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

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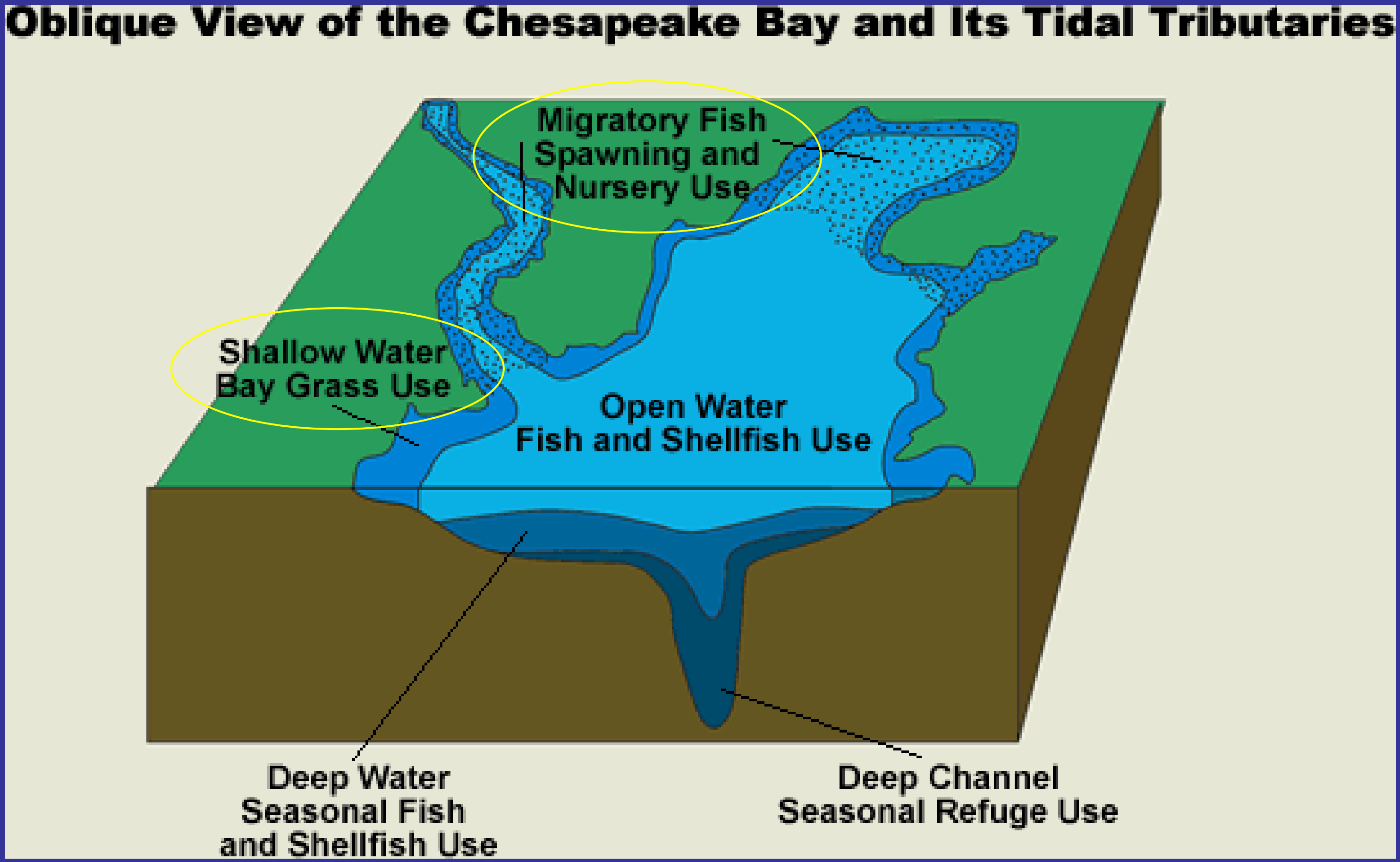
Overview

- Study Systems
- Objectives and Tasks
- Modeling Approach
- Model Structure
- Preliminary Results
- Progress and Next Steps

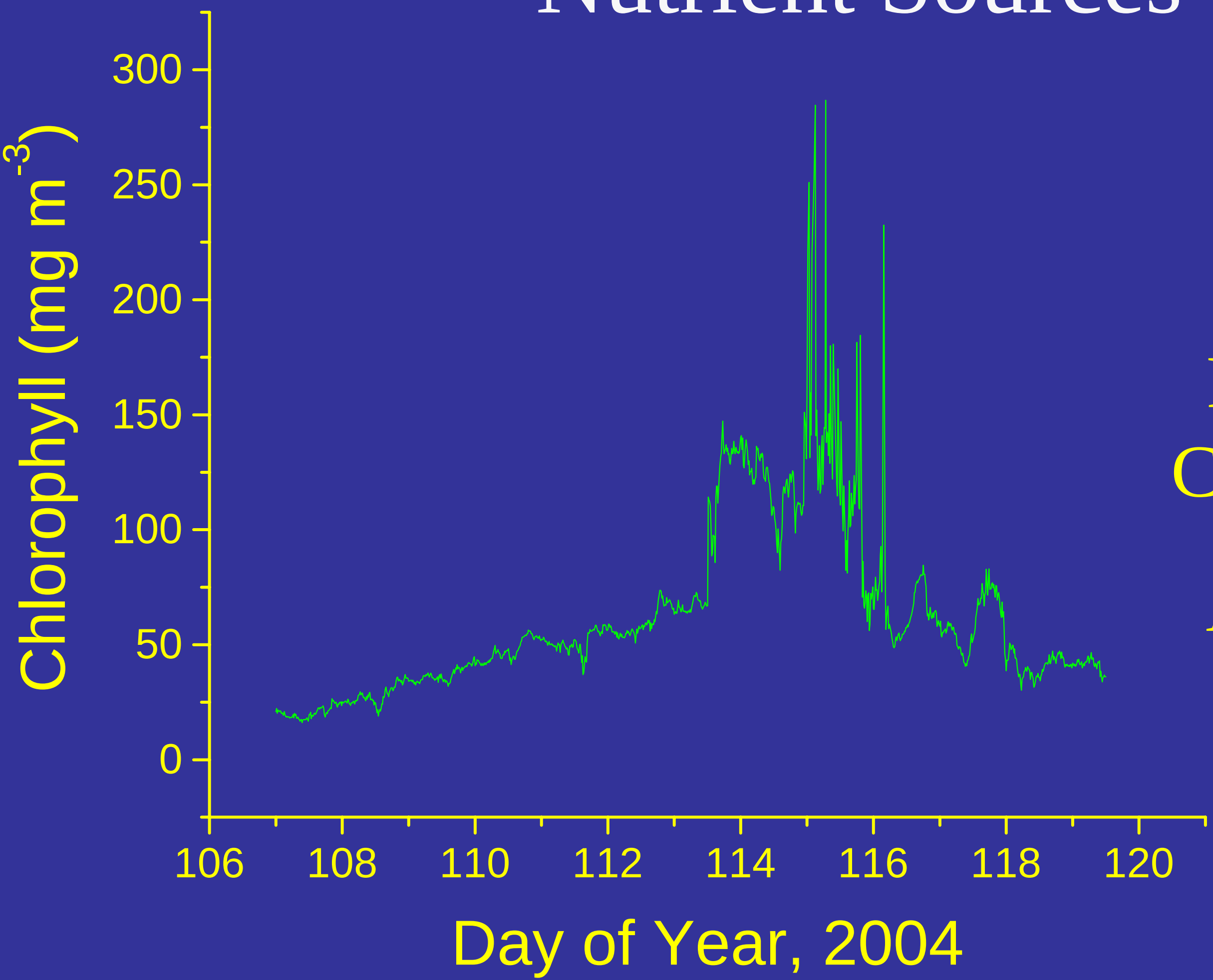
Importance of Shallow-water Tributary Embayments (STE) in Chesapeake Bay

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



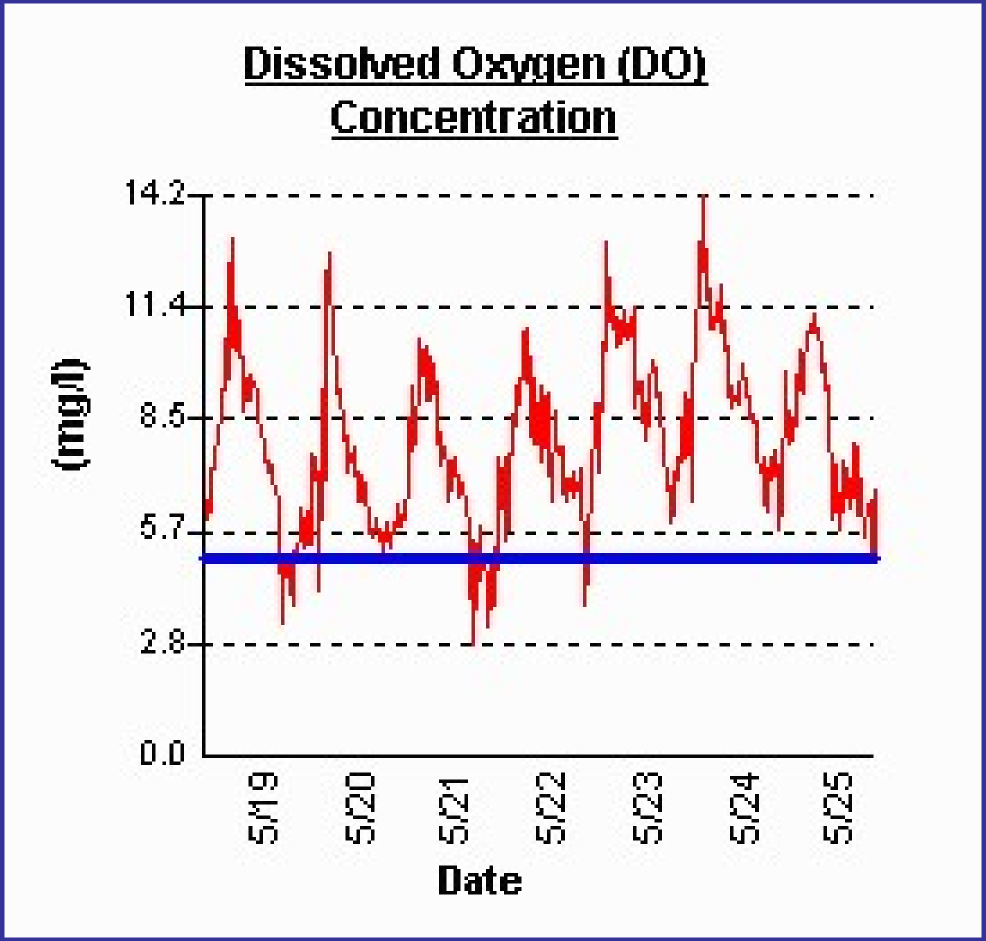
Susceptible to Large Phytoplankton Blooms due to Shallow Water and Proximity to Nutrient Sources



Rhode River, MD
Continuous Monitor

April 16-30, 2004

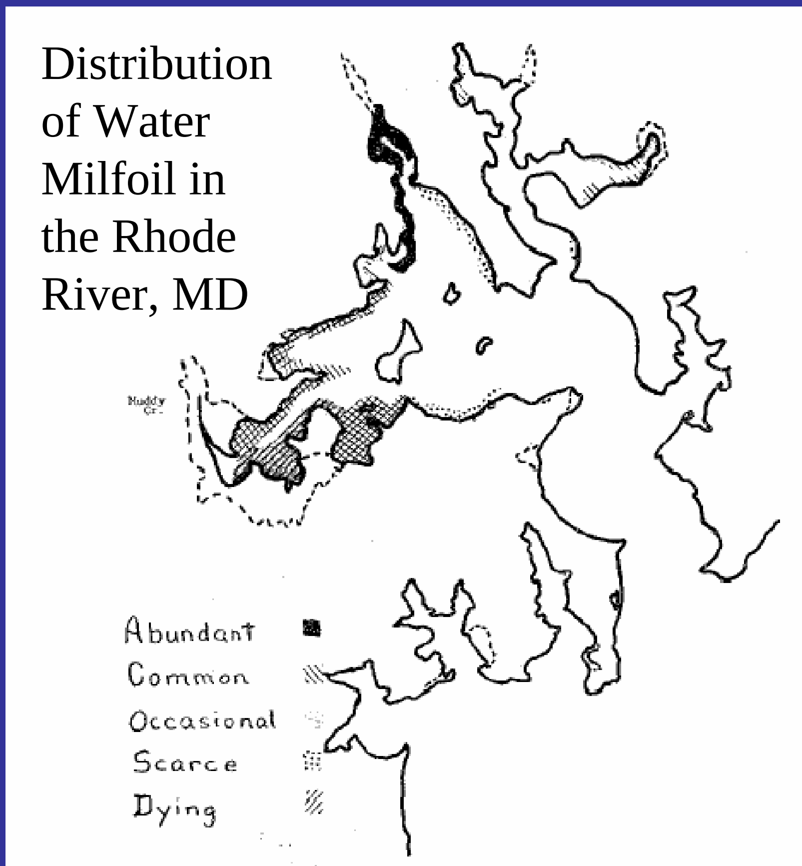
High Phytoplankton Productivity Results in Low A.M. D.O. and Large Diurnal Swings



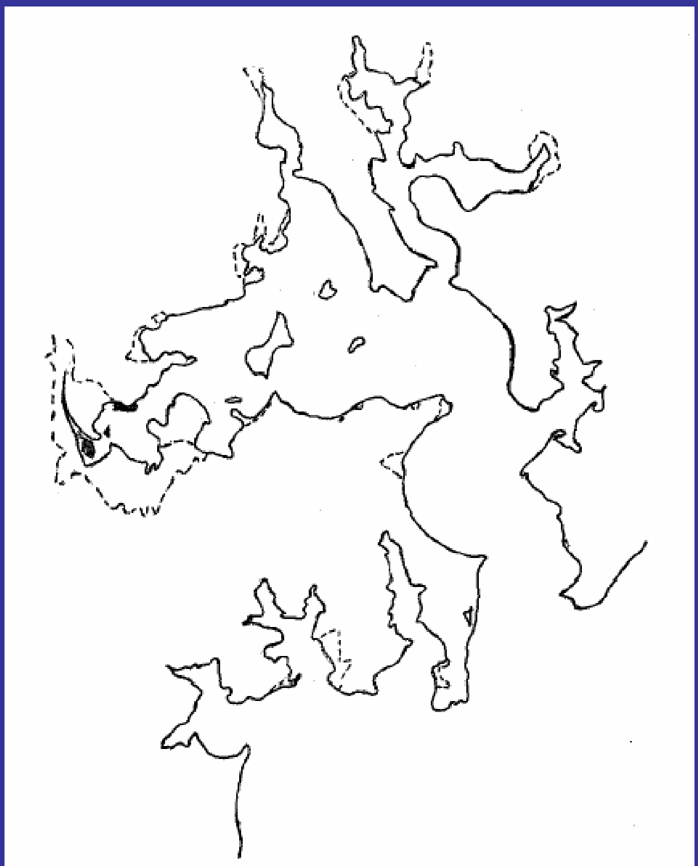
MD Department of Natural Resources, “Eyes on the Bay”, Shallow Water Monitoring Program, Rhode River 2004.

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



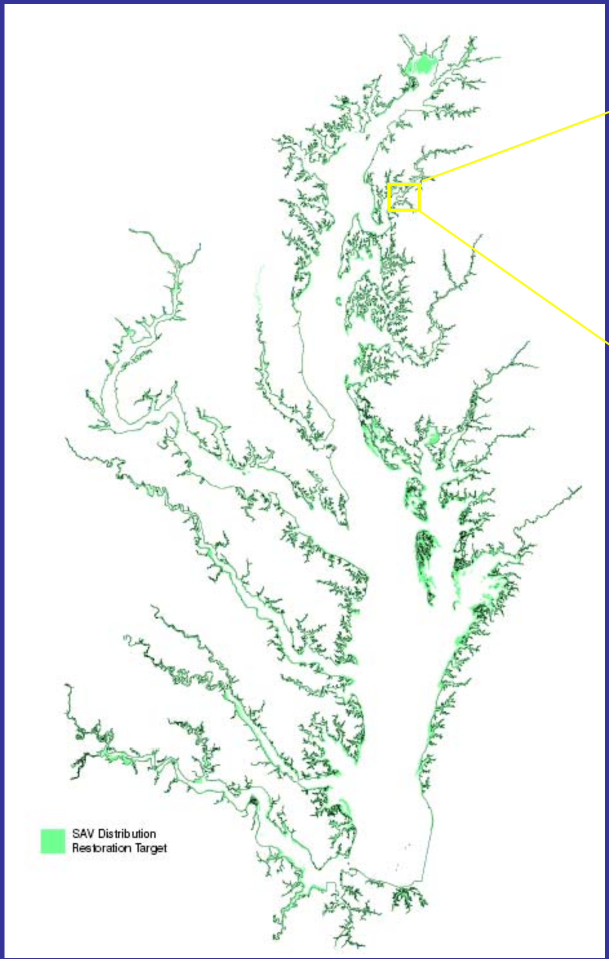
July 1966

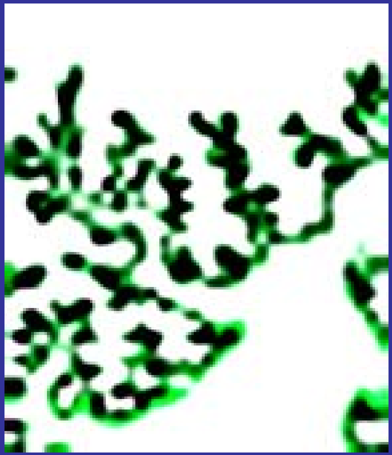


July 1967

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.

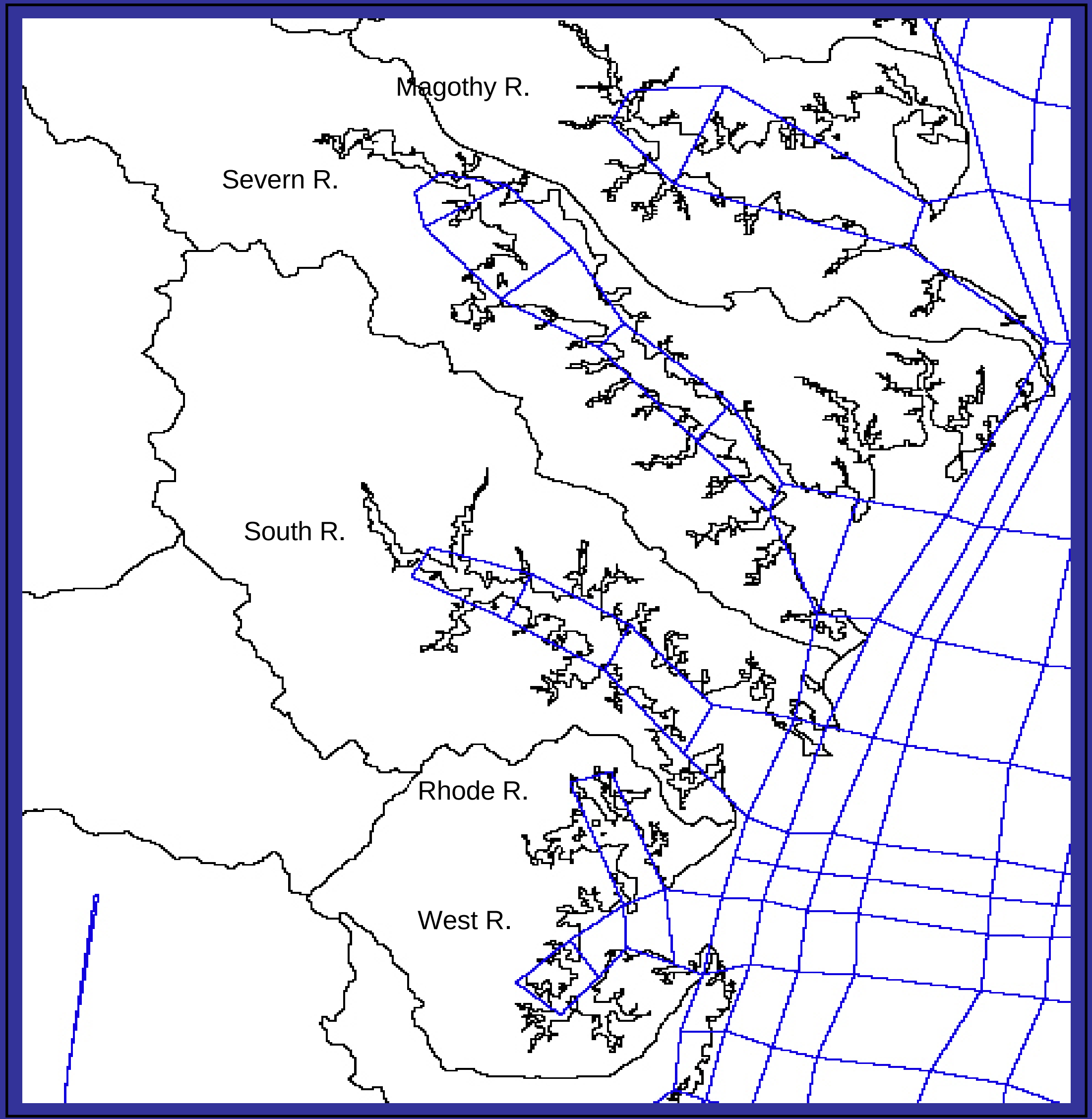
Areas Slated for Restoration of SAV are Concentrated in Shallow Tributary Embayments and Tidal Creeks





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.

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:

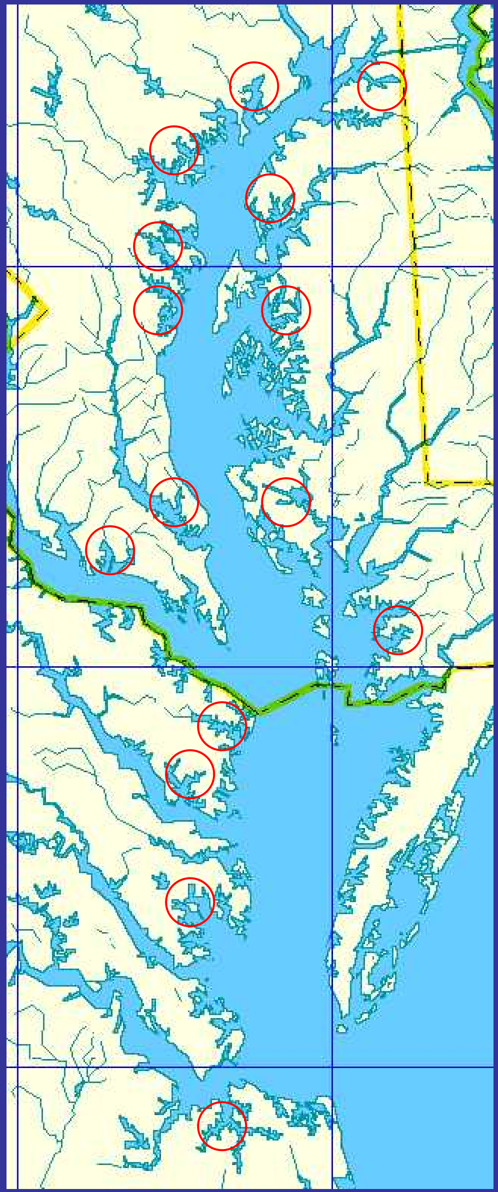
- Phytoplankton Chlorophyll
- Water Clarity (diffuse attenuation coefficient)
- Dissolved Oxygen

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

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

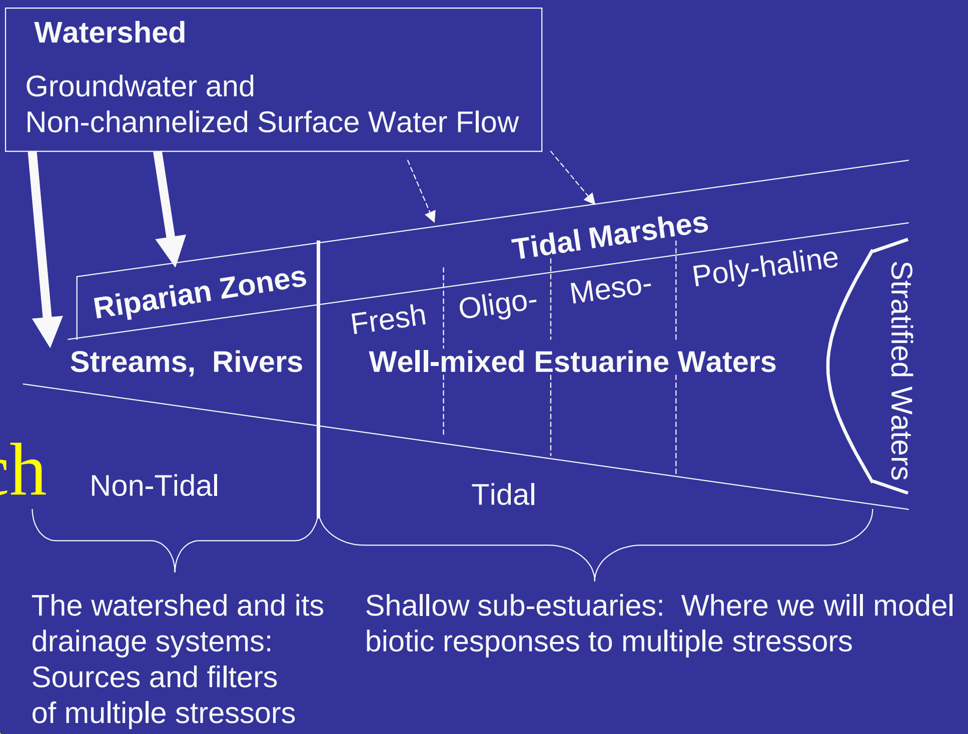


Modeling Approach

- We are employing 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.

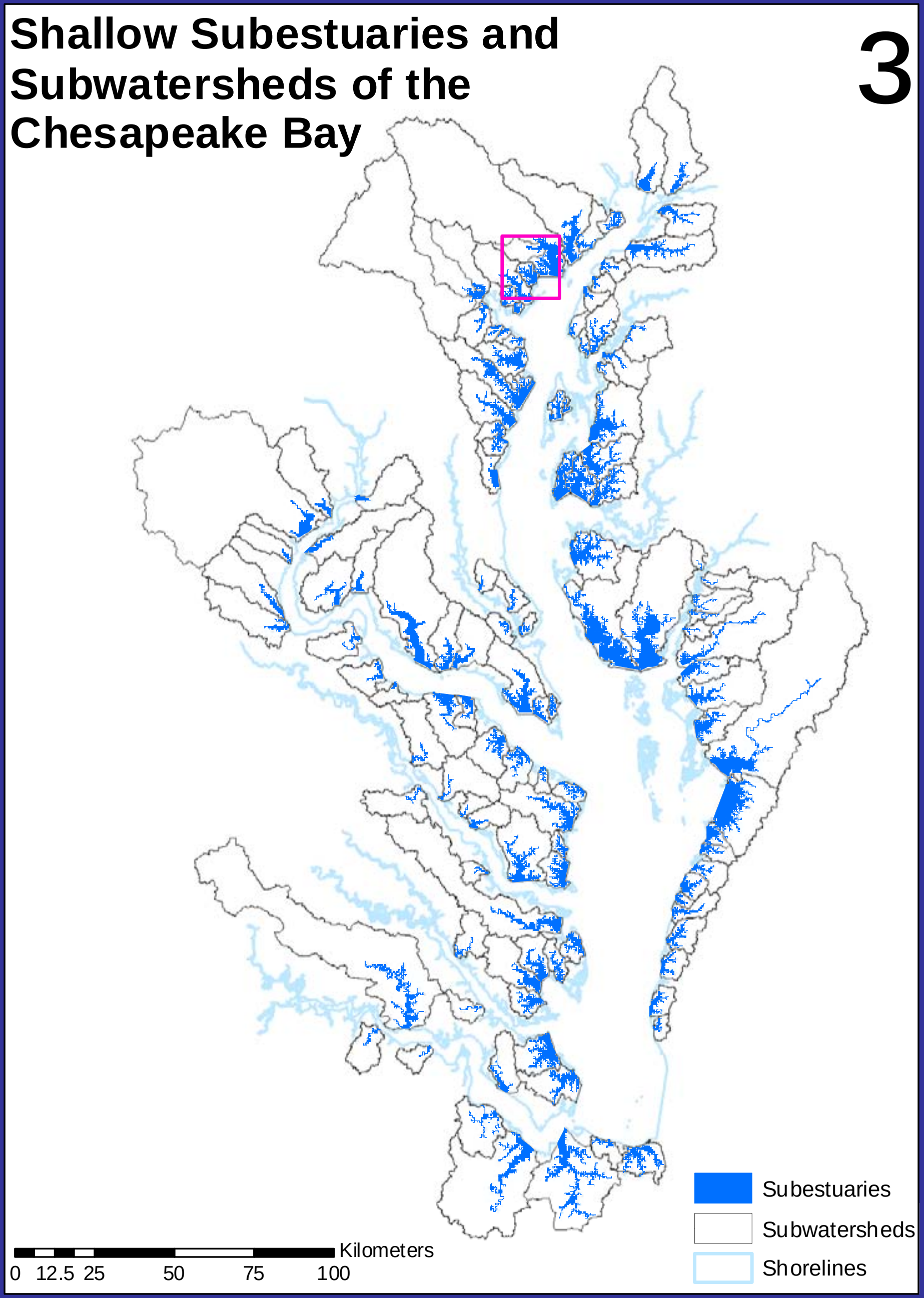
Model Structure: Conceptual

- 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



Subestuary and Watershed Delineation

128 shallow subestuaries and their local watersheds were delineated around the Chesapeake Bay.



Analysis of Subestuary Metrics

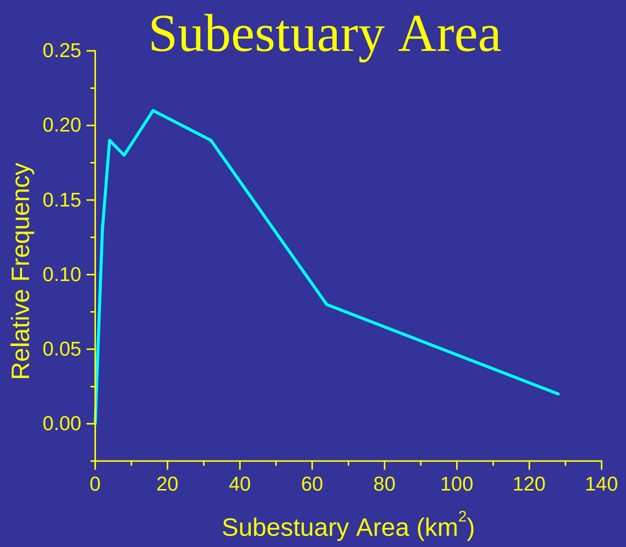
18 subestuary metrics were developed: subestuary area, volume, depth range, percentage of shallow water (0-1m, 1-2m, 0-2m),

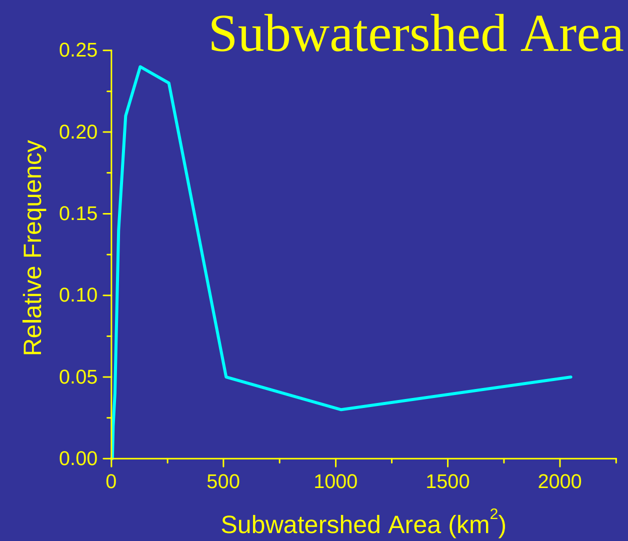
mouth width, etc.

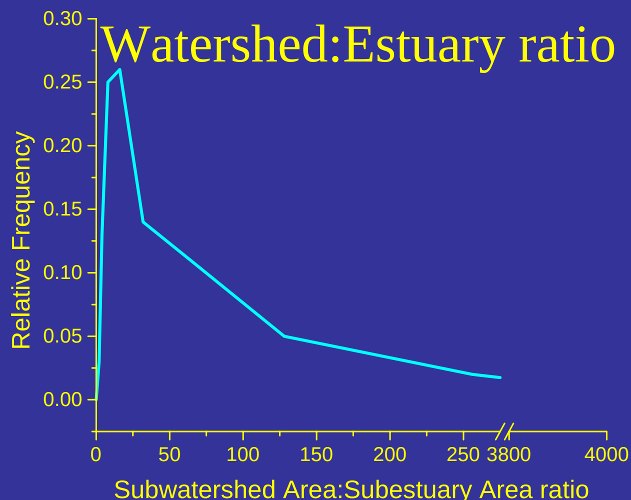
Subestuary ID	Subestuary Name	Subestuary Area(km2)	Subestuary Perimeter(km)	Subestuary Volume(km3)	……
ELK01	Elk River	9.36	59.05	0.0097	
NOR01	Northeast River	15.84	40.63	0.0249	
CB101	Spesuit Narrows	5.50	84.39	0.0039	
CB201	Romney Creek	4.36	41.19	0.0032	
BSH01	Bush River	31.30	107.95	0.0513	
GUN01	Gunpowder River	49.46	192.16	0.0769	
MID01	Middle River	9.86	67.50	0.0142	
PAT01	Old Road Bay	3.43	18.05	0.0063	
PAT02	Bear Creek	4.70	48.83	0.0101	
BAC01	Back River	17.58	68.57	0.0256	
PAT03	Northwest Harbor	3.32	33.12	0.0244	
PAT04	Middle Branch	6.75	41.97	0.0254	
PAT05	Curtis Creek	5.93	52.13	0.0258	
PAT06	Stony Creek	2.64	25.84	0.0052	
……					

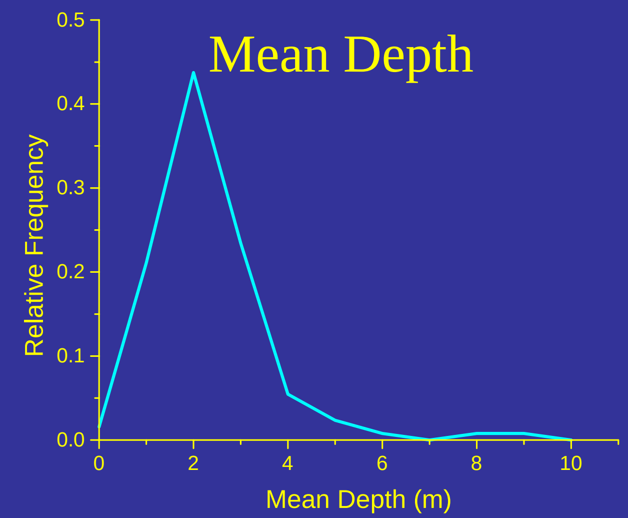
Will provide input for parameter distributions in Generalized Sensitivity Analysis

Some Characteristic Metrics







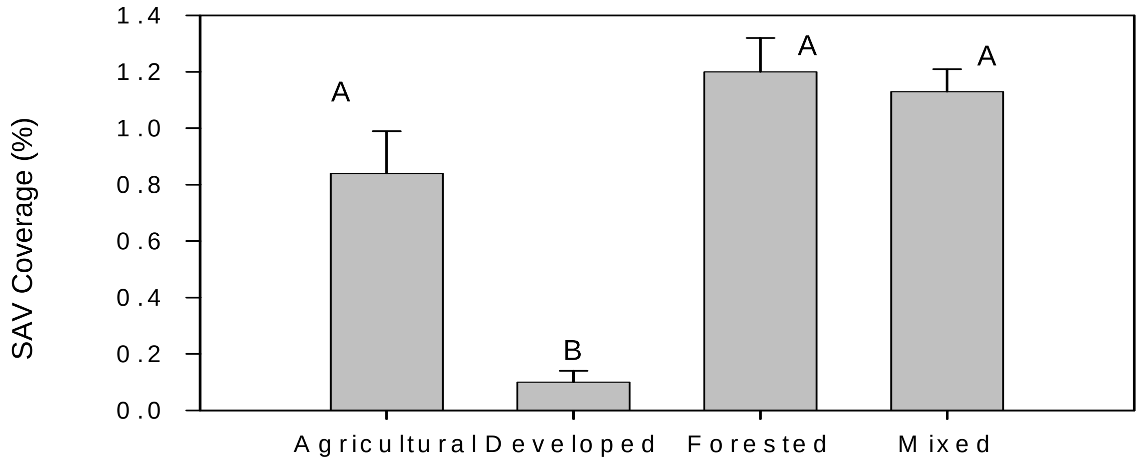


Practical Application of Watershed/Subestuary Delineation

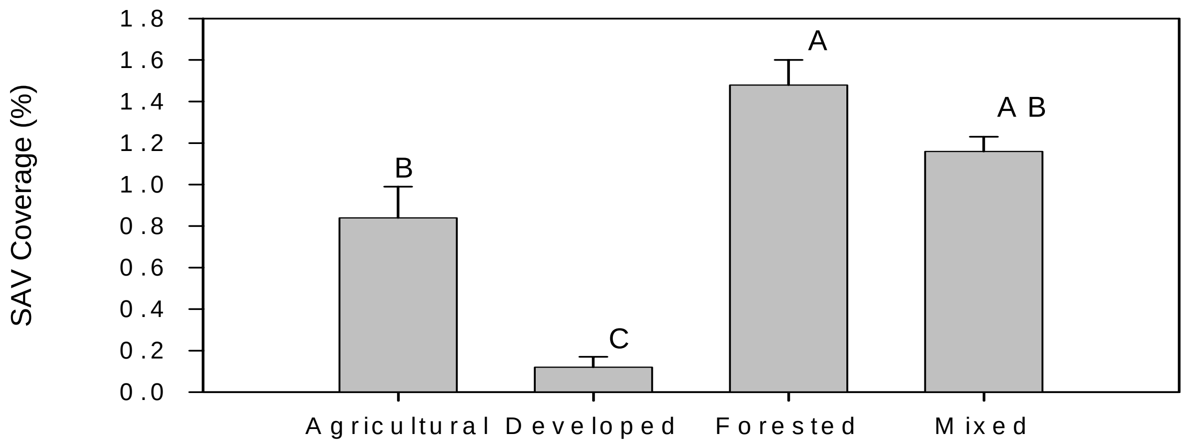
Potential SAV habitat and actual SAV presence in five subestuaries near Baltimore.

Percentage of SAV presence and coverage abundance (1971-2003) were calculated from VIMS SAV dataset.

Land use impact on SAV coverage abundance shows different pattern in different physiographic provinces.



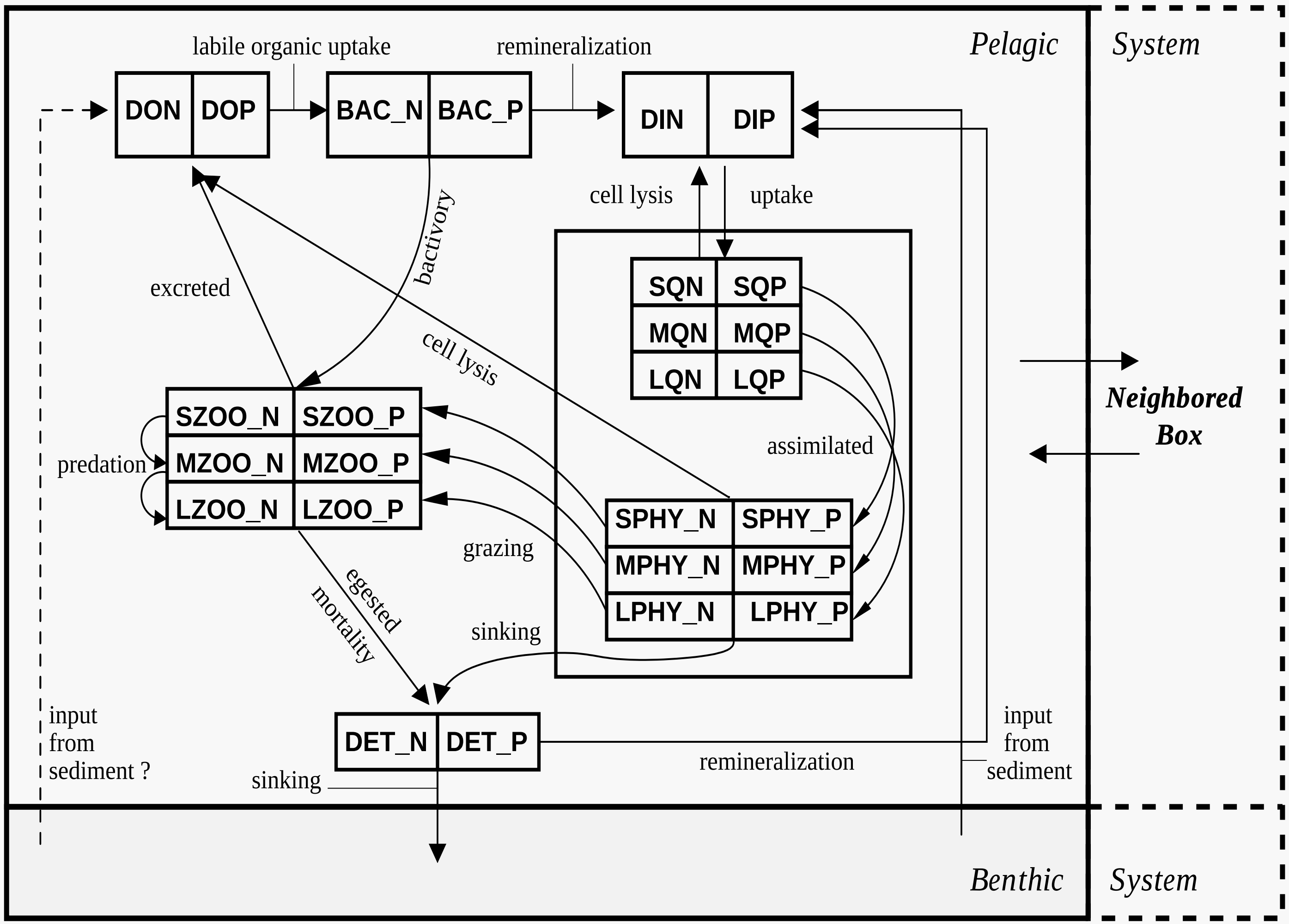
SAV coverage abundance under different land uses for all selected subestuary-watersheds with different physiographic provinces of piedmont, coastal lowland and costal upland.



SAV coverage abundance under different land uses for all selected subestuary-watersheds with physiographic province of coastal lowland and costal upland.

See poster by Yong Li and Don Weller

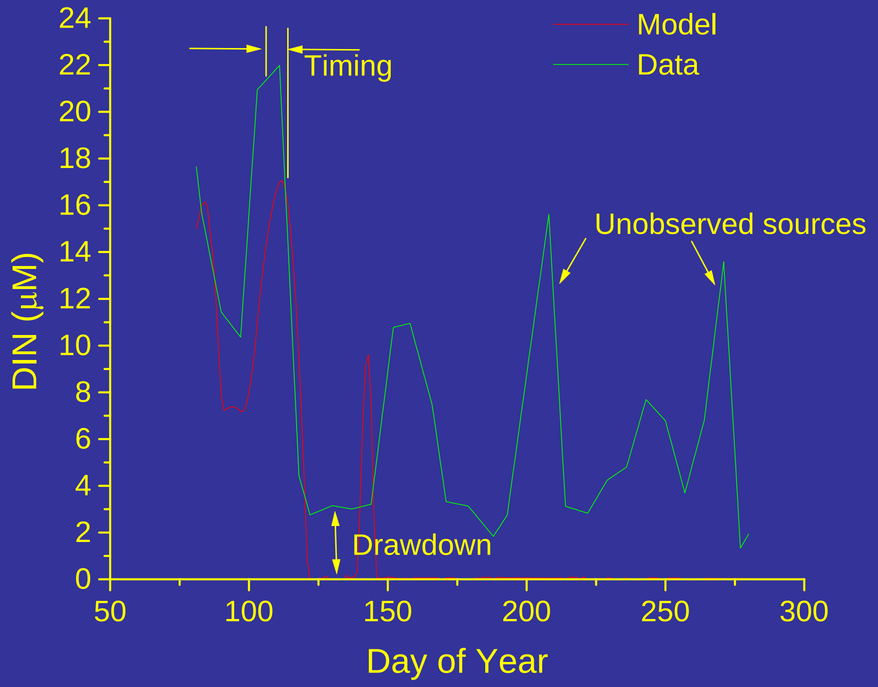
Water Column Model Structure



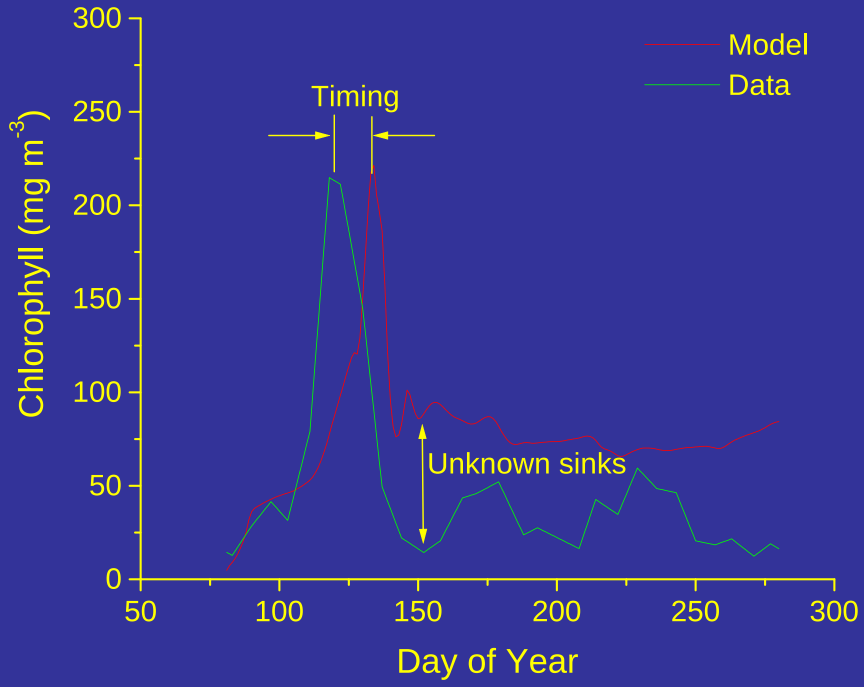
- N vs. P limitation
- 3 Phyto & zoo size-fractions
- Sedimentation & remineralization
- Physical exchange with neighboring segments

Model Testing

Nitrogen



Chlorophyll



*See poster by Hae-Cheol Kim

Progress

Scheduled Activity	**Year 2**				**Actual**
Measure CDOM export from wetlands & watersheds	*	*	*	*	Measurements commenced spring 2004, nearing completion
GIS analysis of subestuaries	*	*			Complete
GIS analysis of coastal plain watersheds	*	*			Complete
Statistical analysis of nutrient discharge data			*	*	Limited progress
Coding of subestuary componene models	*				Draft 1 complete
Validate subestuary model predictions	*	*	*	*	Underway
Link Subestuary and watershed models		*	*	*	To commence
Model flow-alteration/land-use change scenarios			*	*	Pending completion of watershed/subestuary linkage

Next Steps

- Link watershed and subestuary models
- Iron out remaining issues in water column model
- Analyze nutrient discharge data
- Explore model parameter space (preliminary to generalized sensitivity analysis)