Optimization of Inlet Borrow and Beach Nourishment, St. Johns County, FL

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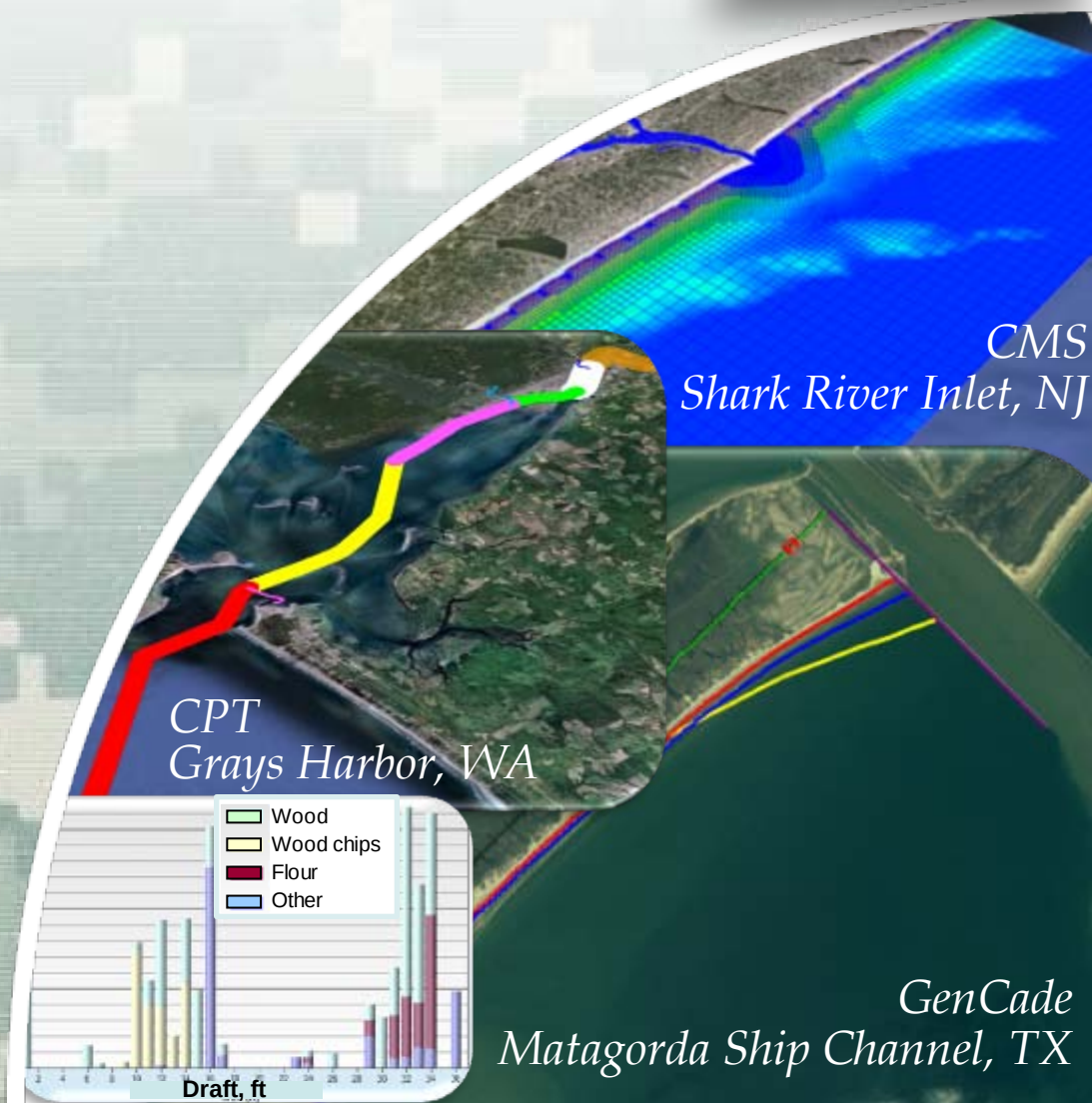
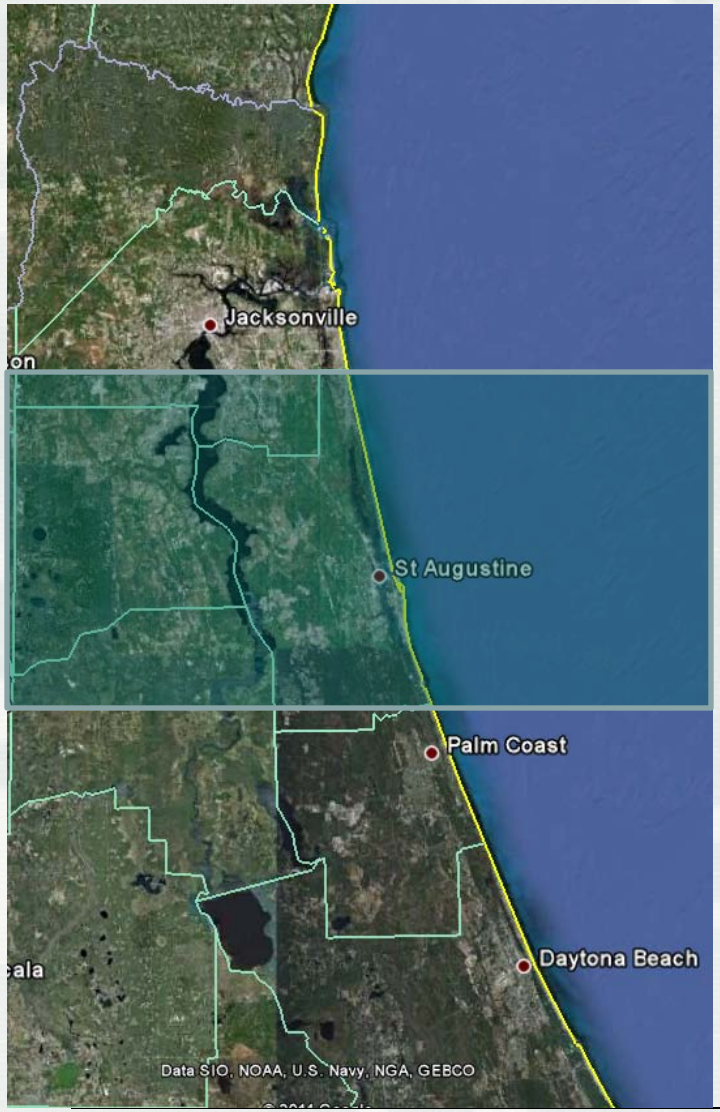


Outline



- Background Information & Historical Change at St. Johns County
- Recent Activity at Inlet & Present Conditions
- Problem Statement
- GenCade Calibration to Measured Datasets
- Optimization of Alternatives using Measured Data, CMS Results, and GenCade
- Results, Discussion, and Summary

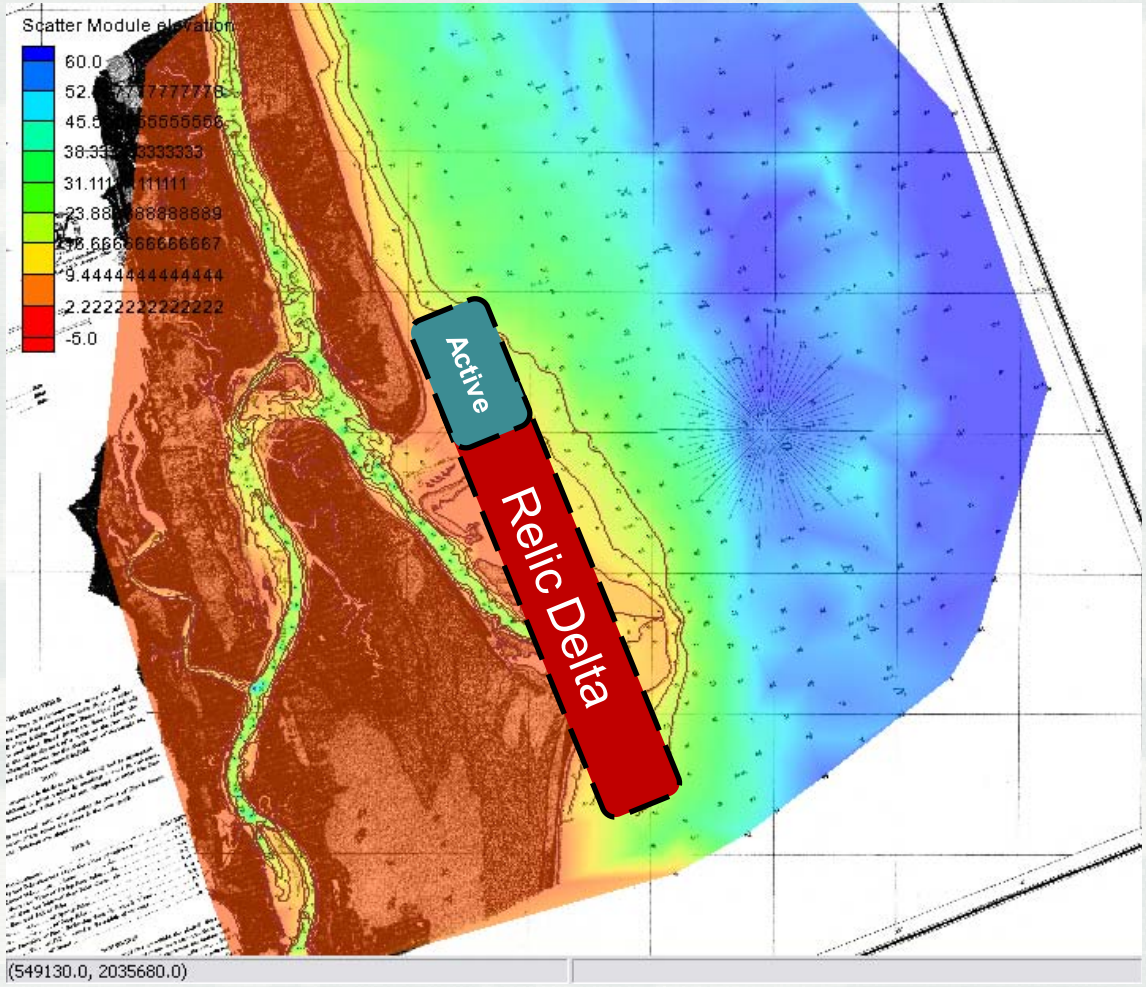
St. Johns County, FL, General Information

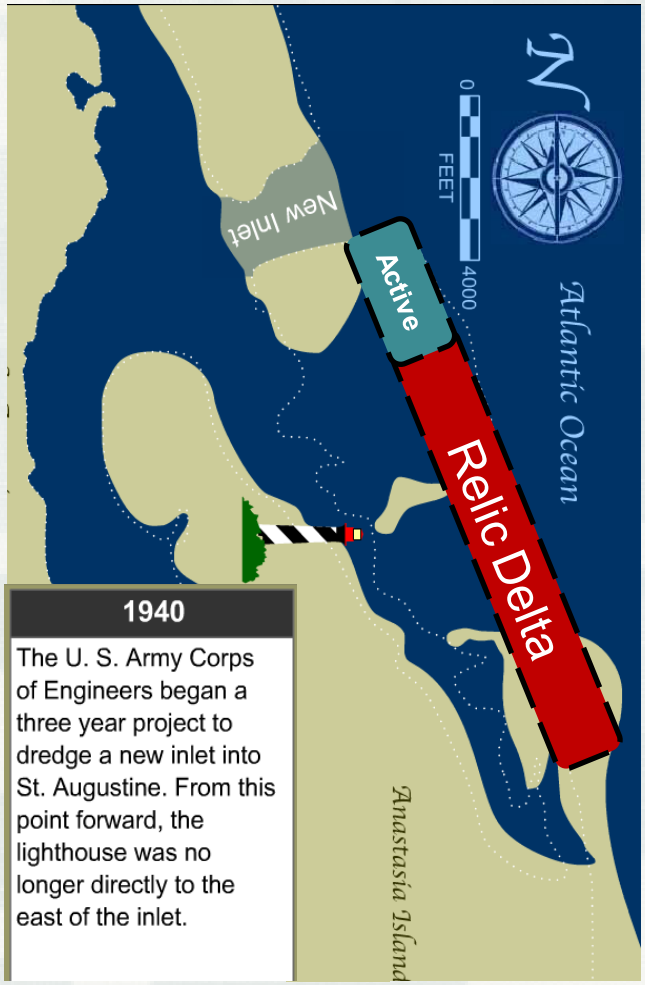
St. Augustine Inlet Federal Navigation Project; St Augustine Beach Shore Protection Project (SPP); Feasibility Study for Vilano Beach SPP

St. A Inlet: Dual-inlet, lagoonal bay system, mixed-energy with St. Augustine the dominant inlet

St. A Beach: Erosional Hotspot with seawall and pier (only beach structures)

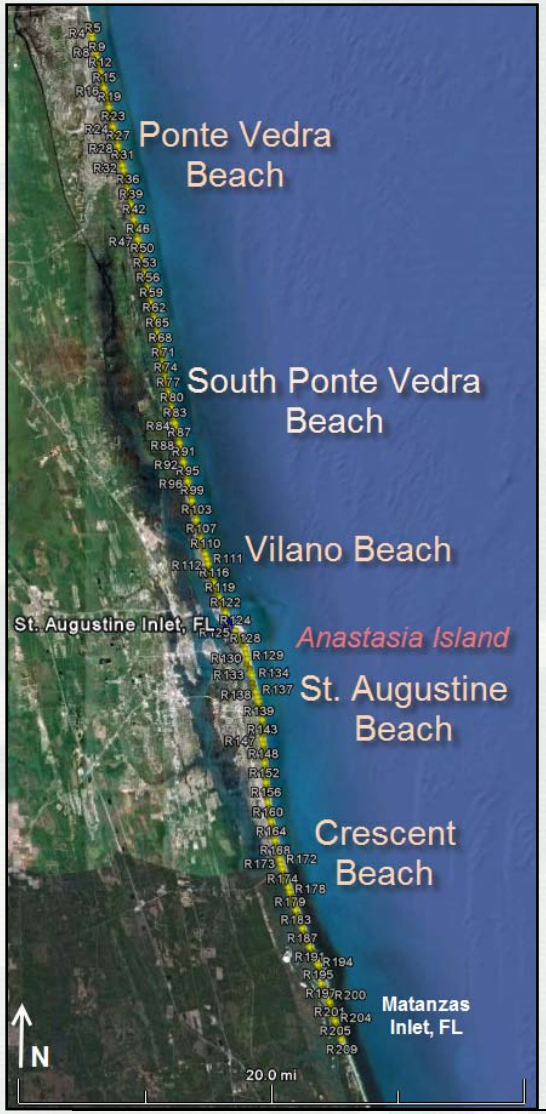
The Erosional Hotspot: Relic protruded platform now eroding





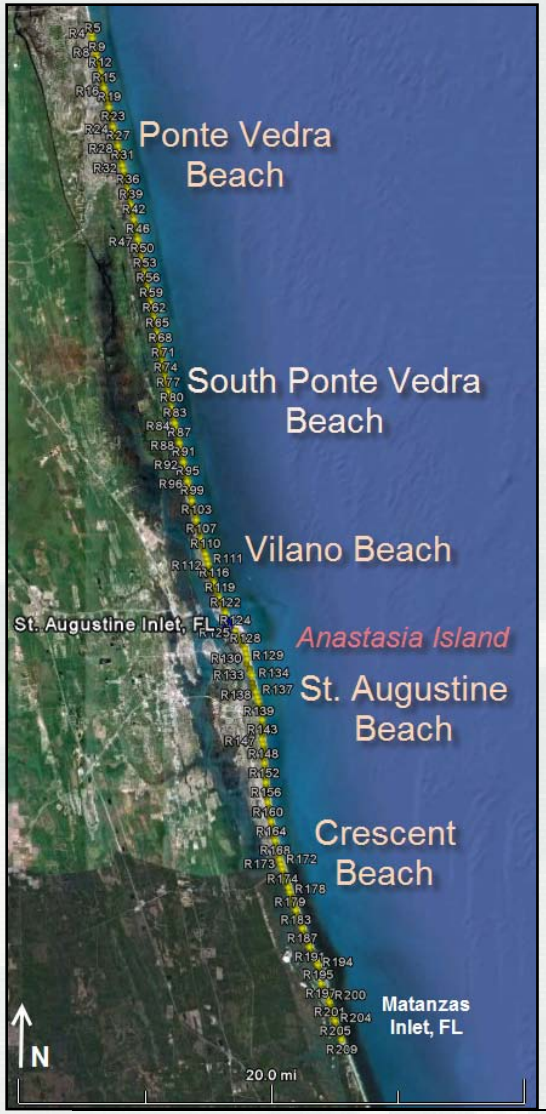
1862 Navigation Map

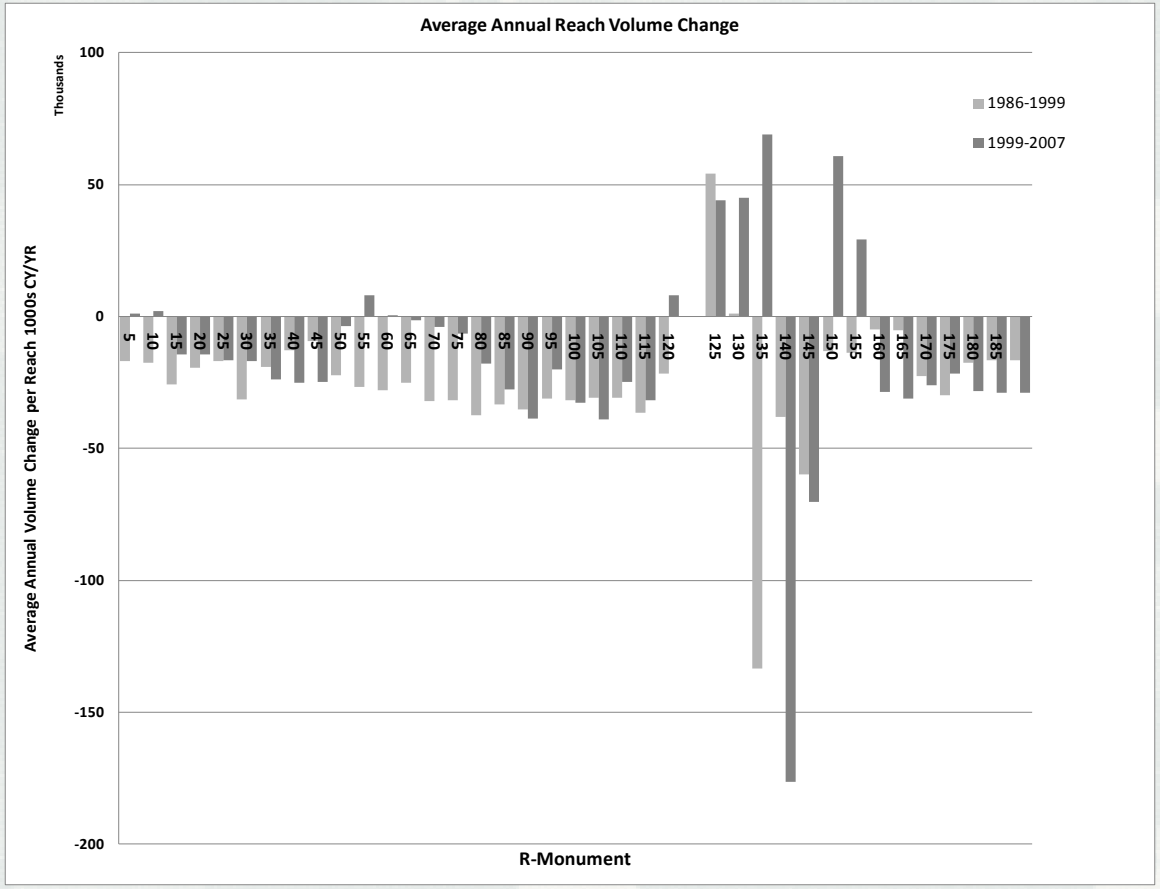
R-Monument Profile Locations



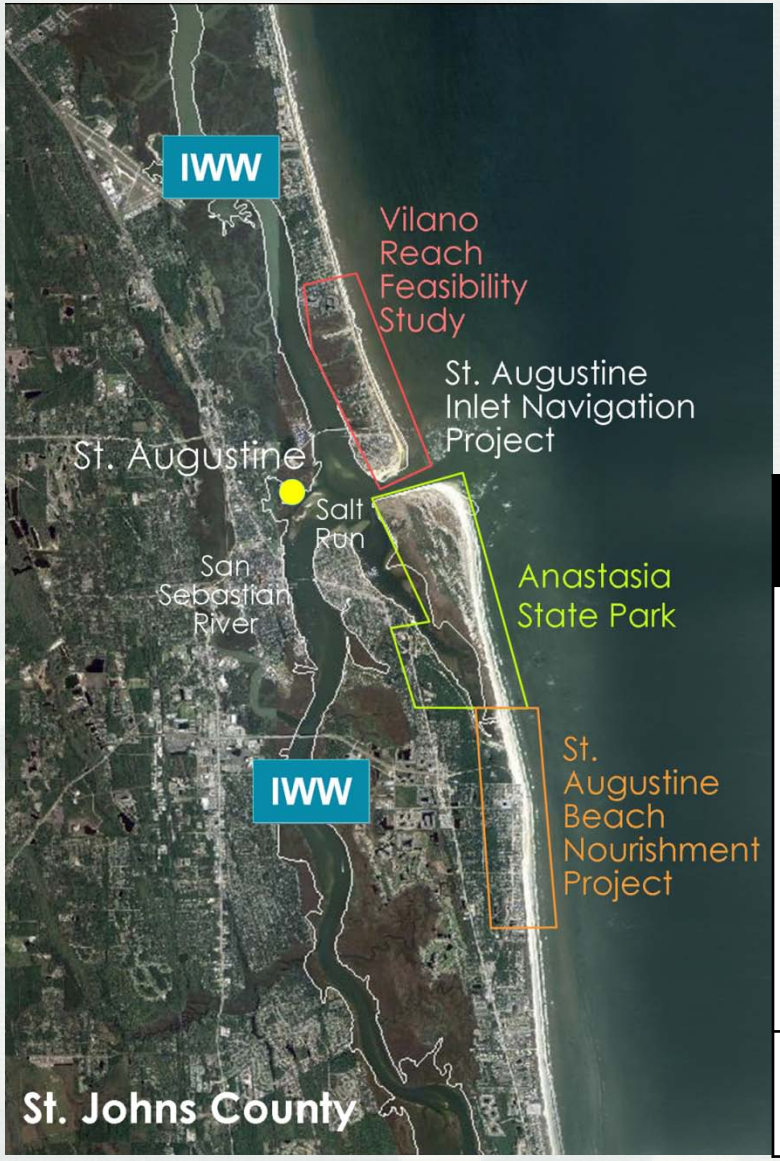
Location	Reach (R-Mon)
Ponte Vedra Beach	R1 – R109
S. Ponte Vedra & Vilano Beach	R109 – R122
St. Augustine Inlet	Ebb & Flood Tidal Deltas
Anastasia Island Headland	R123 – R128
St. Augustine Beach	R128 – R151
Crescent Beach to Matanzas Inlet	R151 – R195

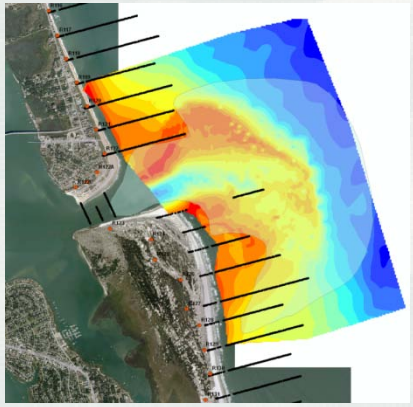
R-Monument Profile Locations



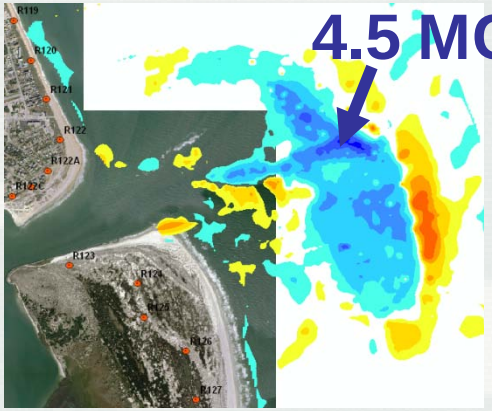


Inlet Ebb-shoal Mining/Beach Protection Projects at St. Augustine Beach





1998 - Bathymetry



1998 – 2003 Difference

Project	Volume Dredged (CY)	Volume Placed (CY)	Placement Area	Construction Dates
2003 Project Phase 1	4.5 mcy	4.2 mcy	R-145 to R-151	Sept 2001-Oct 2001
2003 Project Phase 2			T-132 to R-151	Apr 2002 – Jan 2003
2005 Project	2.8 mcy	2.8 mcy	R-137A to R-151	Jun 2005 – Nov 2005

Problem Statement

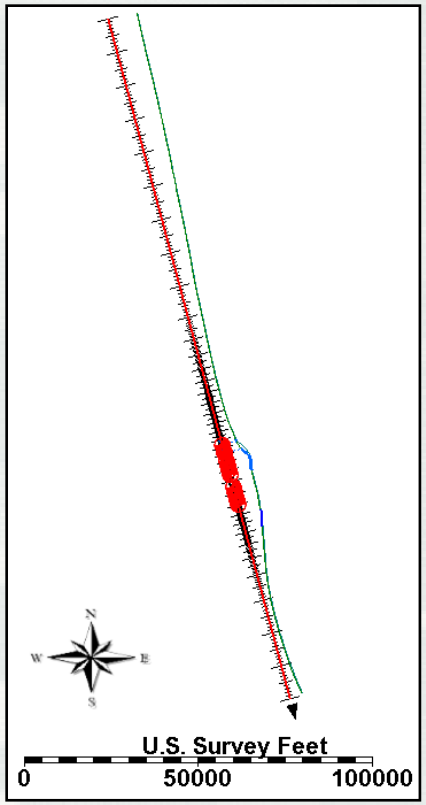
What is the optimal dredging volume and interval, and beach placement volume and interval that will supply adequate sand to maintain two Shore Protection Projects in St. Johns County?

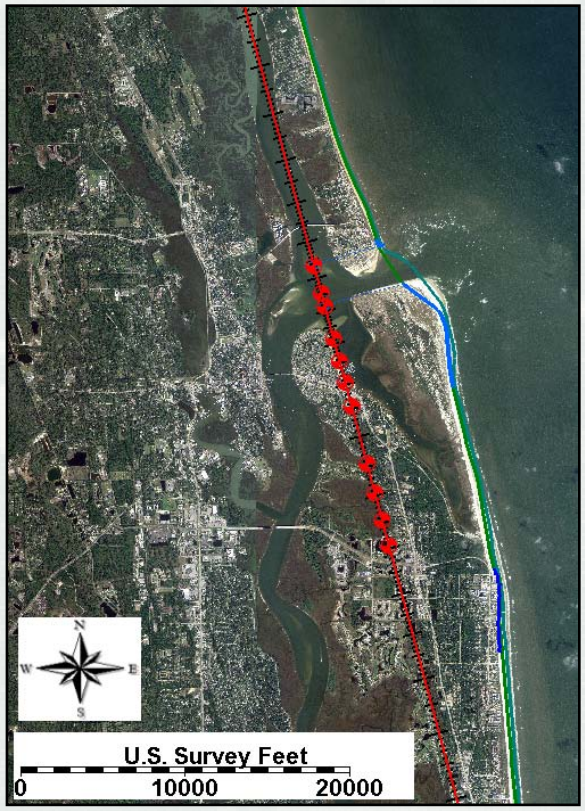
GenCade used to help answer:

What is the volumetric limit (cubic yards of sediment) that can be mined regularly from the ebb shoal in its present condition which does not cause a significant long-term effect on the morphology and volumetric recovery of the shoal?

How much sediment and what nourishment interval is required to maintain present volume of the active and planned Shore Protection Projects?

Setup the GenCade Grid





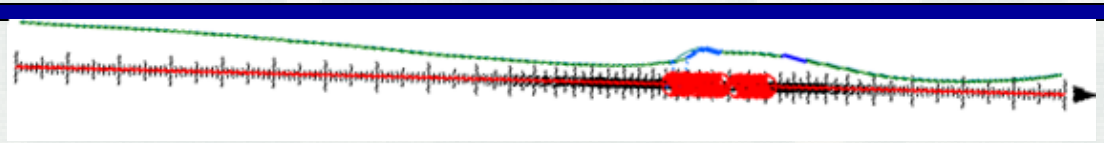
Input:

- 1986, 1999 Shorelines
- Waves
- Dredging/Placement Information
- Structures

Model Calibration Also Dependent On:

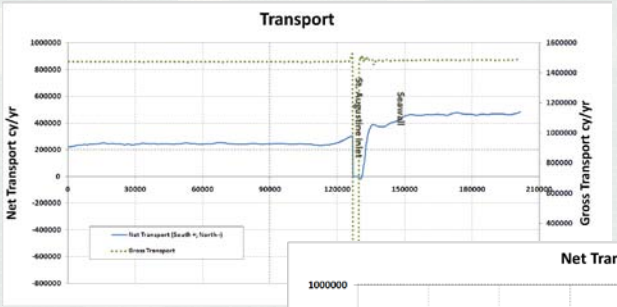
- Equilibrium Shoal Volumes
- Inlet Bypassing Rates & Locations
- Regional Contour
- Interpolation of Waves Between Gage Stationing

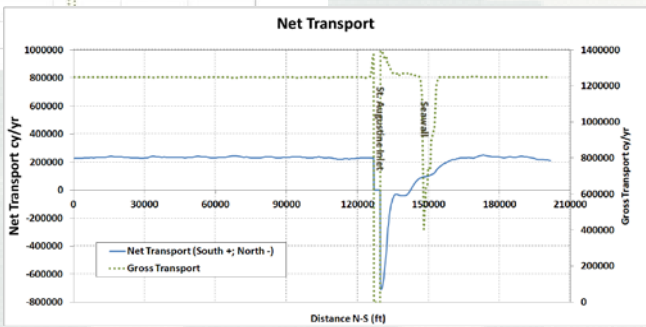
Calibrating GenCade: 1986-1999 Measured Volume Change

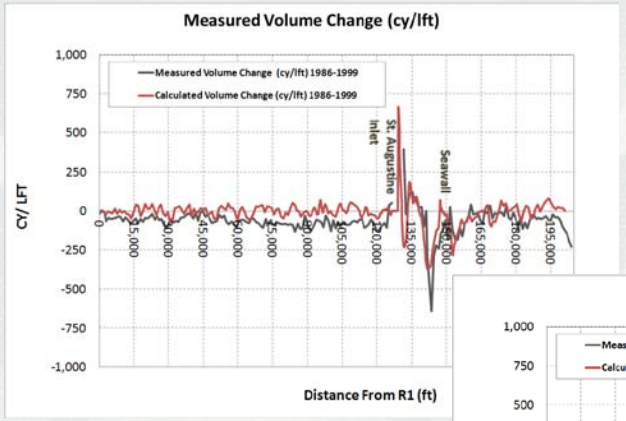


Calibrate:

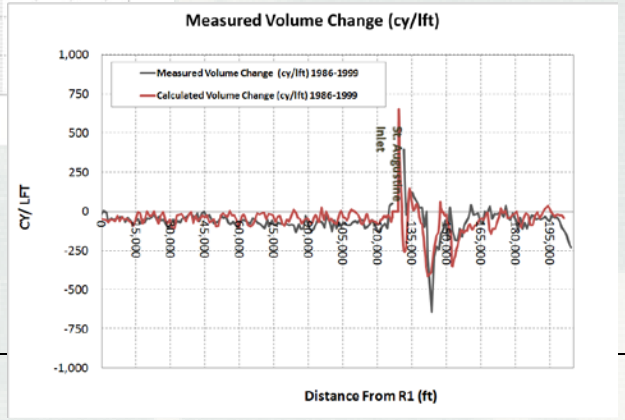
- Est. Sand Transport Rates (K_1 & K_2)
- Waves (WIS does not capture local reversal)
- Bypassing Location & Coefficients
- Groin Permeability
- Background Erosion Rate
- Timestep







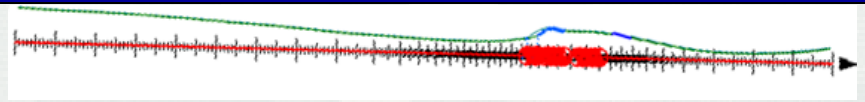
Losing 700KCY/YR

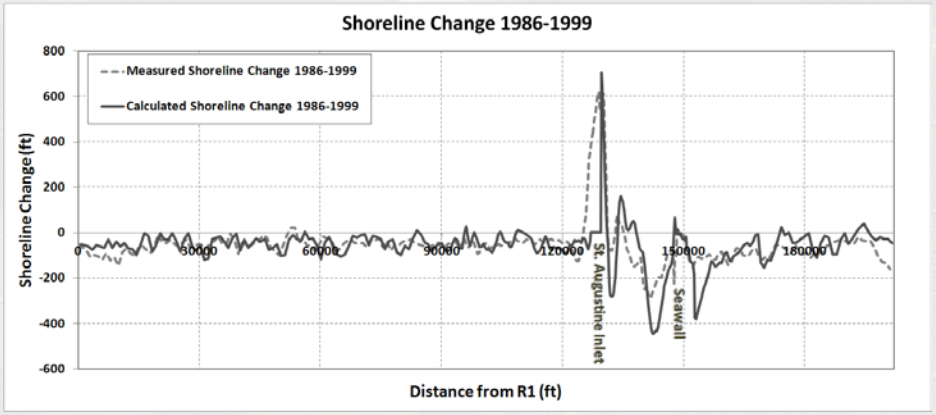


Calibrating GenCade: 1986-1999 Measured Shoreline Change & Final Coefficients

Shoreline Change:

- Spatially varying grain size and resultant equilibrium profile
- Inlet adjacent beaches are dominated by inlet processes not captured in GenCade





Final Coefficients

Feature	Value	Feature	Setting
K1 Coefficient	0.6	Background Erosion Rate (Bypassing Rate)	-80 cy/hr
K1 Coefficient	0.4	Left (north) Lateral Boundary Condition	Moving; 0 ft per simulation
D50 (mm)	0.2	Right (south) Lateral Boundary Condition	Moving; 0 ft per simulation
Berm Height (ft)	5	Inlet Left (north) Jetty Bypassing Coefficient (JBCL)	0.5
Depth of Closure (ft)	20	Inlet Right (south) Jetty Bypassing Coefficient (JBCR)	70
Ismooth (averaging window)	1	Inlet Left (north) Jetty Porosity	0.8
Time Step (hr)	0.0625	Inlet Right (south) Jetty Porosity	0.3

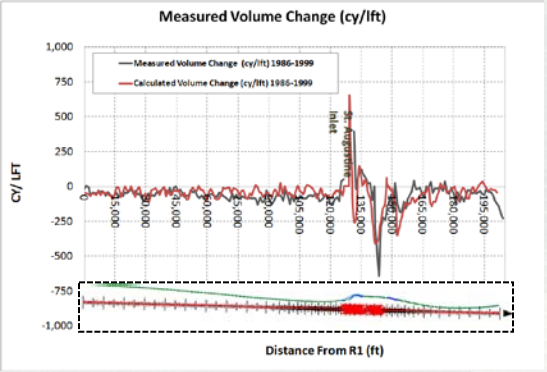
Calibrating Statistics for GenCade

Volumetric Change:

- A one on one comparison of profile volume change over R-Monument reaches (~1000 ft) and found a NRMSE 6.8%
- Calculated and measured volume change for the greater areas was found to have an NRMSE of 10.5%
  - the result of compounded error in summed volume change and different normalization values

Statistics By R-Mon

RMSE	70.7 cy/lft
NRMSE	6.8 %
Correlation Coefficient	0.61
Pattern Correlation (Erosion/Accretion)	93.9%



Statistics By Reach

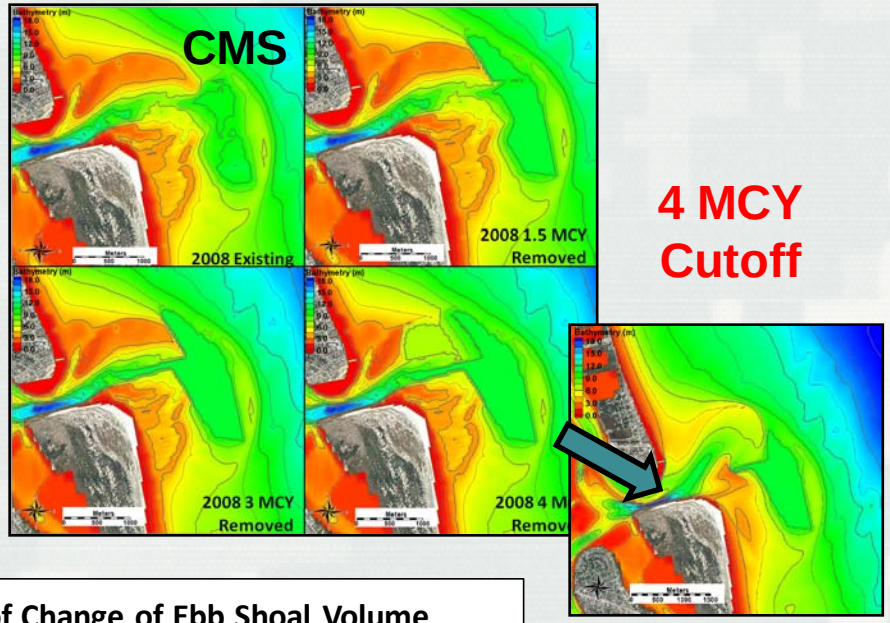
Measured and calculated volume change for St. Johns County beaches and inlet.

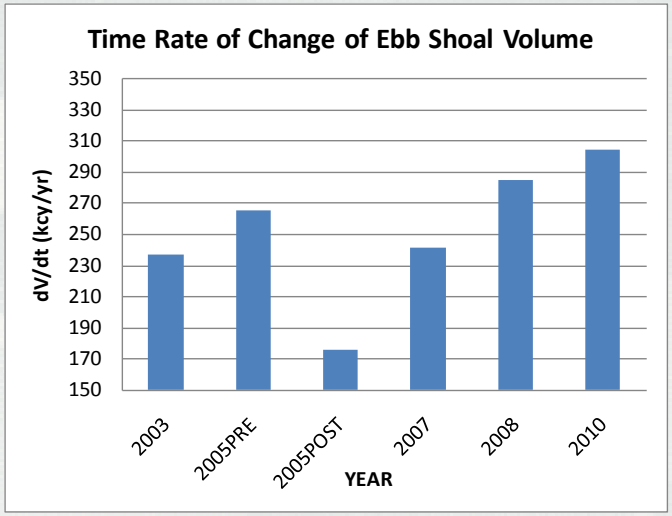
Location	Reach (R-Mon)	Measured 1986-1999 Volume Change	Calculated 1986-1999 Volume Change	Relative Error
Ponte Vedra Beach	R1 – R109	-7,047,494	-5,570,854	21.0%
S. Ponte Vedra & Vilano Beach	R109 – R122	-993,920	-1,750,050	-76.1%
St. Augustine Inlet	Ebb & Flood Tidal Deltas	5,071,250	3,719,711	-36%
Anastasia Island Headland	R123 – R128	816,874	1,928,059	136.0%
St. Augustine Beach	R128 – R151	-3,296,013	-3,526,604	-7.0%
Crescent Beach to Matanzas Inlet	R151 – R195	-2,338,478	-2,986,960	-27.7%

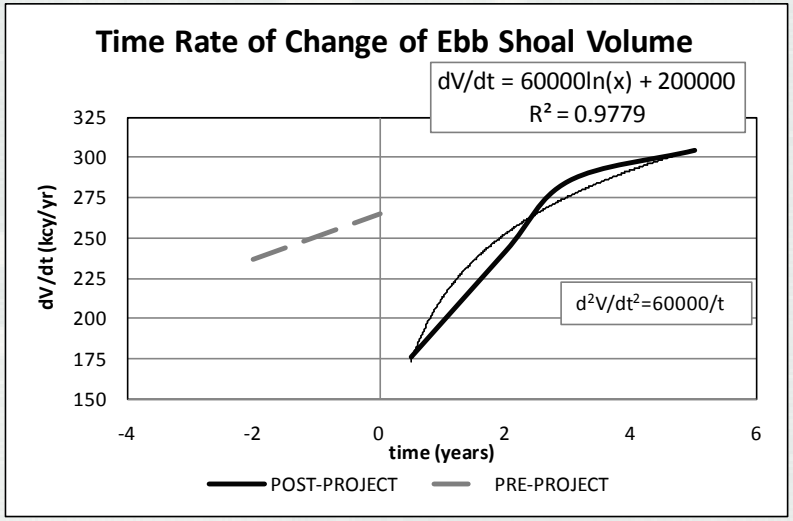
Dredging Boundaries: Historical Data & CMS Results

Ebb Shoal Recovery:

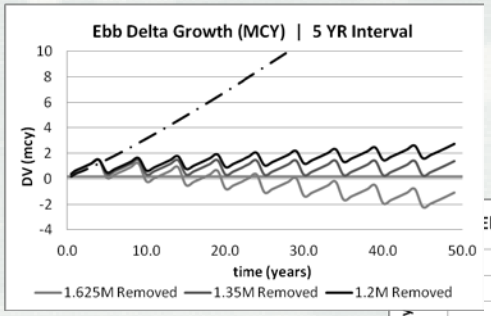
- Cannot remove so much as to force the inlet out of “equilibrium”: <4MCY
- Account for inlet recovery by historical evidence for infilling: Rate of volume change (growth) determined from 2001-03 and 2005 mining events

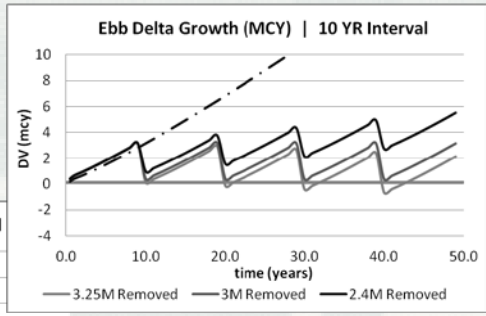


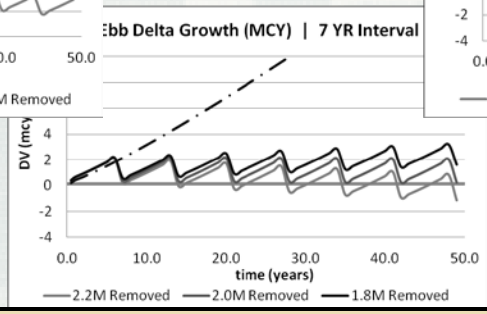




Defining Dredging Interval Alternatives for 50-YR Planning Horizon



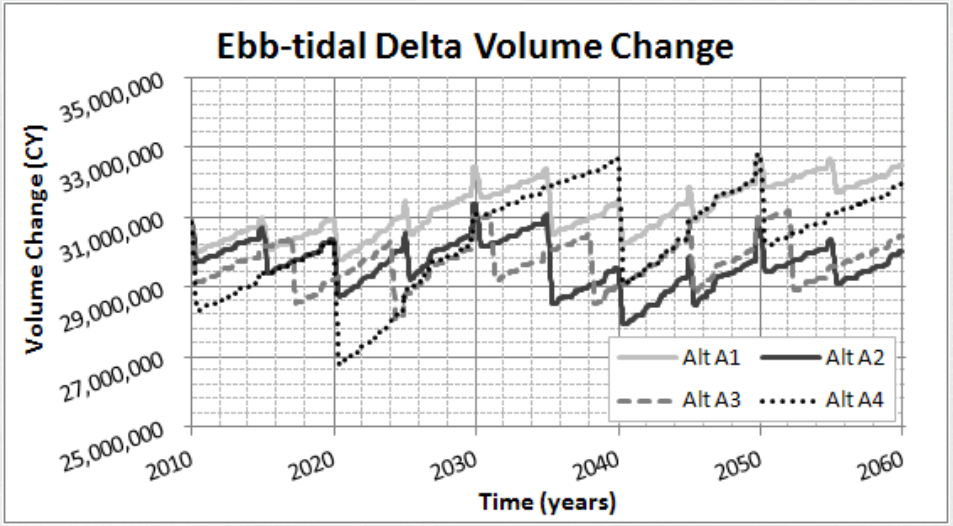




Dredging intensity scenarios considering equal or accretional status of the ebb-tidal delta.

Scenario	Dredged Volume	Dredging Interval	Beach Placement Volume	Beach Placement Location & Length
Alt A1	1.0 MCY	5 Years	1.0 MCY	T137a – R151 (15,000 lft)
Alt A2	1.35 MCY	5 Years	1.35 MCY	T137a – R151 (15,000 lft)
Alt A3	2.0 MCY	7 Years	2.0 MCY	T137a – R151 (15,000 lft)
Alt A4	3.0 MCY	10 Years	3.0 MCY	T137a – R151 (15,000 lft)

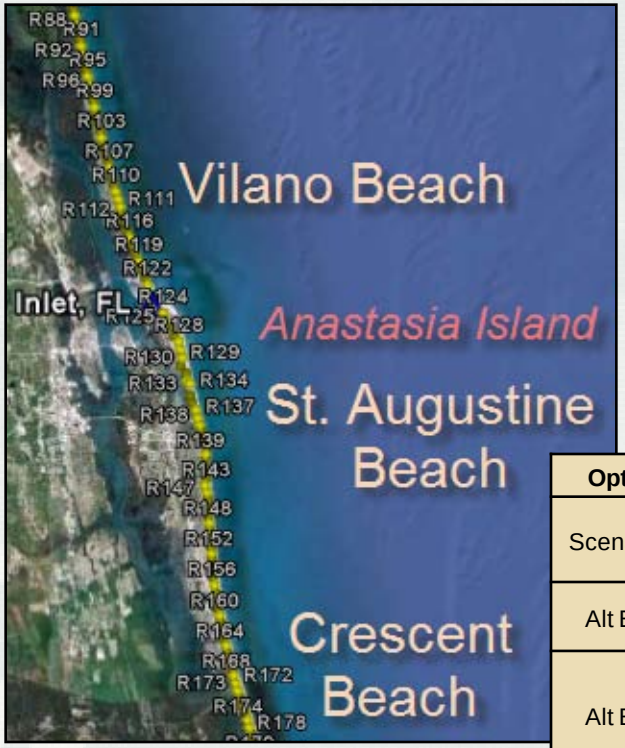
Alternative A: Dredging Interval Results



Final beach profile volume change (cy) of each 50-year simulation and the relative percent difference from the total profile volume (from R-Monument to -20 ft MLW).

Shoreline Reach	A1		A2		A3		A4	
	CY	%	CY	%	CY	%	CY	%
Vilano Beach	-802,066	-8.7	-1,007,726	-11.0%	-1,076,271	-11.7%	-918,879	-10.0%
Anastasia Island Beach	819,196	5.7	559,732	3.9%	504,139	3.5%	853,673	5.9%
St. Augustine Beach	-6,034,964	-42.9	-4,311,594	-30.6%	-2,504,689	-17.8%	-3,305,699	-23.5%

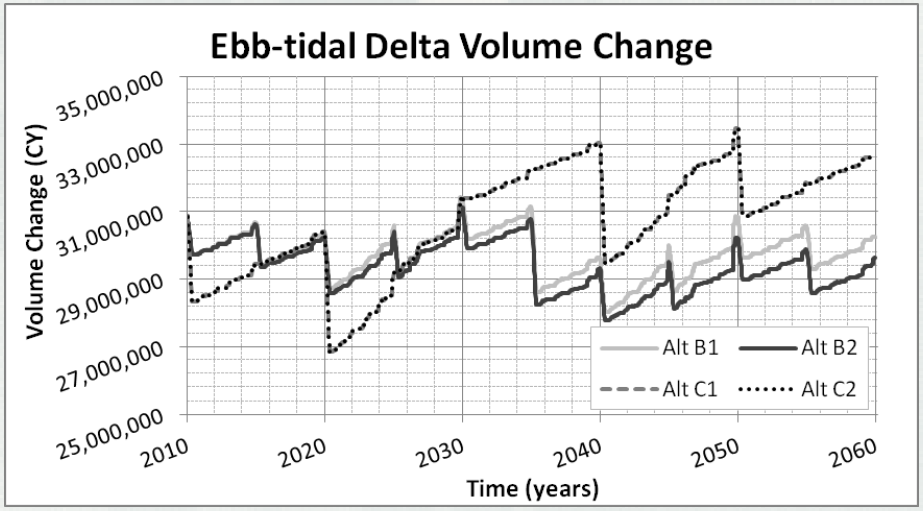
Refined Nourishment Interval Alternatives



Optimized beach fill placement scenarios following the results of the Alternative A dredging scenarios.

Scenario	Dredged Volume	Dredging Interval	Beach Placement Volume		Beach Placement Location & Length
Alt B1	1.35 MCY	5 Years	1.35 MCY	70 cy/lft	T132 – R151 (20,000 lft)
Alt B2	1.65 MCY (Includes Vilano Shoal ~300KCY)	5 Years	1.65 MCY	40 cy/lft	R109 – R120 (11,000 lft)
				80 cy/lft	T137a – R151 (15,000 lft)
Alt C1	3.0 MCY	10 Years	3.0 MCY	50 cy/lft	R109 – R120 (11,000 lft)
				125 cy/lft	T132 – R151 (20,000 lft)
Alt C2	3.0 MCY	10 Years	3.0 MCY	100 cy/lft	R109 – R120 (11,000 lft)
				125 cy/lft	T137a – R151 (15,000 lft)

Alternative A: Dredging Interval Results

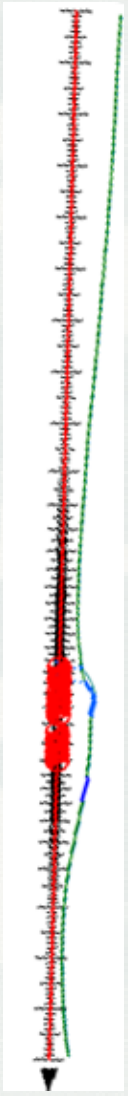


Final beach profile volume change (cy) of each 50-year simulation and the relative percent difference from the total profile volume (from R-Monument to -20 ft MLW).

Shoreline Reach	B1		B2		C1		C2	
	CY	%	CY	%	CY	%	CY	%
Vilano Beach	-1,028,289	-11.2%	-395,760	-4.3%	252,132	2.7%	1,272,387	13.8%
Anastasia Island Beach	894,035	6.2%	622,731	4.3%	1,440,646	10.0%	1,137,457	7.9%
St. Augustine Beach	-4,357,511	-31.0%	-5,257,507	-37.4%	-5,039,507	-35.8%	-6,347,988	-45.1%

Example of Results Plotted on SMS Grid

Discussion of Optimization Results In Terms of Beach Stabilization



St. Augustine Beach (Erosional Hotspot):

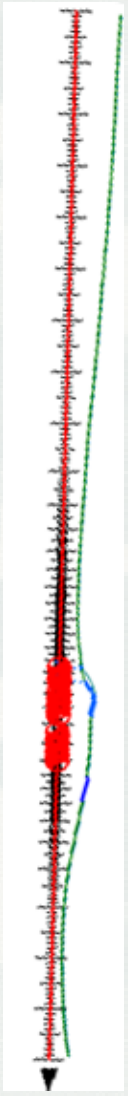
- All alternatives had a negative volume adjustment over the 50-year simulation
- Once the shoreline recedes to the seawall position, erosion accelerates
- This scenario persists for all Alternatives and may only be remedied through increased beach fill volume and placement intervals
- Maintaining the shoreline location and profile volume of 2010 with ebb-shoal mining alone cannot be done based on the results (there is a need for new sediment sources)

Vilano Beach SPP (Feasibility Study):

- Maintained or grew with >50 cy/lft beach fill volumes at 10 year intervals
- Lengthening and coordinating the Vilano Point dredging interval with the ebb-shoal mining for the St. Augustine Beach SPP will provide more than enough sand to maintain this SPP

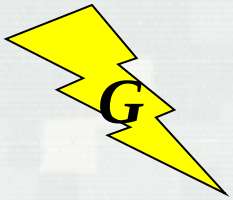
Augustine Island Beach (State Park):

- Inlet adjacent beaches are dominated by inlet processes not captured in GenCade
- The calculated volume growth at this beach represents sediment volumes that might otherwise make it to the inlet shoals
- Needs a process-based morphology model, but inferences can be made on what the volume represents based on morphological observations



Summary:

- The performance and estimate of certainty in GenCade as a sediment management planning tool is relative to the accuracy of the calibration. Furthermore, extensive analysis of measured data must be performed to properly inform the model on realistic bounds in a 3-dimensional morphologic environment.
- Though not all 3-dimensional morphologic processes are represented in the model, most general inferences about sediment transport and bypassing within the coastal zone can be applied to calculating future sediment budgets with GenCade.
- The benefits of coordinating and modifying dredging intervals can be explored simultaneously with varying beach fill volumes and intervals.
- The greatest benefit lies in determining optimal mobilization periods and coordinating regional efforts to save in mobilization and demobilization costs for dredging and beach fill placement.



Thank You!

Questions?