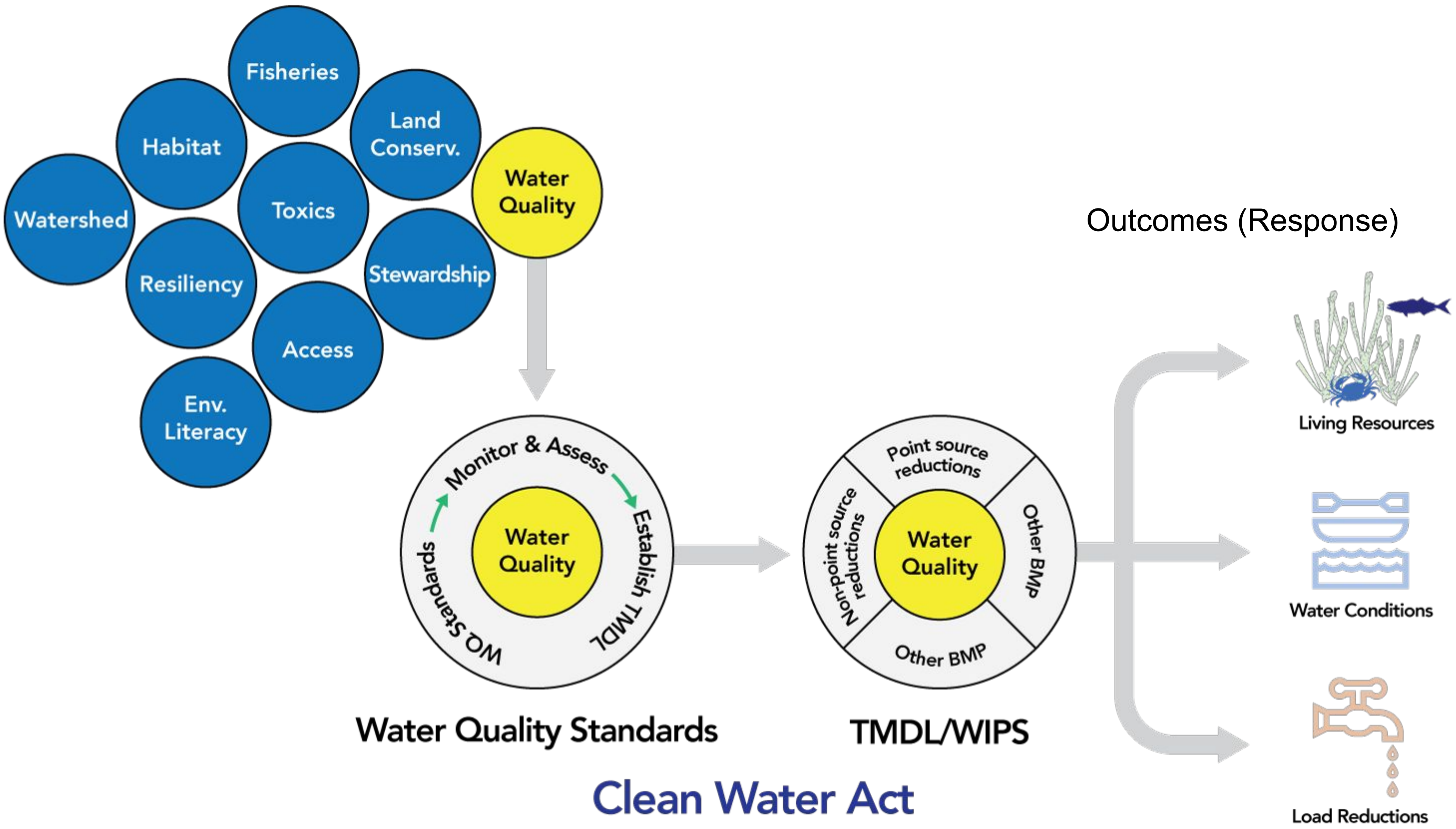
CESR: Comprehensive Evaluation of System Response

A presentation to the Sustainable Fisheries GIT

March 2, 2023

Outcomes of the Chesapeake Bay Agreement



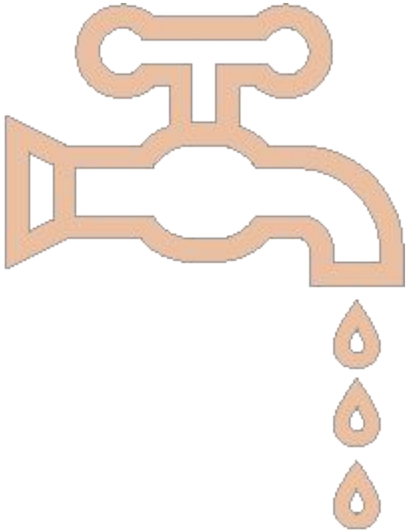
Achieving our desired outcomes is proving more challenging than we expected.

There are opportunities to improve our effectiveness, but they will require a significant change in our thinking and our programs.

Photo by Will Parson/Chesapeake Bay Program

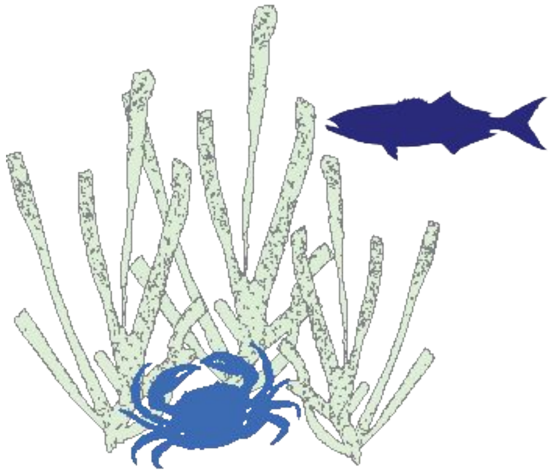
Today's Discussion

What we have learned about:



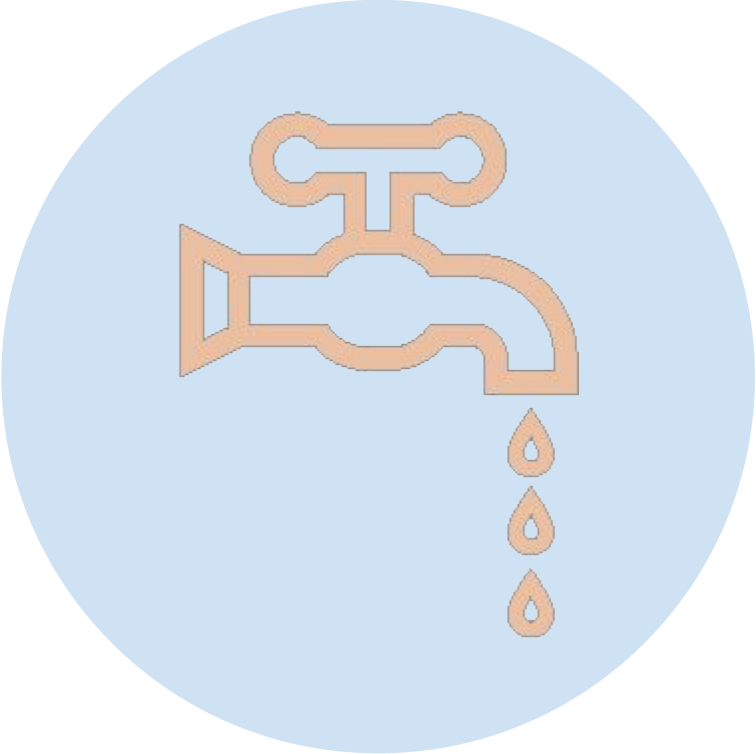
Load Reductions

Water Conditions



Living Resources

Load Reductions

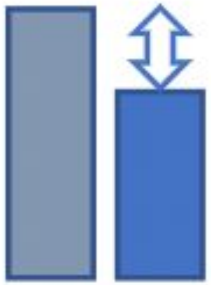


Nutrient and Sediment Response (TMDL)

As we approach 2025, we aimed to reflect on the following questions:

a) Have management efforts to meet TMDL nutrients and sediment reductions produced outcomes consistent with our expectations?

and if not

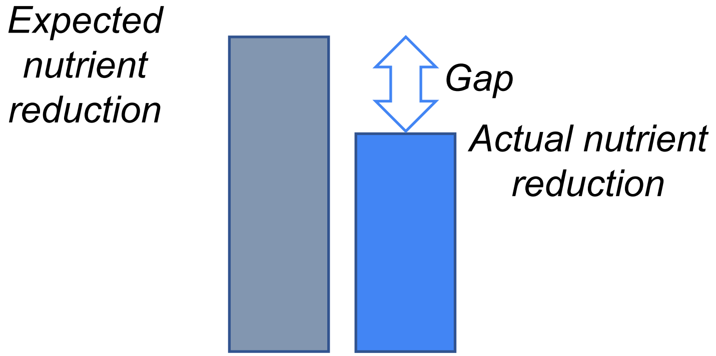


b) Why? What are the possible gaps in system response to reducing nutrient and sediment?

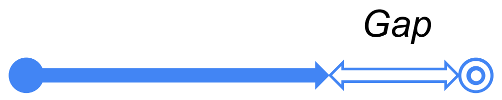
Nutrient/Sediment Load Reductions

- **Implementation gap:** Are management programs able generate enough adoption to achieve TMDL?

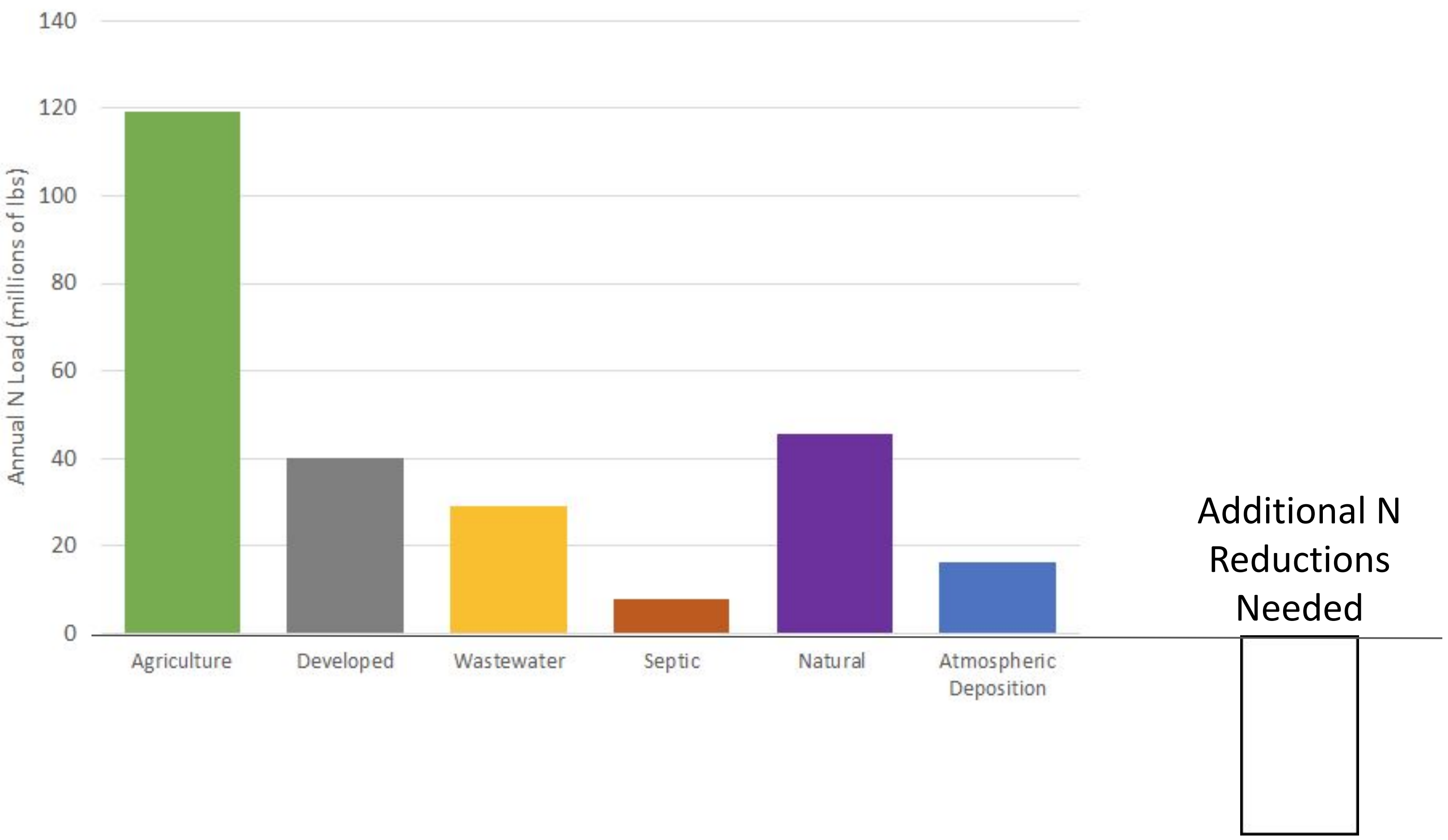
- **Response gap:** Are management actions as effective as we think at reducing pollutants? (difference between expected and actual reductions)



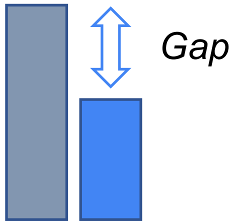
Implementation gap (N example)

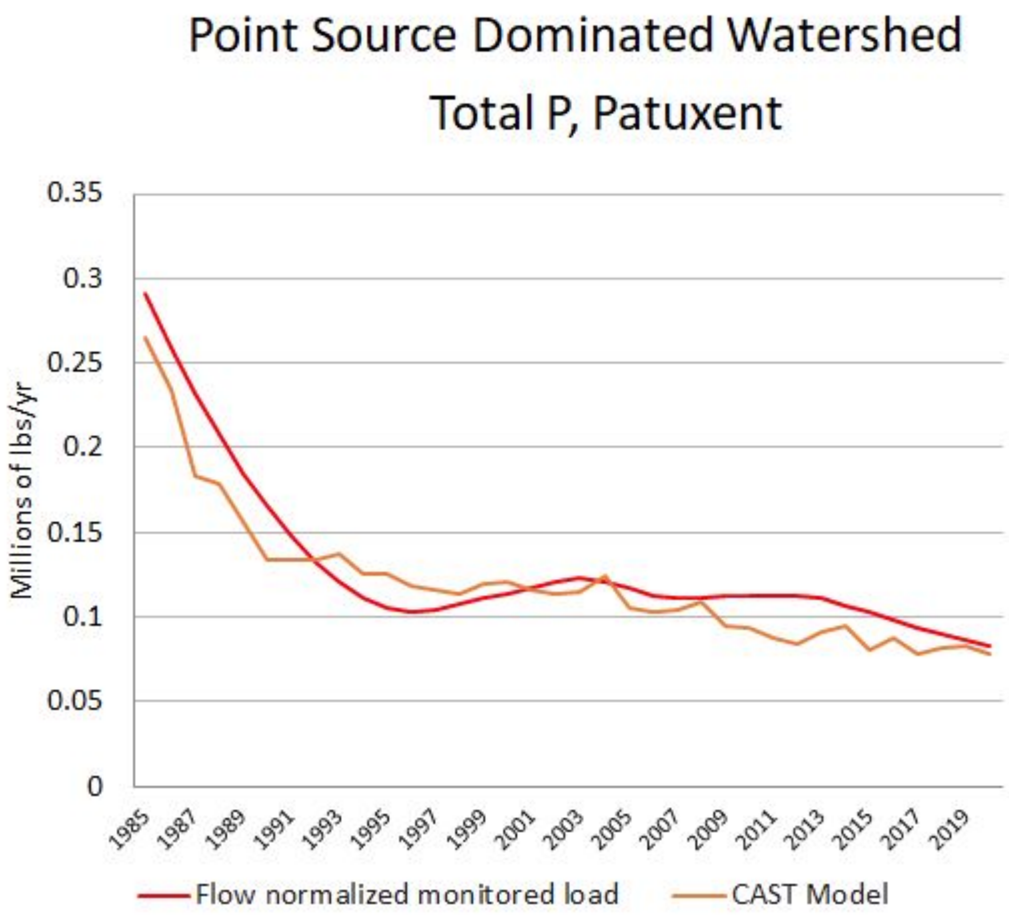


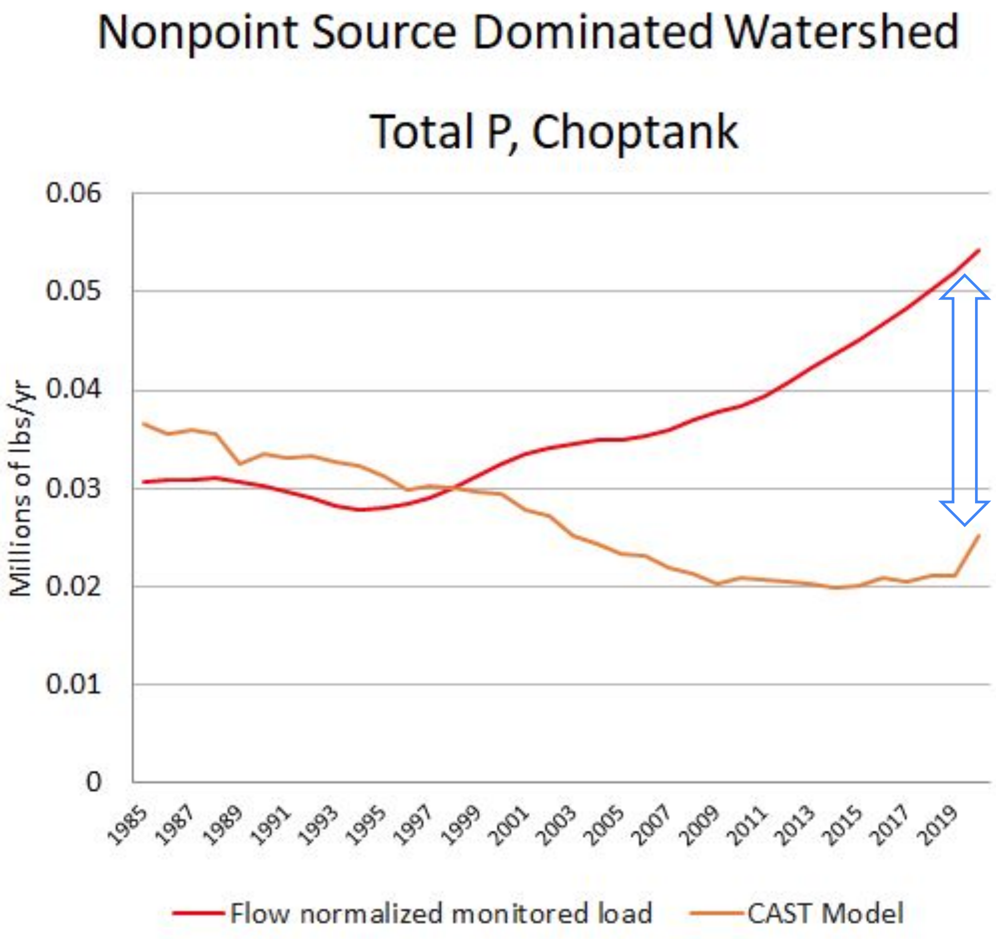
CAST Estimates of N Load to Chesapeake Bay, 2020



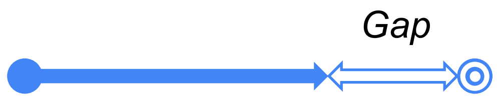
Response Gap (particularly phosphorus)







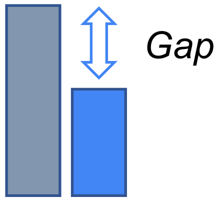
Why Do We Have These Gaps?



Implementation Gap

Limits to Adoption (cost-share)

Mass Nutrient Imbalances



Response Gap

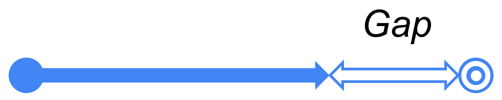
Lag Time/Legacy Pollutants

BMP Effectiveness

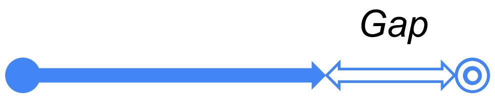
Behavior

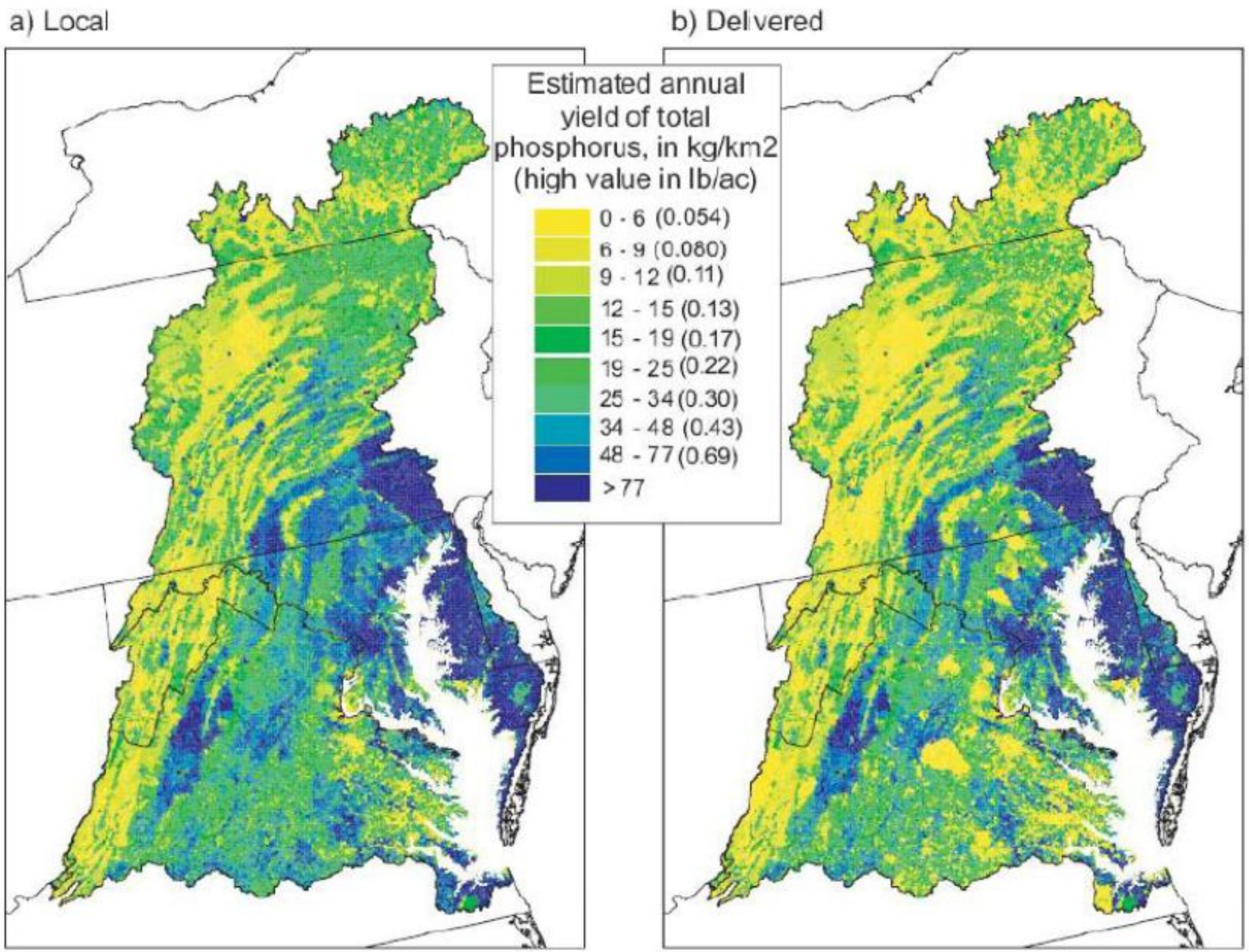
Data/Monitoring Limitations

Implementation Gap
Limits to Adoption (practice-based cost share)



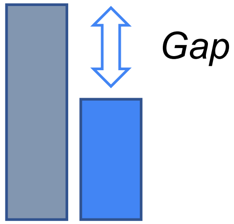
Mass Balance



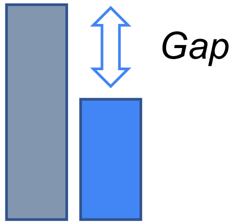


Source: USGS Sparrow Model Output

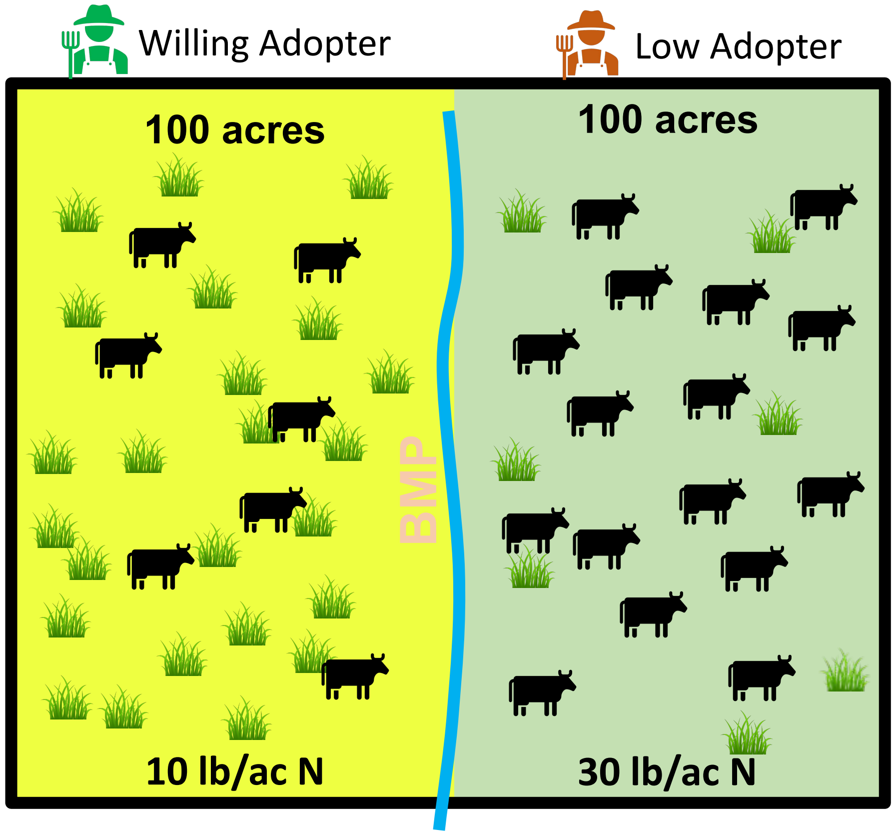
Response Gap: BMP Effectiveness



Response Gap: Behavior

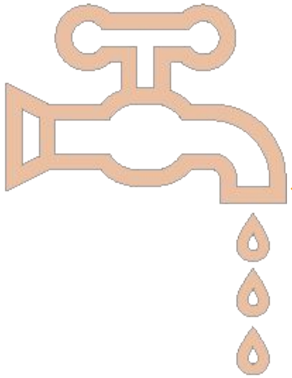


200 acre subwatershed in pasture



Avg 20lb/ac N runoff

FINDING: Existing nonpoint source water quality programs are insufficient to achieve the nonpoint source reductions required by the TMDL



Improving effectiveness of nonpoint source management programs

- Spatial targeting
- Outcomes-based incentive programs
- Targeted, performance-based requirements
- Facilitating policy innovation through “sandboxing”

Water Conditions

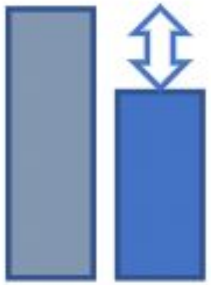
Water Quality Response

As we approach 2025, we aimed to reflect on the following questions:

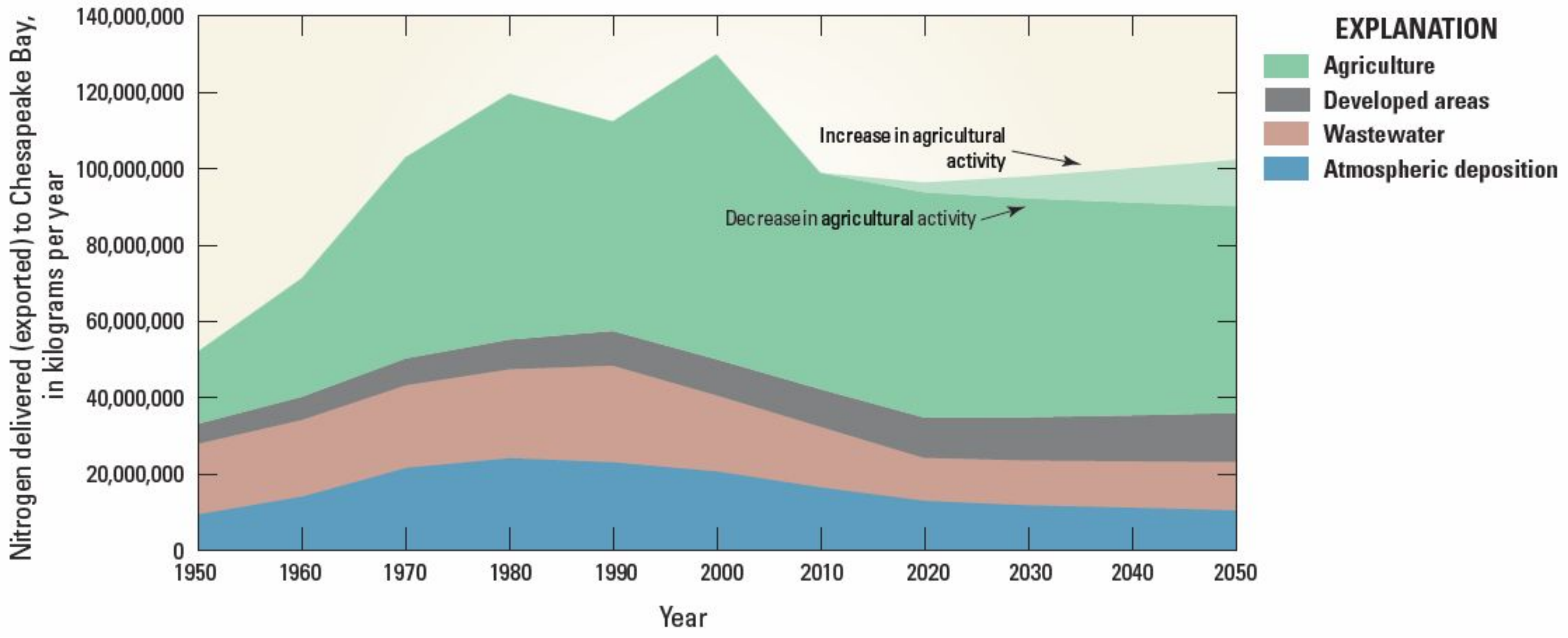
a) Has the recovery trajectory of Bay water quality criteria in response to reduced loads matched our expectations in both direction and magnitude?

and if not

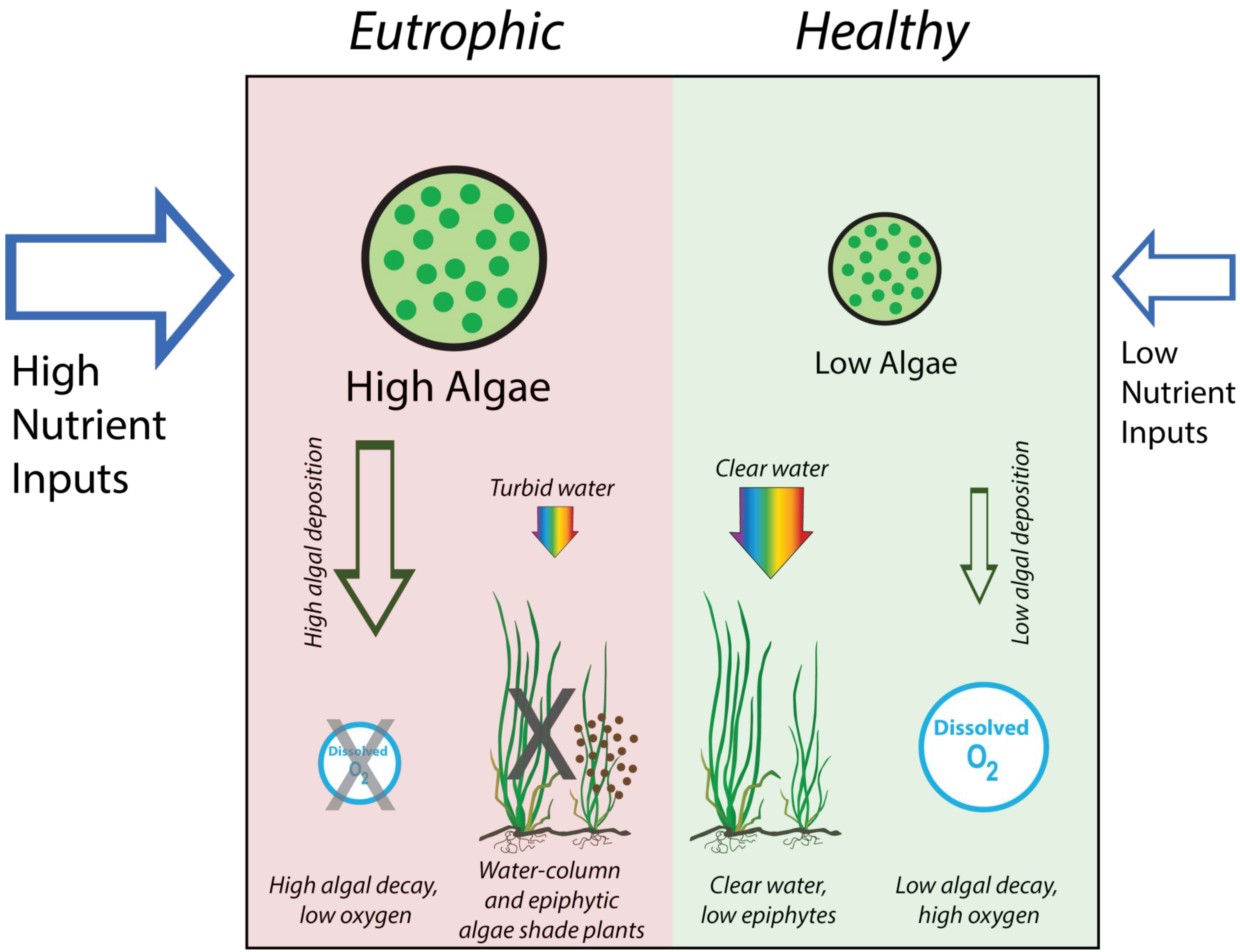
b) Why is there a gap in the response between what we have measured and that which we expected?



How Has Nutrient Load Changed Over Time?



Our Most Basic Model of Bay Water Quality



Loads and Nutrient Concentrations

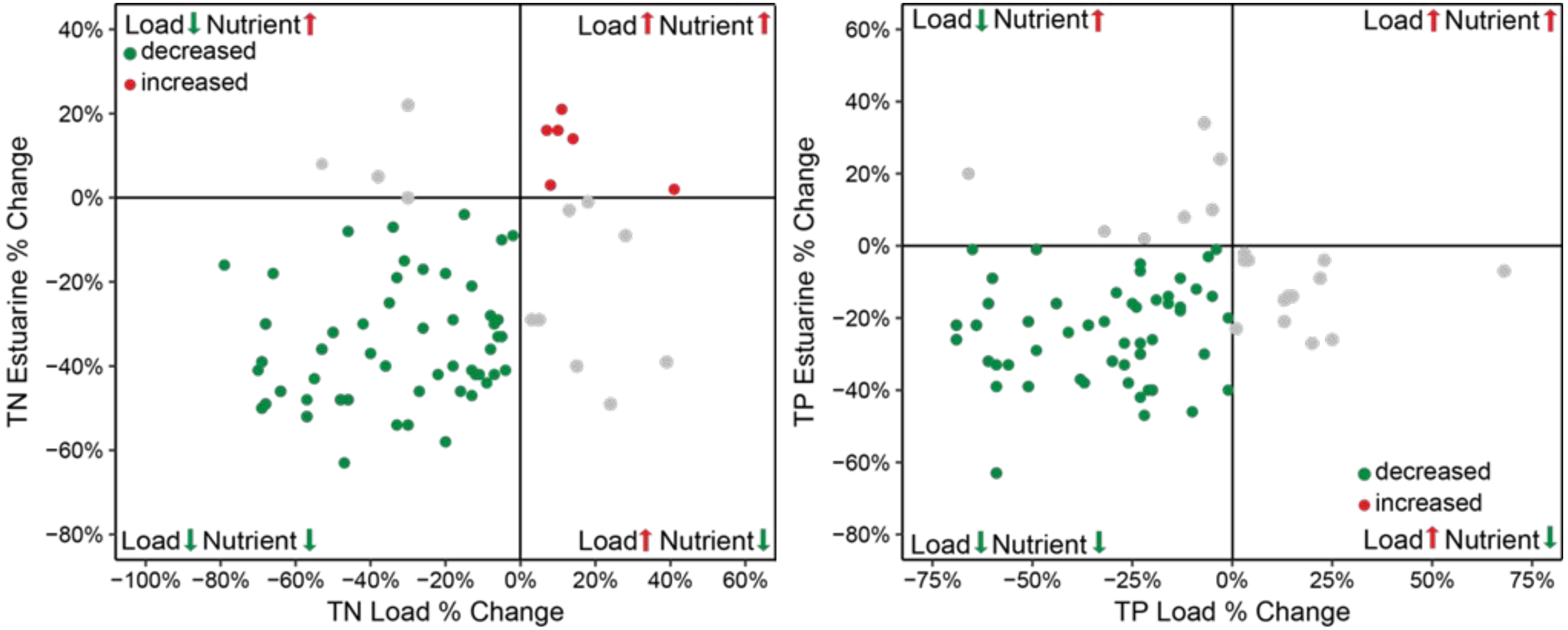


FIGURE 4.6.—Percent change in estuarine TN and TP loads and concentrations, late 1980s to mid-2010s, where each dot represents a Bay segment (Source: Testa et al., 2018).

Water Quality Response at Bay Scale

Chesapeake Bay bottom summer (June-Sept) dissolved oxygen

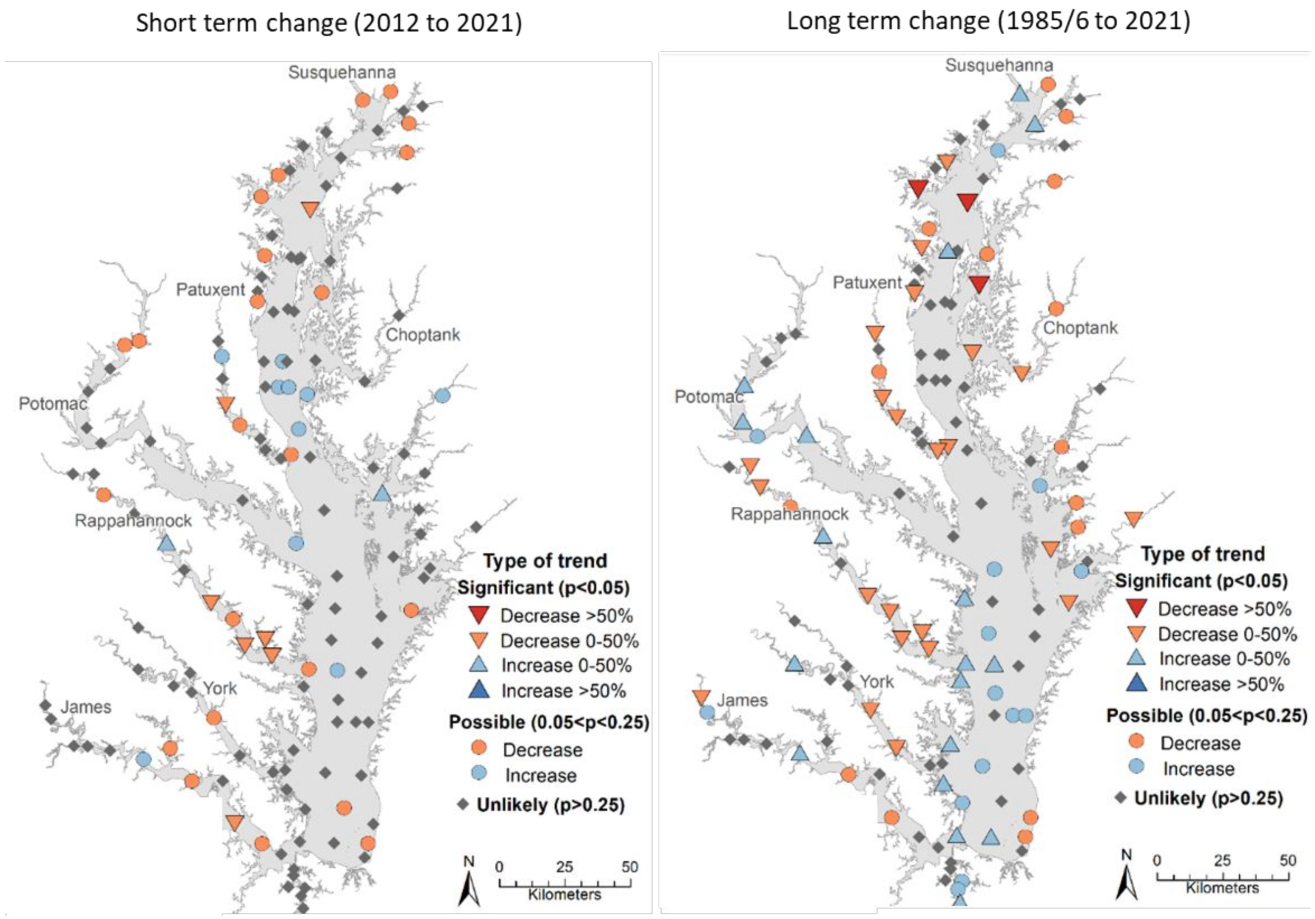
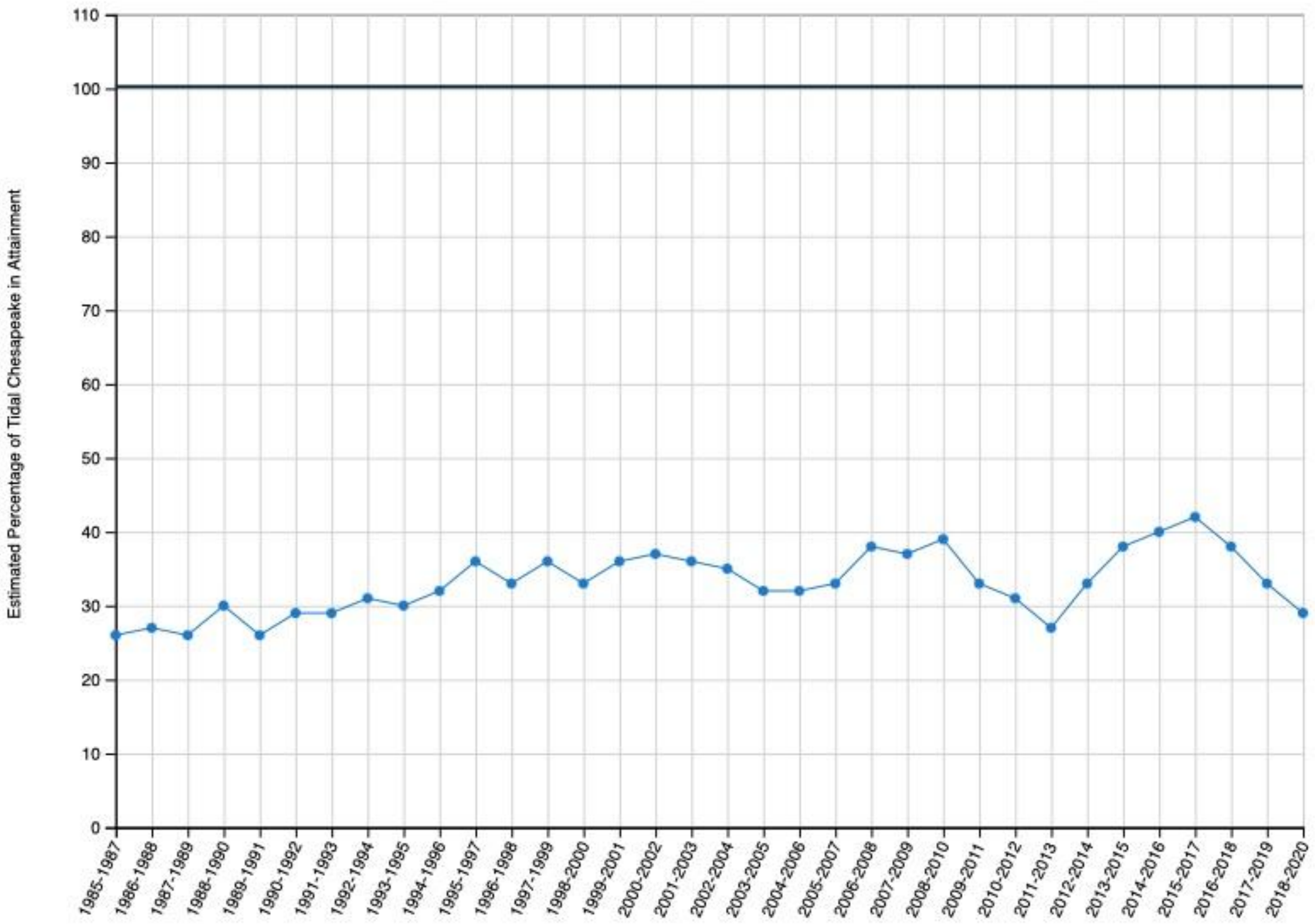


FIGURE 4.7.—Changes in DO in bottom water layer measured during June–September, short-term (left panel) and long-term (right panel); starting dates for long-term measurements vary (Source: CBP, n.d.-b).

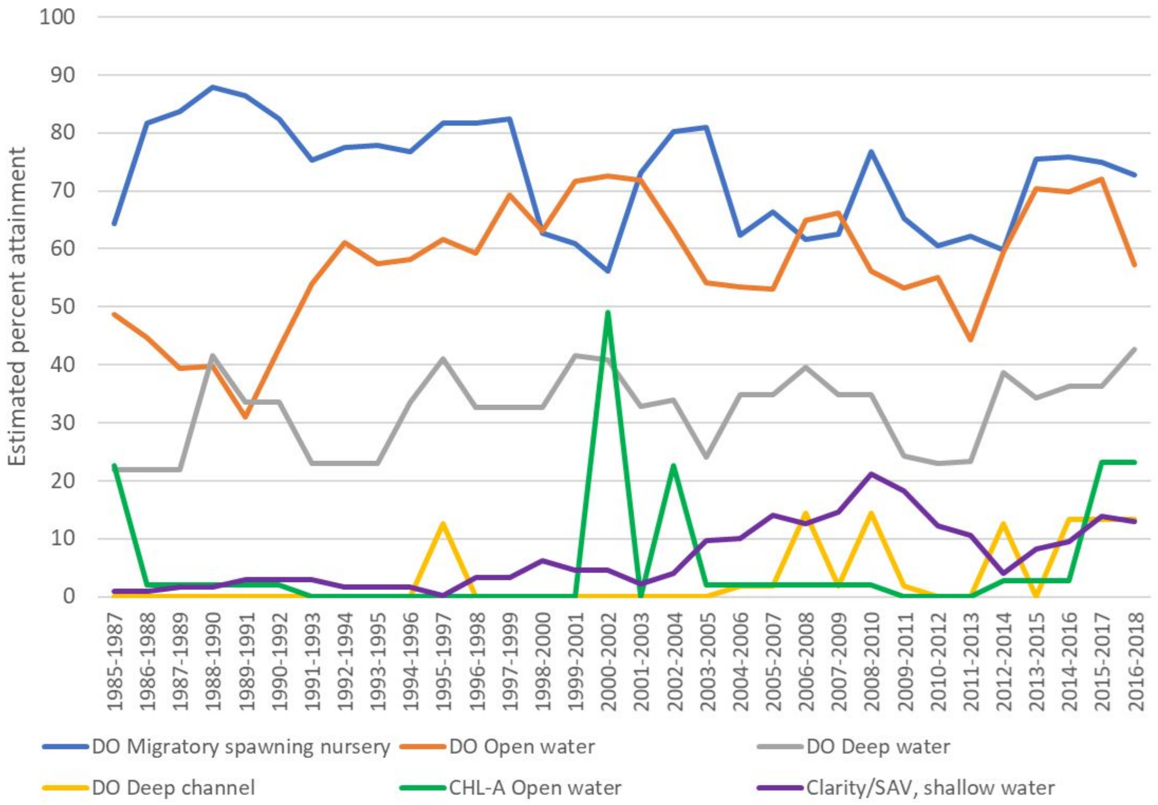
Water Quality Standards Attainment (1985-2020)

Water quality is evaluated using three parameters: dissolved oxygen, water clarity or underwater grass abundance, and chlorophyll a (a measure of algae growth).

VIEW CHART VIEW TABLE



Breaking Down WQC Attainment



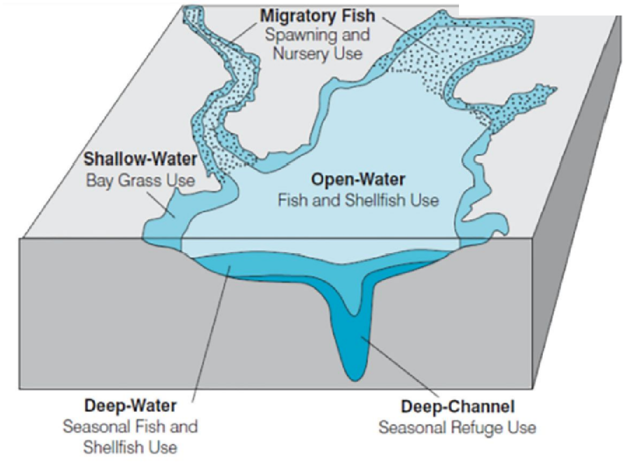


FIGURE 4.8.—Time series of area-weighted estimated WQC attainment for the five DUs, 1985–1987 through 2016–2018 (Source: Zhang, Murphy, et al. [2018] with updated data).

These estimates show high attainment in some habitats, but negative trend
AND low attainment in other habitats, but positive trend

Response Gap for DO across Habitats

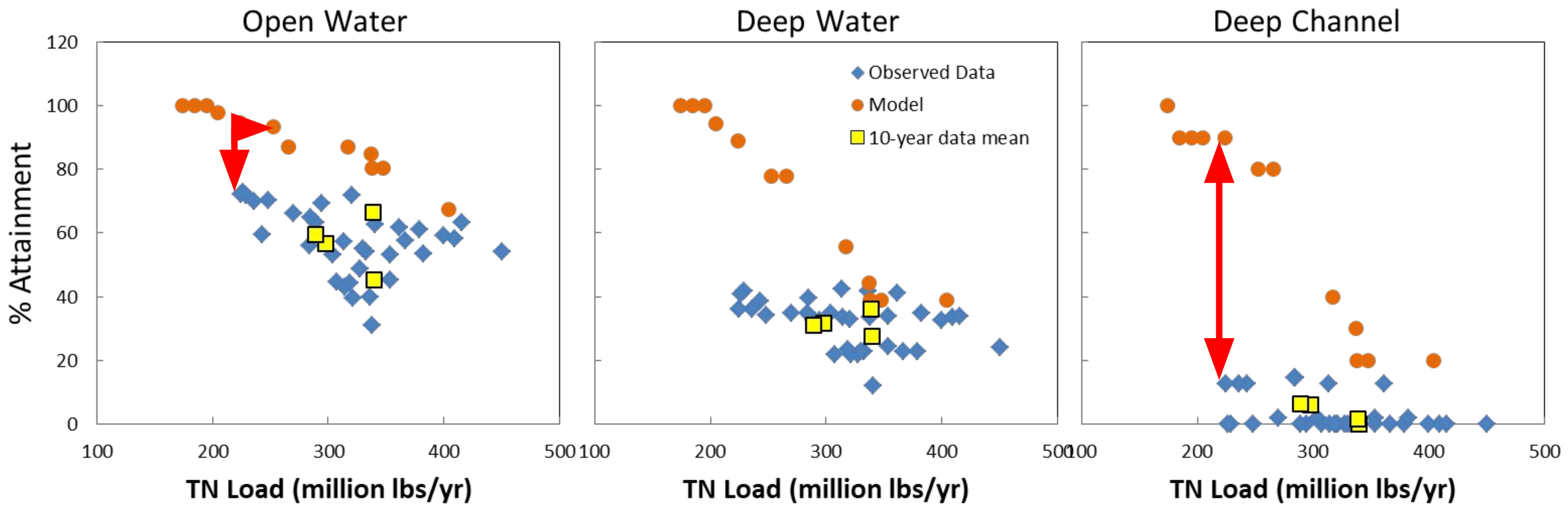
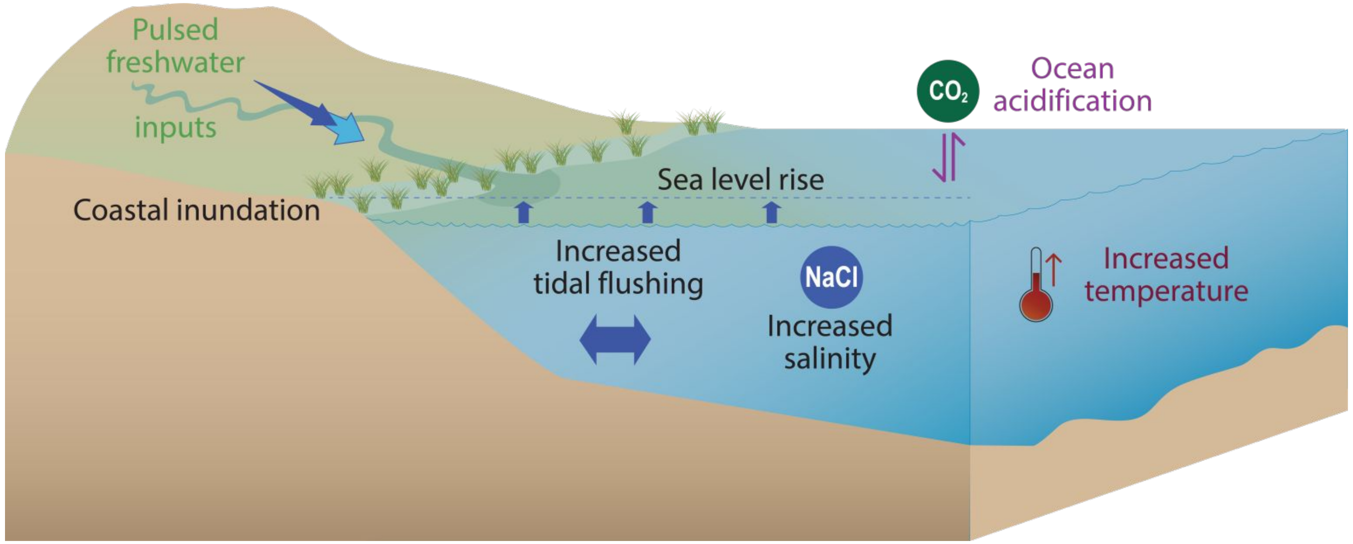


FIGURE 4.9.—Expected and realized relationships between TN loads and DO criteria attainment for open water, deep water, and deep channel habitat, calculated as 3-year running mean observed values (blue diamonds) and expected responses from estuary model (orange dots) for the same time periods. Yellow 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

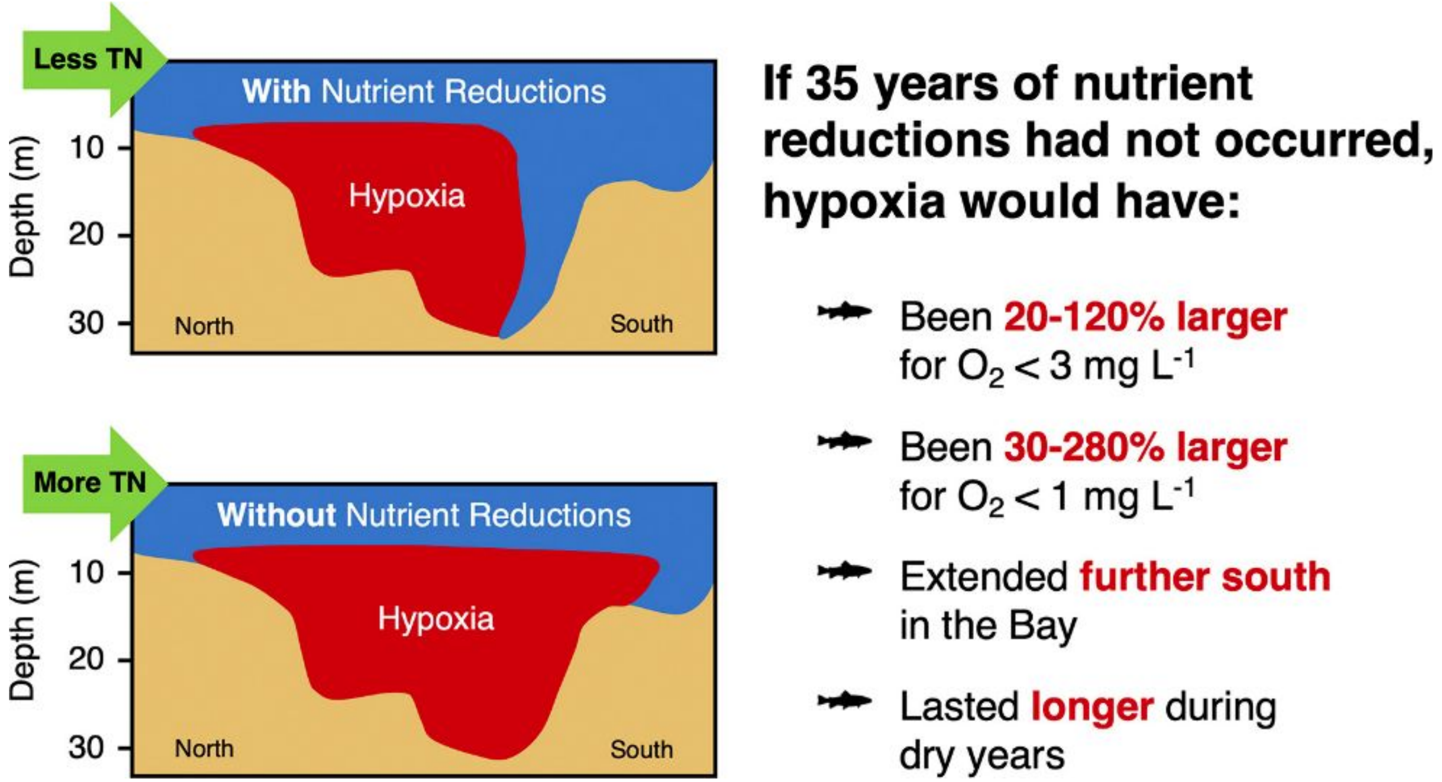
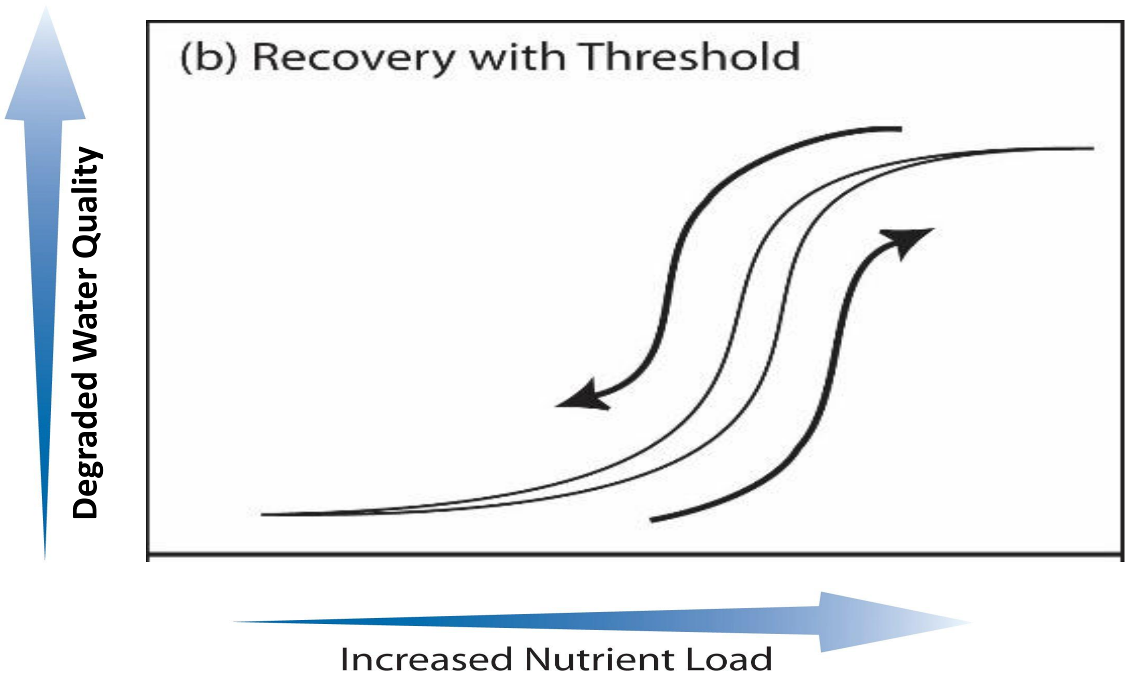
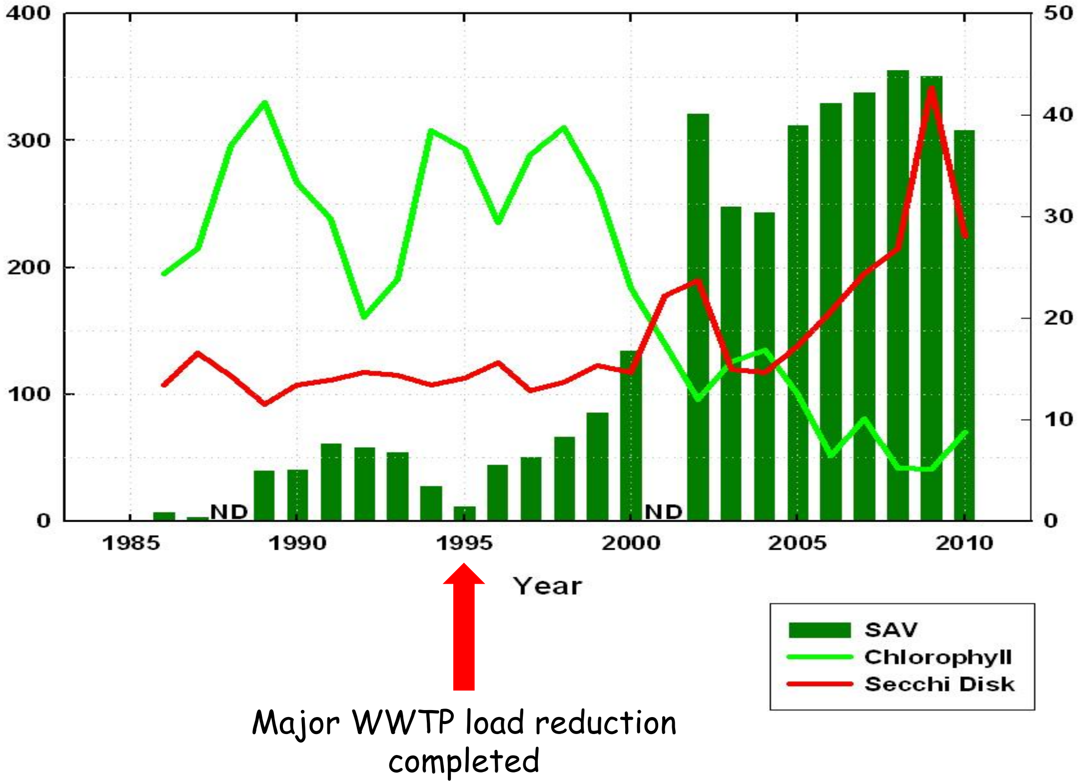


FIGURE 4.13.—Estimated extent of Chesapeake Bay hypoxia with and without 35 years of nutrient reductions (Source: Frankel et al., 2022).

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

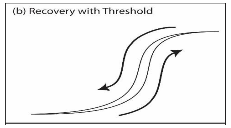


Mattawoman Creek



FINDING: Uncertain if it is possible to achieve water quality criteria (DO, SAV), **but** efforts have stemmed further declines in water quality.

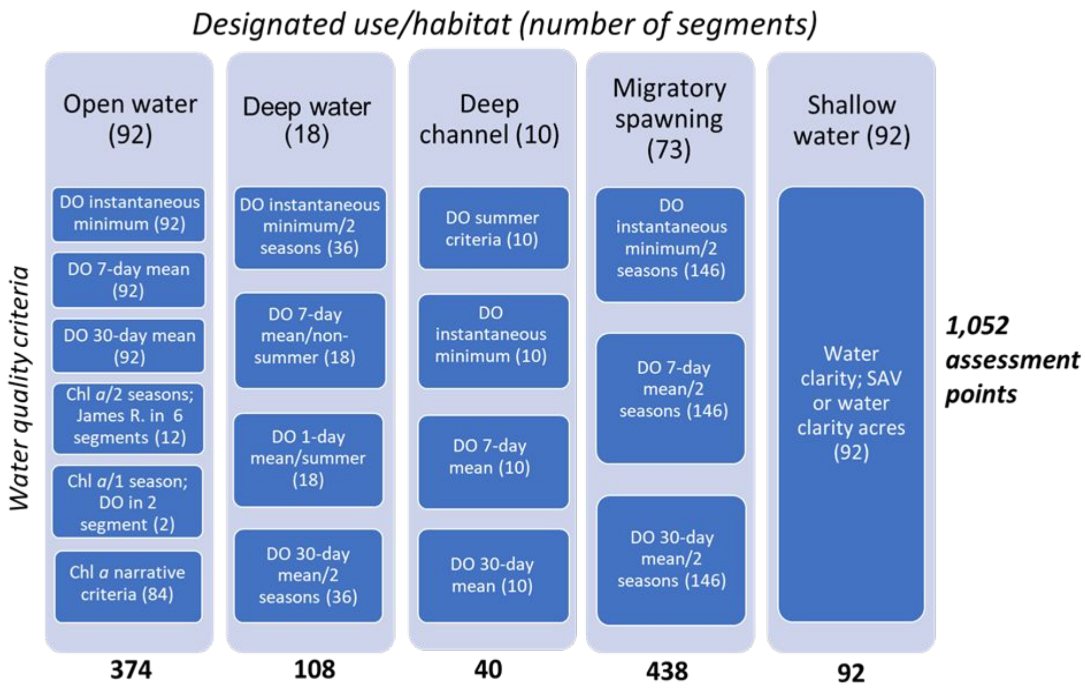
- The modest reductions in nutrient loads we have achieved Baywide, which are substantial in some locales, have initiated a recovery.
- Water quality response to nutrient reductions is less than expected.
- In the deeper waters of the Bay, progress towards attainment has been slow.
- There are tipping points in the Bay ecosystem that can slow recovery in early stages but potentially accelerate recovery down the road.



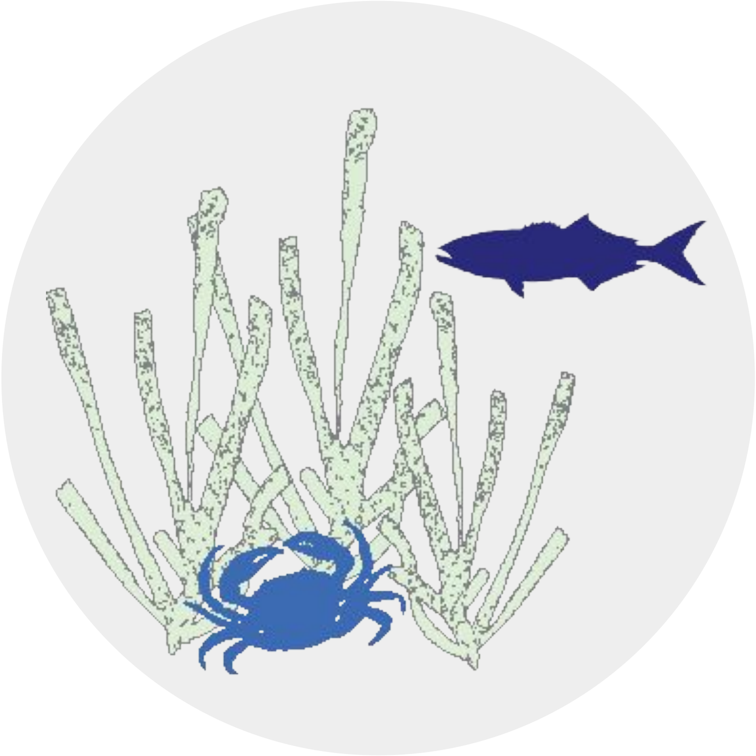
- Some Bay conditions are changing, permanently altered, and irreversible.

Achieving WQS

- Additional nutrient reductions will improve water quality, but water quality criteria may be unattainable in some regions under existing technologies
- Identifying response gaps and causes are limited by our monitoring capabilities



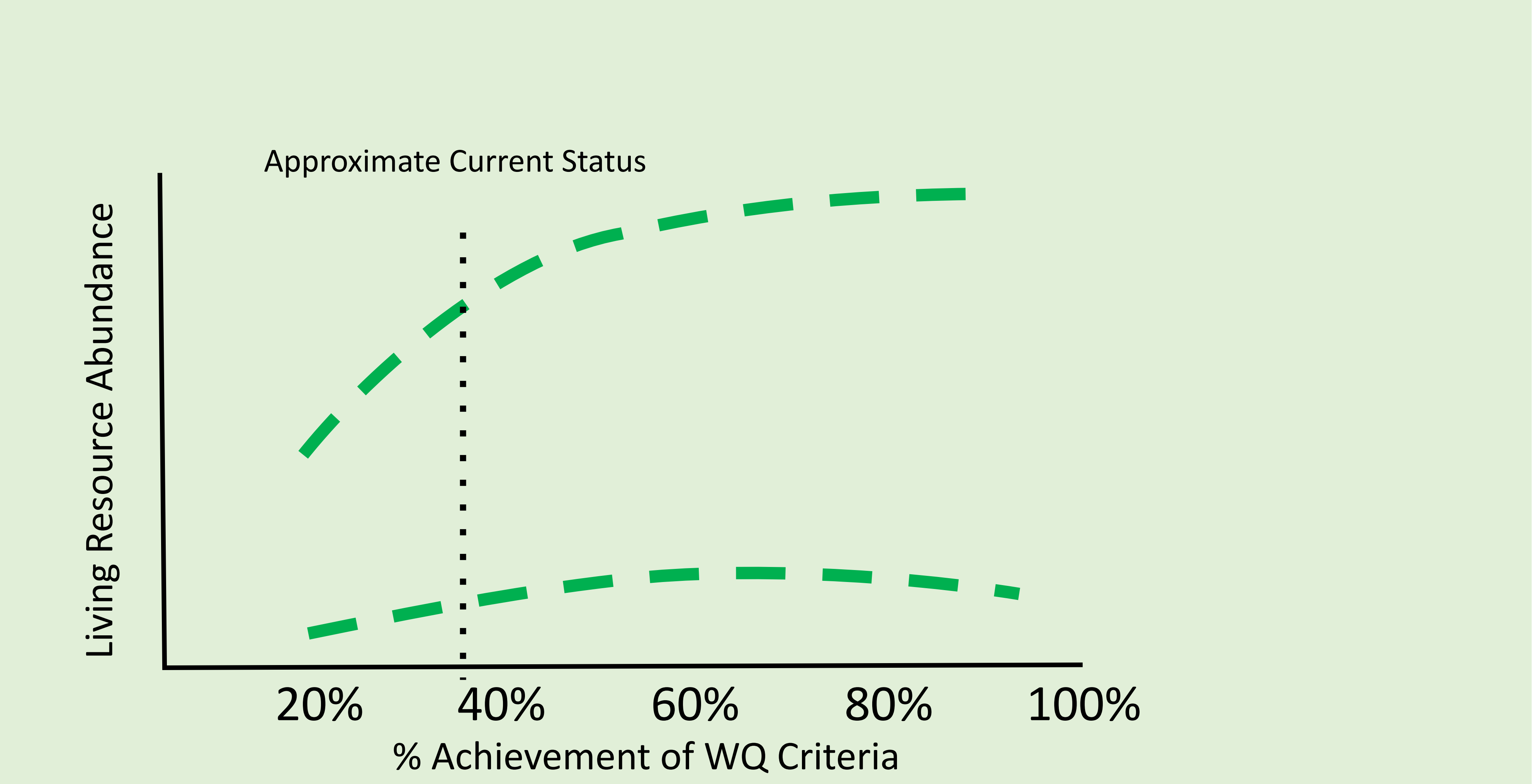
Living Resources



Living Resources Response

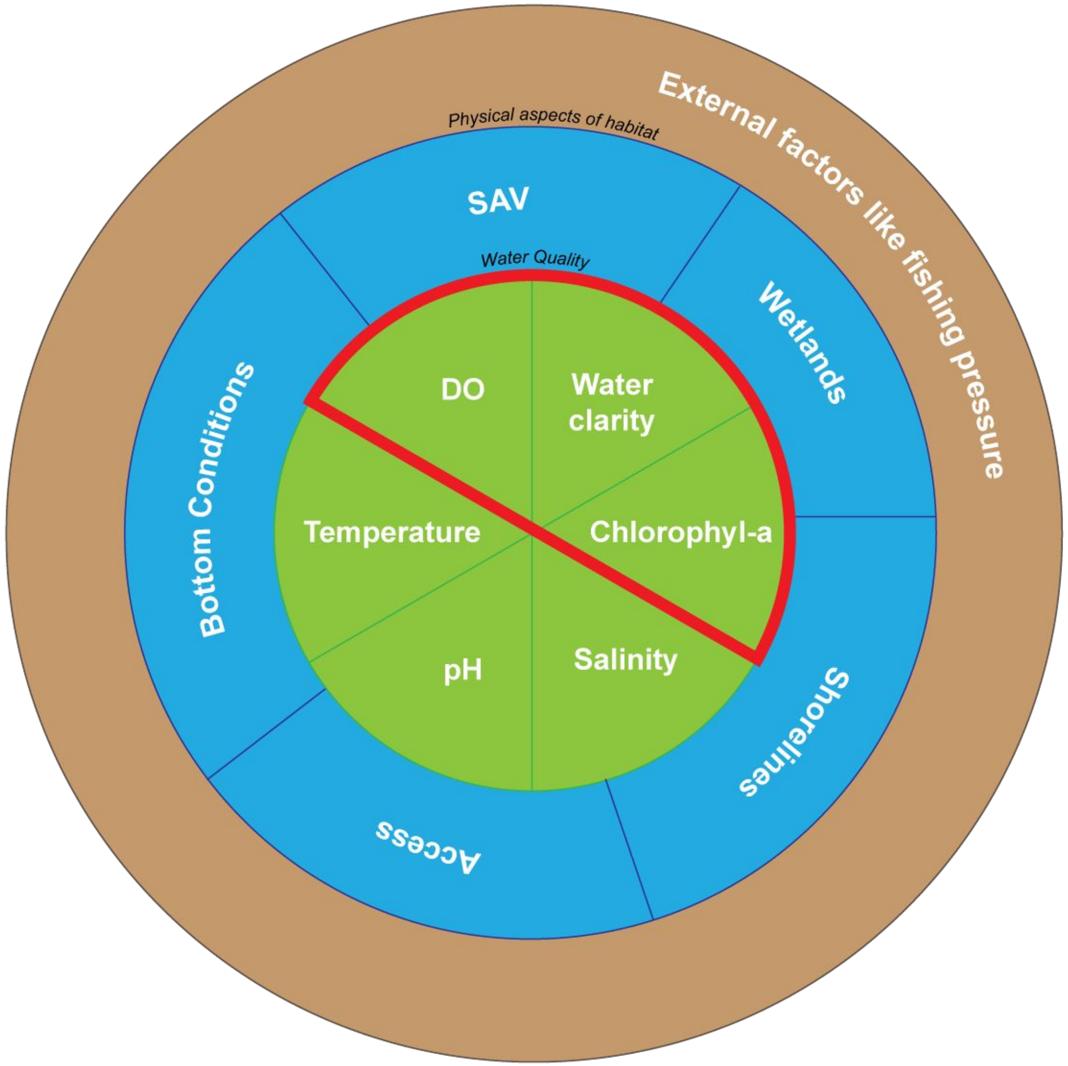
As we approach 2025, we aimed to reflect on the following question:

> To what extent are Bay living resources improving as a result of efforts to improve water quality conditions (particularly the identified water quality criteria DO, water clarity, and Chl-a)?



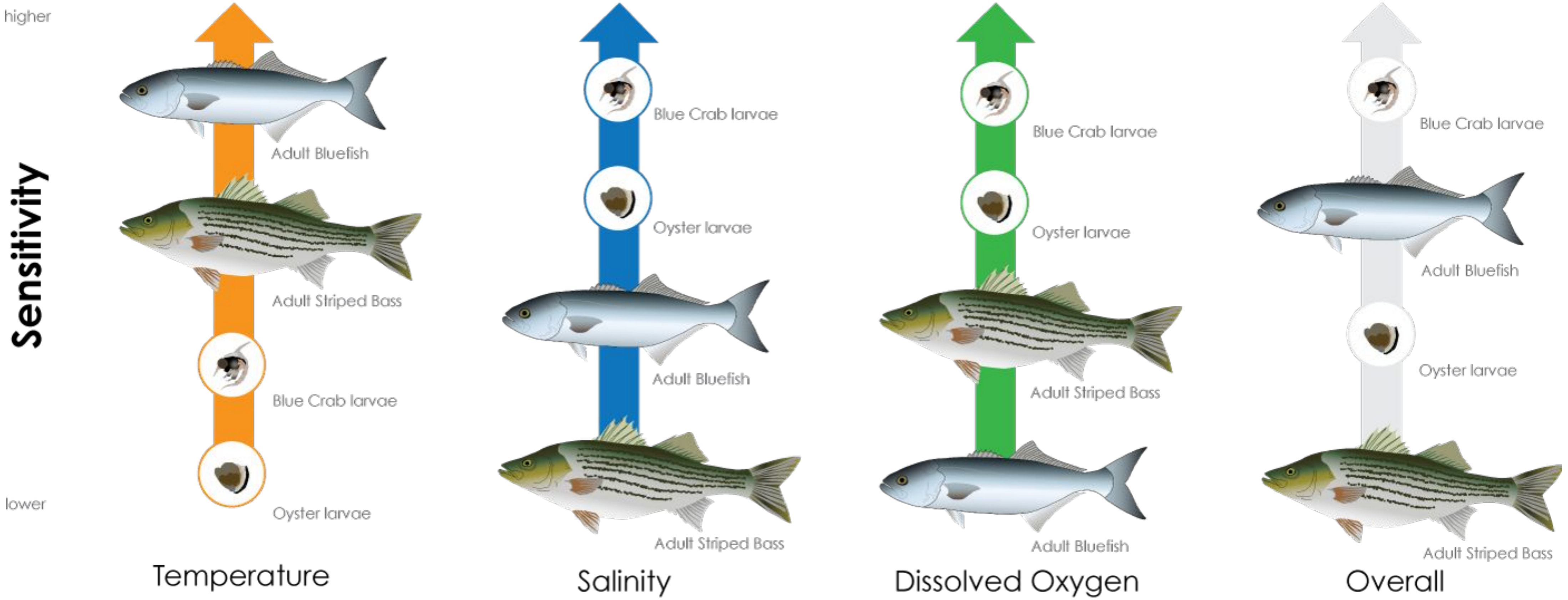
Approximate Current Status
Living Resource Abundance
20%
40%
60%
80%
100%
% Achievement of WQ Criteria

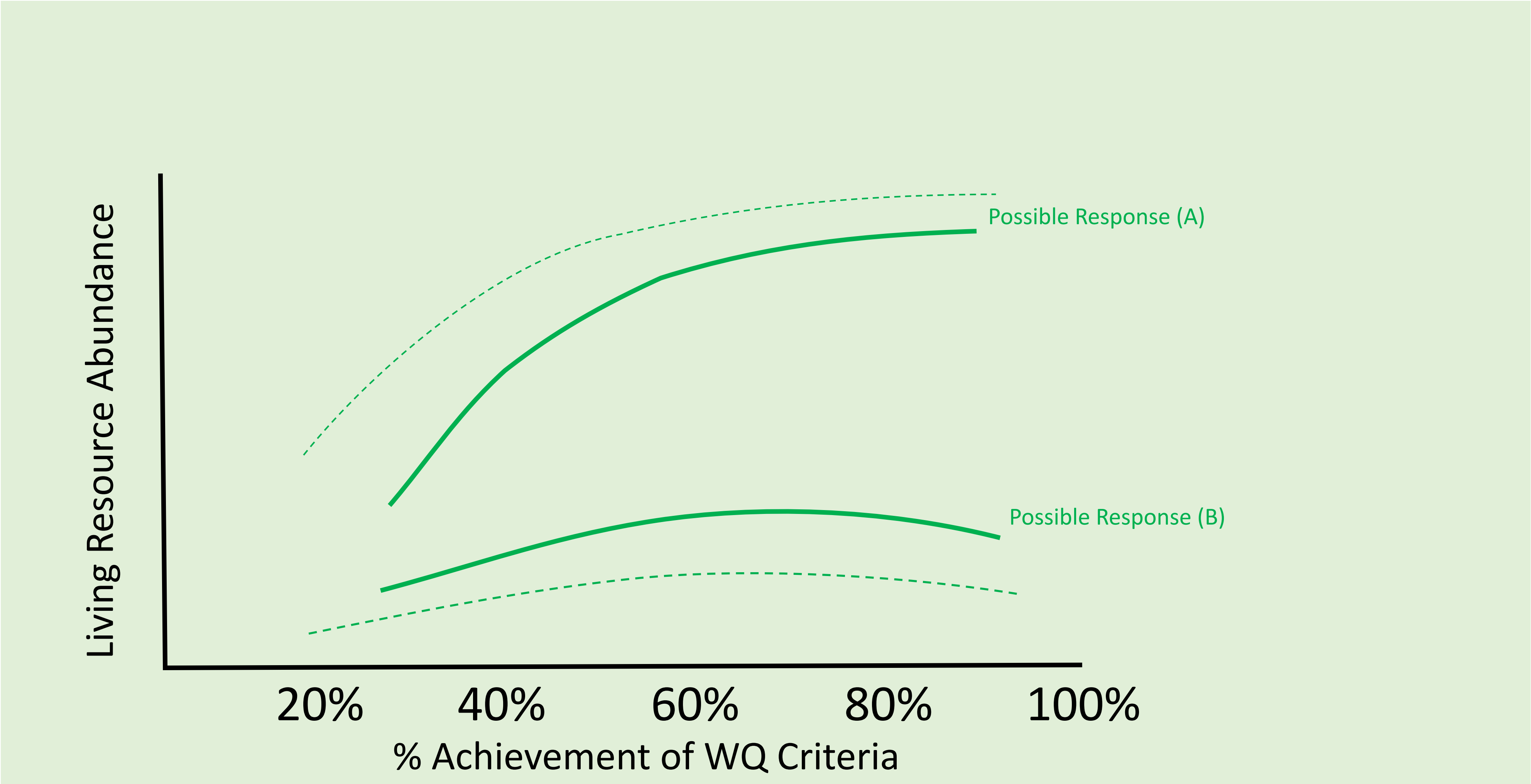
Many Knobs of Living Resource Response



Managed by Bay water quality standards

Many Knobs of Living Resource Response



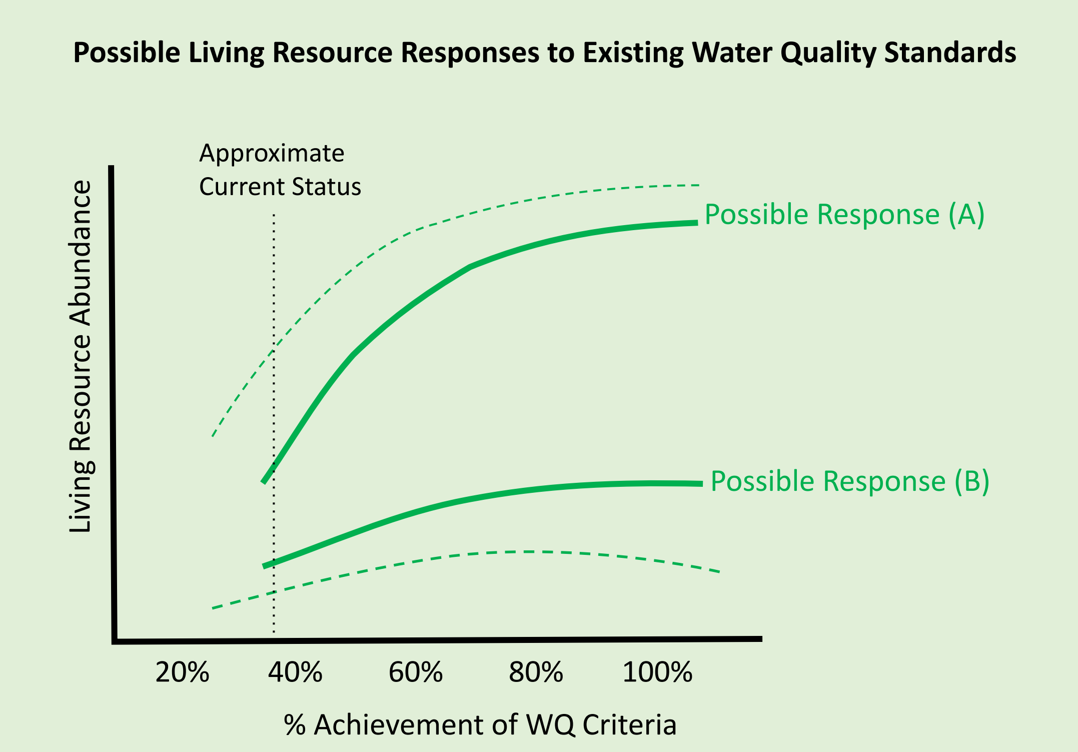

Possible Response (A)
Possible Response (B)
Living Resource Abundance
20%
40%
60%
80%
100%
% Achievement of WQ Criteria

FINDING: It might not be possible to meet the all TMDL and WQ goals **but** this may not be necessary to meet and support living resource goals.

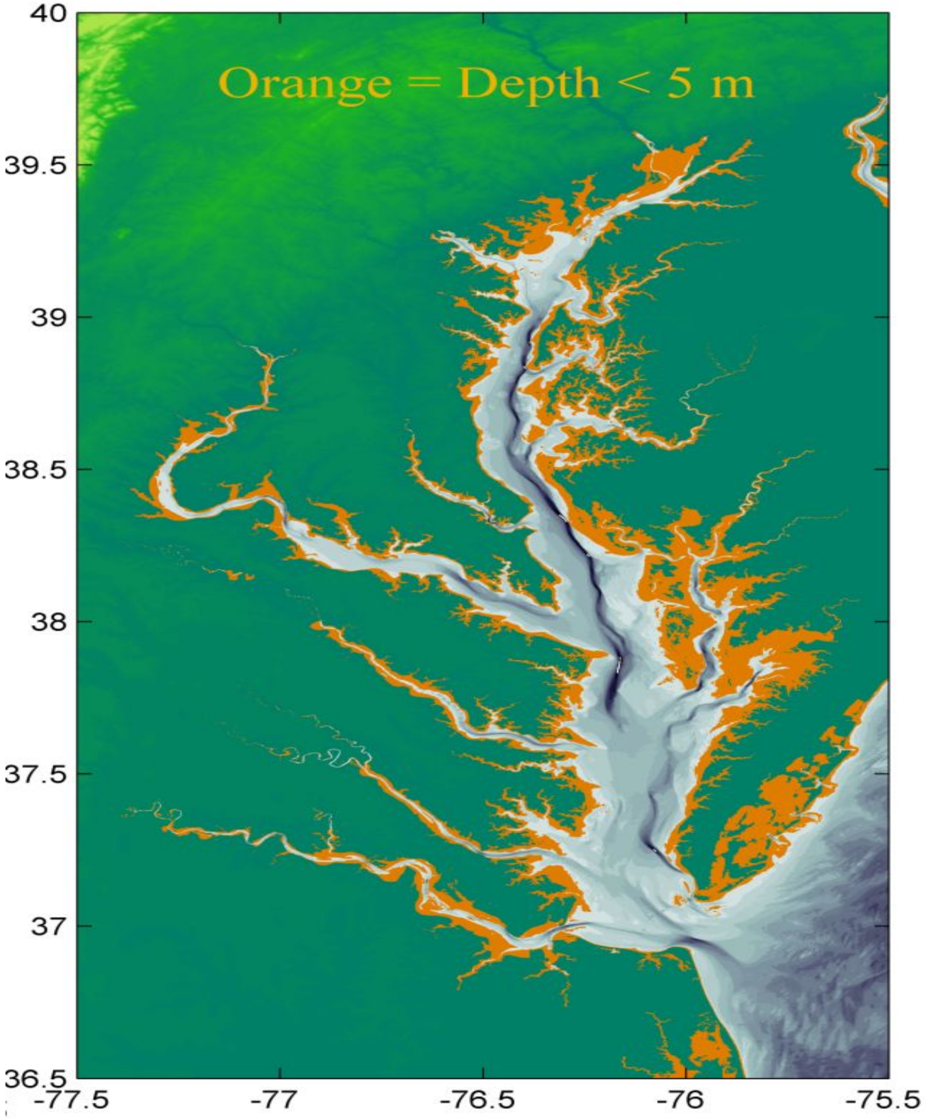
- Water quality improvements in shallow water may have more of a benefit to living resources than elsewhere.
- Water quality alone does not guarantee improvements in Living Resources. There are other factors!

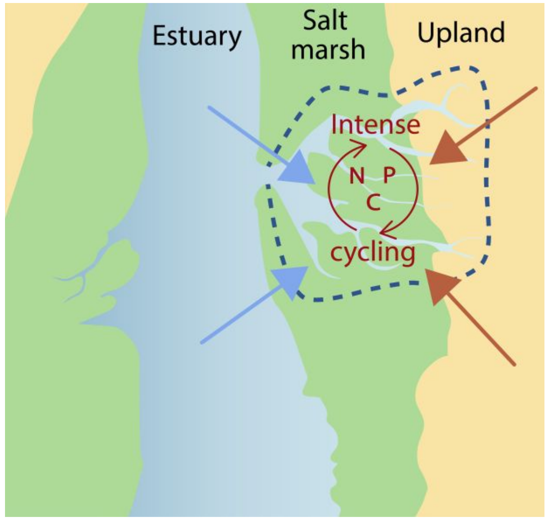
Improving living resource response to water quality management efforts

- Legal requirements of CWA divert attention away from considering multiple means of improving LR (addition of management actions to elevate LR response to WQ management efforts)
- Opportunities exist to adjust water quality goals to prioritize management actions that improve LR (achievement of TMDL targets could be prioritized according to location (segments) or habitat type)

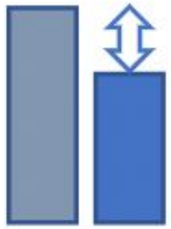


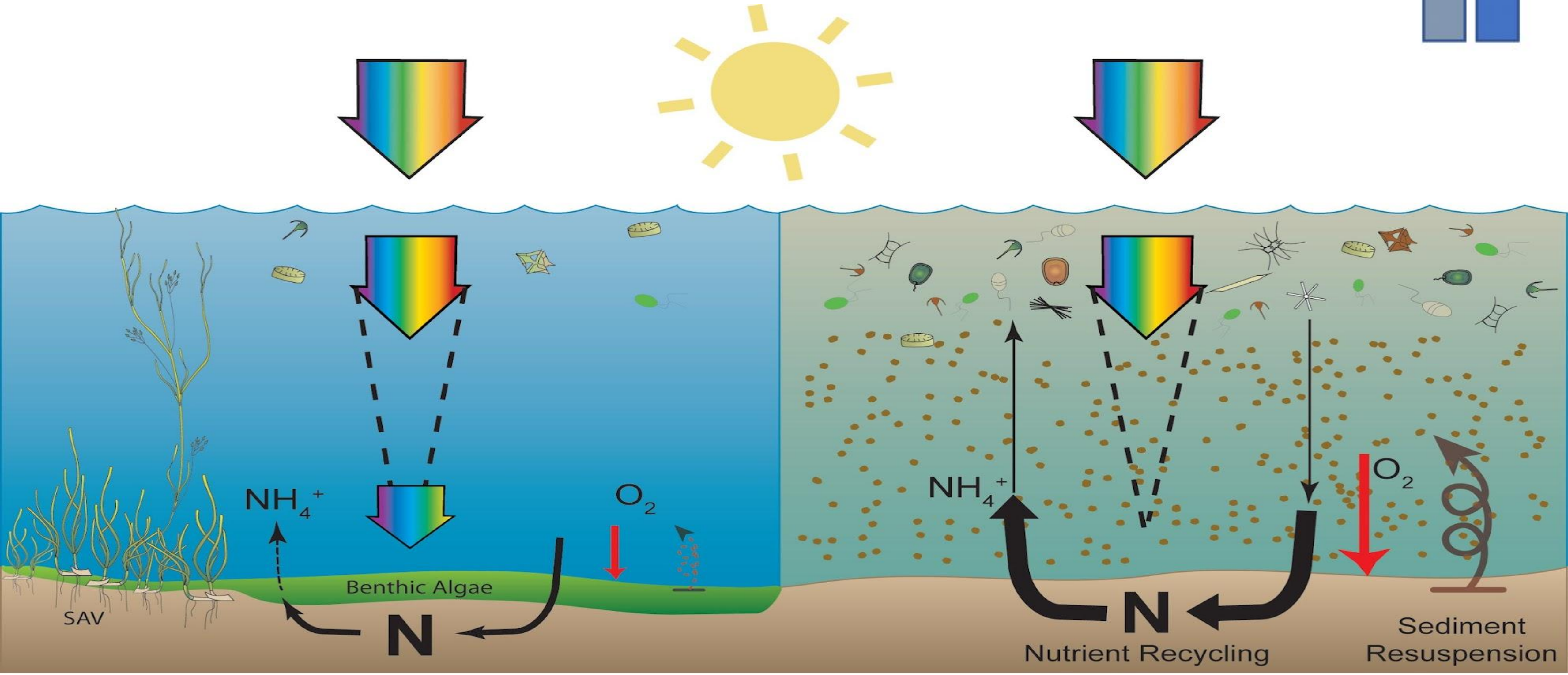
Opportunities For Shallow Water Restoration





Sediments That Receive Light Trap Nutrients



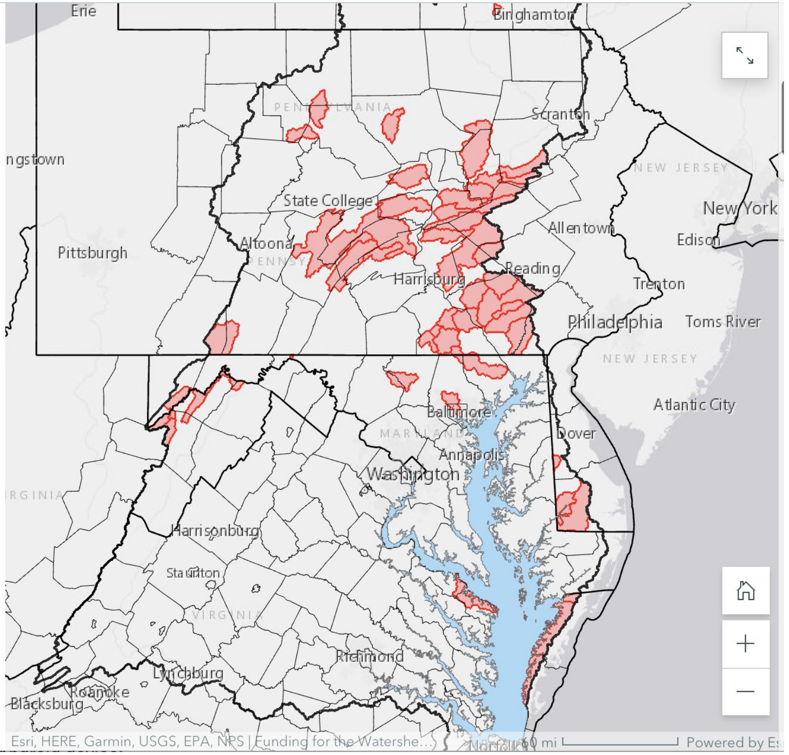


Reimagining Most Effective Basins

Chesapeake Bay Most Effective Basins

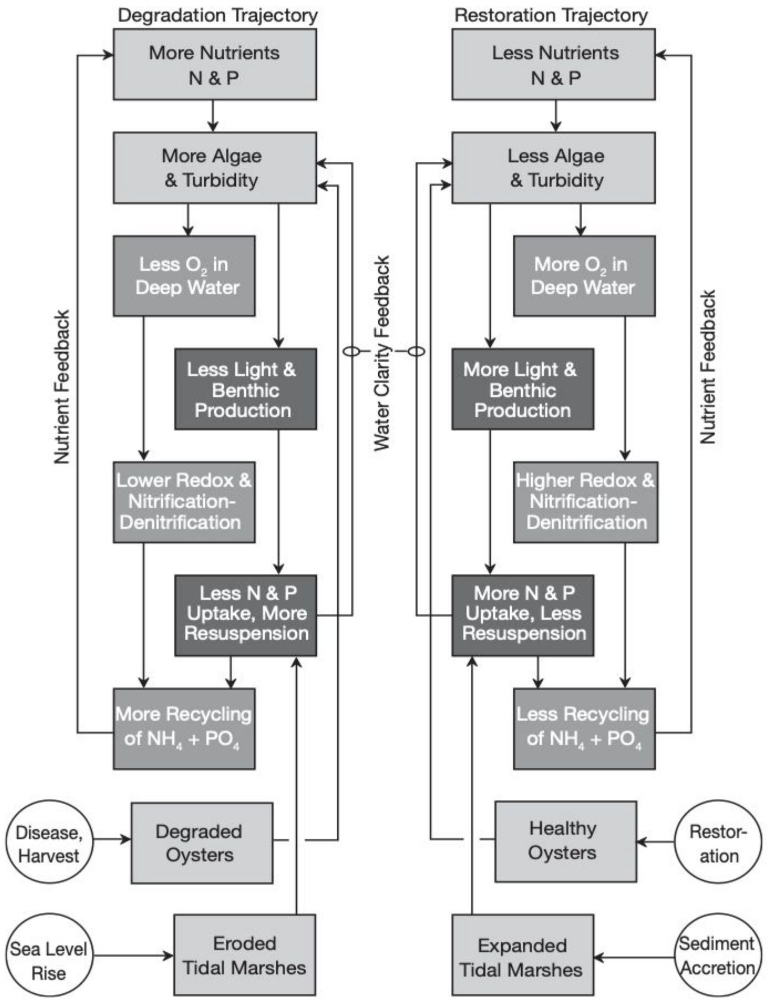
Agriculture MEB

EPA will provide MEB funding to jurisdictions that have committed to reducing the agricultural contribution of nitrogen in their Phase III Watershed Implementation Plans (WIPs) by implementing the most cost-effective best management practices (BMPs). This includes Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia, as the District of Columbia does not have an agricultural commitment through 2025. The $6 million in MEB funding will be allocated to the jurisdictions based on their Phase III WIP agricultural nitrogen commitments through 2025.



“These critical segments are the estuarine monitoring segments CB3MH, CB4MH, CB5MH, and POTMH for deep water and CB3MH, CB4MH, and CB5MH for deep channel.”

Reimagining Most Effective Basins



Selection criteria:

- Underserved communities
- Stakeholder groups
- Tipping points
- Oyster restoration
- Other…..

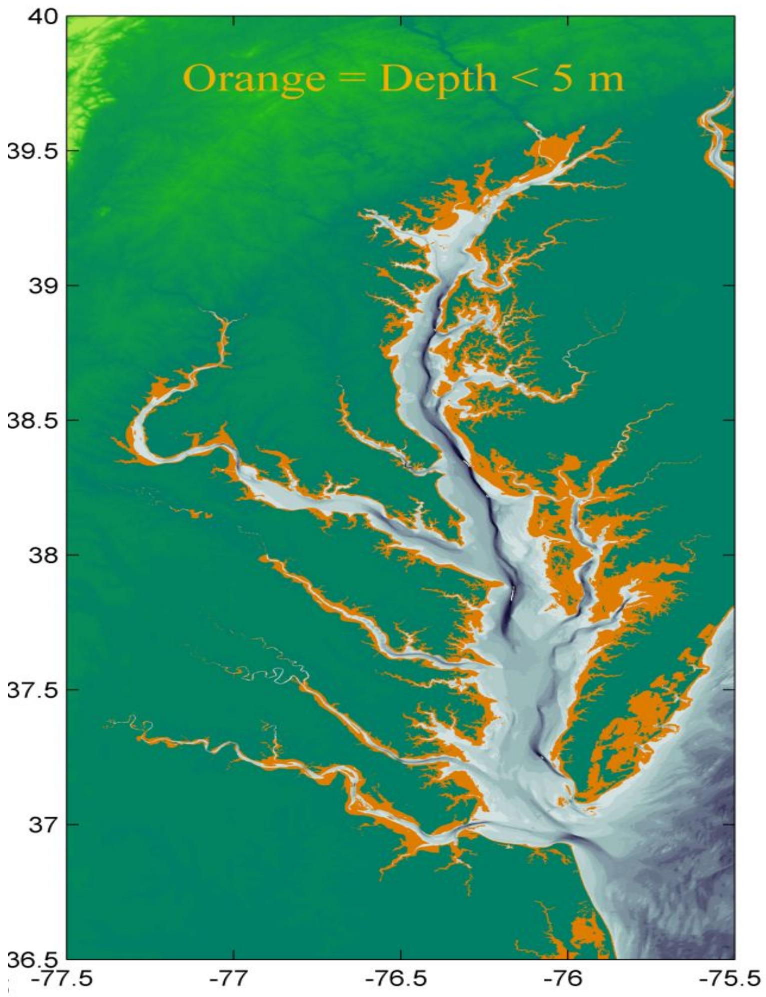
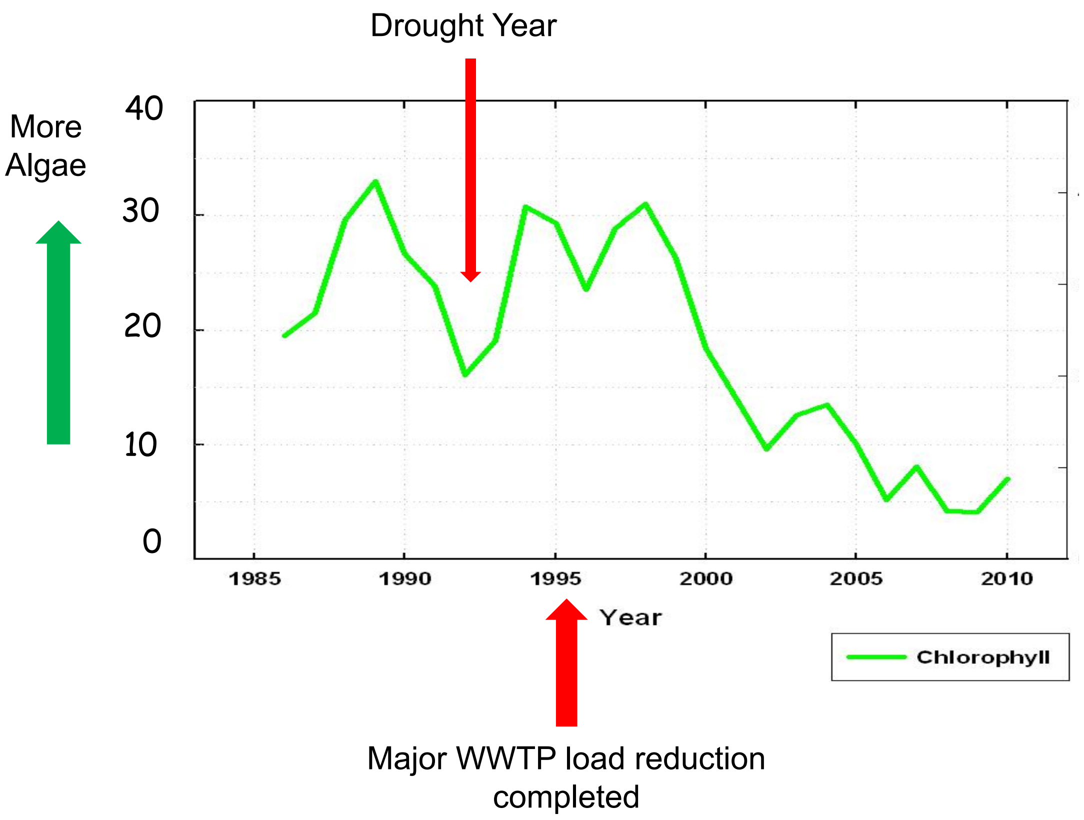


FIGURE 4.12.—Effects of N and P additions on physical, chemical, and biological elements of the estuarine system, including algal biomass, bottom water oxygen, and nutrient recycling. Effects of climate change (save sea level rise) and land cover change are not included (Source: Kemp et al., 2005).

Water Quality Response at Local Scales: Mattawoman Creek

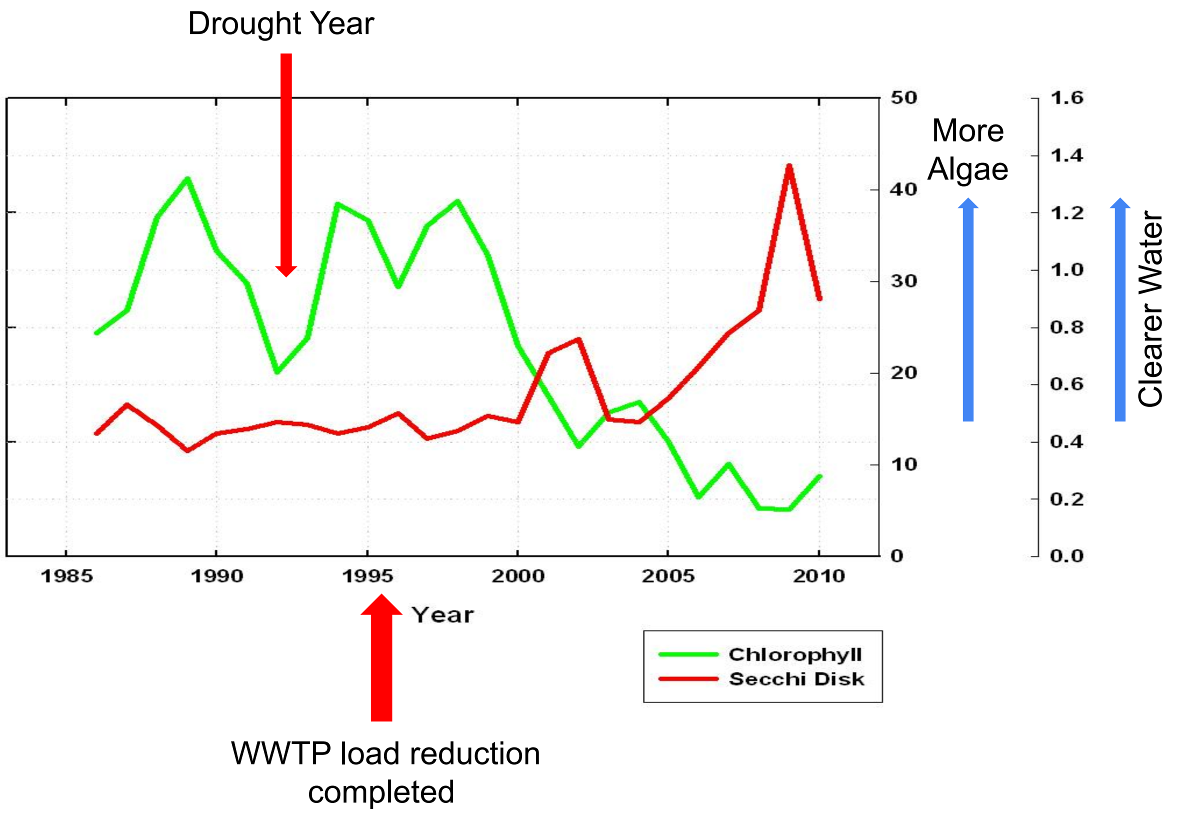
Photo from Elena Gilroy

Algal Biomass Decreased
…with Substantial Lag Time



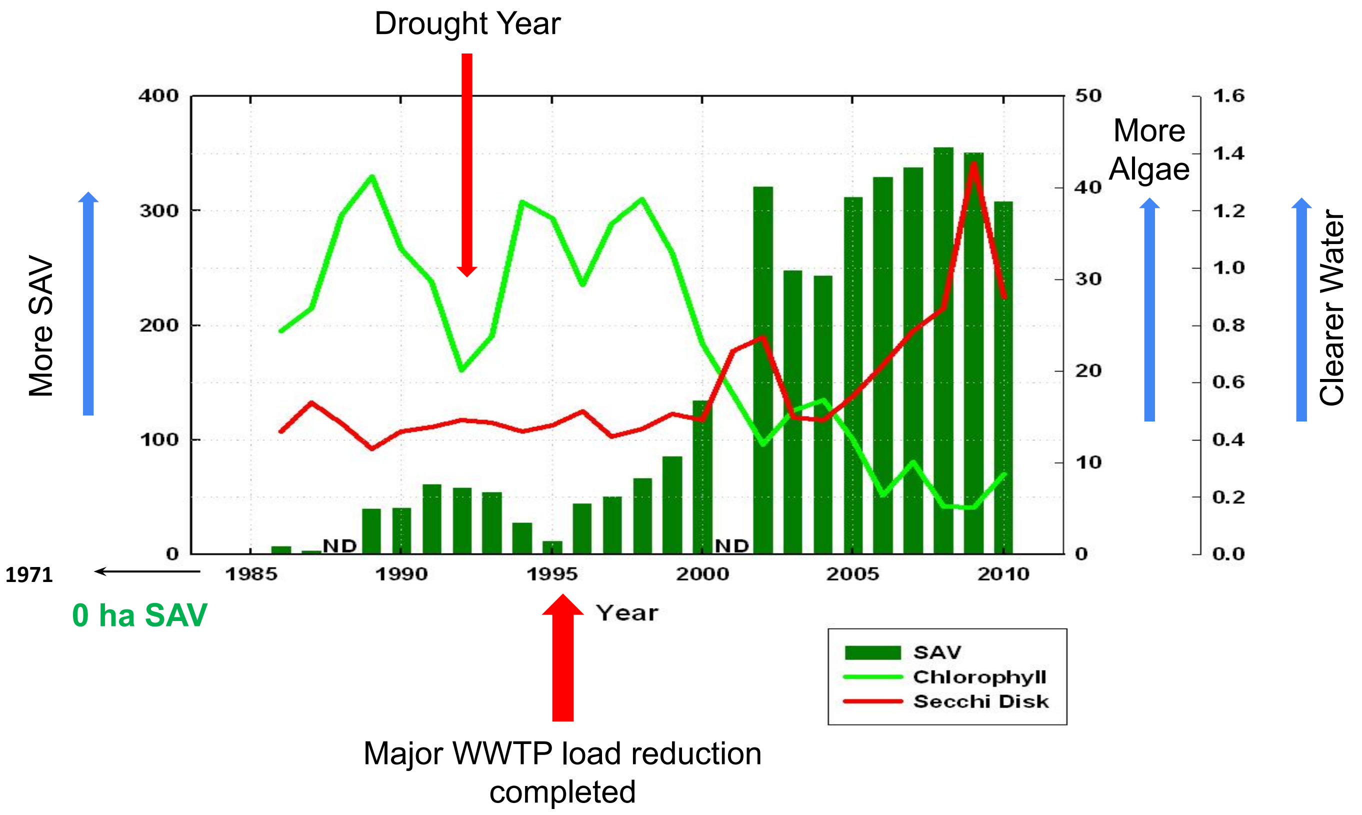
- No clear response for about 4 years followed by sharp decline in algae
- After 2005 low levels of algae became normal

Water Clarity Increased …Also with a Lag Time



- No clear increase for about 8 years followed by sharp increase in clarity
- Water clarity and algae highly correlated in shallow Chesapeake Bay systems

SAV Increased
…Shorter Lag with Threshold Response



- Very low levels of SAV were present prior to nutrient load reductions
- Major expansion of SAV in 2002, a severe drought year
- SAV relatively stable after 2002; lag in SAV relatively short