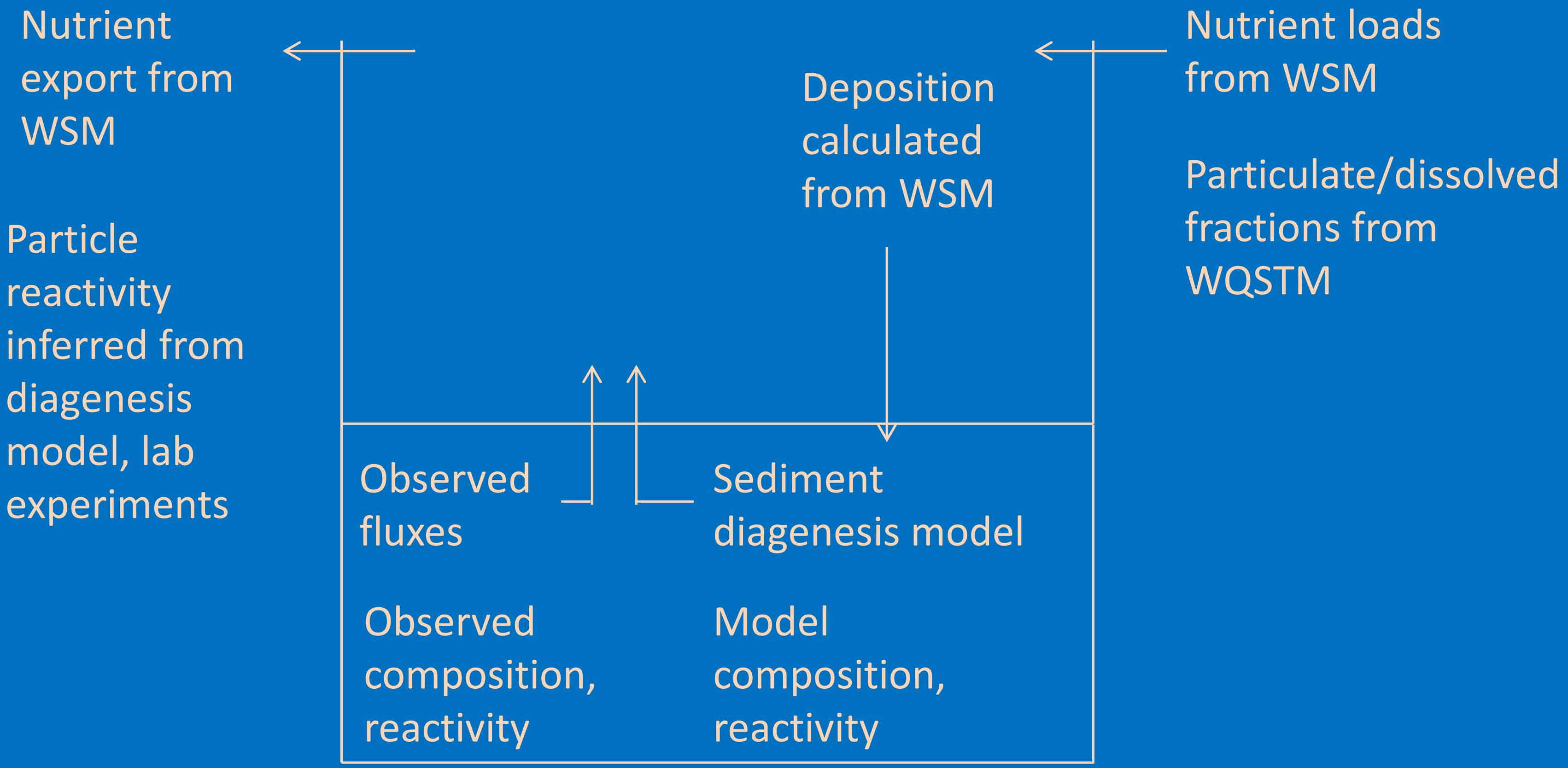
What’s New?

1. Consideration of nutrient loads in addition to watershed, point-source.
    - Conowingo scour
    - Wetlands loss
    - Shoreline erosion
2. Wetlands module.
    - Wetlands functions
    - Projections of future wetlands areas
3. Revisit oysters.
    - Distinguish natural reefs, aquaculture, sanctuaries

Conowingo Reservoir

- Conowingo Reservoir was the subject of a January 2016 STAC workshop.
- For the WQM, we want to know the reactivity of particulate material coming over the dam.
- Distinguish the typical suspended load from the exceptional scoured load.

Conowingo Particulate Reactivity



Nutrient export from WSM

Particle reactivity inferred from diagenesis model, lab experiments

Deposition calculated from WSM

Nutrient loads from WSM

Particulate/dissolved fractions from WQSTM

Observed fluxes

Sediment diagenesis model

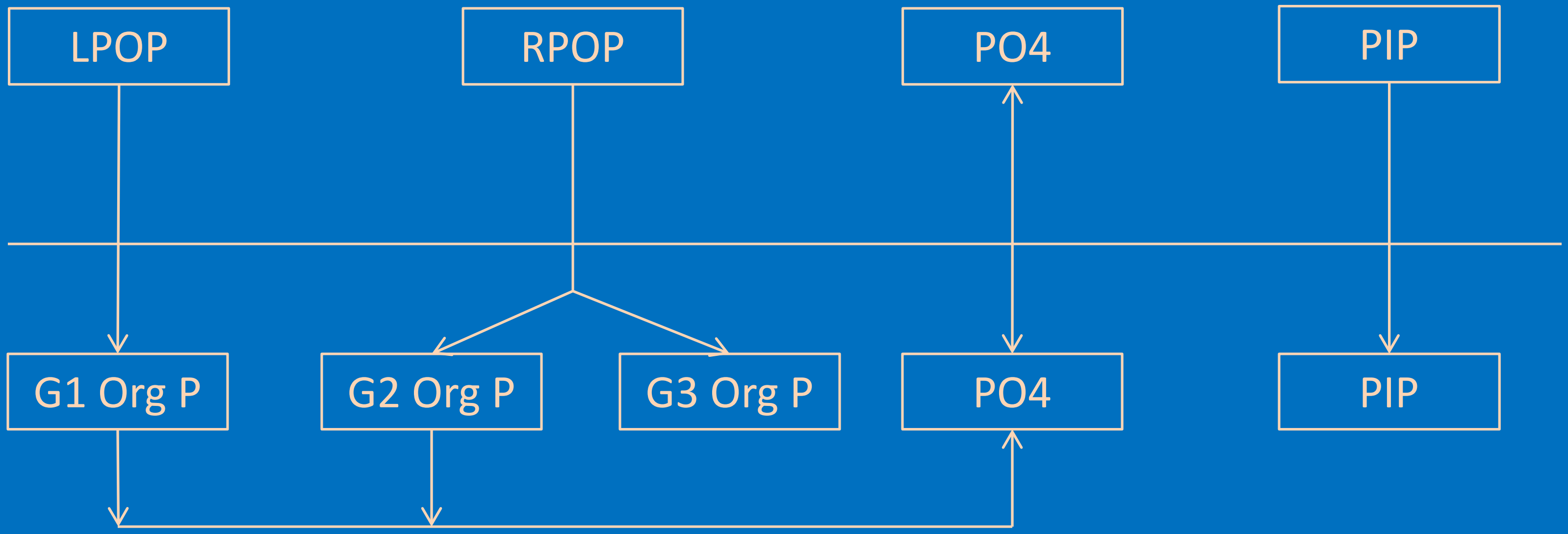
Observed composition, reactivity

Model composition, reactivity

New Model State Variables

- Since the WQM formulation, circa 1987, we have had two classes of reactive particulate organic material in the water column: labile and refractory.
- Since the sediment model formulation, circa 1987, we have had three classes of reactive particulate organic material in the bottom sediments: G1, G2, G3.
- We now have explicit representation of G1, G2, G3 carbon, nitrogen, phosphorus in the water column.

Former Routing of Water Column P to Sediments



LPOP

RPOP

PO4

PIP

G1 Org P

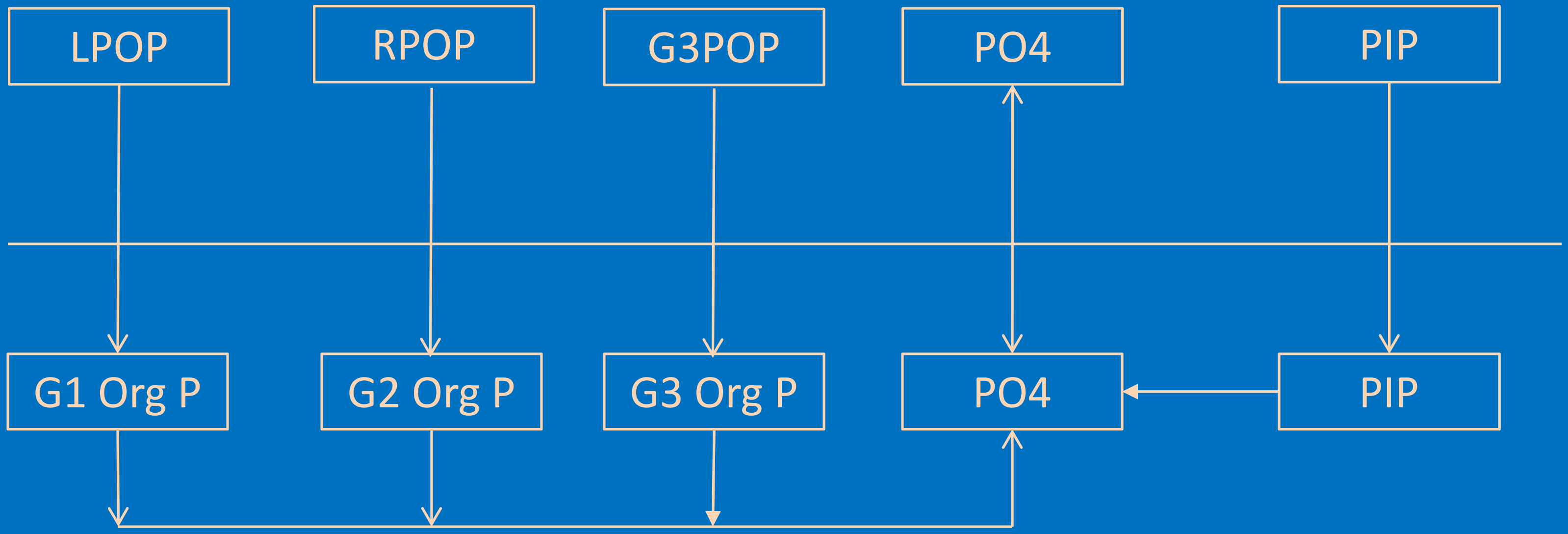
G2 Org P

G3 Org P

PO4

PIP

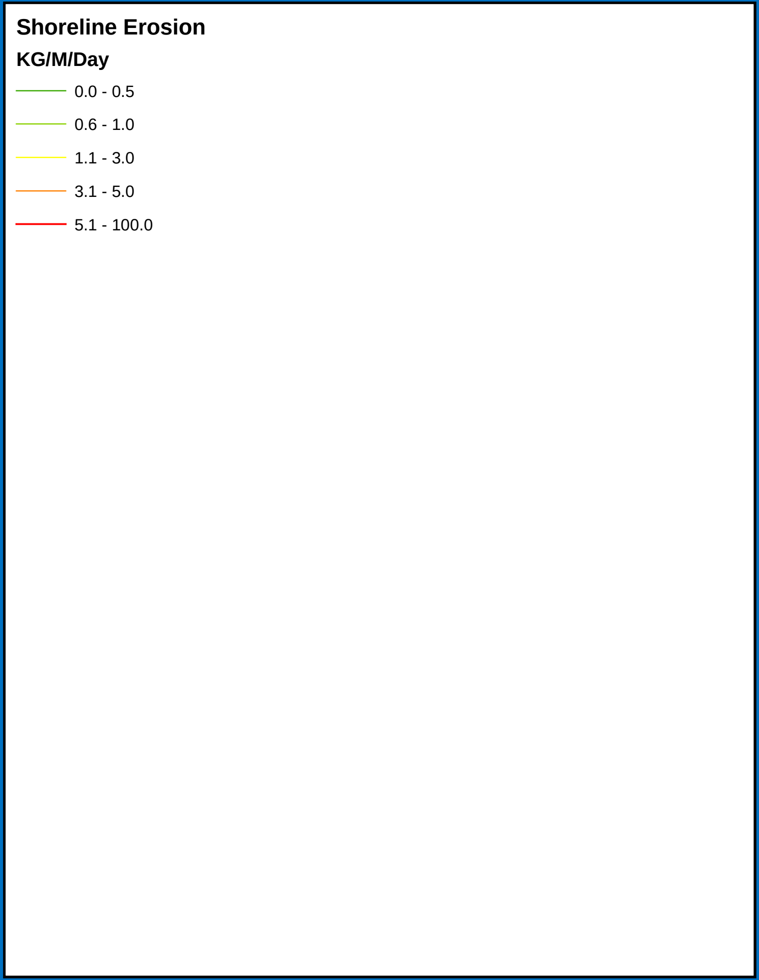
Revised Routing of Water Column P to Sediments



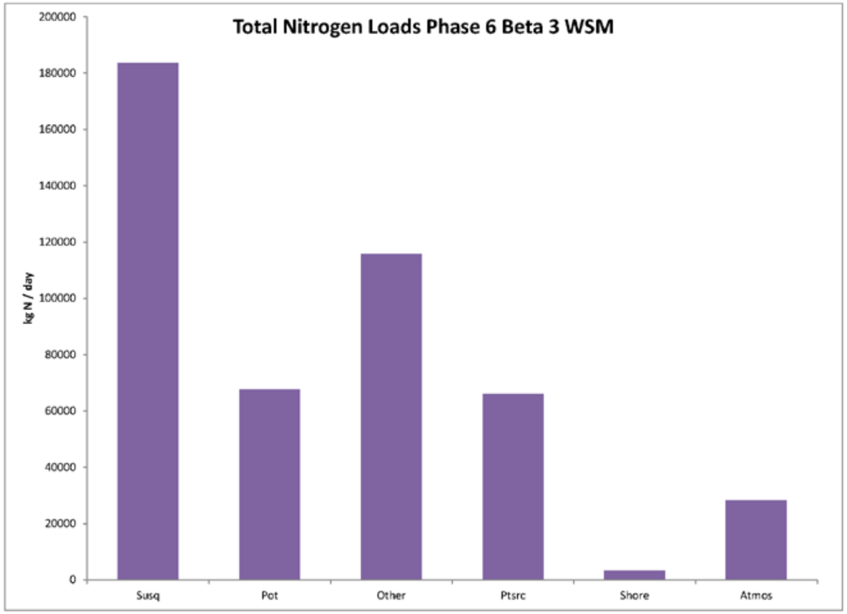
Shoreline Erosion

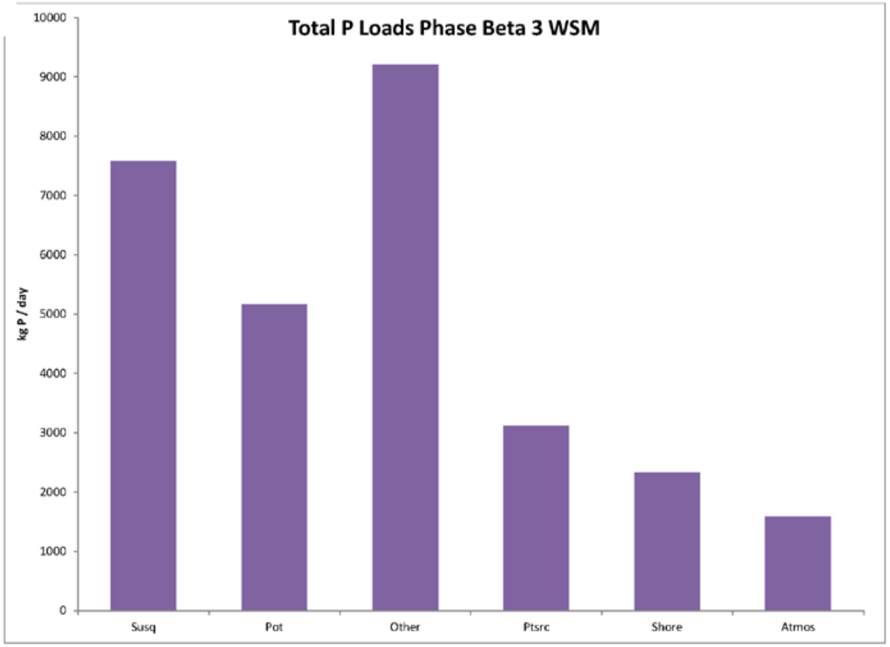
- We have recognized the contribution of shoreline erosion to Chesapeake Bay nutrient budgets (primarily phosphorus) since the earliest model version.
- Shoreline nutrient loads were not included in the 2010 TMDL model version.
- We want to include them now since credits may be given for reductions of shoreline erosion.

Shoreline Erosion



- Bulk rates from expert panel assembled for 2010 TMDL.
- Nutrient composition from Water Quality Goals Implementation Team.
- Reactivity (G1, G2, G3) initially assigned to keep system-wide load of reactive material (G1, G2) equivalent to load prior to addition of bankloads.


Total Nitrogen Loads Phase 6 Beta 3 WSM


Total P Loads Phase Beta 3 WSM

Wetlands Loss

- Suspended solids, organic carbon, and nutrients enter the bay from wetlands erosion.
- We have estimates of wetlands loss from the expert panel (vicinity of Blackwater NWR) and from SLAMM model.
- Experiments are underway to measure reactivity.
- At present, we include only organic carbon loads from Blackwater.

Wetlands Module

- We are constructing a “first order” interactive module to represent wetlands effects on the adjacent water column.
- The module is verified by comparison with observed fluxes collected through the Bay.
- Projections of effects from rising sea level are from the Sea Level Affecting Marshes Model (SLAMM).

Wetlands Module

- We don’t want to develop a complete wetlands biogeochemical model.
- We do want to develop a simplified module that includes:
  - Particle burial (organic and inorganic)
  - Respiration
  - Denitrification
  - Primary production?
  - Others?

Particle Settling

$$V \cdot \frac{dC}{dt} = Transport\ + Kinetics\ - WSw \cdot C \cdot Aw$$

V = volume of WQM cell adjacent to wetlands
C = concentration
WSw = wetland settling velocity
Aw = area of wetland adjacent to WQM cell

This applies to all particles, organic and inorganic. Present settling rates 0.05 m/d for most particles, 0.005 m/d for phytoplankton.

Respiration

$$V \cdot \frac{dC}{dt} = Transport\ + Kinetics\ - f(DO) \cdot f(T) \cdot WOC \cdot Aw$$

V = volume of WQM cell adjacent to wetlands
C = concentration
f(DO) = limiting factor = DO/(Kh+DO)
f(T) = temperature effect
WOC = wetland oxygen consumption
Aw = area of wetland adjacent to WQM cell

At present, WOC = 0.5 g DO/sq m/d at 20C. WOC doubles for a 10C temperature increase. Kh = 1.0 g DO/m3.

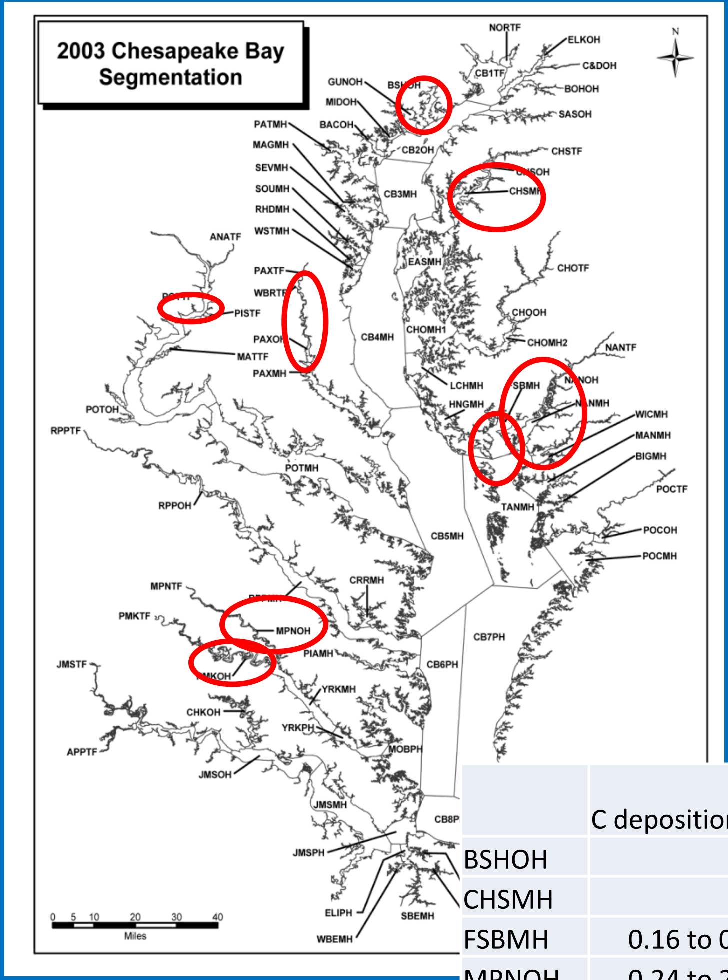
Previous calibration had WOC = 1 g DO/sq m/d and no limiting factor. Wetland areas from TMDL model.

Denitrification

$$V \cdot \frac{dC}{dt} = Transport + Kinetics - MTC \cdot f(T) \cdot C \cdot Aw$$

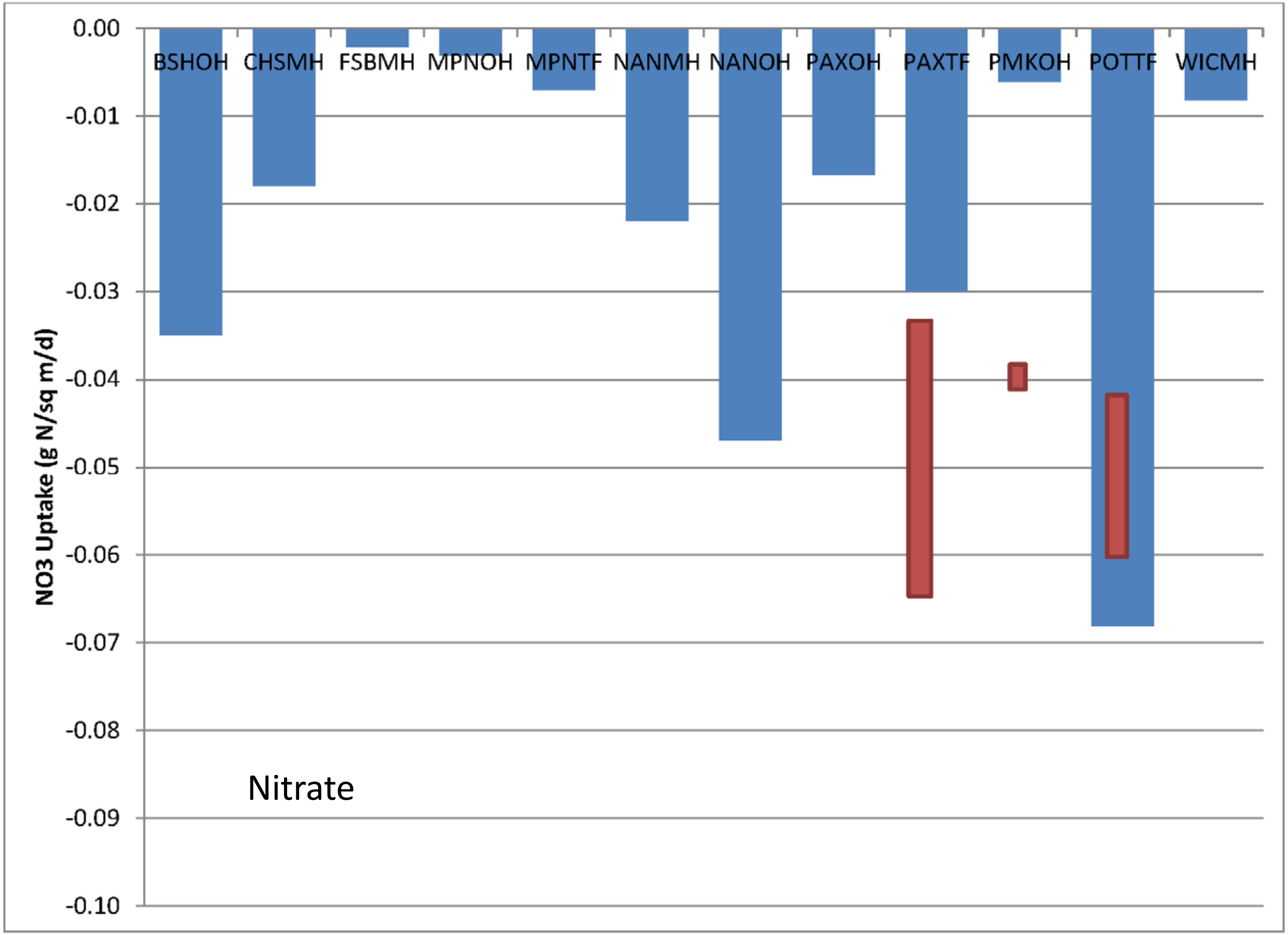
V = volume of WQM cell adjacent to wetlands
C = nitrate concentration
MTC = mass-transfer coefficient
f(T) = temperature effect
Aw = area of wetland adjacent to WQM cell

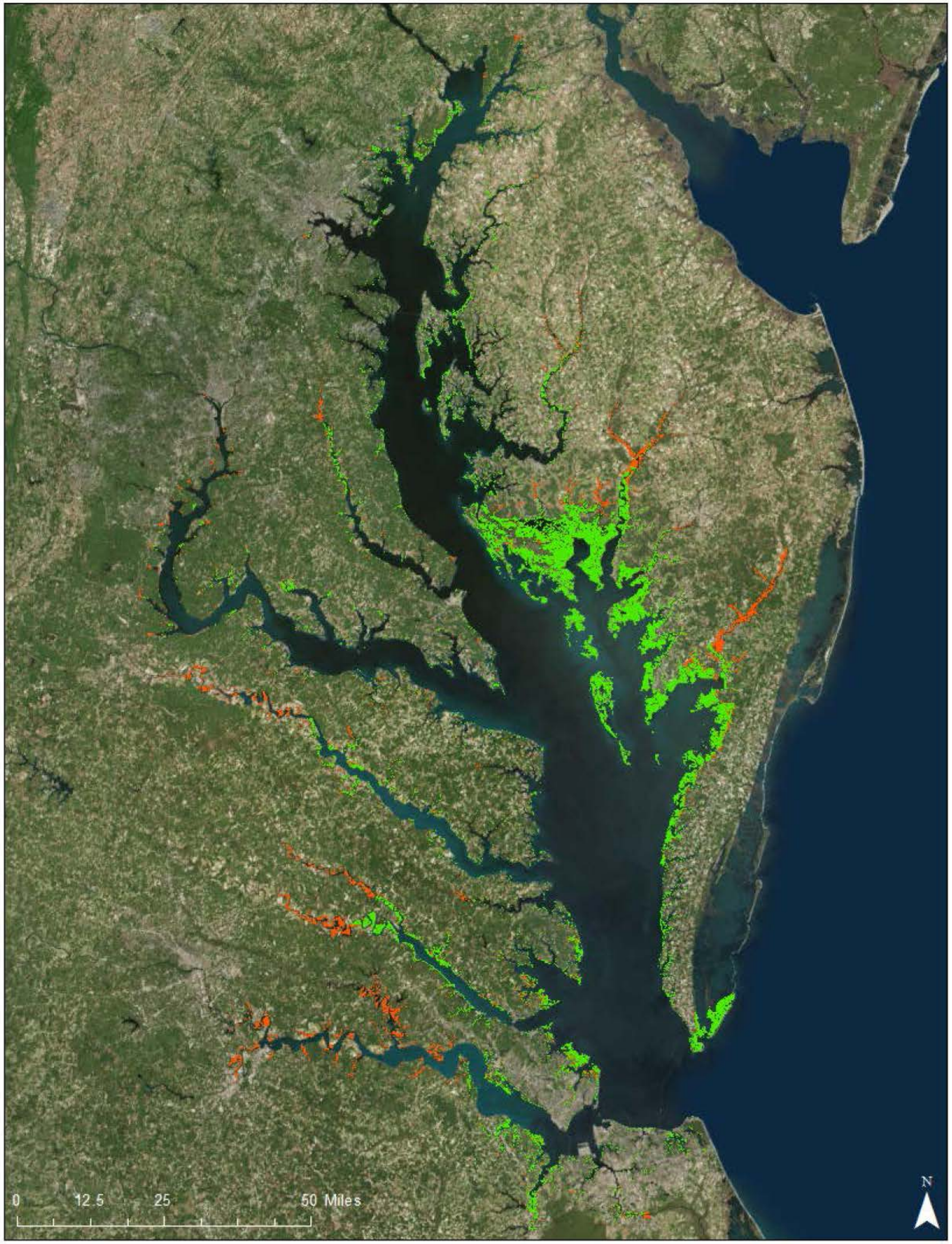
At present, the mass-transfer coefficient is 0.05 m/d.
Denitrification doubles for a 10C temperature increase.



Hot Spots for Calibration

	C deposition	N deposition	P deposition	denitrification	solids deposition	respiration
BSHOH		0.008 to 0.032	0.001 to 0.006			
CHSMH		0.02 to 0.064	0.01 to 0.019		3.6	
FSBMH	0.16 to 0.33				0.3	
MPNOH	0.24 to 2.77	0.019 to 0.238	0.004 to 0.085		1.43 to 42.0	
MPNTF						
NANMH	0.033 to 0.126				1.61 to 8.12	
NANOH	0.033 to 0.126				1.61 to 8.12	
PAXOH		0.008	0.002		5.75	
PAXTF		0.033 to 0.064	0.01	0.108 to 0.197	5.75	
PMKOH	0.61	0.05		0.04		1.12 to 2.77
POTTF	1.44			0.043 to 0.06	5.88	
WICMH	0.033 to 0.126	0.037	2.74x10^-5 to 0.004		1.61 to 8.12	
CHOMH		0.053 to 0.074	4.9x10^-4 to 0.005			
WQGIT			0.0016	0.026		


0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.10
NO3 Uptake (g N/sq m/d)
BSHOH
CHSMH
FSBMH
MPNOH
MPNTF
NANMH
NANOH
PAXOH
PAXTF
PMKOH
POTTF
WICMH
Nitrate

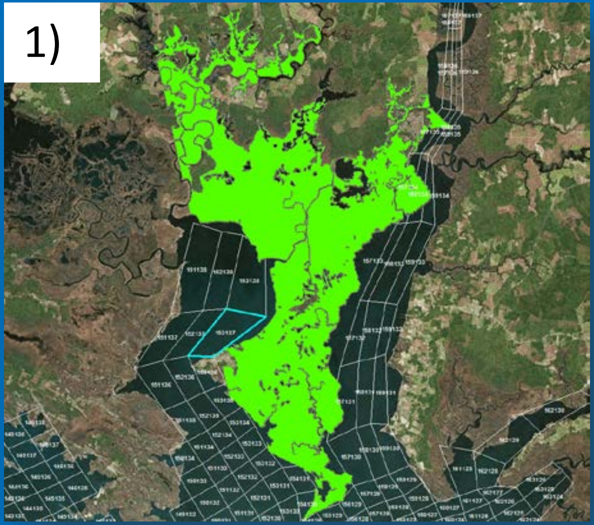


Chesapeake Bay Tidal Wetlands

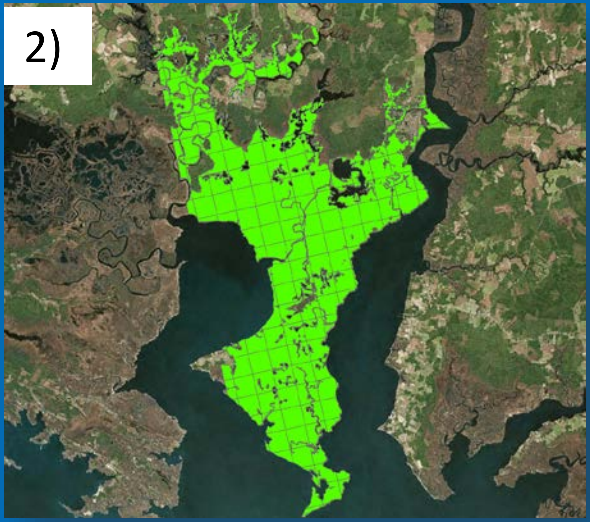
- Extent from National Wetlands Inventory.
- Determined largely from vegetation perceived via aerial photography.
- 125,000 hectares of estuarine (green) and tidal fresh (red) wetlands.
- Shape files provided by Quentin Stubbs and Peter Claggett, EPA Chesapeake Bay Program.

Assign Wetlands Areas to Model Cells

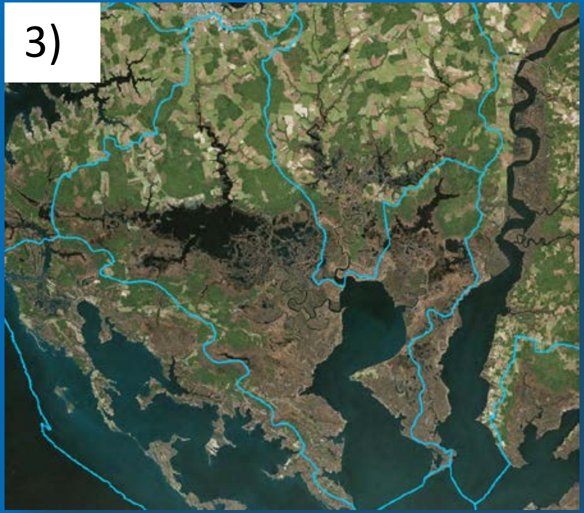
1)



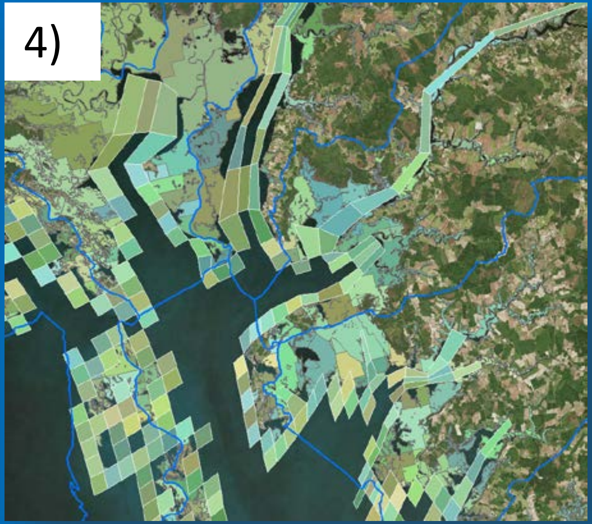
2)



3)



4)



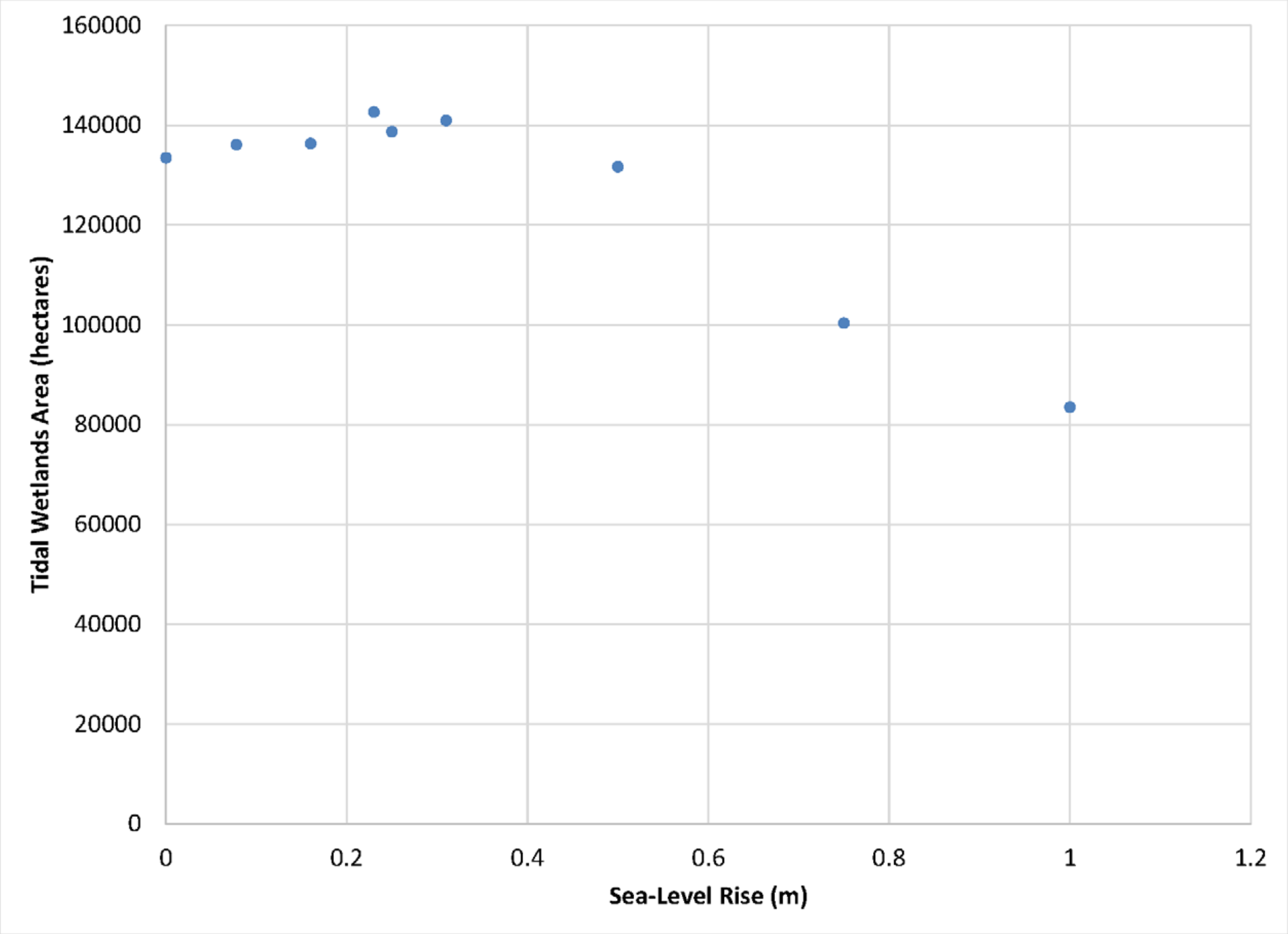
1. Wetlands polygon.
2. Divide polygon into “fishnet.”
3. Overlay 10-digit HUC boundaries.
4. Assign wetlands areas to model cells based on proximity and local watershed boundaries.
5. Thank you, Scott Bourne, ERDC.

SLAMM

- Originated with 2008 report by Patty Glick to National Wildlife Federation.
- Refined in 2014 masters thesis by Jennifer Bryan.
- GIS files provided courtesy of Lora Harris 2016.
- Four Categories:
  - Brackish Marsh
  - Salt Marsh
  - Transitional Marsh
  - Tidal Freshwater Marsh
- The sum of four categories is 133,436 hectares (sufficiently close to NWI 124,834).

SLAMM Scenarios

- IPCC B1: 0.31 m sea-level rise, broken into four increments.
- 1 Meter: 1 m sea-level rise, broken into four increments.


Tidal Wetlands Area (hectares)
160000
140000
120000
100000
80000
60000
40000
20000
0
0
0.2
0.4
0.6
0.8
1
1.2
Sea-Level Rise (m)

Oysters - What Do We Have?

Estuaries and Coasts Vol. 30, No. 2, p. 331–343 April 2007

Can Oyster Restoration Reverse Cultural Eutrophication in Chesapeake Bay?

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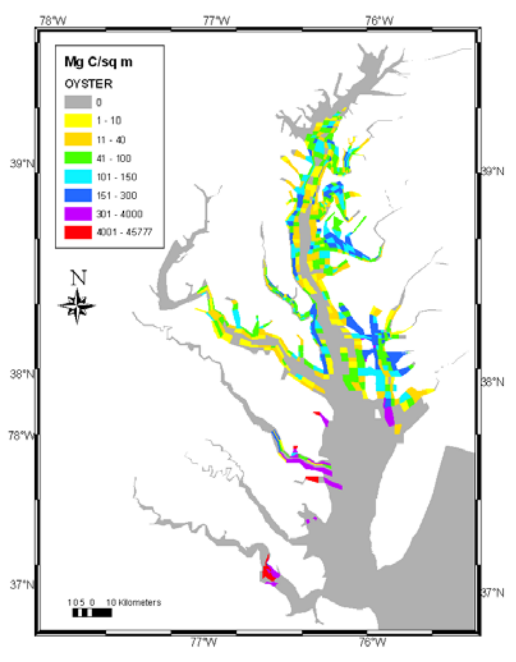
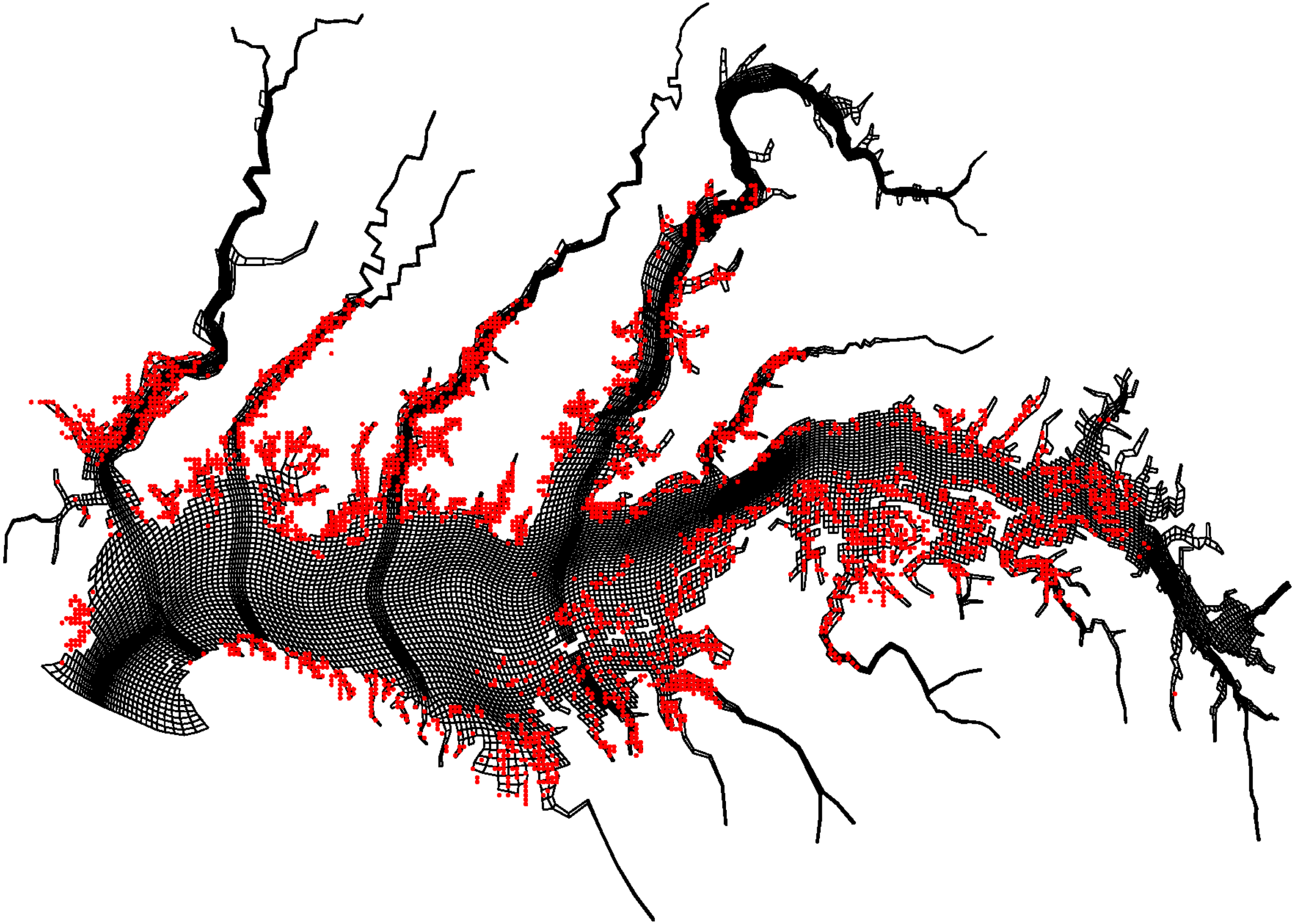
Mail Stop EP-W, U.S. Army Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180

ABSTRACT: We investigated the hypothesis that effects of cultural eutrophication can be reversed through natural resource restoration via addition of an oyster module to a predictive eutrophication model. We explored the potential effects of native oyster restoration on dissolved oxygen (DO), chlorophyll, light attenuation, and submerged aquatic vegetation (SAV) in eutrophic Chesapeake Bay. A tenfold increase in existing oyster biomass is projected to reduce system-wide summer surface chlorophyll by approximately 1 mg m^{-3}, increase summer-average deep-water DO by 0.25 g m^{-3}, add 2100 kg C (20%) to summer SAV biomass, and remove 30,000 kg d^{-1} nitrogen through enhanced denitrification. The influence of oyster restoration on deep extensive pelagic waters is limited. Oyster restoration is recommended as a supplement to nutrient load reduction, not as a substitute.



- The 2005 oyster model is operational in the current model.
- Oysters in the current model are distributed according to a much-improved map of oyster reefs (as per VERSAR, NOAA 2008).
- The oyster model has not been calibrated or compared to data for biomass and distribution.

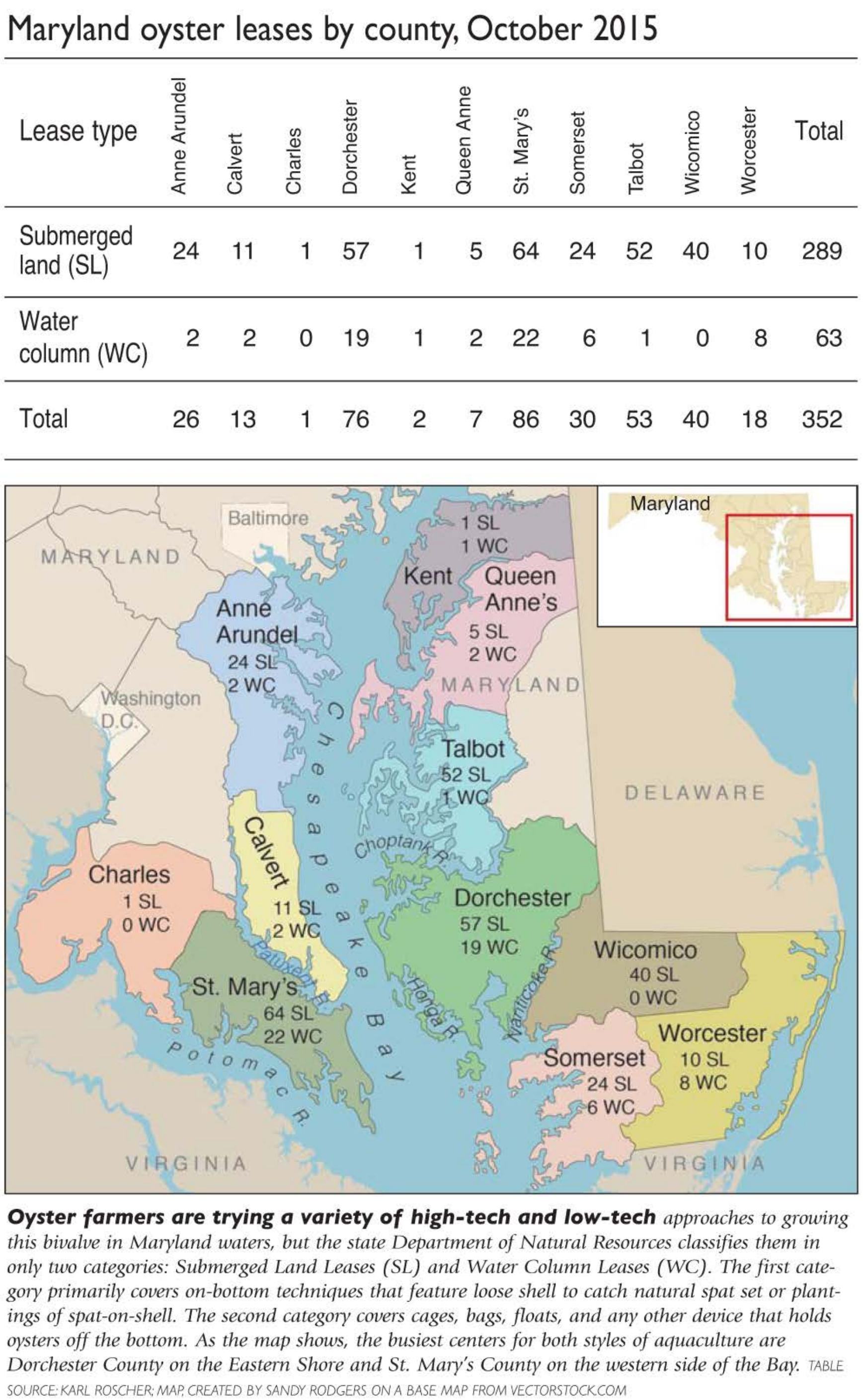
Oyster bars mapped to 50,000-cell grid.



What’s Missing?

- Present oyster biomass and distribution.
- Information on aquaculture (location, methods, harvest).
- Location and biomass in sanctuaries.

Aquaculture

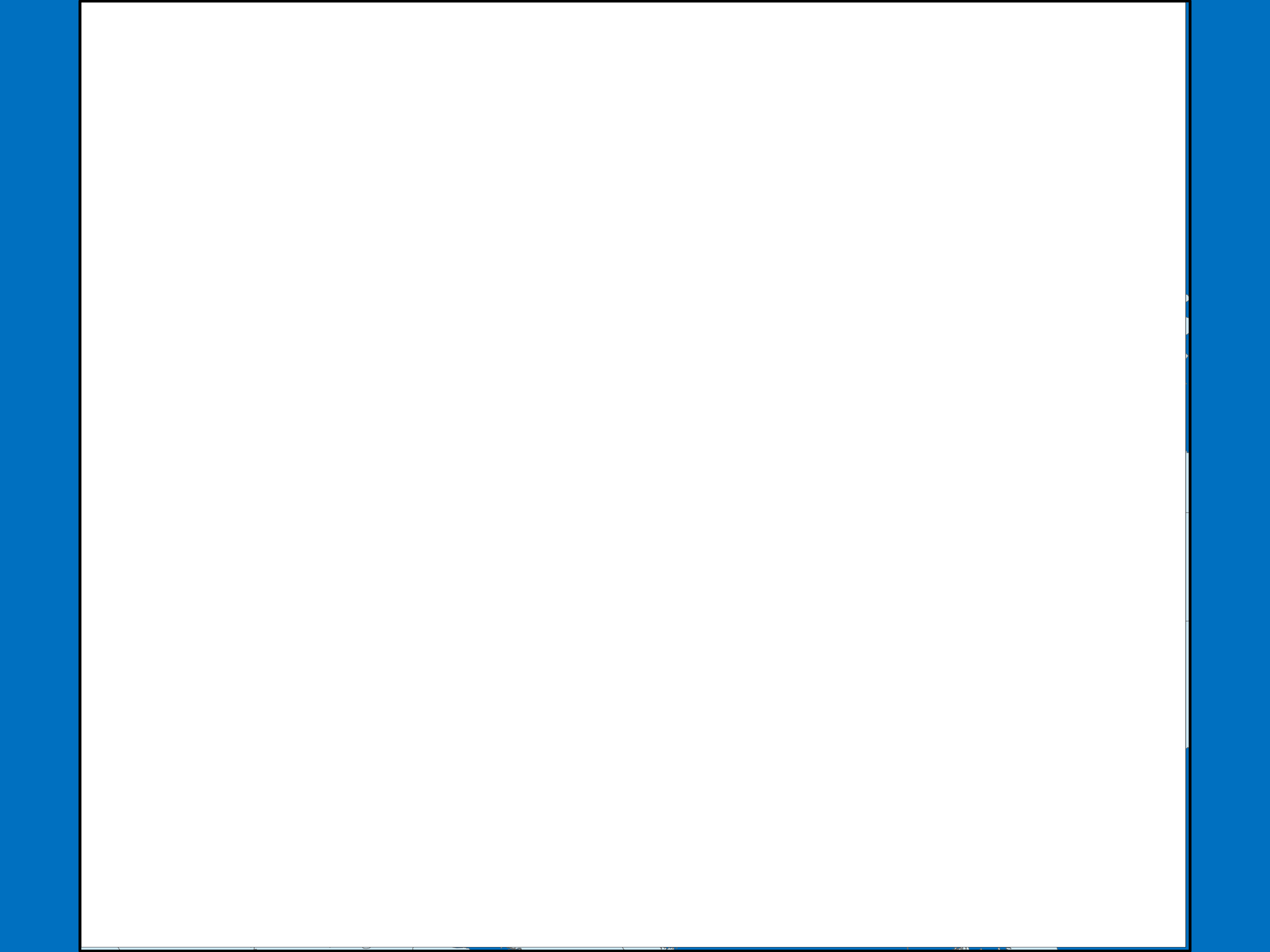


Maryland oyster leases by county, October 2015

Lease type	Anne Arundel	Calvert	Charles	Dorchester	Kent	Queen Anne	St. Mary's	Somerset	Talbot	Wicomico	Worcester	Total
Submerged land (SL)	24	11	1	57	1	5	64	24	52	40	10	289
Water column (WC)	2	2	0	19	1	2	22	6	1	0	8	63
Total	26	13	1	76	2	7	86	30	53	40	18	352

Oyster farmers are trying a variety of high-tech and low-tech *approaches to growing this bivalve in Maryland waters, but the state Department of Natural Resources classifies them in only two categories: Submerged Land Leases (SL) and Water Column Leases (WC). The first category primarily covers on-bottom techniques that feature loose shell to catch natural spat set or plantings of spat-on-shell. The second category covers cages, bags, floats, and any other device that holds oysters off the bottom. As the map shows, the busiest centers for both styles of aquaculture are Dorchester County on the Eastern Shore and St. Mary's County on the western side of the Bay.* TABLE SOURCE: KARL ROSCHER; MAP, CREATED BY SANDY RODGERS ON A BASE MAP FROM VECTORSTOCK.COM

- We have Maryland harvest by county.
- We do not have location of aquaculture facilities.
- As a start, we are assigning aquaculture activity to Maryland waters with salinity > 7 and depth < 12 feet.
- We assume the population is essentially the harvest.
- We will adjust the model until biomass in eligible cells equals harvest.



Sanctuaries

- We have Maryland oyster sanctuaries mapped to the grid.
- We have data on biomass/unit area in sanctuaries.
- We have overlap with the natural reef data from 2008. We are going to have to clear this up.
- We will run the model and calibrate to observed biomass/unit area.

Oysters

- We have located several web sites with estimates of oyster population/biomass. We can use this information to “rough in” the system-wide model for parameter values by comparison with estimate population biomass.
- We have just started. We have a lot of work to do.
- Our first effort is to assess the impact of Maryland aquaculture. If the impact is negligible, we may decide to use resources (manpower) elsewhere.