Webinar on PTM with CMS

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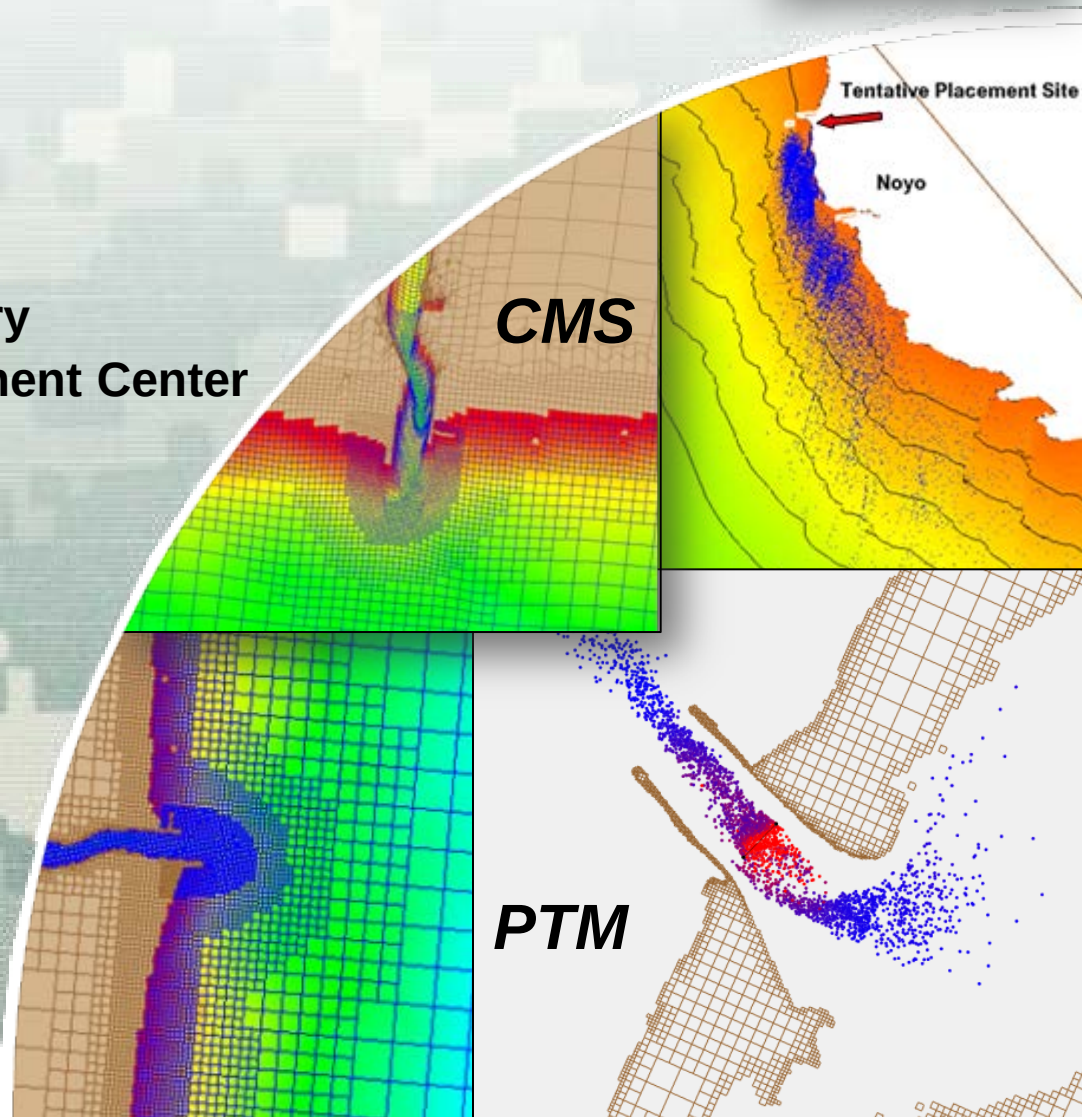

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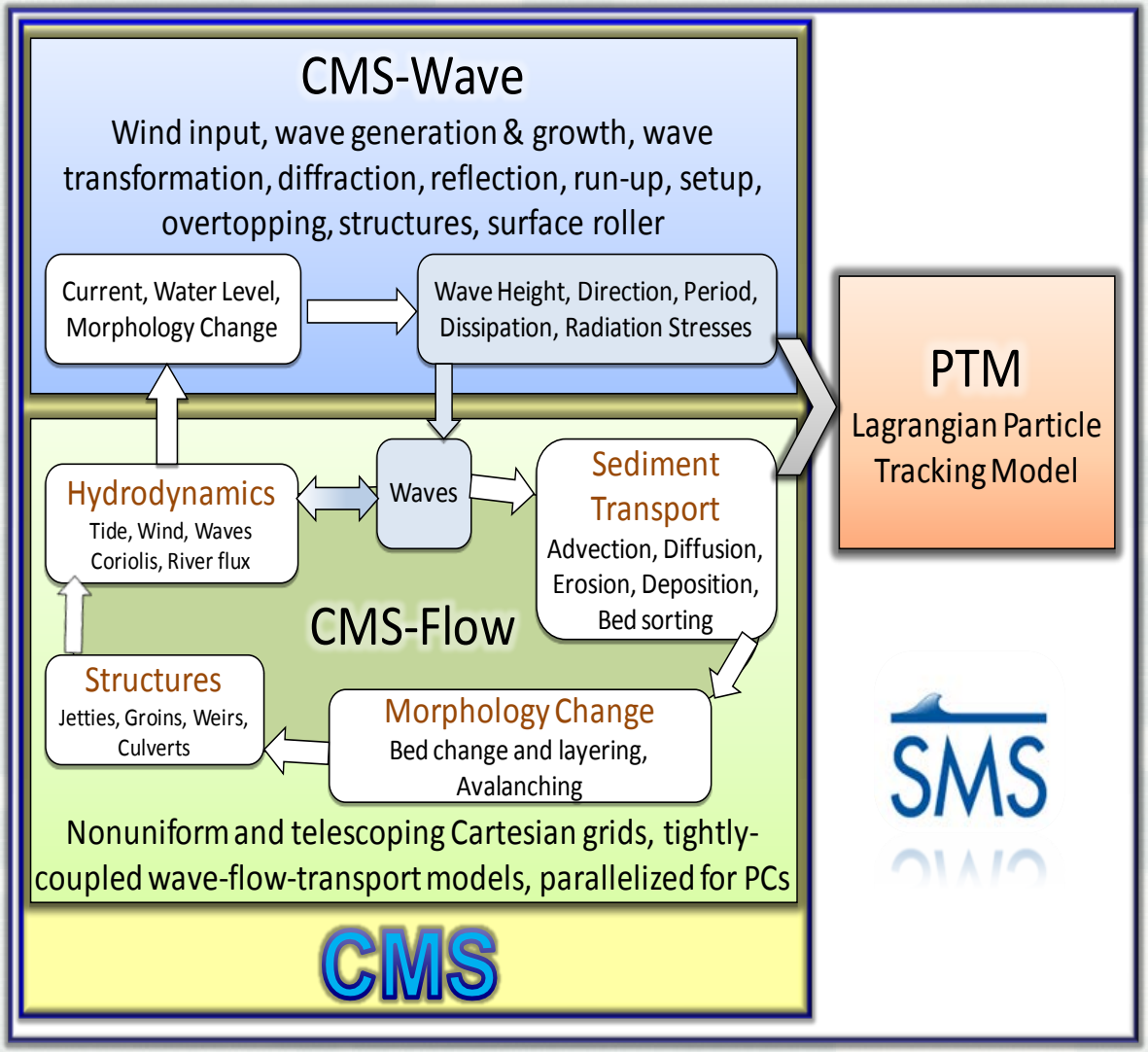
Introduction to CMS

Coastal Modeling System

Integrated waves, current, and sediment transport model in the Surface-water Modeling System (SMS)

CMS-Flow and CMS-Wave

Coupled with Particle Tracking Model (PTM)



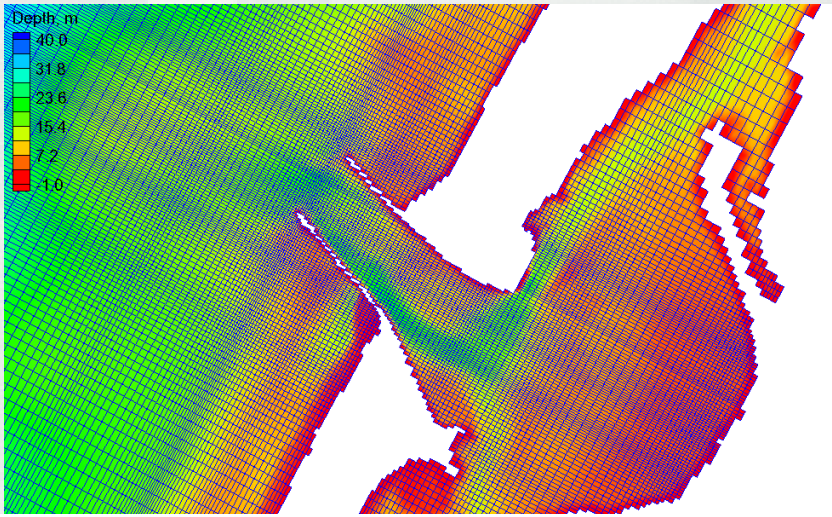
Objective

- Deliver to engineers' desktops advanced models that can be used as practical tools for coastal inlets, coastal navigation channel, and adjacent beach studies.
  - Models efficiently coupled to simulate relevant physical processes
  - PC-based, user-friendly interface, fast, robust and accurate
  - Manuals, tech reports, journal papers, Wiki, workshops, phone help, etc.

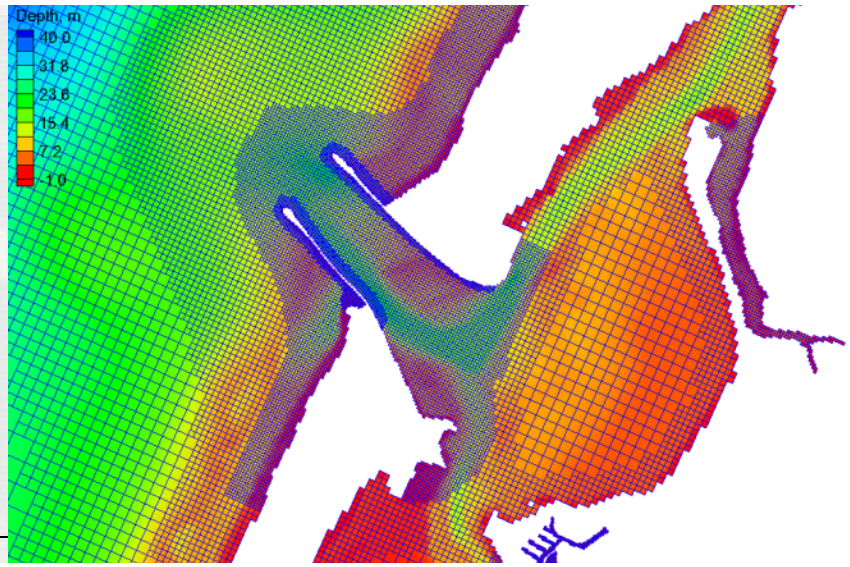
CMS-Flow: Key Features

- Grid options
  - Non-uniform Cartesian grid: Easy to setup
  - Quadtree (telescoping) grid: Efficient, flexible (presently, only available for Implicit model)
- Solver options
  - Implicit: Tidal flow, long-term morphology change, parallel processing.

    ~5 - 30 minute time step
  - Explicit: Flooding, breaching, super-critical flow. ~1 second time step, parallel processing



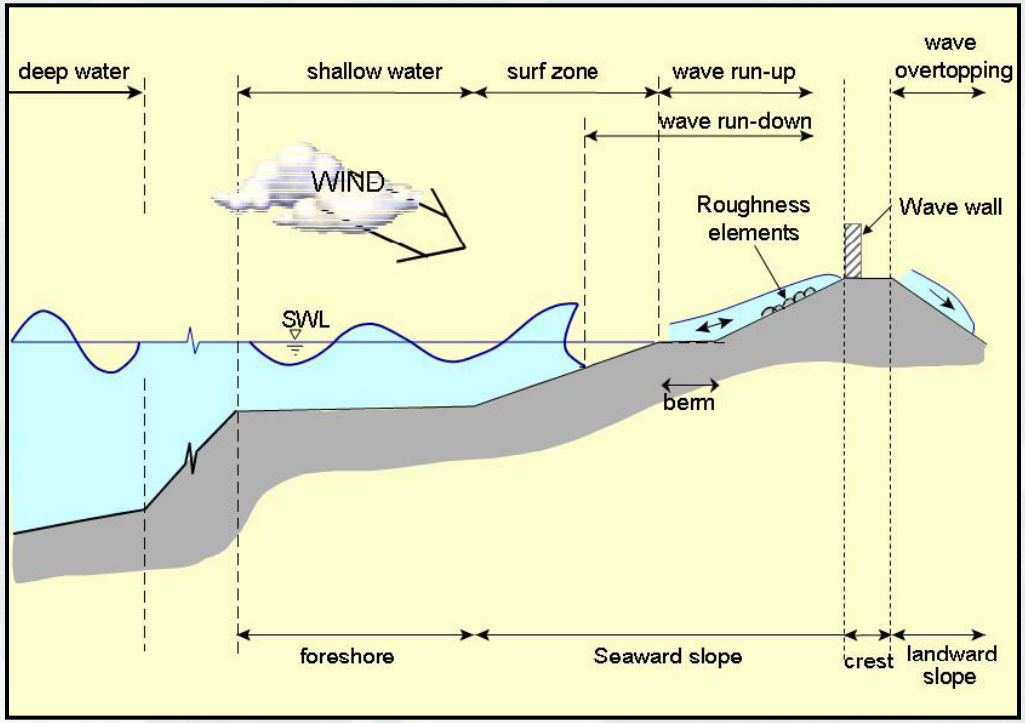
Non-uniform Cartesian grid (Variable spacing)



Quadtree grid (Telescoping)

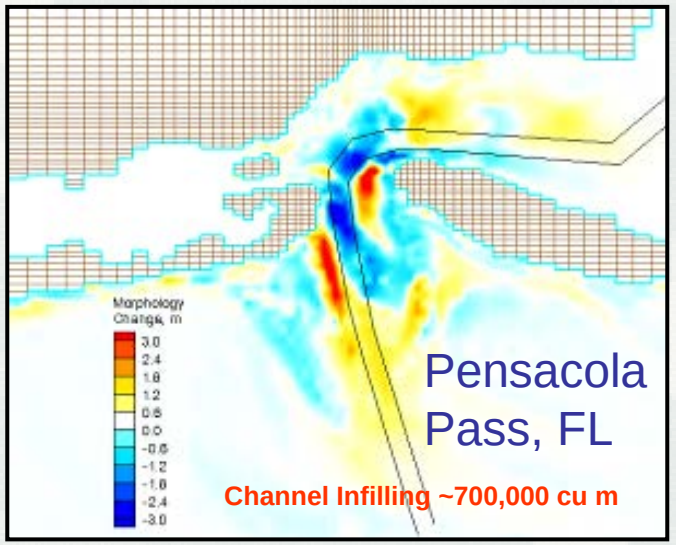
CMS-Wave: Key Features

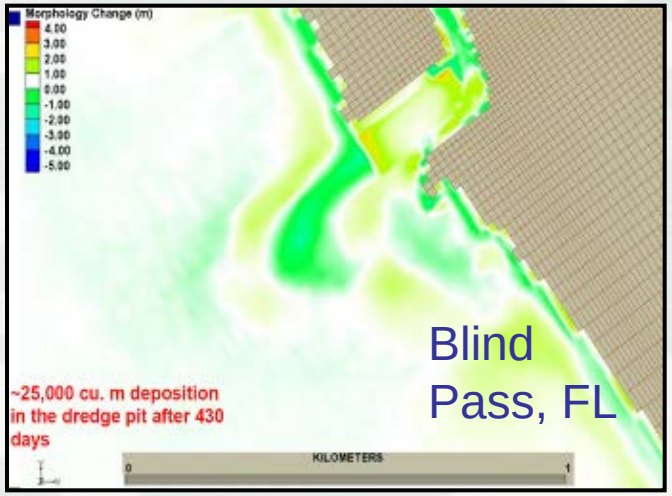
- Shoaling, refraction, diffraction, reflection
- Bottom friction
- White capping
- Wave breaking (4 options)
- Wind generation
- Wave-current, and wave-wave interactions
- Transmission, runup and overtopping
- Muddy bottom
- Automatic grid rotation
- Non-uniform Cartesian grid with nesting capability
- “Fast Mode”



Sediment Transport: Key Features

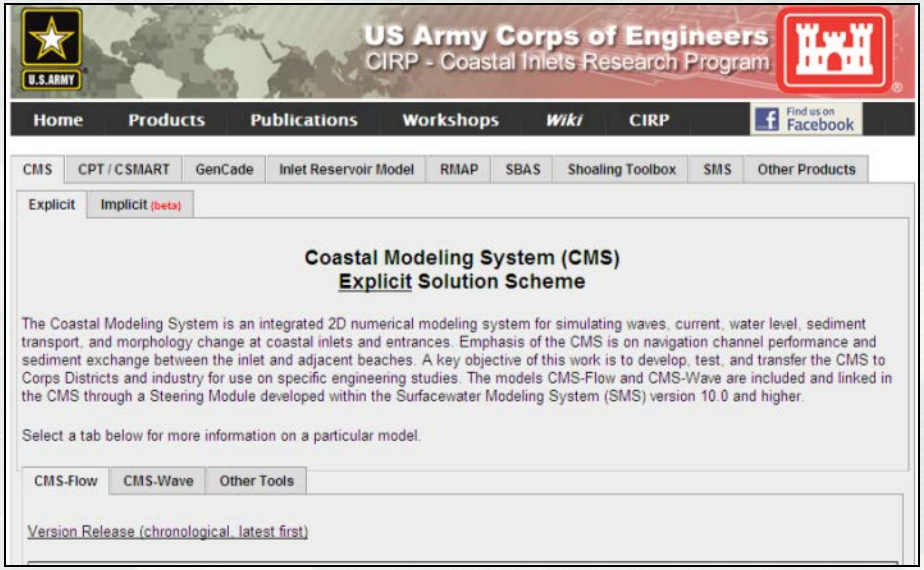
- Sediment transport models
  - Equilibrium Total Load (Exner equation)
  - Eq. Bed Load + Advection-Diffusion (AD) Suspended Load
  - Non-Eq. (AD Total Load)
- Sediment transport formulas
  - Lund-CIRP
  - Van Rijn
  - Watanabe
  - Soulsby
- Hard-bottom
- Avalanching
- Bed slope influence on bed load
- Multiple-sized sed. transport (NEW)





Documentation

- Products
  - CMS
  - GenCade
  - Others
- Publications
  - Technical Reports
  - CHETNS
  - Journal Articles
  - Others
- Tech Transfer
  - Upcoming
  - Recent



CIRP website

http://cirp.usace.army.mil/

CIRP wiki

http://cirpwiki.info/

Introduction to PTM

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

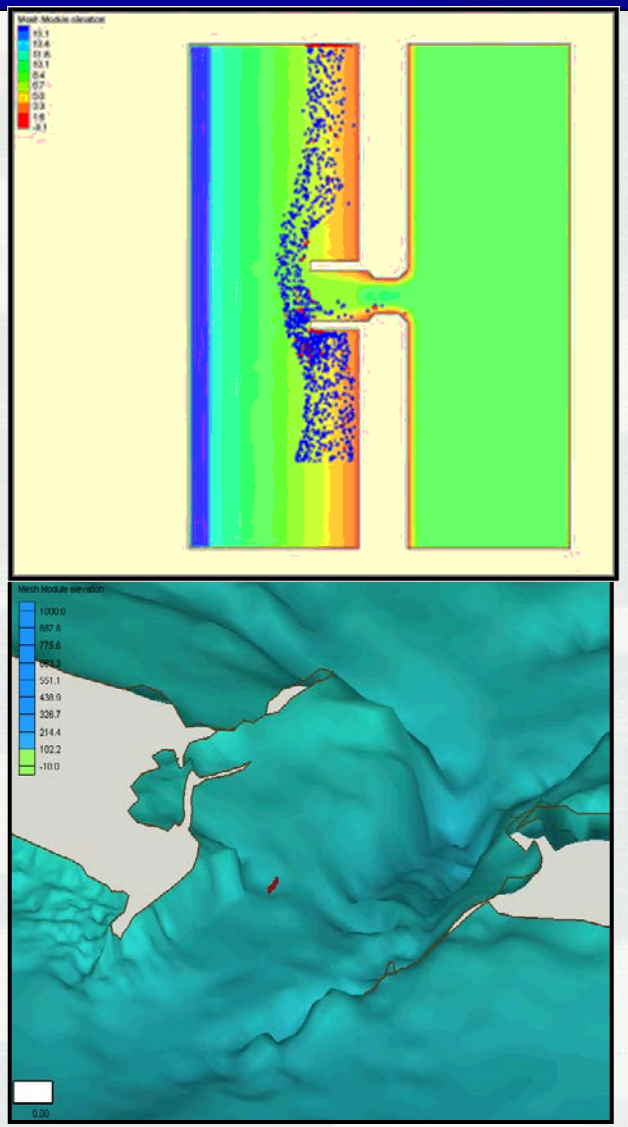
Time-dependent Particle Positions P(t,X,Y,Z)

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

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

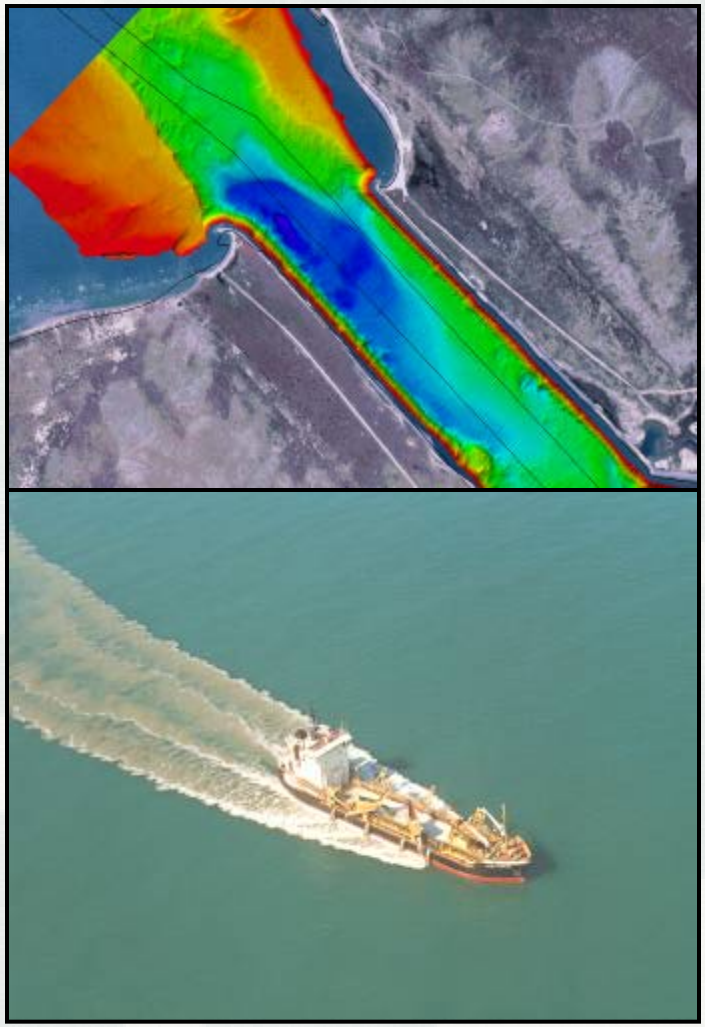
Calculations in the PTM

- 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



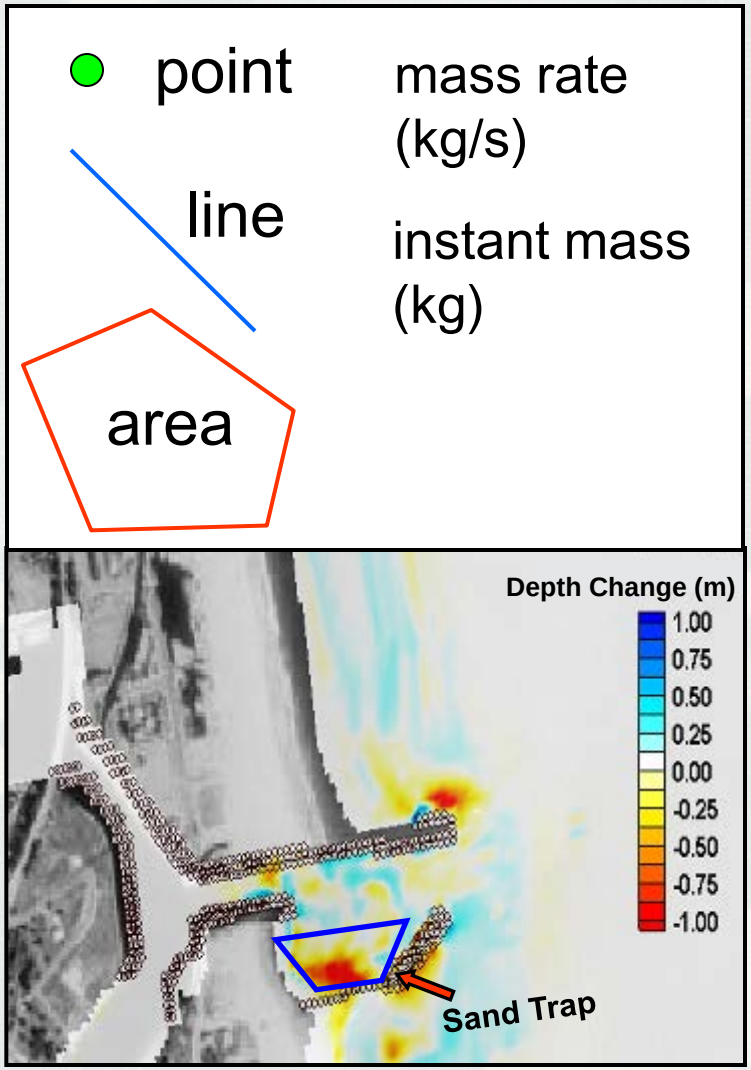
PTM Capabilities

- 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 …



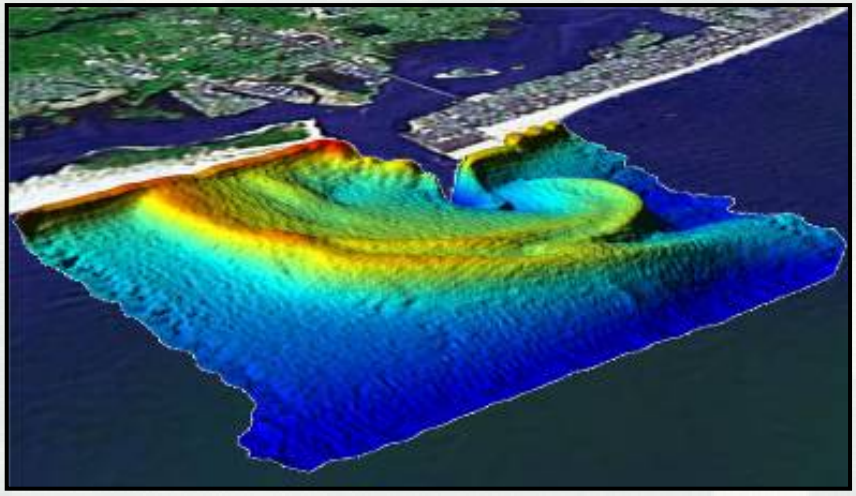
Sediment Sources and Traps

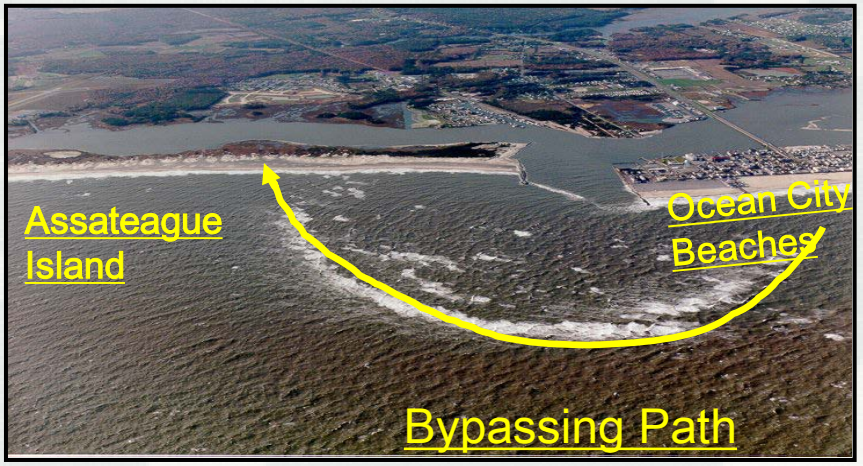
- User-specified particle sources
  - Temporally- and spatially-varying point, line, or area sources
  - Mimic complicated dredging operations
- Particle traps
  - Used to monitor (count/collect) particles
  - Trap types may be defined as a line or area (zone or region)
- Residence time and spatial maps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

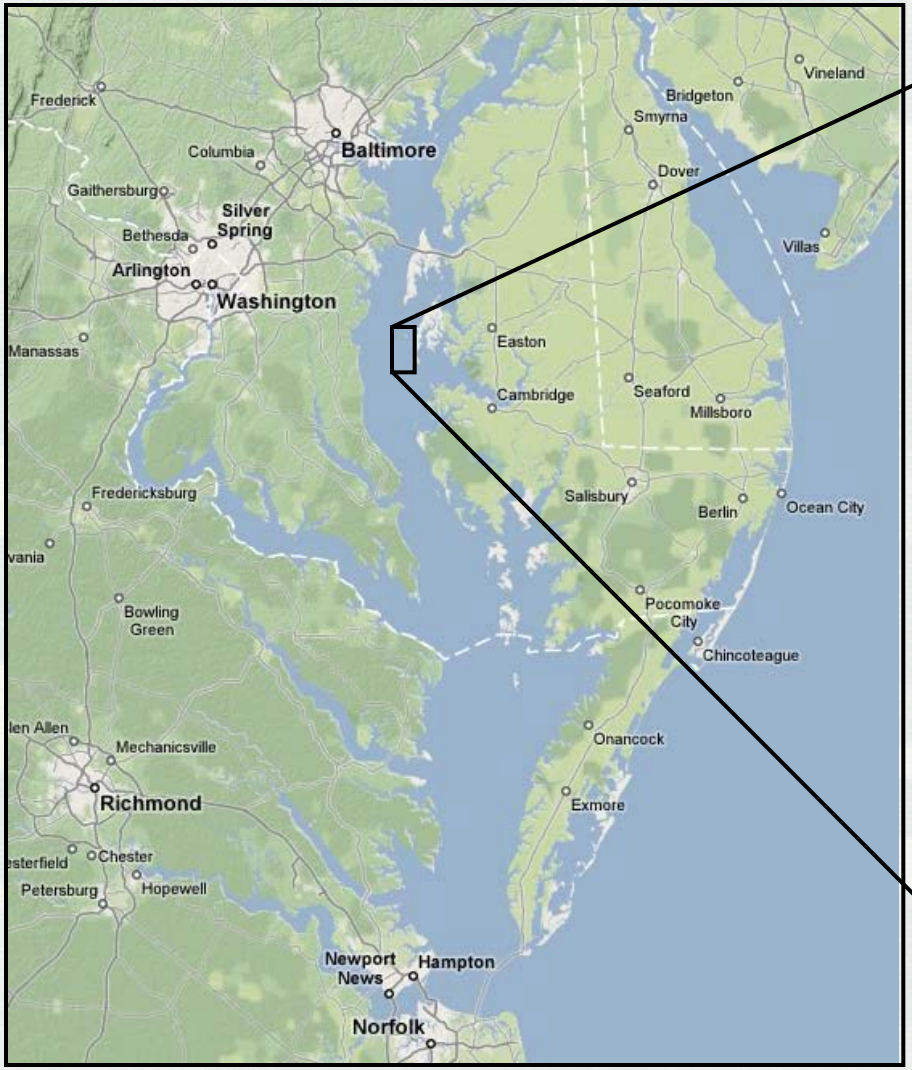




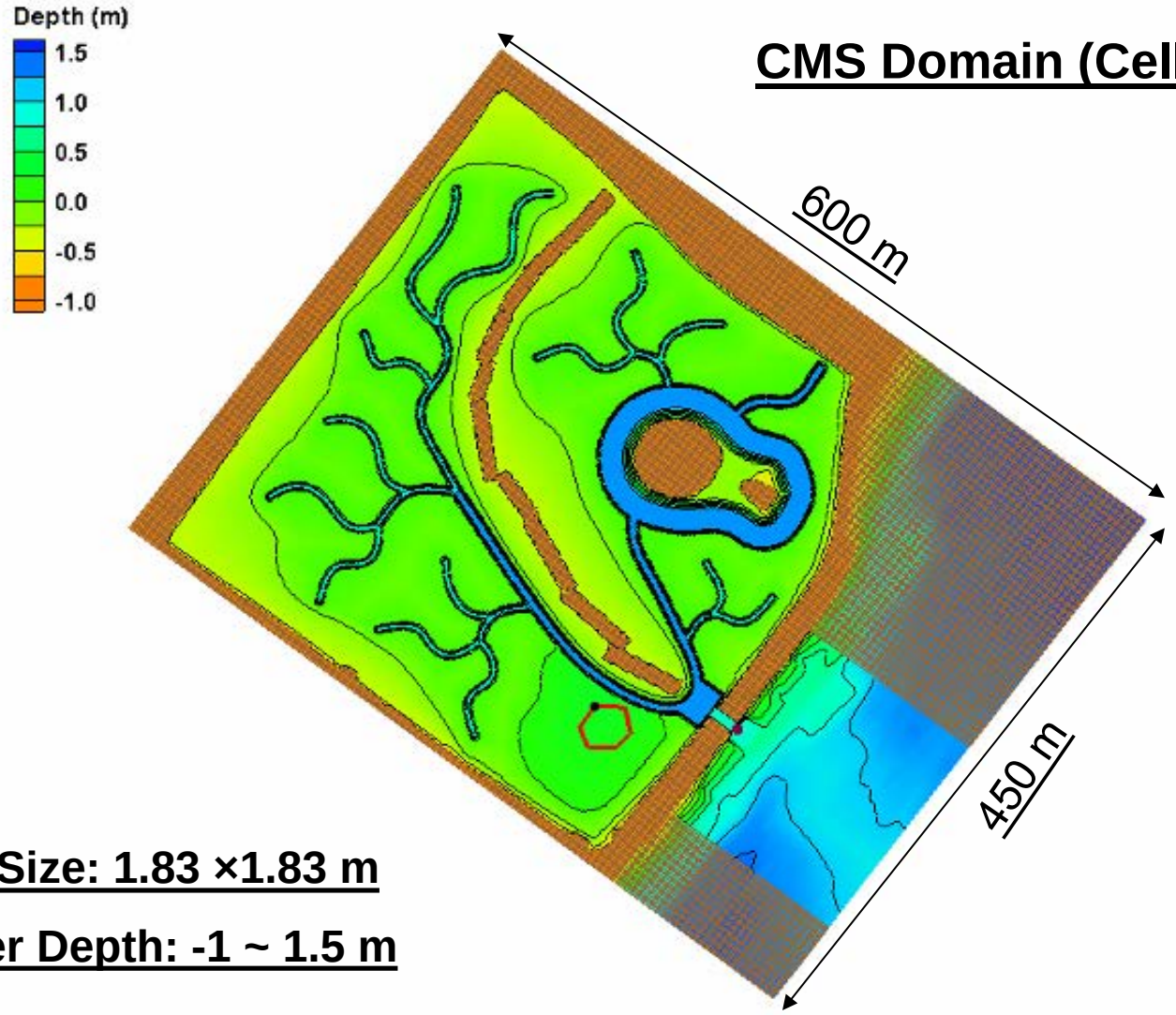
PTM Applications

Poplar Island, MD

Beneficial Use of Sediment Dredged from Navigation Channel



Poplar Island, MD



Cell Size: 1.83 ×1.83 m

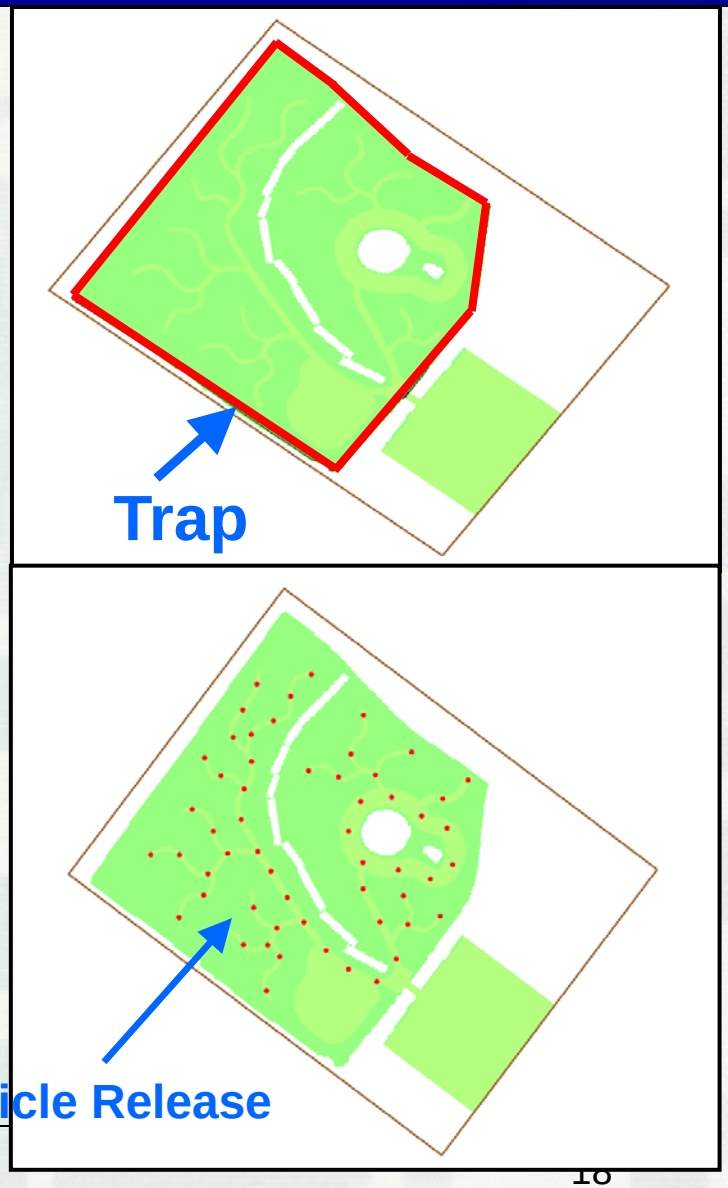
Water Depth: -1 ~ 1.5 m

Residence Time

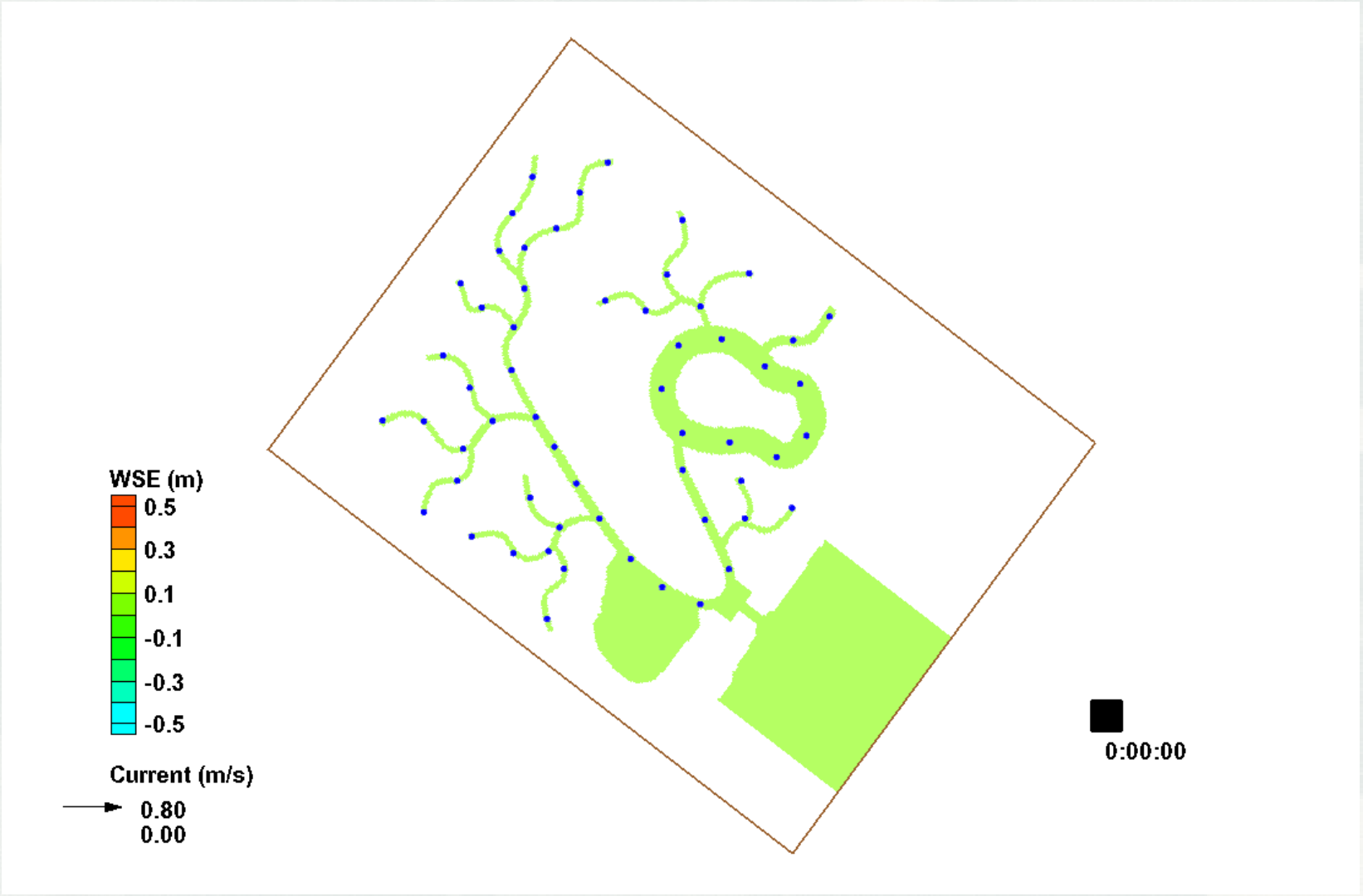
Residence Time:

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)



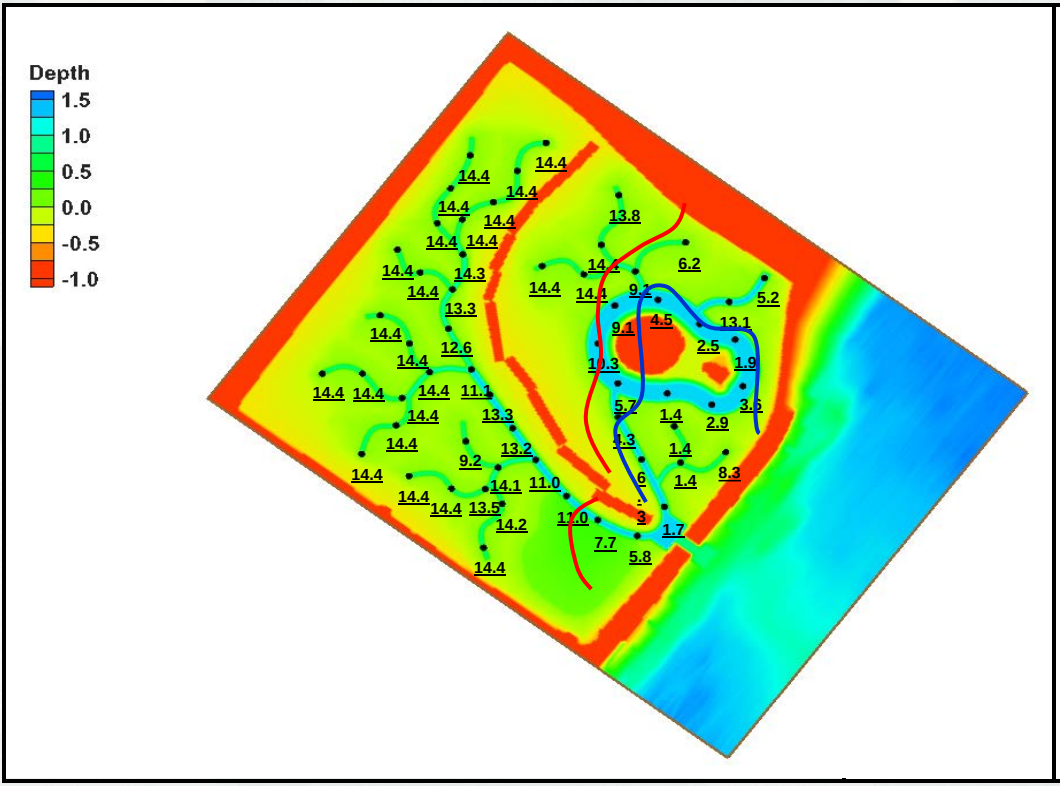
Residence Time



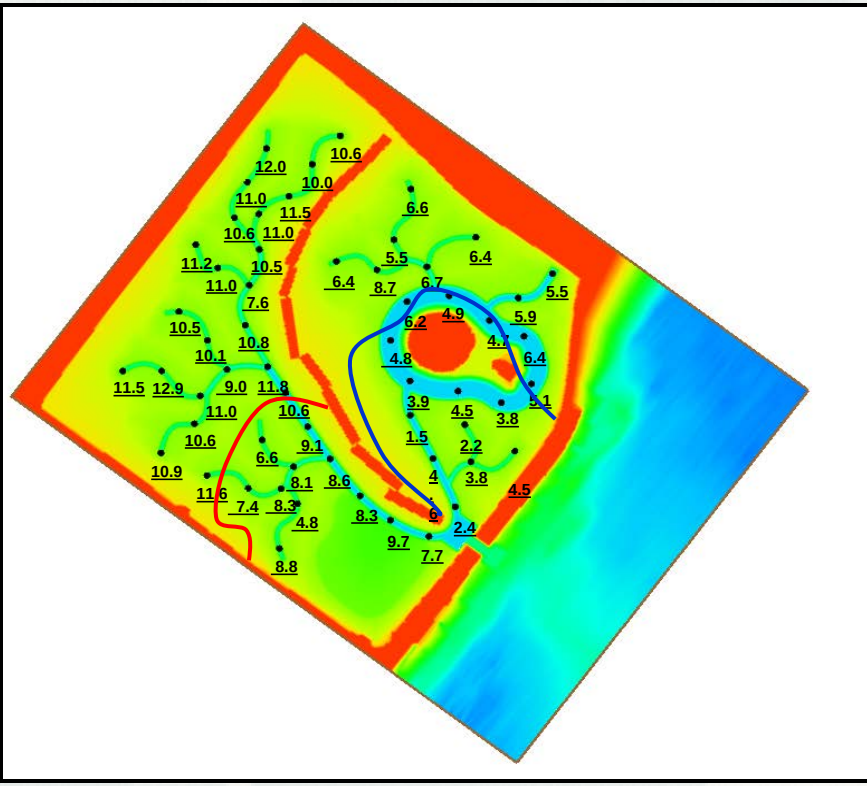
Residence Time

Neutrally Buoyant Particles

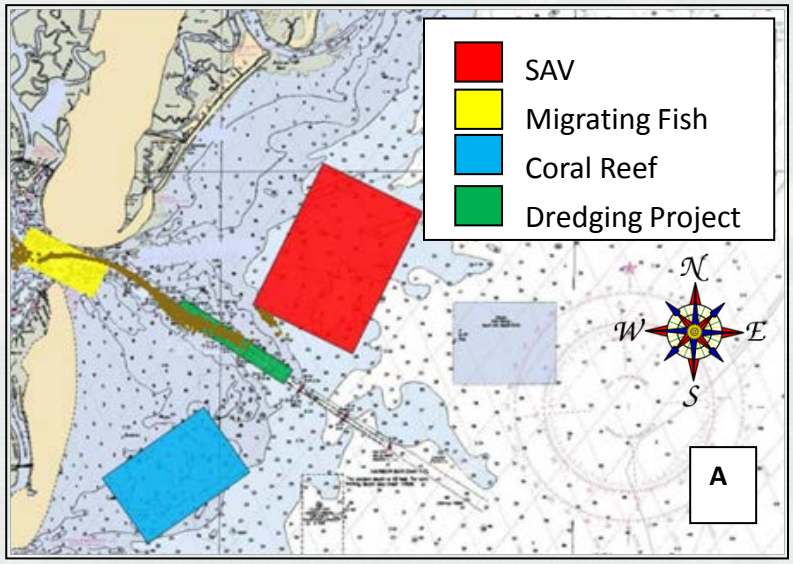
July 07-21, 2007

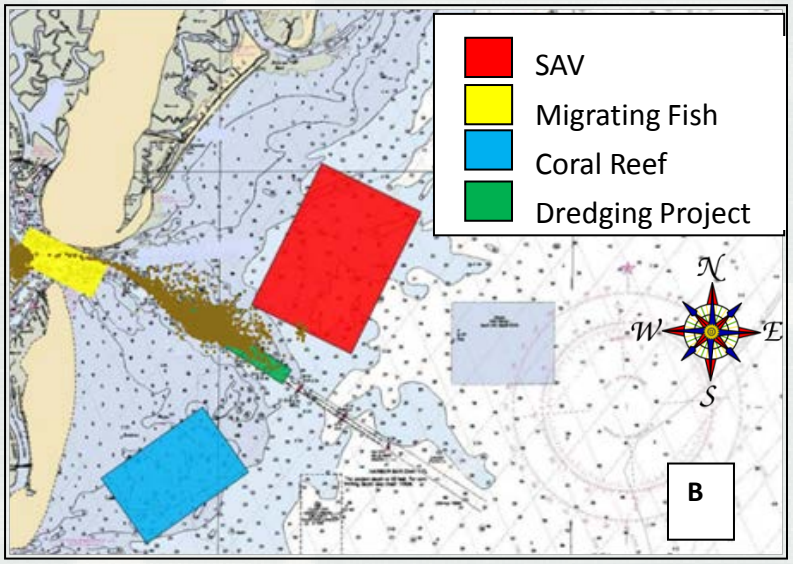


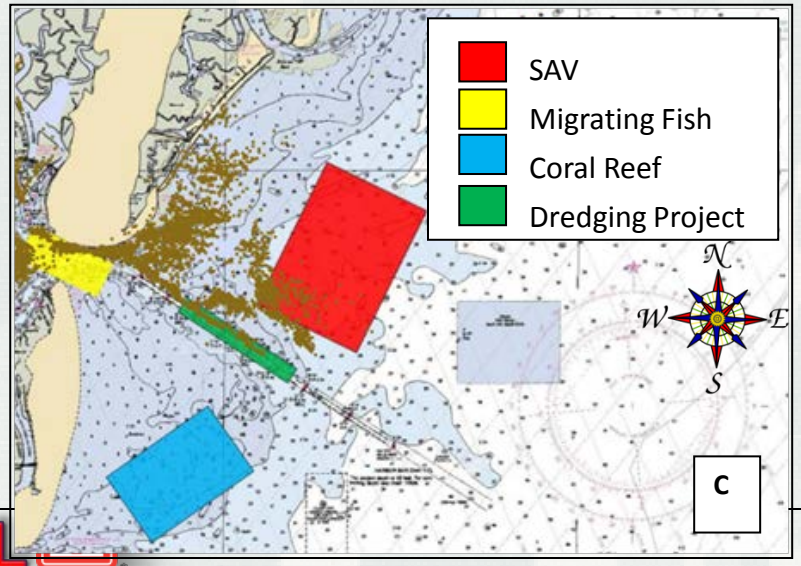
October 21-November 04, 2007

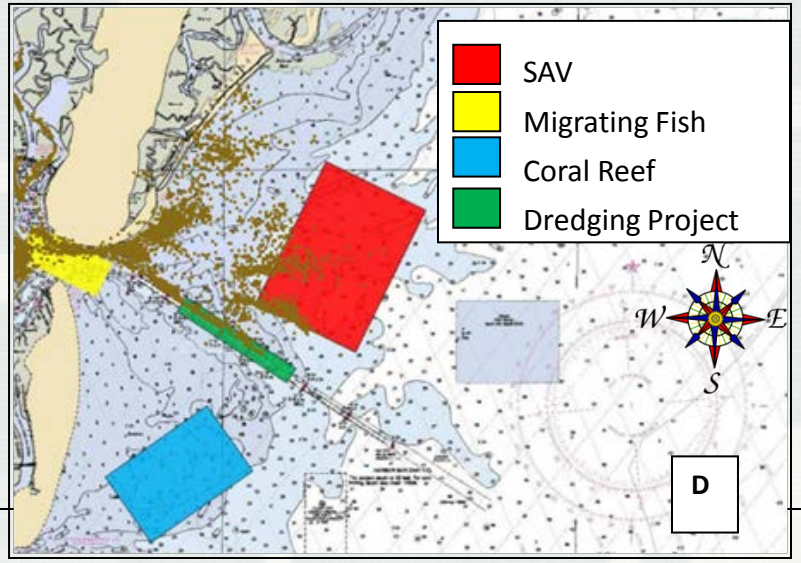


Dredging Materials and Management









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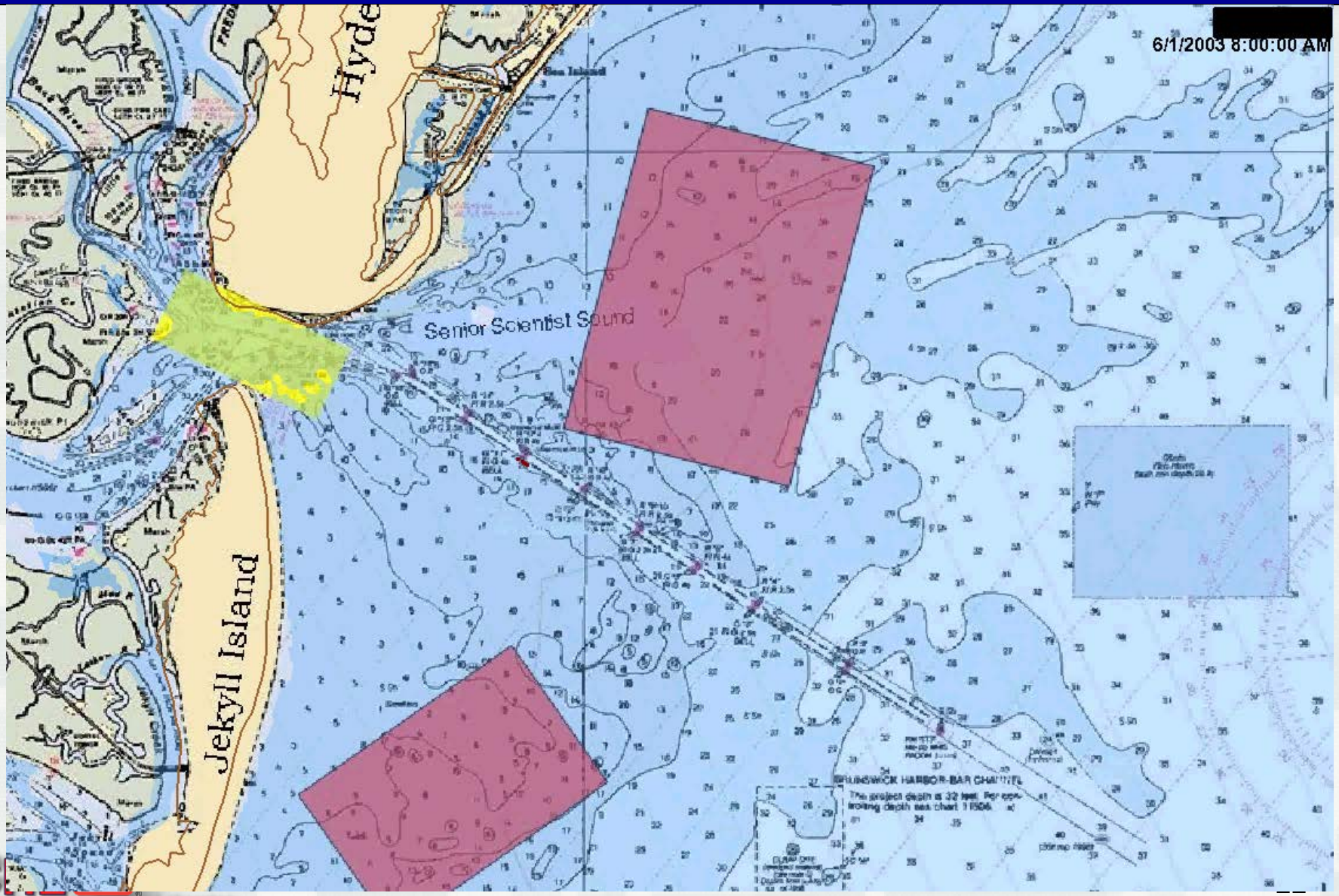
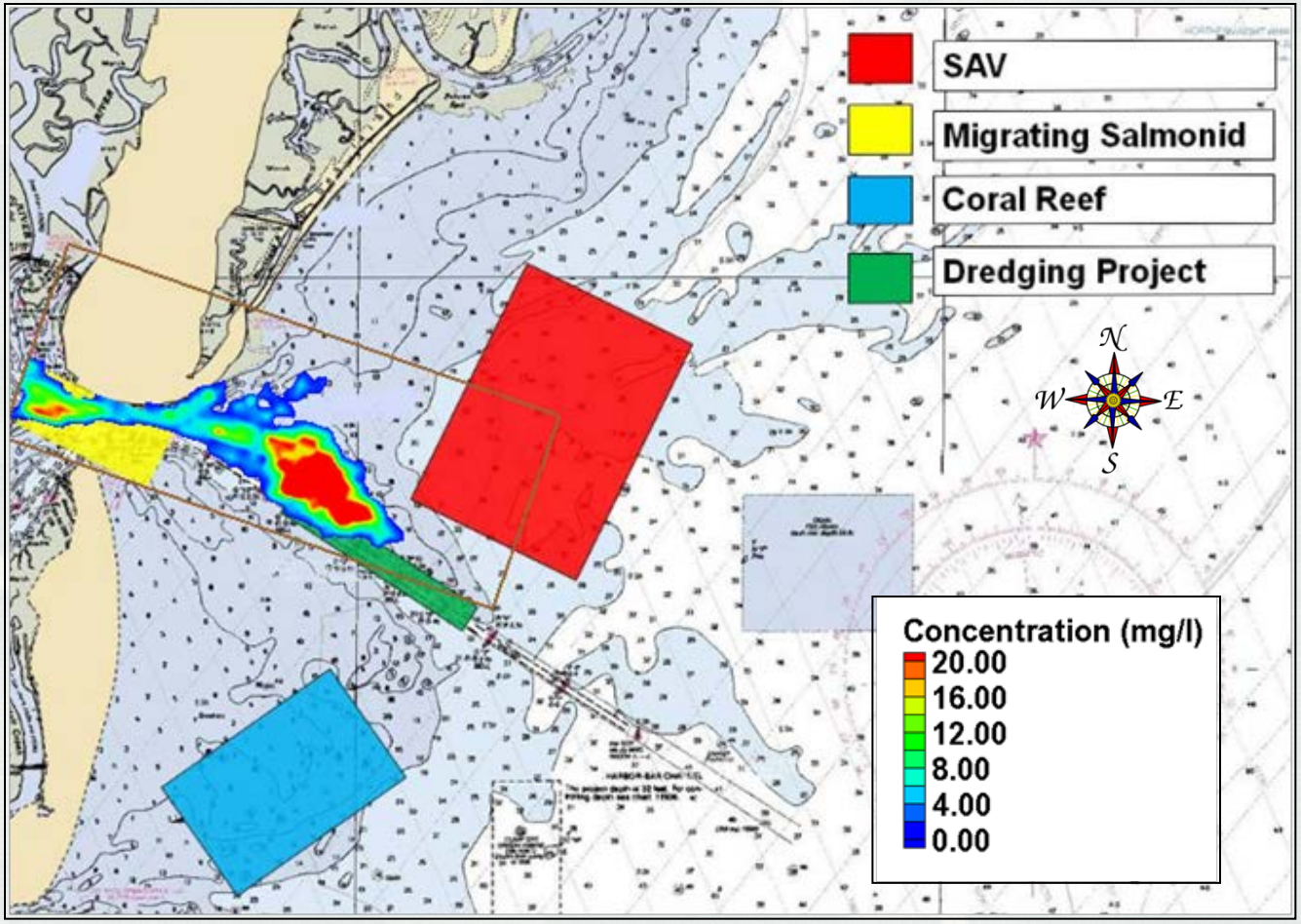


Suspended Sediment Concentration (Particle Density)



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://www.dtic.mil/docs/citations/ADA485347.

- 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://www.dtic.mil/docs/citations/ADA455437.

- 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/technotes.php.

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

CMS Grid and Setting

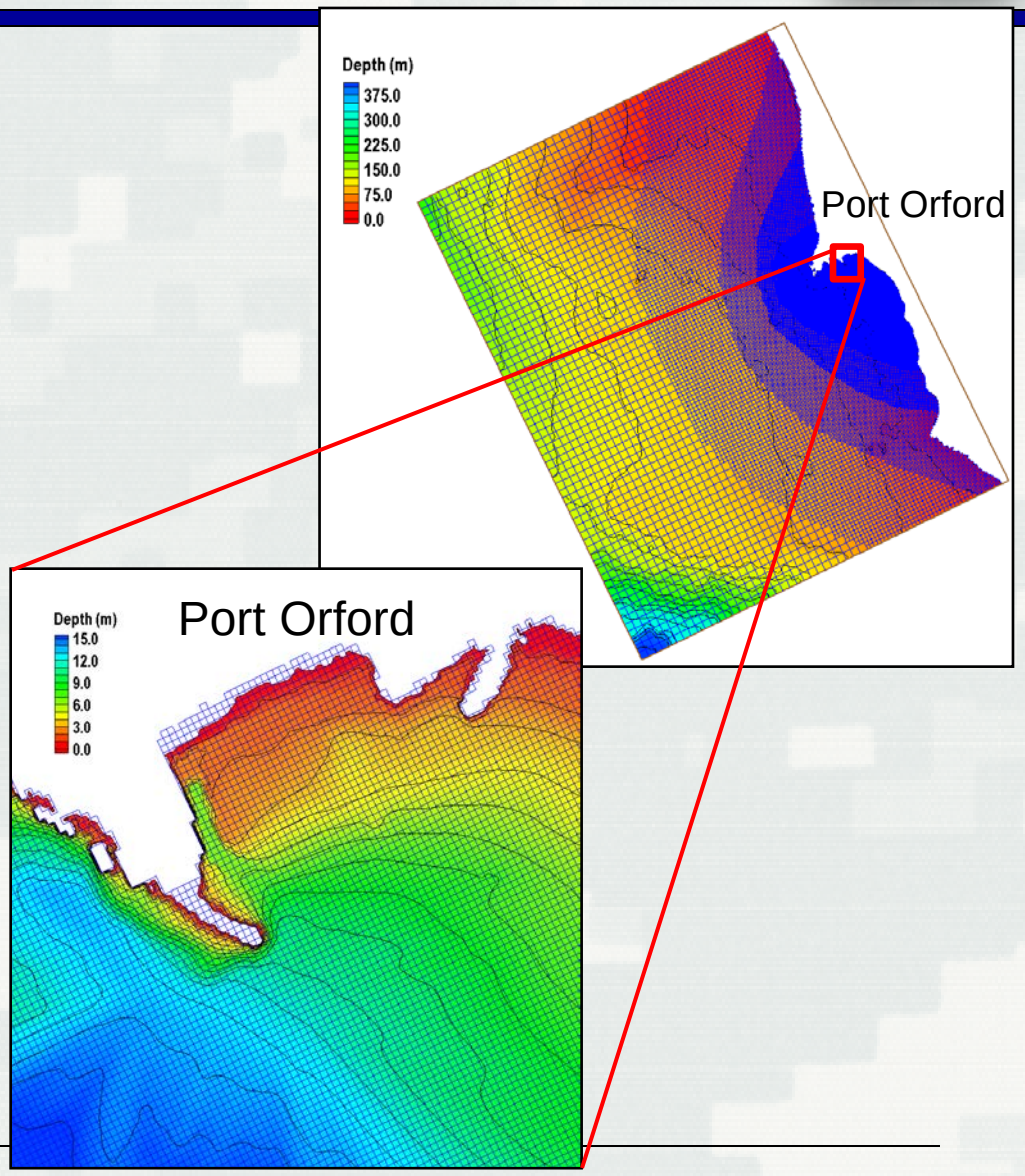
CMS-Flow:

Telescoping

Domain Size: 21 x 16 km

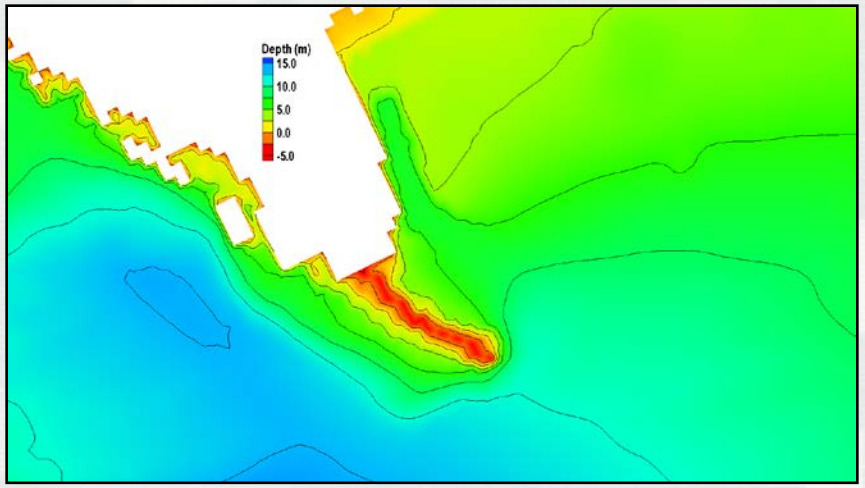
Cell Size: 10 to 3200 m

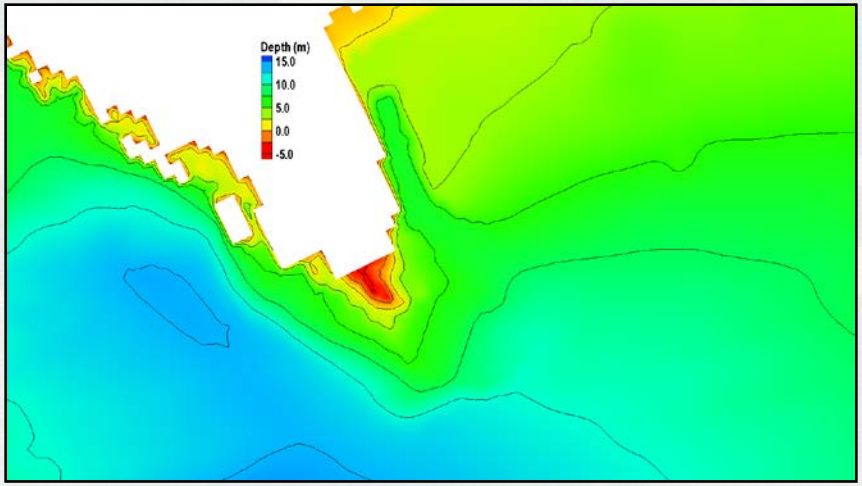
Water Depth: 0 to 400 m

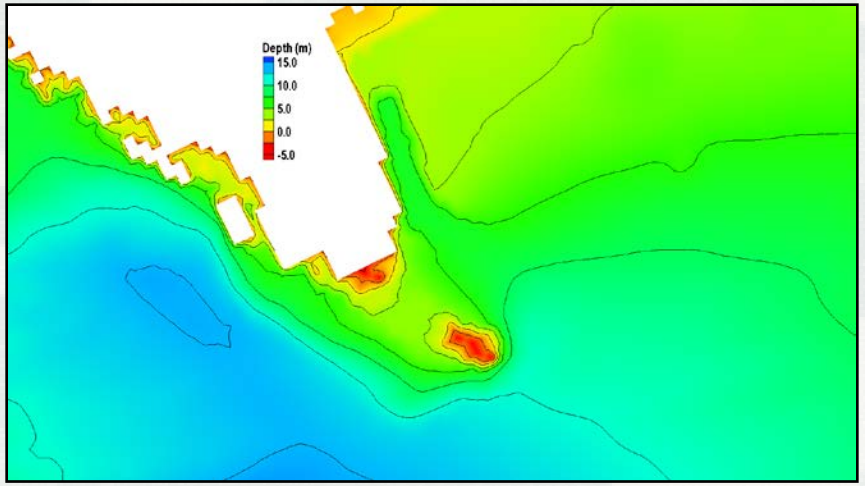


Breakwater Configuration

- 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

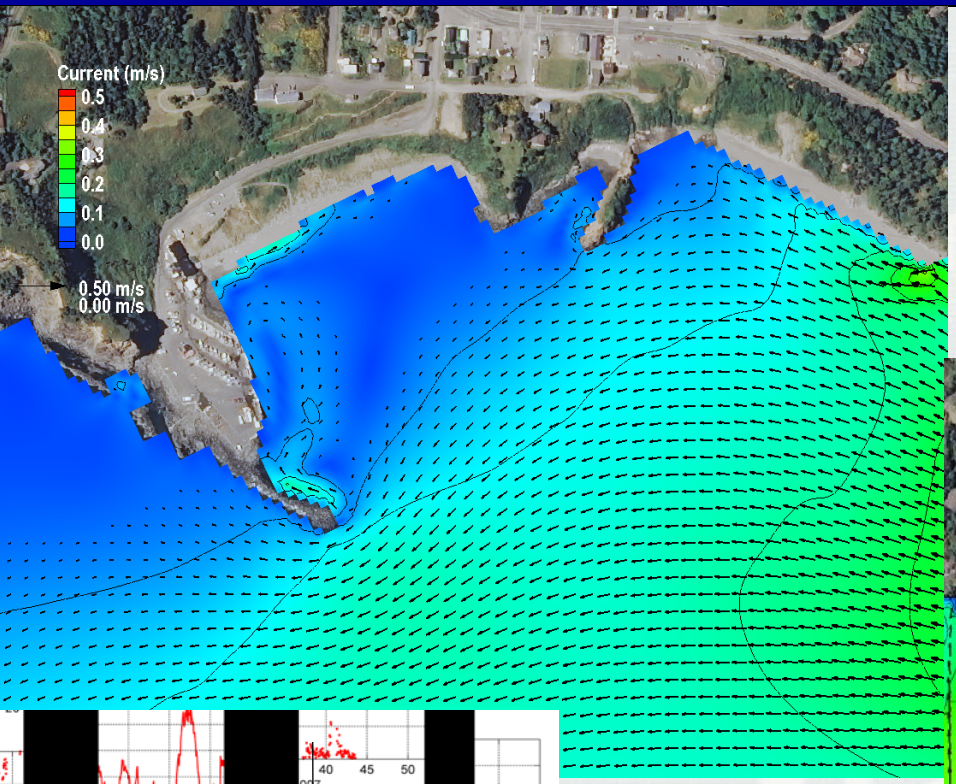


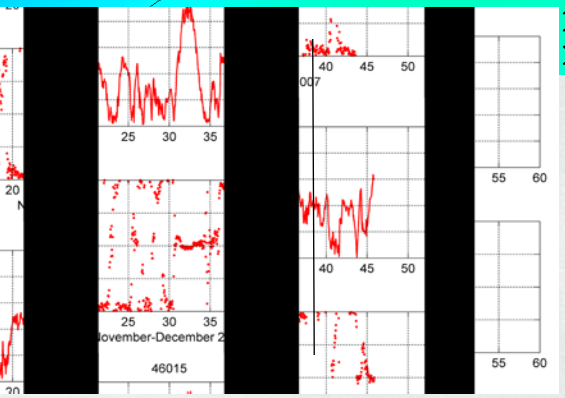


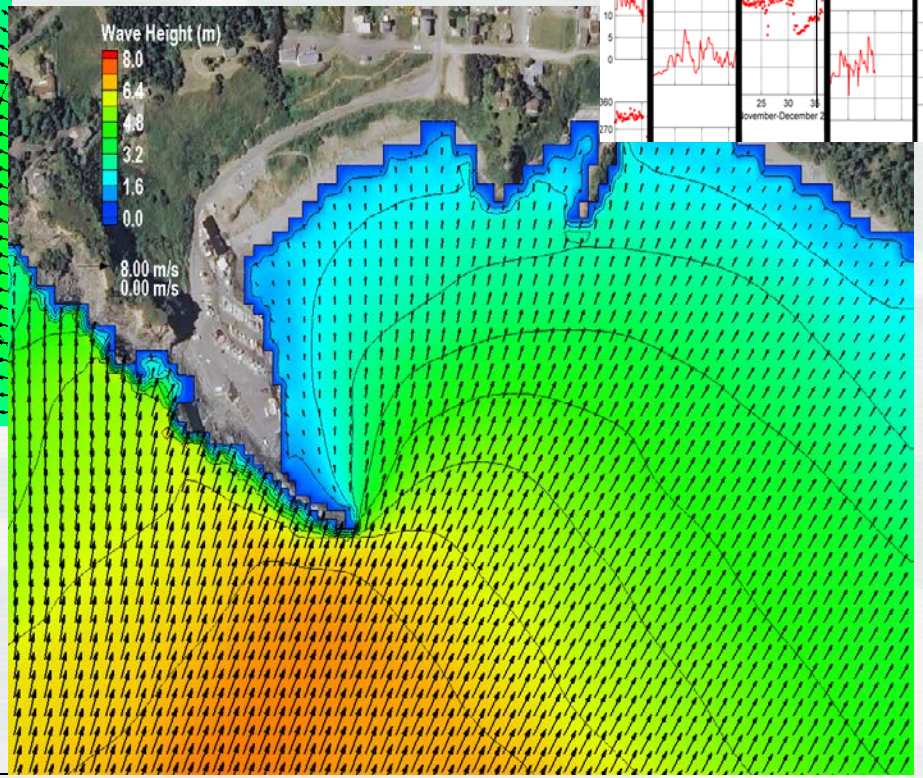


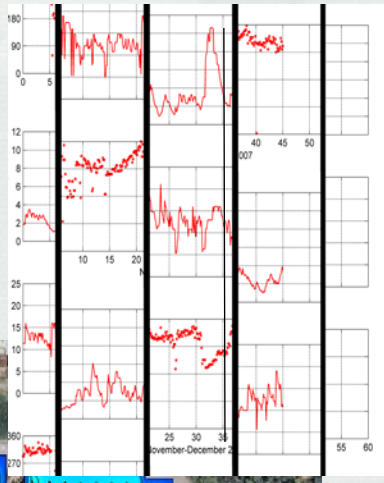
Current and Waves

(Extreme Winter Storm, 3 December, 2007)



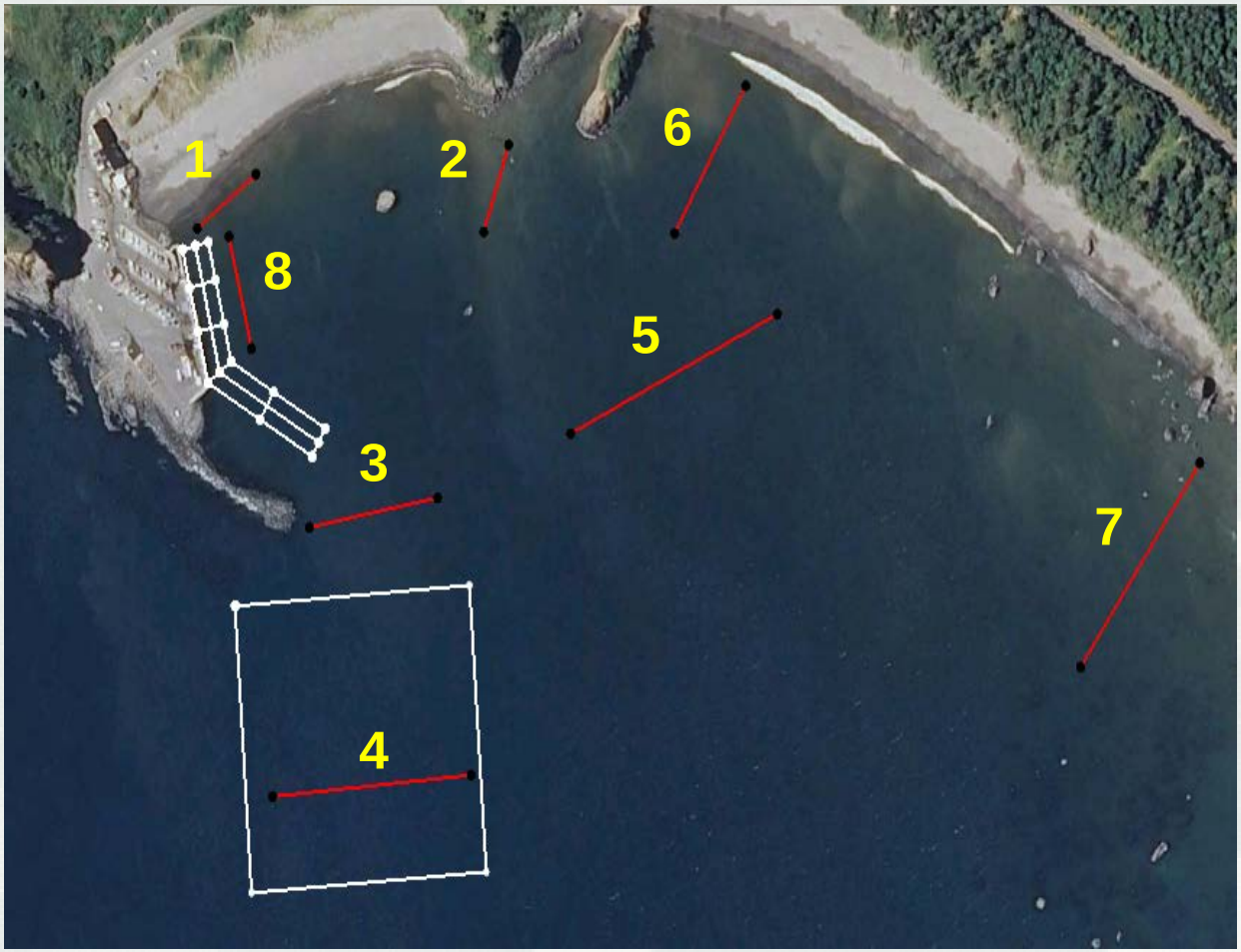




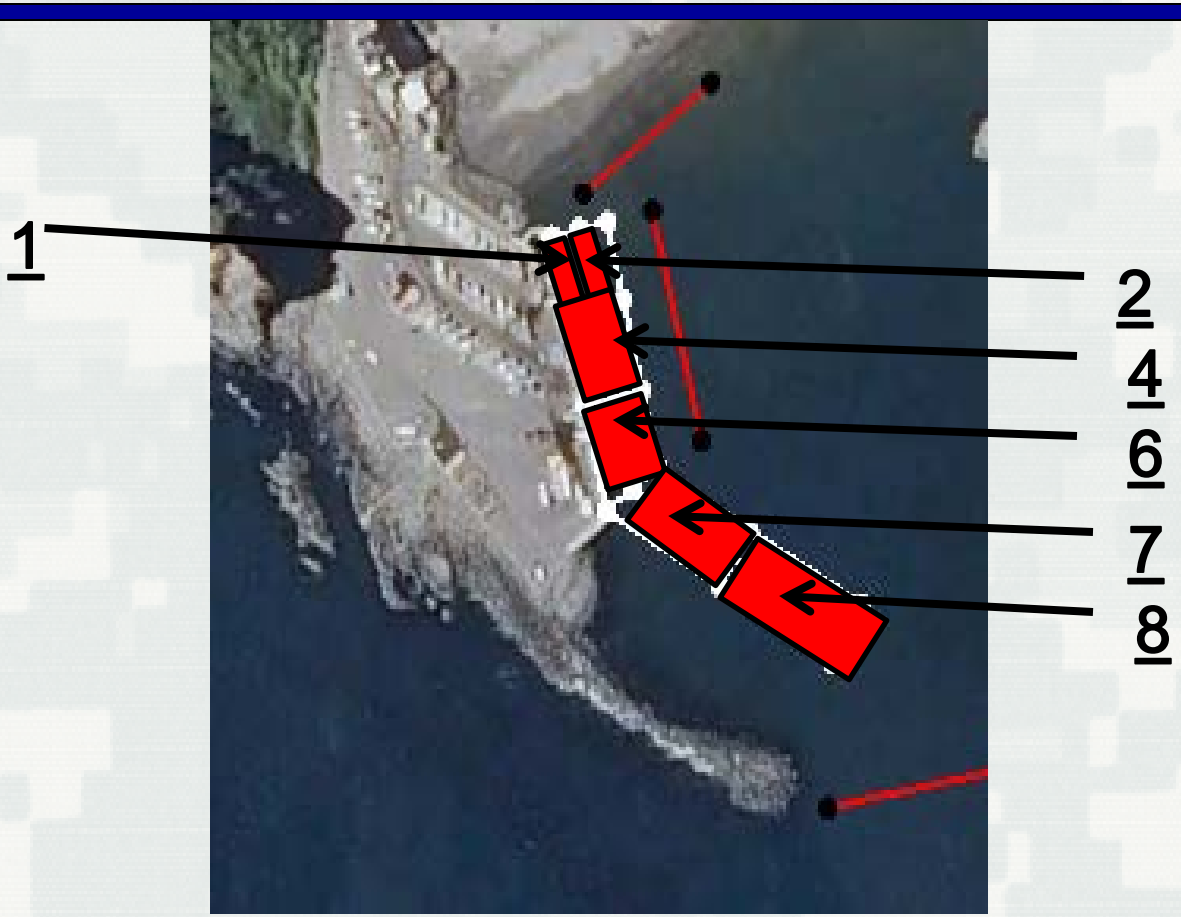


Source Locations

- 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)

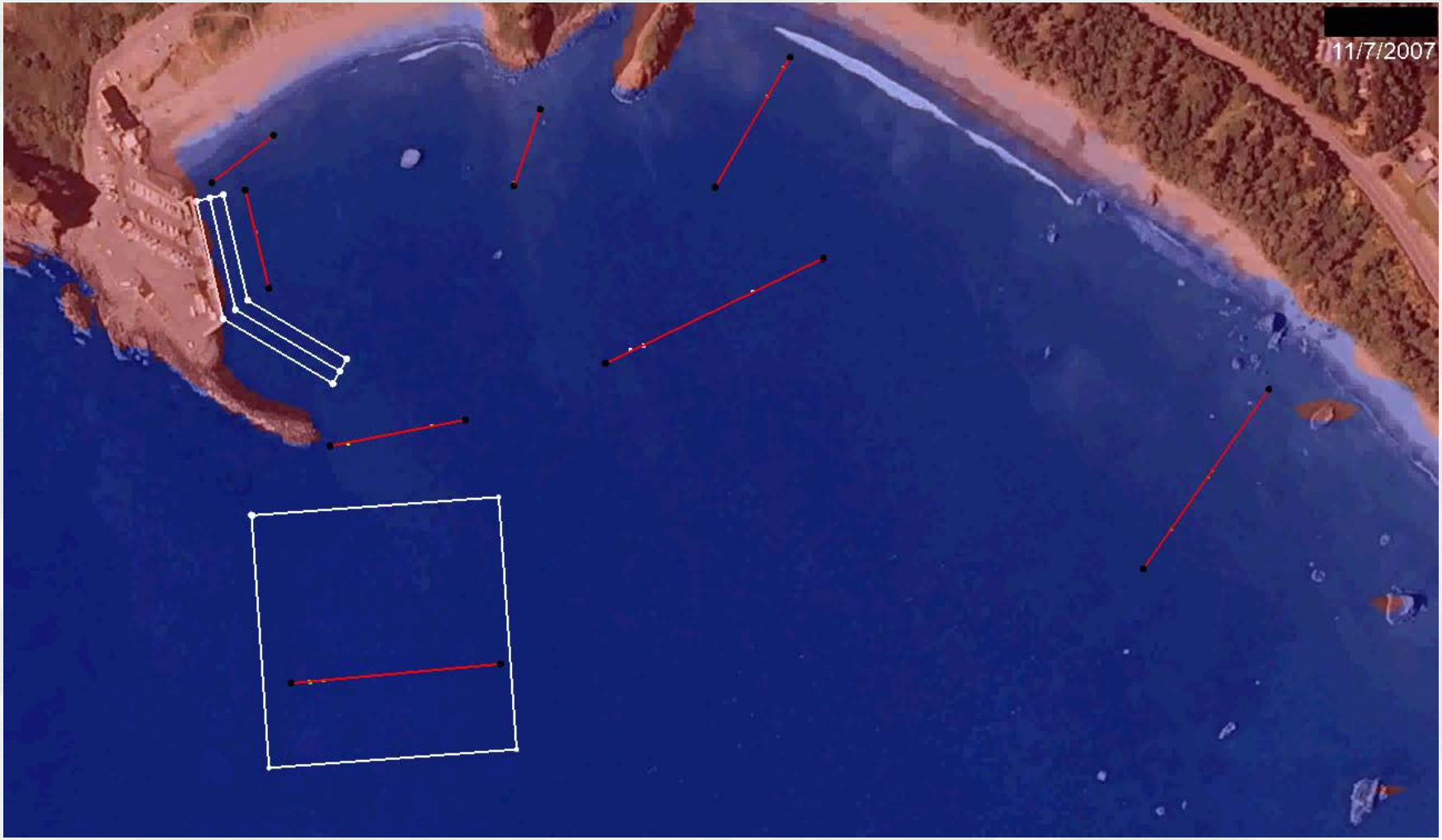


Analysis Traps



- 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)