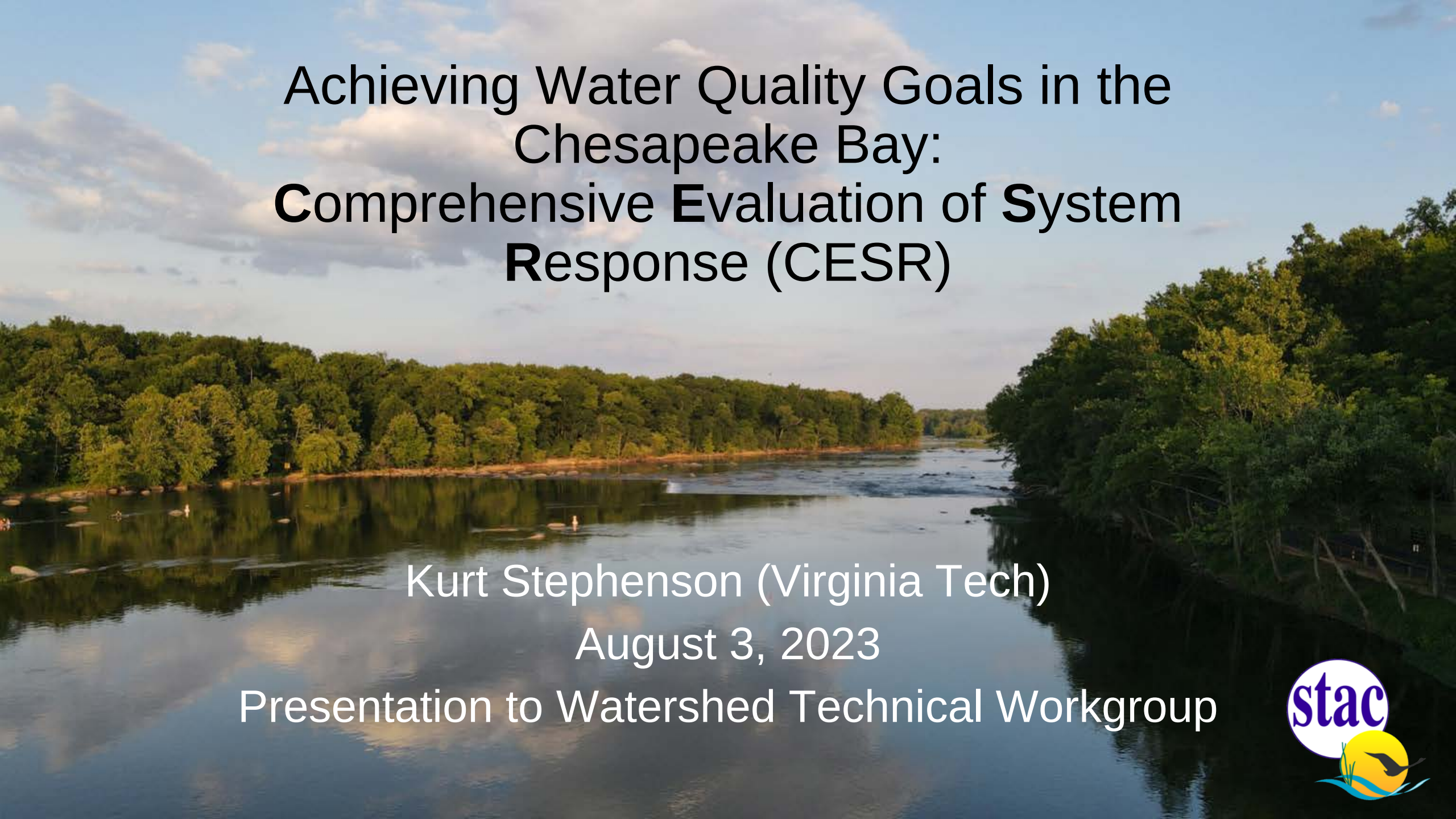
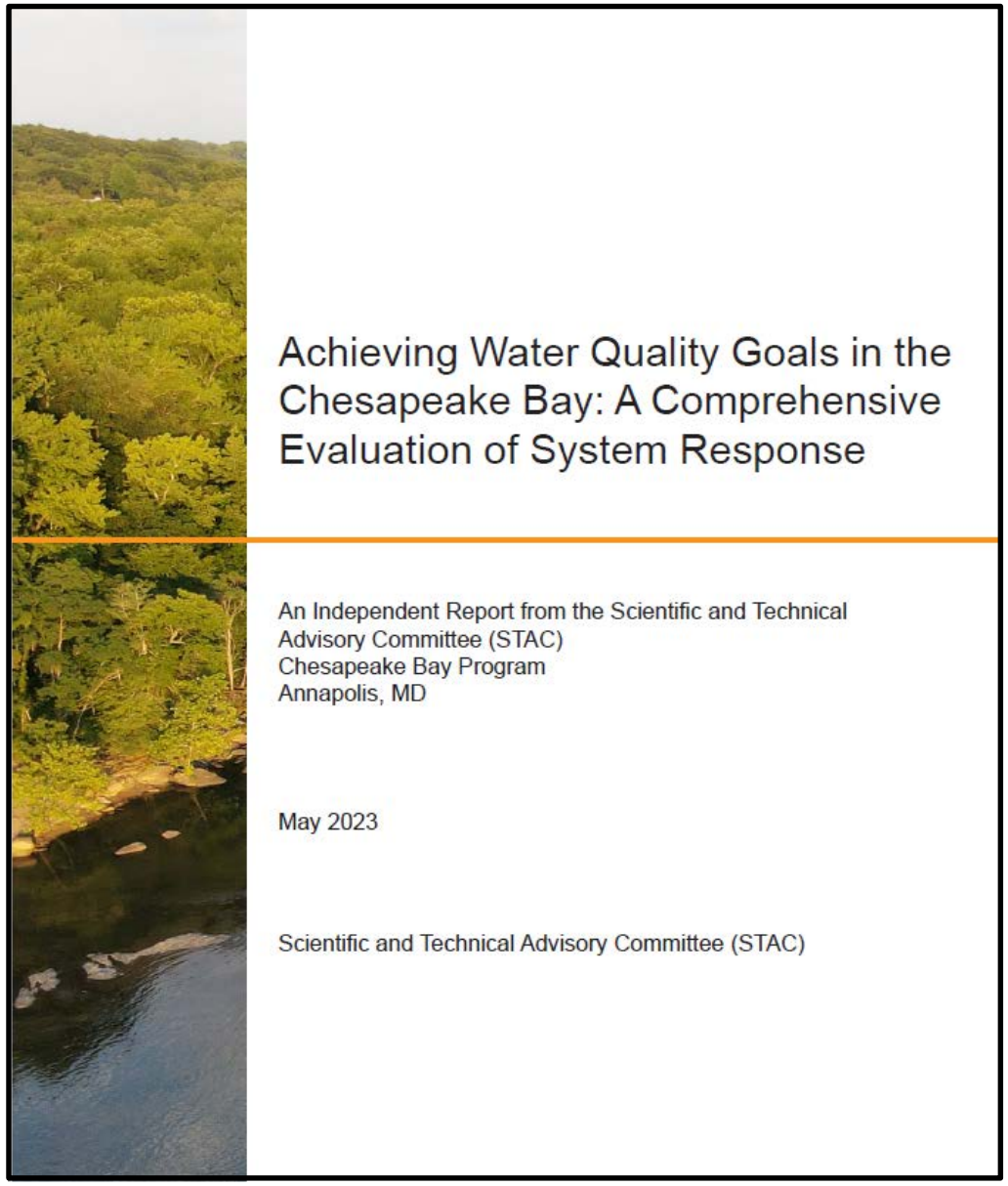


Achieving Water Quality Goals in the Chesapeake Bay: **C**omprehensive **E**valuation of **S**ystem **R**esponse (CESR)

Kurt Stephenson (Virginia Tech)

August 3, 2023

Presentation to Watershed Technical Workgroup



CESR Report

- Self-initiated
- Inclusive of STAC Membership
- Multiple levels of internal and agency review
- Over 50 contributors with unanimous STAC inclusion
- Main report (Co-editors and Steering Committee) plus 3 “Resource Documents”

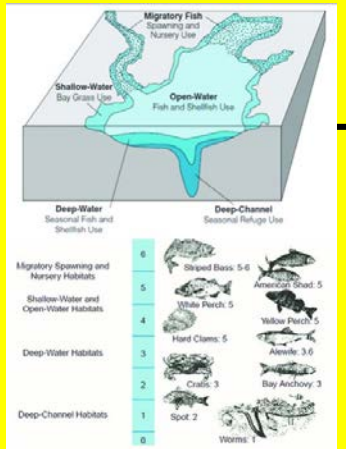
Public Policy

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?

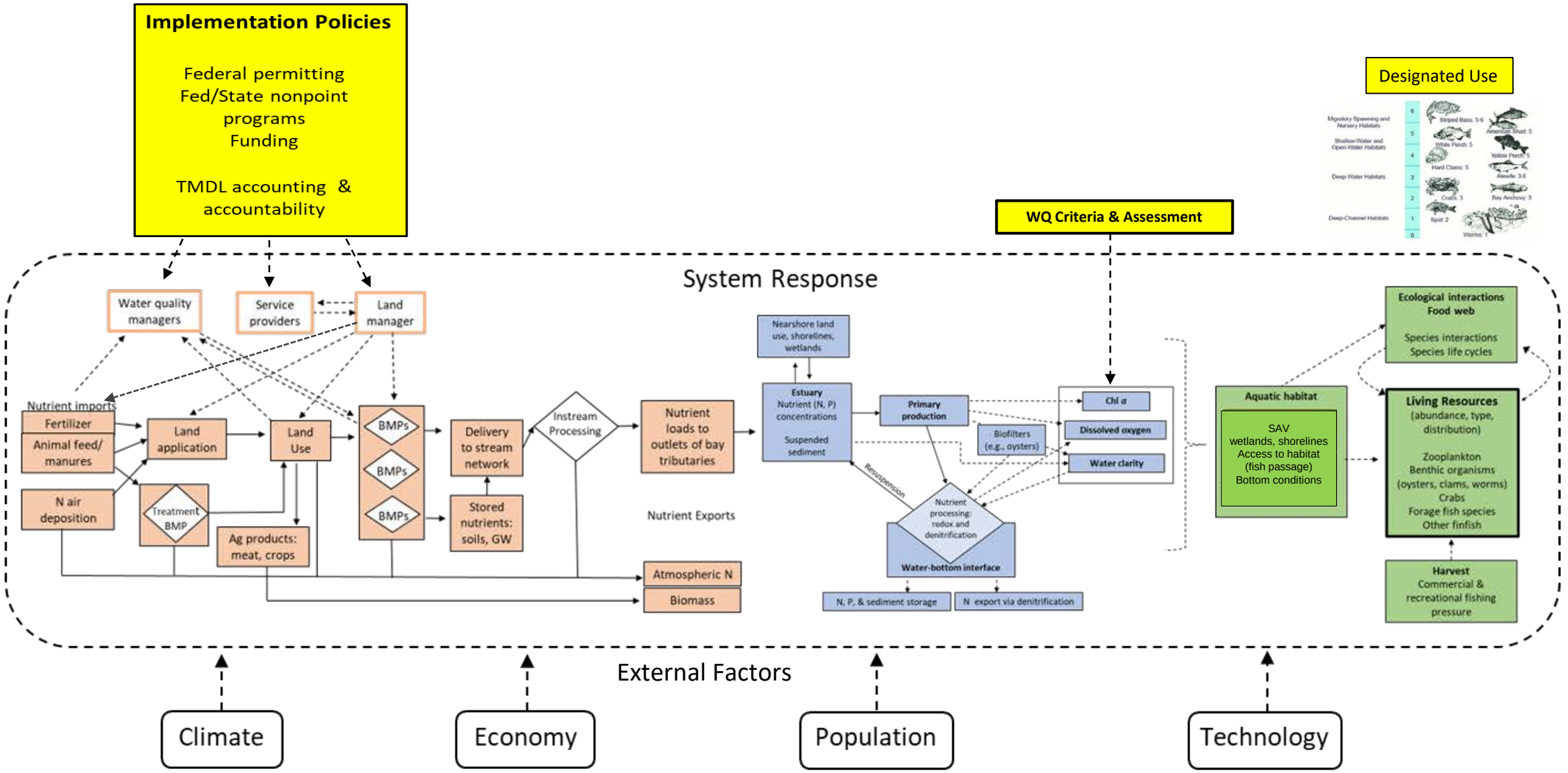
Achieving Water Quality Standards

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?

System Response to Meeting Bay Water Quality Standards



Summary of CESR Findings and Implications

Living Resource Response

Finding: The impact of WQ improvements on living resources depends on where WQ improvements occur and antecedent conditions; impact varies across species.

Implication: Potential to increase the living resource response to our WQ and restoration investments.

Achieving Water Quality Standards

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

Implication*:* Water quality criteria may be unattainable in some regions of the bay

Achieving TMDL

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

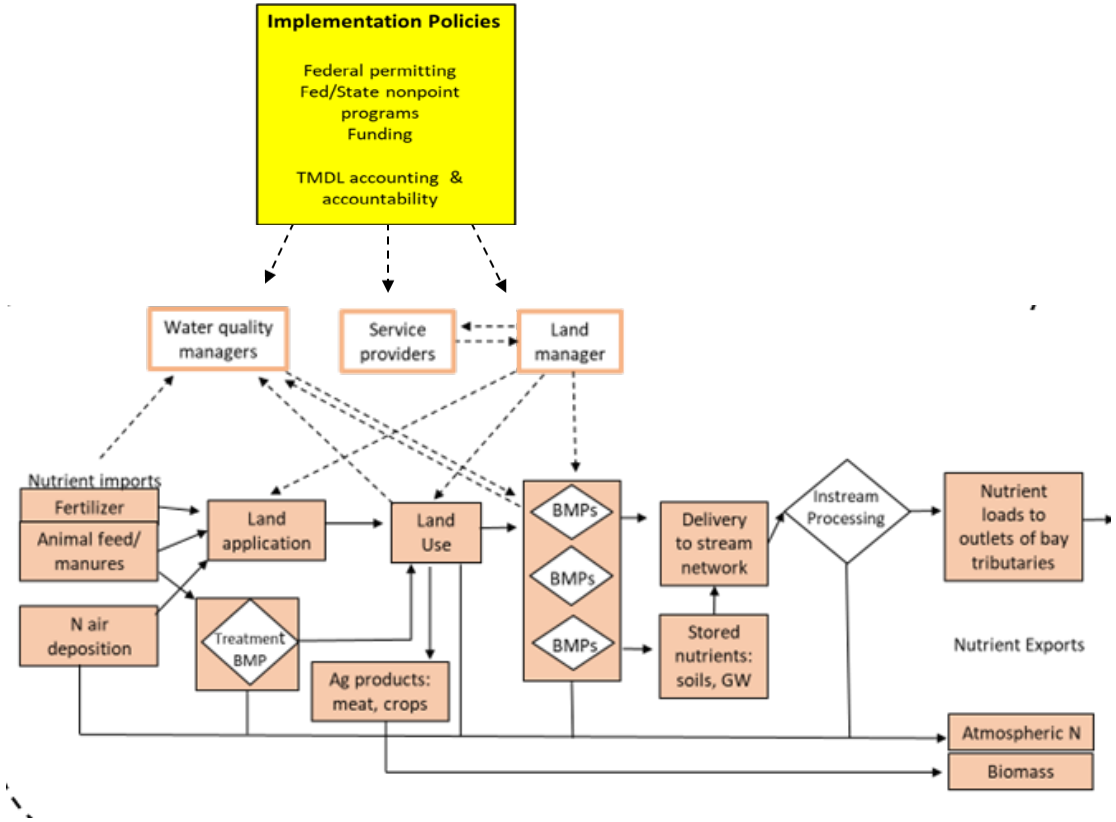
Implication: Substantial improvement in nonpoint source outcomes will require new programs and approaches

Overarching Finding: Challenging problem with tradeoffs, uncertain outcomes, and no single "silver bullet" answer

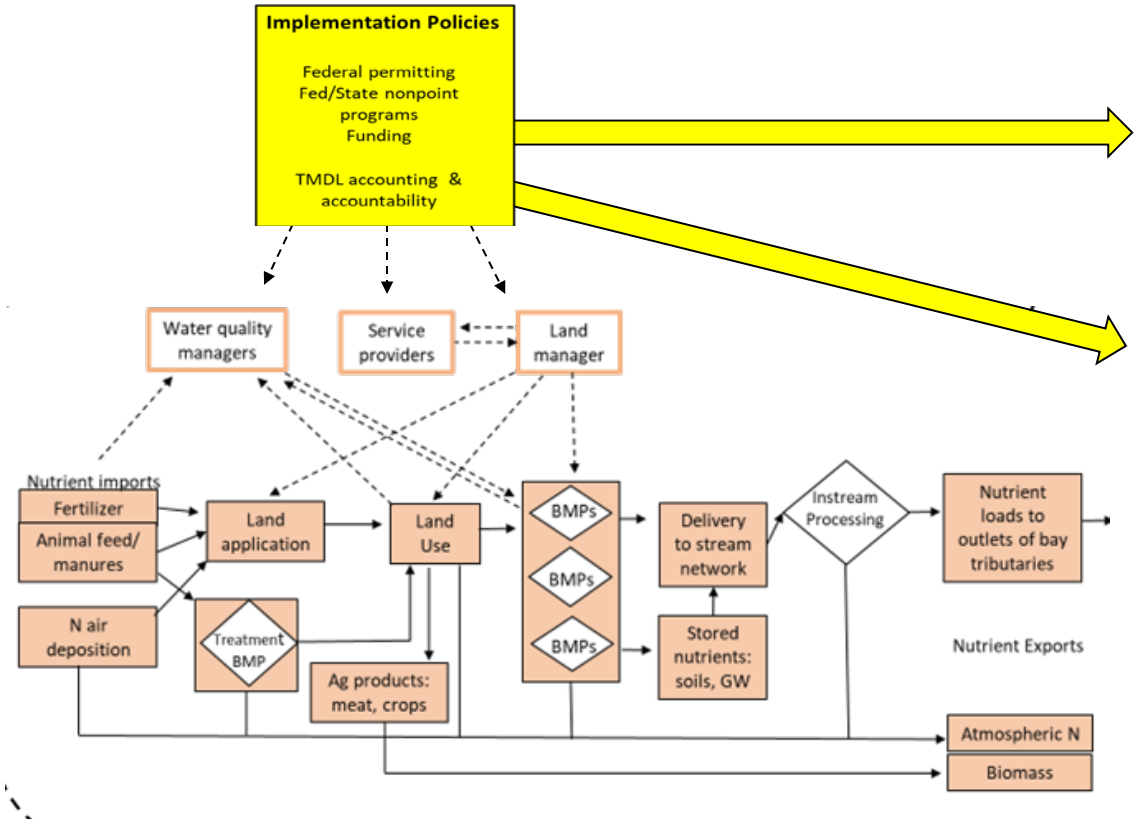
Overarching Implication: Recognize tradeoffs and uncertain outcomes, accelerate innovation, and learn

Achieving TMDL:

Findings and Implications



Nonpoint Source Implementation Policy



Voluntary Financial Assistance: Cost-Share

Offer $ based on portion of installation cost of a practice → $ → Land Manager → Cost → BMP

Crediting nonpoint source reductions & the CAST model

Average N, P, sediment loss (lb/ac) over subwatershed (~5-20,000 acres) X **BMP** (Average % removal) X **Number of acres treated** = **Pounds of N, P, sediment reduction**

CAST model estimates

Nutrient Input Sources
Commercial fertilizer
Manure
Atmospheric deposition

State reporting (BMPs)
Expert panels (removal efficiency)

State reporting

Finding:

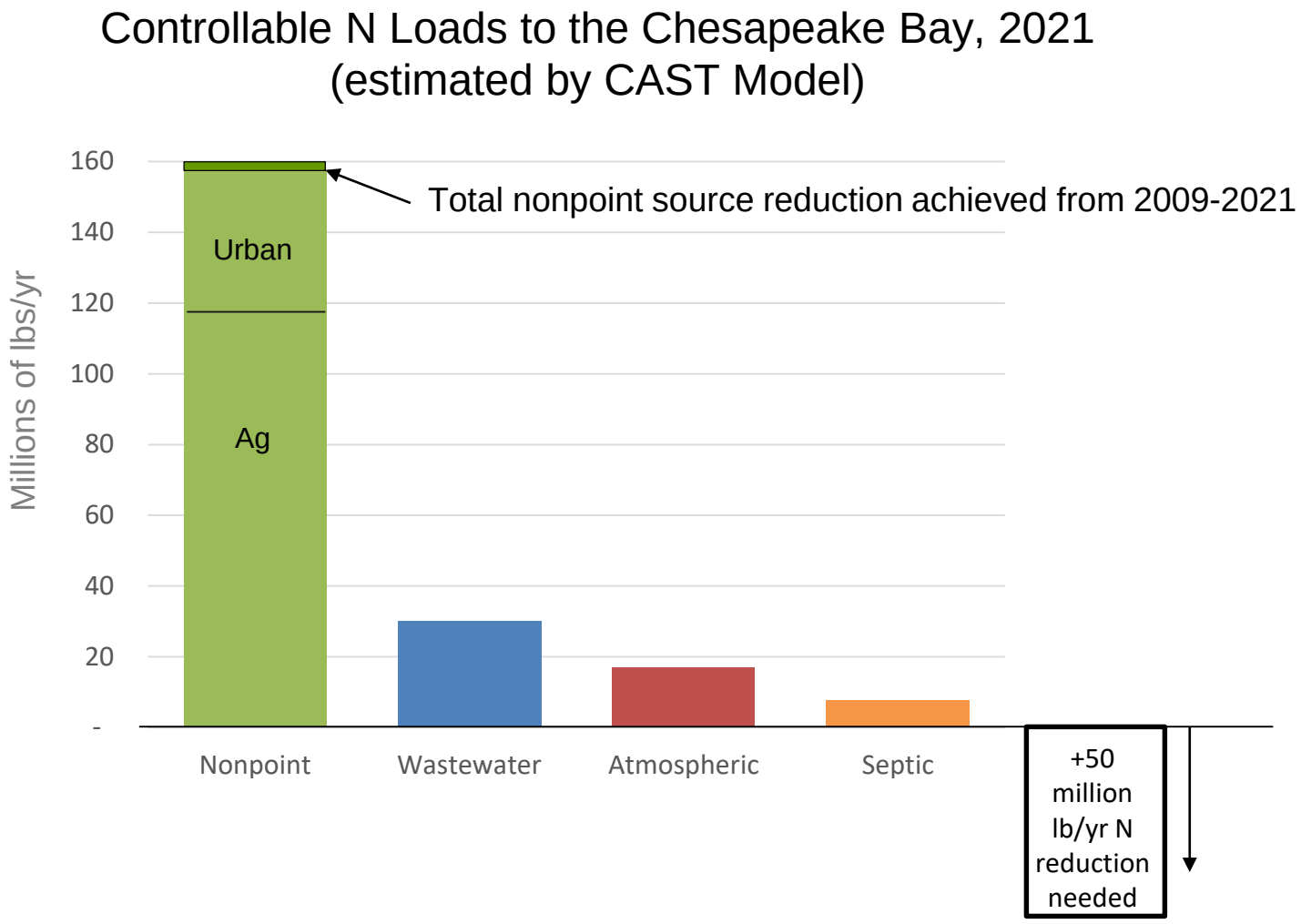
Nonpoint source programs are not generating the scale of reductions needed to achieve TMDL

Two Challenges

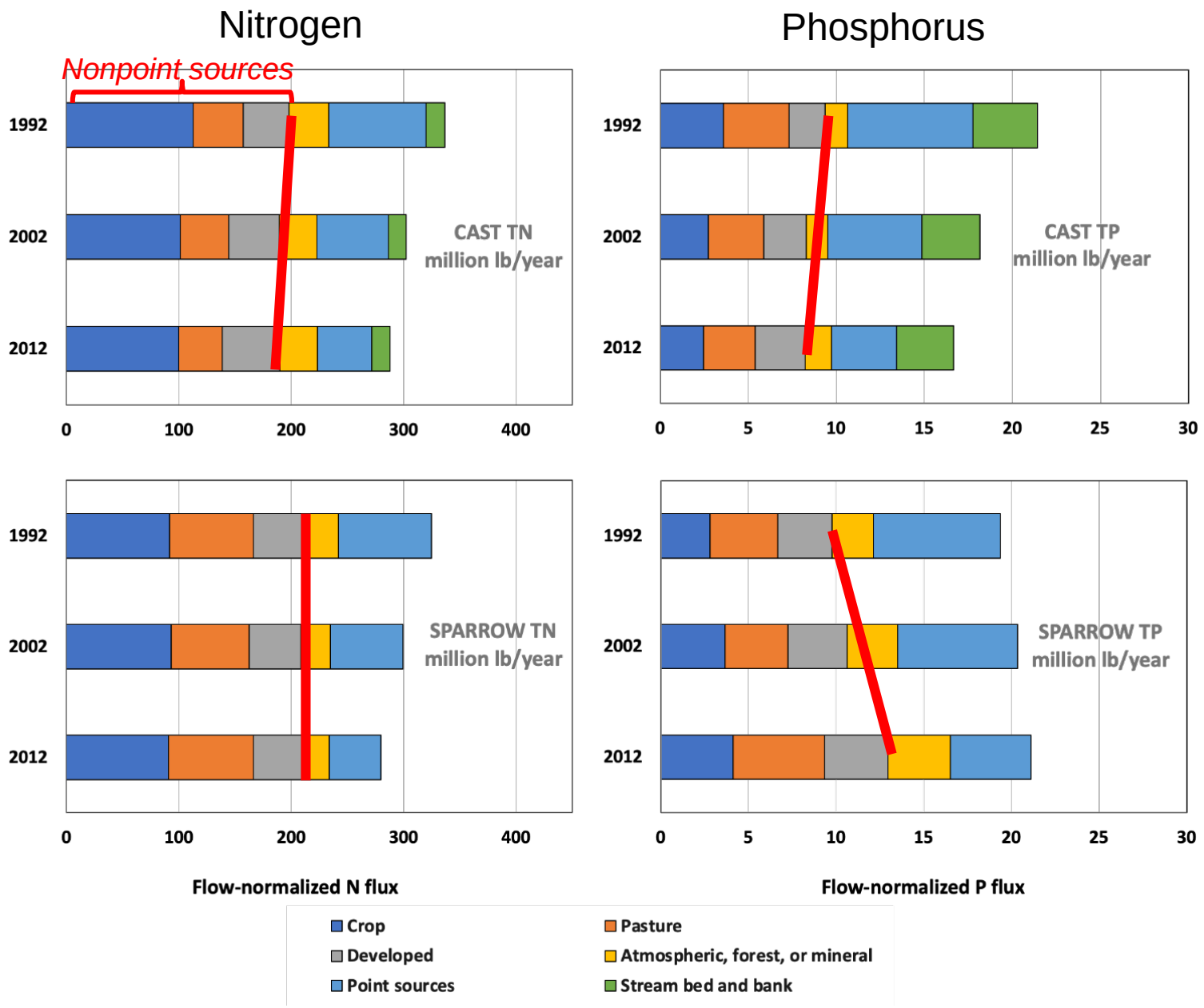
1) Nonpoint source programs are not generating sufficient levels of adoption/behavior change

2) The actions/practices being implemented may not be as effective as expected in producing pollutant reductions

Nonpoint source programs are not generating a sufficient level of implementation



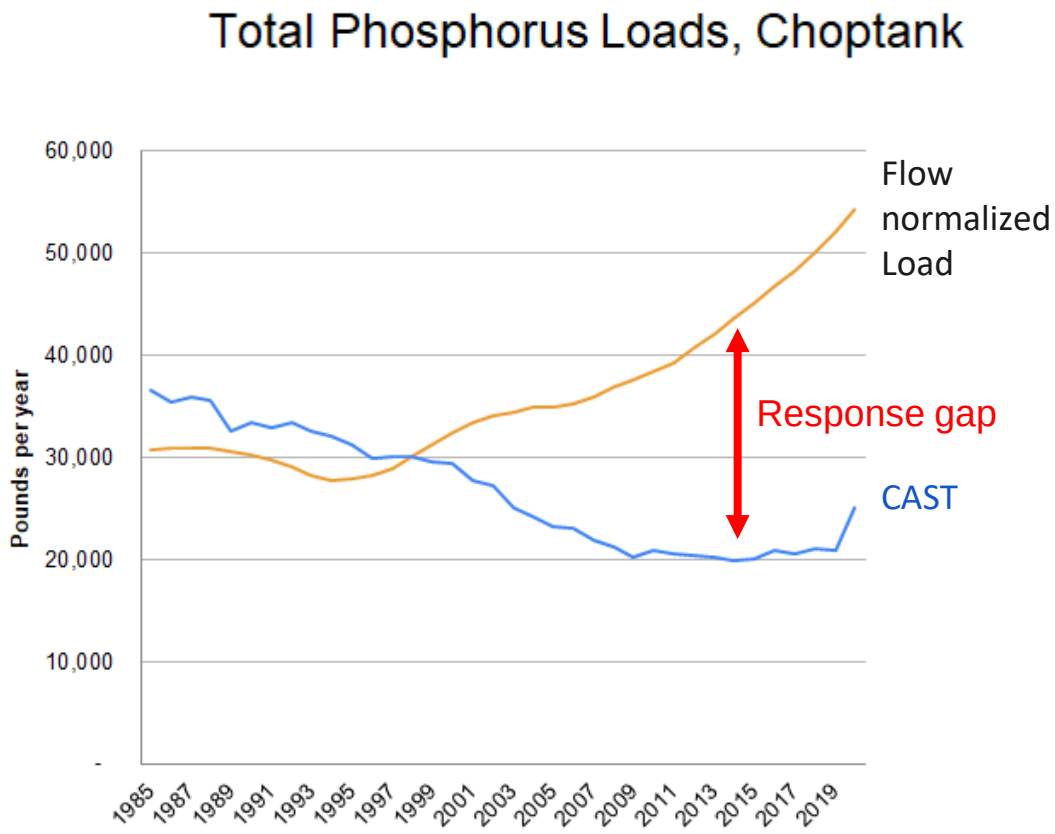
Nonpoint source programs may not be as effective as expected

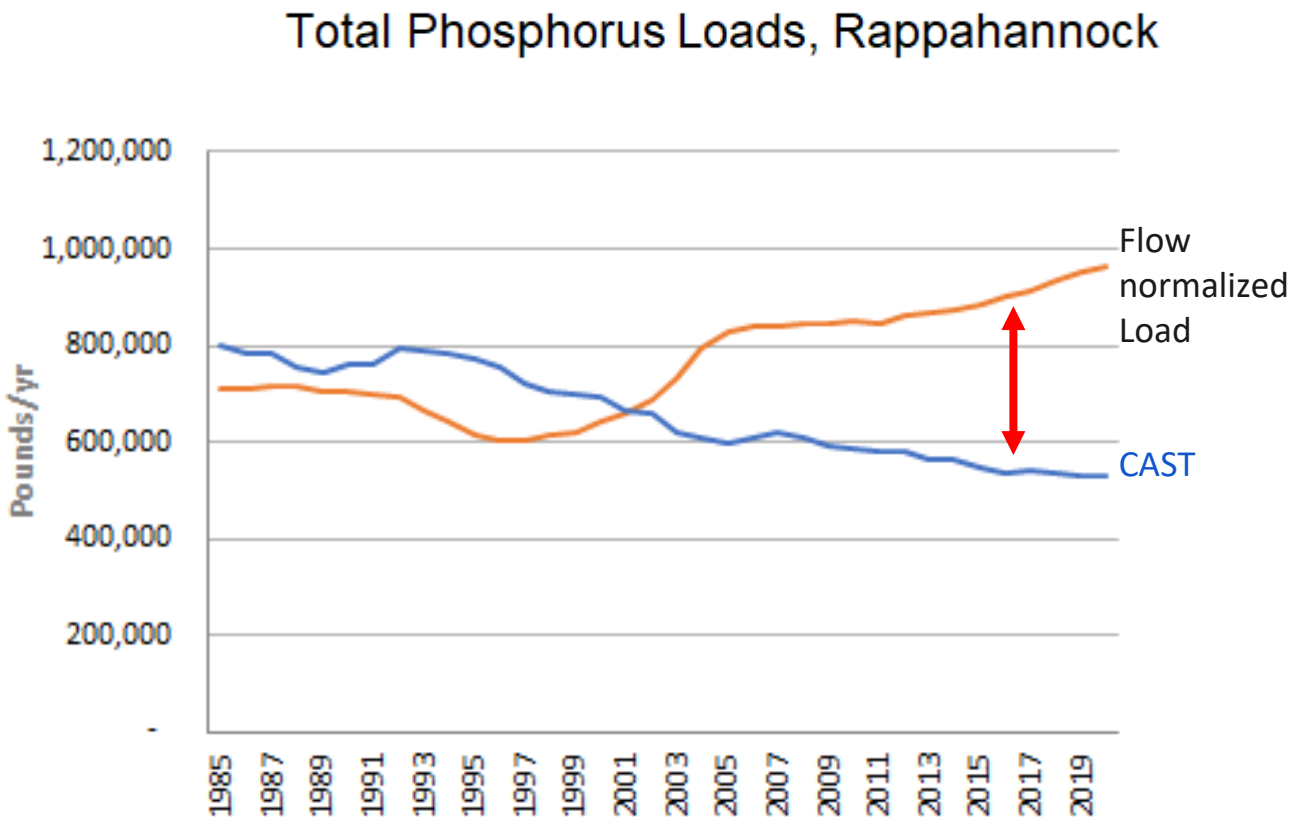


Estimated flow-normalized total and source sector TN and TP fluxes to the Chesapeake Bay for the CAST and SPARROW models

Ator et al. 2020

Difference between expected and observed outcomes





Implications:

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

Ideas to improve nonpoint source program effectiveness

Incentivize Outcomes

Cover crops

Livestock Exclusion Fencing

Denitrifying Bioreactor

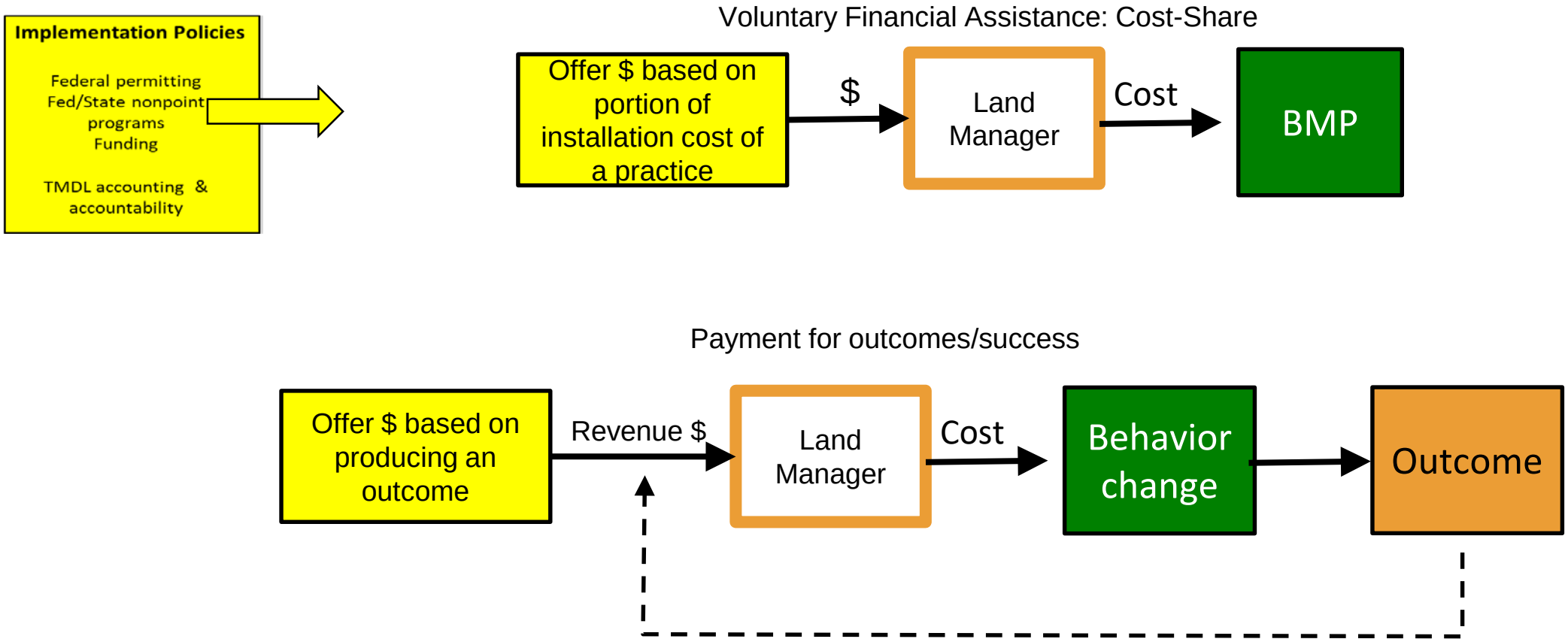
Low upfront installation costs
Private benefits

High up front installation costs
No private benefits

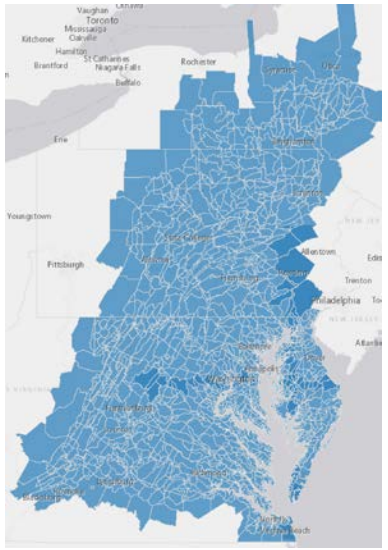
Under voluntary cost-share programs, adoption rates fall from left to right

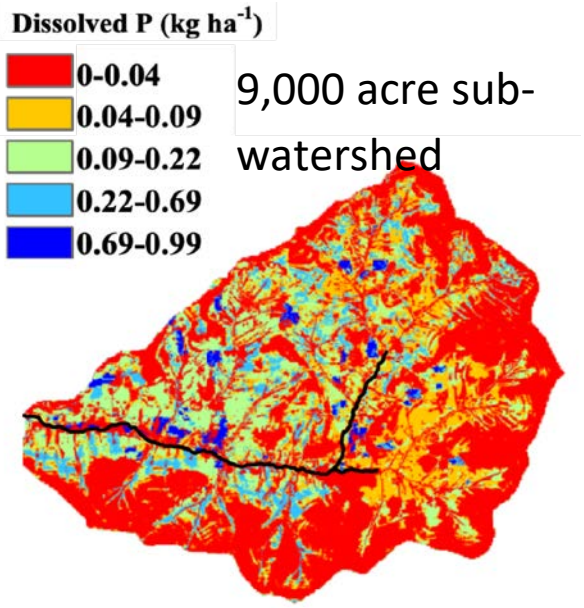
Which is the most cost-effective ($/lb)?
Which practice provides most assurances of delivering reductions?

Incentive Programs



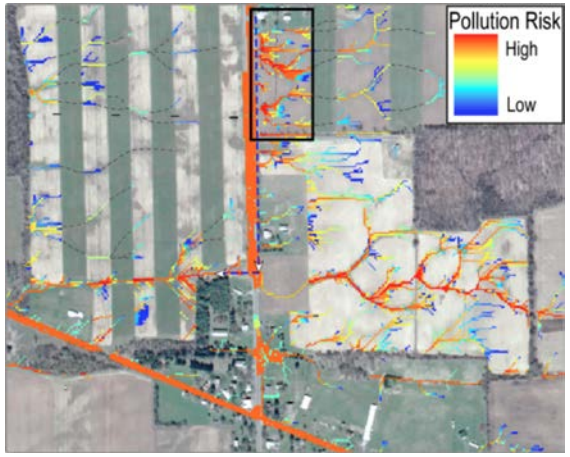
Basin





9,000 acre sub-watershed

25 acre parcel



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

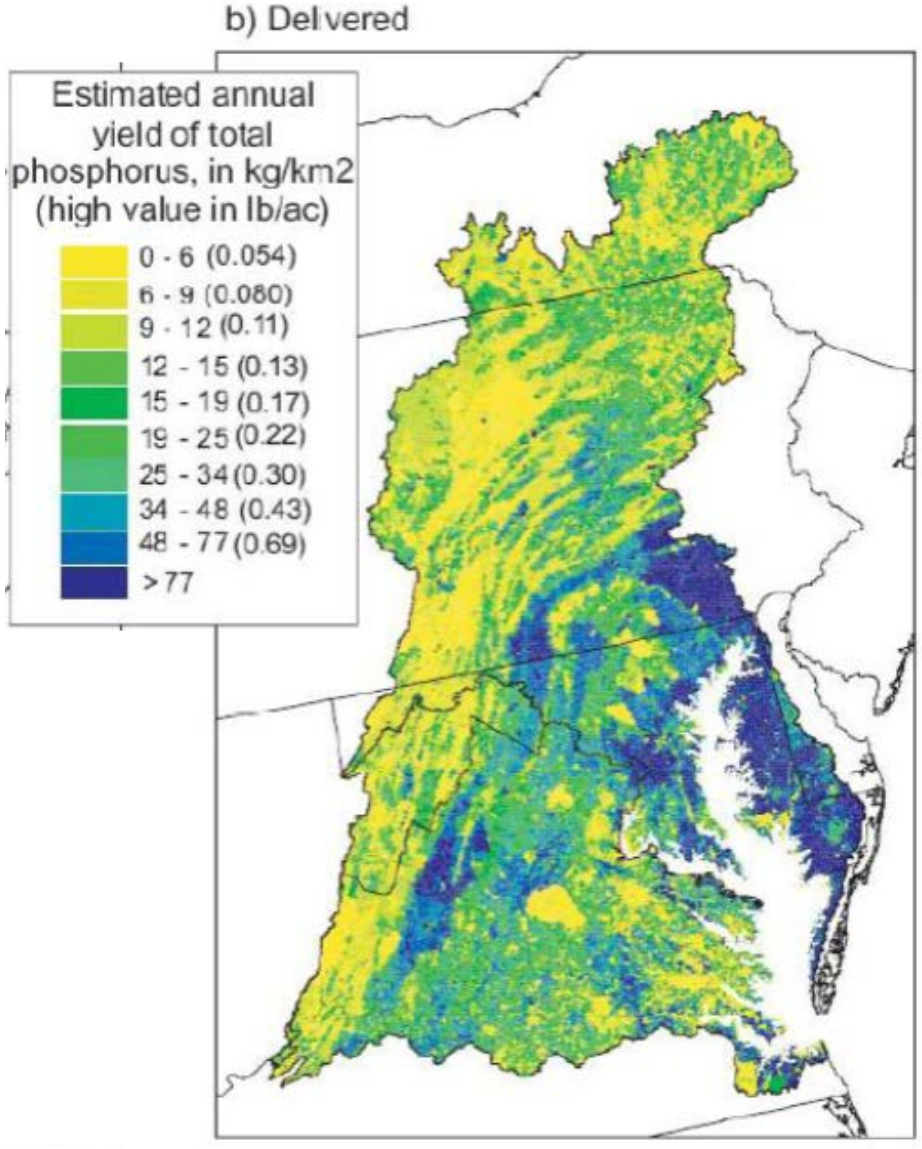
(Source: Pearce & Maguire 2020)

Improve tools and incentives for targeting

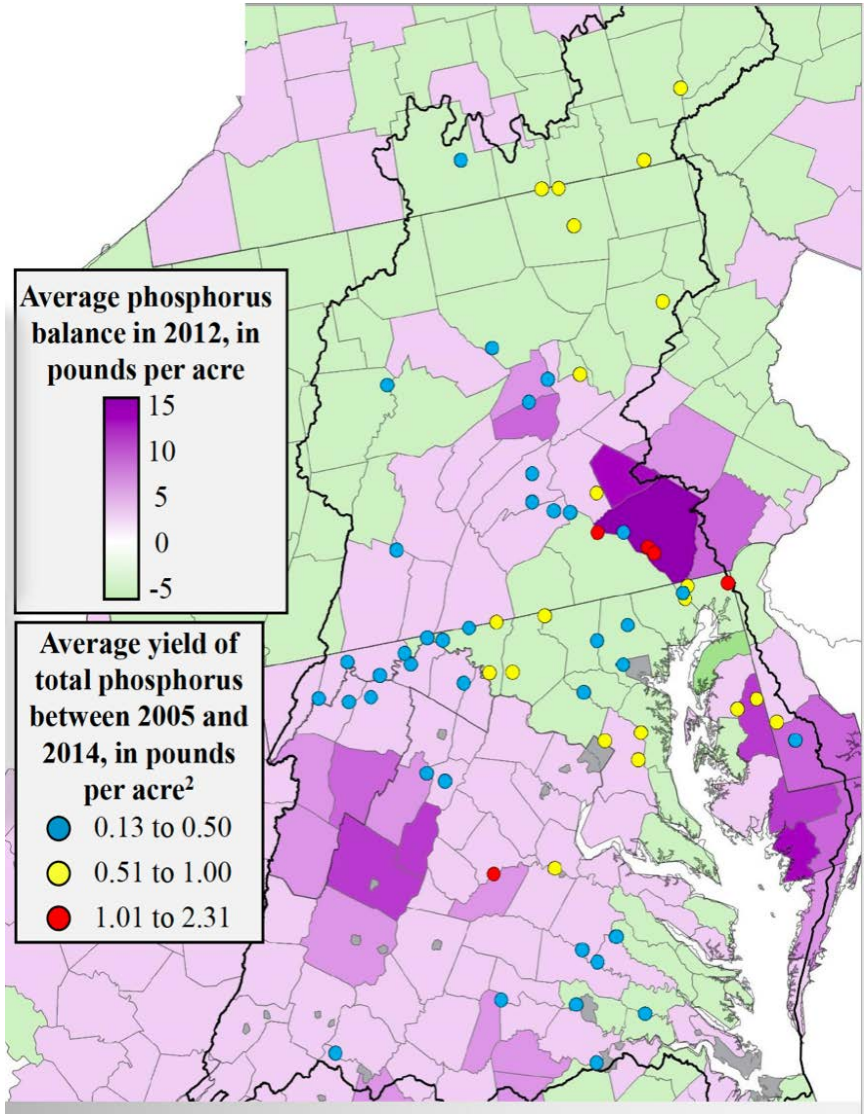
Nutrient loads are highly variable across the landscape across multiple scales and across land managers).

Our accounting and incentive systems only provide limited opportunity to target.

Improve efforts to address mass balance



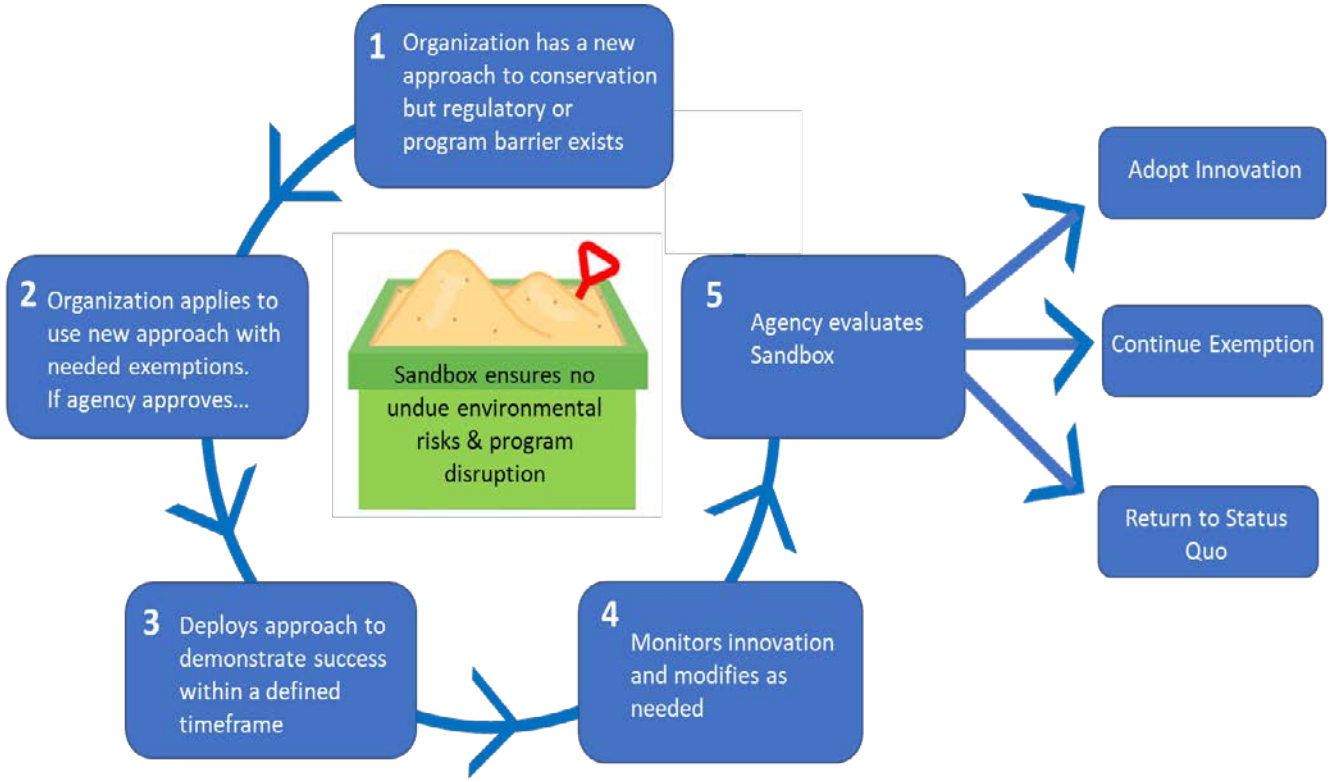
Source: USGS Sparrow Model Output



Moyer et al. 2017, Webber, 2017

Encourage Institutional/policy Innovation

Sandboxing



The Sandboxing Process (Figure adapted from Higgins and Male, 2019)

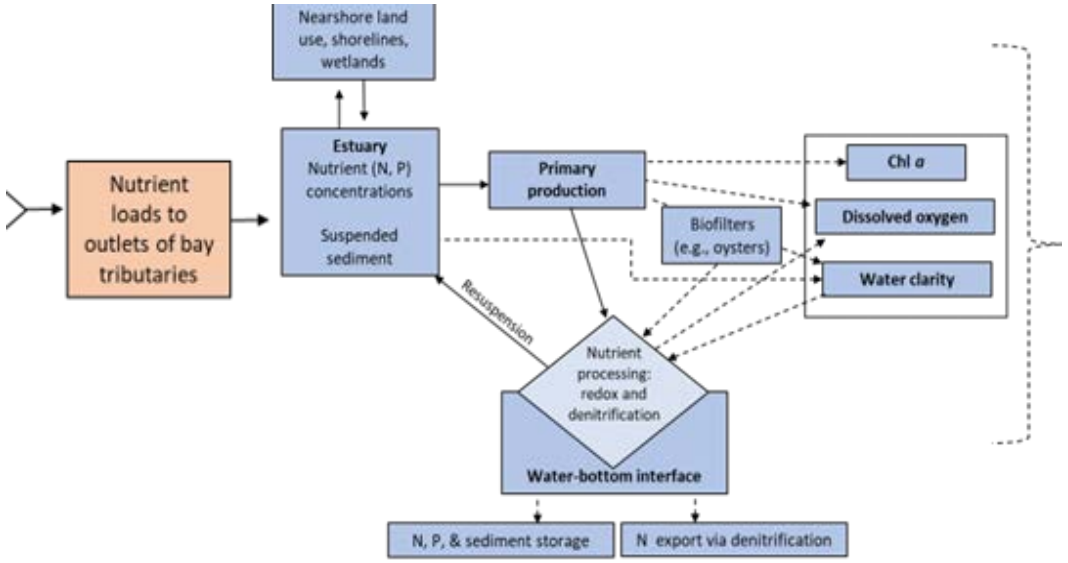
Ideas for what to "Sandbox"

TMDL accounting & accountability (alternative to CAST)

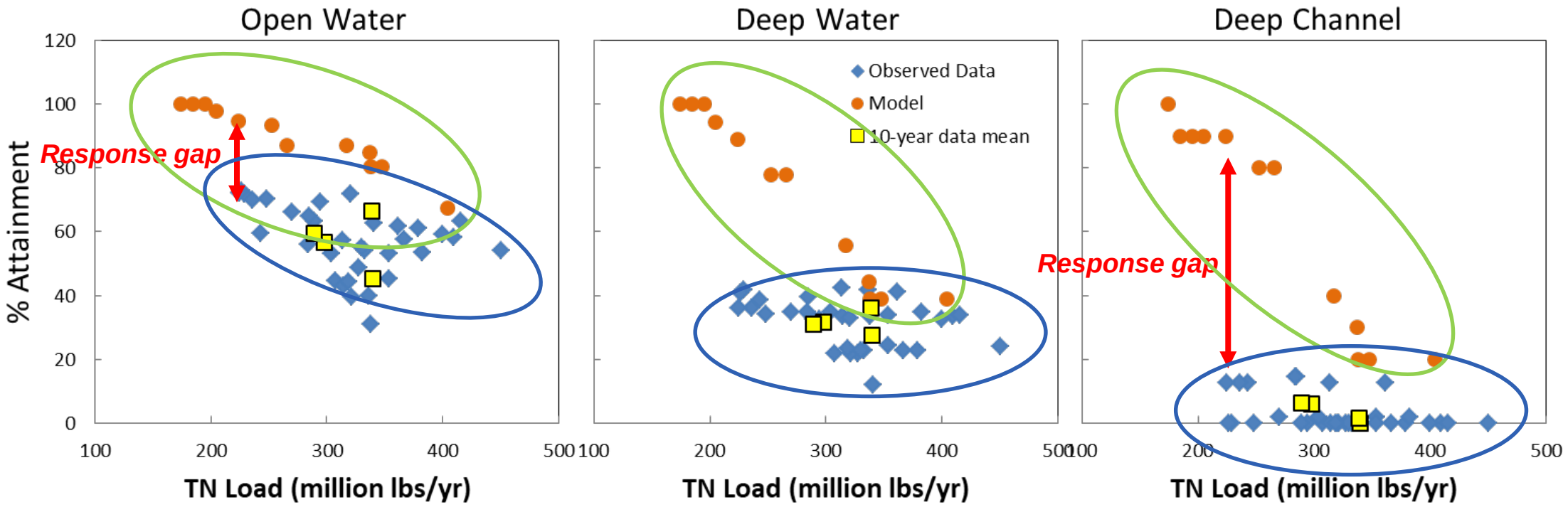
Types of outcome-based incentive programs

Achieving Water Quality Standards:

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



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.

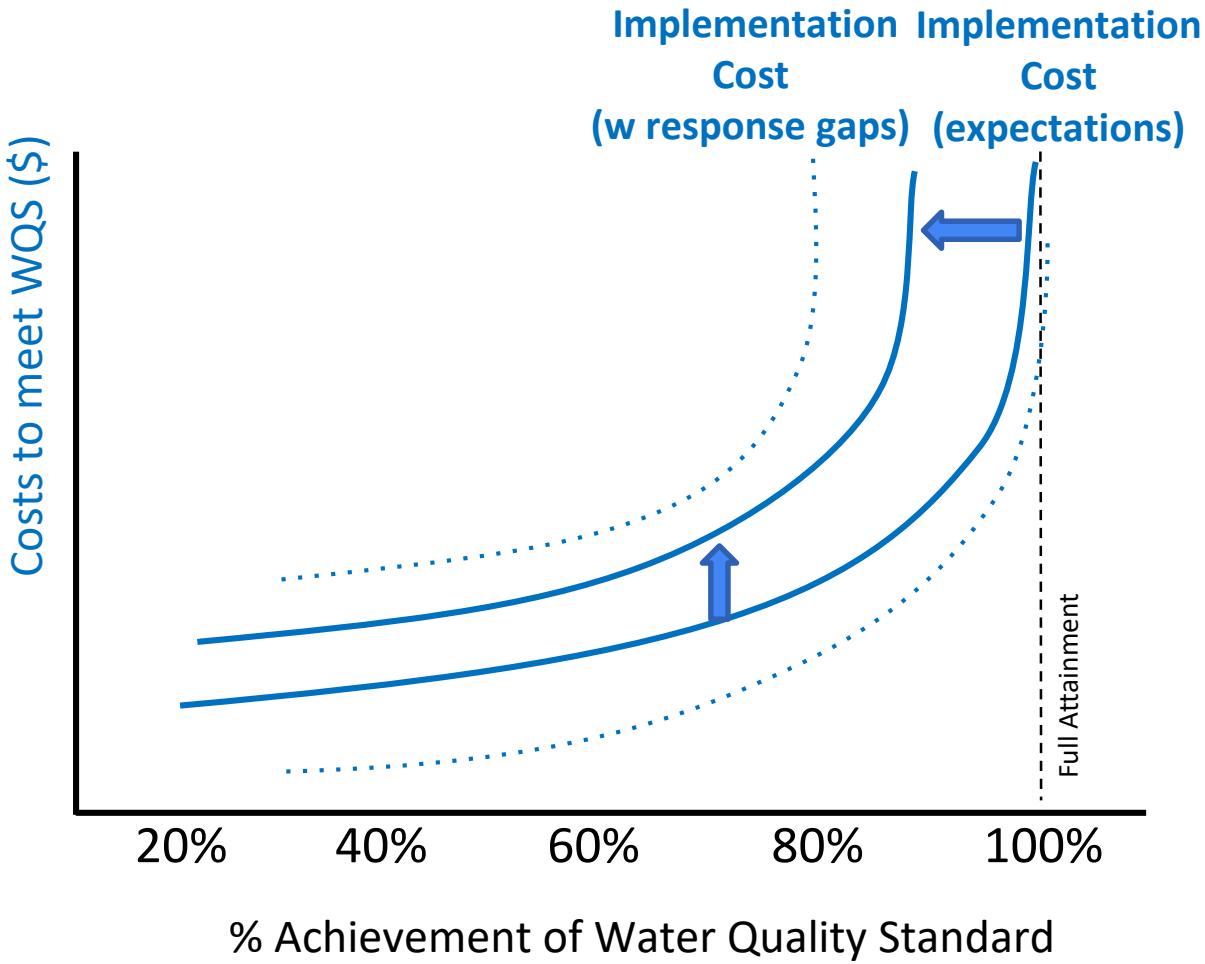
Why response gaps?

- Climate change (ex. warming waters)
- “Tipping points”

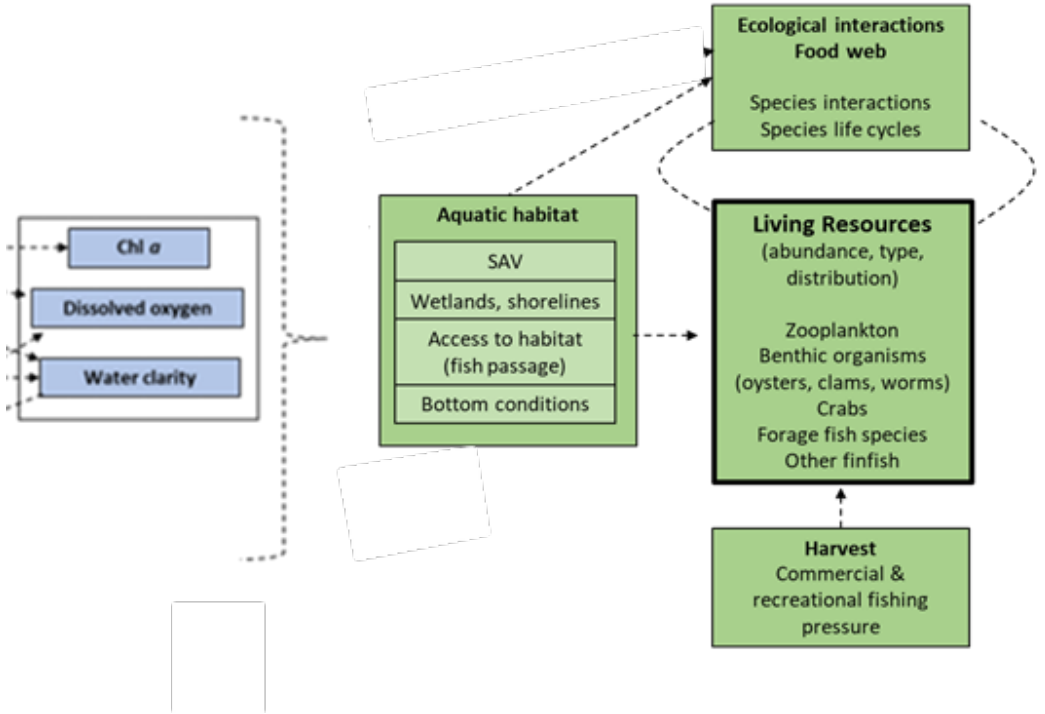
Achieving Water Quality Standards:

Implication: Water quality criteria may be unattainable in some regions of the bay under existing technology

Costs of Achieving TMDL and Water Quality Criteria

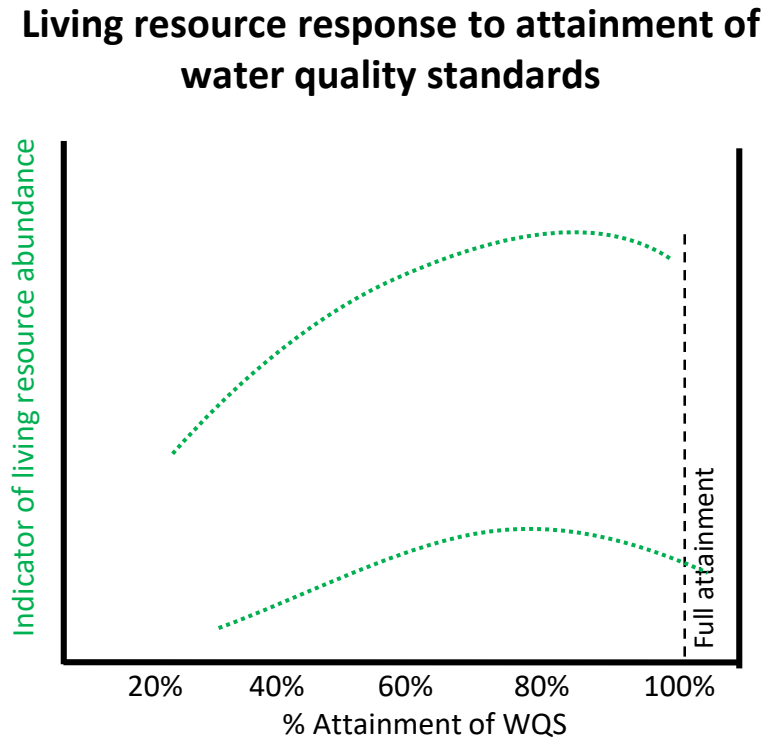


Living Resource Response



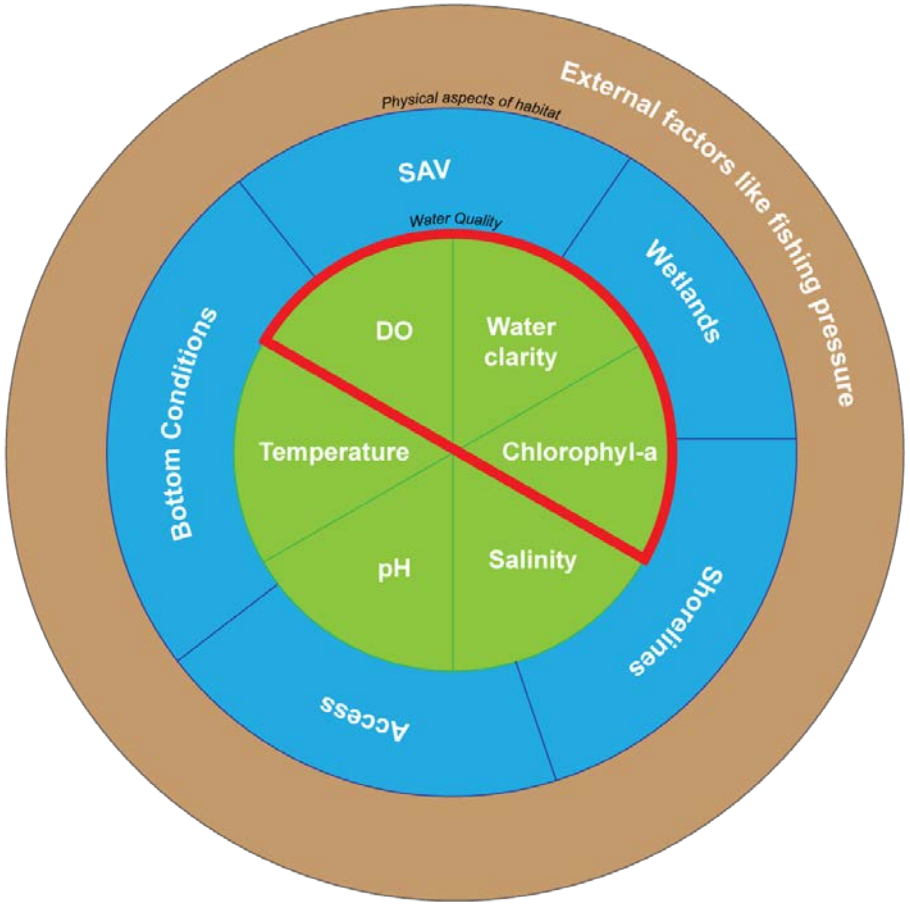
Living Resource Response

Finding: The impact of WQ improvements on living resources depends on where WQ improvements occur and antecedent conditions; impact varies across species.



Living Resource Response

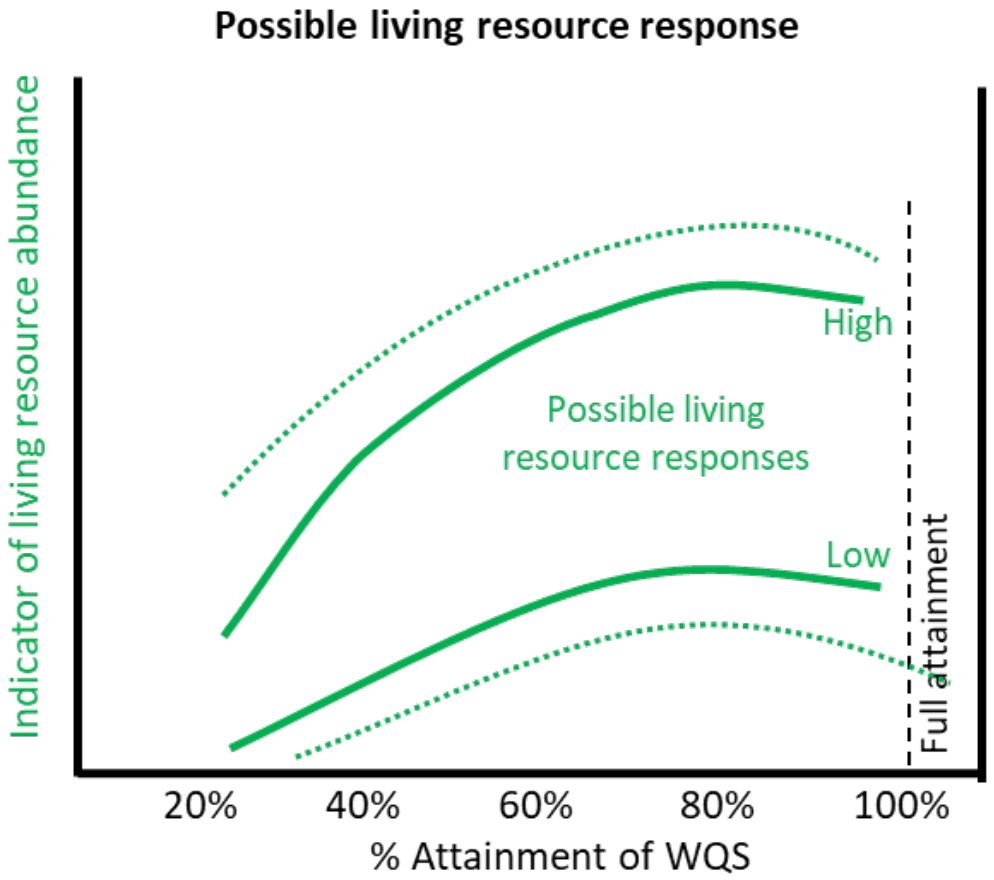
Findings: The impact of WQ improvements on living resources depends on where WQ improvements occurs, antecedent conditions, & impact varies across species.



Managed by Bay water quality standards

Living Resource Response

Implication: Potential to increase the living resource response to our WQ and restoration investments.



Implications

Tradeoffs & Uncertainties

Full attainment may not be necessary to improve and support living resources goals