Climate Change and the Chesapeake Bay: Management Implications

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Beyond Heat and Inundation—AR4

- Coral reefs disappearing
- Permafrost melting
- Global changes in agricultural production.
- Increase in Forest Fires
- Droughts
- Mass Extinctions
- Famine
- Pestilence
- Hellfire
- Brimstone
Certainty

“There are known knowns. There are things we know we know. We also know there are known unknowns. That is to say, we know there are some things we do not know. But there are also unknown unknowns, the ones we don’t know we don’t know.”

— Donald Rumsfeld
Forecasts

- Warm
- Saltier (or Fresher)
- Sea Level Rise
- Vulnerability to Storms
17 of 24 AR4 Models; A2 (high emissions) and B1 (low emissions) scenarios
Bay Temperature

Linear regression on air temperature ($t=0$, $t=-2$ month).

$\text{adj } R^2 = .96$

Eelgrass (*Zostera marina*) $\rightarrow$ Blue crabs

Hypoxia

Habitat reduction

Spawning habitat
Based on regression with precipitation and soil moisture. Adj $R^2 = .39$


Sea level predictions suggest increases in salinity 1.4-3.2 Hilton et al. (2008)
Forecasts for Bay

- Warmer throughout the year with intense, persistent heat waves in summer.
- Wetter winters
- More precipitation in intense events.
- Seasonal effects significant
- Flashier, more variable runoff regime

http://hpl.umces.edu/vcoles/cbayclim.htm
Sea-Level Rise
Subsidence
Rise for Bay since 1961

Global Rise: 1.8mm/yr
Subsidence: 1.7mm/yr
3.5mm/yr

Accelerating
Marsh Loss—Blackwater NWR
Potential Inundation on Maryland’s Eastern Shore

Chesapeake Bay
1933, 2003: Vulnerability

Isabel

August 1933

September 16, 1933
September 18, 1936
Quarter-Wave Seiche
Atlantic Hurricane Activity

North Atlantic Hurricanes and Named Storms (1944-2006)

Source IPCC
Management

• Recognize the possibility of unknown unknowns
• Plan for the known unknowns
• Deal with the known knowns
• Mitigation:
  - Emissions Reductions
  - Forecasts and Planning Tools for Emergency Management
  - Adaptive reuse of dredged materials
• The record of dealing with known knowns is one of failure
Oxygen 5-6 October 03
The evidence shows that ignoring climate change will eventually damage economic growth. Our actions over the coming few decades could create risks of major disruption to economic and social activity, later in this century and in the next, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes.

The Stern Review: The Economics of Climate Change, Royal Society of London October 30, 2006
Declining Ground-Water Levels in Southern Maryland

Water Level (Feet Below Land Surface)

SM Df 71 Aquia Formation

Well location
But...Storm Surges and Waves
Projected globally-averaged sea level rise by the end of the 21st century

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<th>Case</th>
<th>Model-based range excluding future rapid dynamical changes in ice flow</th>
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Source: IPCC *Summary for Policy Makers*, February 2007

Up to 2 feet
Projected globally-averaged sea level rise by the end of the 21st century

Up to 2 feet

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Note: Model-based range excluding future rapid dynamical changes in ice flow

Source: IPCC *Summary for Policy Makers*, February 2007
Salinity 5-6 October 03
Motivation, cont’d

Eutrophication

Salinity

Oxygen
Global Climate Change and Future Sea Level Rise
Jonathan Overpeck, The University of Arizona

Likely warming depends on emissions scenario

Source: IPCC Summary for Policy Makers, February 2007
Tide Gauge Observations

Average Rate $\sim$ 1.8 mm/year

[Church and White, 2006]
2100 Projection

Titus and Richman, 2000

- Red: below 1.5 meters
- Blue: 1.5 - 3.5 meters
- White: above 3.5 meters

20 miles
Methods

1. Interpolate data sets and models to 1/4° resolution.
2. Mask regions.
3. Spatially average.

Surface air temperature (Miroc-medres)
Model Regions

- Chesapeake Watershed region
- Maryland region
- Chesapeake Bay (sea level) region
Snow

Reduced spring freshet -> interactions of anadromous fish spawning (striped bass, white perch) and ETM

Lower spring discharge -> less water storage.

More variability in spring ETM position and intensity, upbay movement in summer.

Chesapeake Watershed Snow Volume Anomaly
Soil Moisture

Less water storage, less shallow groundwater input ->
Riparian plant stress
Marsh upland migration
Forecasts, cont’d

- Seasonal effects are significant.
- Warmer: lower soil moisture
- Event - driven signals suggest a flashier more variable system.
- Need for regional climate modeling coupled with hydrological and estuarine models.