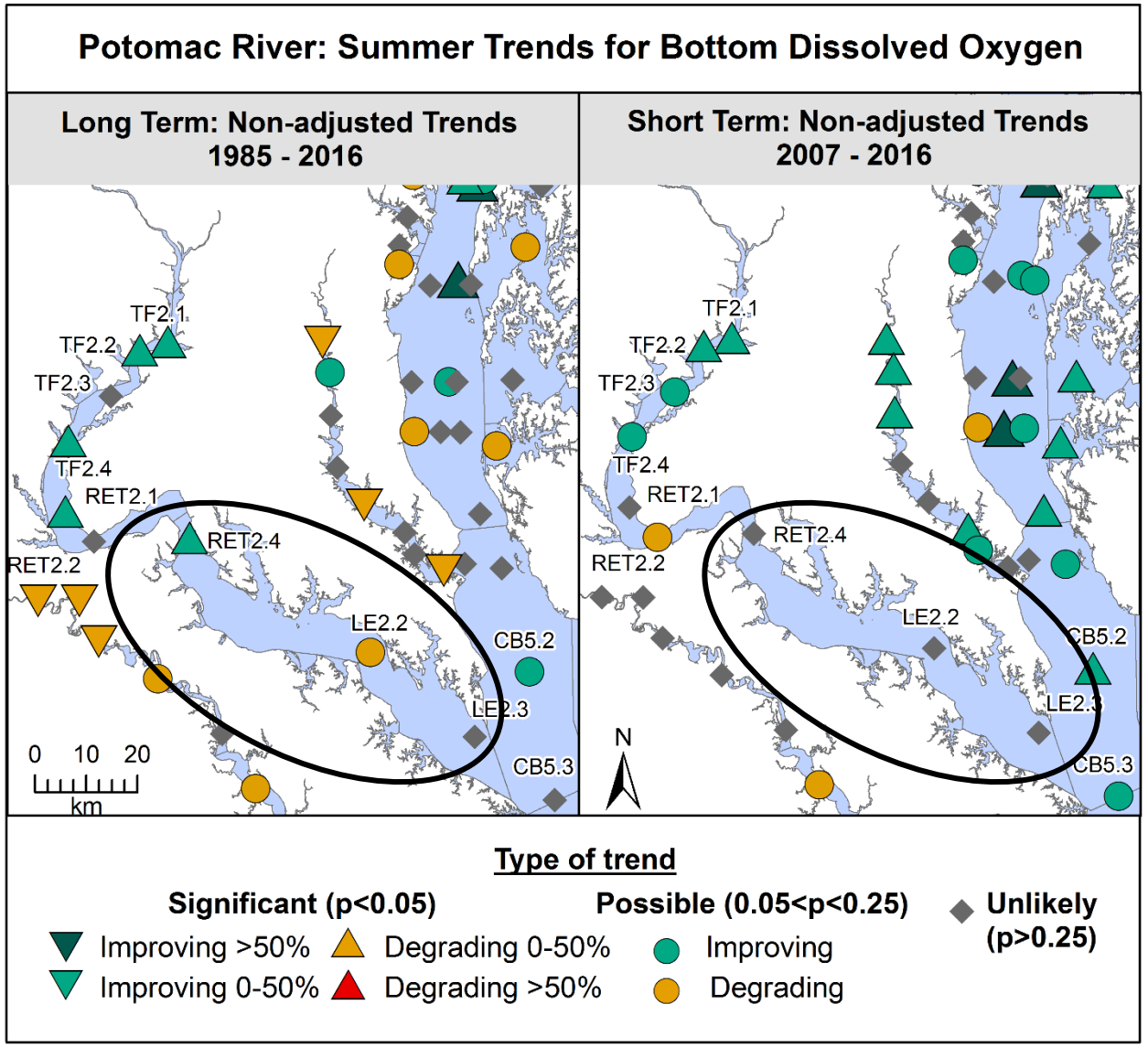
At each monitoring station:

- Records since mid-1980s of: DO, nutrients, chlorophyll-a, clarity, physical conditions
- We collaborate with MDDNR to evaluate these annually
- Using statistical technique (GAMs) to capture both trends and patterns in the data over time[a]

[a]GAM implementation team including Elgin Perry and Jeni Keisman, among others

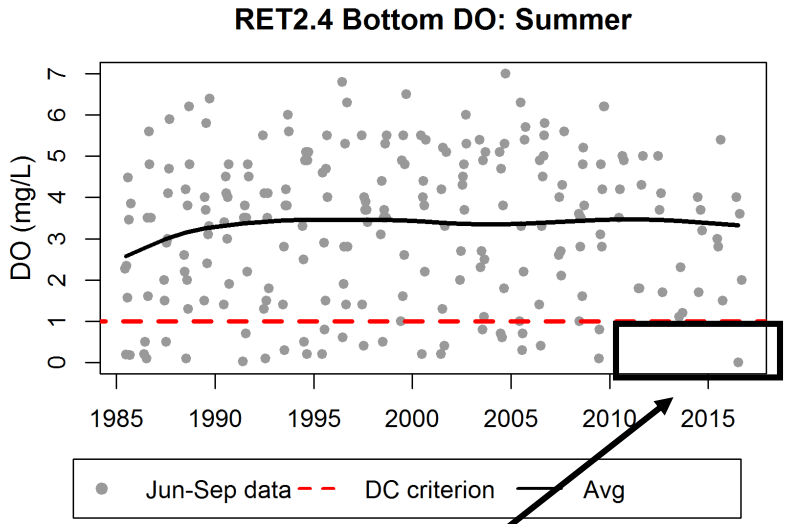
Trends in summer bottom DO

Don’t clearly see this recent improvement in the DO trend maps

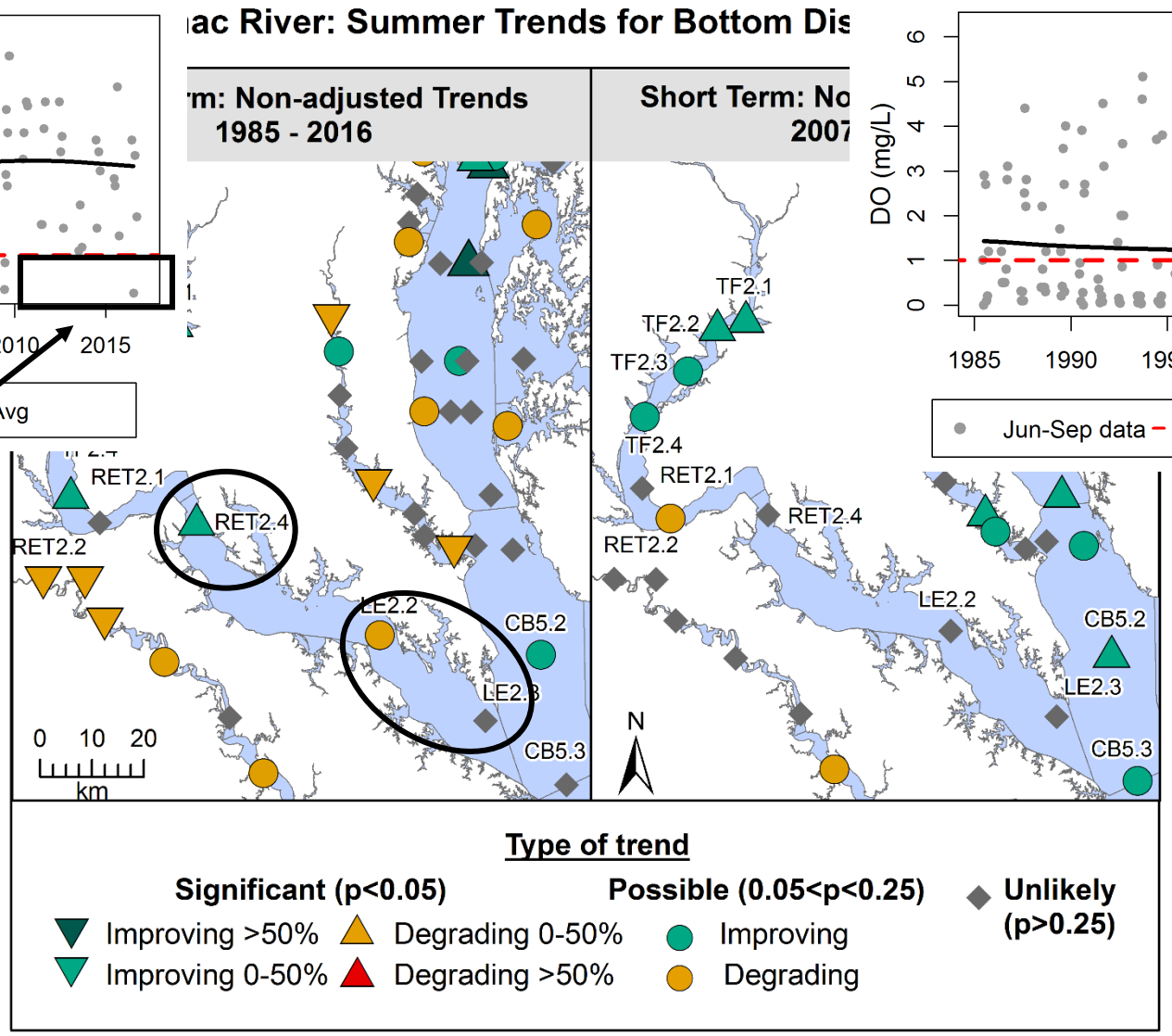


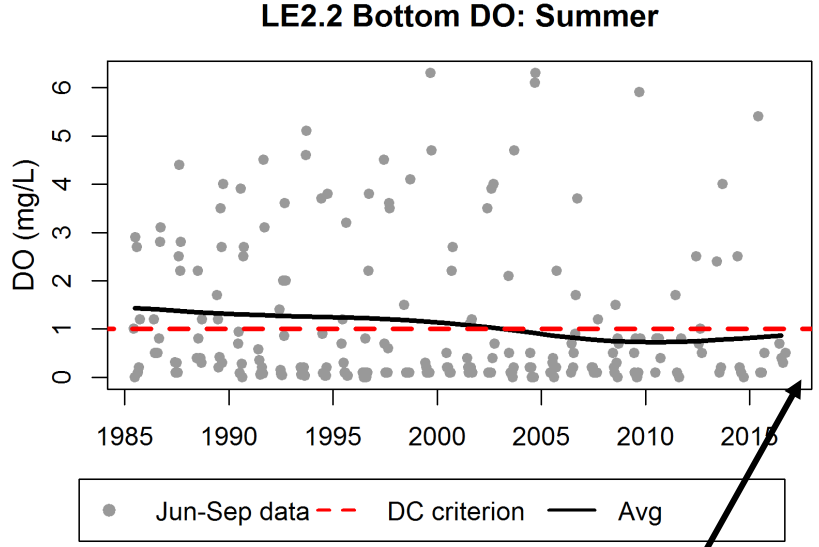
MD trends computed by Renee Karrh, MDDNR

DO: improvements are there, but not big enough yet



Recent years RET2.4 has almost no bottom DO below 1mg/L





Very slight upswings at LE stations (a bit less, but similar to mainstem stations)

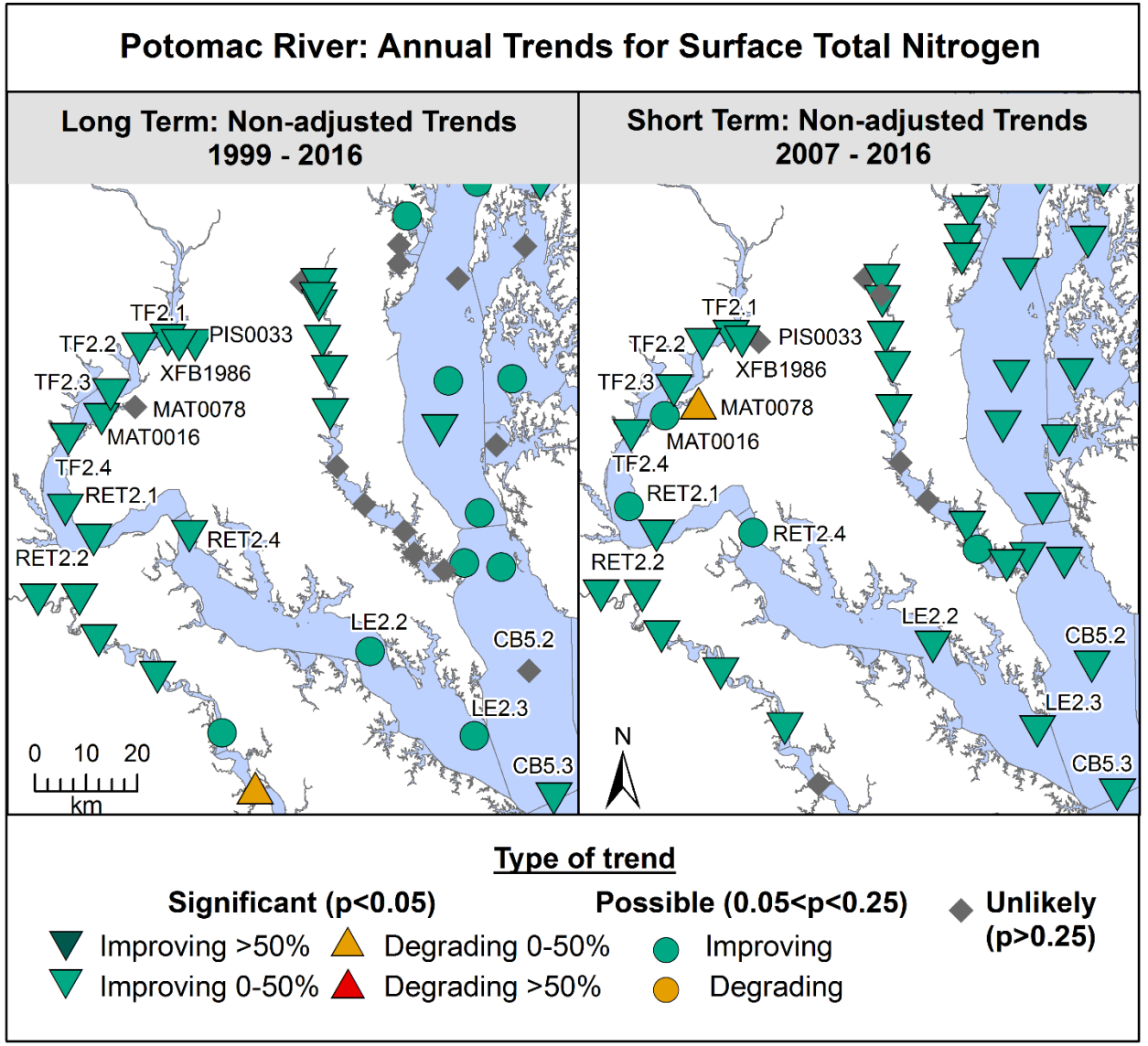
Other water quality parameters

Look at other water quality variables to get signs of the system's trends:

- Total Nitrogen
- Total Phosphorus
- Chlorophyll-a (indicator of algae)
- … and many more possible

Factors affecting DO: Total Nitrogen Trends

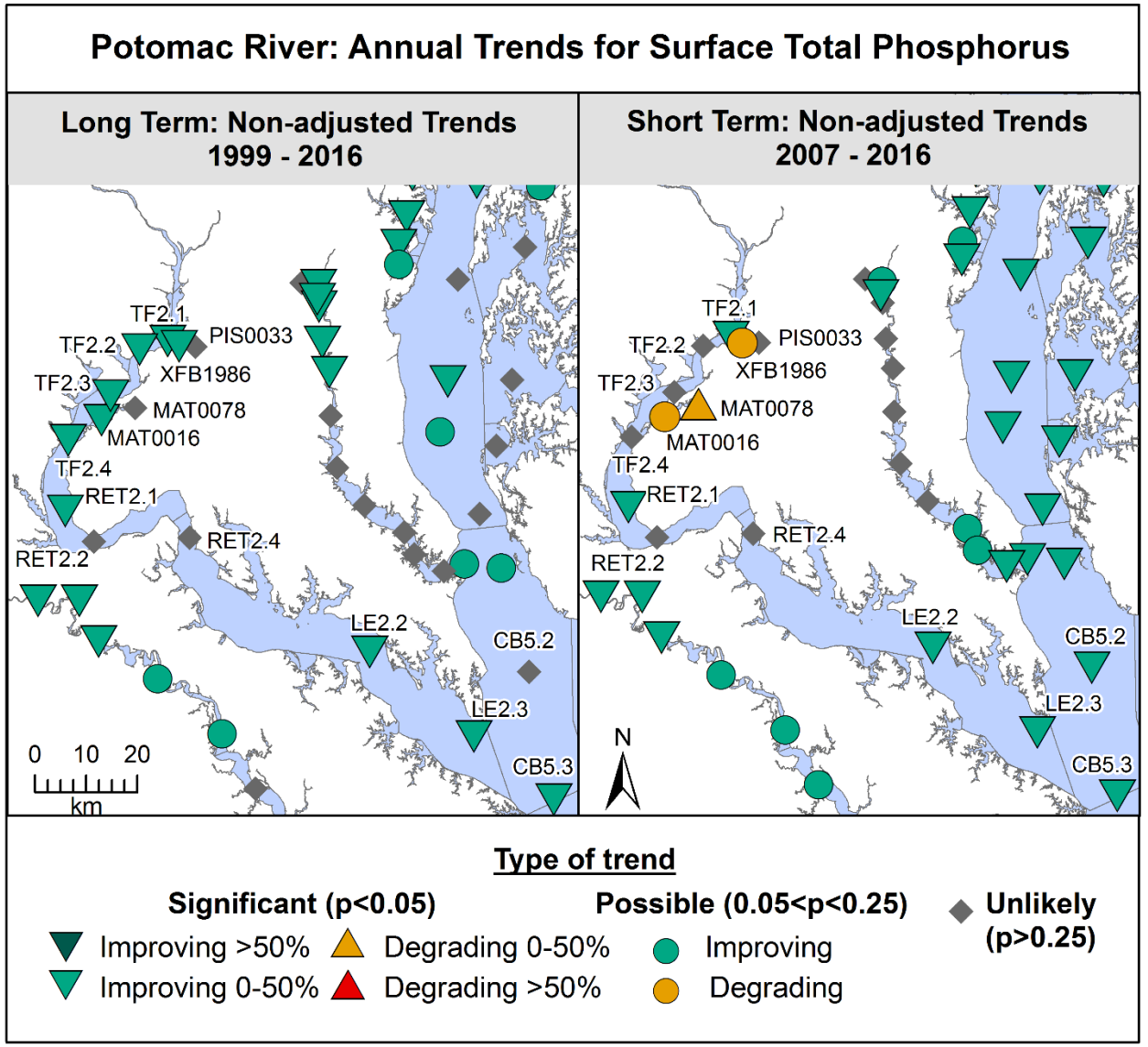
TN trends suggest improving water quality



MD trends computed by Renee Karrh, MDDNR

Factors affecting DO: Total Phosphorus Trends

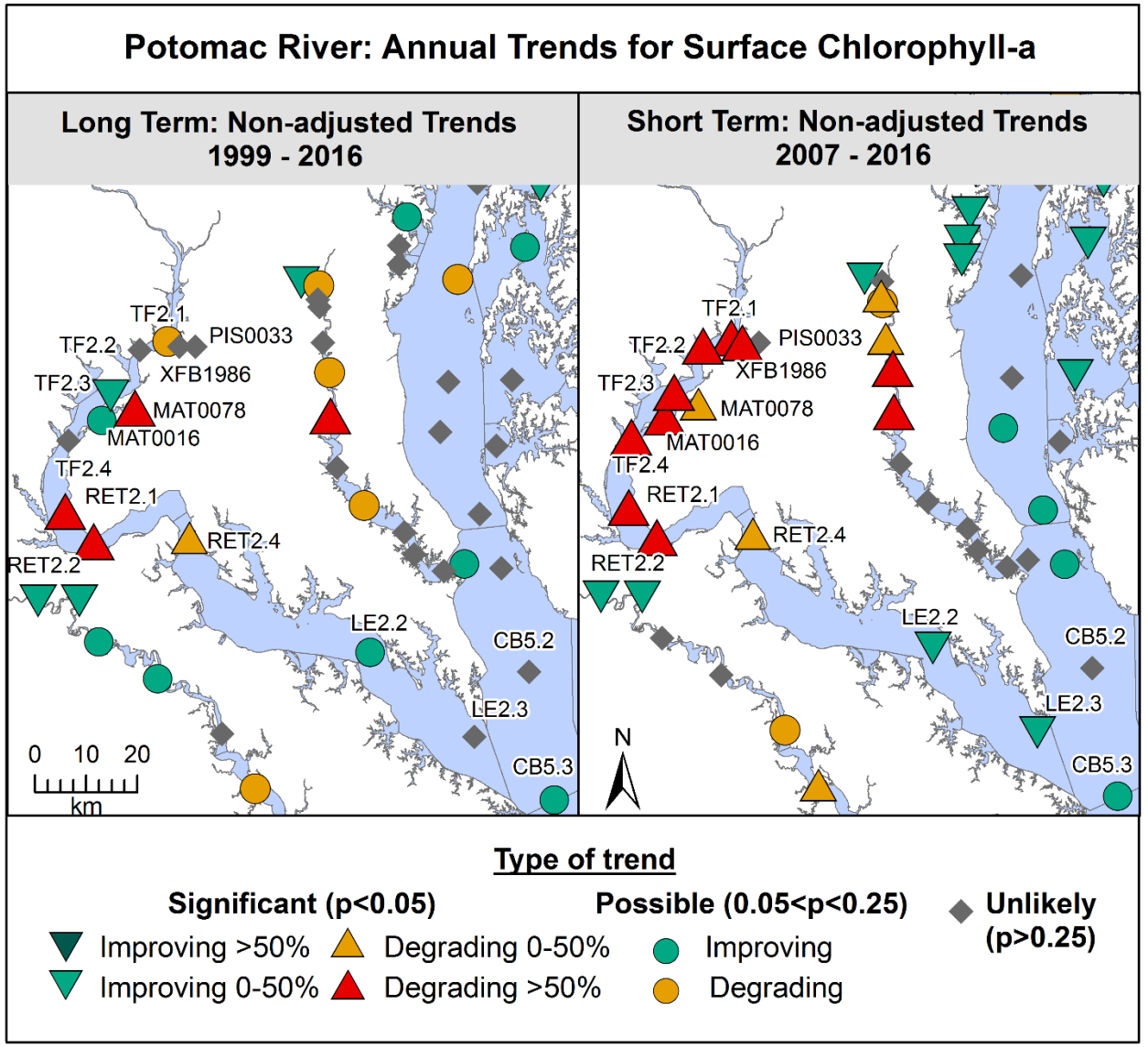
Most TP trends also suggest improving water quality



MD trends computed by Renee Karrh, MDDNR

Factors affecting DO: Chlorophyll-a trends are mixed

Although lower Potomac trends are improving, many upper Potomac trends are increasing



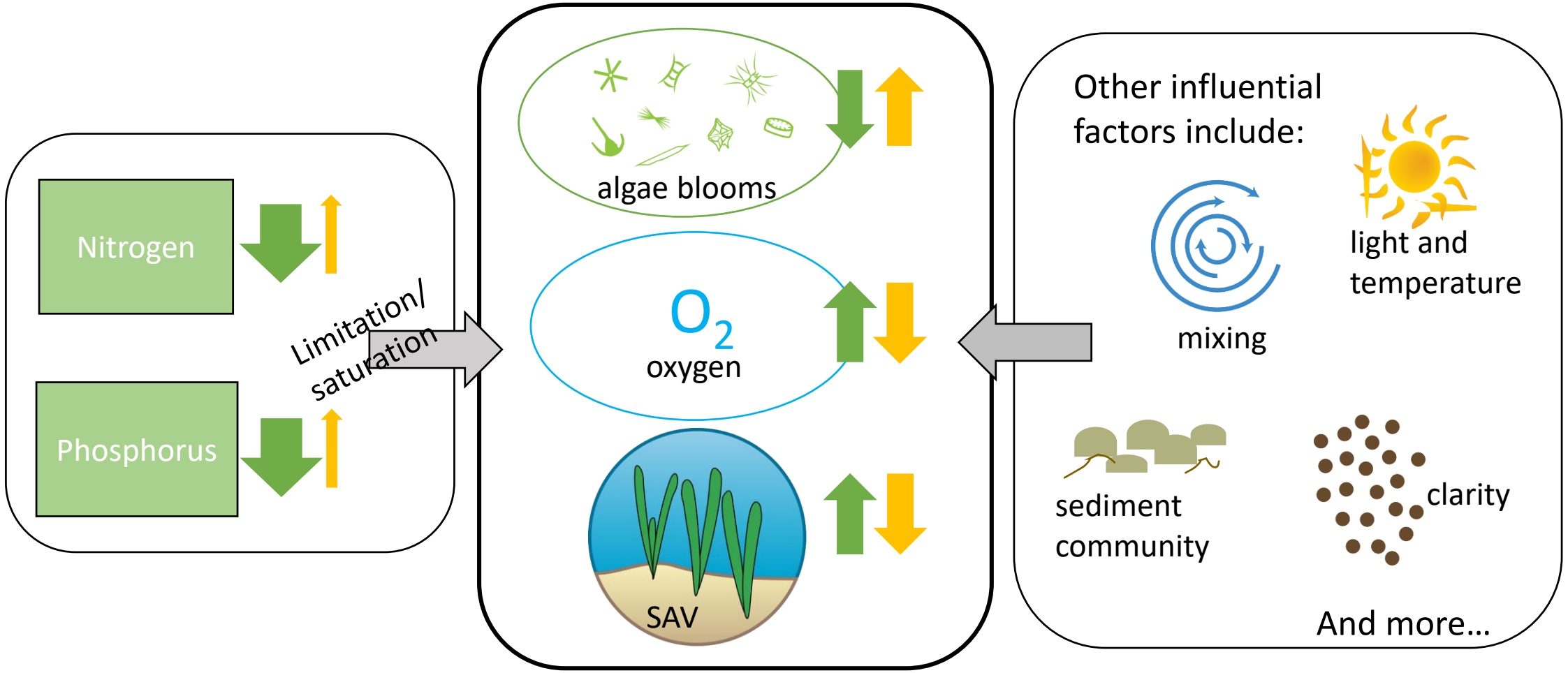
MD trends computed by Renee Karrh, MDDNR

Summary: Oxygen, Nutrient, and Chlorophyll-a trends

- Nutrient concentrations are decreasing throughout the tidal Potomac.
- Chlorophyll-a trends are mixed.
- Oxygen changes are not large enough yet to be significant trends.

→ *Current and existing research is helping us understand these trends:*

Need to consider the whole system



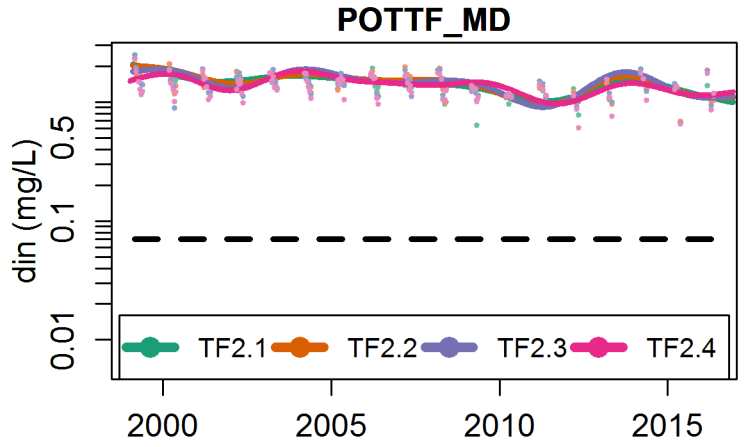
Estuaries are complex environments.
The response to restoration depends on location, season, and physical and biological factors.

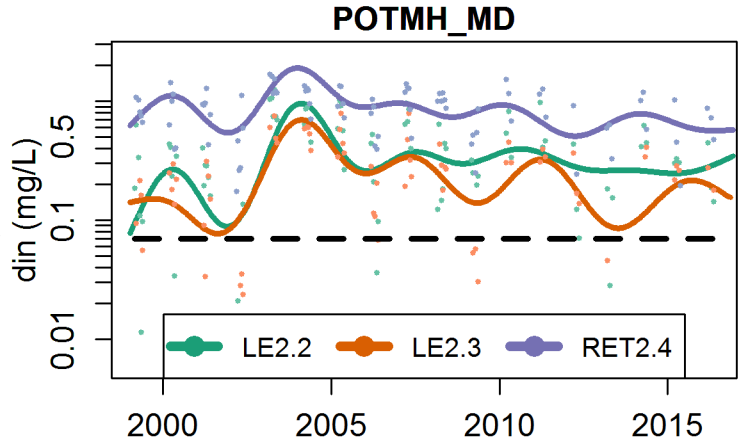
Images from: Tracey Saxby, Jane Thomas and Jane Hawkey, Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/imagelibrary/)

Potomac nutrient concentrations: decreasing, but they are very high

Approximate "saturation limit" for dissolved nitrogen:[a] Above this limit, there is so much DIN that algae can't grow any faster. Need to get below it to really see a response.

Dissolved Inorganic Nitrogen (DIN) in Spring



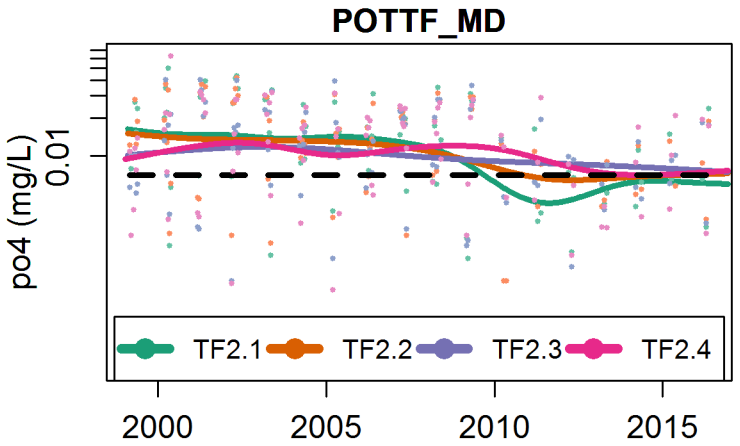


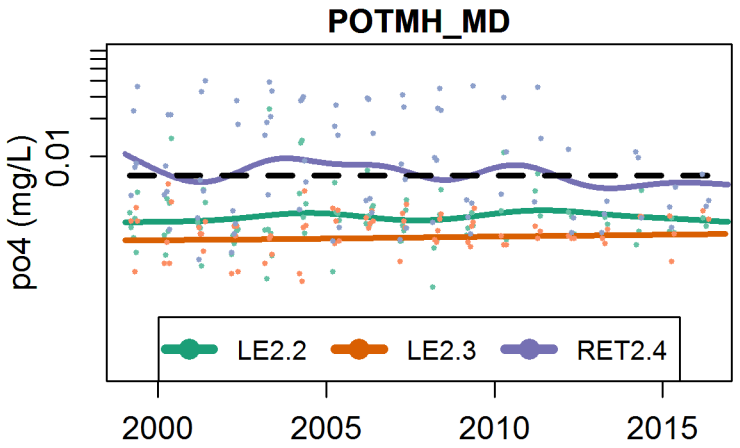
[a] FISHER, T. R. AND A. B. GUSTAFSON. 2003. Nutrient-addition bio- assays in Chesapeake Bay to assess resources limiting algal growth. Progress report: August 1990-December 2002. Prepared for Maryland Department of Natural Resources, Chesapeake Bay Water Quality Monitoring Program, by University of Maryland Horn Point Laboratory, Cambridge, Maryland; Buchanan, C. et al. 2005. Estuaries 28(1): 138-159.

Potomac nutrient concentrations: decreasing, but they are very high

Approximate "saturation limit" for dissolved phosphorus[a]:
Only in recent years, and in lower Potomac do we see concentrations below this. Continued improvements needed.

Dissolved Phosphorus (orthophosphate) in Spring





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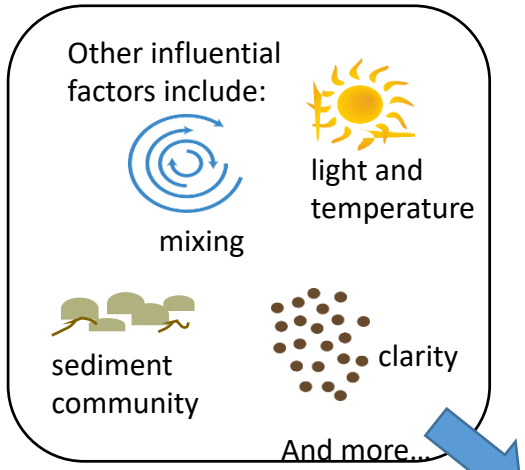
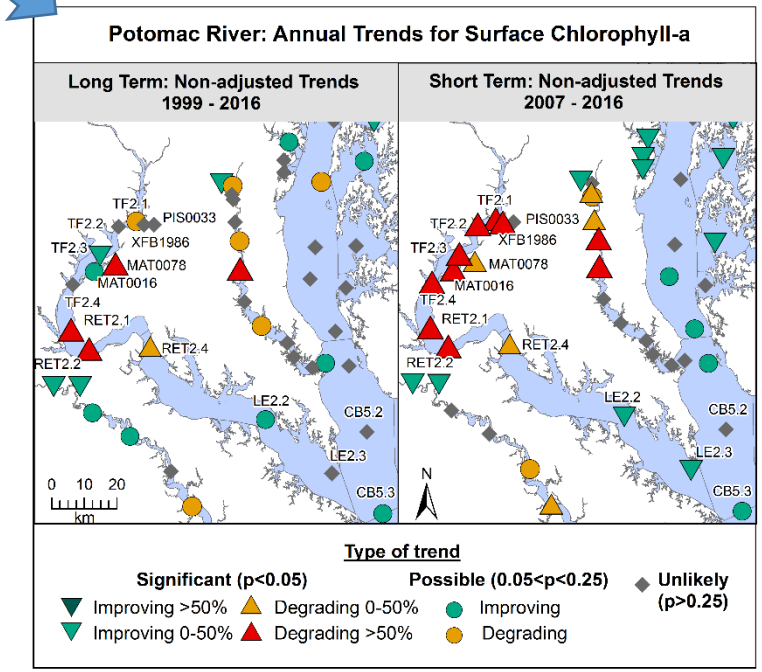
Chlorophyll-a concentrations

- In a recent study, (Harris et al. 2017) found multiple factors might be interacting to cause the mixed chlorophyll-a trends:
  - bivalve abundance drop,
  - temperature increase,
  - light availability,
  - as well as nutrients.
- Research is ongoing





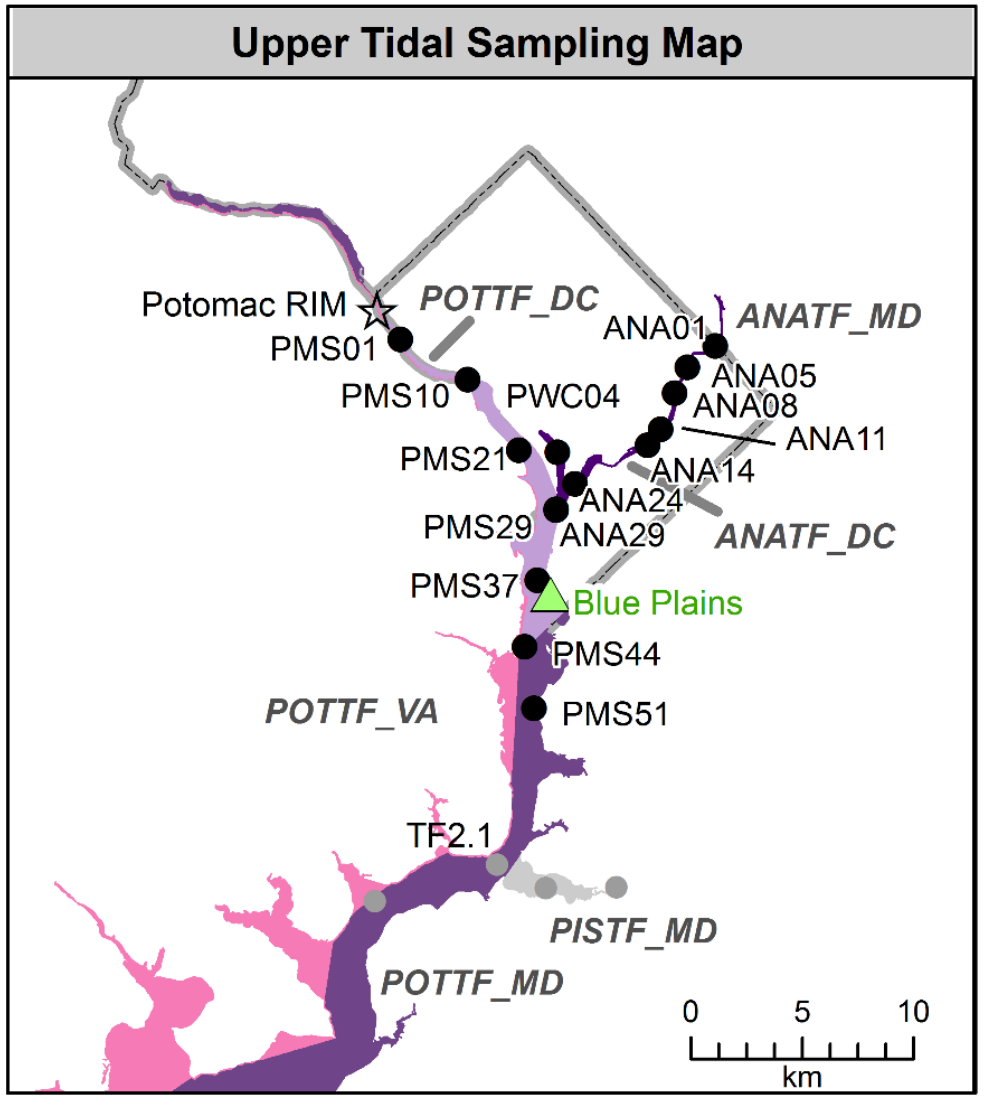
Harris, Murphy, Sabo, Eshleman, Woodland, Liang, and Walker. 2017. *Documenting Impacts of Climate, Clams and a Changing Watershed on the Potomac Estuary.* Presentation at: STAC Workshop Dec 13, 2017.

Lower and Middle Potomac Summary

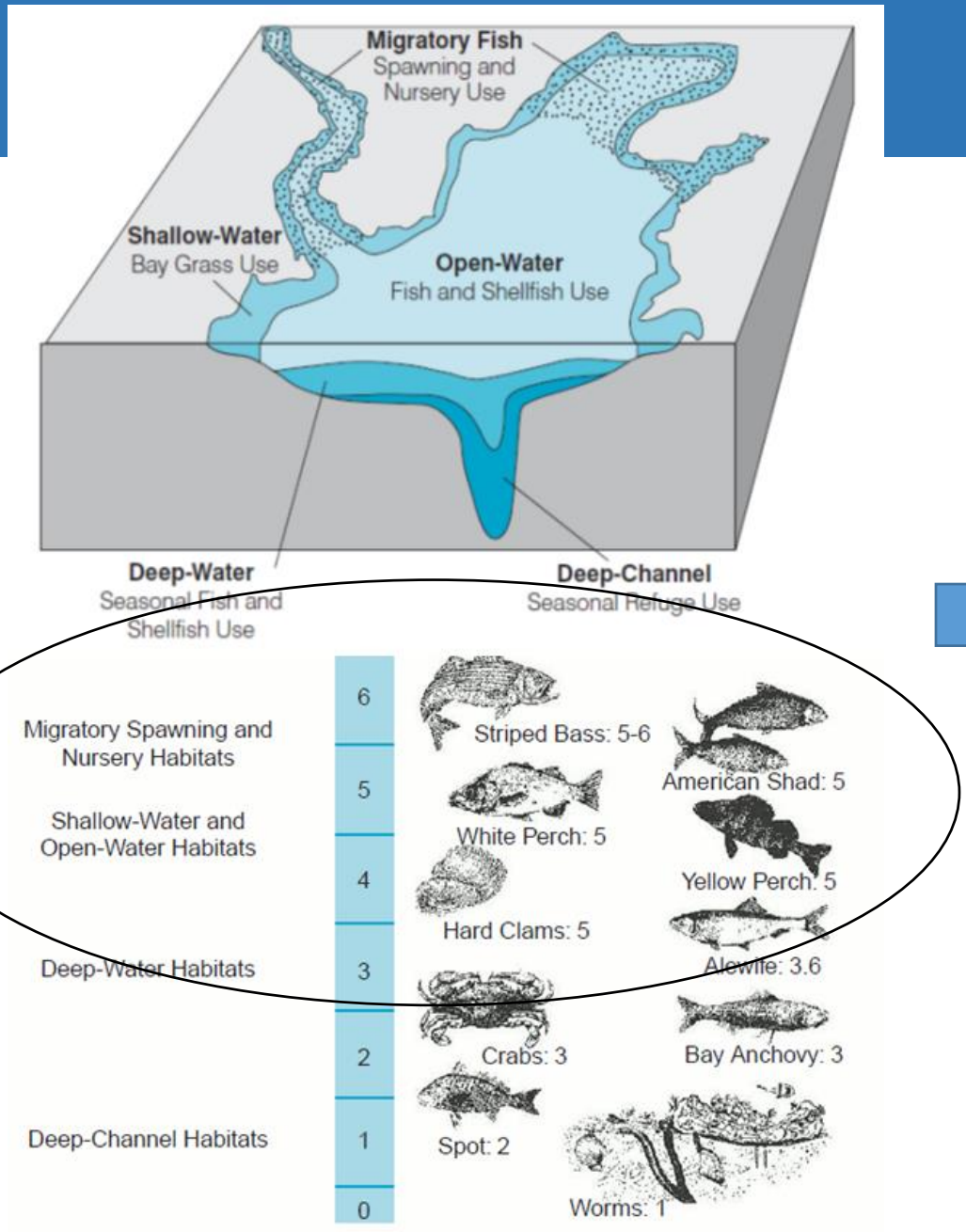
- Recent Potomac criteria attainment patterns are similar to the nearby mainstem.
- Nutrient concentrations are high, but going down.
- Mixed responses are bound to happen in this complex system, but..
- We expect DO to continue improving if nutrients keep going down.

Photo from Chesapeake Bay Program

2. Patterns and trends in the Upper Estuary (DC-region tidal waters)



Designated Uses with DO requirements



Evaluate with monitoring data spatially and temporally combined to determine if conditions are met over 3 year periods

USEPA 2003 and 2004

Open Water 30-day Mean DO criterion status

OW	1985-1987	1986-1988	1987-1989	1988-1990	1989-1991	1990-1992	1991-1993	1992-1994	1993-1995	1994-1996	1995-1997	1996-1998	1997-1999	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016
ANATF_DC																														
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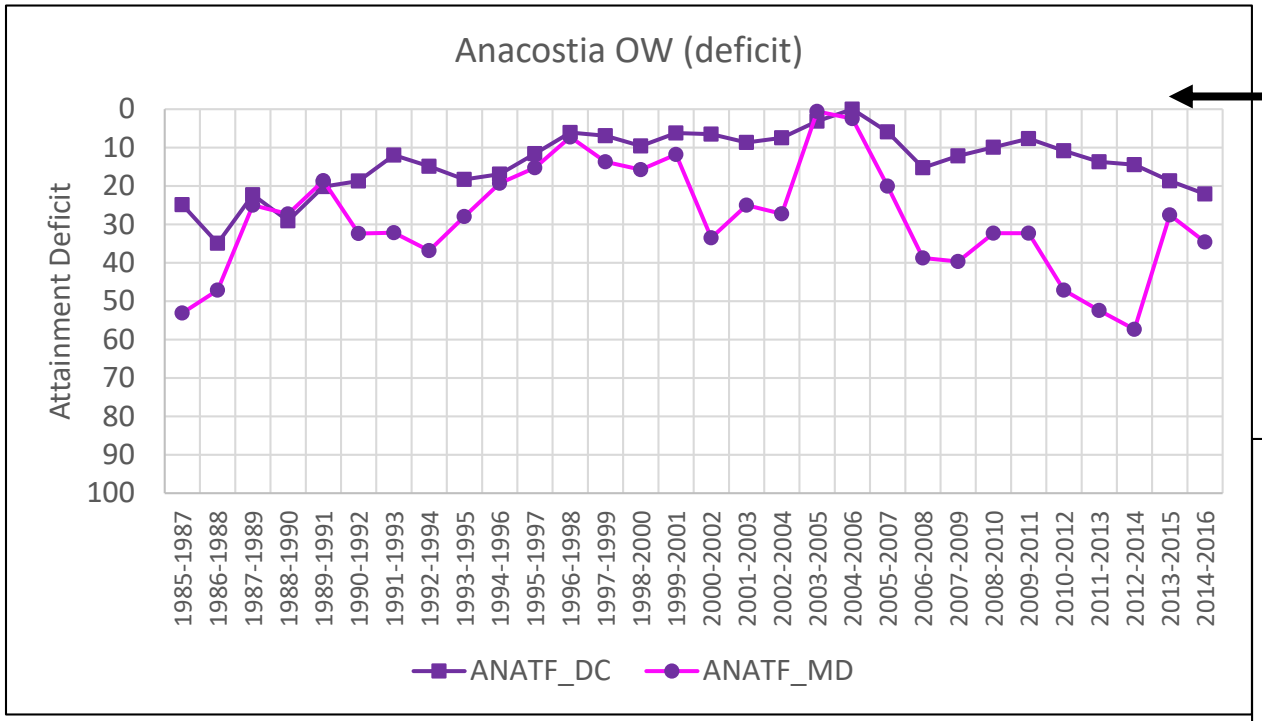
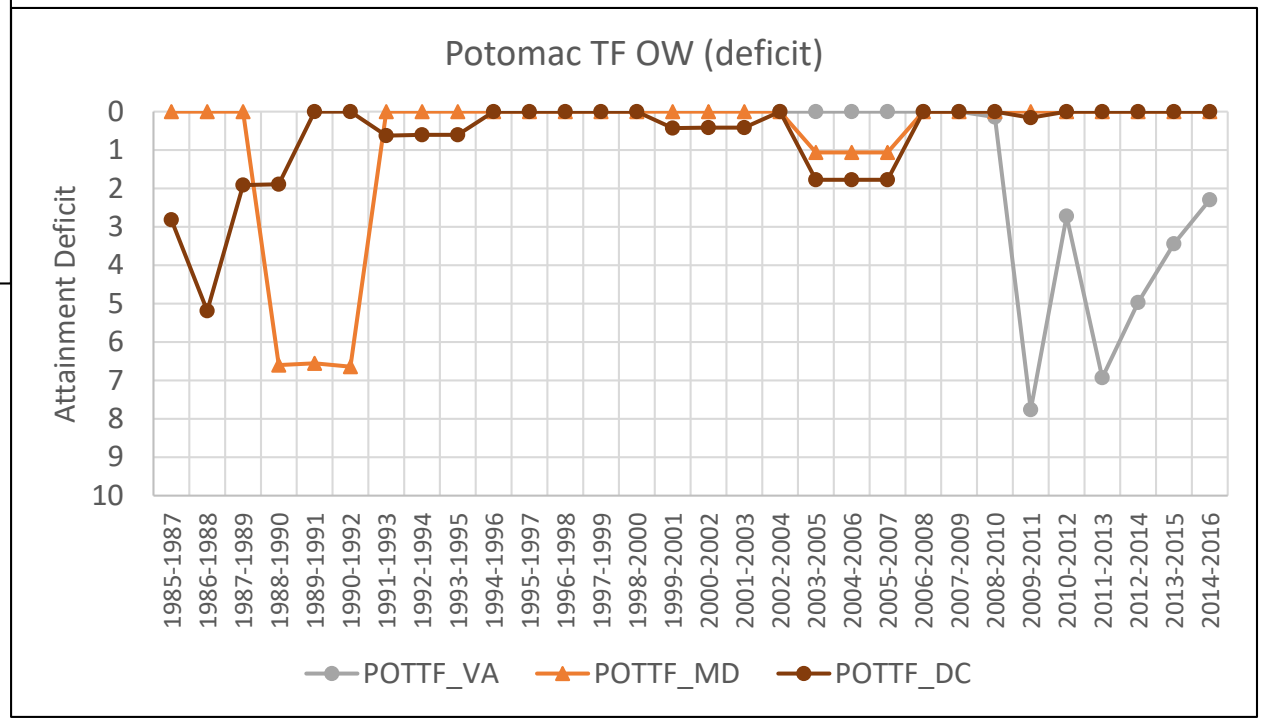
POTTF_DC																														
POTTF_MD																														
POTTF_VA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND													

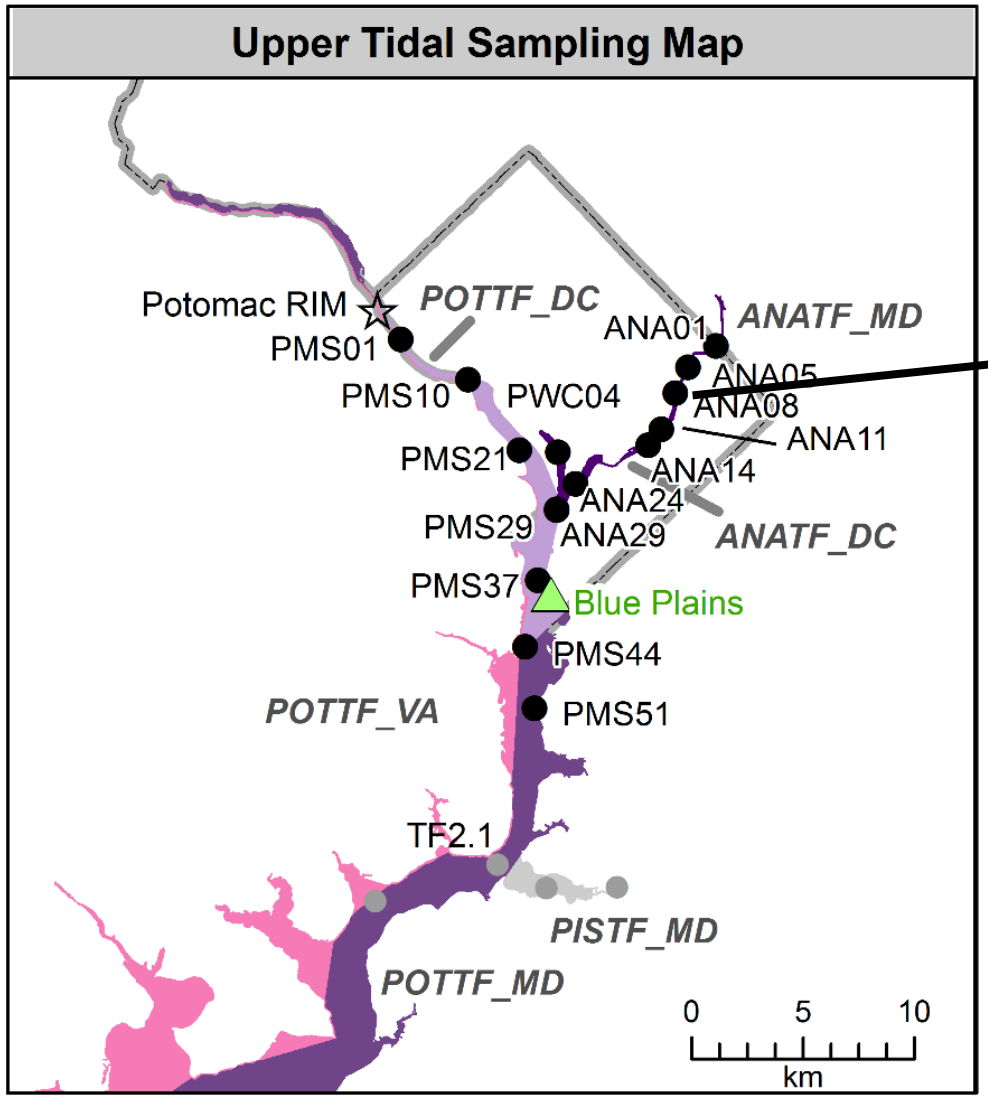
Open Water 30-day Mean DO criterion: deficit

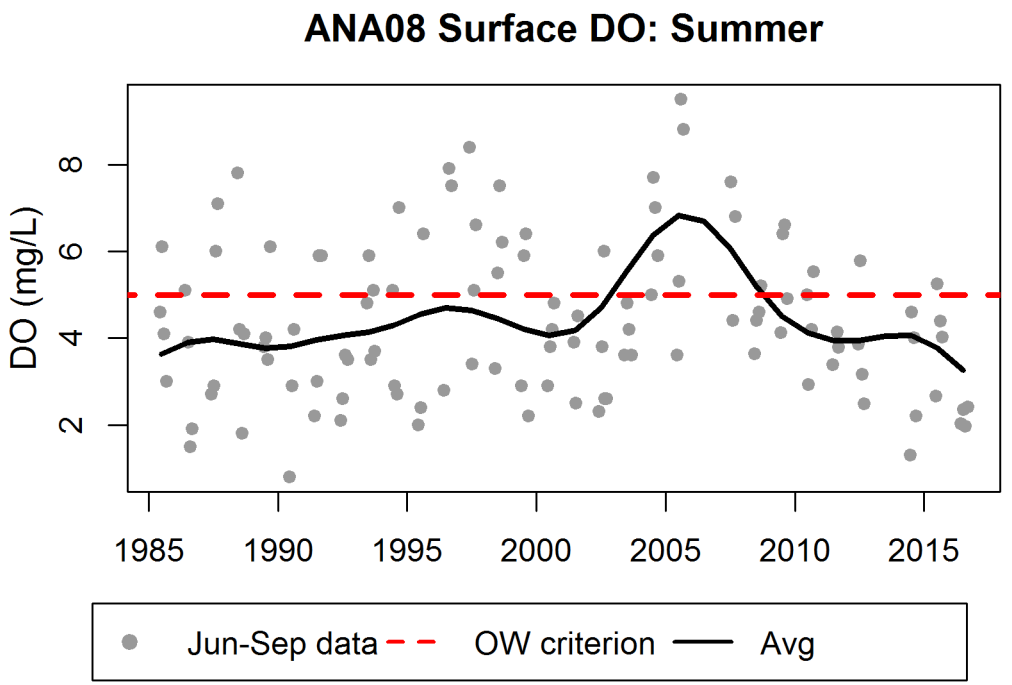


Need deficit
At zero



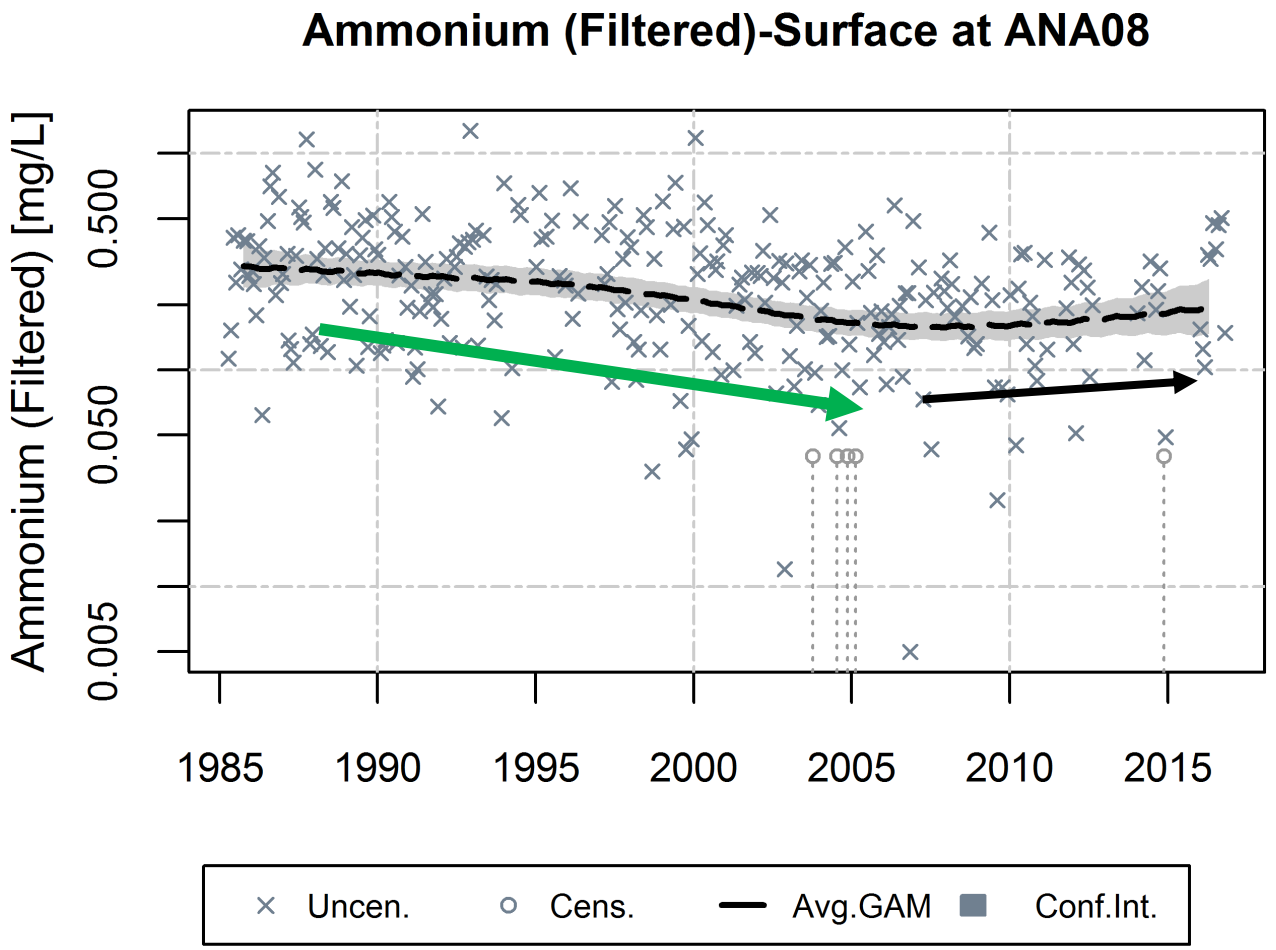
Anacostia: Examine the data





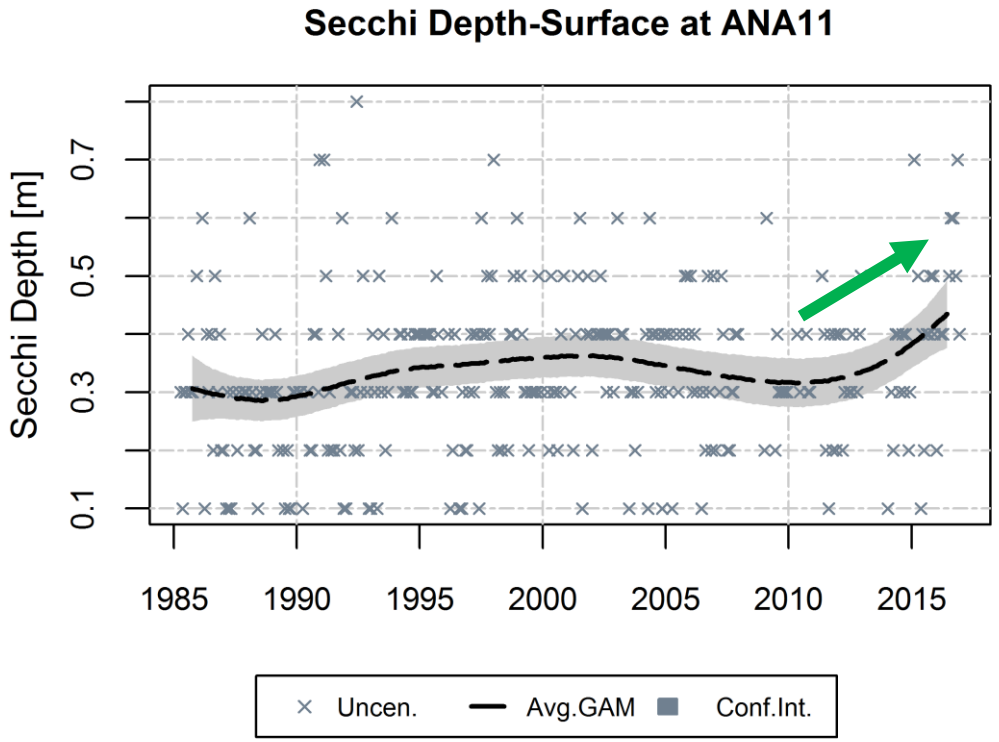
Anacostia: Consider related factors and overall health

- Dissolved nitrogen has decreased over the long-term across the Anacostia stations (and upper Potomac)
- Although there is a slight upswing/leveling out in recent years

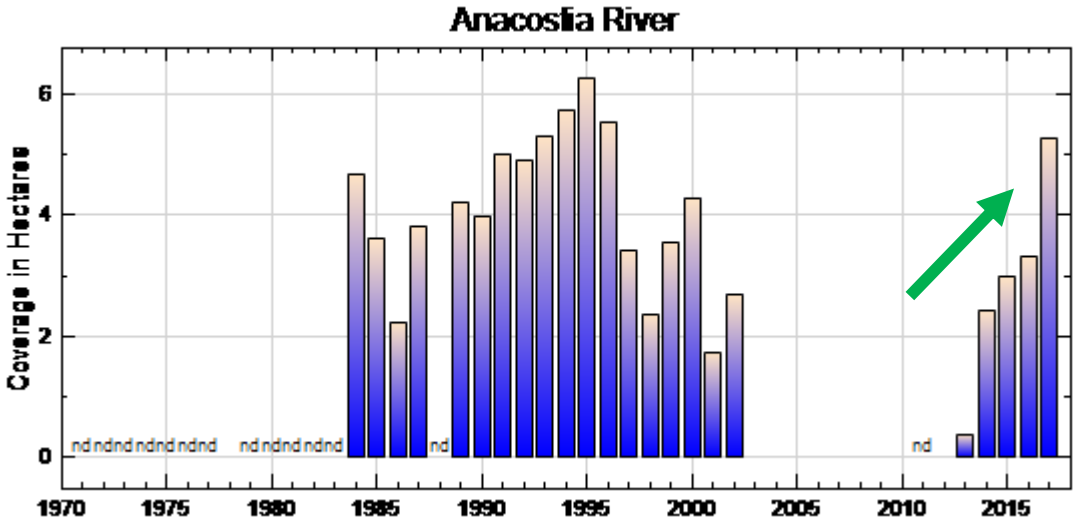


Anacostia: Consider related factors and overall health

Water clarity conditions in Anacostia improving



And SAV coming back in recent years



From VIMS: http://web.vims.edu/bio/sav/index.html

Upper Estuary Summary

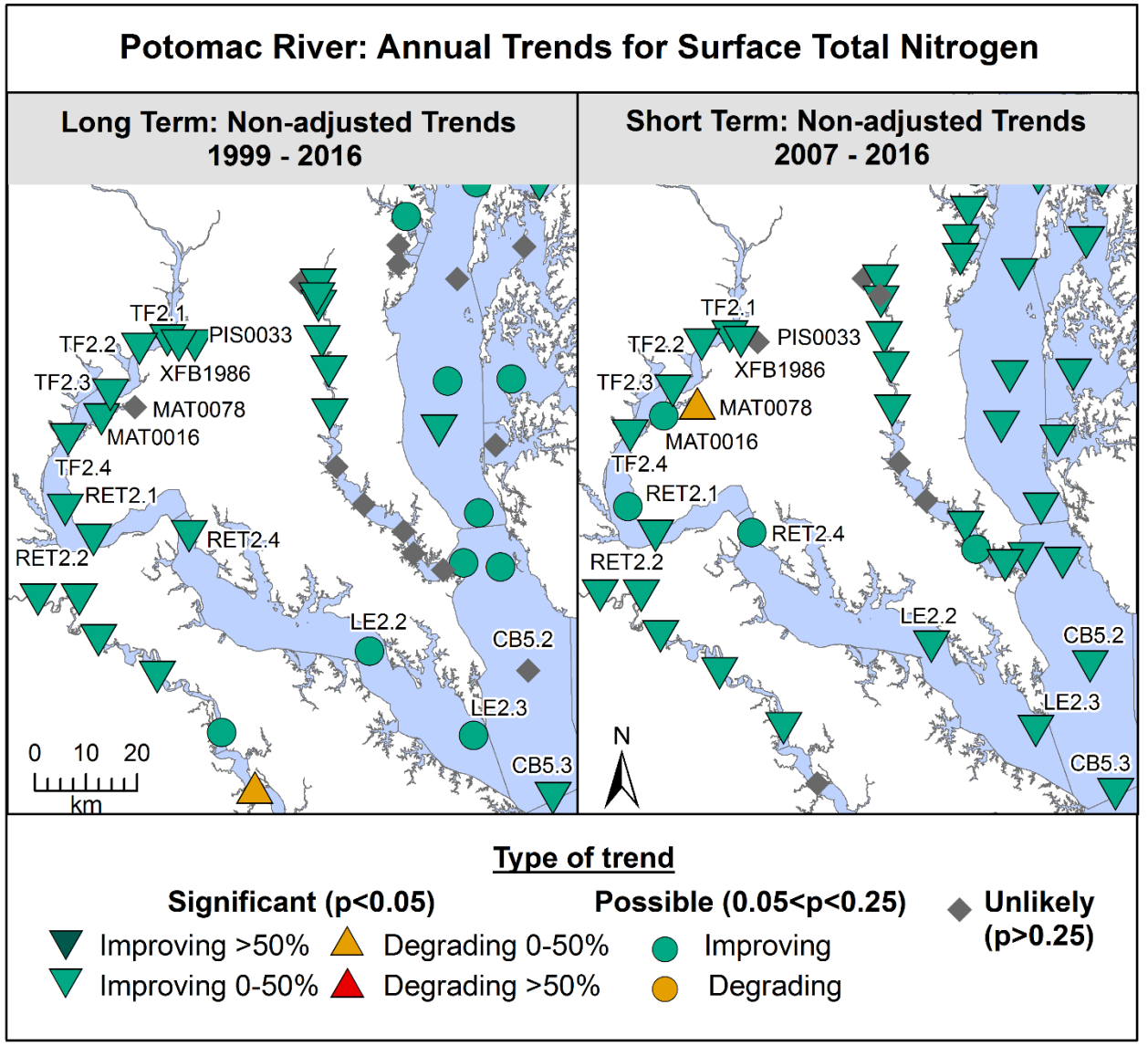
- Upper Potomac is mostly meeting its surface oxygen criteria in recent years.
- The Anacostia story is mixed, but there are some good signs.

- *We will be looking at this data more → any additional insights or your findings are welcome!*

Photo: CBP, Potomac near Roosevelt Island

3. What can all the tidal trends tell us about nutrient sources?

- Nitrogen concentrations have been going down throughout the Potomac tidal waters.
- Since waste water facilities are throughout the watershed, it is hard to distinguish the sources once the N is in the estuary.
- Some information:
  - Baywide source attribution from SPARROW
  - Next talk



Nitrogen sources

- Baywide, decadal SPARROW results[a] suggest that between 1992-2012 the annual flux of N to the bay declined 14%. Of this:
  - 82% of the decline in N is attributable to point sources,
  - 12% atmospheric deposition, and
  - The rest (6%) to urban non-point sources.
- *These numbers could be slightly different in the Potomac*, but show that urban BMPs could be influential, especially as point source reductions reach their limits.
- Also their importance to local water quality can be significant.

[a] Ator et al. 2018 ChesRMS18 conference abstract. Not citable information.

Summary

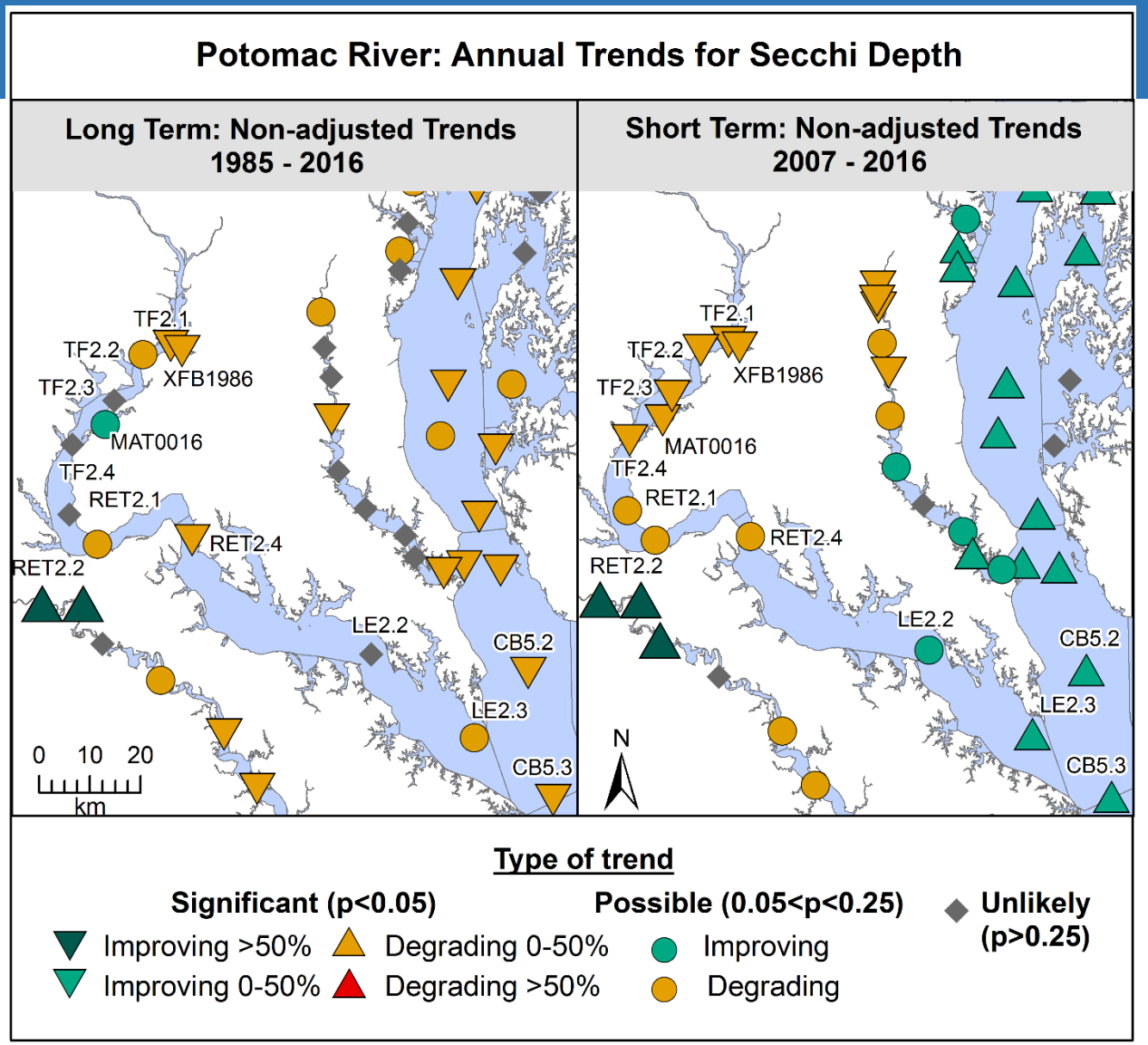
- Nutrient reductions are clear in the Potomac and Anacostia, as major efforts in point source reductions have paid off.
- There are some mixed water quality responses to date because of the complexities of an estuary.
- To meet all the water quality criteria, nutrient reductions need to continue.

Photo from RMurphy

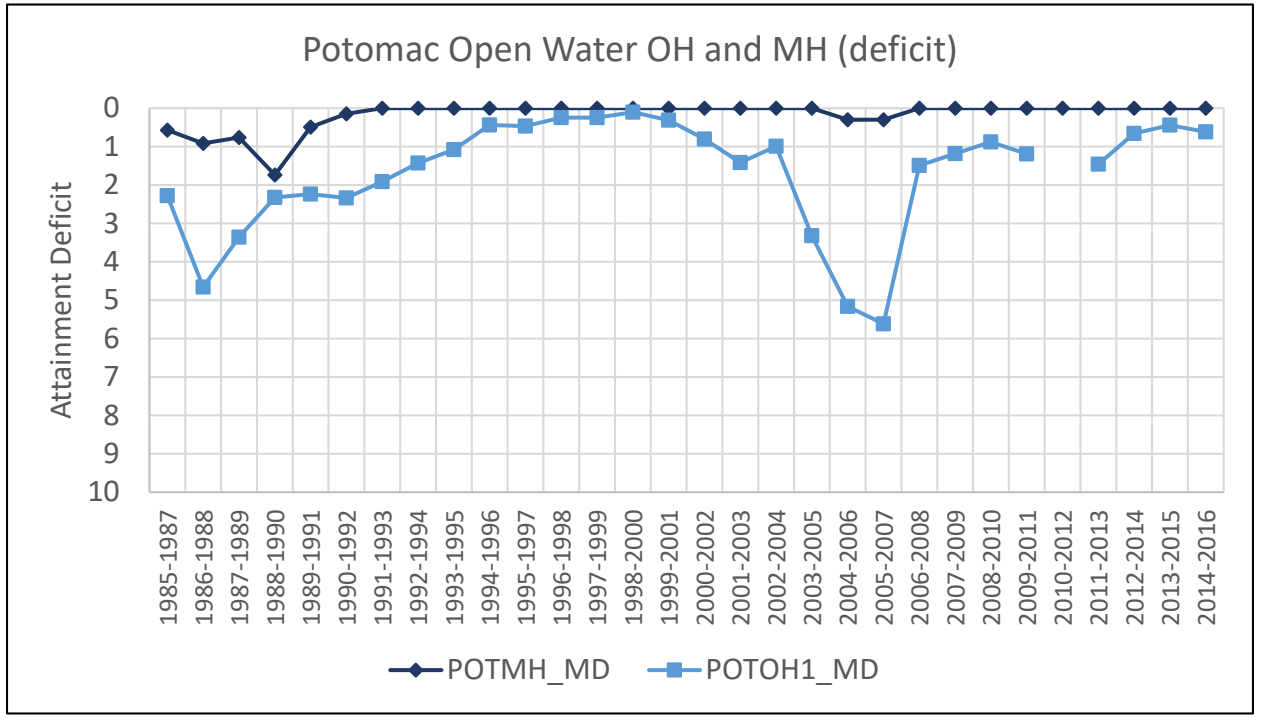
For more info, contact:
Rebecca Murphy, UMCES at CBP rmurphy@chesapeakebay.net
Jeni Keisman, USGS jkeisman@usgs.gov

extras

Secchi


Potomac River: Annual Trends for Secchi Depth
Long Term: Non-adjusted Trends
1985 - 2016
Short Term: Non-adjusted Trends
2007 - 2016
TF2.1
TF2.2
TF2.3
XFB1986
MAT0016
TF2.4
RET2.1
RET2.4
RET2.2
LE2.2
CB5.2
LE2.3
CB5.3
0 10 20
km
N
Type of trend
Significant (p<0.05)
Improving >50%
Improving 0-50%
Degrading 0-50%
Degrading >50%
Possible (0.05<p<0.25)
Improving
Degrading
Unlikely
(p>0.25)

Open Water 30-day Mean DO criterion: Middle and Lower Potomac



Upper tidal Potomac