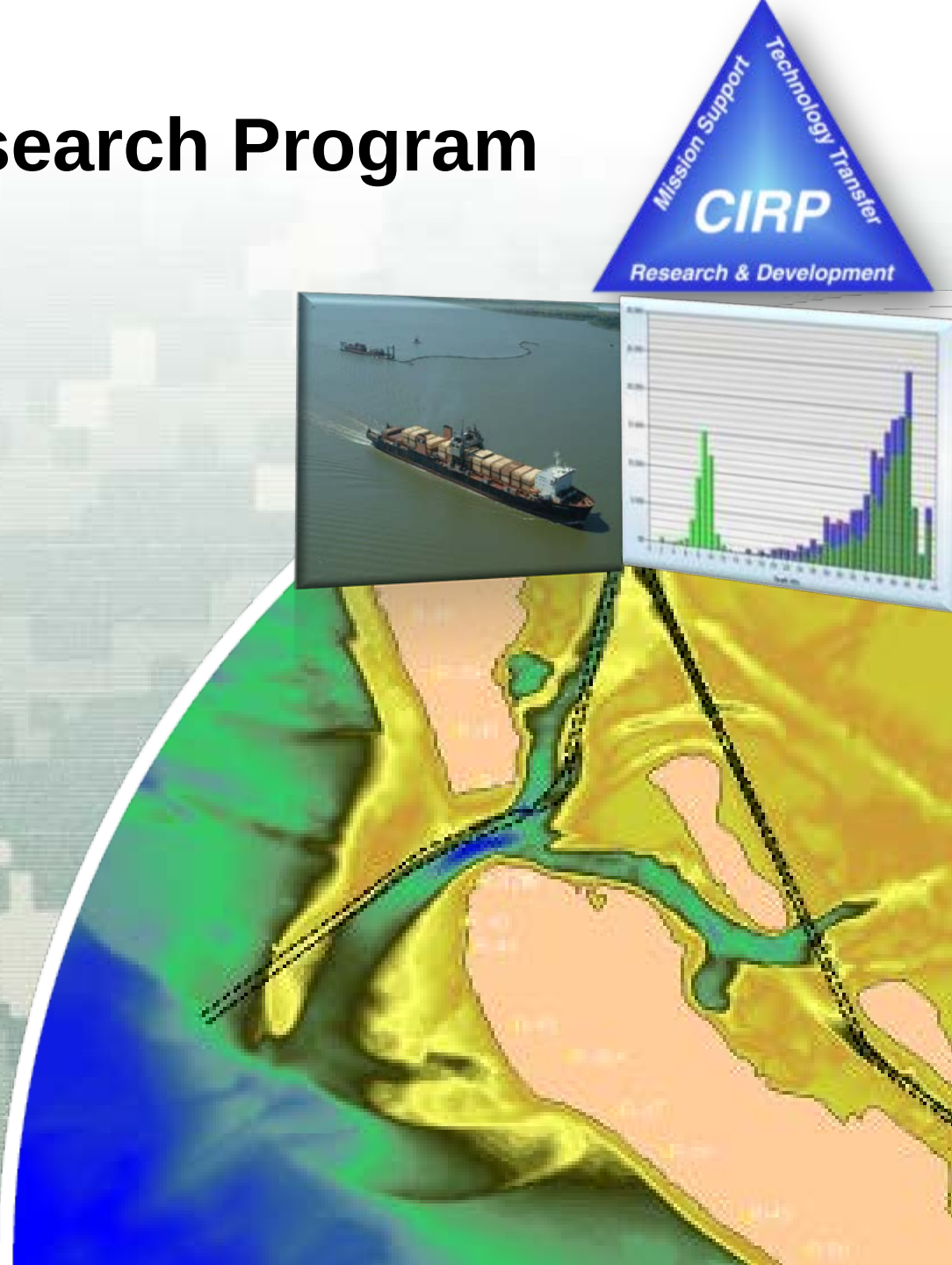
Coastal Inlets Research Program

Julie Dean Rosati
Program Manager

Jim Walker
HQ Navigation Business Line Manager

Jeff Lillycrop
Technical Director

Eddie Wiggins
Associate TD



US Army Corps of Engineers
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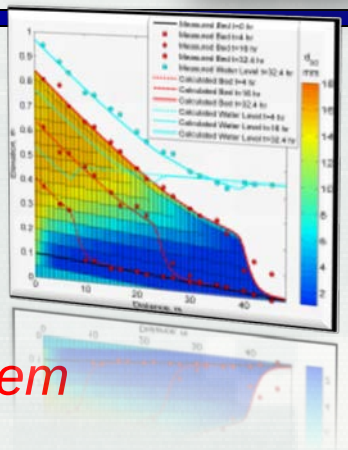
Overview of Presentation



- Coastal Inlets Research Program
  - Mission
  - Technology and Products

- FY12 Activities - *Models in Surface-water Modeling System*
  - **Coastal Modeling System**

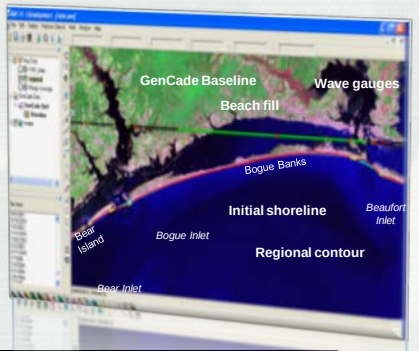
    CMS-Wave, CMS-Flow *SoN 2008-N-6: Long-term Morph Chg*

    CMS-MixSed *Mixed cohesive/non-cohesive sediment transport as forced by waves and currents*

    New! PTM for CMS *Upgrade to operate with telescoping grid*

  - **GenCade**

    SoN 2008-N-6: Long-term Morphology Chg



Overview of Presentation (cont.)

WebTools

- CPT, CSMART

SoN 2009-N-8: Justification for Dredging

- Berm Planning Calculator

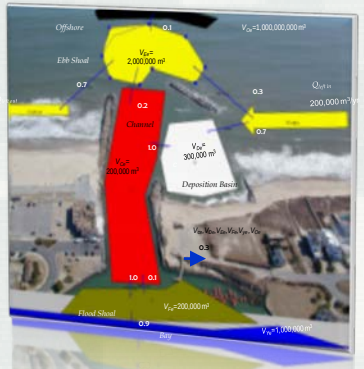
SoNs 2011-N-15b/19b: Nearshore Berms

New!

- WaveNet

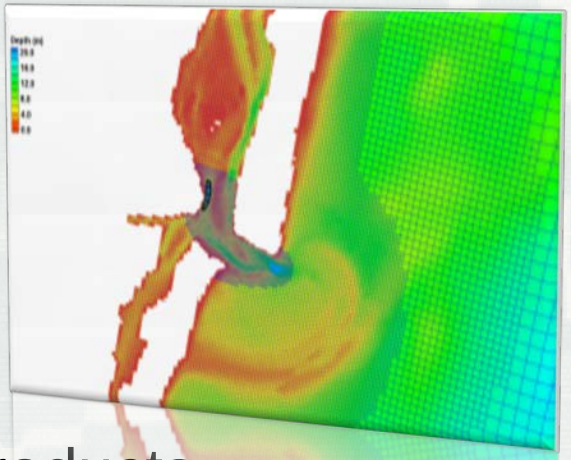
SoN 2011-N-10: Dynamic WebLink Environ

- FY13 Proposed Activities
  - Sea Level Rise Impacts on Coastal Navigation Projects *SoN 2012-N-11*
  - Automated Feature Extraction for Sediment Budgets *SoN 2012-N-15*
  - Validation Measurements *SoN 2009-N-5*



CIRP Mission

- Conduct R&D to reduce O&M costs at coastal navigation projects
  - Include inlets, entrances, ports, marinas, harbors, navigation structures, and adjacent beaches as influenced by metocean forcings.



- Develop tools to support O&M practice
  - Provide Districts tools for in-house PCs.
  - Tools to evaluate inlets, channels, structures, adjacent beaches, dredging and placement within a regional management practice.

- Transfer technology and products
  - Guidance documents, Workshops, models and tools, Web site, Wiki-pages, PC software, Web portals, Mobile device apps.

Coastal Inlets Research Program Mission Areas

Tools and Models:
CMS, CPT, CSMART, GenCade, Inlet Res Model, RMAP, Shoaling Toolbox, CMS pre/post processing tools WaveNet, Nearshore Berm Calculator

Tech Transfer:
Workshops, Website, Wiki, Mobile apps, Video clips, Webinars, TRs, TNs, JPs

Find us on Facebook

R&D: *Berm migration, Mixed-grain sediment transport, Long-term morphology change, Sand sharing relationships for inlets*

CIRP Work Units

Program Management and Technology Transfer

Julie Rosati, Mitch Brown

Coastal Modeling System (CMS)

Alex Sanchez
Honghai Li

Waves at Navigation Structures

Lihwa Lin
Zeki Demirbilek

Geomorphic Evolution

Tanya Beck

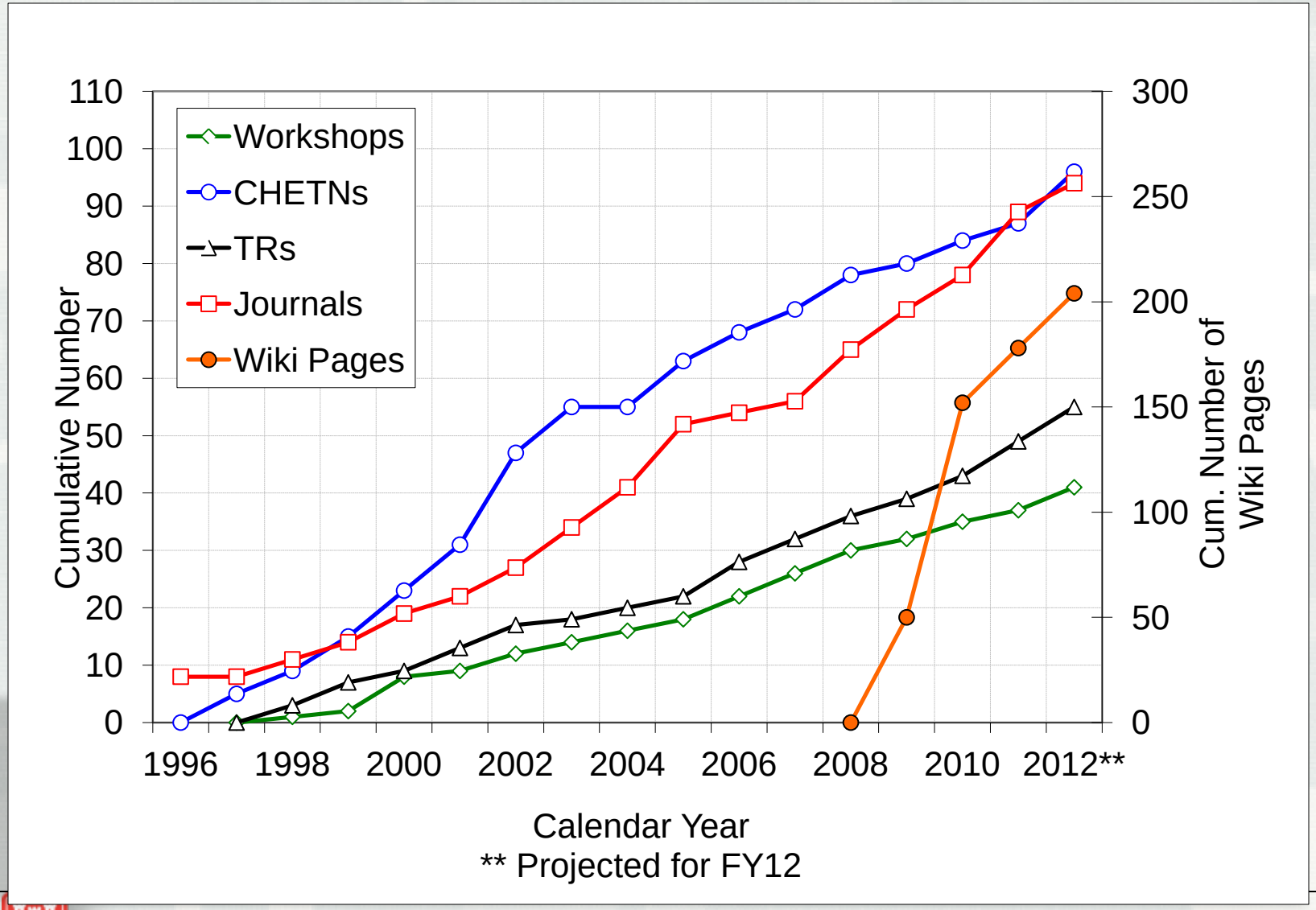
Inlet Engineering Toolbox

Ashley Frey
Julie Rosati

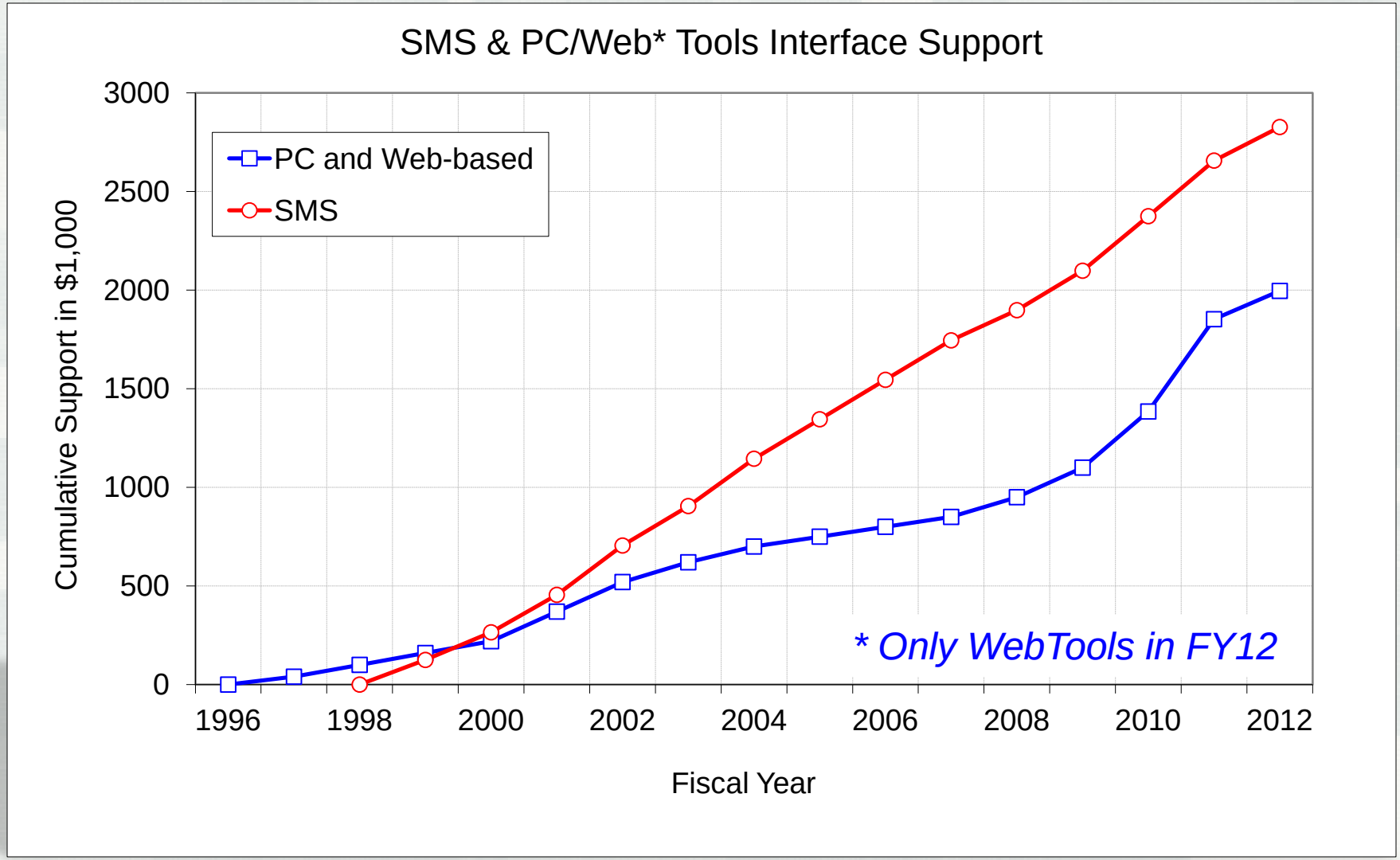
Coastal Navigation Portfolio Management

Ned Mitchell

CIRP Publications and Workshops



Investment Chart



Workshops, Nov98-Aug12

13 Years of Annual Workshops
40 Cumulative Workshops
3 Workshops (2 w/DOTS) and
3 Webinars in FY12

I: Beginning CMS and SMS (Jun 11-15, 1-3 pm CDT)
II: Advanced CMS (Jun 18-22, 1-3 pm CDT)
III: GenCade (Sep 11-13, 1-3 pm CDT)
Register on CIRP Website

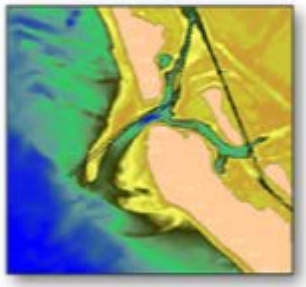
E & W Coasts, Nov 1998	Avalon, NJ/Redondo Beach, CA	Recent developments in CIRP: ADCIRC & STWAVE
#1 – FSBPA, Feb 2000	Wrightsville, FL	[illegible] hydrodynamics, tidal inlet [illegible]
#2 – FSBPA, Feb 2001	Orlando, FL	ADCIRC, STWAVE, & ADCIRC/STWAVE linkages
#3 – FSBPA, Jan 2002	Biloxi, MS	GIS for coastal and navigation projects
Jul 2002	Vicksburg, MS	SMS Steering Module Workshop
#4 – FSBPA, Feb 2003	Ponte Vedra Beach, FL	Hydro Steering Module and sediment transport/ morphology change
May 2003	Clearwater Beach, FL	CS03 Modeling Tidal Inlets
#5 – FSBPA, Feb 2004	Orlando, FL	Calculating sediment transport/morphology change
Aug 2004	New York, NY	Calculating sediment transport/morphology change
#6 – FSBPA, Feb 2005	Destin, FL	Modeling sediment transport and morphology change, channel infilling
Aug 2005	Baltimore, MD	Inlet Modeling System technology transfer workshop
#7 – FSBPA, Jan/Feb 2006	Sarasota, FL	Modeling of waves, circulation, sediment transp. and morph. change
Feb 2006	Vicksburg, MS	Surface Water Modeling System (SMS) Workshop
Jan 2007	Ft. Lauderdale, FL	Empirical and Numerical Techniques for Analyzing Wave Processes
#9 – FSBPA, Jan 2008	Sarasota, FL	Estuarine Design and Research Needs
Jun 2008	Vicksburg, MS	Coastal Structure Assessment Management Workshop
Jun 2008	Vicksburg, MS	Advanced Coastal Modeling System Workshop
#10 – FSBPA, Feb 2009	Sarasota, FL	[illegible] Workshop
#11th Annual, Dec 2009	Seattle District, WA	Integrated Coastal Inlet Simulation with Applications
[illegible]	New Orleans, LA	Advances in Decision-Support: CMS and CPT
#12 FSBPA, Feb 2011	Jacksonville, FL	Modeling & Decision-Support for Coastal Inlets
Aug 2011	San Diego, CA	CMS&GenCade for Regional Sediment Management
#13 NAP, Mar 2012	Philadelphia, PA	Technology Transfer Workshop/Webinar
Jun (2), Sep 2012	Webinars	CMS and GenCade Webinars

Feedback from NAP Workshop

Coming Soon:
Quick-Reference Summary of CIRP's WebTools

CIRP

Numerical Model Tools and Capabilities



U.S. Army Engineer Research and Development Center
Coastal and Hydraulics Laboratory

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Coastal Inlets Research Program

Coastal Inlets Research Program BUILDING STRONG®

numerical model tools and capabilities

Model	What does it do?	What are typical time scales and platforms?	Where has it been validated?	What are advantages?	What are limitations?	Where do I find info?	Who is the main POC?
NOUSS-1D/2D *Wave model for navigation, port/harbor, flood & risk assessment; decision-support*	• High-fidelity, advanced, most accurate model for short and long waves • 1-10 km regions • Wave-structure-ship interactions, ship wake • Surf & swash zone waves (rip currents, runup/over-topping, infra-gravity & tsunamis)	• 20 wave conditions run with rectangular grids in projects • Can be used with one grid or grids for each project alternative • Runs on PC, Linux, and HPCs (supercomputers) • Hours to a week	• 15+ sites including coastal inlets, harbors, ports, flood control structures, and reefs	• Physics & process based; no empiricism • Only DoD model for nonlinear shallow-water waves • Ideal for ports/ harbors/marines, & design/rehab of infrastructure	• Need expertise to run • Time-consuming • Not necessary for all coastal problems • No winds • No unstructured-grid capability	• CIRP, NavSys, FDR, SWIMS websites • Knowledge Hub (KH)	Dr. Zeki Demirbilek
CMS-Flow *2D, depth-integrated*	• Tidal flow, wave-induced currents, sediment transport, and morphology change • Integrated with CMS-Wave	• Runs on multi-core desktop machines • Typical simulation lengths of several months to years	• 20+ sites including coastal inlets, estuaries and beaches	• Integrated system • Robust and fast • Flexible Cartesian meshes • SMS interface • User-friendly	• Depth-integrated • No boundary fitting capability • No swash zone or cross-shore sed transport (yet)		Alex Sanchez
CMS-Wave *2D, depth-integrated*	• Full-plane spectral wave generation-transformation • Integrated with CMS-Flow • Designed for inlet applications	• Runs on PC in SMS, DOS • Typical simulation lengths of several months to years	• 20+ sites: US East and West coasts, Gulf of Mexico • 5+ laboratory and theoretical studies	• Efficient SMS interface • Theoretical-based wave diffraction, reflection • Includes structure-wave interactions	• Empirical wave breaking formula • Structured grid	• CIRP website • KH	Dr. Lihwa Lin
GenCade *1D regional beach and inlet shoal evolution model*	• Can represent coastal structures, beach fills, dredging and placement • Includes Inlet Reservoir Model* to account for inlet shoal and channel evolution *Also available in PC version	• Runs on PC in SMS • Years to multiple decades • Wave conditions representing 1-10 years	• Basic V&V completed • 5+ sites: Onslow Bay, NC; Sargent Beach, TX; St. Johns County, FL; Point Lookout, NY	• User-friendly; easy to learn • Conceptual model = fast grid creation and set up • Integrates cumulative projects • Fast	• Empirically-based sand transport • Explicit solution scheme (solution stability) • Constrained by standard 1-line model assumptions	• CIRP website • KH	Ashley Frey
PTM *Particle Tracking Model for 2D/3D hydro models*	• Joint DOER-CIRP product • Coupled to CMS by CIRP • Predicts particle transport pathways and fate • SMS based interface	• Accepts input from CMS and other hydro and wave models • Runs on desktop PCs and HPCs (super-computers) • Seconds to hours	• Basic V&V completed • Detailed V&V studies in progress	• Fast and efficient • Flexible; not tied to any hydro or wave model • SMS interface connects to flow and wave models	• Not designed for sediment transport calcs • Some empirical formulas • Too many particles can slow runtimes	• CIRP, DOER websites • KH	Drs. Tahirih Lackey (DOER), Honghai Li (CIRP), Zeki Demirbilek (CIRP & DOER)

CIRP Technology & Products*

Surface Water Modeling System

CMS

- CMS-Wave
- CMS-Flow
- PTM

GenCade

Bouss-2D

Web-Tools and Guidance

CPT and CSMART

CHANNEL SHOALING TOOLBOX

CIRP Website & Wiki

Find us on Facebook

Inlets Online

INLETS DATABASE

Section 111 Toolbox

Berms Online

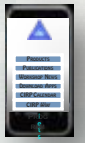
Nearshore Berm Calculator

MetOceanDat: WaveNet

Mobile Device Applications

CPT-LITE

CIRP WEBSITE



PC Tools

Inlet Reservoir Model

RMAP

SBAS-PC

*Active R&D in FY12-FY13; other mature products still available.

CIRP Technology & Products*

Surface Water Modeling System

CMS

- CMS-Wave
- CMS-Flow
- PTM

GenCade

Web-Tools and Guidance

CPT and CSMART

Nearshore Berm Calculator

Channel Shoaling Toolbox

MetOcnDat: WaveNet

IRM Webtool

CIRP Website & Wiki

Find us on Facebook

Inlets Online

Berms Online

Inlets Database

Section 111 Toolbox

Bouss-2D

Mobile Device Applications

CPT-Lite

CIRP Website

PC Tools

Inlet Reservoir Model

*Active R&D in FY12-FY13; other mature products still available.

Coastal Modeling System (CMS)

What is the CMS?

Integrated wave, current, and morphology change model in the Surface-water Modeling System (SMS).

CMS-Wave

Wind input, wave generation & growth, wave transformation, diffraction, reflection, run-up, setup, overtopping, structures, surface roller

Current, Water Level, Morphology Change → Wave Height, Direction, Period, Dissipation, Radiation Stresses

CMS-Flow

Hydrodynamics
Tide, Wind, Waves
Coriolis, River flux

Waves

Sediment Transport
Advection, Diffusion, Erosion, Deposition, Bed sorting

Structures
Jetties, Groins, Weirs, Culverts

Morphology Change
Bed change and layering, Avalanching

Nonuniform and telescoping Cartesian grids, tightly-coupled wave-flow-transport models, parallelized for PCs

PTM

Lagrangian Particle Tracking Model

Coastal Modeling System (cont.)

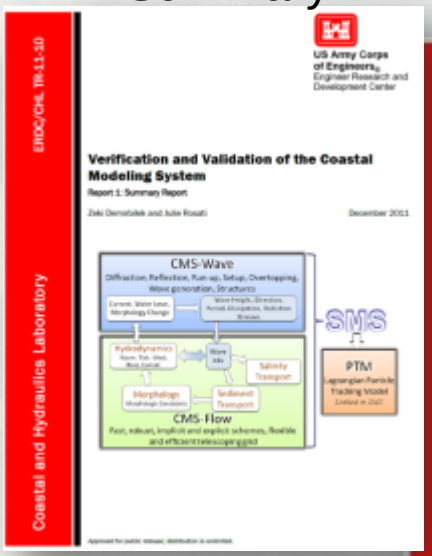
Why CMS?

- Operational at 12 Districts
- Practice-oriented: *1 day simulation ~ 1 hr on PC!*
- Integrated *system for* wave-current-morphology modeling
- 4 Verification & Validation reports document theoretical, laboratory, and real-world applications
- Approved by H&H CoP for use in USACE applications
- Recent Tech Transfer activities
  - Feb 2011: Jacksonville, FL
  - Sep 2011: San Diego, CA
  - Nov 2011: New York District, NY (DOTS)
  - Feb 2012: Baltimore District, MD (DOTS)
  - Mar 2012: Philadelphia, PA

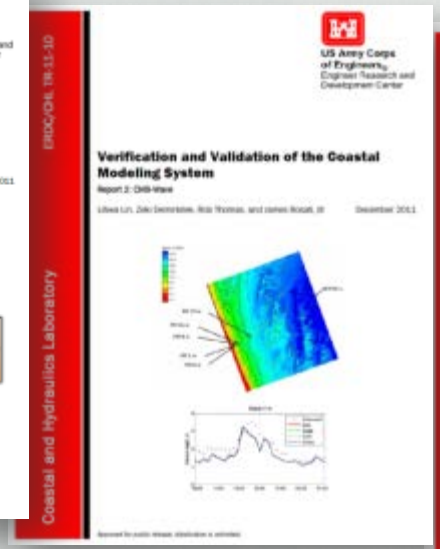
Coastal Modeling System Accomplishments:
Four V&V Reports Published!

- Documents goodness-of-fit statistics for CMS applications:
  - 9 Analytical Cases
  - 13 Laboratory Cases
  - 21 Field Cases
- V&V Study established data bank for coastal wave, flow, and sediment transport model validation

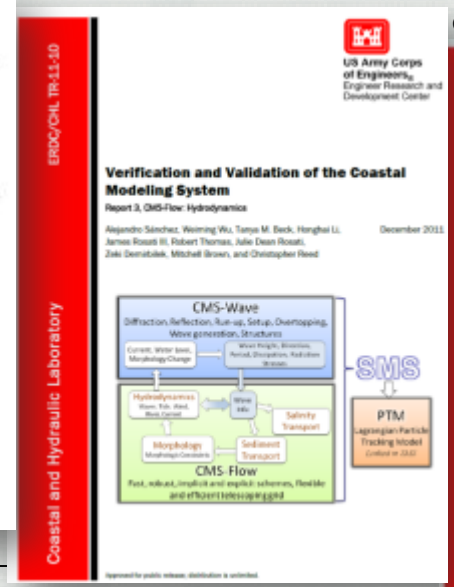
1:Summary



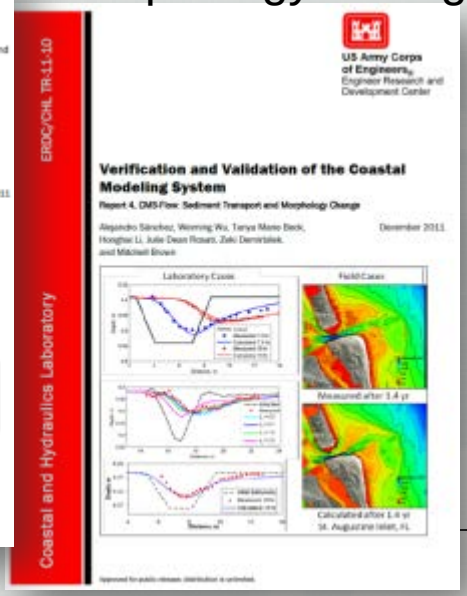
2: Waves



3:Flow



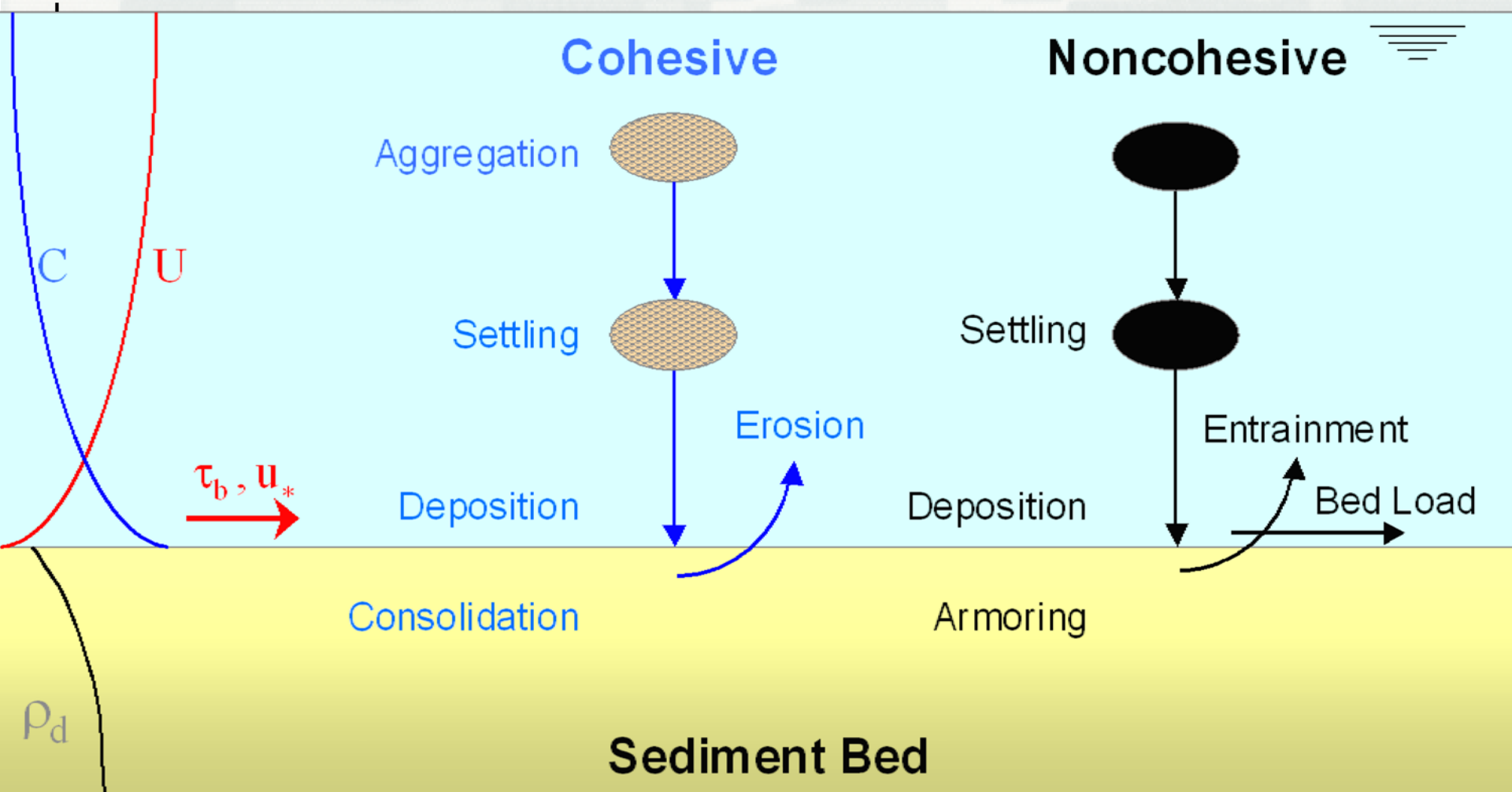
4:Sediment Transport & Morphology Change



FY12 Activities: Implementation of MIXSED into CMS

What is MIXSED?

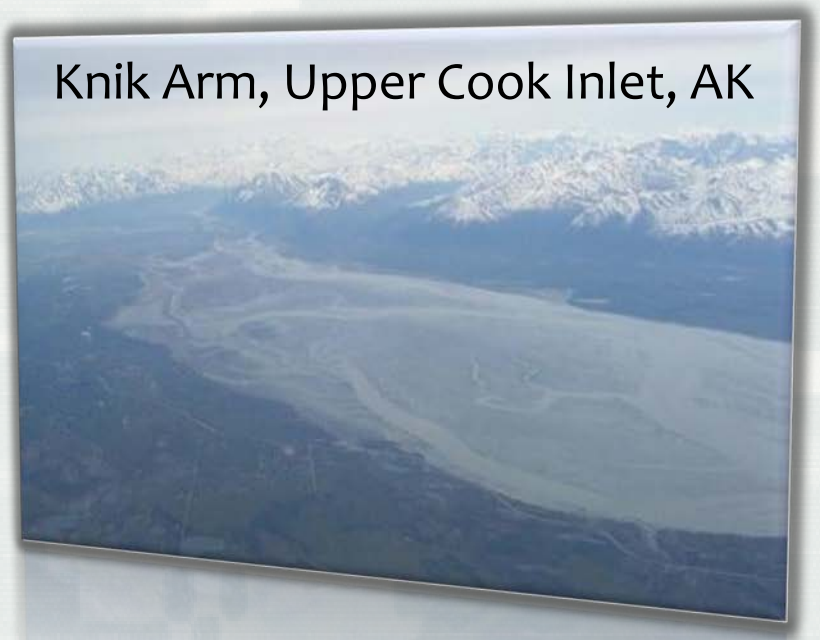
Sediment bed model that enables representation of multiple size classes of cohesive and non-cohesive sediment in coastal projects



FY12 Activities: Capabilities MIXSED Adds to CMS

Simulates erosion and transport of mixed cohesive and non-cohesive sediment under combined wave & currents

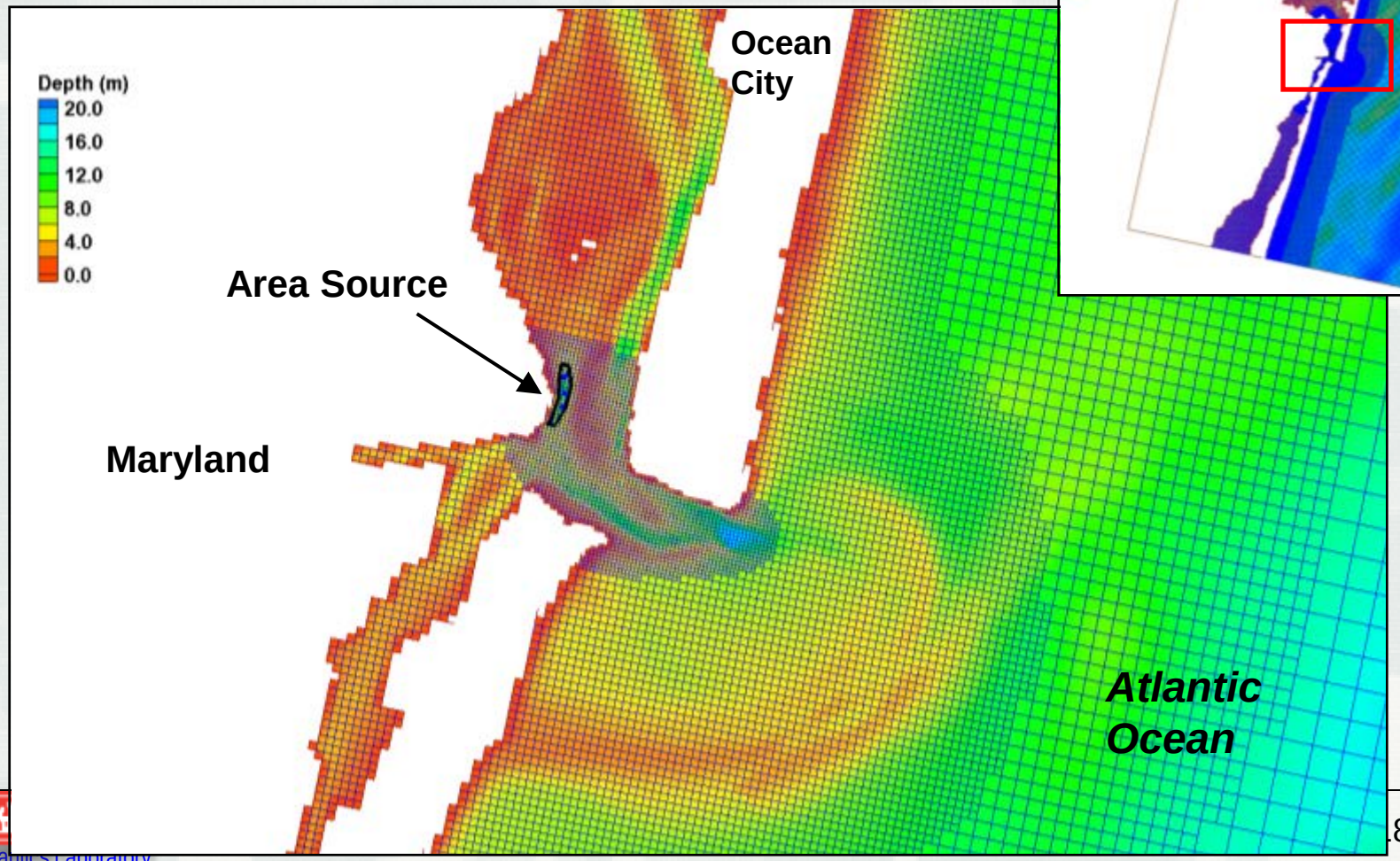
- Nearshore & offshore O&M placement of mixed cohesive/ non-cohesive sediments
- Sediment transport of mixed sediments in inlets, harbors, bays
- Examples:
  - Mobile Bay, AL
  - Galveston Bay, TX
  - Buzzards Bay, MA
  - Upper Cook Inlet, AK

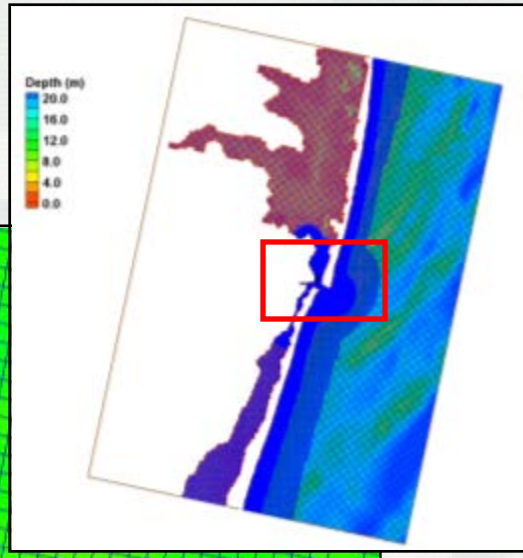


FY12 Accomplishments: PTM Upgrade for CMS Telescoping Grids

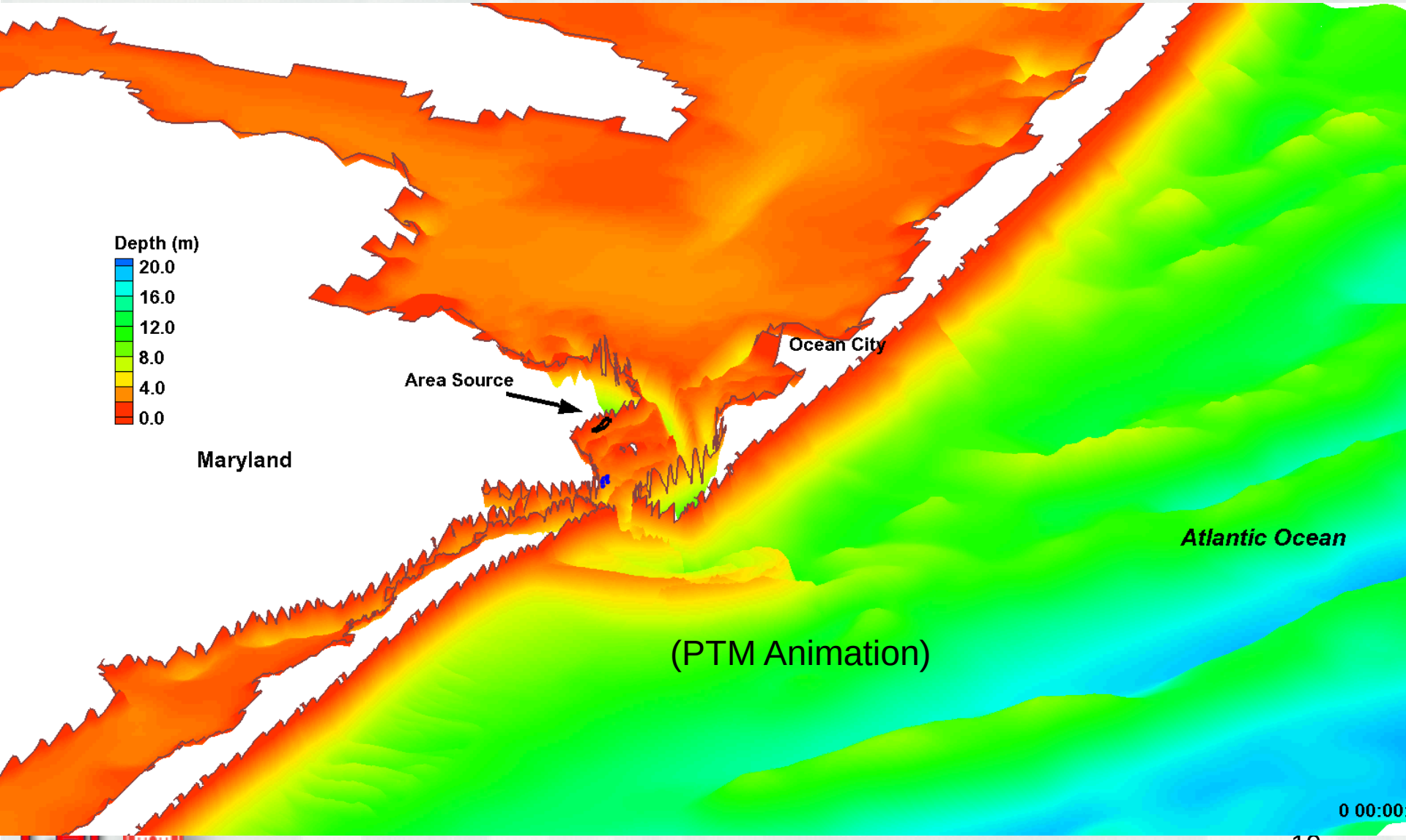
Particles released from deep scour hole

Particle size released (silt): 0.02 mm
Hydrodynamic forcing: Tide and waves

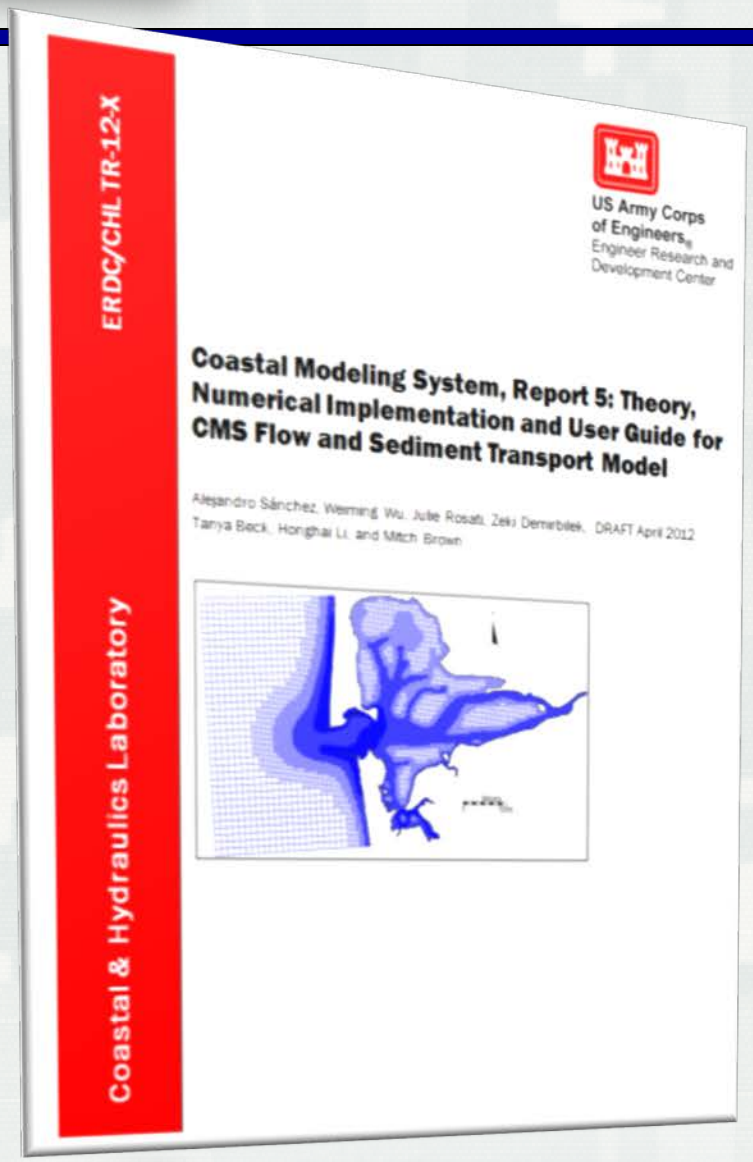




FY12 Accomplishments: PTM Upgrade for CMS Telescoping Grids



FY12 Accomplishments: CMS: Theory & User's Guide



CMS-Flow and Sediment Transport: Theory, Numerical Implementation & User's Guide

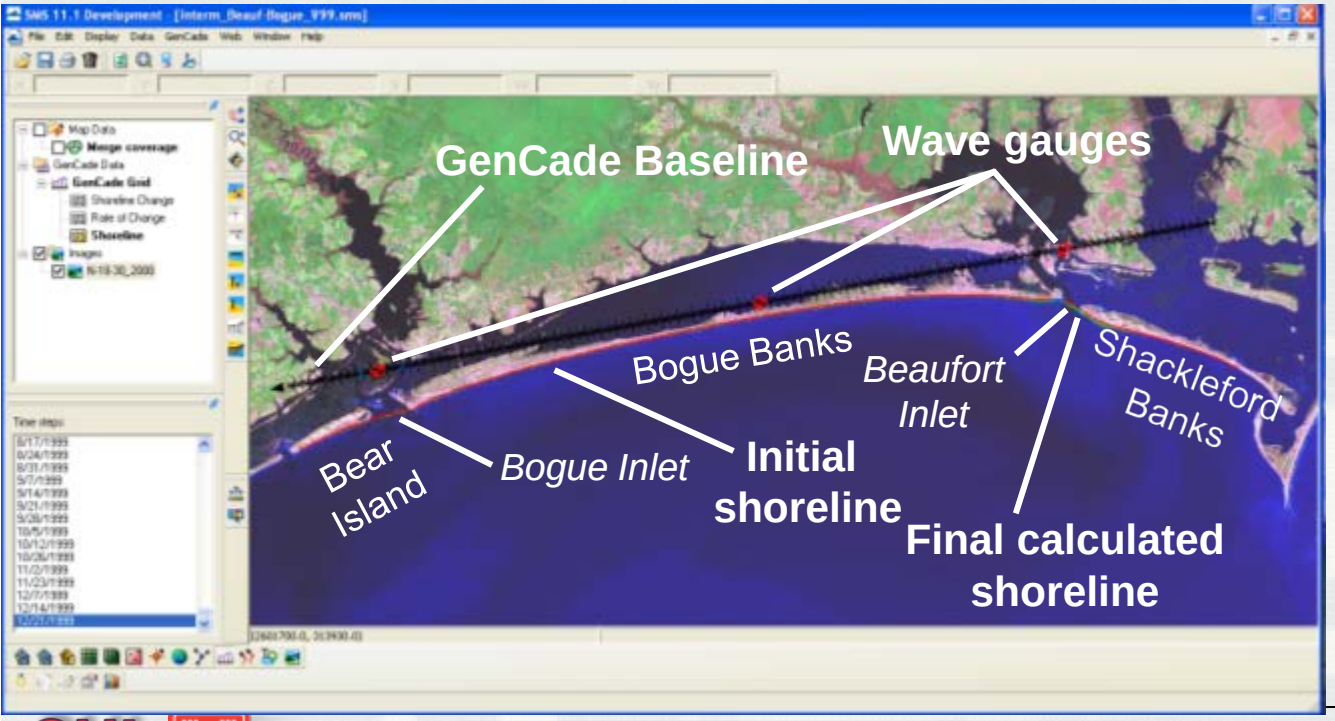
- Theory
  - Hydrodynamics
  - Salinity
  - Sediment Transport
- Numerical Methods
- User's Guide
- Appendices: Input and Output Files

Visit the CMS/PTM Booth!

GenCade

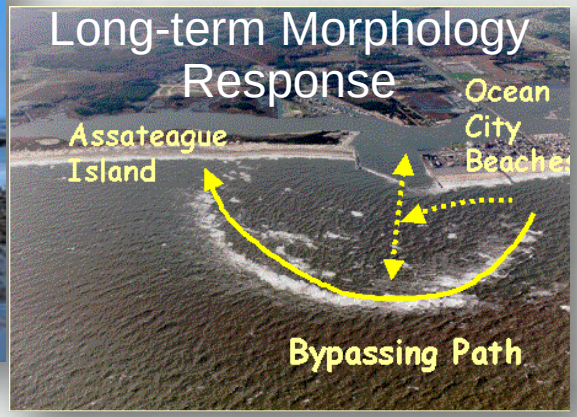
What is GenCade?

- Integrated GENESIS and Cascade models for shoreline change and sand sharing with inlet channels and shoals.
- Connects inlets, navigation channels, ebb and flood shoals, beaches, and engineering activities in a regional framework.
- Decision-making support for planning, operation, and engineering.



Second GenCade Workshop, Aug '11

GenCade (cont.)



Why GenCade?

- Sediment storage and transfer (bypassing, back-passing)
- Navigation channel maintenance
- Multiple interacting inlet dredging & placements on beaches
- Cumulative impacts
- Sources & sinks (shoal dredging and beach nourishment)
- Compatibility with previous calculations
- In SMS 11.1; PC, user-friendly interface for engineers & scientists

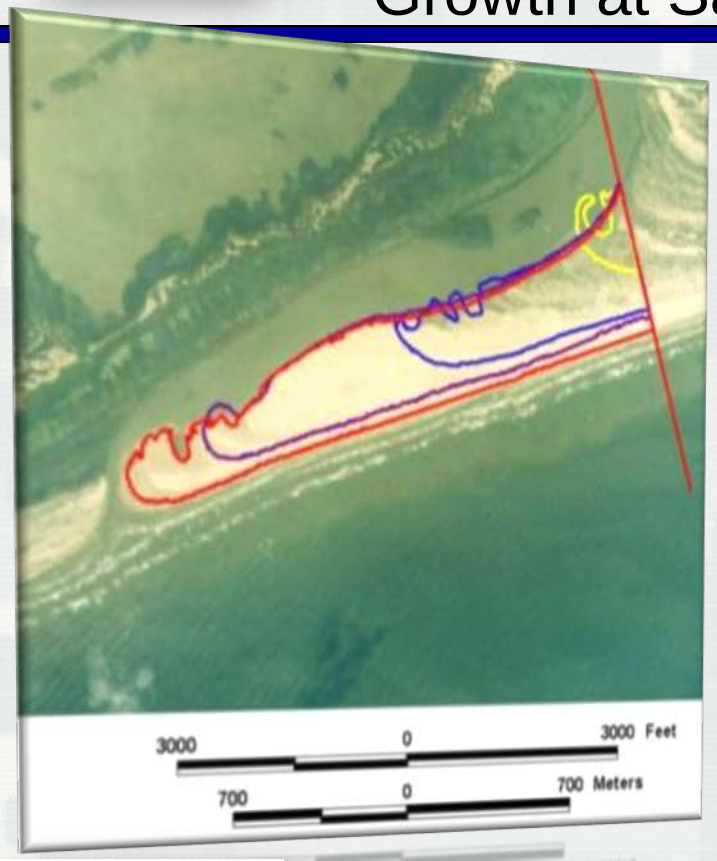
GenCade FY12 Accomplishments

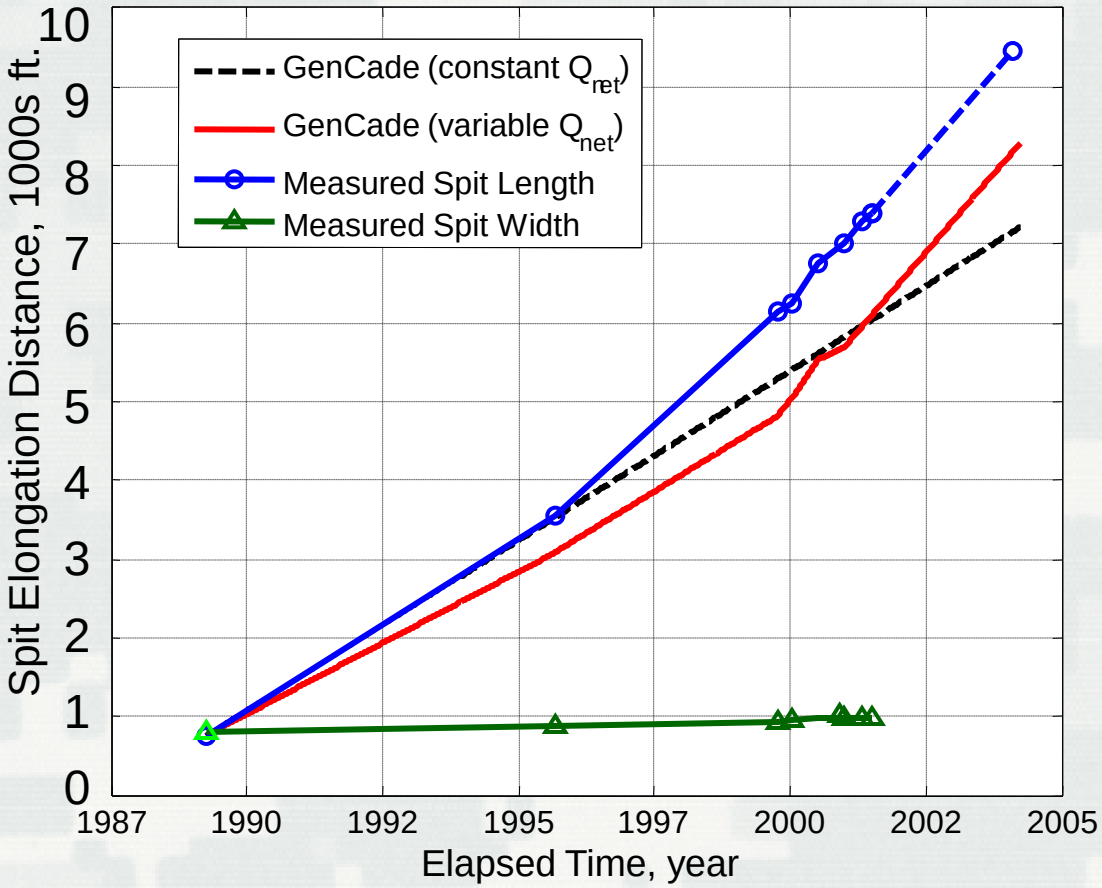
GenCade Model Theory & User's Guide

- Theory
- Validation
- Interface & User's Guide
  - Input & output files
  - Conceptual model
  - Visualization
  - Calibration & developing alternatives
- Application to Long Island, NY

Classic Groin Response: Cape May, NJ

GenCade FY12 Accomplishments: Spit Growth at San Bernard River Mouth, TX





Statements of Need

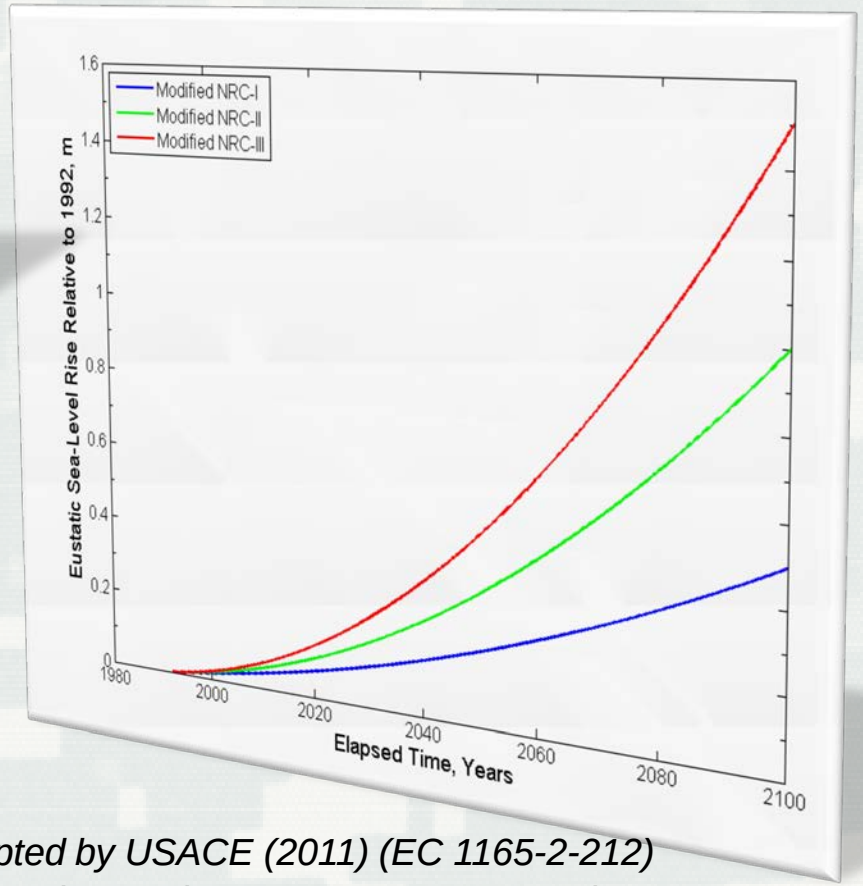
Need long-term morphologic evolution predictors
Tracking Number 2008-N-6

GenCade FY12 Ongoing Activities (cont.)

Incorporating Sea Level Change (SLC)into GenCade Calculations*

- Incorporate USACE (2011) methods for range in SLC as GenCade input
- Add change in sea level into GenCade calculations

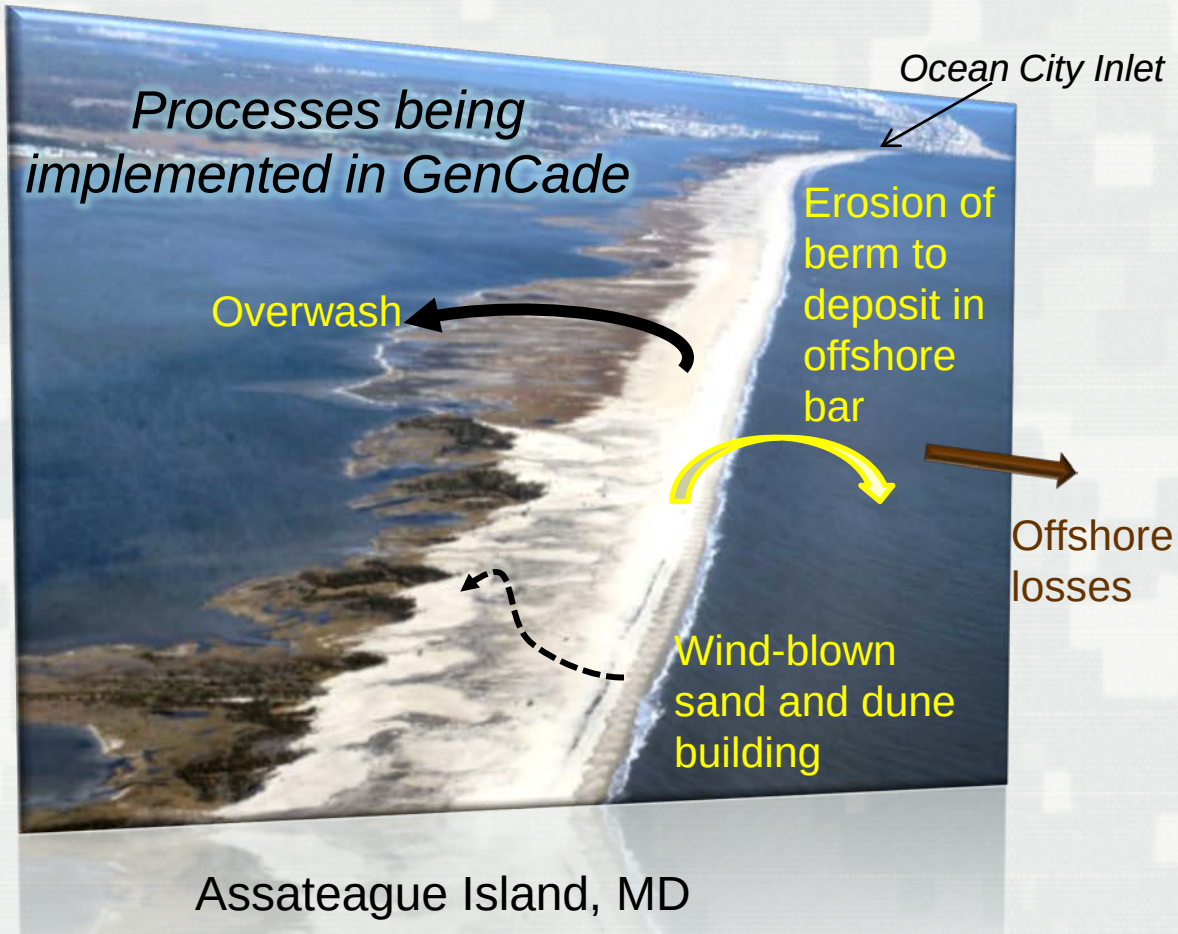
Engineering and planning incorporating SLC can be investigated with GenCade



Adopted by USACE (2011) (EC 1165-2-212)
Based on updates to NRC 1987 equation

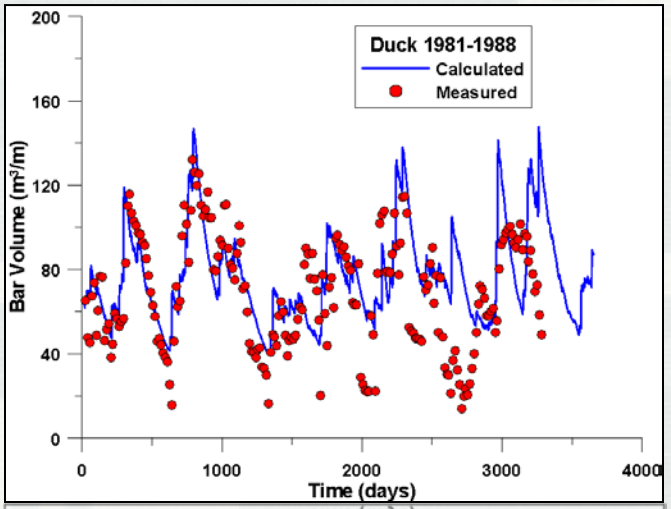
*SLC is presently considered in GenCade applications in an ad hoc manner

Incorporating Cross-Shore Transport in GenCade



Assateague Island, MD

Example comparison between measured and calculated bar volume, Duck, NC



GenCade FY12-FY13 Activities

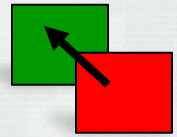
CMS-Wave

Wind input, wave generation & growth, wave transformation, diffraction, reflection, run-up, setup, overtopping, structures, surface roller

→ **GenCade**

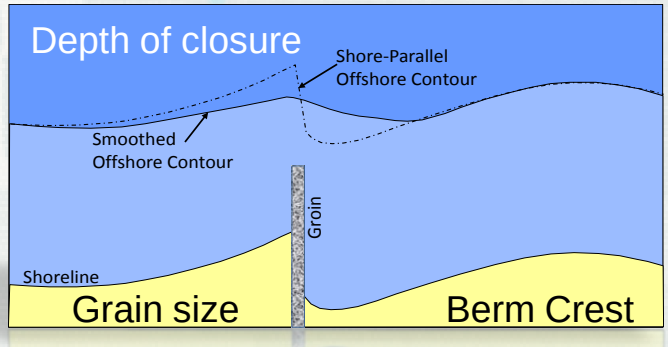
Option for GenCade to accept forcing from an external wave model

GenCade → *SBAS Arc10*



GenCade output used as input to create an SBAS Calculated Sediment Budget

Variable alongshore parameters



Wiki-TN: Standard Methodology for Calibration and Validation

- *Statistical toolkit*
- *Recommended statistics for acceptable Cal/Val*
- *Standard, unified approach*

Visit the GenCade Booth!

CIRP Technology & Products*

Surface Water Modeling System

Web-Tools and Guidance

Mobile Device Applications

CMS

CPT and CSMART

Nearshore Berm Calculator

MetOcnDat: WaveNet

IRM Webtool

Channel Shoaling Toolbox

CIRP Website & Wiki

Find us on Facebook

Inlets Online

Berms Online

Inlets Database

Section 111 Toolbox

CPT-Lite

CIRP Website

PC Tools

Inlet Reservoir Model

• CMS-Wave
• CMS-Flow
• PTM

GenCade

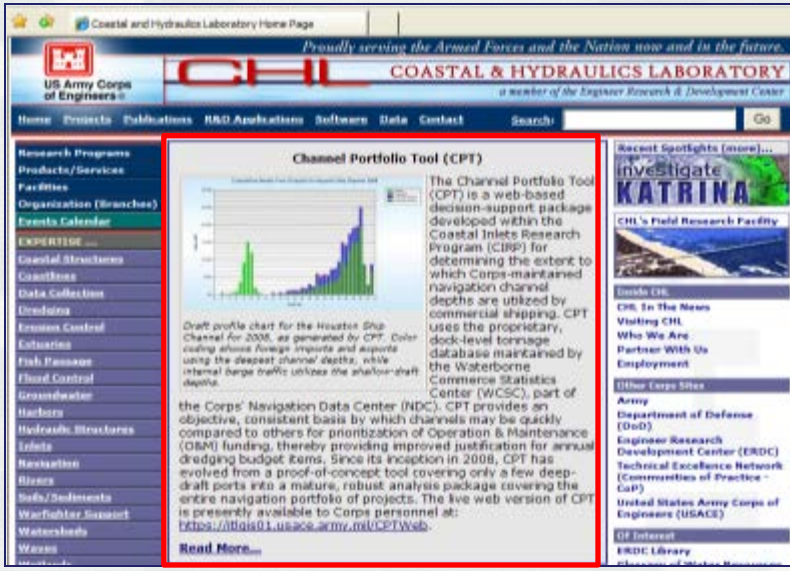
Bouss-2D

*Active R&D in FY12-FY13; other mature products still available.

Channel Portfolio Tool (CPT)

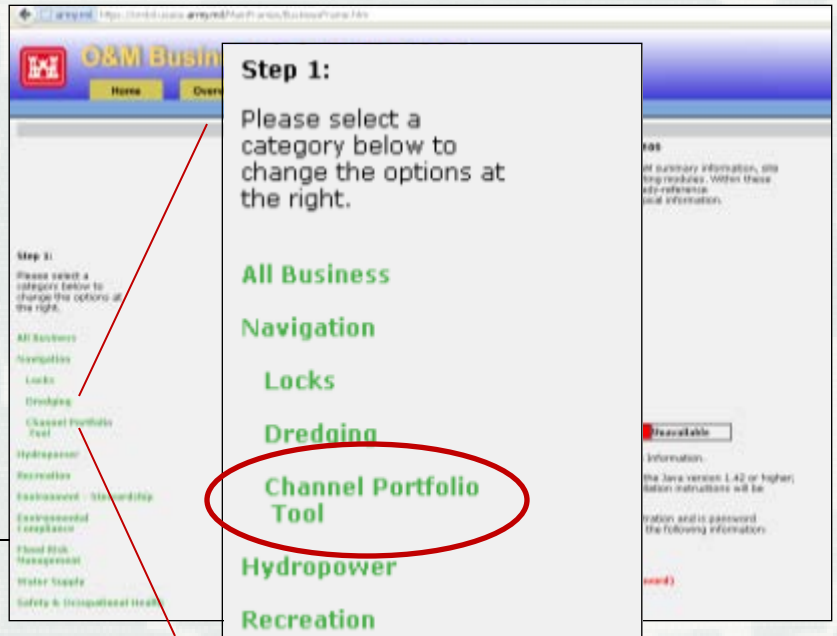
What is CPT?

Web-based application that relates navigable depths to cargo most vulnerable to shoaling. Allows for detailed, reach-level analysis as well as regional and national summaries of the ***waterborne transportation systems*** supported by Corps navigation projects.



https://cpt.usace.army.mil

CPT uses data provided by the Waterborne Commerce Statistics Center (WCSC), and is available via the OMBIL portal.



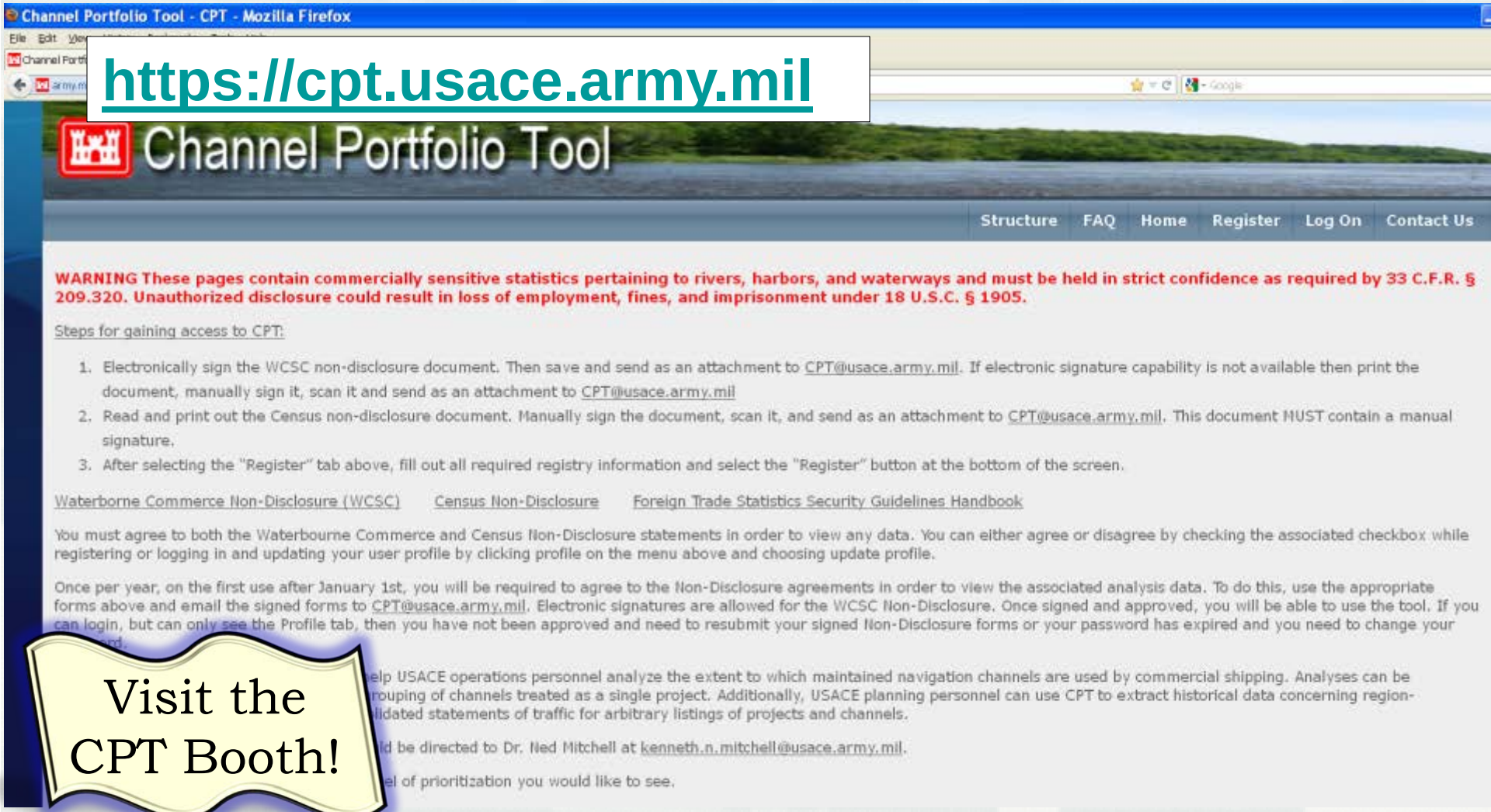
CHL Coastal and Hydraulics Laboratory

Channel Portfolio Tool (cont.)

Why CPT?

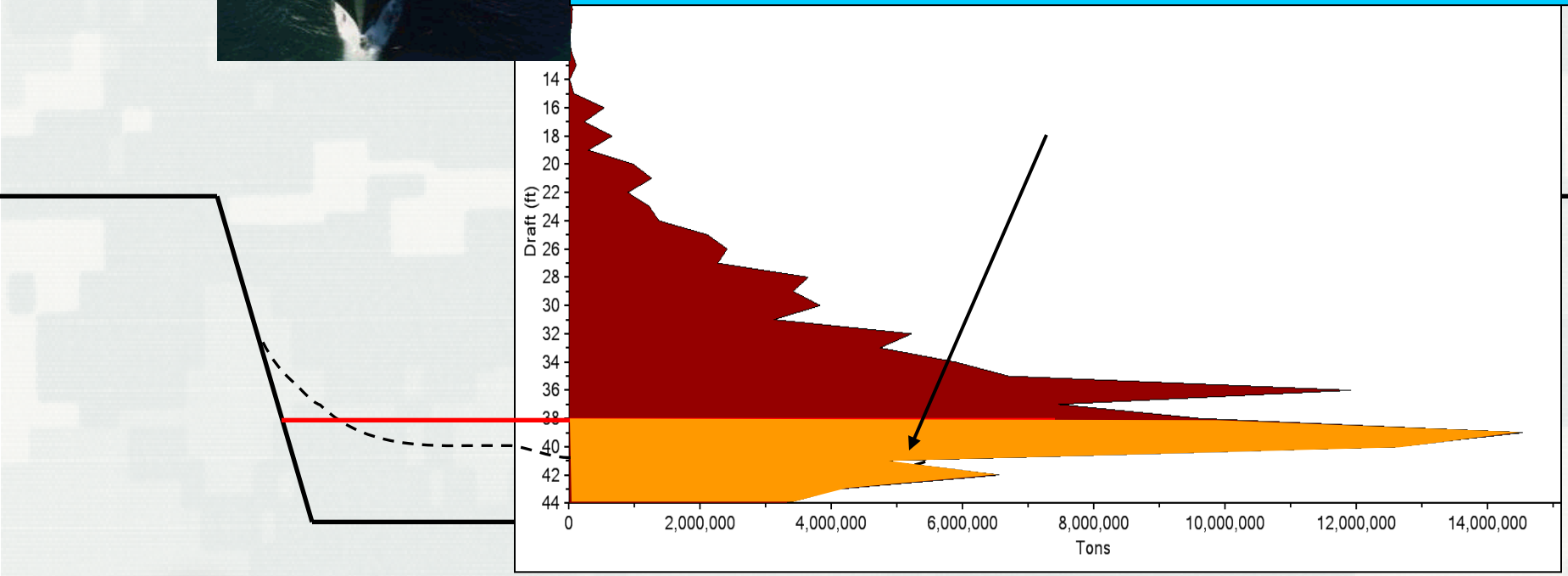
- Navigation project managers need consistent, objective data to justify funding for O&M dredging requests.
- OMB has indicated that improved O&M justification is a precondition for increased outlays from the Harbor Maintenance Trust Fund (HMTF).
- CPT conducts the data processing and filtering necessary for system-level analysis and performance evaluation.

Channel Portfolio Tool (CPT)

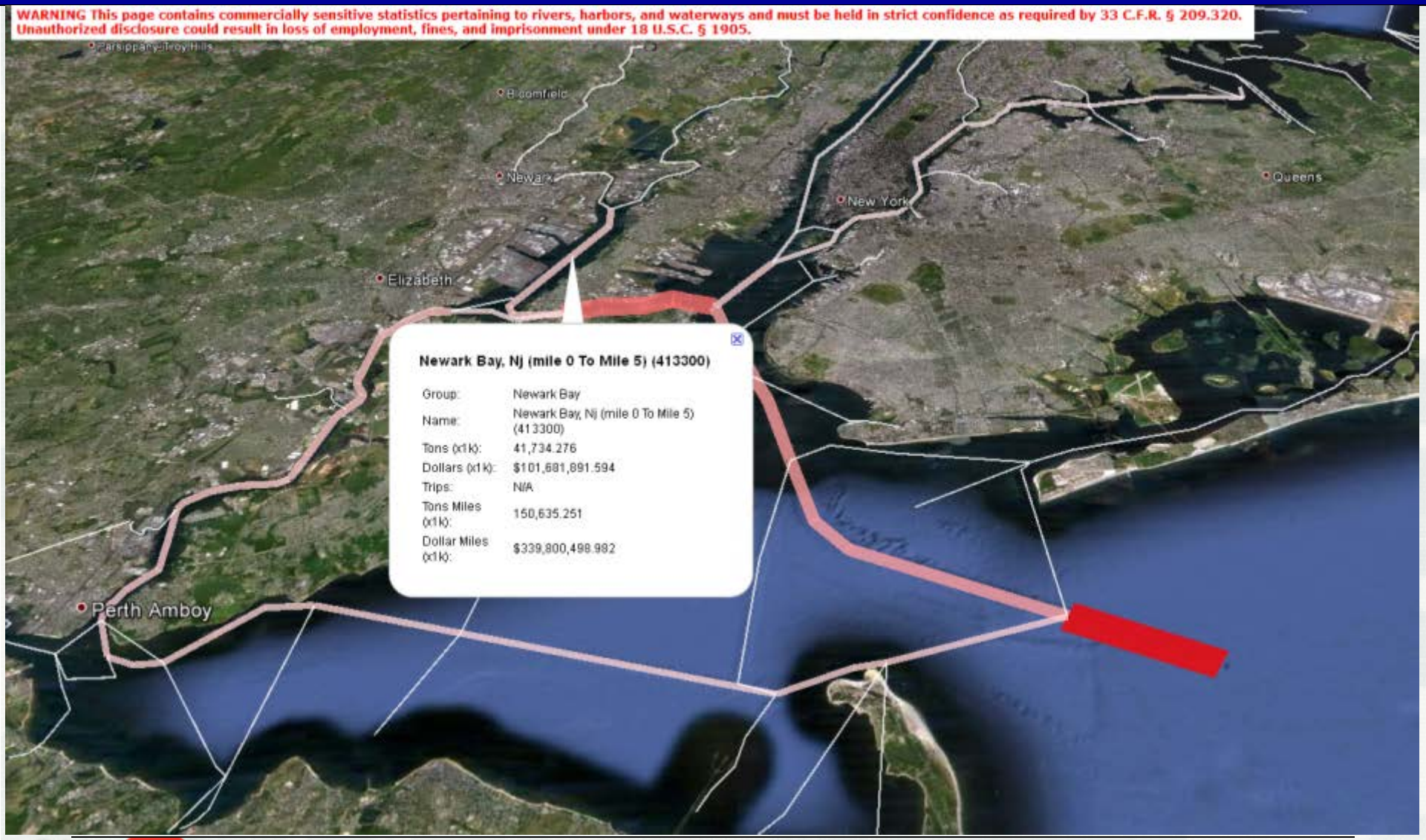


Depth-Utilization Analysis

CPT tabulates the historical rates of shoal-vulnerable tonnage transiting navigation channels and uses the respective quantities as a basis for prioritizing O&M dredging jobs.



Visualization with CPT



CPT and Navigation Systems

New York Harbor: budgeted as separate navigation projects… yet functions as a navigation system.

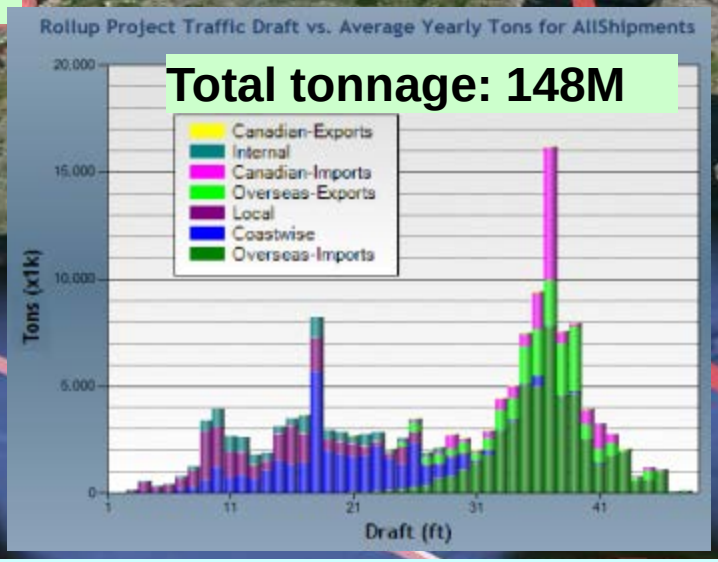
Hudson River: 14.2M tons, 2009

East River: 24.3M tons, 2009

Newark Bay: 39.5M tons, 2009

NY-NJ Channels (Arthur Kill-Kill van Kull): 121.0M tons, 2009

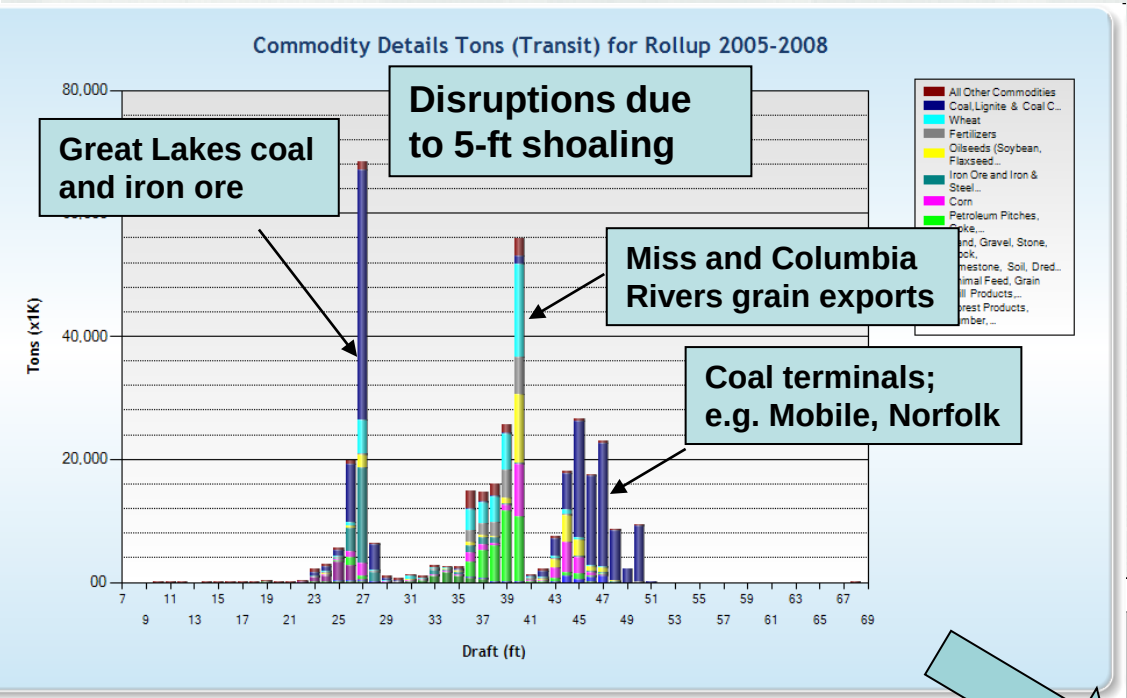
Buttermilk Channel: 23.8M tons, 2009



New York Lower Entrance Channels: 135.4M tons, 2009

CPT is helping to ensure that Project O&M budgeting considers channel depth-utilization, cargo types, and system interdependencies (i.e. condition of other projects!).

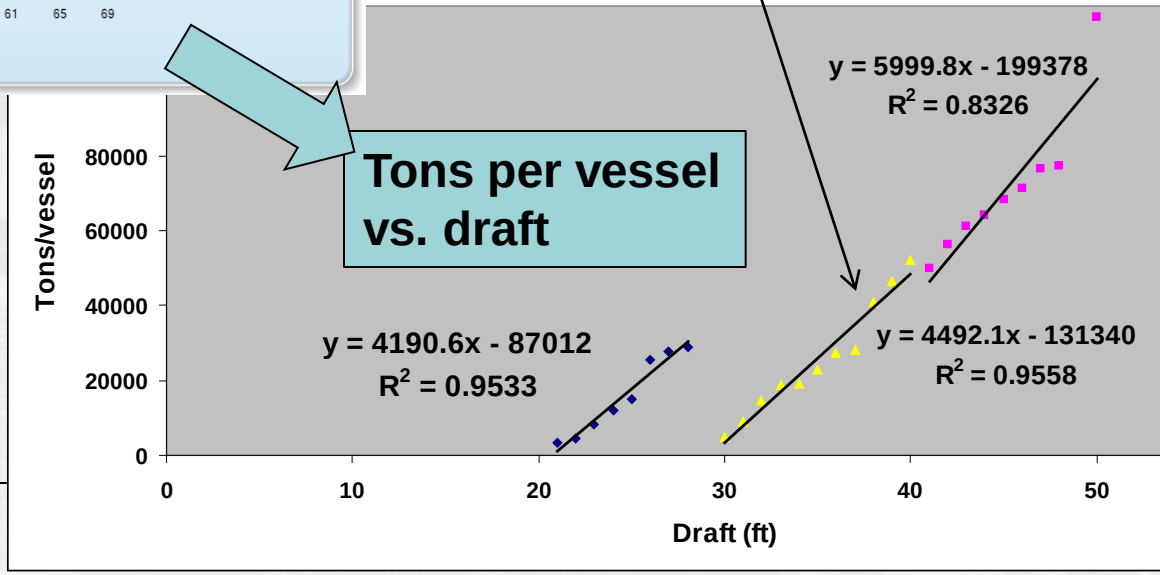
Quantifying Impacts of Shoaling



- Scalable approach for quickly estimating cargo that must be light-loaded due to shoaling conditions.

- Slopes of trend lines indicate the average amount of cargo that must be removed from each vessel in order to reduce vessel draft by 1-ft.

4,500 tons/vessel/ft of depth



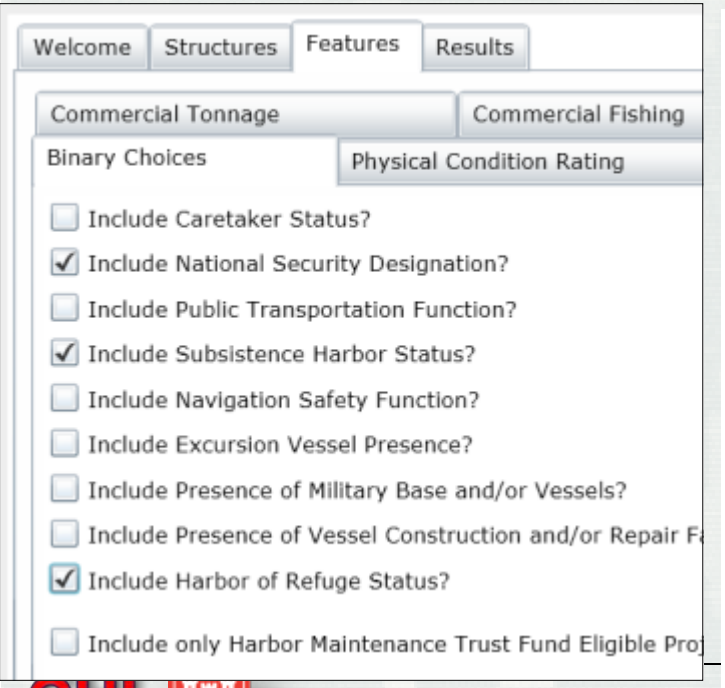
- Approach can be extended to total annual cargo disruptions, number of required additional voyages, and ultimately increased shipping costs.

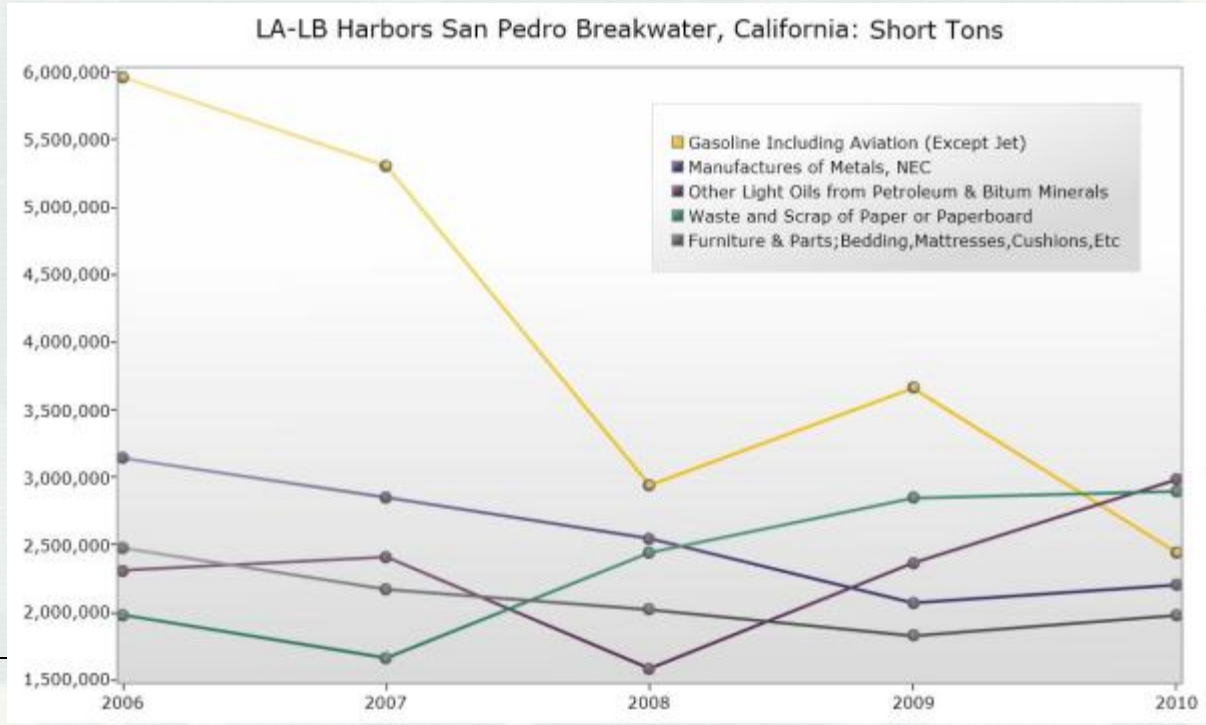
Coastal Structures Management, Analysis, and Ranking Tool (CSMART)

What is CSMART?

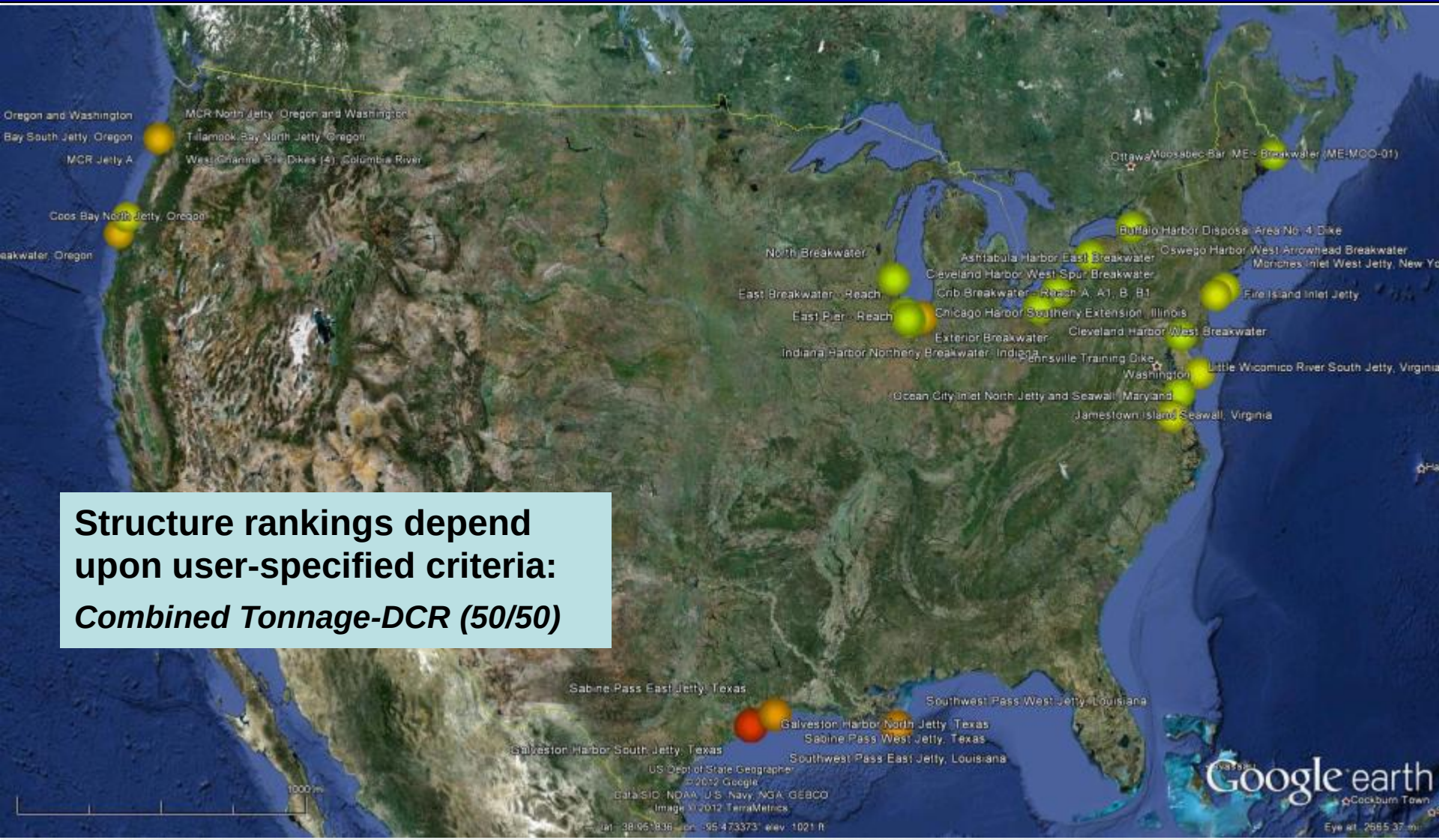
Web-based, Silverlight application that prioritizes coastal structures according to user-specified criteria and weightings on metrics such as condition rating, commercial tonnage, fish landings, and cruise and ferry passengers. Allows local, regional, and national queries and comparisons.

https://itlgis01.usace.army.mil/CPT/Silverlight/CSMART





Structure Prioritization via CSMART

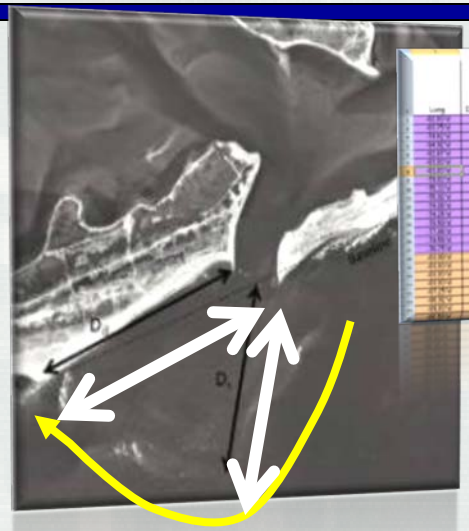


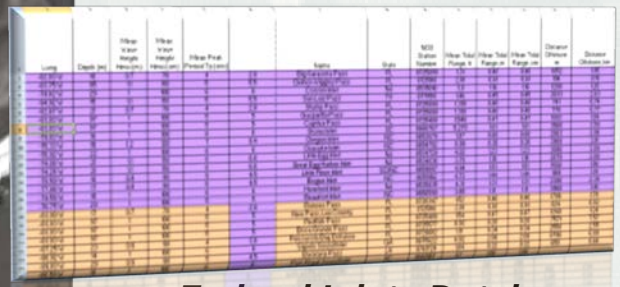
Structure rankings depend upon user-specified criteria:

Combined Tonnage-DCR (50/50)

Geomorphologic Webtools

...seamless connecting data with models and online tools



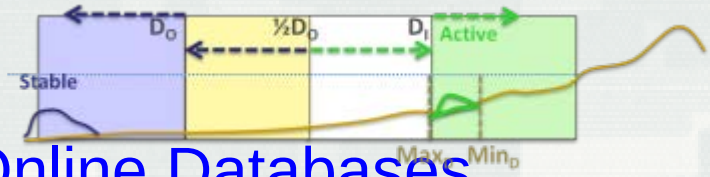


Federal Inlets Database

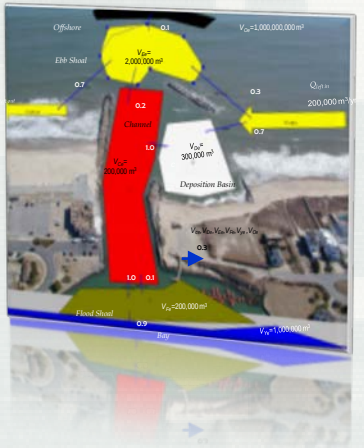
Inlets Online

Berms Online

Nearshore Berm Calculator



Inlet Reservoir Model (Web-based Version)



Inlets and Berms Online Databases to Common Web Platform

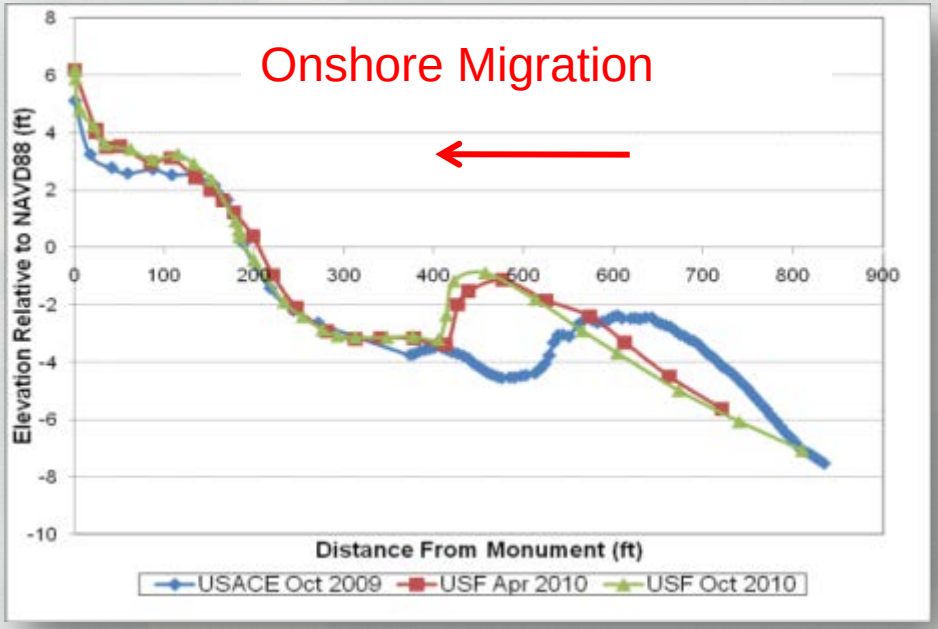
- Geomorphic Properties of Inlets (Hayes Diagram Reform; Ebb Shoal Dimensions)
  - Define areas of influence of inlets
- Berms Online Database
- Nearshore Berm Calculator
- Inlet Reservoir Model (Web Version)

Action 3.2.1 of Navigation Strategic Vision
"Develop an inventory of all federal authorized projects…"

FY12 Nearshore Berms

Questions

- **Placement Method:**
  Pump vs. Hopper Dredge
- **Quantity and Rigor of Design:**
  "Dumped" vs. Designed
- **Cross-shore Location:**
  Feed sand vs. wave break
- **Alongshore Location:**
  Relative to inlet; gaps required?
- **Environmental Concerns:**
  Dispersion of fines over habitat



Statements of Need

Design and Evaluation Tool for Nearshore Berm Placement of Non-Beach Compatible Material
Tracking Number 2011-N-15

Nearshore Placement of Dredged Sediment Assessment
Tracking Number 2011-N-19

FY12 Nearshore Berms Products

Ft. Myers Berm (Completed; Final Report Pending)

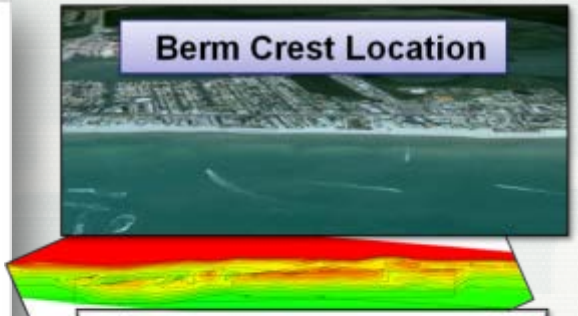
- Sediment dispersion
- Bathymetric change and berm migration rates

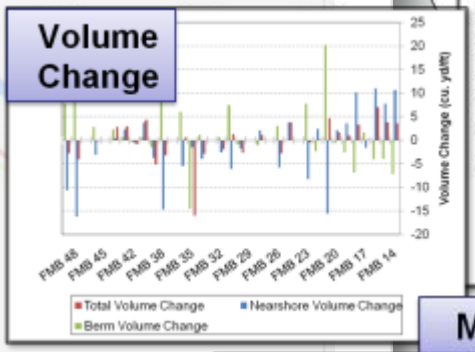
Pensacola Berm (In Monitoring Phase)

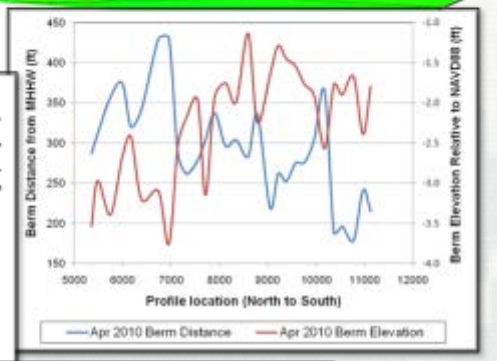
- Sediment dispersion
- Alongshore migration rates
- Pensacola channel infilling rates

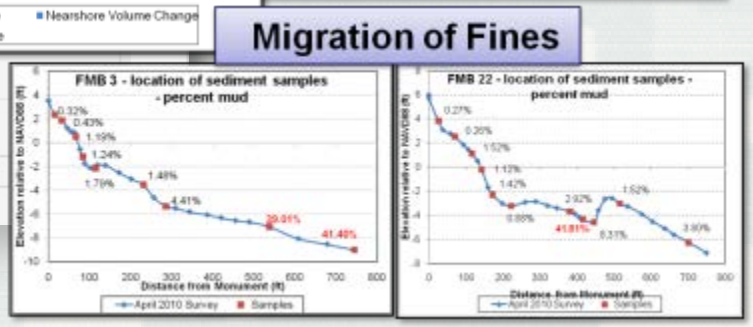
Egmont Berm (In Monitoring Phase)

- Pre-project site characterization
- Post-placement evolution







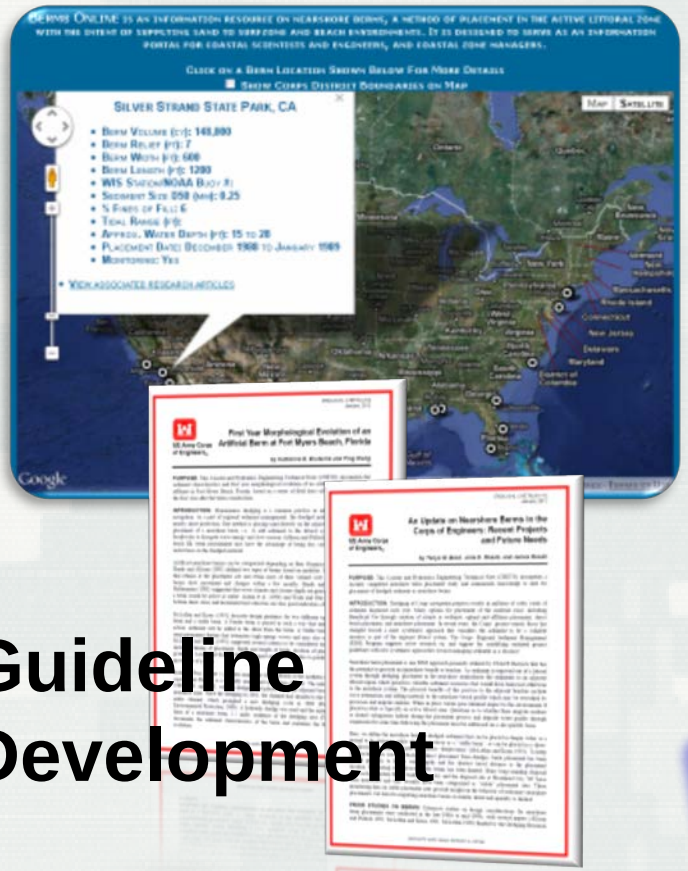


Action 3.2.2 of Navigation Strategic Vision
"Establish practices…optimize environmental windows…maximize beneficial use of O&M"

FY12 Nearshore Berms

Berms Online:

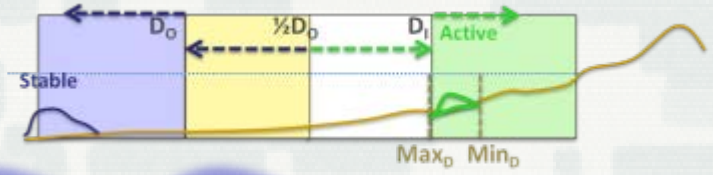
A Nearshore Berm Historical Database

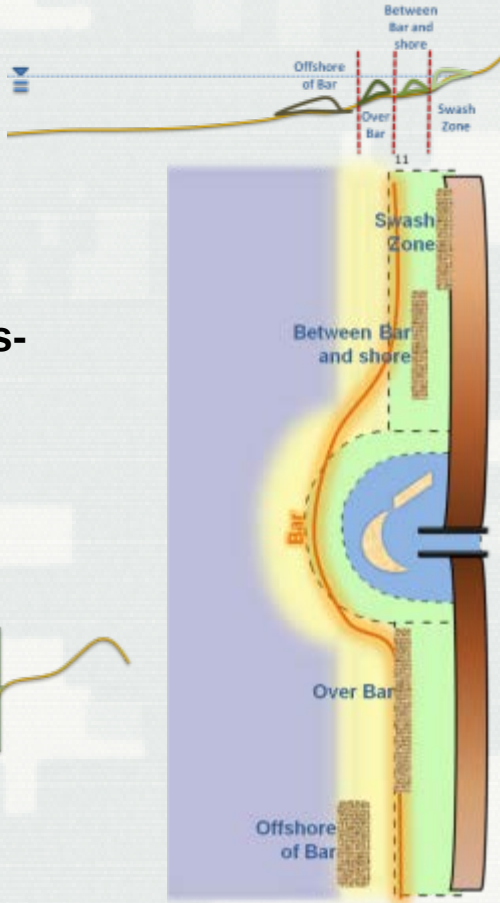


Guideline Development

Simple Planning Calculator Tool

- Developing flexible tools (rapid desk-top to detailed models) for design
- Dredged sediment size(s) and volume
- Placement position in cross-shore, and soon in alongshore
- Site processes represented through empirical formulae





Check out the Berm Booth!

CIRP Future

CIRP Vision for O&M Decision-Support

cirp.usace.army.mil

Find us on Facebook

Advance R&D in models and tools

Link to existing data and databases

Produce accurate calculations with quantified goodness-of-fit

Roll up calculations to speed interpretation

Generate graphical and quantitative output for decision-support

Speed delivery of results to customers

Examples…

Channel Portfolio Tool (CPT), CPT Smart Phone App

Please let us know if you have more ideas!

Models and Tools

GenCade

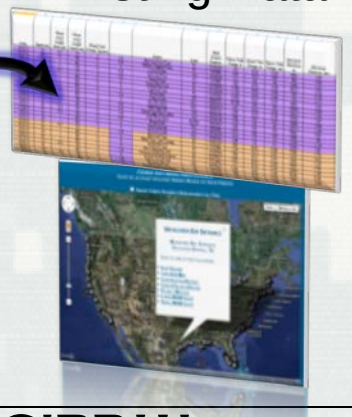
link

Other Models and Tools

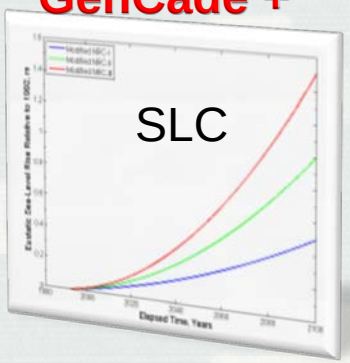
Models and Tools

link

Existing Data



GenCade +



CIRP Website

Field Data at Degraded Jetty/Breakwater

- Decision-support guidance for rehab given damage rate & SLC
- Many federal structures 50+ years old
- Validate wave overtopping, transmission, and sand transport through rubblemound structures
- Rehabilitation multi-million $
- Consider archived AIS vessel movement; is wave transmission through jetties creating navigation hazards?

Action 3.2.3 of Navigation Strategic Vision

"Develop science & engineering risk-management approach…to nationally rank reliability of navigation projects"

Statements of Need

Improving Wave Calculations at Coastal and Estuarine Navigation Channels
Tracking Number 2009-N-5

Statements of Need

Automatic Identification System (AIS) data use in Navigation operations and engineering.
Tracking Number 2013-N-5

CIRP Existing and Future SoNs

Presently Addressing 5 SoNs:

Statements of Need

Need long-term morphologic evolution predictors
Tracking Number 2008-N-6

Statements of Need

Design and Evaluation Tool for Nearshore Berm Placement of Non-Beach Compatible Material
Tracking Number 2011-N-15

Nearshore Placement of Dredged Sediment Assessment
Tracking Number 2011-N-19

Statements of Need

Improved Justification for and Prioritization of Annual Maintenance Dredging Investments
Tracking Number 2009-N-8

Statements of Need

Dynamic Web-link and analysis of environmental Database for Coastal Inlet, Harbor, and Estuary Wave Modeling Projects
Tracking Number 2011-N-10

CIRP Existing and Future SoNs

Propose Adding 4 More in FY13 (discuss Thu):

Statements of Need

Identifying and Addressing Potential Sea Level Change Impacts to Navigation Projects
Tracking Number 2013-N-11

Statements of Need

Automatic Identification System (AIS) data use in Navigation operations and engineering.
Tracking Number 2013-N-5

Statements of Need

Automated Feature Extraction for Sediment Budgets
Tracking Number 2013-N-15

Statements of Need

Improving Wave Calculations
Tracking Number 2009-N-5

Thank you!

Ned, Mary Beth, David, and baby John Mitchell