Inlet And Adjacent Shoreline Processes at Cascading Time Scales Using the Coastal Modeling System and GenCade

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Overview

- Regional Sediment Management Principles
- Background Information & Historical Change of St. Augustine Inlet
- Recent Activity at Inlet & Present Conditions
- Problem Statement: Influence of Dredging on Inlet & Adjacent Beach Dynamics
  - Application of the Coastal Modeling System (CMS) to Both Verify and Predict How Dredging Activities Affect the Inlet
  - Application of GenCade to Determine Optimal Sediment Management Scenarios based upon Shoreline Response
Regional Sediment Management Approach

RSM Operating Principles

- Recognize sediment as a regional resource – connect beaches & inlets
- Evaluate use of all sediment sources & sinks
- Optimize operational efficiencies & natural exchange of sediments
- Balanced, economically viable, environmentally sustainable solutions
- Improve economic performance by linking multiple interacting projects
- Consider regional impacts
- Adaptively manage
The Navigation Project and Erosional Hotspot

U.S. Army Corps of Engineers Projects at St. Johns County, Florida, U.S.

1862 Navigation Map

1940
The U.S. Army Corps of Engineers began a three year project to dredge a new inlet into St. Augustine. From this point forward, the lighthouse was no longer directly to the east of the inlet.
Planned and Historic District Activity in Last Decade

St. Augustine Ebb-shoal Mining

1998 - Bathymetry

1998 – 2003 Difference

4.5 MCY

St. Augustine Beach Shore Protection Project

<table>
<thead>
<tr>
<th>Project</th>
<th>Volume Placed (CY)</th>
<th>Placement Area</th>
<th>Placement Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003 Phase 1</td>
<td>4.2 mcy</td>
<td>R-145 to R-151</td>
<td>1.1 miles</td>
</tr>
<tr>
<td>Phase 2</td>
<td></td>
<td>T-132 to R-151</td>
<td>3.6 miles</td>
</tr>
<tr>
<td>2005</td>
<td>2.8 mcy</td>
<td>R-137A to R-151</td>
<td>2.6 miles</td>
</tr>
</tbody>
</table>

Legault et al., 2012

Vilano Beach Feasibility Study

<table>
<thead>
<tr>
<th>Project</th>
<th>Volume Placed (CY)</th>
<th>Placement Area</th>
<th>Placement Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Project</td>
<td>880 kcy</td>
<td>R-109 to R-120</td>
<td>2.0 miles</td>
</tr>
</tbody>
</table>
Problem Statement

Investigate optimal dredging volumes and intervals, and determine the beach placement volume and interval that will adequately supply sand to maintain two Shore Protection Projects in St. Johns County.

Questions:

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?
The Coastal Modeling System (CMS) at St. Augustine Inlet

Analysis to Conduct:
- Volumetric change of ebb shoal
- Planform change of ebb shoal
- Shoreline position

Beck and Legault, 2012
Comparison to the 1.5 MCY Removed

Planform Extent

A

B

Volumetric Change

Beck and Legault, 2012

Sediment Transport Pathways

Sediment Transport

A

Time: 17 September 2003 0900 hrs
Wave: 2.3 m 6.7 sec

B

Time: 17 September 2003 0900 hrs
Wave: 2.3 m 6.7 sec

Beck and Legault, 2012
Ebb Delta Mining Alternatives

2008 Existing

2008 1.5 MCY Removed

2008 3 MCY Removed

2008 4 MCY Removed
Certain conditions collapse the active shoal through disruption of natural sand pathways by reducing its depth either through deflation or collapse and/or reducing its planform area.

Functionality of the updrift channel margin shoal is crucial – needed to sustain channelized flow to maintain typical bypassing.
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

Time Rate of Change of Ebb Shoal Volume

\[
\frac{dV}{dt} = 60000 \ln(x) + 200000
\]

\[R^2 = 0.9779\]

Legault et al., 2012
Defining Dredging Interval Alternatives for 50-YR Planning Horizon

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

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Dredged Volume</th>
<th>Dredging Interval</th>
<th>Beach Placement Volume</th>
<th>Beach Placement Location &amp; Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt A1</td>
<td>1.0 MCY</td>
<td>5 Years</td>
<td>1.0 MCY</td>
<td>T137a – R151 (15,000 lft)</td>
</tr>
<tr>
<td>Alt A2</td>
<td>1.35 MCY</td>
<td>5 Years</td>
<td>1.35 MCY</td>
<td>T137a – R151 (15,000 lft)</td>
</tr>
<tr>
<td>Alt A3</td>
<td>2.0 MCY</td>
<td>7 Years</td>
<td>2.0 MCY</td>
<td>T137a – R151 (15,000 lft)</td>
</tr>
<tr>
<td>Alt A4</td>
<td>3.0 MCY</td>
<td>10 Years</td>
<td>3.0 MCY</td>
<td>T137a – R151 (15,000 lft)</td>
</tr>
</tbody>
</table>

Legault et al., 2012
Refined Nourishment Intervals for 50-YR Planning Horizon

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

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Dredged Volume</th>
<th>Dredging Interval</th>
<th>Beach Placement Volume</th>
<th>Beach Placement Location &amp; Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt B1</td>
<td>1.35 MCY</td>
<td>5 Years</td>
<td>1.35 MCY</td>
<td>T132 – R151 (20,000 lft)</td>
</tr>
<tr>
<td>Alt B2</td>
<td>1.65 MCY (Includes Vilano Shoal ~300KCY)</td>
<td>5 Years</td>
<td>1.65 MCY</td>
<td>R109 – R120 (11,000 lft)</td>
</tr>
<tr>
<td>Alt C1</td>
<td>3.0 MCY</td>
<td>10 Years</td>
<td>3.0 MCY</td>
<td>R109 – R120 (11,000 lft)</td>
</tr>
<tr>
<td>Alt C2</td>
<td>3.0 MCY</td>
<td>10 Years</td>
<td>3.0 MCY</td>
<td>R109 – R120 (11,000 lft)</td>
</tr>
</tbody>
</table>
The GenCade Model

GenCade is a one-dimensional (1-D) numerical model that calculates regional coastal change including inlet volumetric evolution.

The model is a combination of Genesis, a shoreline change model designed for project-scale engineering studies, and Cascade, a regional alongshore sediment transport model that includes barrier islands and the inlets that separate them.

The combination of the two models, with the addition of the Inlet Reservoir Model, which investigates the sediment sinks in inlets, result in a regional model capable of modeling shoreline change at the structure or project level, up to regional distances on the order of hundreds of kilometers.
## GenCade Reaches of St. Johns Co., FL (R-Monument Profile Locations)

<table>
<thead>
<tr>
<th>Location</th>
<th>Reach (R-Mon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ponte Vedra Beach</td>
<td>R1 – R109</td>
</tr>
<tr>
<td>S. Ponte Vedra &amp; Vilano Beach</td>
<td>R109 – R122</td>
</tr>
<tr>
<td>St. Augustine Inlet</td>
<td>Ebb &amp; Flood Tidal Deltas</td>
</tr>
<tr>
<td>Anastasia Island Headland</td>
<td>R123 – R128</td>
</tr>
<tr>
<td>St. Augustine Beach</td>
<td>R128 – R151</td>
</tr>
<tr>
<td>Crescent Beach to Matanzas Inlet</td>
<td>R151 – R195</td>
</tr>
</tbody>
</table>
RESULTS: Ebb-Tidal Delta Volume Change for Alternatives

U.S. Army Corps of Engineer Projects at St. Johns County, Florida, U.S.
RESULTS: Plotted Shoreline Position on GenCade Grid

Alt B1
- 70 cy/lft
- 5 yr

Alt B2
- 80 cy/lft
- 5 yr

Alt C1
- 125 cy/lft
- 10 yr

Alt C2
- 125 cy/lft
- 10 yr
Volumetric Results of Alternatives

U.S. Army Corps of Engineer Projects at St. Johns County, Florida, U.S.
An analysis of the CMS model results determined that dredging scenarios under 4 MCY removed did not significantly modify the ebb-tidal delta through the 1) elevation and planform extent, 2) sediment transport patterns, or 3) volume flux provided to the adjacent beaches.

The CMS modeling results provided crucial constructive bounds on the optimized scenarios modeled in GenCade.

The benefits of coordinating and modifying dredging volumes and intervals can be explored in GenCade simultaneously with varying beach fill volumes and intervals to calculate how sediment sources and sinks evolve over time for future sediment budgets.

An analysis of the GenCade results found that there is not a sustainable dredging amount and interval for St. Augustine Inlet that will meet the beach fill needs of St. Johns County. At least another 1 MCY/YR is necessary to sustain the present SPP.

The greatest benefit of this methodology is in determining optimal dredging periods and coordinating regional efforts to save in mobilization and demobilization costs for dredging and beach fill placement.
Thank You!

Questions?

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