Shifting Baselines, New Insights and Adaptive Management in Chesapeake Bay

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Chesapeake Watershed Agreement 2014

10 Ecosystem Health Goals
31 Outcomes

Management Strategies and Watershed Implementation Plans support Goals and Outcomes

Pollution Diet Recovery Model
Illustration: IAN Ecocheck

Reduce nutrients and sediment
Improve habitat for living resources
Living Resource Dependent Water Quality Criteria for Habitat Supporting Survival, Growth and Reproduction

- Habitat classifications
- Defining Water Quality Criteria: e.g., Dissolved oxygen requirements
- Management segment boundaries
- Monitoring progress with criteria attainment assessment methods
113 years: Summer Dissolved Oxygen on the Potomac River. Estimated (light blue) and Actual (dark blue) data

Norbert Jaworski, Pers. Comm
Clean Air Act Effects +:
“Technological advances have made great strides in reducing atmospheric nitrogen (N) deposition to the Bay.

Atmospheric point sources and vehicle emissions controls have decreased the levels of nitrogen oxides (NO\textsubscript{x}) in the air.

However, population growth, increased use of vehicles, and intensified agriculture have slowed progress.”

DOI: 10.1021/es4028748, Publication Date (Web): October 3, 2013
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Point Source Mgt late 1970s

Estuary Nutrients Decline over 30 yrs

CHLA declines after 20 yrs

Water Clarity shows improving trend after 15 yrs

Total P load declines

Aquatic grasses resurgence after 20 yrs and it continues...

2000  2005  2008

Water quality improvement and living resource response takes time
Evidence of recovery trajectory with less annual hypoxia over time in the mainstem Chesapeake Bay

![Chesapeake Bay Mainstem Bay Annual Hypoxic Volume Duration (Days)](chart)

- **Zhou et al. 2014** (0.85 cu km threshold hypoxia)
  - Estimated regression line only
- **Bever et al. 2013** (2 cu km threshold hypoxia)
  - From my regression of their scaled data set.

About a 20 day difference due to study decisions on minimum threshold areas in their accounting approaches.

**Chesapeake Bay Hypoxia Summer 2012**
Chesapeake science captures the nature of our non-stationary conditions.

Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering.

January 2008 in Science
Shifting Baselines and Changing the Footprint: Steady population growth in the Chesapeake Bay watershed

- Population grew from 8M in 1950 to 18M in 2017, more than doubling since 1950.

Chesapeake Bay Watershed Population:
- 8M in 1950
- 18M in 2017

Year:
- 1950
- 2017
Shifting baselines: Temperature

- Air temperature rising, locally variability in rate
- Stream temperature rising, some local variation

Mean Annual **AIR** Temperature rising across the watershed

Mean Annual **STREAM** Temperature Rising across the watershed

Climate Influence on the Chesapeake Bay Watershed

Record precipitation and flooding

Rising bay temperatures

Source: CBP Modified UMCES/IAN graphic (2011)
New insights: Keeping all other factors constant, sea level rise and increased watershed flow reduce hypoxia in the Bay, but the predominant influence on dissolved oxygen conditions are the negative impacts of increased water column temperatures.

Source: Lew Linker EPA-CBPO
Science now say the biggest BMP for trapping nutrient and sediment is now full.

- Loss of nutrient and sediment trapping capacity
Phosphorus Loads Into, Trapped Within and Exiting the Reservoir System: 1990s-2010s

Early 1990’s, about 50% of P trapped
~10 ~5

Early 2000’s, about 40% of P trapped
~11 ~6

Early 2010’s, Approaching no net trapping
~8 ~8

Loads Into Reservoir System
Long term improving trend

Loads Out of Reservoir System - Conowingo
Long term degrading trend

“Dynamic equilibrium”

Source: Data from USGS (2016), http://cbrim.er.usgs.gov/loads_query.html
loads are approximate and in units of million lbs/year using estimates for 1992, 2002, and 2012
Challenges

Monitoring and Analysis – Confronting models with data.

- Analysis need: Understanding the relationship between monitoring load trends with model projections for N, P and Sediment 1985-2016 comparisons

Watershed Model

N: improving  Monitoring data
P: improving  mixed
S: improving  degrading

degrad/No Trend

Annual USGS River Input Trends
Short-term: 2007-2016
Long-term 1985-2016
Several tributaries are already overrun with blue catfish, whose population is estimated between 94 million and 111 million. But population numbers alone don’t tell the full story. Blue catfish represent between half and three-quarters of the biomass in the James, Rappahannock and York rivers on Virginia’s western shore of the Chesapeake, says Chris Moore, senior regional ecosystem scientist with 2017 New Insights: Fish community changes are large.
Diet contents were extracted from 2,495 catfish, 69.86% of which had prey items present in their foreguts (N = 1,743).

- Alosines were found in 4.46% of Blue Catfish stomachs, 16.7% of Flathead catfish stomachs.
Shifting baselines

- Removal of many fish passage ways has reopened many miles for fish migration.
Assessments 2000-2013

FISH PASSAGE and SHAD

“With no sign of recovery, VA to halt stocking shad in James.”

The inability to restore fish to what was once a major spawning ground has biologists seeking other approaches.

September 17, 2017 Bay Journal – Karl Blankenship

“Overfishing, pollution, loss of habitat and the construction of dams that closed off historic spawning grounds have all contributed to the population collapse, scientists say.”

...And now blue cats and other invasive spp
Best Management Practices around the Bays

There are a suite of Best Management Practices (BMPs), with many more being developed, that reduce nutrient and sediment loads to the Chesapeake Bay. These may be as simple as individuals not fertilizing their lawn, or only during the recommended time of the year (fall), to large and expensive construction projects such as upgrading municipal wastewater treatment plants. Here are some of the most important and some of the new BMPs being undertaken in agriculture and urban areas.
Summary

Substantial progress has been made to improve water quality and living resource habitat conditions in the watershed and Bay.

New scientific insights are made each year improving our understanding of the ecosystem.

Shifting baselines are evident in the physics, chemistry and biology of the system.

Management continues to account for the new insights and shifting baselines by adjusting and updating policies actions through implementing an adaptive management framework guiding restoration and recovery.