Estimated Influence of 2050 Climate Change on Chesapeake Bay Water Quality Standards.

Water Quality Goal Implementation Team Meeting
NCTC Shepherdstown, WV
December 14, 2015

Lewis Linker[1], Gopal Bhatt[2], Ping Wang[3] , Carl Cerco[4], Gary Shenk[5] , Guido Yactayo[6], and Richard Tian[6]

1. U.S. EPA Chesapeake Bay Program Office (CBPO); 2. Penn State-CBPO; 3. VIMS-CBPO; 4. U.S. COE-ERDC; 5. USGS-CBPO; 6. UMCES-CBPO

Chesapeake Bay Program
Science, Restoration, Partnership

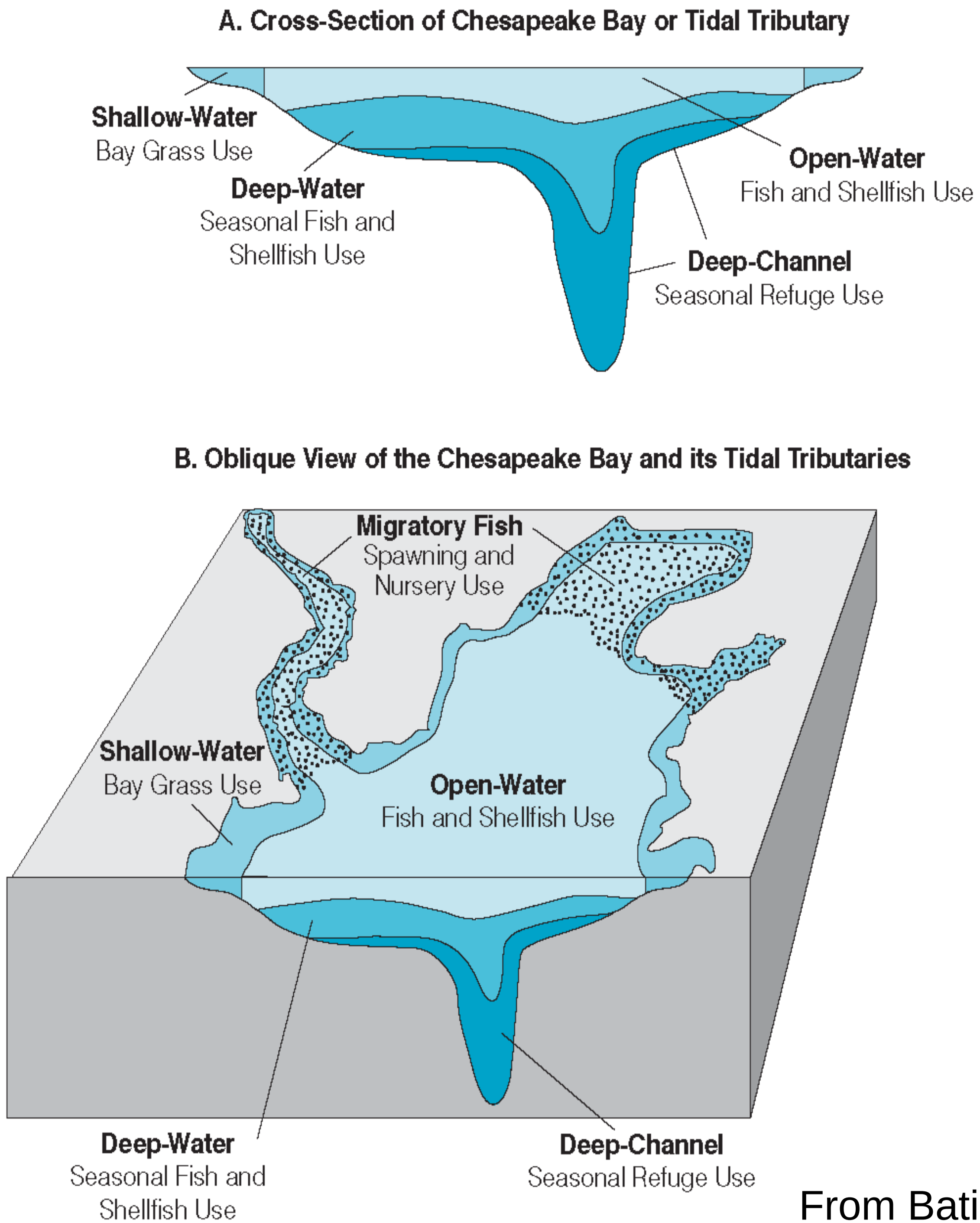
Decision Requested

Agreement on process, schedule, and requested sets of model outputs by which the Partnership will follow and use during 2016 to continue to more completely understand the influence of climate change on 2017 Midpoint Assessment decisions.

Motivation

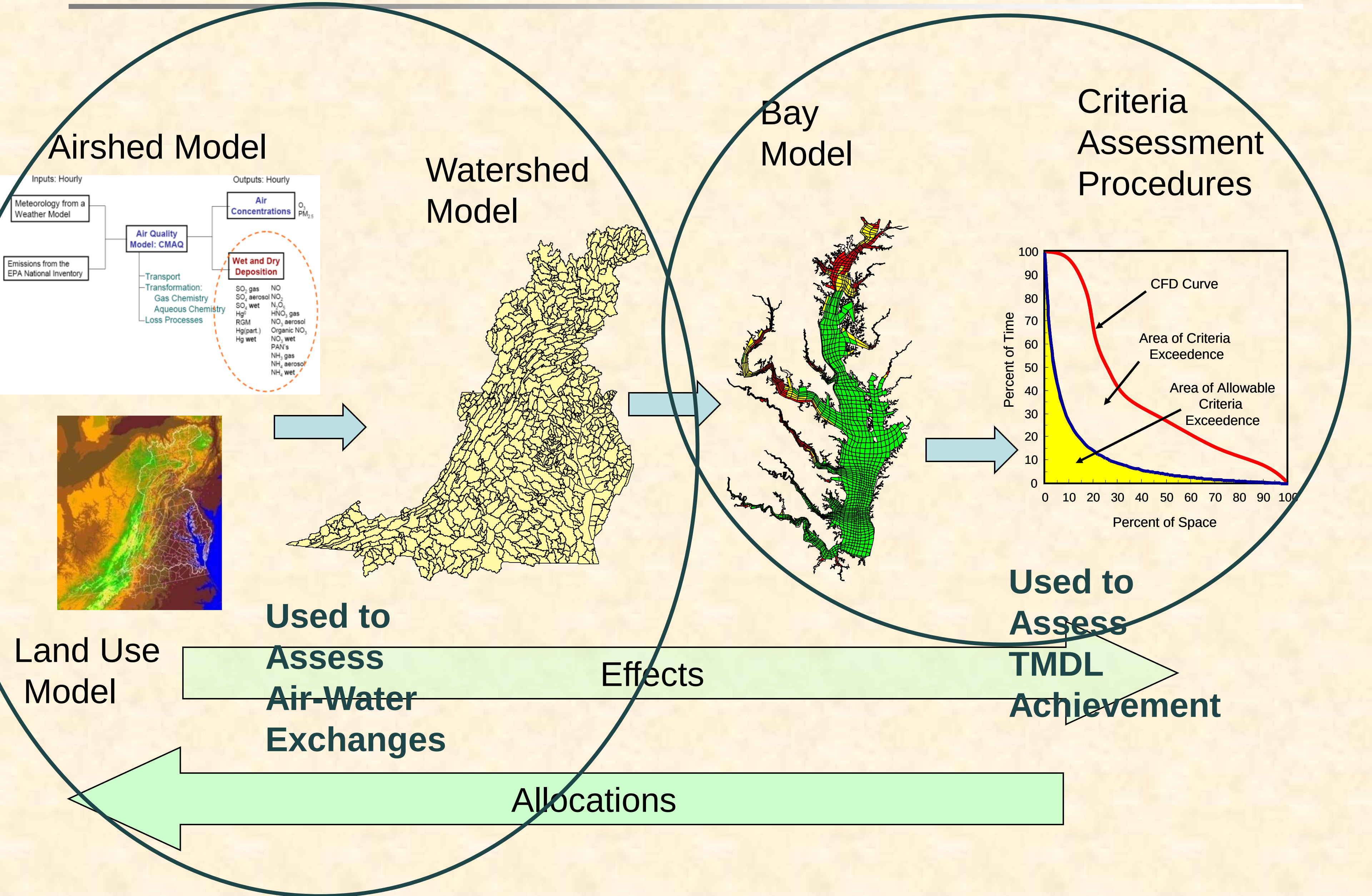
- The Chesapeake Bay Program partners are developing the tools to quantify the effects of climate change on watershed flows and loads, storm intensity, increased estuarine temperatures, sea level rise, and ecosystem influences including loss of tidal wetland attenuation with sea level rise, as well as other ecosystem influences.
- Current efforts are to frame an initial future climate change scenario based on estimated 2050 conditions. An estimate of 2025 climate change conditions is also underway.
- In 2017 the CBP partnership will need to decide if, when, and how to incorporate climate change considerations into the Phase III WIPs.

Water Quality Standards of Deep Water, Deep Channel, Open Water, and Shallow Water Dissolved Oxygen (DO) are key for protection of living resources. Chlorophyll and SAV/clarity standards are also designed to protect living resources.



From Batiuk (2003)

Nutrient Allocation Decision Support System



With the CBP Analysis Tools We're Examining….

Increased Estuarine Temperature

- Direct warming of tidal water
- Indirect warming from watershed inputs
- Indirect warming from ocean boundary inputs

Sea Level Rise

- Influence on hydrodynamics
- Influence on tidal wetland loss and associated loss of nutrient and sediment attenuation
- Increased organic nutrient and sediment loading from tidal wetland erosion

Watershed Hydrologic and Loading Changes

- Changes in precipitation volume
- Changes in precipitation intensity
- Changes in land use

With CBP Analysis Tools We're Examining *(continued)*

Ecological Changes

- Temperature ranges and optima (*Zostera*)
- Other ecological changes

Changes in Airshed

- Changes in precipitation volume
- Changes in precipitation intensity
- Changes ground level ozone with temperature increases

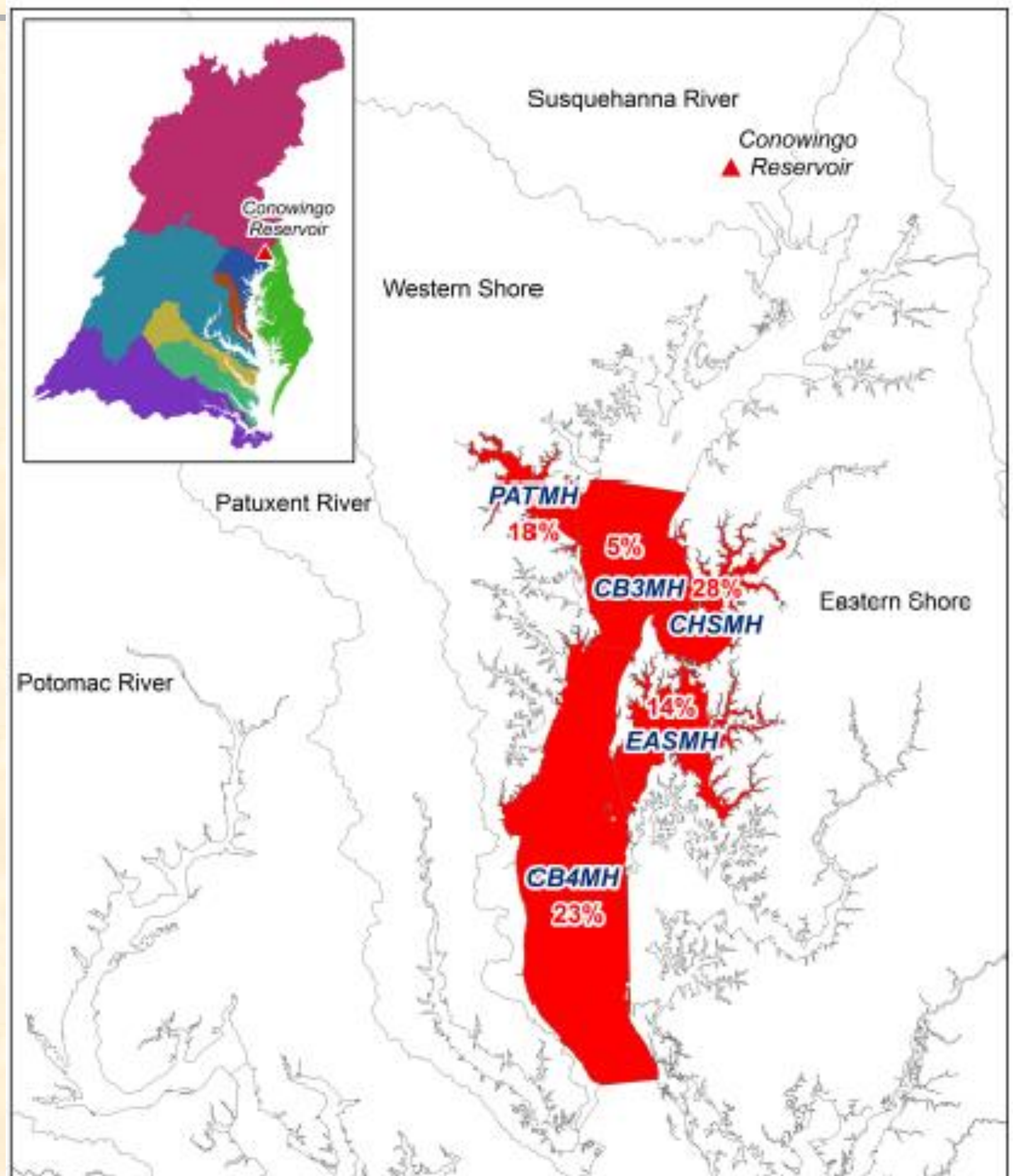
Additional Inputs to the CBP TMDL Climate Change Decision:

- Historical studies of climate change
- Intercomparison of coastal systems
- Other relevant studies, monitoring, and observations
- Other climate change research (a lot!)

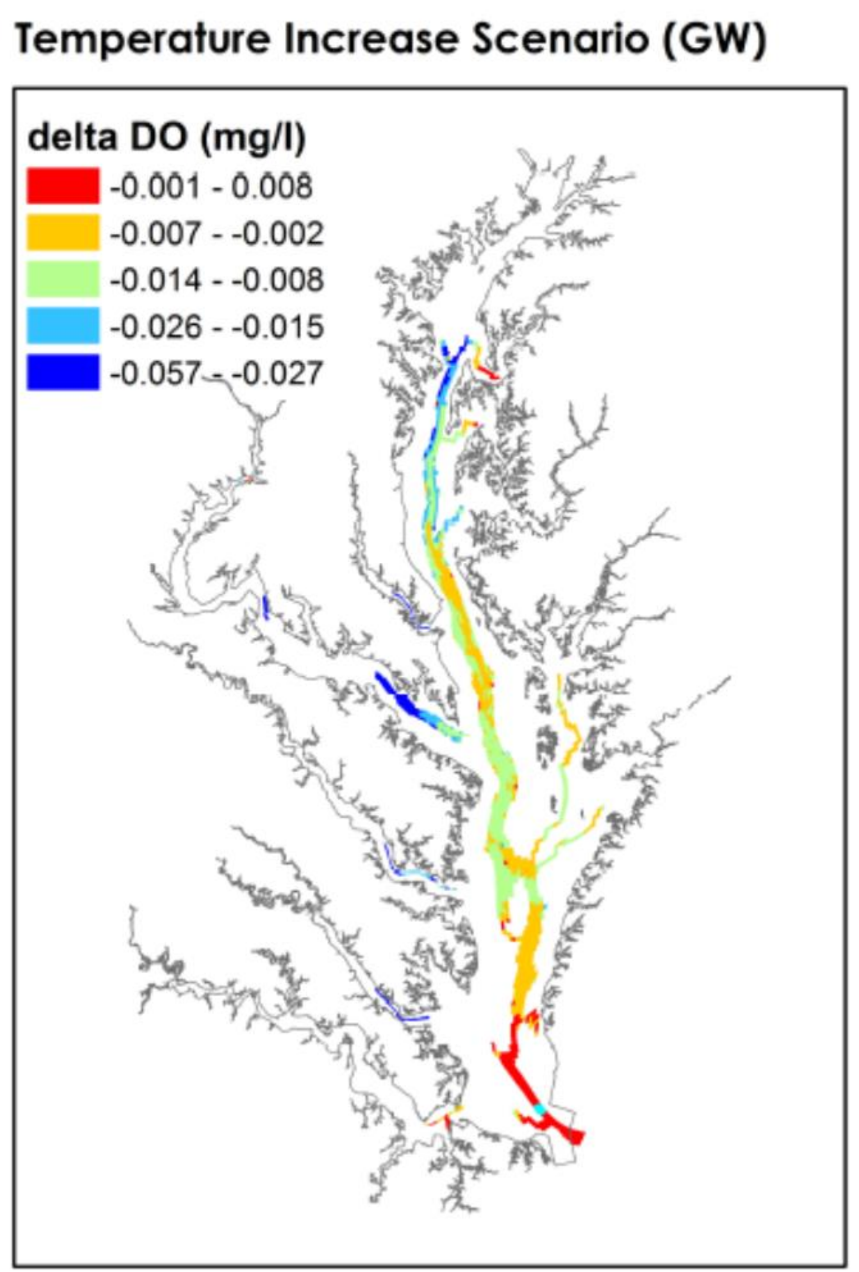
A Key Point of Influence on the Chesapeake TMDL is…

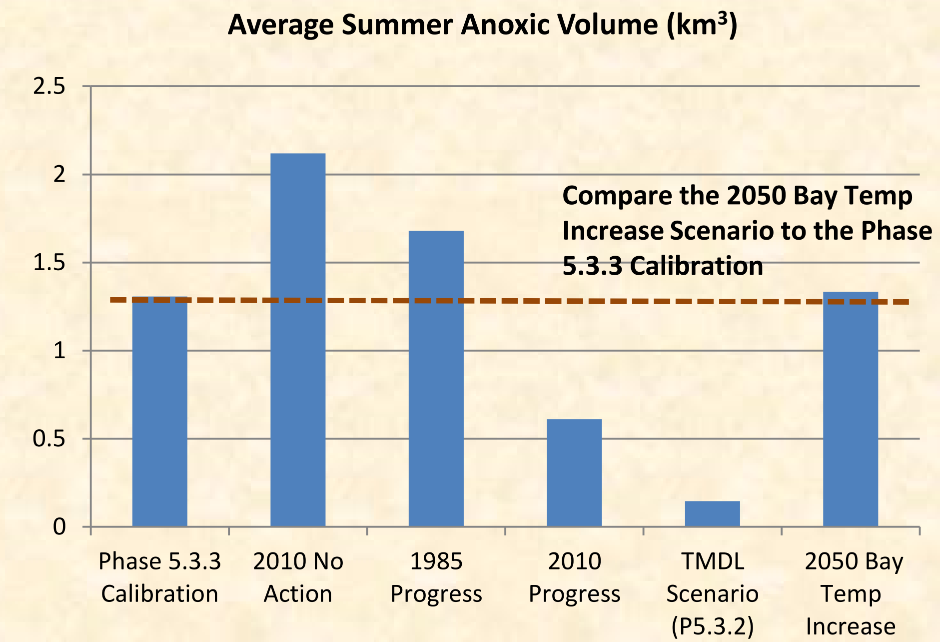
….CB4MH and the adjacent contiguous region of deep-channel and deep water habitat.

Figure shows Chesapeake hypoxia under estimated 2010 conditions represented by deep channel DO standard nonattainment. Insert shows the major basins of the Chesapeake watershed.



Estuarine Temperature Increases



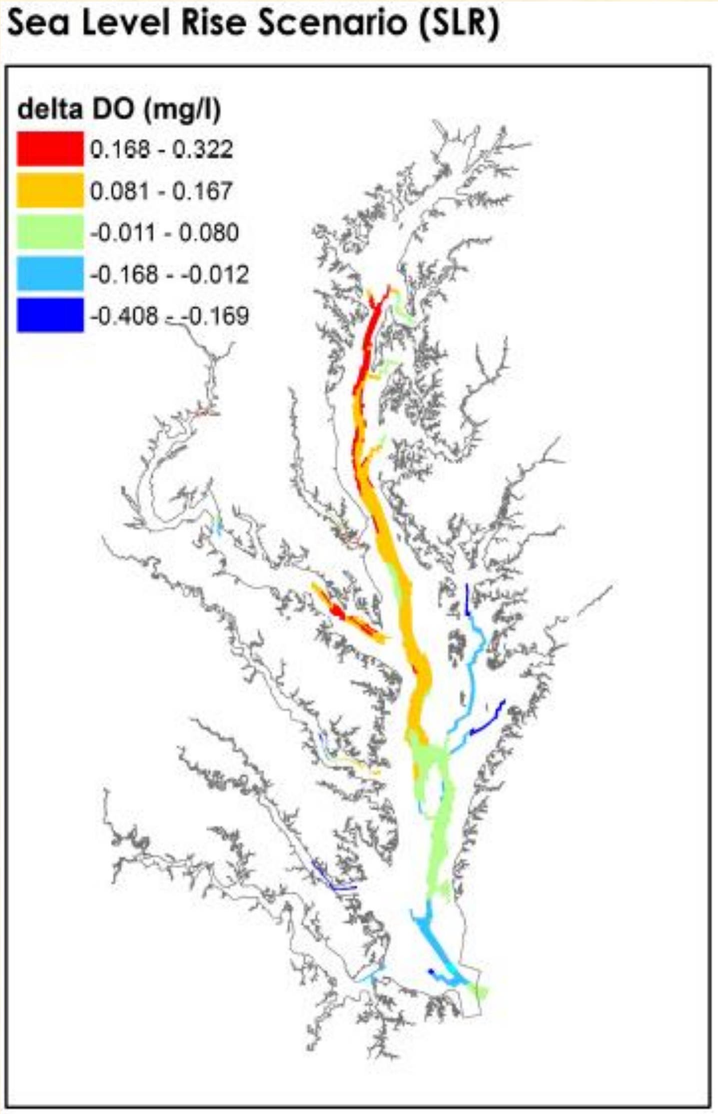


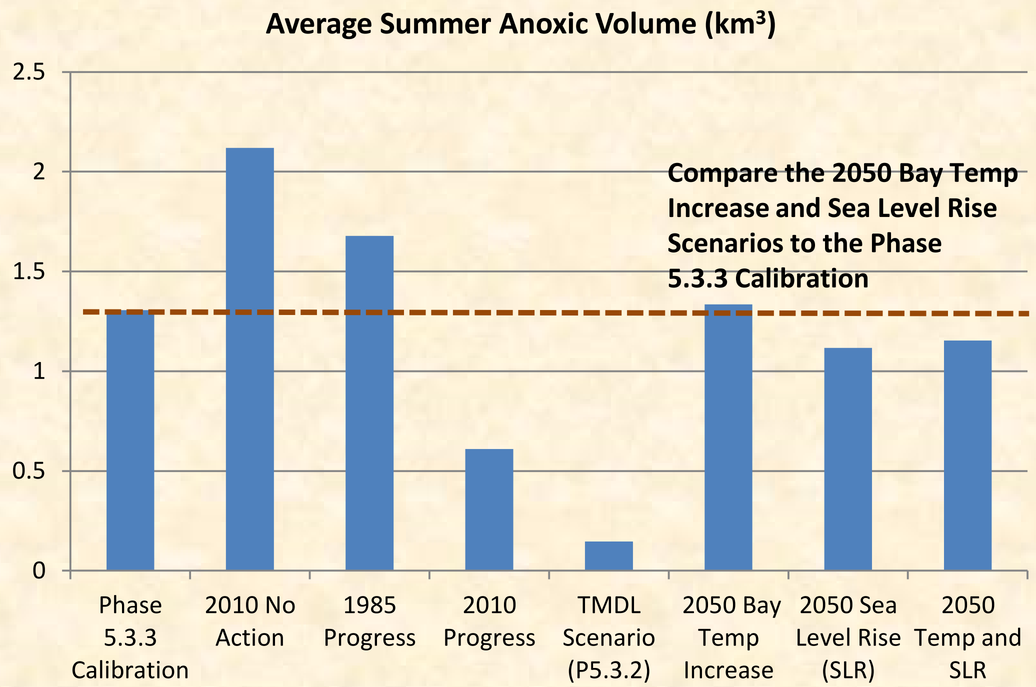
The influence of an 2050 estimated temperature increase on Chesapeake hypoxia is small.

But we can measure in infinitesimal with our models. The estimated delta increase in Chesapeake hypoxia due to 2050 estimated temperature increases ranges from 0.008 to -0.06 mg/l.

Hypoxia increases are due to the increase in vertical stratification due to the increased thermocline and because of increased respiration.

Changes in Hydrodynamics due to Sea Level Rise





The influence of an 2050 estimated sea level rise on Chesapeake hypoxia is also relatively small.

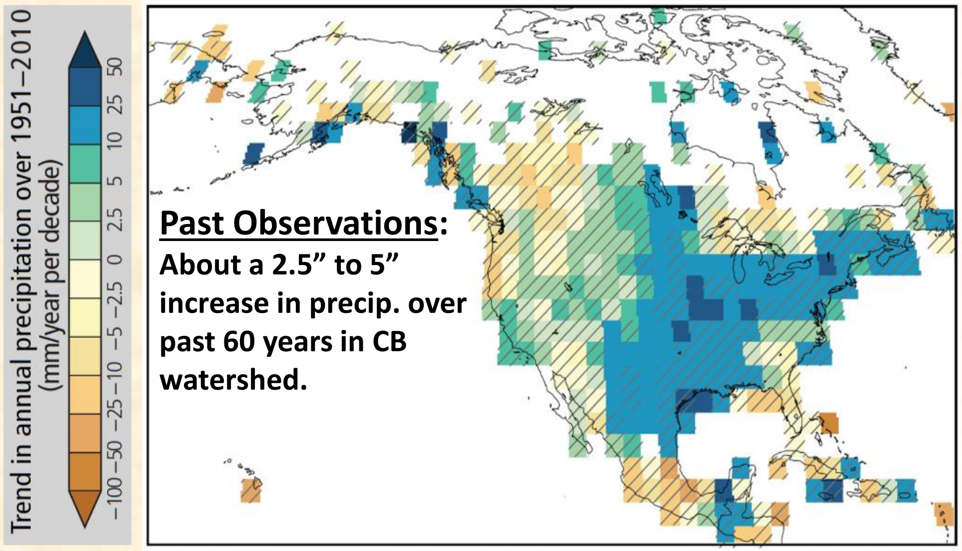
The estimated delta in Chesapeake hypoxia due to 2050 estimated sea level rise ranges from 0.3 to -0.4 mg/l.

Hypoxia decreases in the mid-Bay are due to increased ventilation of deep Chesapeake waters by high DO ocean waters and also to changes in vertical stratification.

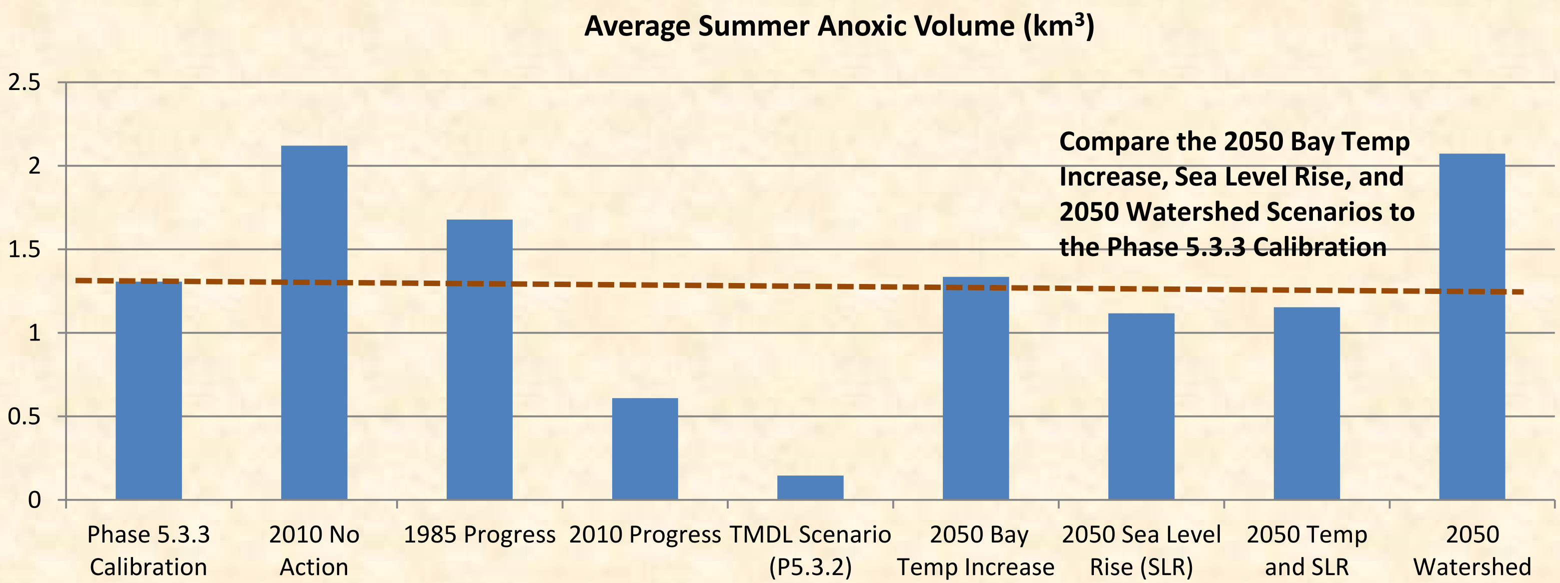
Watershed Hydrologic and Loading Changes

<u>FUTURE ESTIMATES</u>: ***"Over the northeast US, the mean precipitation increases by 15%-25% [about 6 – 10 inches] by the late twenty-first century [2069-2098 period compared to the 1979-2004 period]. The number of relatively heavy precipitation events (>25mm day-1) over the northeast US increases by 50% by the early twenty-first century and increases 4-5 times by the late twenty first century."***

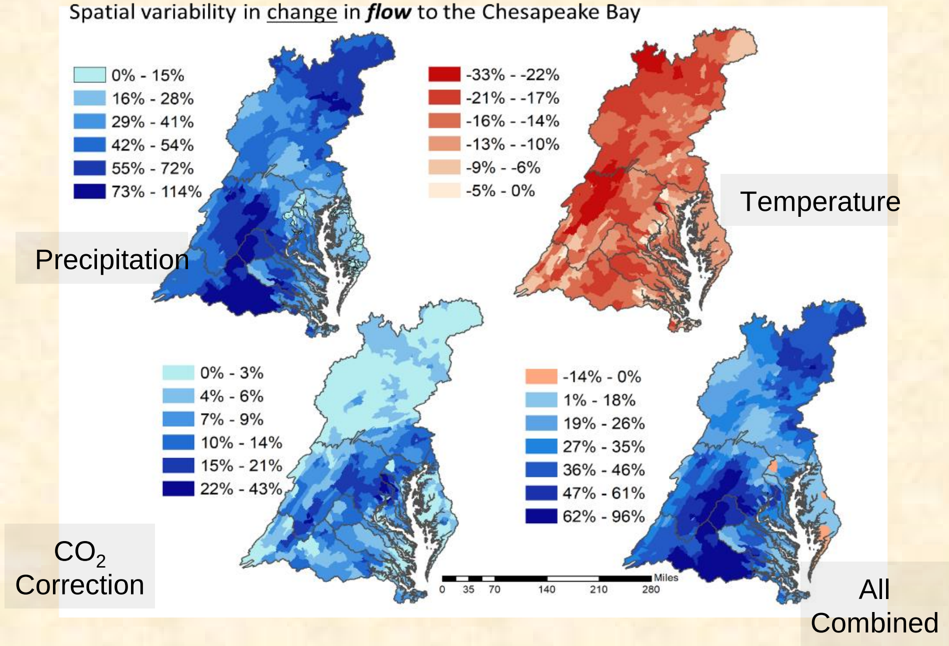
Maloney and 31 others, 2014: North American Climate in CMIP5 Experiments: Part III

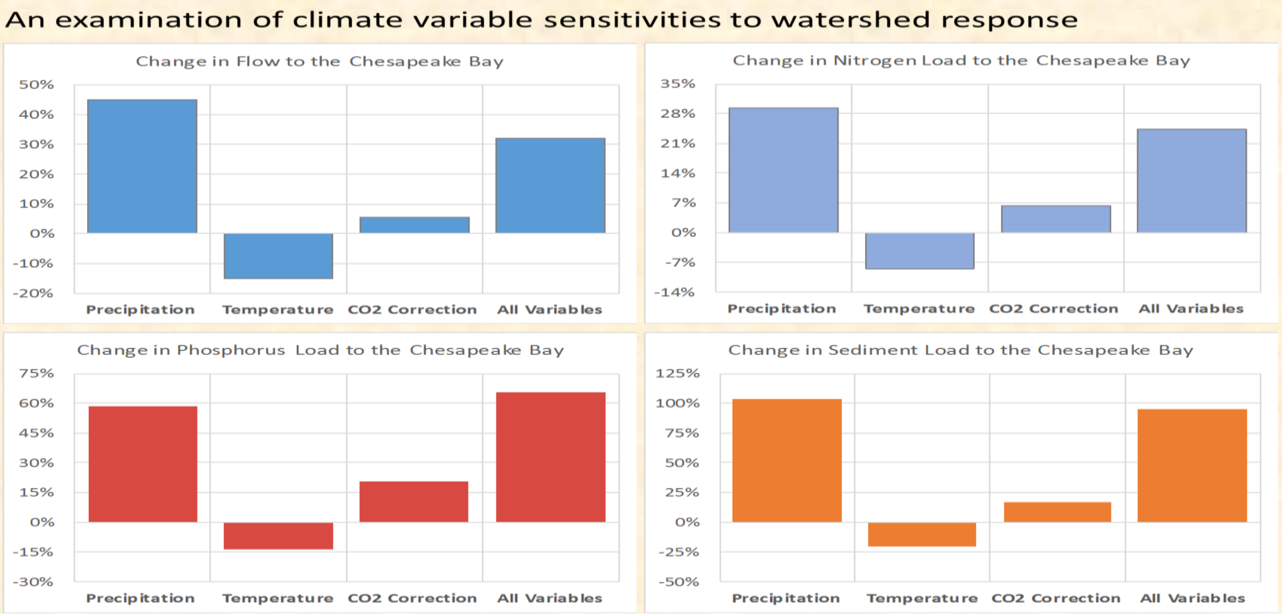


Romero-Lankao and others, North America. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B:

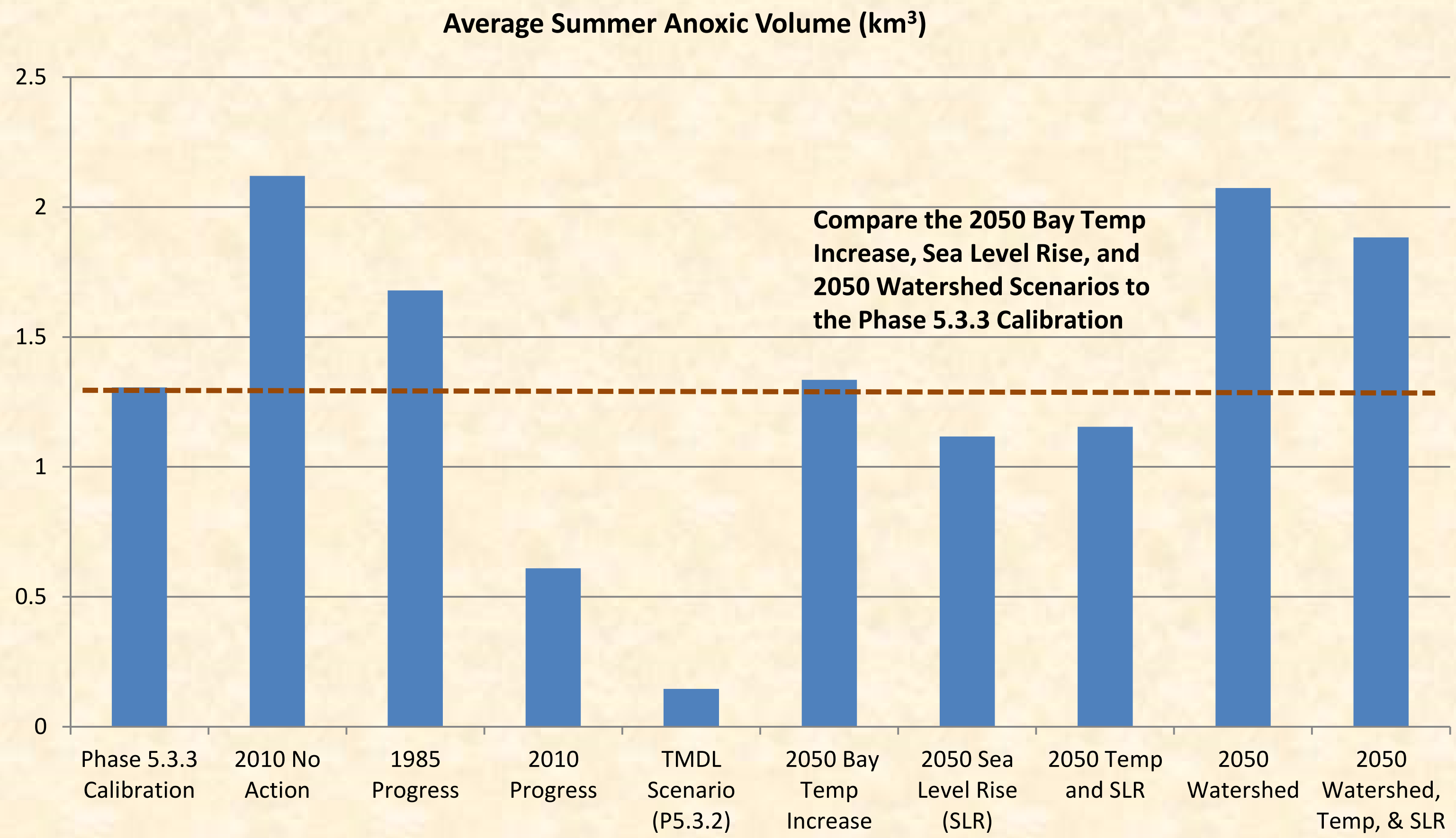


Tracking the Contribution of Temperature, Precipitation, and CO_2 Concentrations to Changes in Flow and Loads





Combined 2050 Watershed, Temp, and SLR

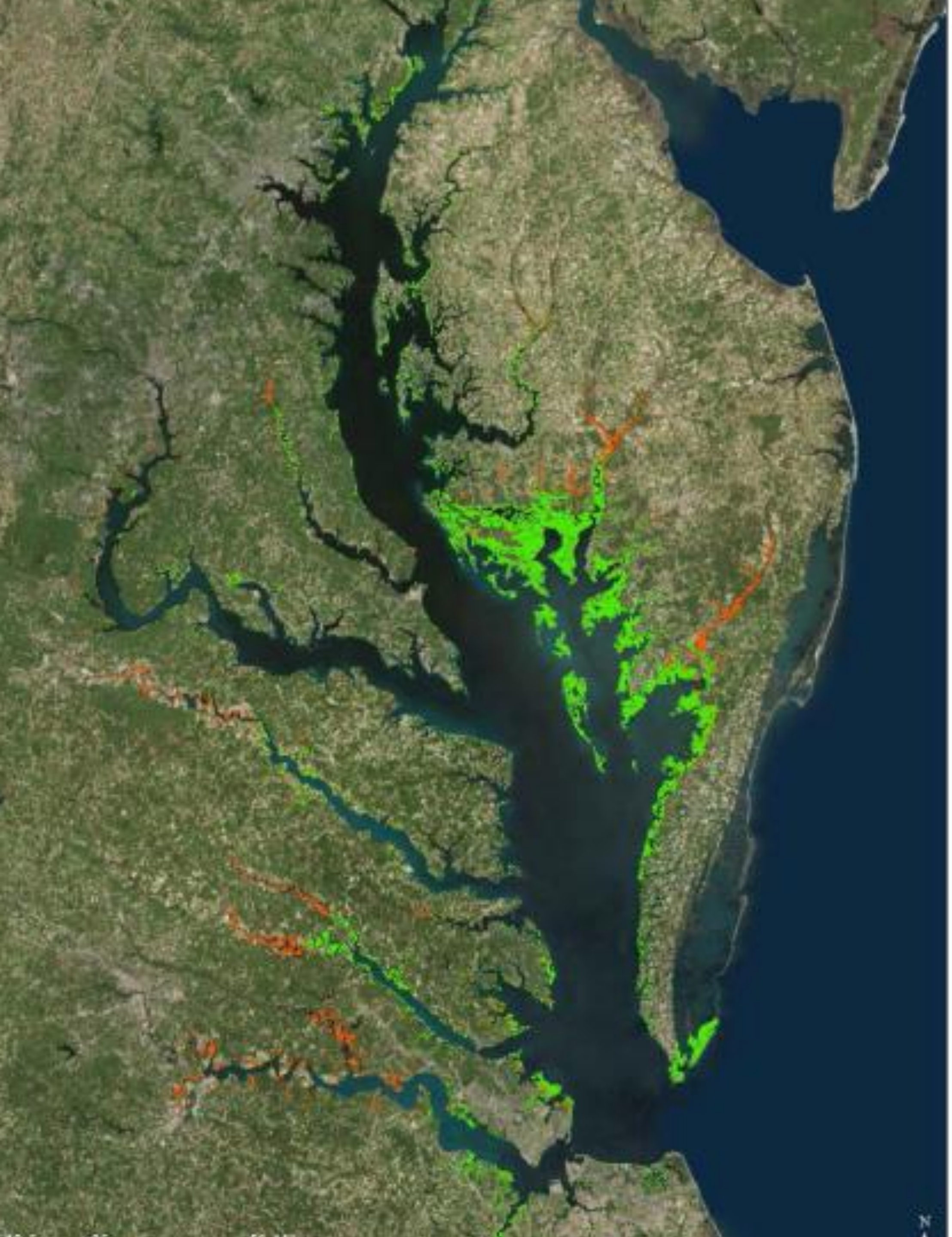


Estimated combined effects so far are about half what it took to get from average 1991-2000 conditions (calibration) to the TMDL.

Sea Level Rise and Loss of Tidal Wetland Attenuation

We are examining the potential impact of tidal wetland loss from sea level rise through a three-phase program including:

- Phase I – Estimate marsh loss and transition due to sea level rise.
- Phase II – Investigate the reactivity and impact of material eroded from marshes and released to Chesapeake Bay waters.
- Phase III – Quantify effects of marsh loss on water quality and examine implications for TMDL.



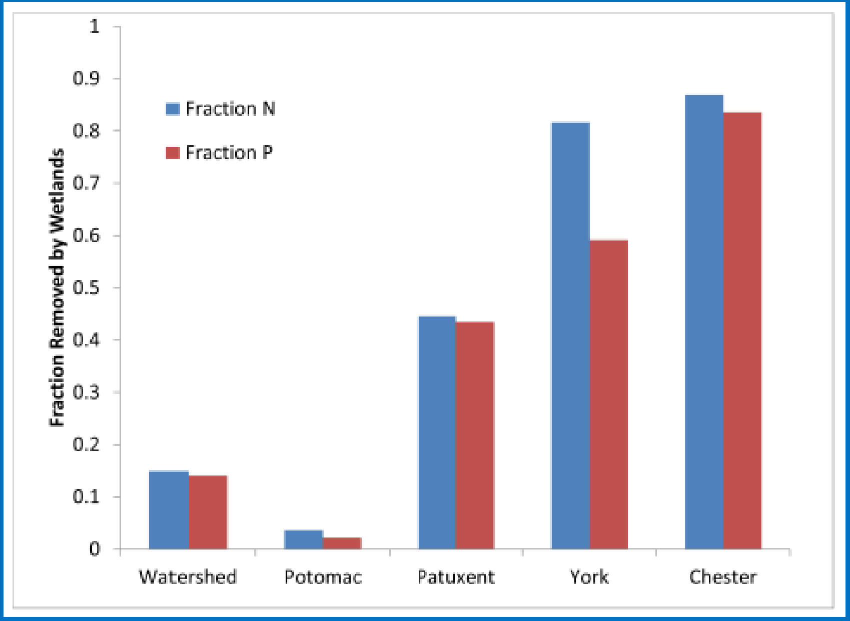
Chesapeake Bay Tidal Wetlands

- Extent form National Wetlands Inventory.
- Determined largely from vegetation perceived via aerial photography.
- 190,000 hectares of estuarine (green) and tidal fresh (red) wetlands.
- Shape files provided by Quentin Stubbs and Peter Claggett, EPA Chesapeake Bay Program.

Wetlands and 1991-2000 Loads

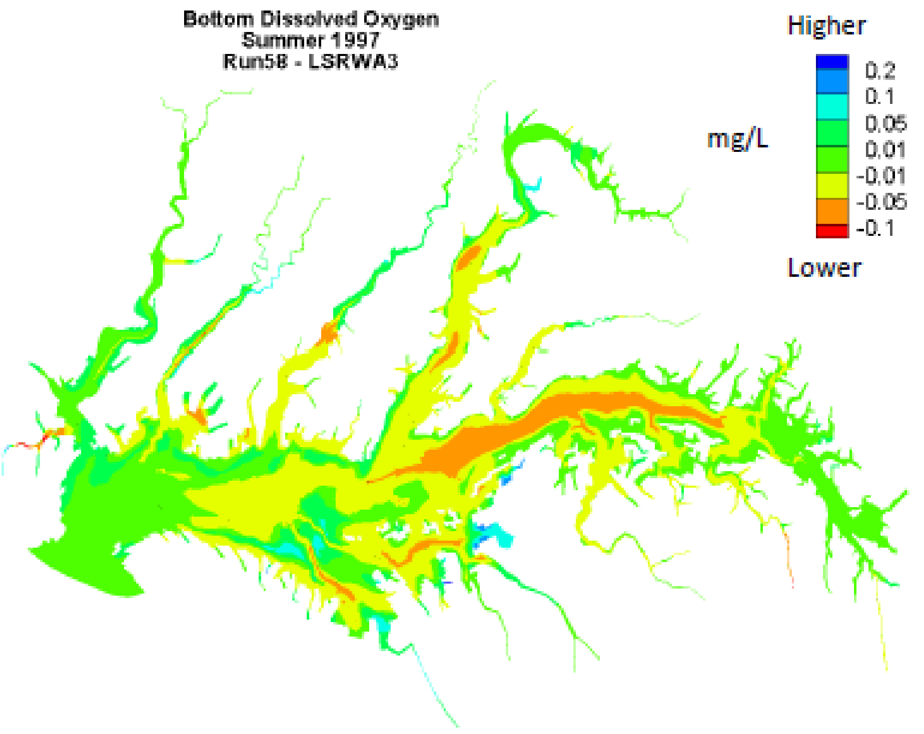
Loads (kg/d)

	N Load	Denit	P load	Burial
Watershed	332,445	49,663	22,010	3,102
Potomac Fall-Line	56,311	2,034	5,765	127
Patuxent Fall-Line	2,023	902	130	56
York Fall-Line	3,906	3,189	337	199
Chester Fall-Line	719	625	47	39

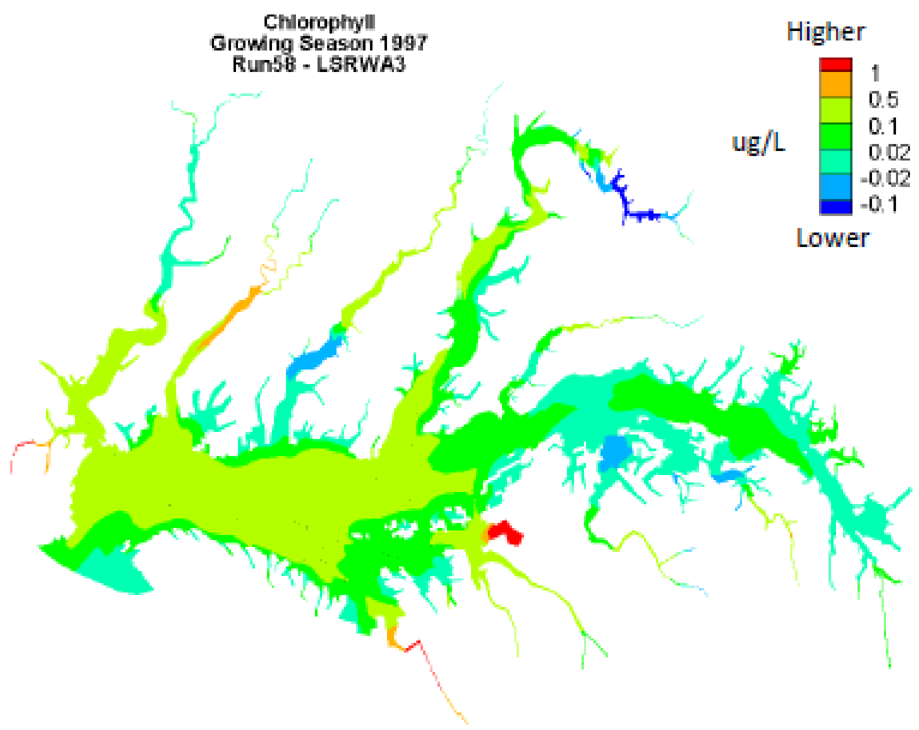


"The tidal marsh-oligohaline estuary removed about 46% and 74% of total annual upland N and P inputs" (Boynton et al., 2008, Nutrient budgets in the Patuxent River estuary)

Marginal Effect of Wetlands Loss on TMDL Conditions



Currently estimating about a 1% increase in Deep Channel DO nonattainment under conditions of 40% loss in estuarine wetlands combined with 25% loss in tidal fresh wetlands.



Conclusions

- 2017 is the year of decision for the Chesapeake Bay Program partners for incorporation of climate change considerations into the Phase III WIPs.
- The analysis for the 2017 decision will be with the best available information, but climate change impacts are wide-ranging, long-term and the uncertainties are high.
- Adaptive management needs to be applied along with the key strengths of the CBP which include the living resource based water quality standards that must be met regardless of challenges.

Conclusions (continued)

• On the other hand, we know how to deal with the challenge at hand. After all, we have full and complete documentation of a century of temperature increases, sea level rise, precipitation intensity increases, precipitation volume increases, and wetland loss in the Chesapeake region. What does climate change look like? It looks a lot like what we've experienced over our entire careers in coast and watershed science.

Conclusions (continued)

- Separation of the different elements of water quality influences that are due to climate change allows more targeted management responses toward tidal marsh loss, stormwater management, or other CBP management responses to climate change.
- Refinements of the CBP assessment of climate change will continue through 2016 guided in part by two major reviews of climate change by CBP’s Scientific and Technical Advisory Committee (STAC). An assessment of 2025 climate change influences on water quality standards is now underway.