PTM with CMS

Honghai Li
Research Physical Scientist

Mitchell E. Brown
Research Physical Scientist

Coastal and Hydraulics Laboratory
Engineer Research and Development Center

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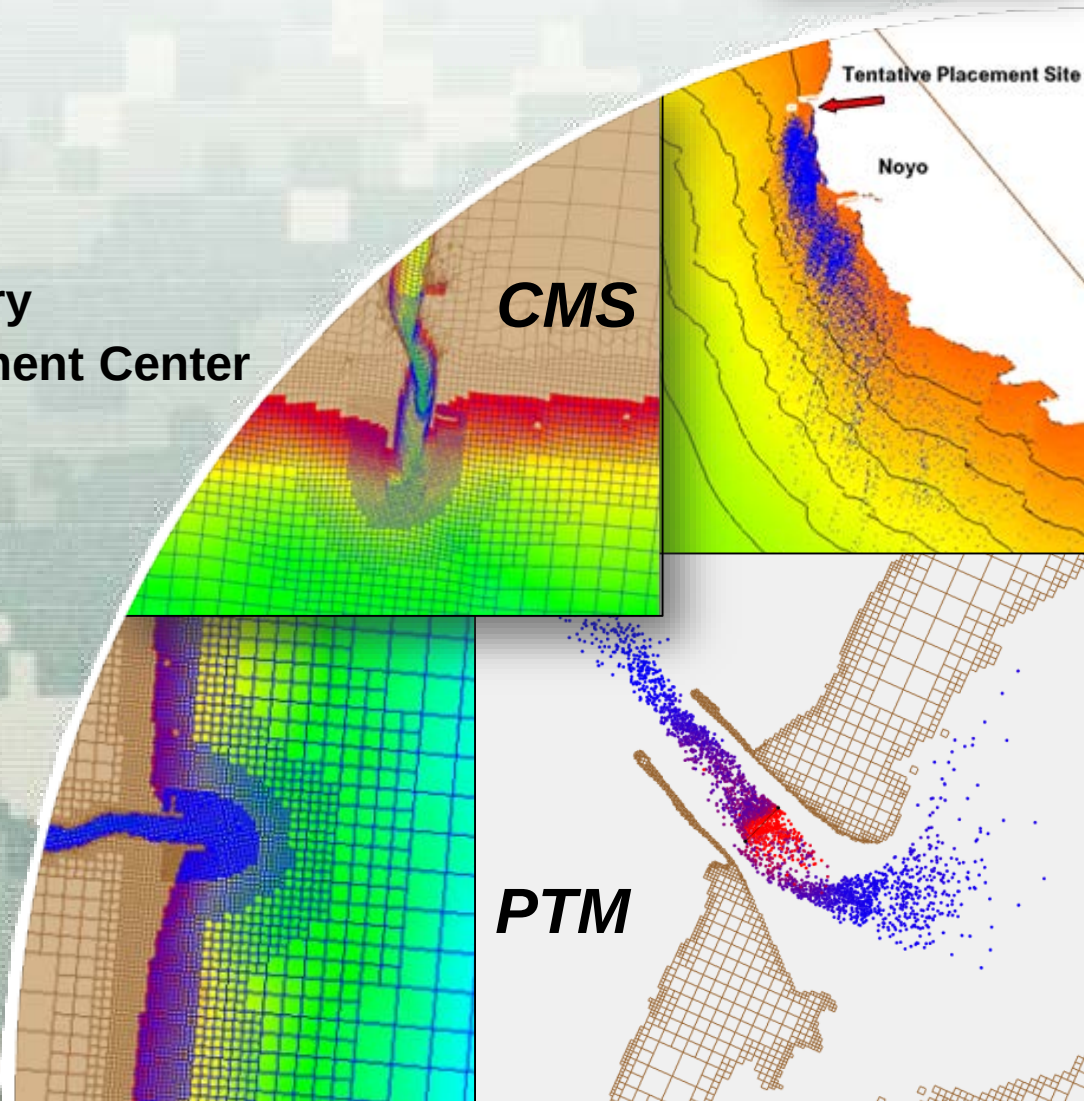

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Particle Tracking Model

PTM is a Lagrangian particle tracker that models transport processes (advection, diffusion, deposition, etc) of representative parcels to determine constituent (sediment, contaminants, biologicals, etc) fate.

Input Requirements

- ❑ Grid/Bathymetry Data
- ❑ Hydrodynamic and/or Wave Data
  - ❑ ADH
  - ❑ ADCIRC
  - ❑ EFDC
  - ❑ CH3D
  - ☑ CMS
- ❑ Native Sediment Data
- ❑ User Defined Source
  - Dredging
  - Placement
  - CSOs

→

PTM

Time-dependent Particle Positions P(t,X,Y,Z)

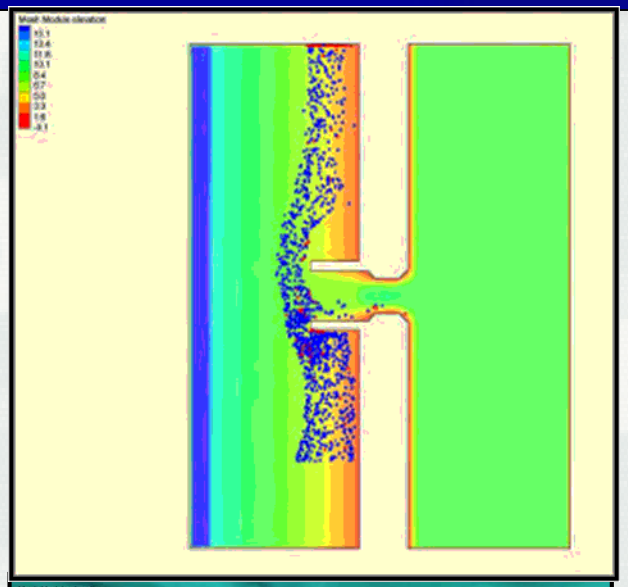
→

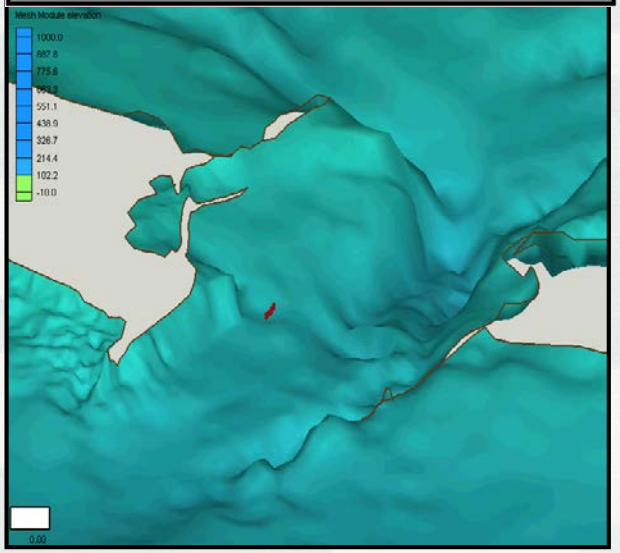
PTM/Surface-water Modeling System (SMS) Data Analysis Tools

- ☑ Deposition
- ☑ Concentration
- ☑ Dose
- ☑ Exposure
- ☑ Accumulation
- ☑ Pathways

Calculations in the PTM

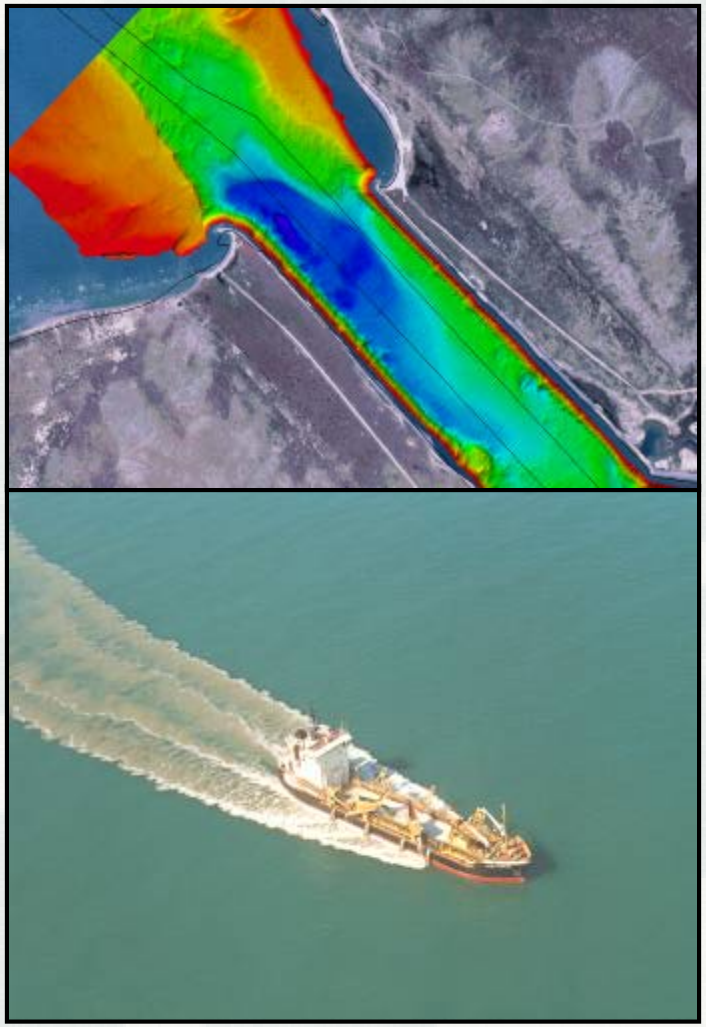
- Combined wave-current sediment mobility (Soulsby & Whitehouse) and bottom shear stresses (O'Connor & Yoo, van Rijn)
- Temporally and spatially varying bedforms (Mogridge et al.) and variable bed roughness for growth/decay of bedforms
- Suspended sediment transport (Rouse, van Rijn)
- Bed load transport (van Rijn)
- Settling and entrainment algorithms (Soulsby)
- Hiding and exposure function (Egiazaroff, Kleinhans & van Rijn)
- Influence of bed slope on transport
- Mixed sand-silt-clay sediment transport algorithms
- Fully-3D transport of particles
- Neutrally-buoyant particles





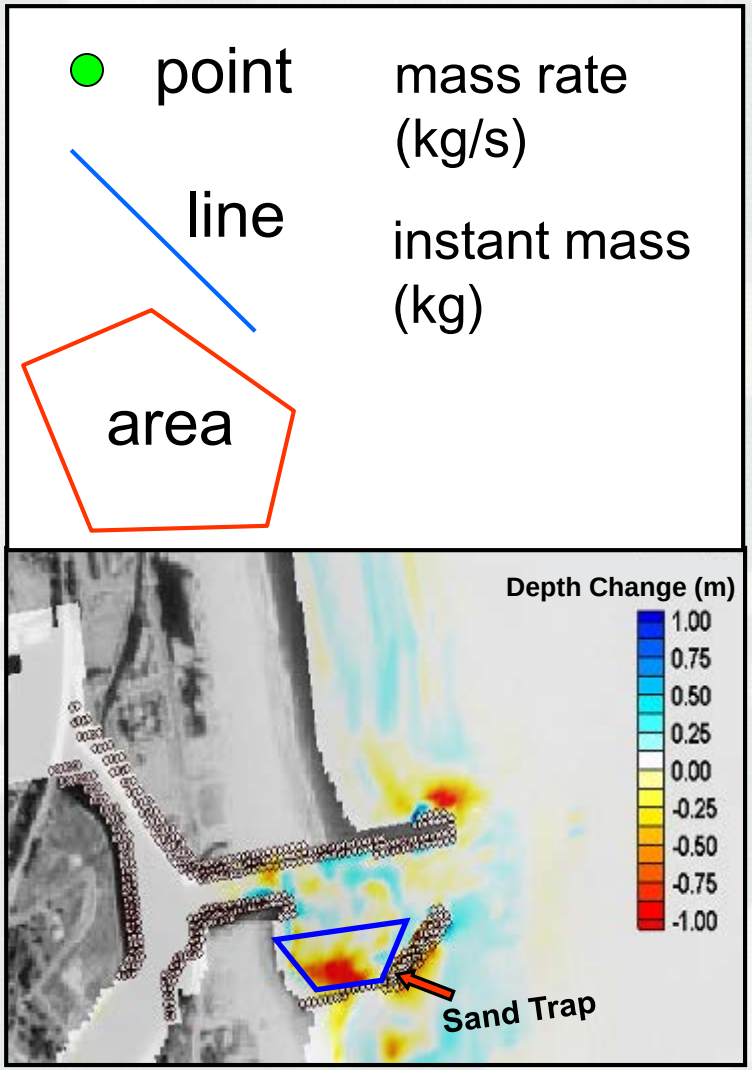
PTM Capabilities

- Visualize particle pathways and fate
- Calculate residence time
- Monitor specific sources of sediment transported to inlets and navigation channels
- Monitor dispersion of 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 …



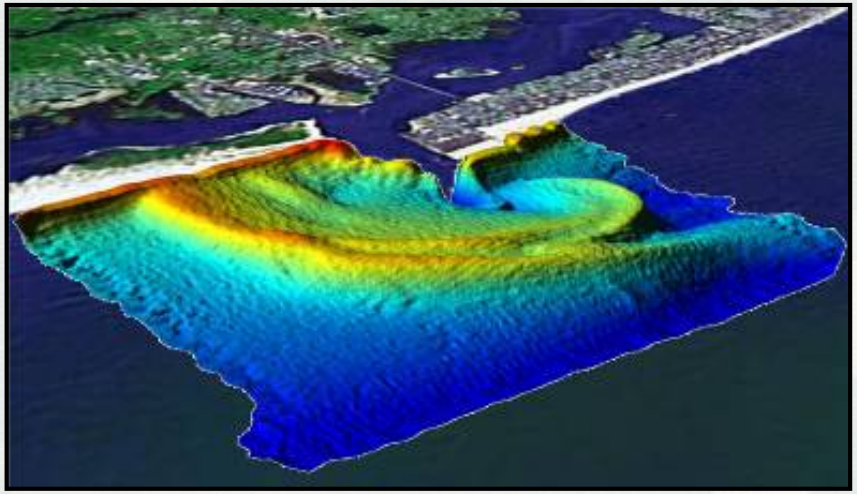
Sediment Sources and Traps

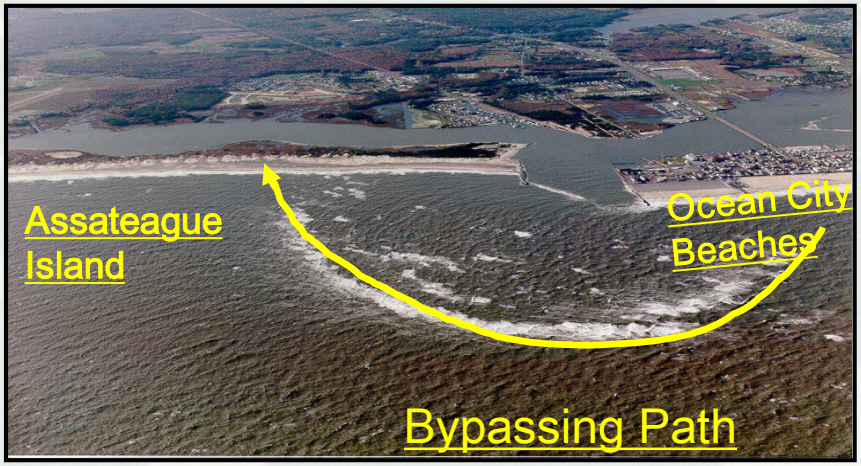
- User-specified particle sources
  - Temporally- and spatially-varying point, line, or area sources
  - Mimic complicated dredging operations
- Particle traps
  - Used to monitor (count/collect) particles
  - Trap types may be defined as a line or area (zone or region)
- Residence time and spatial maps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



PTM Applications

- Sediment transport around inlets, shoals, structures, and adjacent beaches
- Sediment transport related to channel design, infilling, and bypassing projects
- Sediment transport from channel dredge and material placement
- Erosional Transport
- Larval fish, fish egg, and water particulate transport

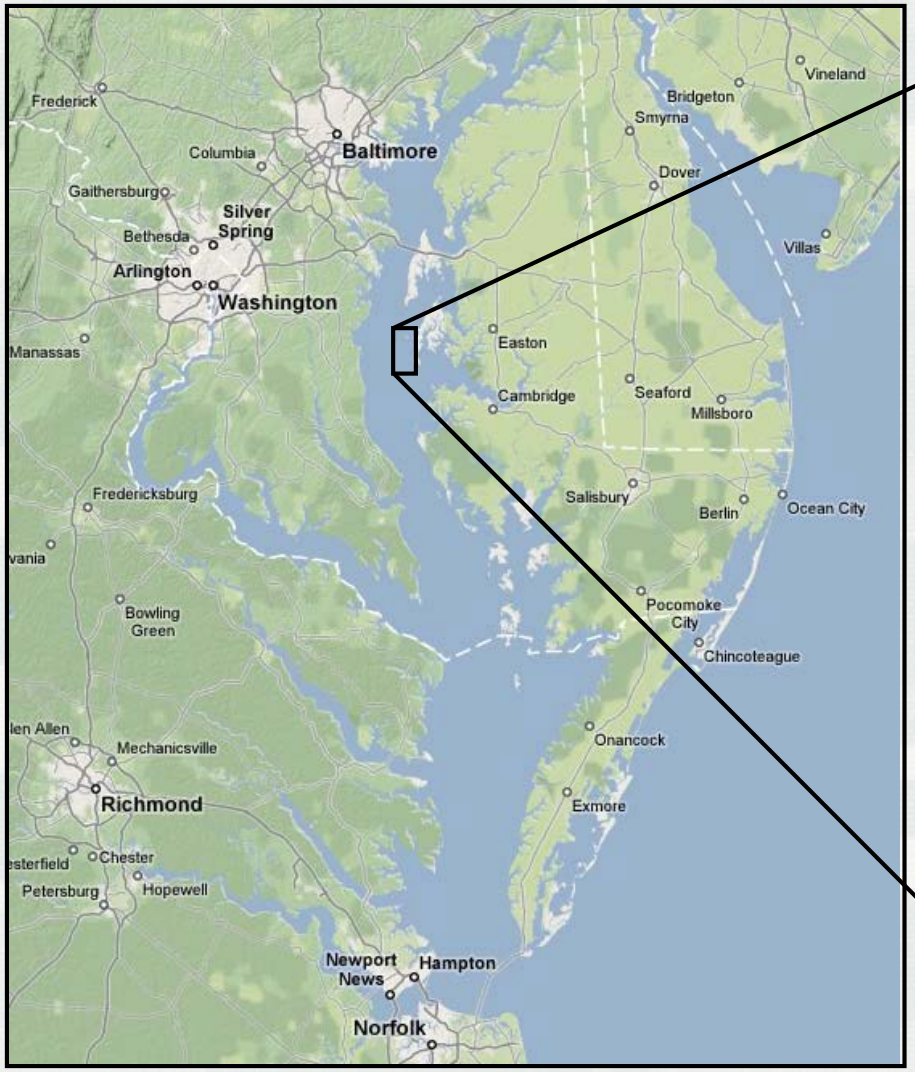




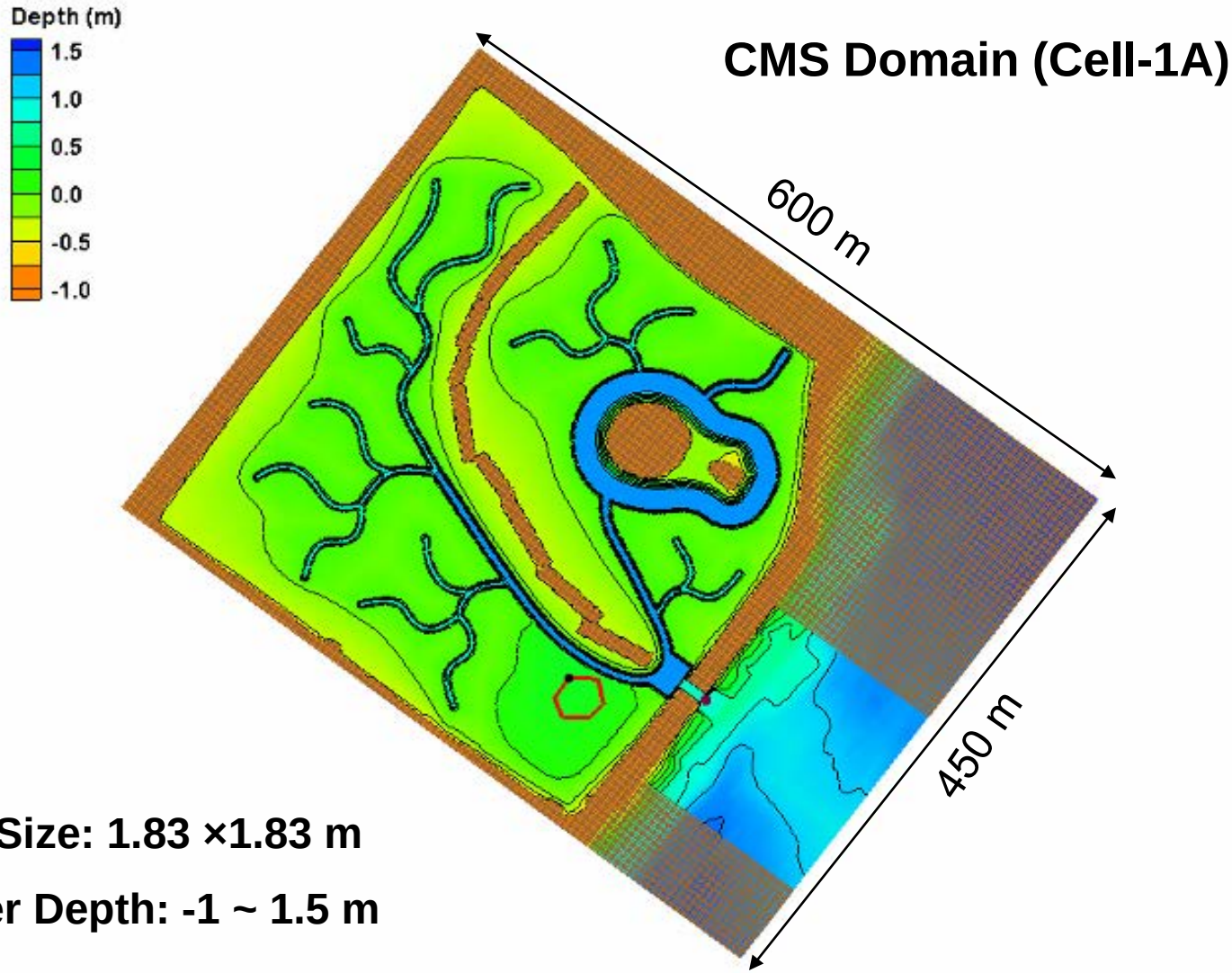
PTM Applications

Poplar Island, MD

Beneficial Use of Sediment Dredged from Navigation Channel



Poplar Island, MD



Cell Size: 1.83 ×1.83 m

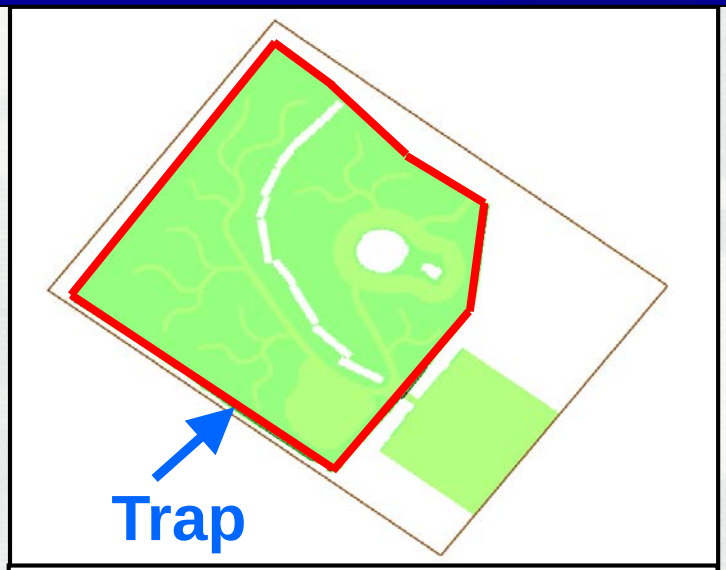
Water Depth: -1 ~ 1.5 m

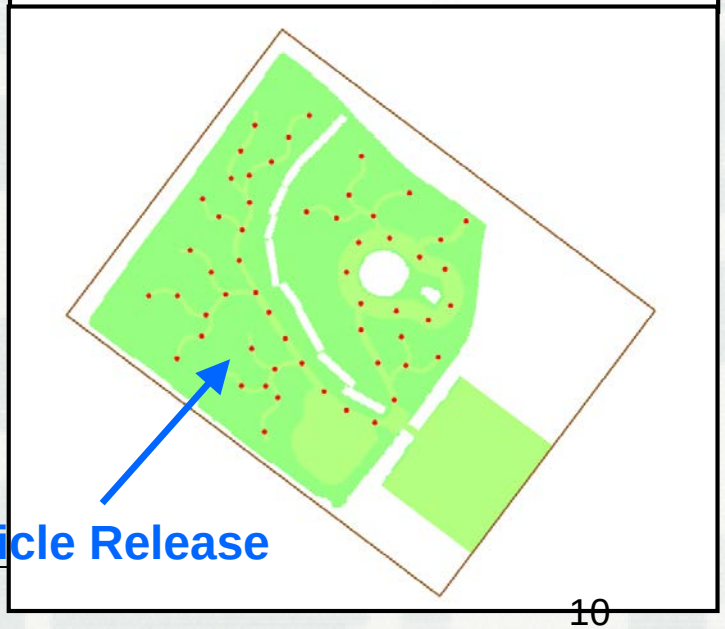
Residence Time

Residence Time:

Time Particles Exit Trap – Time Particles Enter Trap
(TIME OUT) (TIME IN)

- 57 particle point sources
  Instant mass release
- Space Distance
  ~30 m
- Time interval of release
  1 hour
- Release duration
  12 hours (1 tidal cycle)

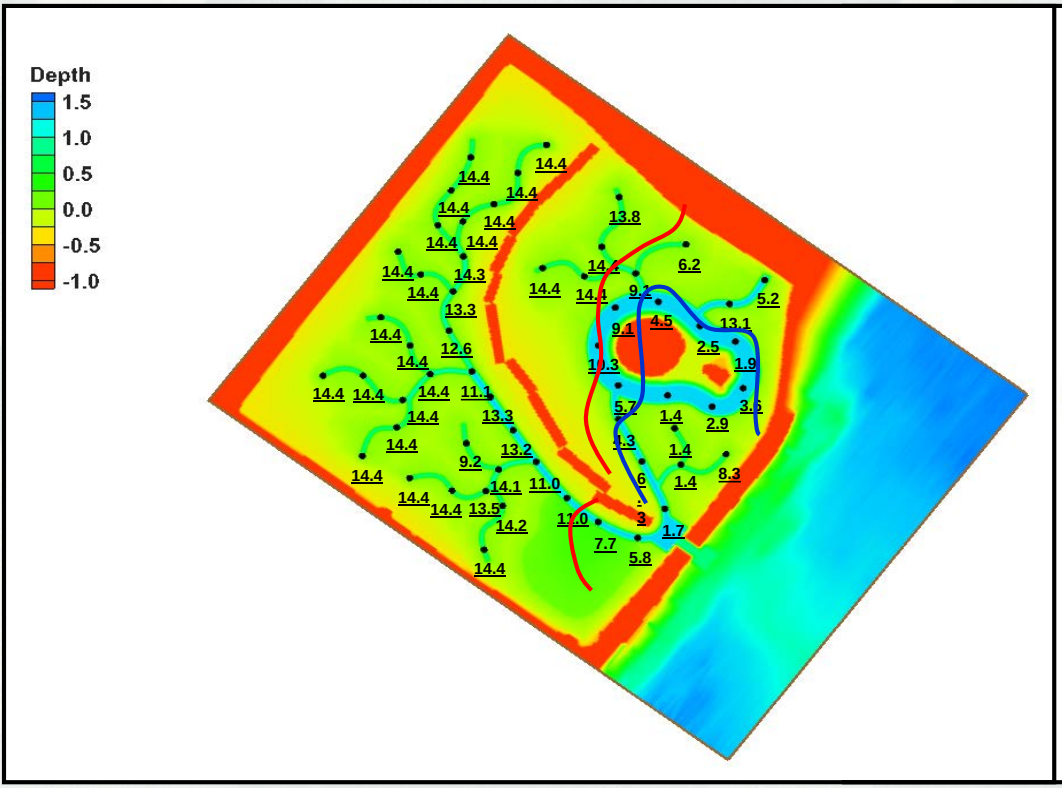




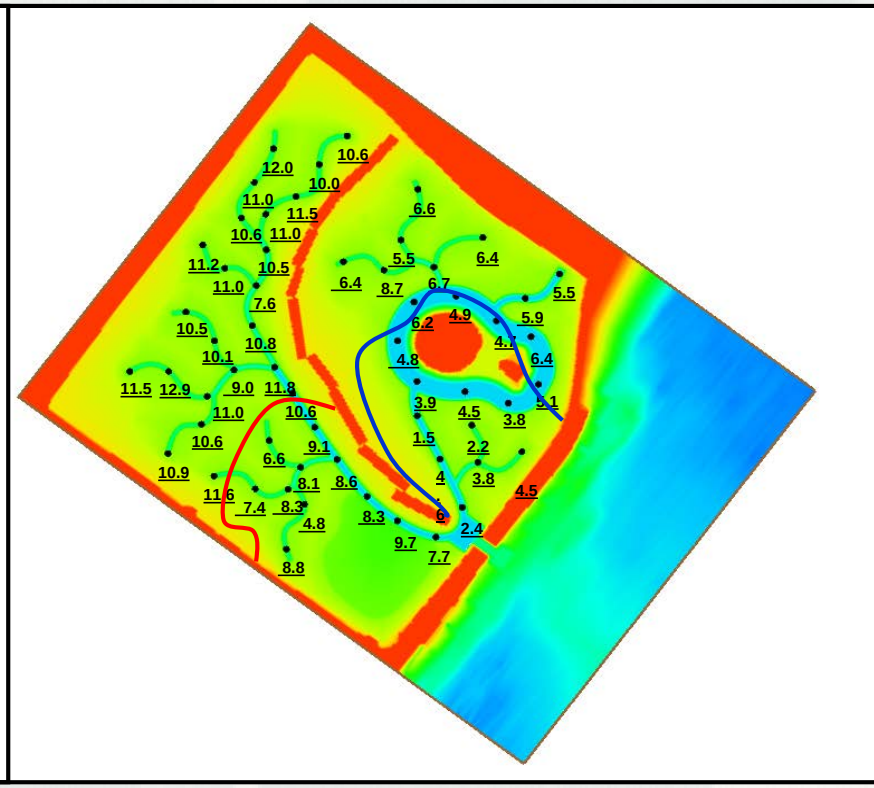
Residence Time

Neutrally Buoyant Particles

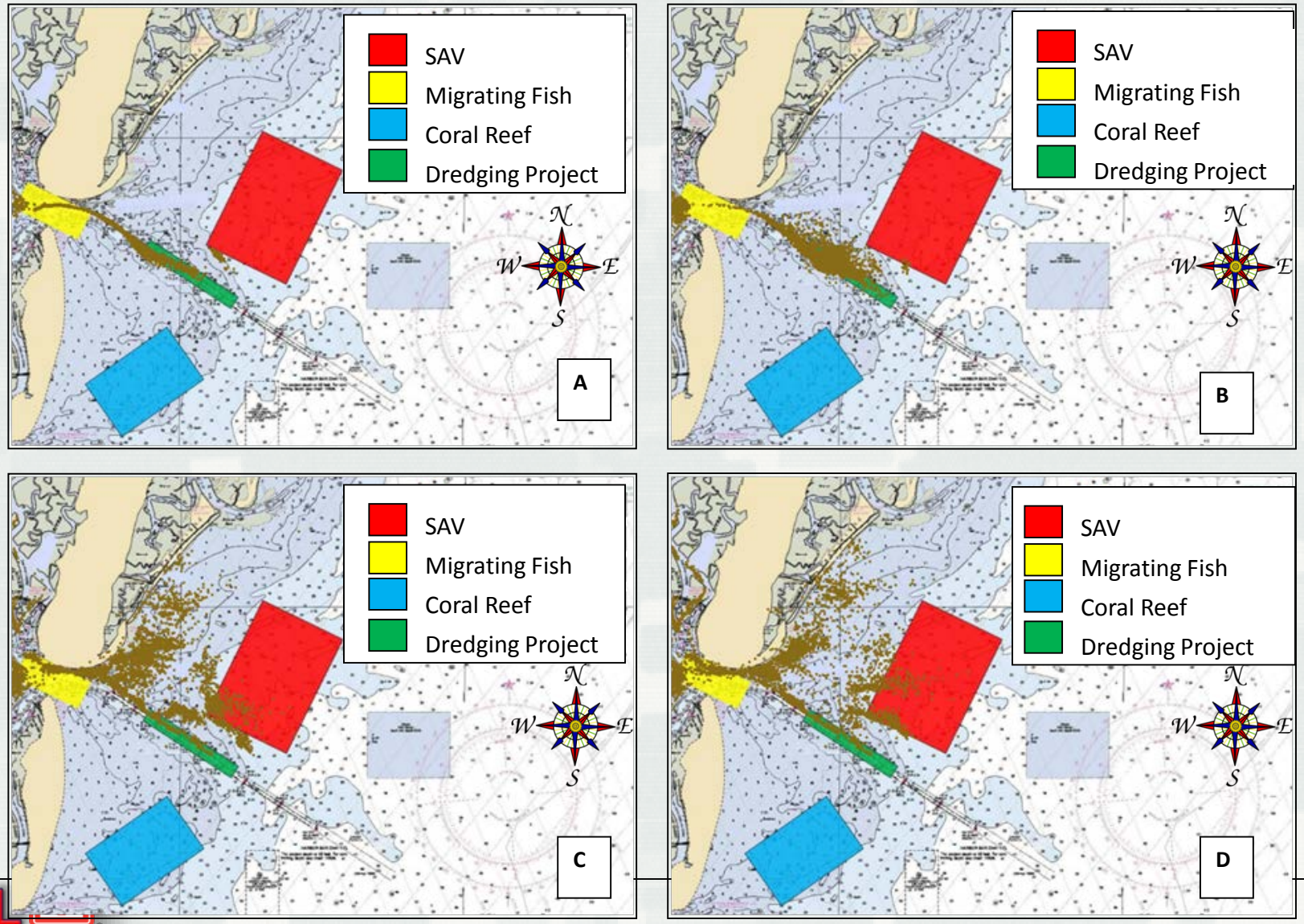
July 07-21, 2007



October 21-November 04, 2007



Dredging Materials and Management



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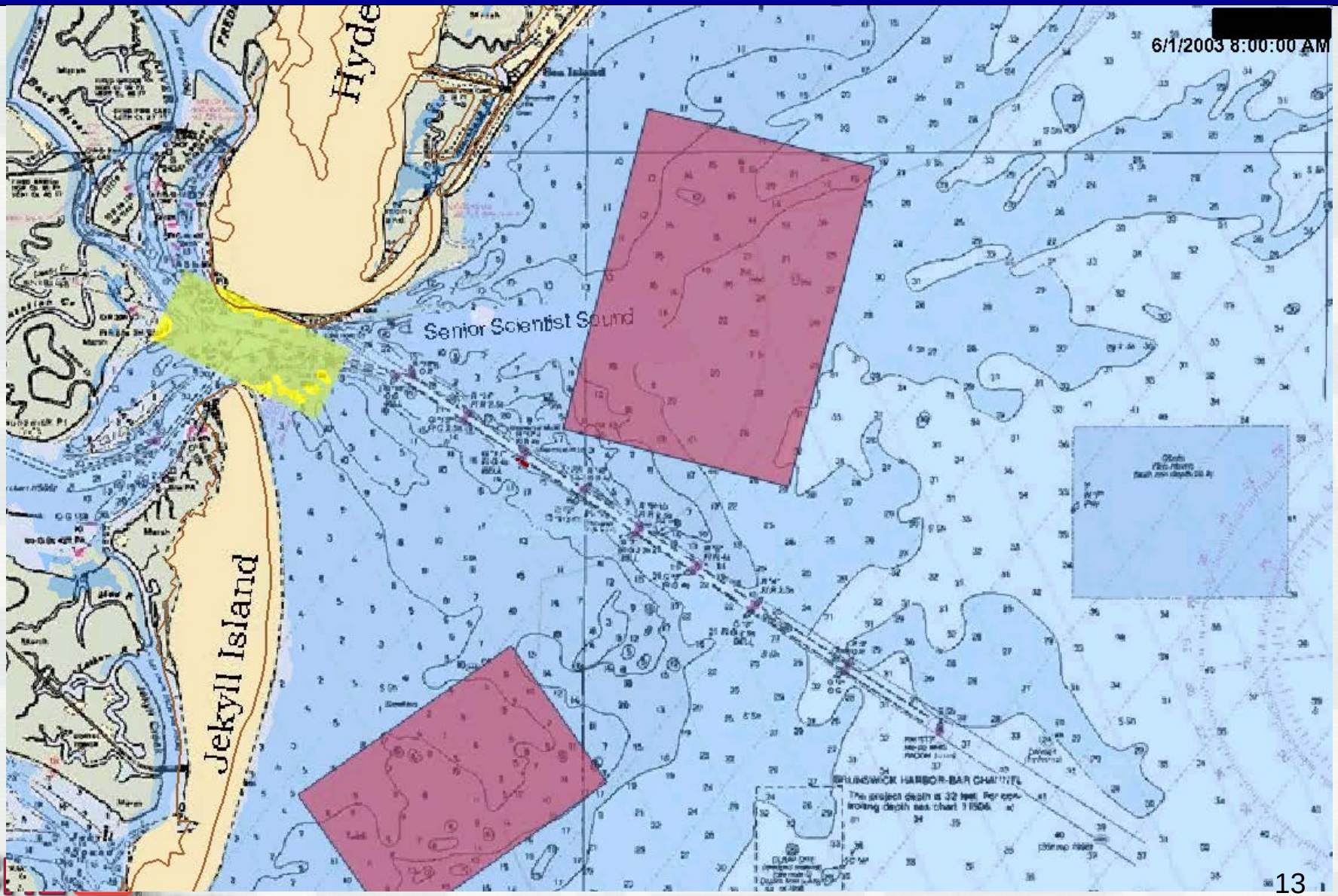
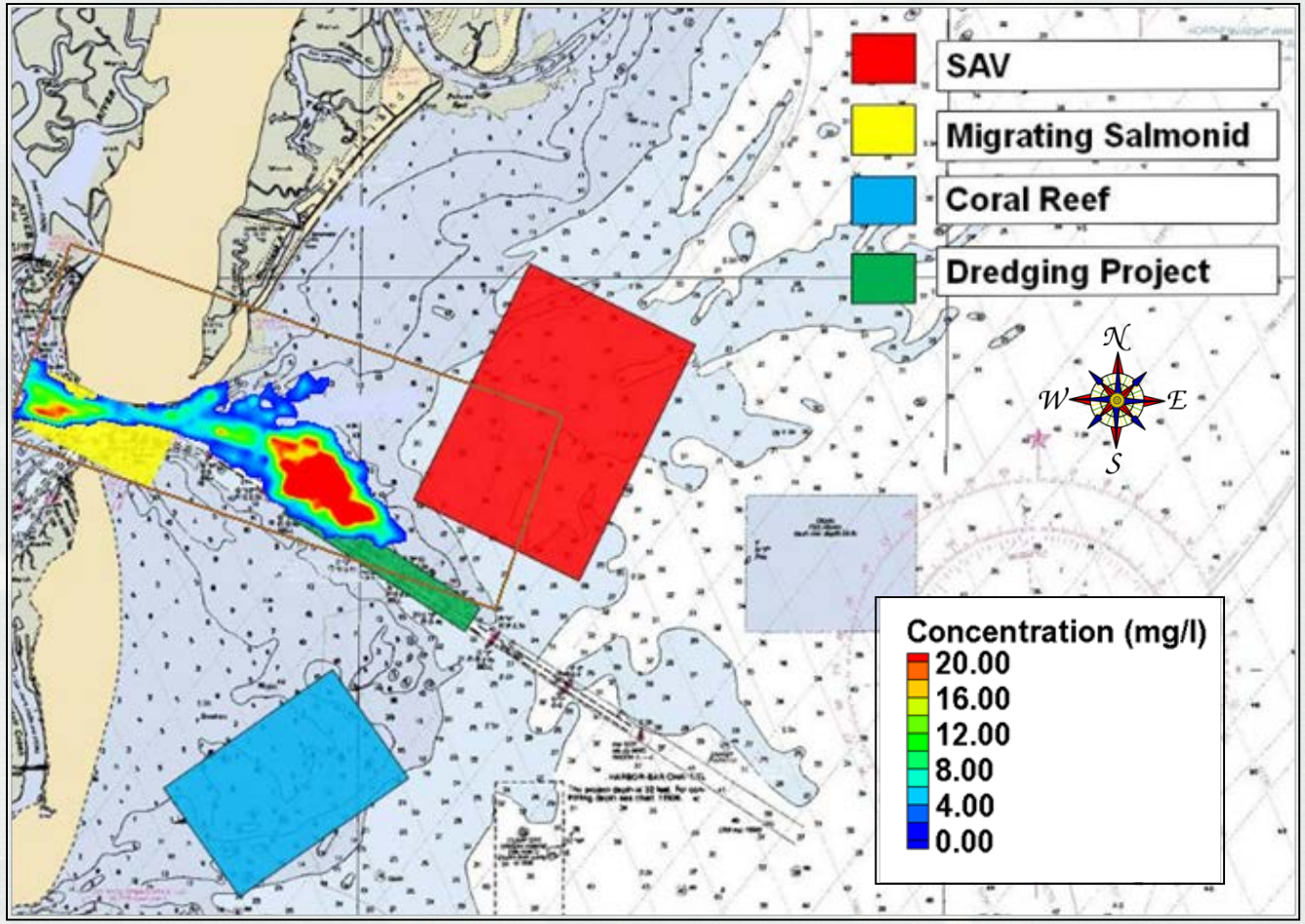


Suspended Sediment Concentration (Particle Density)



Dana Point Harbor, CA

- Sediment seepage increase through the permeable West Breakwater
- Sediment built up inside the breakwater ~ 3 to 5 k cy/year
- Dredge required in last two decades (1989, 1999, 2009)
- Needs for circulation and water quality improvement at Harbor and Baby Beach

Release of Neutrally Buoyant Particles

Simulation: 19-27 November 2009

Particles released within 12 hours, total number of released particles:1080

Release & Tracking Neutrally Buoyant Particles

Number of Particles Leaving Dana Point Harbor after Release
Total Number of Particles Released is 1080

Release Location	West of Baby Beach				East of Baby Beach				Channel			
Day after Release	Particle	Accu Particle	%	Accu %	Particle	Accu Particle	%	Accu %	Particle	Accu Particle	%	Accu %
1	99	99	9.2	9.2	88	88	8.1	8.1	662	662	61.3	61.3
2	120	219	11.1	20.3	84	172	7.8	15.9	33	695	3.1	64.4
3	51	270	4.7	25.0	43	215	4.0	19.9	5	700	0.5	64.9
4	50	320	4.6	29.6	41	256	3.8	23.7	18	718	1.7	66.6
5	25	345	2.3	31.9	34	290	3.1	26.8	11	729	1.0	67.6
6	27	372	2.5	34.4	35	325	3.2	30.0	7	736	0.6	68.2
7	19	391	1.8	36.2	27	352	2.5	32.5	3	739	0.3	68.5
8	5	396	0.5	36.7	10	362	0.9	33.4	3	742	0.3	68.8

Determine Sources of Sediment Responsible for Channel Infilling at Port Orford Port for Different Breakwater Configurations

CMS Grid and Setting

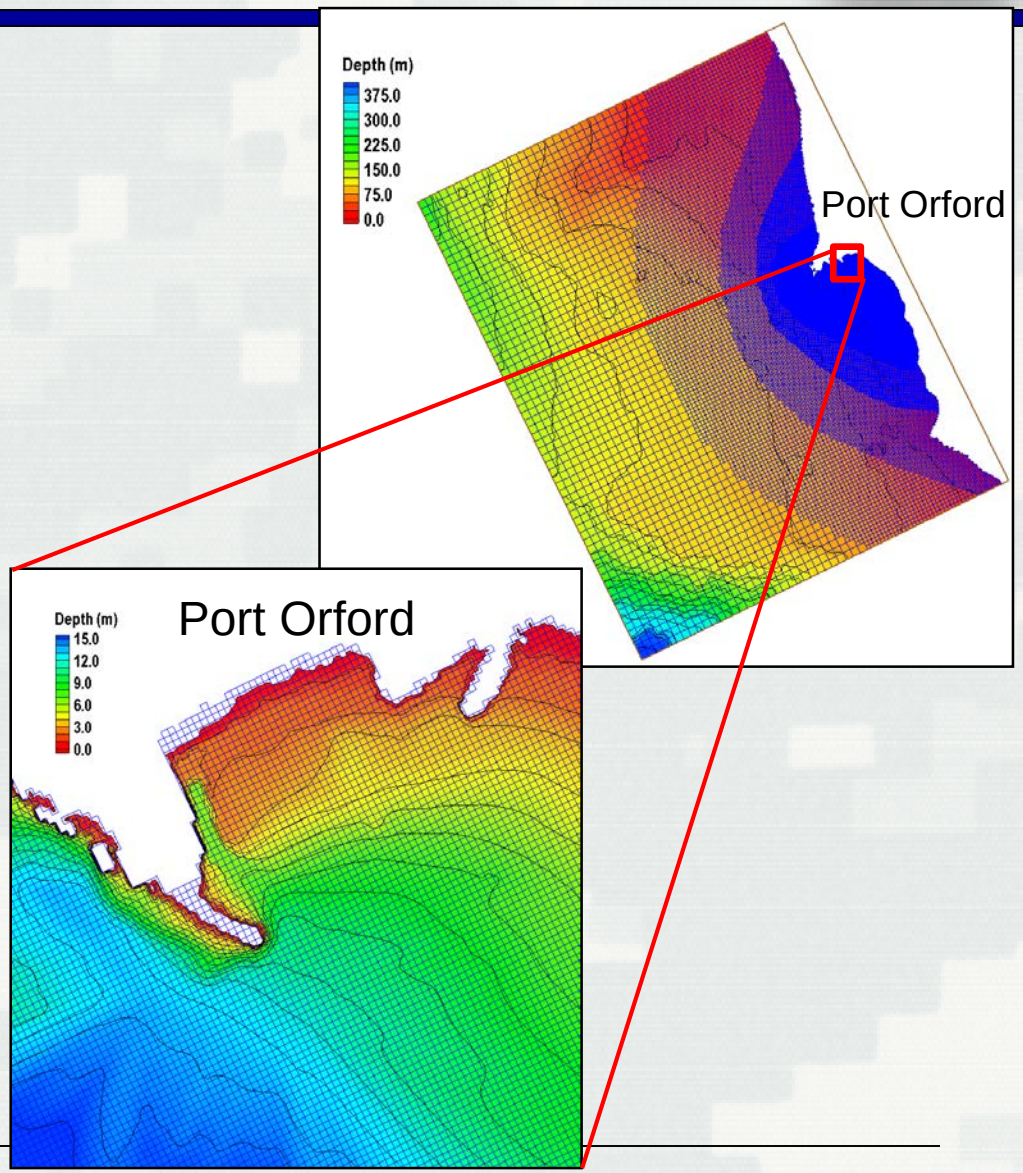
CMS-Flow:

Telescoping

Domain Size: 21 x 16 km

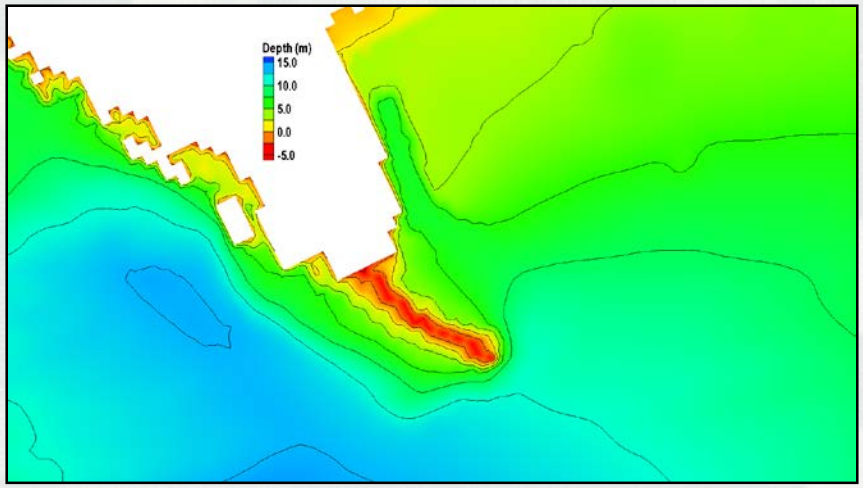
Cell Size: 10 to 3200 m

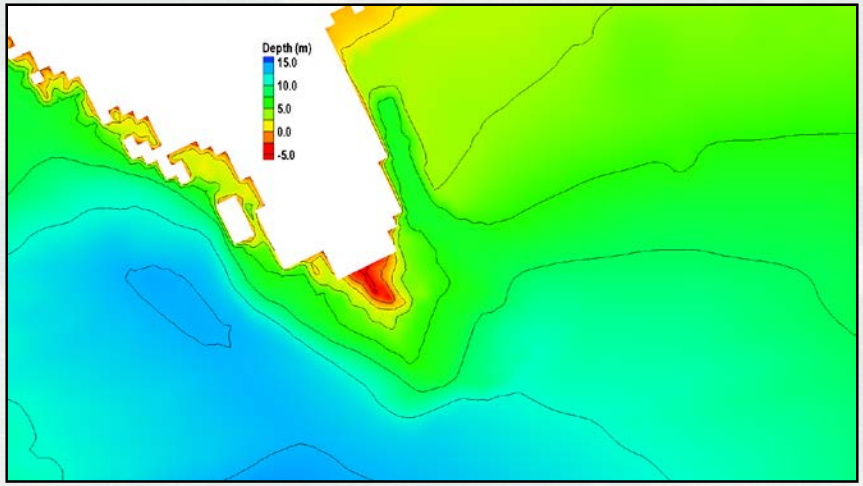
Water Depth: 0 to 400 m

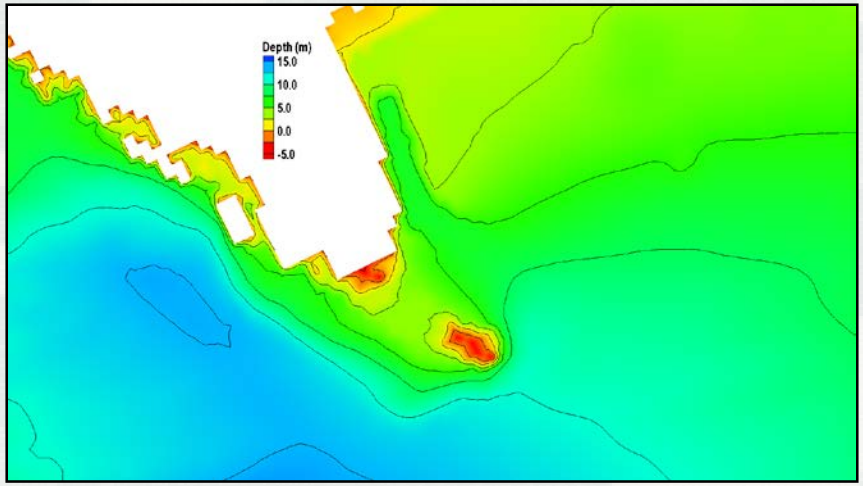


Breakwater Configuration

- Restore breakwater
  Crest elevation:16.1 ft above MSL
- Open mid-section notch
  Length: 250 ft
  Crest elevation: 8.9 ft above MSL
- Remove breakwater

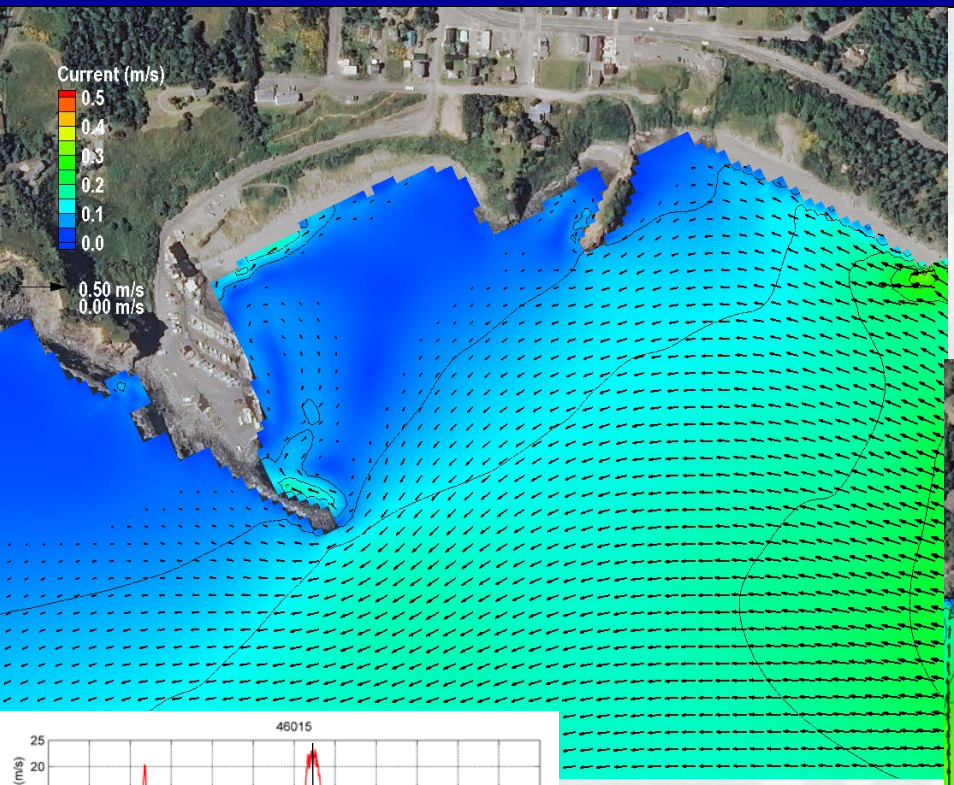


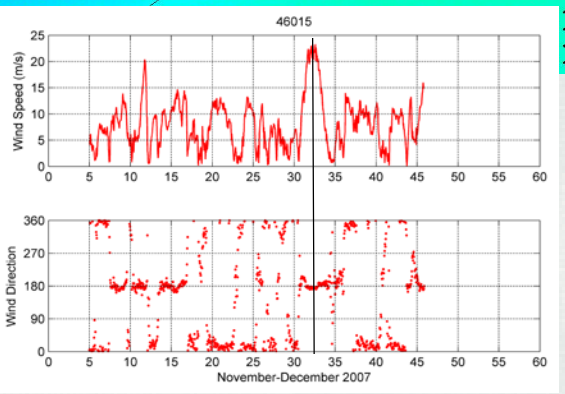


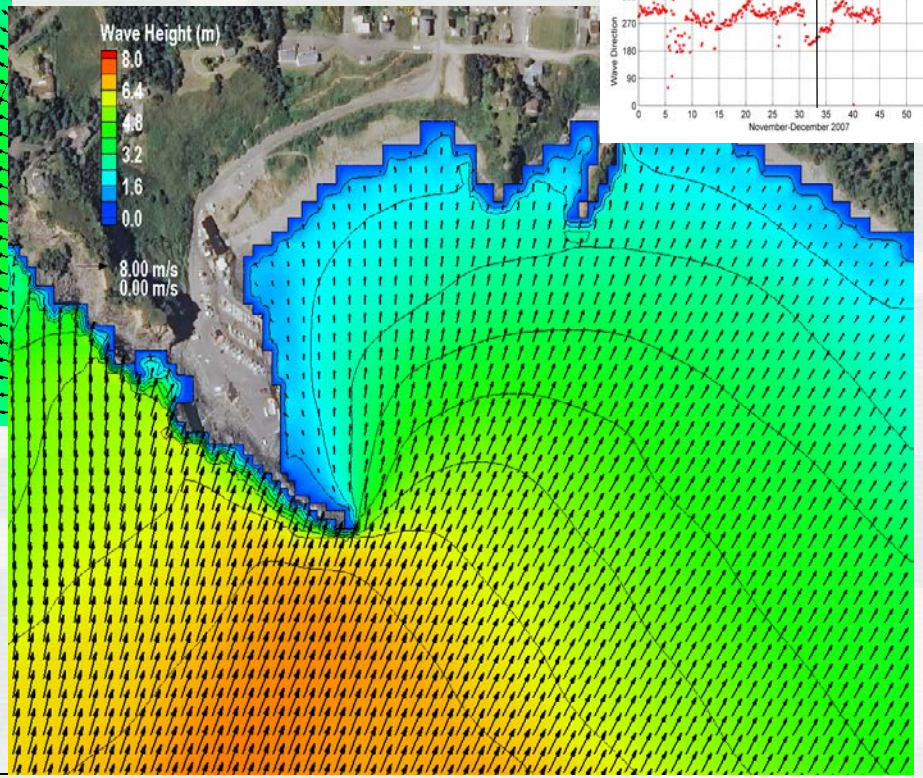


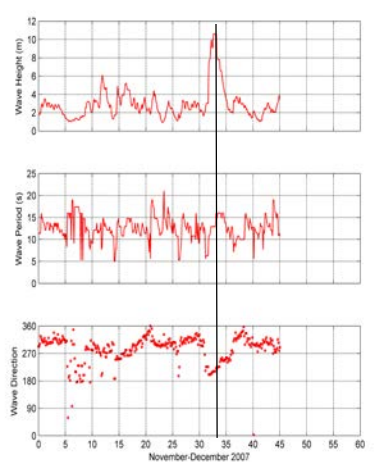
Current and Waves

(Extreme Winter Storm, 3 December, 2007)



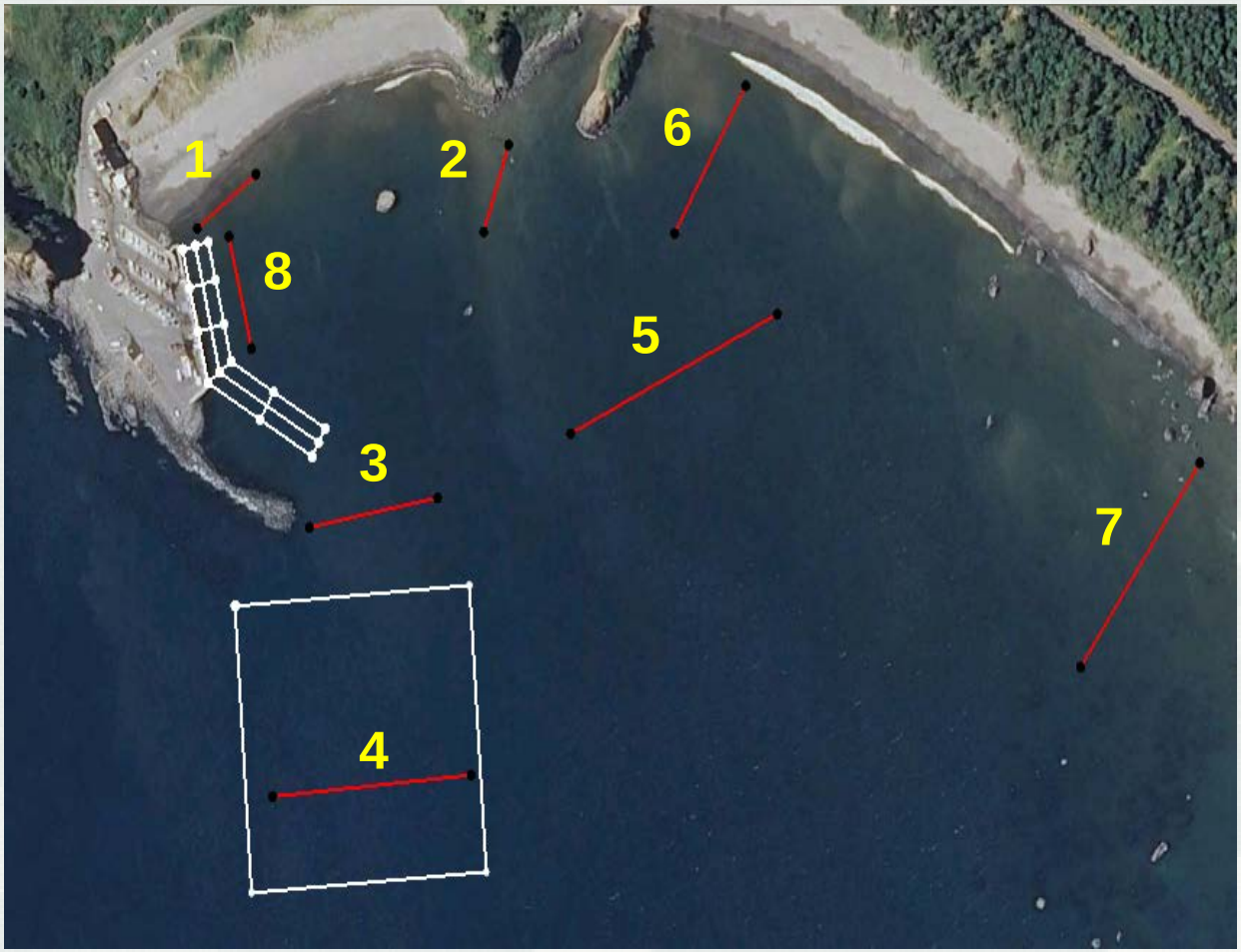




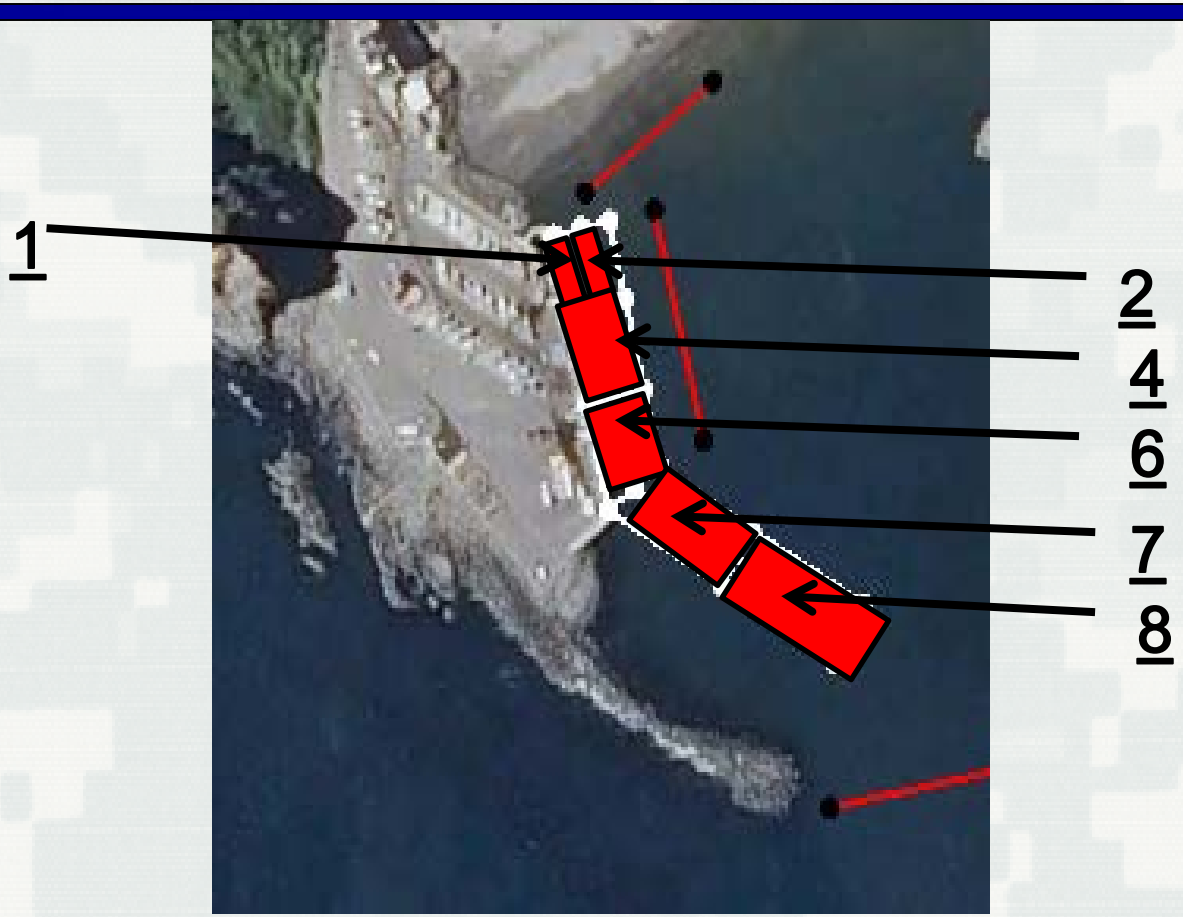


Source Locations

- Sediment sources locations were determined through consultation by:
  - ERDC Team
  - Portland District
  - Port of Port Orford
- Sources are erosion sources (particles are initially at the bed)

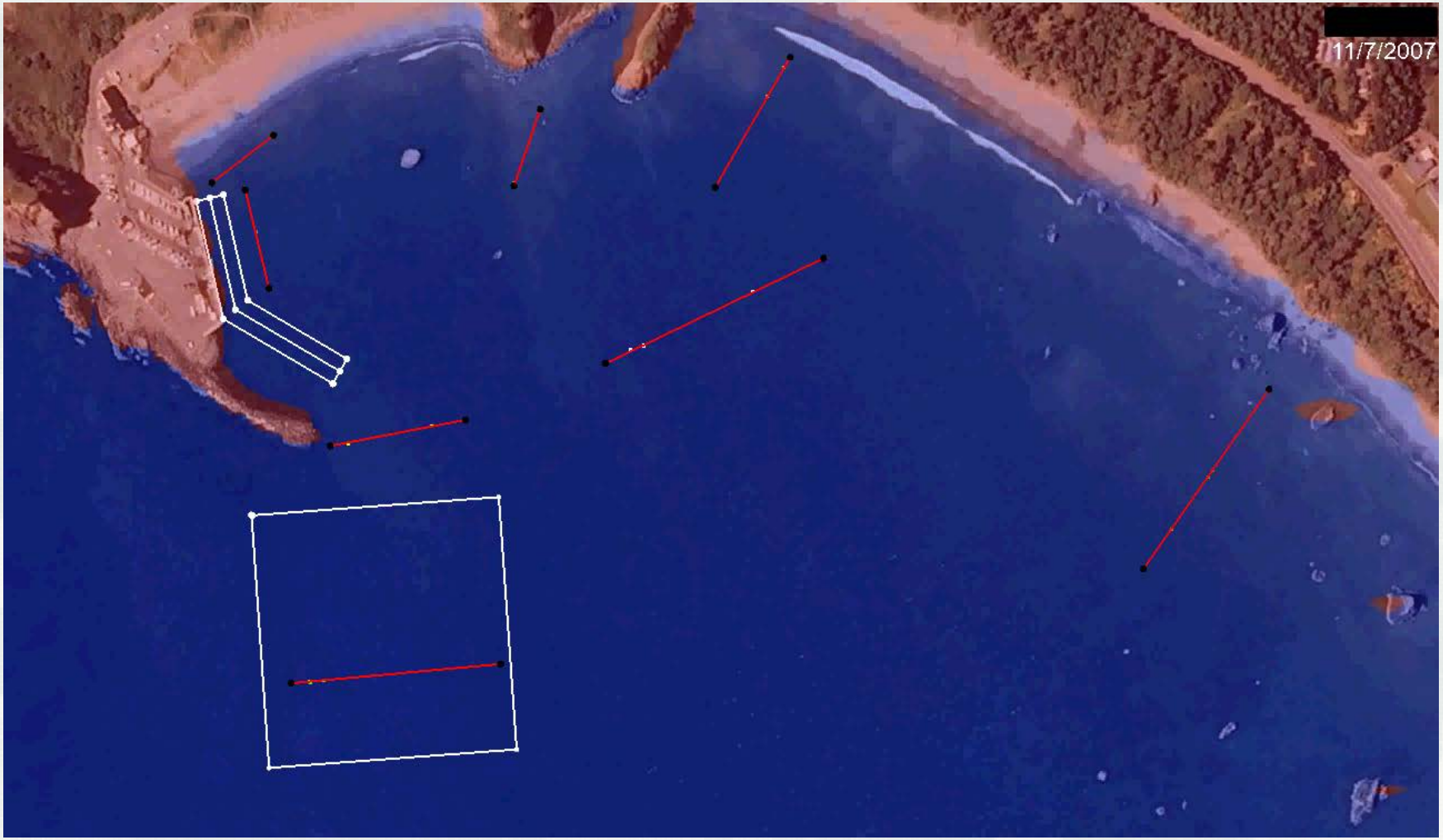


Analysis Traps

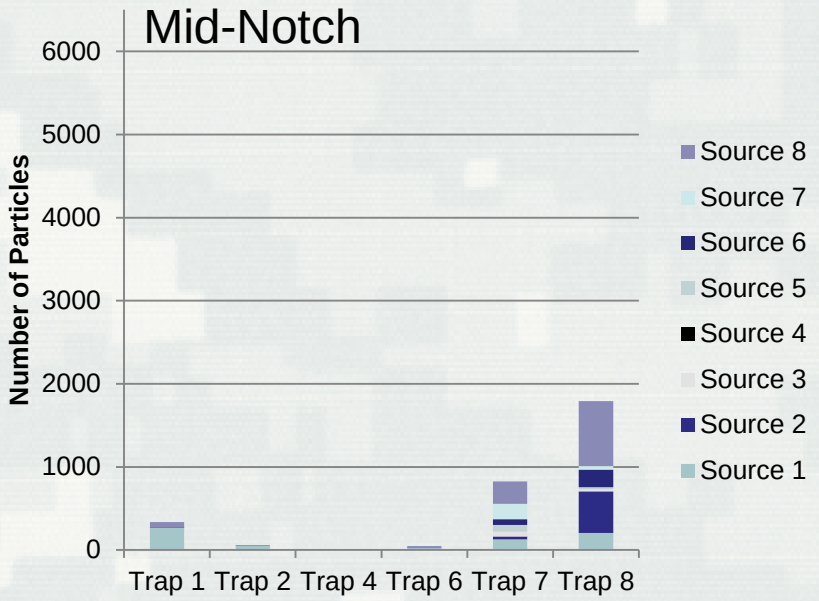


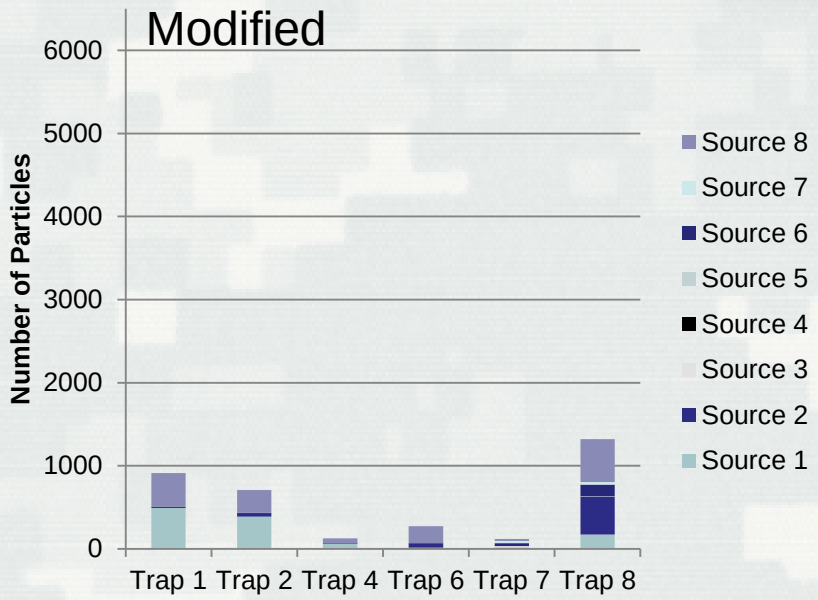
- A series of traps were developed for analysis purposes.
- Trap height is approximately half the depth.
- Traps are designed as closed traps (when a particle enters trap, it is counted and transport calculations for the particle ceases)

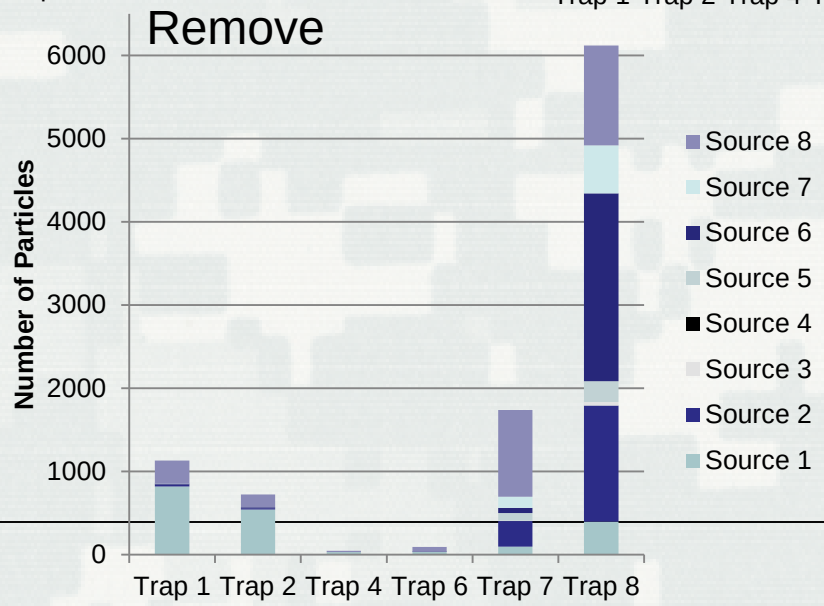
Modified Breakwater



Comparison (Nov/Dec)







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, http://cirp.usace.army.mil/pubs/chetns/CHETN-IV-71.pdf.

- Li, H., and N. J. MacDonald. 2012. Use of the PTM with CMS Quadtree Grids. Coastal and Hydraulics Engineering Technical Note CHETN IV-82. Vicksburg, MS: U.S. Army Engineer Research and Development Center, http://cirp.usace.army.mil/pubs/chetns.php.

- 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, http://cirp.usace.army.mil/pubs/pdf/TR-06-20.pdf.