Shifting Baselines, New Insights and Adaptive Management in Chesapeake Bay

PETER TANGO
USGS@CBPO

SFEI ANNUAL MEETING

OCTOBER 2020

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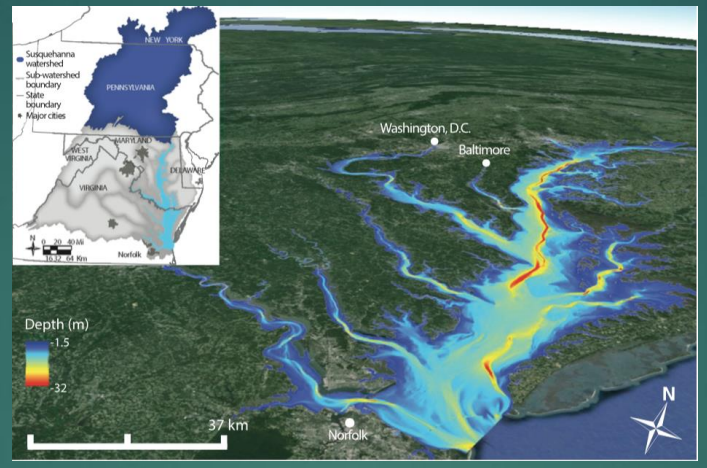
Chesapeake Bay Program
A Watershed Partnership

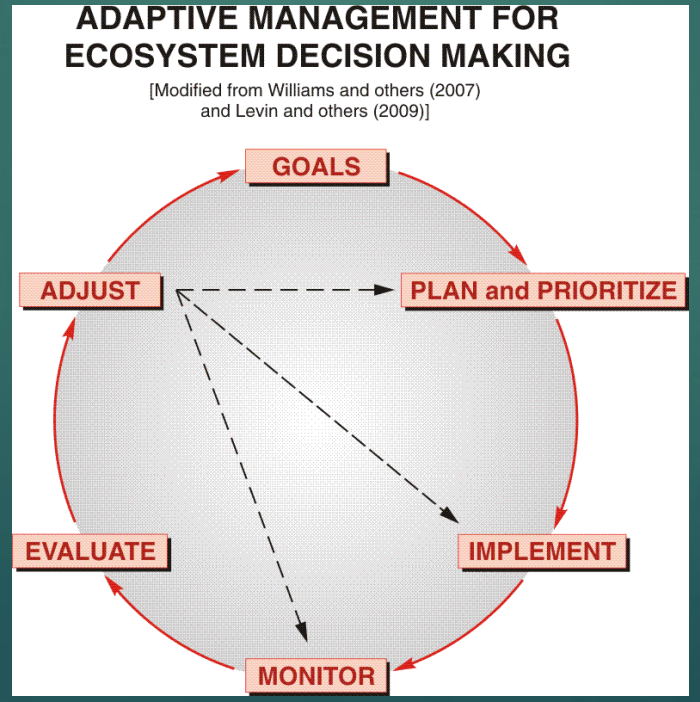
Chesapeake Bay Management Goals and Outcomes

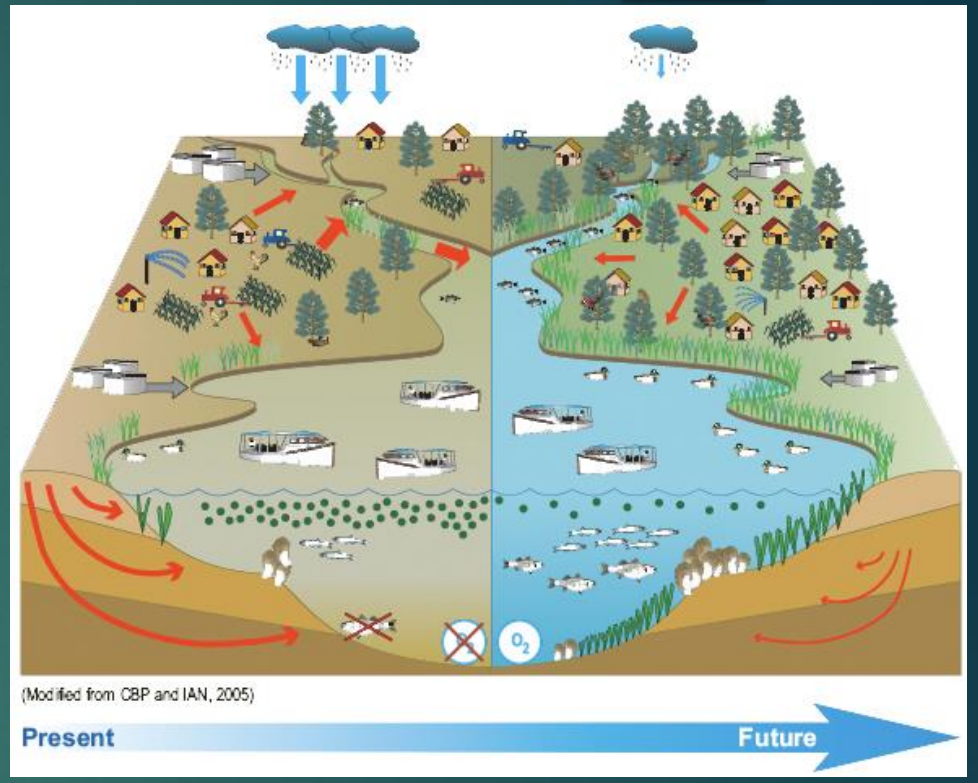
Chesapeake Watershed Agreement 2014

10 Ecosystem Health Goals
31 Outcomes

Management Strategies
and
Watershed Implementation Plans support Goals and Outcomes







Pollution Diet Recovery Model
Illustration: IAN Ecocheck

Reduce nutrients and sediment
Improve habitat for living resources

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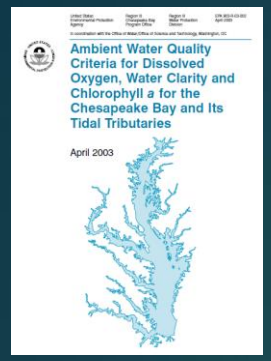
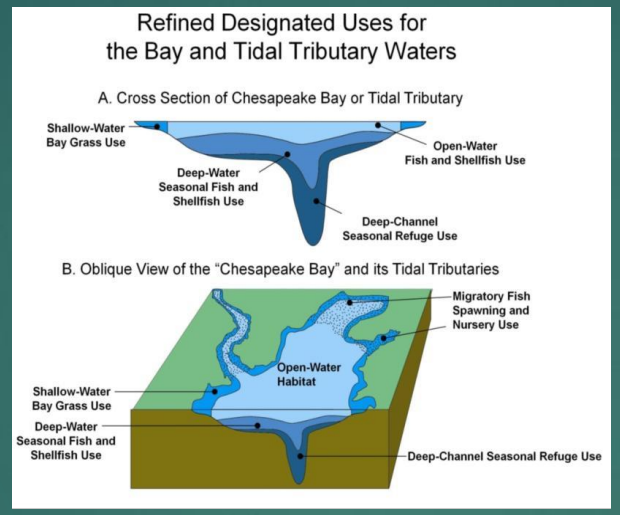
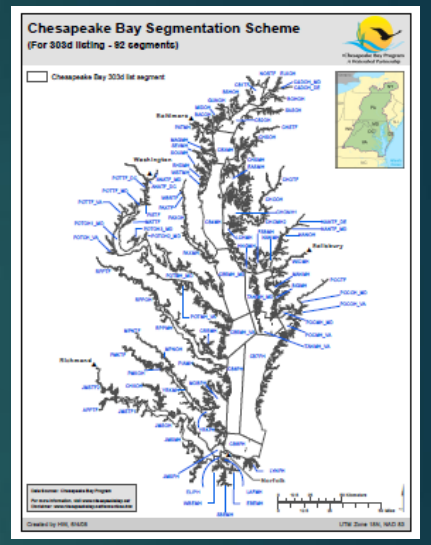


Living Resource Dependent Water Quality Criteria for Habitat Supporting Survival, Growth and Reproduction

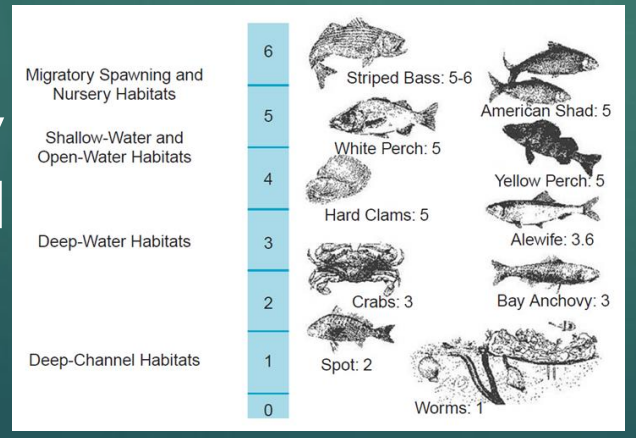
- Habitat classifications



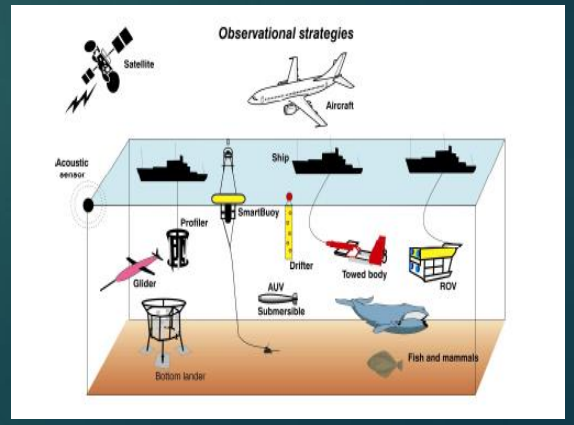
- Management segment boundaries



- Defining Water Quality Criteria: e.g., Dissolved oxygen requirements



- Monitoring progress with criteria attainment assessment methods



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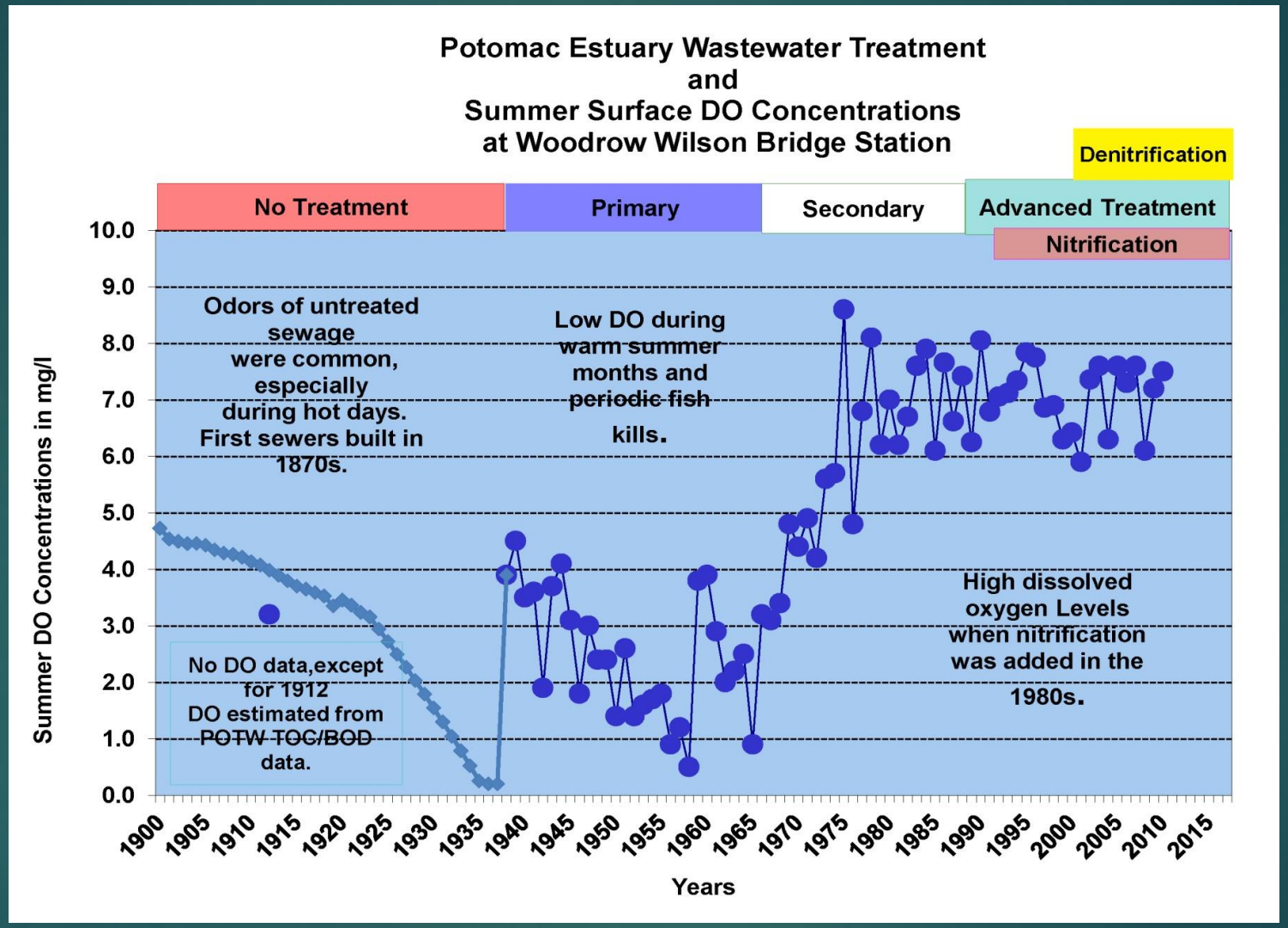
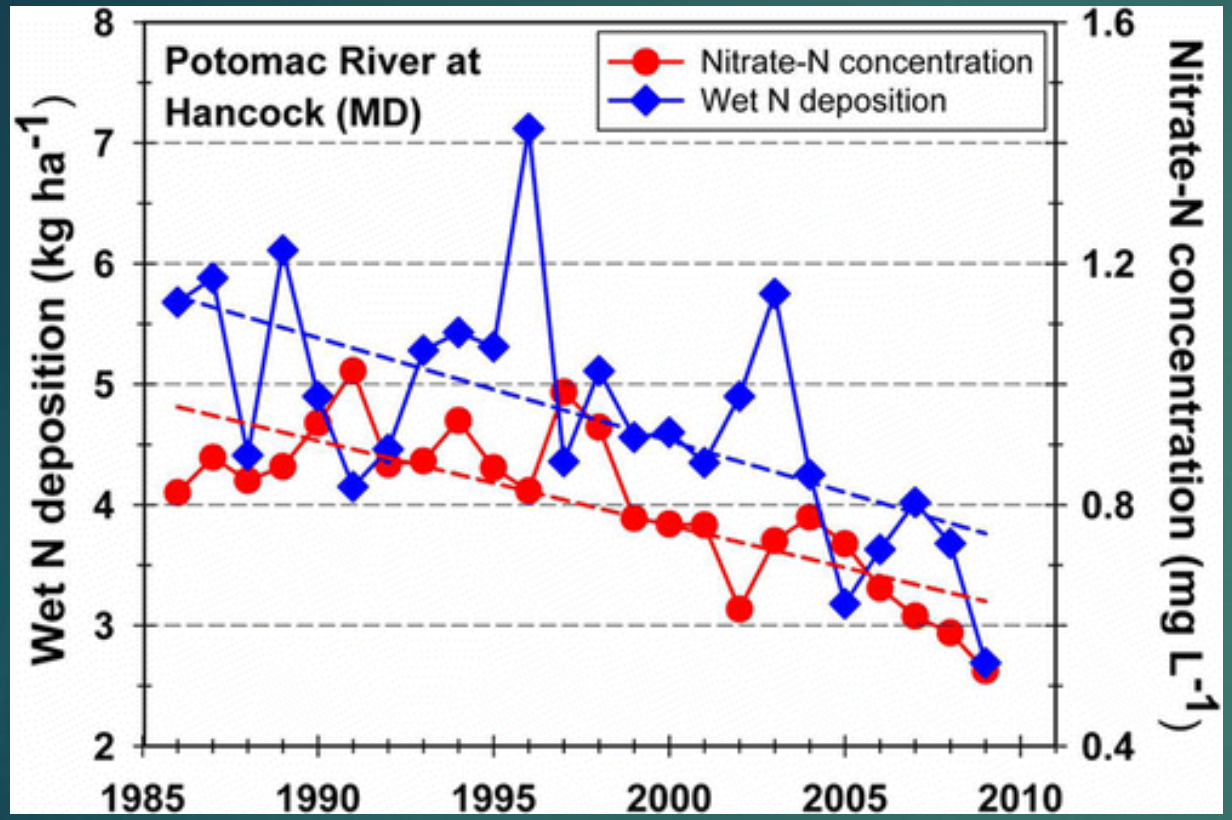
Point Source Nutrient Controls Improve Water Quality



***113 years*: Summer Dissolved Oxygen on the Potomac River. Estimated (light blue) and Actual (dark blue) data**

Norbert Jaworski, Pers. Comm

Nonpoint Nutrient Source Controls Reduce Pollution to the Chesapeake Bay



Surface Water Quality Is Improving due to Declining Atmospheric N Deposition
Keith N. Eshleman*, Robert D. Sabo, and Kathleen M. Kline
† University of Maryland Center for Environmental Science, Appalachian Laboratory, Frostburg, Maryland 21532, United States, *Environ. Sci. Technol.*, 2013, 47 (21), pp 12193–12200
DOI: 10.1021/es4028748, Publication Date (Web): October 3, 2013

Clean Air Act Effects +:
"Technological advances have made great strides in reducing atmospheric nitrogen (N) deposition to the Bay.

Atmospheric point sources and vehicle emissions controls have decreased the levels of nitrogen oxides (NO_x) in the air.

However, population growth, increased use of vehicles, and intensified agriculture have slowed progress."

New Insights Report 2014

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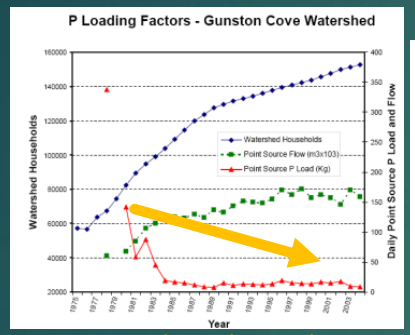
Synthesis! Gunston Cove, Potomac River – Managing Expectations in Response to Management Actions

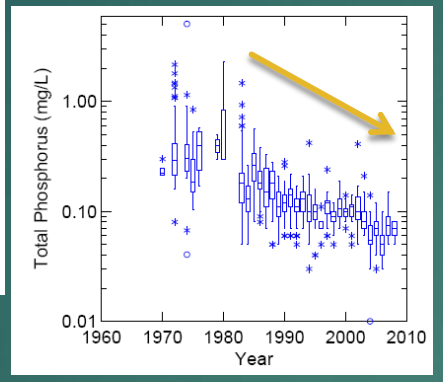
R. Chris Jones
George Mason Univ.

Point Source Mgt late 1970s

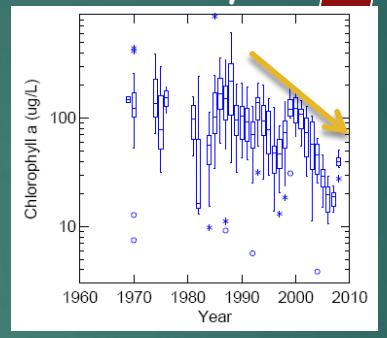


Total P load declines

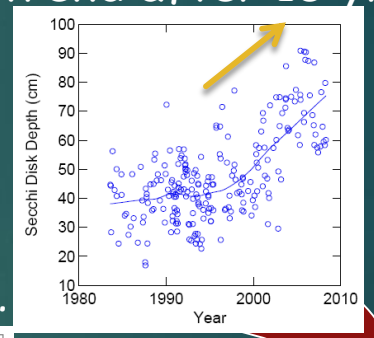
Estuary Nutrients Decline over 30 yrs



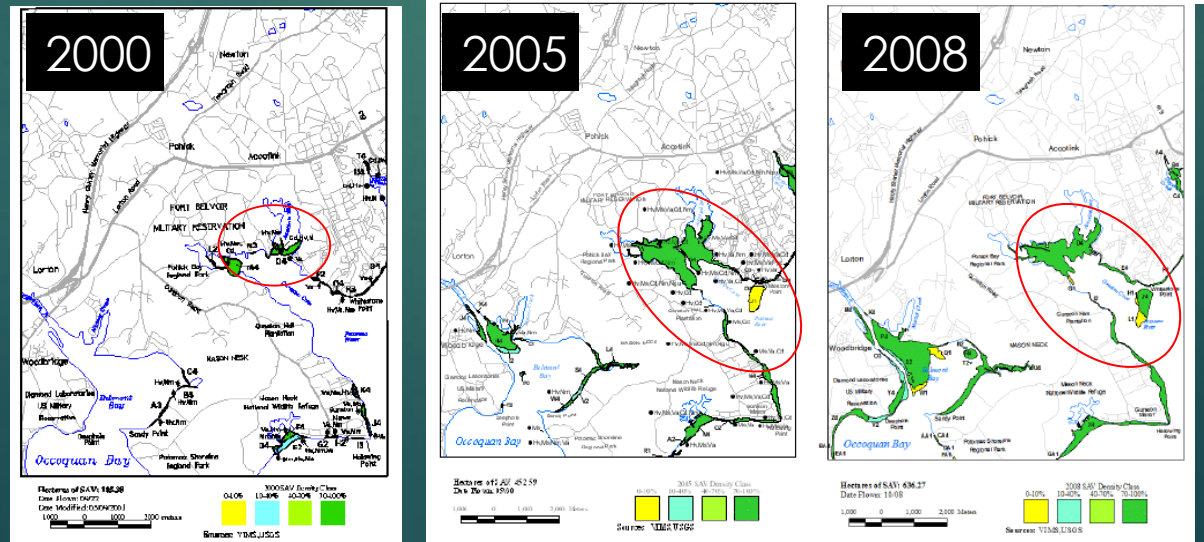
CHLA declines after 20 yrs



Water Clarity shows improving trend after 15 yrs



Aquatic grasses resurgence after 20 yrs and it continues…



Water quality improvement and living resource response takes time

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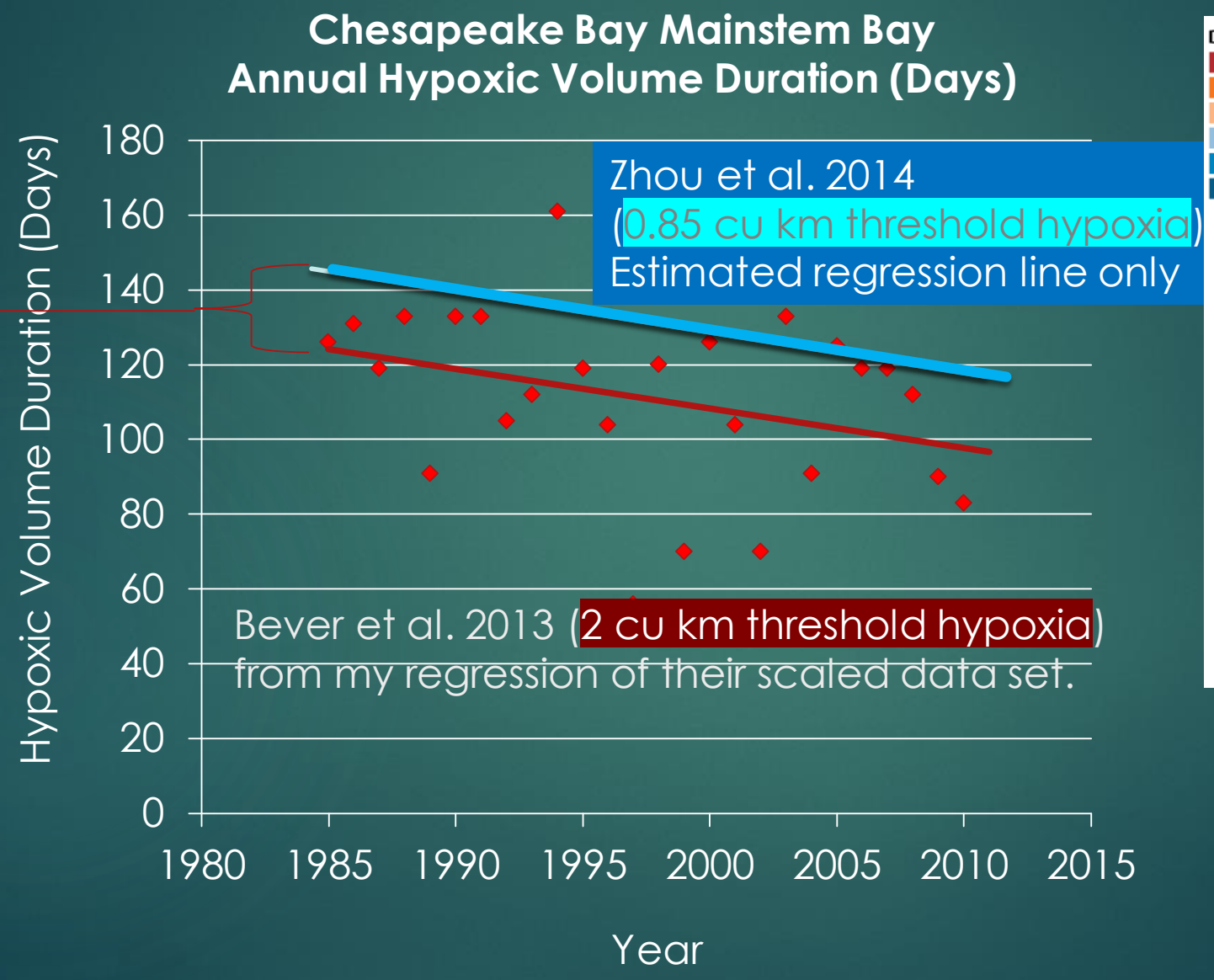
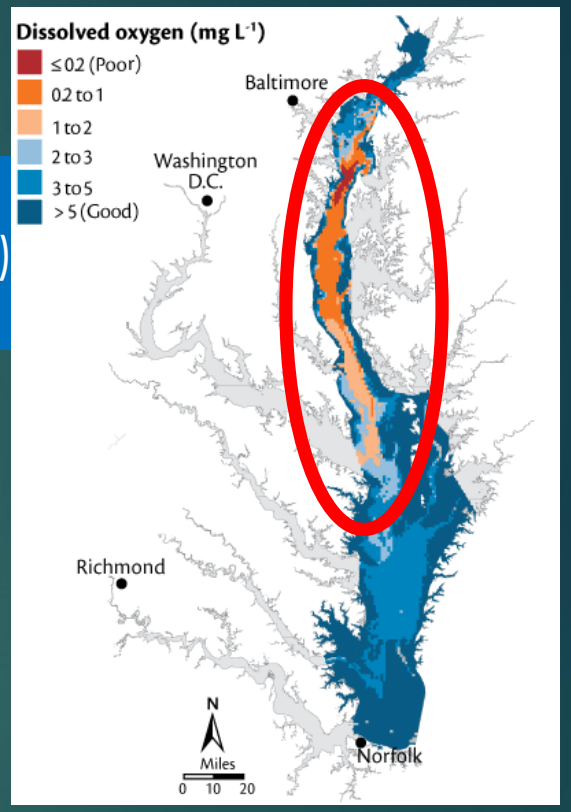
Evidence of recovery trajectory with less annual hypoxia over time in the mainstem Chesapeake Bay

About a 20 day difference due to study decisions on minimum threshold areas in their accounting approaches





Chesapeake Bay Hypoxia Summer 2012

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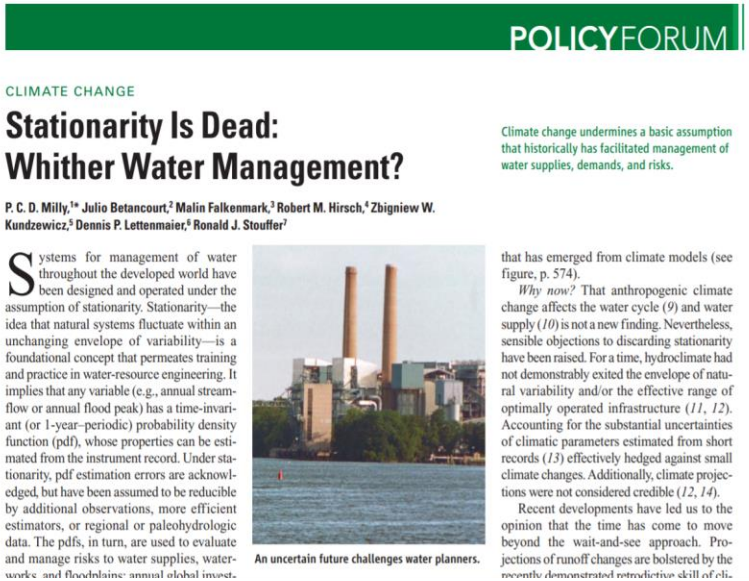
Chesapeake science captures the nature of our non-stationary conditions

- Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering.

January 2008 in Science



POLICYFORUM

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1*] Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g., annual streamflow or annual flood peak) has a time-invariant (or 1-year–periodic) probability density function (pdf), whose properties can be estimated from the instrument record. Under stationarity, pdf estimation errors are acknowledged, but have been assumed to be reducible by additional observations, more efficient estimators, or regional or paleohydrologic data. The pdfs, in turn, are used to evaluate and manage risks to water supplies, waterworks, and floodplains; annual global invest-

An uncertain future challenges water planners.

that has emerged from climate models (see figure, p. 574).

Why now? That anthropogenic climate change affects the water cycle (*9*) and water supply (*10*) is not a new finding. Nevertheless, sensible objections to discarding stationarity have been raised. For a time, hydroclimate had not demonstrably exited the envelope of natural variability and/or the effective range of optimally operated infrastructure (*11*, *12*). Accounting for the substantial uncertainties of climatic parameters estimated from short records (*13*) effectively hedged against small climate changes. Additionally, climate projections were not considered credible (*12*, *14*).

Recent developments have led us to the opinion that the time has come to move beyond the wait-and-see approach. Projections of runoff changes are bolstered by the recently demonstrated retrodictive skill of cli-

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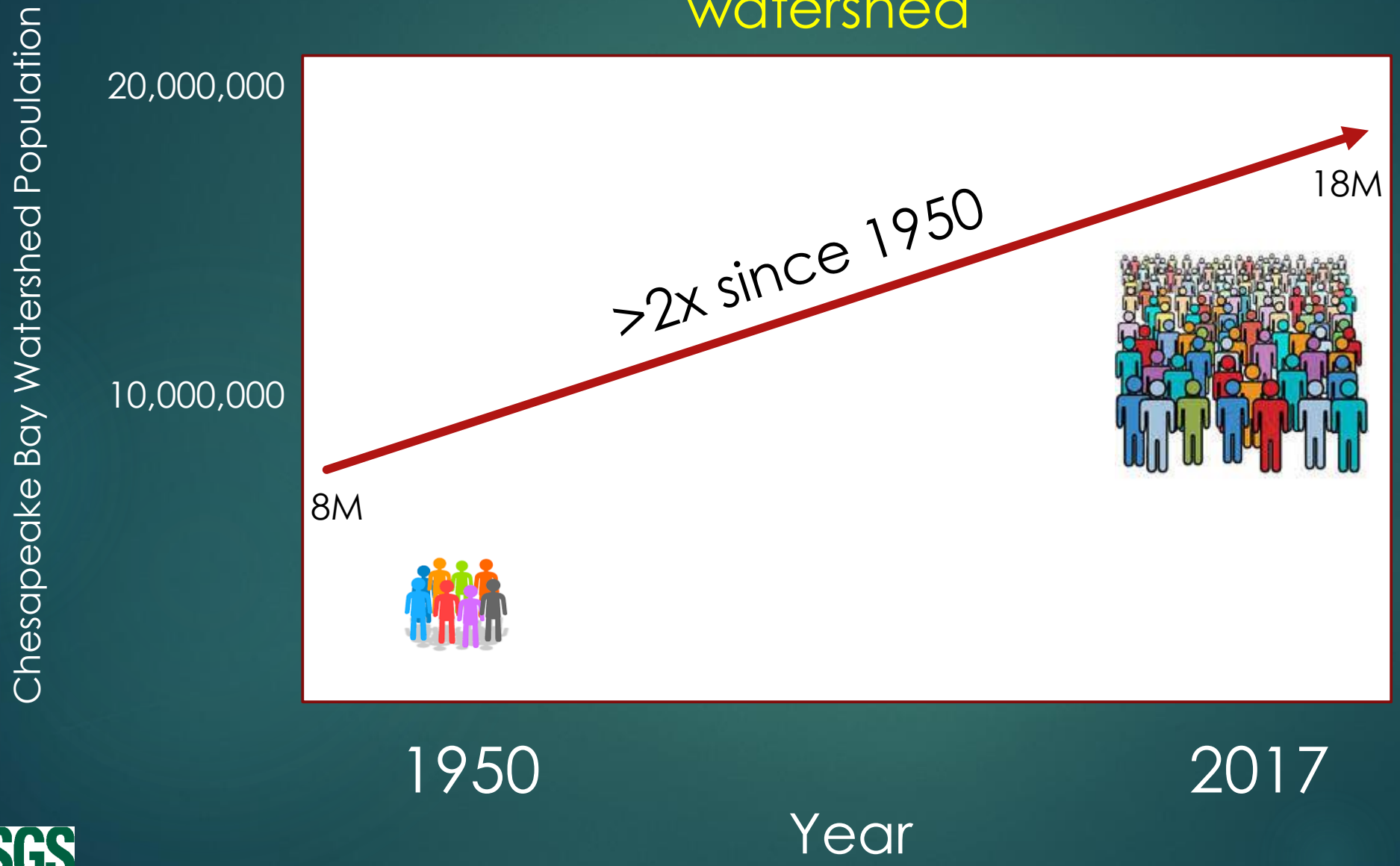
Shifting Baselines and Changing the Footprint: Steady population growth in the Chesapeake Bay watershed



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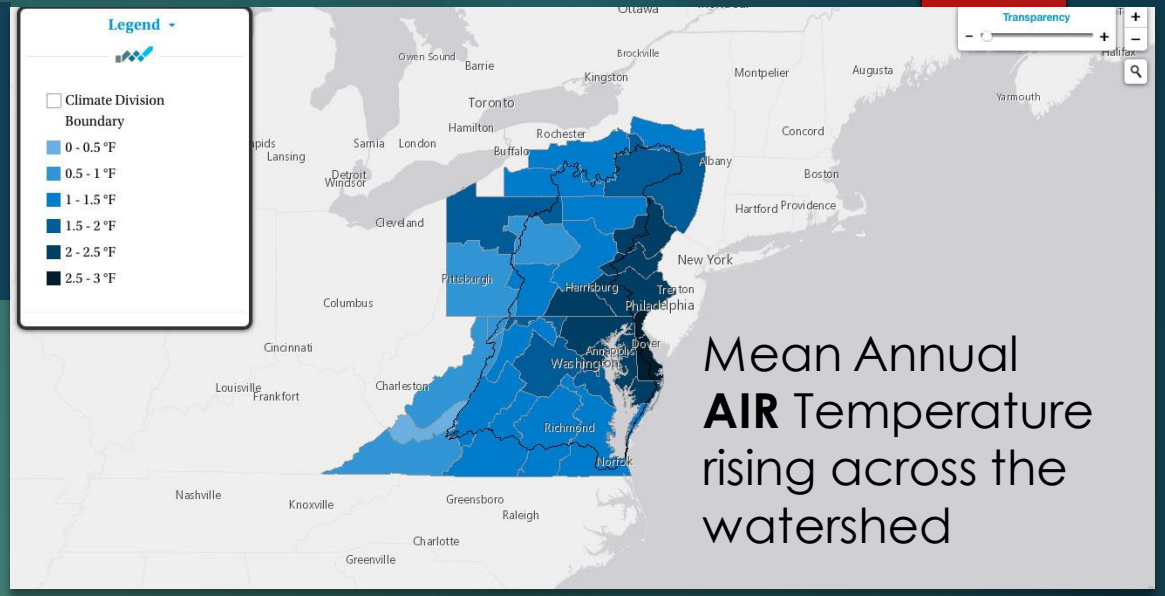
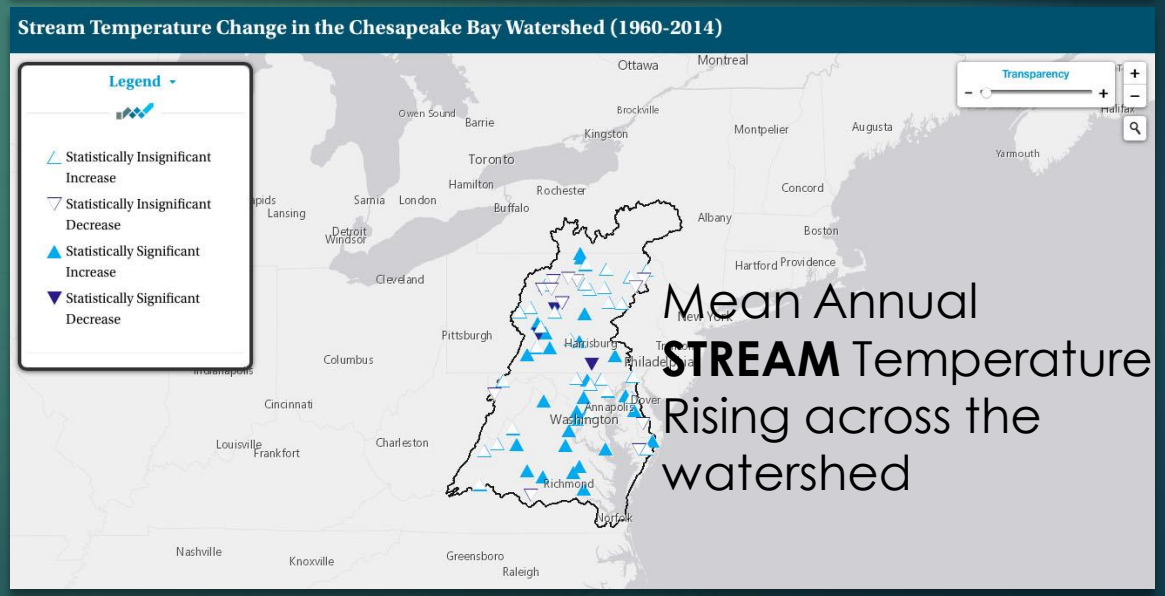
Shifting baselines: Temperature

- Air temperature rising, locally variability in rate
- Stream temperature rising, some local variation





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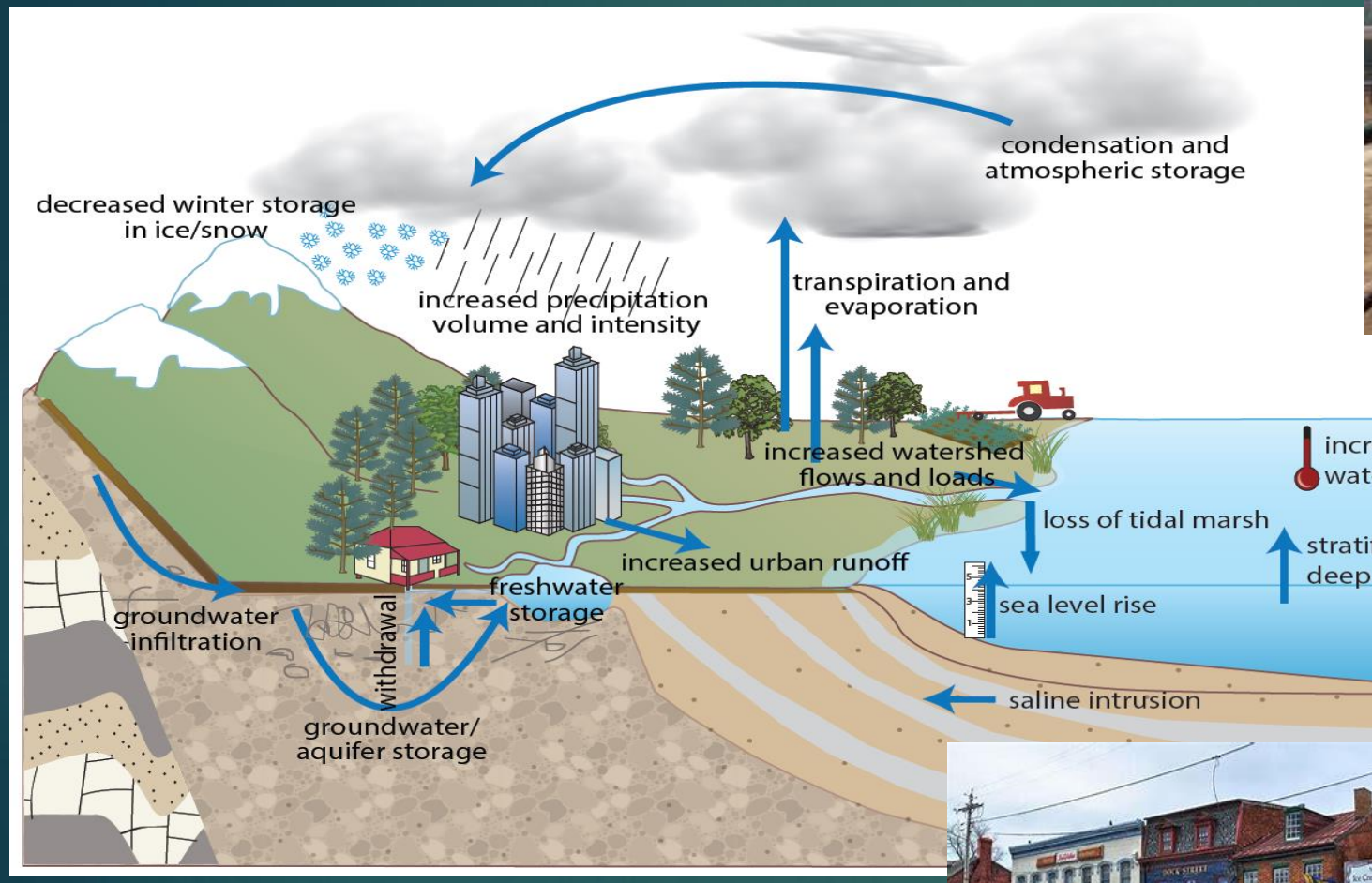
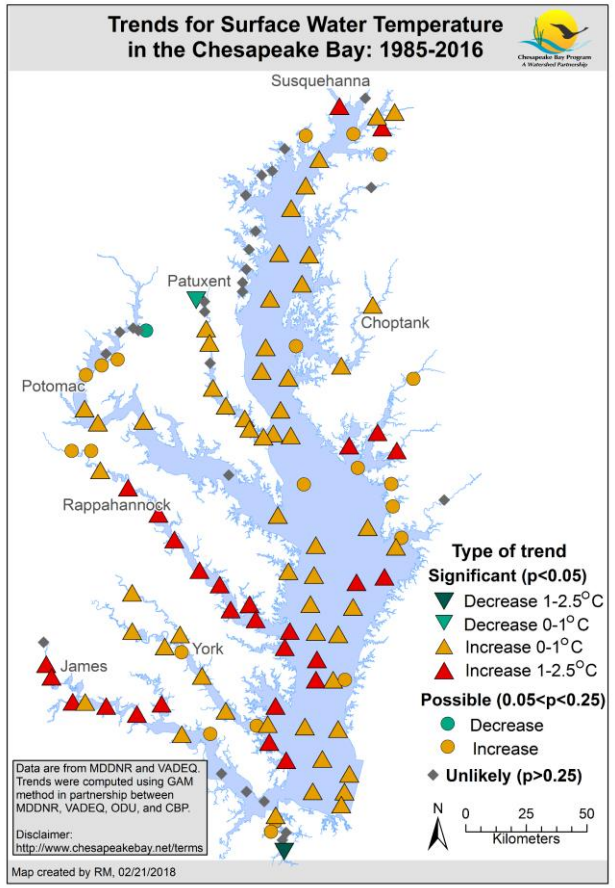
https://www.chesapeakeprogress.com/climate-change/climate-monitoring-and-assessment

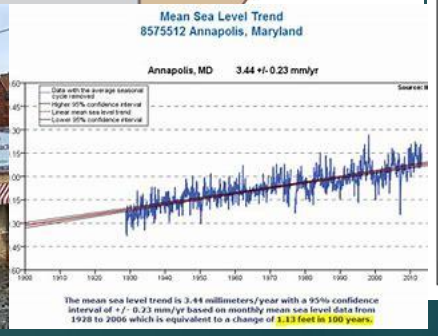
Climate Influence on the Chesapeake Bay Watershed



Source: CBP Modified UMCES/ IAN graphic (2011)

Rising bay temperatures





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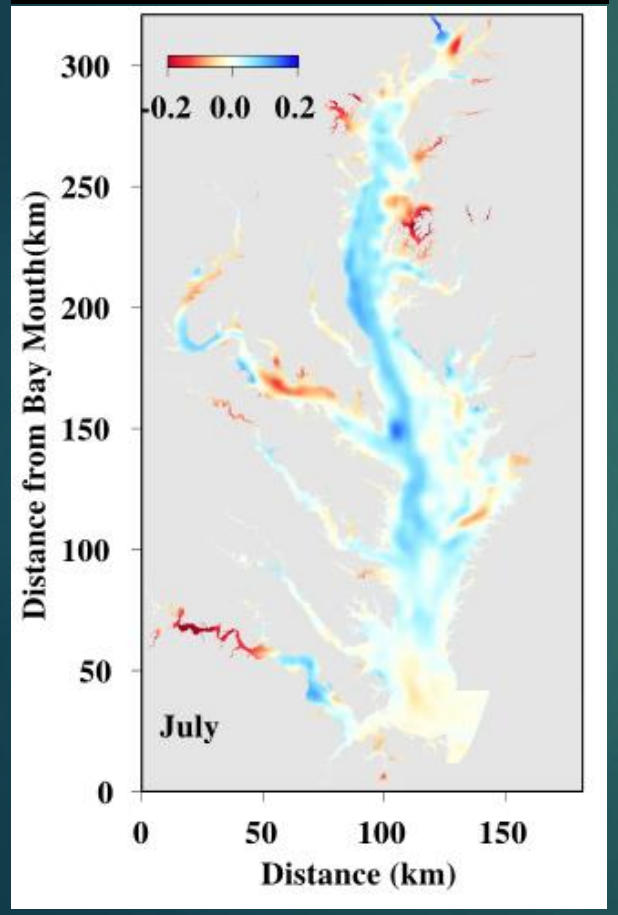
Science, Restoration, Partnership

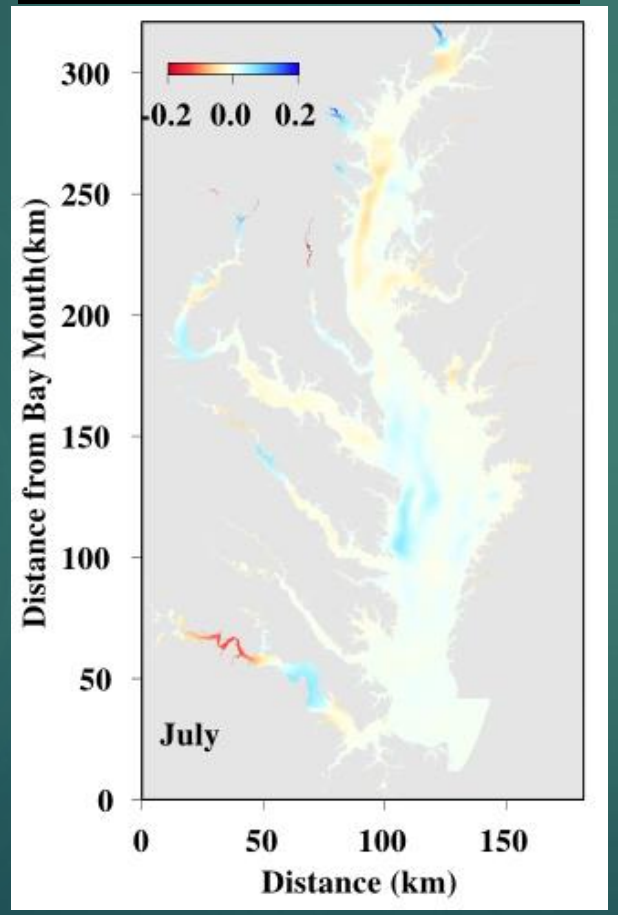
Climate and Bottom Dissolved Oxygen Change: 1995 to 2025

New insights: Keeping all other factors constant, sea level rise and increased watershed flow reduce hypoxia in the Bay, but ***<u>the predominant influence on dissolved oxygen conditions are the negative impacts of increased water column temperatures</u>***.

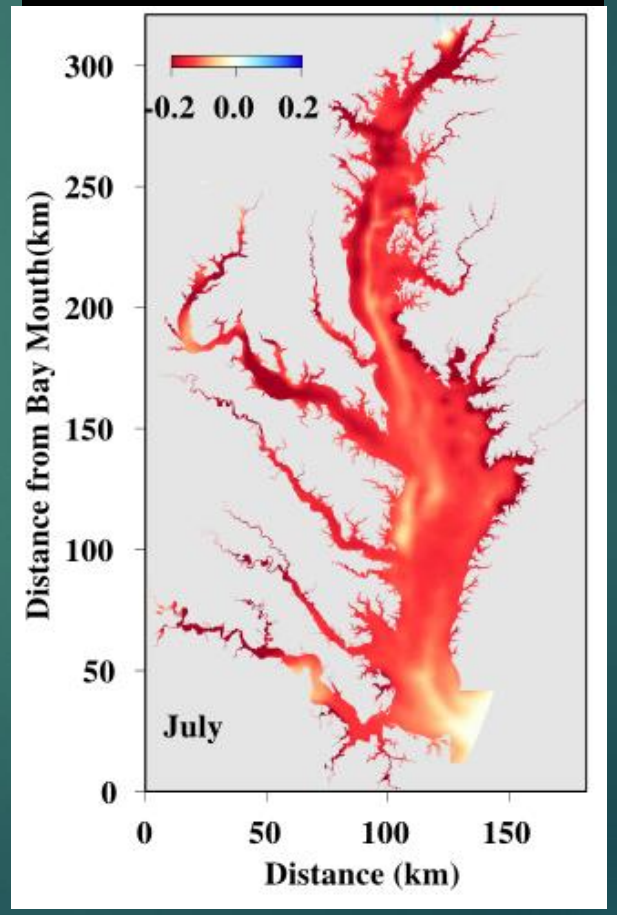
Sea Level Rise



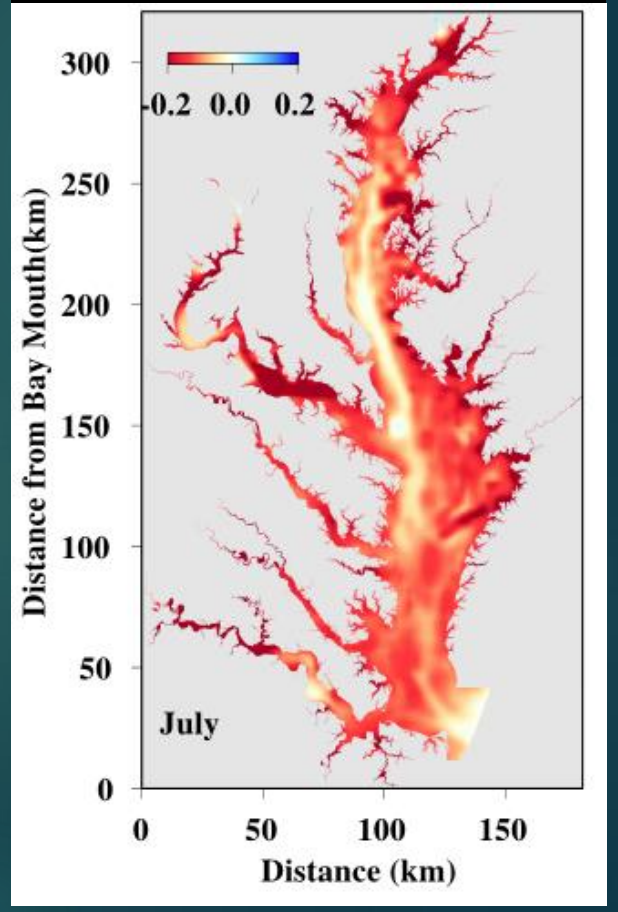
Watershed Flow



Increased Temp.



All Factors



Source: Lew Linker EPA-CBPO

Science now say the biggest BMP for trapping nutrient and sediment is now full.

- Loss of nutrient and sediment trapping capacity

Recent Conowingo science

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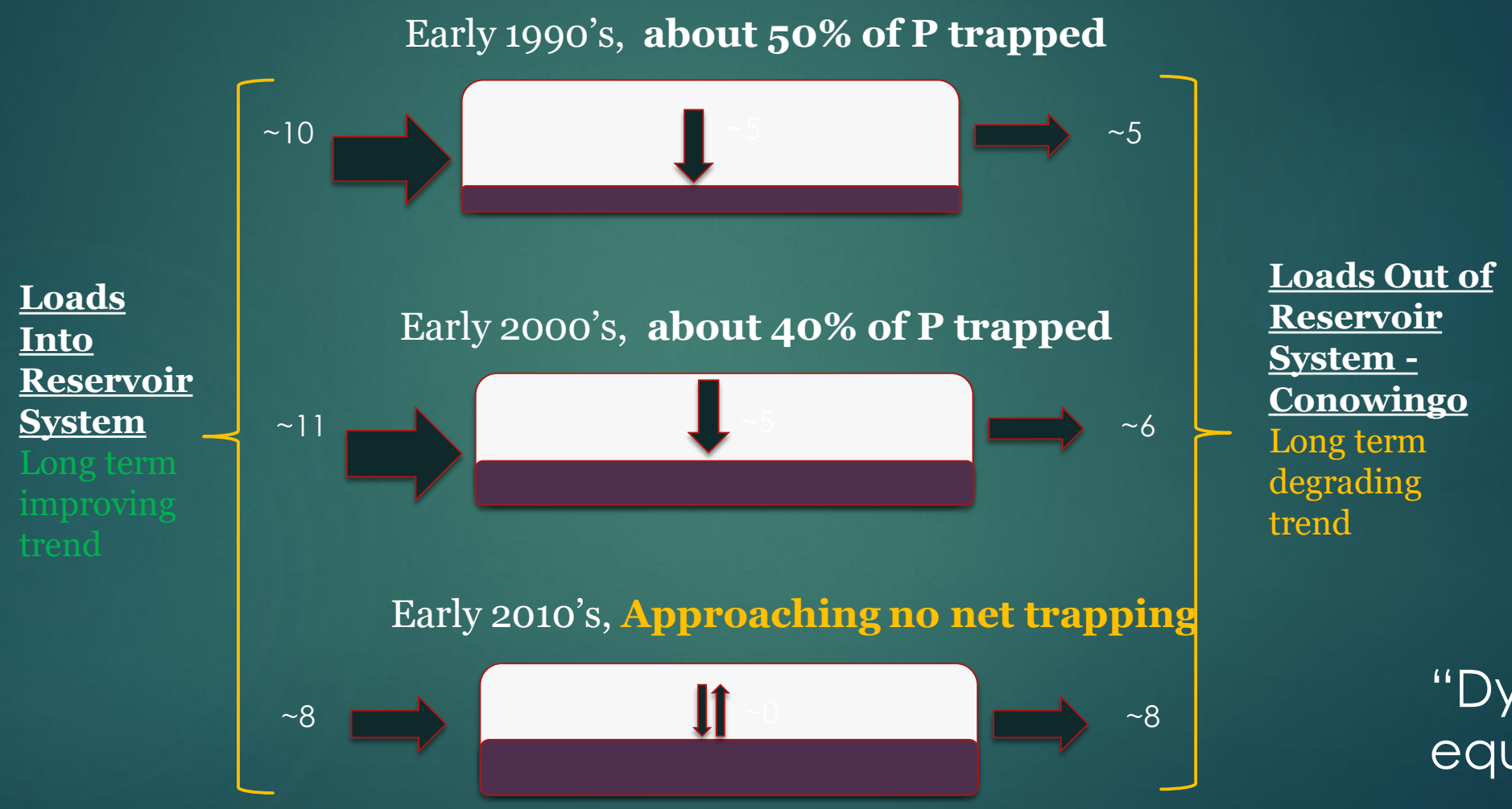
Phosphorus Loads Into, Trapped Within and Exiting the Reservoir System: 1990s-2010s



"Dynamic equilibrium"

Source: Data from USGS (2016), http://cbrim.er.usgs.gov/loads_query.html
loads are approximate and in units of million lbs/year using estimates for 1992, 2002, and 2012

Challenges

Monitoring and Analysis – Confronting models with data.

- Analysis need: Understanding the relationship between monitoring load trends with model projections for N,P and Sediment

1985-2016 comparisons

	Watershed Model	Monitoring data
N	improving	mixed
P	improving	degrading
S	improving	degrade/No Trend

Annual USGS River Input Trends
Short-term: 2007-2016
Long-term 1985-2016

Monitoring station	Total nitrogen load		Total phosphorus load		Suspended-sediment load	
	Long term	Short term	Long term	Short term	Long term	Short term
SUSQUEHANNA RIVER AT CONOWINGO, MD	Improving	Degrading	Degrading	Degrading	Degrading	No trend
POTOMAC RIVER AT WASHINGTON, DC	Improving	Improving	Improving	Degrading	Improving	No Trend
JAMES RIVER AT CARTERSVILLE, VA	Improving	Improving	Improving	No Trend	Degrading	Improving
RAPPAHANNOCK RIVER NR FREDERICKSBURG, VA	Improving	Improving	Degrading	No Trend	Degrading	No Trend
APPOMATTOX RIVER AT MATOACA, VA	No Trend	Degrading	Degrading	Degrading	No Trend	Degrading
PAMUNKEY RIVER NEAR HANOVER, VA	No trend	Degrading	Degrading	No trend	Degrading	Degrading
MATTAPONI RIVER NEAR BEULAHVILLE, VA	Improving	Degrading	No Trend	Degrading	No Trend	No Trend
PATUXENT RIVER NEAR BOWIE, MD	Improving	Improving	Improving	Improving	Improving	Degrading
CHOPTANK RIVER NEAR GREENSBORO, MD	Degrading	Degrading	Degrading	Degrading	Improving	Degrading

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The Frederick News-Post

New Insights: Fish community changes are large. <1970 = 0 blue catfish in Chesapeake Bay

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Blue catfish are destroying the Chesapeake Bay

By Tim Carman The Washington Post Jun 15, 2017 1

Several tributaries are already overrun with blue catfish, whose population is estimated between 94 million and 111 million.

*But population numbers alone don't tell the full story. **Blue catfish represent between half and three-quarters of the biomass in the James, Rappahannock and York rivers** on Virginia's western shore of the Chesapeake, says Chris Moore,*

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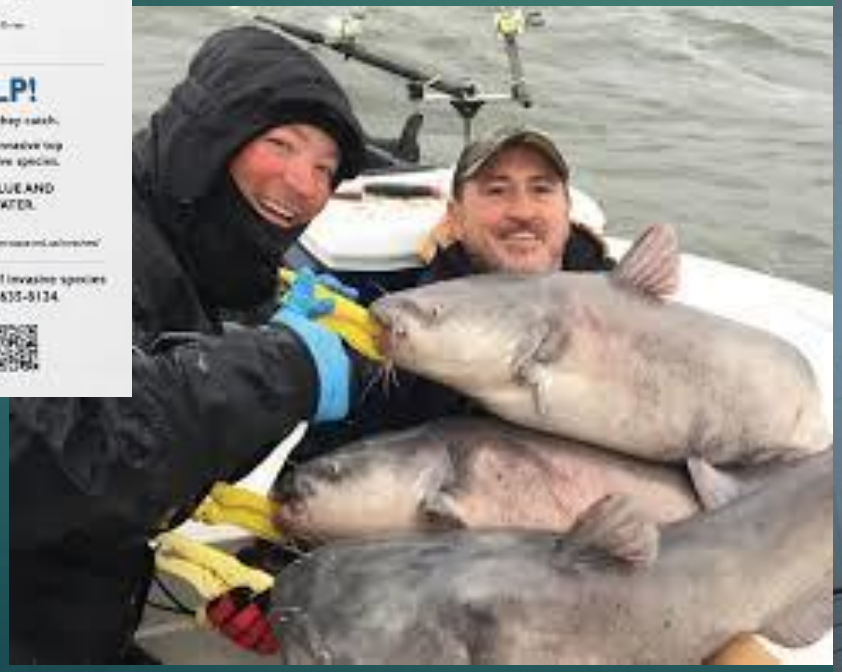
Science-based decision support:

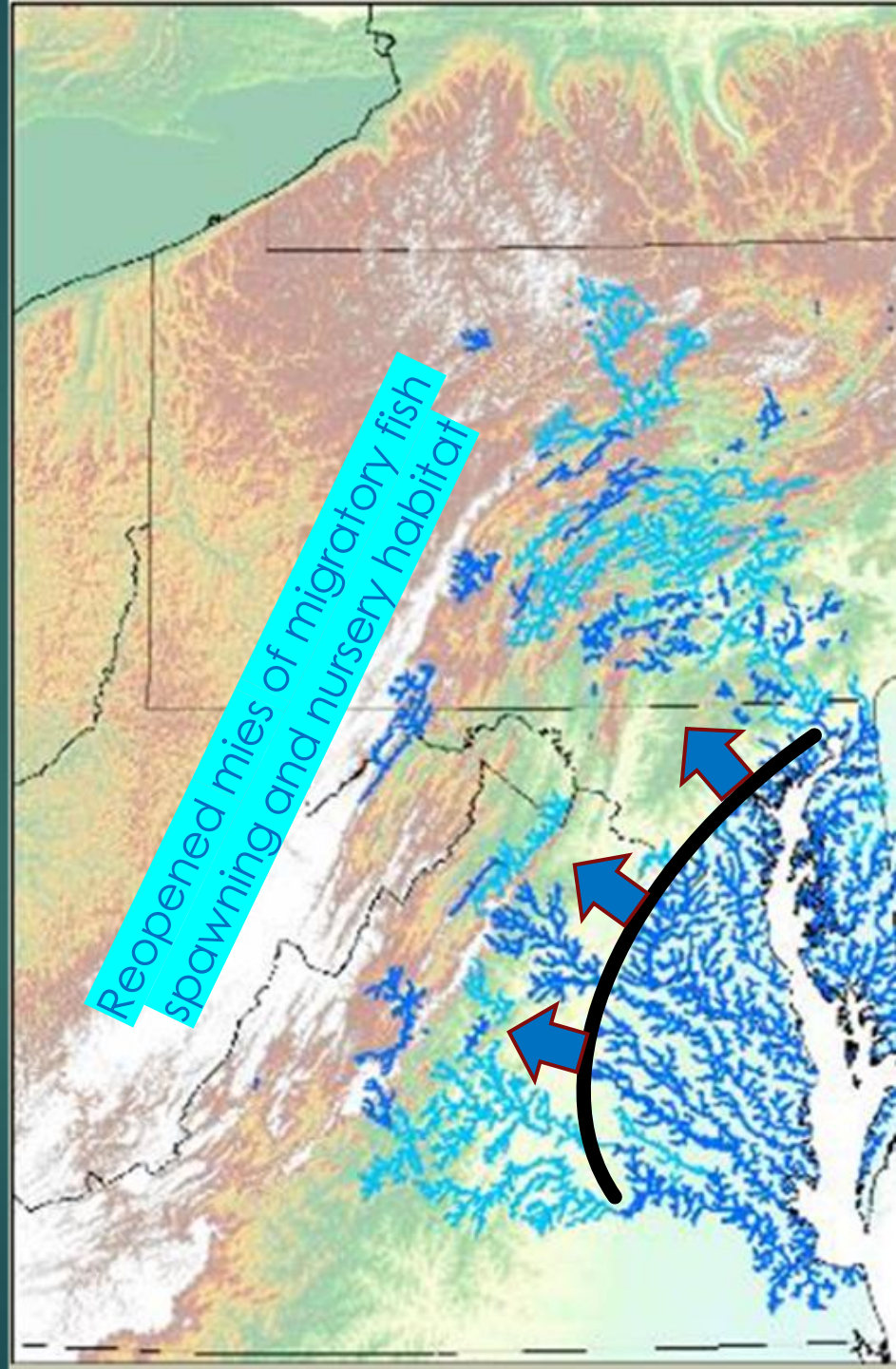
Schmitt et al. 2017. Predation and Prey Selectivity by Nonnative Catfish on Migrating Alosines in an Atlantic Slope Estuary. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 9:108–125.

- Diet contents were extracted from 2,495 catfish, 69.86% of which had prey items present in their foreguts (N = 1,743).
- Alosines were found in 4.46% of Blue Catfish stomachs, 16.7% of Flathead catfish stomachs.



Shifting baselines

- Removal of many fish passage ways has reopened many miles for fish migration



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FISH PASSAGE and SHAD

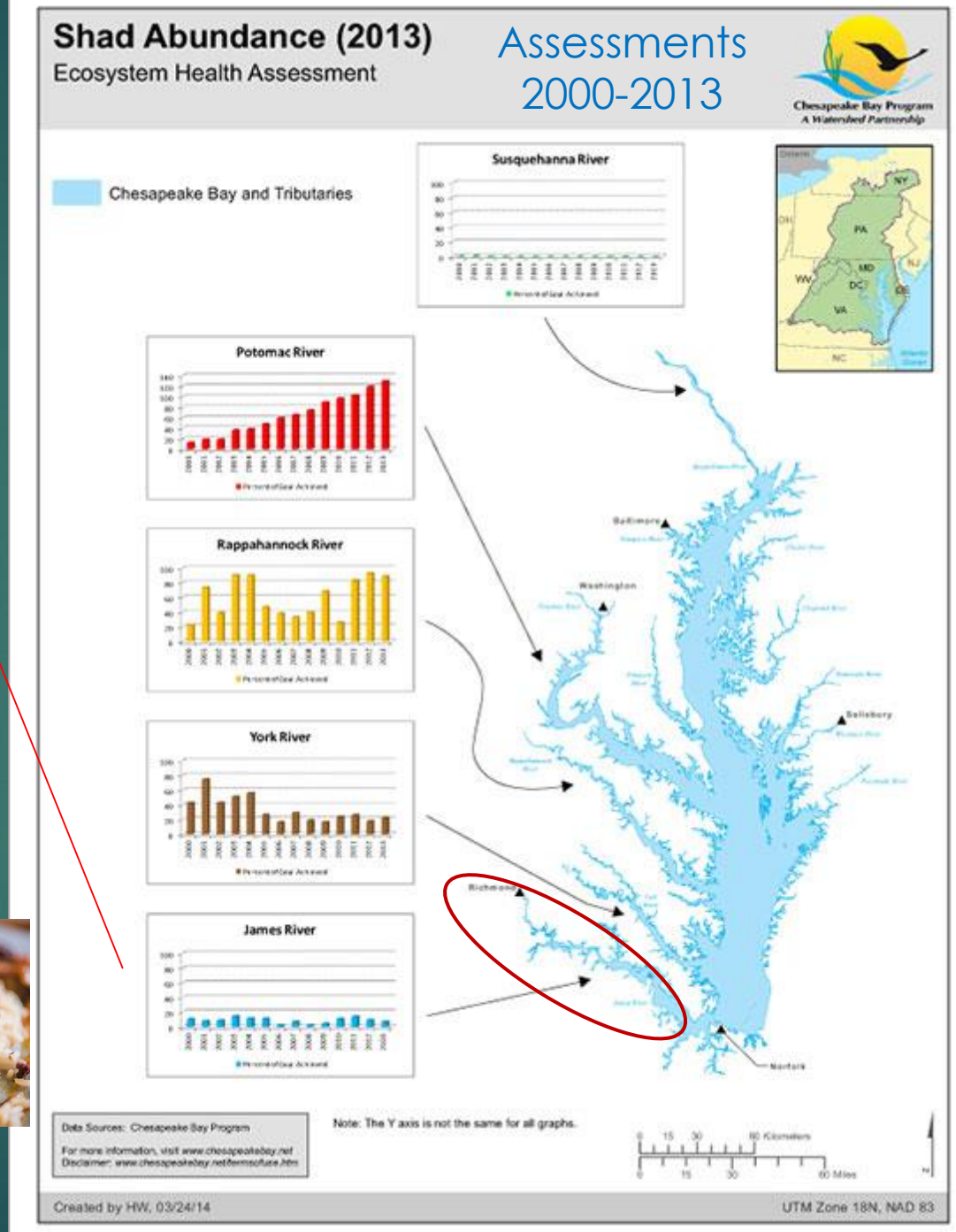
"With no sign of recovery, VA to halt stocking shad in James."

The inability to restore fish to what was once a major spawning ground has biologists seeking other approaches.

September 17, 2017 Bay Journal – Karl Blankenship

"Overfishing, pollution, loss of habitat and the construction of dams that closed off historic spawning grounds have all contributed to the population collapse, scientists say."

…And now blue cats and other invasive spp



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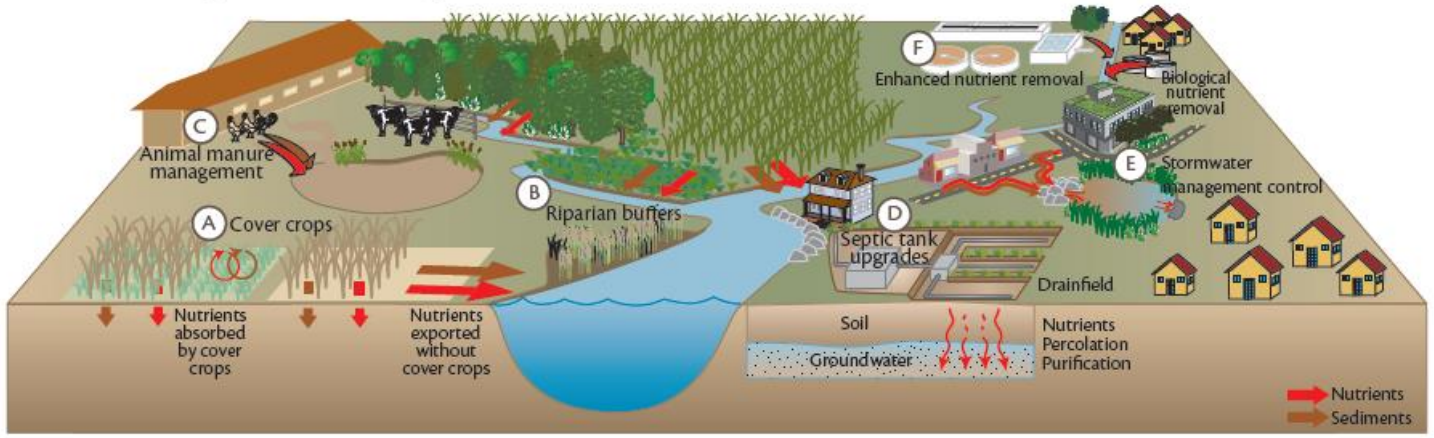
Best Management Practices around the Bays

There are a suite of Best Management Practices (BMPs), with many more being developed, that reduce nutrient and sediment loads to the Chesapeake Bay. These may be as simple as individuals not fertilizing their lawn, or only during the recommended time of the year (fall), to large and expensive construction projects such as upgrading municipal wastewater treatment plants. Here are some of the most important and some of the new BMPs being undertaken in agriculture and urban areas.

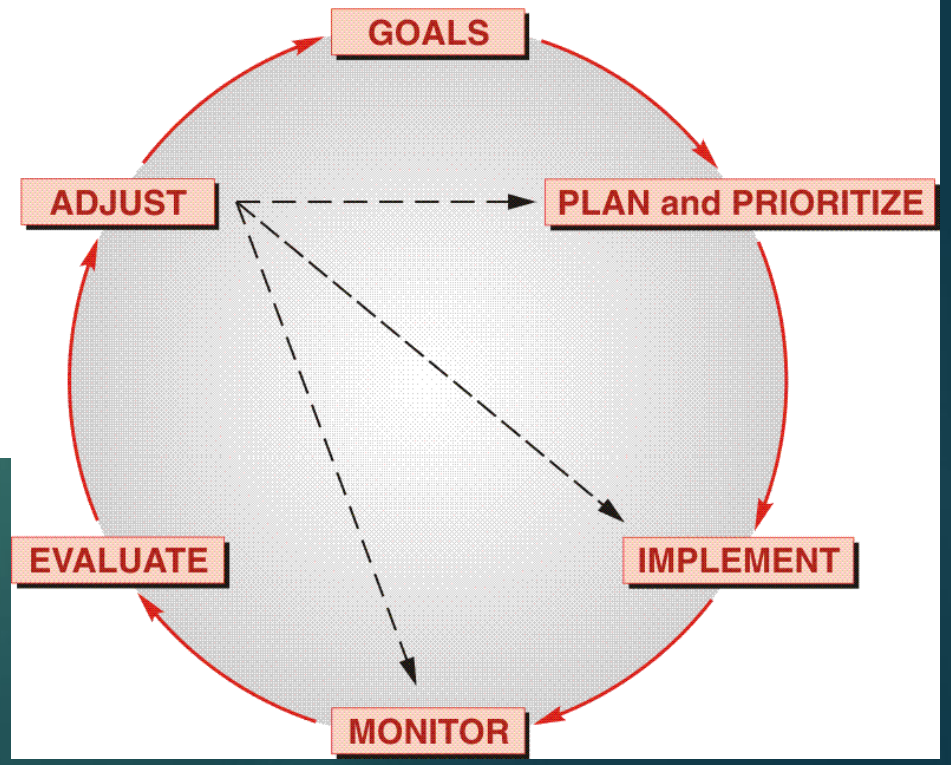


Agricultural BMPs

Urban BMPs

ADAPTIVE MANAGEMENT FOR ECOSYSTEM DECISION MAKING

[Modified from Williams and others (2007) and Levin and others (2009)]



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Summary

Substantial progress has been made to improve water quality and living resource habitat conditions in the watershed and Bay

New scientific insights are made each year improving our understanding of the ecosystem

Shifting baselines are evident in the physics, chemistry and biology of the system

Management continues to account for the new insights and shifting baselines by adjusting and updating policies actions through implementing an adaptive management framework guiding restoration and recovery

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