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

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Presentation to Principals’ Staff Committee
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

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

Public Policy

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

Implementation Policies

- Federal permitting
- Fed/State nonpoint programs
- Funding
- TMDL accounting & accountability

WQ Criteria & Assessment

Designated Use

External Factors

- Climate
- Economy
- Population
- Technology

System Response

- Nutrient Imports
  - Animal feed/manures
  - N air deposition
- Nutrient Exports
  - Atmospheric N
  - Biomass
- Nutrient loads to outlets of bay tributaries
- Nutrient concentration in estuary
- Nutrient processing: nitrification & denitrification
- Nutrient processing: removal and denitrification
- Nutrient removal: wetlands, shorelines
- Access to habitat (fish passage)
- Bottom conditions
- Water clarity
- C02
- Dissolved oxygen
- Water quality criteria

Aquatic habitat

SAV wetlands, shorelines
Access to habitat (fish passage)
Bottom conditions

Living Resources
- Abundance, type, distribution
- Zooplankton
- Benthic organisms (oysters, clams, worms)
- Crabs
- Forage fish species
- Other finfish

Ecological interactions
- Food web
- Species interactions
- Species life cycles

Harvest
- Commercial & recreational fishing pressure
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 under existing technologies.

**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

Controllable N Loads to the Chesapeake Bay, 2021 (estimated by CAST Model)

- Urban
- Ag

Total nonpoint source reduction achieved from 2009-2021

+50 million lb/yr N reduction needed
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

Total Phosphorus Loads, Choptank

Total Phosphorus Loads, Rappahannock

Flow normalized Load

Response gap

CAST
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) at reducing pollutants?
Which practice provides most assurances of delivering reductions?
Incentive Programs

Voluntary Financial Assistance: Cost-Share

Offer $ based on portion of installation cost of a practice

Land Manager

Cost

BMP

Payment for outcomes/success

Offer $ based on producing an outcome

Land Manager

Cost

Behavior change

Outcome
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.

Total phosphorus balance across 58 dairy farms in Shenandoah Valley Virginia, 2018

<table>
<thead>
<tr>
<th>Quartile</th>
<th>Total P balance (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>-30.9</td>
</tr>
<tr>
<td>1st Quartile</td>
<td>1.5</td>
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<tr>
<td>Median</td>
<td>12.4</td>
</tr>
<tr>
<td>3rd Quartile</td>
<td>18.7</td>
</tr>
<tr>
<td>Maximum</td>
<td>97.6</td>
</tr>
</tbody>
</table>

(Source: Pearce & Maguire 2020)
Improve efforts to address mass balance

Source: USGS Sparrow Model Output

Moyer et al. 2017, Webber, 2017
Encourage Institutional/policy Innovation

Sandboxing

1. Organization has a new approach to conservation but regulatory or program barrier exists
2. Organization applies to use new approach with needed exemptions. If agency approves...
3. Deploys approach to demonstrate success within a defined timeframe
4. Monitors innovation and modifies as needed
5. Agency evaluates Sandbox

Adopt Innovation
Continue Exemption
Return to Status Quo

Ideas for what to “Sandbox”

TMDL accounting & accountability (alternative to CAST)

Types of outcome-based incentive programs

The Sandboxing Process (Figure adapted from Higgins and Male, 2019)
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
Living Resource Response
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**Finding:** The impact of WQ improvements on living resources depends on where WQ improvements occur and antecedent conditions; impact varies across species.
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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.