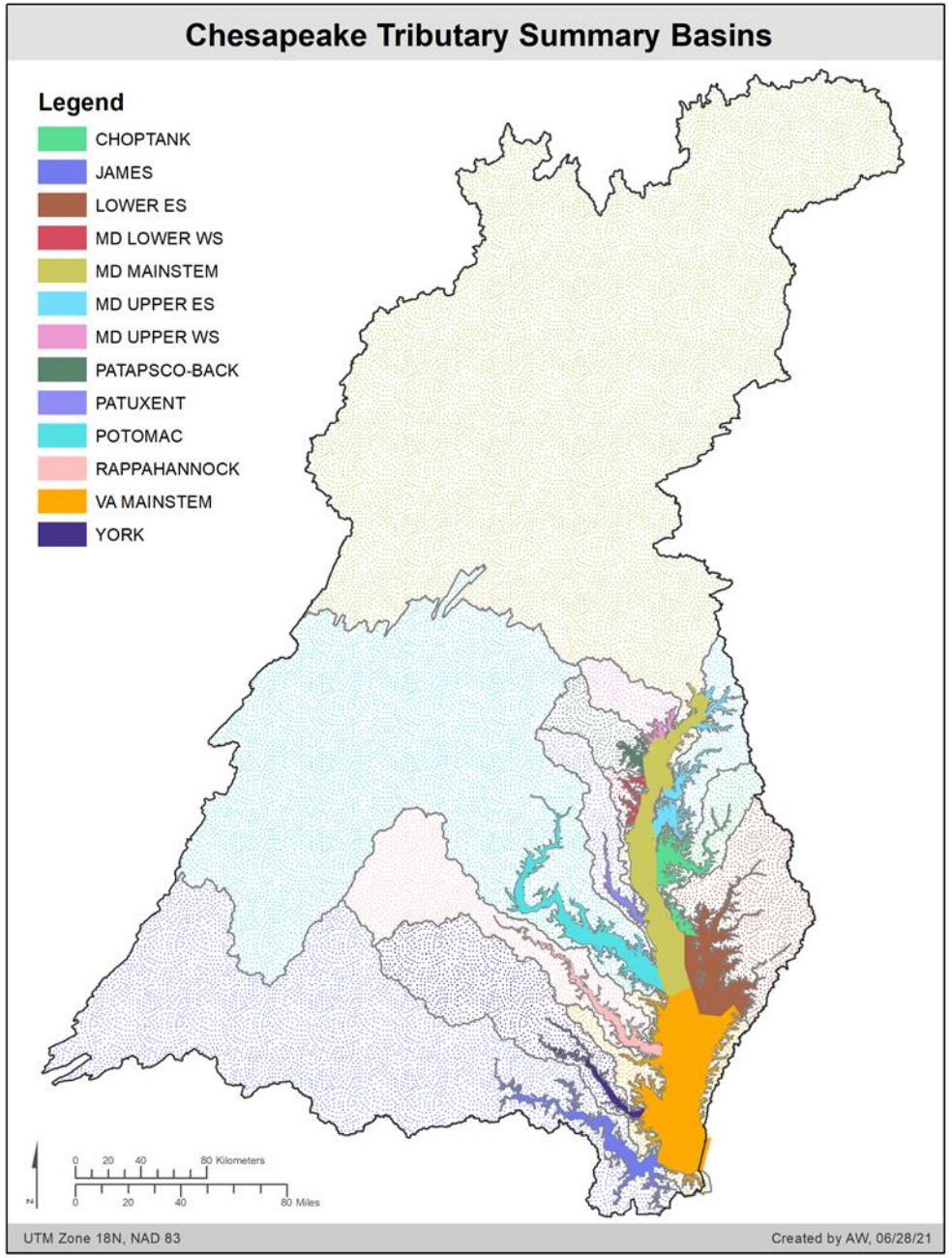
Update on Chesapeake Bay and Potomac River Tidal Monitoring Data

Nov. 5, 2021
COG Water Resources Technical Committee

Rebecca Murphy (UMCES at Chesapeake Bay Program)

In collaboration with CBP's Integrated Trends Team, including:
Jeni Keisman (USGS), Renee Karrh (MDDNR), Qian Zhang (UMCES), Peter Tango (USGS), Jimmy Webber (USGS), and Olivia Devereux (Devereux Consulting)

New ITAT leadership: Breck Sullivan (USGS) and Vanessa Van Note (EPA)



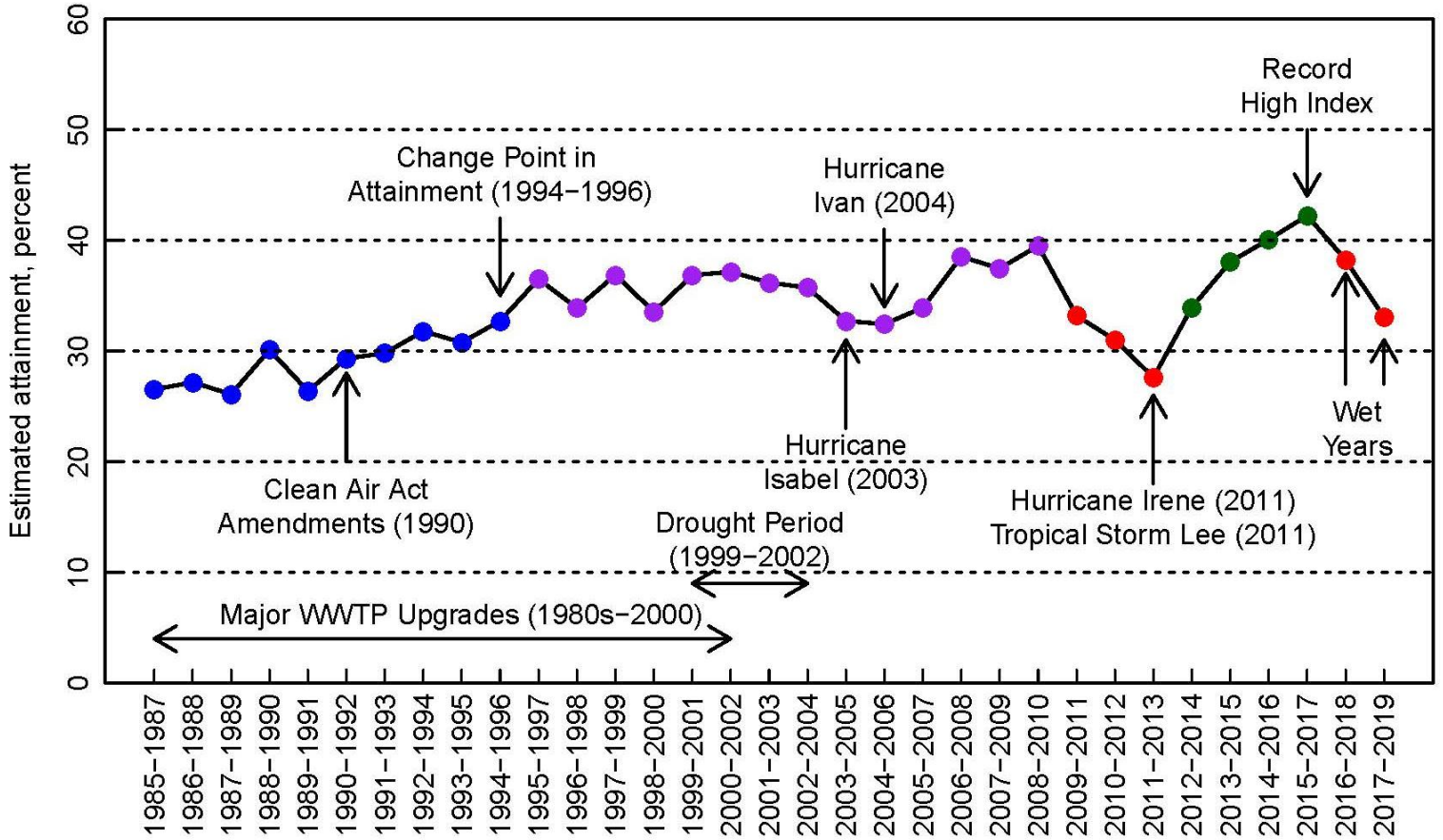
Outline

- Overview: Bay-wide attainment indicator
- Tributary Summaries
- Tidal Potomac data
- Tidal Maryland Mainstem data

Water quality standards attainment indicator

Long-term WQS indicator

- Reached its peak (42%) in 2015-2017 but dropped to 33% in 2017-2019.
- It is responsive to extreme weather events but can quickly recover afterwards.
- The indicator has a positive long-term trend ($p < 0.05$) in 1985-2019.

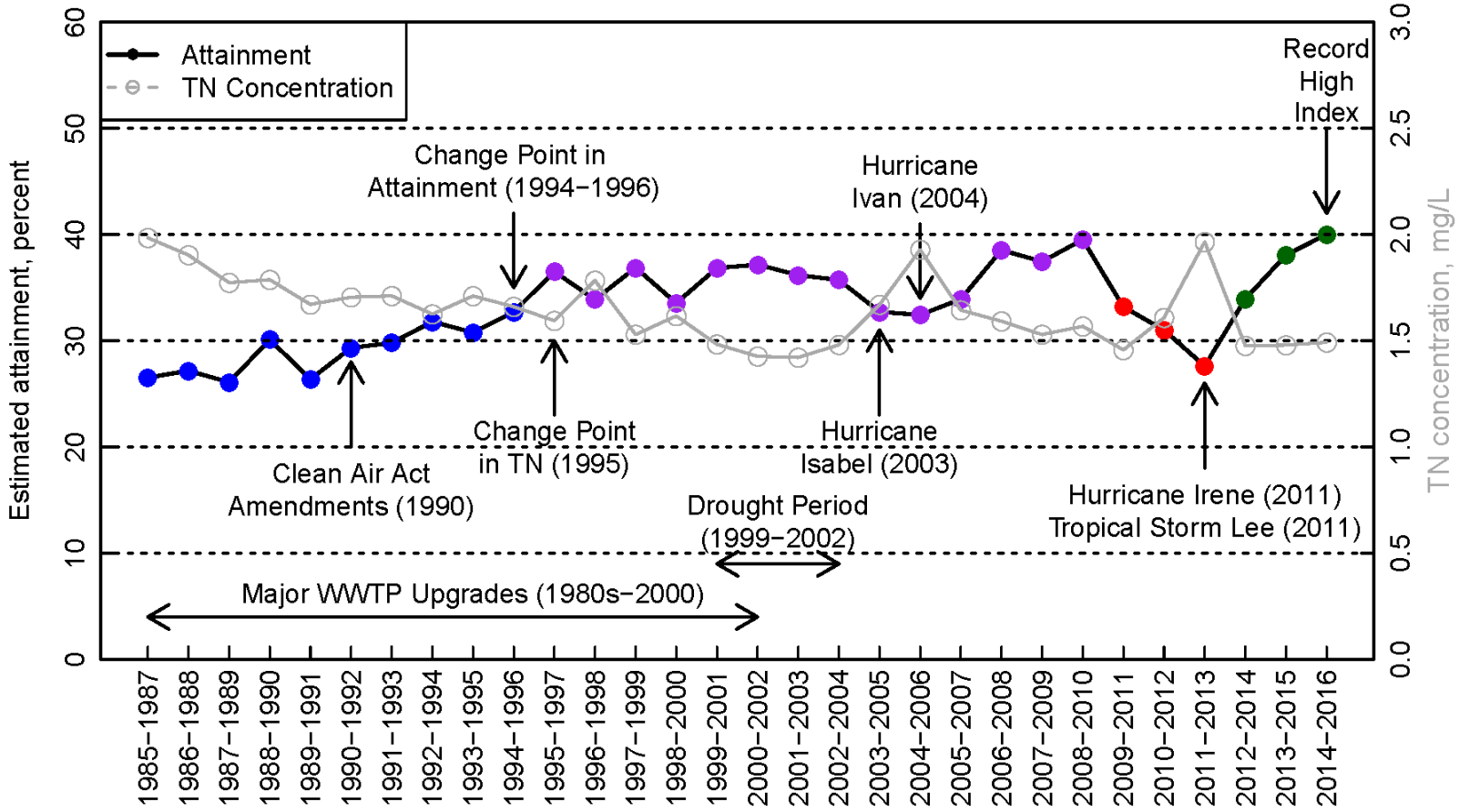


Slide from Qian Zhang (UMCES) and Peter Tango (UGSG)

Cause of the long-term improvement in the overall indicator?

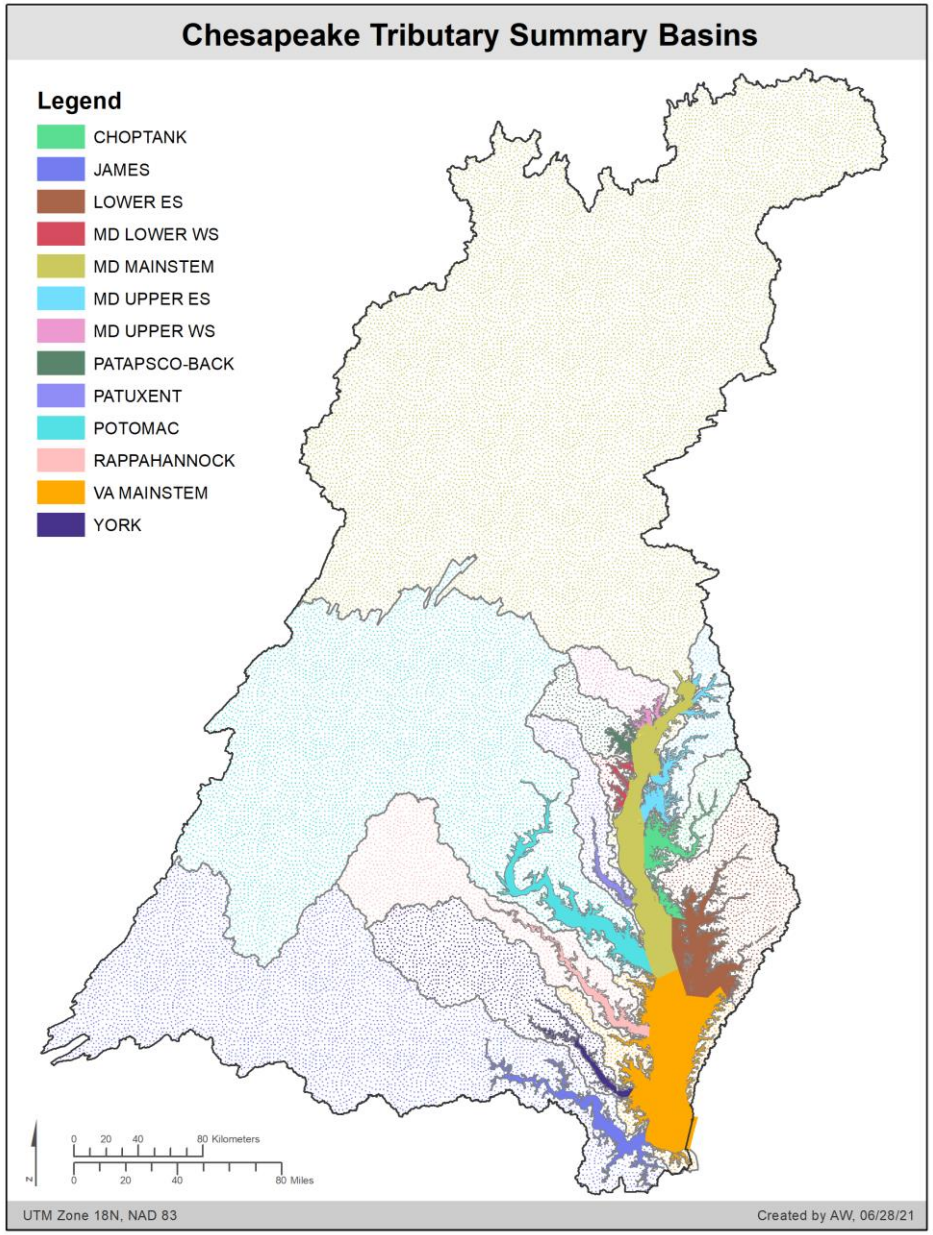
- The improvement in the Baywide attainment was statistically linked to the decline of TN input from the watershed, suggesting the effectiveness of nutrient control actions.

- Additional factors (TP, flow, WTEMP, Secchi, etc.) are under investigation.



Slide from Qian Zhang (UMCES) and Peter Tango (UGSG)

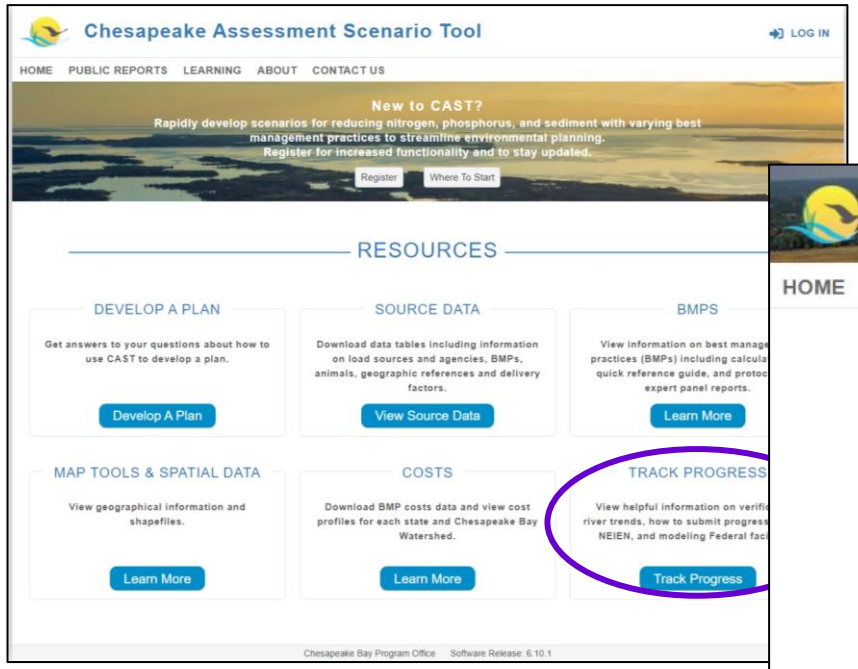
13 Tributary Trend Summaries

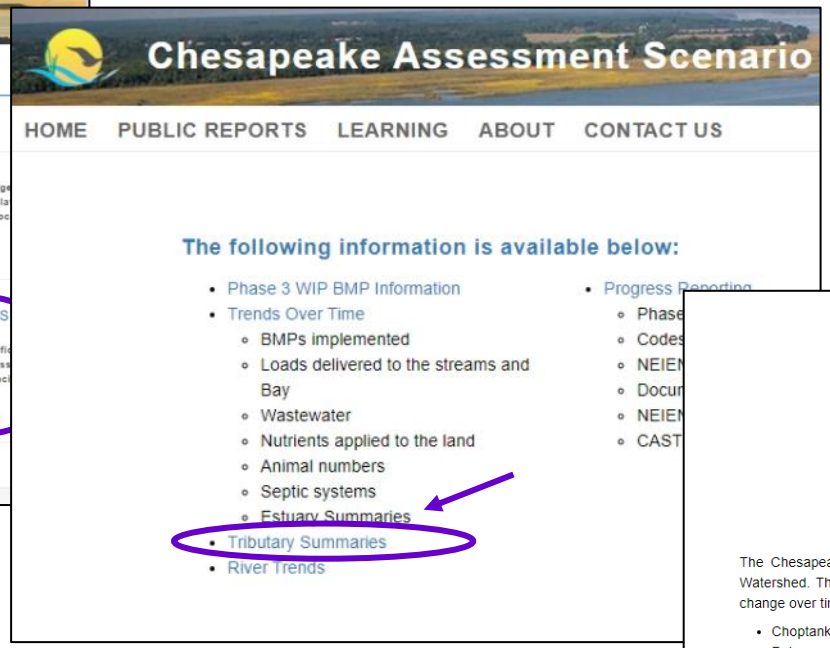


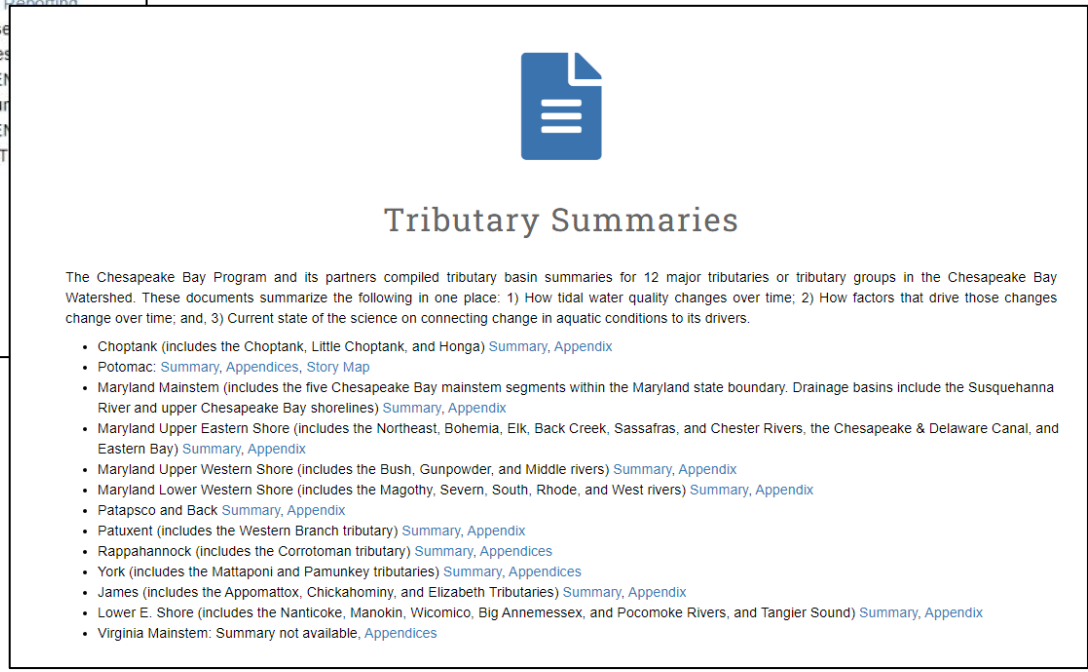
- **Maryland Mainstem** *(The 5 Chesapeake Bay mainstem segments within the MD state boundary. Drainage basins include the Susquehanna River and upper Chesapeake shorelines)*
- **Maryland Upper Eastern Shore** *(The Northeast, Bohemia, Elk, Back Creek, Sassafras, and Chester Rivers, the C&D Canal, and Eastern Bay)*
- **Choptank** *(the Choptank, Little Choptank, and Honga)*
- **Maryland Upper Western Shore** *(Bush, Gunpowder, Middle Rivers)*
- **Maryland Lower Western Shore** *(Magothy, Severn, South, Rhode, and West)*
- **Patapsco & Back Rivers**
- **Patuxent** *(includes the Western Branch tributary)*
- **Potomac**
- **Rappahannock** *(includes the Corrotoman tributary)*
- **York** *(includes the Mattaponi and Pamunkey tributaries)*
- **James** *(includes the Appomattox, Chickahominy, and Elizabeth tributaries)*
- **Lower E. Shore** *(includes the Nanticoke, Manokin, Wicomico, Big Annemessex, and Pocomoke rivers & Tangier Sound)*
- **Virginia Mainstem** *(no summary but Appendices are provided)*

Available for download

https://cast.chesapeakebay.net/







Tributary Summaries

The Chesapeake Bay Program and its partners compiled tributary basin summaries for 12 major tributaries or tributary groups in the Chesapeake Bay Watershed. These documents summarize the following in one place: 1) How tidal water quality changes over time; 2) How factors that drive those changes change over time; and, 3) Current state of the science on connecting change in aquatic conditions to its drivers.

- Choptank (includes the Choptank, Little Choptank, and Honga) Summary, Appendix
- Potomac: Summary, Appendices, Story Map
- Maryland Mainstem (includes the five Chesapeake Bay mainstem segments within the Maryland state boundary. Drainage basins include the Susquehanna River and upper Chesapeake Bay shorelines) Summary, Appendix
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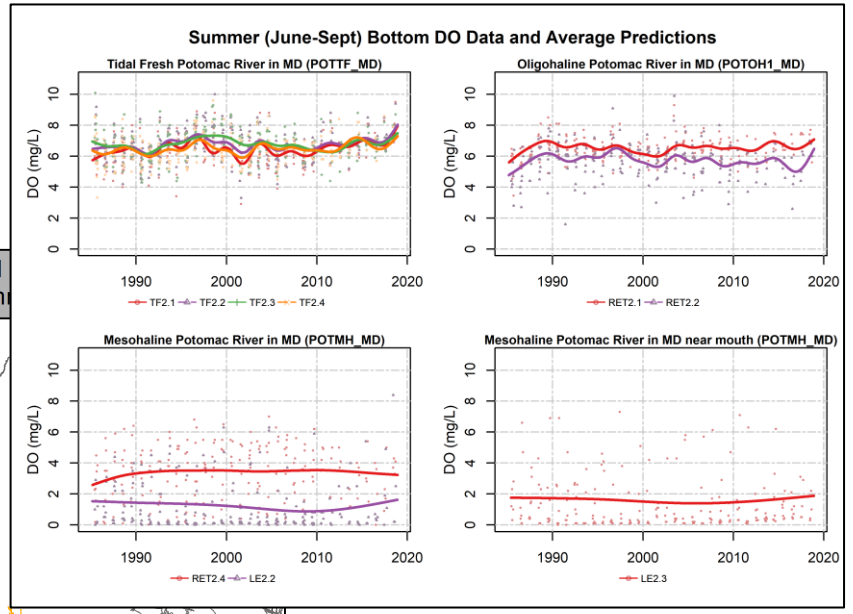
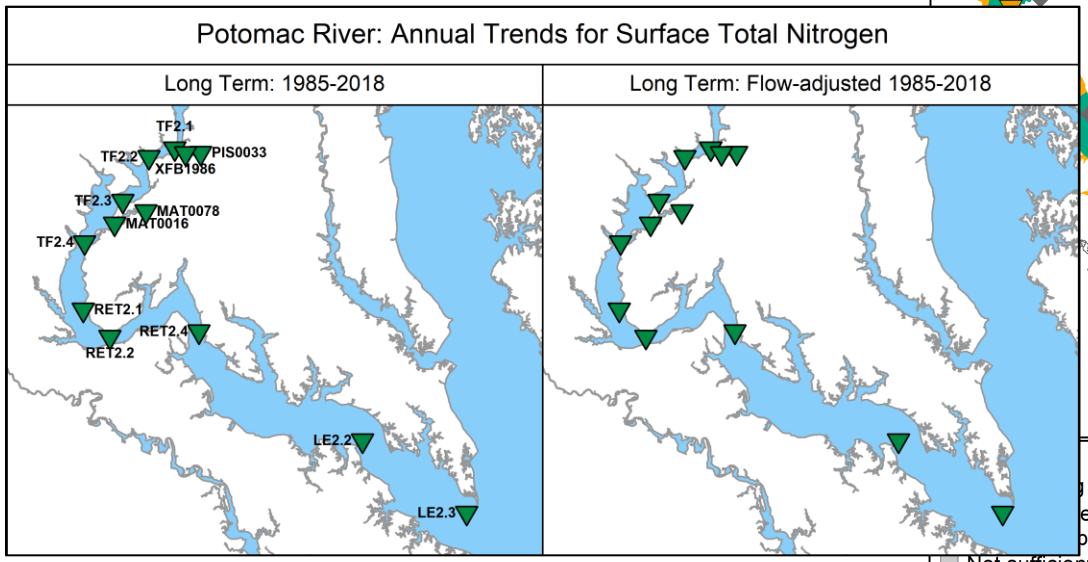
- Virginia Mainstem: Summary not available, Appendices

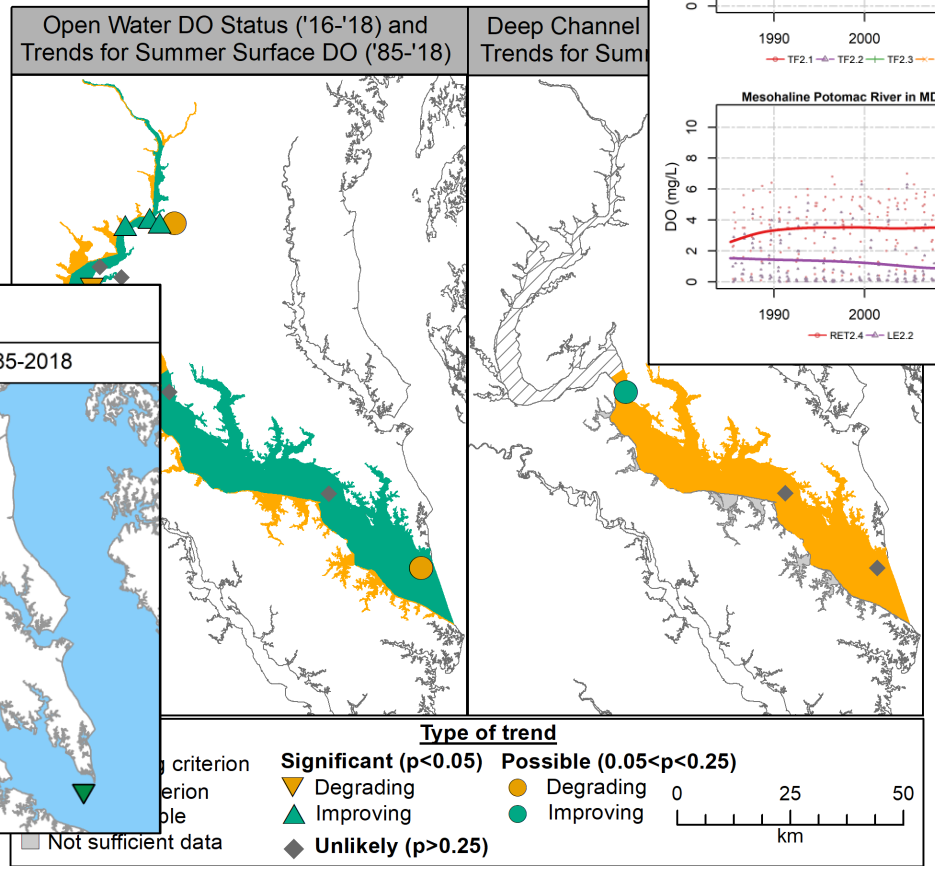
What are the Tributary Summaries?

A compilation of information by tributary or region on:

- **Tidal water quality and trends**







What are the Tributary Summaries?

A compilation of information by tributary or region on:

- Tidal water quality and trends,
- **Watershed characteristics and changes**

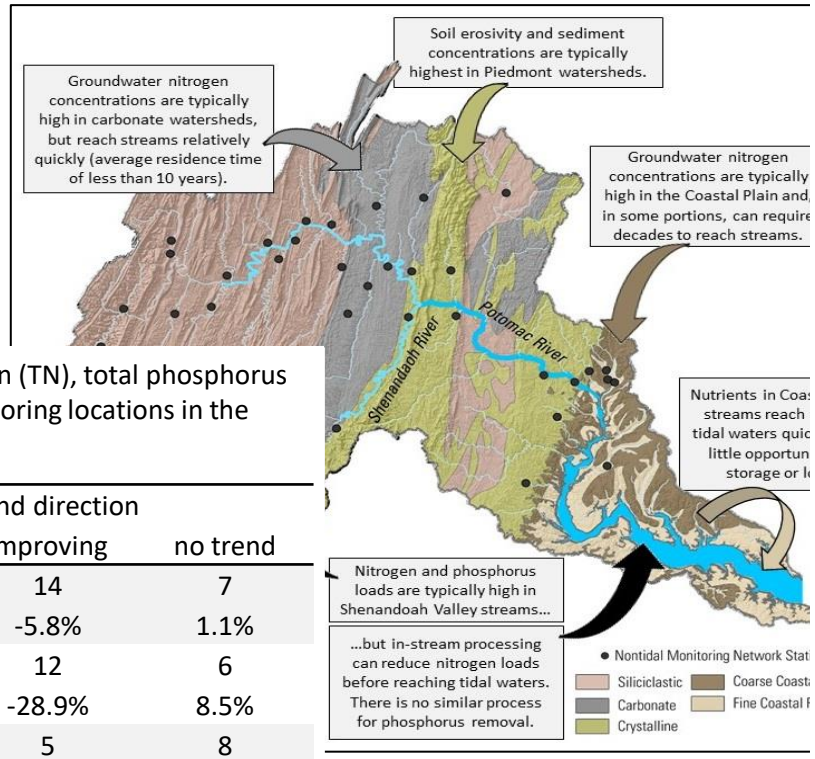


Table 3. Trends (2009 – 2018) in flow normalized total nitrogen (TN), total phosphorus (TP), and suspended sediment (SS) for nontidal network monitoring locations in the Potomac River watershed.

Parameter	No. of stations	Value	Trend direction		
			degrading	improving	no trend
TN	28	n	7	14	7
		median %	15.4%	-5.8%	1.1%
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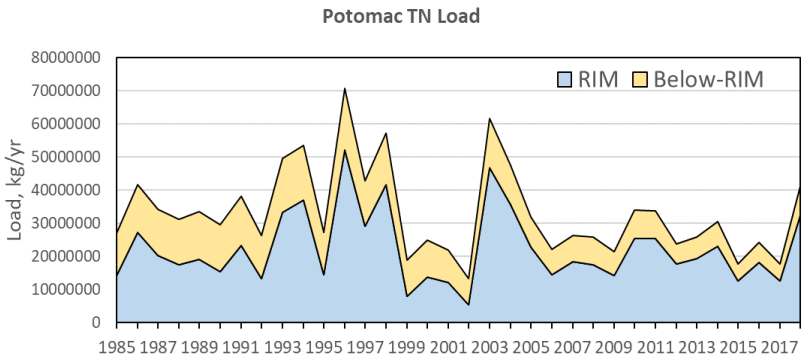
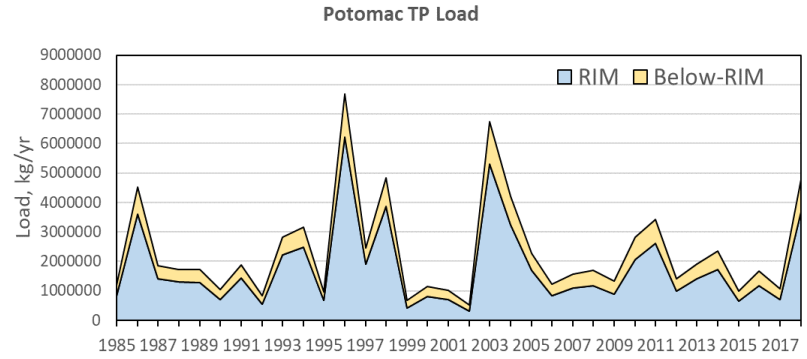
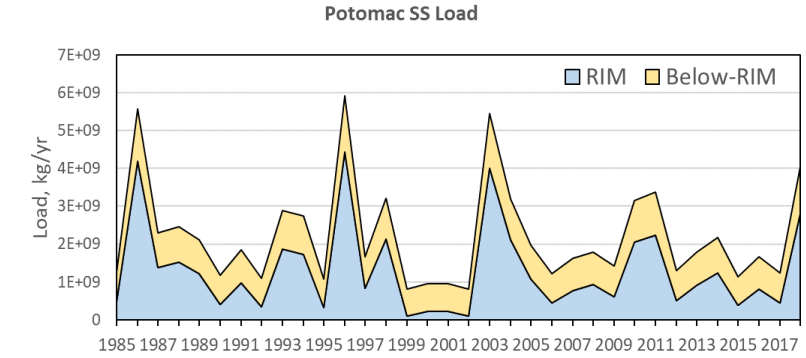


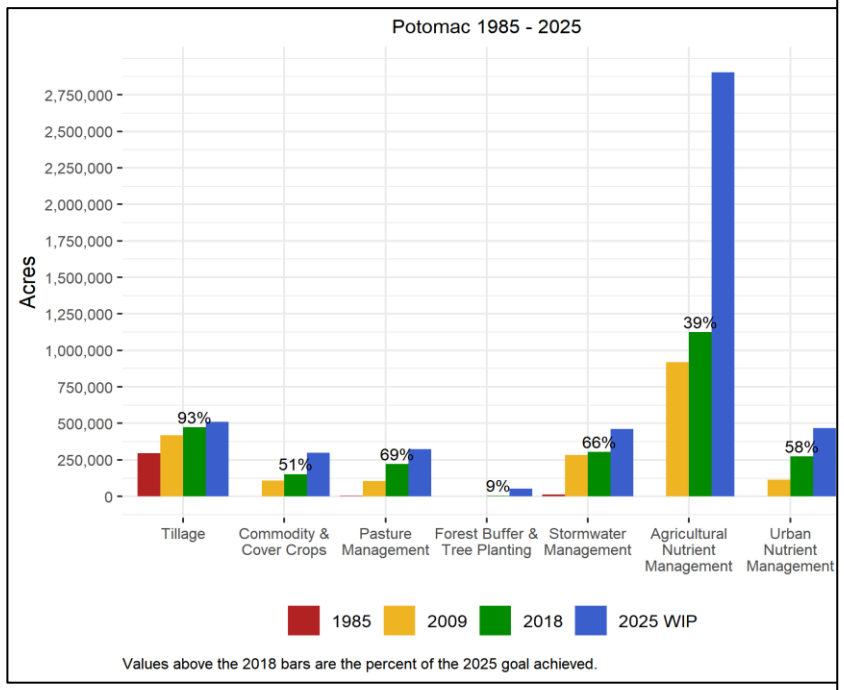


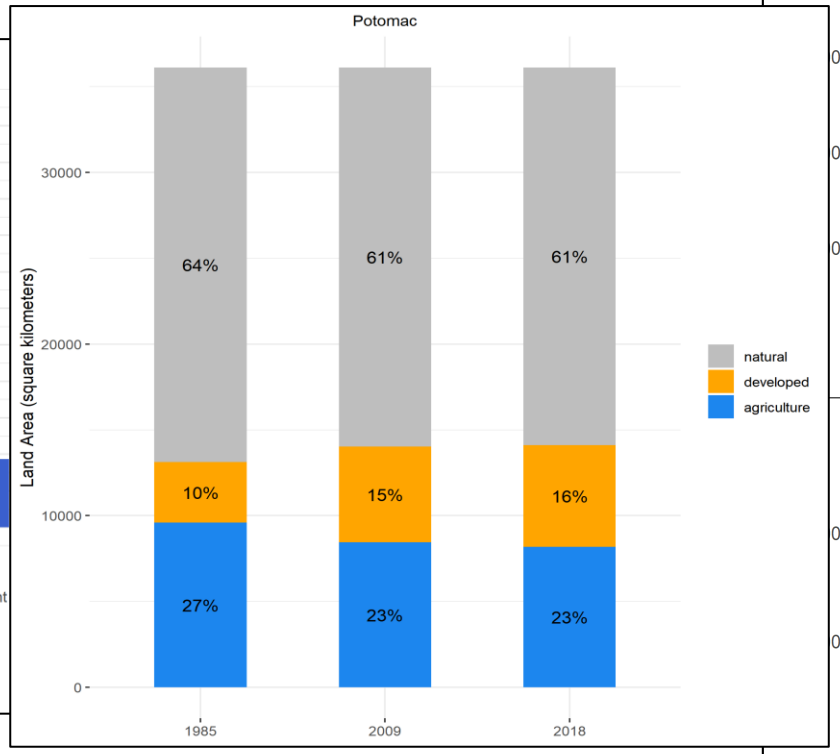


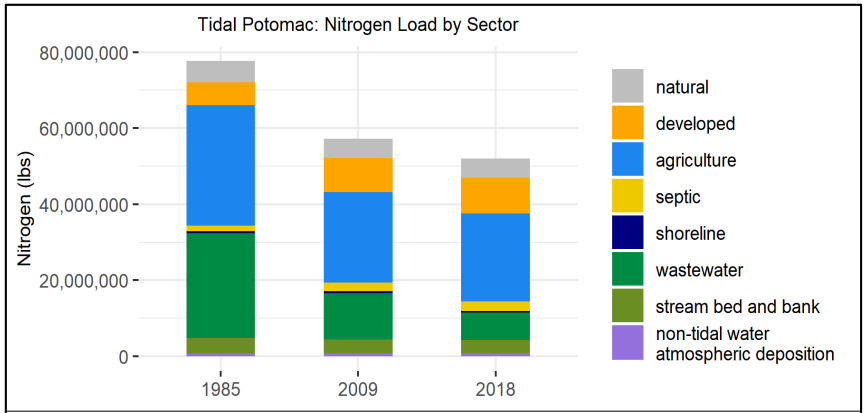
What are the Tributary Summaries?

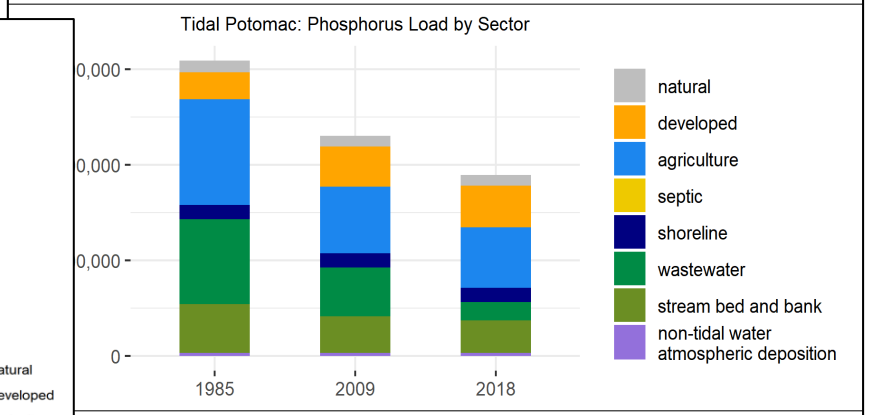
A compilation of information by tributary or region on:

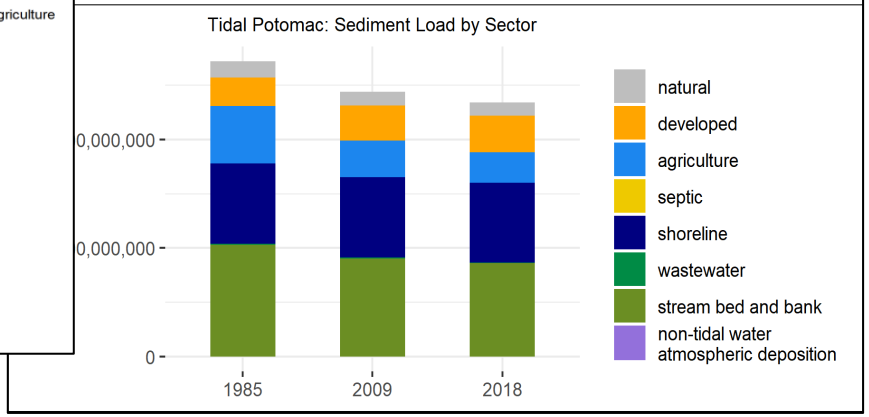
- Tidal water quality and trends,
- Watershed characteristics and changes,
- **Landscape drivers.**











Location, land use, physiography

Criteria status

Tidal water quality trends and maps (plus more in appendix)

Loads, source change, BMPs

Insights/evaluation of tidal trends (only for Potomac)

Contents

Audience

Technical managers within jurisdiction agencies
Local watershed organizations
Federal, state, and academic researchers

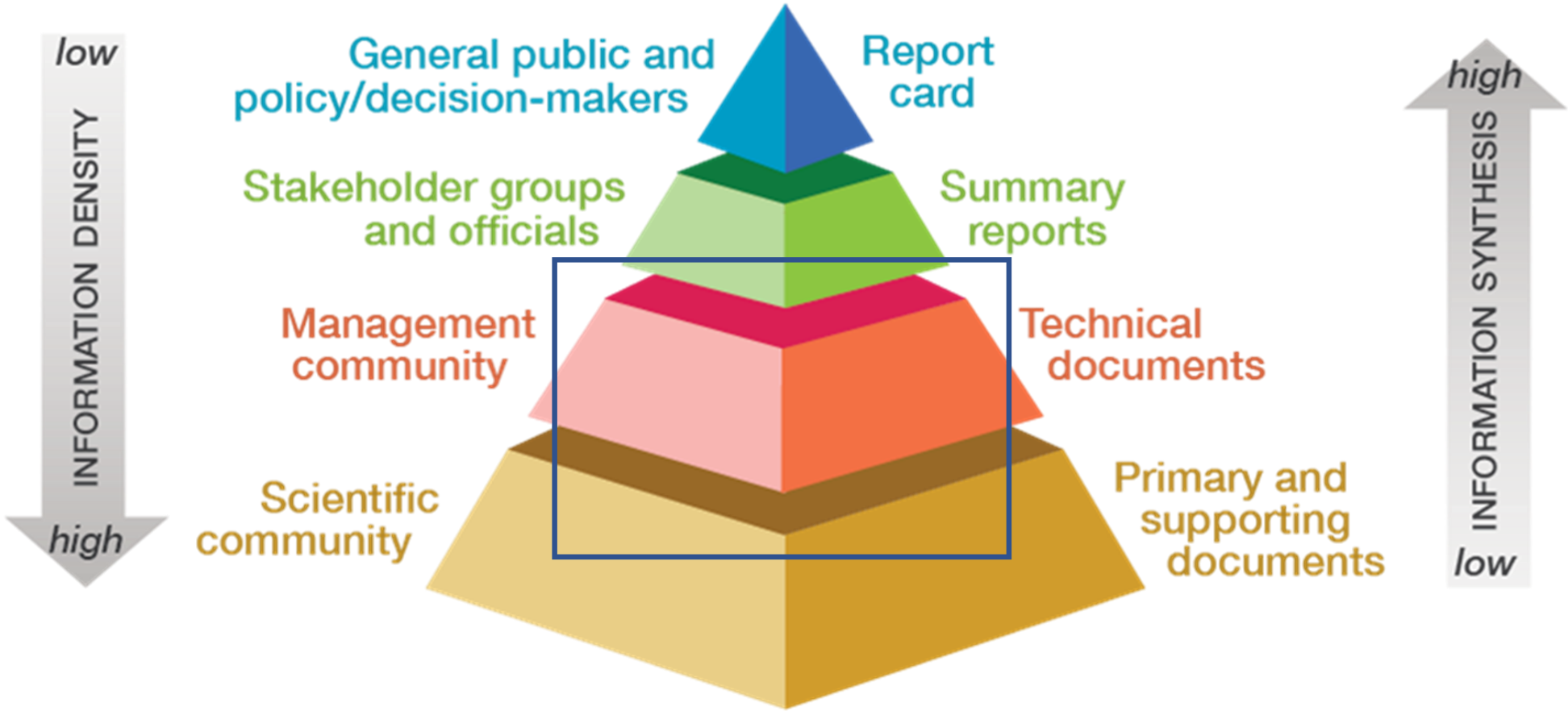


Figure courtesy UMCES Integration and Application Network, ian.umces.edu

Questions the tributary summaries can answer

1. Have water quality indicators in my river been improving or degrading over time?

2. How have landscape factors that drive water quality change in my watershed changed over time?

3. What clues do they provide that might explain observed water quality change (or lack of change)?

4. What should I target to turn a degrading trend around or maintain improvements for future water quality and living resource conditions?

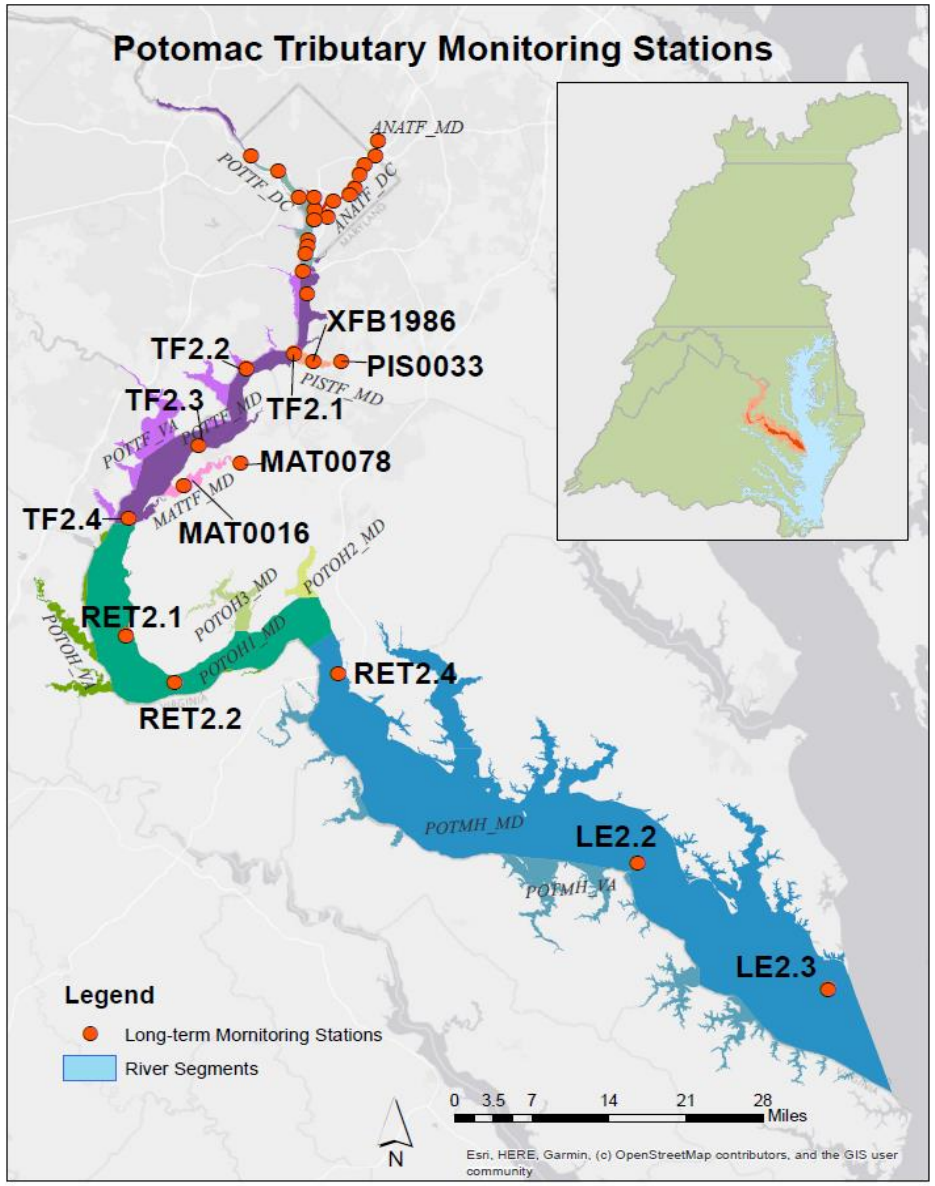
5. What should scientists focus our analyses on to provide better answers in the future?

Potomac Tributary Report

- Completed Dec, 2020.
- Uses data from 1985-2018.

Keisman, J., Murphy, R. R., Devereux, O.H., Harcum, J., Karrh, R., Lane, M., Perry, E., Webber, J., Wei, Z., Zhang, Q., Petenbrink, M. 2020. Potomac Tributary Report: A summary of trends in tidal water quality and associated factors. Chesapeake Bay Program, Annapolis MD.

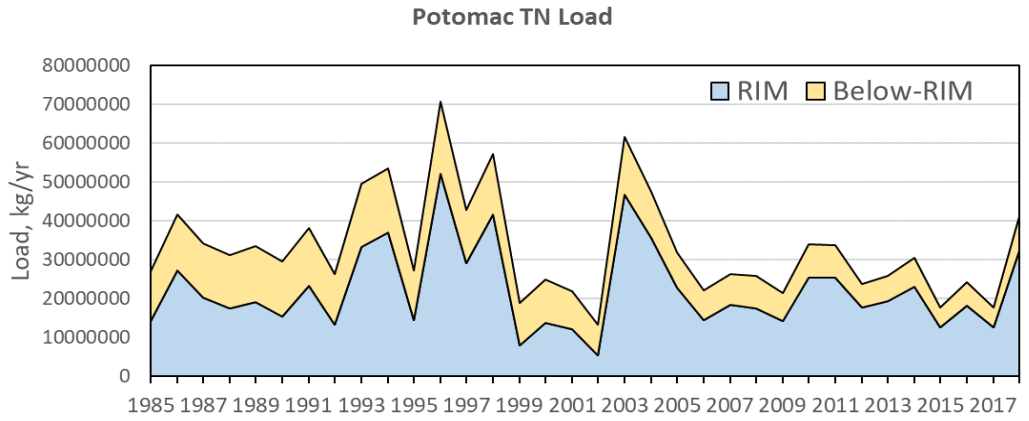
- Story Map produced by USGS: https://wim.usgs.gov/geonarrative/potomactrib/

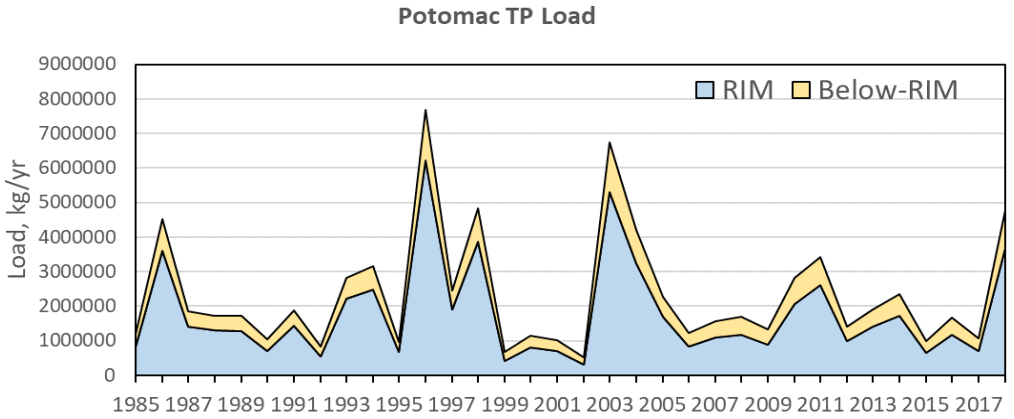


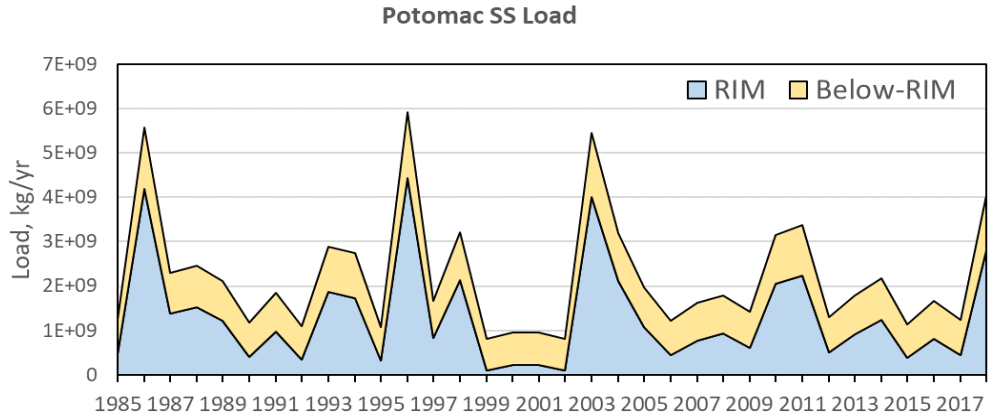
Potomac: Loads

- True condition loads are highly variable due to freshwater flow,
- BUT these are what directly impact estuarine water quality.
  - Trend results show that total TN has decreased, total TP has no trend.
  - Point source loads have decreased for both.
- Note that “flow-normalized” loads are mostly decreasing in the watershed.

Total estimate of observed loads to tidal Potomac

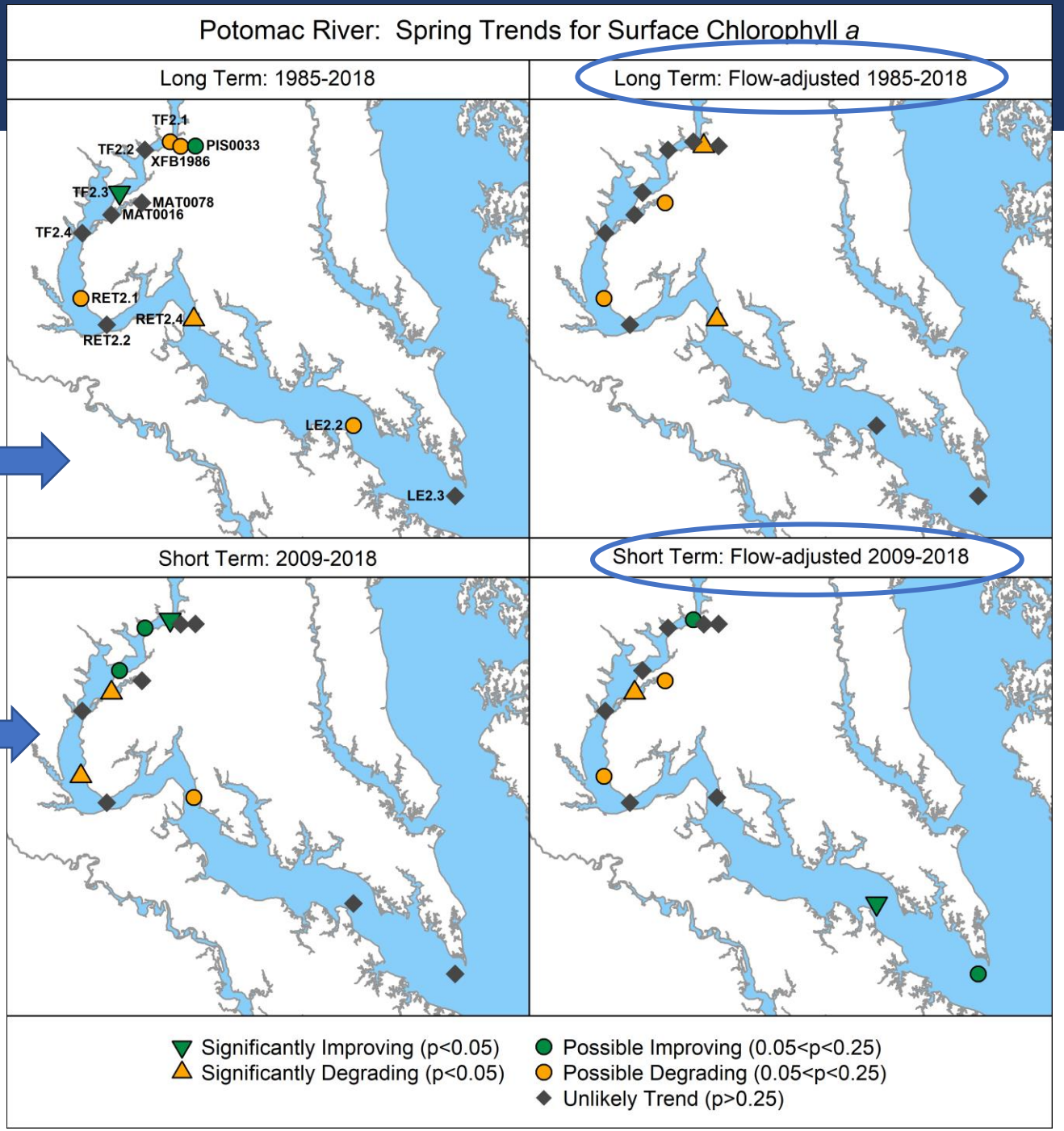






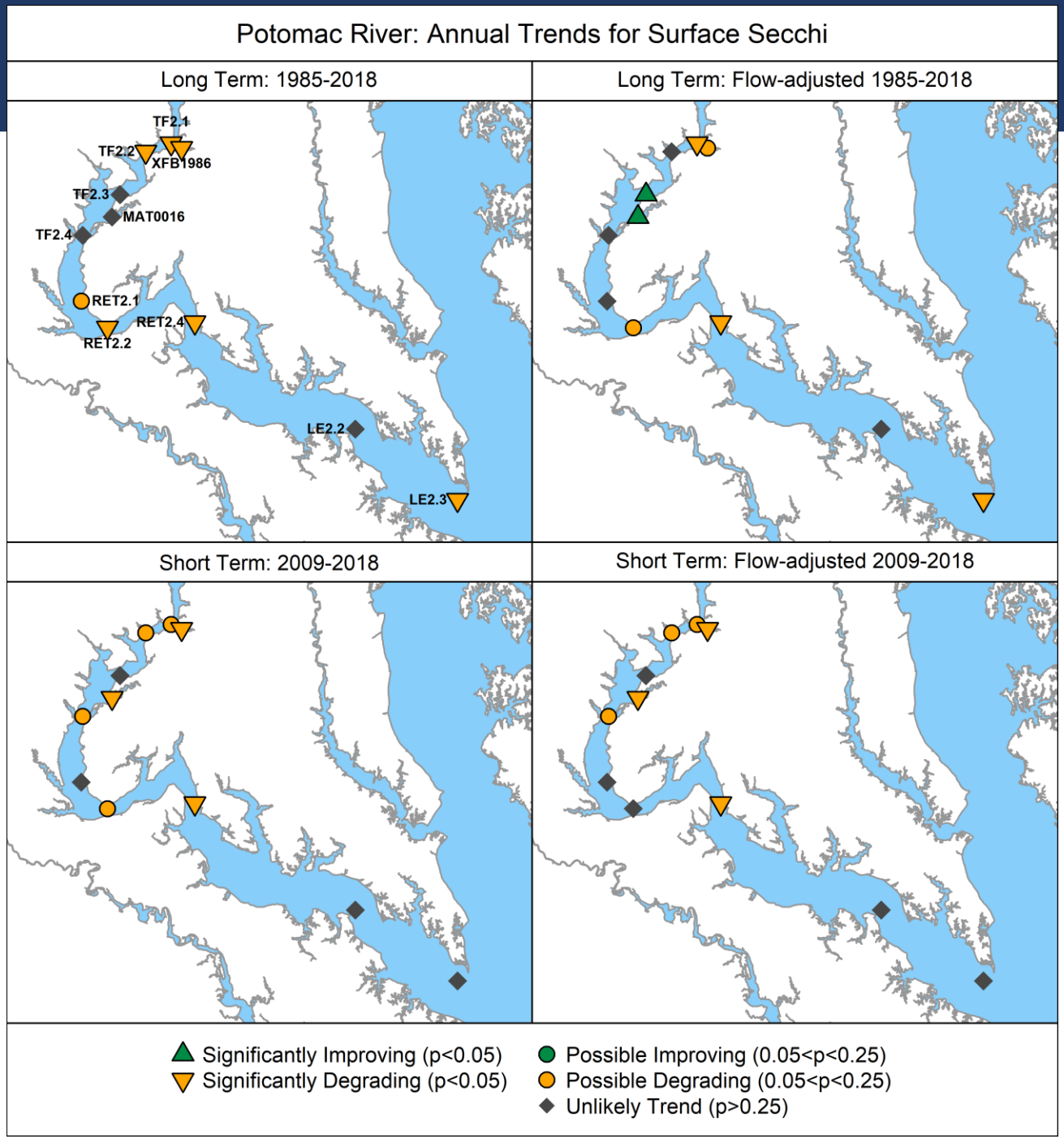
Potomac: Chlorophyll *a*

- Four maps show a mixture of trends:
  - Long term observed change
  - Long term flow-adjusted change (i.e., if flow had been average)
  - Recent 10-year observed change
  - 10-year flow-adjusted



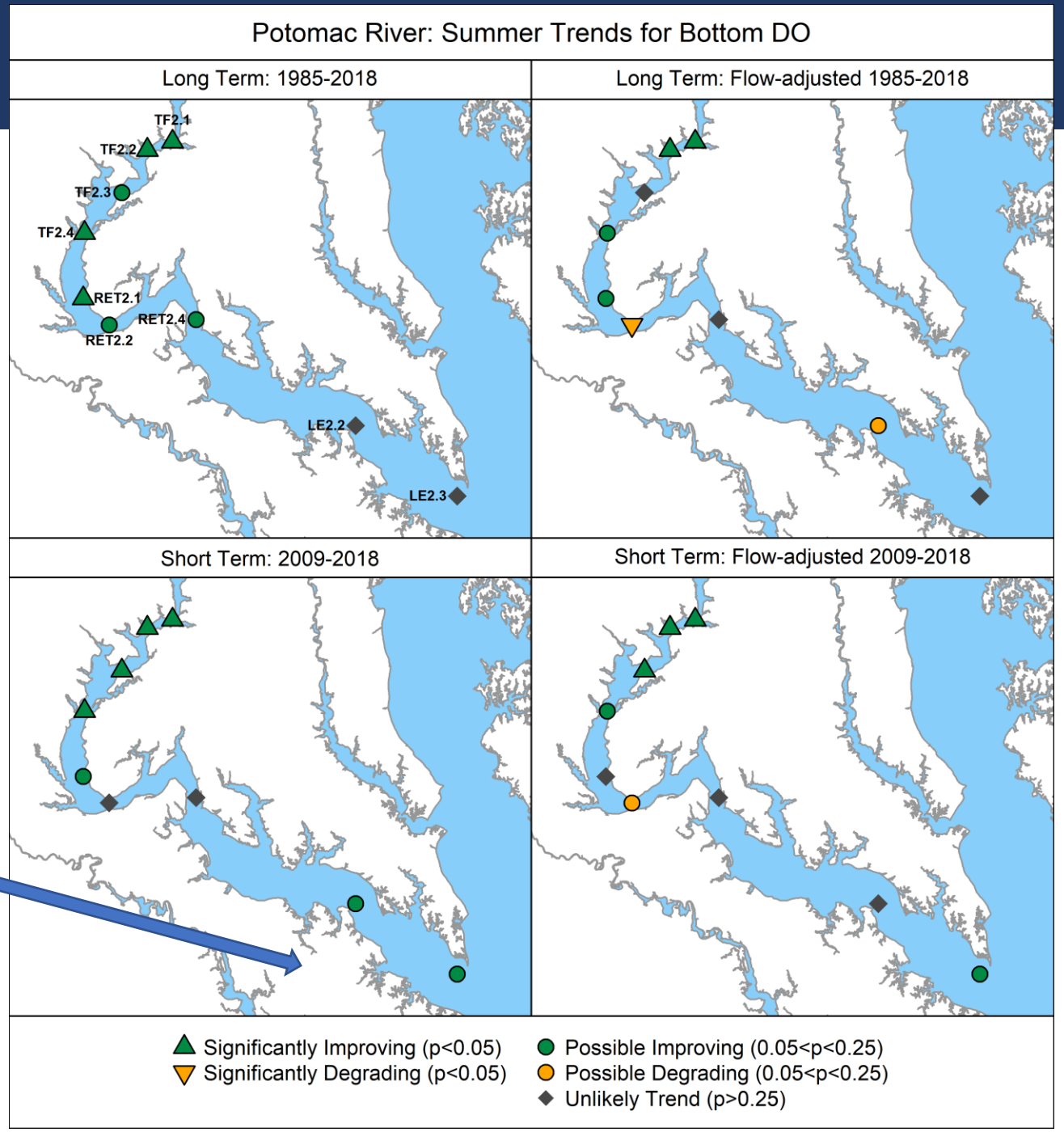
Potomac: Secchi

- Secchi as a measure of visibility through the water shows mostly degradation or no trend.
- Fairly consistent with chlorophyll *a*.



Potomac: Bottom DO

- Summer (June-Sept) bottom DO is improving at many stations overall.
- Possible improvements over the short-term at the deepest stations are a good sign too (and consistent with other deep places in the Bay).



Potomac: WQ Criteria

- We include a record of the evaluation results indicating whether different Potomac segments have met or not met specific WQ criteria for DO.
- Open Water summer

Open Water Summer Criteria Status

time period	ANATF_DC	ANATF_MD	PISTF	MATTF	POTTF_DC	POTTF_MD	POTTF_VA	POTOH1_MD	POTOH2_MD	POTOH3_MD	POTOH_VA	POTMH_MD	POTMH_VA
1985-1987							ND		ND	ND	ND		ND
1986-1988							ND		ND	ND	ND		ND
1987-1989							ND		ND	ND	ND		ND
1988-1990							ND		ND	ND	ND		ND
1989-1991							ND		ND	ND	ND		ND
1990-1992							ND		ND	ND	ND		ND
1991-1993							ND		ND	ND	ND		ND
1992-1994							ND		ND	ND	ND		ND
1993-1995							ND		ND	ND	ND		ND
1994-1996							ND		ND	ND	ND		ND
1995-1997							ND		ND	ND	ND		ND
1996-1998							ND		ND	ND	ND		ND
1997-1999							ND		ND	ND	ND		ND
1998-2000							ND		ND	ND	ND		ND
1999-2001							ND		ND	ND	ND		ND
2000-2002							ND		ND	ND	ND		ND
2001-2003							ND		ND	ND	ND		ND
2002-2004									ND	ND			
2003-2005									ND	ND			
2004-2006													
2005-2007													
2006-2008													
2007-2009													
2008-2010													
2009-2011									ND	ND			
2010-2012									ND	ND			
2011-2013									ND	ND			
2012-2014									ND	ND			
2013-2015									ND	ND			
2014-2016									ND	ND			
2015-2017									ND	ND			
2016-2018									ND	ND			

Potomac: WQ Criteria

- Also deep channel and deep water criteria status over time for Potomac segments

Deep Water and Channel Status

time period	Deep Water		Deep Channel	
	POTMH_MD	POTMH_VA	POTMH_MD	POTMH_VA
1985-1987		ND		ND
1986-1988		ND		ND
1987-1989		ND		ND
1988-1990		ND		ND
1989-1991		ND		ND
1990-1992		ND		ND
1991-1993		ND		ND
1992-1994		ND		ND
1993-1995		ND		ND
1994-1996		ND		ND
1995-1997		ND		ND
1996-1998		ND		ND
1997-1999		ND		ND
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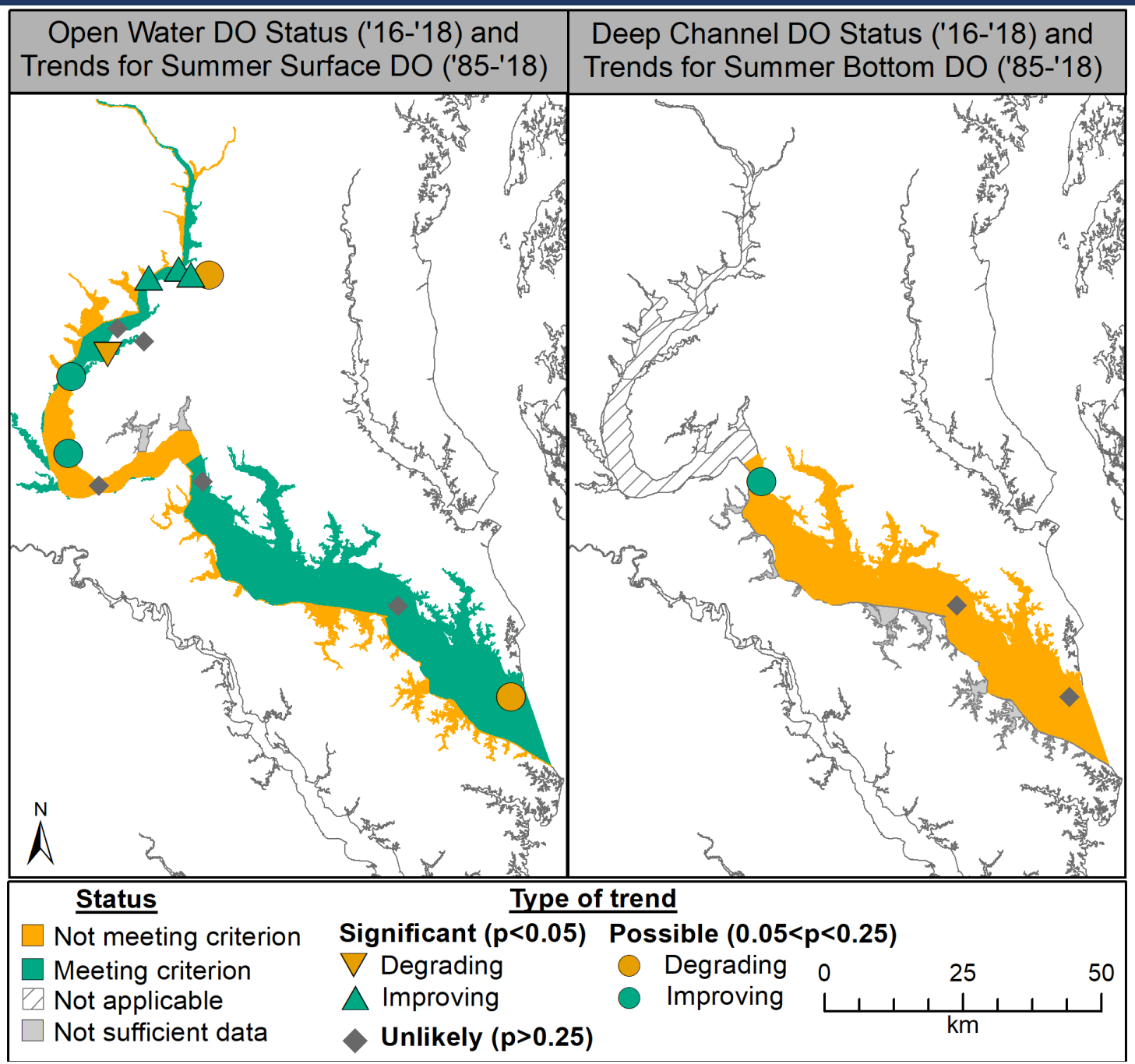
2005-2007				
2006-2008				
2007-2009				
2008-2010				
2009-2011				
2010-2012		ND		ND
2011-2013				ND
2012-2014				ND
2013-2015				ND
2014-2016				ND
2015-2017				ND
2016-2018				ND

Potomac: Criteria

- Status and trends in relevant DO combined



Potomac: Insights section

→ ***How do tidal waters respond to actions in the watershed?***

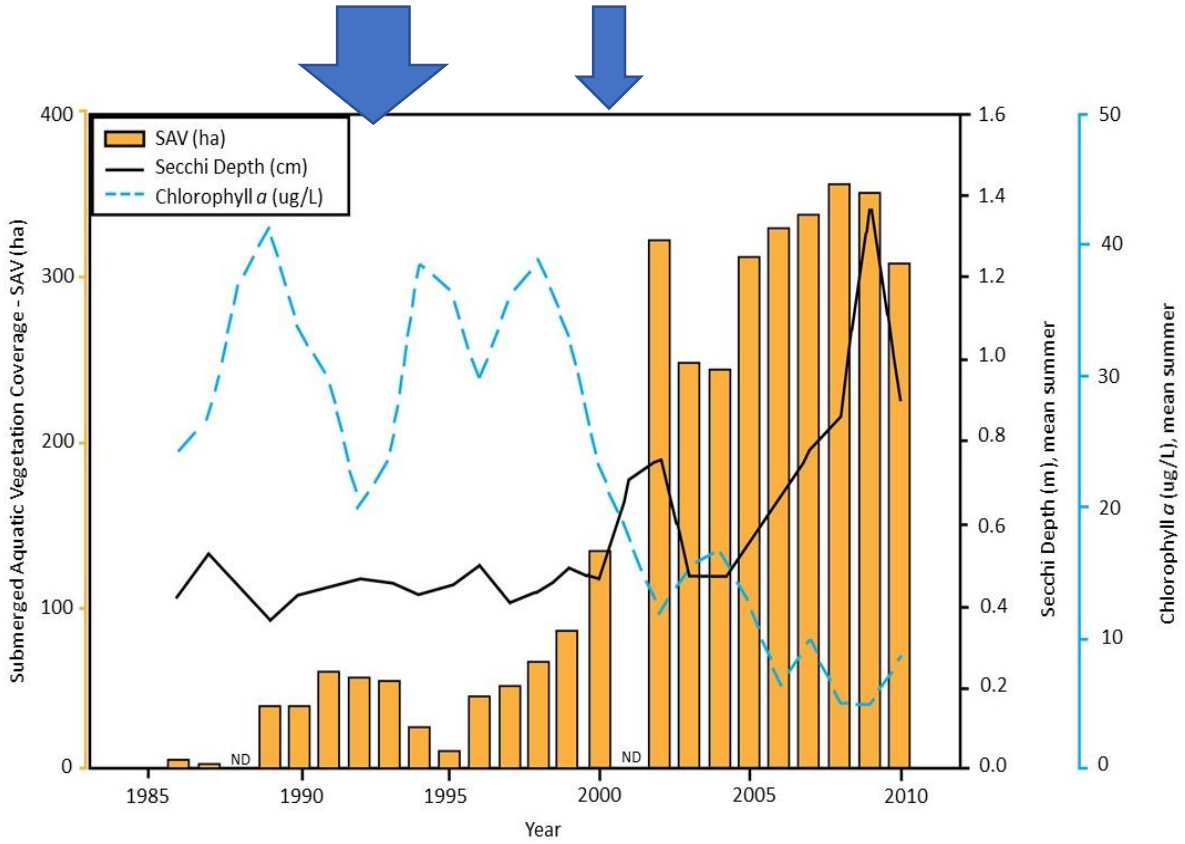
Two important findings:

1. Local response to large nutrient reductions happens and is clearly shown with the data.

2. Long-term response to watershed-wide nutrient reductions is happening in the tidal waters.

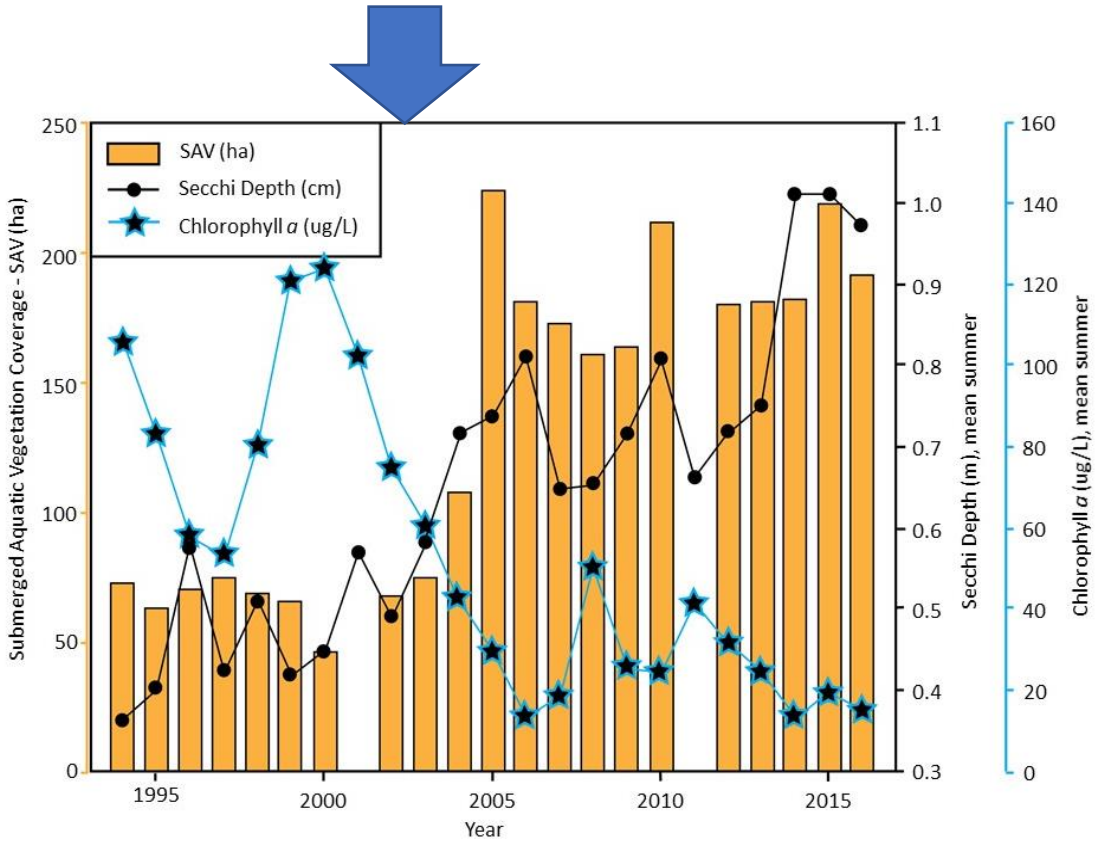
1) *Local response to large nutrient reductions happens*

Mattawoman Creek: Very large WW load reductions



SAV coverage (ha), water clarity (Secchi disk depth), and algal biomass (chlorophyll *a* concentration) in Mattawoman Creek. From Boynton *et al.* (2014).

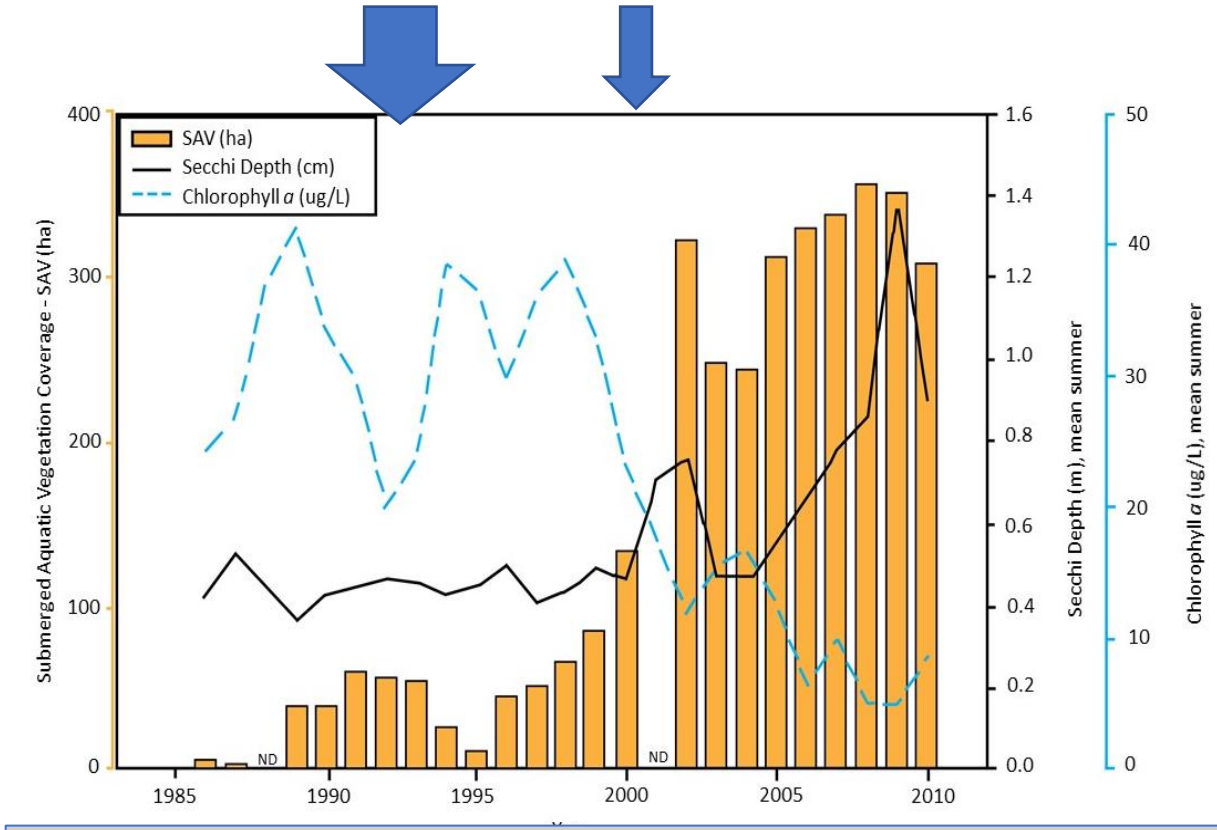
Gunston Cove: Very large WW load reduction



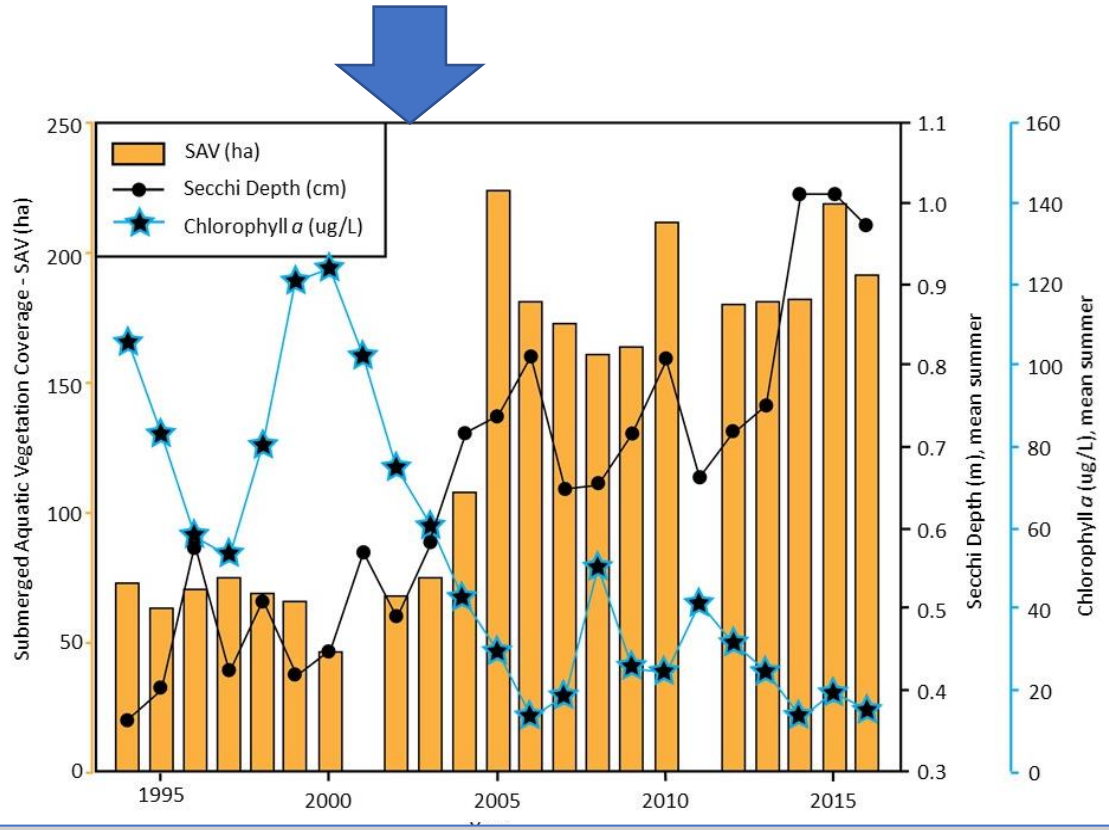
Algal biomass (as chlorophyll *a*), Secchi depth, and SAV acreage for the period 1994 – 2016 in Gunston Cove. From Jones *et al.* (2017).

1) *Local response to large nutrient reductions happens*

Mattawoman Creek: Very large WW load reductions



Gunston Cove: Very large WW load reduction



<u>What this tells us:</u> This data clearly shows that investment in large-scale nutrient reductions is successful for improving water quality dramatically in local systems.

2) Long-term response to watershed changes is happening

- Over the long-term, nutrient loads have decreased across the Potomac watershed.
- Tidal nutrient concentrations have decreased at almost all tidal stations.

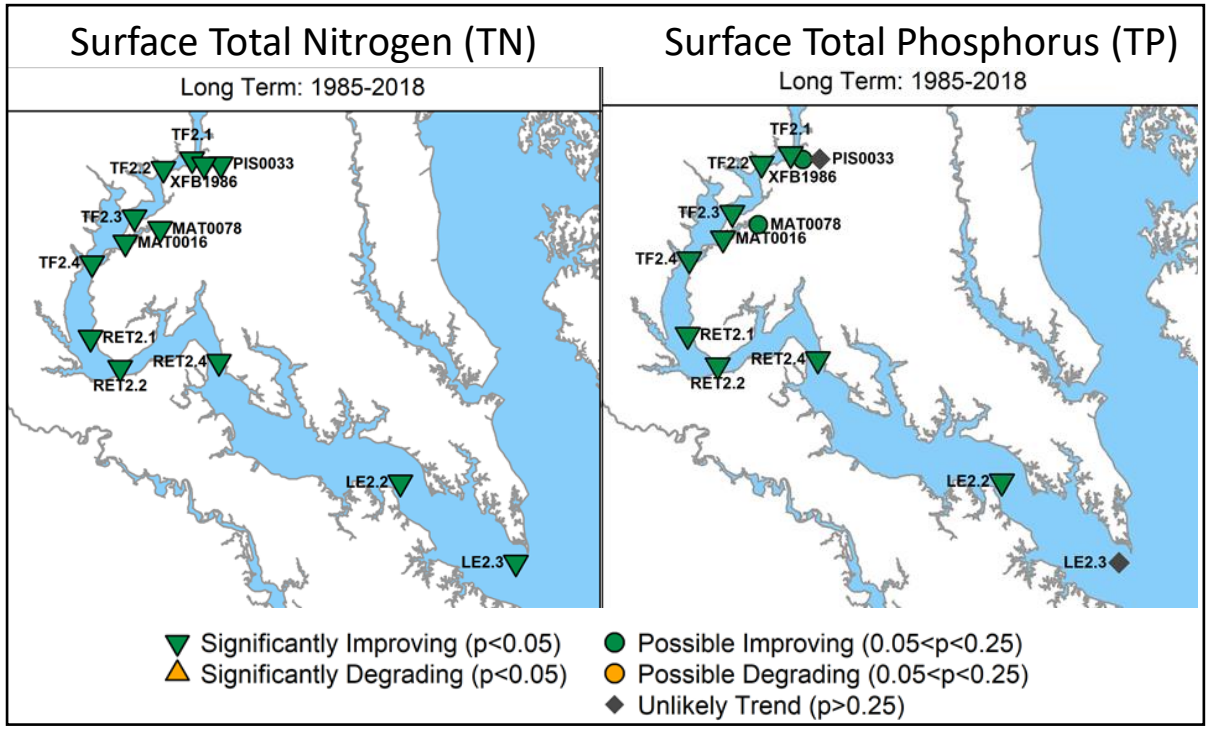


Table 3. Trends (2009 – 2018) in flow normalized total nitrogen (TN), total phosphorus (TP), and suspended sediment (SS) for nontidal network monitoring locations in the Potomac River watershed.

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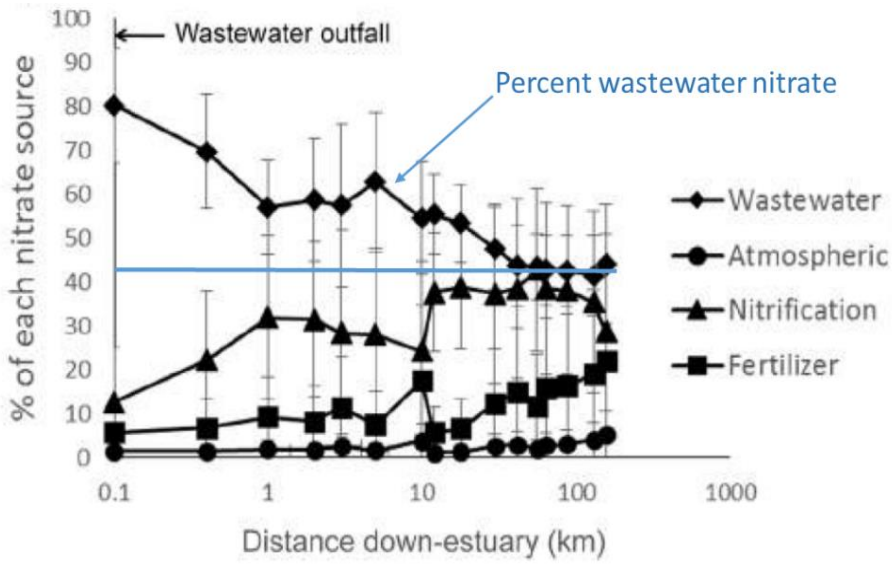
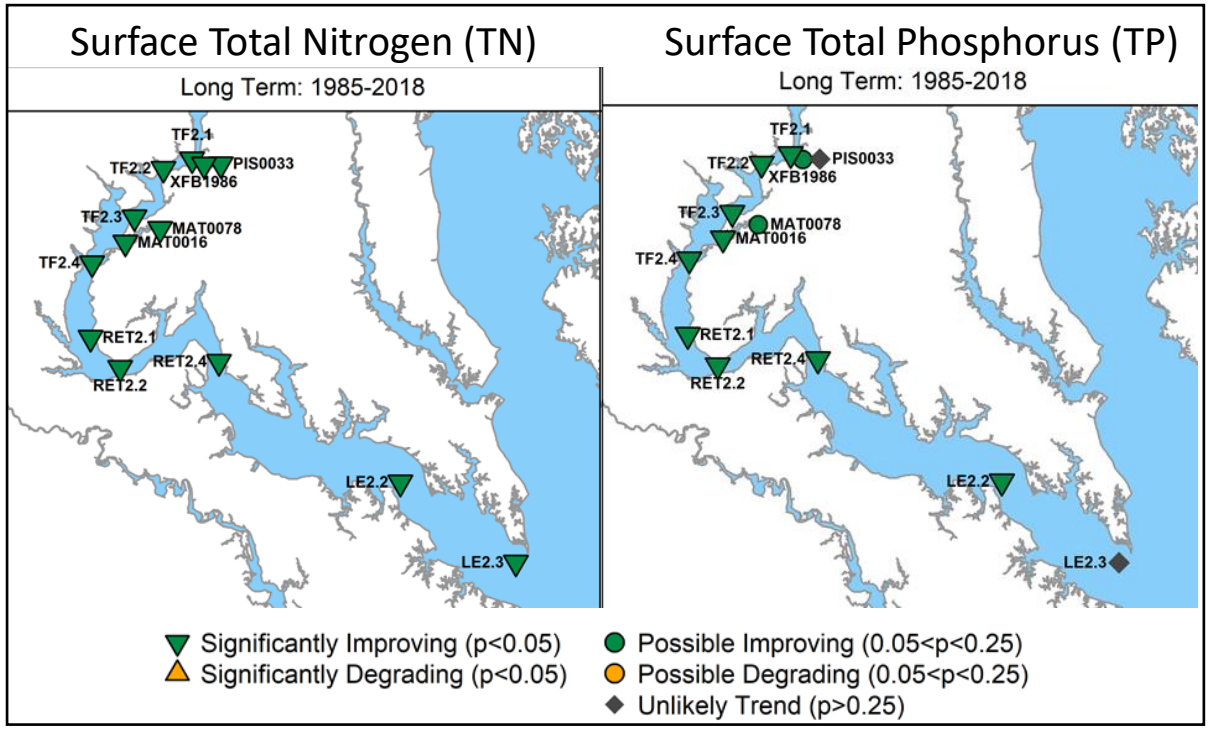
2) Long-term response to watershed changes is happening

- These tidal trends are **not just local response**, but have been shown to be impacted by loads from many types of sources.

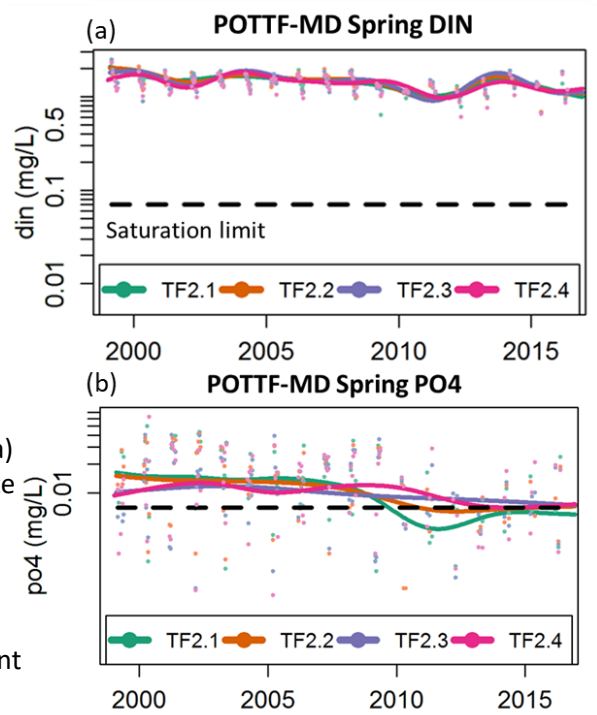


Mean annual change in the percent contribution of nitrate from wastewater, fertilizer, atmospheric deposition, and nitrification, based on an isotope mixing model, with distance down-estuary from wastewater treatment plant output. Adapted from Pennino *et al.* (2016).

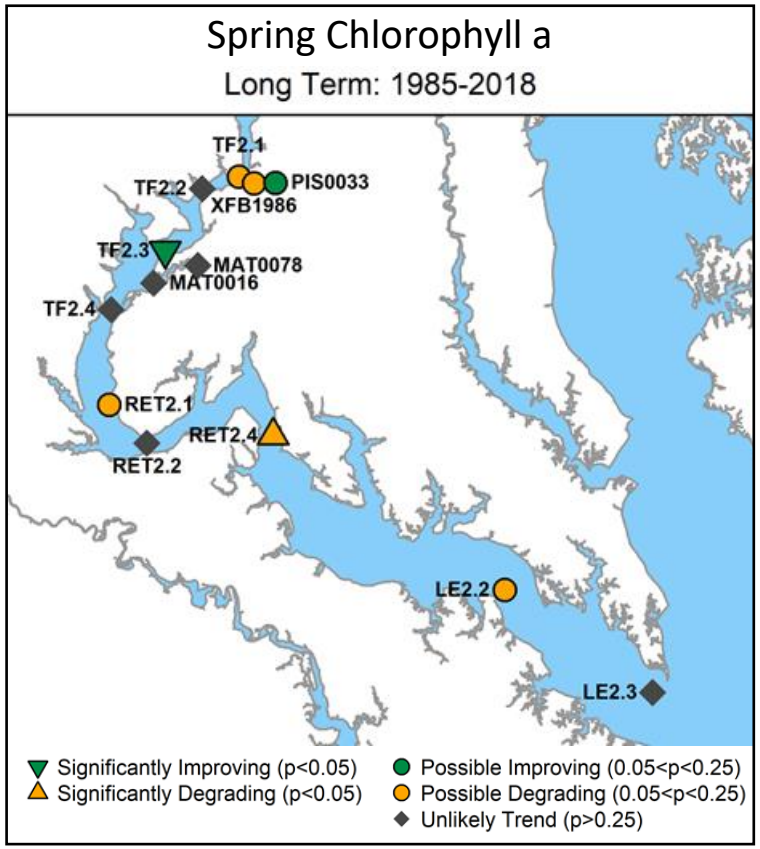


2) Large-scale, long-term response is happening

- Other water quality responses are not as clear
- But research shows there is a reason: Nutrients have improved, but still need to be lower to limit phytoplankton growth in most places.



Spring dissolved inorganic nitrogen (a) and spring phosphate (b) at monitoring stations in the tidal Potomac River from 1999 to 2018. Black dotted lines represent nutrient saturation thresholds.



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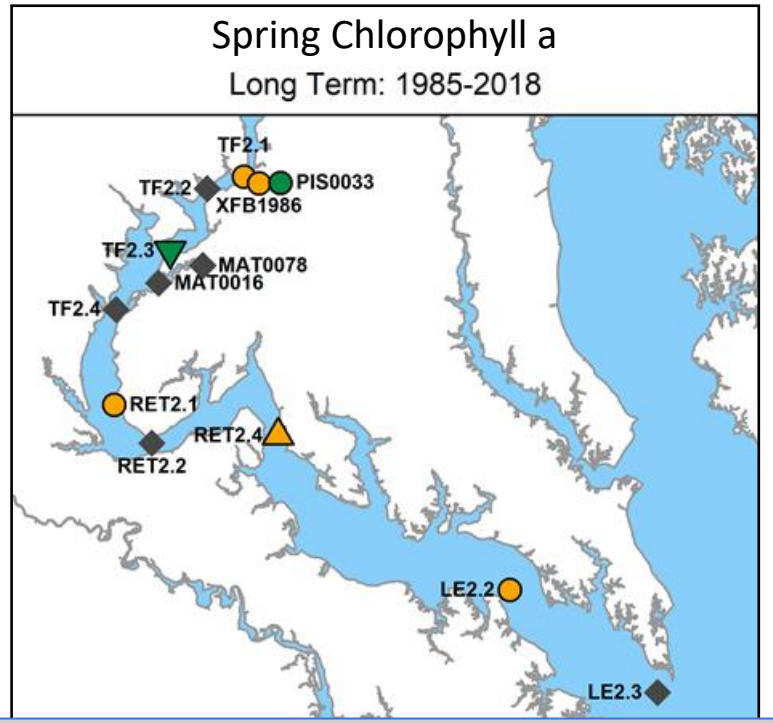


<u>What this tells us:</u> The data shows that watershed-wide nutrient reductions have improved nutrients in the Potomac. The science supports the conclusion that with more reductions, improvements will continue.

Potomac Summary

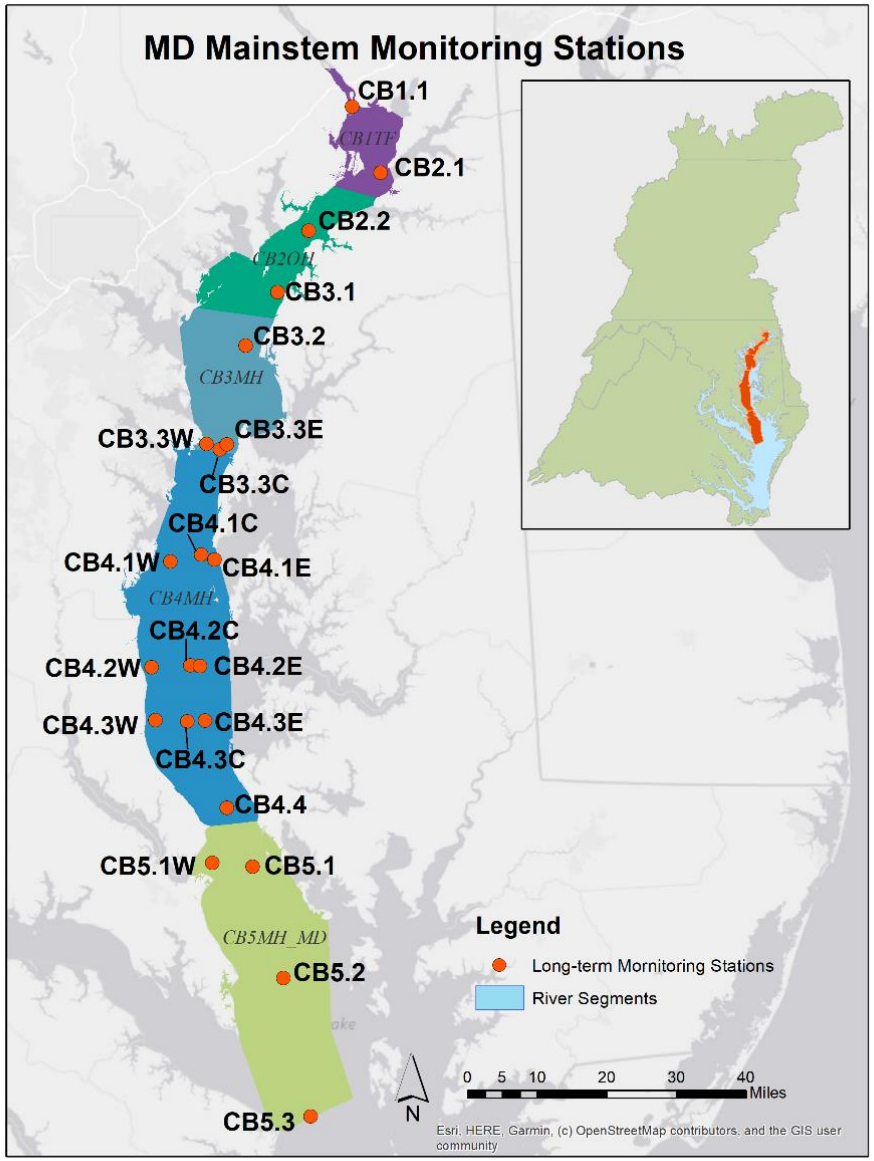
- Nutrient load and concentration reductions have occurred, but may have slowed in recent years.

- Response in the estuary is clear:
  - Nutrient trends,
  - Some DO improvement, and
  - Local case studies with large improvements.

- More improvement is expected with continued action.

Maryland Mainstem Tributary Summary

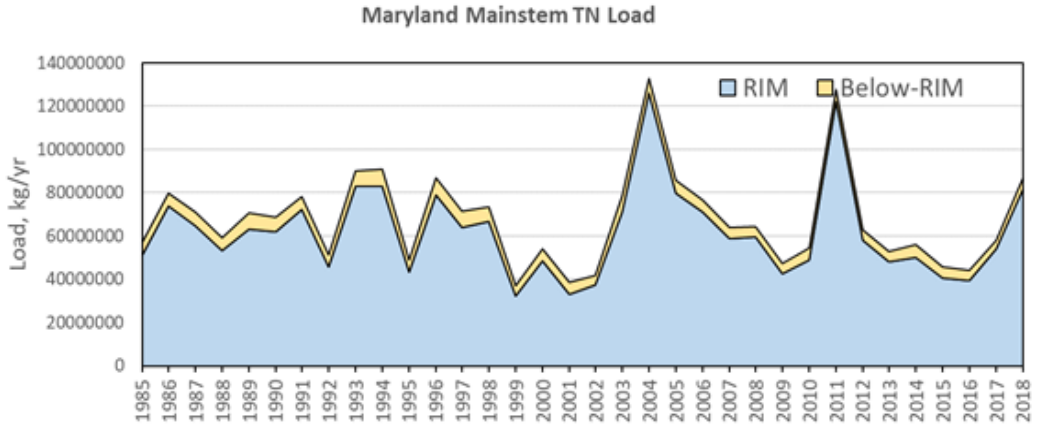
- Focused on fixed-station monitoring in MD mainstem.
- Watershed graphics/summaries are mostly for Susquehanna watershed plus some near-tidal regions.
  - Although we know that these waters are influenced by much of the whole Bay watershed.

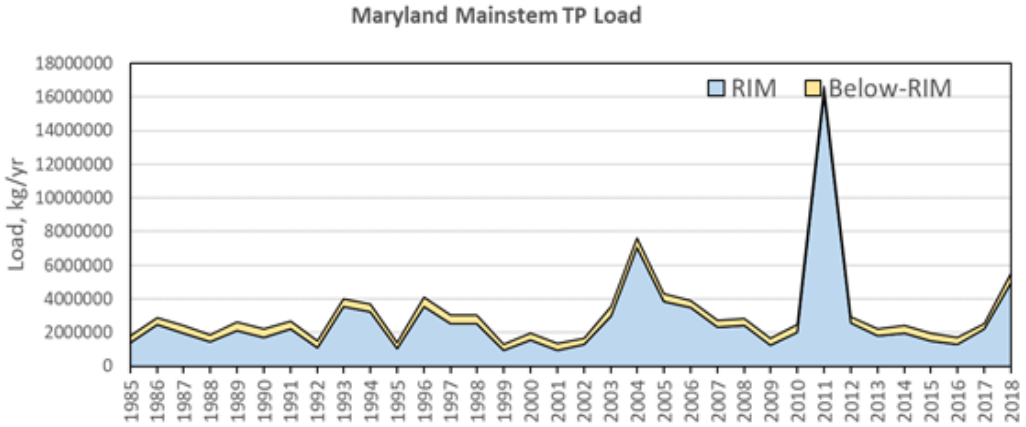


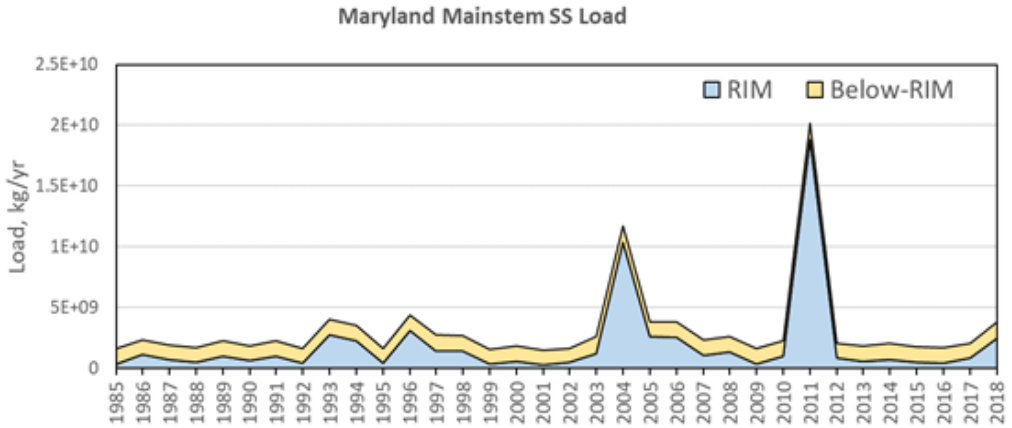
MD Mainstem: Loads

- Just like the Potomac, huge variability year-to-year of inputs to the estuary.
- But flow-normalized decrease in TN and increase in TP over this period.

Loads to tidal MD Mainstem (primarily Susquehanna)

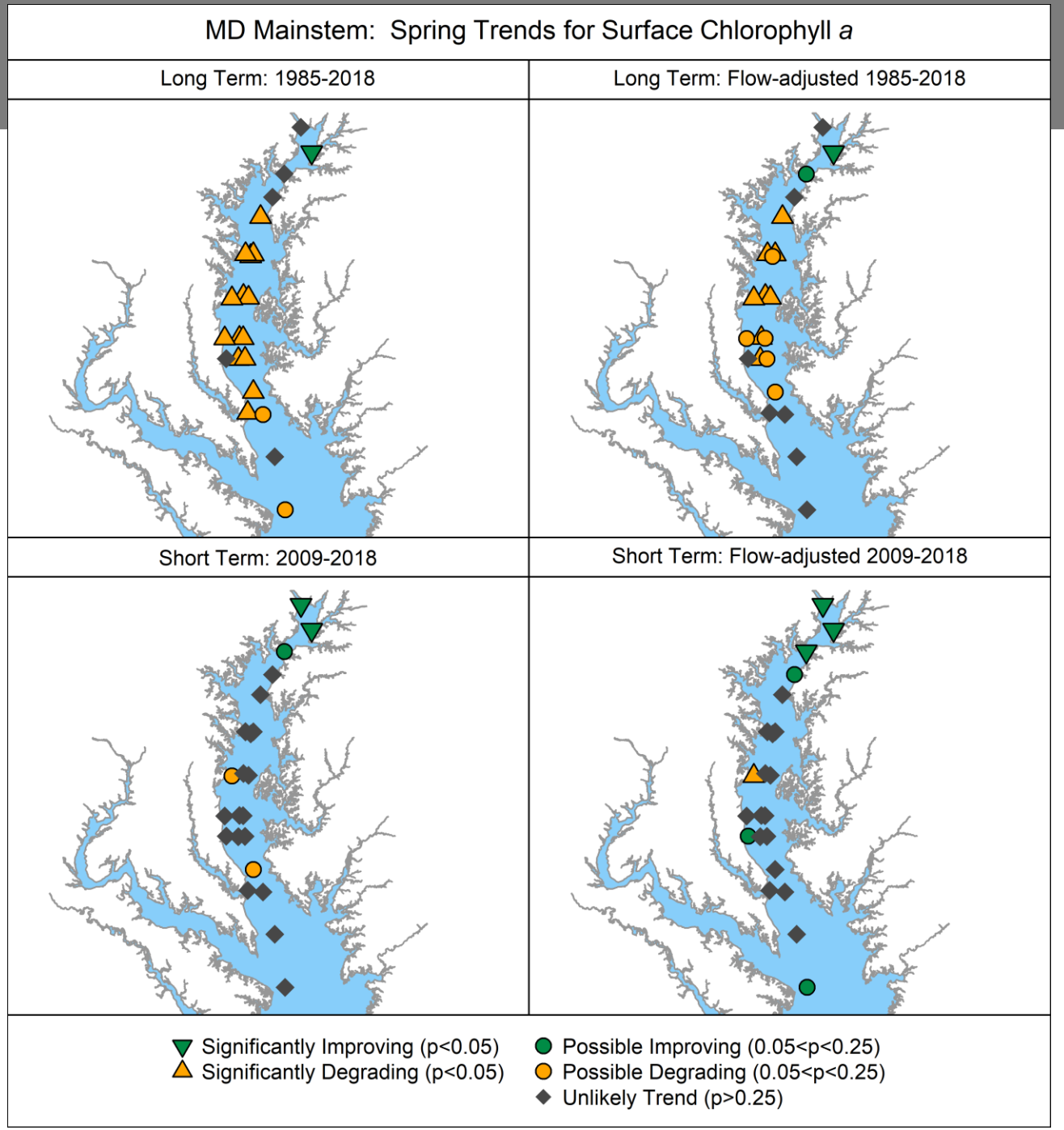






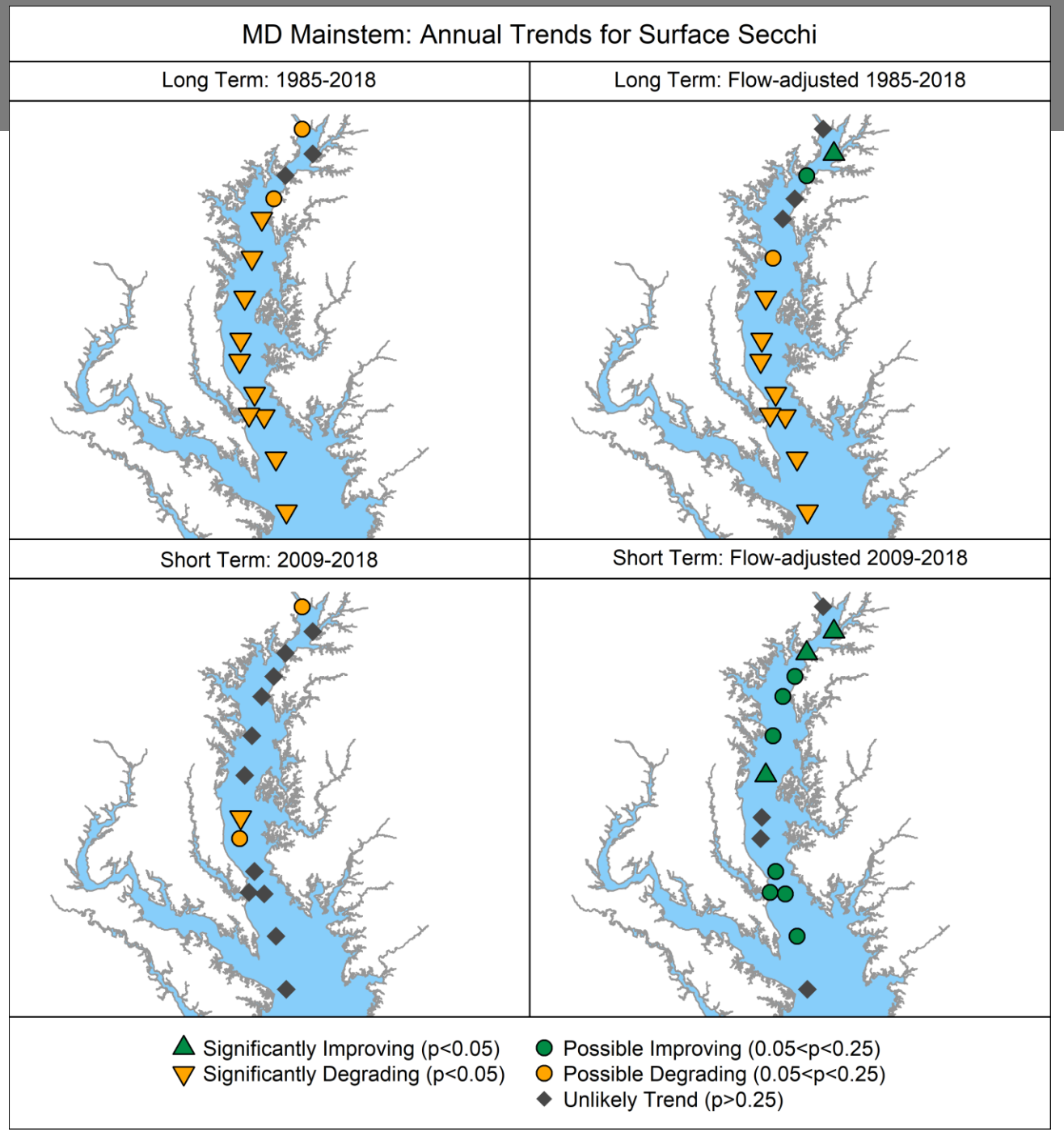
MD Mainstem: Chlorophyll *a*

- Long term decrease in tidal fresh but increase in saltier regions.
- Short-term, many increases have become "no trend."



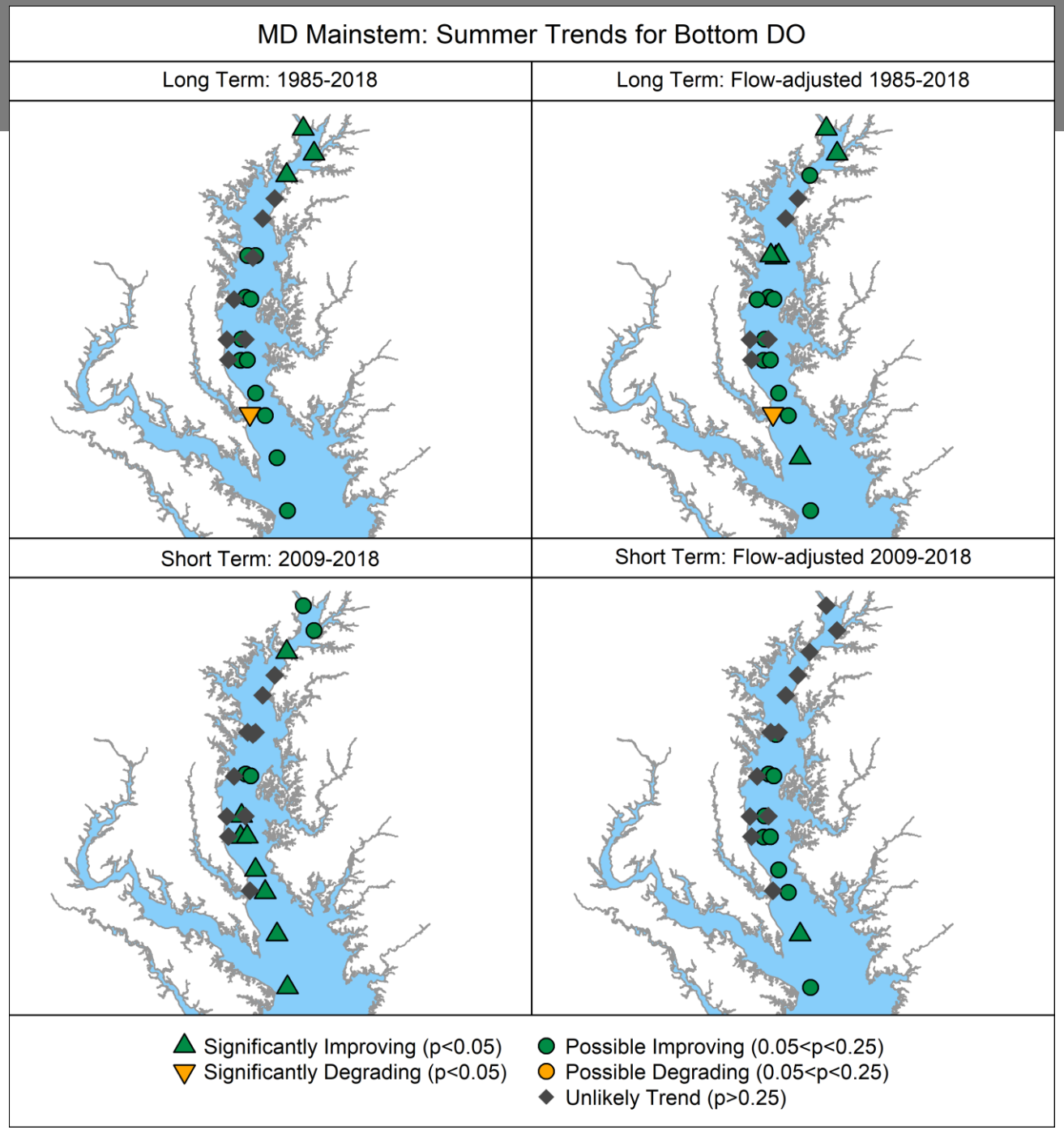
MD Mainstem: Secchi

- Secchi long-term fairly similar to chlorophyll *a*.
- But short-term is showing even more improvements after accounting for flow.



MD Mainstem: Bottom DO

- This is June-Sept bottom DO.
- Many long- and short-term improvements across these stations.



MD Mainstem: Criteria

- Open water summer DO status is fairly consistent across segments.

Open Water Summer Criteria Status

Time Period	CB1TF	CB2OH	CB3MH	CB4MH	CB5MH_MD
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					
2015-2017					
2016-2018					

MD Mainstem: Criteria

- Deep water and channel criteria have never been met.

Deep Water and Deep Channel Summer DO

Time Period	Deep Water			Deep Channel		
	CB3MH	CB4MH	CB5MH_MD	CB3MH	CB4MH	CB5MH_MD
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						
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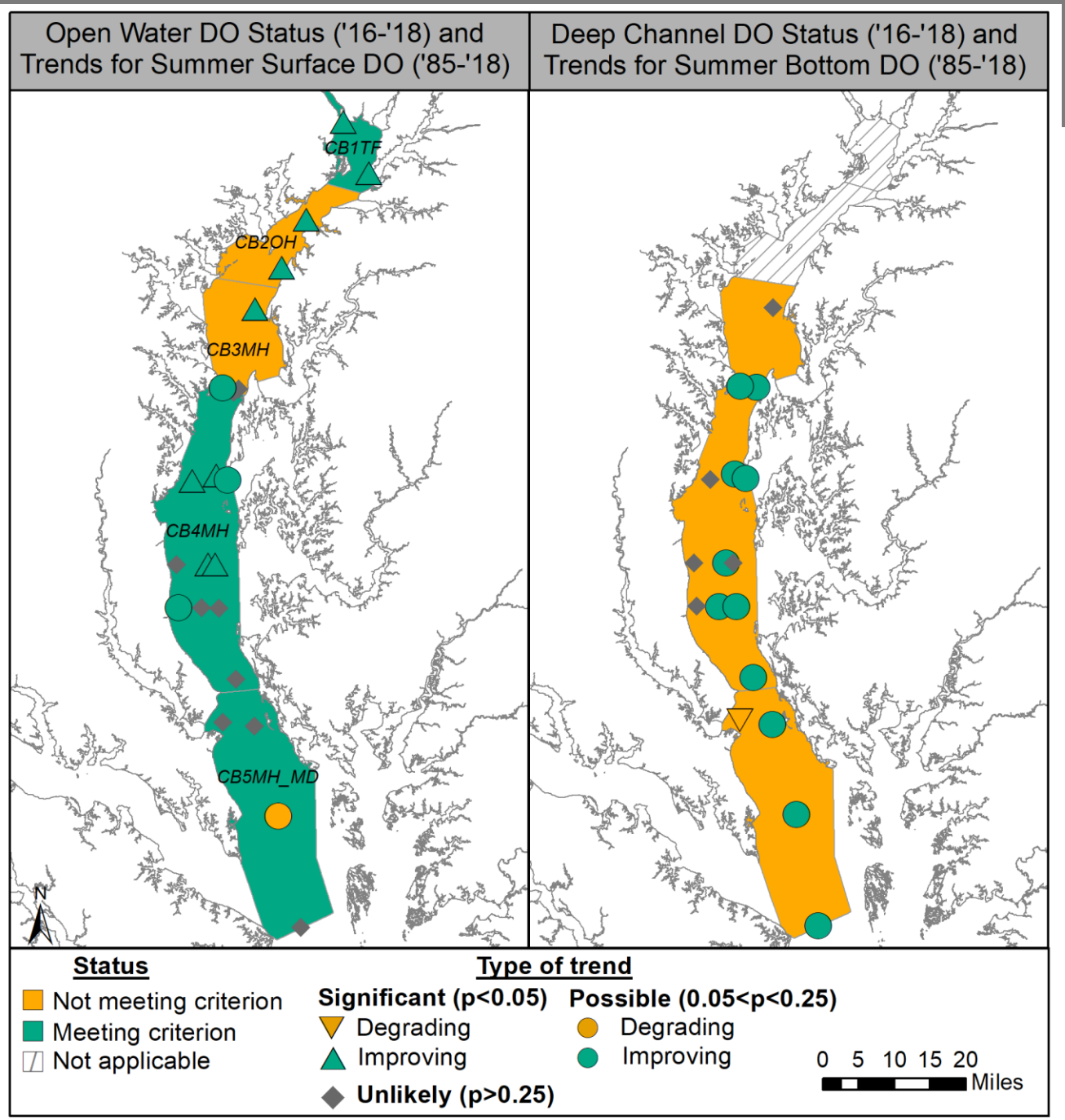
2000-2002						
2001-2003						
2002-2004						
2003-2005						
2004-2006						
2005-2007						
2006-2008						
2007-2009						
2008-2010						
2009-2011						
2010-2012						
2011-2013						
2012-2014						
2013-2015						
2014-2016						
2015-2017						
2016-2018						

MD Mainstem: Criteria

- Improvements in segments that are not meeting the criteria is promising.



Summary and research questions

- **Key unexplained changes:** Increasing chlorophyll *a* and lack of improvement in Secchi depth.
  - We see this in multiple tributaries.
  - Nutrient concentrations are still high despite reductions, meaning limitation of algae growth is not occurring all the time.

- But:
  - **Nutrient loads have gone down** from sources in the watershed, and we see decreasing nutrient concentrations in the estuary.
  - **Oxygen is responding** in some places, particularly in the mesohaline Potomac and the mainstem bay.

Contacts

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  - Breck Sullivan, USGS: bsullivan@chesapeakebay.net
  - Vanessa Van Note, EPA: VanNote.Vanessa@epa.gov