Achieving Water Quality Goals in the Chesapeake Bay: A Comprehensive Evaluation of System Response (CESR)

Key Takeaways for LGAC

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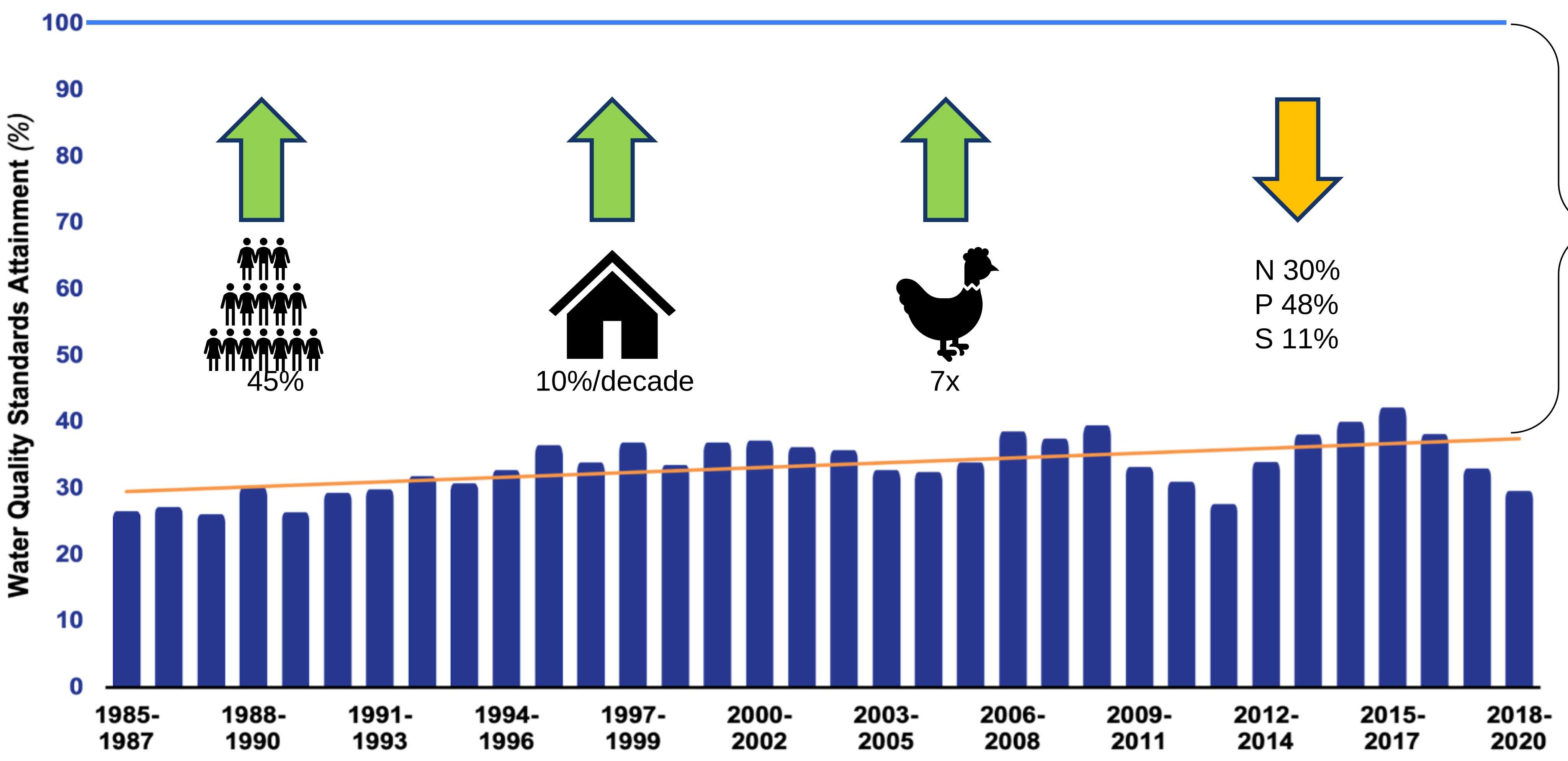
4 September 2025

Why this report, at this time, by these people?



Why?

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Public Policy

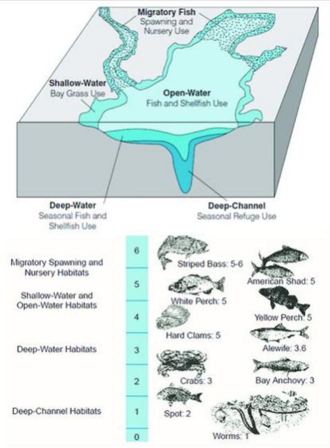
Chesapeake Bay Agreement: Restoration Goals

Sustainable Fisheries
Vital Habitat
Water Quality
Toxic Contaminants
Heathy Watershed
Climate Resiliency
Land Conservation
Stewardship
Public Access
Environmental Literacy

→

Water Quality Standards

Designated Uses



→ **Water Quality Criteria**
Dissolved Oxygen,
Water clarity/SAV,
& Chl-a
across 5 habitats

→

TMDL: Stressor Reduction Goals

Targets: Nitrogen, phosphorus, sediment

TN: 214.6 m/lbs/yr
TP: 13.4m lb/yr
TSS: 18,587m lb/yr

→

Implementation Policies

Federal permitting
Fed/State nonpoint programs
Funding

TMDL accounting & accountability

Biological, Physical, and Social System Response

Living Resource Response

How are living resources responding to changing water quality conditions?

←

Achieving Water Quality Standards

Are nutrient & sediment reductions producing expected water quality response?

←

Achieving TMDL:

Are implementation policies and management actions sufficient to achieve nitrogen, phosphorus and sediment goals in the TMDL?

Summary of CESR Findings and Implications

Living Resource Response

Findings: The impact of WQ improvements on living resources depends on where WQ improvements occurs, antecedent conditions, & impact varies across species.

Implications: Potential to increase the impact on living resources from our WQ and restoration investments.

Achieving Water Quality Standards

Findings: Bay water quality is improving, but the magnitude of the improvement appears to be lagging behind expectations

Implications: Full (100%) achievement of Bay water quality standards is a distant and doubtful.

Achieving TMDL

Findings: Nonpoint source programs are not generating the scale of reductions needed to achieve TMDL

Implications: To substantially improve nonpoint source outcomes will require new programs and approaches

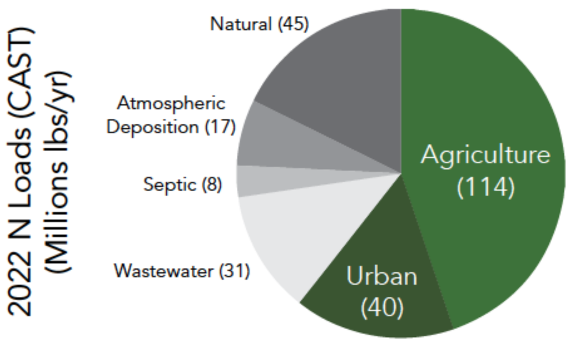
Overarching Finding: Complex problem with tradeoffs, uncertain outcomes, and no single “silver bullet” answer

Overarching Implication: Experiment, learn, and adapt

Finding: Nonpoint source programs not generating enough pollutant reductions to meet the TMDL.

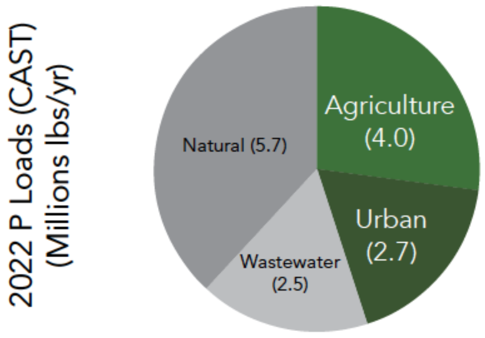
Nonpoint source reductions are essential to meeting pollutant reduction goals.

Nitrogen

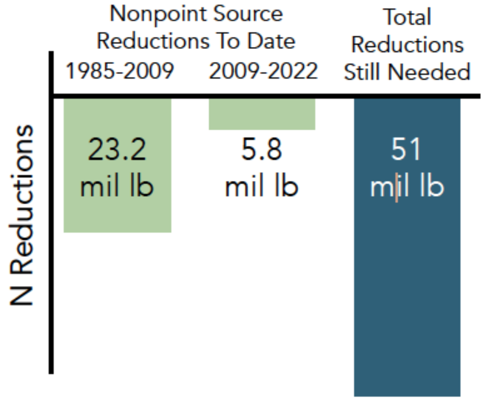


Point source nutrient loads, primarily wastewater loads, have been dramatically reduced already, leaving little opportunity for more reductions. The CESR report focuses on the largest, manageable sources of nutrients to the Bay – agricultural (green) and urban (dark green) nonpoint source pollution.

Phosphorus



Current nonpoint source programs are not producing enough adoption.



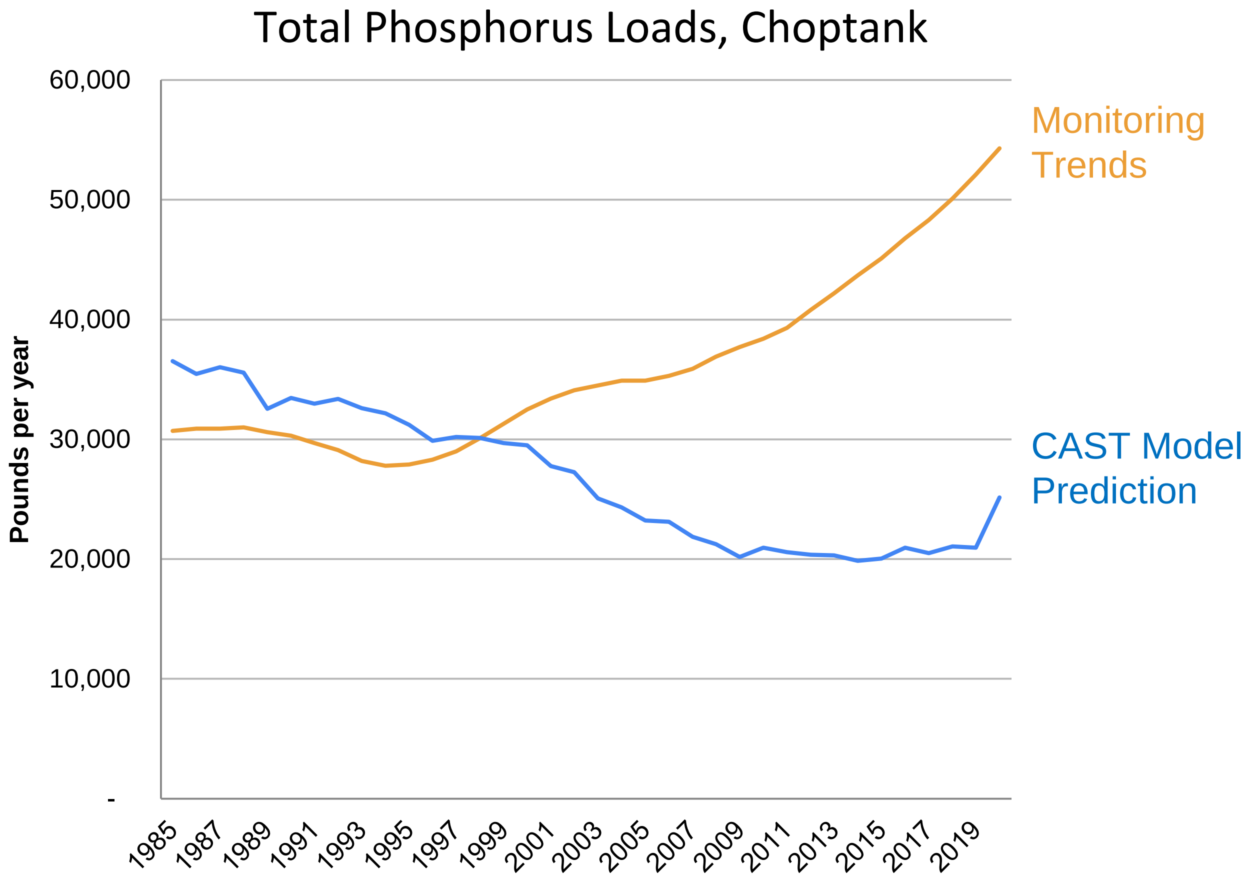
To reduce nutrient pollution, new approaches must accelerate adoption of nutrient reduction practices in the locations with the greatest load reduction potential. Over 50 million pounds of nonpoint nitrogen reduction is still needed to meet the current target, but it has taken over a decade to generate less than six million pounds of nonpoint nitrogen reductions.

Findings: Achieving Pollutant Reductions

Nonpoint source programs may not be as effective as expected

Long term Trends in Total Phosphorus Loads

Rivers	Monitoring Observations	CAST model
Susquehanna	—	↓
Potomac	↓	↓
Choptank	↑	↓
Patuxent	↓	↓
Rappahannock	↑	↓
Mattaponi	—	↑
Pamunkey	↑	↓
James	↓	↓
Appomattox	↑	↓

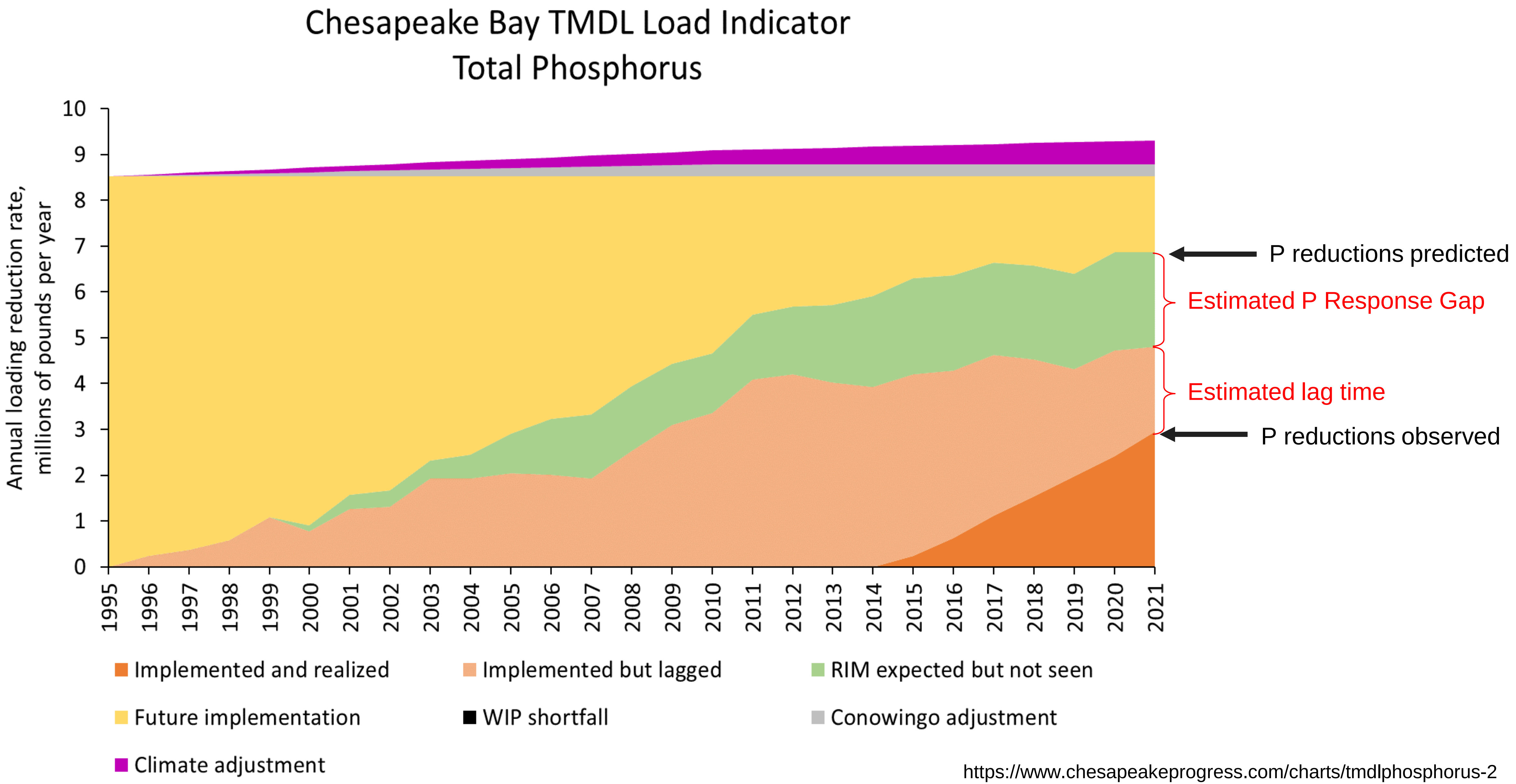


What might explain the difference?

Lag times (solution: wait)

Knowledge gaps and uncertainties in understanding system response

Phosphorus Response Gap

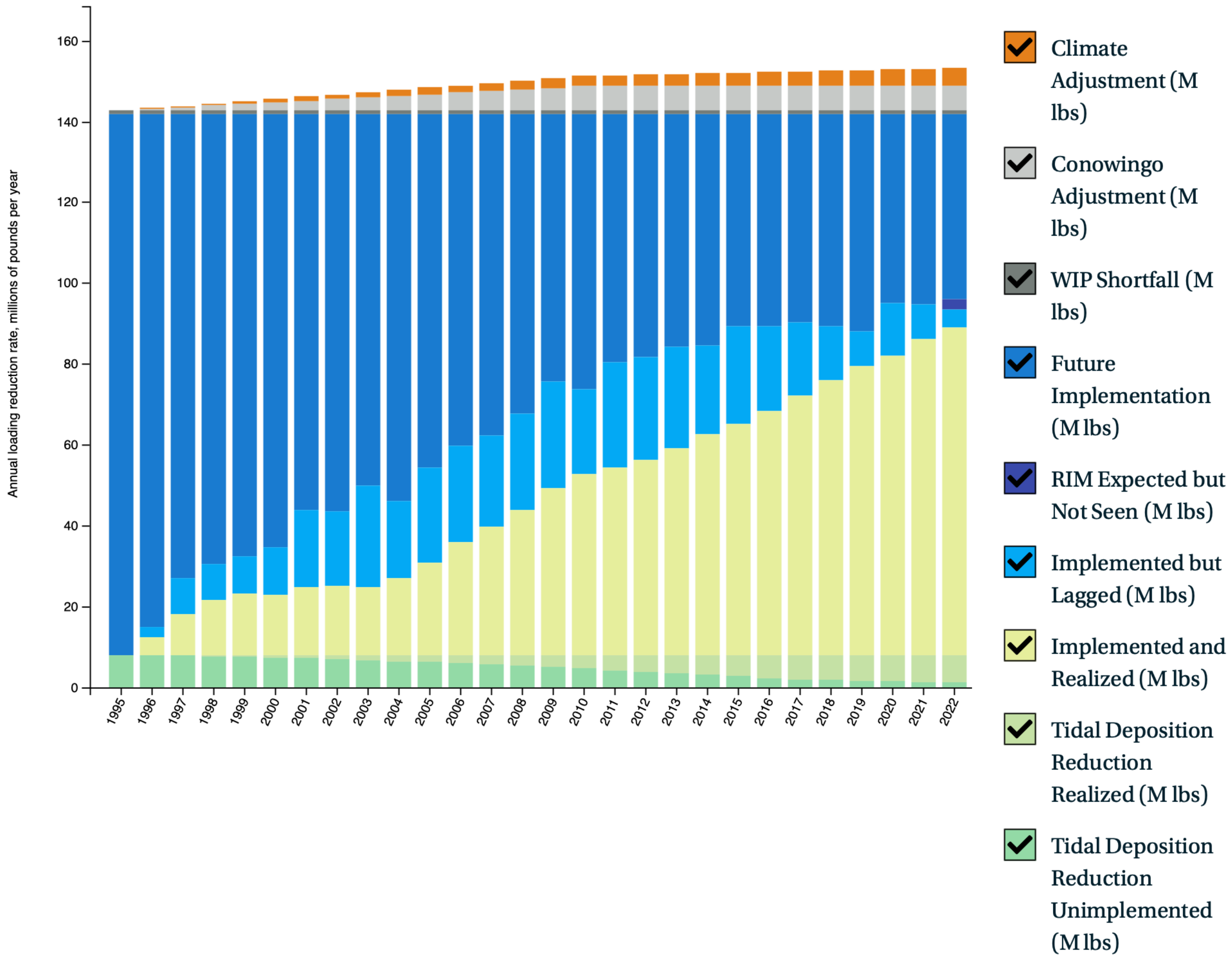


https://www.chesapeakeprogress.com/charts/tmdlphosphorus-2

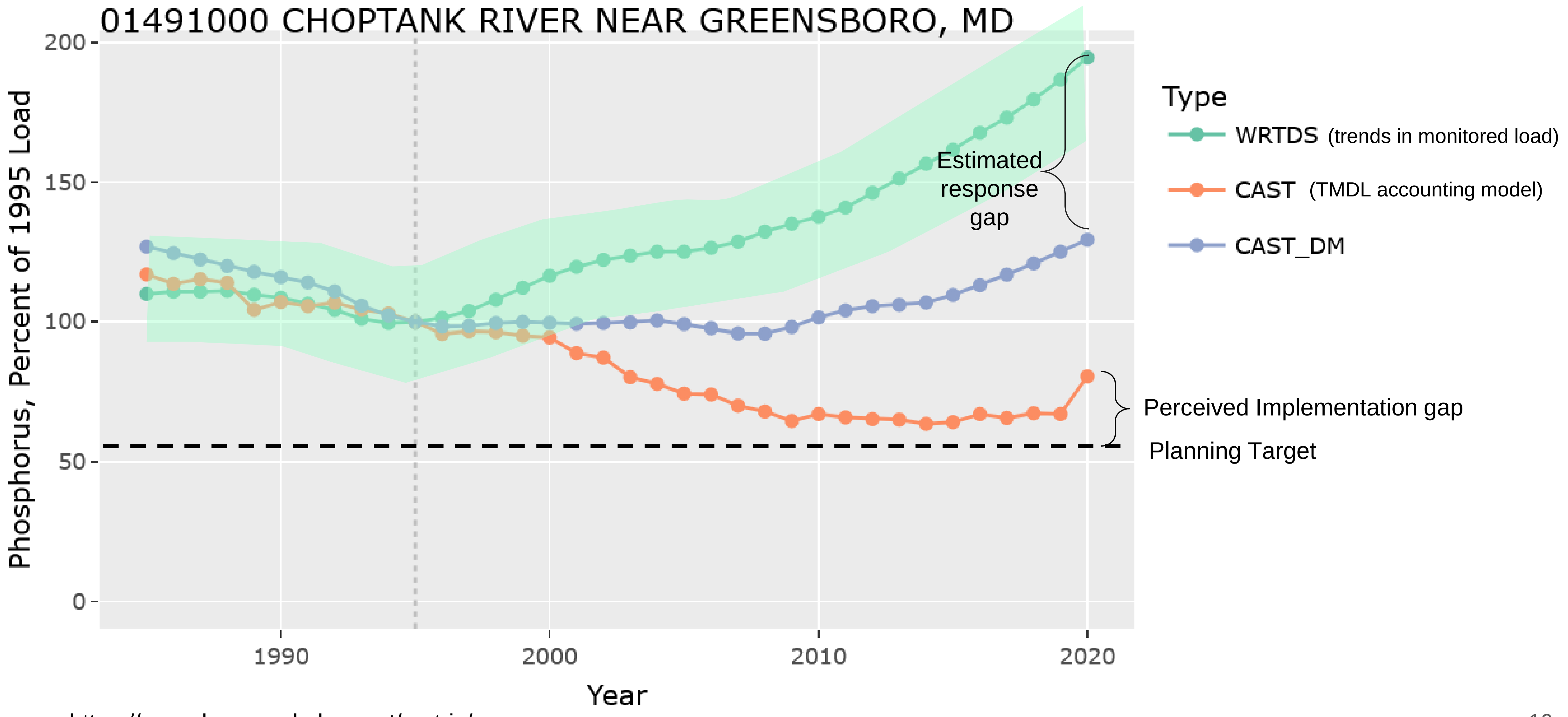
Bay TMDL Indicator

VIEW CHART VIEW TABLE

Nitrogen Phosphorus

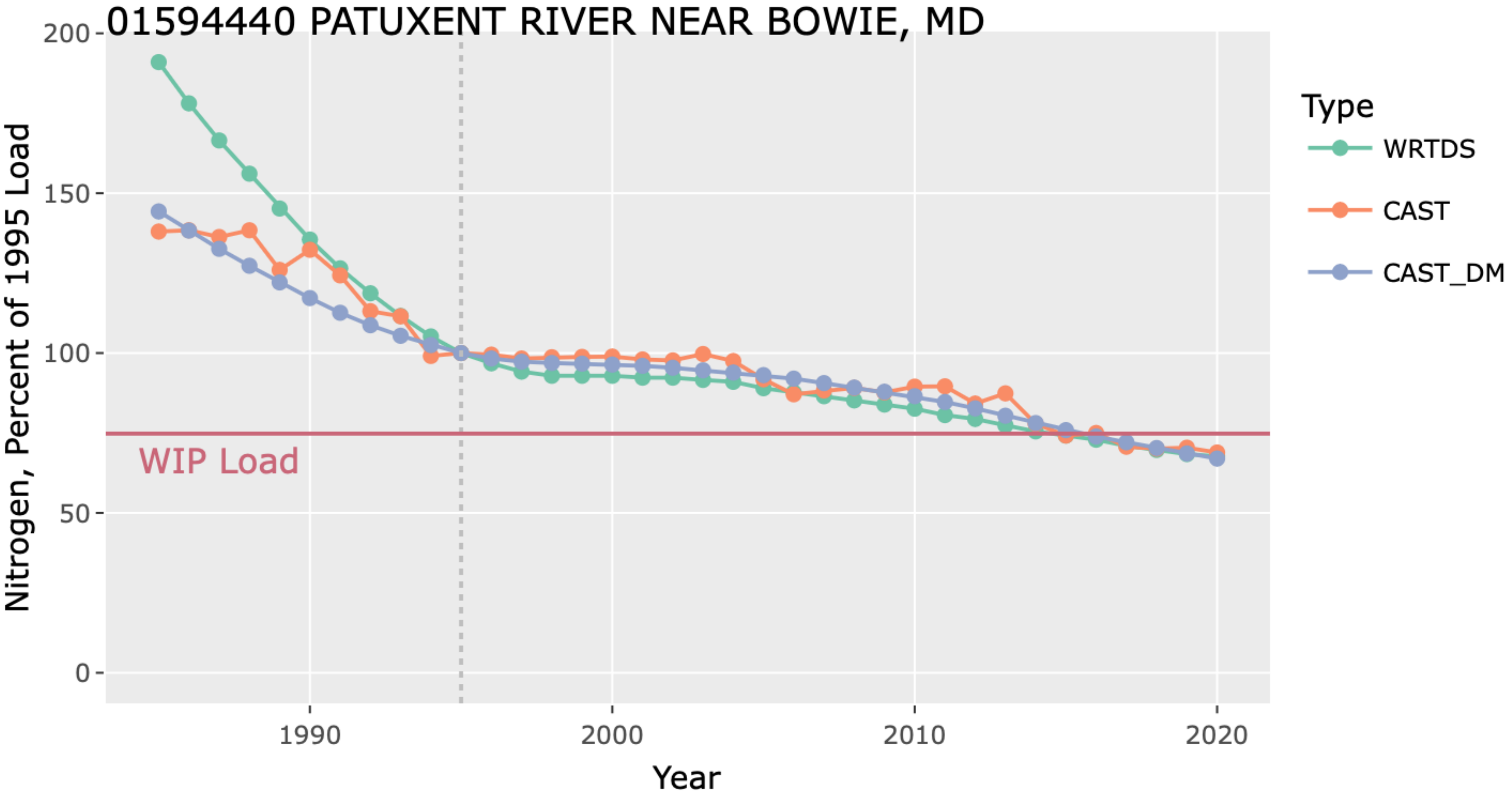


Response gaps at local scales (Phosphorus)



Source: https://wqs.chesapeakebay.net/metric/

Response gaps at local scales (Nitrogen)

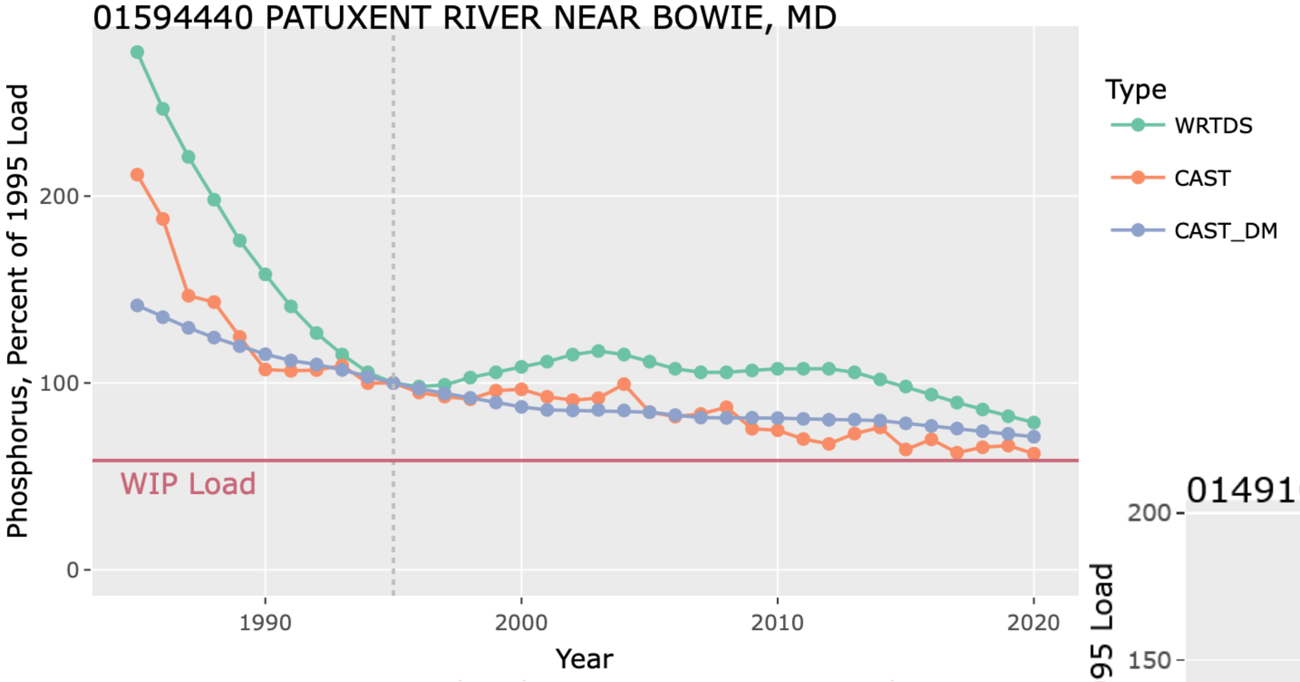


(trends in monitored load)

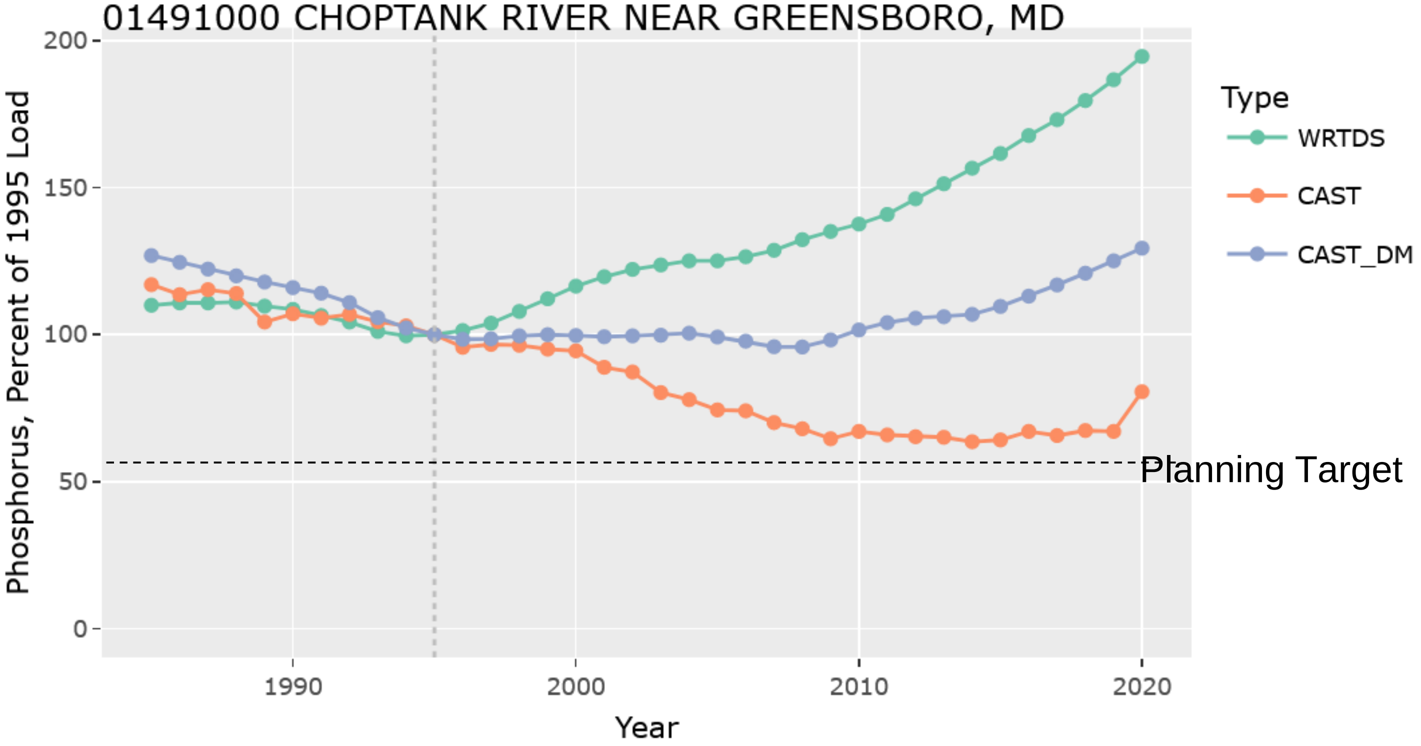
(TMDL accounting model)

Source: https://wqs.chesapeakebay.net/metric/

Different Stories Across the Watershed

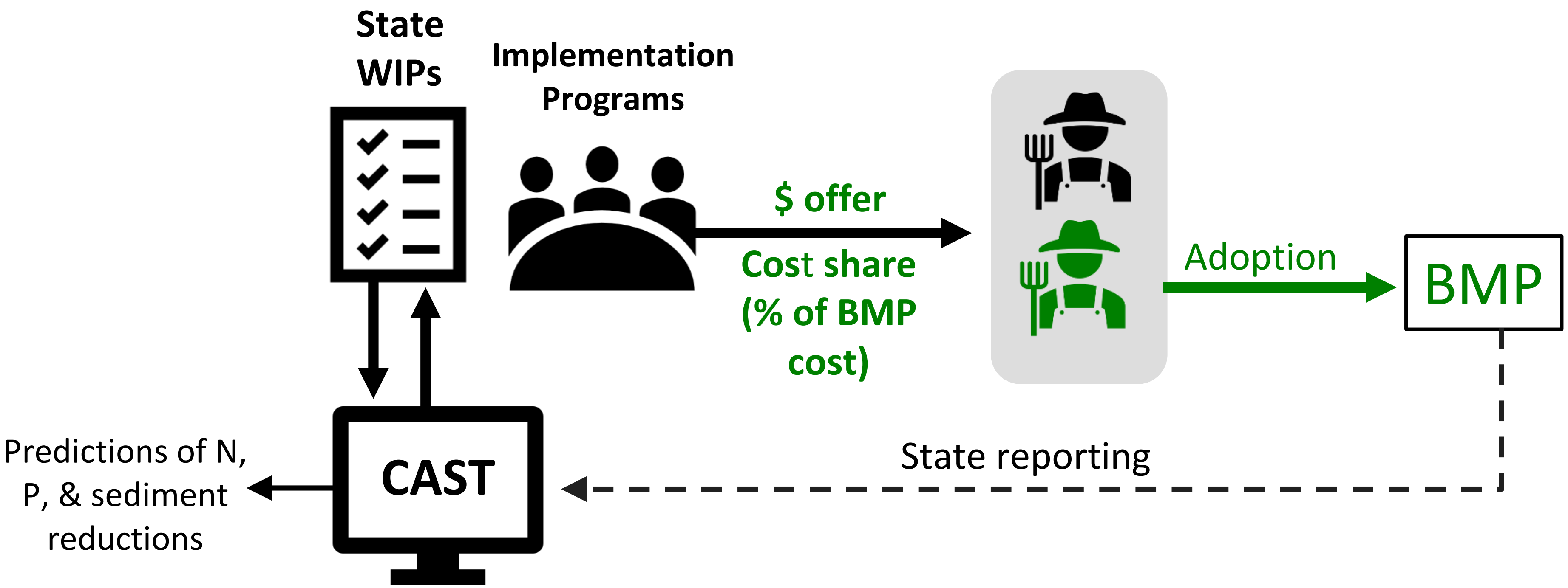


Perceived
Implementation gap



Source: https://wqs.chesapeakebay.net/metric/

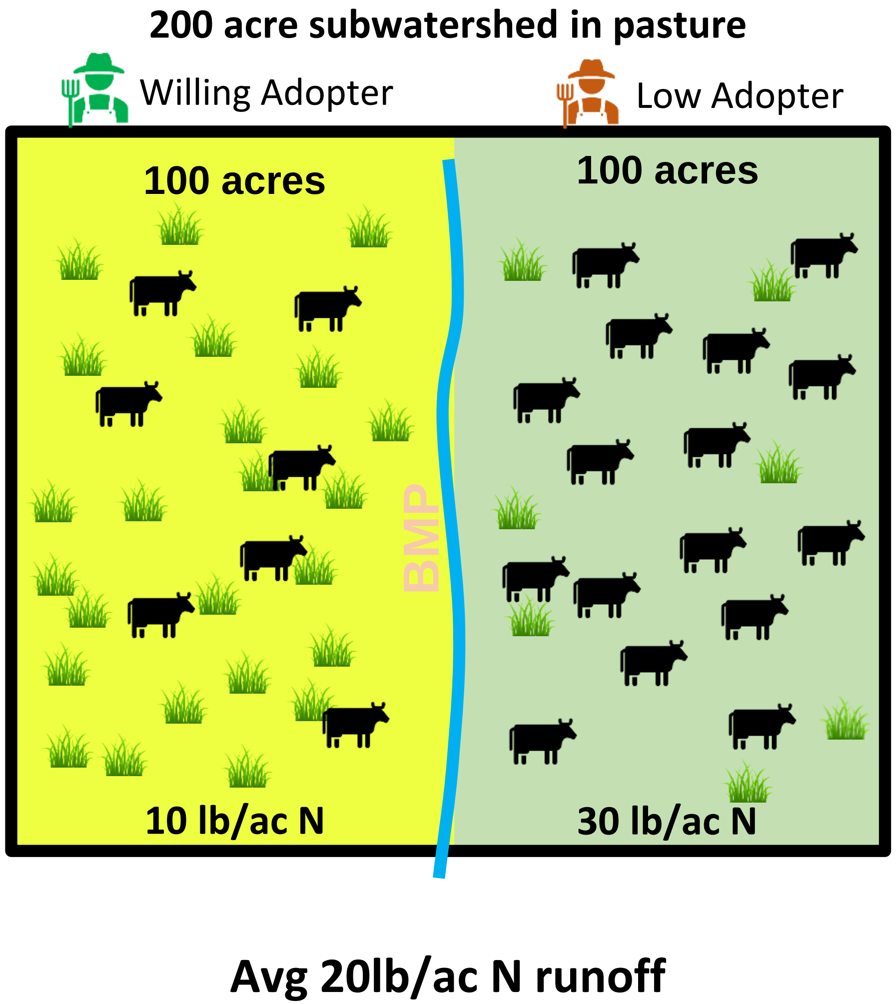
Nonpoint Source Policy



Nonpoint source implementation programs

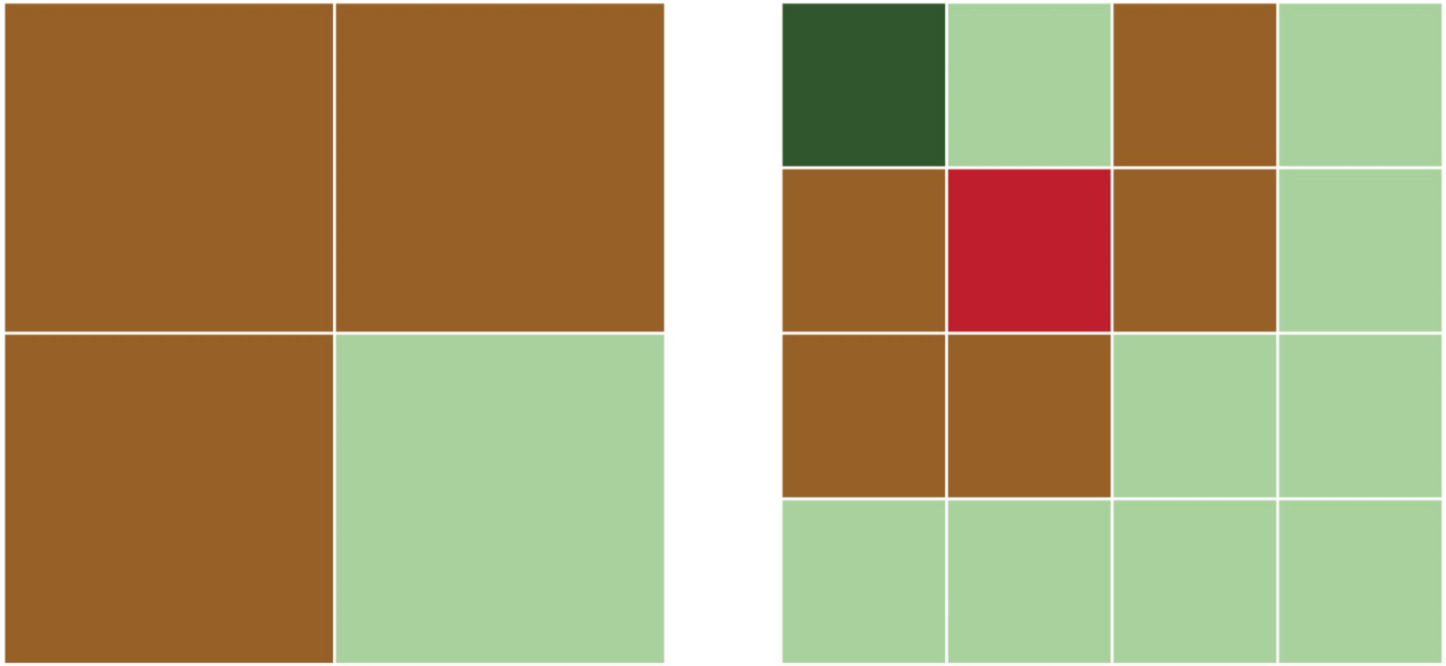
TMDL nonpoint source accounting and accountability

The problem with coarse scale



Scenario	Willing Adopter	Low Adopter	Total Load
Actual Starting	1000 lbs	3000 lbs	4000 lbs
CAST Assumed Starting	2000 lbs	2000 lbs	4000 lbs
CAST w/BMP: 50% reduction on 50% of area	1500 lbs	1500 lbs	3000 lbs
Actual w/ 50% reduction by Willing Adopter	500 lbs	3000 lbs	3500 lbs

Targeting Conservation



Larger scale makes it more difficult to pinpoint the problem
Targeting helps identify problem areas (red square)

Incentivize Outcomes

Cover crops

Livestock Exclusion Fencing

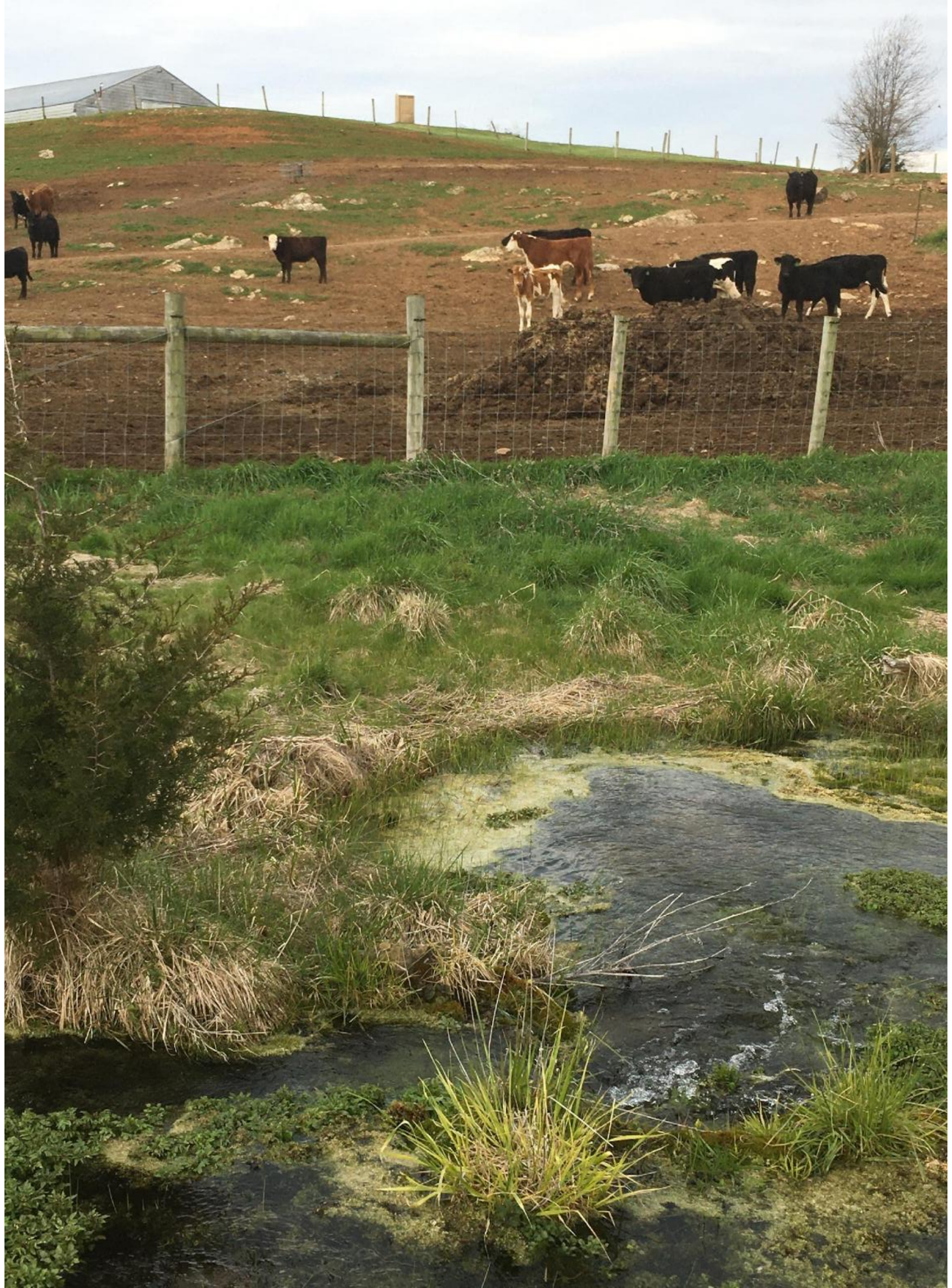
Bioreactor

Low upfront installation costs
Private benefits

High up front installation costs
No private benefits

Under voluntary cost-share programs, adoption rates fall from left to right

Would different incentive systems create different adoption behaviors?



Additional Focus on Mass Balance

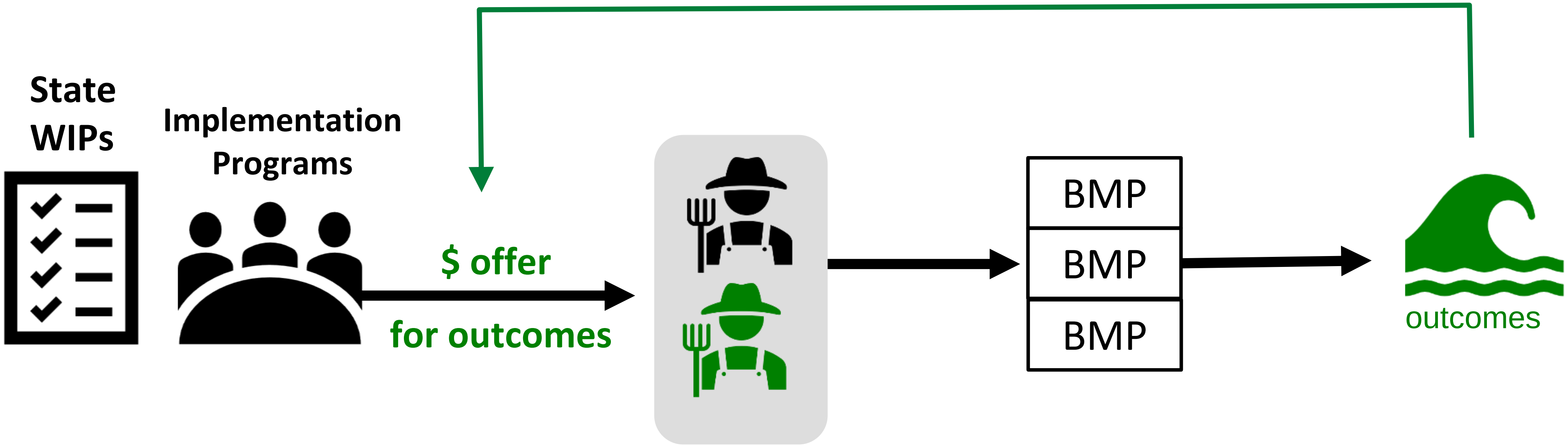
3x increase in animal numbers

Result:
Increasing N and P loads

4x increase in BMPs

Sabo et al. 2021

Pay for Performance (outcomes)



Brief Refresher on Bay Water Quality Criteria

Numeric Criteria

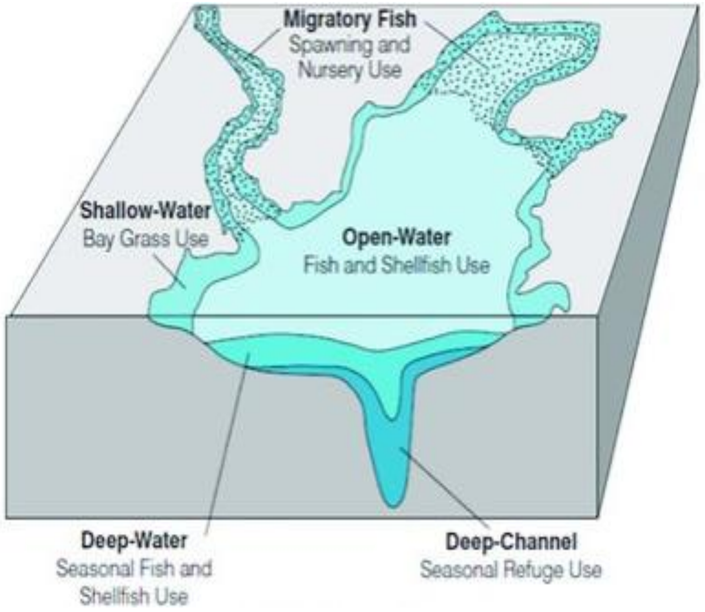
Dissolved Oxygen (DO) (30 day avg, 7 day avg, instantaneous):

Water Clarity/Aquatic Vegetation

Chlorophyll a

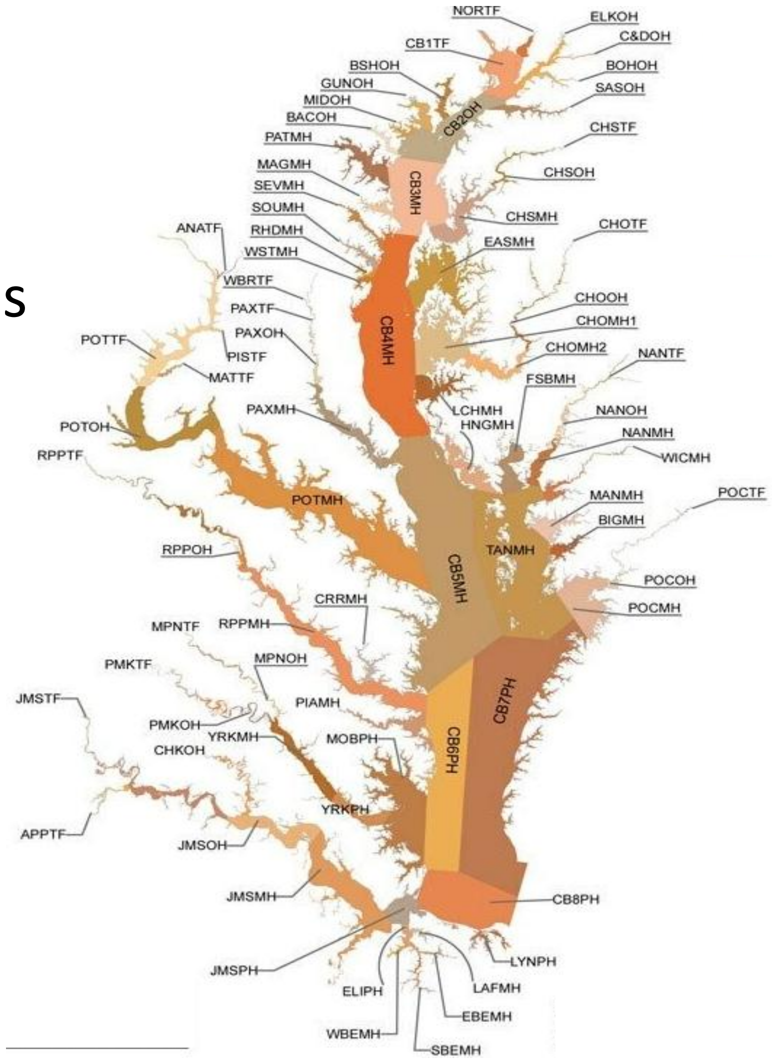
within

5 Bay habitats

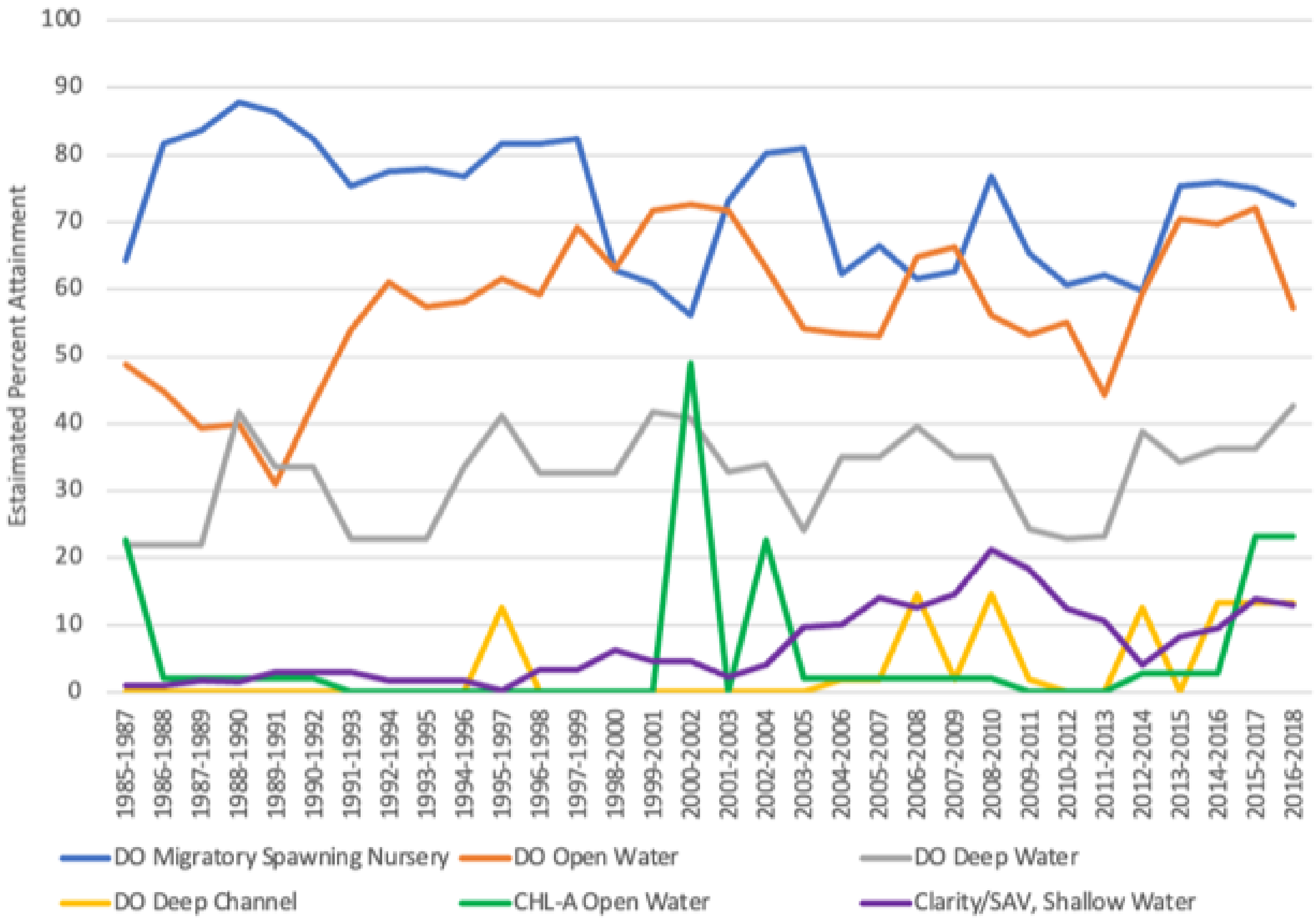


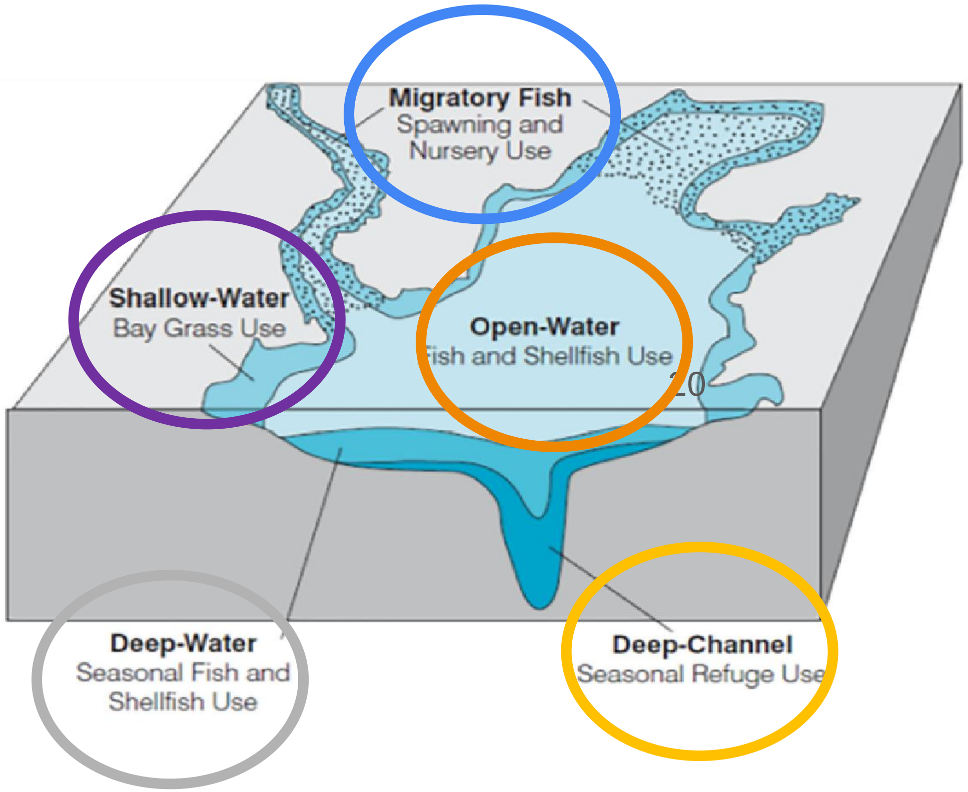
across

92 “segments”



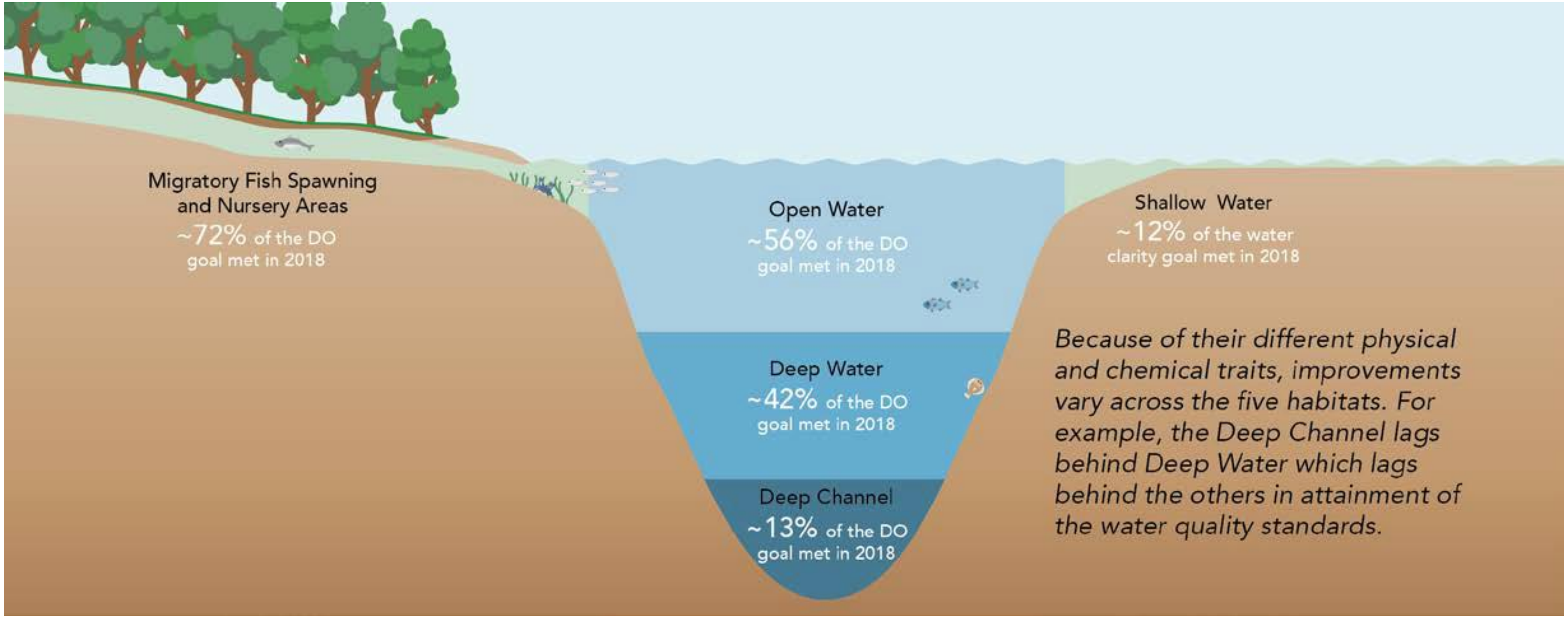
Attainment of Water Quality Criteria Across Habitats





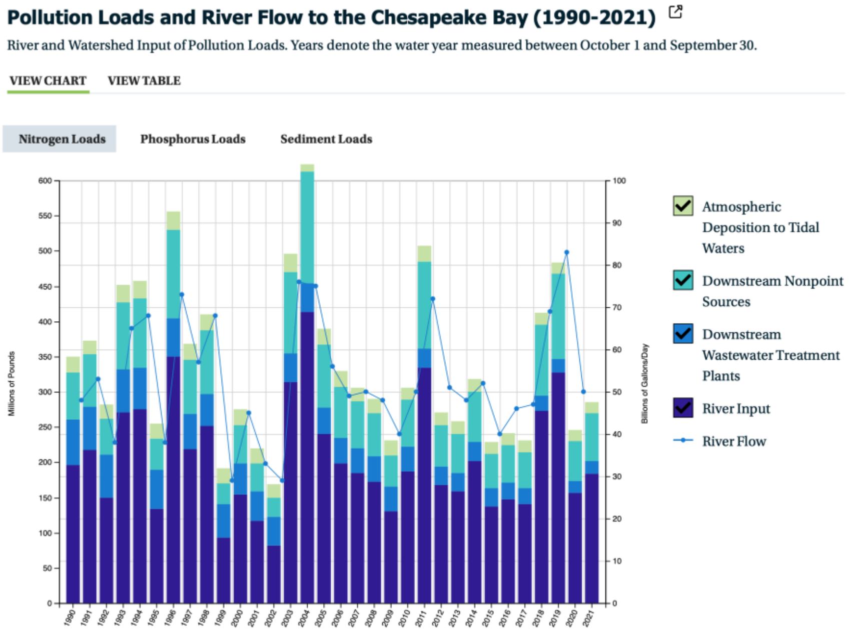
Source: Zhang et al. 2018 (with updated data)

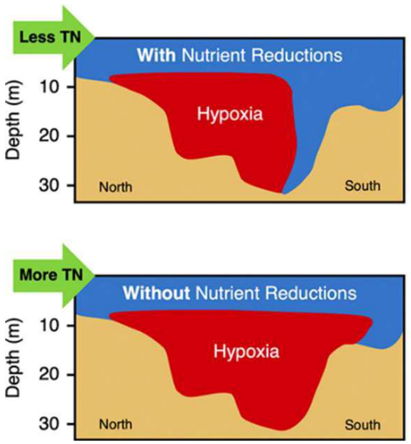
Finding: Water quality is improving, but not as expected. Some habitats are resistant to improvement, suggesting that our goals might not be met, or at least might remain unmet until the distant future.



Why?

- Load reductions are not sufficiently large over an extended period
- Climate change, especially warming of Bay waters, has dampened the response that we expected from load reductions



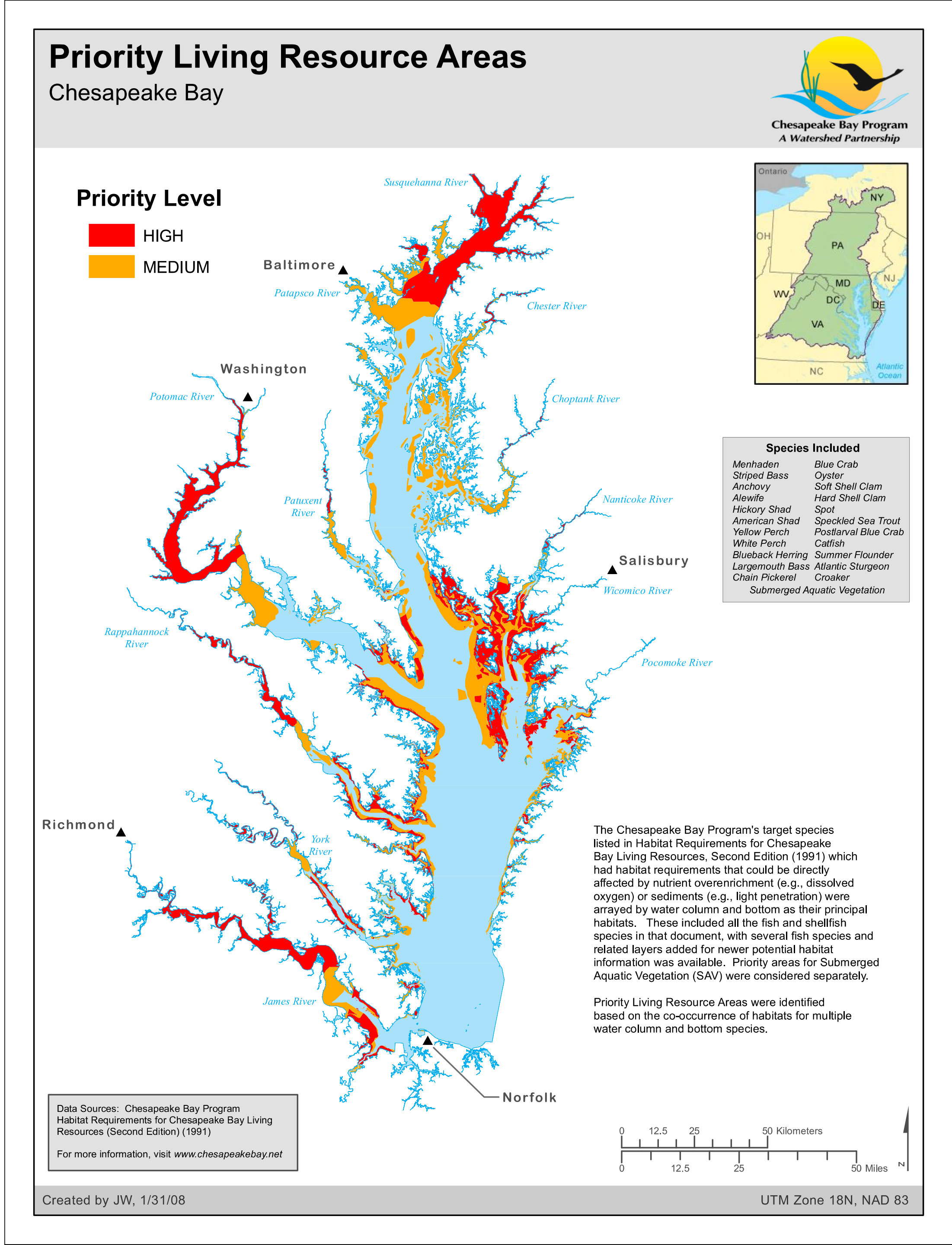


If 35 years of nutrient reductions had not occurred, hypoxia would have:

- Been **20-120% larger** for $O_2 < 3$ mg L^{-1}
- Been **30-280% larger** for $O_2 < 1$ mg L^{-1}
- Extended **further south** in the Bay
- Lasted **longer** during dry years

Achieving Bay Water Quality Goals

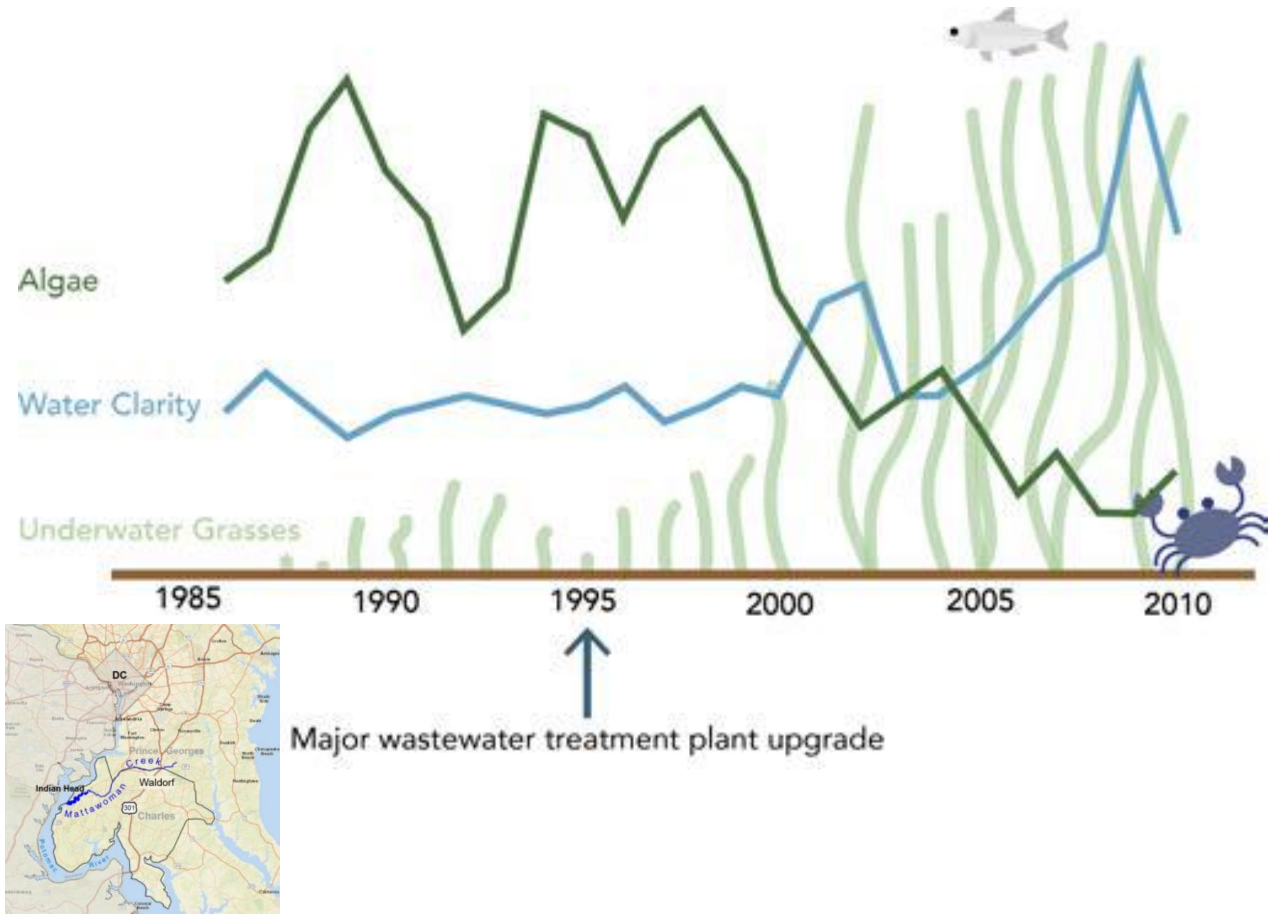
Opportunity: Prioritize our efforts to attain water quality standards so that we can achieve the largest possible benefit to living resources (example: tiered TMDL)



Achieving Bay Water Quality Goals

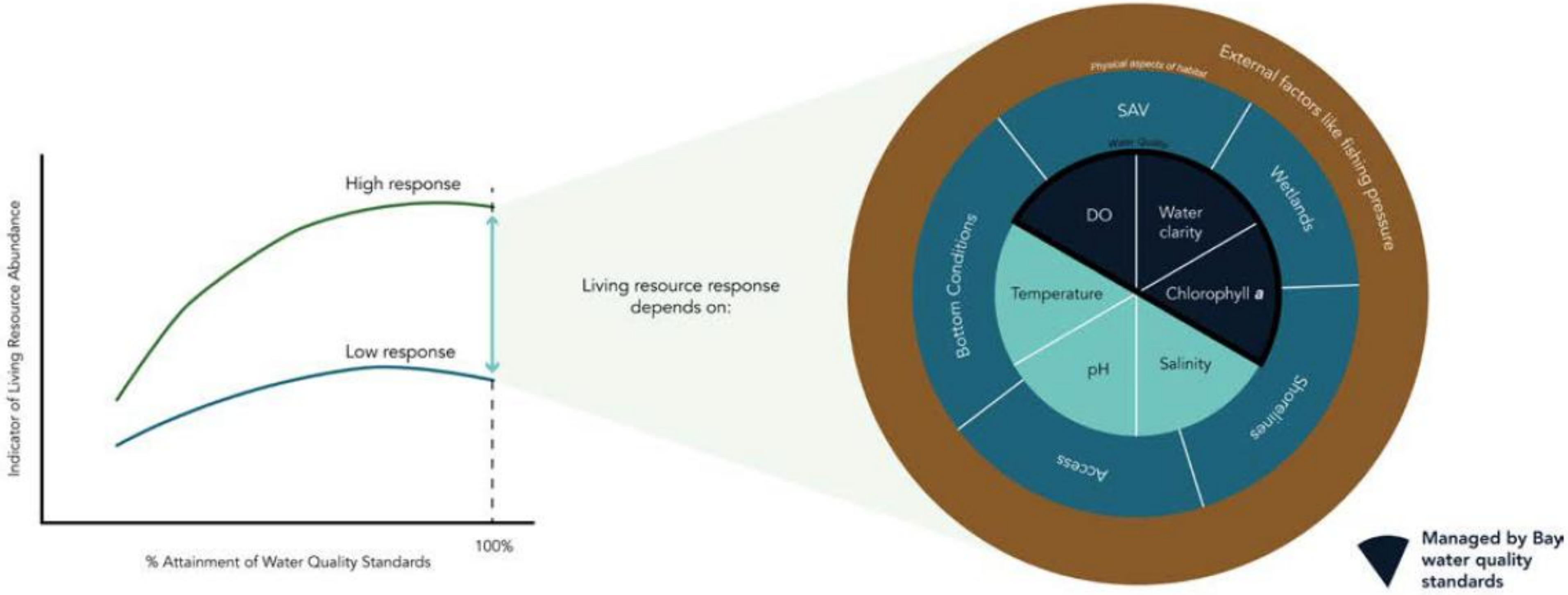
Opportunity: Full attainment of water quality standards may not be possible, but steps can be taken to maximize living resource response to improvements.

Mattawoman Creek



Achieving Bay Water Quality Standards/Living Resource Response

Opportunity: Significant enhancement of LR can be achieved with additional management actions without complete attainment of water quality goals



Achieving Bay Water Quality Standards/LR Response

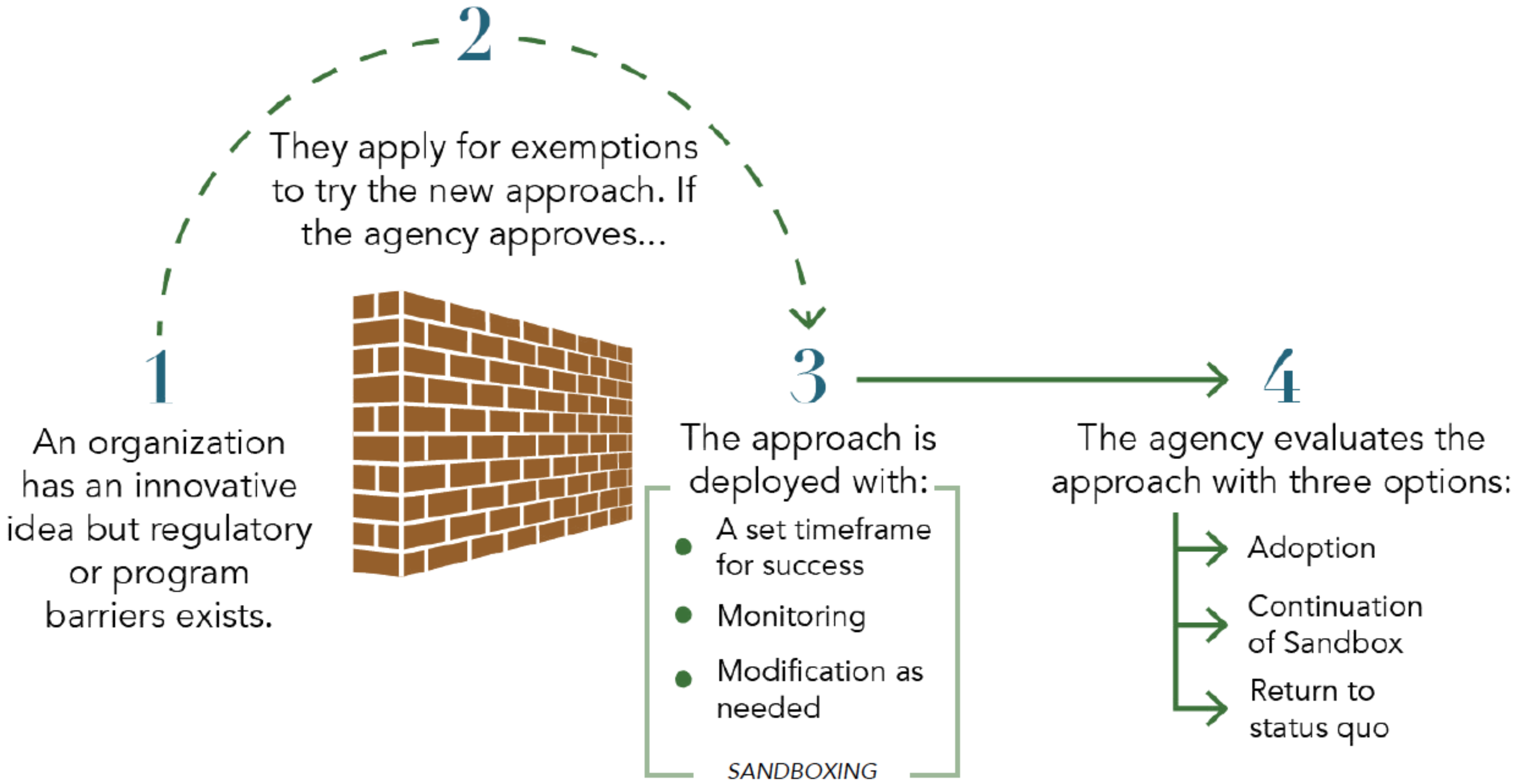
Opportunity: Don’t leave benefits to Living Resources on the table

Jane Hawkey, Integration and Application Network (ian.umces.edu/media-library)

Credit: Center for Coastal Resources Management; Kelsey Broich, Network for Engineering with Nature, University of Georgia; Integration and Application Network (ian.umces.edu/media-library)

Adaptive Management

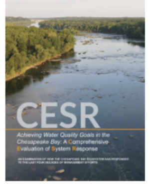
Finding: Making “learning while doing” central to Bay management



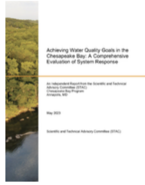
Achieving Water Quality Goals in the Chesapeake Bay: A Comprehensive Evaluation of System Response (CESR)

https://www.chesapeake.org/stac/cesr/

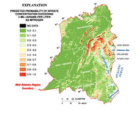
The Report



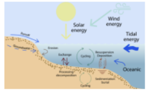
CESR Executive Summary



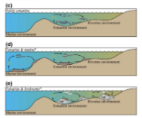
Achieving Water Quality Goals in the Chesapeake Bay: A Comprehensive Evaluation of System Response



Resource Document: Evaluation of Management Efforts to Reduce Nutrient and Sediment Contributions to the Chesapeake Bay Estuary



Resource Document: Knowledge Gaps, Uncertainties, and Opportunities Regarding the Response of the Chesapeake Bay Estuary to Restoration Efforts



Resource Document: A Proposed Framework for Analyzing Water Quality and Habitat Effects on the Living Resources of Chesapeake Bay

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