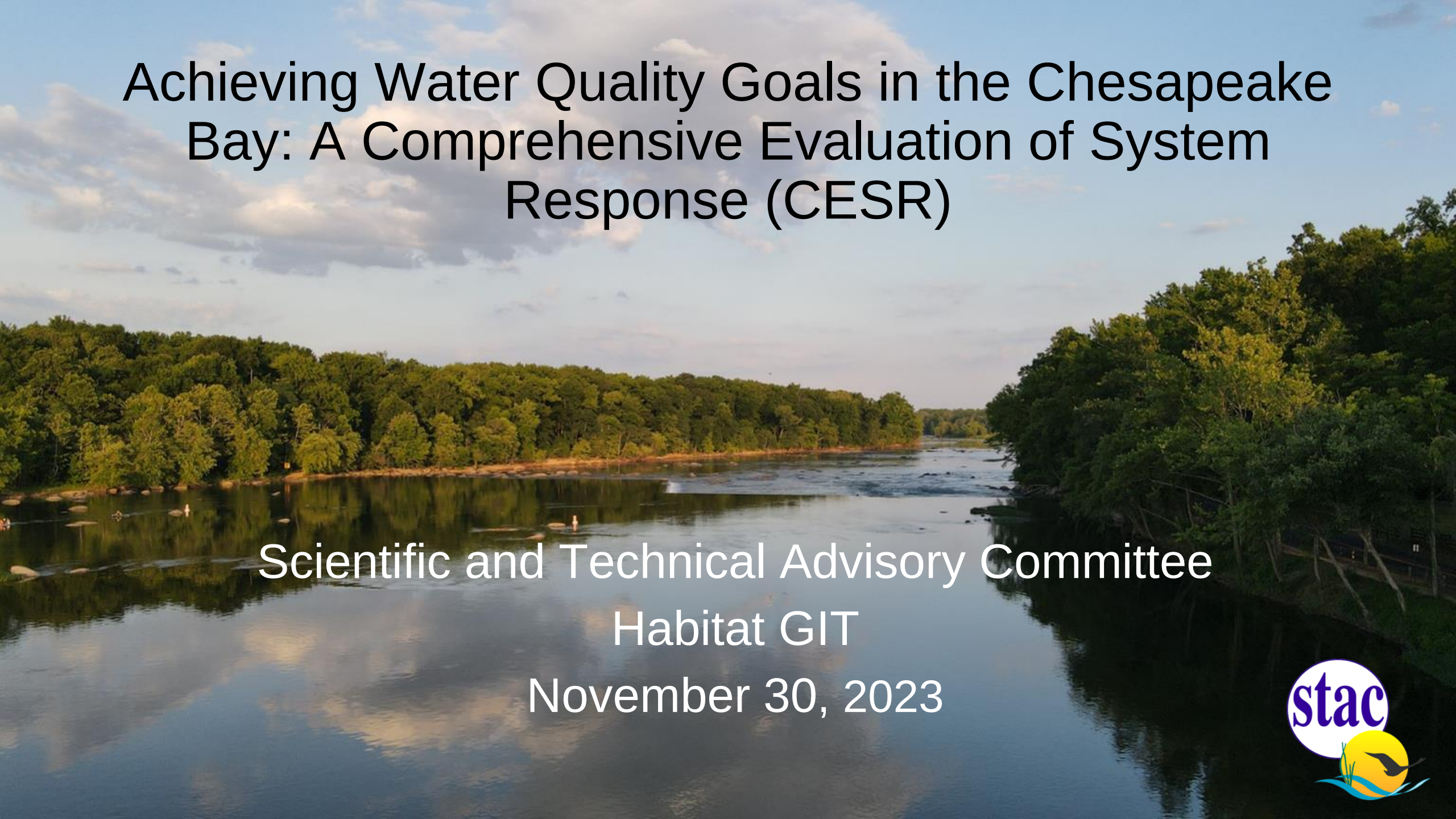
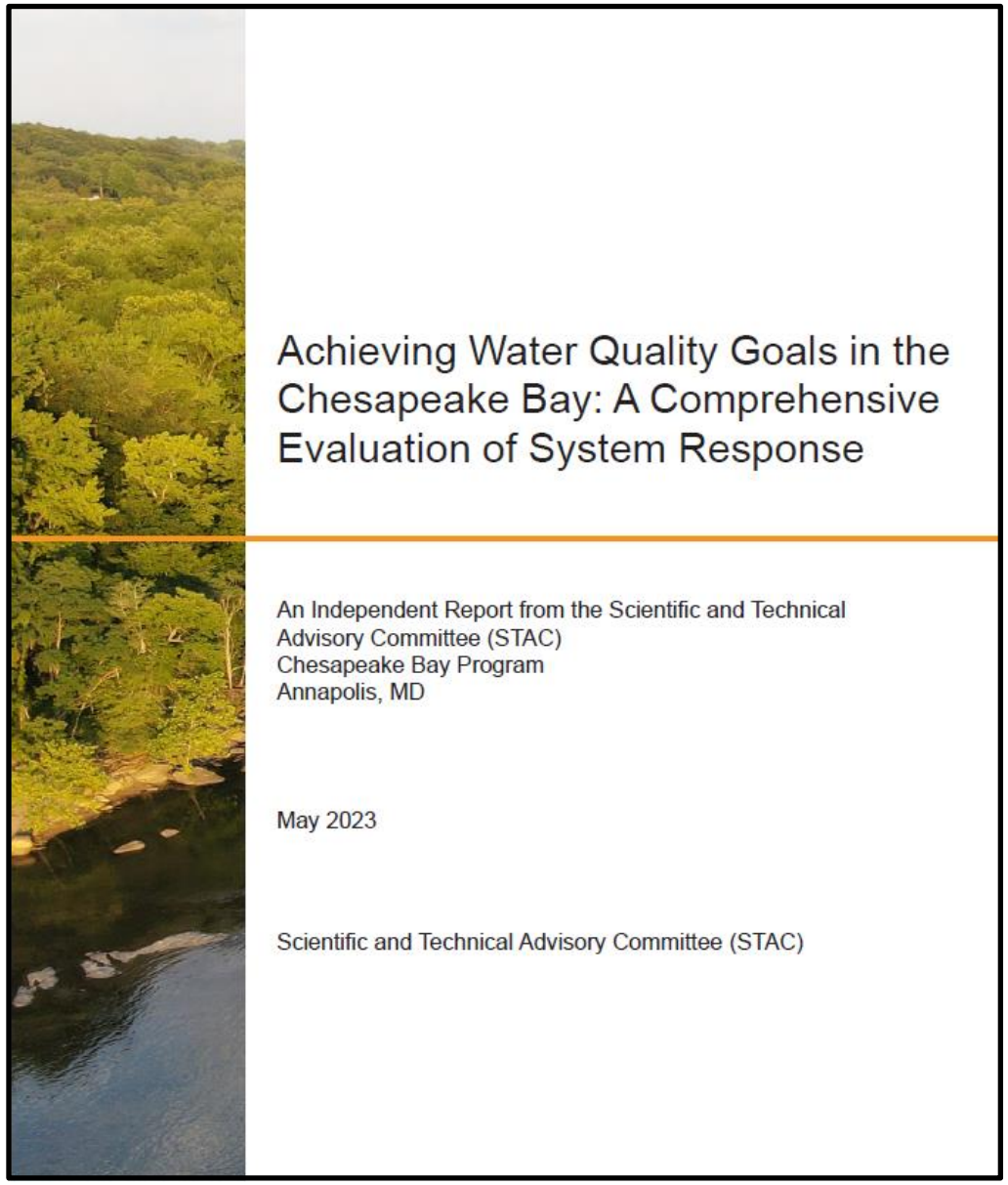
Achieving Water Quality Goals in the Chesapeake Bay: A Comprehensive Evaluation of System Response (CESR)



Scientific and Technical Advisory Committee

Habitat GIT

November 30, 2023



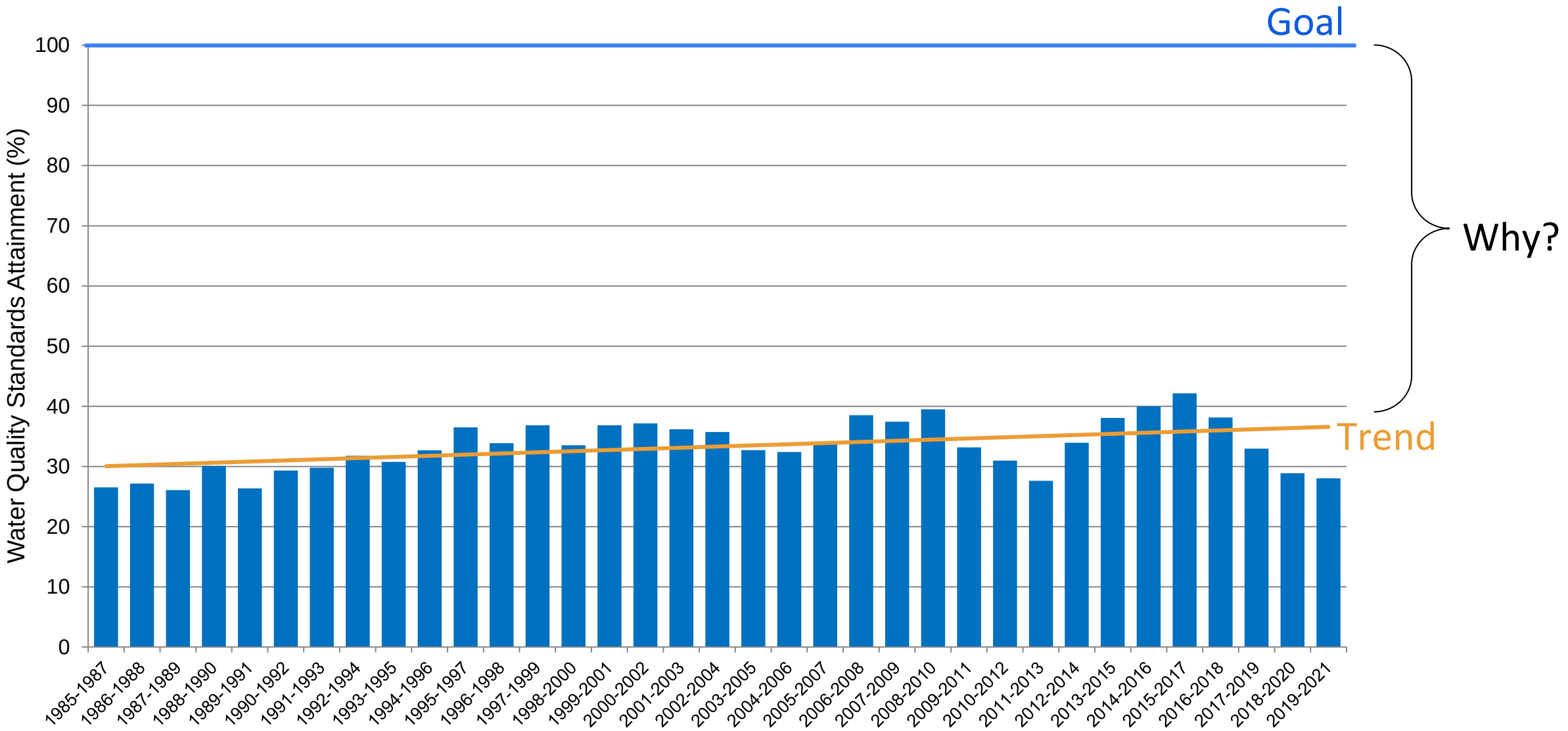
CESR Report

- Self-initiated
- Inclusive of STAC Membership
- Steering Committee
- 3 Resource Documents

Writer's Group

Bill Dennison
Zach Easton
Mark Monaco
Kenny Rose
Leonard Shabman
Kurt Stephenson (co-editor)
Jeremy Testa
Denice Wardrop (co-editor)

Motivation for CESR



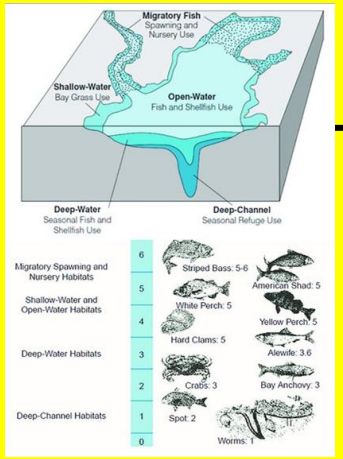
Public Policy

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 (CESR)

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 to meet WQS?

Achieving TMDL:

Are implementation policies and management actions producing sufficient nitrogen, phosphorus and sediment reductions to meet the TMDL?

CESR Executive Summary: Findings and Policy Implications

Achieving TMDL

FINDING: Existing implementation actions to reduce nonpoint sources of nutrients are insufficient to achieve the TMDL

IMPLICATION There are opportunities to further reduce nutrients from nonpoint sources, but changes to programs and policies need to be considered.

Achieving Water Quality Standards

FINDING: Preliminary analyses suggest that nutrient load reductions have not produced the expected level of improvement in estuary water quality, and this response gap is particularly pronounced in the Bay's deep channel.

IMPLICATION: Additional nutrient reductions will improve water quality, but water quality criteria may be unattainable in some regions of the Bay under existing technologies.

IMPLICATION: Opportunities to prioritize our efforts to attain water quality standards so that we can achieve the largest possible benefit to living resources

Living Resource Response

FINDING: Significant enhancement of living resources can be achieved through additional management actions without complete achievement of water quality standards across all habitats.

IMPLICATION: The legal requirements of the Clean Water Act (the water quality goal) divert attention away from considering multiple means of improving living resources (support of aquatic life as the designated use) as articulated in the Chesapeake Bay Watershed Agreement.

IMPLICATION: Opportunities exist to adjust approaches to prioritize management actions that improve living resource response

Enhancing Adaptive Mgmt

FINDING: The Chesapeake Bay Program's current portfolio of adaptive management processes is inadequate to address the uncertainties and response gaps described in this report

IMPLICATION: Expanding the scope of adaptive management could address critical uncertainties and response gaps.

Achieving TMDL:

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

Two Challenges

1) Nonpoint source programs not generating the scale and type of adoption/behavior change needed to meet TMDL ("Implementation Gap")

2) Nonpoint source programs may not be as effective as expected in producing nutrient reductions ("Response Gap")

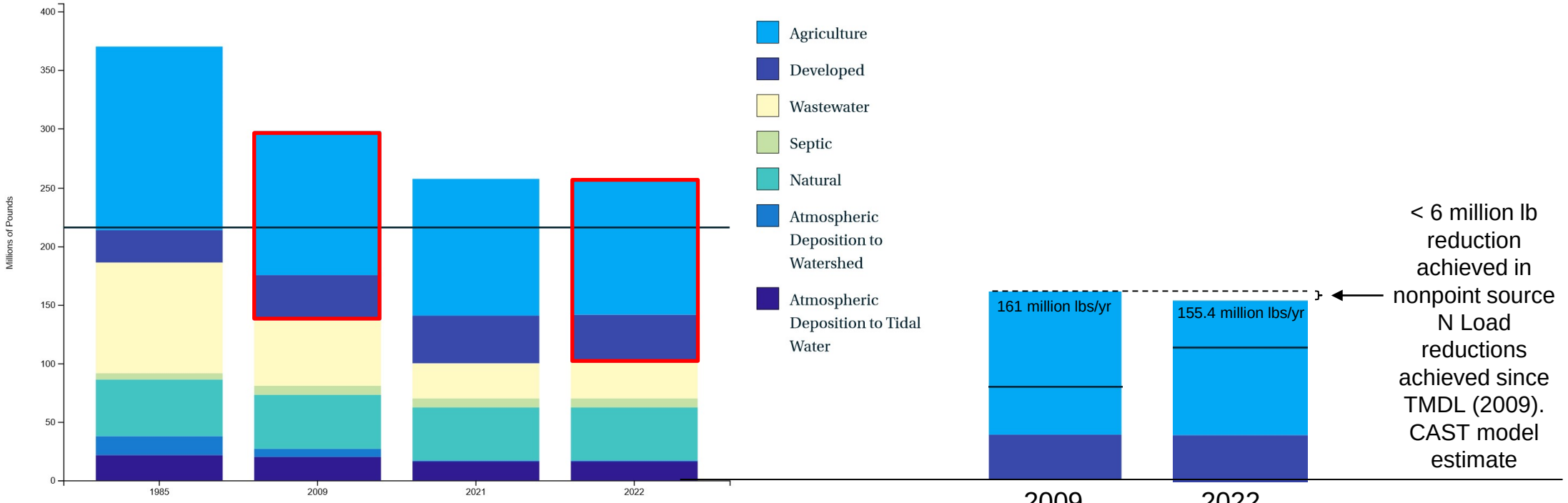
Nonpoint Source Implementation Gap: Are nonpoint source programs generating enough reductions?

Modeled Nitrogen Loads to the Chesapeake Bay (1985-2022)

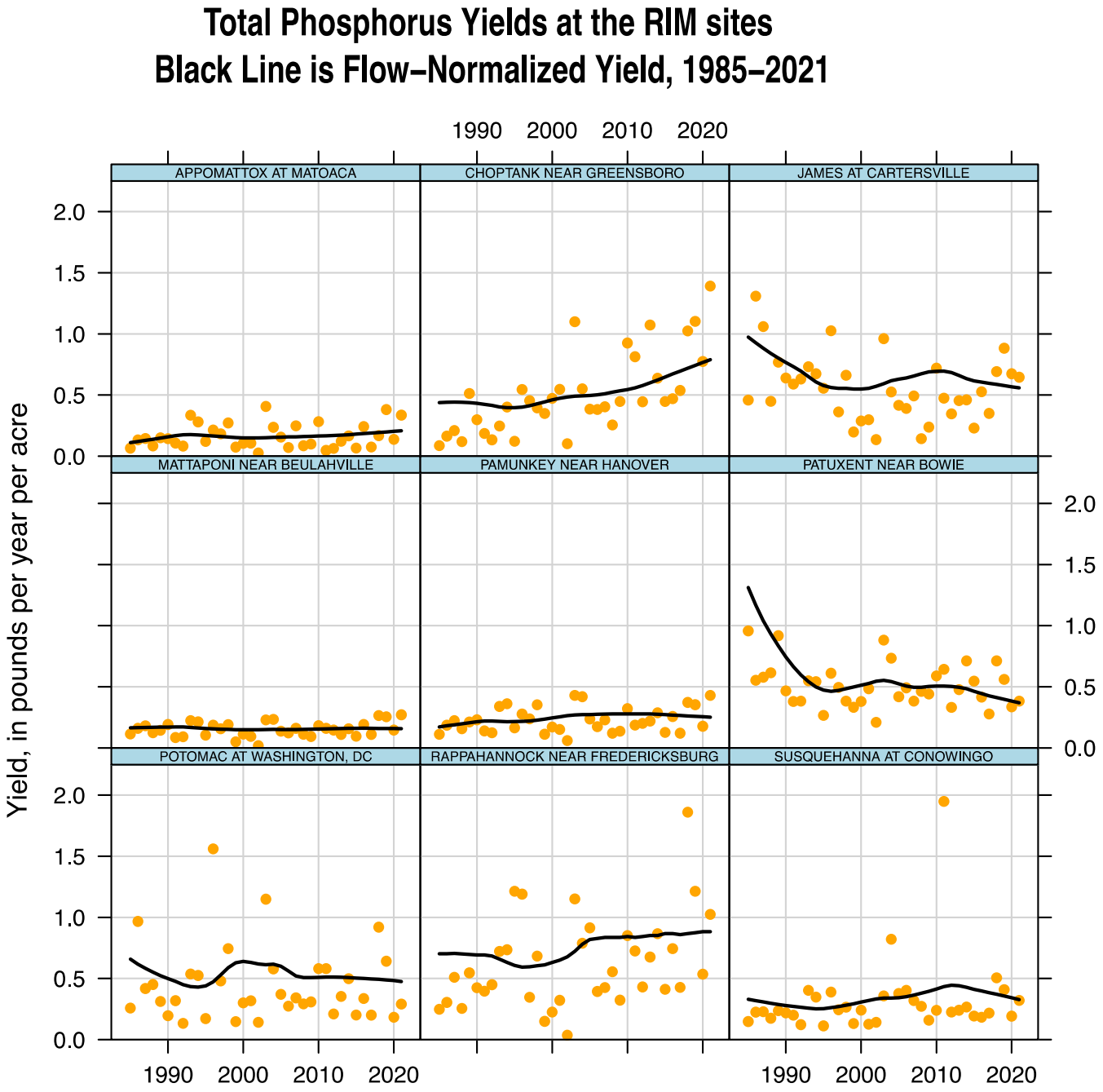
Loads simulated using CAST-19 and jurisdiction-reported data on wastewater discharges. *The natural sector includes, in part, forests and wetlands which are preferable land use types with the lowest loading rates among sources.

VIEW CHART VIEW TABLE

Loads by Source Loads by Jurisdiction



< 6 million lb reduction achieved in nonpoint source N Load reductions achieved since TMDL (2009). CAST model estimate



Mason and Soroka, 2022

USGS estimates of long term trends in TN and TP loads in 9 RIM stations (1985-2021) (trends shown on left):

Declining TP loads:

James, Potomac, and Patuxent.

Increasing TP loads:

Appomattox, Choptank, Rappahannock, Pamunkey.

No detectable trend:

Susquehanna (Conowingo), Mattaponi,

CAST model estimates (% change since 1985)

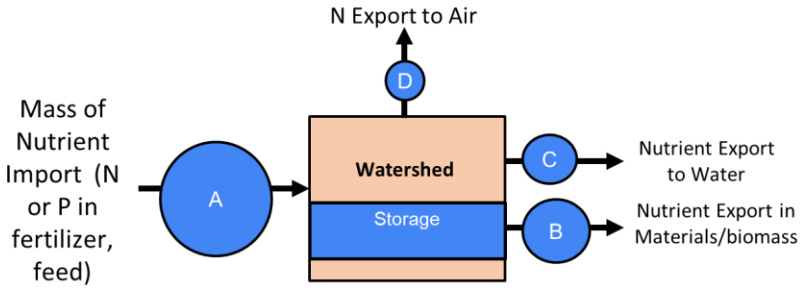
Declining TP loads:

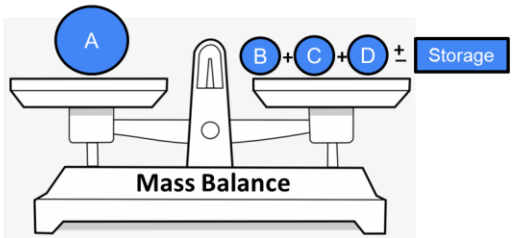
James (-73%), Potomac (-70%), Patuxent.(-19%), Susquehanna (-72%), Appomattox (-11%); Pamunkey (-28%); Rappahannock (-51%), Choptank (-45%)

Increasing TP loads:

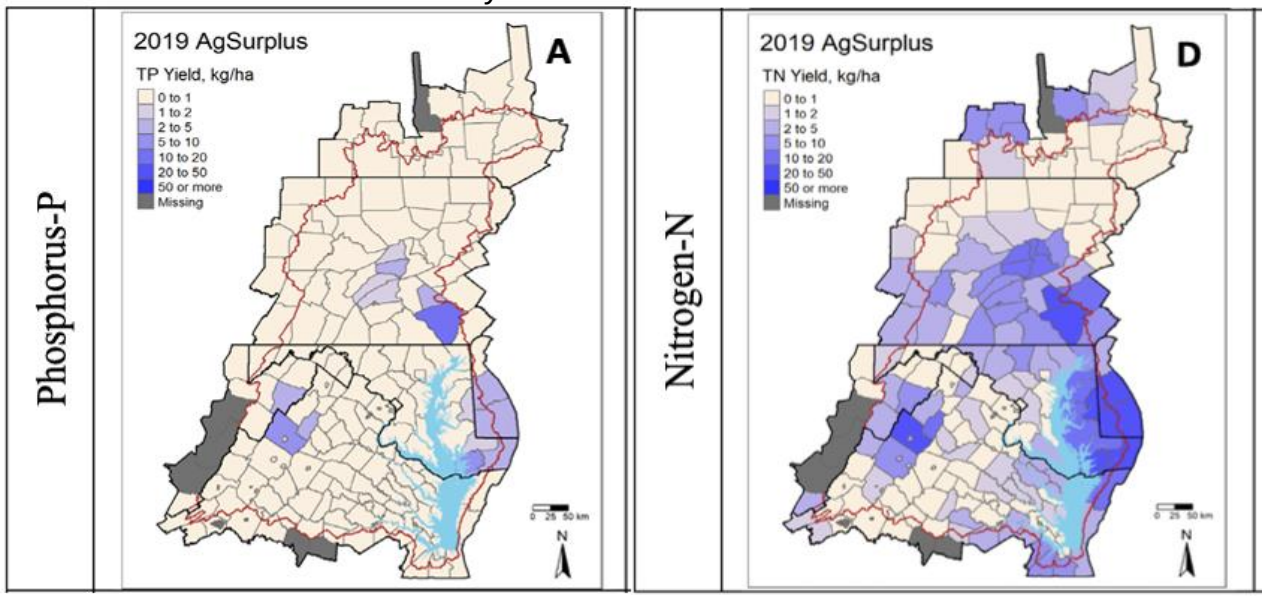
Mattaponi (+6%)

Nutrient Mass Balance



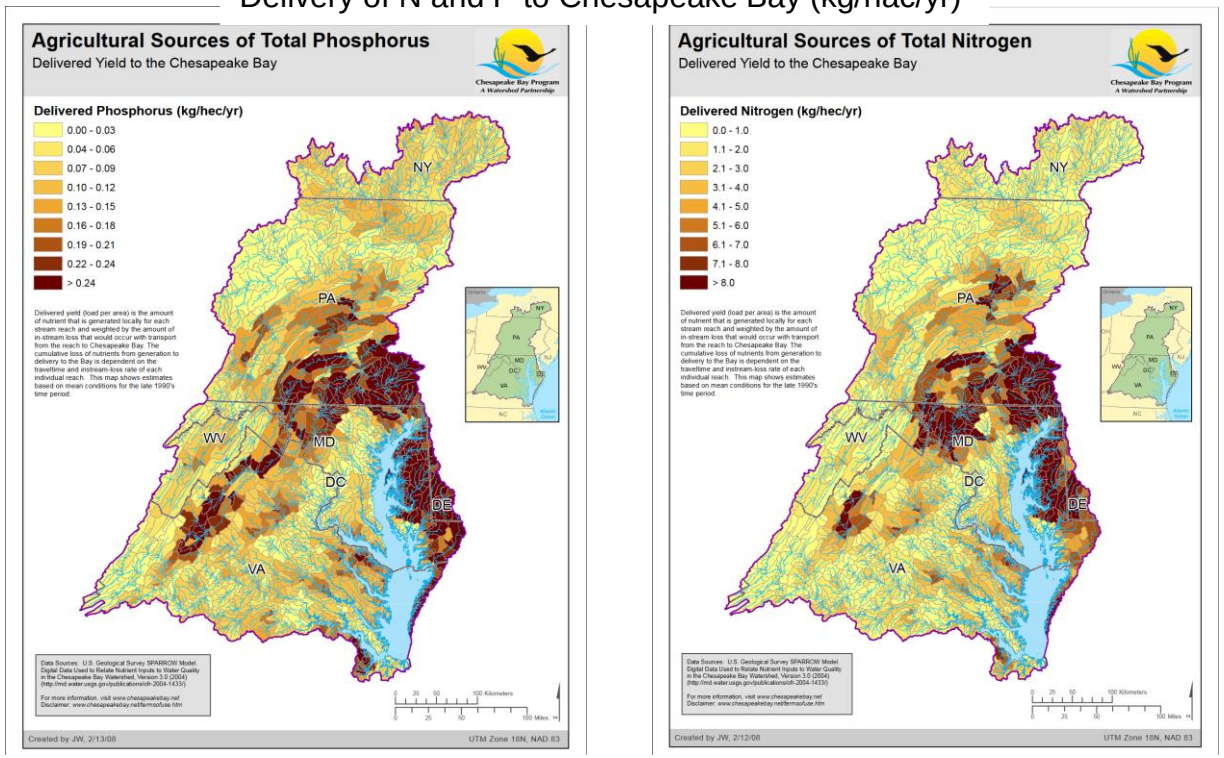


County-level Nutrient Mass Balances



Sabo et al. 2022

Delivery of N and P to Chesapeake Bay (kg/hac/yr)



Achieving TMDL

How/ how much have changes and intensification in ag production and imported nutrients affected quantifying BMP effectiveness?

Illustration of a CBP showcase watershed: Smith Creek, VA

Over past 3 decades, the number of animal units increasing

Over past 3 decades, 4x increase in # of BMPs installed in watershed

Pictured: riparian buffer at headwater spring

Net Result:

TN loads increasing over time

Data: Jimmy Webber, USGS

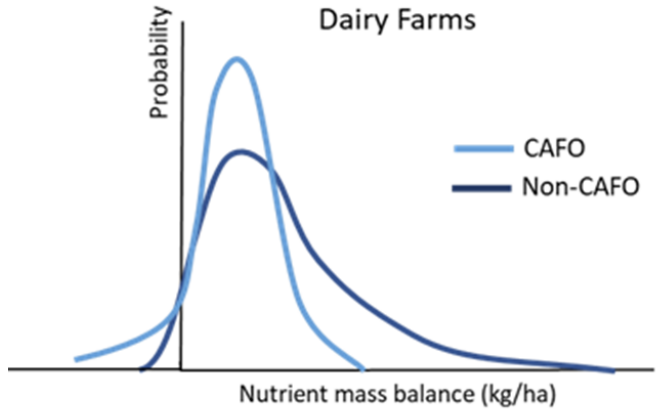
Opportunities to Target Nonpoint Source Investments

What will the report's impact be for efforts to get agricultural BMPs on the ground? ie: Targeted BMPs/watersheds?

Nutrient loads also vary across land managers

Total Phosphorus Balance Across 58 Dairy Farms in Shenandoah Valley Virginia, 2018

Quartile	Total P balance (kg/ha)
Minimum	-30.9
1st Quartile	1.5
Median	12.4
3rd Quartile	18.7
Maximum	97.6



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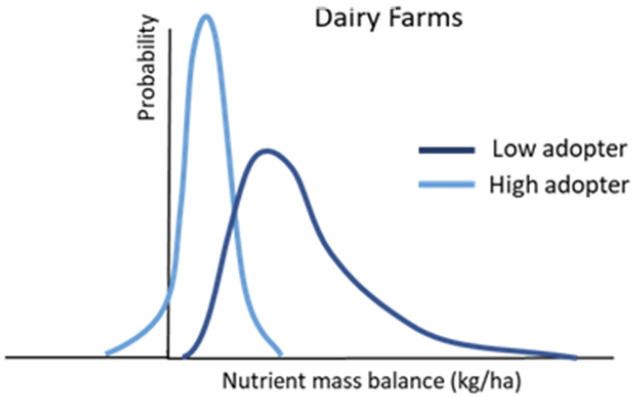


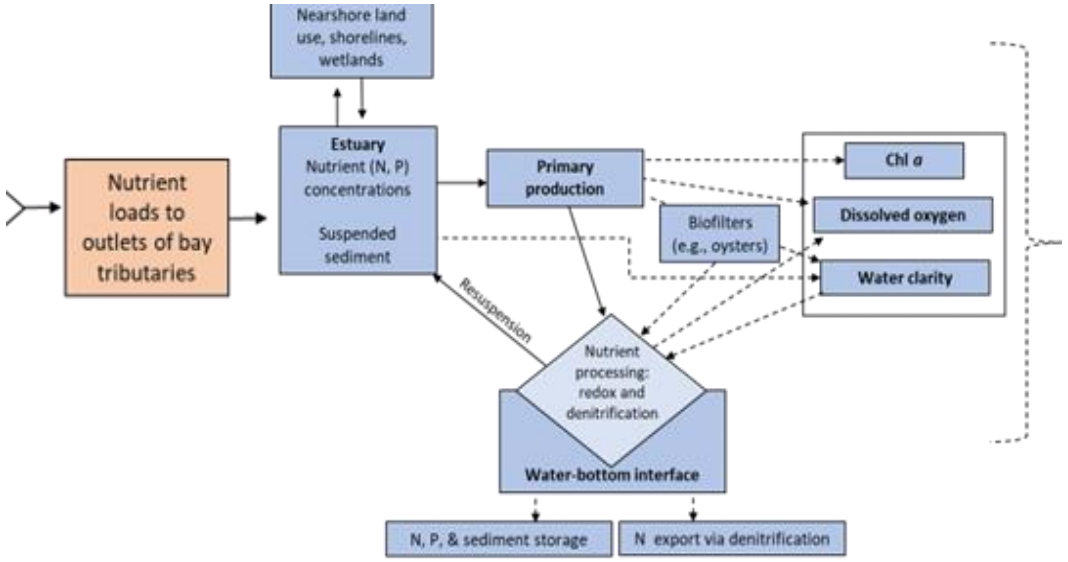
Pearce & Maguire 2020

Opportunities to Improve Nonpoint Source Program Effectiveness

Shift emphasis on Outcomes
Improved Targeting
Outcome-based Incentives (“pay for performance” “pay for success”)
Additional Emphasis on Mass Balance

Achieving Water Quality Standards:

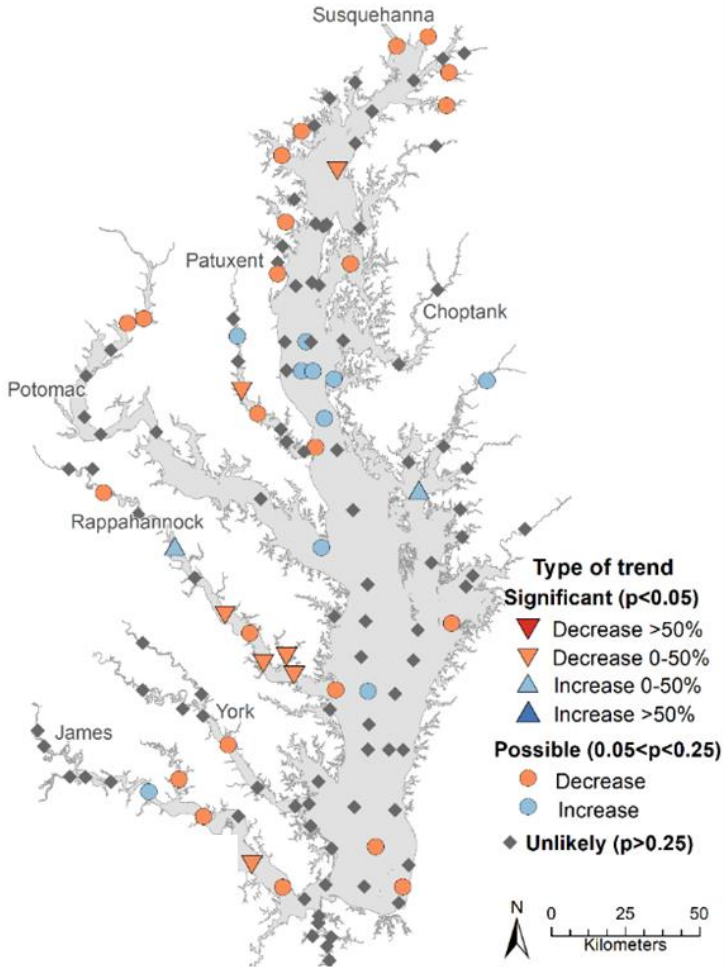
Findings: Bay water quality is improving, but the magnitude of the improvement appears to be lagging behind expectations



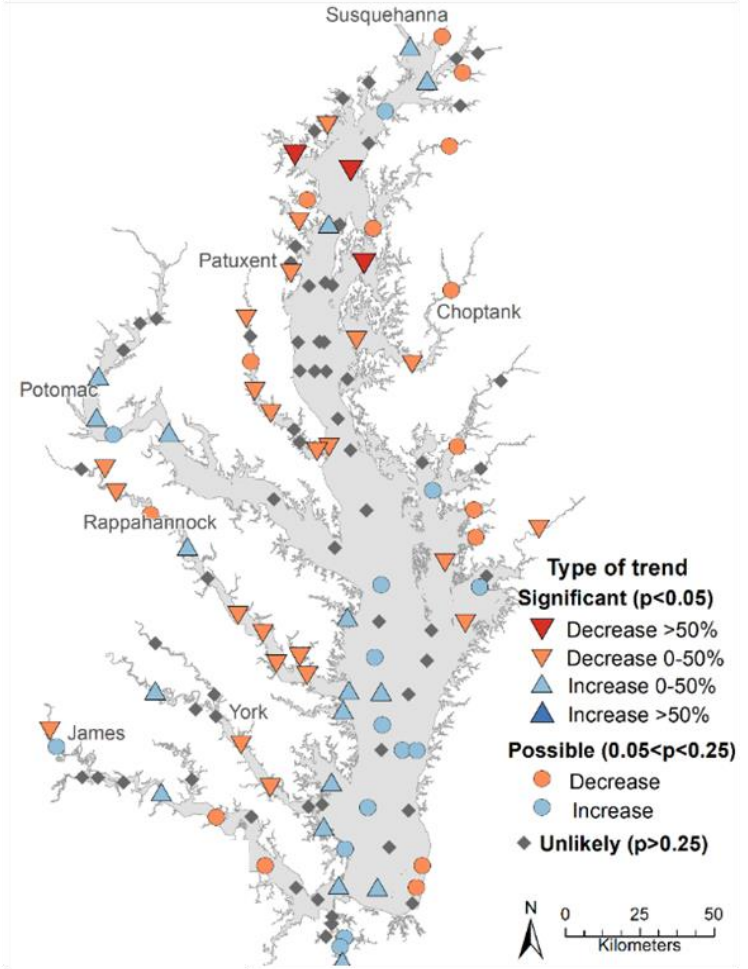
Dissolved Oxygen Response at Bay Scale

Chesapeake Bay bottom summer (June-Sept) dissolved oxygen

Short term change (2012 to 2021)

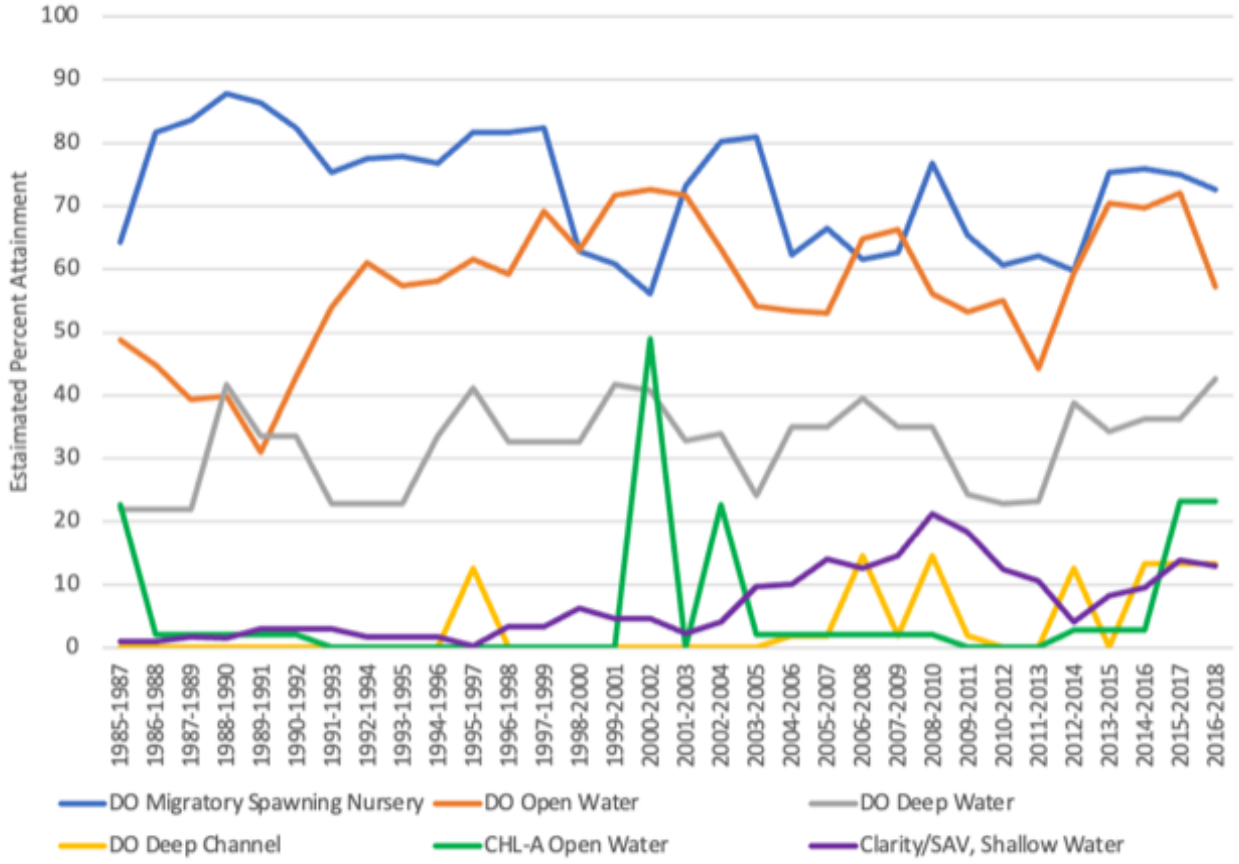


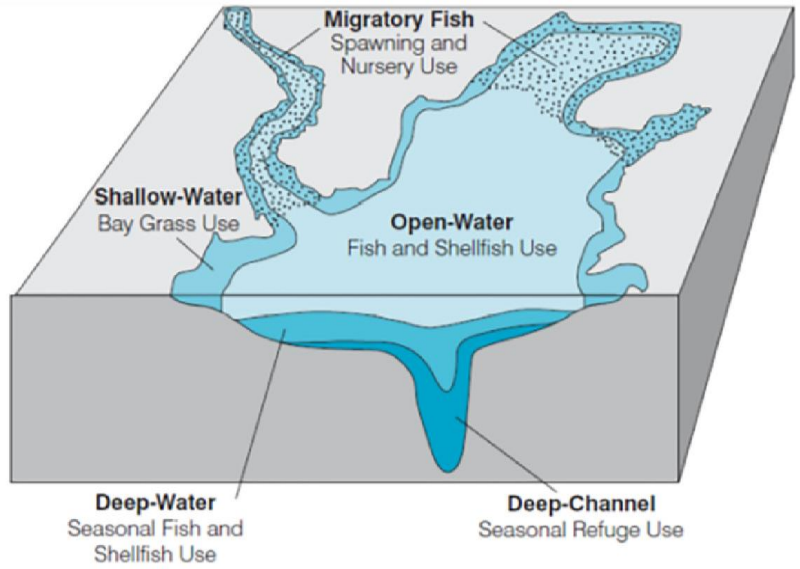
Long term change (1985/6 to 2021)



(Source: CBP)

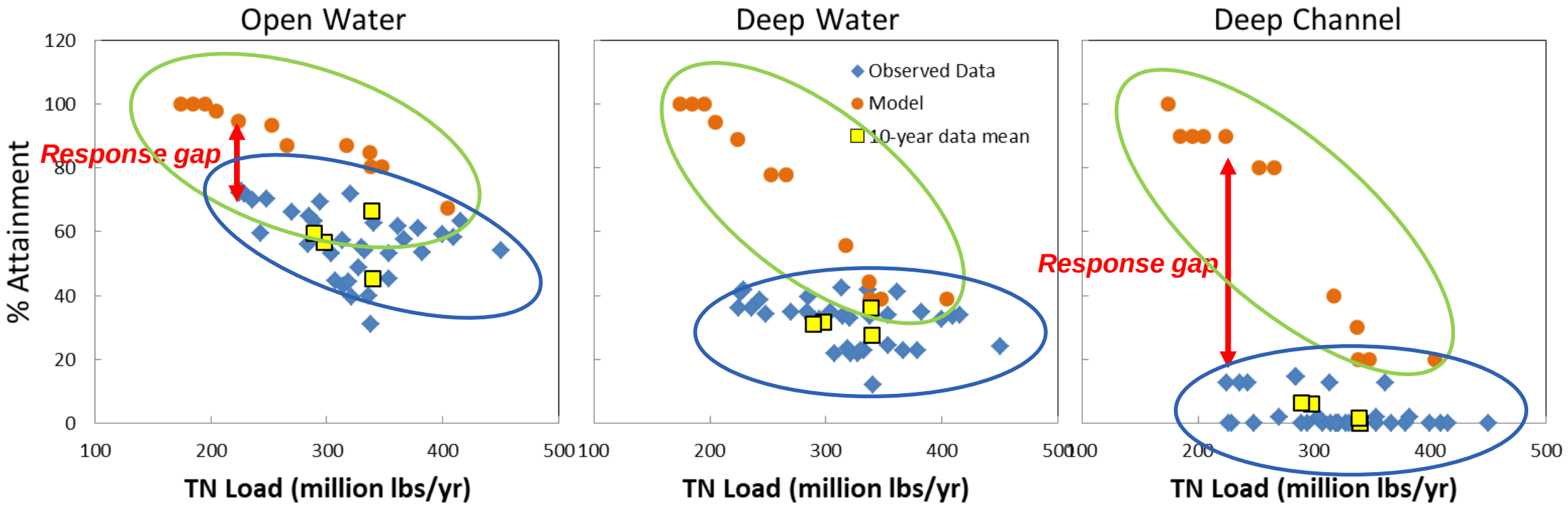
Observed Attainment of Water Quality Criteria Across Habitats





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

Finding: DO Response across Habitats

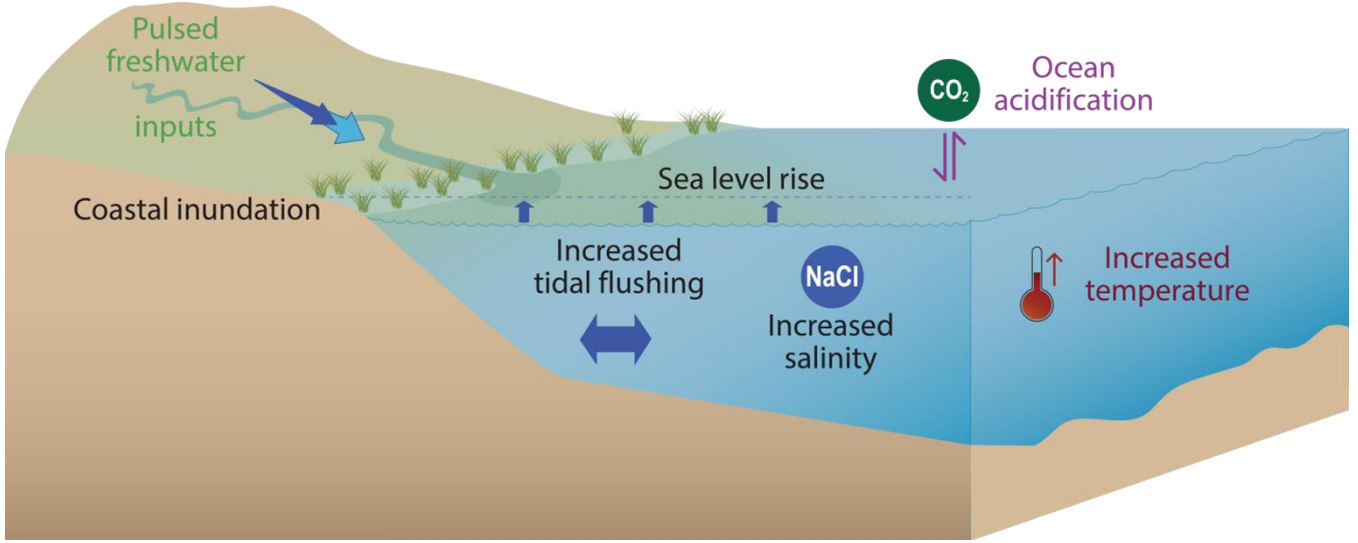


Expected and realized relationships between TN loads and DO criteria attainment for open water, deep water, and deep channel habitat, calculated as 3-year running mean observed values (blue diamonds) and expected responses from estuary model (orange dots) for the same time periods. Yellow squares are 10-year means of the observed data.

Why Do We have Response Gaps?

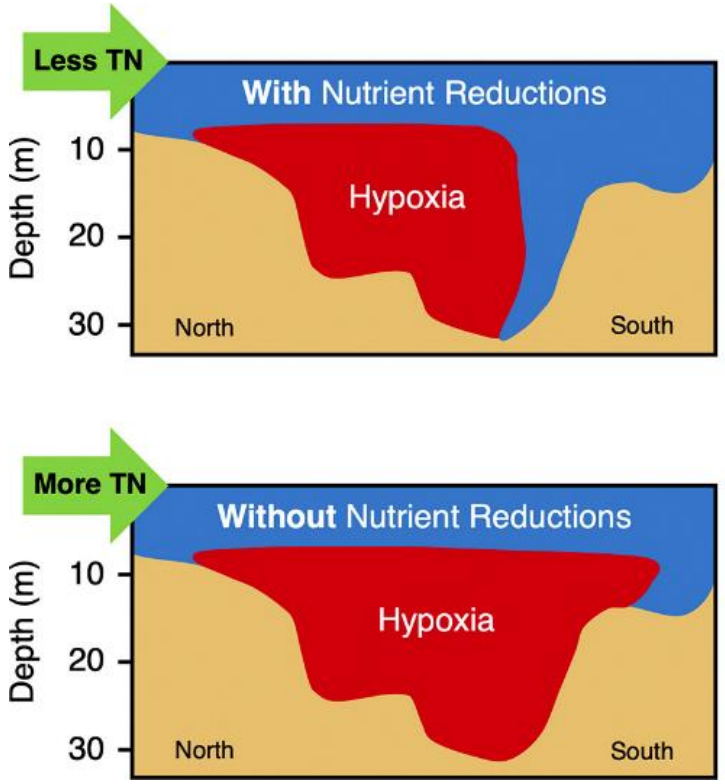
Some Answers (all have uncertainties):

(a) **Climate change**: warming, sea level rise, precipitation



(b) **Tipping points and associated feedbacks**: Features that make Bay changes not always immediately available

Climate Change

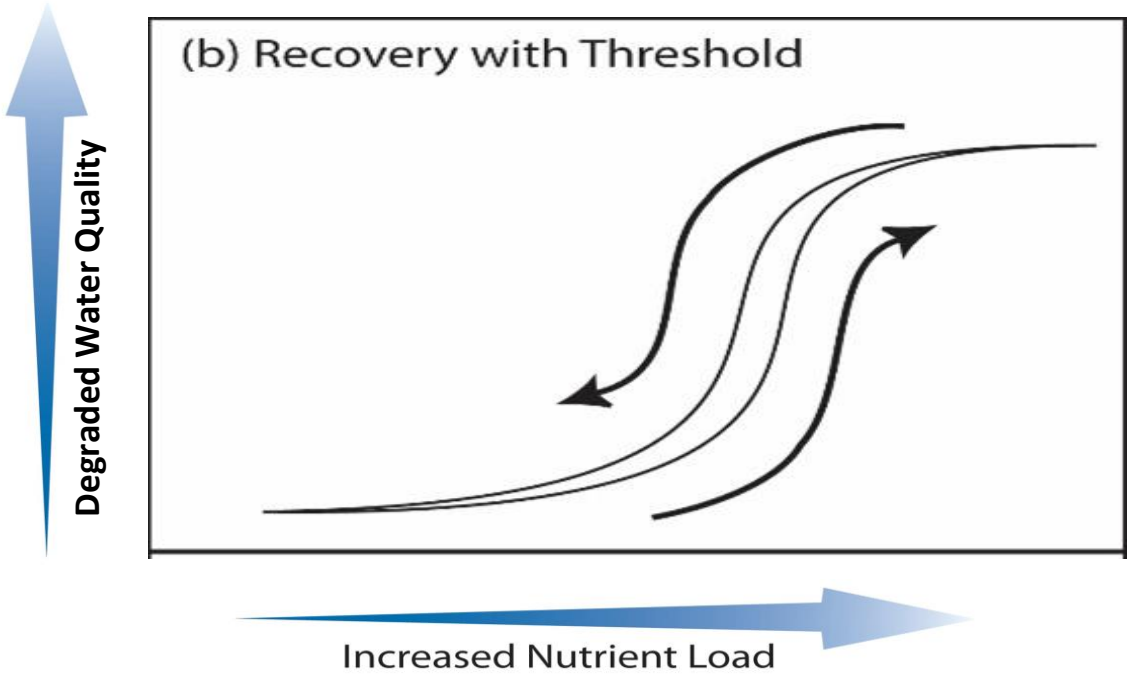


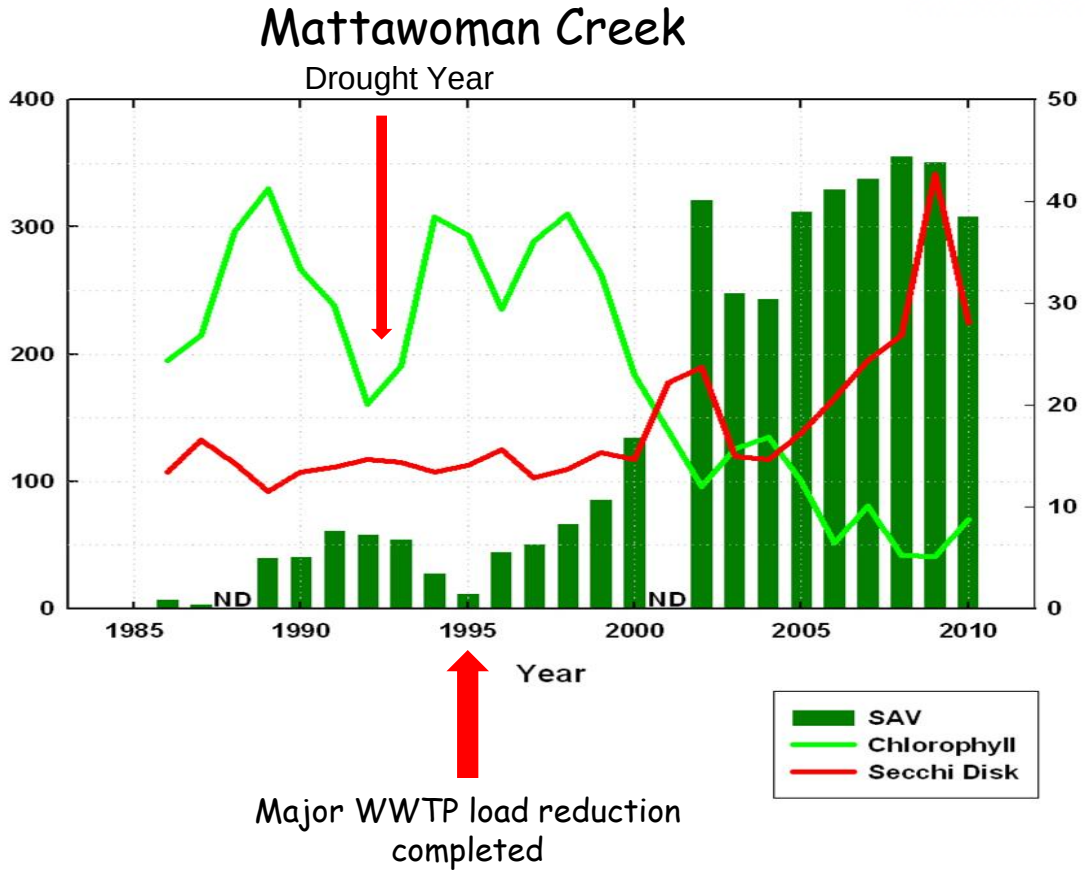
If 35 years of nutrient reductions had not occurred, hypoxia would have:

- 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

FIGURE 4.13.—Estimated extent of Chesapeake Bay hypoxia with and without 35 years of nutrient reductions (Source: Frankel et al., 2022).

Tipping Points and Feedbacks:
Where Restoration Stalls, or Takes off



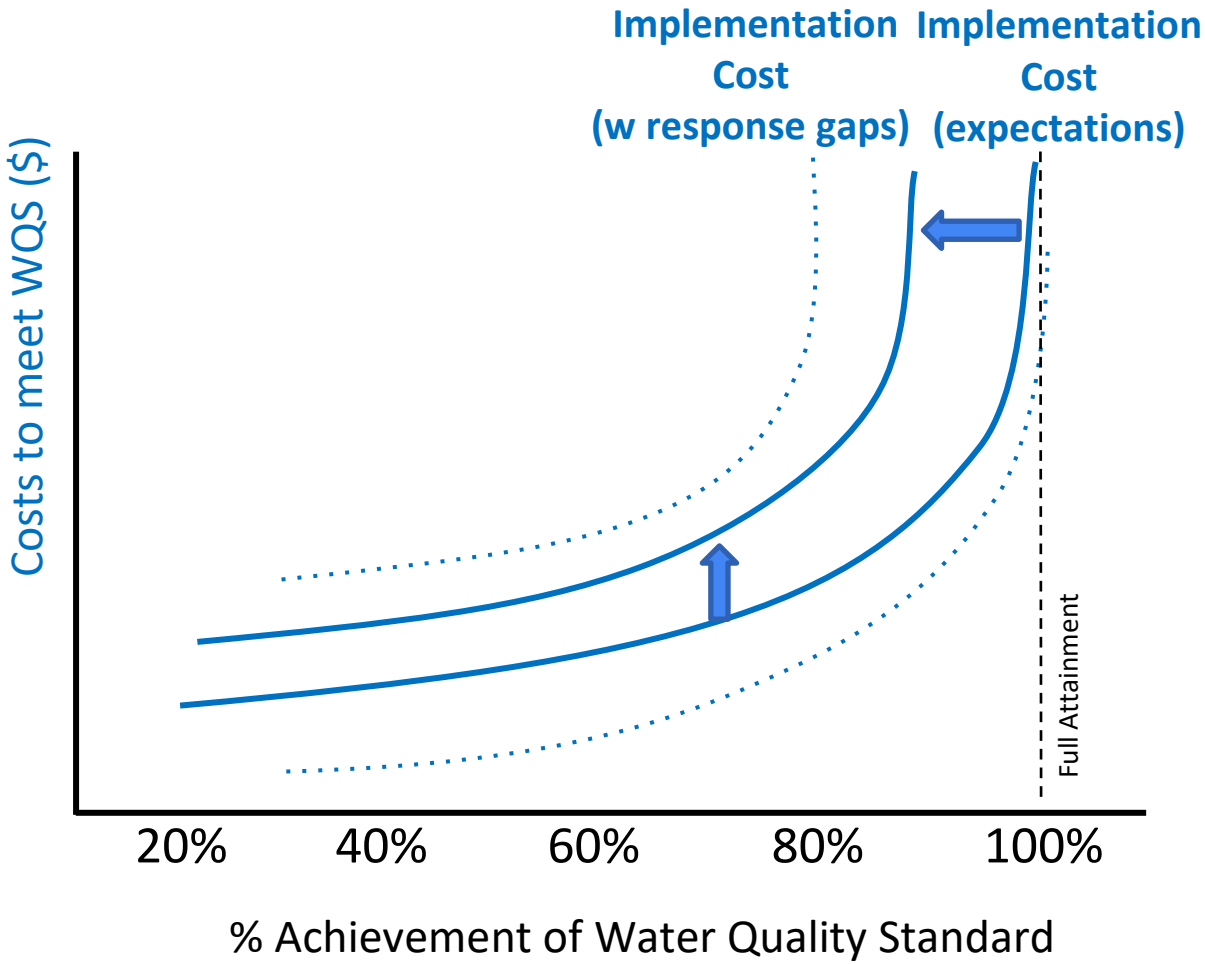


Achieving Water Quality Standards:

Implications: Water Quality Criteria may be unattainable in some regions of the Bay under existing technologies.

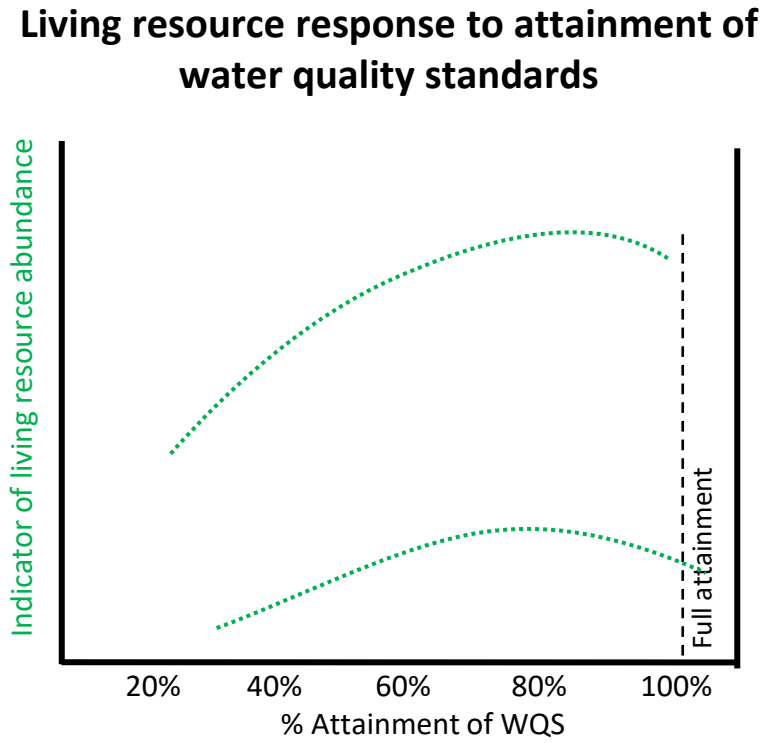
Implications: Opportunities to prioritize our efforts to attain water quality standards to achieve greater benefit to living resources

Costs of Achieving TMDL and Water Quality Criteria

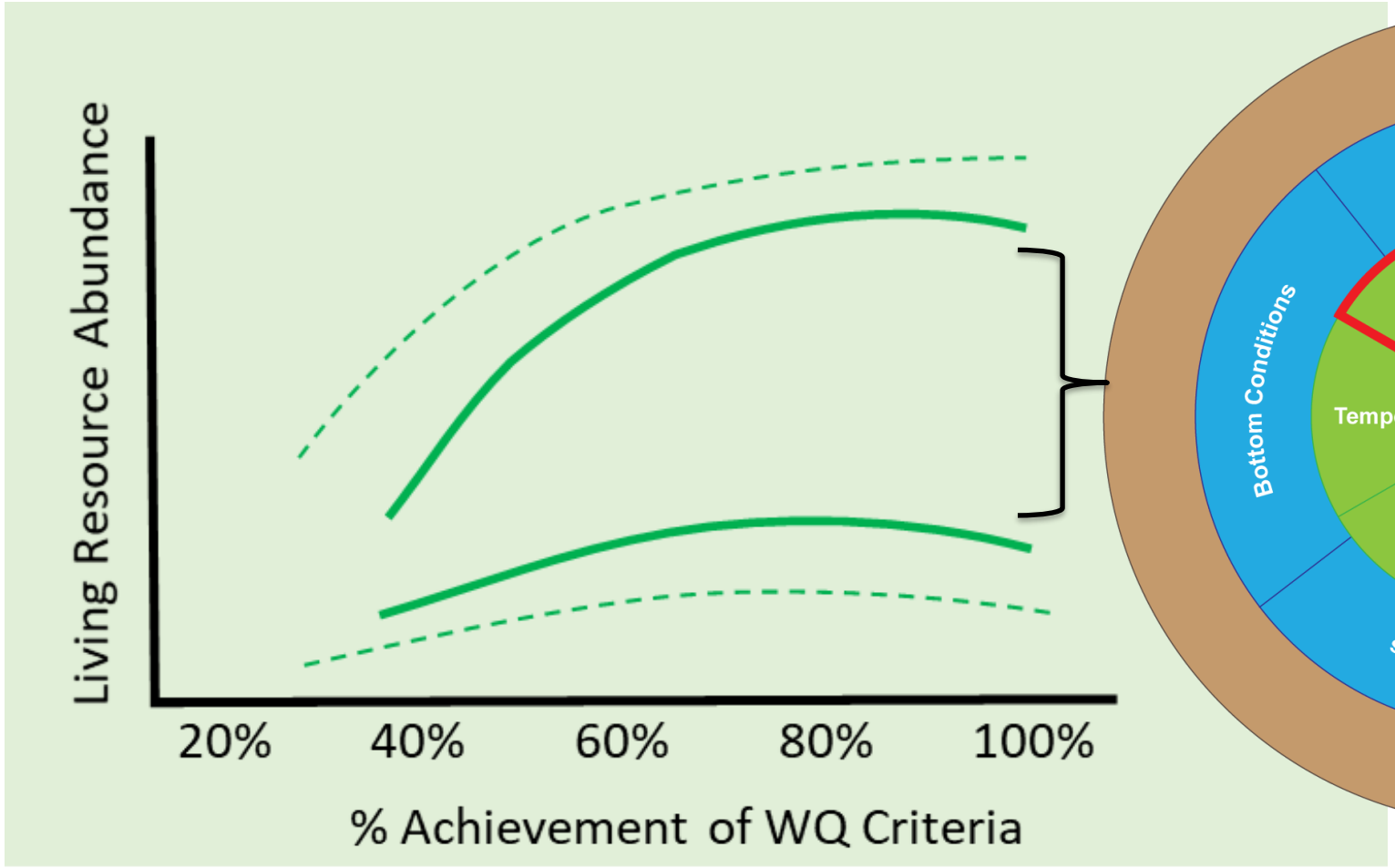


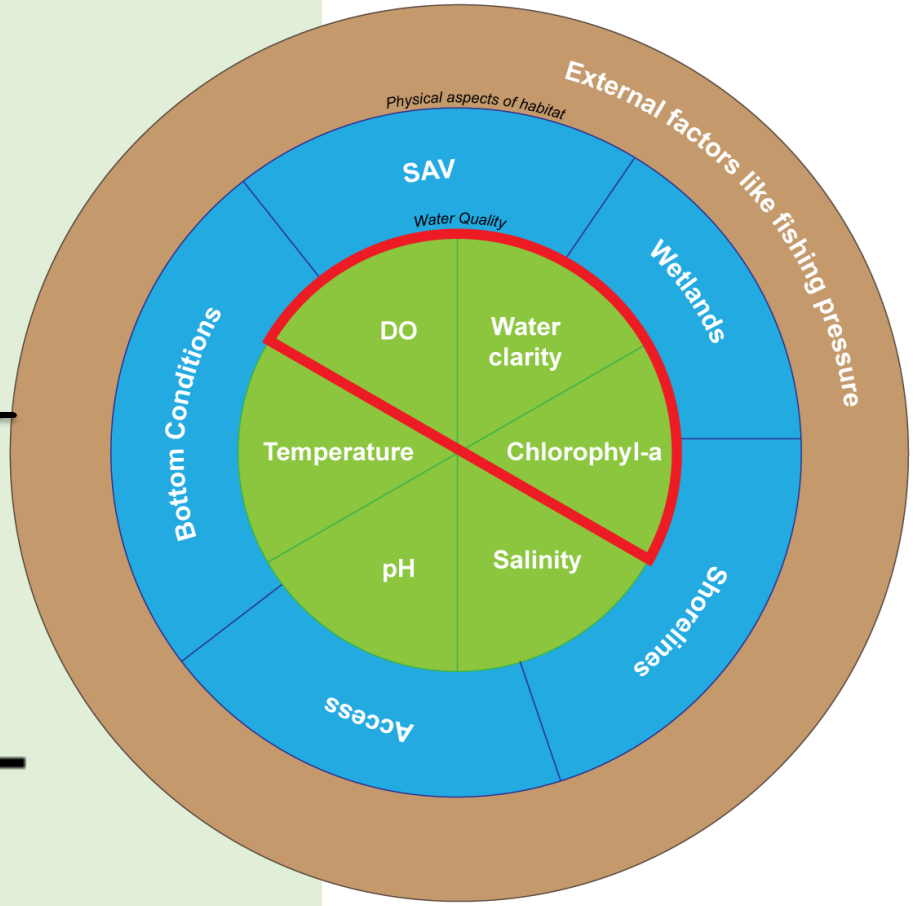
Living Resource Response

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



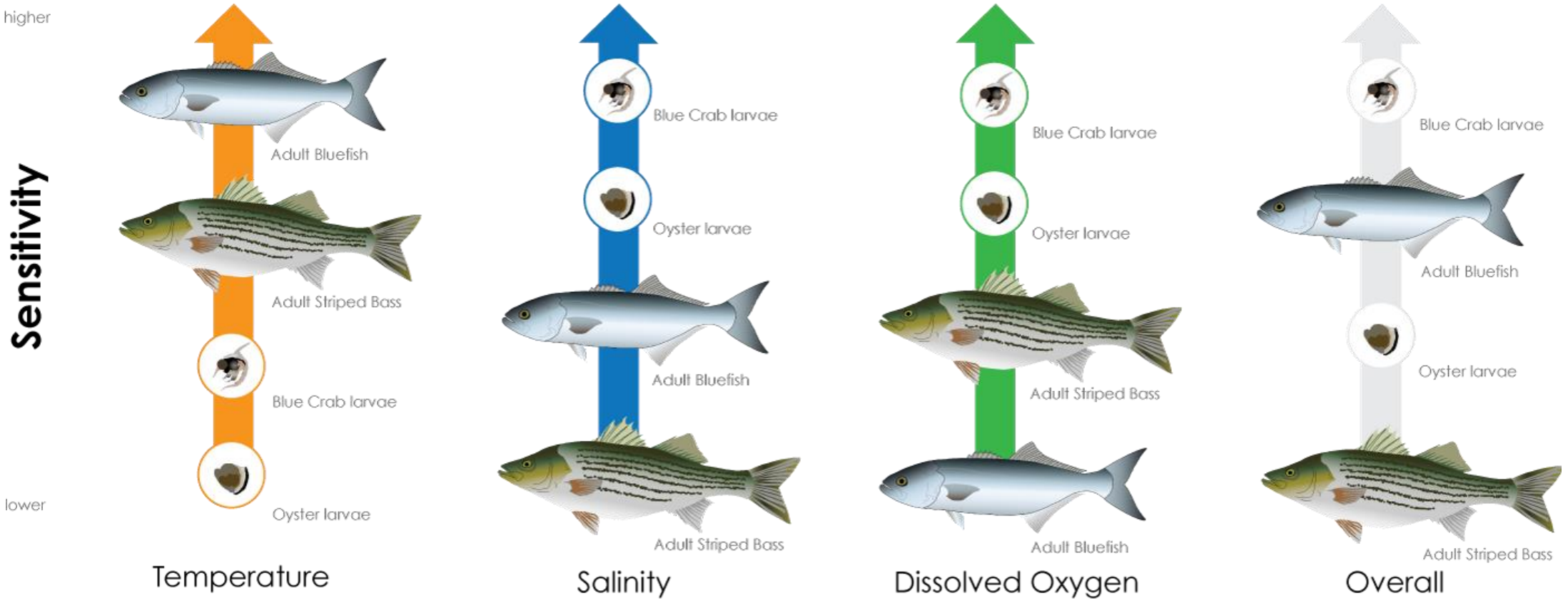
Boosting Living Resource Response





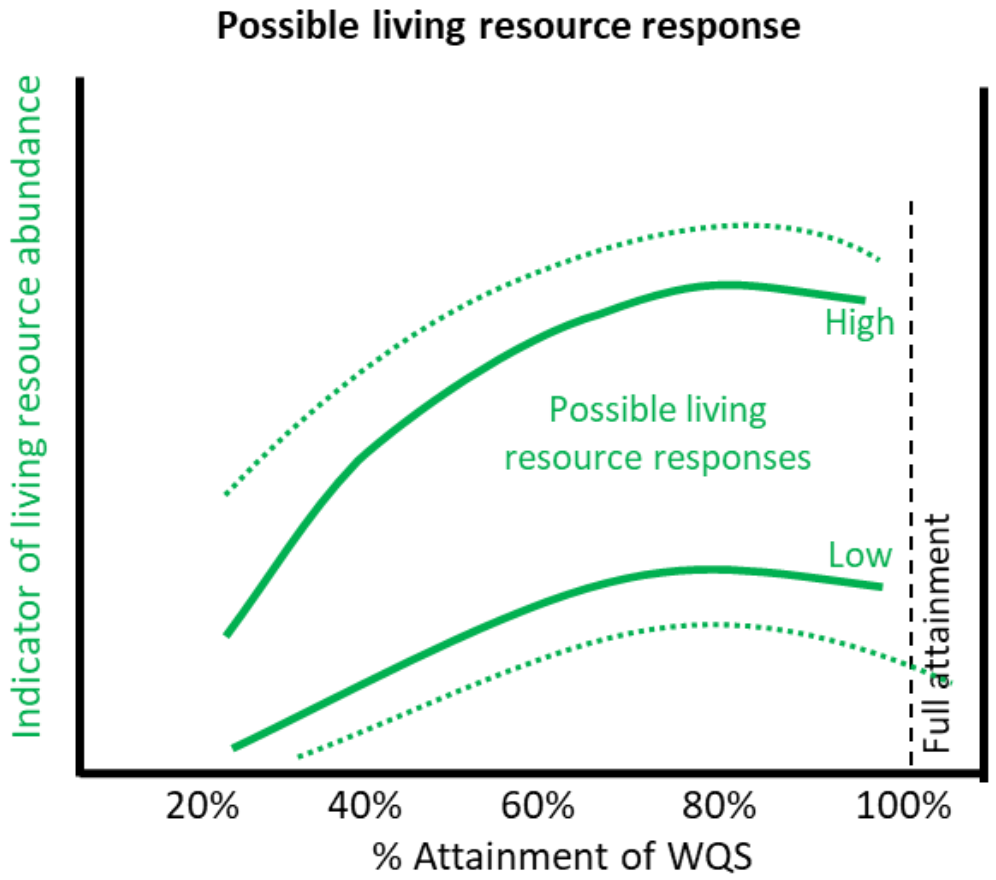
Managed by Bay water quality standards

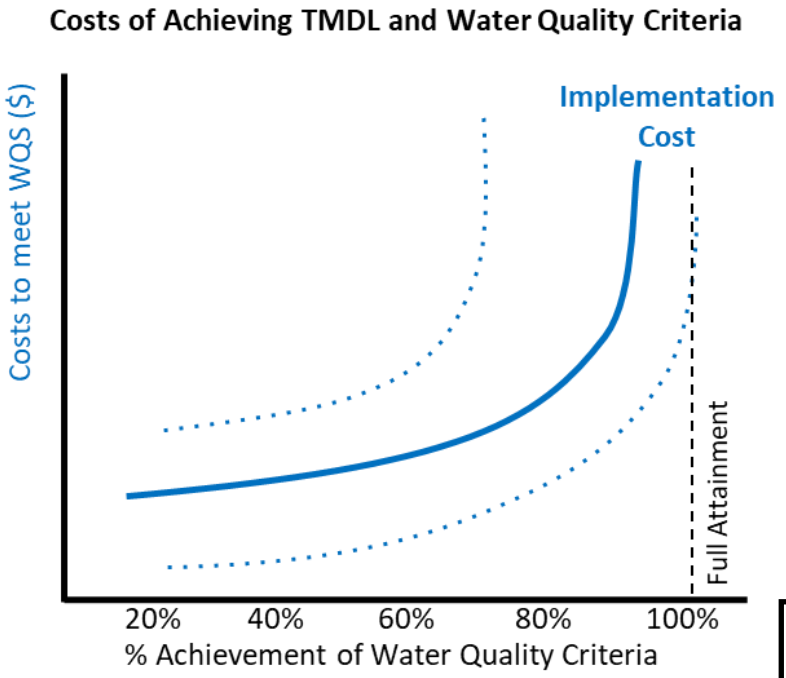
Many Knobs of Living Resource Response

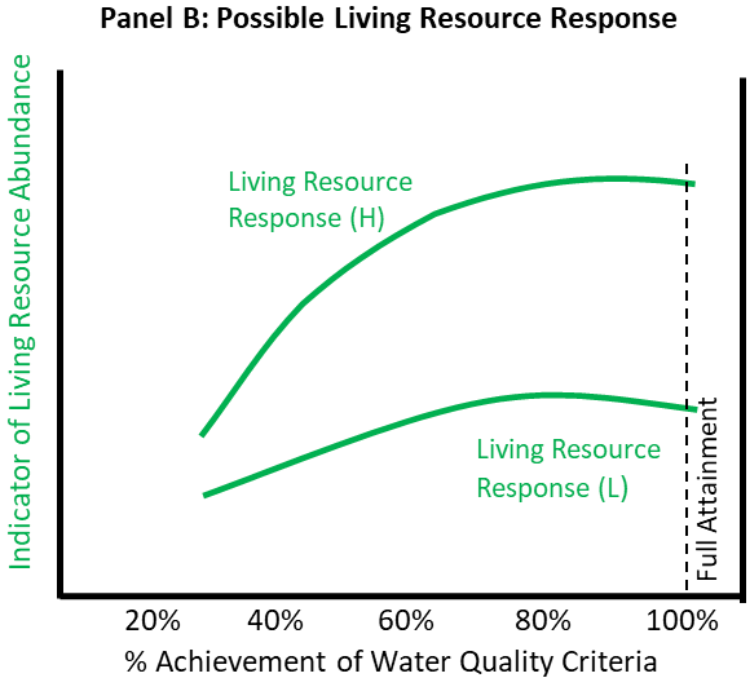


Living Resource Response

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







Implications for adaptive implementation