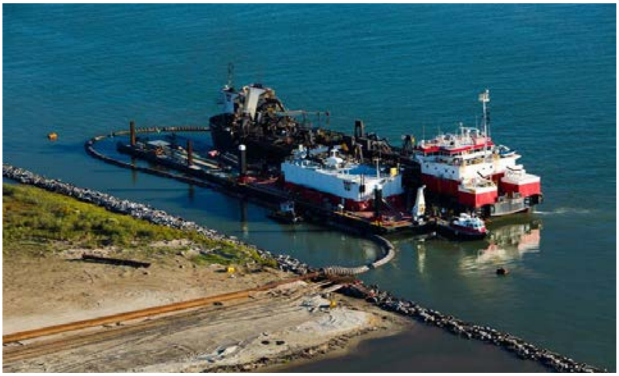
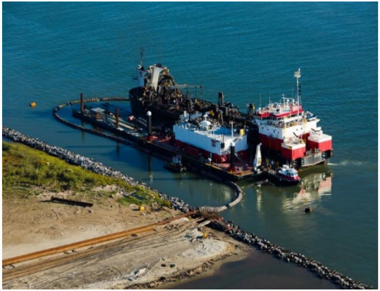
Economic and Geomorphic Comparison of Nearshore vs. OCS Sand for Coastal Restoration Projects



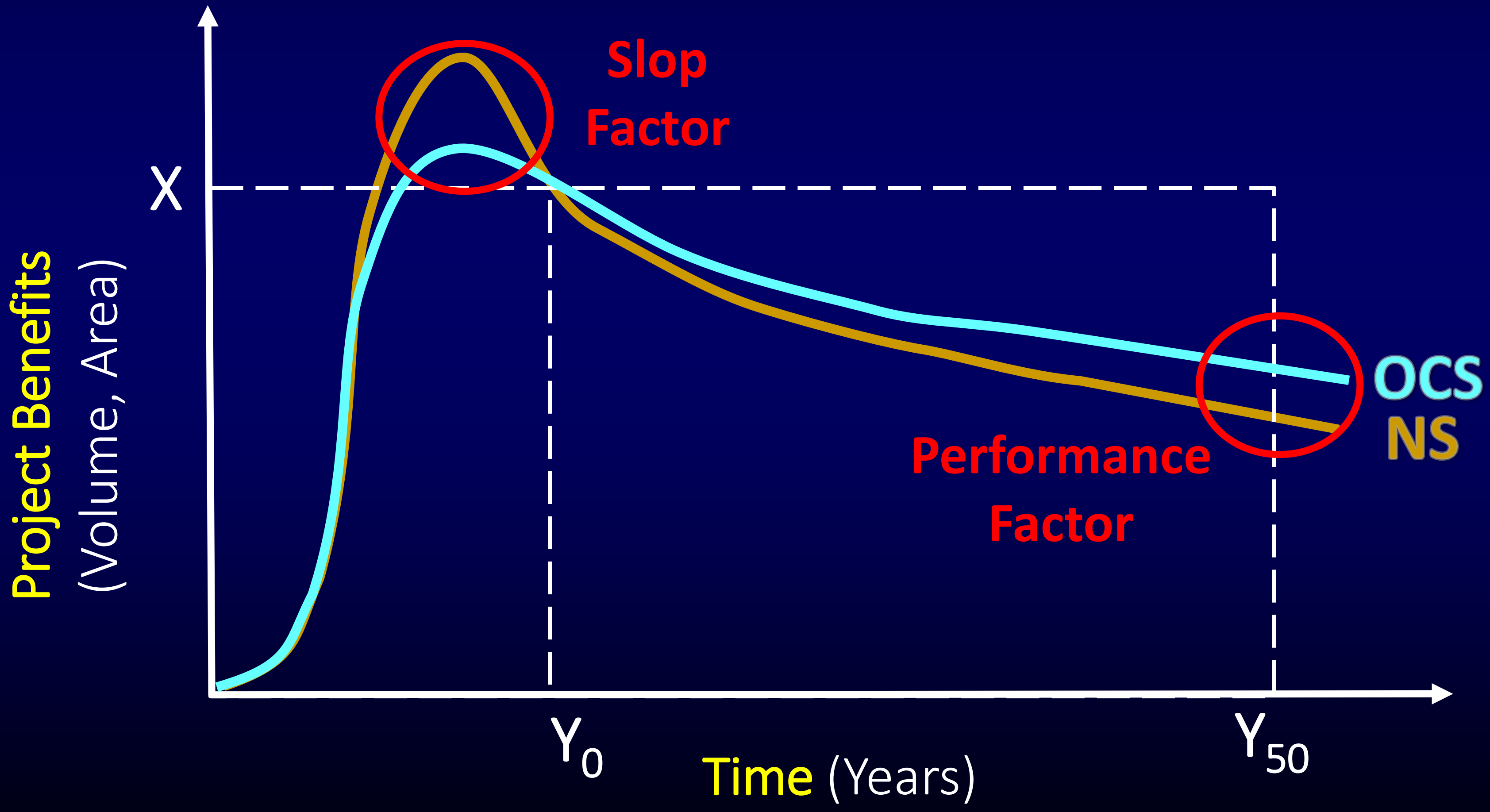
R. Caffey, D. Petrolia, H. Wang, I. Georgiou., and M. Miner

M15AQC0013 Team Meeting
June 29, 2018 New Orleans, Louisiana



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

Source	Obs.	$/Acre	$/CuYd	Distance Miles (range)	Cuyd/Acre
NS	32	71,187	$8.37	3 (1-8.5)	10,199
OCS	39	134,684	$14.31	18 (4-34.5)	9,235

Potential Cost Model Variables

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

Construction costs is ultimately a function of quantity and distance

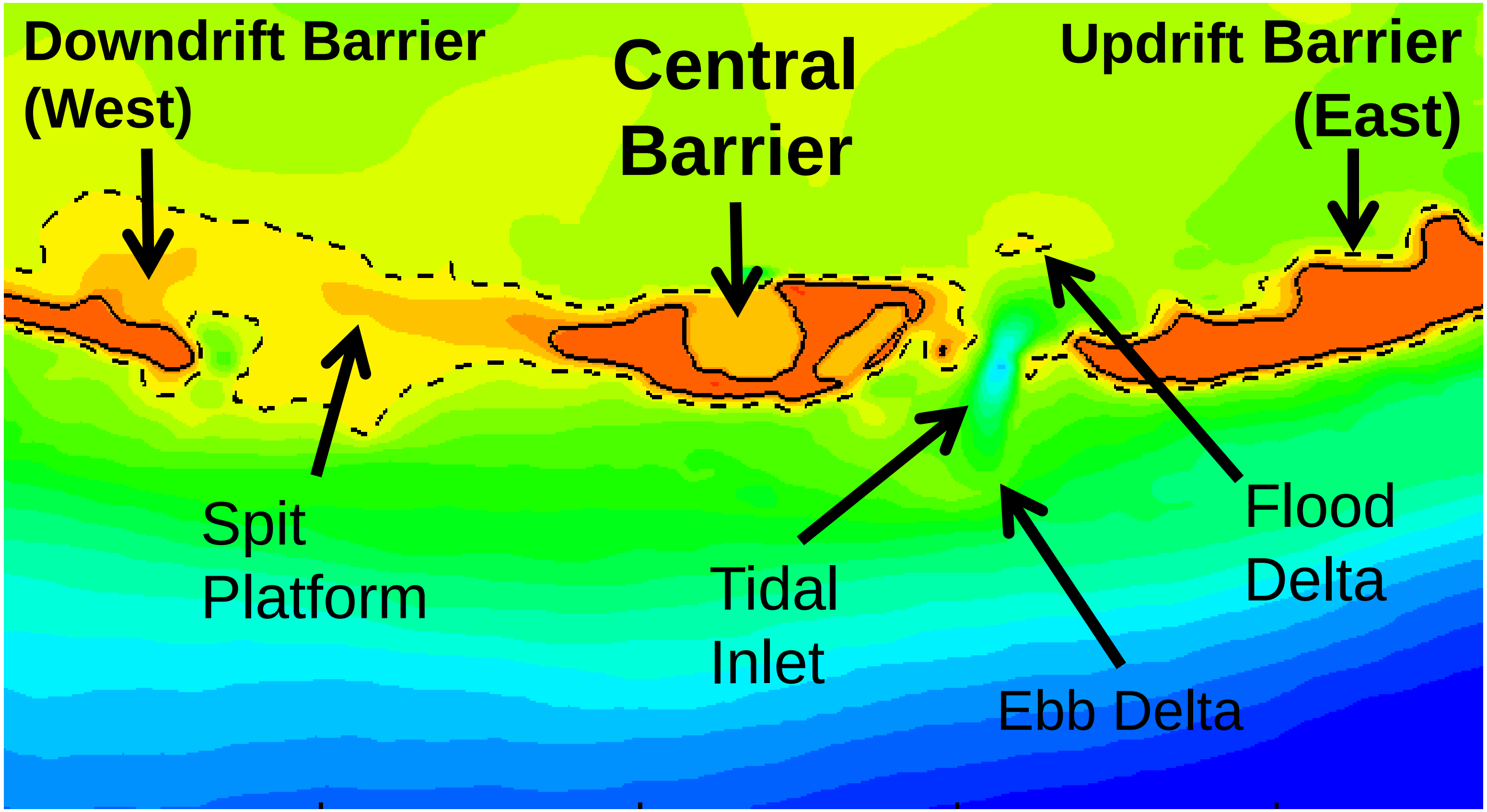
	Coef.	Std.Err.	t	P>|t|	95% Conf.Interval	
CYD	5854.336	1041.422	5.62	0.000	3782.617	7926.055
Distance	3301.997	969.7537	3.4	0.001	1372.848	5231.146
Distance^2	-59.88951	28.56021	-2.1	0.039	-116.705	-3.07416
Program_n 1	-10240.96	6852.879	-1.49	0.139	-23873.5	3391.595
2	5697.694	3112.825	1.83	0.071	-494.706	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



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

----- Subaqueous barrier (-0.5m) below MSL

Geophysical Model Setup

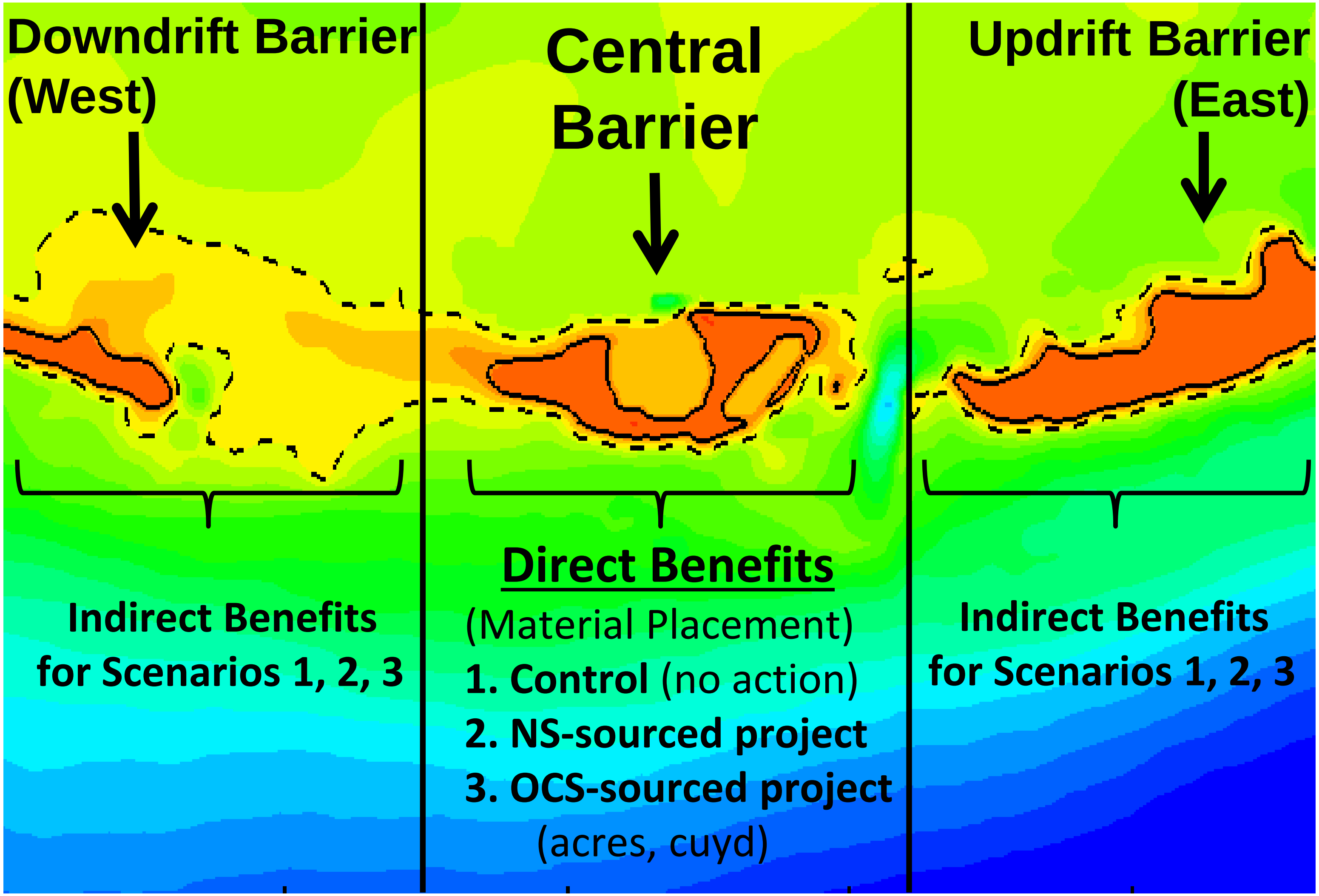
- Delft 3D-SWAN hydrodynamic and sediment transport model driven by tides, waves, storms and RSLR over a 192 x 384 grid of varying resolution (1 Km- 20m).

- 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)

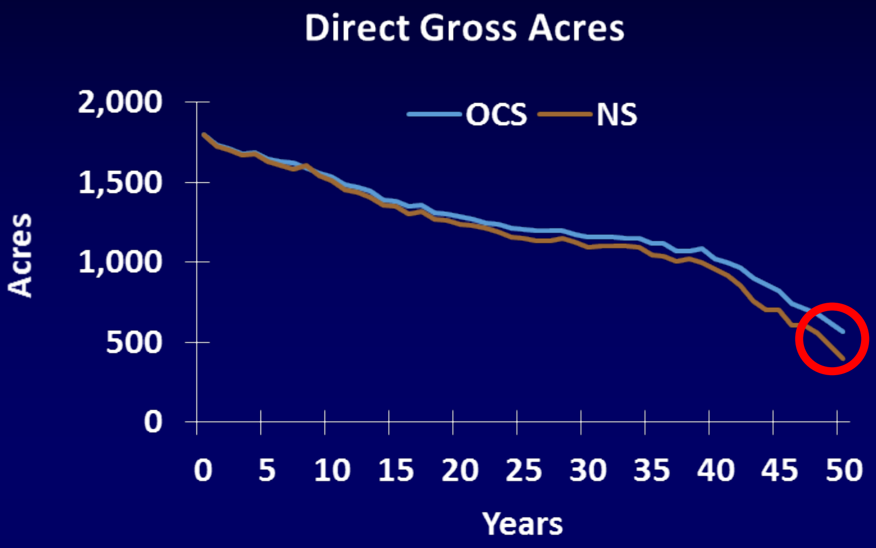
1. **Control** (no action)
2. **NS-sourced project**
3. **OCS-sourced project**

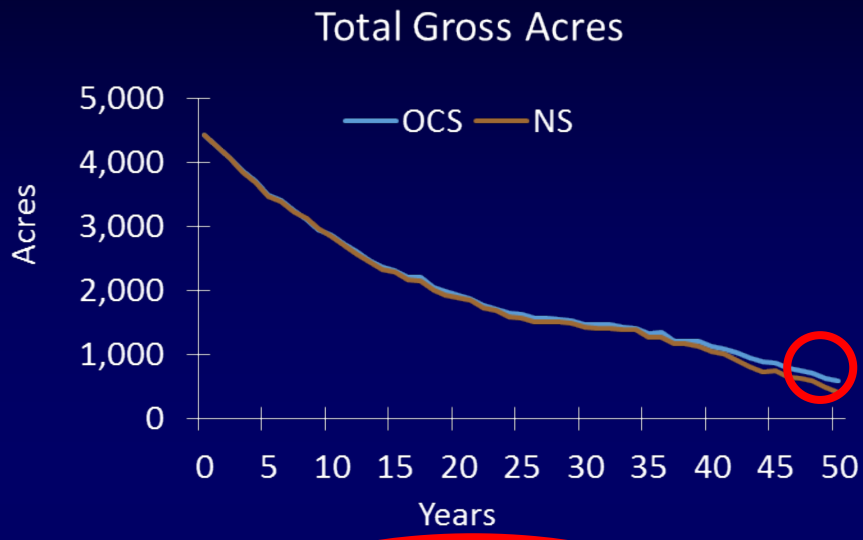
(acres, cuyd)

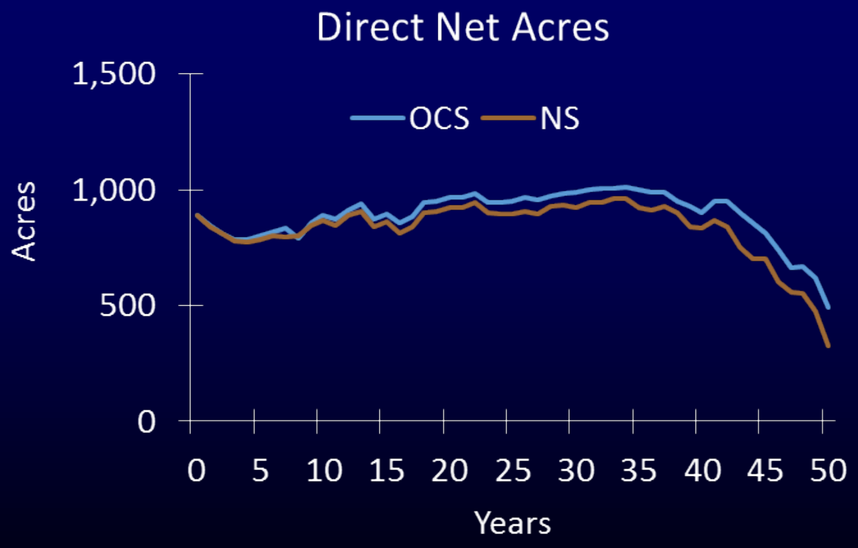
Indirect Benefits for Scenarios 1, 2, 3

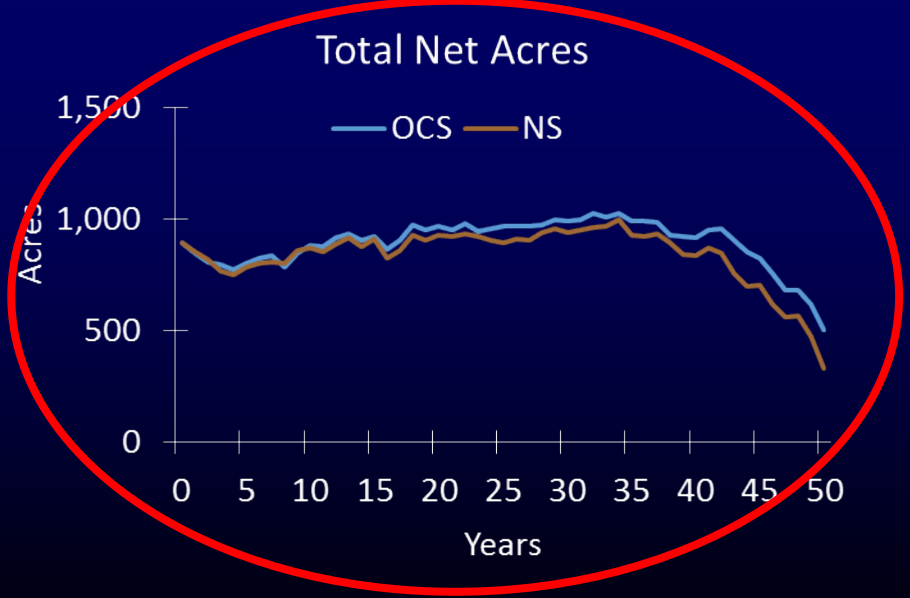
Geophysical Model Output

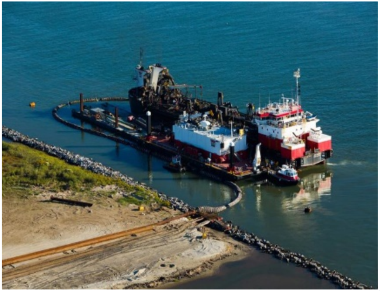
Simulation A: Single Project Comparison (Subaerial)


Direct Gross Acres

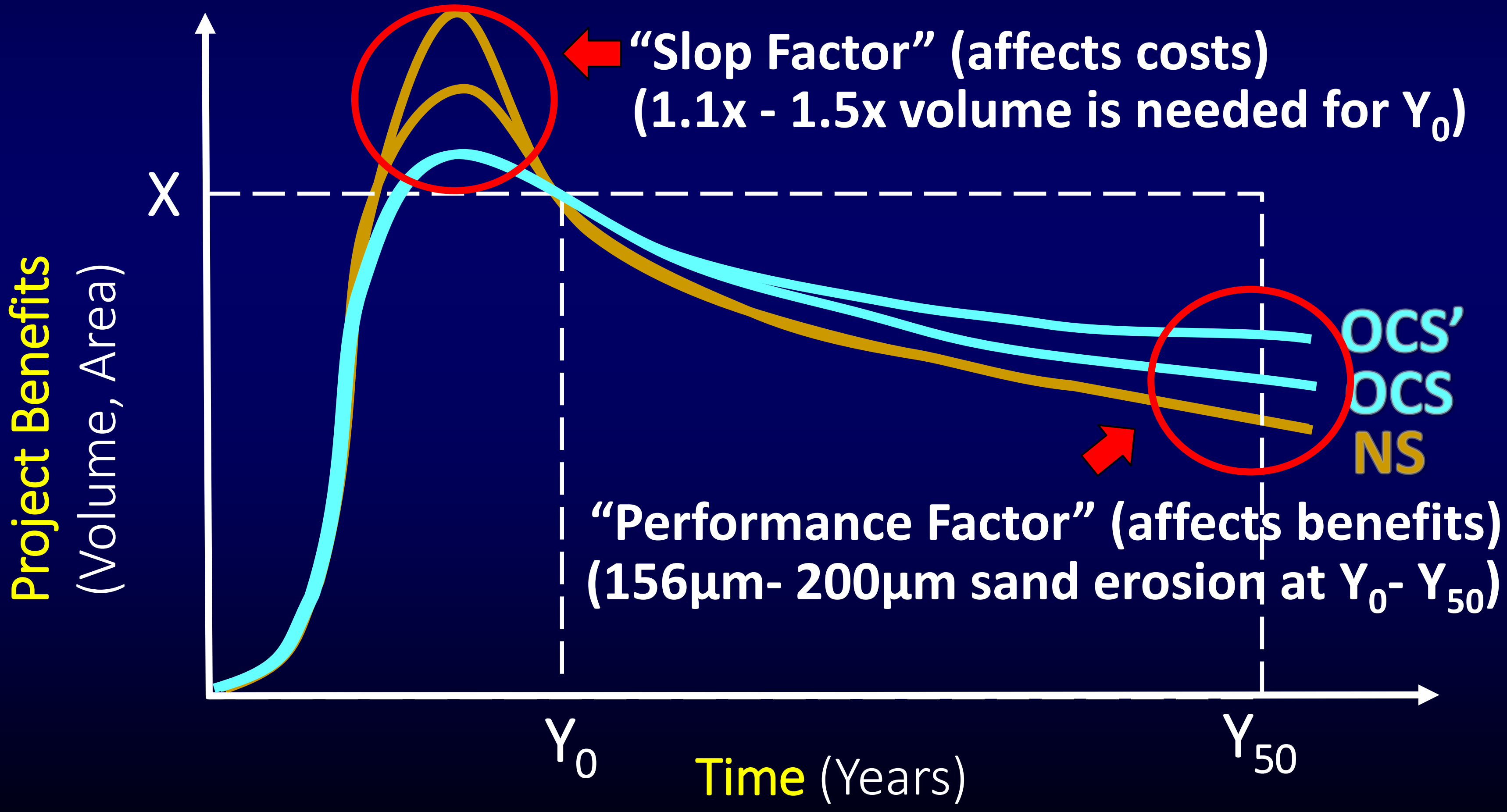

Total Gross Acres


Direct Net Acres


Total Net Acres



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 =

Monetizing Benefits

Break-Even Analsysis

$$\text{BC Ratio} = \sum_{t=1}^{T} \frac{B_t}{(1+R)^t} \Big/ \sum \frac{C_t}{(1+R)^t} = \mathbf{1.0}$$

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.

Coupled Mechanics for Break-Even Analysis

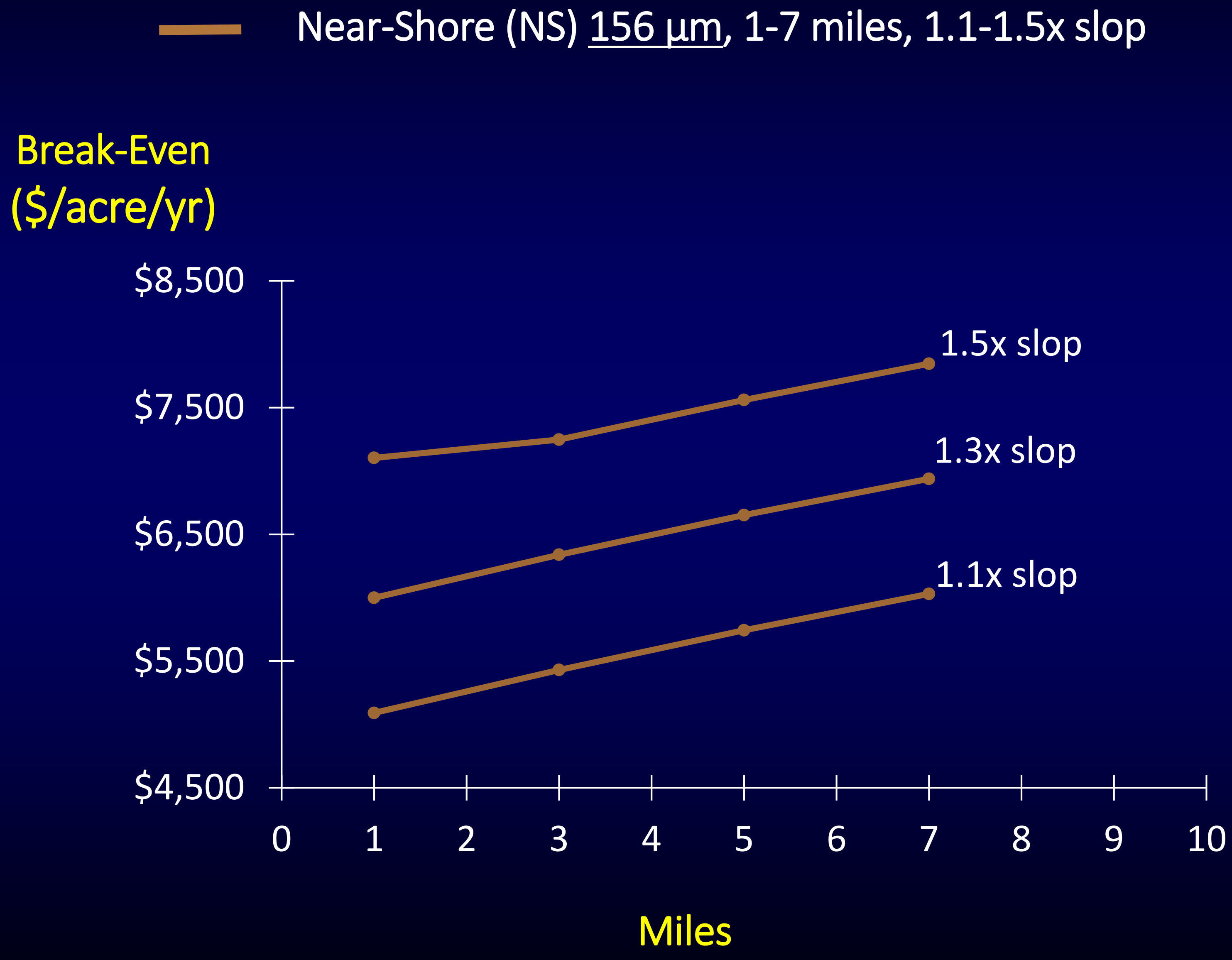
1. Cost Model (NS and OCS data combined)
   - ➢ Function of sediment quantity, distance, program, payment type

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, ….50 years
   - ➢ Total Effects (West + Central + East)

3. Assumptions for Single Project Simulations
   - ➢ Starting Quantity (Q): = 10,700,000 cuyds, ~ 1800 acres
   - ➢ Distance: 1-30 miles
   - ➢ Slop Factors (Qx): 1.1x - 1.5x
   - ➢ Performance Factors (Grain sizes: 156µm -200µm)
   - ➢ Hurricane impact - early (y5) and later (y20)
   - ➢ 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?



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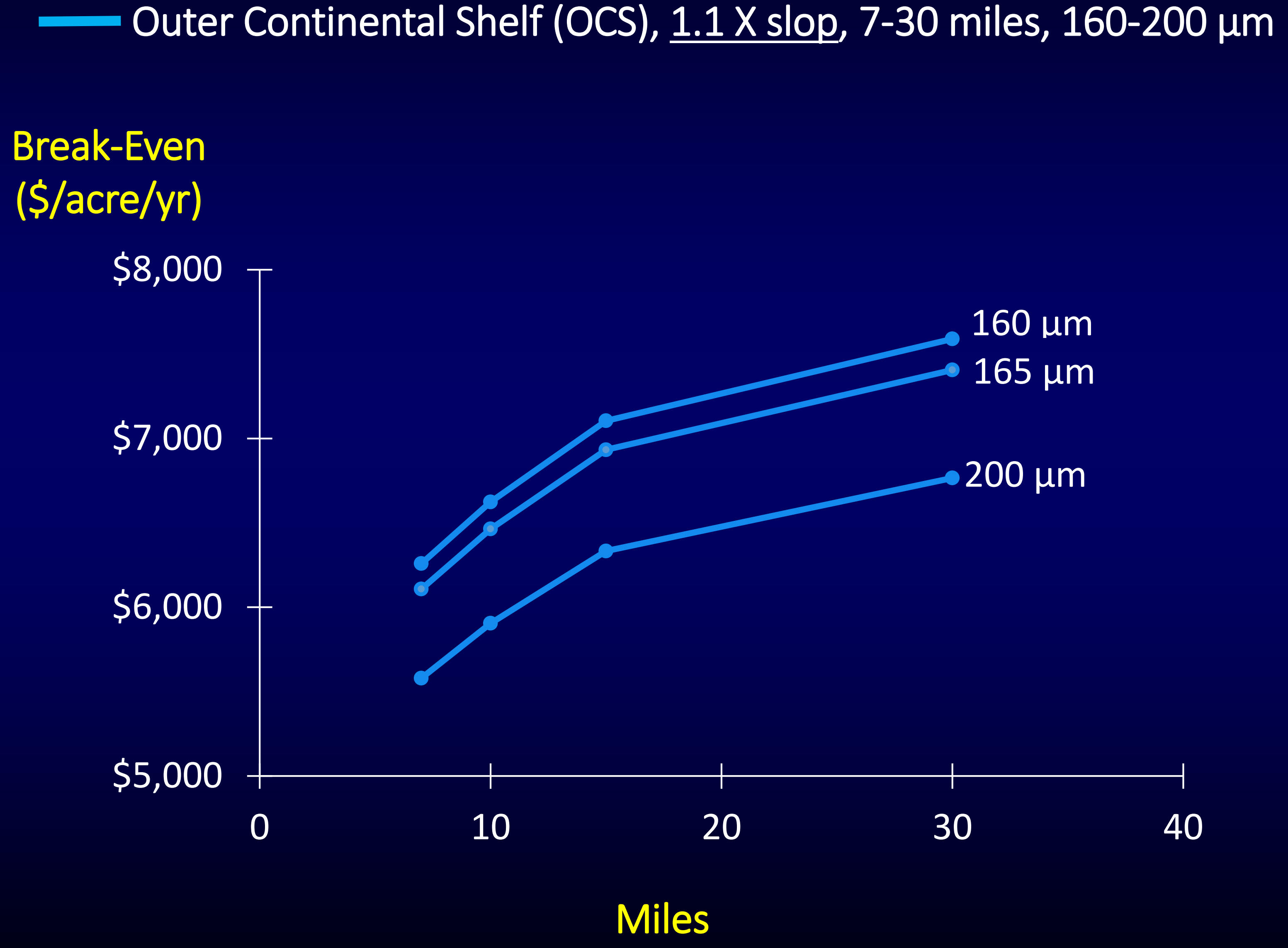

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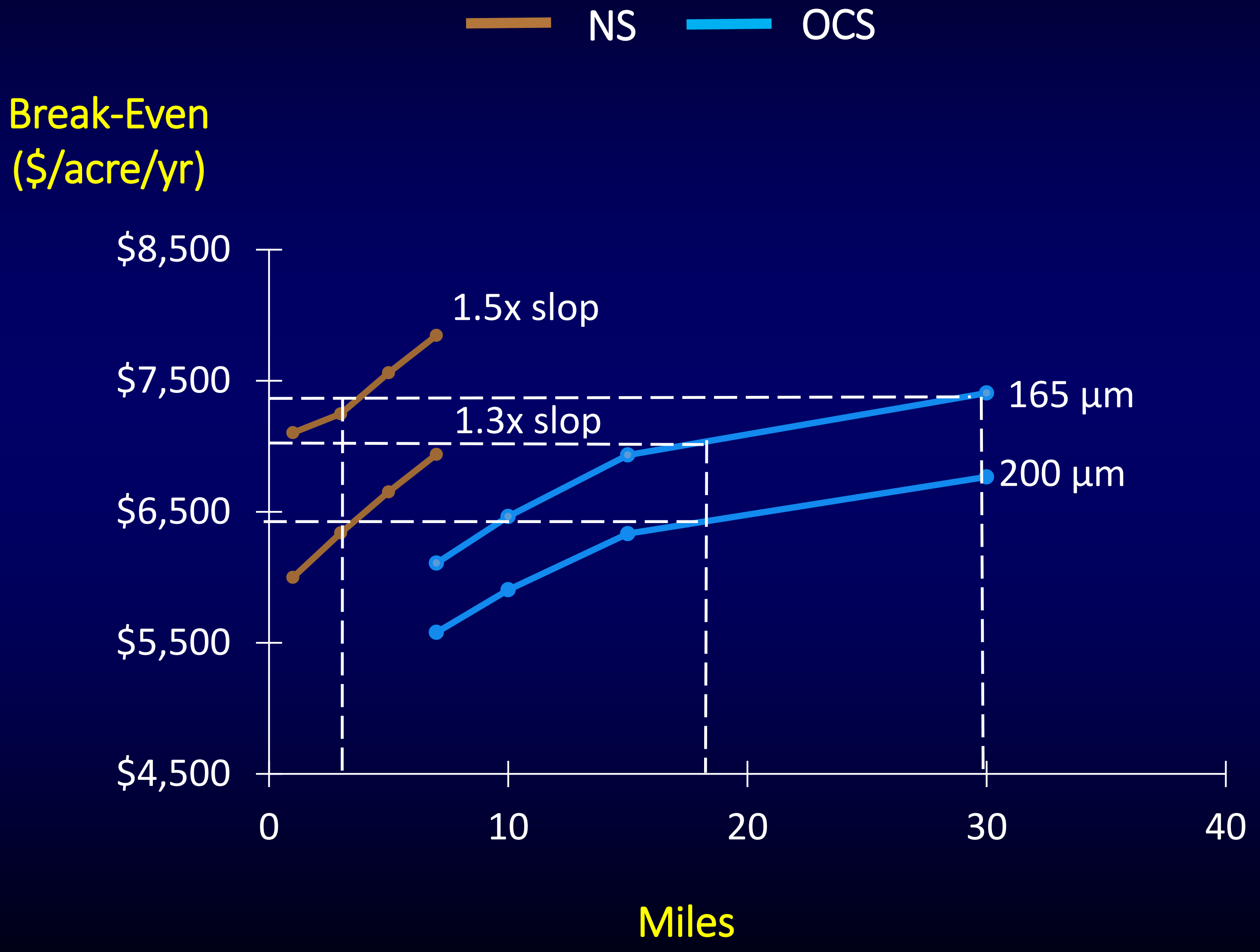


Preliminary Observations

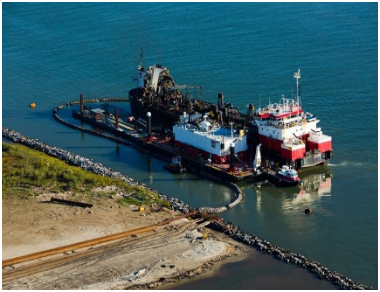
- Traditional cost comparisons depict OCS projects as more expensive, approximately 2x that of the $/acre NS for projects of similar size, *but*…

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

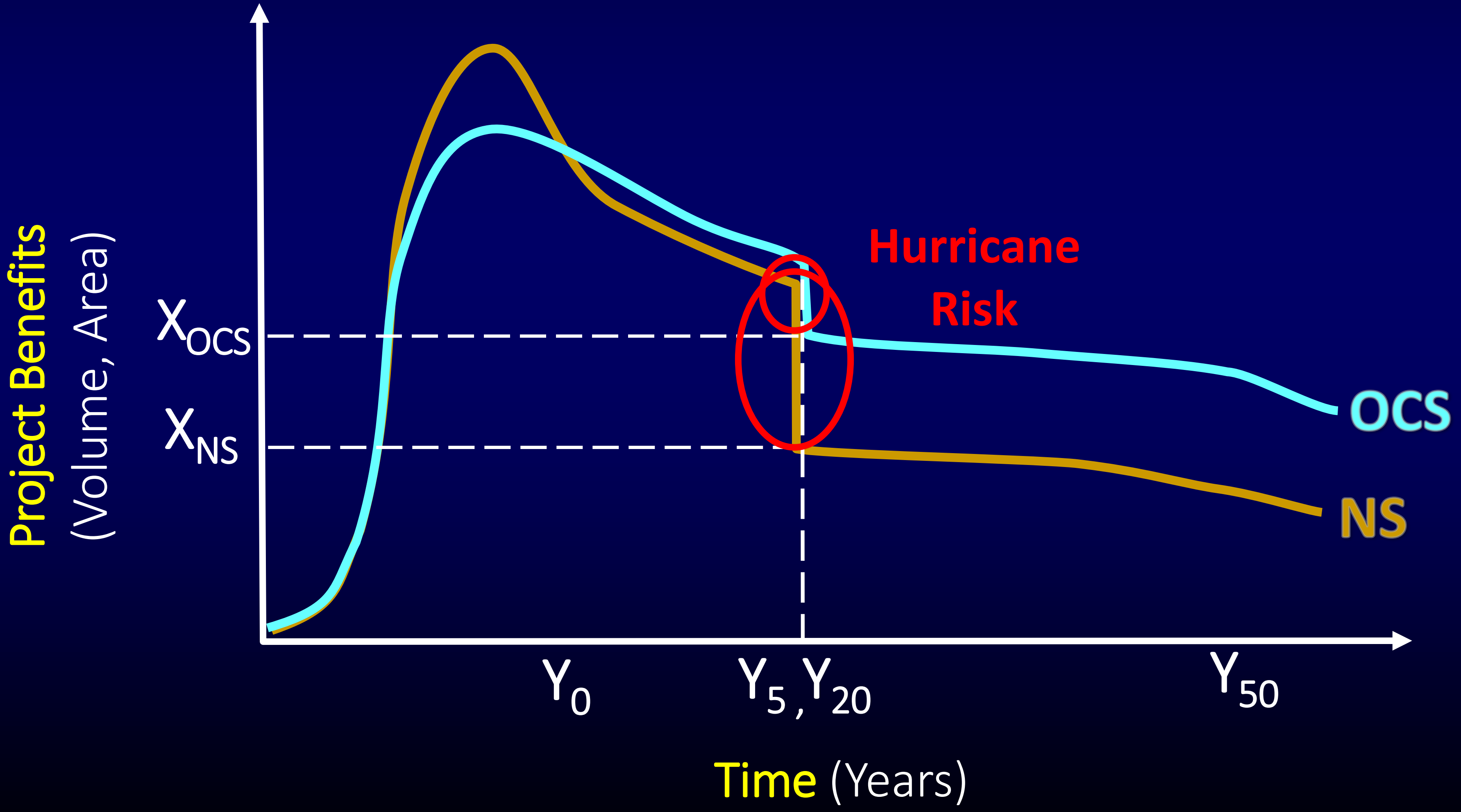
- These comparisons are based on initial costs (Y_1) and terminal benefits (Y_{50}) and fail to account for the flow of costs and benefits over time ($Y_1 - Y_{50}$), *moreover*….

- 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



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).

Status

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