Tidal Water Quality Status and Trends

Aquatic Conditions Respond to Watershed Changes

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Multi-institution ITAT research synthesis teams

CBP Principle Staff Committee Meeting
Baltimore, MD
March 2, 2018

Chesapeake Bay Program
Science. Restoration. Partnership.

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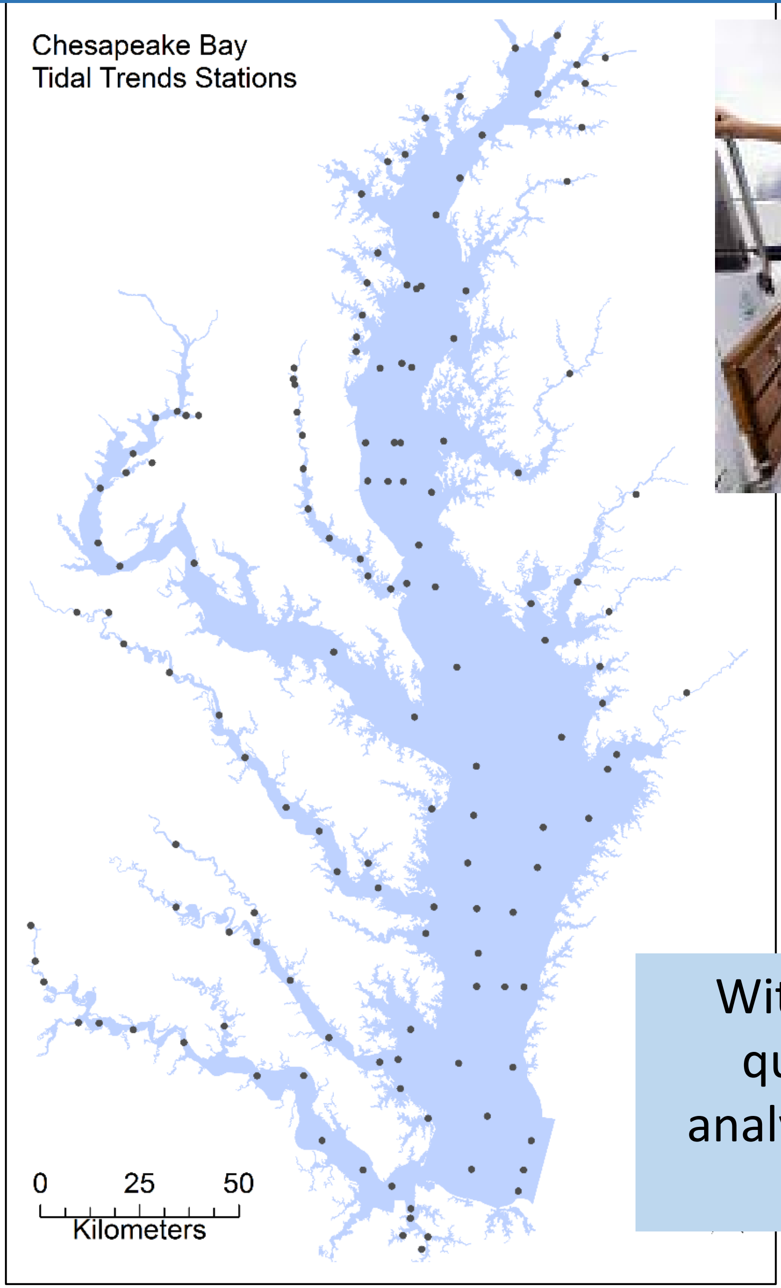
Tidal Water Quality Monitoring Program

Water quality data are collected at 150+ locations in tidal waters throughout Chesapeake Bay. Long-term monitoring stations have been visited by boat 1 or 2 times per month every year since 1985.

This monitoring program is a cooperative effort between MD DNR, VA DEQ, and the EPA CBPO.



Photos: Matt Rath/Chesapeake Bay Program

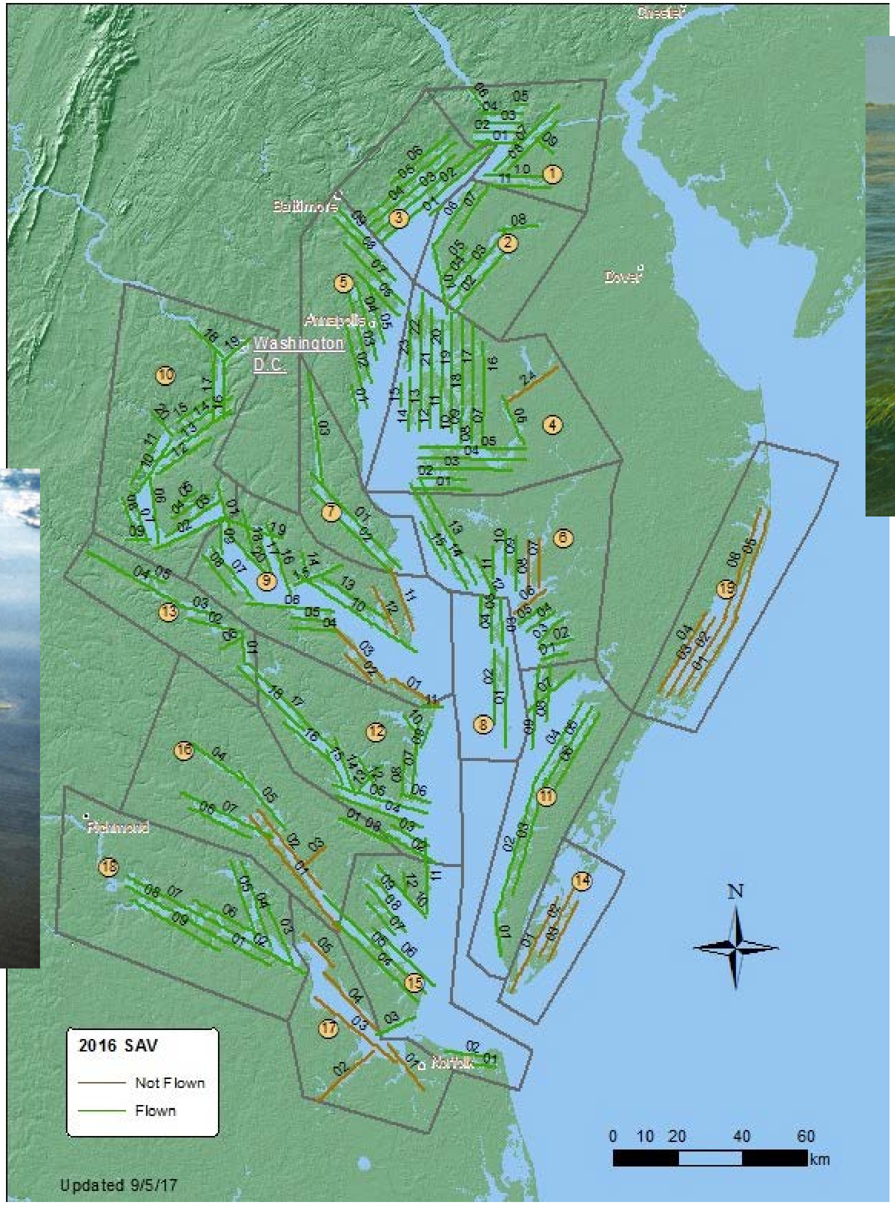
With over 30 years of standardized, high-quality data, we can now use powerful analytics to understand how and why water quality is changing over time

Tidal Submerged Aquatic Vegetation Monitoring Program

Over 187 flight lines are flown each year to track loss and recovery this important habitat. Baywide SAV abundance has been collected annually since 1984 by VIMS.

http://www.vims.edu/about/photo_galleries/sav/index.php

Support for this program is provided by US EPA, VA DEQ, VA CRM, MD DNR, and MDE



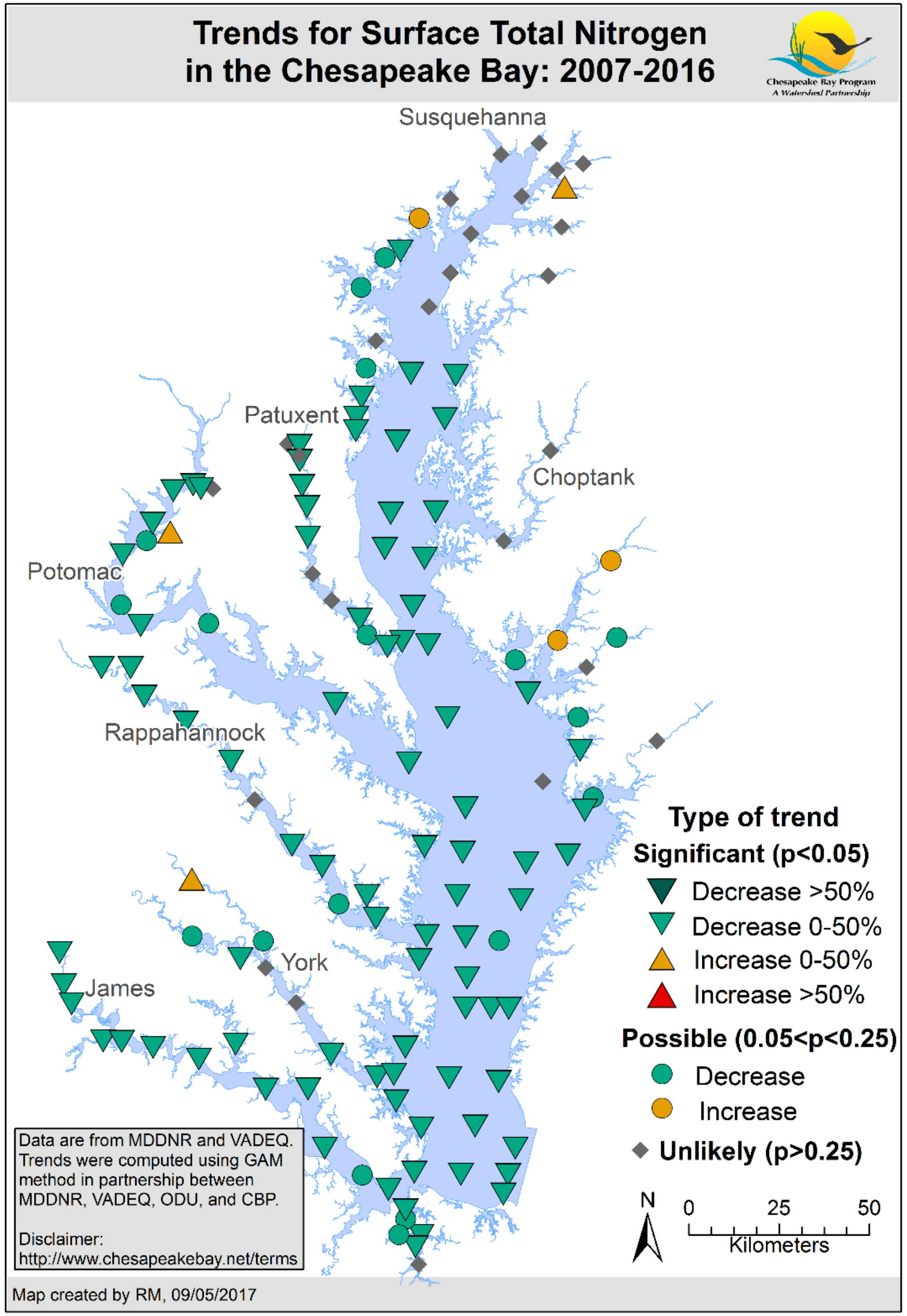
http://web.vims.edu/bio/sav/sav16/flightline_index.html

https://www.bayjournal.com/article/largescale_sav_restoration_discouraged_until_water_quality_improves

This world-class dataset has allowed us to document an unprecedented resurgence in SAV acreage in areas where water quality has improved

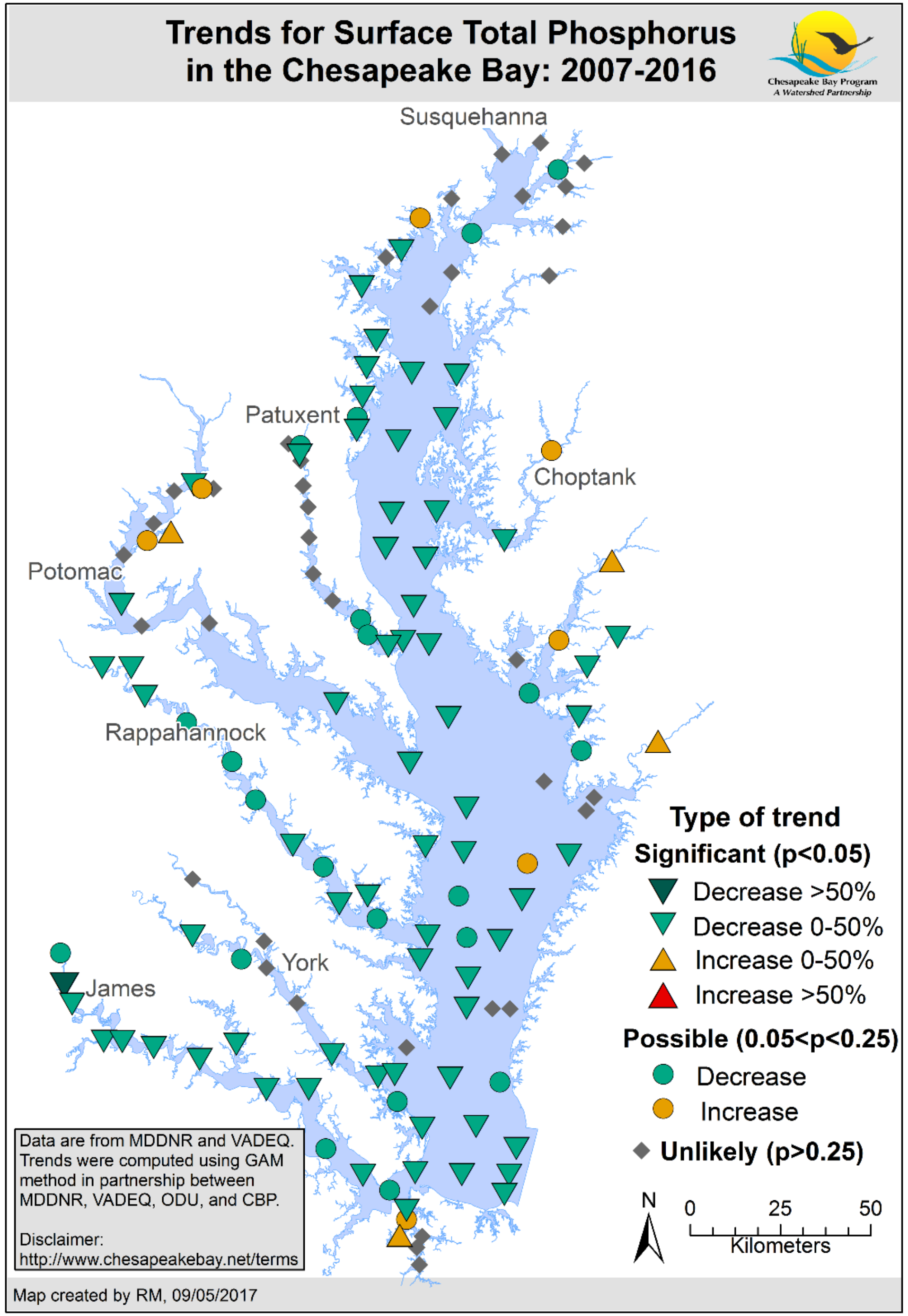
Nutrient Trends: Surface Total Nitrogen

2007-2016 Trends	
Trend in TN concentration	**Percent of Stations**
Significant decrease (improvement)	63%
Significant increase (degradation)	2%
No significant trend	35%



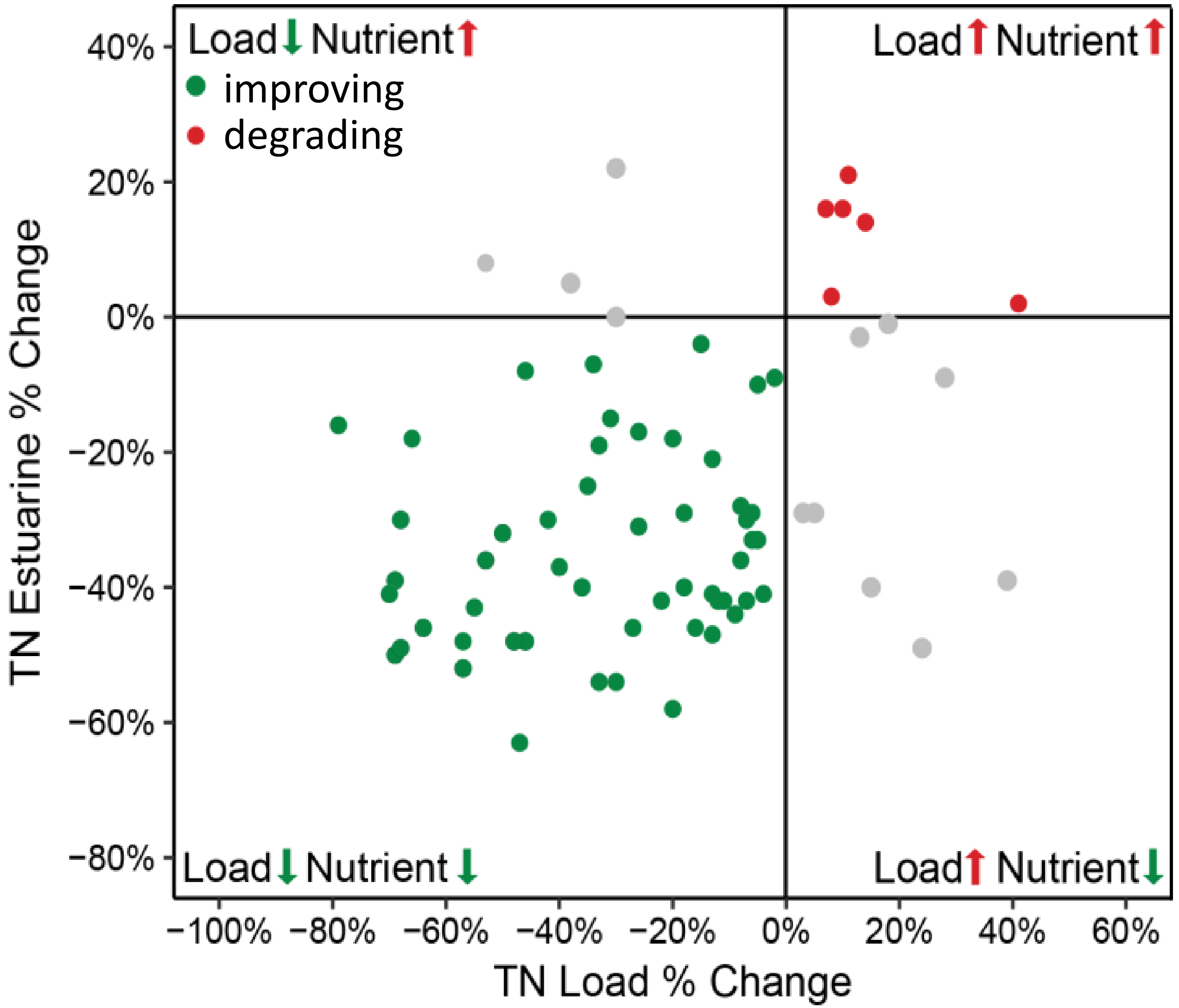
Nutrient Trends: Surface Total Phosphorus

2007-2016 Trends	
Trend in TP concentration	**Percent of Stations**
Significant decrease (improvement)	49%
Significant increase (degradation)	3%
No significant trend	48%



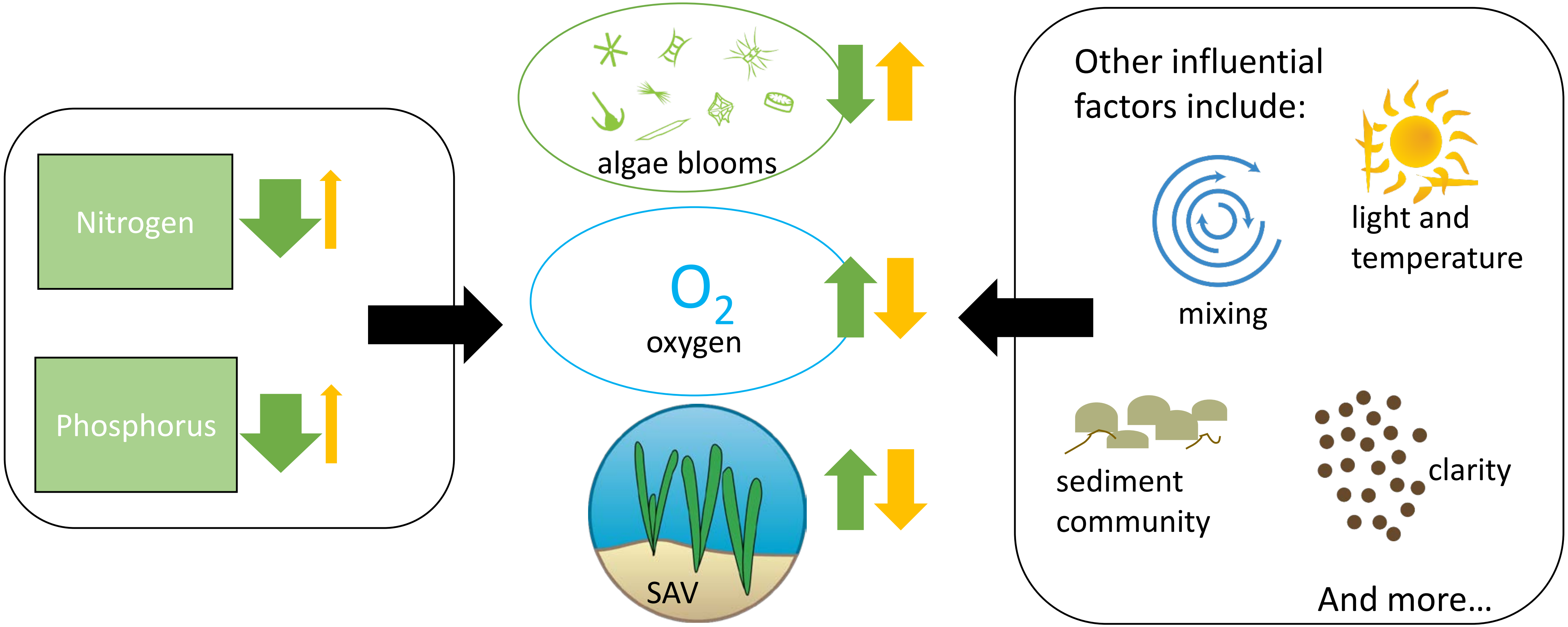
Estuarine nutrient concentrations respond to watershed loads

In the majority of drainage areas, the trends in tidal nutrient concentrations are in the same direction as the trends in watershed inputs.



Change in CBP watershed model loads and tidal nitrogen concentrations from 1989-91 to 2012-14 (Testa et al. 2018a.)

How are other tidal water quality indicators responding?

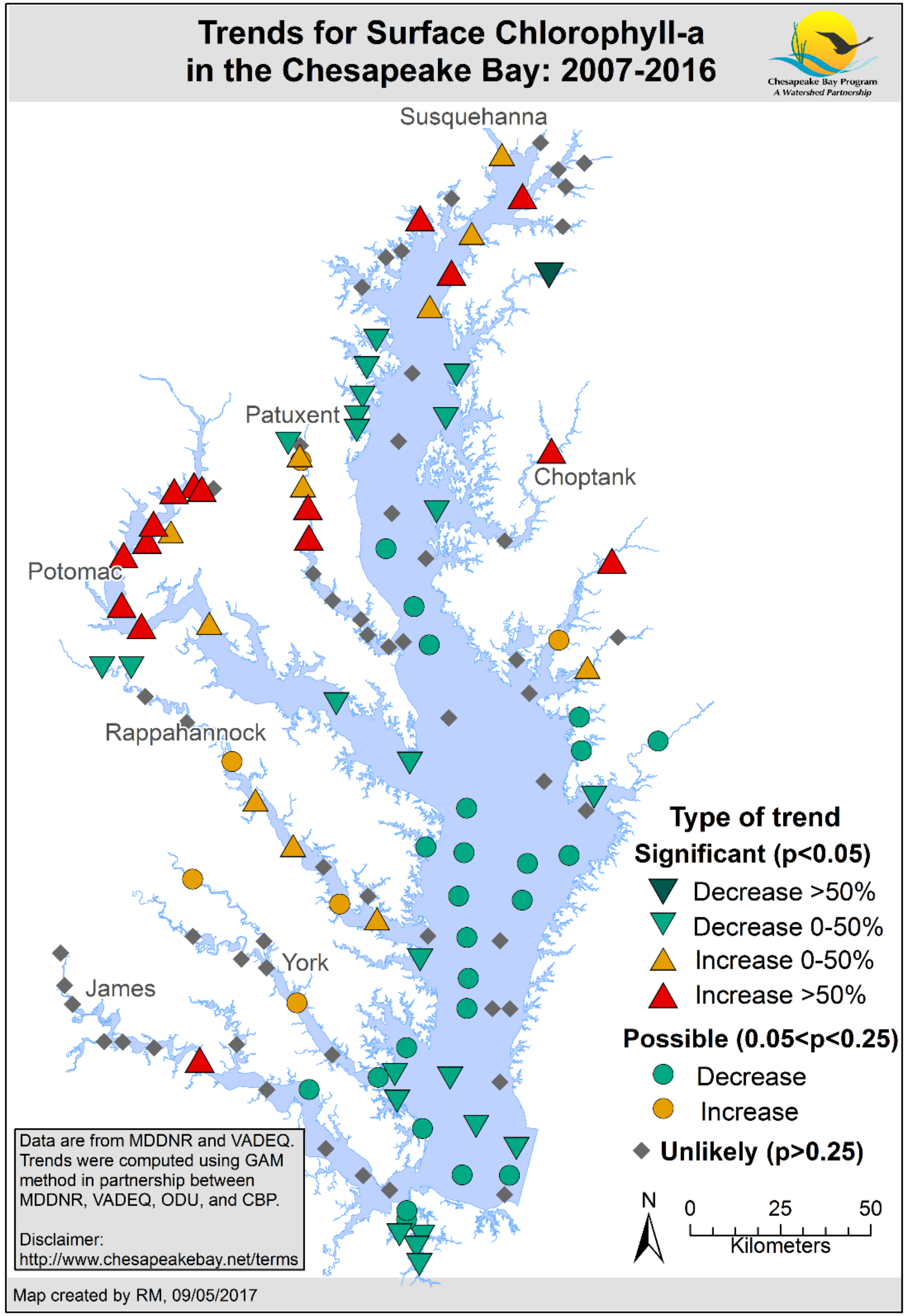


Estuaries are complex environments.
The response to restoration depends on location, season, and physical and biological factors.

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

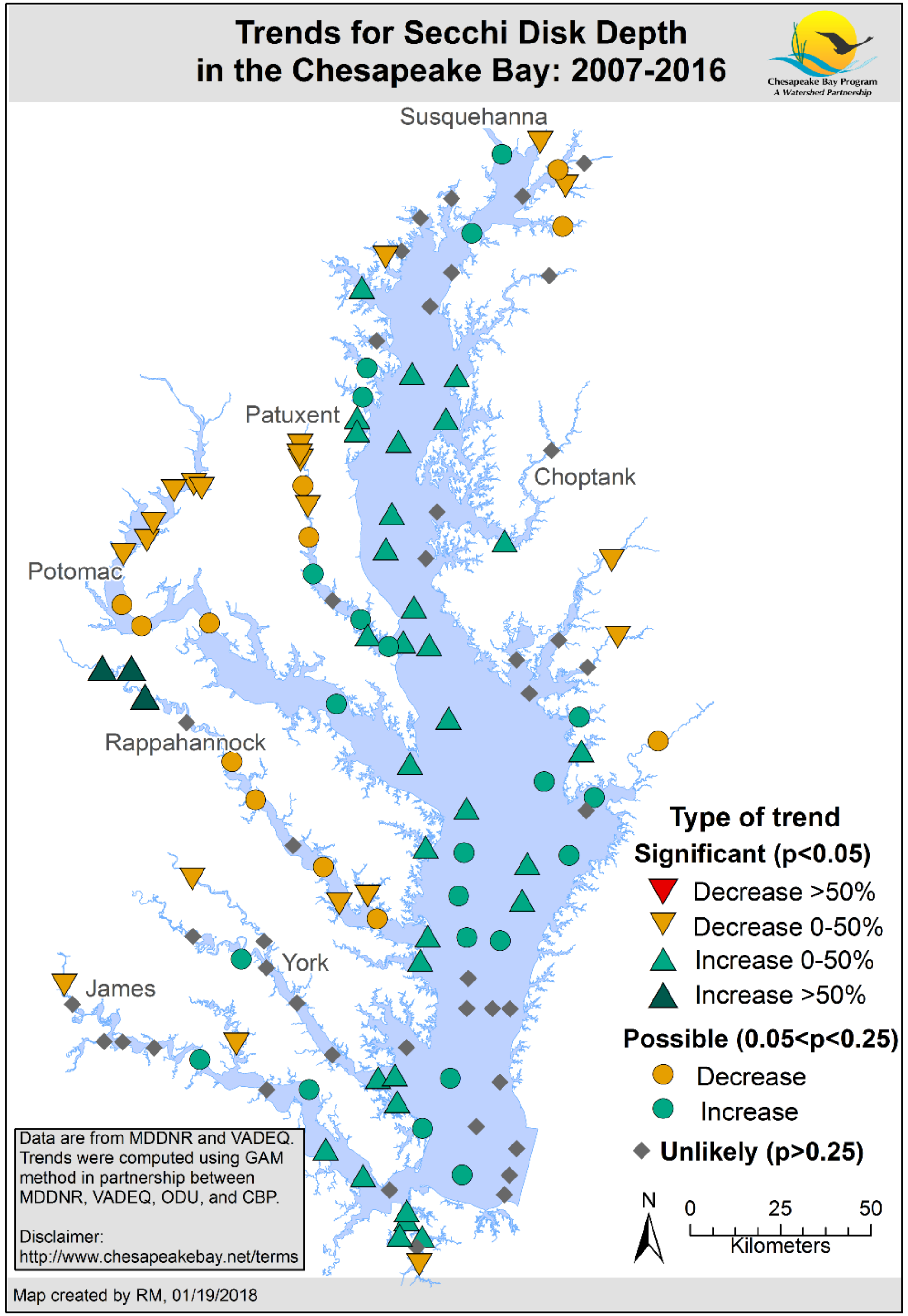
Algal Biomass Trends: Surface Chlorophyll *a*

2007-2016 Trends	
Trend in chl-a concentration	**Percent of Stations**
Significant decrease (improvement)	18%
Significant increase (degradation)	20%
No significant trend	62%



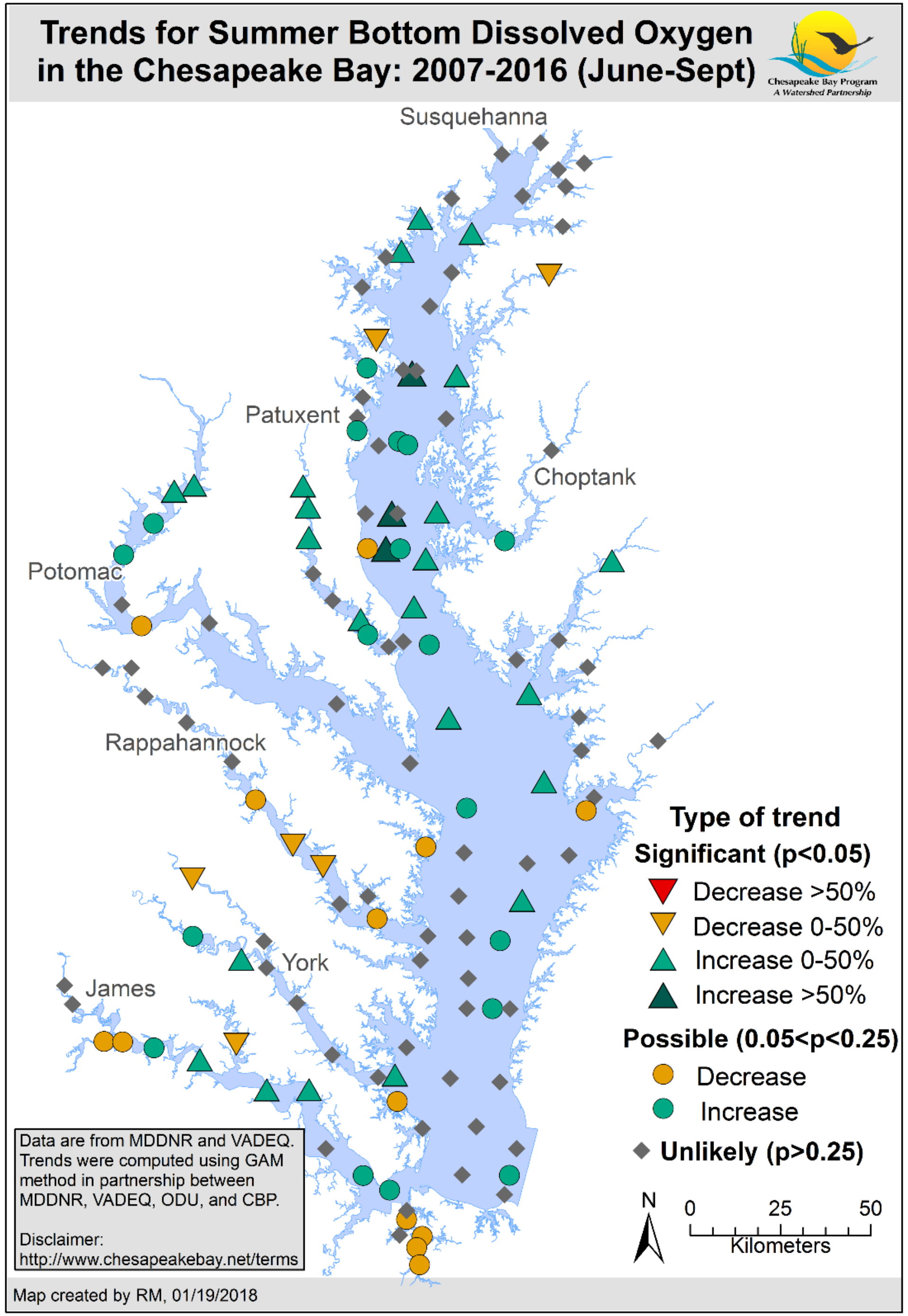
Water Clarity Trends: Secchi Depth

2007-2016 Trends	
Trend in Secchi depth	**Percent of Stations**
Significant increase (improvement)	26%
Significant decrease (degradation)	16%
No significant trend	58%

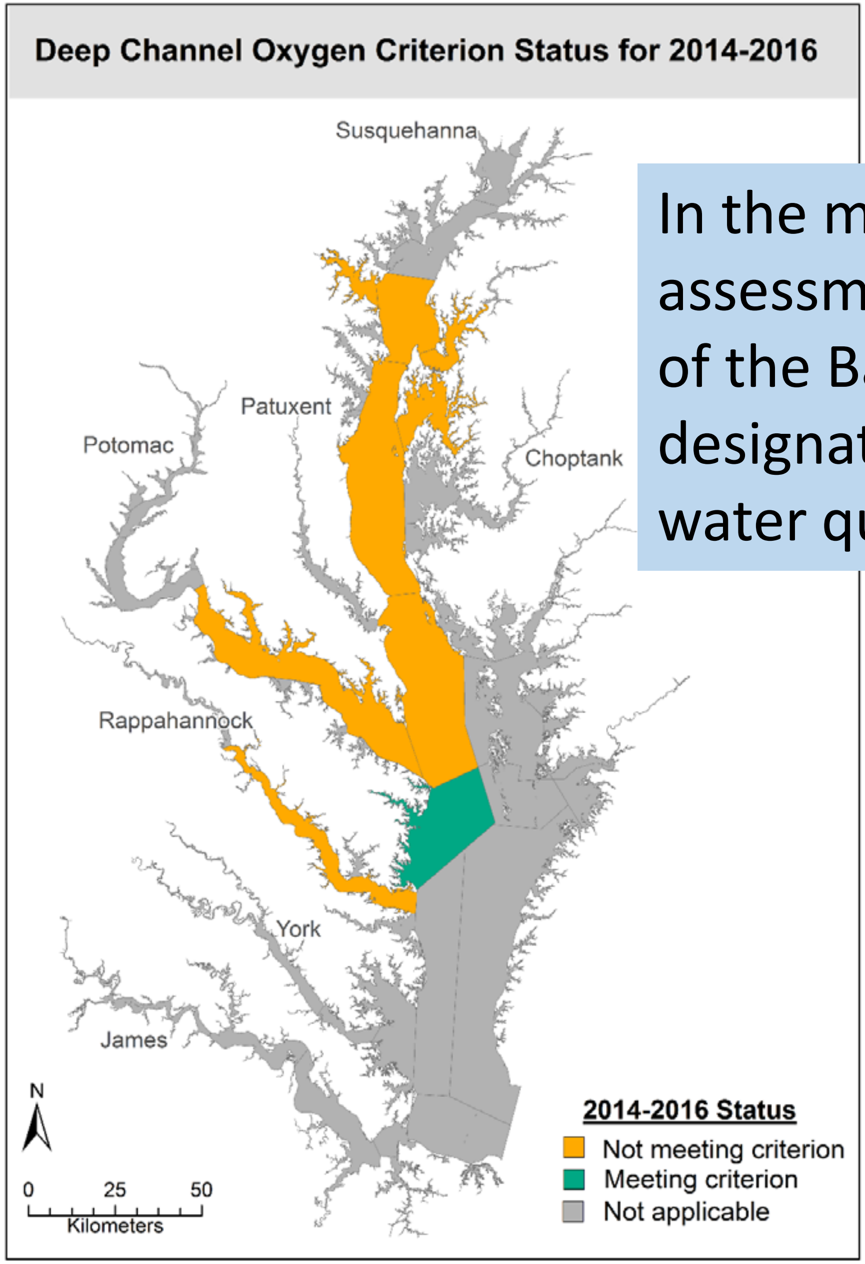


Dissolved Oxygen Trends: Summer; Bottom

2007-2016 Trends	
Trend in DO concentration	**Percent of Stations**
Significant increase (improvement)	19%
Significant decrease (degradation)	4%
No significant trend	76%

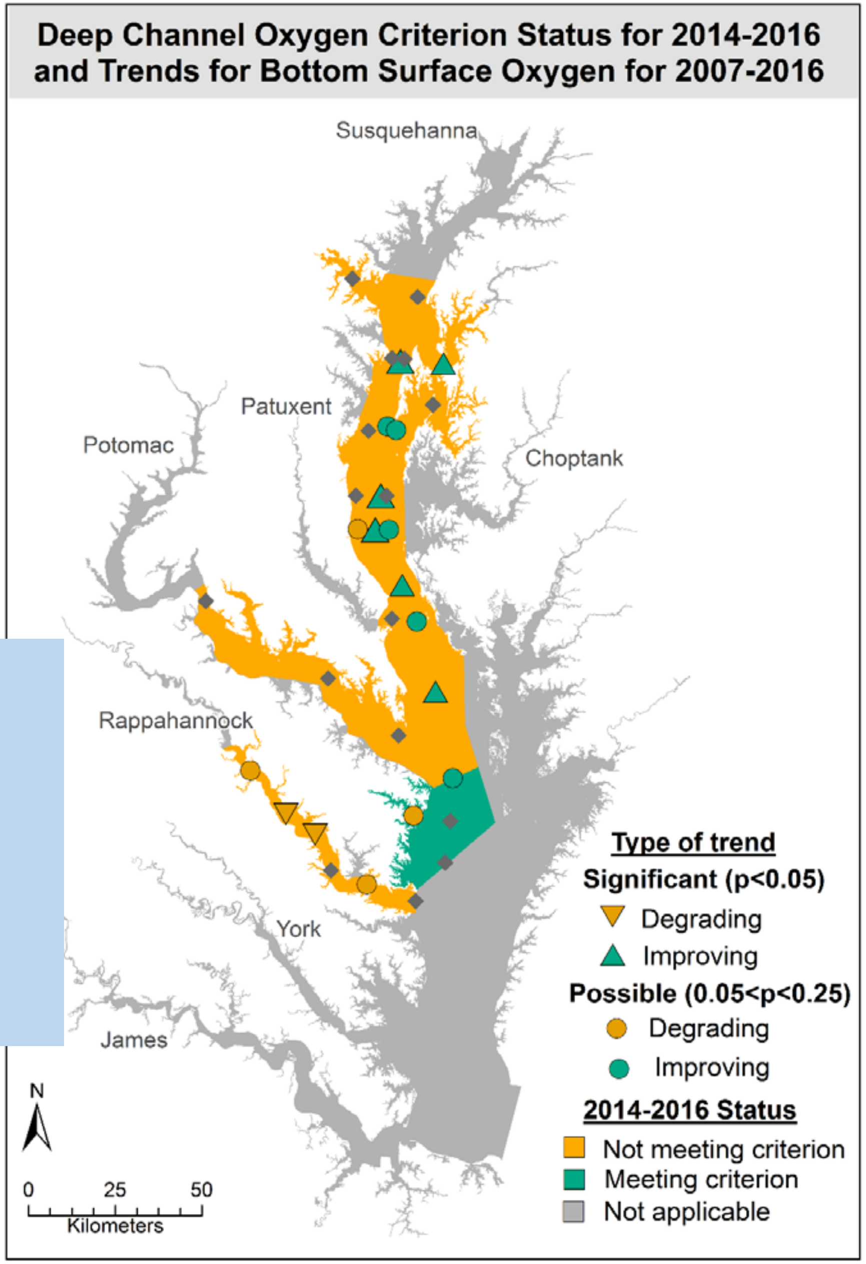


Dissolved Oxygen Status and Trends: Deep Channel

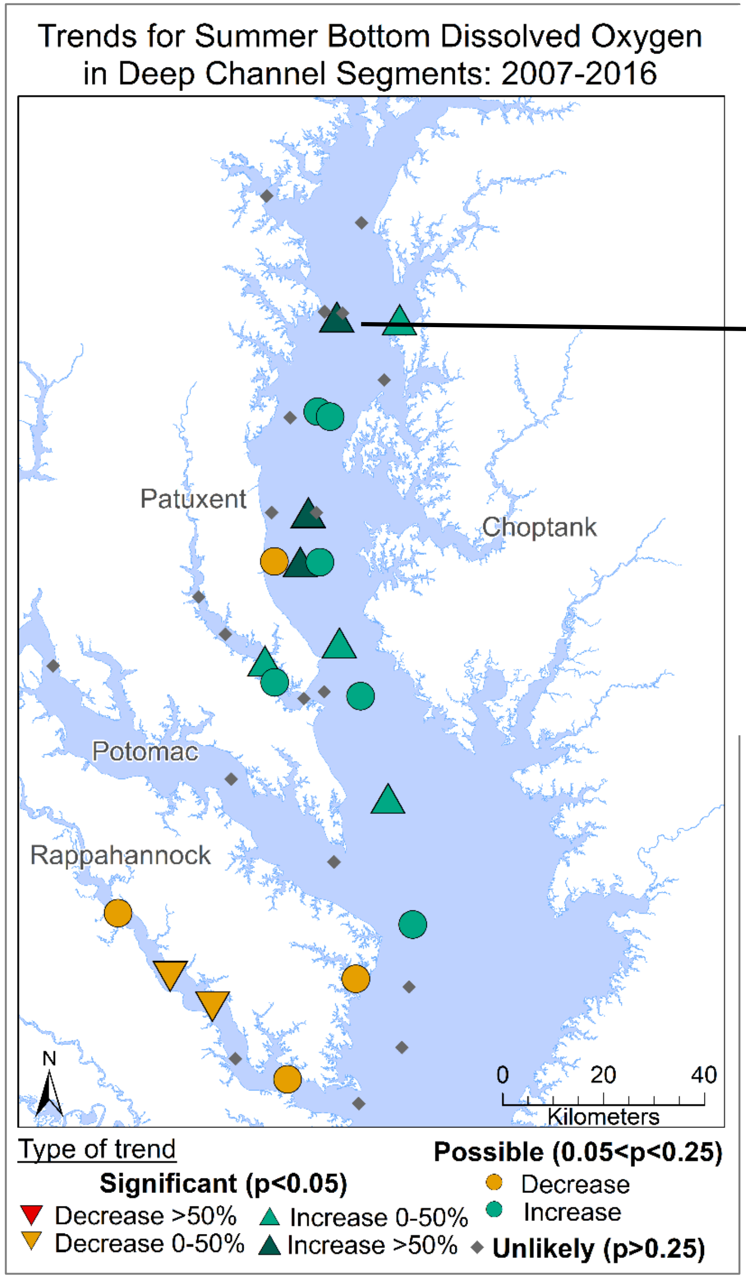


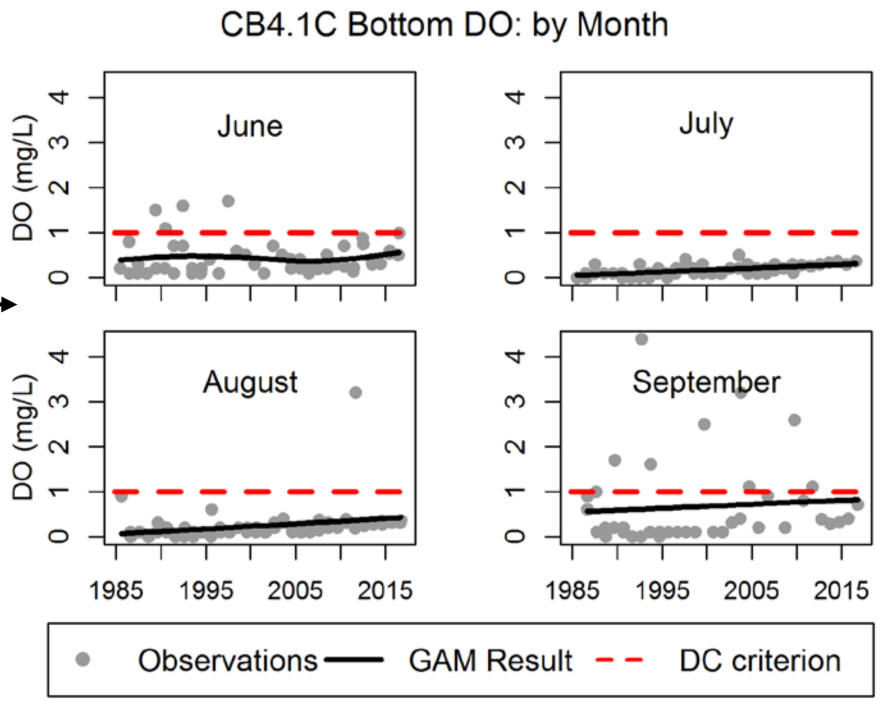
In the most recent assessment, about 12.5% of the Bay's Deep Channel designated use met DO water quality standards.

Trends analysis provides valuable information on the trajectory of conditions



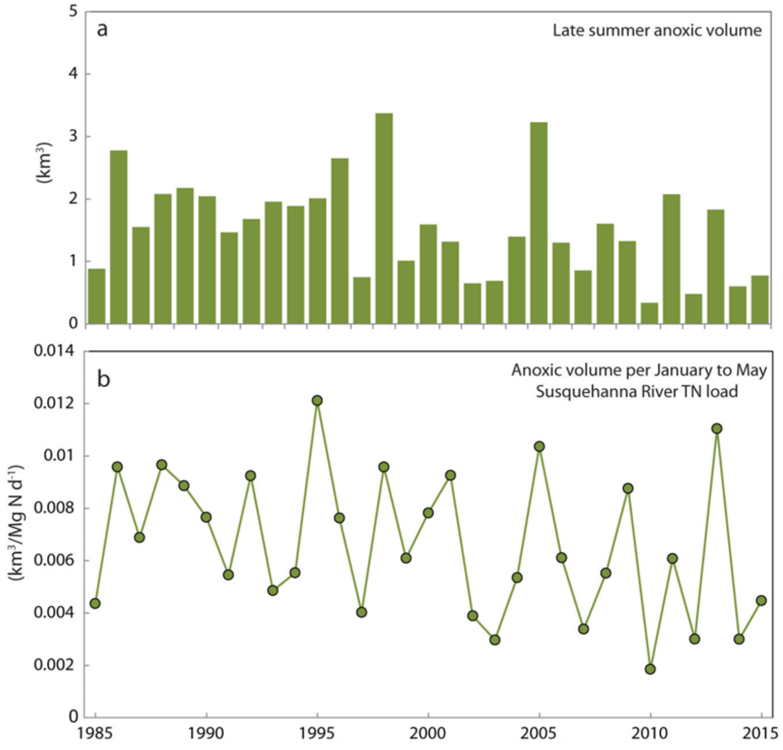
Explaining Deep Channel DO attainment and trends





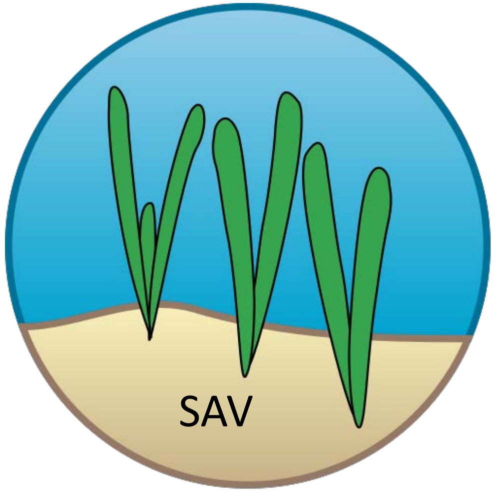
...and hypoxia reduction corresponds to observed nutrient load reductions

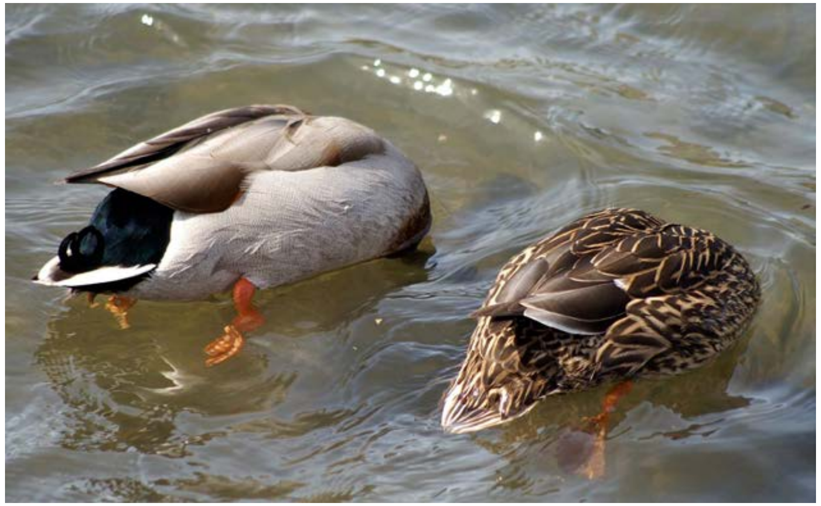
Most measurements are still below the water quality standard, but summer patterns are changing...



Testa et al. 2017 Bioscience 67(7): 614-626

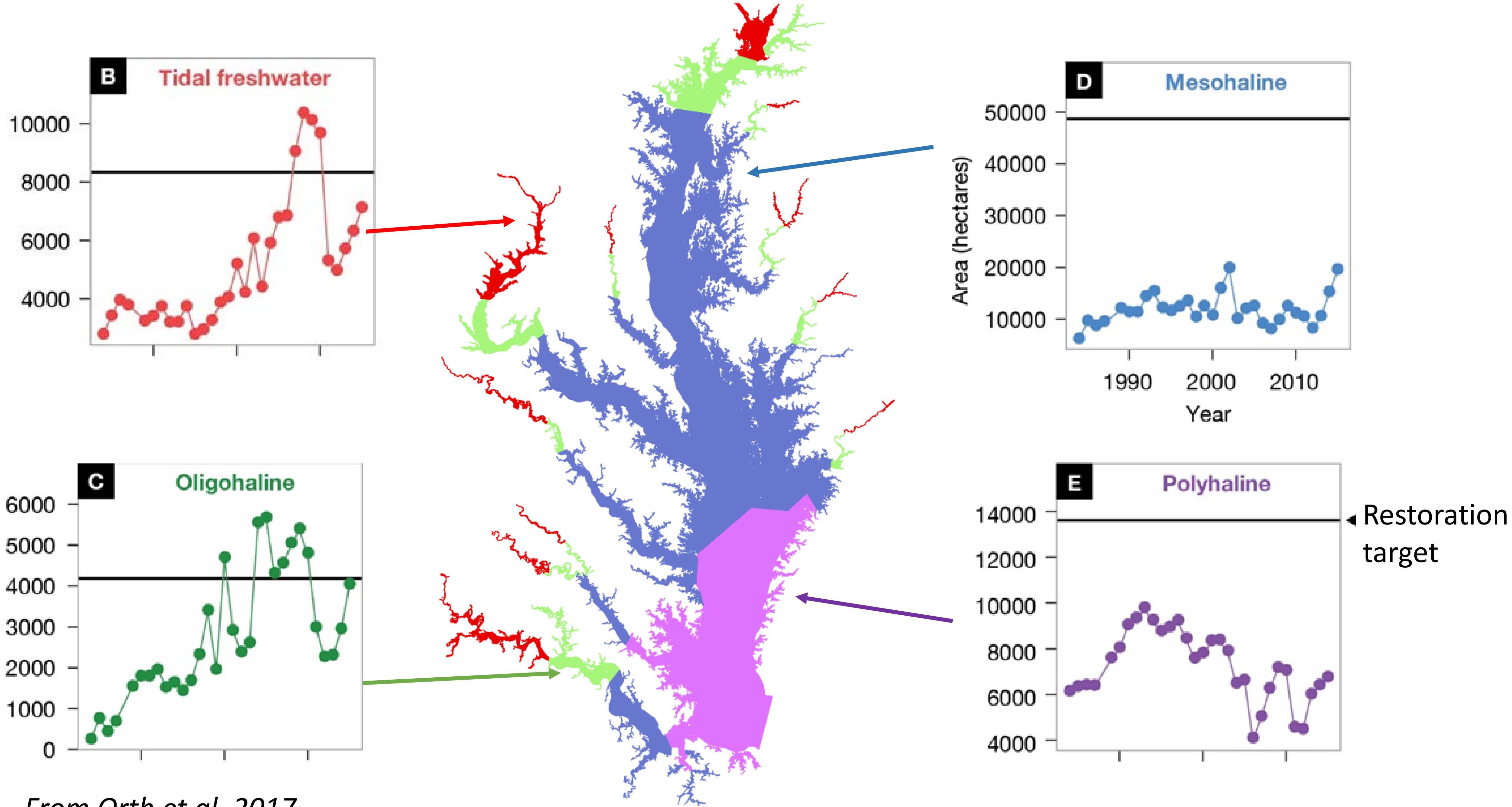
Submerged Aquatic Vegetation: A critical habitat for living resources





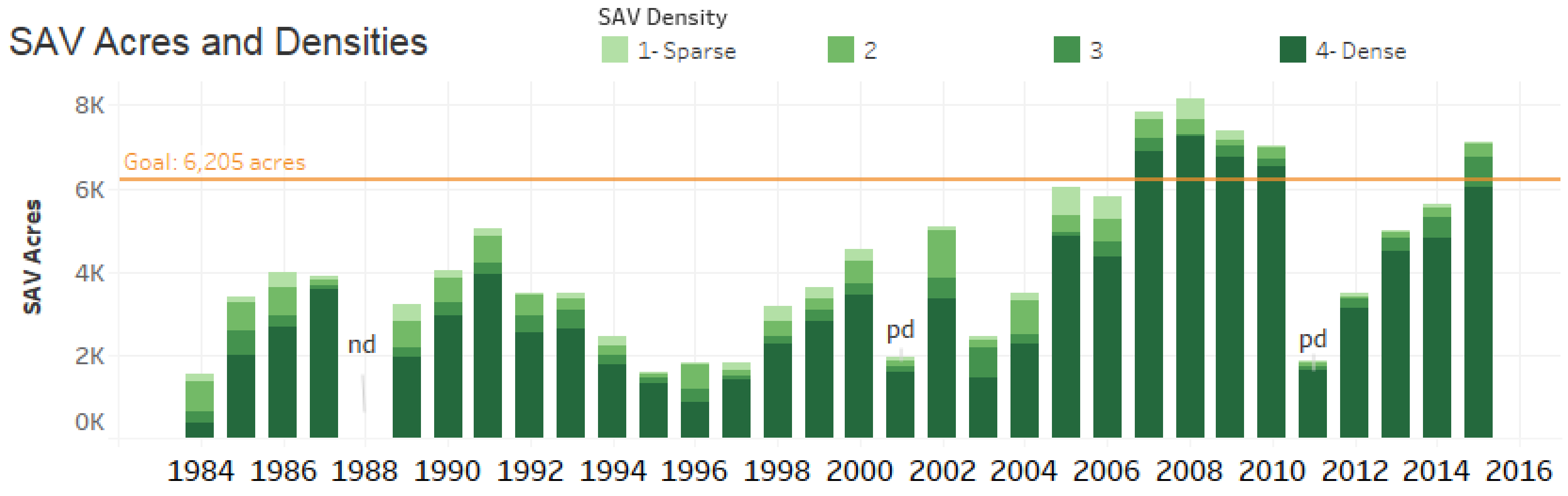
Images from: Tracey Saxby, Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/imagelibrary/)
Photos: ***from VIMS or CBP? Double check***

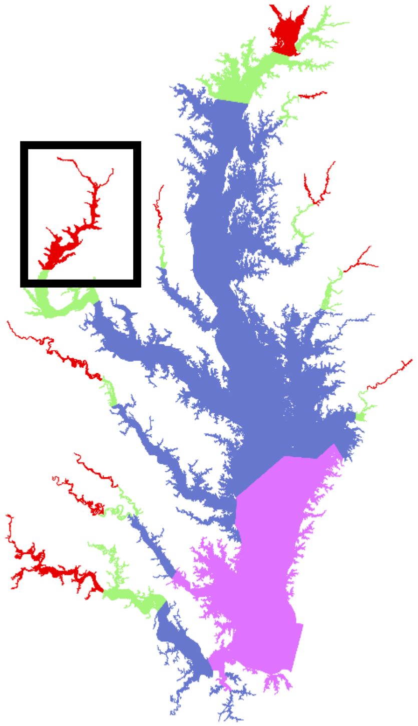
Bay-wide SAV Trends

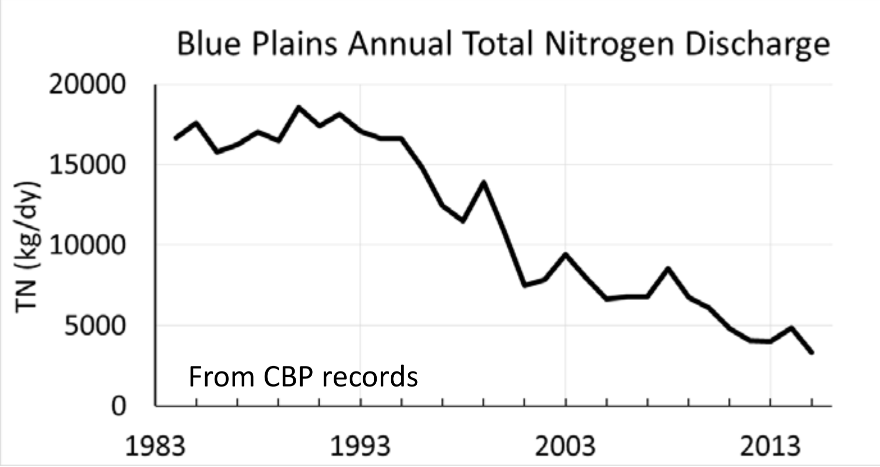


From Orth et al. 2017

SAV Case Study: Upper Tidal Potomac



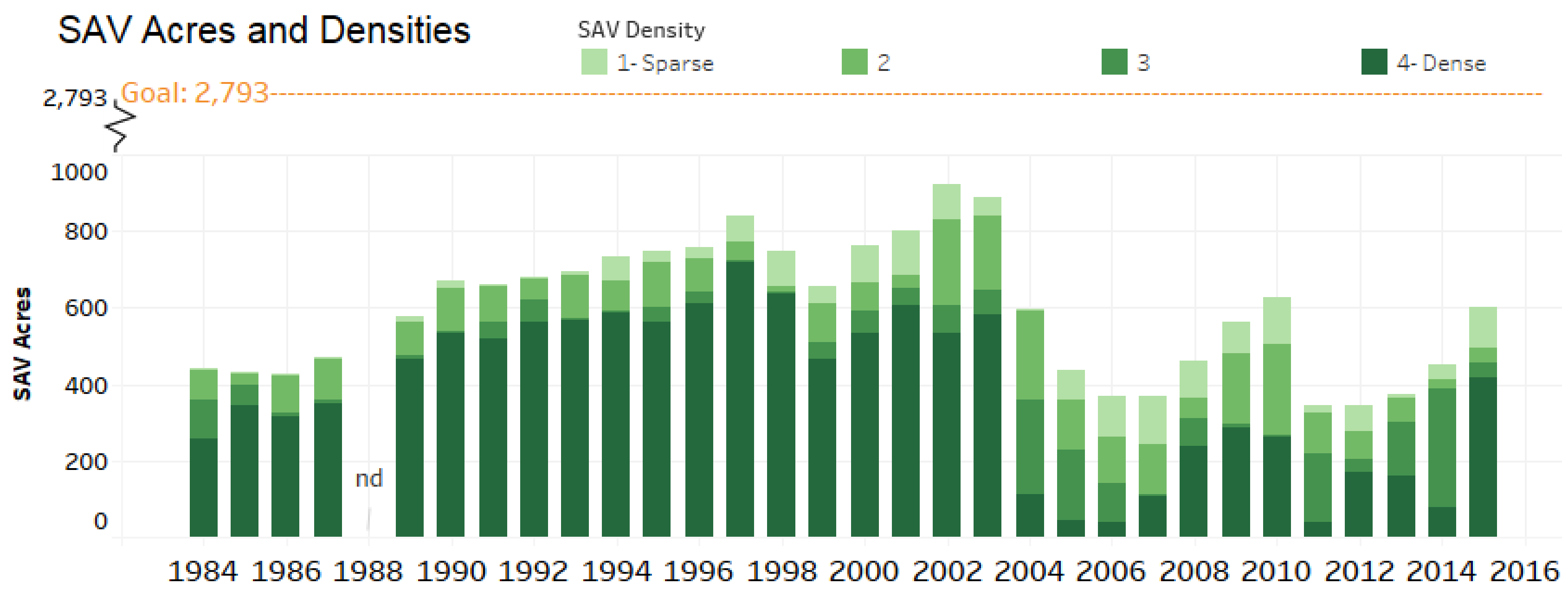


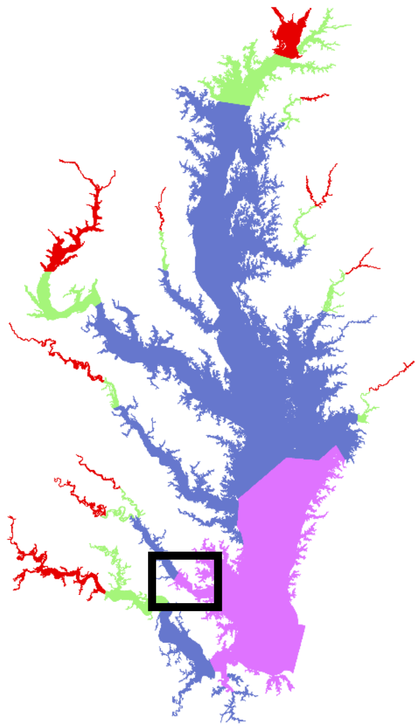


Research studies find that expansion of SAV from nearly zero in mid-1900s to attaining the goal attributed to:

- Dramatic improvements in nutrient concentrations from WWTP upgrades (Ruhl and Rybicki 2010)
- Enhanced water clarity due to exotic clam (Phelps 1994)
- Non-native plant introduction facilitating recolonization of multiple species (Rybicki and Landwehr 2007)

SAV Case Study: Lower York





Research studies find that the distance from the goal and recent degradation are due to:

- Increasing occurrence of high temperature events (Moore et al. 2014; Lefcheck at al. 2017)
- Declining water clarity (Lefcheck et al 2017)
- Low number of species that exist in polyhaline (Orth et al. 2010)

Summary

- **Tidal nutrient concentrations are improving in most locations.**
  - *Many of these reductions can be directly linked to reductions from point sources or the watershed.*

- **Water quality has improved enough in some locations to support recovery of SAV.**
  - *Once SAV is present, it helps to further improve water quality and supports other important living resources.*

- **In some locations, conditions continue to degrade.**
  - *Degradation has been linked to high nutrient inputs from agriculture, and to urbanization.*

- **Location, season, and biological factors affect how tidal waters respond to management actions.**
  - *We are now applying novel analytical techniques to better trace changes in water quality back to their causes.*

Upcoming Products

- **Maps of trends in tidal water quality parameters for 2007-2016 and 1985-2016**
  - Available for download at https://www.chesapeakebay.net/who/projects-archive/integrated_trends_analysis_team

- **Fact sheets on SAV abundance for 57 locales.**
  - Available May 2018

- **Tidal tributary summaries**
  - Integrating patterns of nutrients, algal biomass, water clarity, and dissolved oxygen
  - Linking them to causal factors
  - **June 2018:**
    - Mainstem bay
    - Choptank River
    - Potomac River
    - James River
  - **July – December 2018:**
    - Chester
    - Sassafras
    - Lower E. Shore
    - MD Lower Western Shore
    - Patapsco
    - Patuxent
    - Rappahannock
    - York

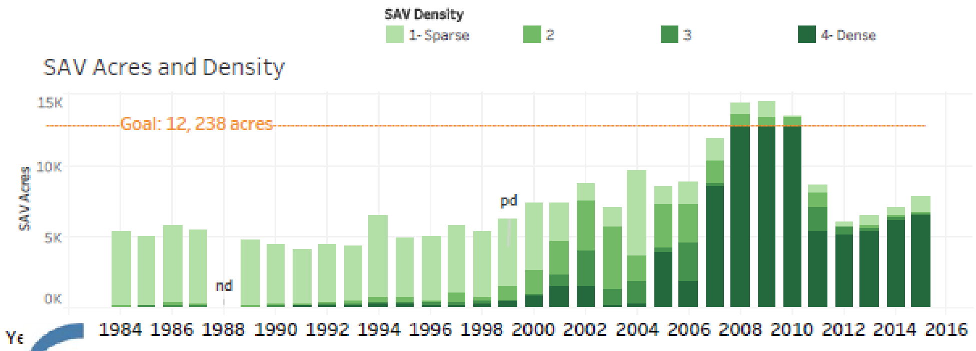
SAV Fact Sheets: Susquehanna Flats Example

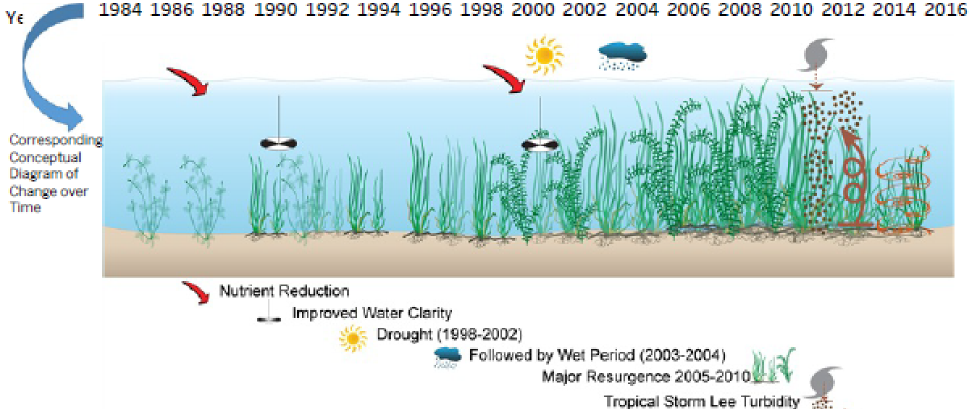
SAV Segment Susquehanna Flats (CBTF2 and NORTF)

(http://vims.edu/bio/sav/SegmentAreaChart.htm)

Current Expansive Freshwater SAV Beds in the Upper Chesapeake Bay near Havre de Grace

Executive Summary: Historic SAV beds that supported migrating waterfowl populations were decimated by 1972 through dominance of milfoil that outcompeted native species and Tropical Storm Agnes that resulted in large amounts of sediments and nutrients that smothered existing SAV. Following two decades of minimal to no recovery, SAV beds on the Susquehanna fFats began recovering due to reductions in total nitrogen and improving water clarity, achieving the restoration goals of these segments by 2008. Tropical Storm Lee and the accompanying residual turbidity reduced the coverage below the restoration goal, but steady recovery has been facilitated by the dense, resilient SAV beds that persisted after Tropical Storm Lee.





Take Home Points

- Goal is attainable
- Extreme Runoff Event Susceptibility, but Resilient
- Resuspension following Tropical Storm Lee
- Changing patterns in SAV species diversity and habitat quality
- SAV Meadow Critical Mass
- Lyngbya Expansion
- Management Implications

Footnotes:

Susquehanna Flats (Synthesis of 2 segments - CBTF2 and NORTF) http://vims.edu/bio/sav/SegmentAreaChart.htm)

Goal is attainable.
The goal is 12, 237 acres. This goal was achieved from 2008-2010, following a decade of increasing of improving water quality, reduction in total nitrogen, and expanding SAV. In September 2011, Tropical Storm Lee led to the second highest flow amount recorded from the Susquehanna River at the Conowingo dam, resulting in high turbidity in the upper bay, resulting in the decline of SAV primarily at the deeper sections of the SAV beds.

Extreme runoff event susceptibility but resilient.
SAV that had been recovering following the loss of milfoil in the 1960s which had outcompeted native species in the late 1950 through the early 1960s were decimated by Tropical Storm Agnes in 1972, , leading to a two decade period without appreciable SAV presence. Following the resurgence of SAV in the region through 2011, Tropical Storm Lee in Sept., 2011 (http://ian.umces.edu/ecocheck/summer-review/chesapeake-bay/2011/indicators/influencing_factors/) , led to a dramatic decline of SAV because of prolonged turbidity. However, the large dense beds protected the interior of the meadow from the river-borne turbidity, with losses primarily in the deeper, south and east ends of the Flats. But these beds proved to be resilient in that unlike Tropical Storm Agnes, large and dense grass beds persisted, facilitating a steady recovery in the years following Lee.

Resuspension following Tropical Storm Lee
The fine grain sediments that overtopped the Conowingo Dam were resuspended and persisted for years following their deposition. This shows the resuspension following storm events and fine grain sediment deposition can have lingering long term effects in water clarity and SAV abundance, influencing the trajectory of the recovery.

Changing patterns in SAV species diversity and habitat quality
This region historically supported a dense, diverse SAV assemblage which provided habitat for a myriad of migratory waterfowl. The Susquehanna Flats was the premier wintering waterfowl habitat of the mid-atlantic coast. The appearance of milfoil in the late 1950s dramatically altered the presence of native species. The disappearance of milfoil beginning in the late 1960s allowed some native species to return but in 1972, the passage of Agnes was the coup de gras for the native SAV species. Over the next two decades, some recovery of native species occurred on the flanks of the Susquehanna Flats, but little recovery on the main flats. Over the last two decades, the flats have become colonized by a dense and diverse SAV community of up to 15 species.

Lyngbya Expansion
Expansion of invasive bluegreen cyanobacteria shades SAV from light. Lyngbya thrives in warm, clear water. Lyngbya can also fix nitrogen and produce toxins. It forms dense floating mats, and loosely attaches to SAV. In other regions of the world, Lyngbya has been known to decrease SAV density. Lyngbya can be very ephemeral, disappearing quickly due to viral lysis.

Managment Implications
The two major issues that will influence the continued abundance and diversity of SAV in this region will be additional sediments that will be released from behind the Susquehanna Dam now that it is full, and nitrogen loads coming into the river. While we have shown the resiliency of this vast expanse of SAV following Tropical Storm Lee, the persistent release of sediments have the potential of altering the dynamics of SAV, either by the shoaling of the Flats, or the smothering of SAV by the sediments.

References- Gurbisz et. al 2016. Bailey 78 et. al, Orth et. al 2010, Dennison 1993 et. al, Kemp et. al 2005,
http://web.vims.edu/bio/sav/bibliography/Bibliography.html?