Economic and Geomorphic Comparison of Nearshore vs. OCS Sand for Coastal Restoration Projects

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Trajectory Economics

What are the restoration tradeoffs between Materials of different quantity, quality, and costs over time with risk?
Components and Structure of Project

- Cost Model
- Benefits Model
- Integrated Model
- Observations
Cost Modeling: Based on Historical Project Data

Scofield Island
Projects for OCS and NS Cost Modeling

1. BA-30 East Grand Terre Island Restoration
2. BA-35 Pass Chaland to Grand Bayou Pass Barrier Shoreline Restoration
3. BA-38-1 Pelican Island Restoration
4. BA-38-2 Chaland headland Restoration
5. BA-40 Riverine Sand Mining/Scofield Island Restoration
6. BA-45 Caminada Headland Beach and Dune Restoration
7. BA-76 Cheniere Ronquille Barrier Island Restoration
8. BA-110 Shell Island East BERM Restoration
9. BA-111 Shell Island West NRDA Restoration
10. BA-143 Caminada Headland Beach and Dune Restoration INCR2
11. CS-31 Holly Beach Sand Management
12. CS-33 Cameron Parish Shoreline Restoration
13. TE-20 Isles Dernieres Restoration East Island
14. TE-24 Isles Dernieres Restoration Trinity Island
15. TE-27 Whiskey Island Restoration
16. TE-25&30 East Timbalier Island Sediment Restoration
17. TE-37 New Cut Dune and Marsh Restoration
18. TE-40 Timbalier Island Dune and Marsh Creation
19. TE-48-2 Raccoon Island Shoreline Protection and Marsh Creation
20. TE-50 Whiskey Island Back Barrier Marsh Creation
21. TE-52 West Belle Pass Barrier Headland Restoration
22. TE-100 Caillou Lake Headlands Restoration
Modeling Project Costs

Data Sources:

• Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA)
• Coastal Information Management System (CPRA)
• CPRA Annual Barrier Island status reports
• Commercial Sector
  Weeks Marine, Great Lakes Dredge & Dock, C.F. Bean, Manson, T.L. James, Bryd Bros, Central Gulf Dredging, etc.

Observations:

• Project Completion Reports (n=22)
• Project bids for restorations projects (n=71)
### Descriptive Data: Nearshore (NS) vs. OCS

<table>
<thead>
<tr>
<th>Source</th>
<th>Obs.</th>
<th>$/Acre</th>
<th>$/CuYd</th>
<th>Distance Miles (range)</th>
<th>CuYd/Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>32</td>
<td>71,187</td>
<td>$8.37</td>
<td>3 (1-8.5)</td>
<td>10,199</td>
</tr>
<tr>
<td>OCS</td>
<td>39</td>
<td>134,684</td>
<td>$14.31</td>
<td>18 (4-34.5)</td>
<td>9,235</td>
</tr>
</tbody>
</table>
## Potential Cost Model Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean</th>
<th>Std.Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CC ($)</strong></td>
<td>Construction Cost (2016 $)</td>
<td>4.13e+07</td>
<td>3.38e+07</td>
</tr>
<tr>
<td><strong>Independent Variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CYD</strong></td>
<td>Total Dredged Material (cubic yard)</td>
<td>3678946</td>
<td>1753443</td>
</tr>
<tr>
<td><strong>MOB</strong></td>
<td>Mobilization/Demobilization ($)</td>
<td>5348487</td>
<td>3910962</td>
</tr>
<tr>
<td><strong>DIST</strong></td>
<td>Average Distance from borrow site to project site (mile)</td>
<td>9.43</td>
<td>10.31</td>
</tr>
<tr>
<td><strong>AD</strong></td>
<td>Access Dredging/Channels ($)</td>
<td>57406</td>
<td>146225</td>
</tr>
<tr>
<td><strong>NA</strong></td>
<td>Net Acres Created (acre)</td>
<td>402</td>
<td>167</td>
</tr>
<tr>
<td><strong>DUNE</strong></td>
<td>Average Dune Elevation (feet)</td>
<td>6.39</td>
<td>1.20</td>
</tr>
<tr>
<td><strong>TES</strong></td>
<td>Threatened or Engangered Species (Yes=1)</td>
<td>0.46</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>PROGRAM</strong></td>
<td>Coastal Program (CWPPRA=1)</td>
<td>0.61</td>
<td>0.49</td>
</tr>
<tr>
<td><strong>WEEKS</strong></td>
<td>Bidder (WEEKS=1)</td>
<td>0.38</td>
<td>0.49</td>
</tr>
<tr>
<td><strong>BP</strong></td>
<td>Booster Pump (Yes=1)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>PYT</strong></td>
<td>Payment Type (Fill=1)</td>
<td>0.61</td>
<td>0.49</td>
</tr>
<tr>
<td><strong>CUTTER</strong></td>
<td>Dredge Equipment (Cutterhead=1)</td>
<td>0.86</td>
<td>0.35</td>
</tr>
<tr>
<td><strong>RH</strong></td>
<td>Re-handing (Yes=1)</td>
<td>0.27</td>
<td>0.45</td>
</tr>
<tr>
<td><strong>OFFSHORE</strong></td>
<td>Project Borrow Source Location (OCS=1)</td>
<td>0.55</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>BASIN</strong></td>
<td>Coastal Basin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calcasieu/Sabine=2</td>
<td>5.63</td>
<td>5.63</td>
</tr>
<tr>
<td></td>
<td>Terrebonne=3</td>
<td>45.07</td>
<td>50.70</td>
</tr>
<tr>
<td></td>
<td>Barataria=1</td>
<td>49.30</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent</th>
<th>Cum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.63</td>
<td>5.63</td>
</tr>
<tr>
<td>45.07</td>
<td>50.70</td>
</tr>
<tr>
<td>49.30</td>
<td>100</td>
</tr>
</tbody>
</table>
Construction costs is ultimately a function of **quantity** and **distance**

| Coef.     | Std.Err. | t    | P>|t| | 95% Conf.Interval     |
|-----------|----------|------|------|----------------------|
| CYD       | 5854.336 | 1041.422 | 5.62 | 0.000 | 3782.617 - 7926.055 |
| Distance  | 3301.997 | 969.7537 | 3.4  | 0.001 | 1372.848 - 5231.146 |
| Distance^2| -59.88951| 28.56021 | -2.1 | 0.039 | -116.705 - -3.07416 |
| Program_n 1| -10240.96| 6852.879 | -1.49 | 0.139 | -23873.5 - 3391.595 |
| 2         | 5697.694 | 3112.825 | 1.83 | 0.071 | -494.706 - 11890.09 |
| 4         | 64210.22 | 12233.62 | 5.25 | 0.000 | 39873.65 - 88546.78 |
| 5         | 8693.607 | 3377.576 | 2.57 | 0.012 | 1974.534 - 15412.68 |
| 6         | -3931.343| 4514.036 | -0.87 | 0.386 | -12911.2 - 5048.513 |
| Dune Elevation | 820.1013 | 1037.745 | 0.79 | 0.432 | -1244.31 - 2884.507 |
| Pay on fill | 7983.267 | 3580.617 | 2.23 | 0.029 | 860.2798 - 15106.25 |
| _cons     | -15971.52 | 6636.243 | -2.41 | 0.018 | -29173.1 - 2769.92 |

Linear Regression: N=93, R-square = 0.93, 
F( 10,82) = 79.52, Prob > F = 0.0000, Root MSE = 9179.3
Benefit Modeling: Based on Proxy Barrier System

Isle Dernieres - Trinity
(Shea Penland)
Proxy Barrier System

Downdrift Barrier (West)

Central Barrier

Updrift Barrier (East)

Spit Platform

Tidal Inlet

Flood Delta

Ebb Delta

Subaerial barrier (0 m) Mean Sea Level (MSL)

Subaqueous barrier (-0.5m) below MSL
Geophysical Model Setup

- Delft 3D-SWAN hydrodynamic and sediment transport model driven by tides, waves, storms and RSLR over a 192 x 384 grid of varying resolution (1 Km- 20m).

- Waves forced offshore ~6 hours (USACE-WIS), flow and waves coupled every 6 hours, RSLR changes from CPRA 2017.

- Sediment transport (van Rijn) with 2 sand classes to depict bathymetry updating (NS=156µm, OCS=160-200µm), morphodynamic upscaling, bed-load and suspended load transport (e.g. accounts for wash-over, breaching, lateral migration, sediment bypassing).

- Simulates sediment placement dynamics for direct effects and total effects (direct and indirect) across a closed template at contours of 1.0, 0.0, and -0.5 meters.
Basic Model Scenarios

Downdrift Barrier (West)

Central Barrier

Updrift Barrier (East)

Indirect Benefits for Scenarios 1, 2, 3

**Direct Benefits** (Material Placement)
1. Control (no action)
2. NS-sourced project
3. OCS-sourced project (acres, cuyd)

Indirect Benefits for Scenarios 1, 2, 3
Geophysical Model Output
Simulation A: Single Project Comparison (Subaerial)
Nearshore (NS) vs. OCS Sediments

- **Slop Factor** (affects costs): (1.1x - 1.5x volume is needed for $Y_0$)
- **Performance Factor** (affects benefits): (156µm - 200µm sand erosion at $Y_0$ - $Y_{50}$)
Integrated Model: Based on Benefit-Cost Analysis

\[
\text{C:E Ratio} = \frac{\text{Total Project Costs (\$)}}{\text{Total Project Benefits (units)}}
\]

- Ecosystem Services for NS vs. OCS in dollars

\[
\text{Ecosystem Services} = \text{NS} + \text{OCS}
\]
Monetizing Benefits

Break-Even Analysis

\[ BC \text{ Ratio} = \frac{\sum_{t=1}^{T} \frac{B_t}{(1+R)^t}}{\sum_{t=1}^{T} \frac{C_t}{(1+R)^t}} = 1.0 \]

**Where:**

- \( B_t \) is benefit in time \( t \) in $.
- \( C_t \) is cost in time \( t \) in $.
- \( R \) is the discount rate.
- \( t \) is the year (\( T=1-50y \)).

Since we know costs ($) and physical quantities (x) at time \( t \), we can set \( B:C=1.0 \) and solve for the ESV ($) required to “break-even” under different scenarios.
1. Cost Model (NS and OCS data combined)
   - Function of sediment quantity, distance, program, payment type

2. Benefit Models (Control, NS, OCS)
   - Same environmental forcing $Y_0 - Y_{50}$
   - Dynamics driven by sediment quality
   - Annual volume & acreages at $t = 0, 1, 2, 3, \ldots 50$ years
   - Total Effects (West + Central + East)

3. Assumptions for Single Project Simulations
   - Starting Quantity ($Q$): $= 10,700,000$ cuyds, $\sim 1800$ acres
   - Distance: 1-30 miles
   - Slop Factors ($Q_x$): $1.1x - 1.5x$
   - Performance Factors (Grain sizes: $156\mu$m - $200\mu$m)
   - Hurricane impact - early ($y_{5}$) and later ($y_{20}$)
   - Subaerial (0.0 m) and Subaqueous (-0.5 m)
Comparing Break-Even Values

What are the efficiency trade-offs of material quantity, quality, and distance?

Near-Shore (NS) 156 μm, 1-7 miles, 1.1-1.5x slop

Break-Even ($/acre/yr)

<table>
<thead>
<tr>
<th>Miles</th>
<th>1.1x slop</th>
<th>1.3x slop</th>
<th>1.5x slop</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$4,500</td>
<td>$5,500</td>
<td>$6,500</td>
</tr>
<tr>
<td>1</td>
<td>$4,600</td>
<td>$5,600</td>
<td>$6,600</td>
</tr>
<tr>
<td>2</td>
<td>$4,700</td>
<td>$5,700</td>
<td>$6,700</td>
</tr>
<tr>
<td>3</td>
<td>$4,800</td>
<td>$5,800</td>
<td>$6,800</td>
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<tr>
<td>4</td>
<td>$4,900</td>
<td>$5,900</td>
<td>$6,900</td>
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<tr>
<td>5</td>
<td>$5,000</td>
<td>$6,000</td>
<td>$7,000</td>
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<td>6</td>
<td>$5,100</td>
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<tr>
<td>7</td>
<td>$5,200</td>
<td>$6,200</td>
<td>$7,200</td>
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<tr>
<td>8</td>
<td>$5,300</td>
<td>$6,300</td>
<td>$7,300</td>
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<tr>
<td>9</td>
<td>$5,400</td>
<td>$6,400</td>
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</tr>
<tr>
<td>10</td>
<td>$5,500</td>
<td>$6,500</td>
<td>$7,500</td>
</tr>
</tbody>
</table>
Comparing Break-Even Values

What are the efficiency trade-offs of material quantity, quality and distance?

Outer Continental Shelf (OCS), 1.1 X slope, 7-30 miles, 160-200 μm

Break-Even ($/acre/yr)

- 160 μm
- 165 μm
- 200 μm

Miles

Break-Even Values
Comparing Break-Even Values

What are the efficiency trade-offs of material quantity, quality and distance?

Break-Even ($/acre/yr)

- NS
- OCS

Break-Even Values:
- $4,500
- $5,500
- $6,500
- $7,500
- $8,500

Miles:
- 0
- 10
- 20
- 30
- 40

Thickness:
- 165 μm
- 200 μm

Slope:
- 1.3x slope
- 1.5x slope
Traditional cost comparisons depict OCS projects as more expensive, approximately 2x that of the $/acre NS for projects of similar size, but...

Material budgets for NS projects are greater, averaging 10% more cuyd/acre than OCS projects of similar size, yet...

These comparisons are based on initial costs ($Y_1$) and terminal benefits ($Y_{50}$) and fail to account for the flow of costs and benefits over time ($Y_1 - Y_{50}$), moreover....

Geophysical modeling shows that under similar starting conditions and forcing, OCS and NS trajectories diverge over time, with higher resilience for OCS materials of higher quality, however...

The time required for this divergence to fully manifest (under typical forcing) is a constraint - given that simulated project life is only 50 years, but consider...
Nearshore (NS) vs. OCS Sediments

Project Benefits (Volume, Area)

Time (Years)

Y_0, Y_5, Y_{20}, Y_{50}

Hurricane Risk
Preliminary Observations

- Under storm-punctuated simulations, trajectory divergence is more pronounced, with greater economic implications for earlier ($Y_5$) versus later occurring storms ($Y_{20}$), yet...

- Storm impacts only serve to exacerbate the quantity-quality-distance tradeoffs, where..

- For NS projects, the most limiting economic factor is “slop” (pre-project materials losses from handling, fines, and settling),...and for OCS projects, the most limiting economic factor is distance and grain size, so...

- In the absence of storms, the break-even costs for highest quality sand at 18 miles is basically equal to NS projects with an average distance and slop (3 mile, 1.3x), and..

- The highest slop factors for NS projects (1.5 x) completely negate any economic advantages over OCS up to 30 miles for medium to high quality sands (165µm - 200µm).
Completed:

**Simulation Type A: Single project comparisons**
Economic trade-offs between NS and OCS sources hinge on quality (grain size), quantity (slop), and distance (miles).

**Simulation Type B: Larger grain size for OCS**
Larger OCS grain sizes (160µm - 200µm) yield performance benefits and greater economic efficiency

**Simulation Type C: Including subaqueous benefits**
Capturing subaqueous project benefits at the -0.5 contour affects absolute magnitude but not relative difference

Finalizing:

**Simulation Type D: Hurricane impact scenarios**
Major storm impacts at Year 5 and Year 20. Preliminary results suggest earlier storms have greater economic implications and tend to favor OCS-sourced projects
Thank you