

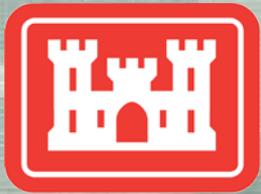
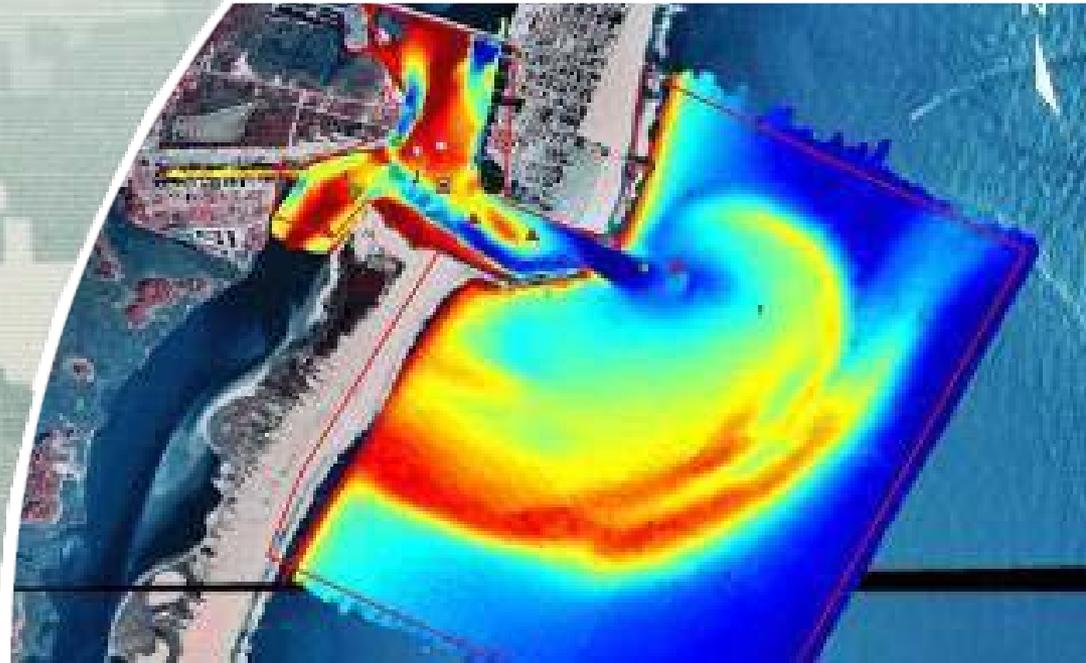
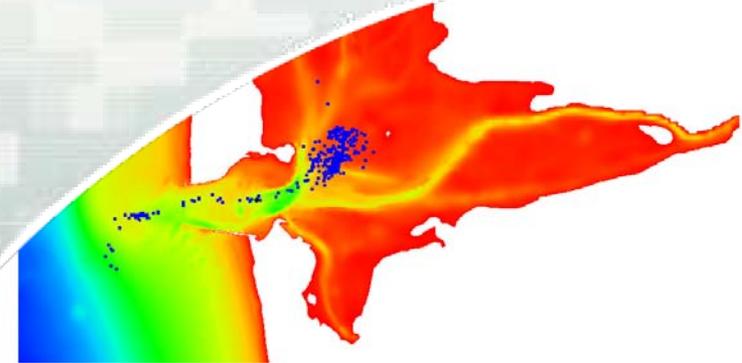
INTRODUCTION TO PARTICLE TRACKING MODEL (PTM) IN THE CMS



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ERDC CHL

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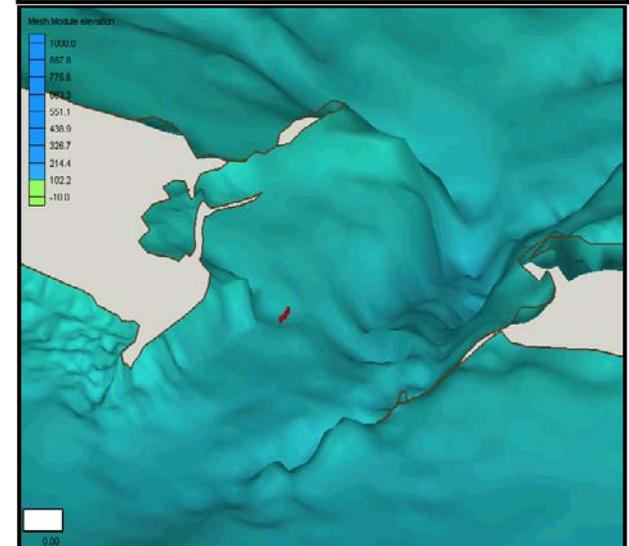
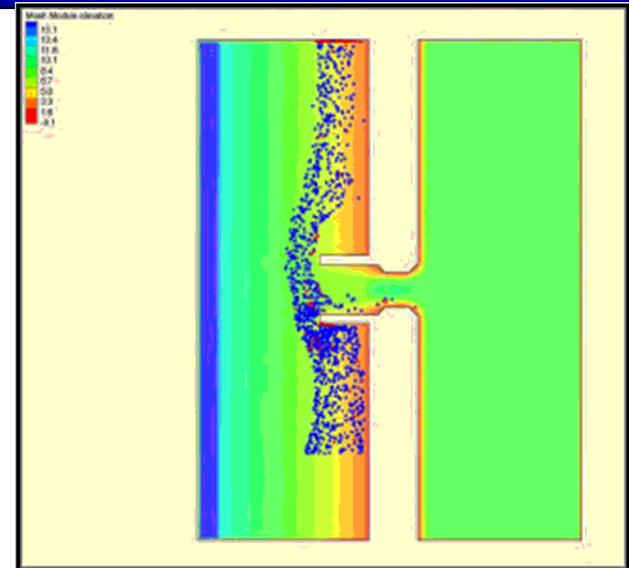
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What is the PTM?



- The PTM is a Lagrangian model
- Designed to evaluate behavior of materials under combined waves and currents
- Implement a Lagrangian approach to track particles
 - ▶ parcel calculation technique used
 - ▶ a parcel is represented by particles with known attributes (diameter, density, mass)
 - ▶ parcels are free to advect, disperse, settle or be entrained from the bed

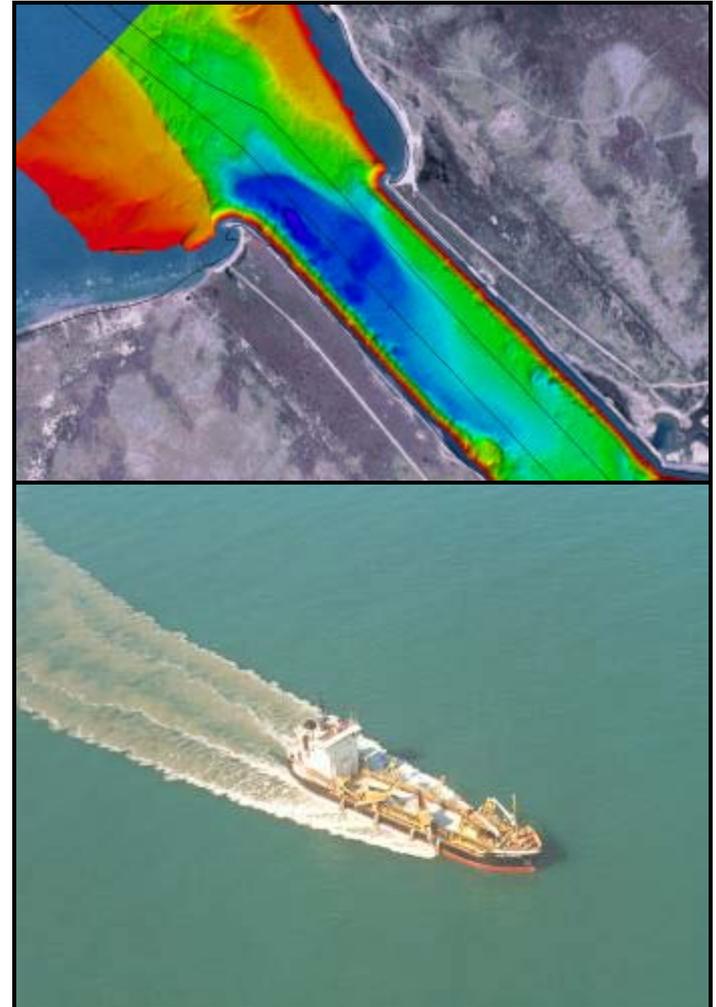




PTM Capabilities



- Visualize particle pathways and fate
- Calculate residence time
- Monitor specific sources of sediment transported to inlets and navigation channels
- Monitor dispersion sediment from dredged material placement sites
- Predict accretion and erosion zones
- Forecast potential increase in turbidity and deposition
- Isolate and track particles from other sources, such as outfalls, propeller-induced suspension, ...

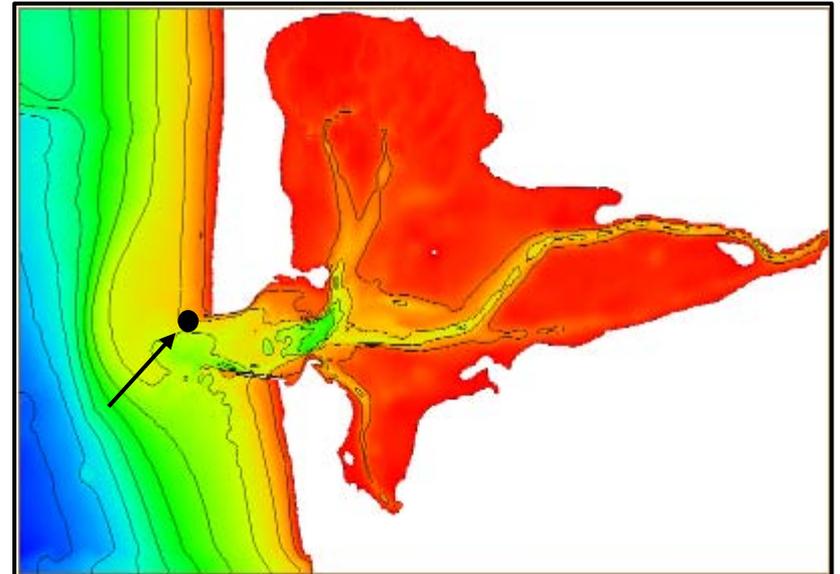




The CMS-PTM Coupled System



- The CMS is a coupled and integrated wave, flow, sediment transport, and morphology change modeling system
- The CMS provides hydrodynamic output (waves and current) to the PTM
- The PTM determines migration of particles based on the CMS input
- The CMS-PTM is implemented in the SMS (Surface-water Modeling System)





Calculations in the PTM



- Current and wave conditions required as from the CMS
- Combined wave-current sediment mobility (Soulsby & Whitehouse)
- Temporally and spatially varying bedforms (Mogridge et al.)
- Combined wave-current bottom shear stresses (O'Connor & Yoo, van Rijn)
- Suspended sediment transport (Rouse, van Rijn)
- Bed load transport (van Rijn)
- Settling and entrainment algorithms (Soulsby)
- Hiding and exposure function (Egiazaroff, Kleinhans & van Rijn)
- Neutrally-buoyant particles



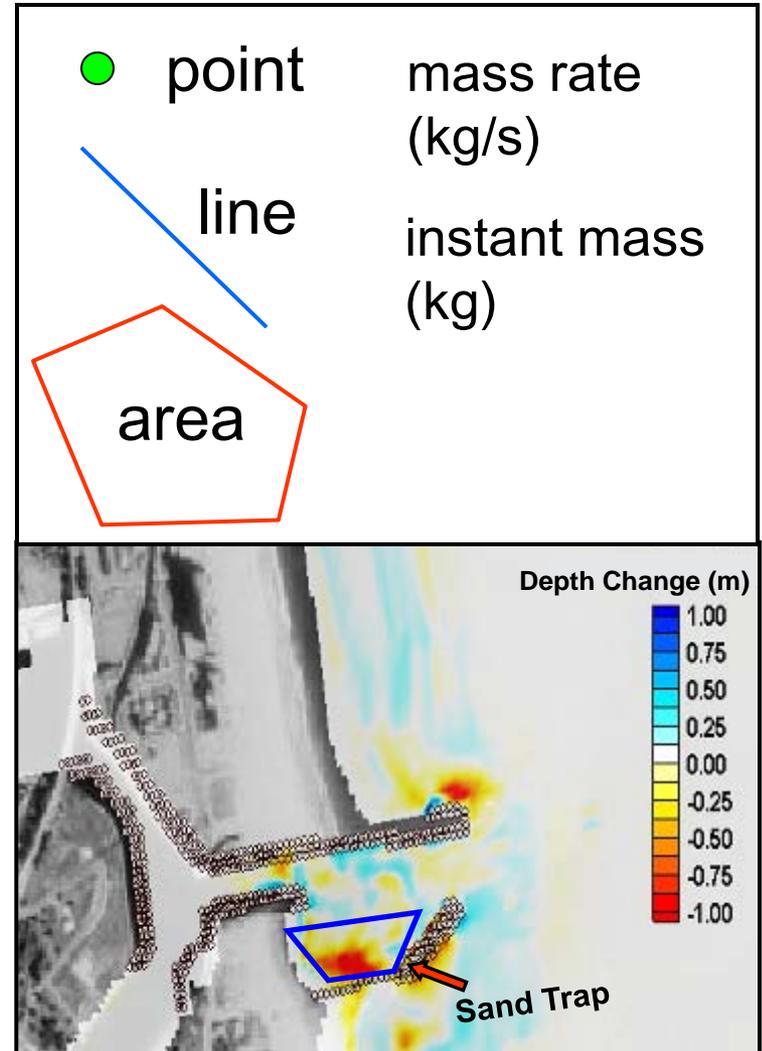
- Influence of bed slope on transport
- Mixed sand-silt-clay sediment transport algorithms
- Active layer mixing/armoring
- Variable bed roughness for growth/decay of bedforms
- Fully-3D transport of particles



Sediment Sources and Traps



- User-specified particle sources
 - ▶ Temporally- and spatially-varying point, line, or area sources
 - ▶ Mimic complicated dredging operations
- Particle traps
 - ▶ Used to monitor (count/collect) particles
 - ▶ Trap types may be defined as a line or area (zone or region)
- Residence time and spatial maps of particle transport parameters
 - ▶ Mobility, shear stress, and bedform
 - ▶ Pathways





PTM Applications



- Reconnaissance, feasibility, and design of O&M projects
- Inlet channels, shoals, structures, and adjacent beaches
- Channel design, infilling, and bypassing projects
- Study of fate and pathways of sediments in evolution of inlets
- Short-term (storm) analysis to long-term (project life) trend





PTM Applications



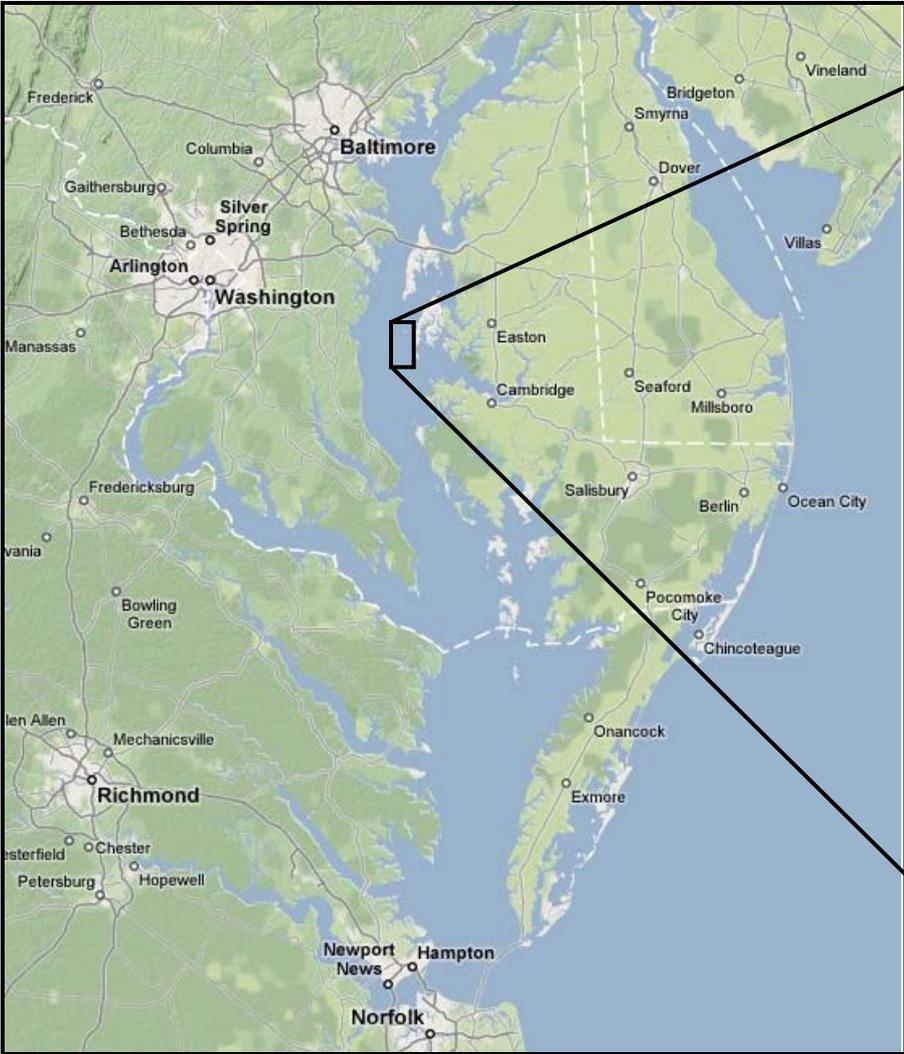
- CMS-PTM coupling
 - ▶ Idealized Inlet studies (R&D)
 - ▶ Grays Harbor (NWS)
 - ▶ Mouth of Columbia River (NWP)
 - ▶ Matagorda Ship Channel (SWG)
 - ▶ Packery Channel (SWG)
 - ▶ Chesapeake Bay/Poplar Island (NAB)
 - ▶ Sabine-Neches Waterway (SWG)

- DOER (Dredging Operations & Environmental Research) Program applications: LA/LB Complex (SPL); Willamette River (NWP); Port of Anchorage & Cook Inlet (POA); Cleveland Harbor (LRD); Brunswick Harbor (SAS); Providence River (NAD); Keith Lake River (SWG)



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Poplar Island, MD

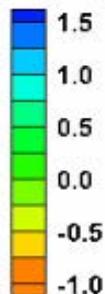




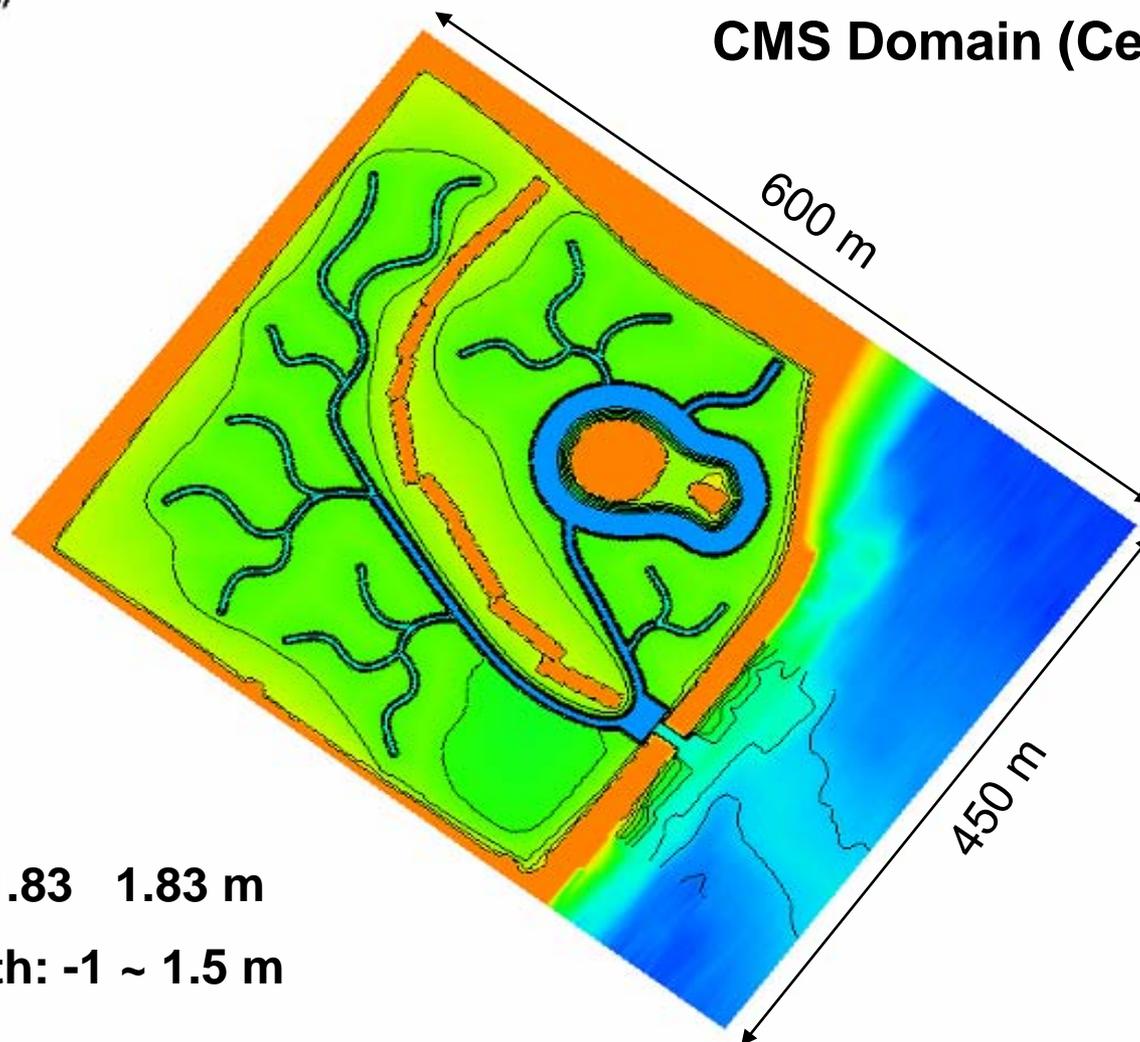
Poplar Island, MD



Depth (m)



CMS Domain (Cell-1A)

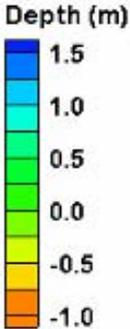


Cell Size: 1.83 1.83 m

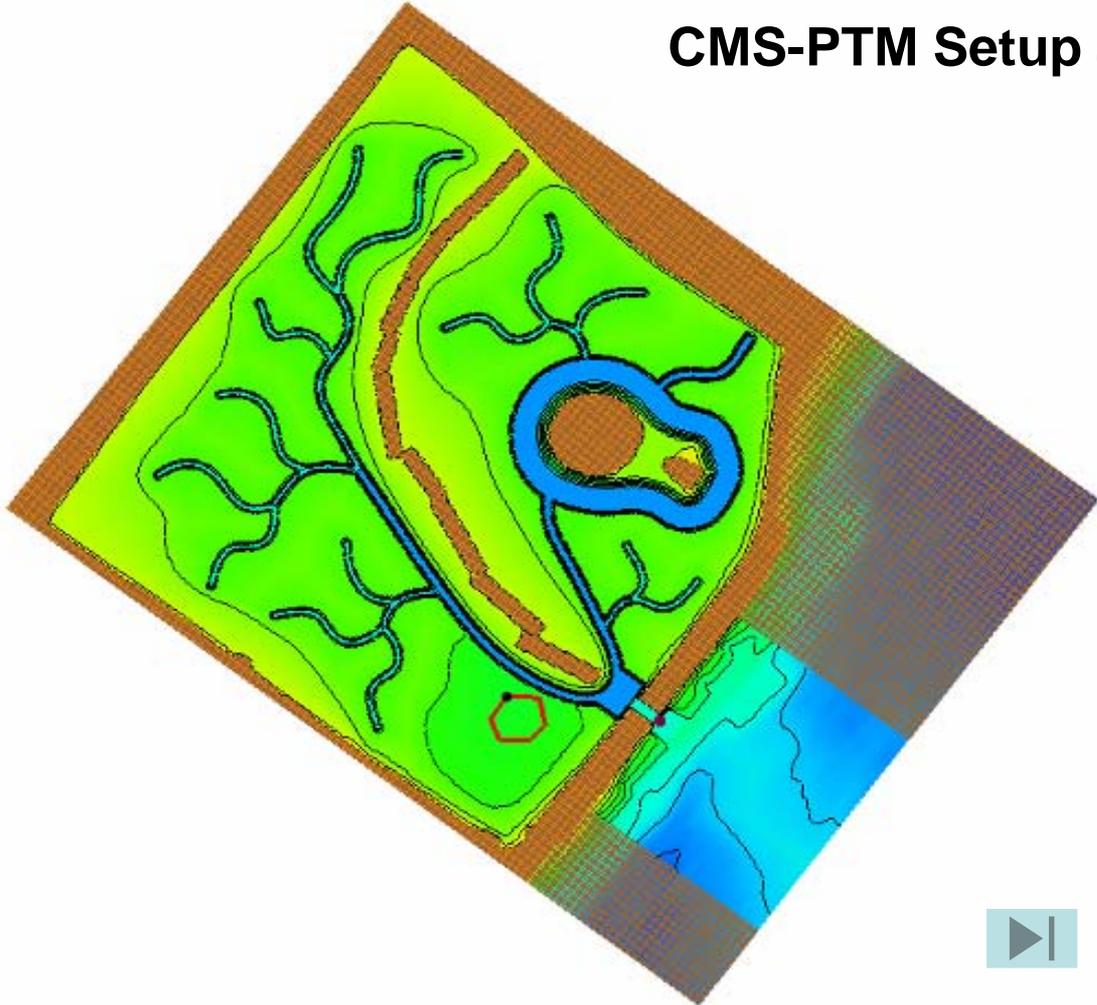
Water Depth: -1 ~ 1.5 m



Poplar Island, MD



CMS-PTM Setup and Results





Residence Time*



PARTICLES	AREA	TIME IN	TIME OUT	RESIDENCY (s)
7810	1	2001/01/01 07:20:20.0	2001/01/01 07:25:20.0	300.0
8228	1	2001/01/01 07:18:40.0	2001/01/01 07:28:20.0	580.0
9975	1	2001/01/01 07:27:20.0	2001/01/01 07:30:20.0	180.0
9378	1	2001/01/01 07:17:50.0	2001/01/01 07:30:40.0	770.0
9835	1	2001/01/01 07:17:20.0	2001/01/01 07:30:50.0	810.0
128	1	2001/01/01 07:17:40.0	2001/01/01 07:31:30.0	830.0
1576	1	2001/01/01 07:25:20.0	2001/01/01 07:32:20.0	420.0
9279	1	2001/01/01 07:21:30.0	2001/01/01 07:32:40.0	670.0
1318	1	2001/01/01 07:20:40.0	2001/01/01 07:33:20.0	760.0
7070	1	2001/01/01 07:28:20.0	2001/01/01 07:33:20.0	300.0
6417	1	2001/01/01 07:16:40.0	2001/01/01 07:33:30.0	1010.0
3615	1	2001/01/01 07:20:20.0	2001/01/01 07:34:00.0	820.0

.....

*Residence Time = Time Particles Exit the Trap - Time Particles Enter the Trap
(TIME OUT) (TIME IN)



Statistics of Residence Time Computations



Residence Time	Neutrally Buoyant		$D_{50} = 0.0005$ mm	
	Second	Minute	Second	Minute
Average	2545	42.4	3139	52.3
Minimum	20	0.3	20	0.3
Maximum	13560	226.0	144980	2416.3
Median	1490	24.8	1615	26.9
Standard Deviation	2851	47.5	9904	165.1



Noyo Pilot Study (Dredge Placement)



Placement Site: 9 miles north of Noyo Harbor. Near bottom release

Placement Area: 155,480 yd²

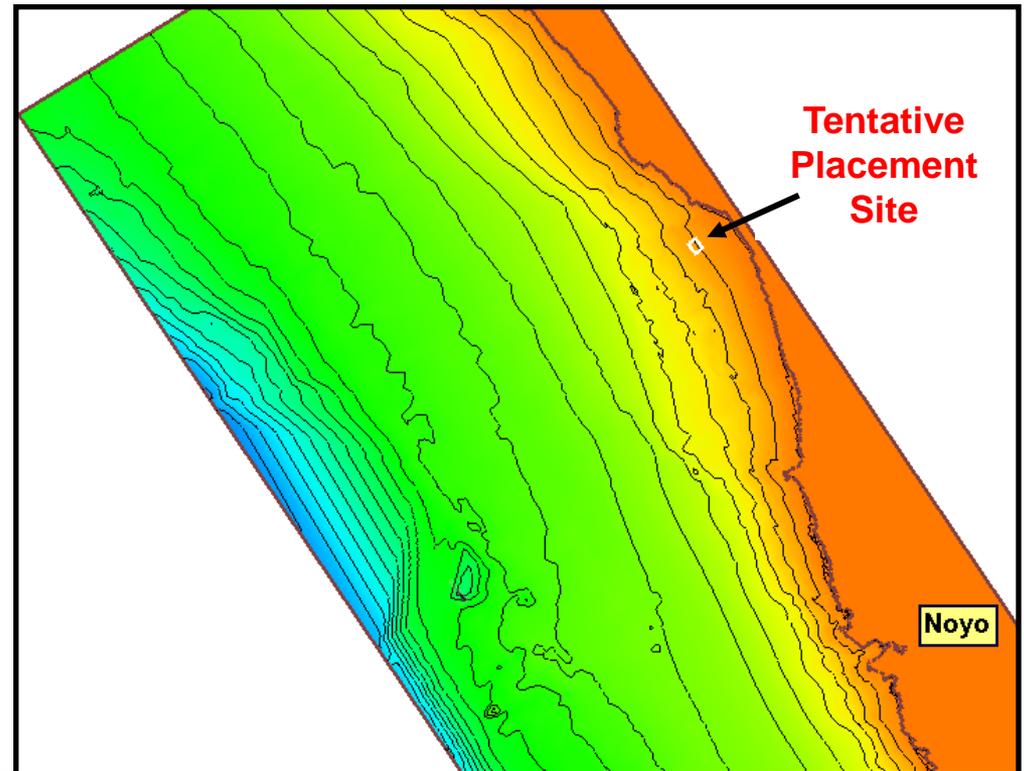
Each Placement:

Silt: ~11.0 cy

Clay: ~8.0 cy

Simulation Period:

August 1-30 2008

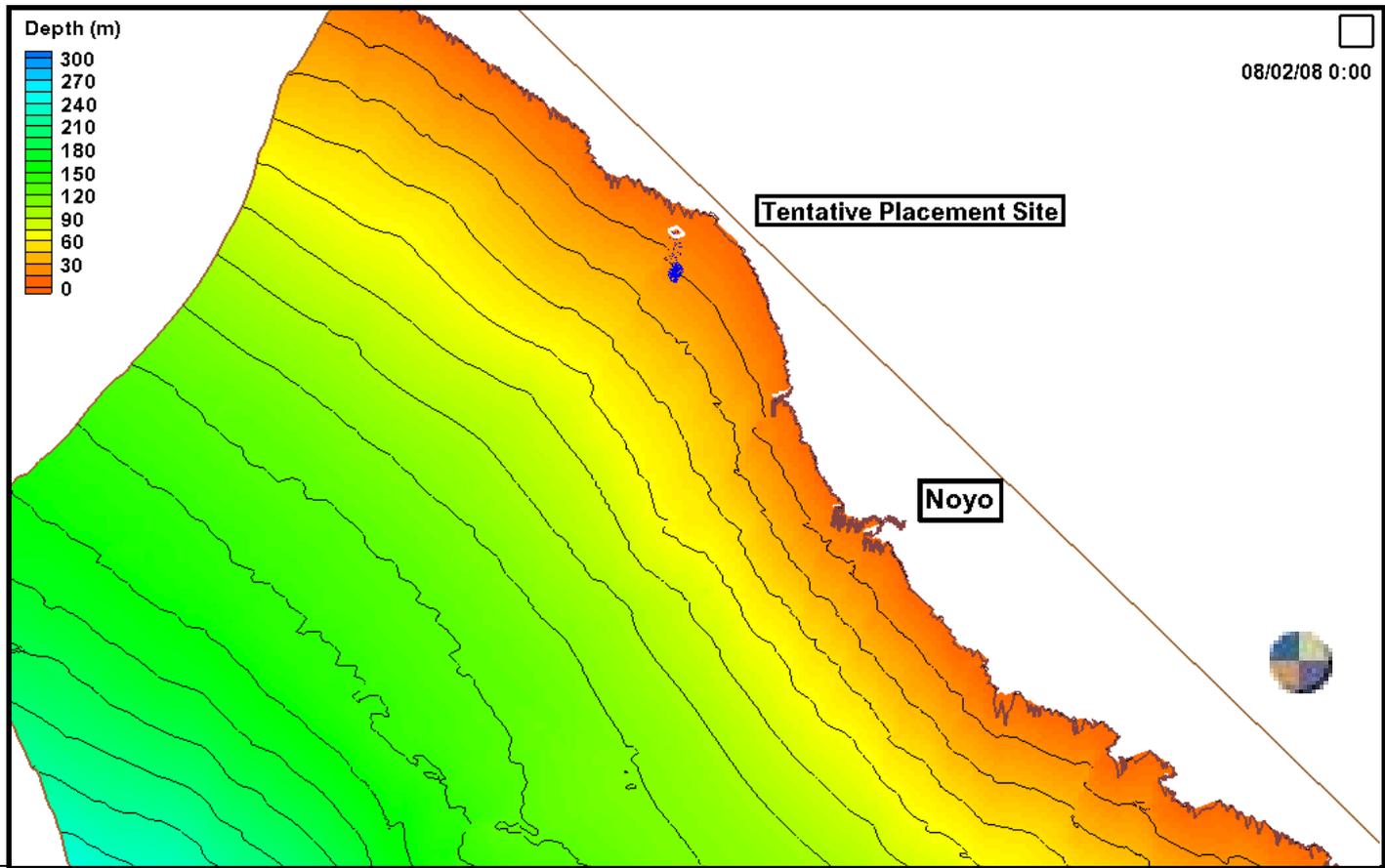




Noyo PTM

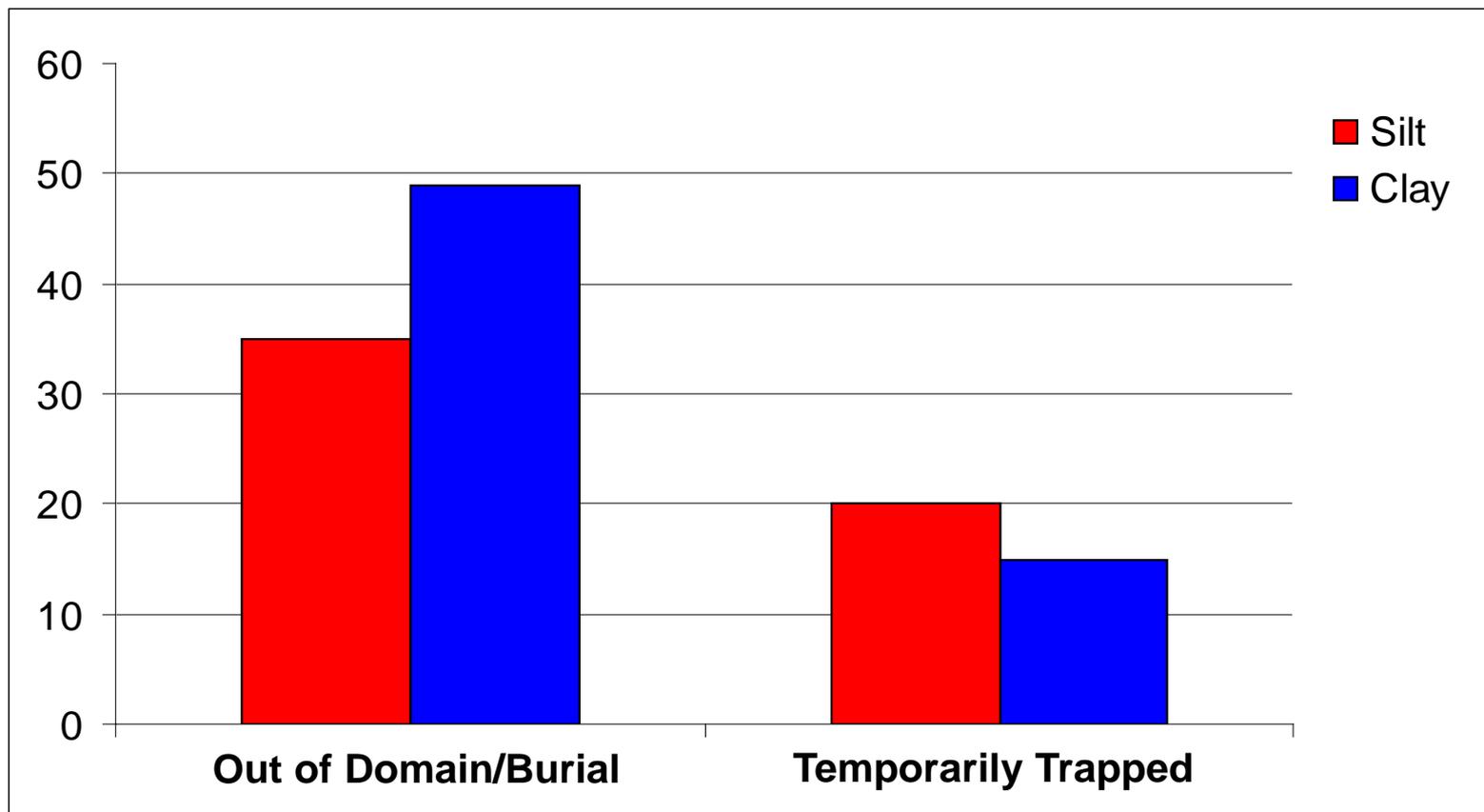


- 30-day simulation
- Clay release twice daily for first 12 days
- Total mass released – 198 cy





PTM Preliminary Results





Future PTM Improvement



- CMS-specific PTM interface to simplify model setup
- Incorporation of sediment transport calculations of CMS and PTM (algorithms and parameters)
- Sediment concentration, cohesive sediment flocs, deposition mapping



Publications



- Demirbilek, Z., K. J. Connell, and N. MacDonald (2008). **Particle Tracking Model (PTM) in the SMS 10: IV. Link to Coastal Modeling System**, ERDC TN-IV-71.
- MacDonald, N., M. Davies, A. Zundel, J. Howlett, Z. Demirbilek, J. Gailani, T. Lackey, and J. Smith (2006). **PTM: Particle Tracking Model, Report 1. Model Theory, Implementation, and Example Applications**, ERDC/CHL TR-06-21

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