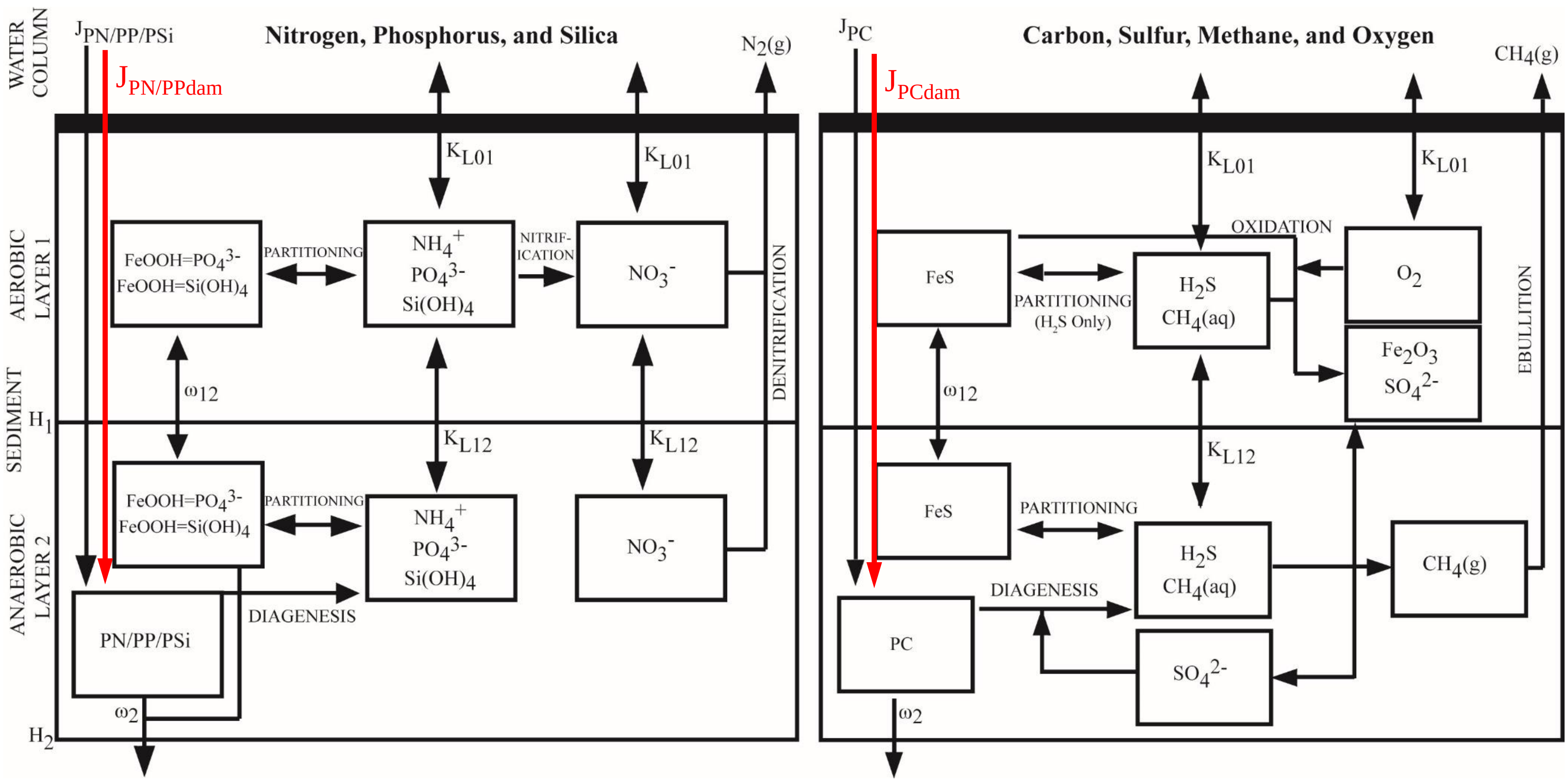
UMCES Conowingo Studies Update November 4, 2015

Jeremy Testa, Michael Kemp, Jeff Cornwell, Hamlet Perez, Ming Li, Xiaohui Xie, Larry Sanford, Stephanie Barletta

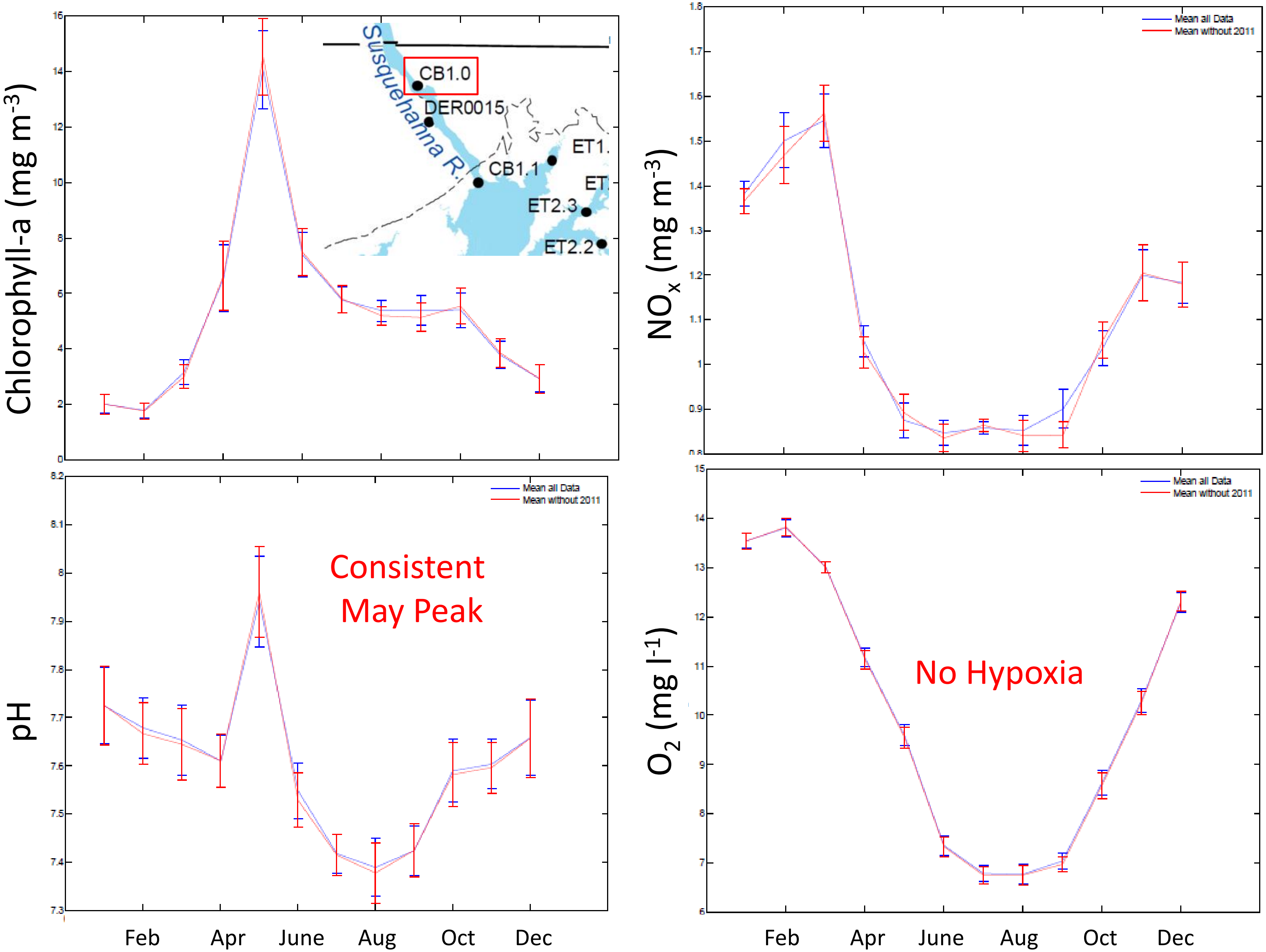
Sediment Flux Modeling
Jeremy Testa and Michael Kemp

SFM Schematic

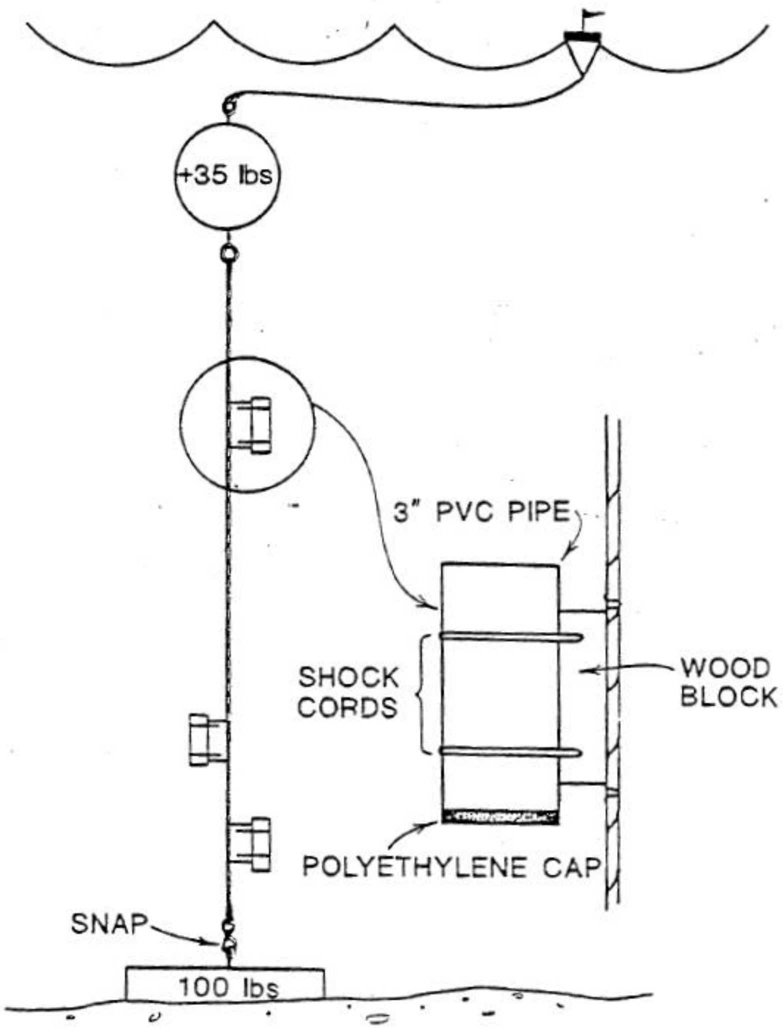


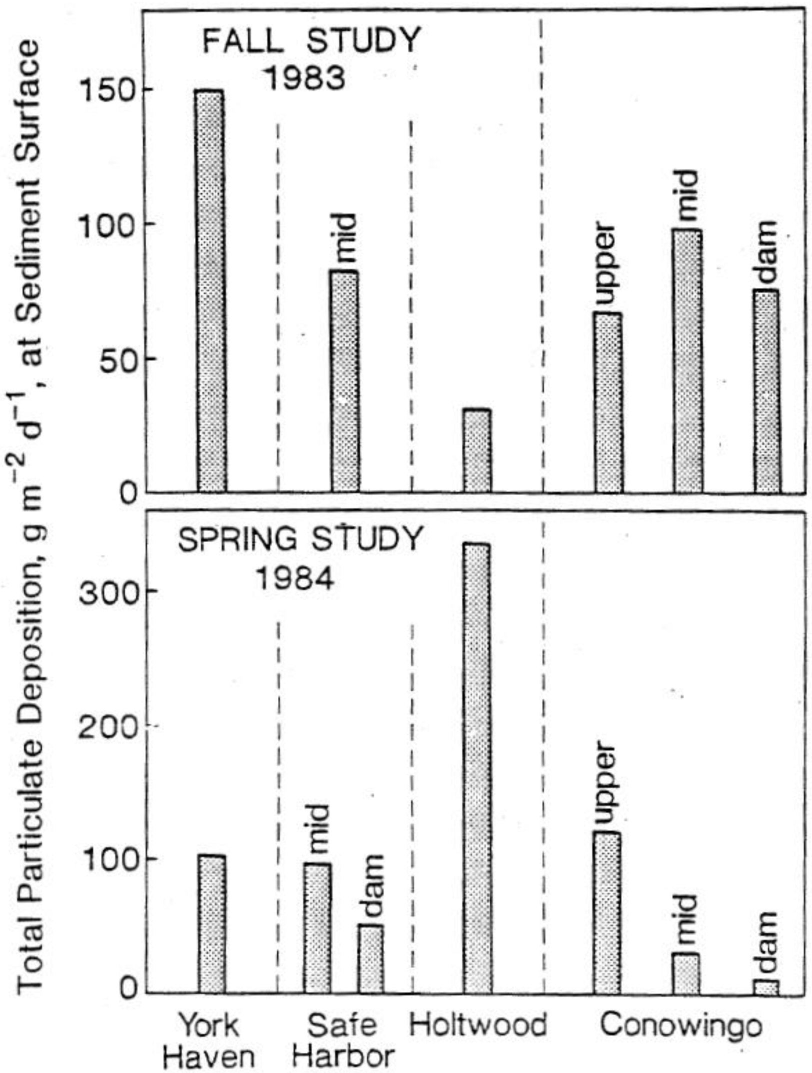
*Deposited organic matter partitioned into 3 reactivity classes, representative of algal material
*New organic matter pool partitioned differently with different nutrient ratios and reactivity

Climatology of Overlying Water Conditions



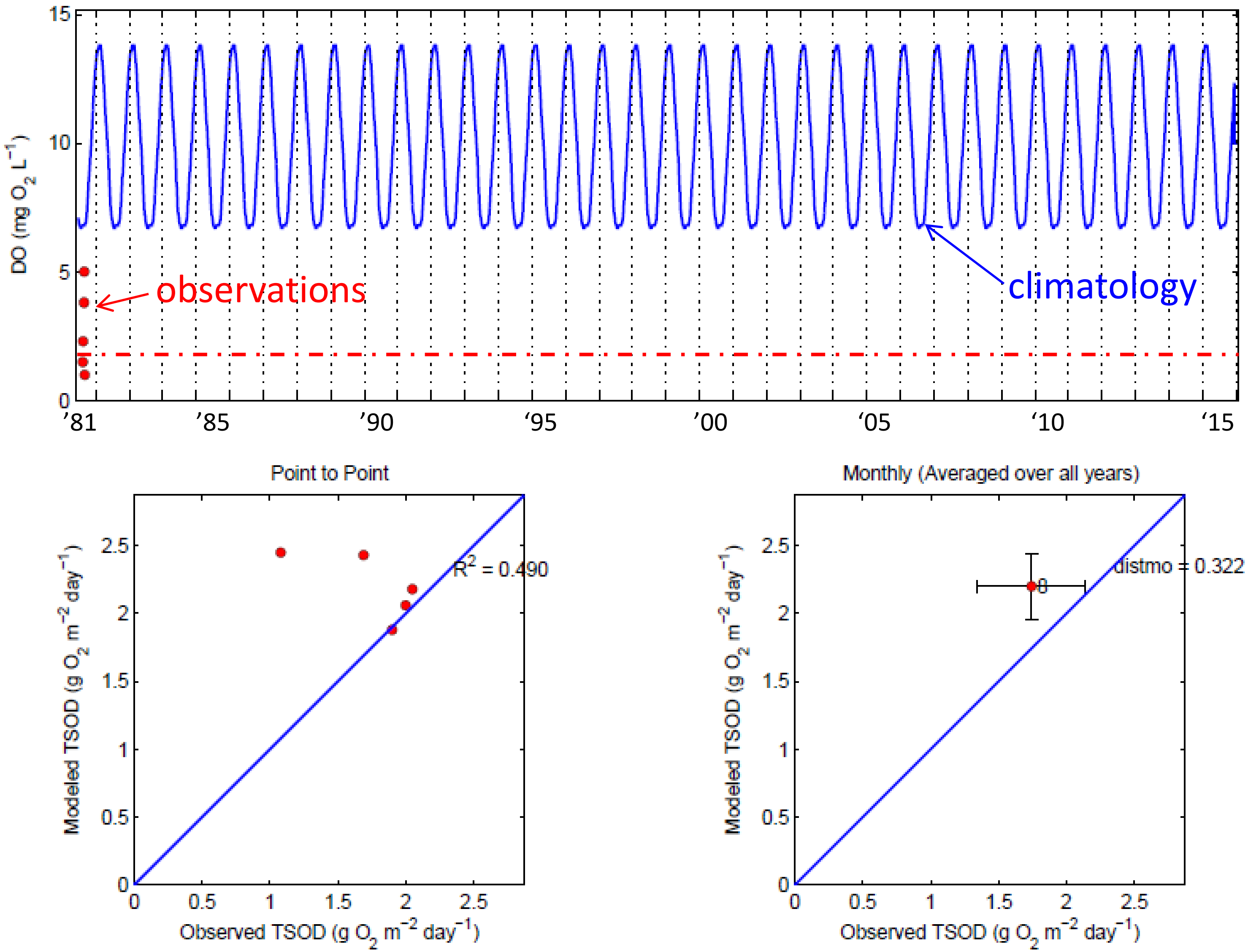
Past Sediment-Trap Observations in Reservoirs





Observations of water-column nutrients, O_2, and sediment oxygen demand
C:N, CHL-a measured in deposited material

Preliminary SFM Simulations in Conowingo Pond



Plans for Next 6 Months – SFM Modeling

(1) What activities are planned for next 6 months

- Diagnostic SFM Simulations in Pond to interpret PI Cornwell sediment-water fluxes and understand key controls
- Interpolation of diagnostic SFM Simulations in Pond to estimate sediment-water contribution to Pond nutrient balance
- Simulations of scour material addition to Bay sediments under low salinity/oxygenated conditions and high salinity/anoxic conditions

(2) *What will these activities contribute to Bay modeling (in Conowingo and Bay)*

- SFM diagnostic can contribution to Pond mass balance
- PI Testa is working with Carl Cerco to test new SFM parameterizations in WQSTM

(3) *What products/information can realistically be generated by May 2016*

- Sensitivity tests of new SFM parameters in WQSTM
- Pond sediment-water flux contribution

Conowingo Project

Biogeochemistry Lab.

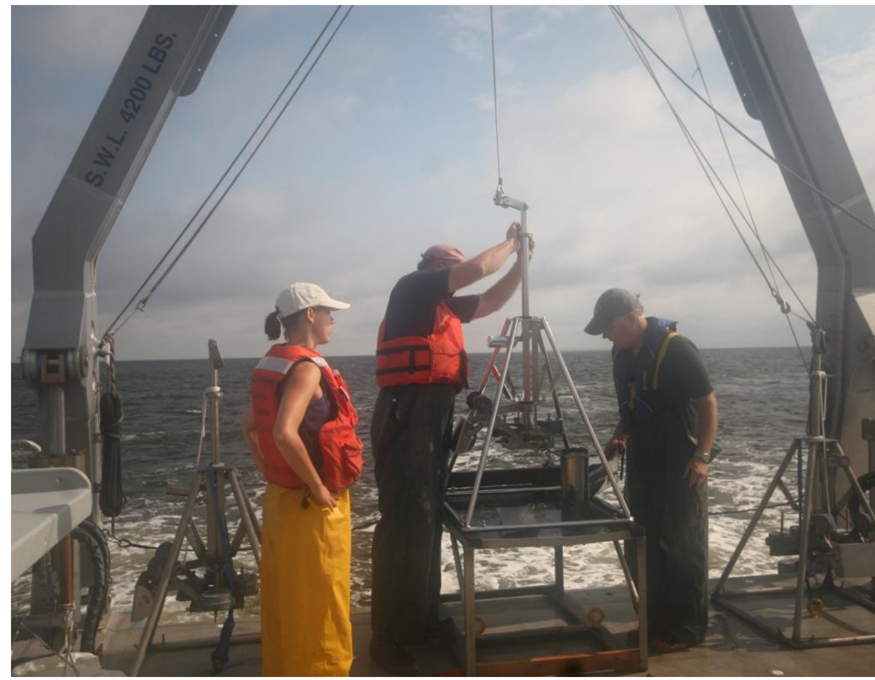
Field/Lab. Measurements

Hamlet Pérez and
Jeff Cornwell

Cornwell -Biogeochemistry Lab.-UMCES

Biogeochemical Team

- **Jeffrey Cornwell**, Research Professor
- **Michael Owens**, Senior Faculty Research Associate
- **Alison Sanford**, Senior Faculty Research Assistant
- **Zoe Vulgaropoulos**, Graduate Research Assistant
- **Hamlet Pérez**, Assistant Research Scientist



Conowingo Project
Biogeochemistry outline

Upstream Inputs
- Inputs to Conowingo
- Pool – P characterization
- N & P release during decomposition exp.

Reservoir processes/Biogeochemistry
- Net exchange of N & P
- Pore water
- Spatial distribution of OM reactivity
- *Grain size, porosity, nonreactive carbon (coal)
- *Short & long-lived nuclides

*Palinkas Lab.-UMCES

Impact on Bay Processes
- P release as a function of Sal/redox
- N decomposition rates

Shallow Core Sampling

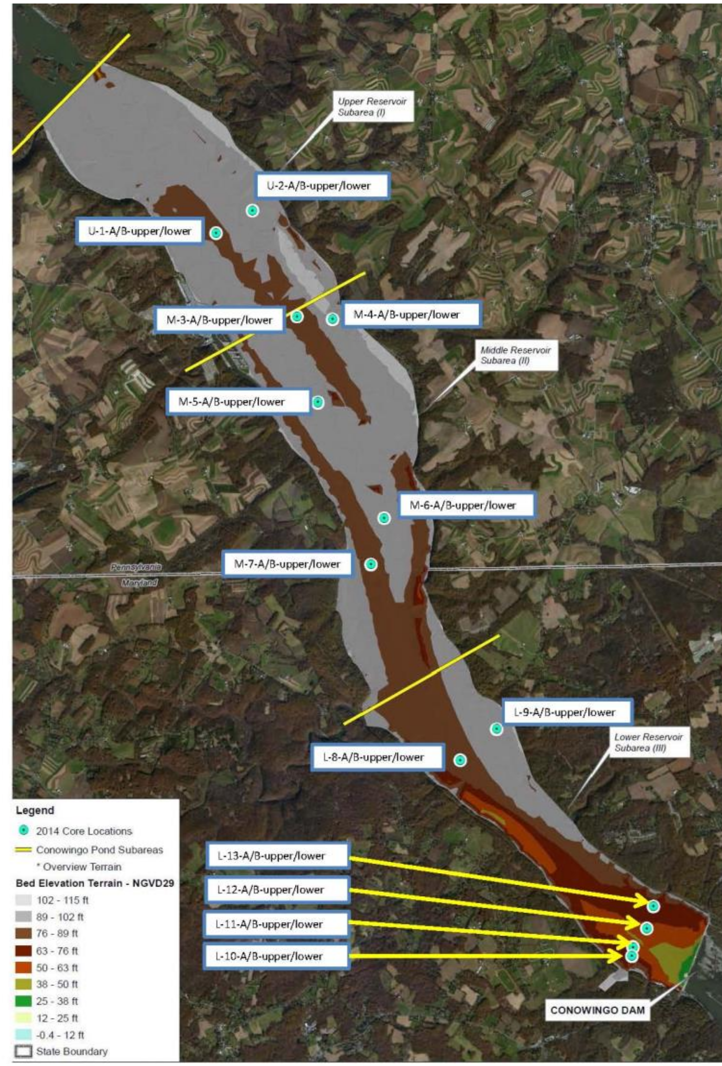
May 2015

- Cores from 13 sites, replicate incubations at 3 sites
- Sediment box cored, pole cored, return to HPL for incubation
- Diagenesis on one 0-2 cm sediment section

July & September 2015

- 8 Sites of the 13 sampled, all sites with duplicate cores
- Fluxes, diagenesis
- Extra sediment collected for experimental addition to Chesapeake cores

Sampling went exceptionally well, as did incubations



Conowingo Project
Biogeochemistry outline

- **Fluxes in Upper Chesapeake Bay**

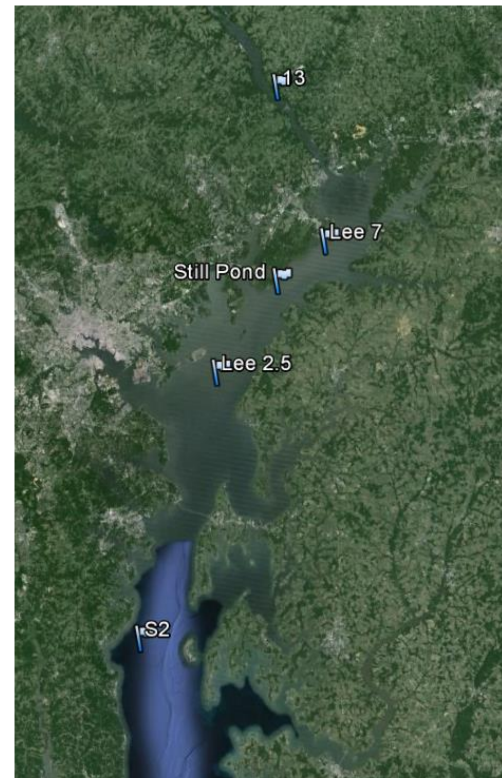
- Addition of Conowingo surface Sediment on the Sediment Cores from Upper Chesapeake Bay
- Likely will repeat lower bay site summer 2016

Still Pond
Lee 7
S2
Lee 2.5

August 11, 2015

Still Pond
Worm Activity

Still Pond and Lee 2.5 mixed by worms and clams

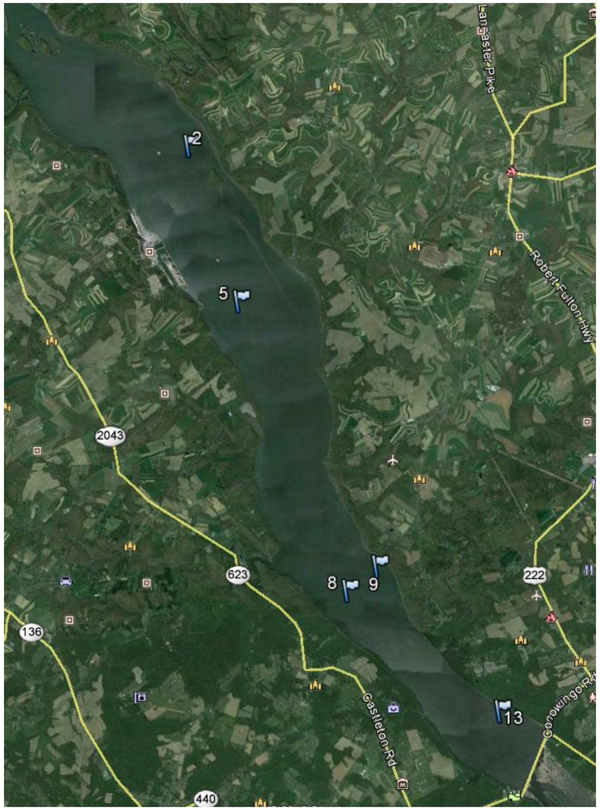


Conowingo Project
Biogeochemistry outline

Long Core Characterization

- Pore water
- Solids
- Diagenesis

5 sites	August 7-25, 2015



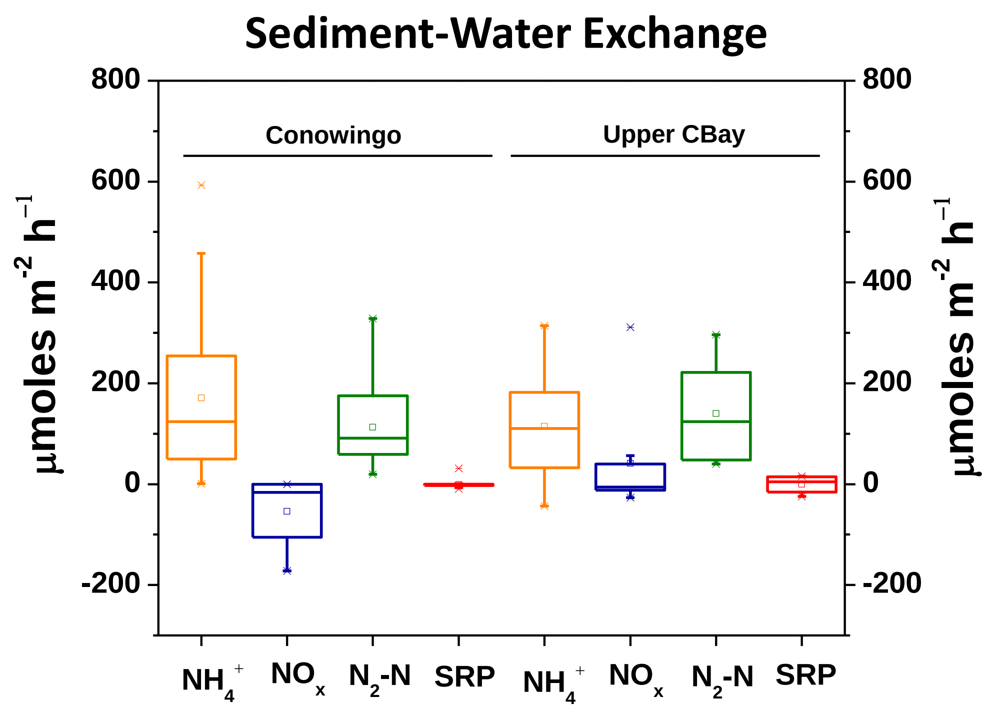
Preliminary Data

Most Net N flux: Ammonium

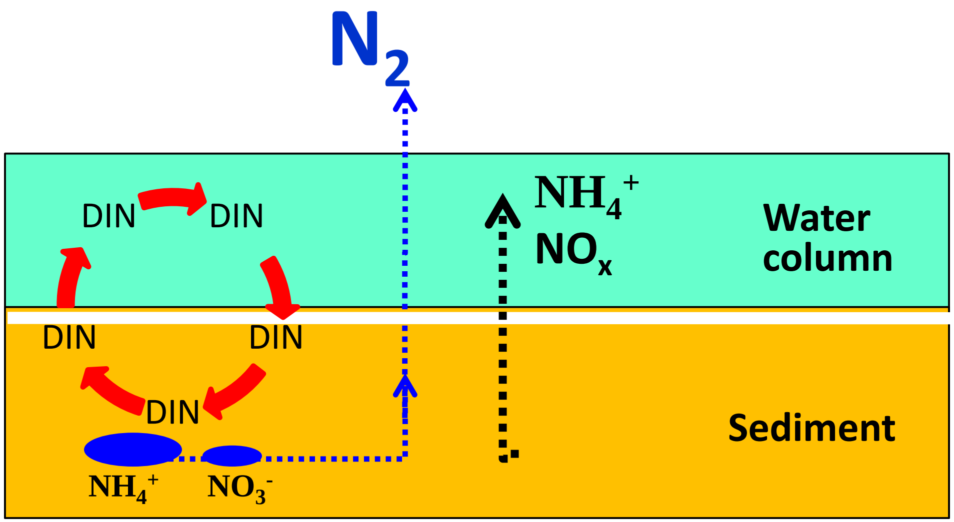
Conowingo Denitrification: from water column nitrate

Upper Chesapeake Bay Denitrification: from sed. nitrate

SRP net flux: negligible.



Preliminary Data



Denitrification efficiency

Recycling

Vs

Denitrification

Denitrification Efficiency (%)	
Cono	CBay
49	47

2015 Thus Far:

Successes

- Sediment-water exchange data appears coherent, biogeochemically consistent
- Diagenesis experiment are becoming routine, despite many hundreds of vials
- We have carried out all aspects of the project – we are ready for the “big one”.

Works in Progress

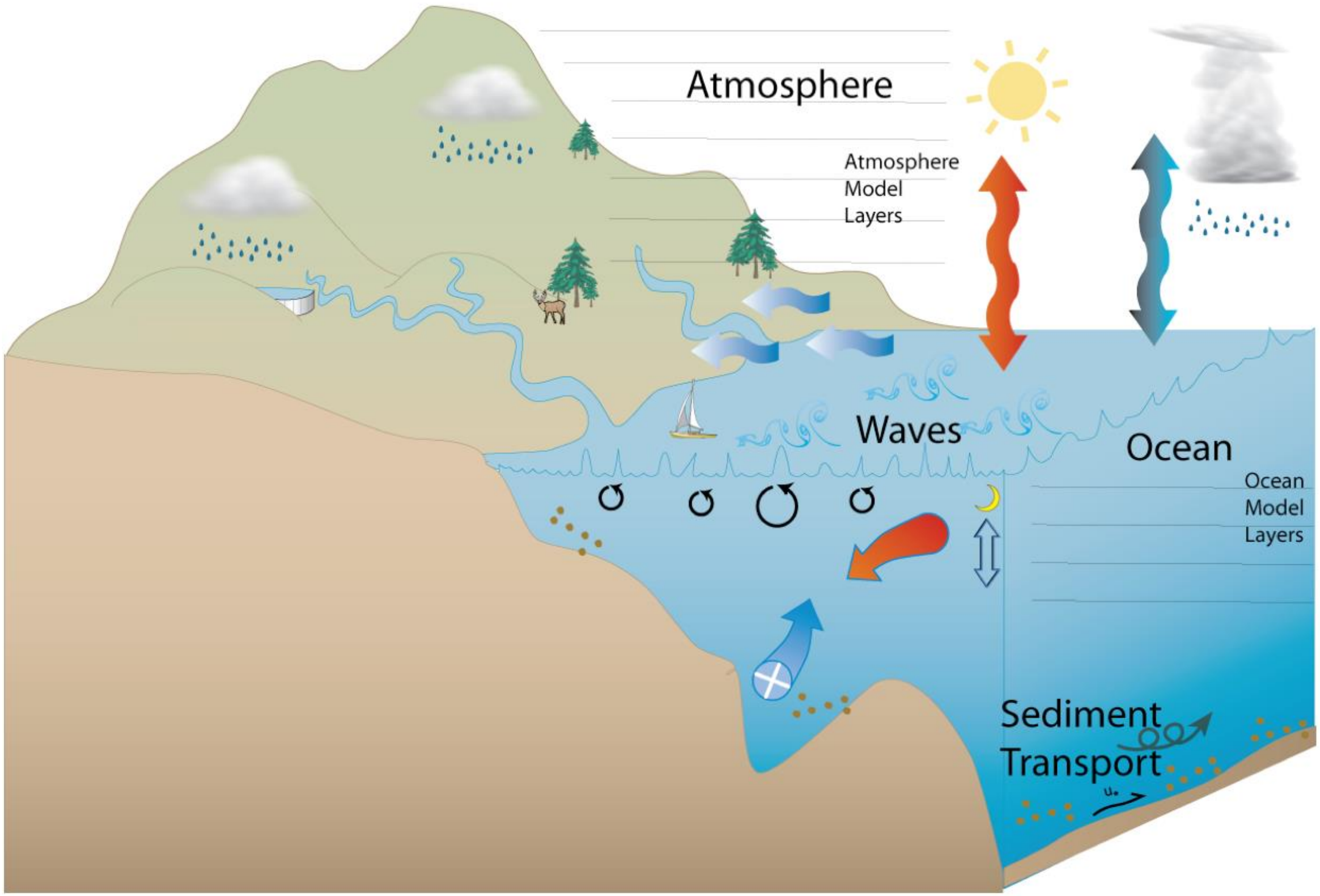
- Late start on long core diagenesis, won’t have all data until mid-2016

Conclusions

- Reservoir sediments are biogeochemically very reactive, and appear to efficiently deliver remineralized N as NH_4^+ to the water column. This suggests poor efficiency of nitrification.
- Phosphorus fluxes appear low

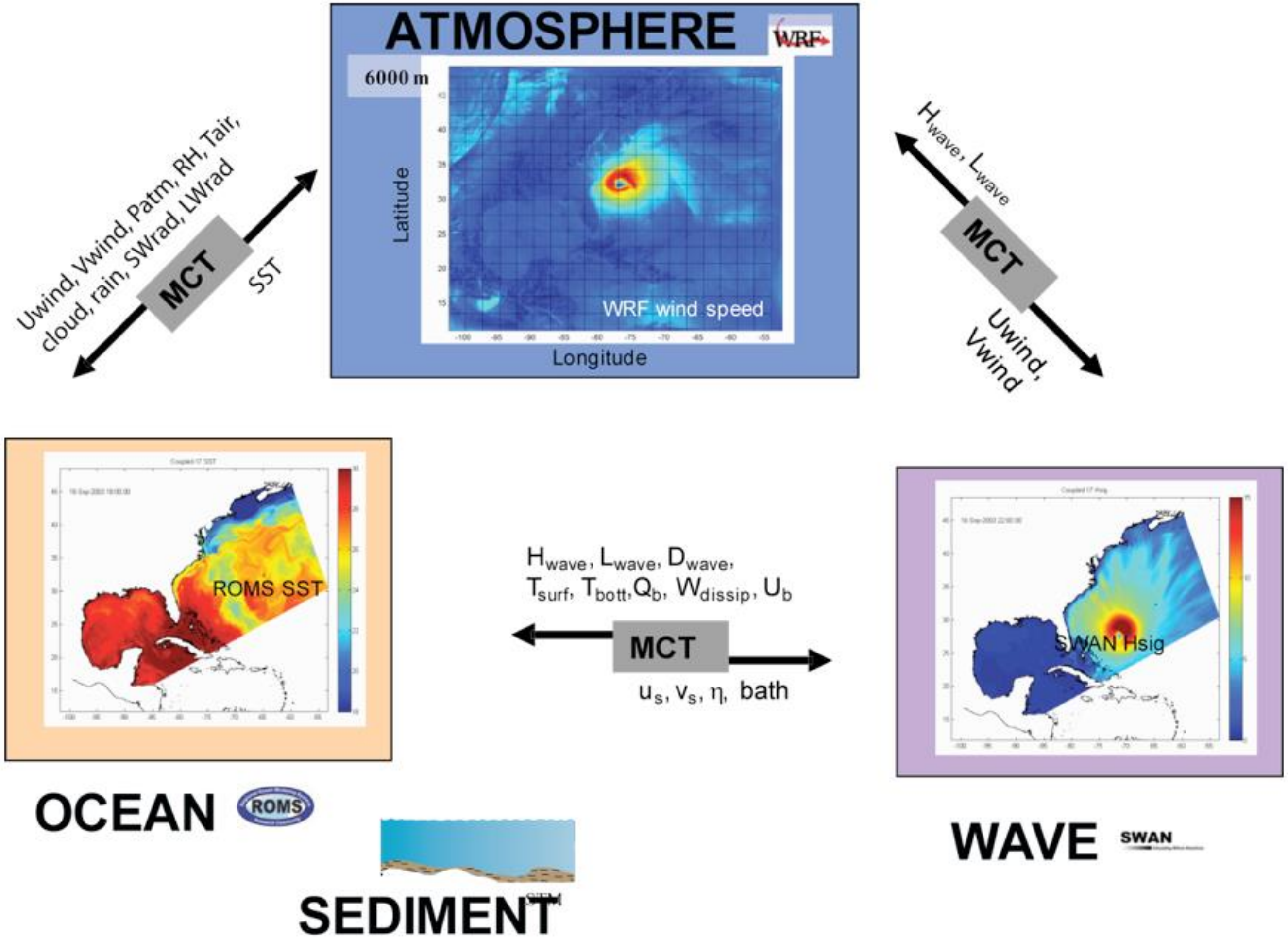
Sedient Transport Modeling
Ming Li and Xiaohui Xie

COAWST Modeling System



Development of a coupled modeling system (COAWST) of Chesapeake Bay to investigate how currents and waves affect sediment transport and deposition during storms and flood events.

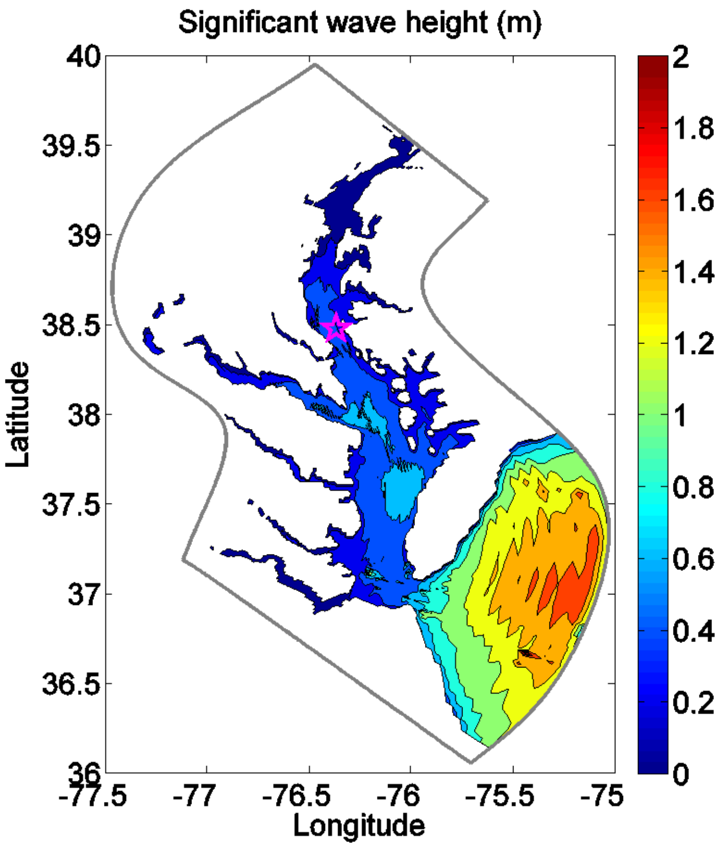
Modeling Components in COAWST



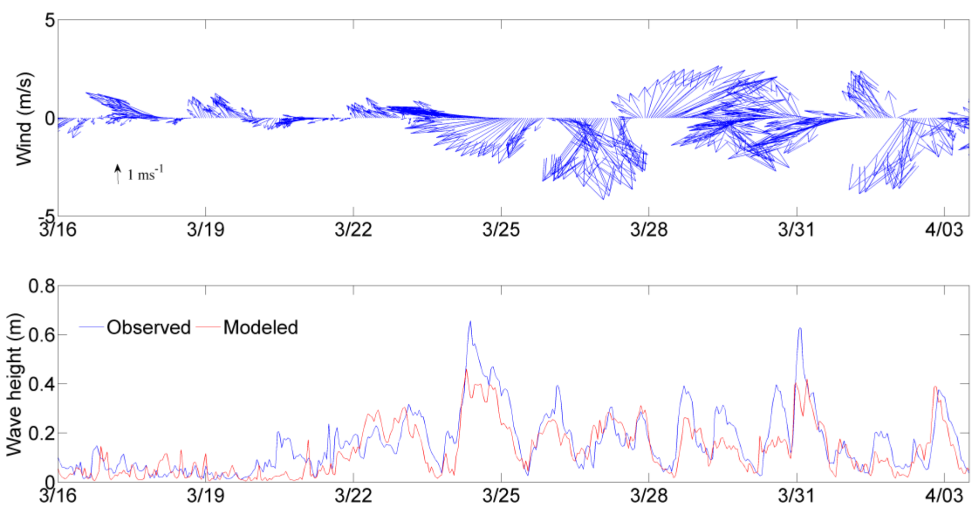
The COAWST modeling system consists of atmospheric (WRF), hydrodynamic (ROMS), surface waves (SWAN), and sediment-transport (CSTM) models. In our implementation, atmospheric forcing is obtained from wind observations and NARR, although WRF forecast is available during storms.

Surface Wave Predictions

Distribution of wave heights

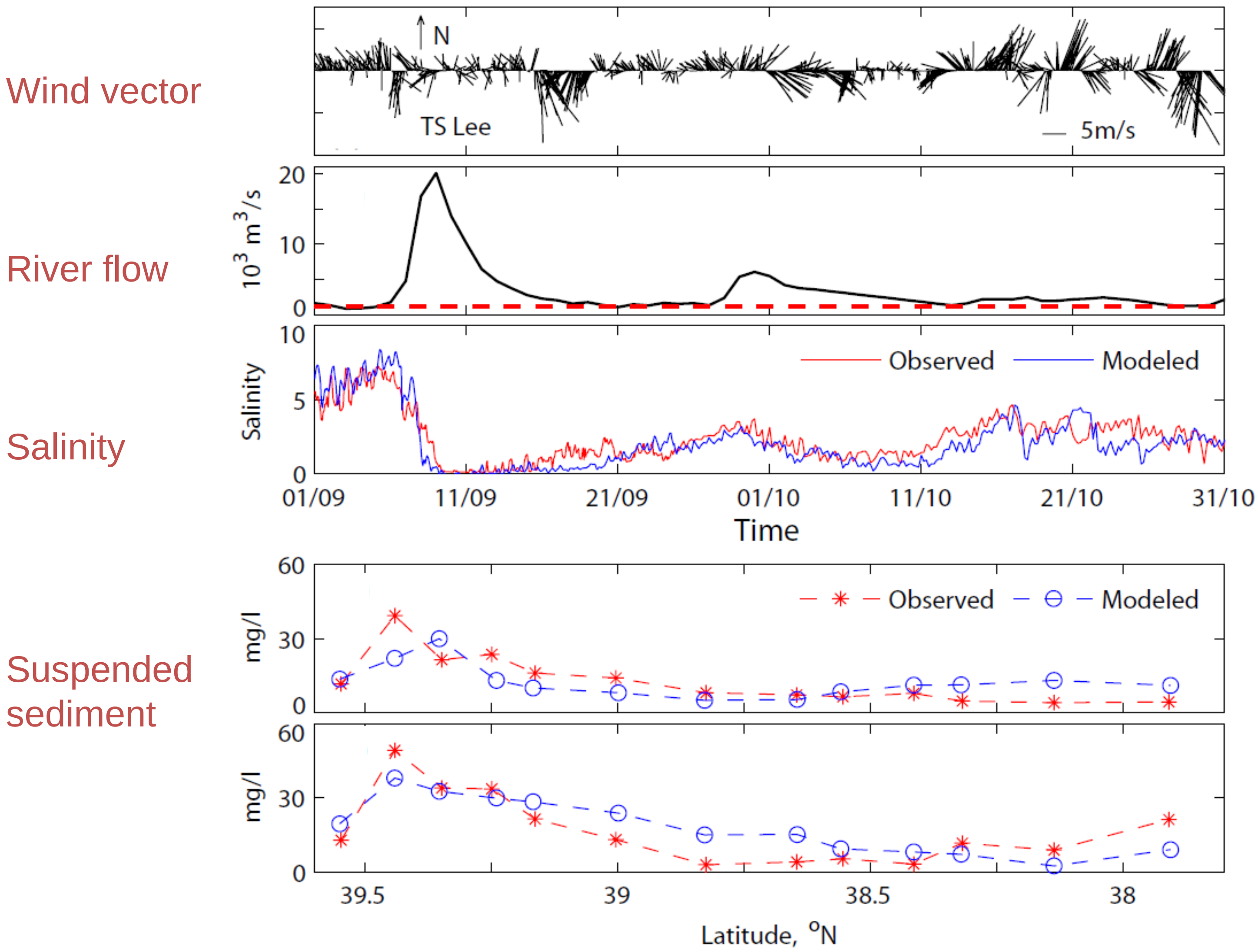


Comparison of predicted and observed wave heights at a mid-Bay station in a hindcast model run for March, 2012.



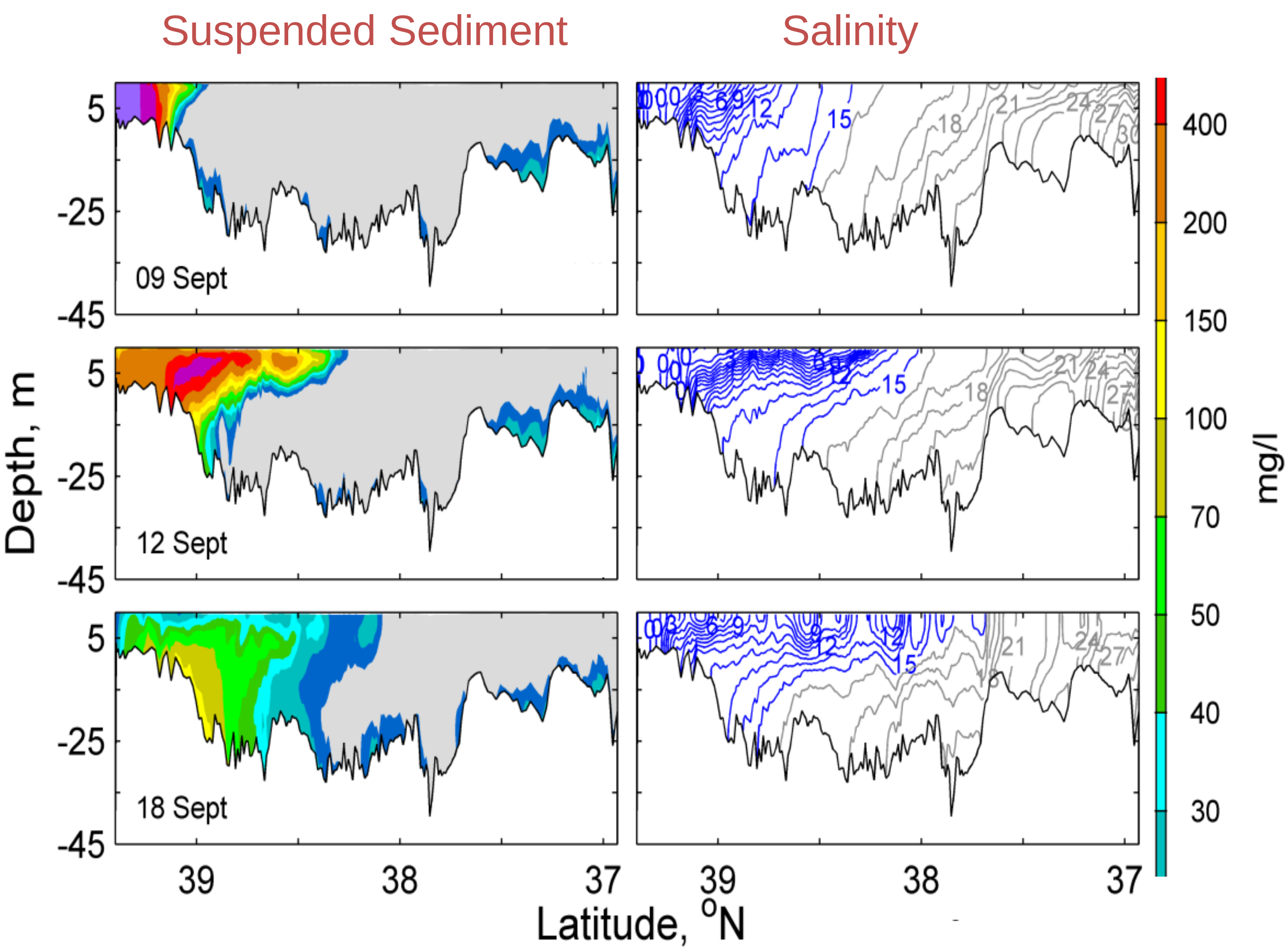
Model simulations showed that COASWT produced reasonable predictions of surface waves. Wave-induced stress is a key factor for sediment suspension. Coupling wave model to sediment-transport model is needed to calculate sediment transport, resuspension and deposition.

Simulating Tropical Storm Lee (2011)



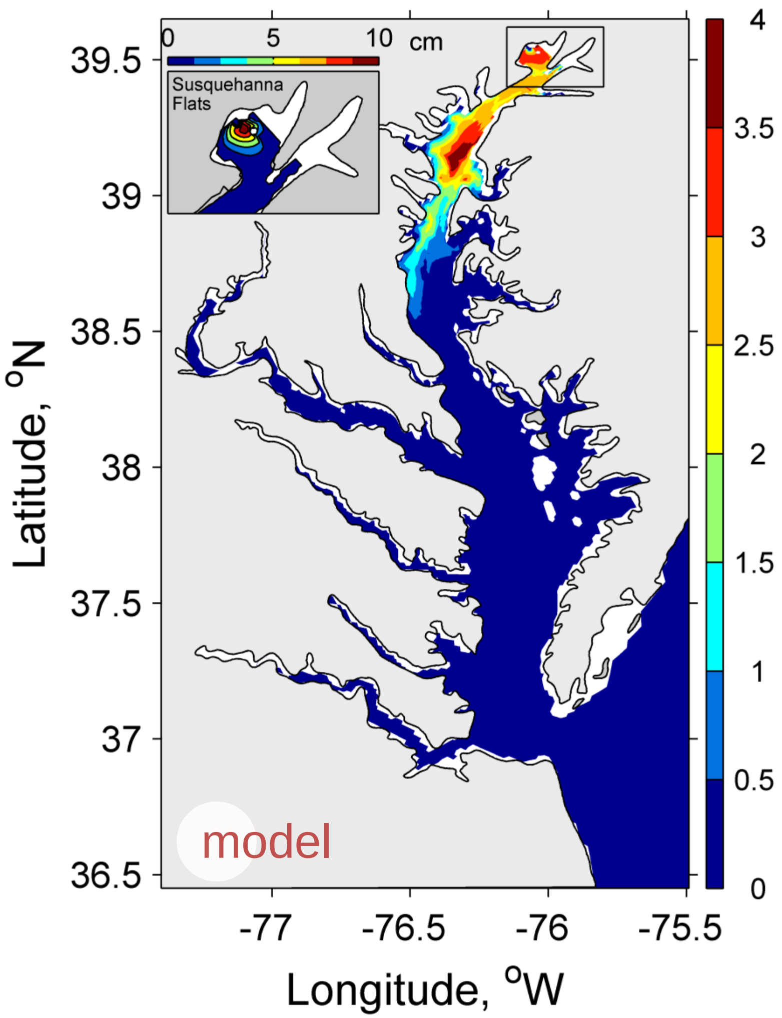
Model captures rapid salinity decrease due to the flood and reproduces observed suspended sediment concentrations.

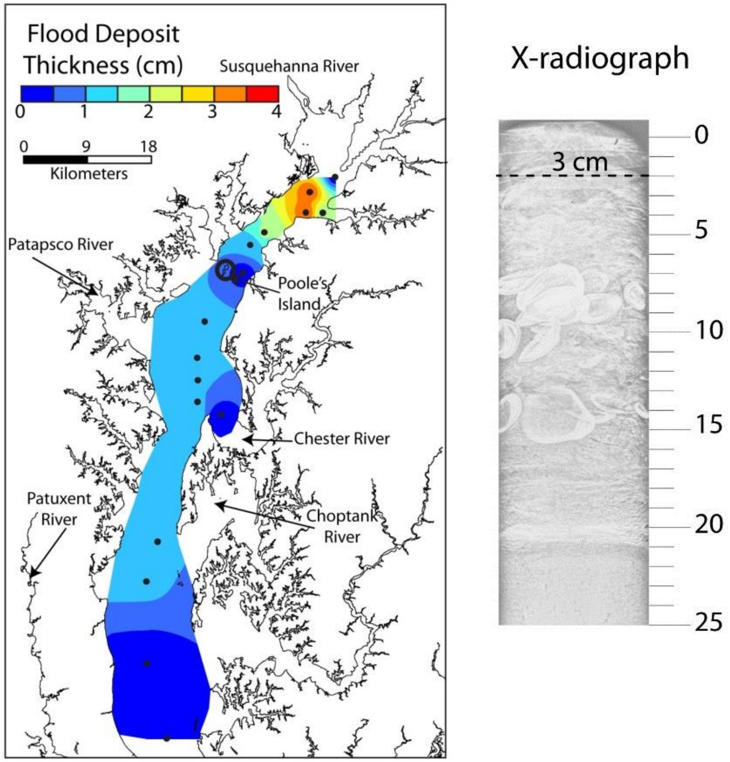
Evolution of sediment plume and salinity



Sediment plume evolved in three stages: river forcing; gravitational adjustment and sediment setting.

Sediment deposition





observations from sediment cores

T.S. Lee discharged 6.7 million tons of suspended sediments (~ 6 years) and ~1 year of particulate nitrogen and phosphorous.
3-4 cm of silts and clays were deposited in upper Bay.

Plans for Next 6 Months – Sediment-Transport Modeling

(1) *What activities are planned for next 6 months*

- Complete the development of the coupled modeling system COAWST.
- Conduct hindcast simulations for select past storms: Hurricane Irene (2011) and Tropical Storm Lee (2011).
- Conduct model simulations for storms or flood events observed during this project and validate model results against observational data.

(2) *What will these activities contribute to Bay modeling (in Conowingo and Bay)*

- COAWST simulation results and model configuration files will be made available to the Bay modeling team.

(3) *What products/information can realistically be generated by May 2016*

- A validated model for simulating sediment transport, suspension and deposition in Chesapeake Bay.

Particle Transport Processes

Sanford Group (Larry Sanford, Stephanie Barletta, Debbie Hinkle, Catherine Fitzgerald, Alex Fisher)

Primary Study Objectives

1. Work with USGS and Exelon/AECOM to sample Conowingo overflow during 6 events, characterizing changes in particle characteristics over time during each event. Characterize settling velocity distributions and nutrient (P) partitioning on fast/slow settling particles. Compare settling velocity distributions to size distributions. 1.5 events sampled to date.

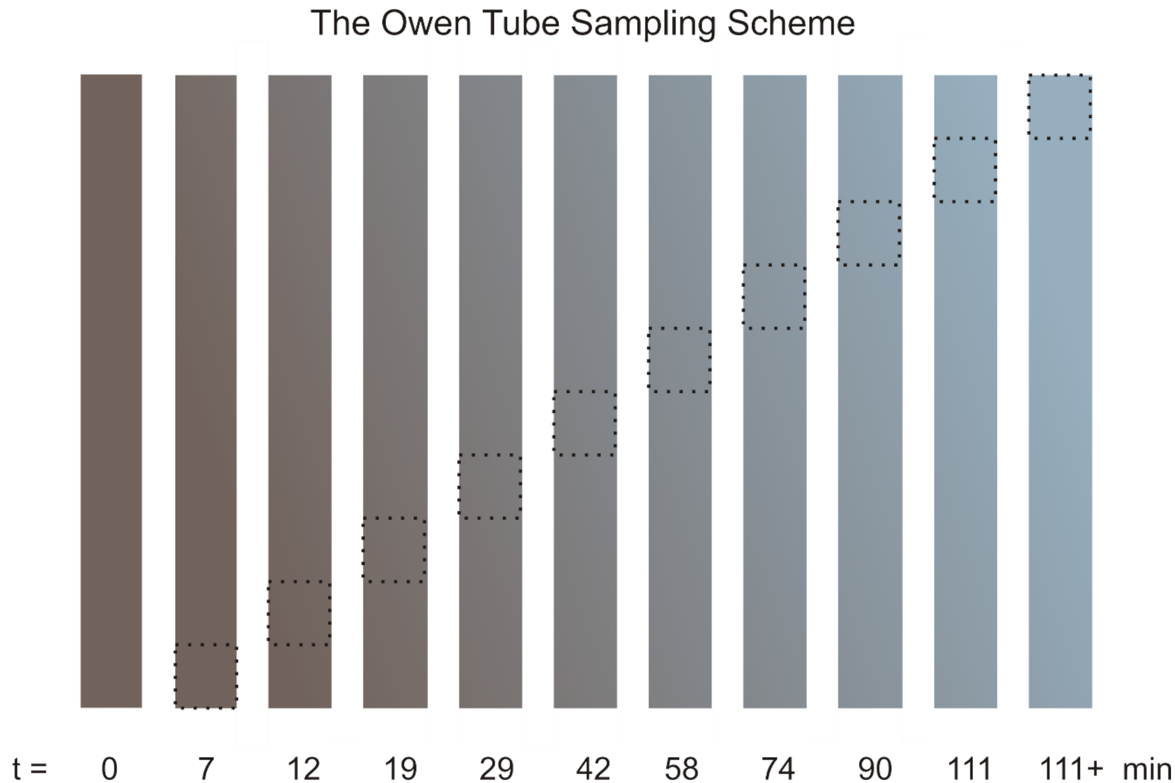
2. Carry out field surveys of upper Bay (to Havre de Grace) during 2 of these events. Axial surveys with CTD, water samples, underway current profiling on northward transect, detailed sampling at specific stations on southward transect, including settling velocity, TSS, nutrients, tracers. (To be followed by Bay sediment coring program.)

Settling tube measurements

Sampling at the Catwalk

Settling tube experiment

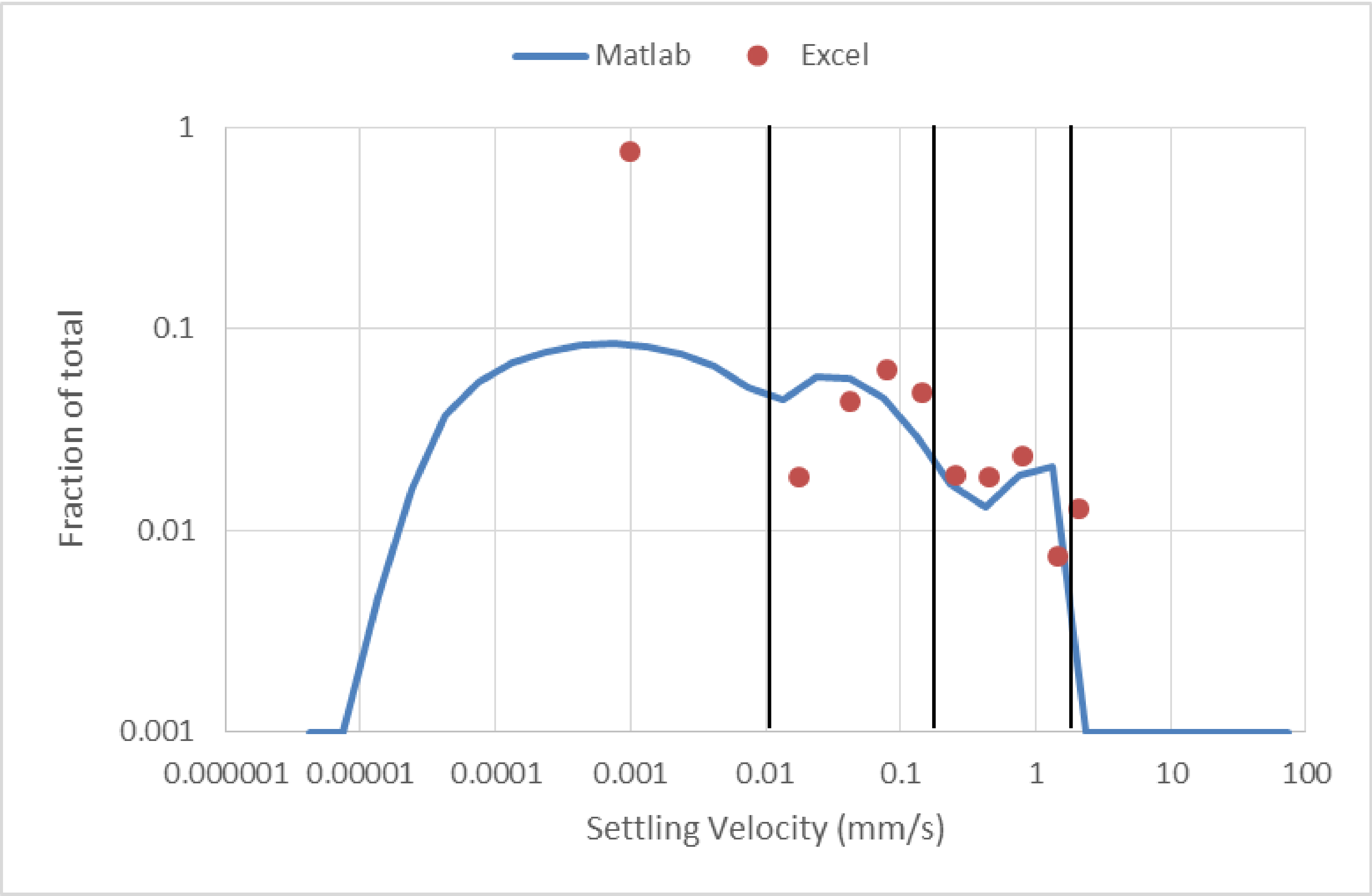
How does a settling tube work?

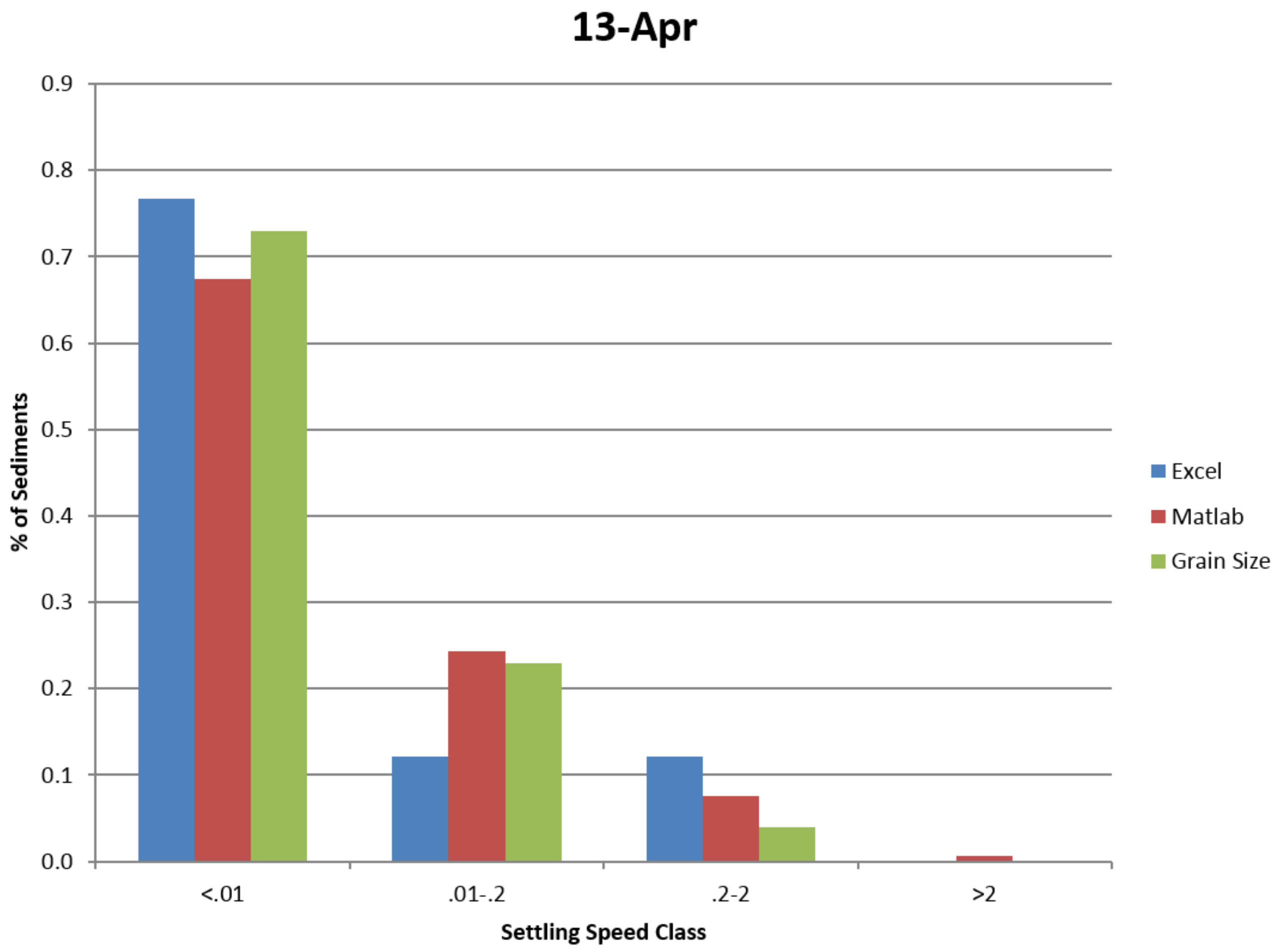


Two possible methods of data analysis:

1. Spreadsheet Implementation of Analysis Procedure (Malpezzi, Sanford, and Crump 2014)
2. Matlab (curve-fitting) implementation of analysis procedure (Malarkey et al. 2013)

Compare Matlab and Excel Analyses for Spillgate Samples 4/13/15

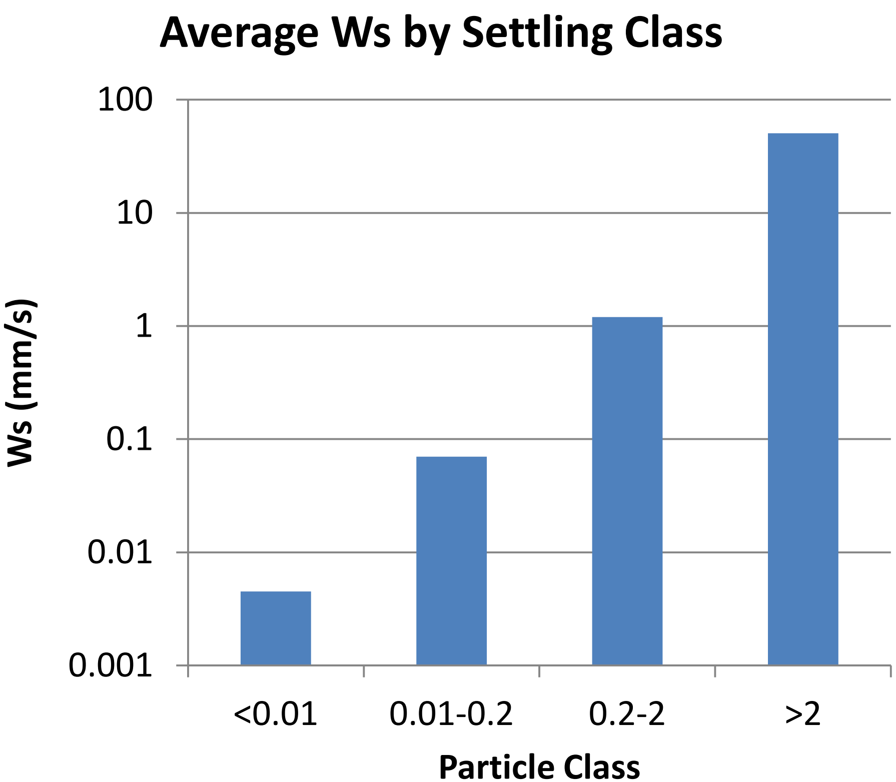


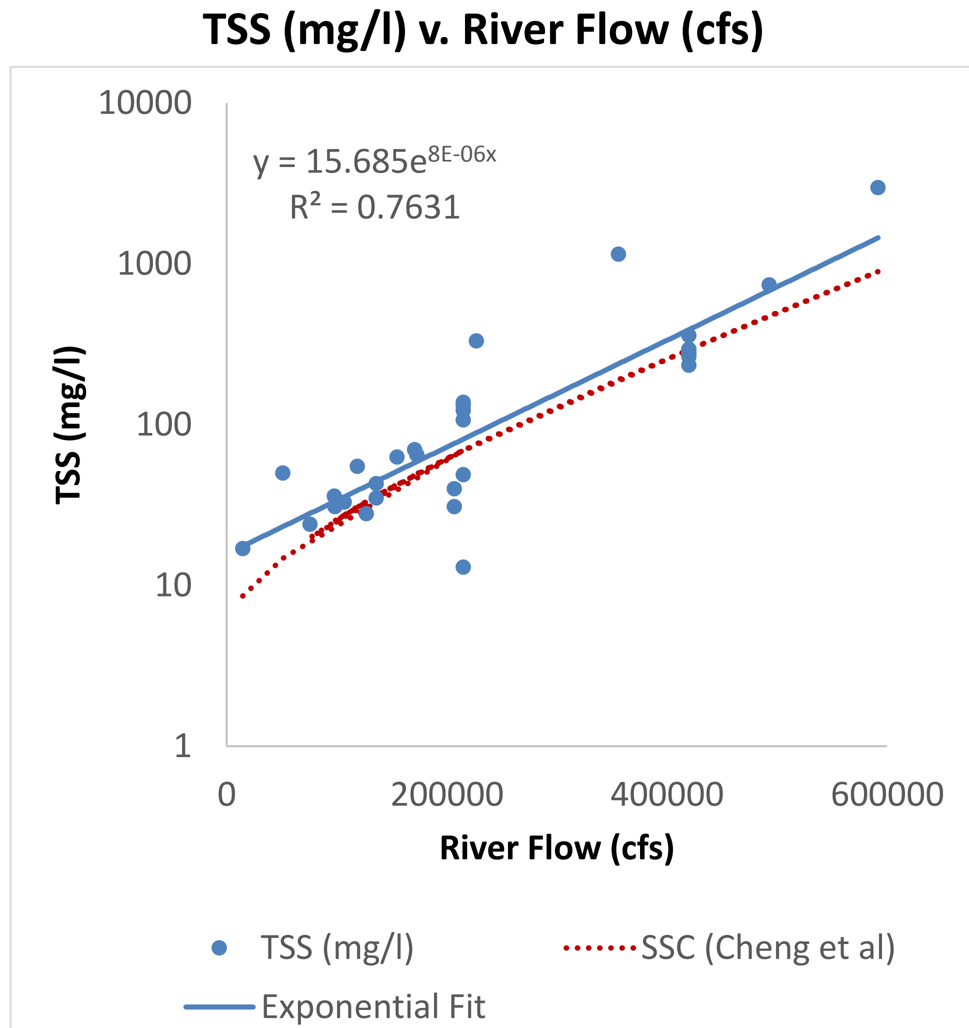


Grain size based settling velocities calculated using Stokes settling velocity formula, assuming solids density is 2,650 kg m^{-3}

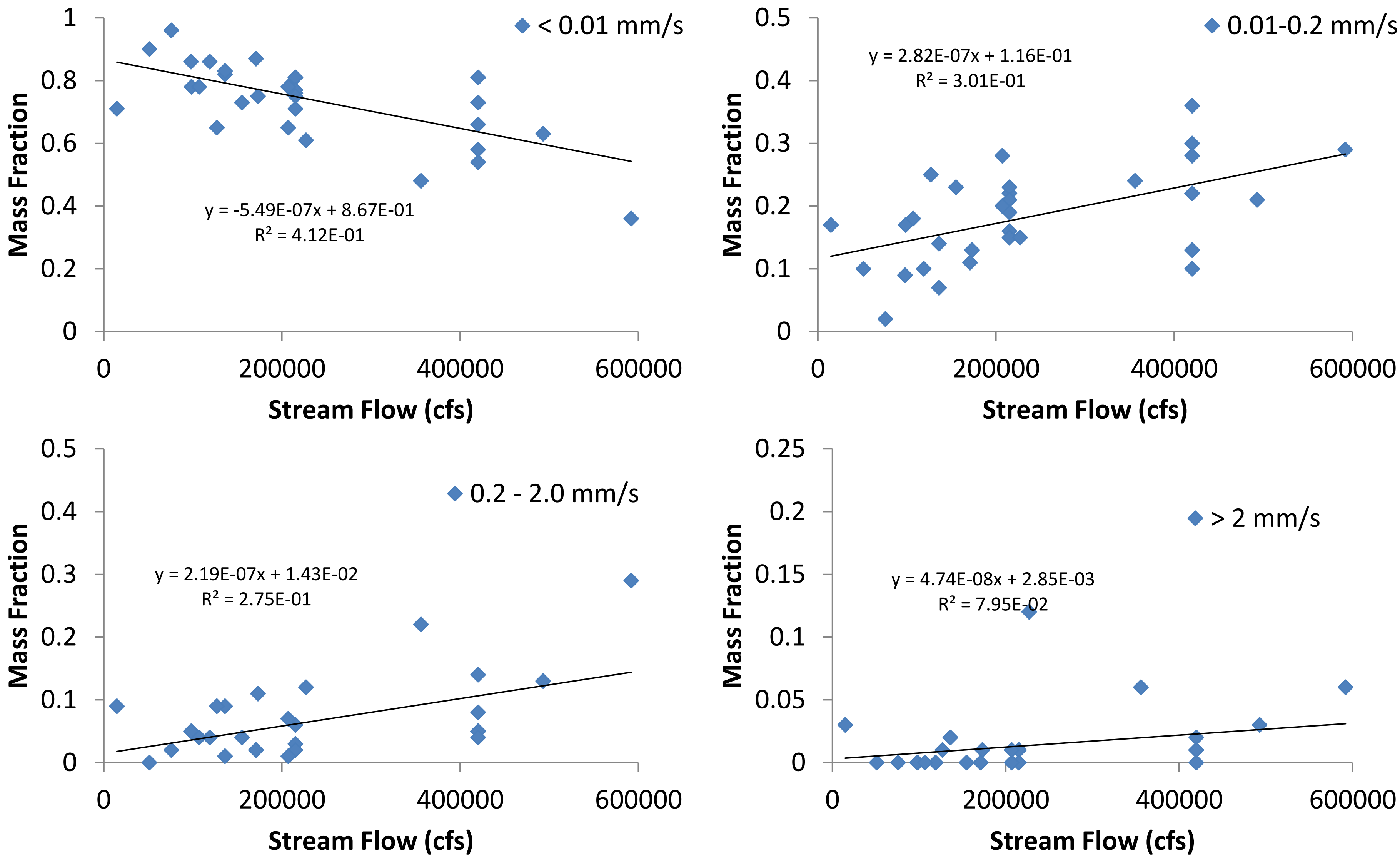
Plot comparing % of total sediments for each of the four settling classes found using the UMCES settling tube analyses and the USGS grain size analysis for the event on April 13th, 2015. The data agrees nicely, as the percentages are similar for each class across the three methods. This means that using the more readily available grain size data for events such as this one is sufficiently accurate.

Settling velocity calculations based on grain size samples collected by USGS 32 times between 1979 and 2015. Analyzed using the same size/settling speed classes as above.





Mass Fractions in Different Settling Velocity Classes as a Function of Flow Speed from USGS Particle Size Observations. Different fractions sum to 1 at all settling speeds.



Implications for Sediment Transport Modeling – Particle classes and settling velocities

Cerco et al. (2013) – Bay Program/WES Model

Table 1
Suspended solids model parameter summary. Settling velocity for organic solids indicates transport through the water column. Net settling velocity describes deposition to bottom sediments. *D* is depth of the water column. (–) indicates not applicable.

	Fine clay	Clay	Silt	Sand	Organic solids
Settling velocity ($\mu m\ s^{-1}$)	12	30	100	1000	11.6
Critical shear stress for erosion (P)	0.03	0.03	0.03	2	(–)
Erosion rate per unit of excess shear stress ($g\ m^{-2}\ s^{-1}\ P^{-1}$)	1	1	1	(–)	(–)
Net settling velocity ($\mu m\ s^{-1}$)	(–)	(–)	(–)	(–)	0.116, $D < 9.8$ m 2.32, $9.8 < D < 23.5$ 11.6, $D > 23.5$ m

Cheng et al (2014) – UMCES Model

Table 1. Parameters for the Sediment Transport Model

	Fluvial Sediment			
Sediment Parameters	Clay	Silt	Sand	Bay Bottom Sediment
Grain size (mm)	0.004	0.008	0.069	0.022[a]
Settling velocity (mm/s)[ab]	0.02	0.03	1	0.31
Critical shear stress (N/m^2)[c]	0.013	0.022	0.09	0.049
Erosion constant ($kg/m^2/s$)[a]	4×10^{-5}	4×10^{-5}	4×10^{-5}	5×10^{-5}
Fraction (%)[b]	40	50	10	100
Bottom porosity[d]	0.91	0.91	0.91	0.91

This study (to date)

Particle Size (mm)	.003	.009	.035	0.5
Ws (mm/s)	.0045	.07	1.2	50*

Implications for Particulate Nutrient Transport Modeling

Cerco et al. (2013) – Bay Program/WES Model
Particulate nutrient (PIP, POC, PON, etc) transport is not linked to the sediment transport model, behaves independently

Cheng et al (2014) – UMCES Model
Particulate nutrient transport not currently part of modeling plans for Conowingo study

This study (to date)
PIP samples collected in settling tubes, not yet analyzed, may inform settling of nutrients in Bay Program model

Preliminary Conclusions

- 2 Settling tube analysis methods generally agree, transition from slowest resolved ws to slower unresolved ws needs some work
- At these low concentrations, settling tube estimates agree with disaggregated USGS particle size estimates
- Total TSS compares well to Exelon/USGS samples (33 ± 20 mg/l)
- Initial results indicate 3-4 fine suspended sediment classes (no sand present in these samples)
- Analysis of previous USGS particle size data at different flows indicates flow/concentration dependence of mass fractions in different size classes
- **Need to complete PIP phosphorus settling analysis, look for previous data as well**
- **Need to work with modeling team to incorporate settling velocity information in sediment transport model and explore POC/PIP settling parameterization**