GENCADE: THE INLET RESERVOIR MODEL (IRM) AND BEACH NOURISHMENT

INLET ENGINEERING TOOLBOX

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COASTAL INLETS RESEARCH PROGRAM

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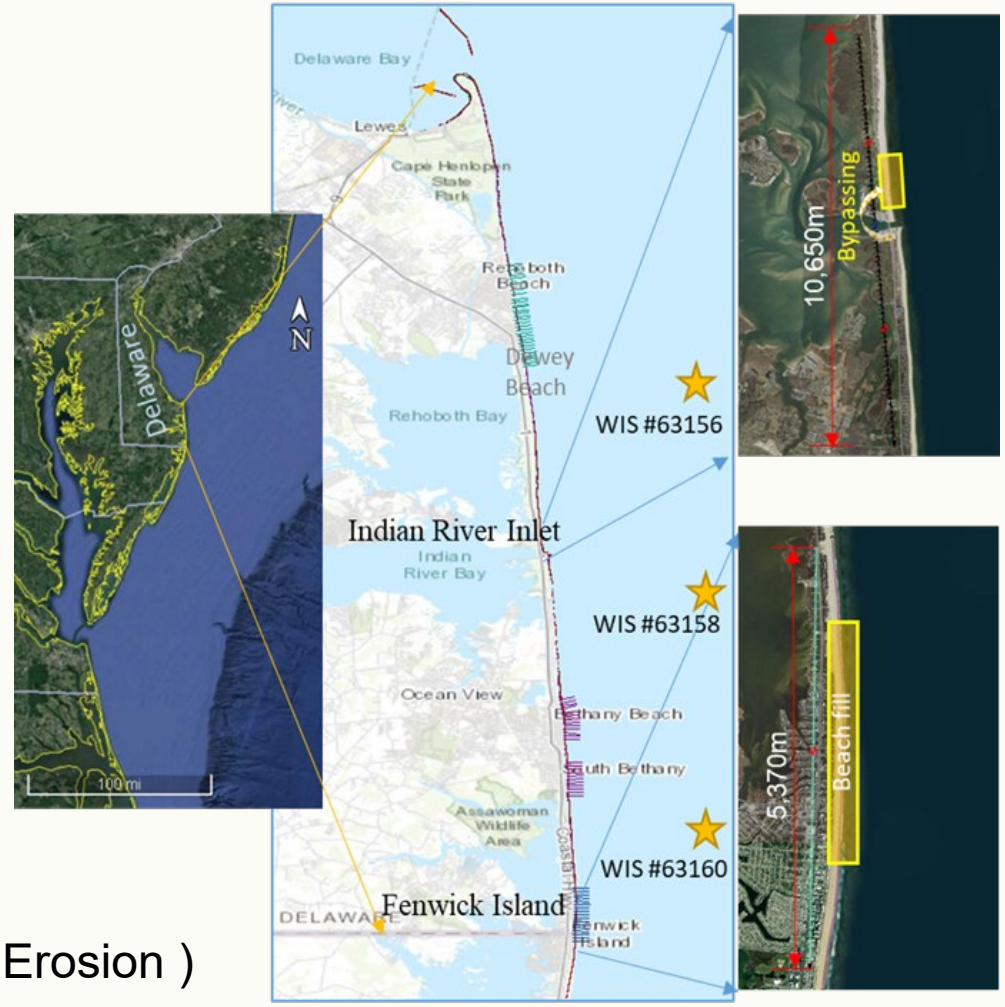
Problem Statement

- **Prediction of long-term (decadal to centennial) shoreline evolution is essential to planning and managing effective coastal erosion protective measures for supporting sustainable shorelines.**
- **Inlet Reservoir Model (IRM) is a key for GenCade to simulate regional-scale shoreline evolution connected by inlet sediment exchanges.**
- **It is difficult to evaluate long-term effects of erosion protection measures (e.g. bypassing, beach fills, sand nourishment).**
- **Verify beach profile survey data to extract shoreline positions on the same datum (e.g. MSL)**



Strategic R&D: Innovation in Sediment Management (Shoreline Erosion)

SoN 2017-N-71 (Modeling Effects of Sea Level Change at Tidal Inlets)
SoN 2017-N-67 (Guidance for Numerical Modeling of Inlet Ebb Shoal and Navigation Mining Studies)
SoN-NFE-1538 (Nearshore Processes Research and Development),

Capability and Strategic Impact Statement

- **Prediction of long-term sediment volume changes is important for sediment management and planning of coastal protection measures.**
- **Validated GenCade shoreline evolution model can be used for assessing long-term performance of sand bypassing across inlet and beach fills.**
- **Development of an inlet sediment transfer factor (γ) facilitates evaluation of sediment exchanges between shoals/bars and adjacent coastlines and volume changes of shoals/bars.**

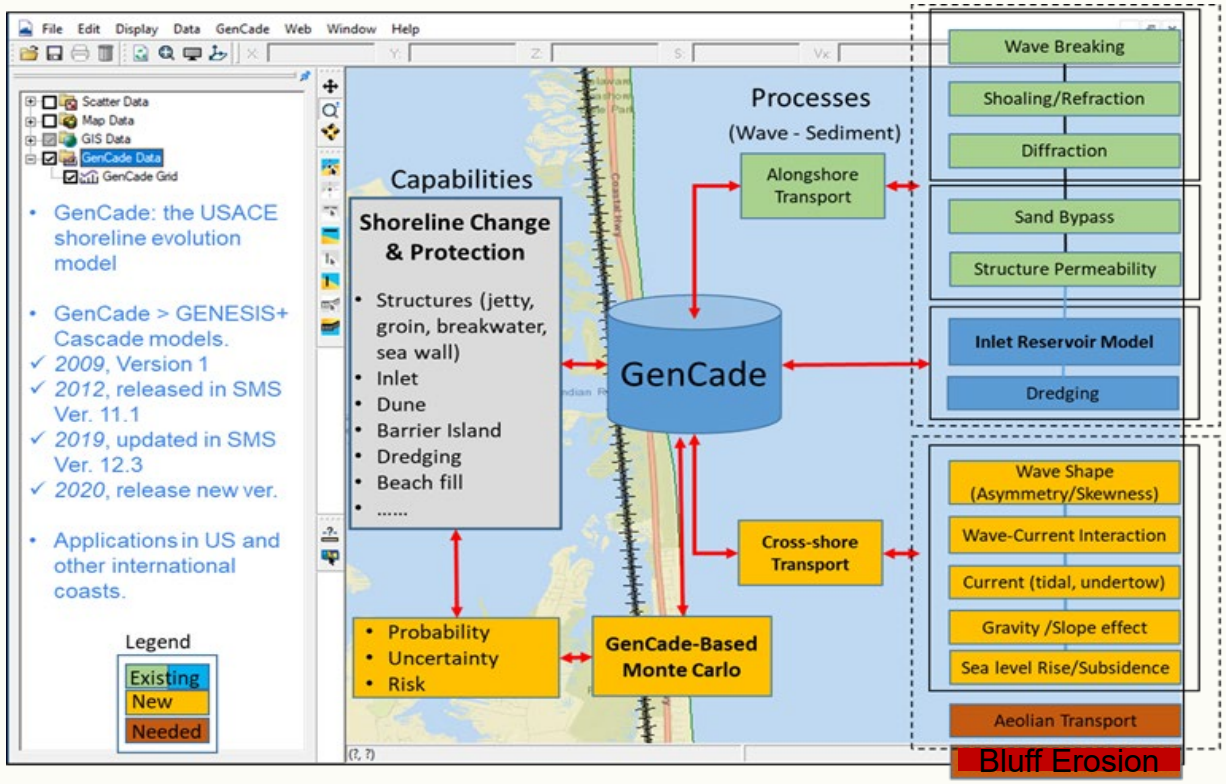


Fig. Capabilities and nearshore processes in GenCade

Inlet Reservoir Model (IRM)

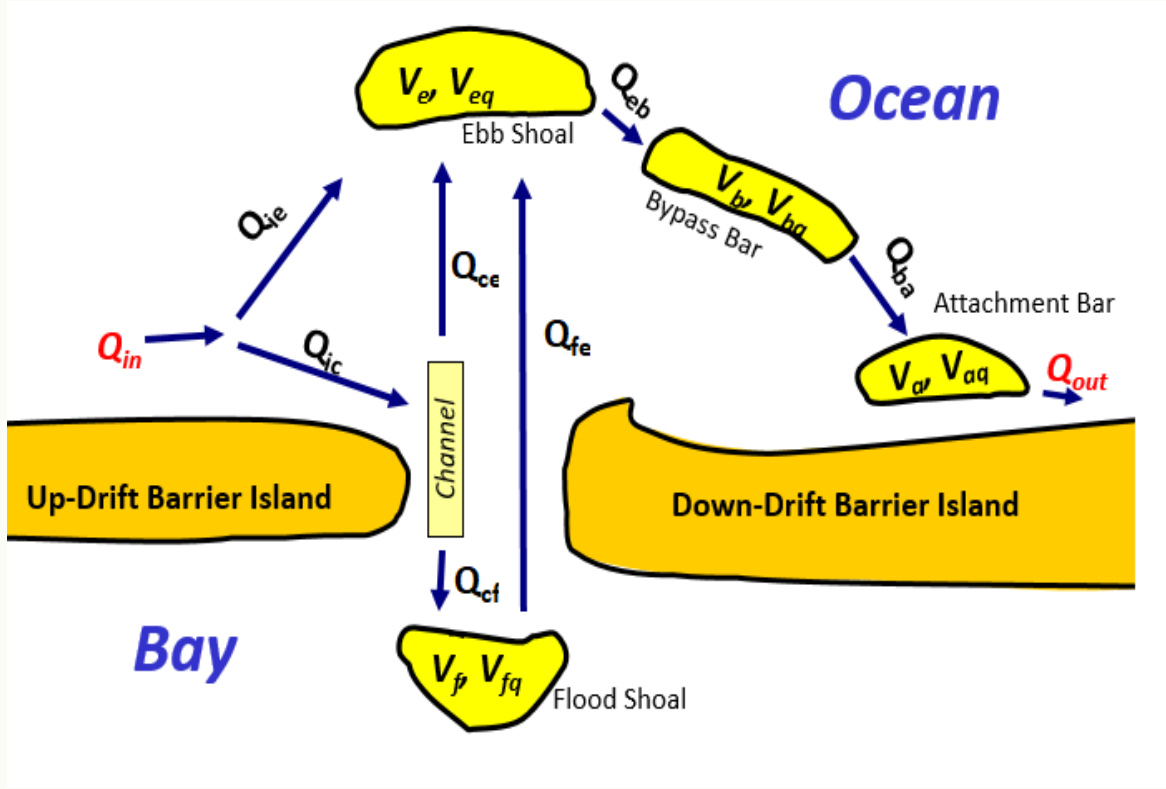
IRM (Kraus 2000, Larson et al. 2003, 2006) was implemented into GenCade to simulate the inlet sediment bypassing from the updrift barrier to the downdrift barrier and between flood and ebb shoals, based on an assumption of equilibrium shoal volumes.

$$Q_{out} = \begin{cases} \frac{V_e}{V_{eq}}\frac{V_b}{V_{bq}}\frac{V_a}{V_{aq}}\left[(\delta+\beta(1-\delta))\right]Q_{in}, & V_f \le V_{fq} \\ \frac{V_e}{V_{eq}}\frac{V_b}{V_{bq}}\frac{V_a}{V_{aq}}\left[(\delta+\beta(1-\delta))+\frac{V_f - V_{fq}}{Q_{in}\Delta t}\right]Q_{in}, & V_f > V_{fq} \end{cases}$$

Inlet sediment transfer factor: $\gamma = \frac{Q_{out}}{Q_{in}}$

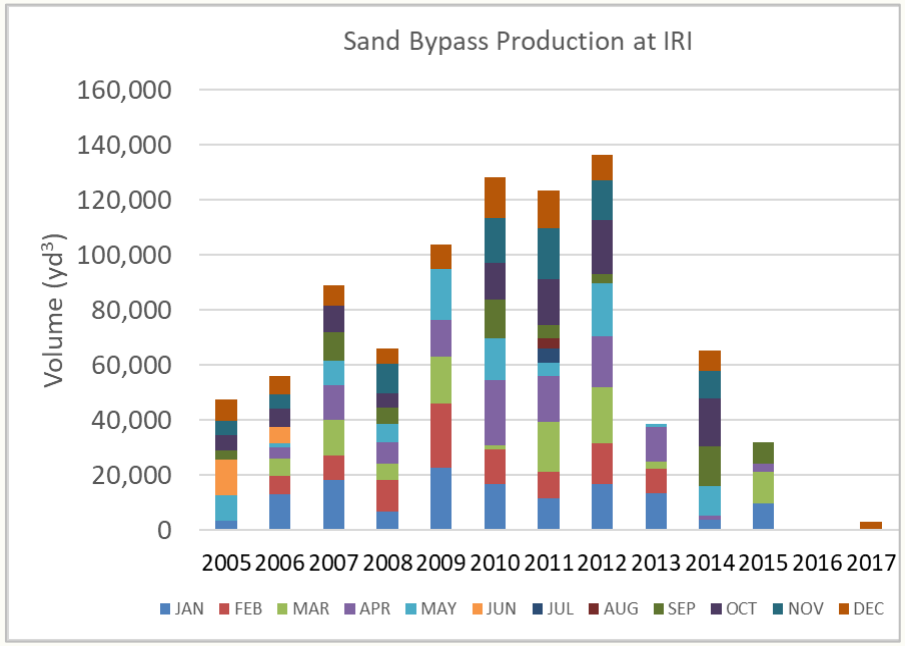
Table Estimated initial and equilibrium volumes for Indian River Inlet (IRI)

	Initial (yd^3)	Equilibrium (yd^3)
Ebb shoal (*Ve*)	4,900,000	7,000,000
Flood shoal (Vf)	2,800,000	3,500,000
North bypass bar (Vb)	76,540	175,000
North attachment bar (Va)	56,000	70,000
South bypass bar (Vb)	764,500	1,749,999
South attachment bar (Va)	305,800	700,000

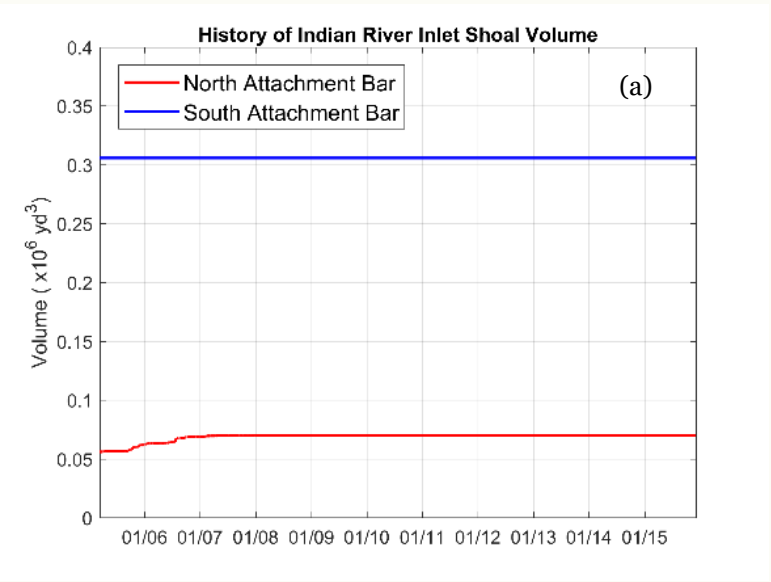


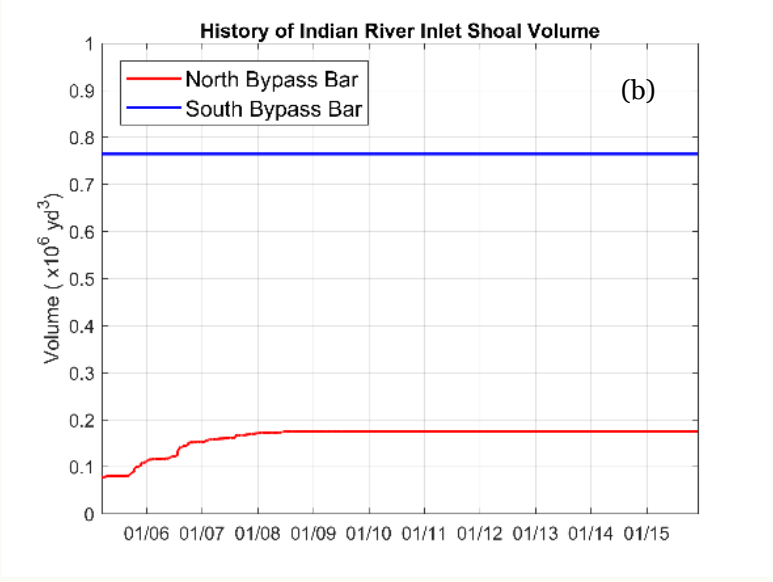
Case 1: Simulation of Shoreline Changes near IRI

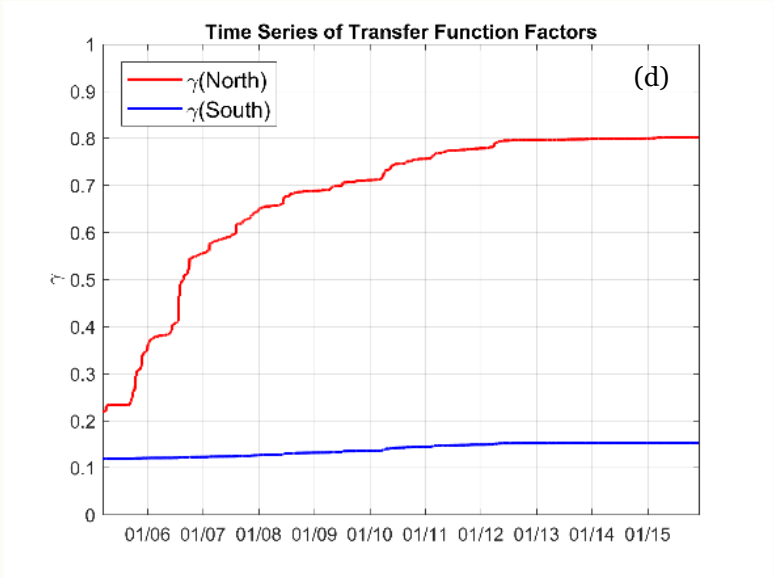
- **Validation**: 2006-2016
- **Sand Bypassing**: actual production volume, Total=882,155 yd^3 (2006-2016)
- **Beach nourishment**: 527,850 yd^3, May-Nov 2013

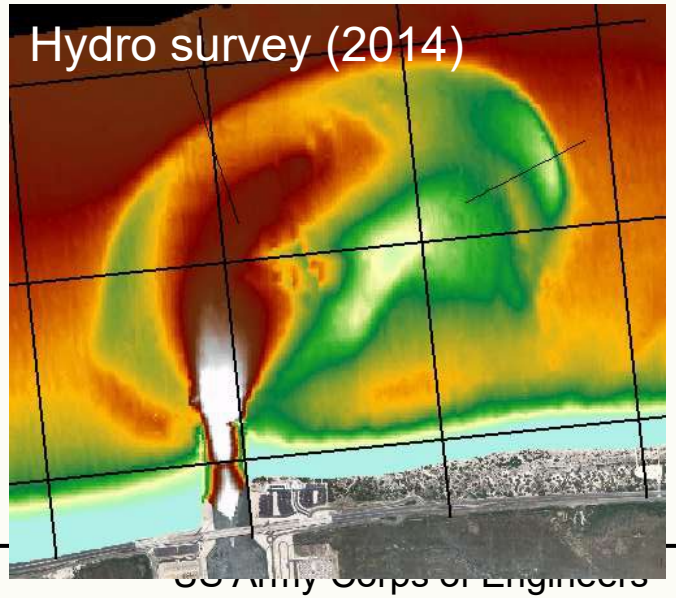


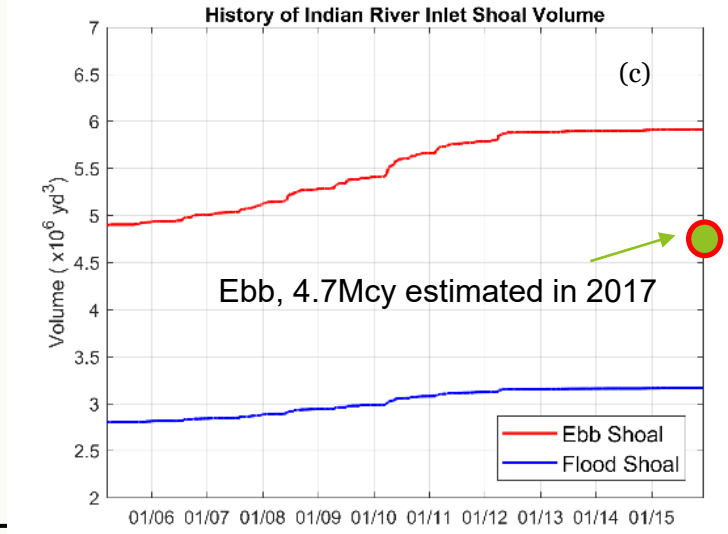
Evolution of inlet shoal and bars

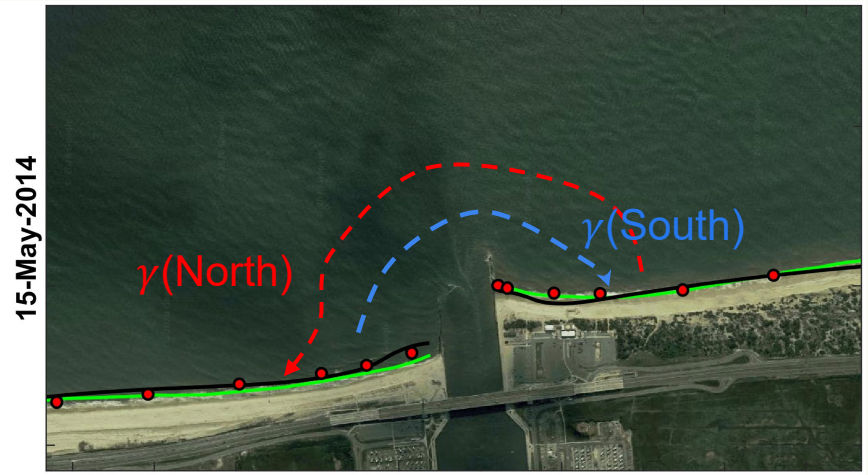












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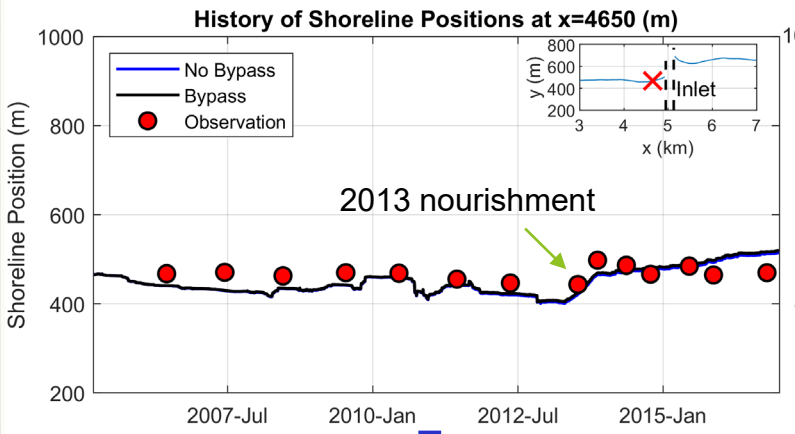
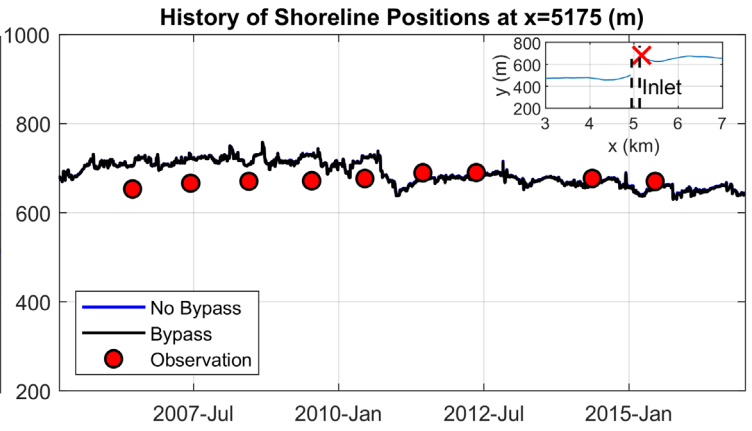
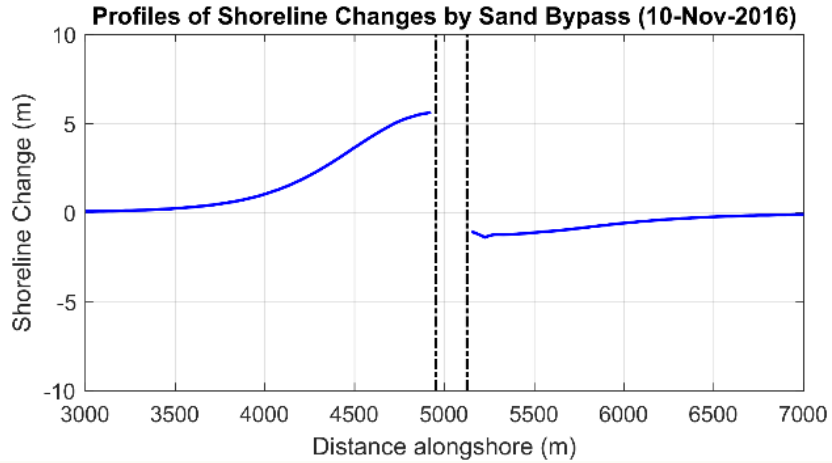
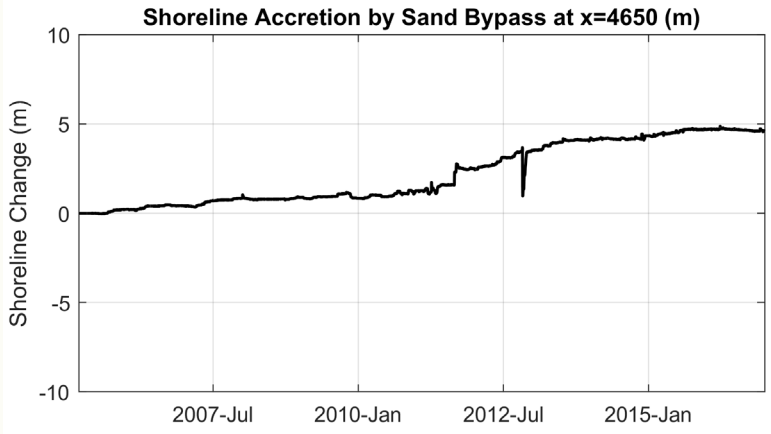
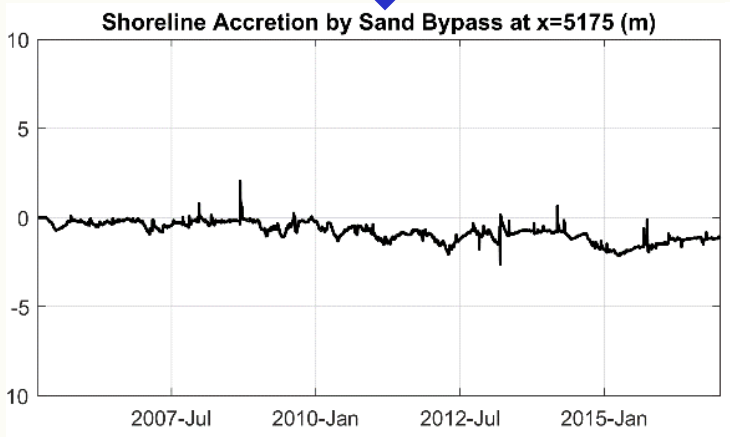
Effect of Sand Bypassing

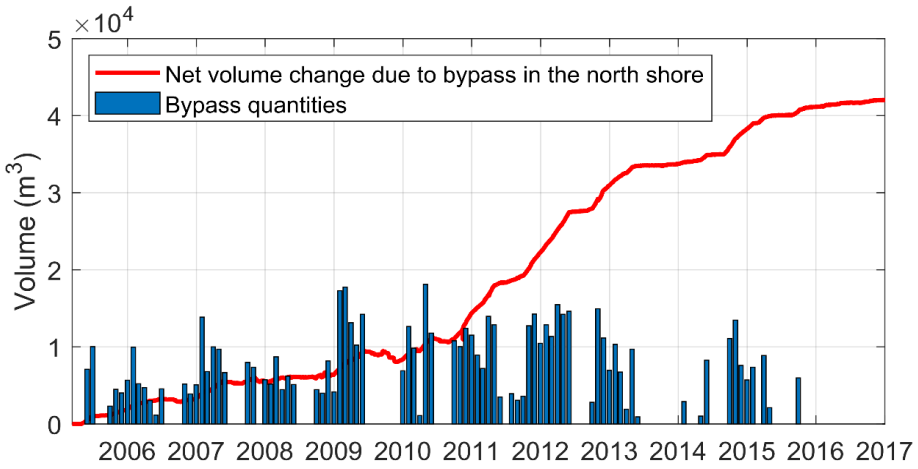












(a) North Shore

(b) South Shore

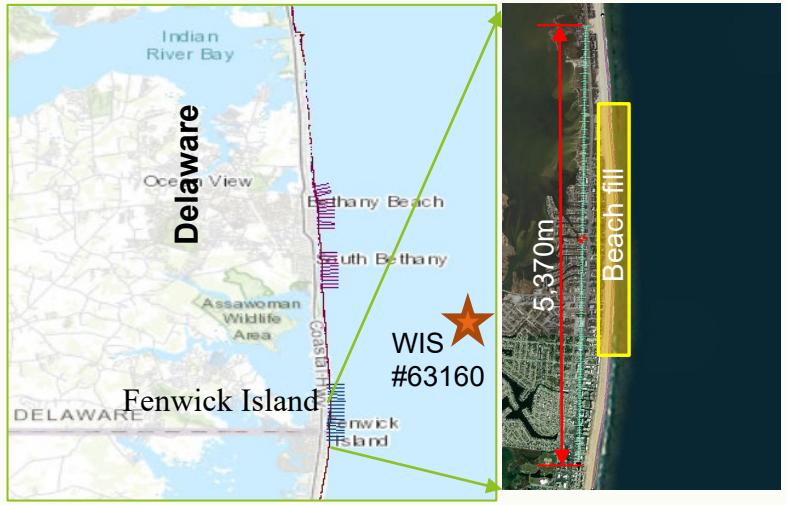
(c) Net volume of bypass sand in north shore. The bars show the monthly bypass Rate.

Case 2:
Beach Fills in Fenwick Island

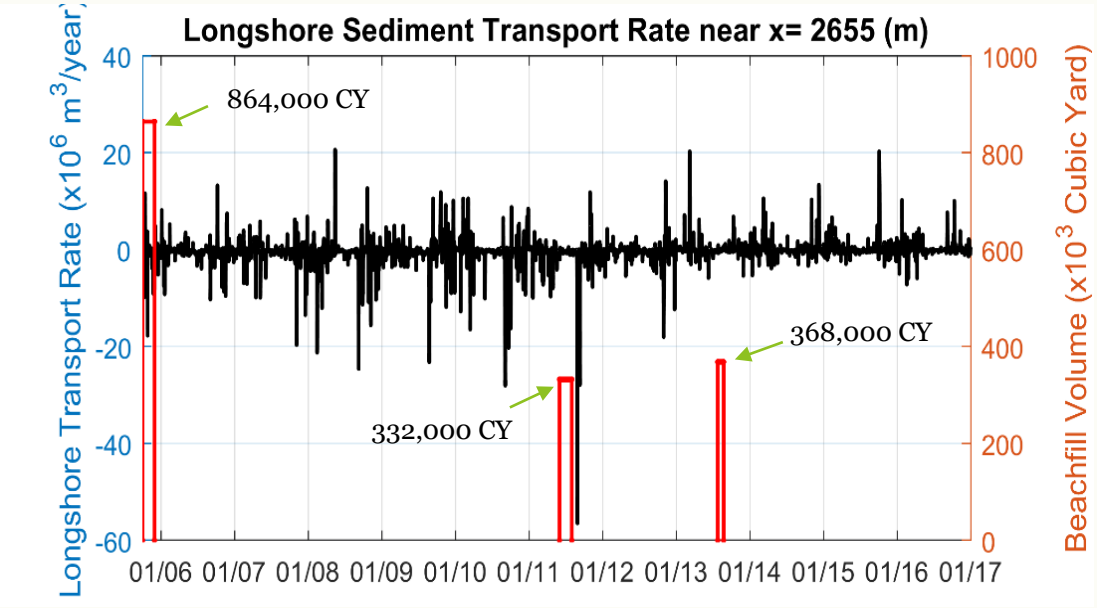
Objectives: (1) to validate the GenCade model by using shoreline survey data provided by NAP and DNREC, and
(2) to evaluate the effects of beach fills.

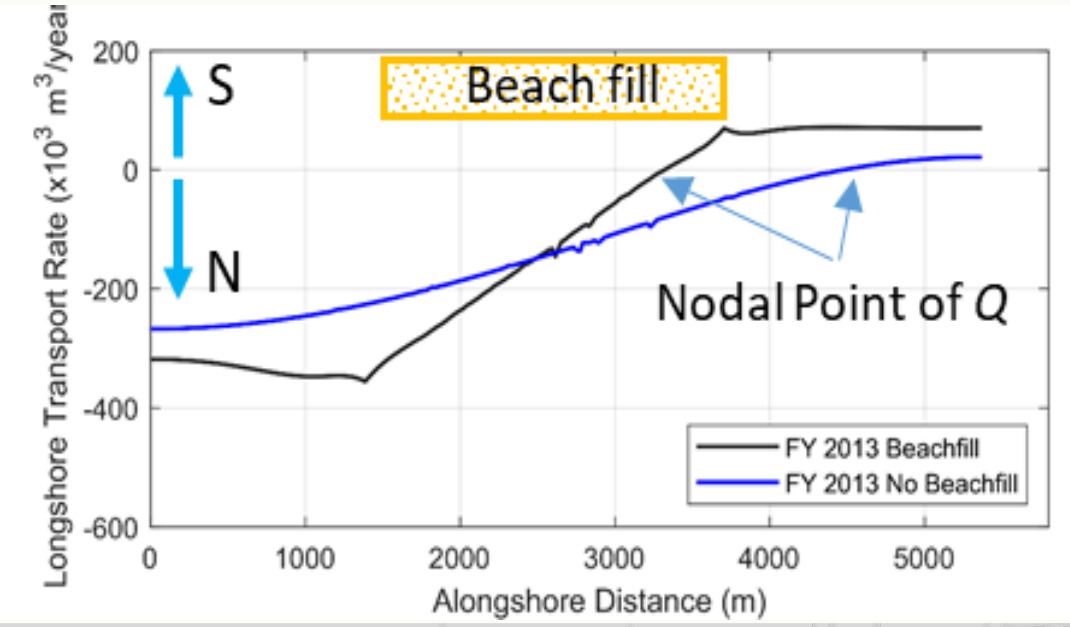
Computational Period: 11 years (Nov.2005 – Jan. 2017)

Wave: WIS **Station ID: 63160**



Longshore transport rate (a black line) and beachfill volumes

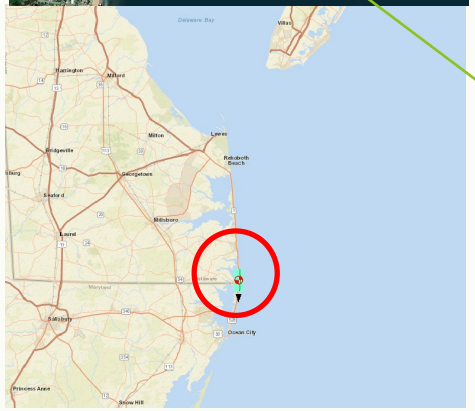


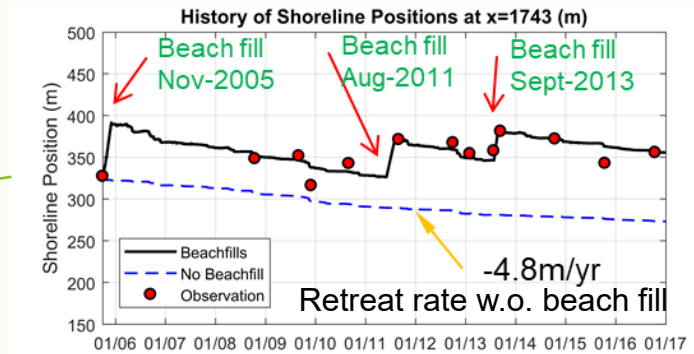


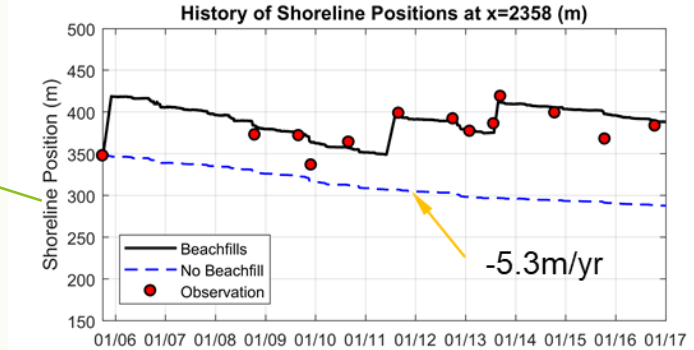
Shoreline Positions and Profiles: GenCade vs Observation, with and without beach fills

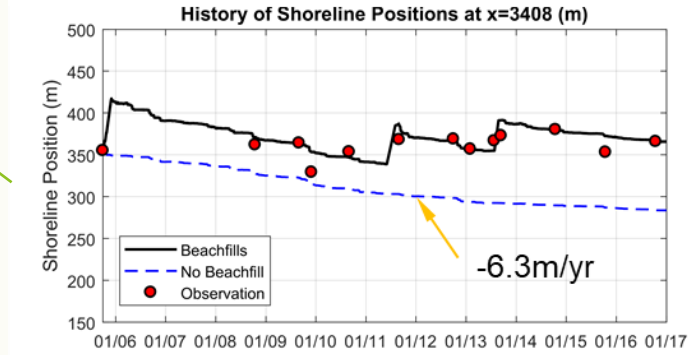
(d)

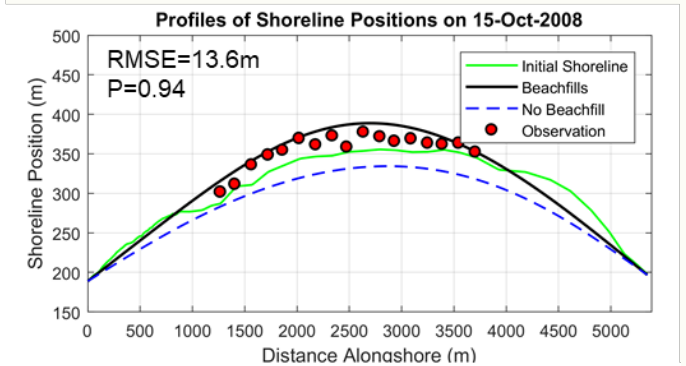
- 12-year Shoreline Changes (2005-2017)
- Periodical beach fills : 2005, 2011, & 2013

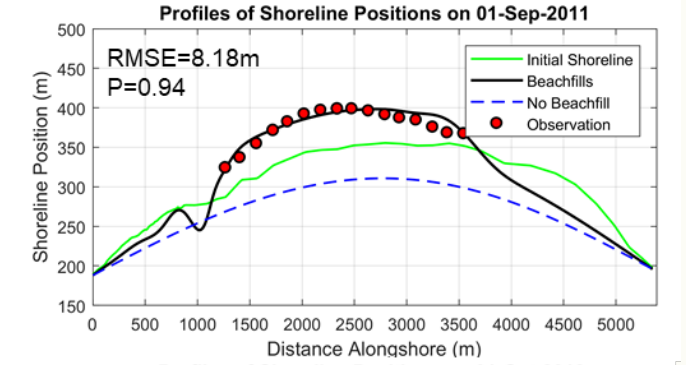


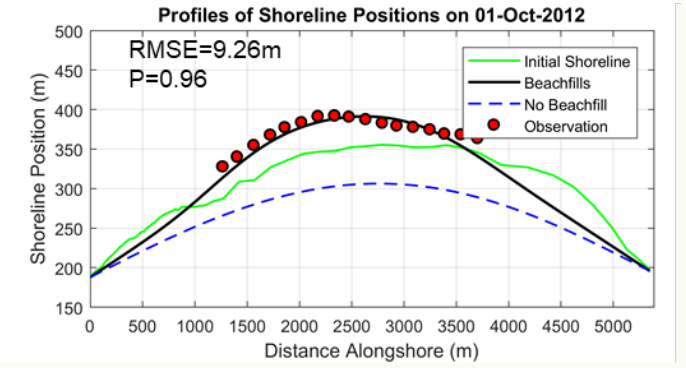












Summary

FY20 Major Advances in Capability

- Upgrade and test the release version of GenCade
- Validated the model using actual bypass rate
- Update SMS Interface, Develop visualization using ArcGIS and GoogleMap
- Redefined the model skill assessment metrics (Pearson coefficient, RMSE, SI, NB)

FY20 Major Products & Collaborations

- JA (1, revision), TR (1), CHETN (1), CP (1)
- 1 Webinar (LRD)
- 1 CIRP TD
- 1 Conference Presentation (ASBPA 2019)
- Collaboration with RSM-SBAS project (PI: Eve Eisemann), USACE-NAN (Long Island), Texas A&M (Mega beach nourishment in the Netherlands)
- GenCade user services

FY21 Products/Advances

- Technical Transfer (SMS Dynamic Interface, webinars, TDs, etc)
- IRM: using hydro survey data and/or 2-D model results (CMS) to re-construct the model – toward a data-driven parametric model
- Test GenCade capability for predicting beach volume changes for assessing beach nourishment and beach fills
- Study effect of cross-shore transport on beach fills and inlet sediment transport
- Develop an automatic system to calibrate multi-variables (12) in IRM model and other empirical model parameters! → data-driven simulation model

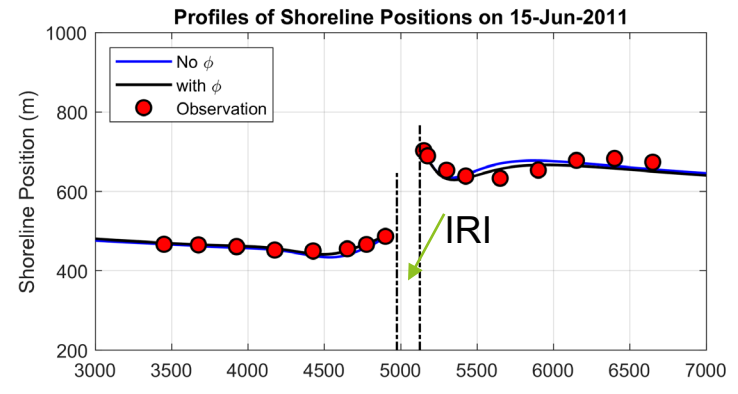


Fig. Effect of cross-shore transport on shoreline changes near IRI