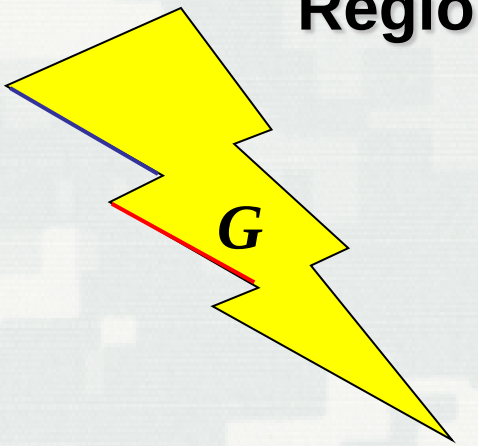
GenCade

Combining and Extending the GENESIS and Cascade Models for Planning and Design in a Regional Sediment Management Framework



Presented by Nicholas C. Kraus

For the GenCade Development Team

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Sophie Munger, Ashley Frey, Tanya Beck, Nick Kraus

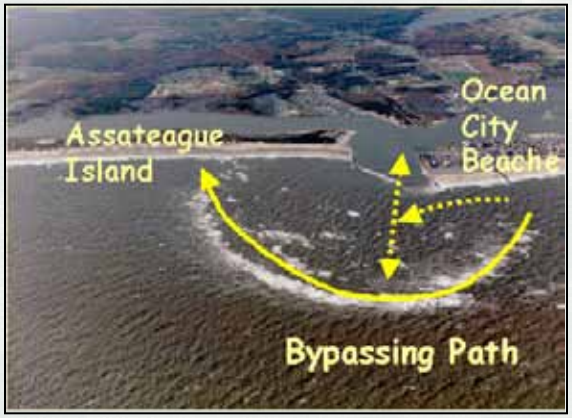
February 3-5, 2010
Crowne Plaza Melbourne Oceanfront
Indialantic, FL

23rd Annual
National Conference on Beach
Preservation Technology

GenCade Applicability

Regional processes,
Long-term morphology change

Project Planning & Design

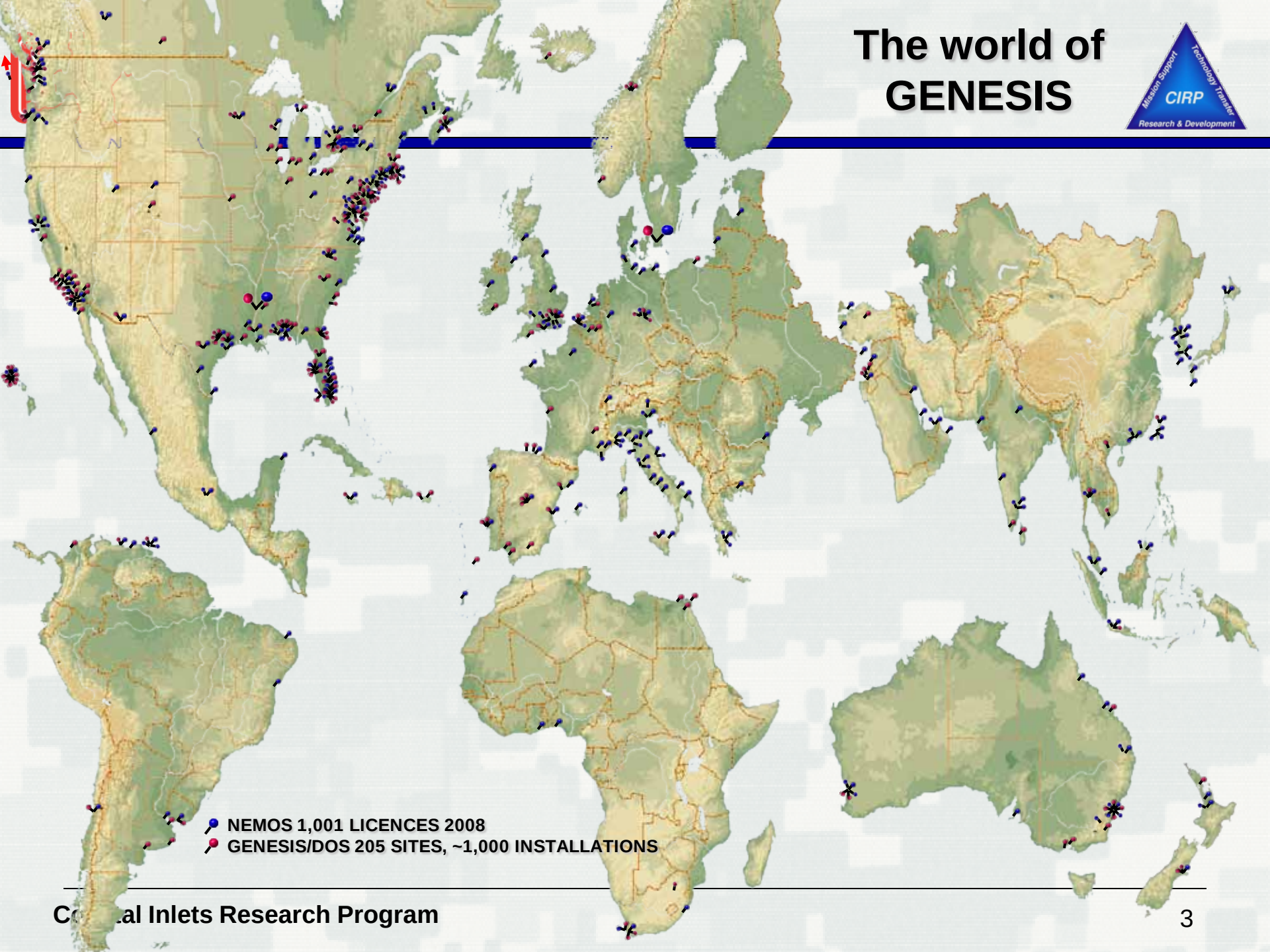


Habitat Change

- **Regional Sediment Management**
  - **Beach fills**
  - **Inlet bypassing**
  - **Channel maintenance**
- **<u>Unifying technology</u> for multiple projects**
- **Intuitive interface (SMS)**

- **Storm erosion hazard management**
- **Dune erosion, overwash, & breach susceptibility; coastal response to SLR**
- **Habitat evolution (Piping Plover; vegetation)**

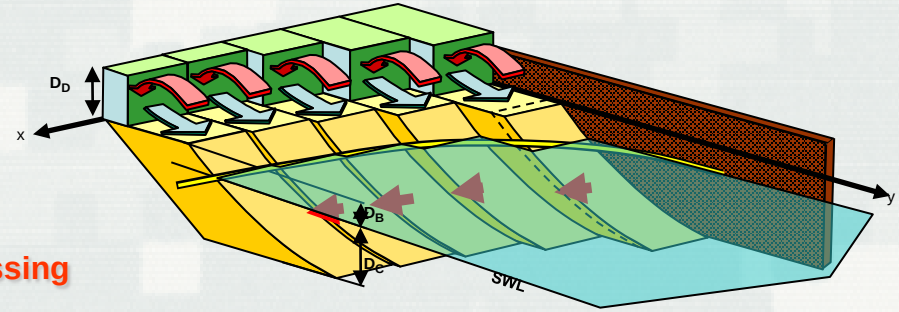
The world of GENESIS

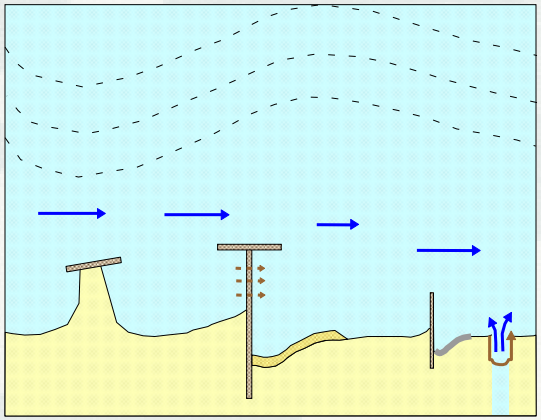


GENESIS and Cascade Chronology

GENESIS & Cascade Evolution

1976-1980 – Proto-GENESIS
1984 – Major prototype application: Oarai Beach, Japan
1985 – Seawall representation
1985 – GENESIS goes to CERC
1986 – Generalized interface: Named GENESIS
1987 – GENESIS gets a Ph.D. (Hans Hanson)
1989 – Transmissive detached breakwaters included
1993 – Improved groin representation: Transmission & bypassing
1996 – Research: migrating longshore sand waves
1997 – Research: cross-shore seasonal variation
1999 – Economic optimization of beach fill transition
2000 – Representation of tombolos
2000 – Research: transport function of waves + tidal currents
2001 – Representation regional morphologic trends
2002 – Cascade, including regional contour & Inlet Reservoir Model
2002 – Time-dependent detached breakwater transmission
2003 – Cascade, spatially varying K and D_C: nesting with GENESIS through regional lateral BCs
2004 – Cascade, inclusion of refined inlet Reservoir Model
2004 – Research: Offshore losses of fine sediments
2004 – Representation of T-head groins
2006 – Cascade, cross-shore model of combined dune erosion, overwash, and wind-blown sand
2007 – Research: New longshore transport formula
2008 – Cascade, Rapid calculation of breaking wave properties representation
GenCade – based on USACE release code
2008 – Research: Beach-dune interaction
2009 – Variable grid alongshore; other speed-ups
2009 – Inlet Reservoir Model included





GENESIS + Cascade à GenCade

Cascade (top to bottom)

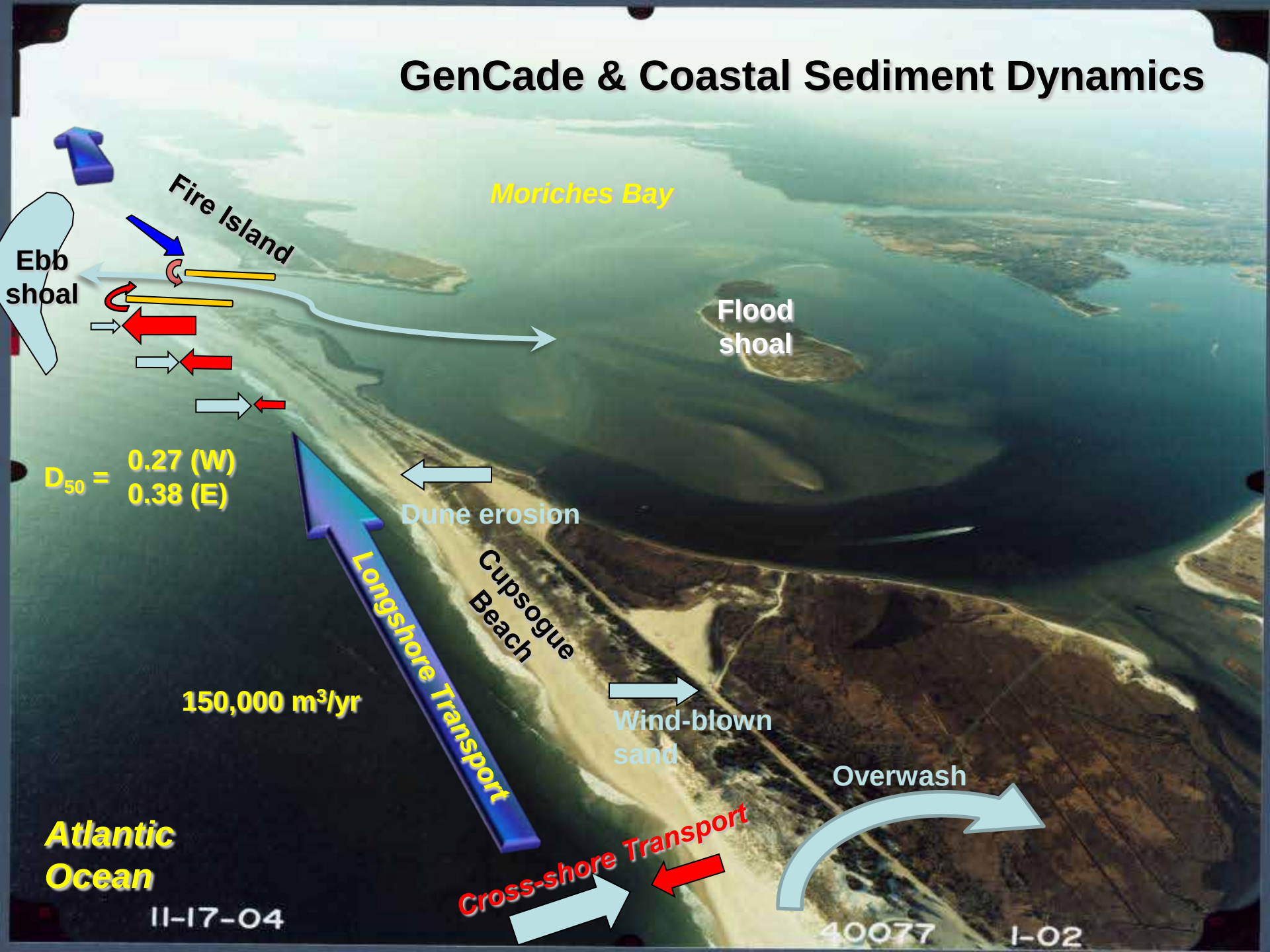
- Planning tool (RSM Support)
- Time scales: months to centuries
- Multiple inlets, shoals, and barrier islands; cumulative impacts; retains curvature of regional geomorphology
- Fast
- Typical grid resolution ~ 500 m
- Cross-shore processes in future

GENESIS (bottom to top)

- Engineering design tool
- Can represent all engineering details – structures, etc.
- Mature technology – big payback by updating
- Typical grid resolution ~ 25 m

- Integrate from planning through engineering design
- Cover time scales from days to centuries
- Preserve regional trends
- Furnish regionally consistent boundary conditions to local projects
- Represent cumulative local projects interacting regionally
- Represent inlet bypassing and tidal delta evolution
- Resolve engineered elements
- Include variable grid resolution for accuracy and efficieny
- Improve computational efficiency (over GENESIS)

Strategy: Add Cascade capabilities to GENESIS to automatically include all GENESIS features


GenCade & Coastal Sediment Dynamics
Moriches Bay
Fire Island
Ebb shoal
Flood shoal
D_{50} = 0.27 (W)
0.38 (E)
Dune erosion
Cupsogue Beach
Longshore Transport
150,000 m³/yr
Wind-blown sand
Overwash
Cross-shore Transport
Atlantic Ocean
11-17-04
40077 I-02

GenCade in the SMS Interface
Surface-water Modeling System

- Intuitive interface for project: conception à completion
  - Data entry, cleaning, and archiving
  - GenCade grid and input development: baseline and alternatives
  - GenCade simulations: baseline and alternatives
  - Post-processing, analysis, and figure generation
- World coordinates – everything georeferenced
- Datum reprojection and transformation
- Georeferenced aerial photograph support
- GIS functions and connections to ArcGIS® and Google Earth™
- CAD display and conversion support for AutoCAD® & MicroStation®
- Improved graphics
- Potential to connect to other USACE numerical models in the SMS

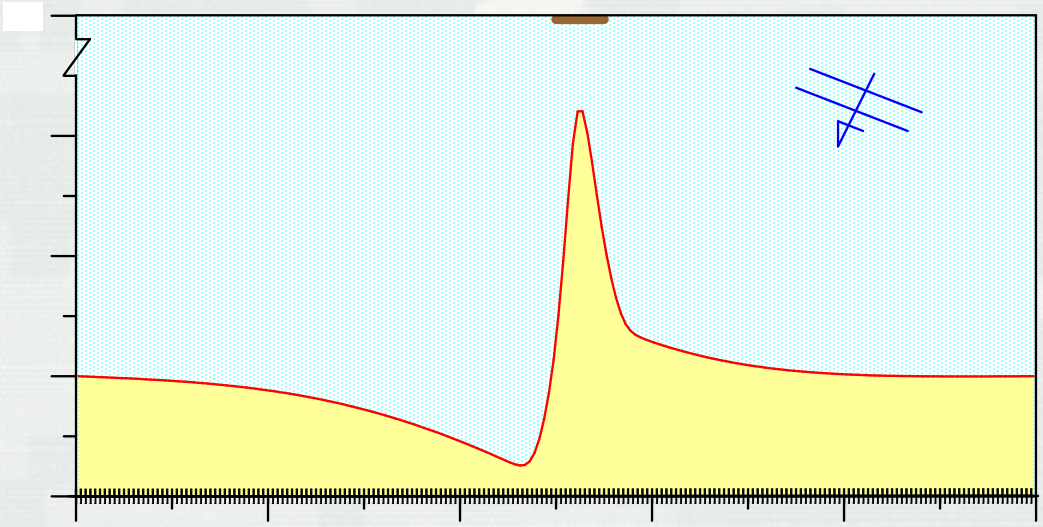
GenCade – variable grid alongshore

Detached Breakwater
3-month simulation

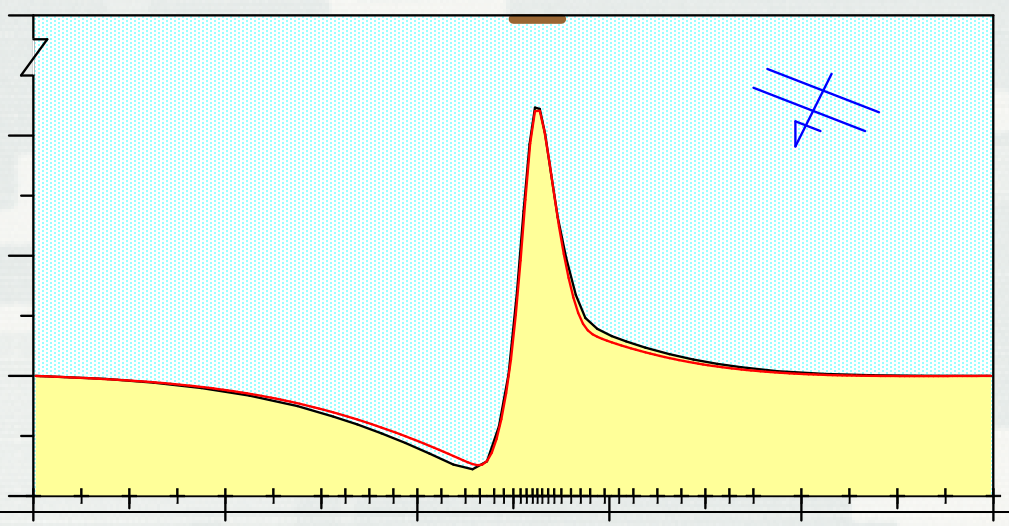
250 m offshore
100 m long

H = 1 m, T = 5 sec, θ = -5 deg.

N = 200
DX = 10 m



N = 40
DX_{max} = 100 m
DX_{min} = 10 m



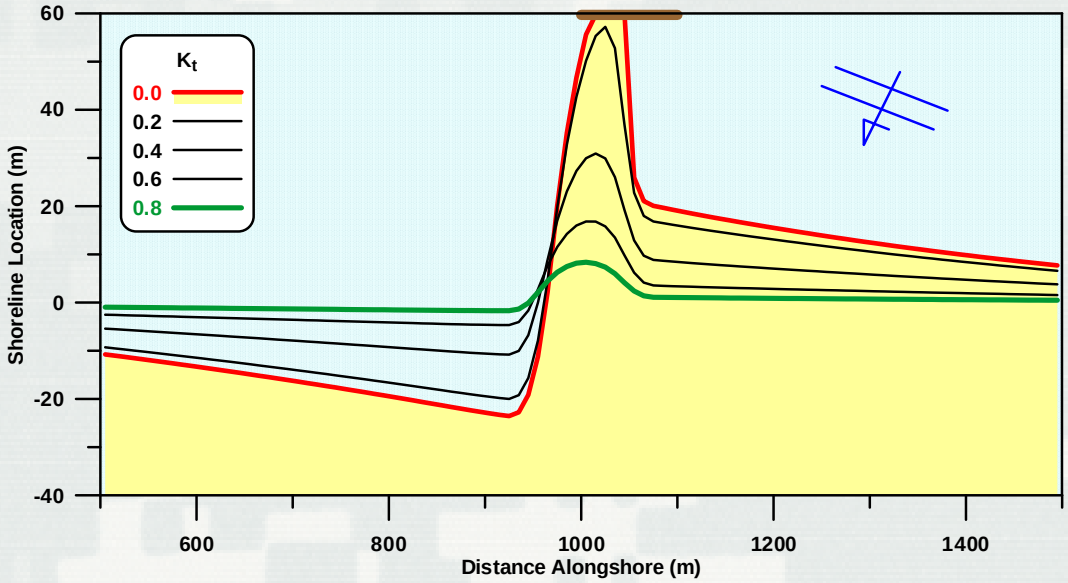
GenCade – Transmissive Breakwater

Detached Breakwater
12-month simulation

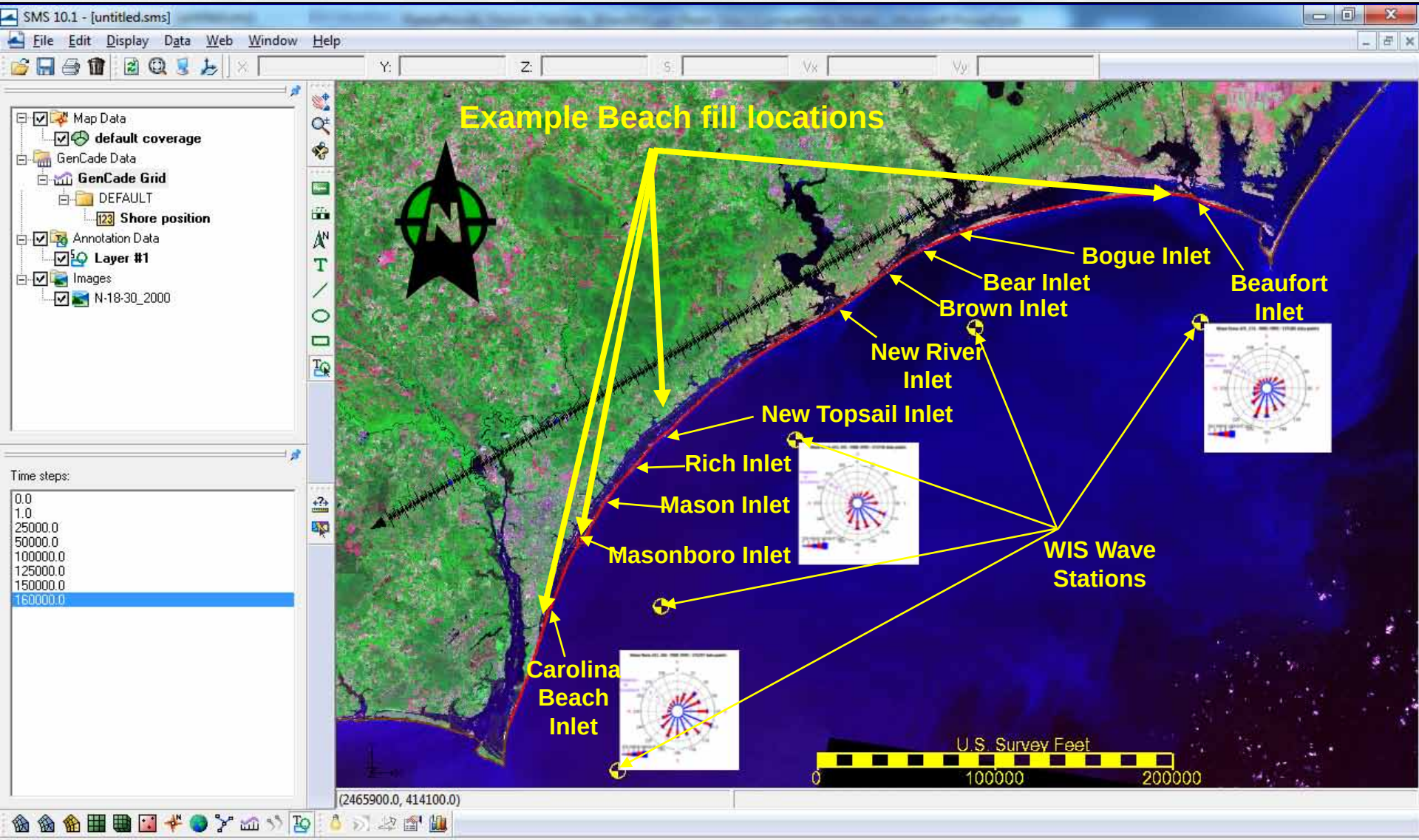
60 m offshore
100 m long

H = 1 m, T = 5 sec, θ = -5 deg.

N = 200
DX = 10 m



GenCade Interface (in the SMS)



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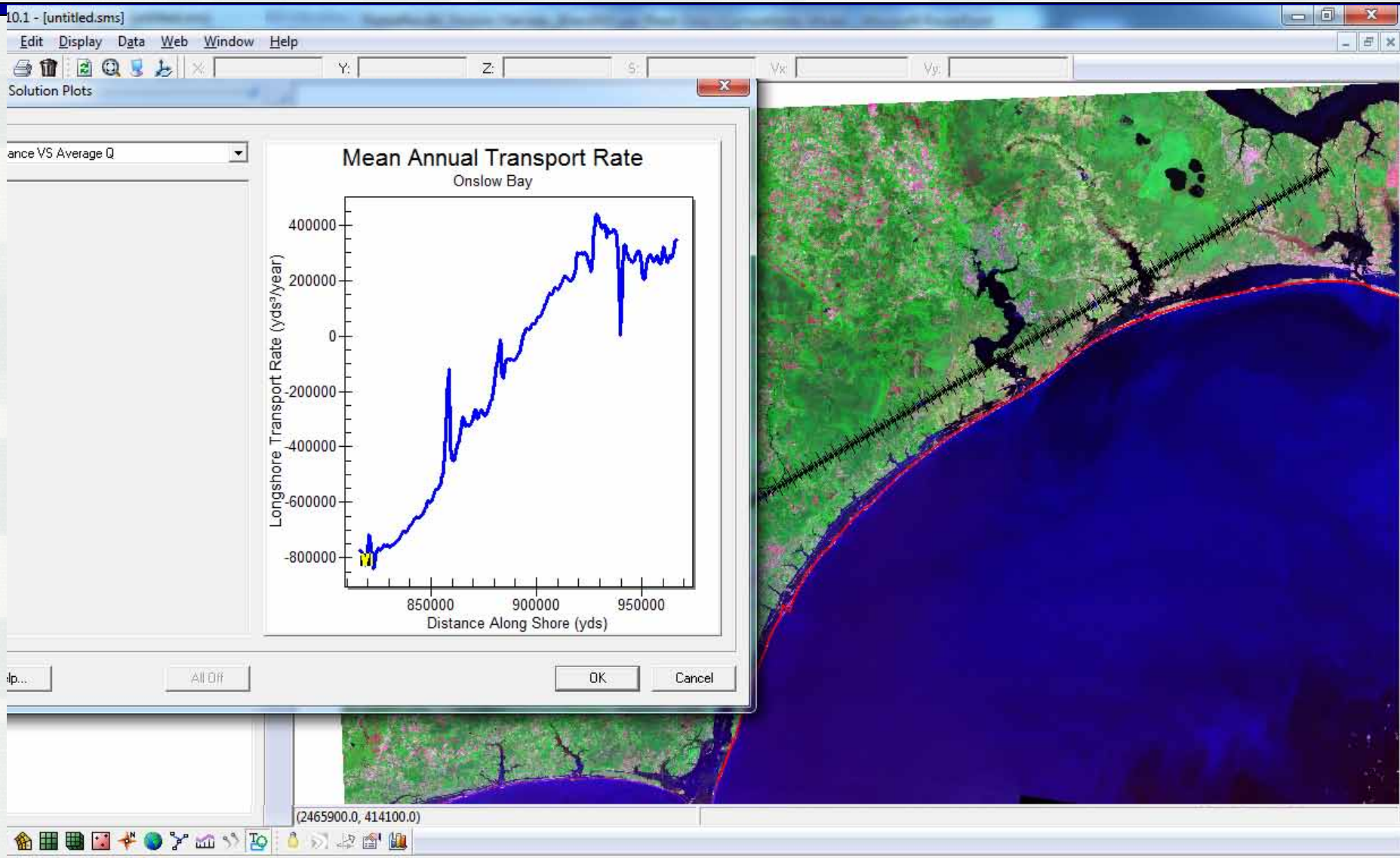
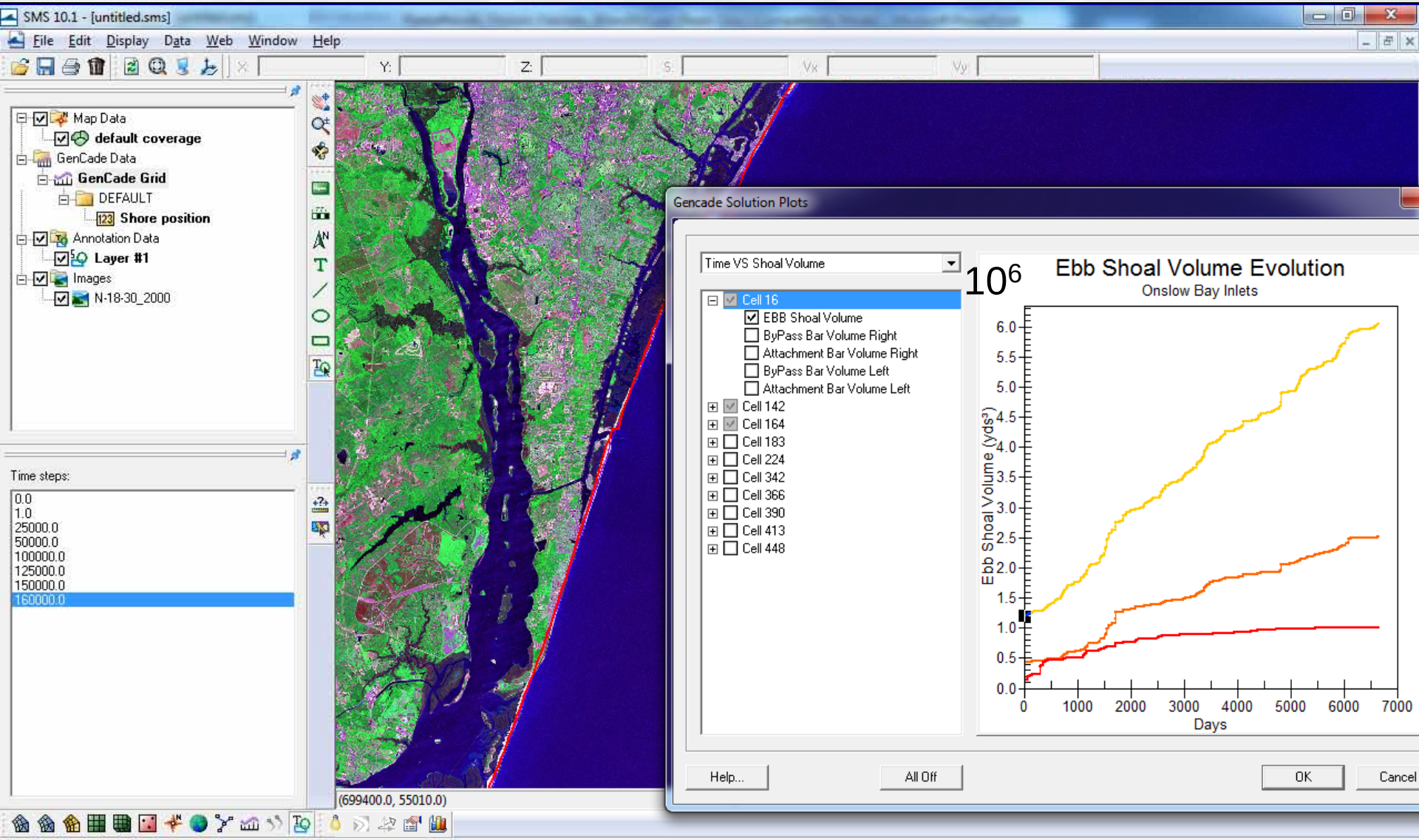
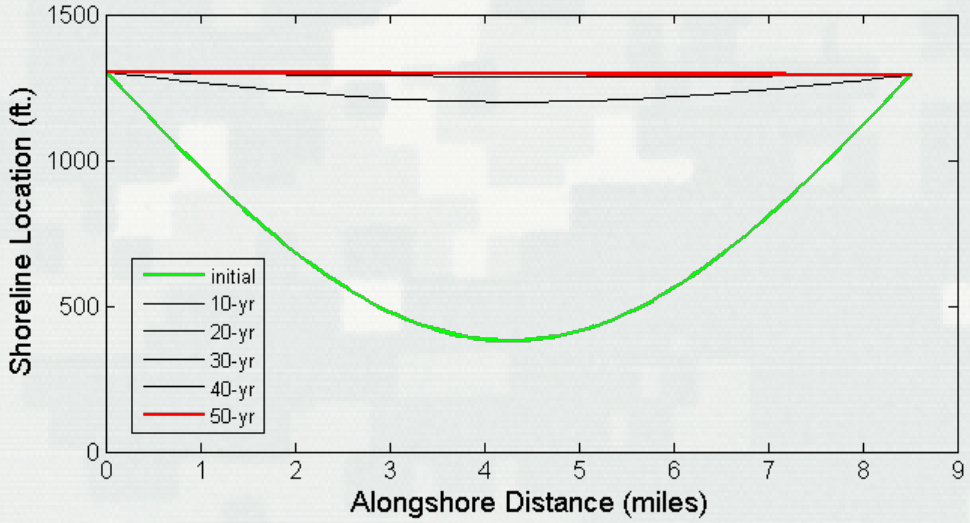


GenCade Interface (in the SMS)

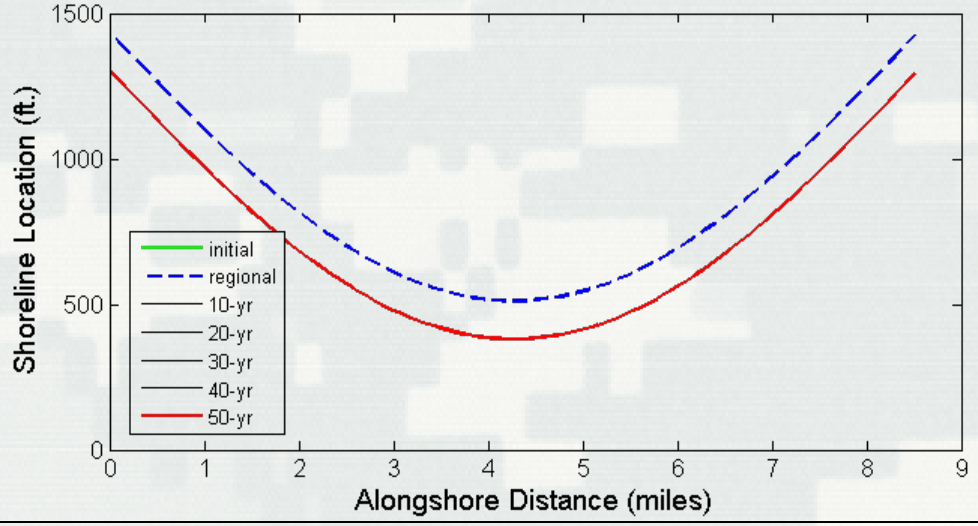


Example
Necessity for Regional Contour

No regional contour

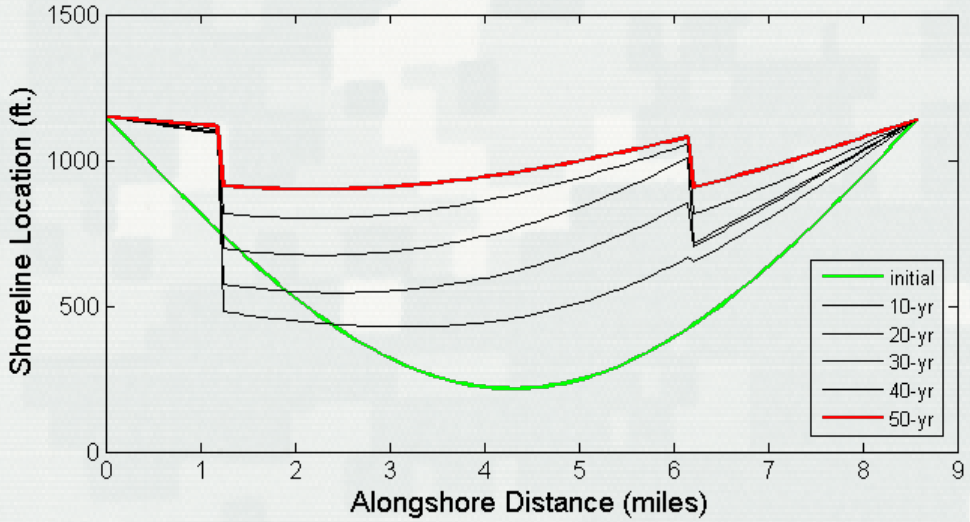


With Regional Contour

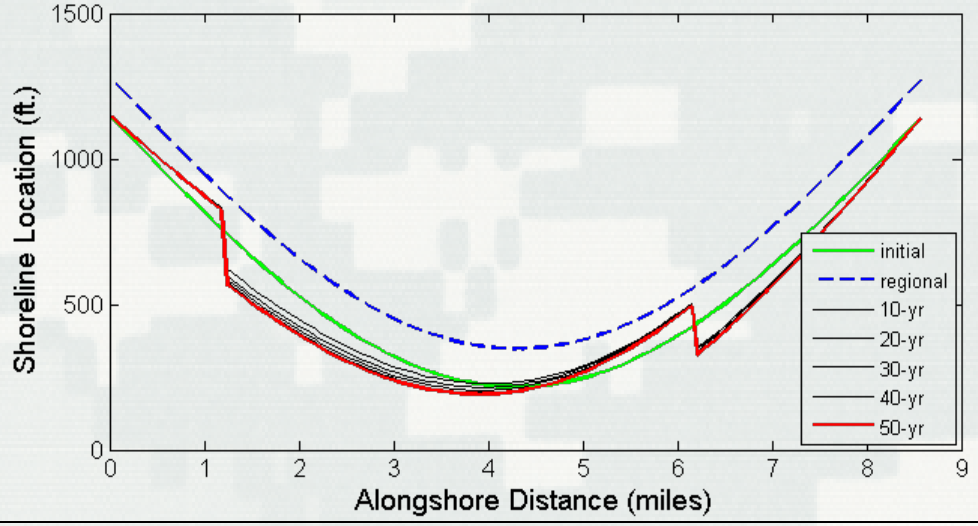


Example – Jetties on Concave Coast (Local projects in regional context)

No regional contour

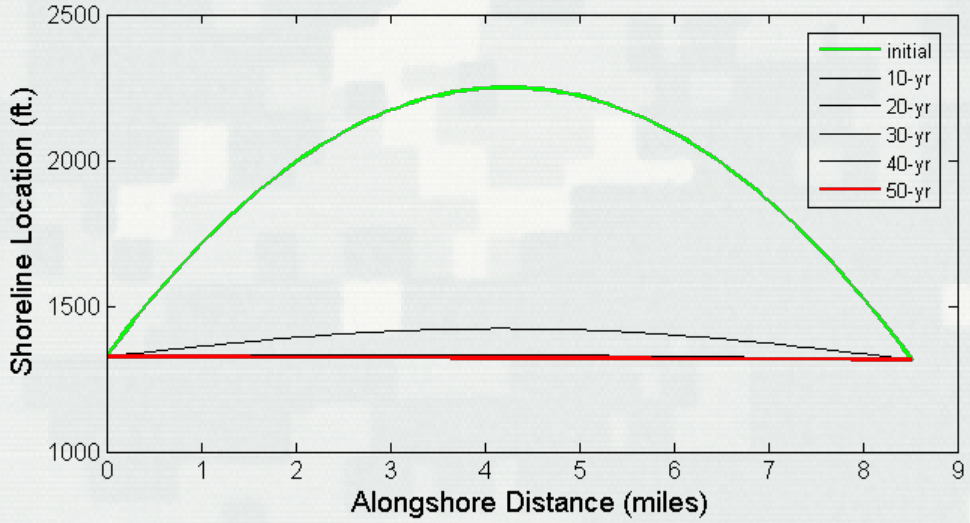


With regional contour

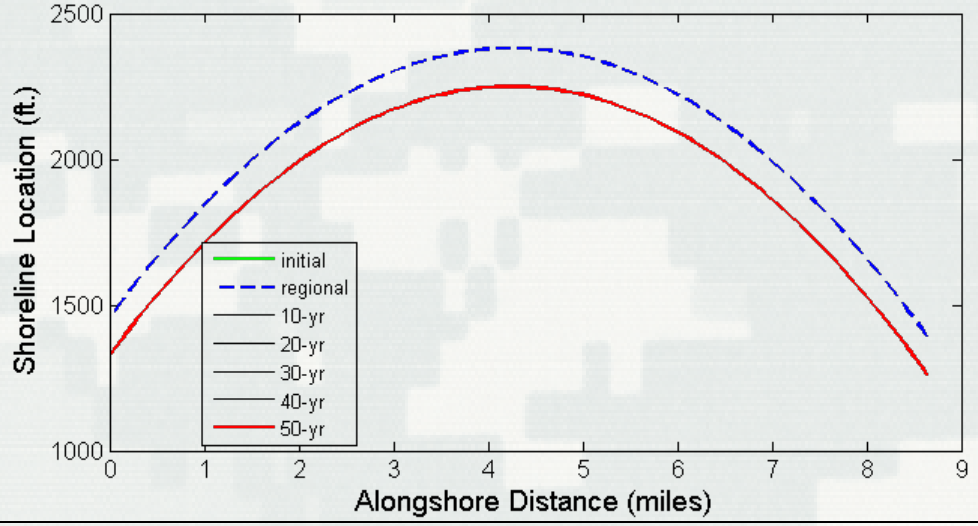


Example
Concave Coast

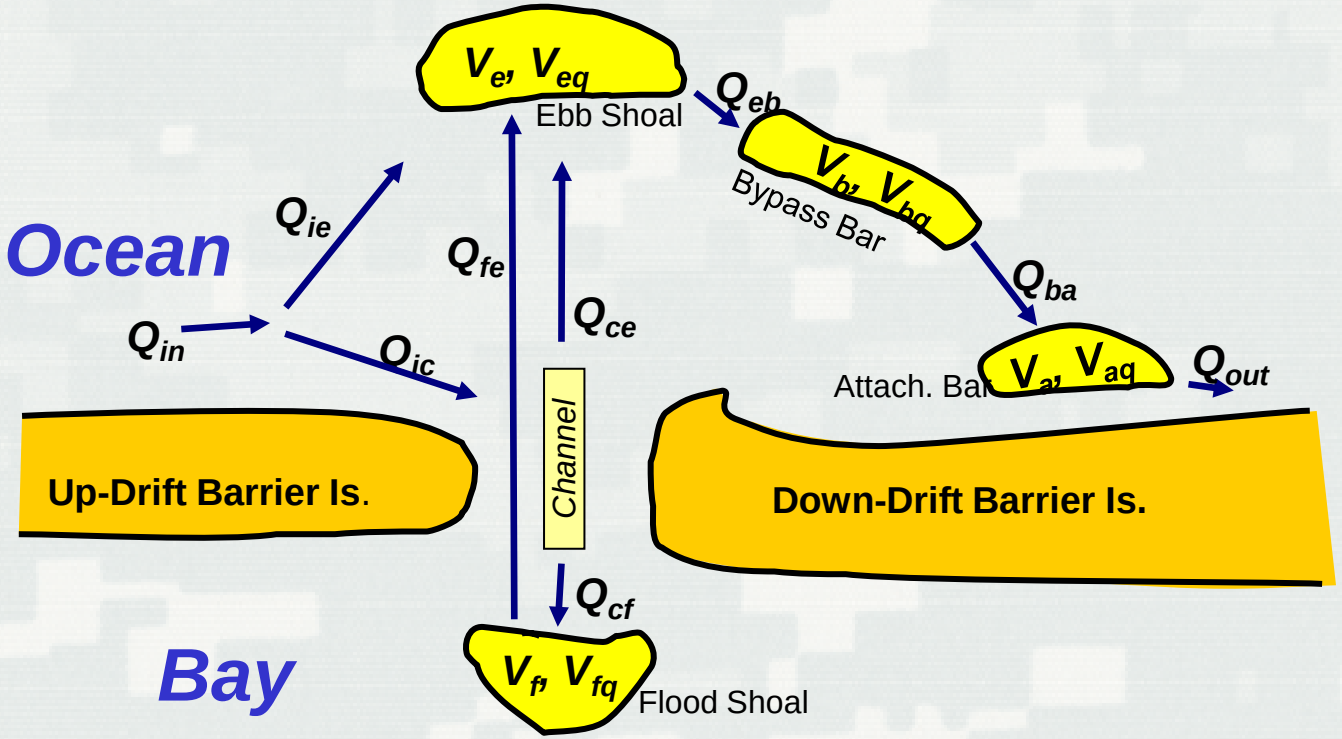
No regional contour



With regional contour



Inlet Reservoir Model
Inlet bypassing and evolution of inlet deltas

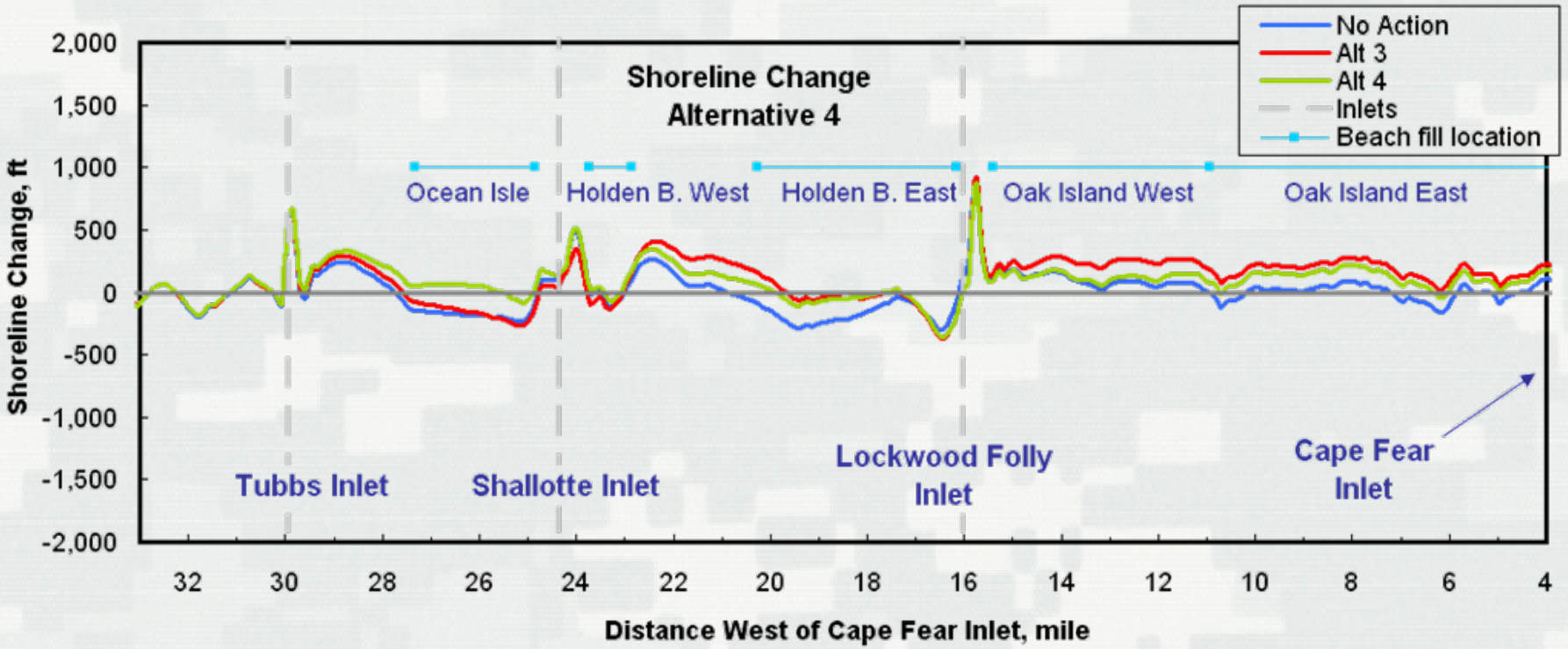


$$Q_{ie} = \delta Q_{in}$$
$$Q_{ic} = (1-\delta) Q_{in}$$
$$Q_{ce} = \beta Q_{ic} = \beta(1-\delta) Q_{in}$$
$$Q_{cf} = (1-\beta) Q_{ic} = (1-\beta)(1-\delta) Q_{in}$$
$$Q_{fe} = (V_f - V_{fq})/dt,\ V_f > V_{fq}$$

$$Q_{eb} = \frac{V_e}{V_{eq}}(Q_{ie} + Q_{fe} + Q_{ce})$$
$$Q_{ba} = \frac{V_b}{V_{bq}} Q_{eb}$$
$$Q_{out} = \frac{V_a}{V_{aq}} Q_{ba}$$
$$\delta = (V_e + V_f)/(V_{eq} + V_{fq})$$

$$dV_e = (Q_{ie} + Q_{fe} + Q_{ce} - Q_{eb})dt$$
$$dV_f = (Q_{cf} - Q_{fe})dt$$
$$dV_b = (Q_{eb} - Q_{ba})dt$$
$$dV_a = (Q_{ba} - Q_{out})dt$$
$$\beta = (1 - V_e/V_{eq})/(2 - V_e/V_{eq} - V_f/V_{fq})$$

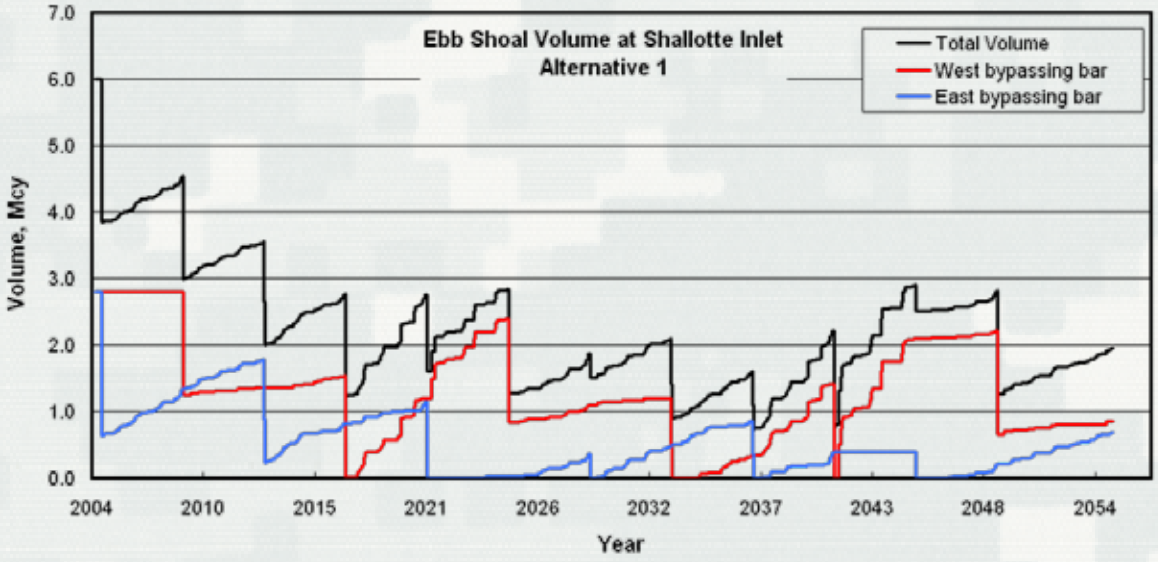
Example Application (Cascade)
Brunswick County, NC, Cascade 2009



Brunswick County, NC, Cascade
Connecting Beaches and Coastal Inlets

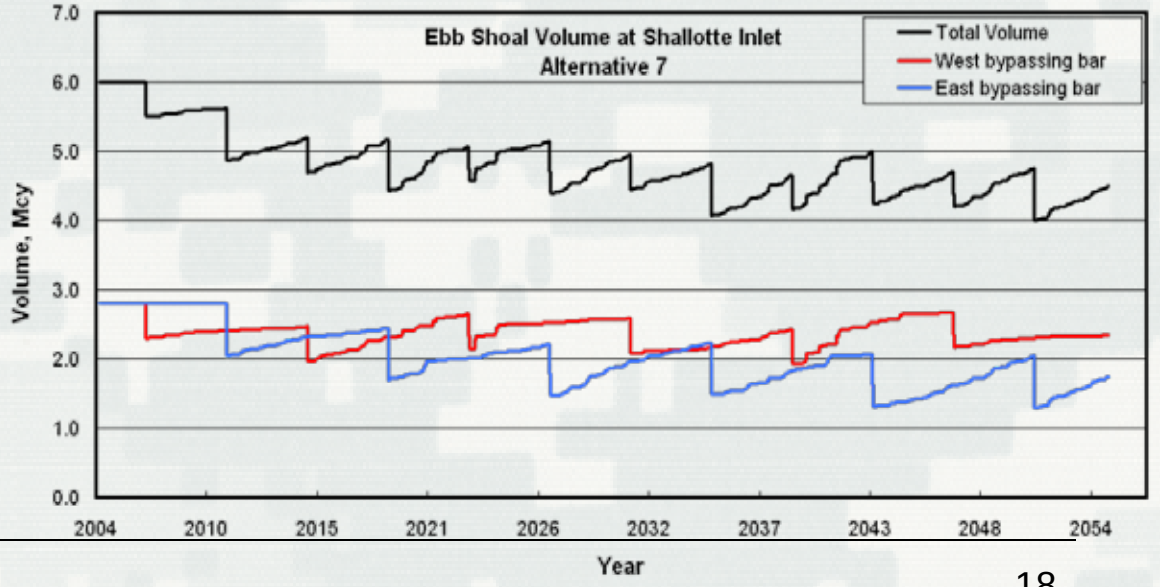
Wutkowski et al. (2009) Regional analysis for Brunswick County, NC, Beaches & Inlets. Proc. FSBPA 2009.

Alt 1: 49. 7M cy, 48 yr



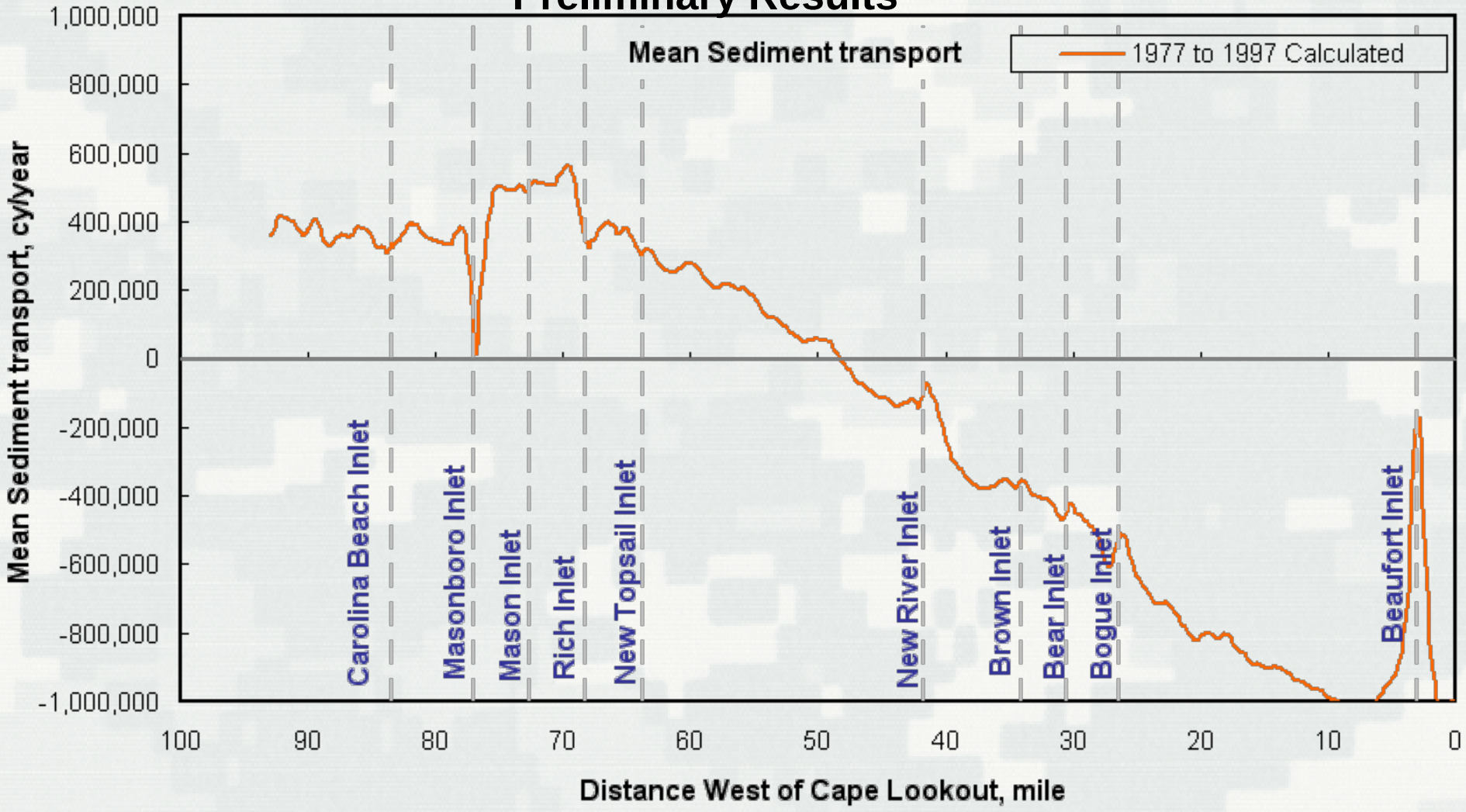
Alt 8: 20.7 M cy, 48 yr
Recycle sand between inlets and beaches

(Saves more than half the cost of the original alternative)

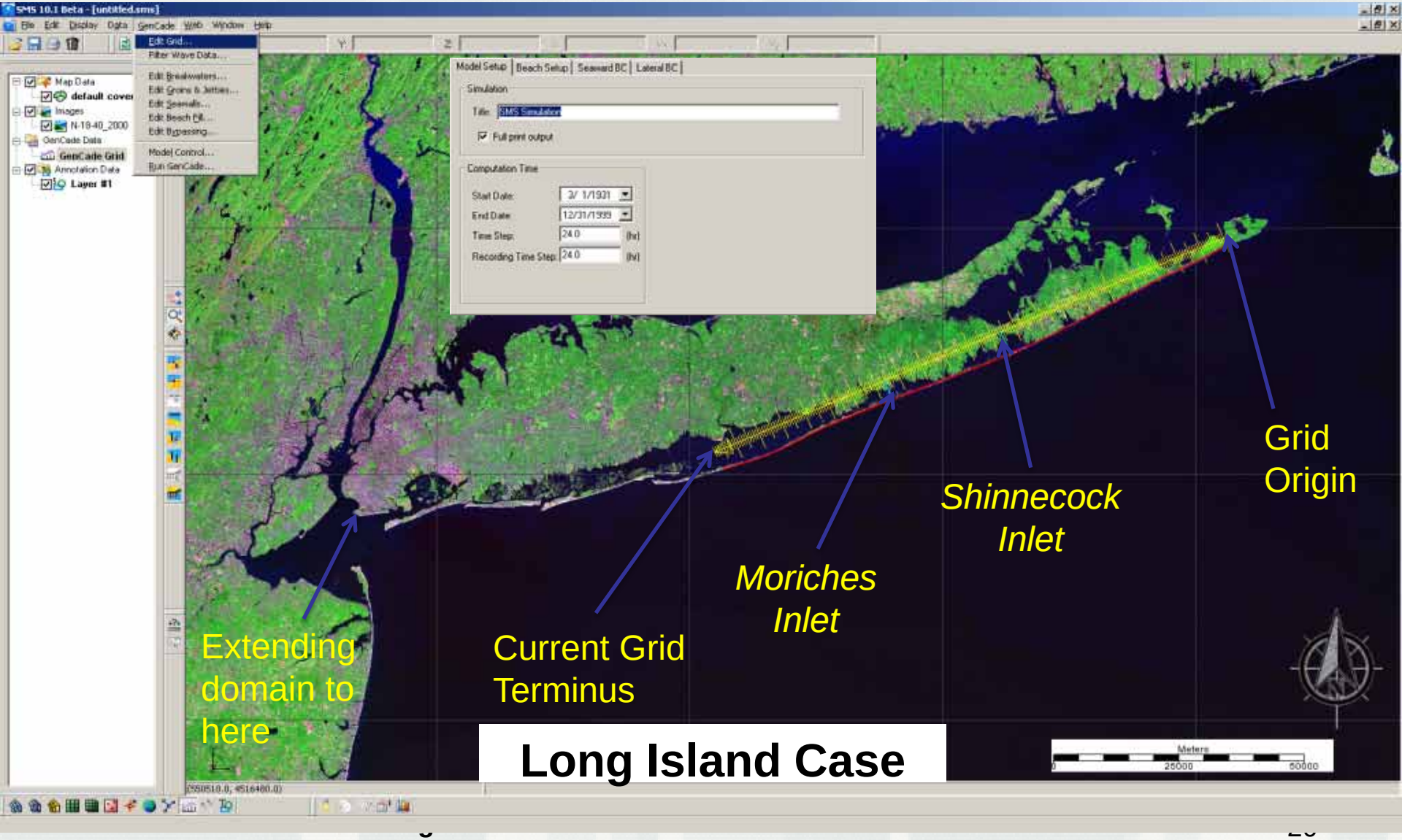


Onslow Bay, NC, GenCade (Prelim!)
Connecting Beaches and Coastal Inlets

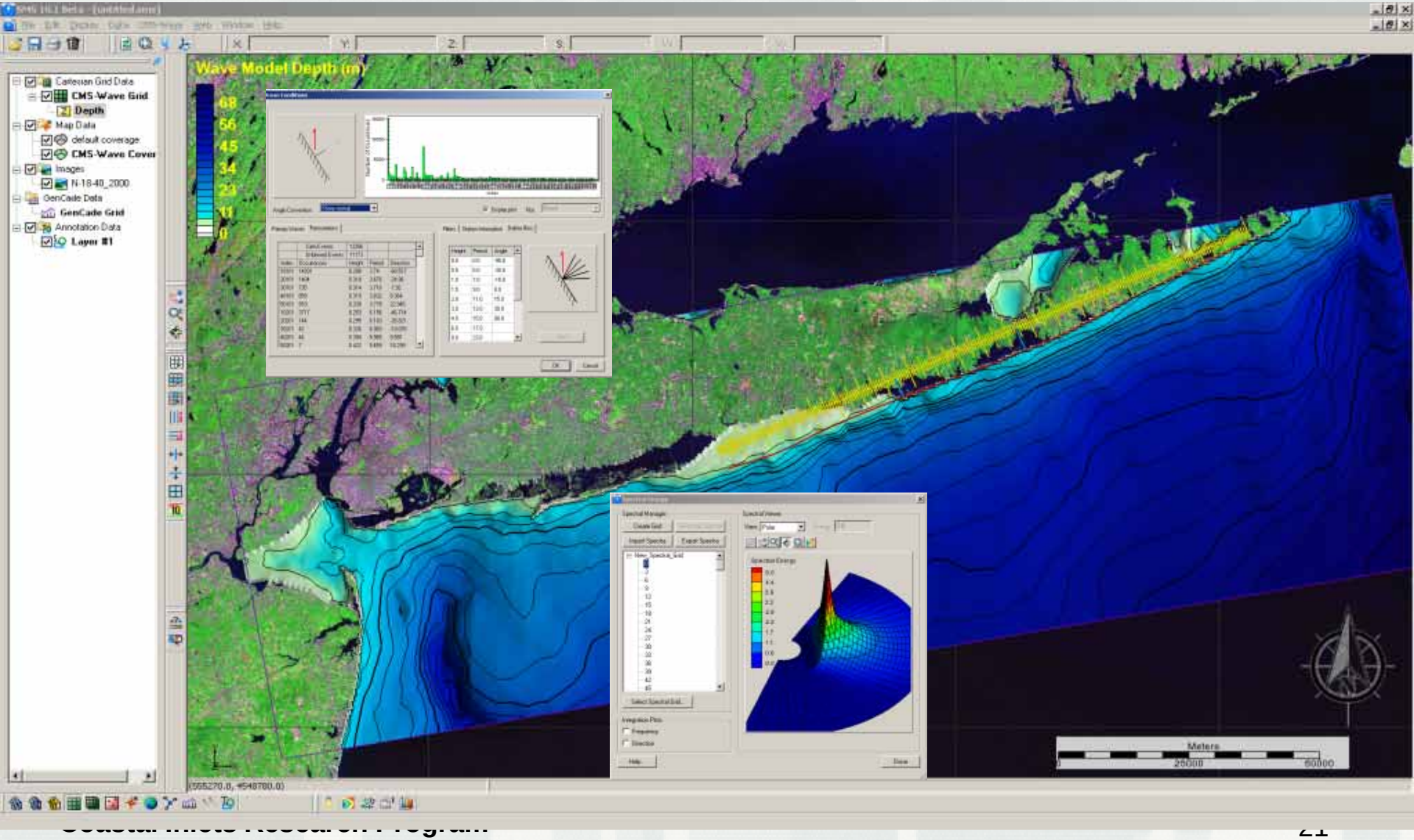
Preliminary Results



GenCade for Long Island

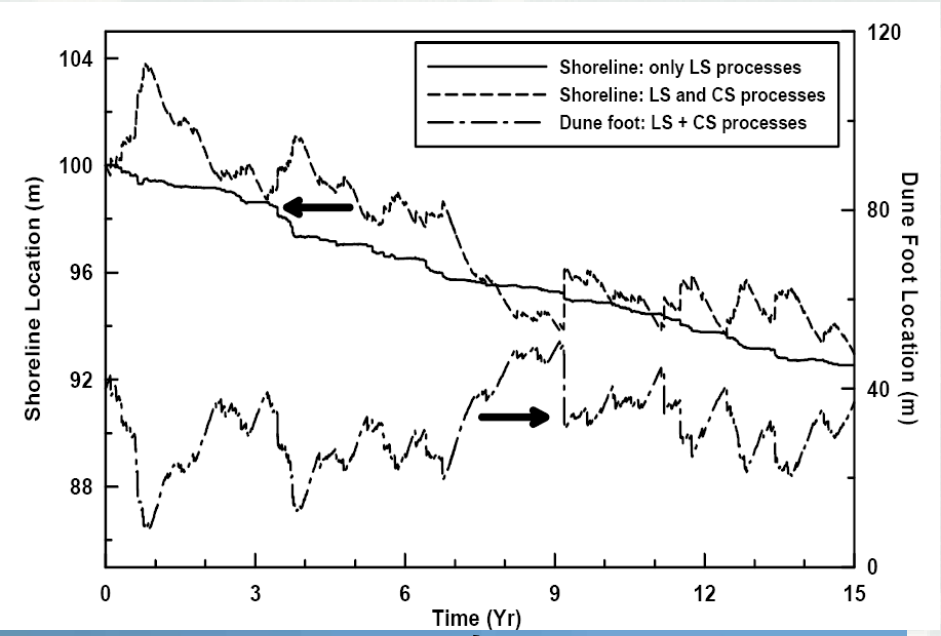


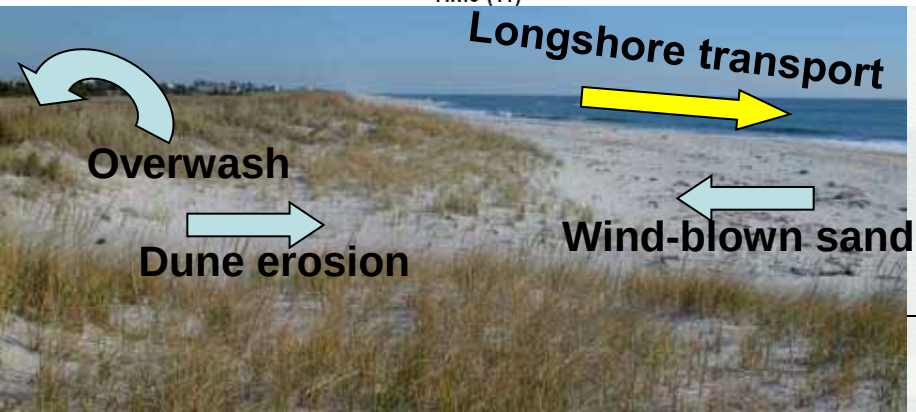
Internal and External Wave (and other) Model Interconnectivity – SMS interface



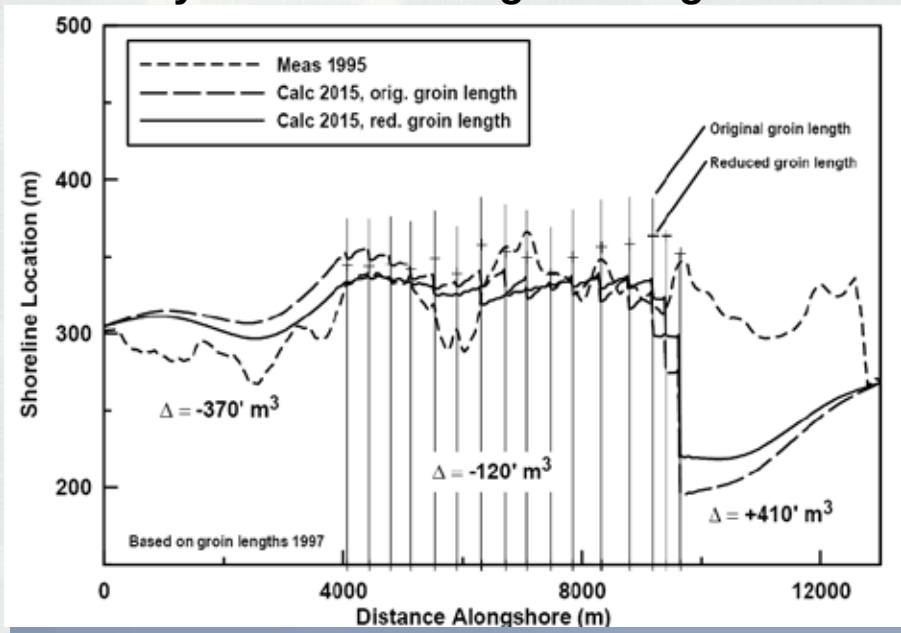
GenCade Development Available in 2011

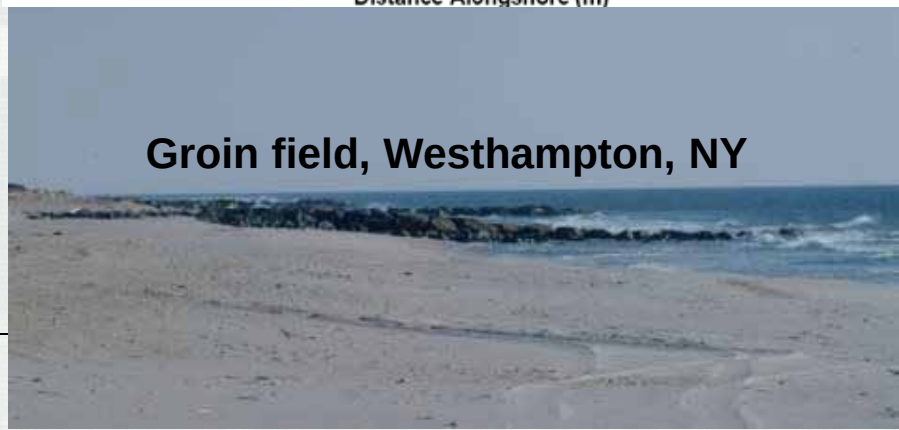
Longshore processes only vs. longshore with cross-shore processes





Measured and calculated shoreline change and analysis of reduced groin length





GenCade – Summary

- New model from the USACE
  - Shoreline response to engineering actions
  - Connects inlets and beaches
  - Regional trends represented
  - Planning through engineering
- Available in the SMS
  - September 2010 – longshore processes
    - Beta users? – no pain, no gain – please sign up for earlier testing
  - September 2011 – cross-shore processes
  - World coordinates
- Habitat modeling planned

Thank you for your attention