Knowledge Gaps, Uncertainties, and Opportunities Regarding the Response of the Chesapeake Bay Estuary to TMDLs

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How did we approach this document?

We could have approached our report simply with answers to the question:

Is the Bay's tidal water quality response to efforts to meet the TMDL consistent with expectations?

In many ways, we looked past this Y/N question, perhaps because:

(1) we would have needed a long-term research program to answer that question ***in detail*** on our own,

(2) a wealth of literature had recently emerged to show ecosystem responses in line with nutrient load reductions where they were substantial, and

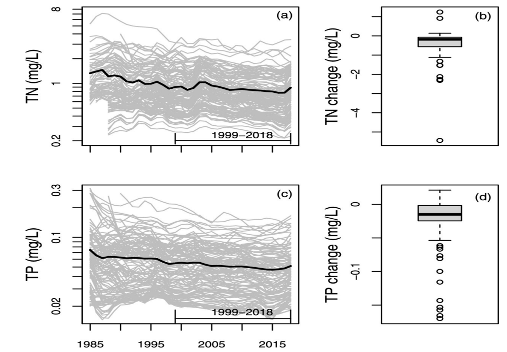
(3) we decided that a broader view of the tidal Bay restoration was needed

Do we think the Bay is responding to the TMDL as expected?

Answer: Yes…., and No (not as much as expected)

YES

Murphy et al. 2022

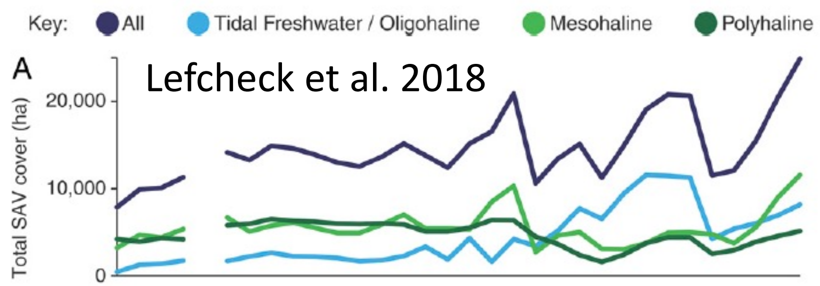


Nutrient Improvements in Chesapeake Bay: Direct Effect of Load Reductions and Implications for Coastal Management

Rebecca R. Murphy,* Jennifer Keisman, Jon Harcum, Renee R. Karrh, Mike Lane, Elgin S. Perry, and Qian Zhang

Increasing Severity of Phytoplankton Nutrient Limitation Following Reductions in Point Source Inputs to the Tidal Freshwater Segment of the James River Estuary

Joseph D. Wood · Paul A. Bukaveckas



Long-term nutrient reductions lead to the unprecedented recovery of a temperate coastal region

Jonathan S. Lefcheck[a,b,1], Robert J. Orth[b], William C. Dennison[c], David J. Wilcox[b], Rebecca R. Murphy[d], Jennifer Keisman[e], Cassie Gurbisz[f,g], Michael Hannam[h], J. Brooke Landry[i], Kenneth A. Moore[b], Christopher J. Patrick[j], Jeremy Testa[k], Donald E. Weller[h], and Richard A. Batiuk[l]

Biogeochemical states, rates, and exchanges exhibit linear responses to large nutrient load reductions in a shallow, eutrophic urban estuary

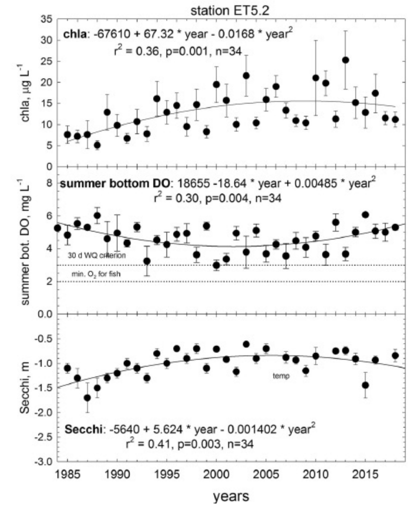
Jeremy M. Testa,* Walter R. Boynton, Casey L. S. Hodgkins, Amanda L. Moore, Eva M. Bailey, Johanna Rambo

Localized Water Quality Improvement in the Choptank Estuary, a Tributary of Chesapeake Bay

Thomas R. Fisher[1] · Rebecca J. Fox[2] · Anne B. Gustafson[1] · Erika Koontz[1] · Michelle Lepori-Bui[1,3] · James Lewis[4]

Multi-decade Responses of a Tidal Creek System to Nutrient Load Reductions: Mattawoman Creek, Maryland USA

W. R. Boynton · C. L. S. Hodgkins · C. A. O'Leary · E. M. Bailey · A. R. Bayard · L. A. Wainger



Fisher et al. 2021

But why not as much as expected?

Potential Key Uncertainties:

- ***Natural variation and inherent randomness:***
  - The climate is already changing, and the Bay (and watershed) is responding
  - Species distributions are changing
- ***Parameter uncertainty***
  - Even with substantial nutrient load reductions in some regions, mostly driven by wastewater and atmospheric deposition (pipes), loading is increasing or stable in many locations, and nutrient legacies still unknown → **tipping points?**
  - Parameters in numerical models
- ***Structural uncertainty***
  - Unaccounted systems processes or drivers limit capacity to predict system behavior → **terrestrial-estuarine transition zone (T-zone)** regulates interactions between the watershed and the mainstem

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- ***Observational uncertainty***

What steps should we take to reduce uncertainties?

(1) Targeted new monitoring, modeling and research in the T-zone

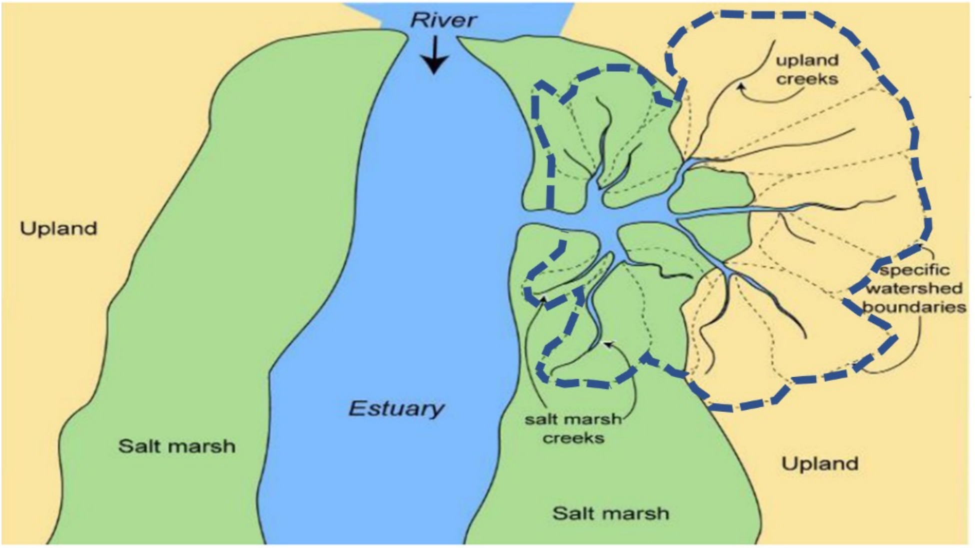
(2) Greater emphasis on nearshore, shallow systems (triblets) as harbingers of change

(3) Come to terms with the fact that we are chasing a moving target, rethink what we want through restoration (i.e., *increase certainty in shared goals, consensus)*

(4) Ensure that next generation model frameworks include the capacity for different recovery trajectories – tipping points, new species, disappearance of old species, changing habitats.

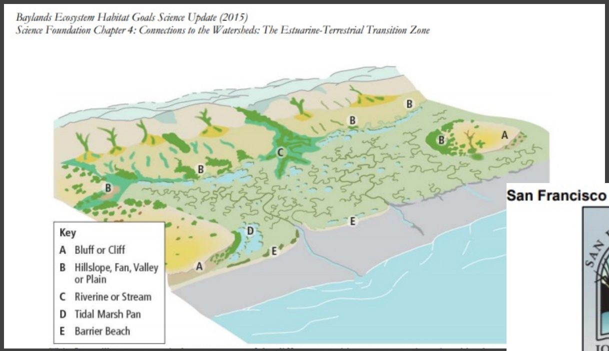
Triblet:

A waterway and its adjacent floodplain corridor that flows through T-zone and connects uplands to coastal waters.



Terrestrial-Estuarine Transition Zone (T-zone):

“the area of *existing and predicted future* interactions among tidal and terrestrial or fluvial processes that result in mosaics of habitat types, assemblages of plant and animal species, and sets of ecosystem services that are distinct from those of adjoining estuarine, riverine, or terrestrial ecosystems.”



San Francisco Bay Joint Venture

Ensign and Noe 2018
CBP 2018

Resource Document Key Quotes

"As we look forward, we envision that the pressure of climate change combined with an expectation of tipping points in the estuarine response to both TMDL-related activities and climate change will demand a new suite of monitoring, data analysis, and modeling tools to better quantify uncertainties in restoration outcomes."

"To accelerate restoration, we need to better understand and predict:

(a) how restoration proceeds under alternative management and climate change scenarios;

(b) how can we meaningfully identify and evaluate new potential restoration means/strategies;

(c) accordingly, where and how to best spend our restoration dollars"