A Shallow-water Coastal Habitat Model for Regional Scale Evaluation of Management Decisions in the Chesapeake Region

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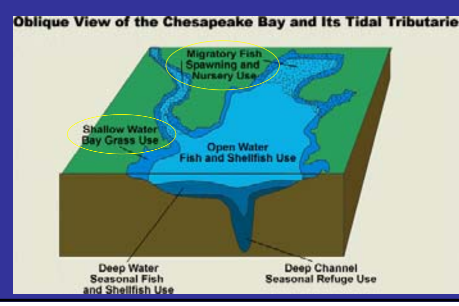
Overview

- Study Systems
- Stressors of Interest
- Objectives and Tasks
- Modeling Approach
- Model Structure
- Users, Products, and Progress

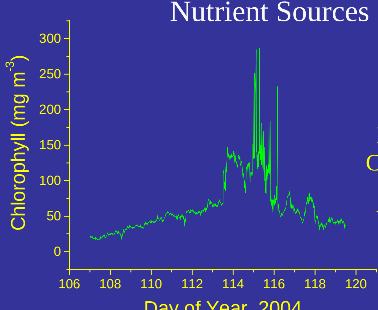
Importance of Shallow-water Tributary Embayments (STE) in Chesapeake Bay

Formation of estuaries as drowned river mouths has resulted in highly articulated shorelines for east coast estuaries.

Shallow-water Tributary Embayments are Critical to Two of the Designated Use Categories



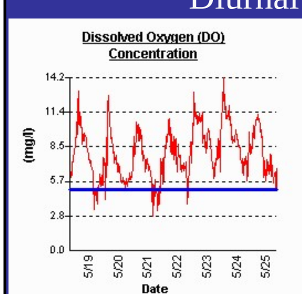
Susceptible to Large Phytoplankton Blooms due to Shallow Water and Proximity to Nutrient Sources



Rhode River, MD Continuous Monitor

April 16-30, 2004

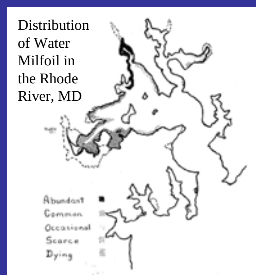
High Phytoplankton Productivity Results in Low A.M. D.O. and Large Diurnal Swings



MD Department of Natural Resources, “Eyes on the Bay”, Shallow Water Monitoring Program, Rhode River 2004.

http://mddnr.chesapeakebay.net/newmontech/contmon/eotb_results_graphs.cfm?station=SERC

Catastrophic Losses of SAV in Chesapeake Bay Occurred First in Western Shore STE

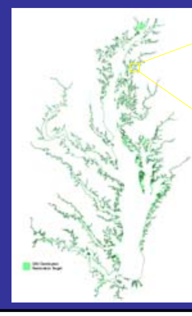


July 1966


July 1967

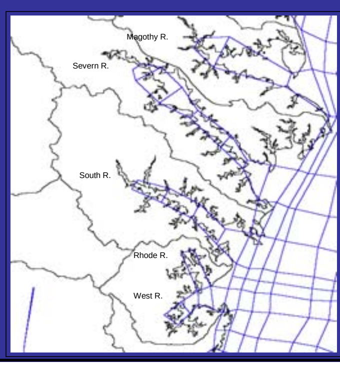
Bayley, S., H. Rabin and C. H. Southwick, 1968. Recent decline in the distribution and abundance of Eurasian milfoil in Chesapeake Bay. Chesapeake Science 9: 173-181.

Areas Slated for Restoration of SAV are Concentrated in Shallow Tributary Embayments and Tidal Creeks



Chesapeake Bay Program Tier-II Restoration Goal: Restore SAV to the 1-m contour in areas in which it historically occurred.

Main CB Model Segmentation Scheme Treats Most STE as 1 to 3 Cells



Premise: The ecological importance of shallow-water tributary embayments far exceeds their volumetric contribution to the Bay, and the main-stem concentrations of water quality constituents.

Global Change-related Stressors of Interest

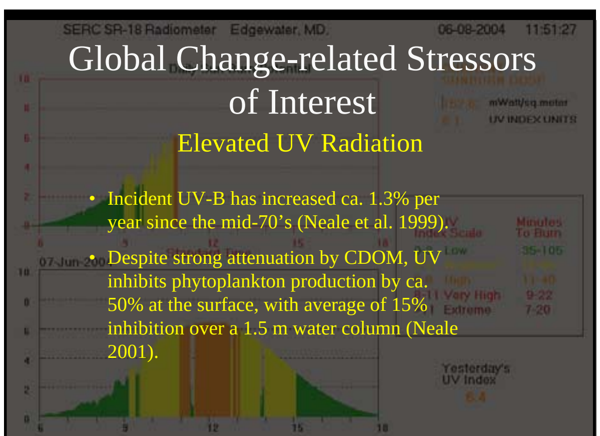
Atmospheric CO_2

Concentrations rose by 30% in 20th century, and continuing to rise at ca. 1% per year.

Potential Impacts on Shallow Tributary Embayments

- Altered growth rates of emergent vegetation
- Uncertain effects on export of carbon from wetlands
- Uncertain effects on seasonally average temperatures
- Uncertain effects on rainfall and runoff patterns

Global Change-related Stressors of Interest



Elevated UV Radiation

- Incident UV-B has increased ca. 1.3% per year since the mid-70's (Neale et al. 1999).
- Despite strong attenuation by CDOM, UV inhibits phytoplankton production by ca. 50% at the surface, with average of 15% inhibition over a 1.5 m water column (Neale 2001).

Objectives and Tasks: Estuarine Modeling End Points

Objective: To provide a tool to predict the magnitude and trends of existing and emerging indicators of the ecological condition of critical shallow water habitats.

Important Stressors:
- Suspended Sediments
- Nutrients
- UV Irradiance

Model Output:
- Phytoplankton Chlorophyll
- Water Clarity (diffuse attenuation coefficient)
- Dissolved Oxygen

Questions of Interest

- How do nutrients and suspend sediments interact to determine the growth of phytoplankton under altered land-use and climate regimes?
- How will concentrations of CDOM respond to changes in land use (e.g. wetland coverage) or in situ eutrophication, and what are the implications for penetration of UV radiation?

Objectives and Tasks: Watershed Inputs to STE

- Use spatial analysis to describe the “population” of STE around the shore of Chesapeake Bay and its major tributaries
- Apply previously developed statistical models relating land cover and physiographic province to nutrient discharges to quantify the distributions of local watershed inputs of water and nutrients across the population of STE

Objectives and Tasks: Carbon Export from Wetlands

- How does export of DOC from wetlands depend on concentration of atmospheric CO_2?
- How does export of CDOM vary among physiographic province and land cover?

Modeling Approach

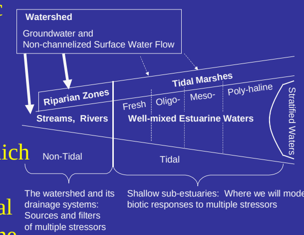
- STE exhibit a wide range of sizes, shapes, influence by local watershed, and exchange with main stem estuary
- STE are far too numerous to model individually, on a creek-by-creek basis

Modeling Approach

- We will employ an approach that uses a large number of simple, generic models of subestuaries and tidal creeks, incorporating inputs from local watersheds, internal processing, and exchange at the seaward boundaries
- Our approach will make extensive use of Monte Carlo simulation and generalized sensitivity analysis to determine a range of outcomes, under different management scenarios, for the diversity of shallow-water systems encountered around Chesapeake Bay.

Model Structure: Conceptual

- We conceive of STE as part of a continuum of aquatic ecosystems linking watersheds with coastal marine waters
- Focus on well-mixed estuarine tidal waters, which contain a mixture of freshwater from their local watershed, and more saline water from adjacent estuarine or coastal waters



Model Structure: Stressor Interactions

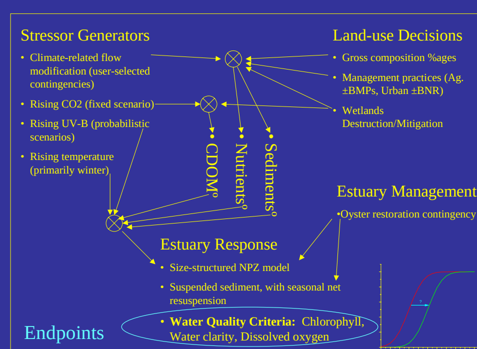
•Important stressors vary in different component ecosystems in the landscape

•Response variables in watersheds and wetlands are sources of stressor inputs to STE

•Response variables within STE are the indicators being used to evaluate management success

Ecosystem Component	Stressor Interactions Within-Component	Response Variable: Stressor Delivery to- or Response within-Estuary
Watershed	Land-use × Climate-related flow alteration	Nutrients, sediment, and CDOM
Wetlands and Marshes	Rising CO_2 × Changing wetlands distribution	Below-ground CDOM flux
Estuary	Nutrients, sediment, & CDOM × Rising UV	Phytoplankton chlorophyll Water clarity Dissolved oxygen

Model Structure: Flow



Products and Users

- Cumulative distribution functions of indicators being used for assessment of CWA compliance
- Chesapeake Bay Program
- State agencies
- Tributary strategy teams
- Watershed planners

Progress

Scheduled Activity	Year 1				Actual
Measure CDOM export from wetlands & watersheds	*	*	*	*	Measurements commenced spring 2004
GIS analysis of subestuaries	*	*	*	*	Basic size and land-use metrics
GIS analysis of coastal plain watersheds					analyzed for ca. 80 STE
Statistical analysis of nutrient discharge data			*	*	Limited progress
Coding of subestuary componene models		*	*	*	Limited progress