Chesapeake Bay Water Quality

Climate Drivers and Information Needs for Adaptation Planning

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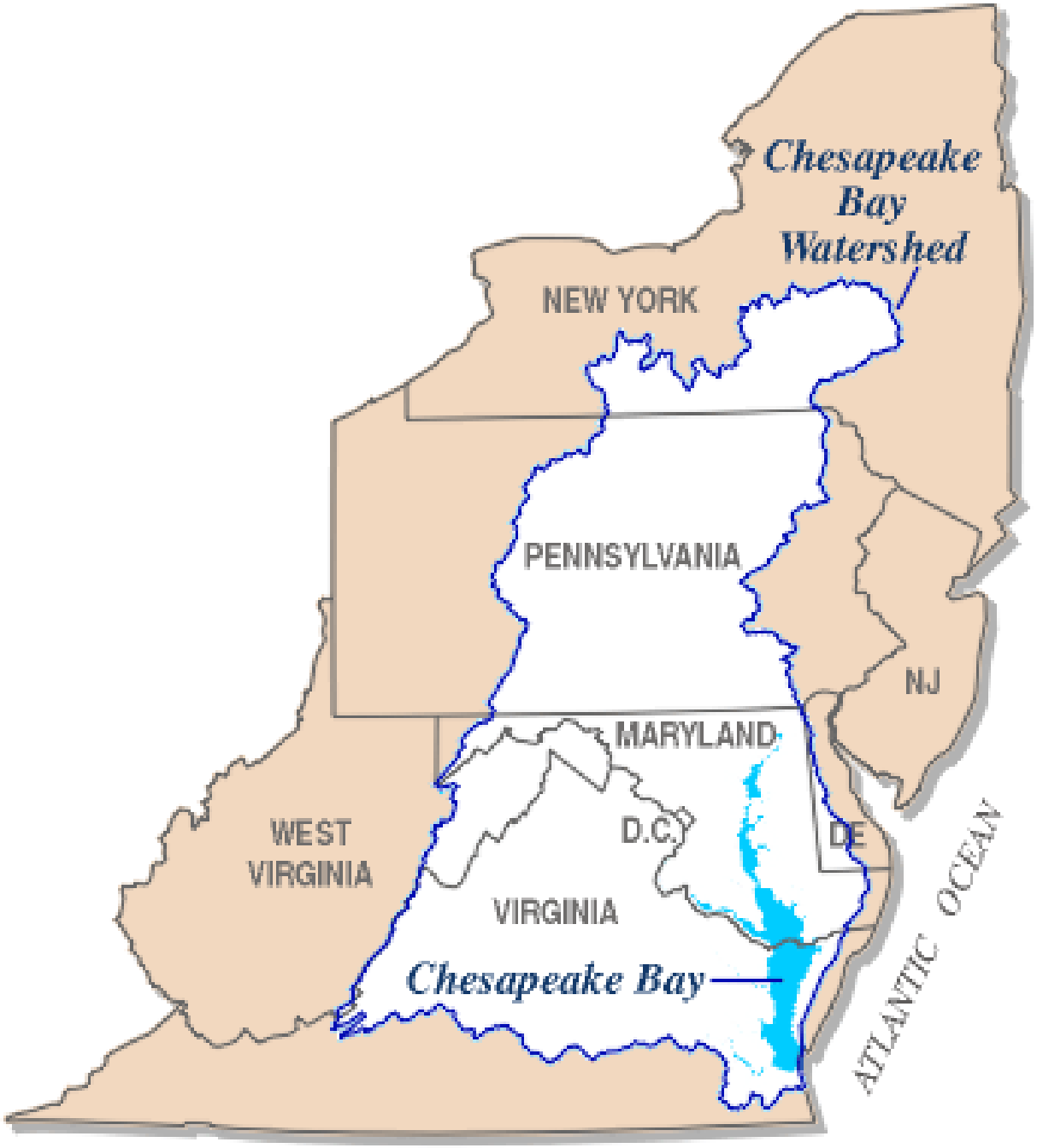
Metropolitan Washington Council of Governments and Northrop Grumman

Washington, DC

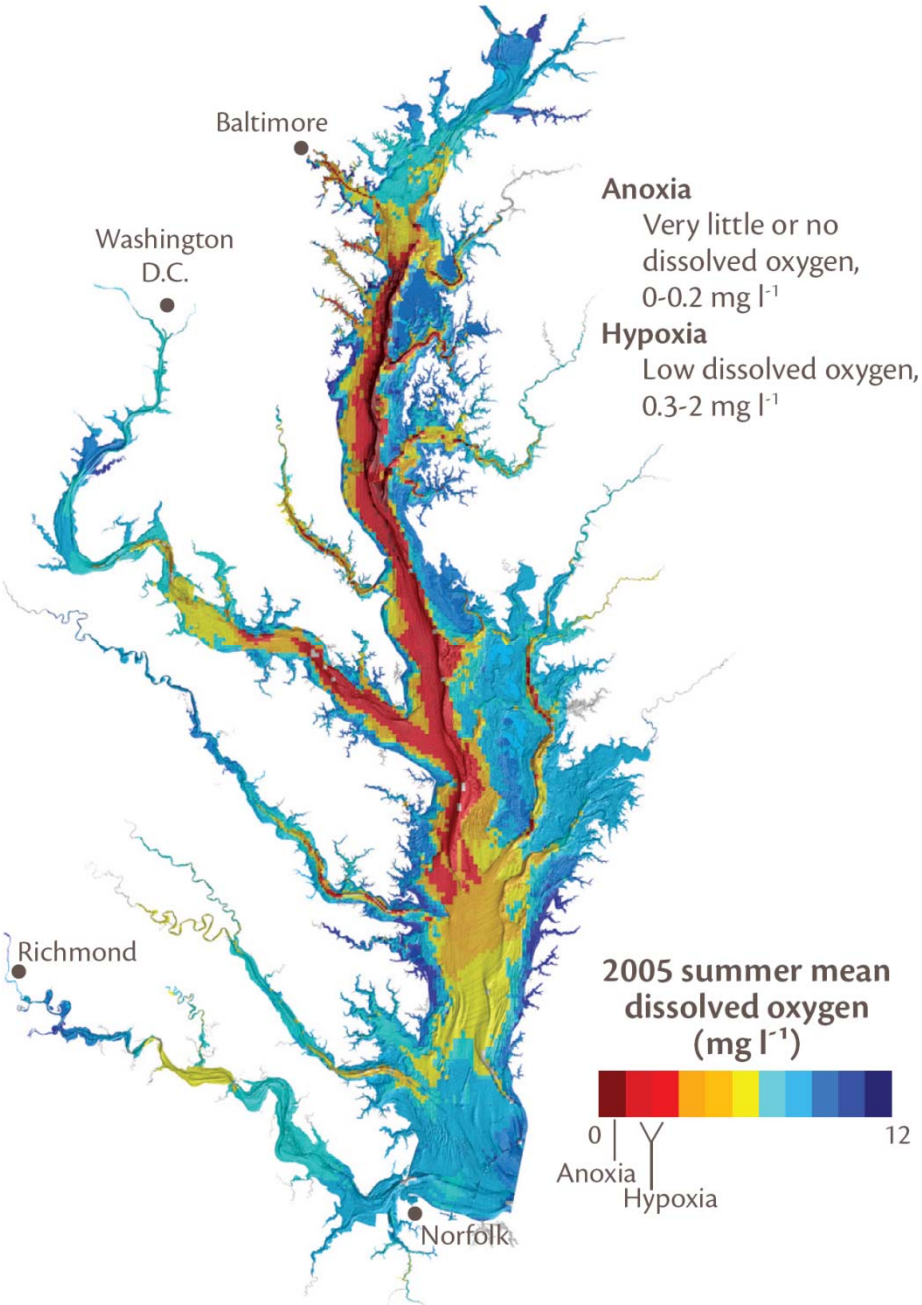
July 23, 2009



Chesapeake Bay Watershed

Chesapeake Bay Overview

- Largest of 130 estuaries in the United States
- Length is 200 miles
- Width ranges from 3.4 to 35 miles
- Average depth is 21 feet
- Deep trough (up to 174 feet) along its length
- 64,000 square-mile watershed area
- ***Land-to-water ratio of 14:1***
- 11,684 miles of shoreline
- 150 major rivers and streams in watershed
- Susquehanna River provides 50 percent of the freshwater input
- Watershed population of 15 million



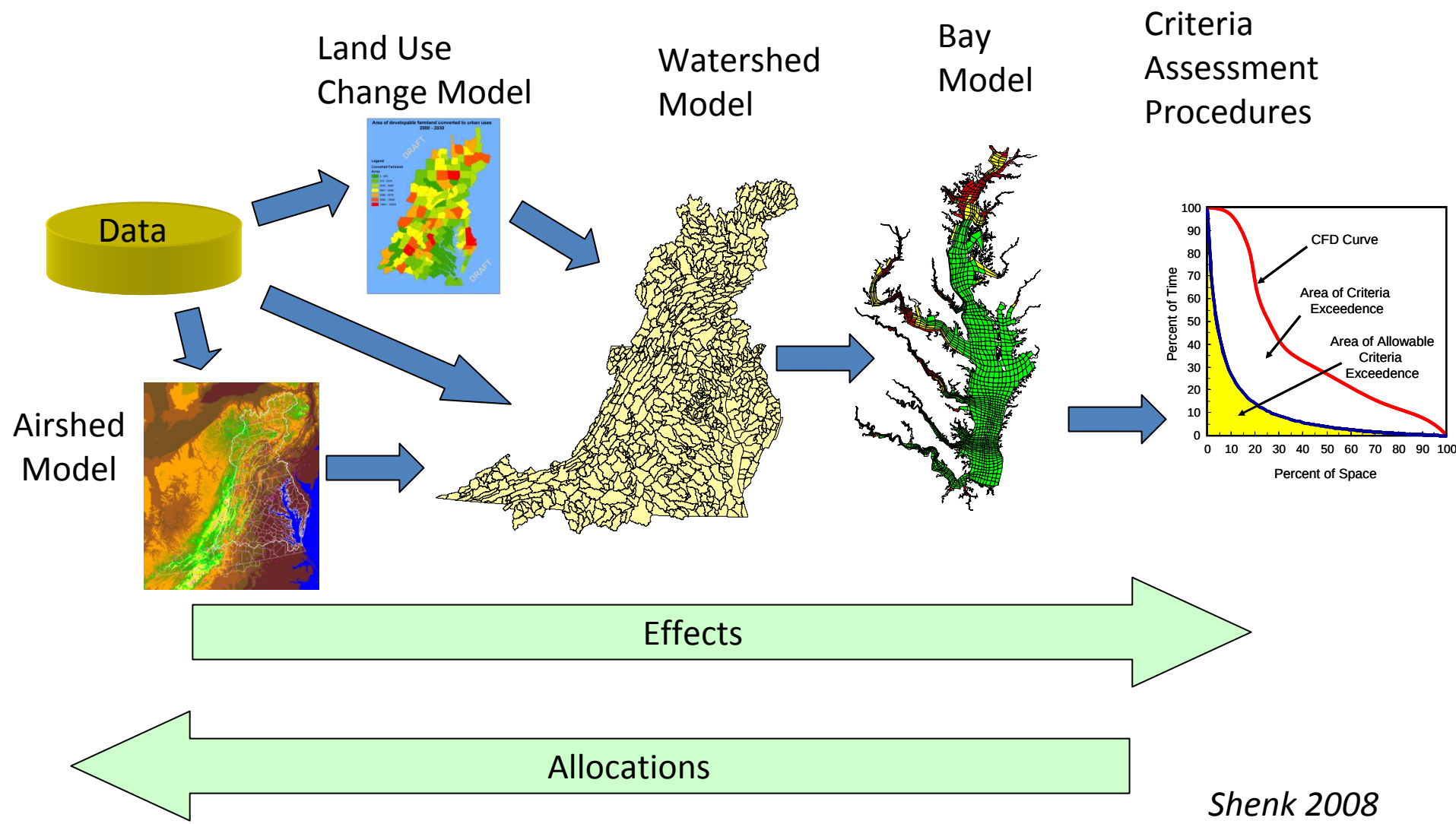
Chesapeake Bay is impaired by low dissolved oxygen …

Wicks et al. 2007

Principal Water Quality Drivers

- Stream and river inflows
- Nutrient (N and P) and solids loads
- Temperature
- Wind
- Sea level
- Bathymetry
- Chemical-biological processes

Existing Decision Support System



Shenk 2008

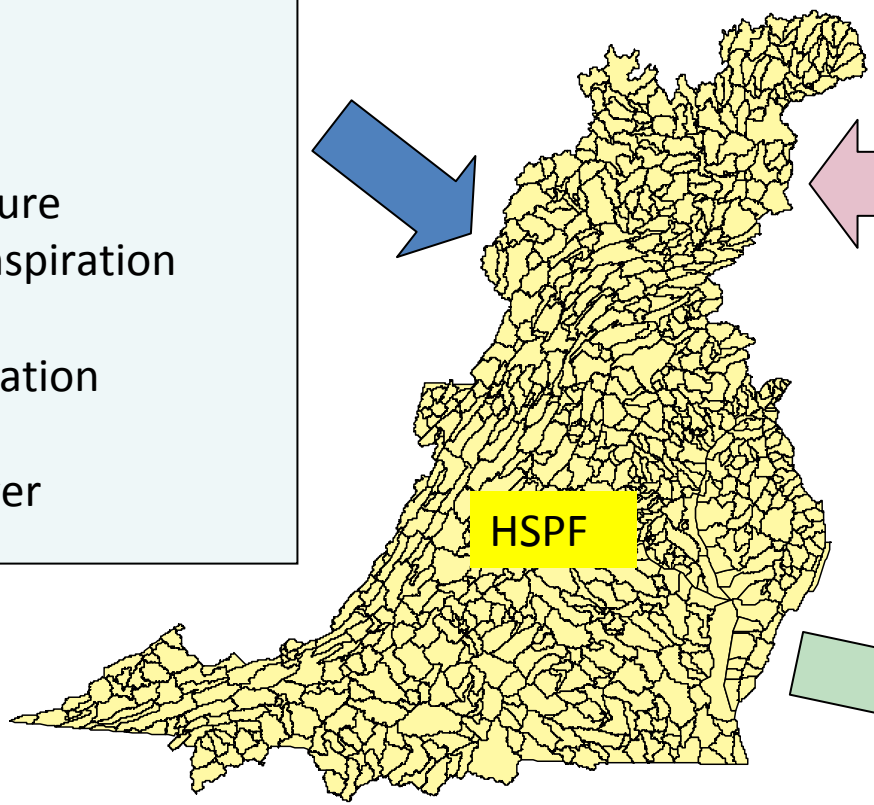
Watershed Model Inputs

Hourly Values:

Rainfall
Snowfall
Temperature
Evapotranspiration
Wind
Solar Radiation
Dewpoint
Cloud Cover

Annual or Monthly:

Land Use Acreage
BMPs
Fertilizer
Manure
Atmospheric Deposition
Point Sources
Septic Loads

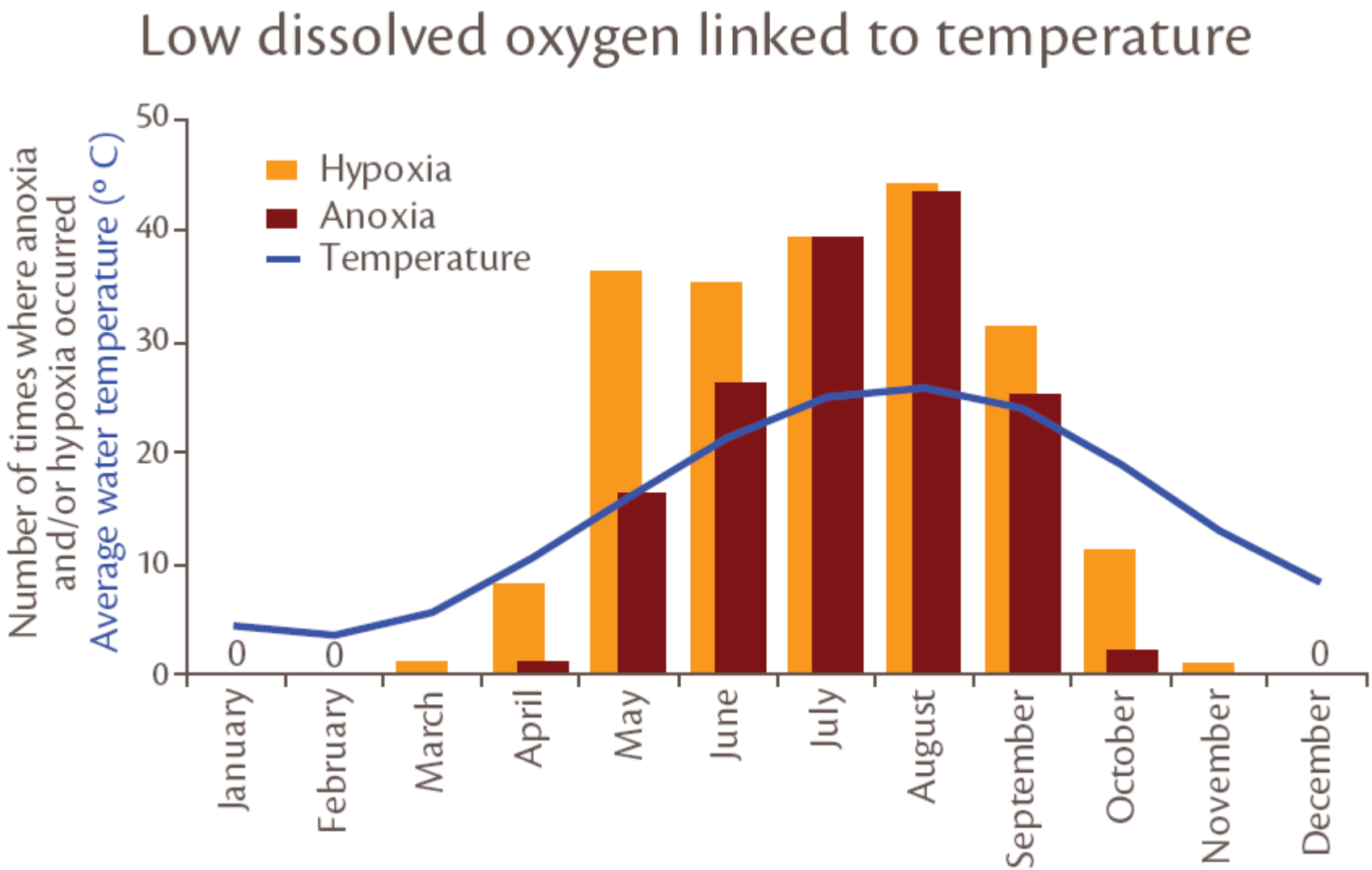


Daily output compared
To observations

Shenk 2008

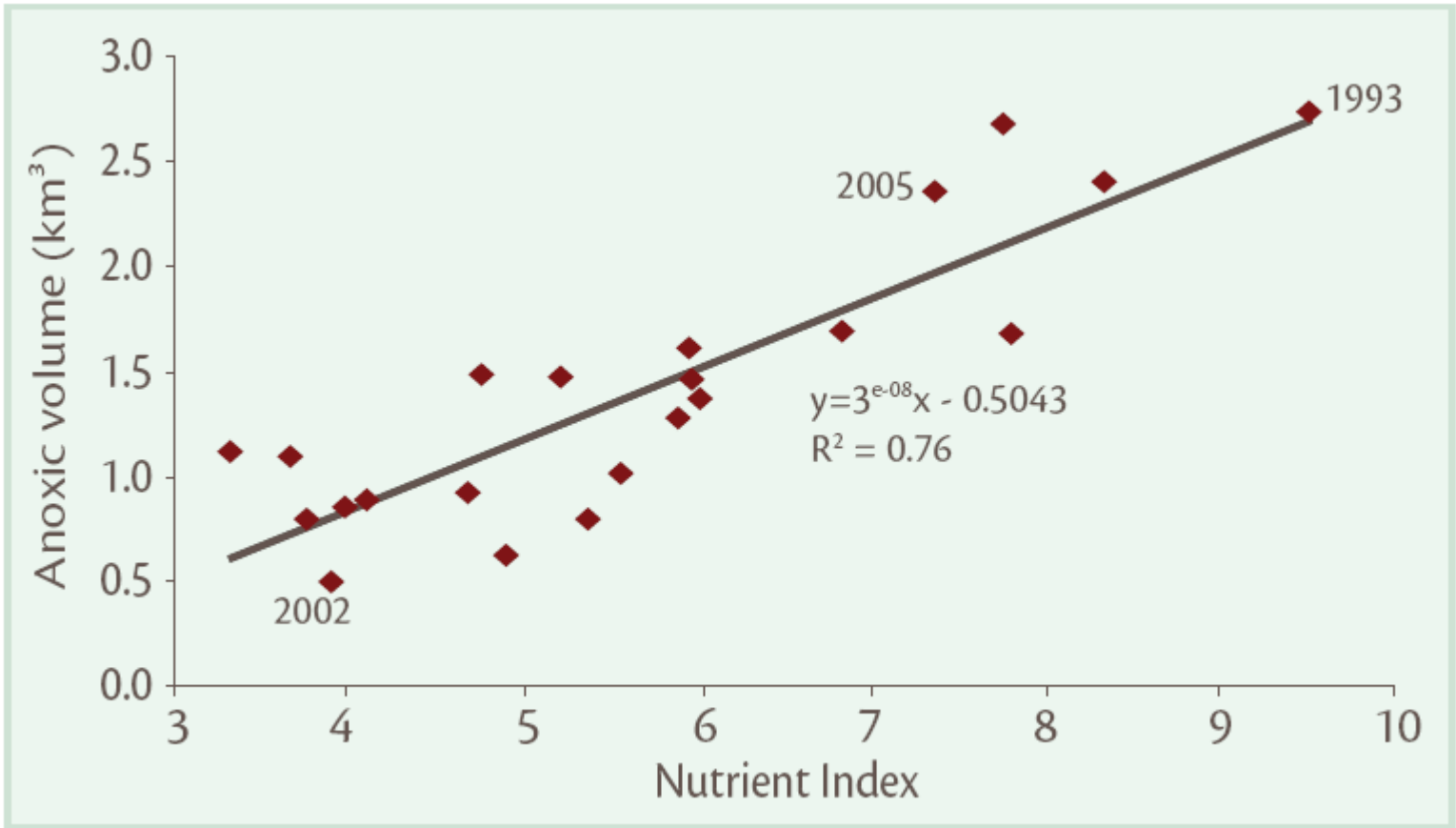
Principal Climate Drivers

- Temperature
  - Bay water
  - Evapotranspiration
- Precipitation
  - Stream and river inflows
- Wind
  - Water column mixing
- Sea level
  - Bay water depth and volume



Wicks et al. 2007

Low dissolved oxygen linked to nutrient loads



Wicks et al. 2007

Projected Changes for Chesapeake Bay

- Temperature
  - Increase (high certainty)
- Precipitation
  - Increase in winter and spring (likely)
  - Winter and spring streamflows will increase (likely)
  - ***Uncertainty in both magnitude and direction of changes in annual streamflows***
- Wind
  - Storm intensity will increase (likely)
- Sea level
  - Increase (high certainty)

Summarized from STAC 2008

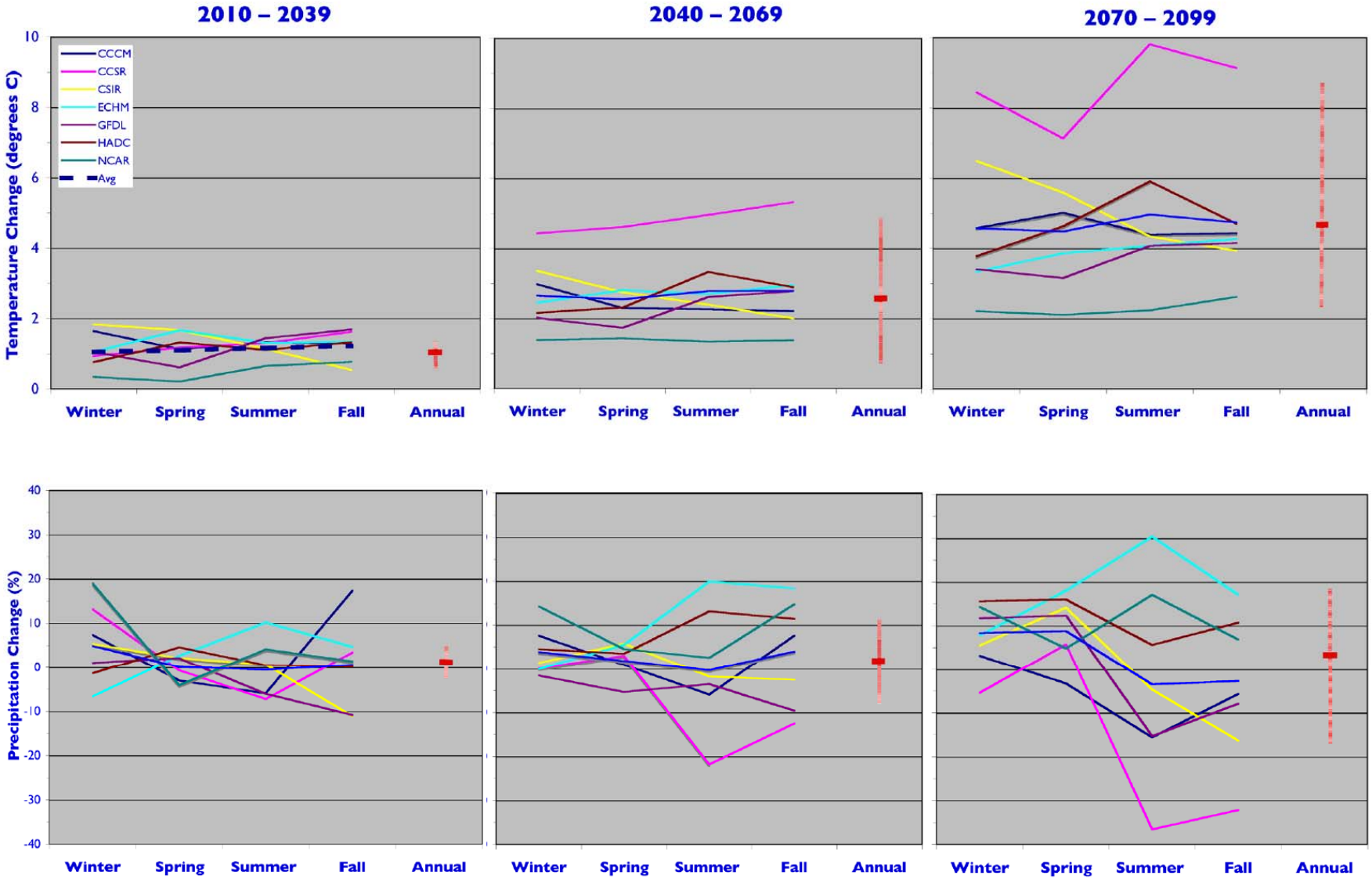


Figure 3. *Seasonal temperature (top) and precipitation (bottom) changes averaged over the Chesapeake Bay watershed with respect to 1971 to 2000 predicted under the A2 scenario by seven climate models for 2010 – 2039, 2040 – 2069, and 2070 – 2099. At the far right of each panel are the annual average changes for the seven-model mean and the overall model range (reproduced from Najjar et al. [2008]).*

STAC 2008

Table 1. *Summary of hydrological modeling studies showing the influence of climate change on streamflow in the Mid-Atlantic region (reproduced from Najjar et al. [2008]).*

Reference	Region	CO_2 Scenario	Time Period	Number of GCMs	Annual Streamflow Change (%)
McCabe and Ayers (1989)	Delaware River Basin	Doubling	–	3	- 39 to 9
Moore et al. (1989)	Mid-Atlantic/New England	Doubling	–	4	- 32 to 6
Najjar (1999)	Susquehanna River Basin	Doubling	–	2	24 ± 13
Neff et al. (2000)	Susquehanna River Basin	1% yr^{-1} increase	1985 – 1994 to 2090 – 2099	2	- 4 to 24
Wolock and McCabe (1999)	Mid-Atlantic	1% yr^{-1} increase	1985 – 1994 to 2090 – 2099	2	- 25 to 33
Hayhoe et al. (2007)	Pennsylvania/New Jersey	A1F1 and B1	1961 – 1990 to 2070 – 2099	2	9 to 18

STAC 2008

Climate Driver	Direct Effect	Secondary Effect	Influence on Hypoxia
Increased temperature	More evapotranspiration	Decreased streamflow	+
		Land-use and cover changes	+/–
	Less snow cover	More nitrogen retention	–
	Warmer bay temperature	Stronger bay stratification	+
		Higher metabolic rates	+
More precipitation	More streamflow	Stronger bay stratification	+
		More nutrient loading	+
	More extreme rainfall	Greater erosion of soil P	+
Less precipitation	Less streamflow	Weaker bay stratification	–
		Less nutrient loading	–
Higher sea level	Greater bay depth/volume	Stronger bay stratification	+
		Greater bottom water volume	–
		Less hydraulic mixing	+
	Less tidal marsh	Diminished nutrient trapping	+
Weaker summer wind	Less water column mixing	More persistent stratification	+
Stronger summer wind	More water column mixing	Less persistent stratification	–

Boesch et al. 2007

Chesapeake Bay Water Quality
Information Needs for Adaptation Planning

Parameters

- Precipitation
- Snowfall
- Temperature
- Evapotranspiration
- Wind
- Solar radiation
- Dewpoint
- Cloud cover

Spatial-Temporal Scales

- Watershed Model land segment (usually county)
- Period of simulation 1984-2005
- Hourly temporal resolution