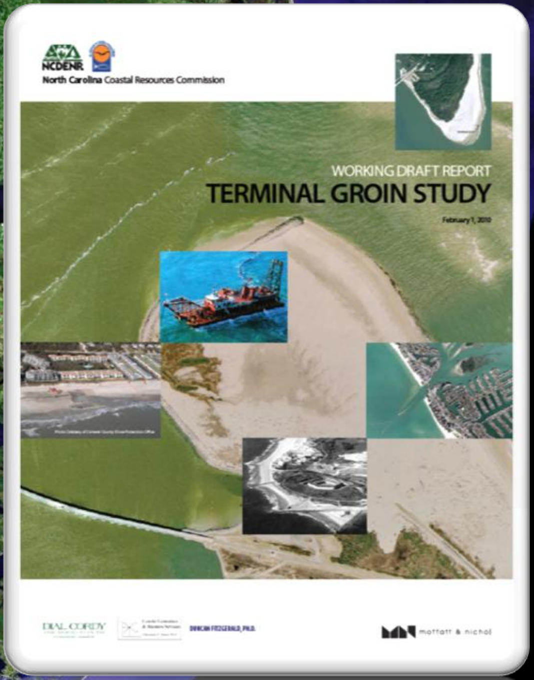
NC Terminal Groin Study:

Feasibility and Advisability of the Use of a Terminal Groin as an Erosion Control Device

DISCUSSION OF DRAFT REPORT

Steering Committee Meeting

February 15, 2010



MOFFATT & NICHOL

DIAL CORDY AND ASSOCIATES INC
Environmental Consultants

Meeting Agenda

- Introductions
- Study Overview
- Discussion of Draft Report
  - Coastal Engineering Analysis and Geological Assessment (Section II & III)
  - Environmental Assessment (IV)
  - Economic Assessment (VI)
  - Construction Techniques, Costs, Locations (V, VII, VIII)
- Next Steps

House Bill 709

SECTION 2:

"The Coastal Resources Commission, in consultation with the Division of Coastal Management, the Division of Land Resources, and the Coastal Resources Advisory Commission, shall conduct a study of the feasibility and advisability of the use of a terminal groin as an erosion control device at the end of a littoral cell or the side of an inlet to limit or control sediment passage into the inlet channel. For the purpose of this study, a littoral cell is defined as any section of coastline that has its own sediment sources and is isolated from adjacent coastal reaches in terms of sediment movement."

Items Identified In House Bill 709

Shall consider:

(1) Scientific data regarding the effectiveness of terminal groins constructed in North Carolina and other states in controlling erosion. Such data will include consideration of the effect of terminal groins on adjacent areas of the coastline.

(2) Scientific data regarding the impact of terminal groins on the environment and natural wildlife habitats.

(3) Information regarding the engineering techniques used to construct terminal groins, including technological advances and techniques that minimize the impact on adjacent shorelines.

Items Identified In House Bill 709

Shall consider:

(4) Information regarding the current and projected economic impact to the State, local governments, and the private sector from erosion caused by shifting inlets, including loss of property, public infrastructure, and tax base.

(5) Information regarding the public and private monetary costs of the construction and maintenance of terminal groins.

(6) Whether the potential use of terminal groins should be limited to navigable, dredged inlet channels.

Items Identified In House Bill 709

Public Input

- In conducting the study, the Commission shall hold at least **three public hearings** where interested parties and members of the general public will have the opportunity to present views and written material regarding the feasibility and advisability of the use of a terminal groin as an erosion control device at the end of a littoral cell or the side of an inlet to limit or control sediment passage into the inlet channel.

Public Hearing Location	Date and Time
Sheraton Atlantic Beach	Oct. 29, 2009 - 5 p.m.
Kill Devil Hills Town Hall	Dec. 16, 2009 - 5 p.m.
North Raleigh Hilton, Raleigh	Jan. 13, 2010 - 4:30 p.m.
New Hanover County Government Complex, Wilmington	Feb. 17, 2010 - 5 p.m.
Sea Trail, Sunset Beach	March 24 or 25, 2010

Items Identified In House Bill 709

Public Input

- DCM Website: http://www.nccoastalmanagement.net

- Email Comments: jim.gregson@ncdenr.gov

Report

- No later than **April 1, 2010**, the Commission shall report its findings and recommendations to the Environmental Review Commission and the General Assembly.

Project Team Members

Project Team Members

- **Moffatt & Nichol** – Coastal Engineering
- **Dial Cordy and Associates, Inc.** - Environmental
- **Dr. Duncan FitzGerald** (Boston University) – Coastal Geology
- **Dr. Chris Dumas** (UNCW) – Economics

Roles of CRC/CRAC, Science Panel

CRC/CRAC

– Will Provide Guidance to M&N During the Study

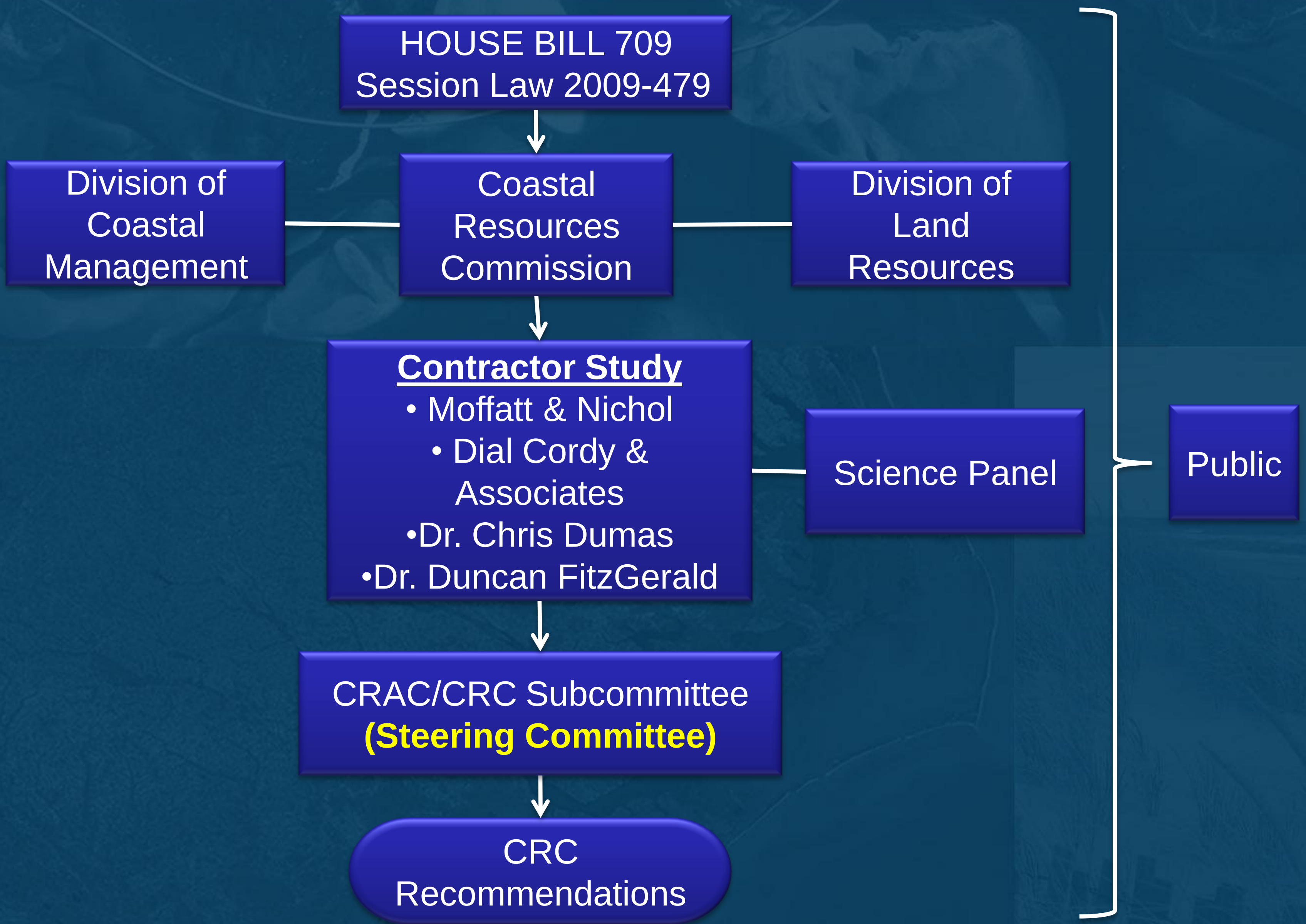
– Will be Responsible for Developing the Policy Conclusions and Recommendations to be Supplied to the ERC and Ultimately the General Assembly

Science Panel

– Science Panel was Involved in the Project Scoping, Approval of Study Methodologies, and Providing “Peer Review” (Advisory Role and Comment) of Report

– Five Scheduled Meetings (Sept. 29, Dec. 1, Jan. 19, Feb. 8, and Mar. 12)

Overall Study Organization



Selected Sites Based on September 29th Science Panel Meeting

North Carolina
- Oregon Inlet
- Fort Macon

Florida
- Amelia Island
- Captiva Island
- John’s Pass

Overall Project Work Plan

Task 1 – Coastal Engineering Analyses of Effectiveness and Impacts of Terminal Groins

Task 2 – Environmental Resource Analyses of Potential Effects of Terminal Groins

Task 3 – Construction Techniques to Limit Impacts

Task 4 – Economic Study of Impacts of Shifting Inlets

Task 5 – Initial Construction and Maintenance Costs

Task 6 – Potential Locations Study

Task 7 – Public Input

Task 8 – Draft and Final Report

II & III – Coastal and Geological Assessment

Method/Approach

- Gather and Compile Physical Data
- Shoreline Change
  - GIS Shorelines (DCM, NCDOT, FL DEP) from available pre- and post-terminal groin periods
  - Measure shoreline change along transects every 50 m for 3 miles each side of inlet
  - Calculate pre and post shoreline change rates (cumulative averages and averages over intervals)
- Beach Volume Changes
  - Use available profiles near each site to shoreline change to beach volume relationships
  - Compute beach volume changes based on shoreline change

II & III – Coastal and Geological Assessment

Method/Approach (con’t)

- Nourishment
  - Determined nourishment and placement volumes and locations
  - Calculated volume changes pre- and post-structure netting out all nourishment (subtract nourishment volumes)
- Dredging
  - Determined dredging volumes
  - Presented scenarios for amounts of dredge material (excluding sidecaster) that may have otherwise have naturally bypassed the inlet (add back percentage of dredging volumes)
- Geologic setting
  - Review literature for 5 sites
  - Discuss physical and geologic processes as they relate to terminal groins (examine aerial photography, longshore sediment transport behavior, morphological changes, human impacts)

II & III – Coastal and Geological Assessment

ANALYSIS OVERVIEW

Shoreline Change

- Measure differences between historic shoreline positions
- Includes effects of:
  - Sea Level Rise
  - Storms
  - Beach Nourishment / Placement
  - Dredging
  - Structures
  - Long-term Natural Regional Shoreline Processes

II & III – Coastal and Geological Assessment

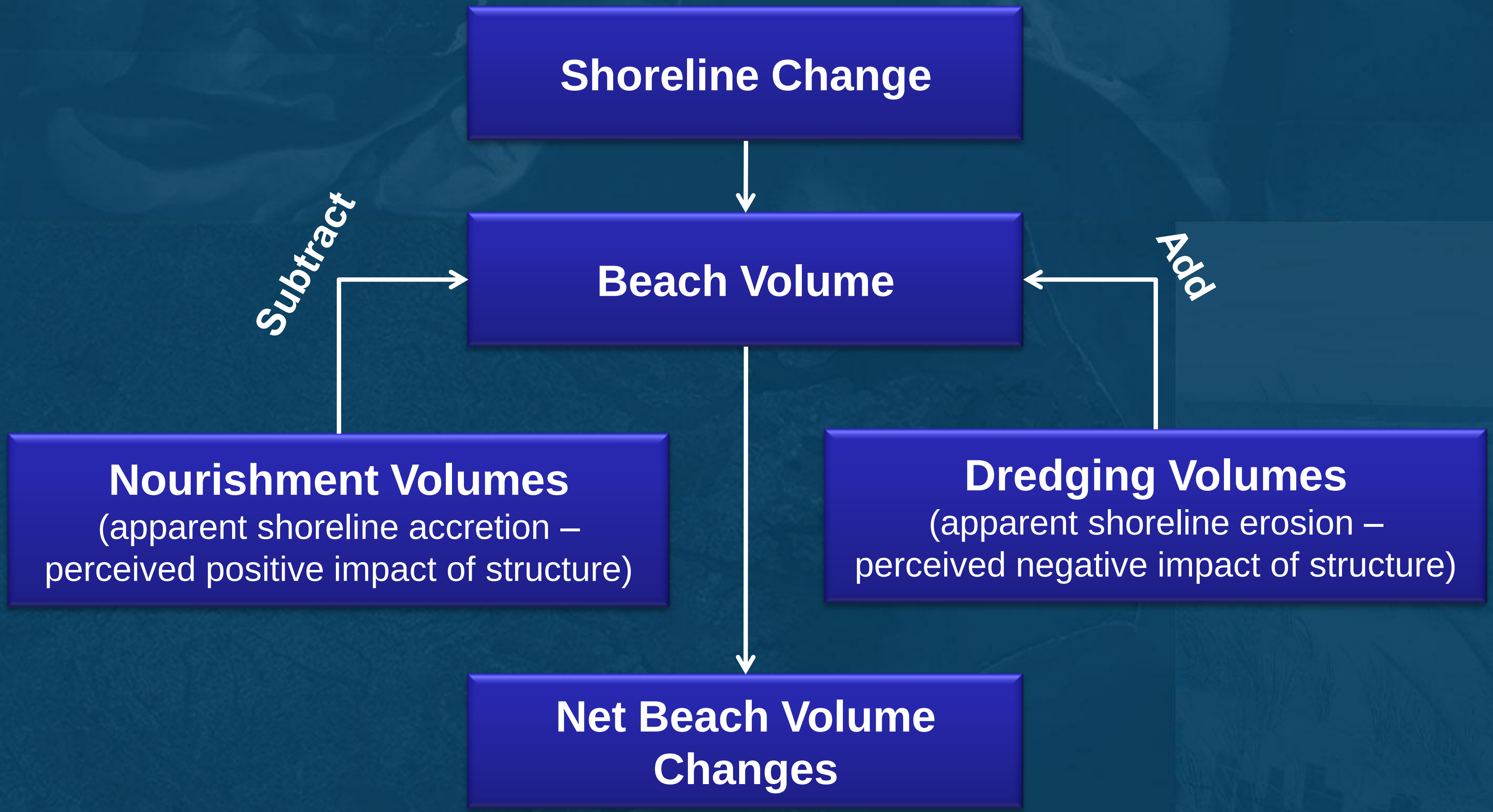
ANALYSIS OVERVIEW

Shoreline Change

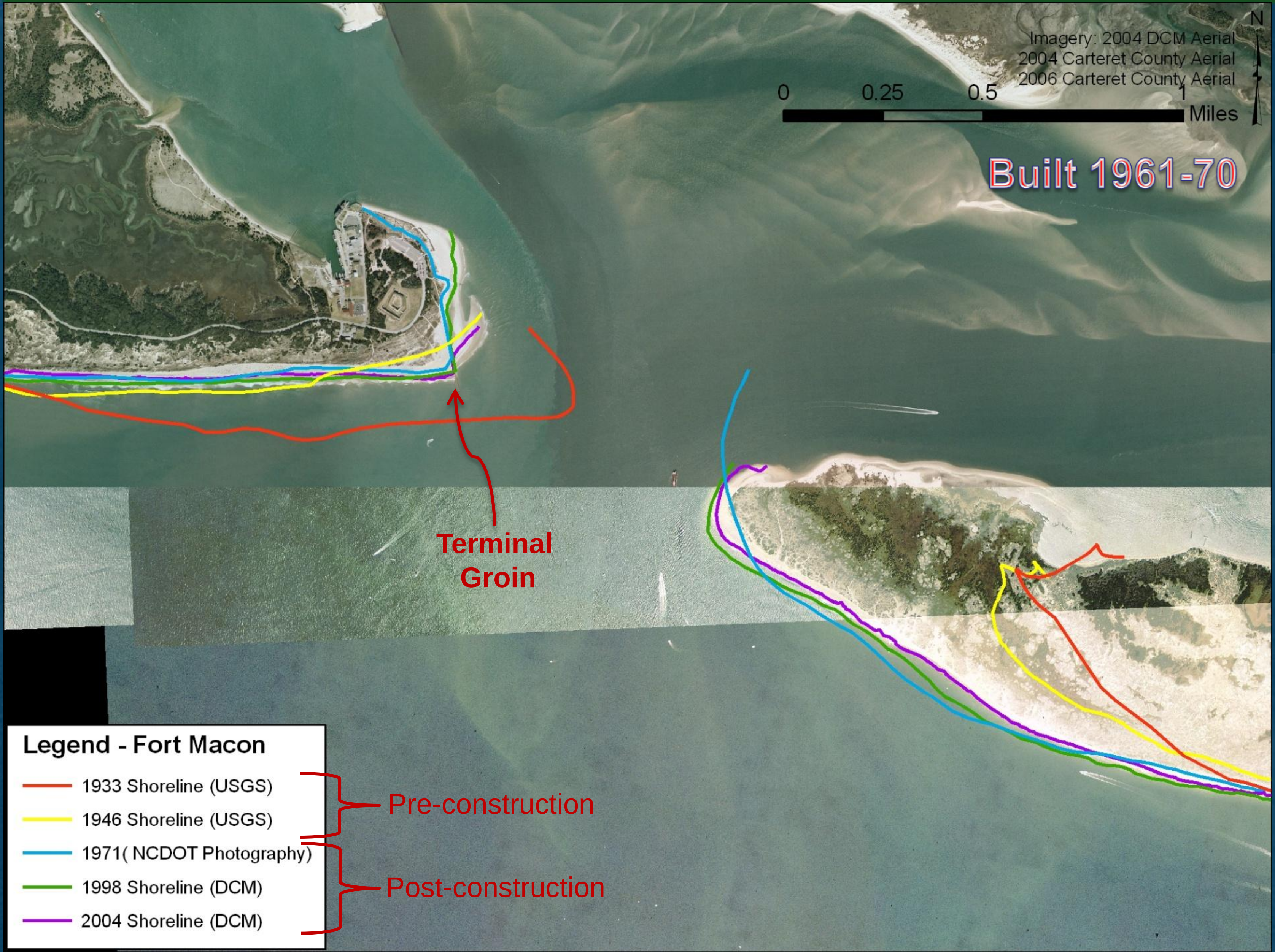
- Measure differences between historic shoreline positions
- Includes effects of:
  - Sea Level Rise
  - Storms
  - Beach Nourishment / Placement
  - Dredging
  - Structures
  - Long-term Natural Regional Shoreline Processes

II & III – Coastal and Geological Assessment

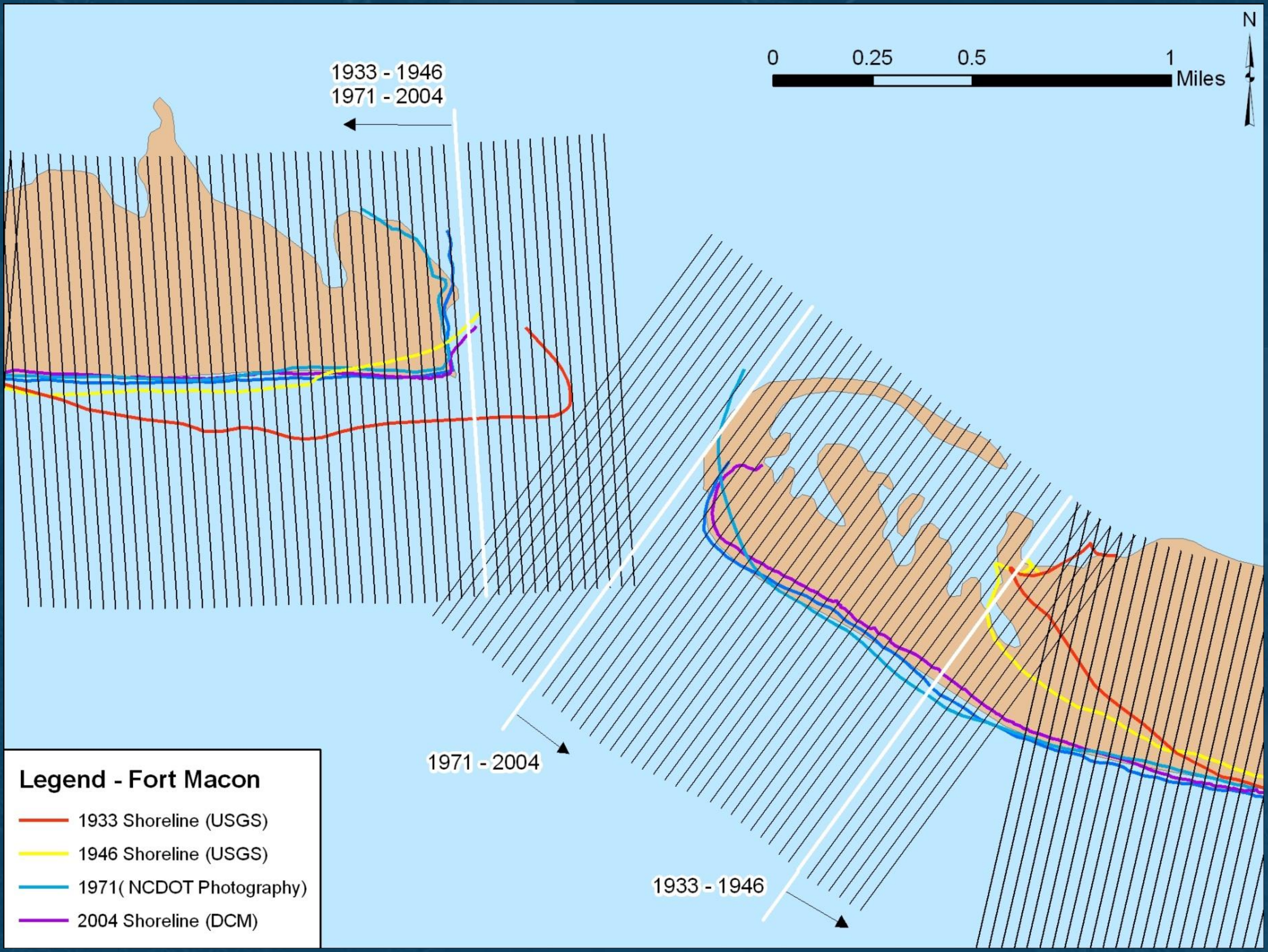
ANALYSIS OVERVIEW



Fort Macon – Shoreline Change



Fort Macon – Shoreline Change

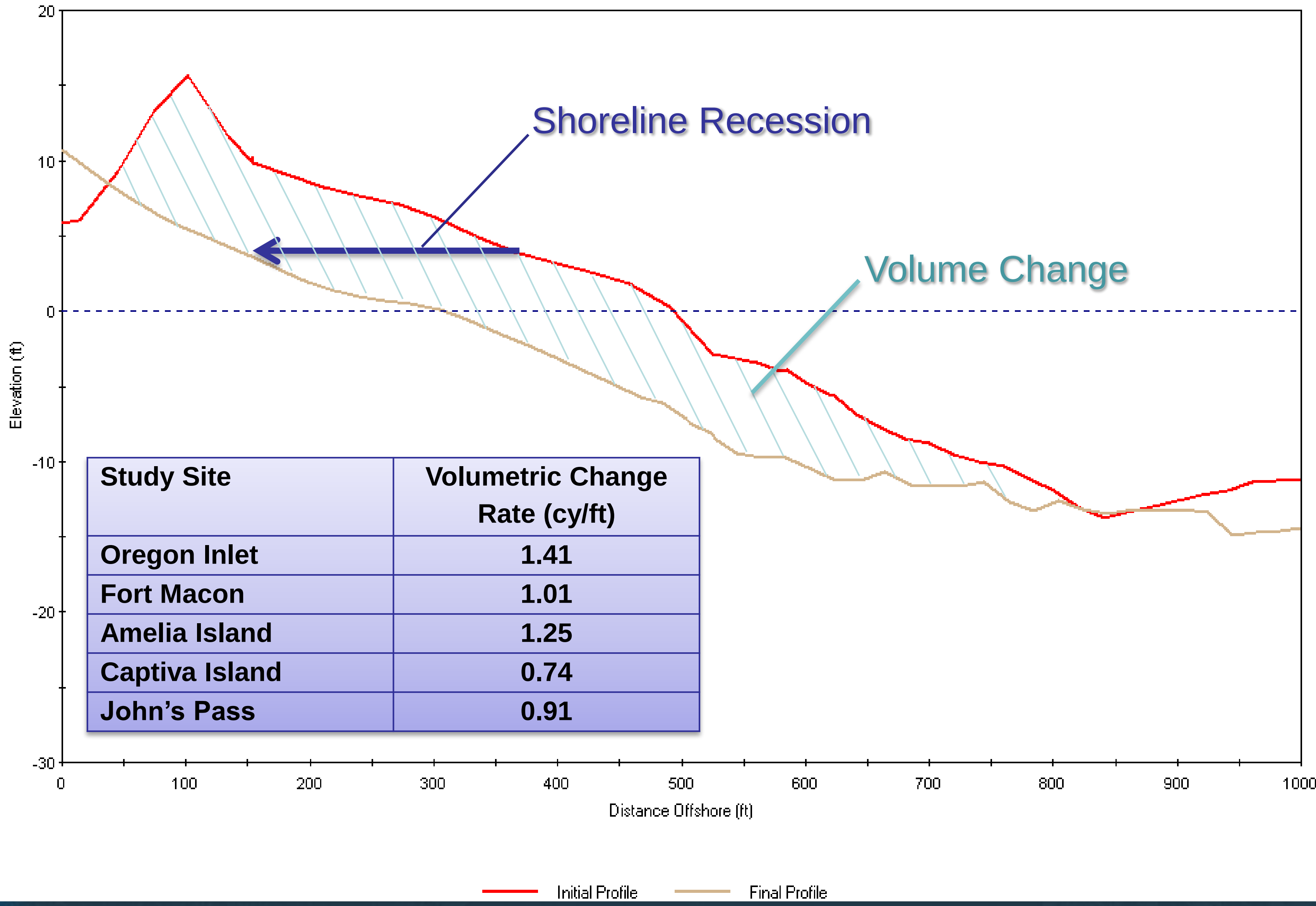


Fort Macon – Shoreline Change

Distance from Inlet (mi)	Pre-Structure: 1933 - 1946 West Average Change Rate (ft/yr)	Pre-Structure: 1933 - 1946 East Average Change Rate (ft/yr)	Post -Structure: 1971-2004 West Average Change Rate (ft/yr)	Post -Structure: 1971 - 2004 East Average Change Rate (ft/yr)
Total Change (cumulative)				
0 - 0.25	74.2	55.0	13.0	8.9
0 - 0.5	66.6	43.5	7.6	7.1
0 - 0.75	57.8	28.8	5.0	7.3
0 - 1	49.8	18.8	3.6	7.8
0 - 2	23.6	3.9	2.8	3.4
0 - 3	15.7	0.5	3.0	2.3
Interval Change				
0 - 0.25	74.2	55.0	13.0	8.9
0.25 - 0.5	59.0	32.0	2.2	5.3
0.5 - 0.75	40.1	0.5	0.2	7.7
0.75 - 1	25.7	11.1	0.5	9.4
1 - 2	2.6	11.1	1.9	1.0
2 - 3	0.0	6.3	3.6	0.2

Shoreline recession (erosion)
Shoreline advancement(accretion)

Shoreline Recession and Volume Change



Study Site	Volumetric Change Rate (cy/ft)
Oregon Inlet	1.41
Fort Macon	1.01
Amelia Island	1.25
Captiva Island	0.74
John’s Pass	0.91

Fort Macon – Beach Volume Change

	Pre-Structure		Post -Structure	
Distance from Inlet (mi)	1933 - 1946 West Total Volume (cy/yr)	1933 - 1946 East Total Volume (cy/yr)	1971 - 2004 West Total Volume (cy/yr)	1971 - 2004 East Total Volume (cy/yr)
Total Change				
0 - 0.25	98,414	72,948	17,297	11,783
0 - 0.5	176,629	115,382	20,197	18,772
0 - 0.75	229,835	114,658	19,921	29,027
0 - 1	263,955	99,926	19,308	41,469
0 - 2	250,254	41,117	29,190	36,101
0 - 3	250,326	7,499	41,845	36,905
Interval Change				
0 - 0.25	98,414	72,948	17,297	11,783
0.25 - 0.5	78,215	42,433	2,900	6,989
0.5 - 0.75	53,206	723	276	10,255
0.75 - 1	34,120	14,732	613	12,442
1 - 2	13,701	58,808	9,883	5,368
2 - 3	71	33,619	12,655	804

Beach Volume Loss(erosion)
Beach Volume Gain(accretion)

Fort Macon – Beach Nourishment

		Pre-Structure		Post -Structure	
	Distance from Inlet (mi)	1933 - 1946 West (cy/yr)	1933 - 1946 East (cy/yr)	1971 - 2004 West (cy/yr)	1974 - 2004 East (cy/yr)
Total Amounts	0 - 0.25	0	0	21,542	0
	0 - 0.5	0	0	43,084	0
	0 - 0.75	0	0	64,626	0
	0 - 1	0	0	86,168	0
	0 - 2	0	0	136,292	0
	0 - 3	0	0	165,368	0
Interval Amounts	0 - 0.25	0	0	21,542	0
	0.25 - 0.5	0	0	21,542	0
	0.5 - 0.75	0	0	21,542	0
	0.75 - 1	0	0	21,542	0
	1 - 2	0	0	50,123	0
	2 - 3	0	0	29,077	0

Fort Macon – Volume Change Net Nourishment

		Pre-Structure		Post -Structure	
	Distance from Inlet (mi)	1933 - 1946 West Total Volume (cy/yr)	1933 - 1946 East Total Volume (cy/yr)	1971 - 2004 West Total Volume (cy/yr)	1971 - 2004 East Total Volume (cy/yr)
Total Change	0 - 0.25	98,414	72,948	4,245	11,783
	0 - 0.5	176,629	115,382	22,887	18,772
	0 - 0.75	229,835	114,658	44,705	29,027
	0 - 1	263,955	99,926	66,861	41,469
	0 - 2	250,254	41,117	107,101	36,101
	0 - 3	250,326	7,499	123,523	36,905
Interval Change	0 - 0.25	98,414	72,948	4,245	11,783
	0.25 - 0.5	78,215	42,433	18,642	6,989
	0.5 - 0.75	53,206	723	21,818	10,255
	0.75 - 1	34,120	14,732	22,155	12,442
	1 - 2	13,701	58,808	40,241	5,368
	2 - 3	71	33,619	16,422	804

Net Beach Volume Loss(erosion)

Net Beach Volume Gain(accretion)

Fort Macon – Dredging Volumes

1933 - 1946 Total Volume (cy/yr)	1971 - 2004 Total Volume (cy/yr)
606,769	809,230

*Beaufort Inlet / Morehead City Harbor Channel

- **Some of this material would have naturally been deposited on the beach.**

Fort Macon – Beach Volume Change Net Nourishment and Dredging

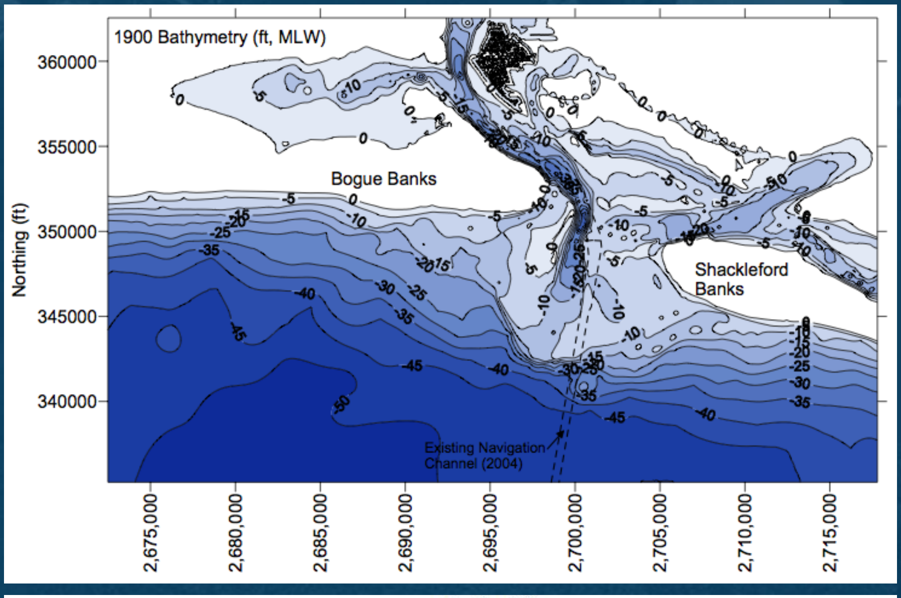
Bogue Banks (Fort Macon)

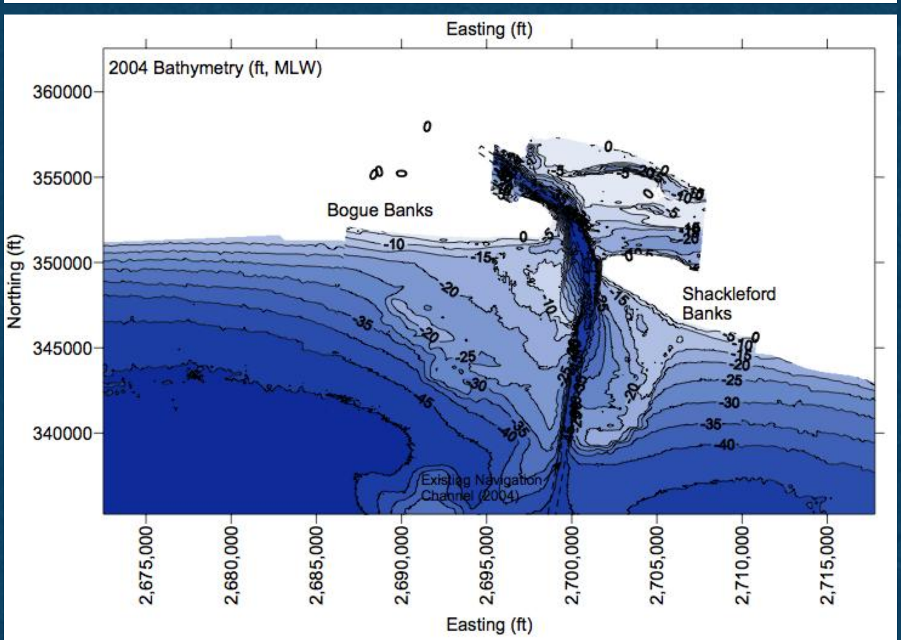
Distance from Inlet	Dredging Percentage Added to the West	1933 - 1946 West Total Volume	1971 - 2004 West Total Volume
(mi)	(%)	(cy/yr)	(cy/yr)
0 - 3	0%	250,326	123,523
0 - 3	25%	98,633	78,784
0 - 3	50%	53,059	281,092

Shackleford Banks

Distance from Inlet	Dredging Percentage Added to the East	1933 - 1946 East Total Volume	1971 - 2004 East Total Volume
(mi)	(%)	(cy/yr)	(cy/yr)
0 - 3	0%	7,499	36,905
0 - 3	25%	159,191	165,403
0 - 3	50%	310,884	367,710

Fort Macon - Geological Setting





Dredging and Tidal Prism Changes…

Resulting Offshore Bar (Terminal Lobe) Changes

II & III – Coastal and Geological Assessment

Summary Results

- Shoreline Change (only based on shorelines)
  - All shorelines on the structure side of the inlet were eroding prior to groin construction
  - Shorelines on opposite side of inlet do not display a clear trend
  - However due to nourishment and dredging activities assessments cannot be made on shorelines alone
- Nourishment and nearshore disposal volumes
  - On structure side of inlets after removing (netting out) all beach nourishment and nearshore disposal, the beach along 3 miles generally display a reduction in eroded volume (except Amelia and one of the Pea Island time periods calculated)
  - Beach volume changes on opposite side of the inlet again do not show a clear trend

II & III – Coastal and Geological Assessment

Summary Results (con't)

- Dredging
  - If 25% of material dredged had naturally bypassed the inlet and deposited on the beach no negative impact would be shown on Shackleford Banks or Pea Island only remaining increased eroded volume is Bodie Island

IV - Environmental Analysis

– Major Emphasis:

- An Analysis of Available Environmental Data

– Approach: Collected and Analyzed Biological Data and Scientific Literature

- State and Federal Agencies
- Non-Profit Organizations
- Non-Governmental Organizations

– Analysis: Evaluated Readily Available Biological Data

- Spatial and Temporal (Pre- and Post-Construction)
- Similar Sites Adjacent to Study Areas (Regional Perspective)
- Graphical Representation (Observations/Year)
- Evaluated Storm and Renourishment Data
- Numerical Description of Population Data

IV - Environmental Analysis

Biological Resources Evaluated

- Shorebirds and Waterbirds
  - Observation Data; Nests; Areas Surveyed; Source
- Sea Turtles
  - Nests; False Crawl; Distance; Source
- Benthic Resources
  - Minimal Empirical Data; Past Studies
- Fisheries
  - Minimal Empirical Data; Past Studies
- Habitat Change
  - Scientific Literature; Aerial Photography
- Water quality
  - Minimal Empirical Data; Historical Studies

USFWS

IV - Environmental Analysis

Technical Qualifiers

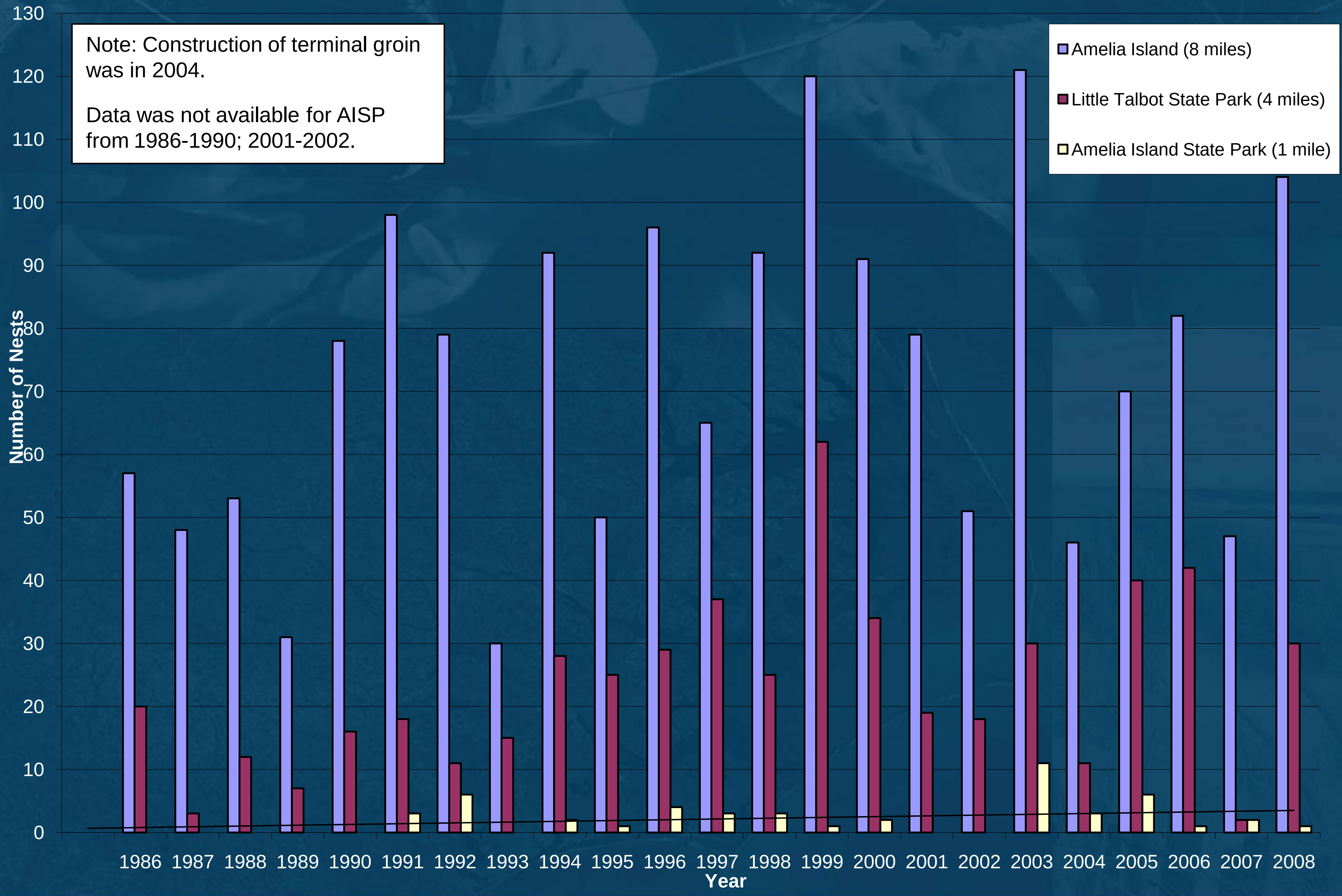
- No New Natural Resource Data Were Collected During This Study;
- Existing Secondary Sources and Raw Data Were Collected To Evaluate Environmental Effects;
- Available Data Were Not Directly Related To Construction of Terminal Groin; and
- Prior to Construction and After Construction Data Were Only Available for Two Sites and Limited Resources.

South Amelia Island, Florida Case Study

Data Collected:
•Sea Turtle Nest Data
•Shorebird Observational and Nest Data

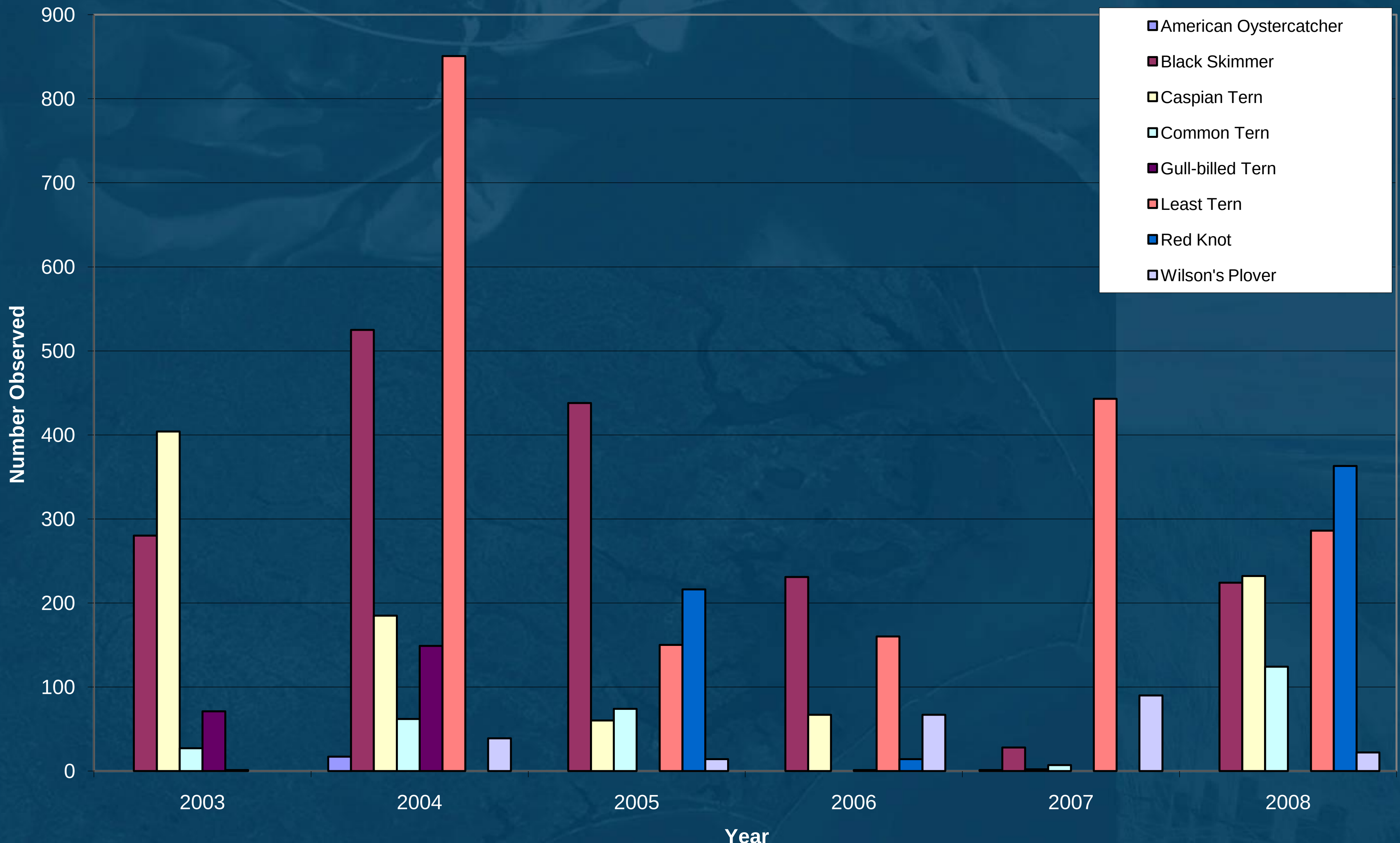
Sources:
•Florida State Parks
•Florida Fish and Wildlife Commission
•Environmental Assessments
•US Fish and Wildlife Service
•USACE

Sea Turtle Nesting Data

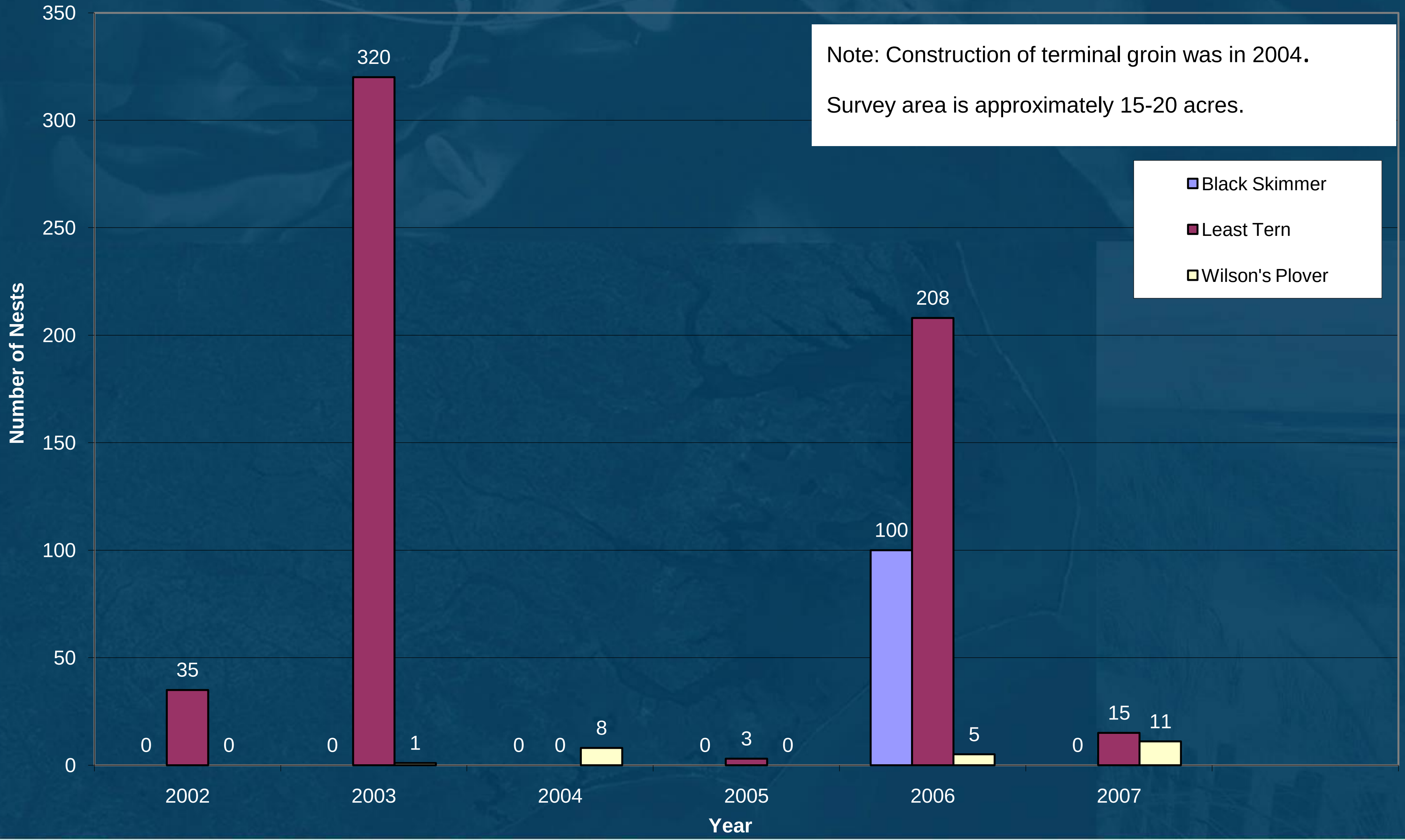


AISP Non-Nesting Shorebird Observations

Note: Construction of terminal groin was in 2004.

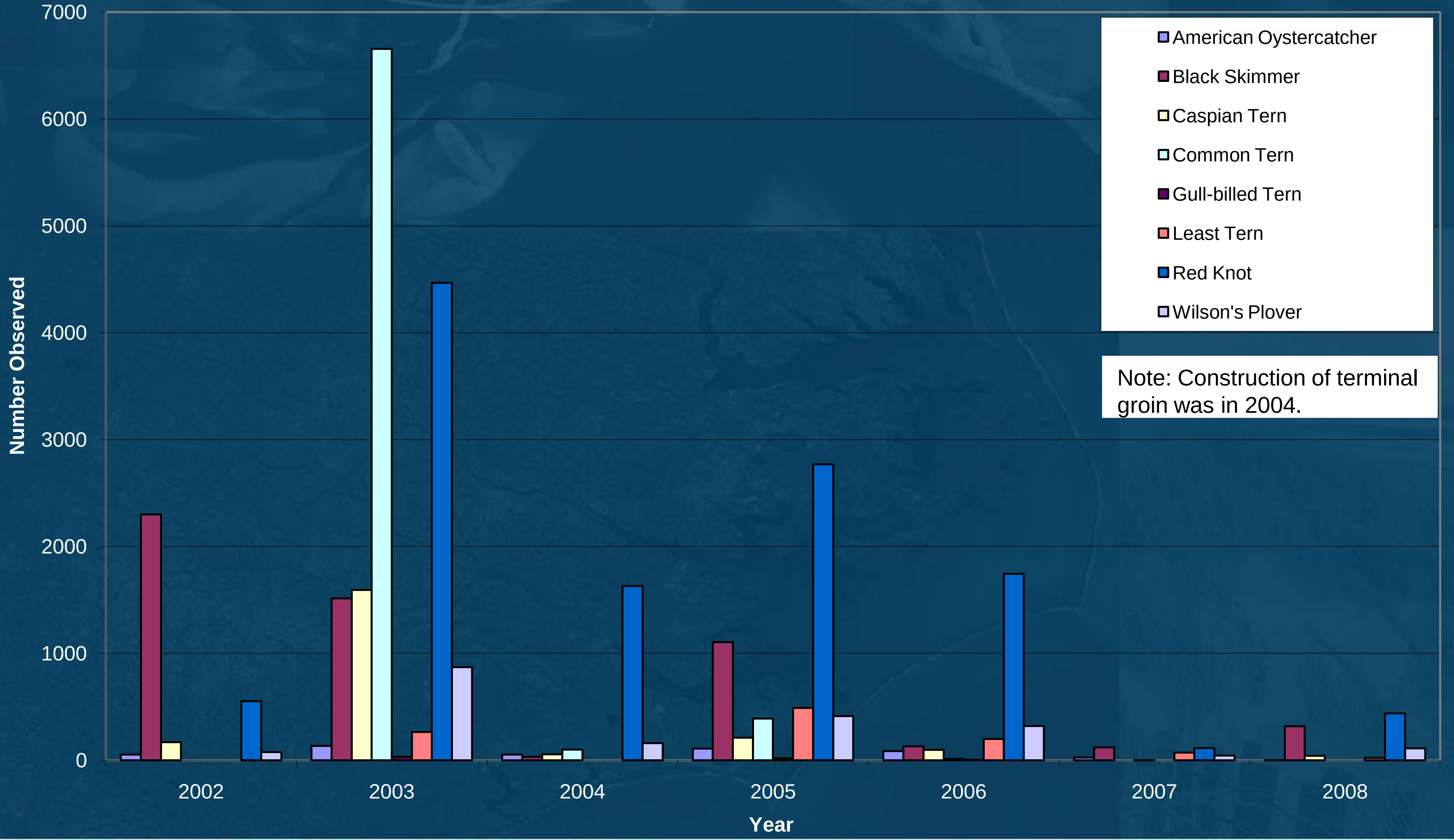


AISP Nesting Shorebird Observations



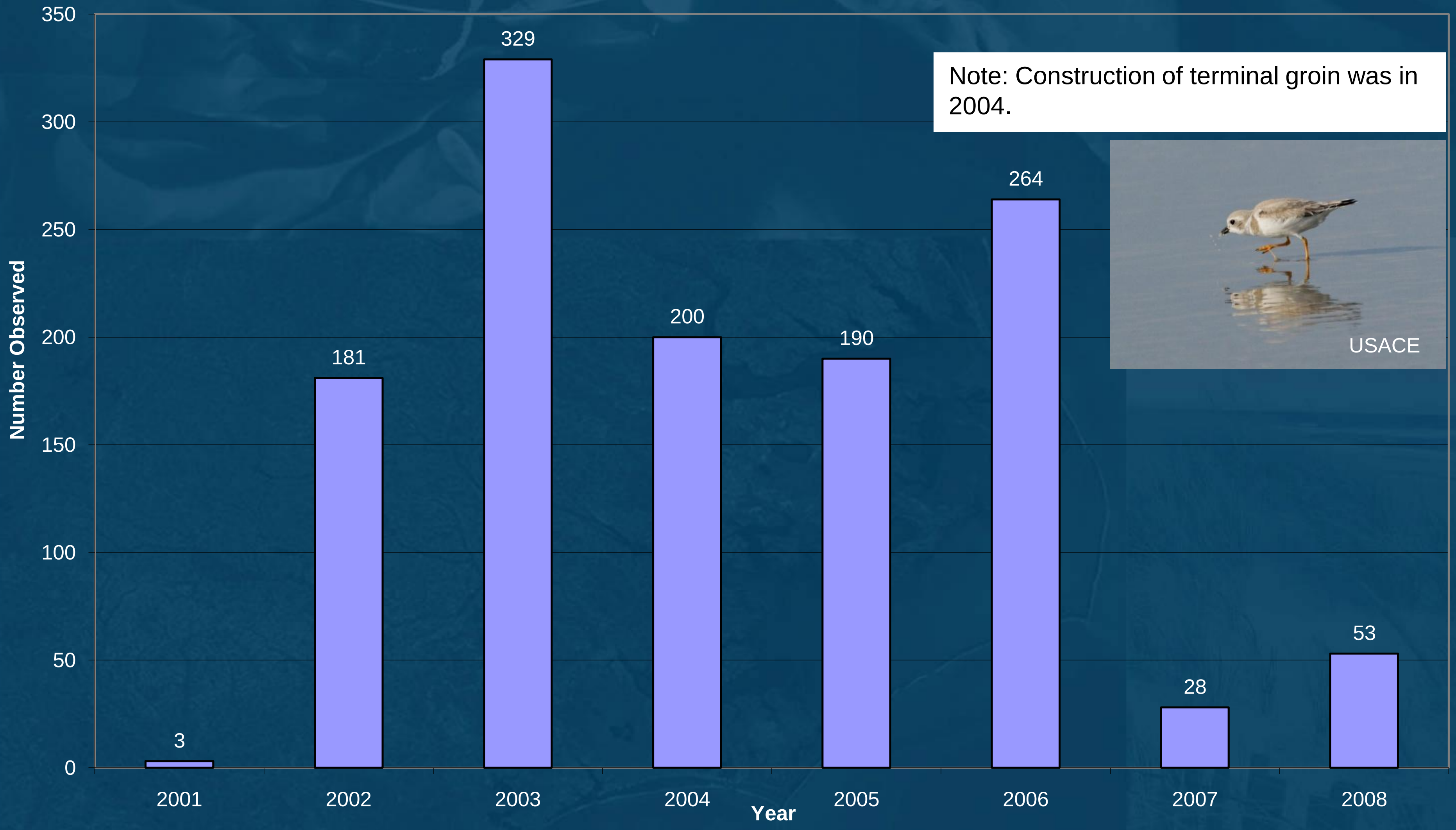
Nassau Sound Islands
(Bird Islands)

Bird Islands Non-Nesting Shorebird Observations



Piping Plover Observations for Nassau Sound

Note: Construction of terminal groin was in 2004.



IV - Environmental Analysis

Summary of Findings

- Minimizing Natural Overwash at the End of an Island Prevents Natural Barrier Island Processes which Affects Inlet Habitats, thus Affecting Species Use
- Anchoring the End of an Island May Curtail an Inlet's Natural Migration Patterns thereby Minimizing the Formation of Sand Flats
- Fillet Material Should be Compatible to Minimize Effects on Benthic Infauna Recovery and Upper Trophic Levels
- Resources Continue to Use locations where Terminal Groins Exist, However, if Habitat Succession Occurs, Species Suitability May Be Affected
- Available Data and a Limited Time Frame Resulted in Non-Conclusive Site Specific Results

VI – Economic Study

Method/Approach

- Identify Properties and Infrastructure at Risk (Use Proposed 30-yr Risk Lines)
- Assemble Current Property and Infrastructure Location and Value Data – Location (County Parcel Data) – Value (County Appraisals, NCDOT, Utility Companies)
- Add Up Economic Value – Tabulate Each Side of Inlet
- Include Property Loss, Public Infrastructure, and Tax Base Losses
- Discussions on Diminished Market Value, Impact on Second Row, Environmental and Recreational Values

VI – Economic Study

VI – Economic Study

Value Type	West Side of Inlet (Bear Island side)	East Side of Inlet (Emerald Island Side)
Residential Property Value		
Number of Parcels	None (undeveloped island)	63 single family 33 condo units
Land Value	-----	$54,920,000
Structure Value	-----	$33,460,000
Other Value	-----	$1,070,000
Total Value	-----	$89,450,000
Commercial Property Value		
Number of Parcels	None (undeveloped island)	None known.
Land Value	-----	-----
Structure Value	-----	-----
Other Value	-----	-----
Total Value	-----	-----
Government Property Value		
Number of Parcels	None (undeveloped island)	None known.
Land Value	-----	-----
Structure Value	-----	-----
Other Value	-----	-----
Total Value	-----	-----
Road Infrastructure Value		
Type	None (undeveloped island)	2-lane road w. 2' paved shoulders (no curb, gutter, parking or sidewalk)
Length (ft)	-----	5818
Replacement Cost / ft	-----	$568
Total Value	-----	$3,304,624
Waterline Infrastructure Value		
Type	None (undeveloped island)	Typical
Length (ft)	-----	5818
Replacement Cost / ft	-----	$55
Total Value	-----	$319,990
Sewer Infrastructure Value		
Type	None (undeveloped island)	Typical
Length (ft)	-----	5818
Replacement Cost / ft	-----	$150
Total Value	-----	$872,700
GRAND TOTAL VALUE	**None (undeveloped island)**	**$93,947,314**

VI – Economic Study

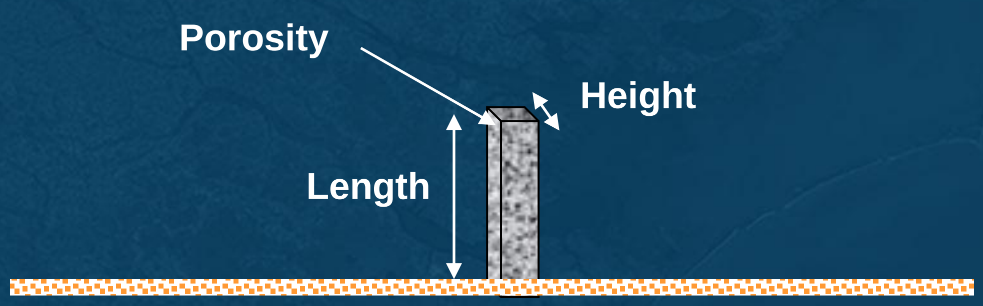
Summary Results

- Economic Impacts Vary Widely By Inlet and Side of Inlet
- Inlets With Higher Development May Have In Excess of $100 M of Infrastructure and Property at Risk Over the Next 30 Years
- All Areas Denoted By 30-yr Risk Lines May Not Be Protected By a Terminal Groin Structure
- Additional Factors Such as Recreation, Environmental Economic Value, and Property Transfer Value Can Be Important

V – Construction Techniques

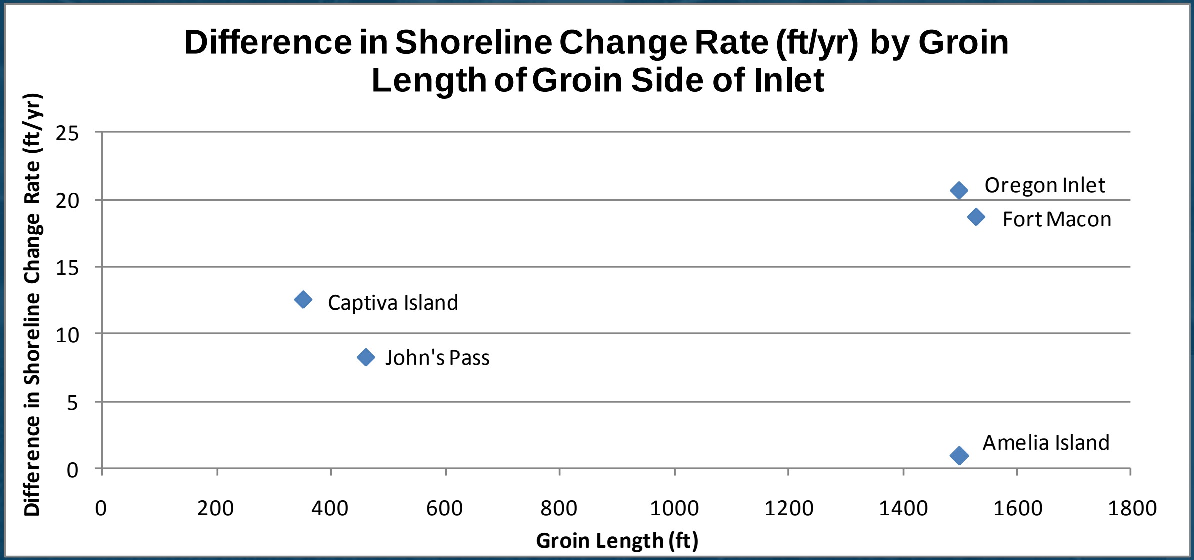
Method/Approach

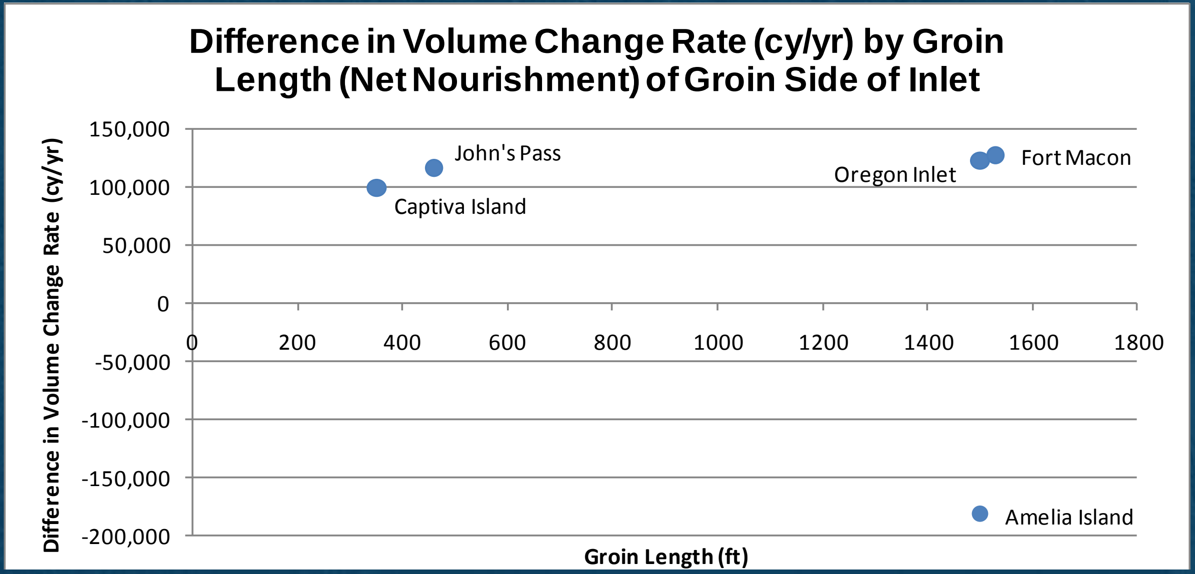
- Literature Review of Techniques Used to Limit Impacts on Adjacent Shorelines:
  - Limits on Groin Height and Length
  - Porosity of Structures (Sediment Transmission)
  - Materials, etc.
- Parametric Study With Available Data for Five Sites



V – Construction Techniques

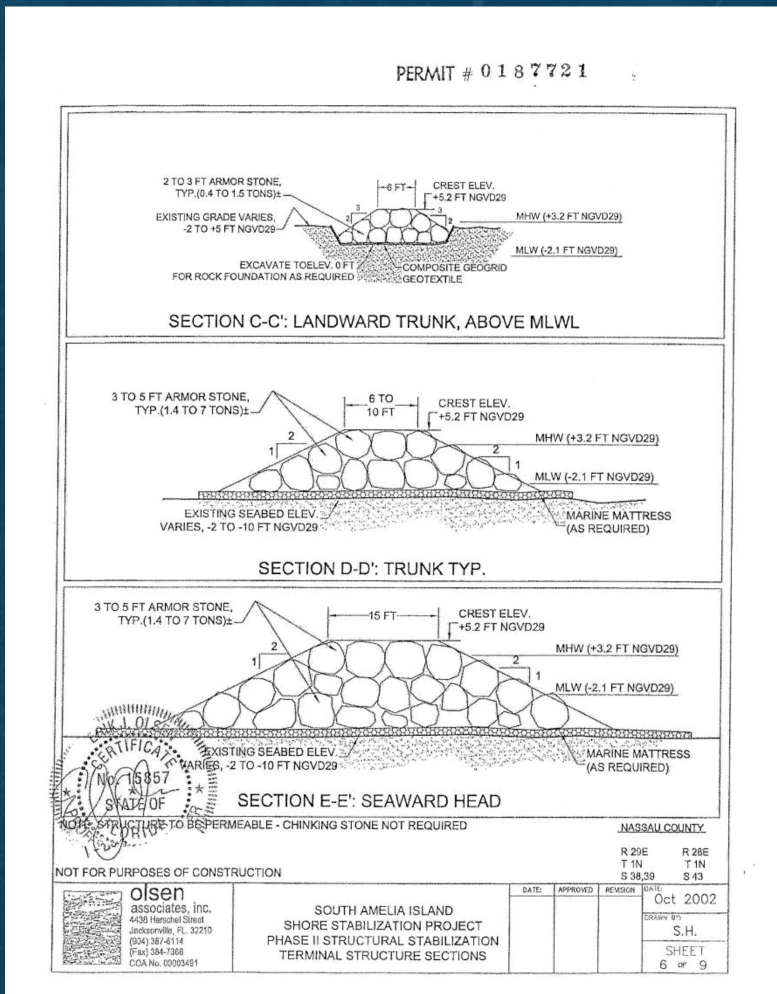
Parametric Study Example

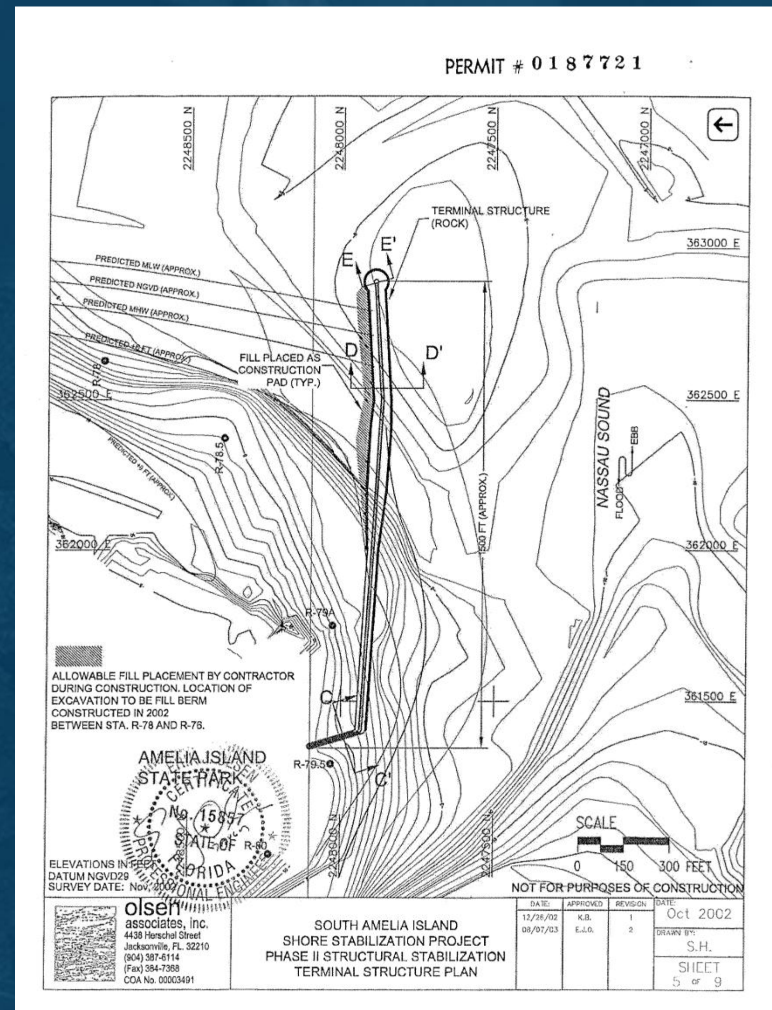




V – Construction Techniques

Amelia Island – Leaky Groin





V – Construction Techniques

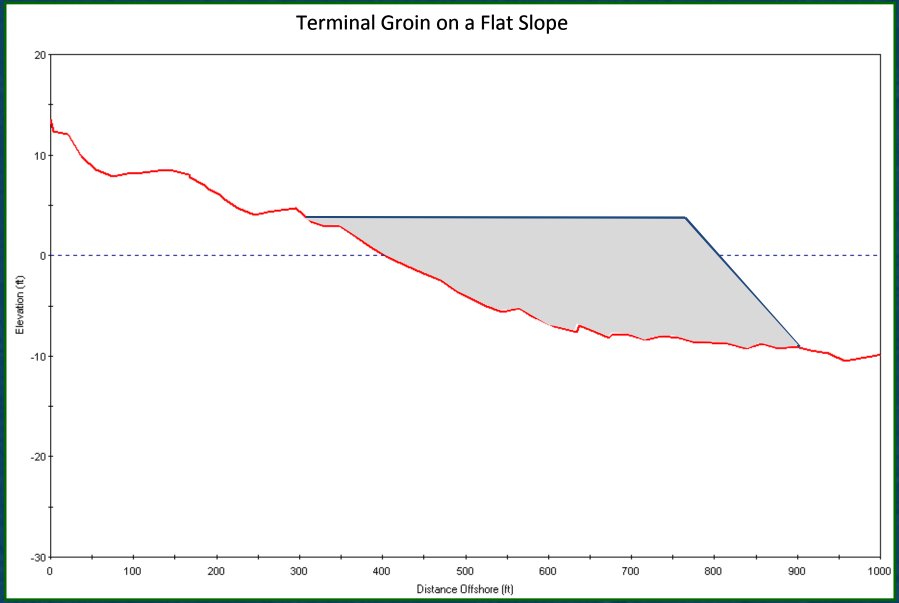
Summary Results

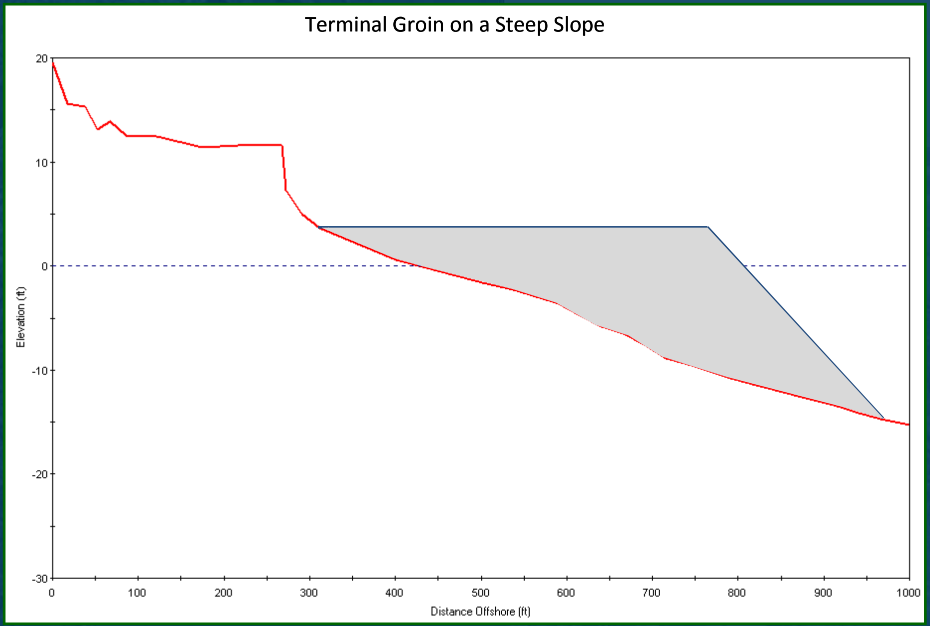
- Longer Length Has More Effect - Threshold
- Higher Elevation Has More Effect – Threshold
- Leaky Groin at Amelia Appears to Have Minimal Impact and Limited Length of Benefit
- Groin Structure Shape Also Has Influence - Inclined And Notched Structures As Well As Various Planform Shapes (T-shaped, L-shaped, Dogleg, Etc.)
- Material Types Have Also Been Shown To Affect Sediment Transport Rates And Shoreline Behavior. Concrete, Steel, And Timber Sheeting And Pilings Allow For Adjustments In The Field As Well As Removal Of The Structures If Shown To Have An Unacceptable Adverse Impact.

VII – Initial Construction & Maintenance Costs

Method/Approach

- Review Available Cost Data For Existing Terminal Groins Including Public and Private Costs
- Develop Ranges of Potential Costs Based on Typical Expected Terminal Groin Dimensions and Typical North Carolina Offshore Slopes





VII – Initial Construction & Maintenance Costs

Summary Results

- Typical $/ft Costs (Depending on Structure Height and Section)
- Rock: $1200 - $6500/ft; Steel and Concrete: $4000 - $5000/ft
- Timber: $4000 - $5000/ft; Geotextile Tube: $250 - $1000/ft
- Some Materials Not Suitable for Larger Structures in Deeper Water
- Annual Maintenance Costs – Between 5-10% of Initial Cost – 10-15% Including Sea Level Rise and Storms
- Initial Beach Nourishment Costs Should Also Be Included 100,000 – 300,000 cy – $1.2 - $3.6 M
- Permitting & Design (20%), Monitoring ($100k-$500k) and Removal Costs ($500/ft) Should Also Be Included

VII – Initial Construction & Maintenance Costs

Summary Results (con't)

Initial Costs	Cost	Short (450')	Long (1500')
Initial Cost (LS)	--	$1,000,000	$6,000,000
Initial Beach Nourishment (LS)	--	$1,200,000	$3,600,000
Permitting and Design	20.0%	$200,000	$1,200,000
Total Initial Costs	**Total**	**$2,400,000**	**$10,800,000**

Removal ($/LF)	$500	$225,000	$750,000

Annual Costs			
Annual Maintenance ($/yr)	12.5%	$125,000	$750,000
Annual Monitoring (LS/yr)		$300,000	$300,000
Total Annual Maintenance Costs	**Total**	**$425,000**	**$1,050,000**

VIII – Potential Terminal Groin Locations

Method/Approach

- Literature Review of Existing Locations (Inlets – dredged, natural)
- Issues With Respect to Use at Navigable, Dredged Inlets vs. Non-dredged Inlets
- Inlet Behavior
- Assess And Comment On The Locations Of Terminal Groins With Respect To The Inlet Conditions As Well As The Geologic And Hydrodynamic Setting Of Each Of The Five Study Cases

VIII – Potential Terminal Groin Locations

- **Environmental Conditions at Five Selected Study Sites**

Study Site	Average Tidal Range (MHHW – MLLW)	Average Offshore Significant Wave Height*	Average Offshore Peak Wave Period*	Adjacent Inlet Width
Oregon Inlet	2.43 ft	3.9 ft	7 s	2,800 ft
Fort Macon	3.93 ft	3.3 ft	5 s	3,700 ft
Amelia Island	5.34 ft	3.3 ft	7 s	10,300 ft
Captiva Island	2.10 ft	2.3 ft	4 s	700 ft
John's Pass	2.40 ft	2.3 ft	4 s	600 ft

*From 1980-99 WIS Hindcast (Typically 15-20 m depth)

VIII – Potential Terminal Groin Locations

Summary Results

- Most Existing Sites Include Navigable, Dredged Inlets
- Only Inlet Locations Considered for Study
- Five Sites Have Similar Hydrodynamic Conditions As NC Inlets
- Significant Range of Inlet Management Also Covered
- Level of Interventions (Nourishment & Dredging) Along With Terminal Groin Dimensions Determine Relative Scale Effect of Groin
- Nourishment and Some Level of Inlet Management Would Likely Be Required to Limit Potential Impacts and Inlet Behavior

Next Steps

- Next CRC Meeting and Public Hearing – February 17, 2010 – Wilmington
- Final Report (Contractor Study) – March 1, 2010
- Science Panel Meeting – March 12, 2010 – Raleigh
- Steering Committee Meeting – March 18, 2010 – New Bern
- Final CRC Meeting and Public Hearing – March 25, 2010 – Sea Trail/Sunset Beach
- CRC Report to ERC – April 1, 2010