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Benefit-Cost Analysis of Using OCS vs. Nearshore Sand for Coastal Restoration

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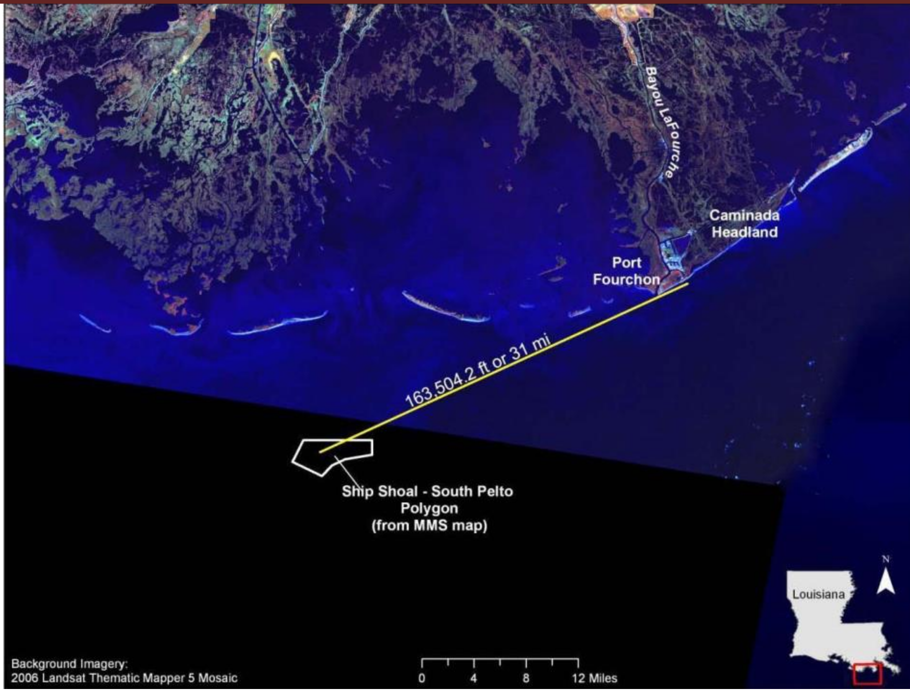
Motivation

- **~80% of restoration budget is exploration, dredging, and emplacement of sediment (Khalil et al. 2010, Wang 2011)**

- Projects are typically evaluated based on:
  - cost effectiveness
  - subaerial land only
  - direct benefits at project site only

Summary of Key Tradeoffs

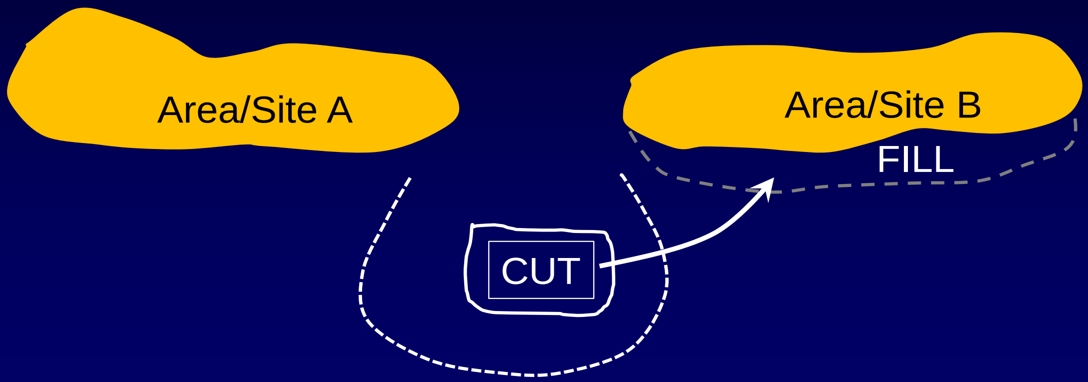
- Nearshore Sand
  - Cheaper per unit
  - Lower Quality
  - Dredging potentially impacts project area dynamics
  - Constrained by sand availability
- OCS Sand
  - More expensive per unit
  - Higher Quality
    - Less mud (less sand required per unit area built)
    - Larger grains (erodes slower)
  - Dredging does not impact local project area
  - Augments nearshore sand budget
  - No quantity constraint



Scenario 1 – NS sediment excavated from within the system

Indirect benefits at t=0,1,2..n)
(Down-drift barrier)

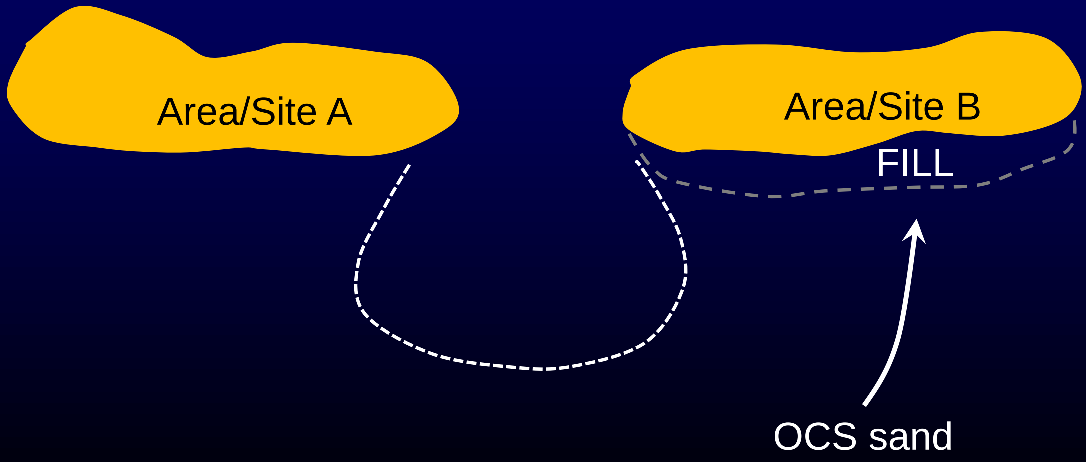
Direct benefits at t=0,1,2..n)
(Up-drift barrier)



Scenario 2 – OCS sand from outside the system

Indirect benefits at t=0,1,2..n)
(Down-drift barrier)

Direct benefits at t=0,1,2..n)
(Up-drift barrier)



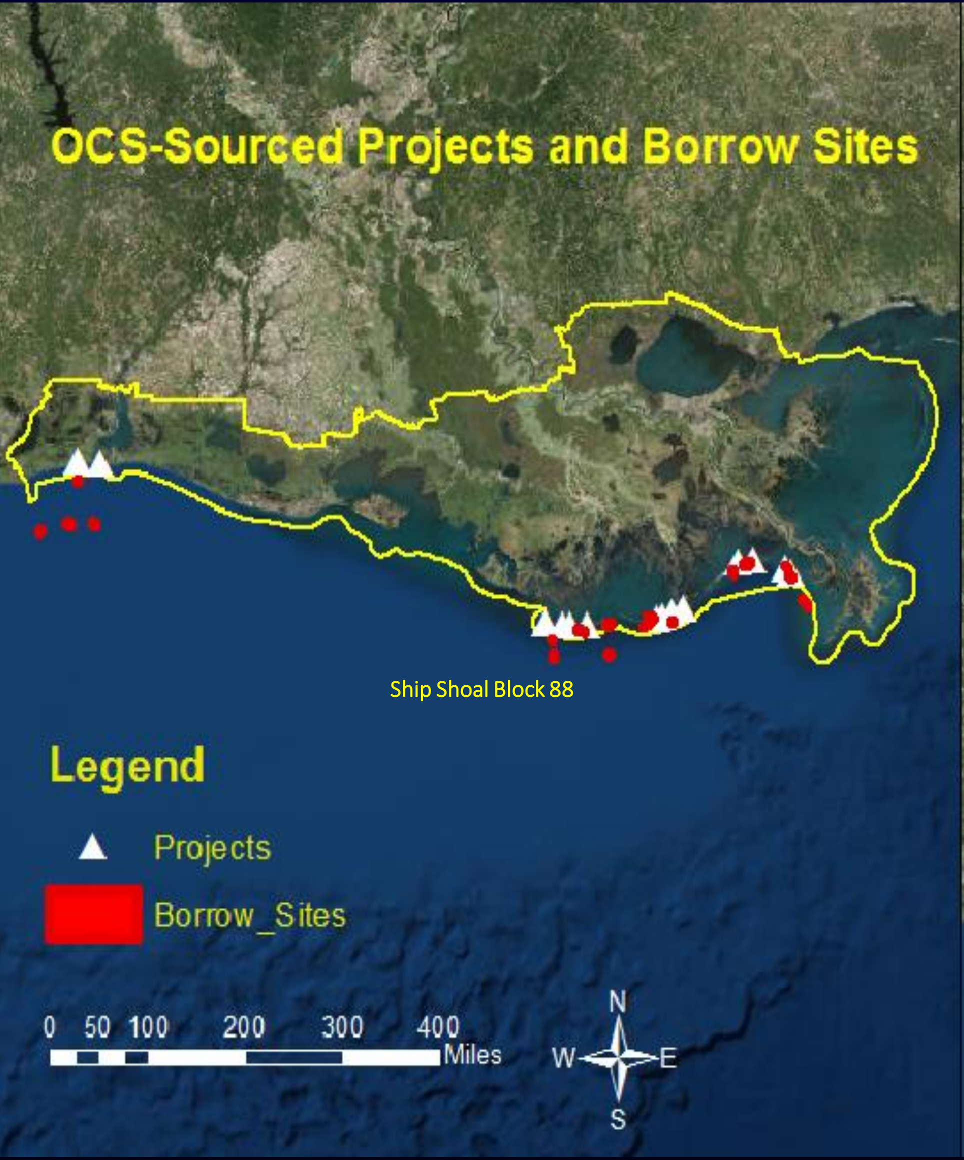
BCA Components

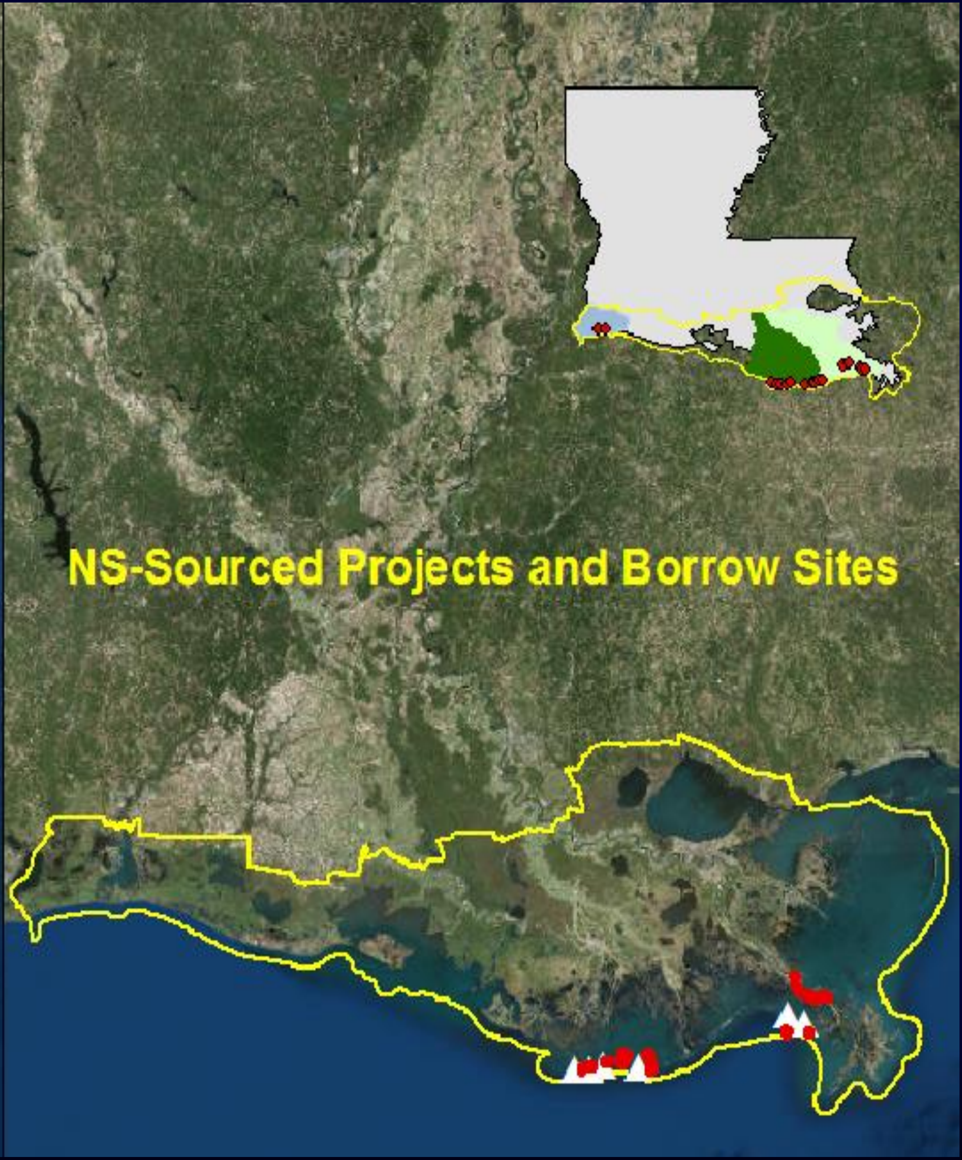
- Universal Standing
- Alternatives:
  - Nearshore vs. OCS @ site
- Assumptions
  - Costs @ t=0, Benefits @ t=1-50
  - Benefit attached to acre of sand
  - Subaqueous benefits some fraction of subaerial benefits
  - Mud has zero value
- Unquantified impacts
  - Sand benefits below depth threshold
  - Non-sand benefits
  - Env/habitat costs associated with dredging

Pelican Island, Louisiana Dune and Marsh Restoration

Costs
(based on historical project data)

Borrow Sites and Projects





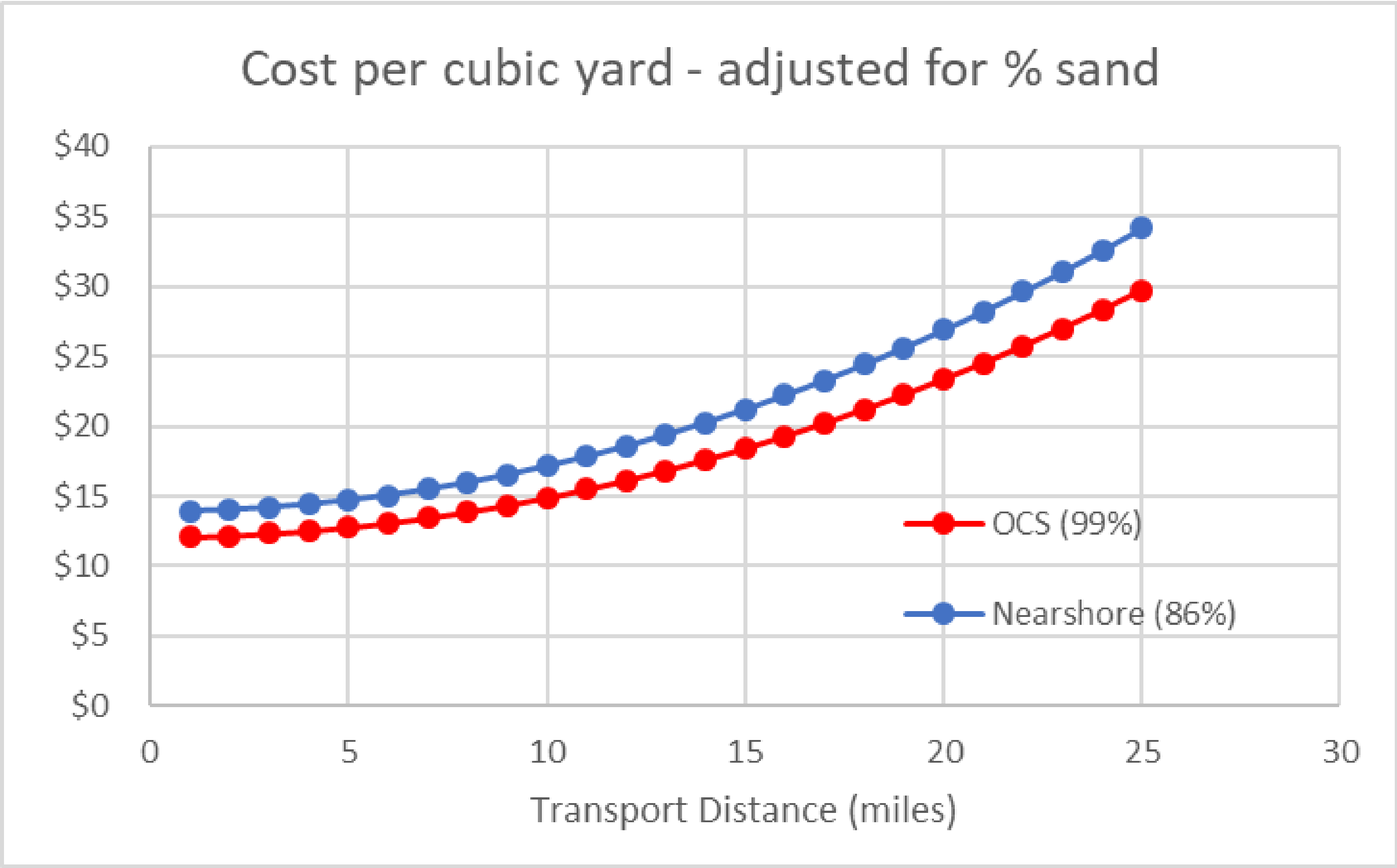
Estimated Cost Model

```
. reg cc16_1000 cy_1000 dist_sq river cutter calc_sabine year, vce(robust)

Linear regression                               Number of obs     =         71
                                                F(6, 64)          =     156.13
                                                Prob > F          =     0.0000
                                                R-squared         =     0.9207
                                                Root MSE          =     9946.2
```

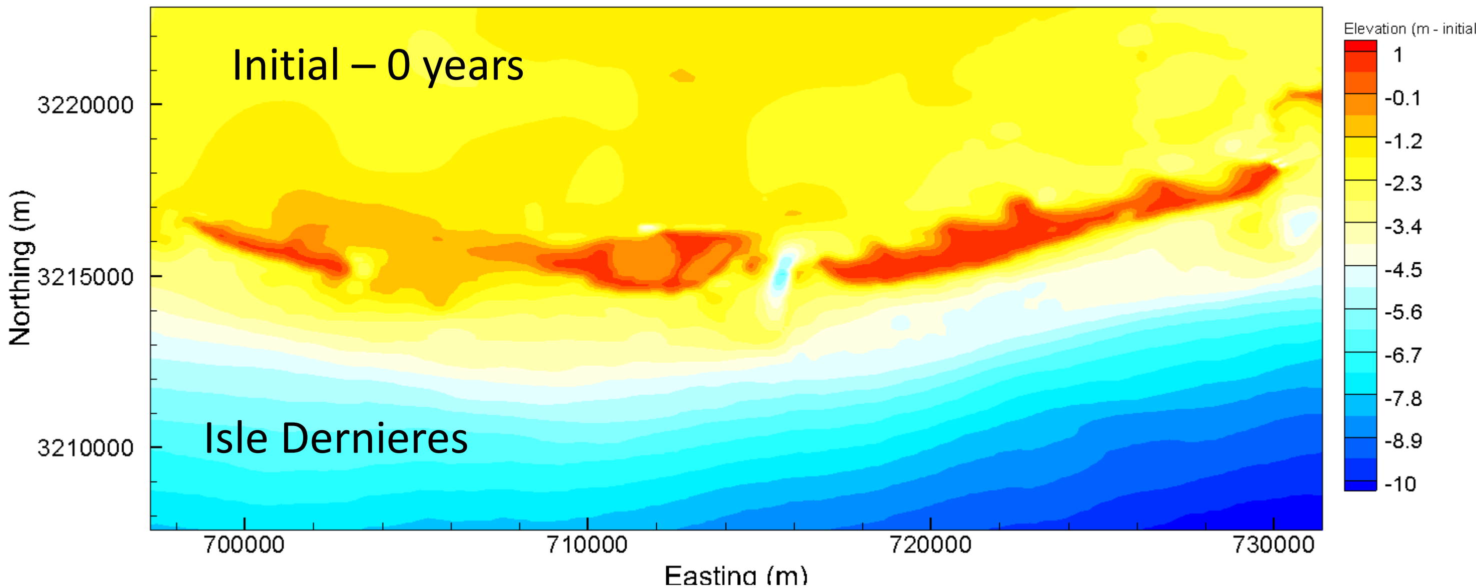
cc16_1000	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
cy_1000	8.162706	.4912622	16.62	0.000	7.181297	9.144115
dist_sq	102.7833	18.91829	5.43	0.000	64.98967	140.5769
river	-14482.89	4753.367	-3.05	0.003	-23978.83	-4986.944
cutter	46380.43	17462.67	2.66	0.010	11494.73	81266.13
calc_sabine	18070.81	7438.343	2.43	0.018	3211.012	32930.61
year	1454.14	133.0298	10.93	0.000	1188.382	1719.897
_cons	-2965469	265195	-11.18	0.000	-3495257	-2435681

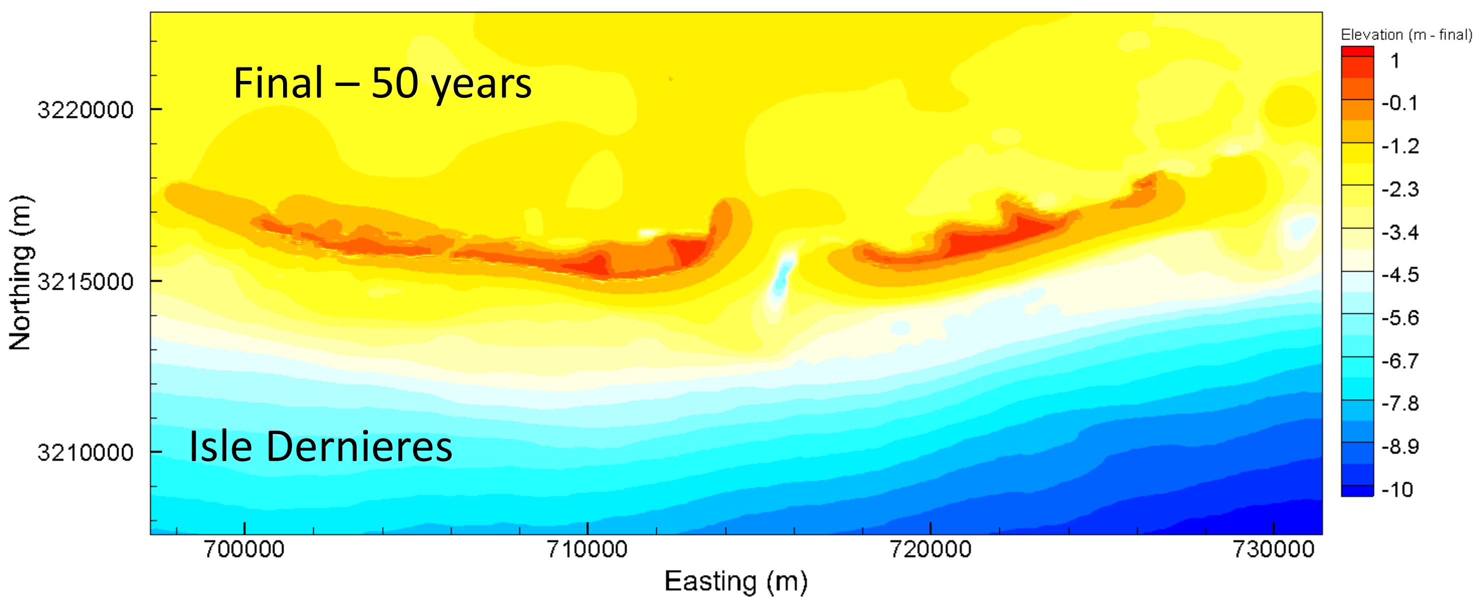
Estimated Cost Model



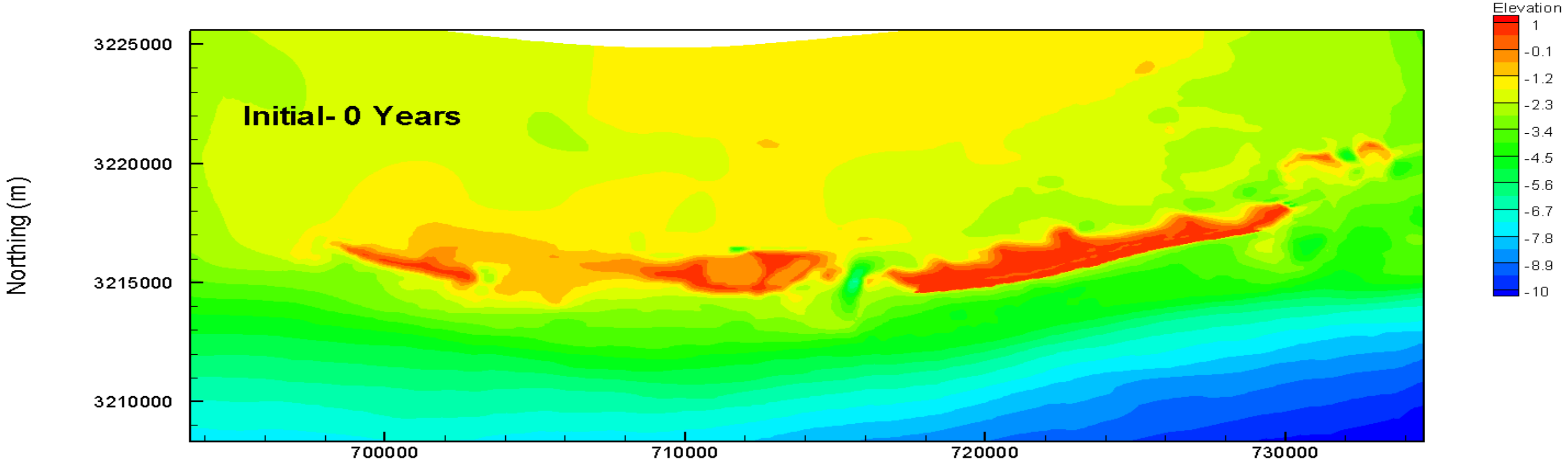
Benefits
(based on simulation data)

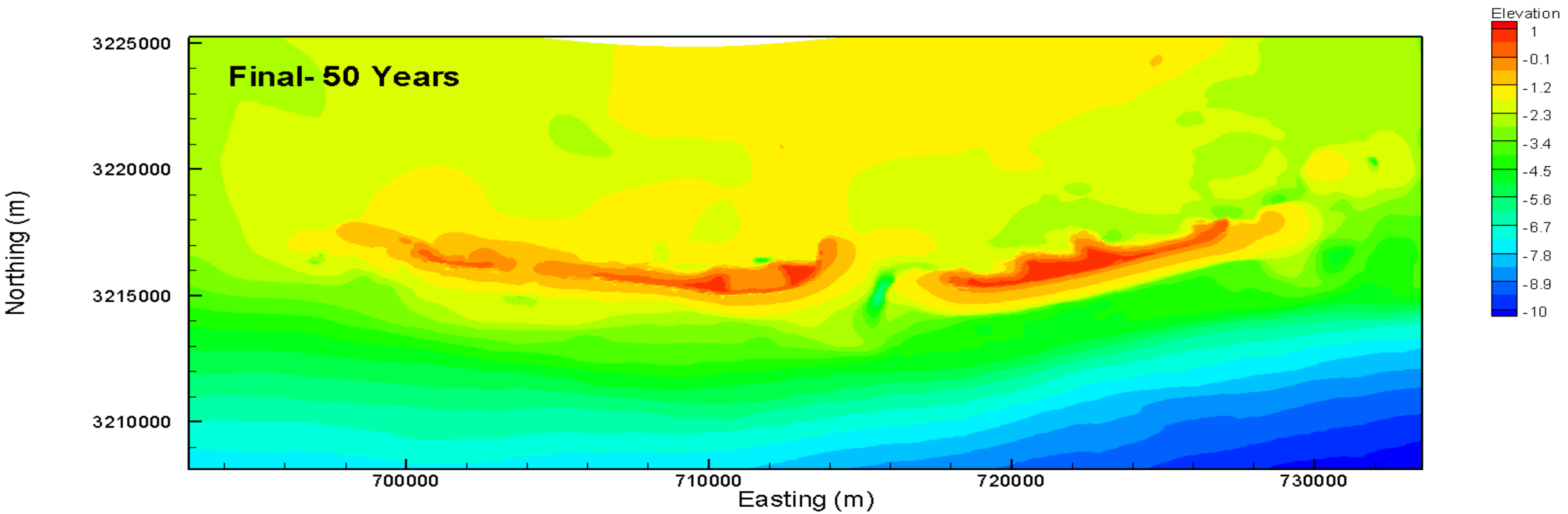
Control Experiments





Nourished OCS Experiments





Conceptual Benefits Model: "Direct" vs. "Indirect" Benefits & Subaerial vs. Subaqueous Benefits

- "Direct": @ project site
- "Indirect": @ updrift & downdrift sites
- "System" = Direct + Indirect

Net sand gain/loss via natural processes

Dredged sand

$$\Delta Q_t = \sum_{s=1}^{S} \Delta q_{st} = \underbrace{h_{1t}^{a} + n_{1t}^{a}}_{Direct\ Subaerial} + \underbrace{h_{1t}^{b} + n_{1t}^{b}}_{Direct\ Subaqueous} + \underbrace{\sum_{s=2}^{S} n_{st}^{a}}_{Indirect\ Subaerial} + \underbrace{\sum_{s=2}^{S} n_{st}^{b}}_{Indirect\ Subaqueous}$$

q: quantity (area)
s: site
t: time period
"a": subaerial sand (as seen from helicopter)
"b": subaqueous sand (underwater, down to arbitrary threshold depth)

Conceptual Benefits Model

- Assume value of subaqueous sand benefits is some fraction of value of subaerial sand benefits: $p^b = \alpha p^a \qquad (0 \le \alpha \le 1)$
- Summing over all sites & periods, NPV(Benefits) =

$$\Delta B = \sum_{s=1}^{S}\sum_{t=0}^{T}\Delta b_{st} = \underbrace{p^a \sum_{t=0}^{T}\delta^t\left(h_{1t}^a + n_{1t}^a\right)}_{Direct\ Subaerial} + \underbrace{\alpha p^a \sum_{t=0}^{T}\delta^t\left(h_{1t}^b + n_{1t}^b\right)}_{Direct\ Subaqueous}$$

$$+ \underbrace{p^a \sum_{s=2}^{S}\sum_{t=0}^{T}\delta^t n_{st}^a}_{Indirect\ Subaerial} + \underbrace{\alpha p^a \sum_{s=2}^{S}\sum_{t=0}^{T}\delta^t n_{st}^b}_{Indirect\ Subaqueous}$$

Candidate benefit values per unit

Petrolia, Interis, & Hwang
(Marine Resource Economics 2014)

Table 8. Comparison of WTP Estimates of Wetland Restoration

				Reported (nominal) Mean WTP per Household		Present Value of Mean WTP per Household, Inflation Adjusted (2011$)*	
	Study Area	Survey Year	Project Scale (acres)	One-time ($)	Annually ($)	Per Project ($)	Per Project Acre ($)
Present Study	LA	2011	234,000	973		973	0.004
Landry et al. (2011)[†]	LA	2007	N/A	103		112	
				552		599	
Petrolia and Kim (2011)	LA	2009	448,000		111	1,025	0.002
Farber (1996)	LA	1990	N/A		66	997	
Bergstrom et al. (1990)	LA	1986	1,600,000		360	6,492	0.004
Farber and Costanza (1987)	LA	1985	N/A		103	1,901	
Petrolia and Kim (2009)	MS	2008	2,338	144		150	0.064
Bauer, Cyr, and Swallow (2004)							
Udziela and Bennett (1997)							
Bateman et al. (1995)							
Loomis et al. (1991)							
Whitehead and Blomquist (1991)							

LA HHs = 1,656,053

Table 6. Estimated Means and Confidence Intervals (in brackets) of WTP Based on Binary-Choice Results

	Consequential Respondents Only	All Respondents
Resource Users*	$3,125 [2,029, 4,825]	$2,710 [1,618, 4,181]
Resource Non-Users	$1,637 [1,271, 2,242]	$1,184 [894, 1,592]

→ $11,451 – $29,590 / ac

Petrolia & Kim
(Marine Resource Economics 2009)

	Pre-Camille Option	
	Turnbull	RE Probit
Mean	$152	$144
95% CI*	$136 ~ $167	$65 ~ $186

→ $96,331- $118,290 / ac

Moving Forward

- Simulations will be run for NS and OCS
  - without and without nourishing
  - under alternative weather scenarios
  - (possibly) under alternative grain size and % mud assumptions
- These will yield (simulated) time-series data on subaerial and subaqueous acreage (w/ bounds)
- Robustness checks:
  - alternative costs
  - alternative prices (benefit values)
  - alternative α's
  - alternative discount rates
  - alternative time frames

In the Meantime: A Thought Experiment

- Suppose:
  - 221 ac project
  - 9235 cy/ac
  - OCS 99% sand, nearshore 86% sand
  - 20-mi offshore site, 1-mi nearshore site
  - 3% discount rate
  - 50 year time-frame (2017 proj year)
  - Ignore subaqueous and indirect benefits
  - Nearshore/offshore performance differential captured in relative annual acreage loss rate (offshore fixed at 0)
  - Benefit per ac: $11,451 <u>or</u> $96,331

- **Under <u>Low</u> Benefit: Nearshore must perform 2% worse in terms of annual acreage loss relative to offshore to justify offshore project**
- **Under <u>High</u> Benefit: Nearshore must perform only 0.2% worse**
- And relative performance even lower if offshore sand leads to more indirect benefits
  - Ongoing work will better inform this question

Questions / Suggestions?

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