The National Conference on Beach Preservation Technology
28th Annual Technical Conference

Sea Level Rise Effects on Beaches and Beach Nourishment

Andrew Condon, Ph. D.

Michael Walther, P. E., D. CE

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FSBPA Annual Meeting Summary

	Classic Beach Management Objectives			
Alternative	Protection	Preserve Land	Recreational Beach	Habitat
Beach Fill	Yes	Yes	Yes	Yes
	limited by Design	MHWL fluctuates	beach width fluctuates	habitat fluctuates
Retreat	No	No	Yes	Somewhat
	"demolished/ relocated"	MHWL recedes	width same & migrates	loss of upland habitat
Seawall	Yes	Somewhat	No	No
	limited by Design	landward of seawall	beach width diminishes	loss of beach habitat

Outline

- Sea Level Rise in Florida
  - Historical
  - Projected
- Historical erosion and sea level rise – 2 Case Studies
  - Navarre Beach, Santa Rosa County
  - South County Beaches, St. Lucie County
- Effectiveness of Bruun Rule on estimating recession
- Future nourishment needs
- Conclusions

Recorded Sea Level Change

		MSL Trend	
Location	Period	(in/yr)	(ft/cen)
Fernandina Beach	1897 – 2006	0.08	0.67
Mayport	1928 – 2006	0.09	0.75
Daytona Beach Shores	1925 – 1983	0.09	0.75
Miami Beach	1931 – 1981	0.09	0.75
Key West	1913 – 2006	0.09	0.75
Naples	1965 – 2006	0.08	0.67
Fort Myers	1965 – 2006	0.09	0.75
St. Petersburg	1947 – 2006	0.09	0.75
Clearwater Beach	1973 – 2006	0.1	0.83
Cedar Key	1914 – 2006	0.07	0.58
Apalachicola	1967 – 2006	0.05	0.42
Pensacola	1923 - 2006	0.08	0.67
	Average:	**0.08**	**0.69**

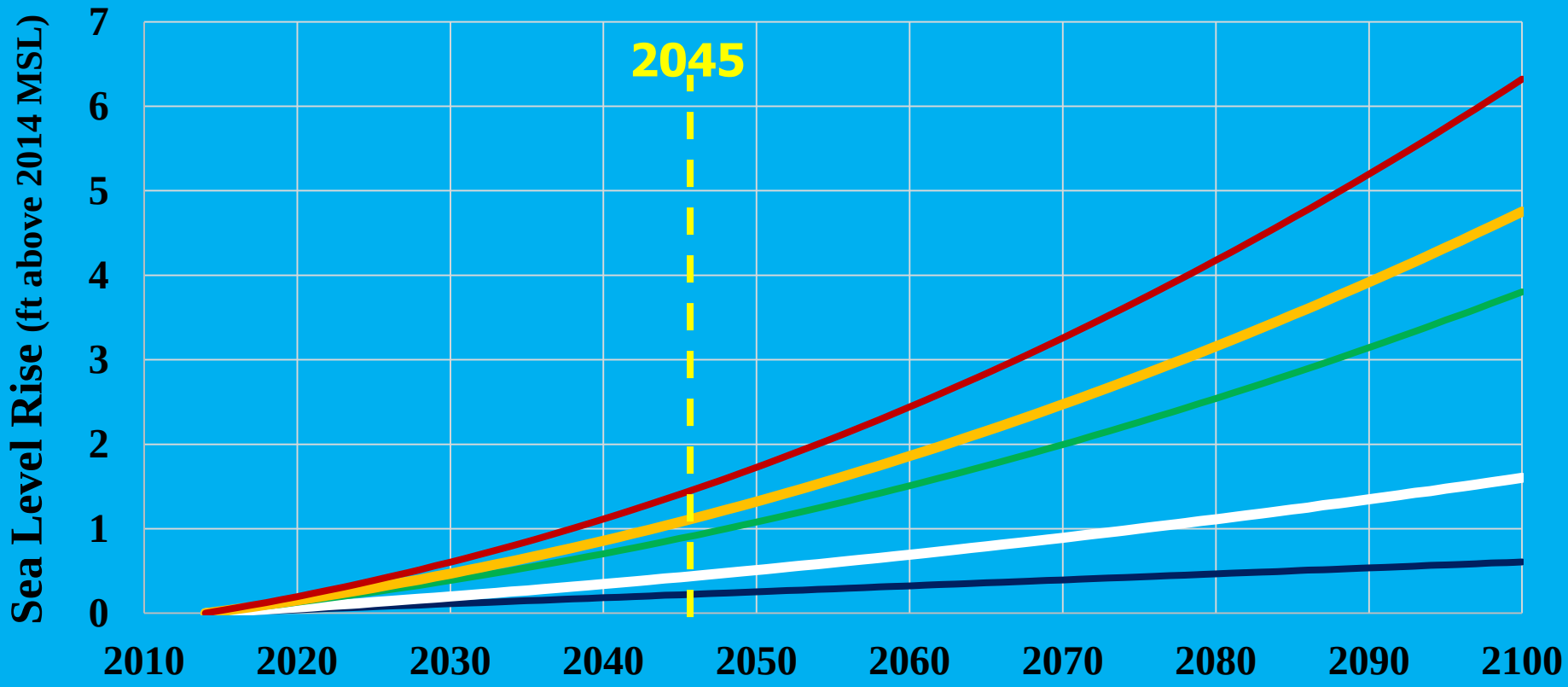
Adapted From: "Sea Level Variations of the United States 1854-2006", NOAA December 2009

Sea Level Rise Effects on Beaches and Beach Nourishment

Florida

Projected Sea Level Change

Florida: All Gauges Average



Adapted from: USACE Sea-Level Change Curve Calculator
https://corpsclimate.us/ccaceslcurves.cfm

3/23/2015

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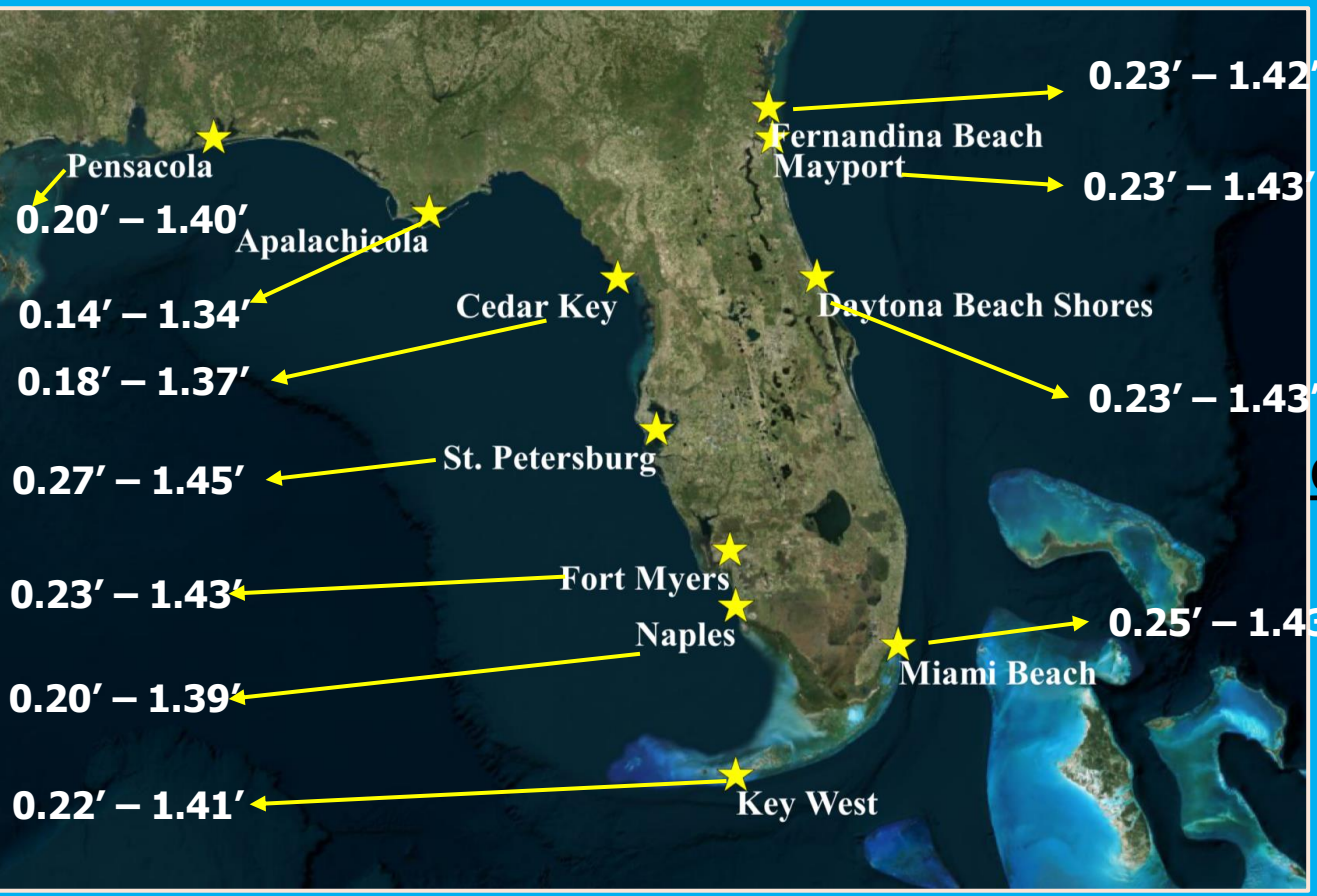
Florida

Projected Sea Level Change – 2045 (30 years)



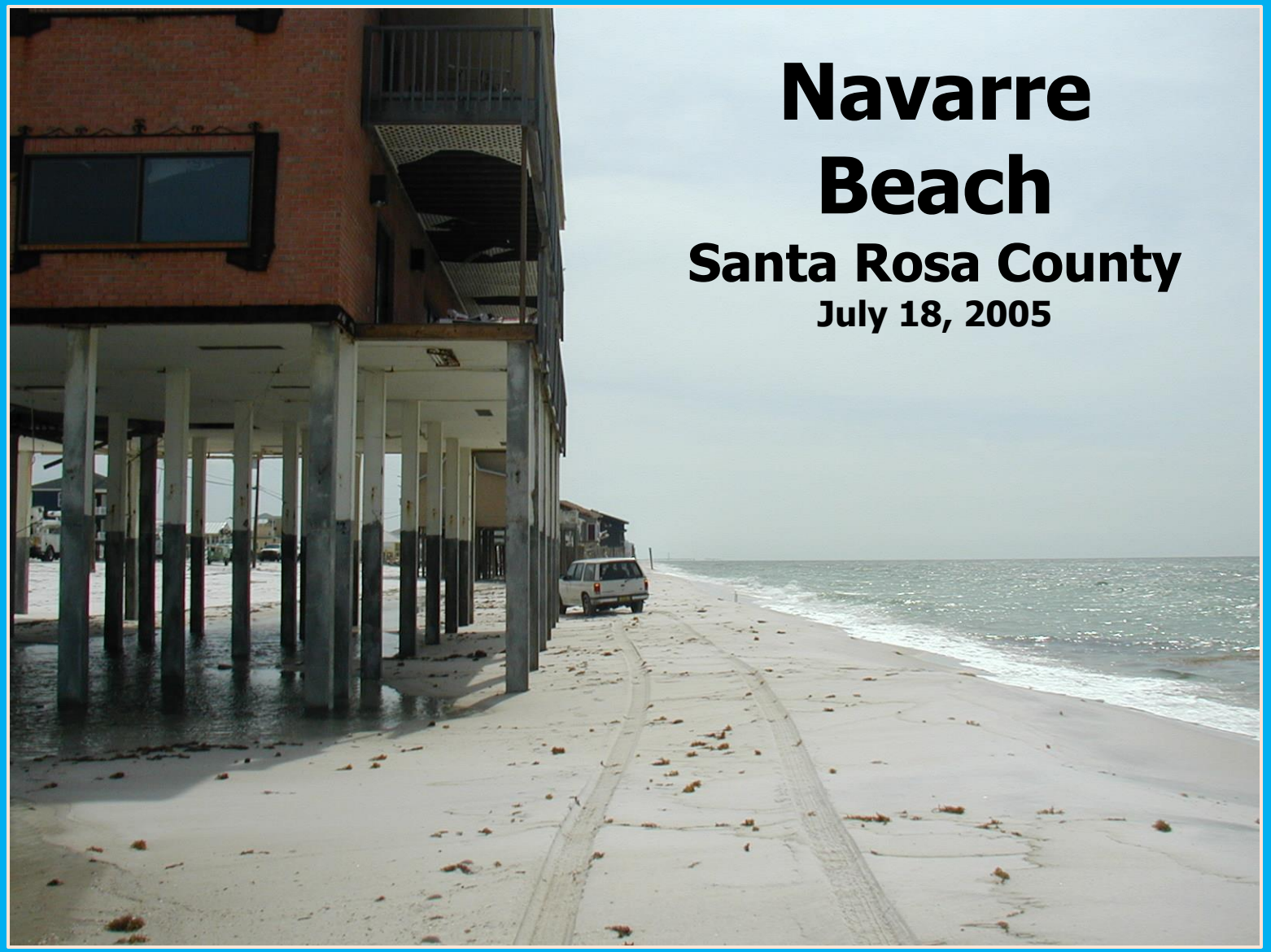
State-wide Lowest to Highest Range per USACE

<u>Overall</u>: 0.14 feet to 1.45 feet

Adapted from: USACE Sea-Level Change Curve Calculator https://corpsclimate.us/ccaceslcurves.cfm

Sea Level Rise Effects on Beaches and Beach Nourishment

Sea Level Rise Effects on Beaches and Beach Nourishment



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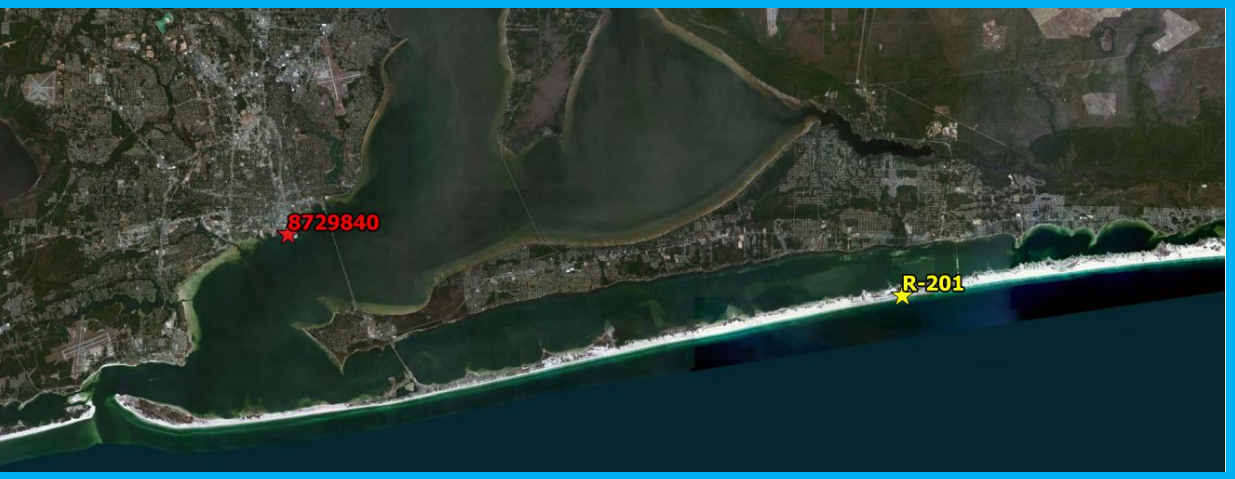
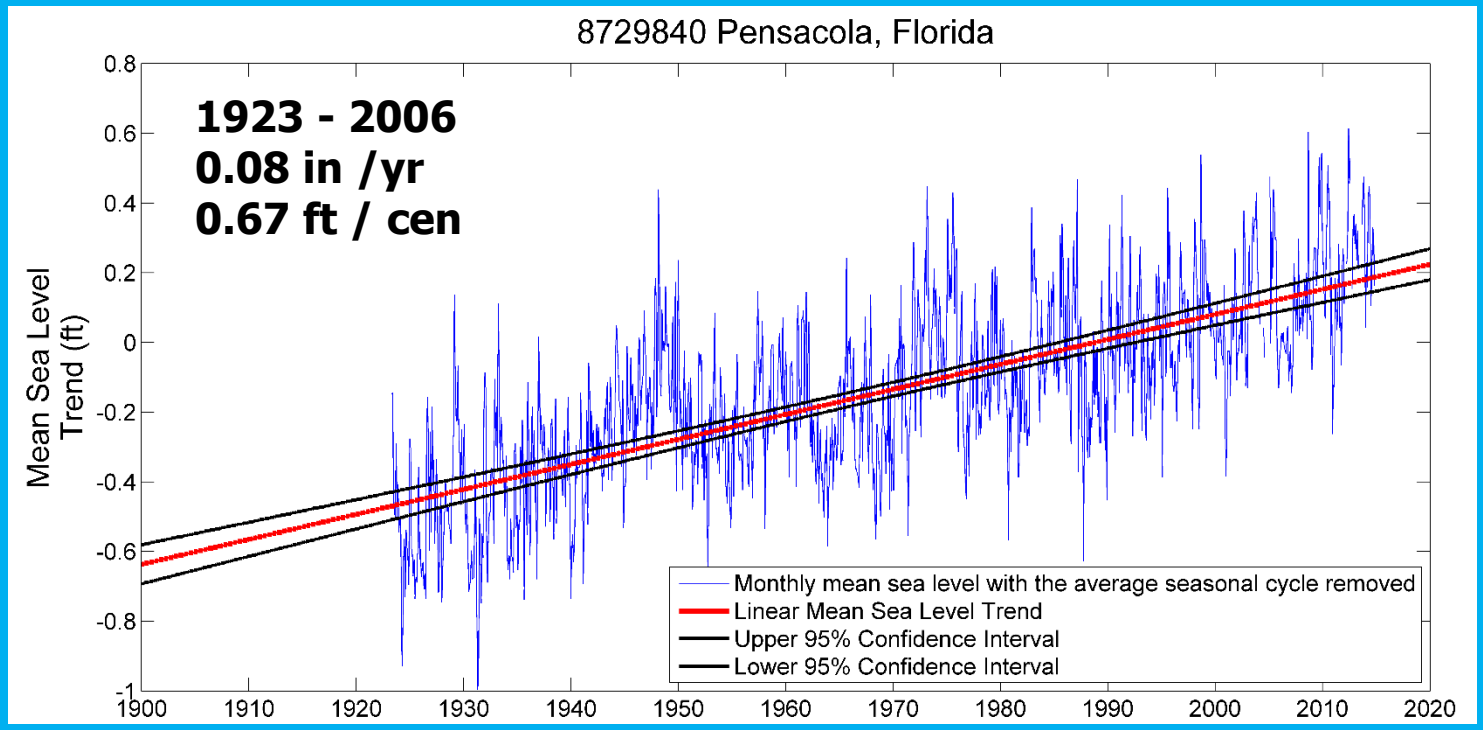


Let's Look at the Past

Santa Rosa County



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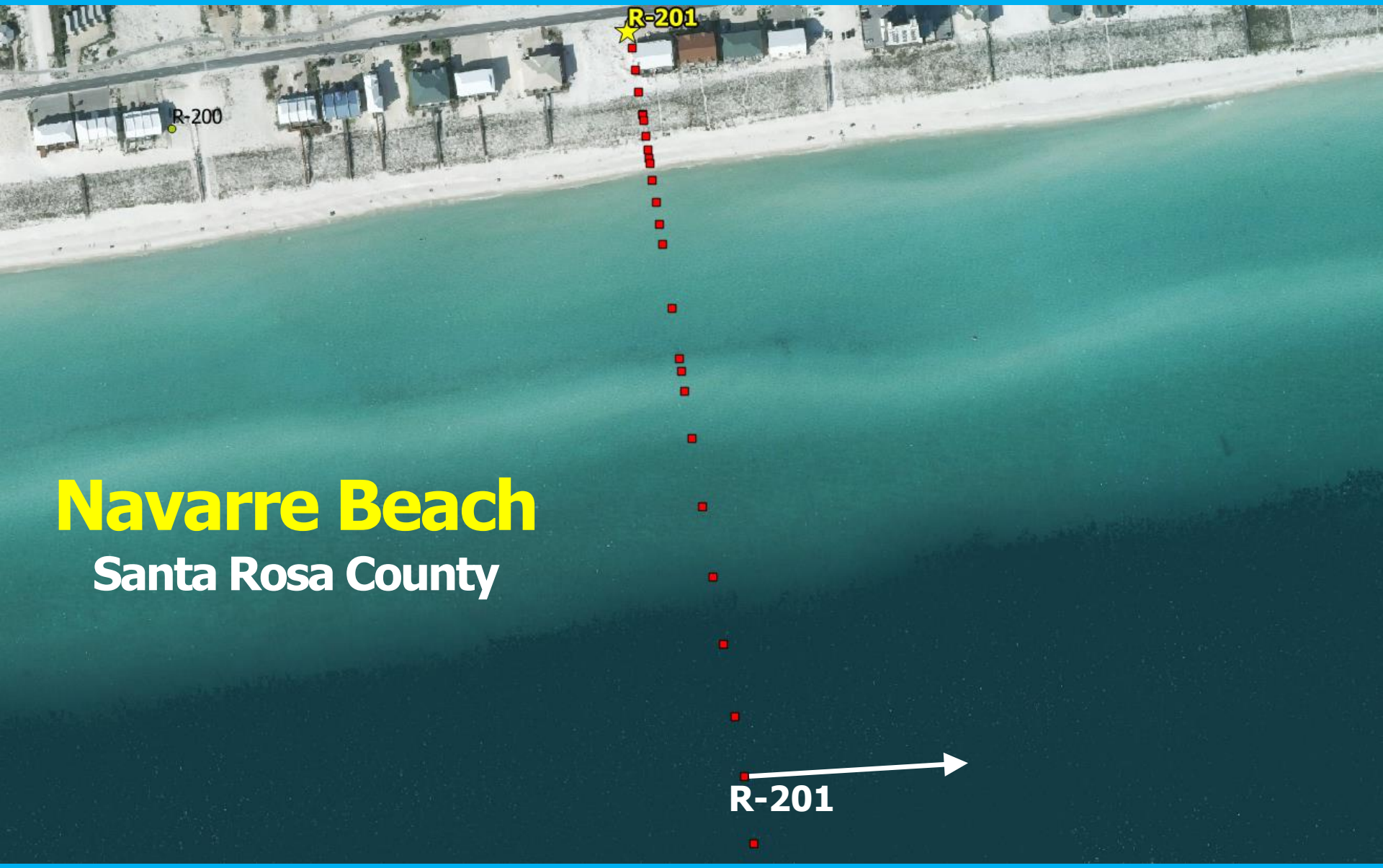
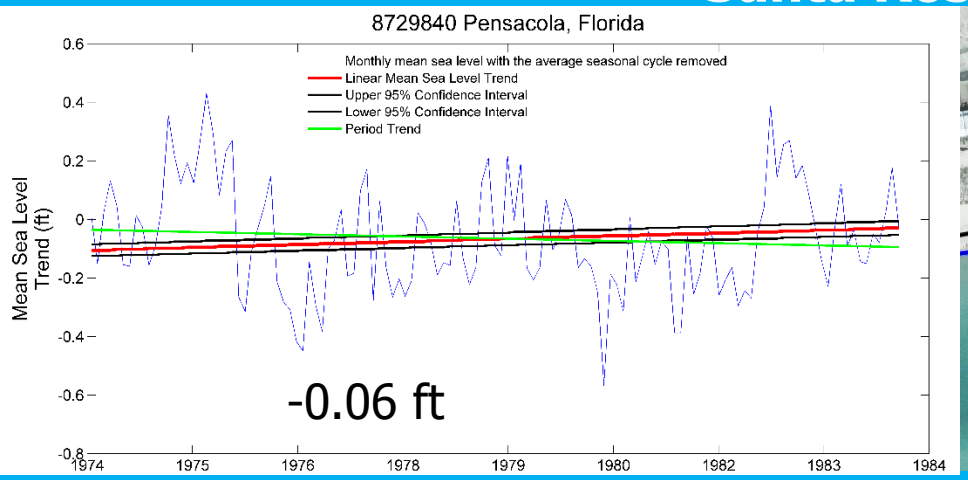
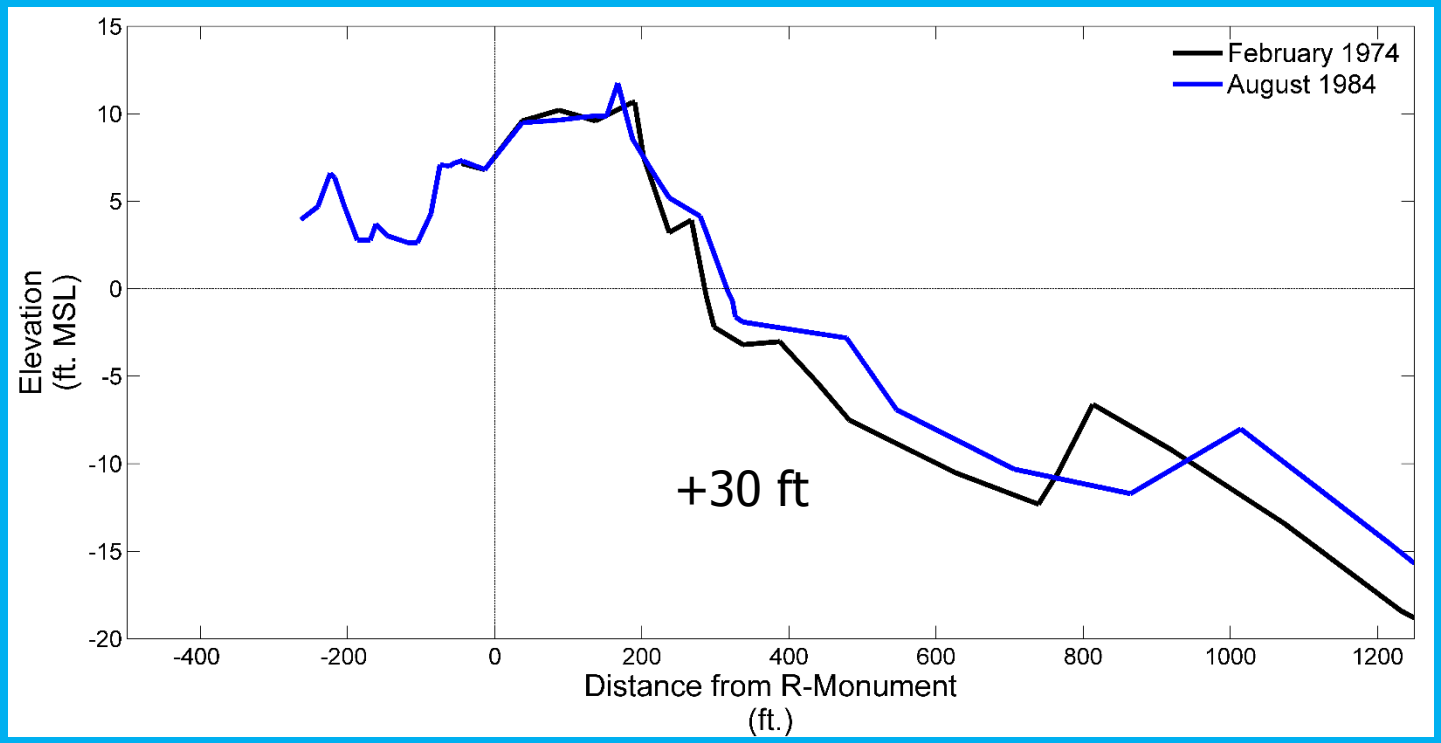


Sea Level Rise Effects on Beaches and Beach Nourishment
Santa Rosa County





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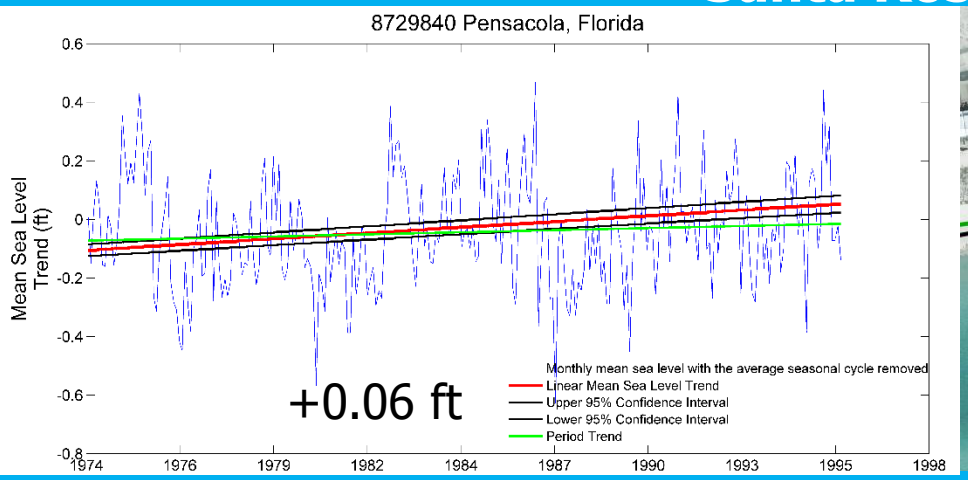

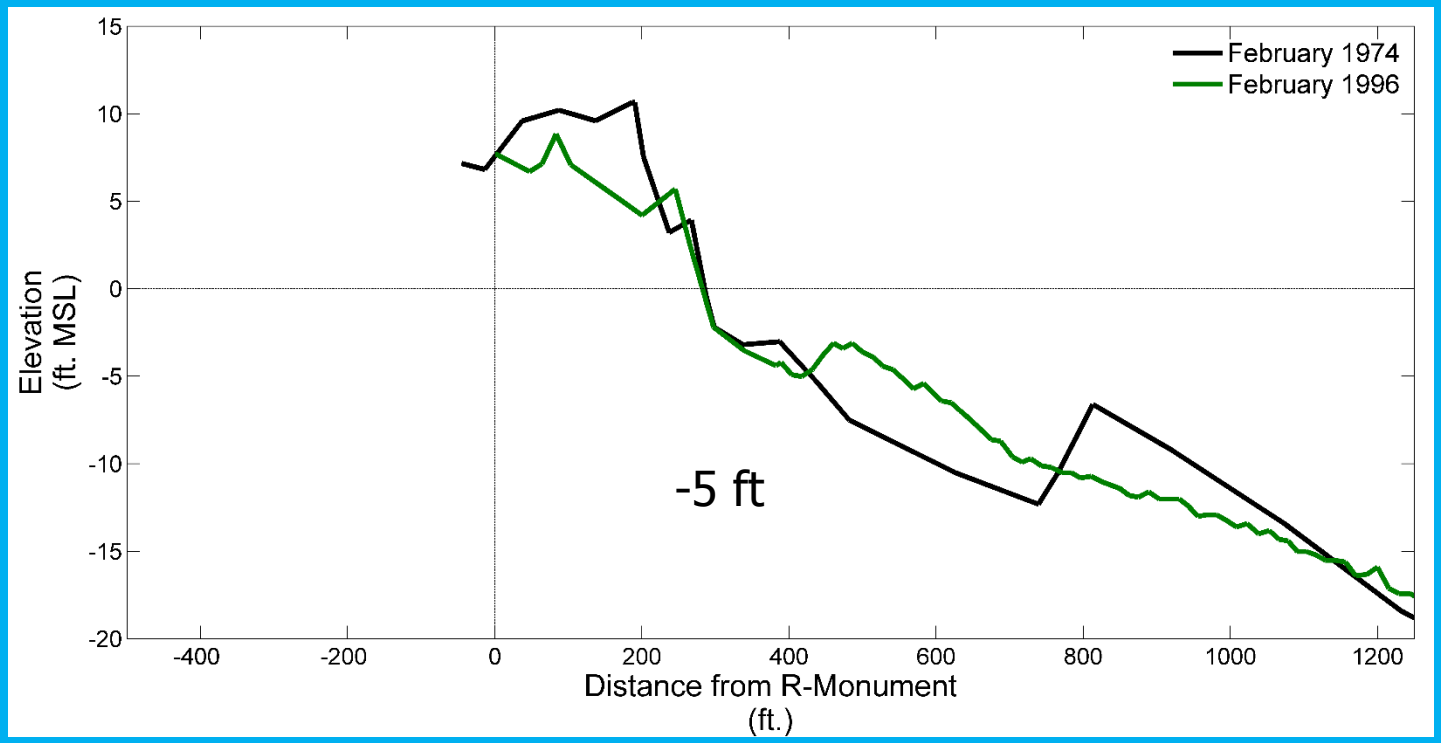

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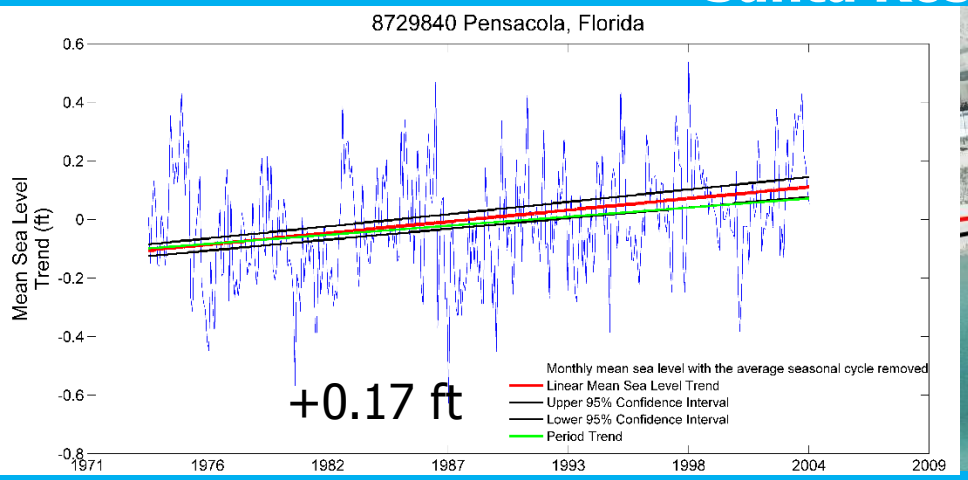

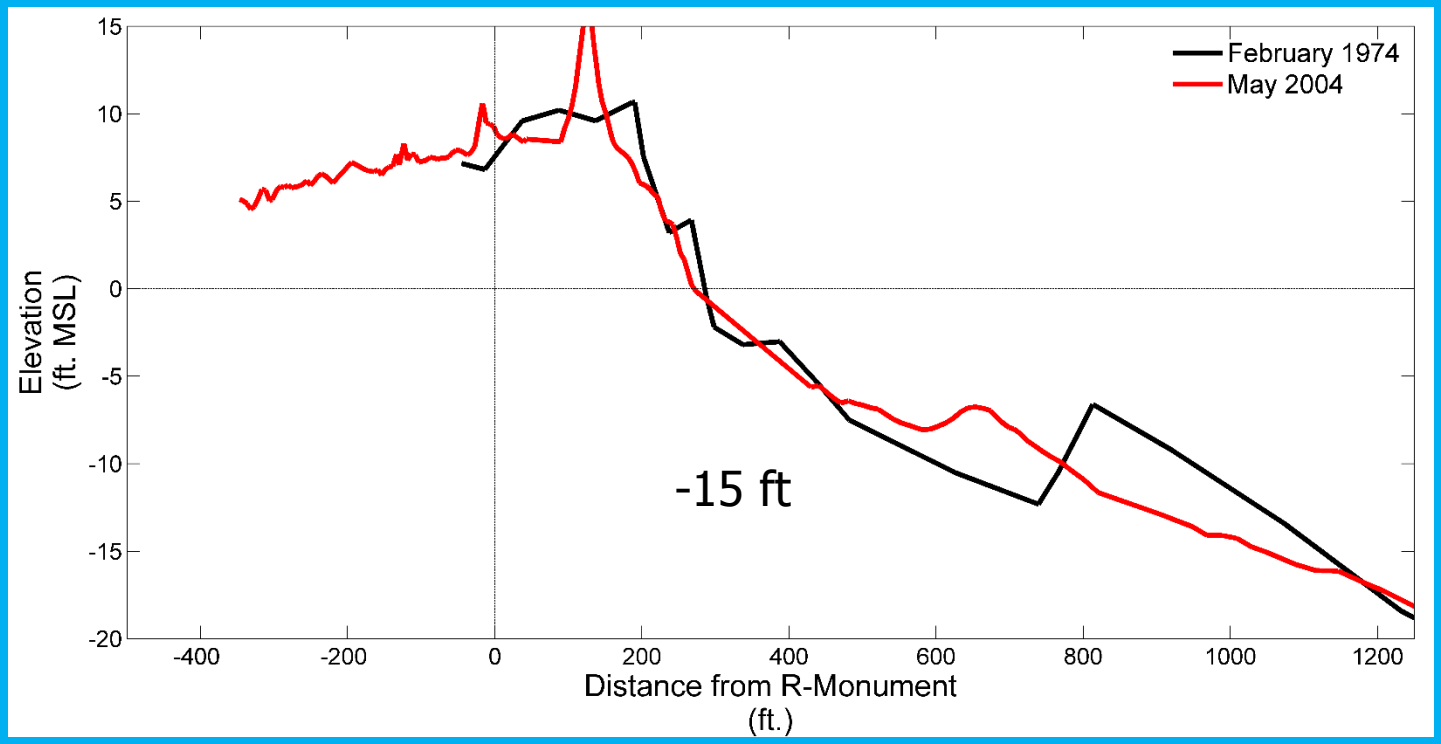

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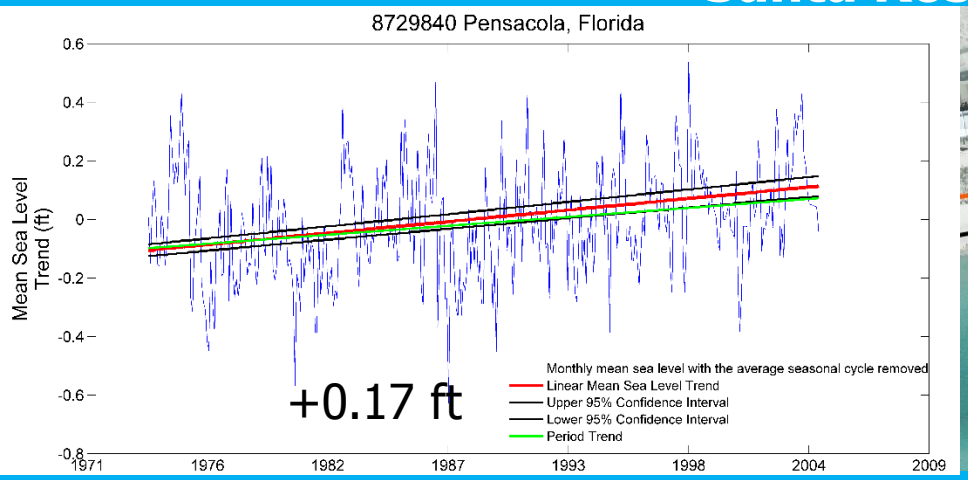

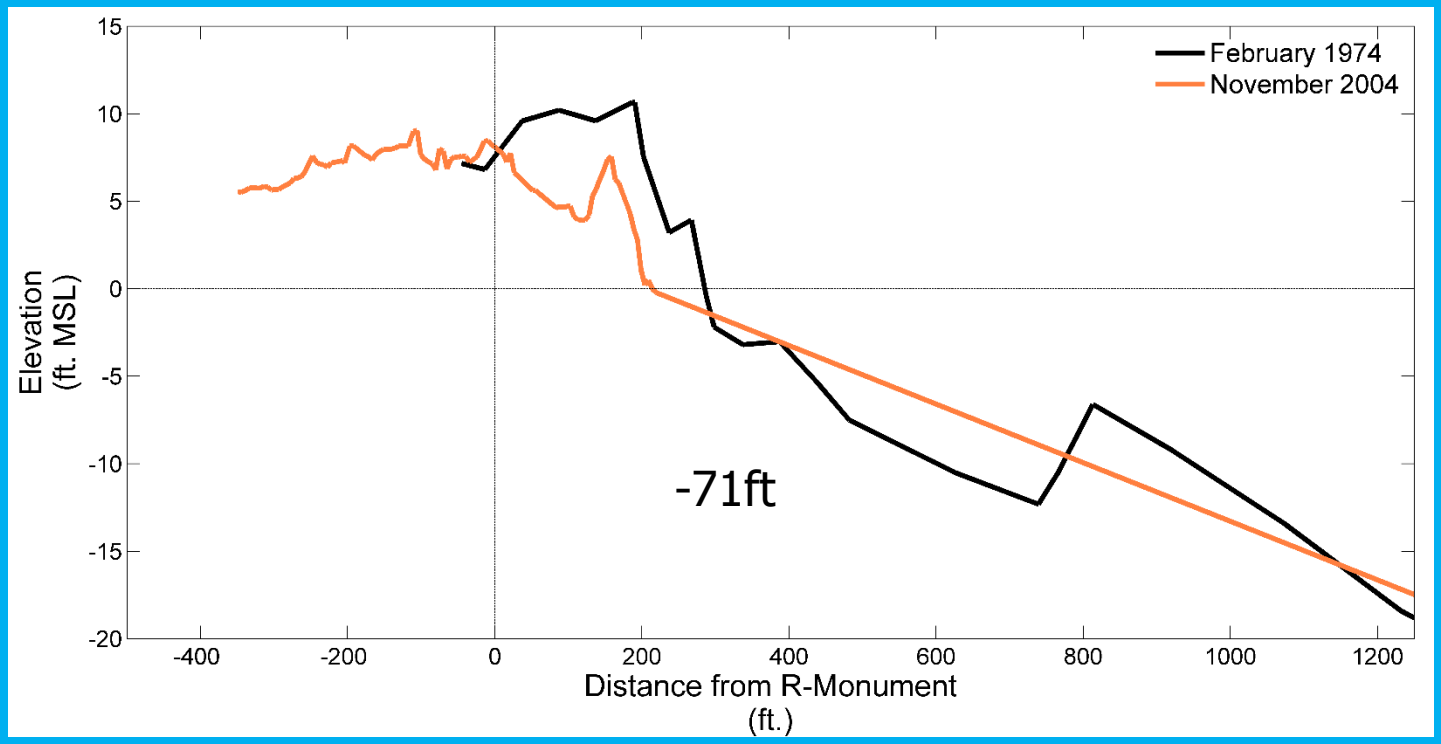

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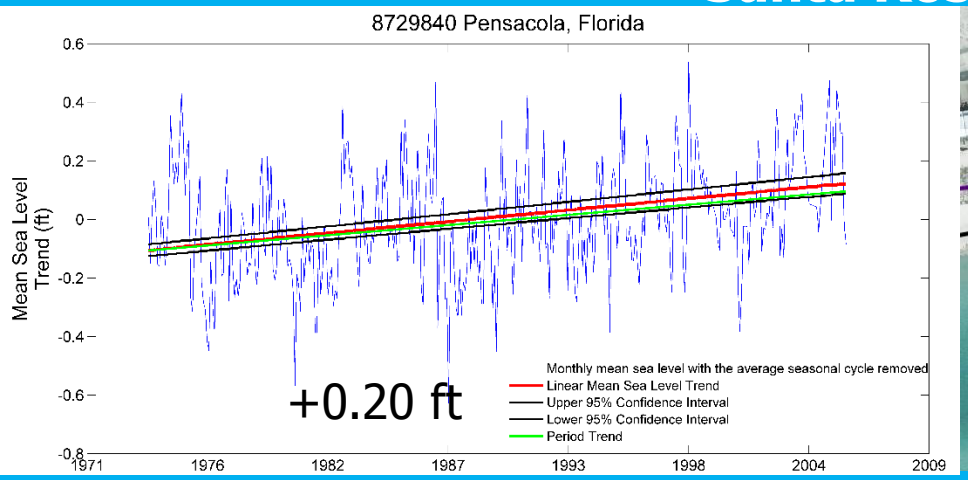

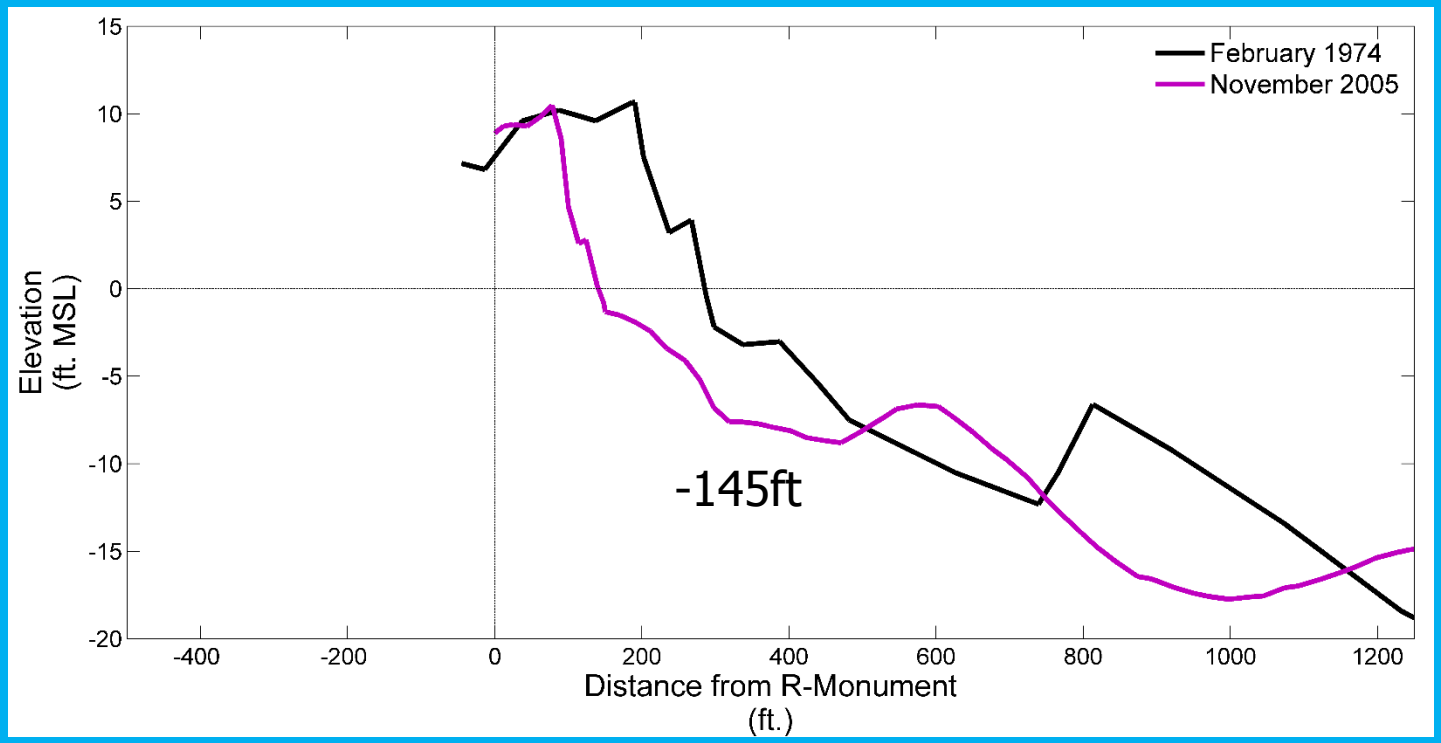

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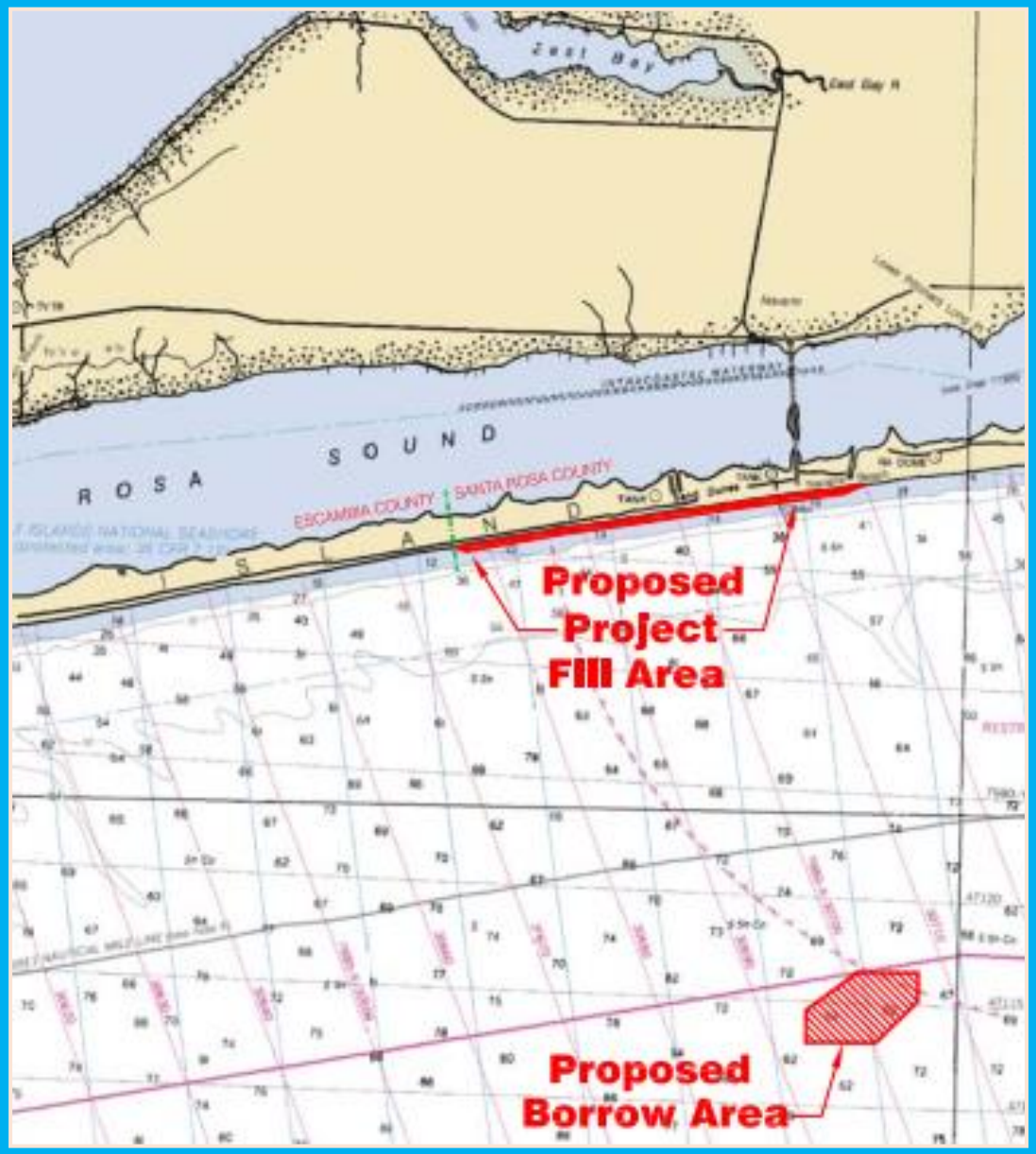


Navarre Beach

Santa Rosa County

Initial Construction:

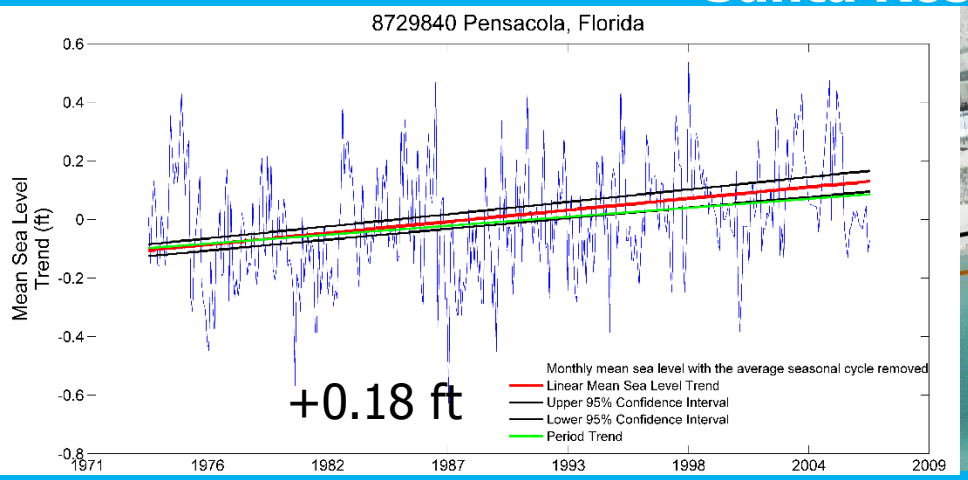
2.95 Mcy

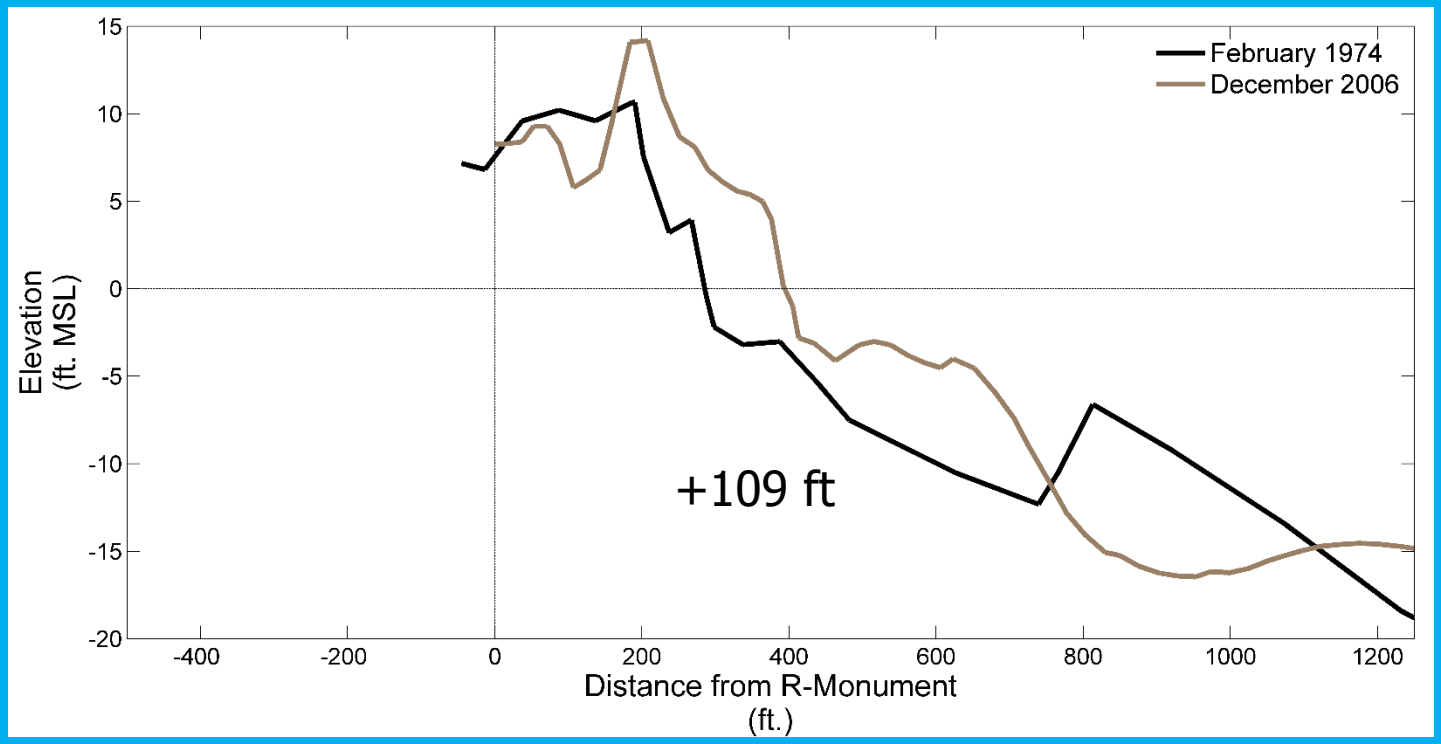
4.1 miles

136 cyds/ft

2006

Sea Level Rise Effects on Beaches and Beach Nourishment
Santa Rosa County





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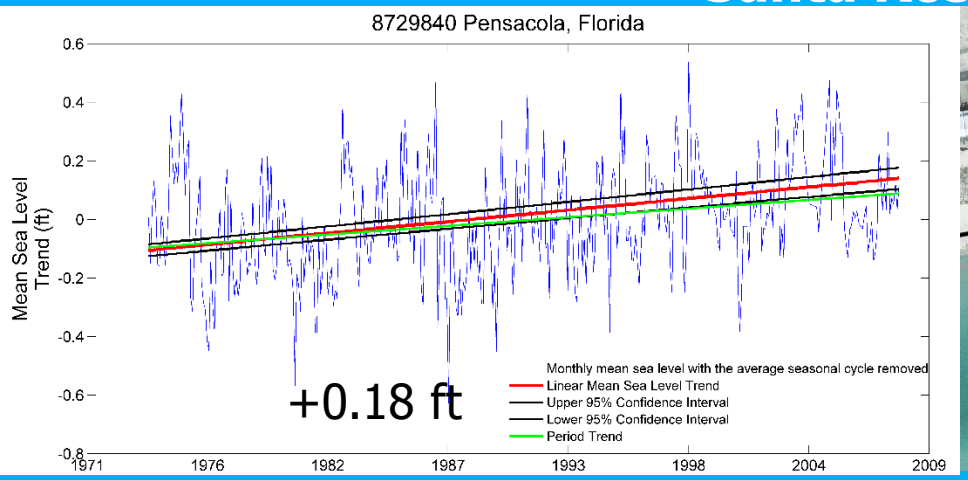

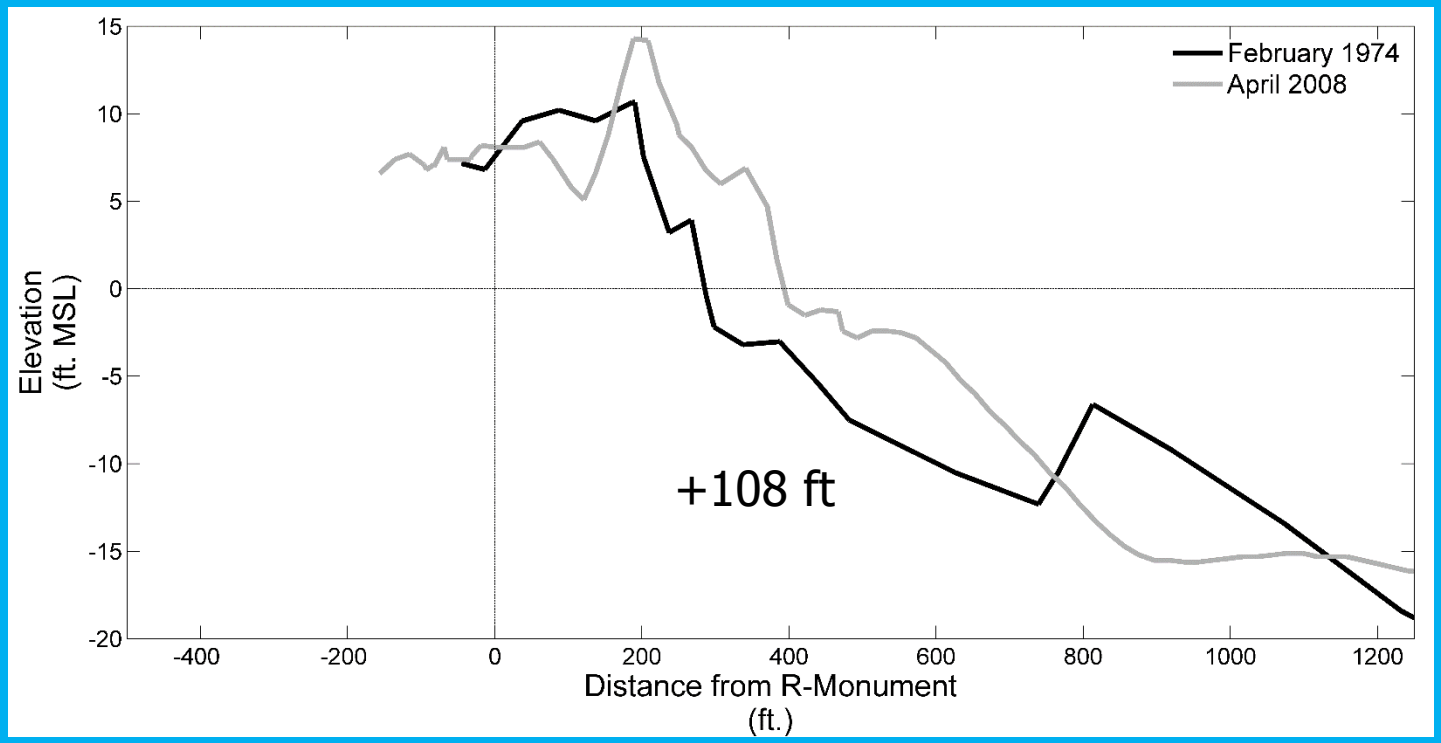

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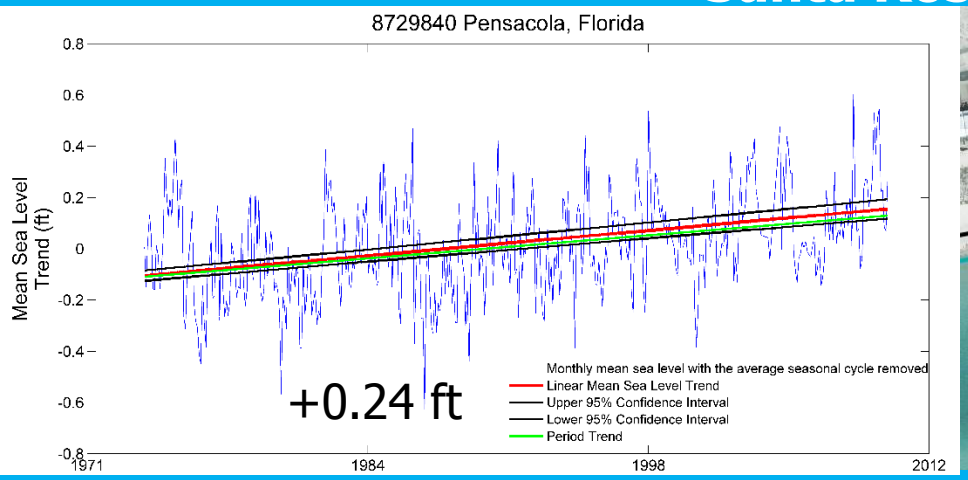

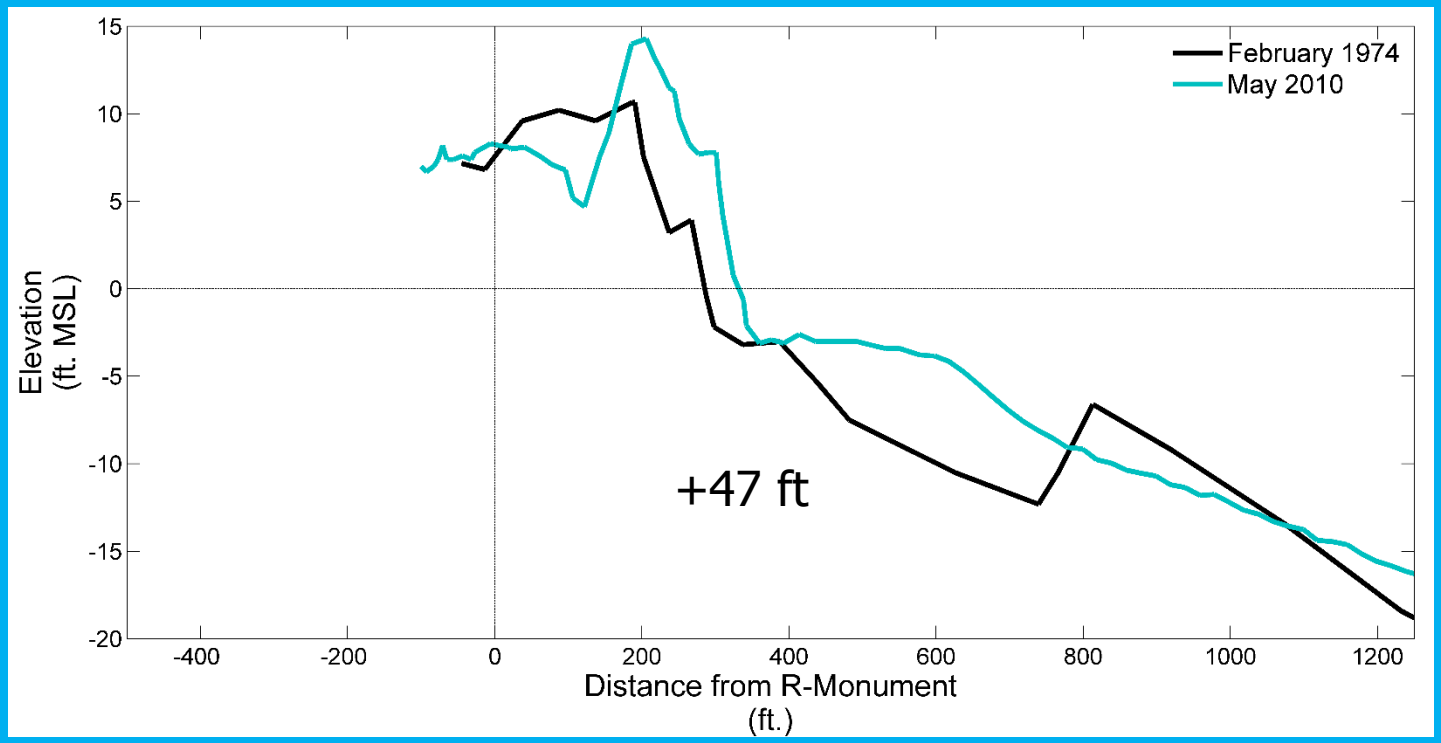

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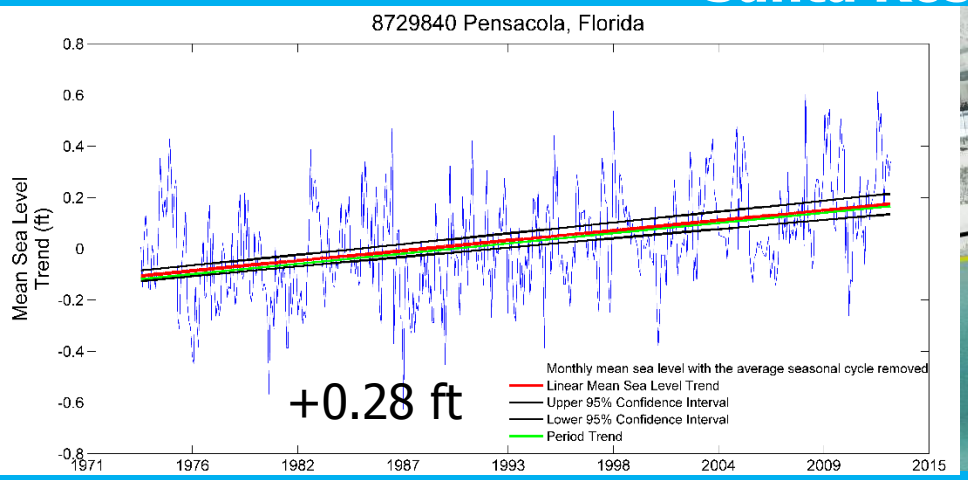

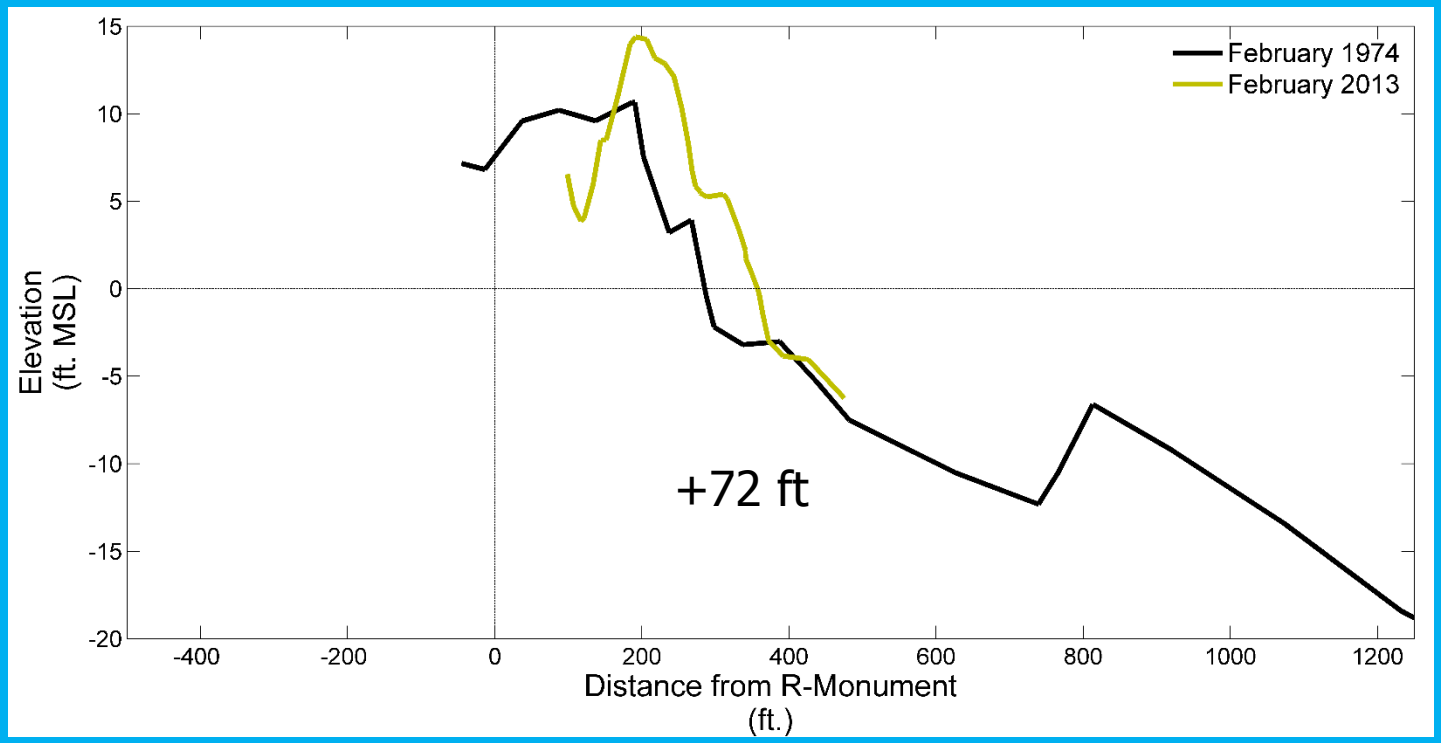

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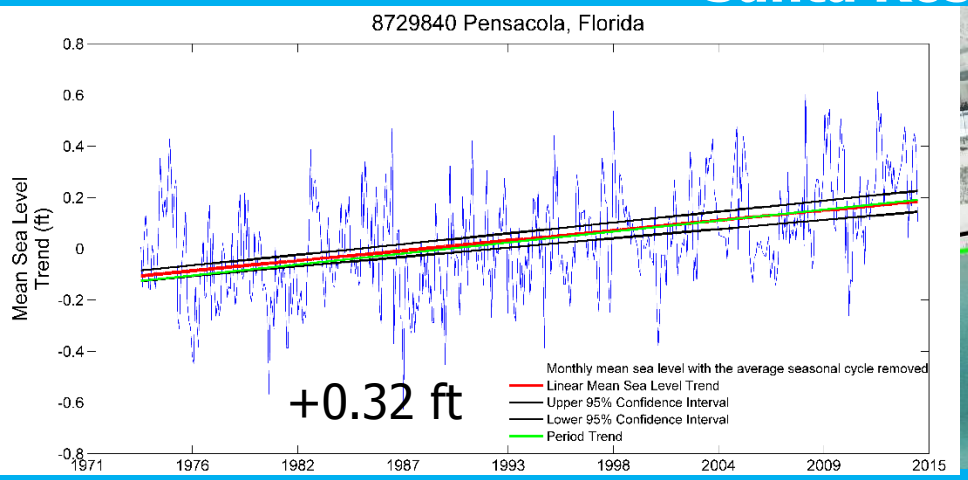
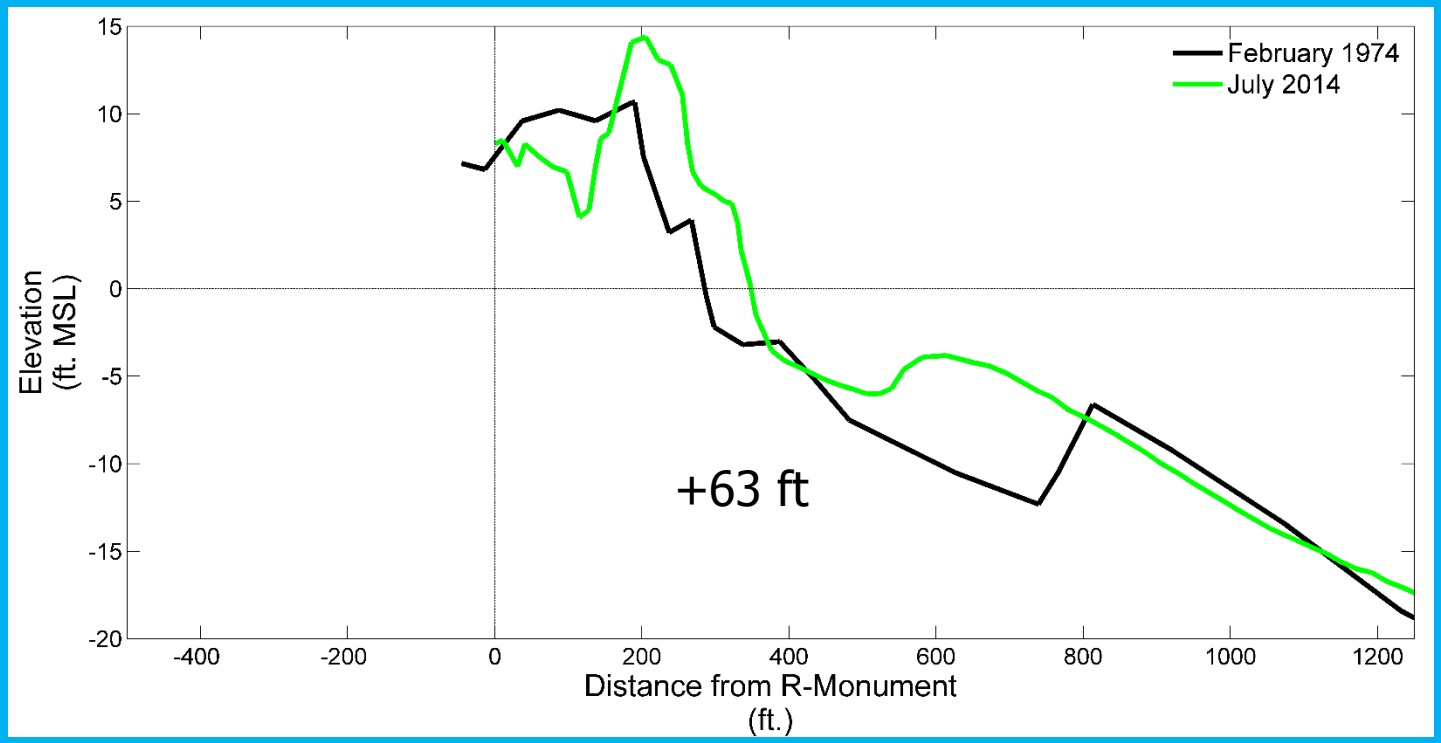




Sea Level Rise

Shoreline Recession: Equilibrium Profile

Assumes

1. **Beach shaped to equilibrium by steady state sea conditions**
2. **Erosion 2-dimensional mass balance of accretion & erosion**
3. **Profile shape given by power series**

$$h = Ax^m$$

Where

- h **= stillwater depth above the equilibrated profile**
- x **= the horizontal distance from the shoreline**
- **m = exponent to fit**
- **A = Dimensional scale parameter related to sediment**

Adapted from: Dean, R.G and Dalrymple, R.A., 2002. "*Coastal Processes with Engineering Applications*". Cambridge: Cambridge University Press, 475 p.

Sea Level Rise

Shoreline Recession: Bruun Rule

Assumes

1. **Profile shape does not change with respect to the water line.**
2. **The sand volume in the profile must be conserved.**

$$\Delta y = -R = -S\frac{W_*}{(h_* + B)}$$

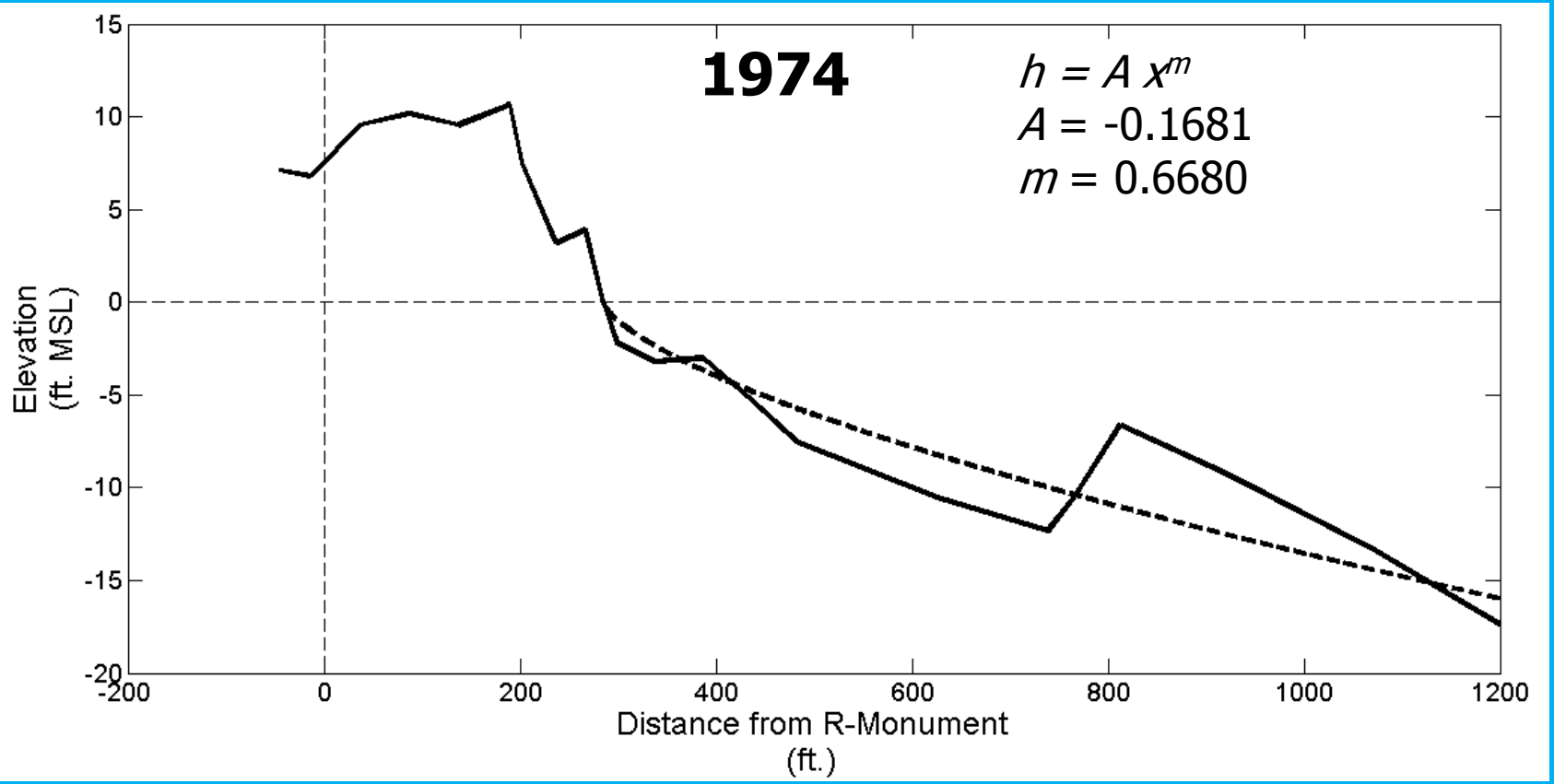
Where

- Δy **= -R = Horizontal shoreline recession**
- S **= Sea level rise**
- W_* **= Width of the active beach profile** $(h_*/A)^{1/m}$
- h_* **= Depth of closure**
- B **= Berm height**

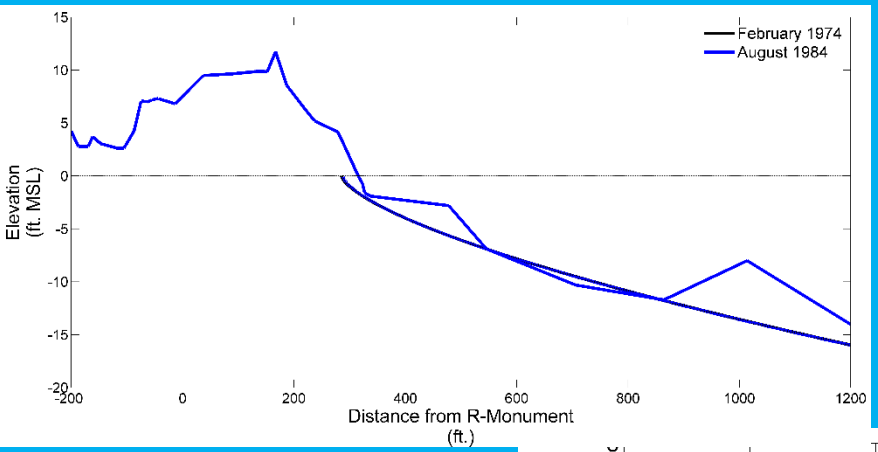
Adapted from: Dean, R.G and Dalrymple, R.A., 2002. "*Coastal Processes with Engineering Applications*". Cambridge: Cambridge University Press, 475 p.

Sea Level Rise

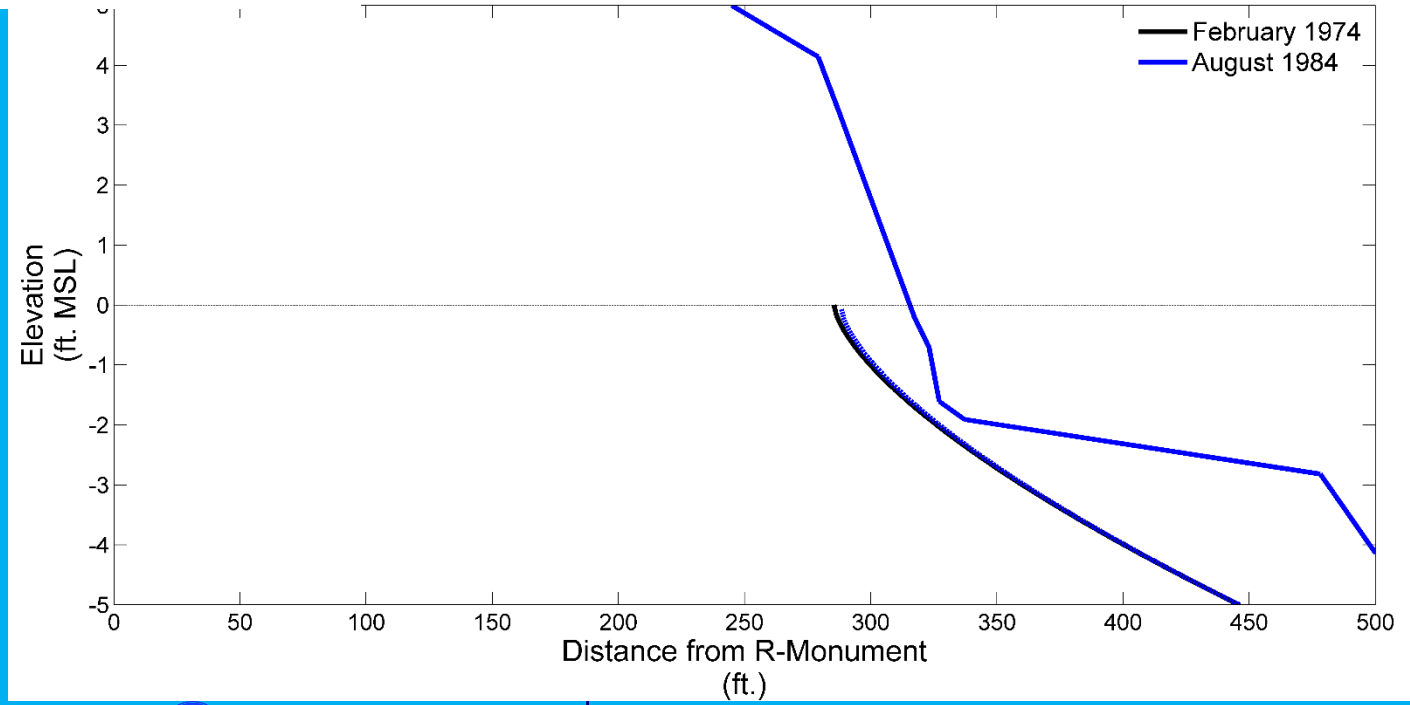
Shoreline Recession: Bruun Rule



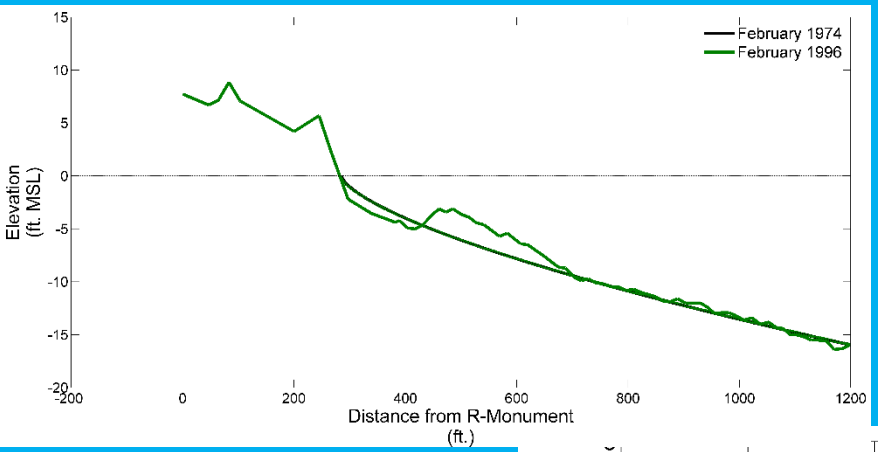
Shoreline Recession: Bruun Rule



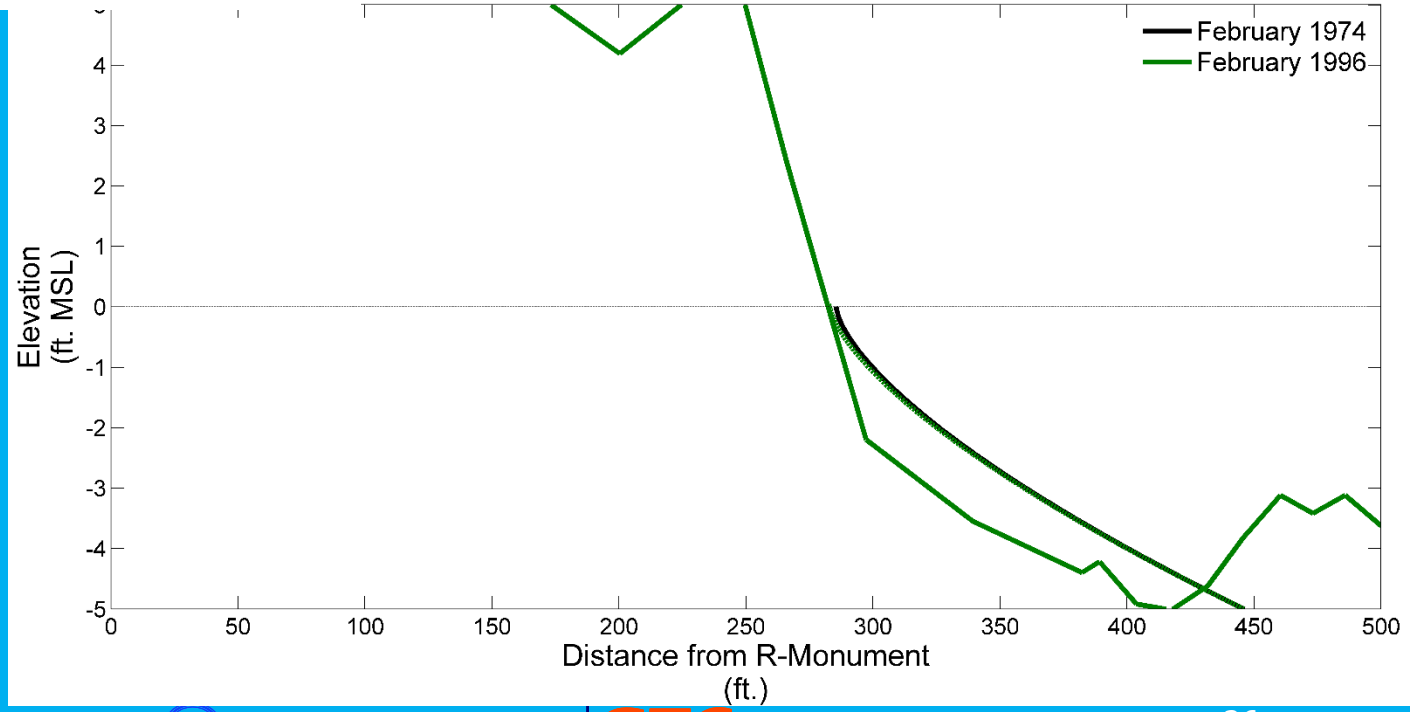
SLR = -0.06
Actual Recession = -30.12
Bruun Recession = -2.90



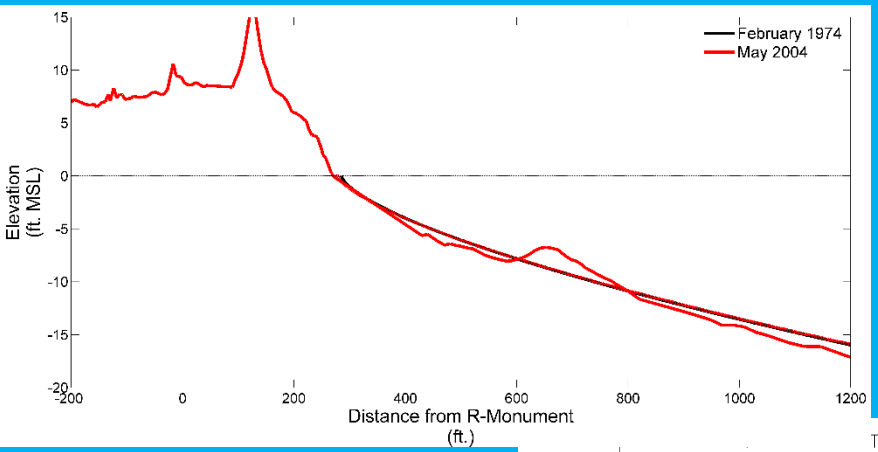
Shoreline Recession: Bruun Rule



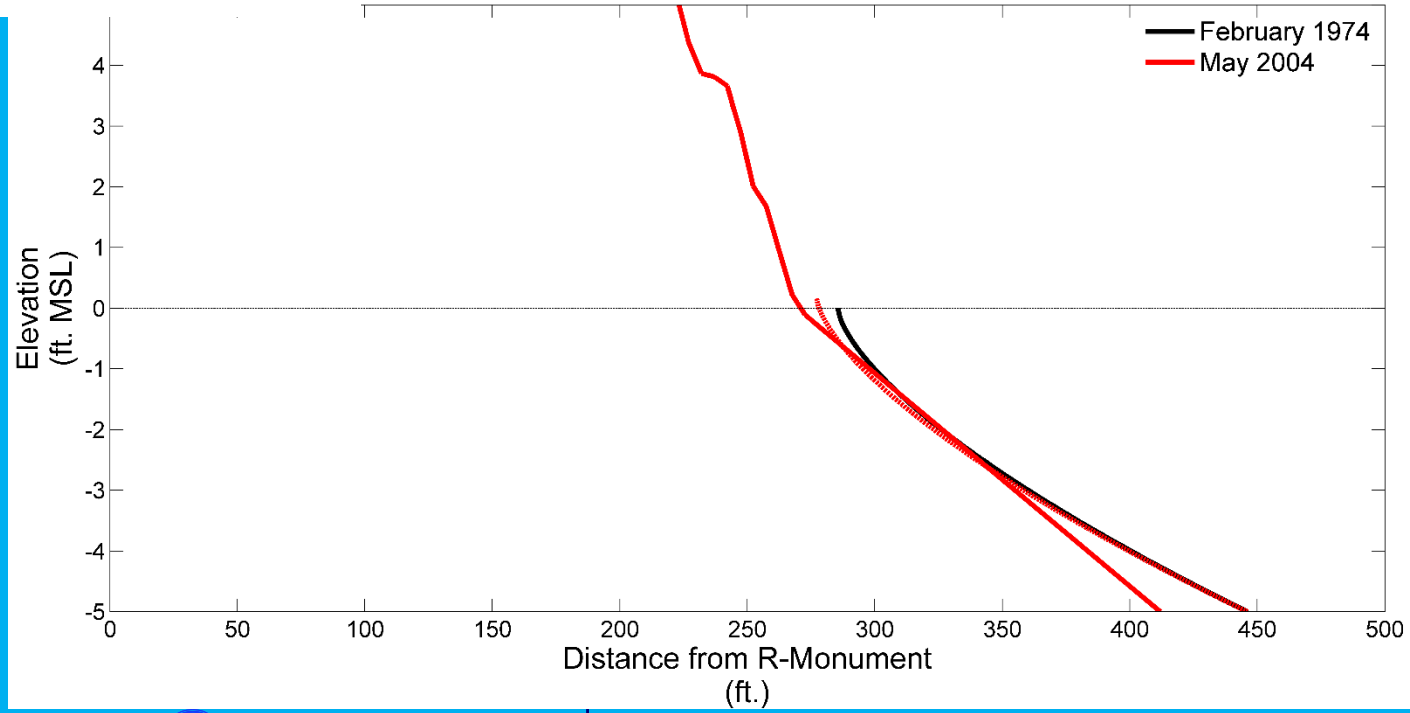
SLR = +0.06
Actual Recession = 4.87
Bruun Recession = 2.81



Shoreline Recession: Bruun Rule



SLR = +0.17
Actual Recession = 14.96
Bruun Recession = 8.35



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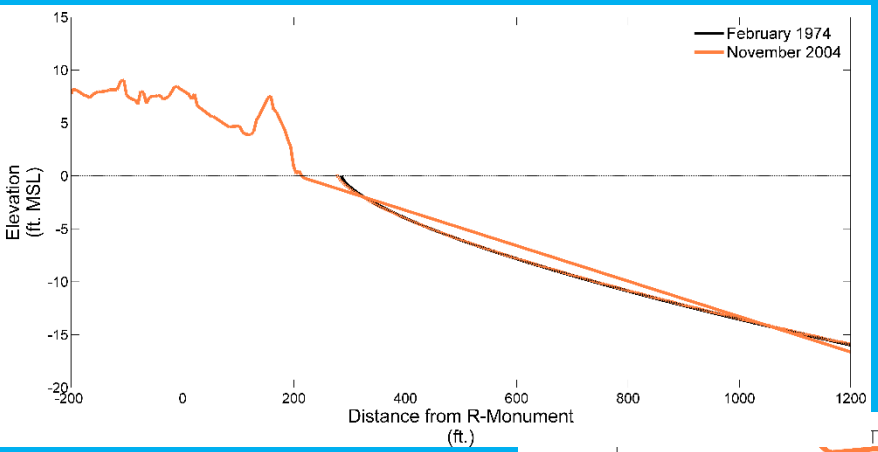

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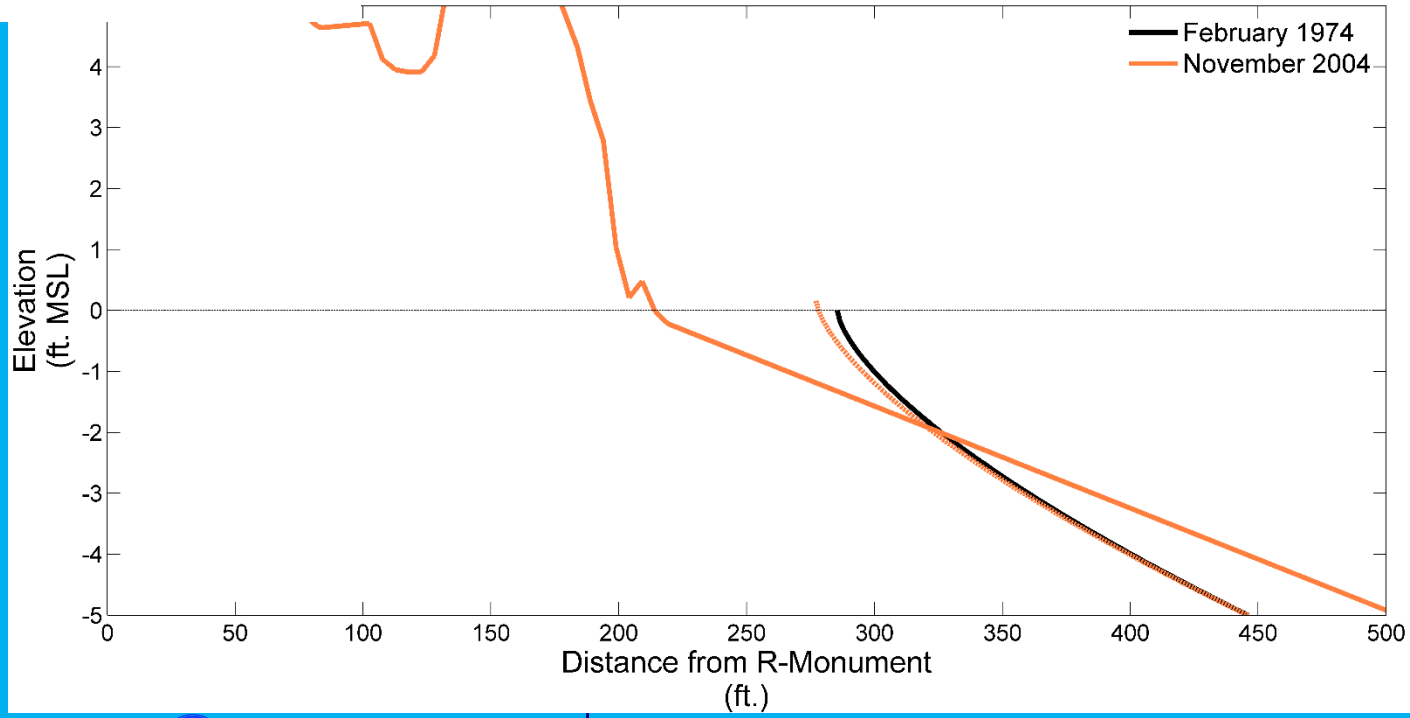
Bruun Recession = 8.35



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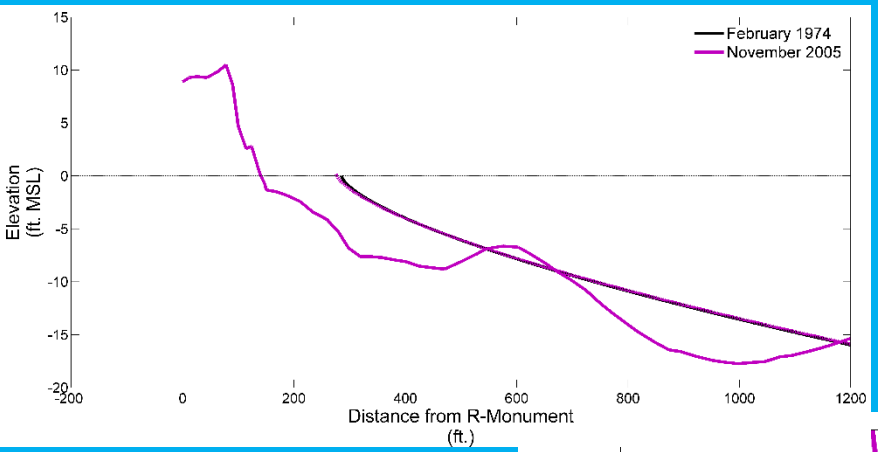
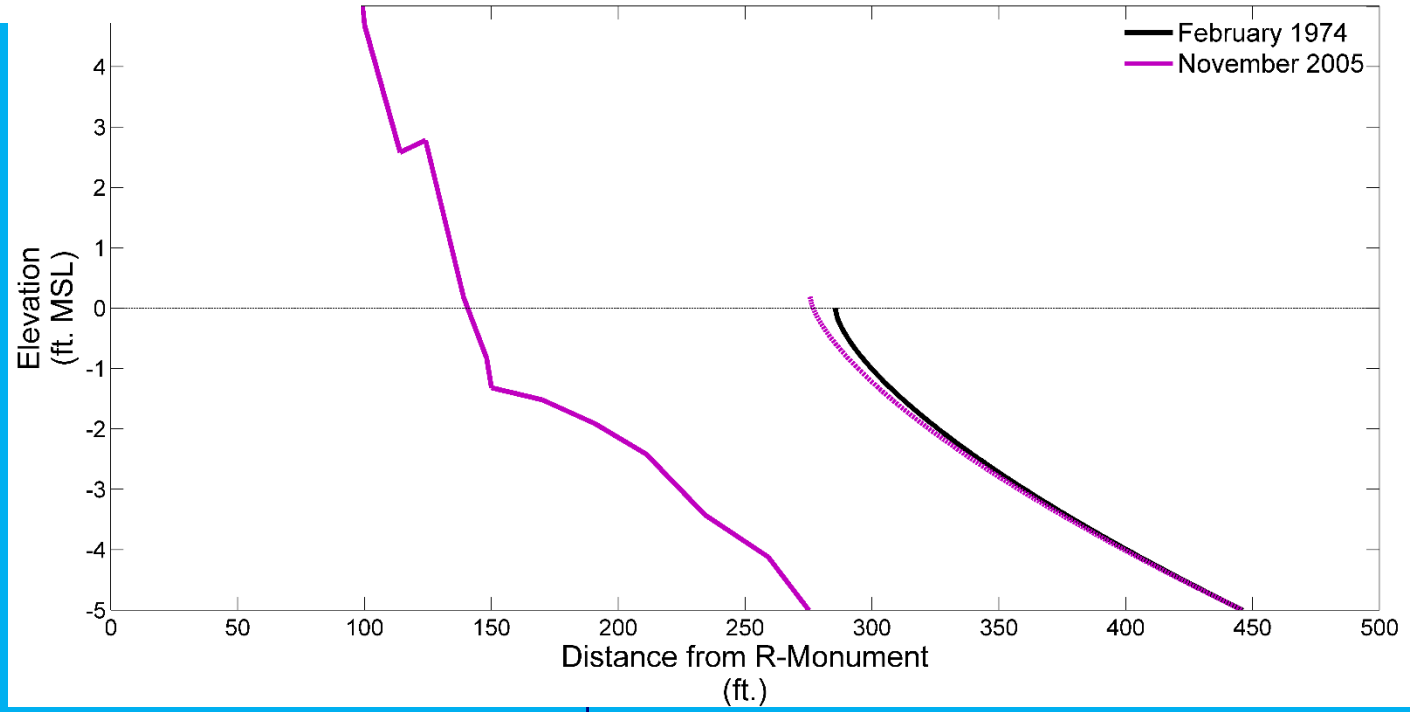
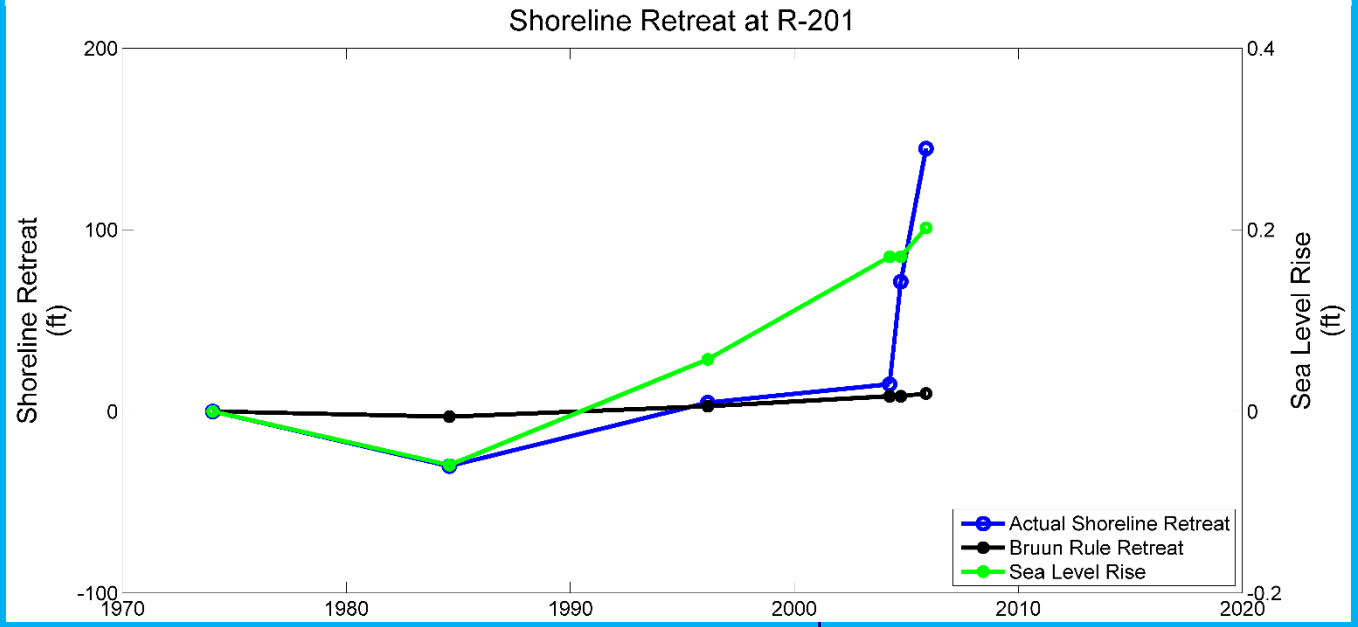


SLR = +0.20
Actual Recession = 144.75
Bruun Recession = 9.91



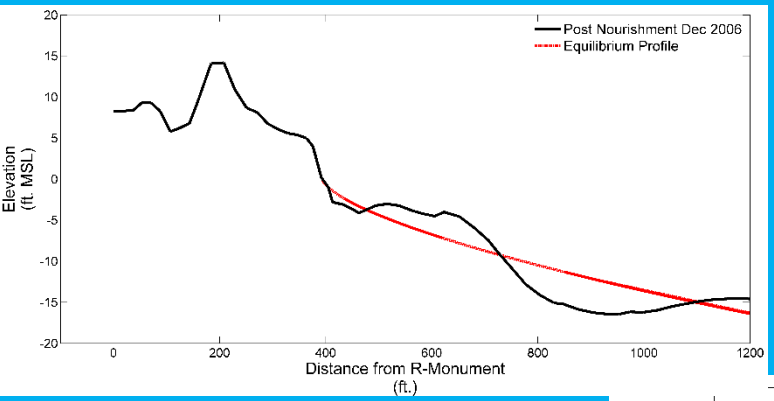
Shoreline Recession: Bruun Rule

Year	Bruun (ft)	Actual (ft)	Difference (ft)	% Error
1984	2.90	30.12	27.22	90
1996	-2.81	-4.87	2.06	42
2004 (May)	-8.35	-14.96	6.61	44
2004 (Nov)	-8.35	-71.43	63.08	88
2005	-9.91	-144.75	134.84	93

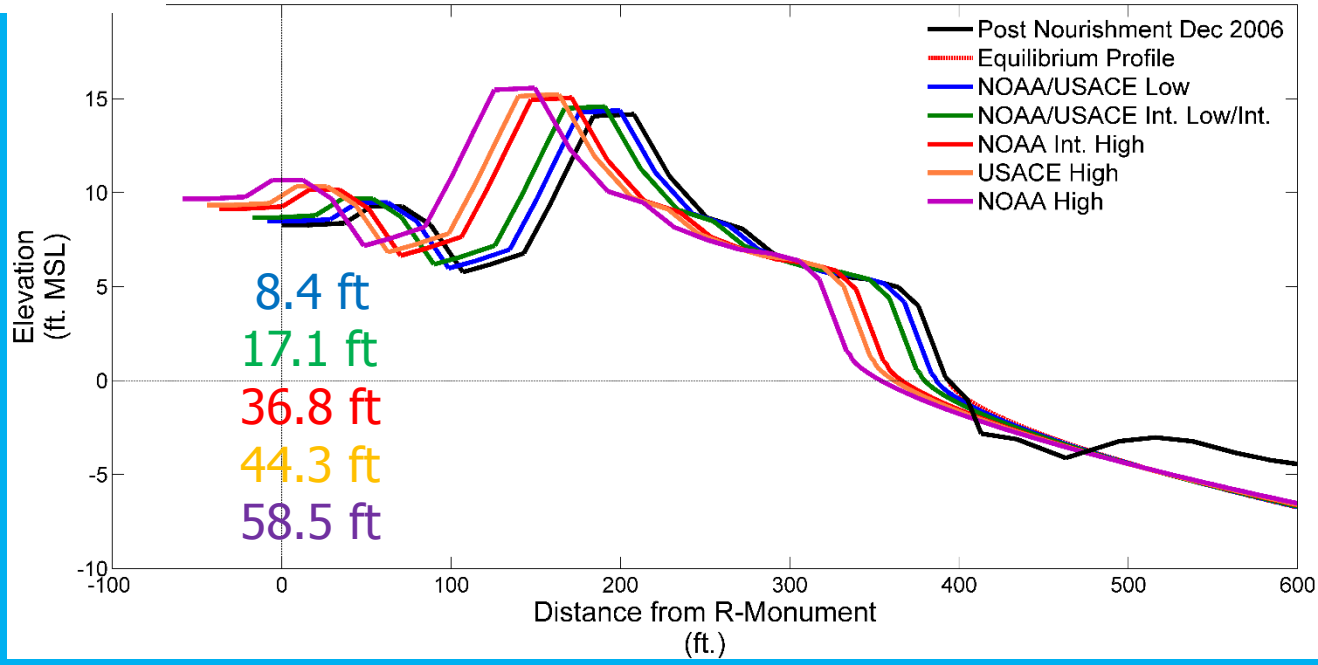


Sea Level Rise - Projections

Shoreline Recession: Bruun Rule



1974 – 2004 (May)
30 Year period
Recession: 15.0 ft
SLR ~ 0.17 ft



Sea Level Rise Effects on Beaches and Beach Nourishment

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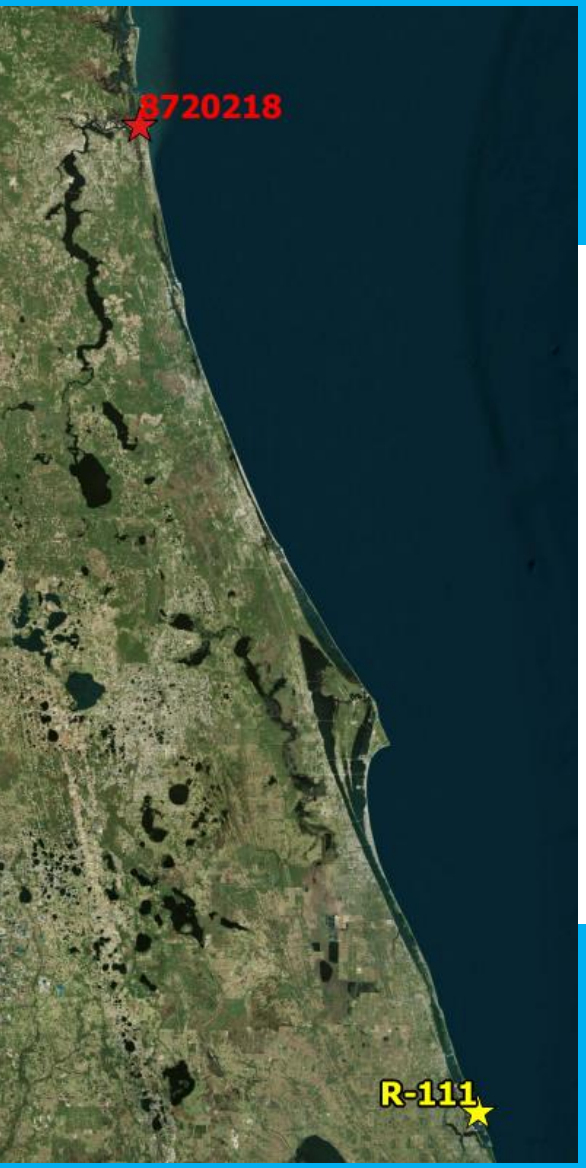
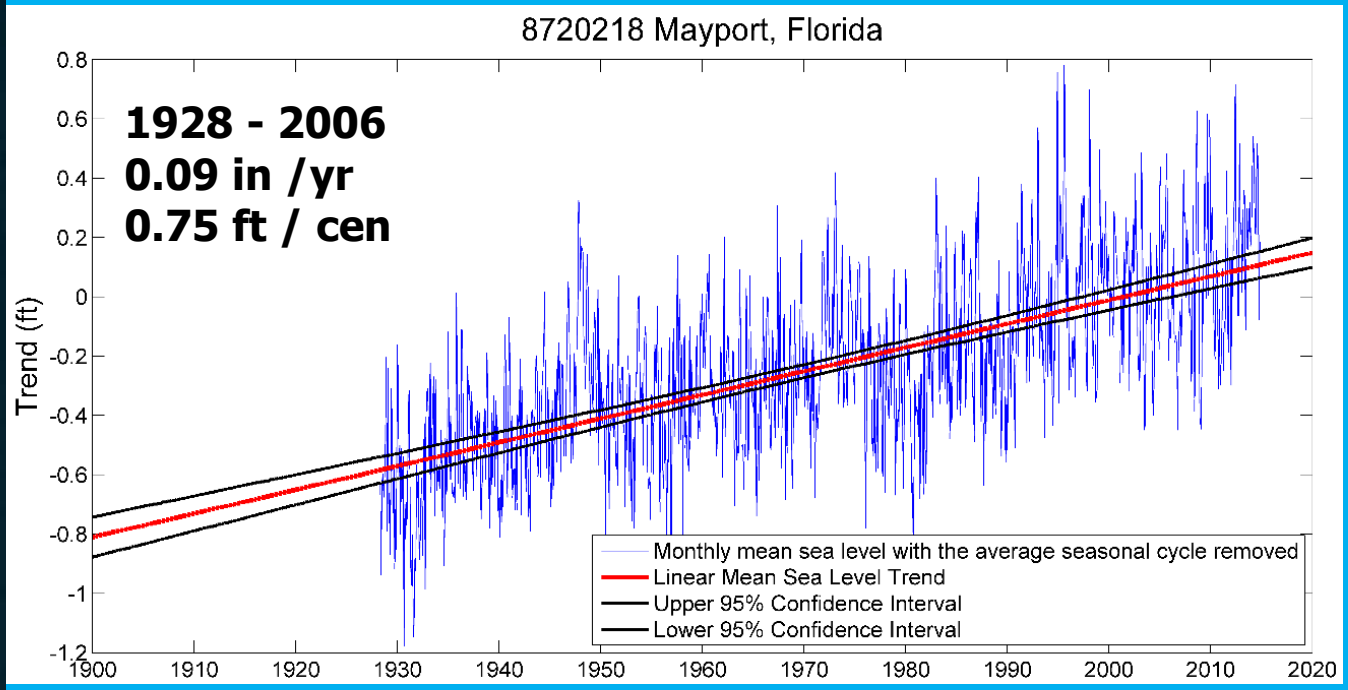


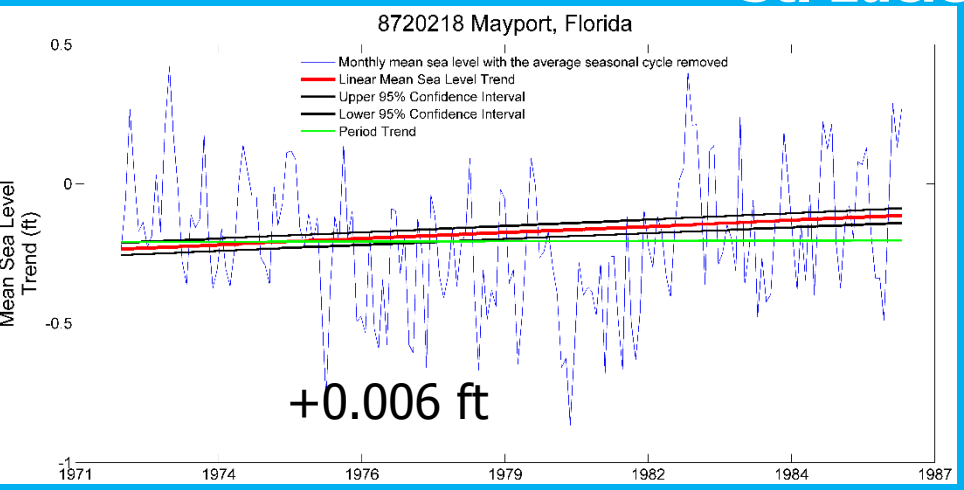
Let's Look at the Past

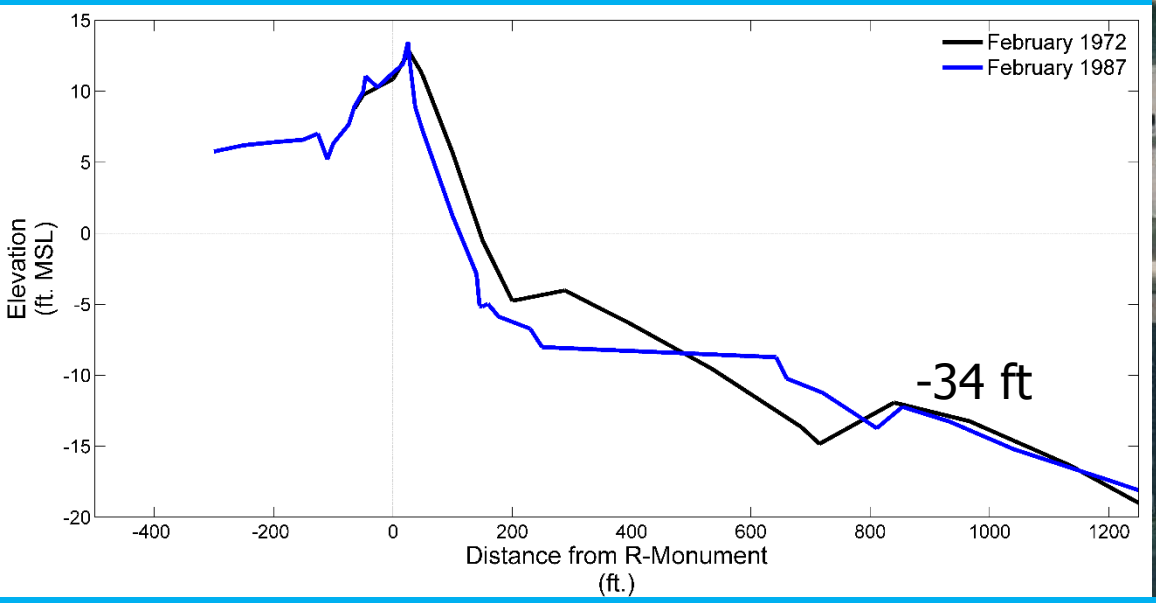
St. Lucie County

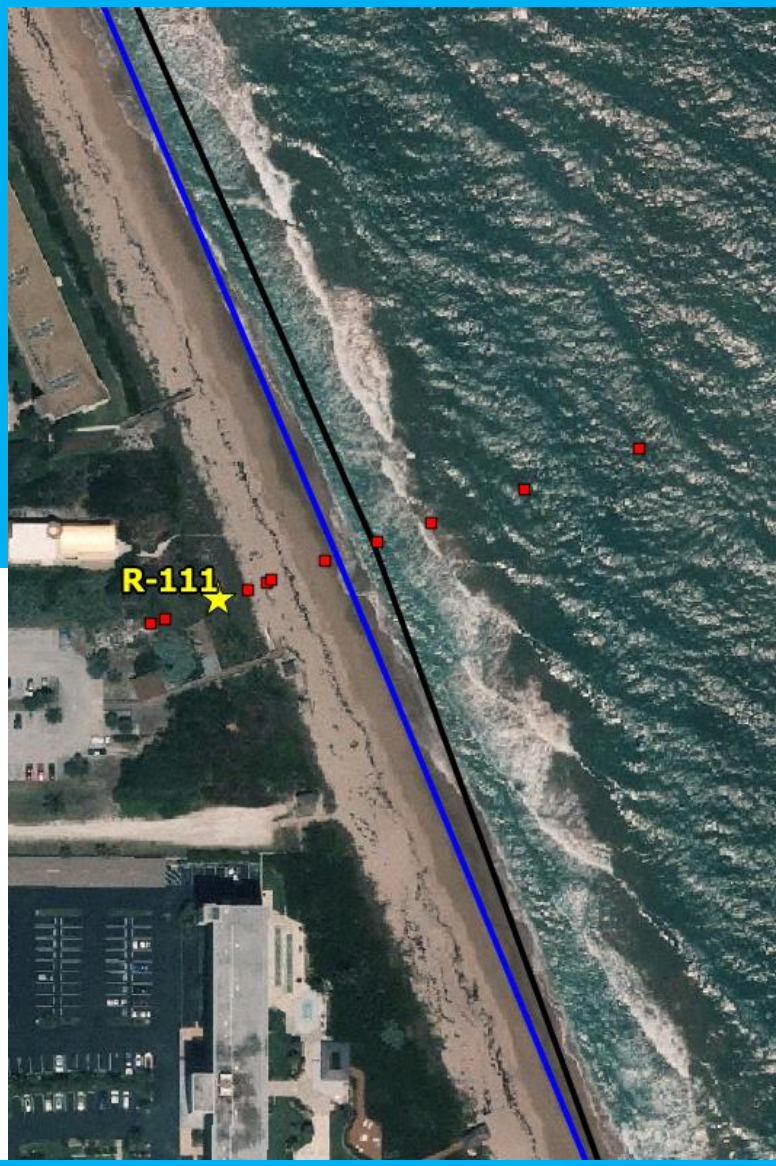


South County - St. Lucie County

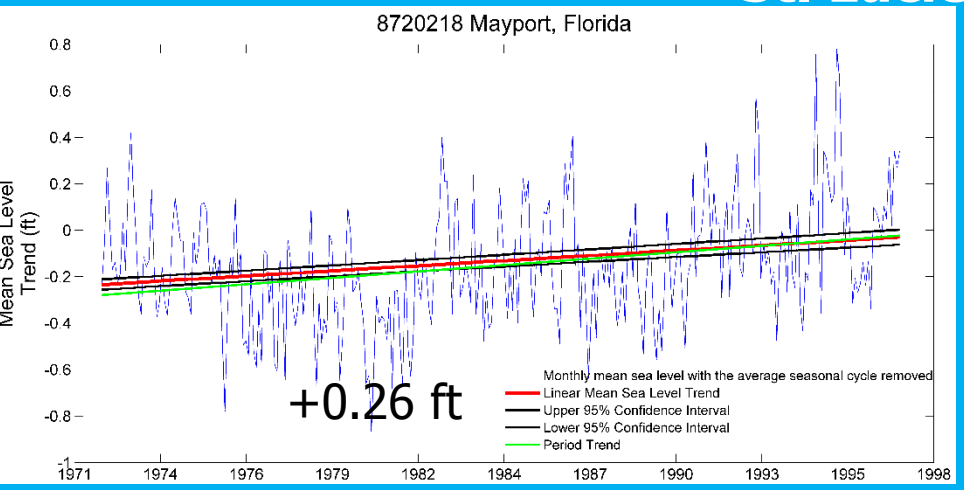
Sea Level Rise Effects on Beaches and Beach Nourishment
St. Lucie County

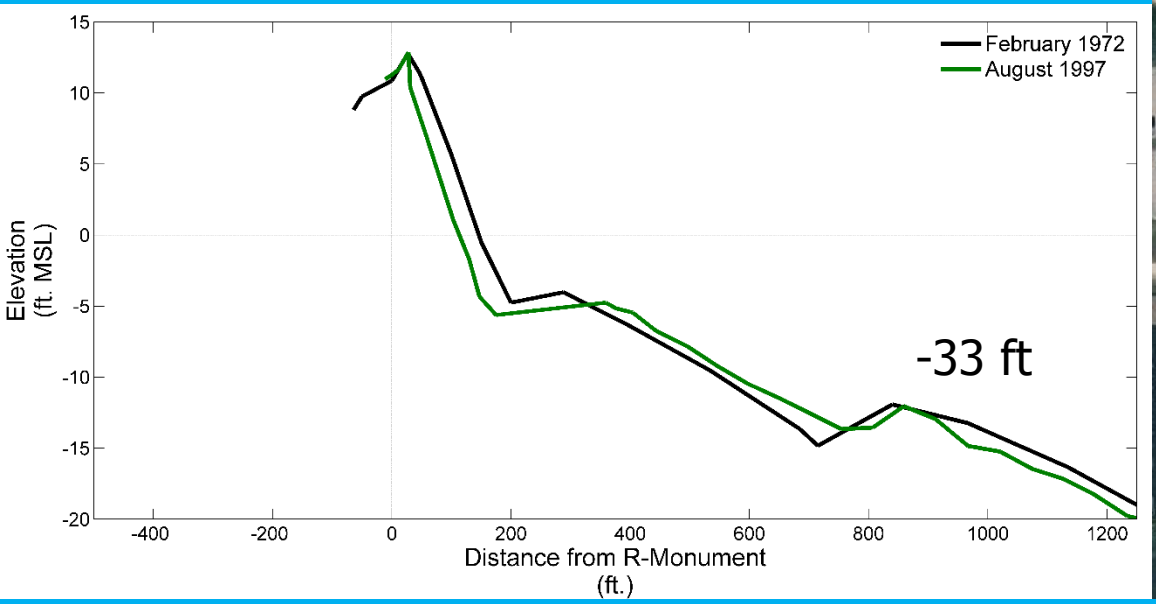




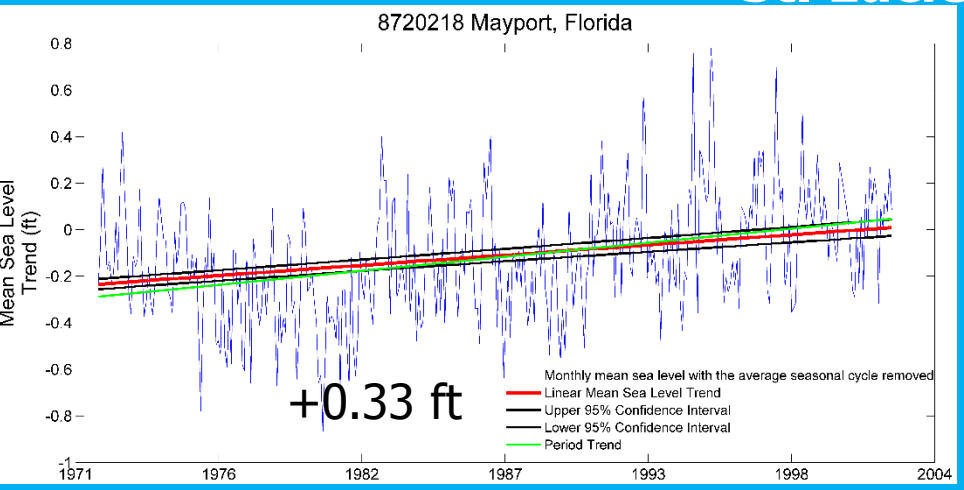


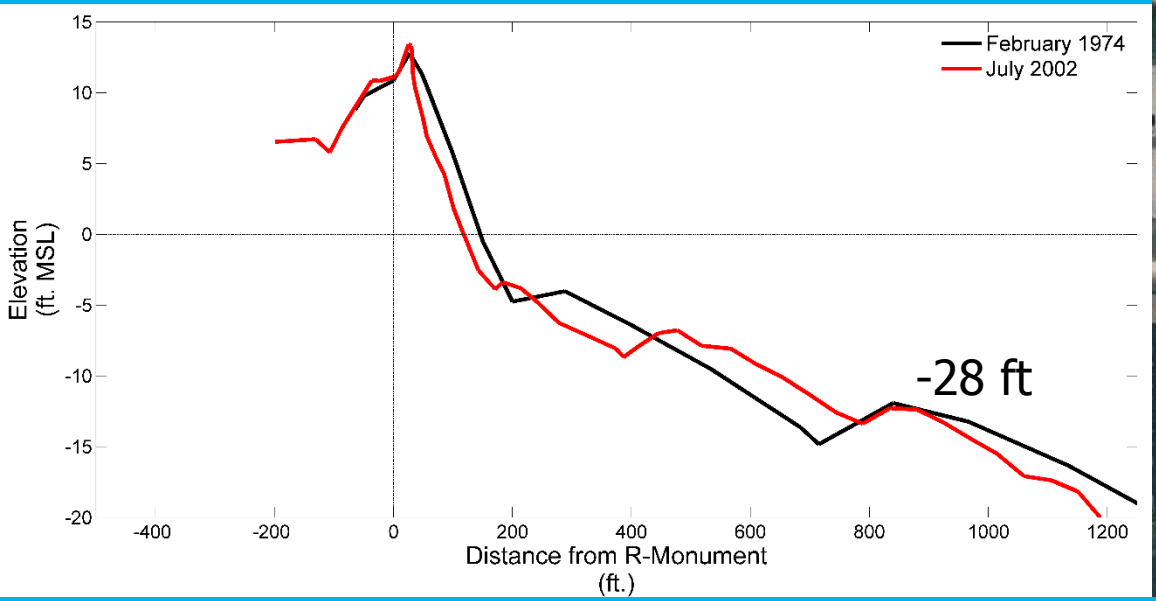
Sea Level Rise Effects on Beaches and Beach Nourishment
St. Lucie County

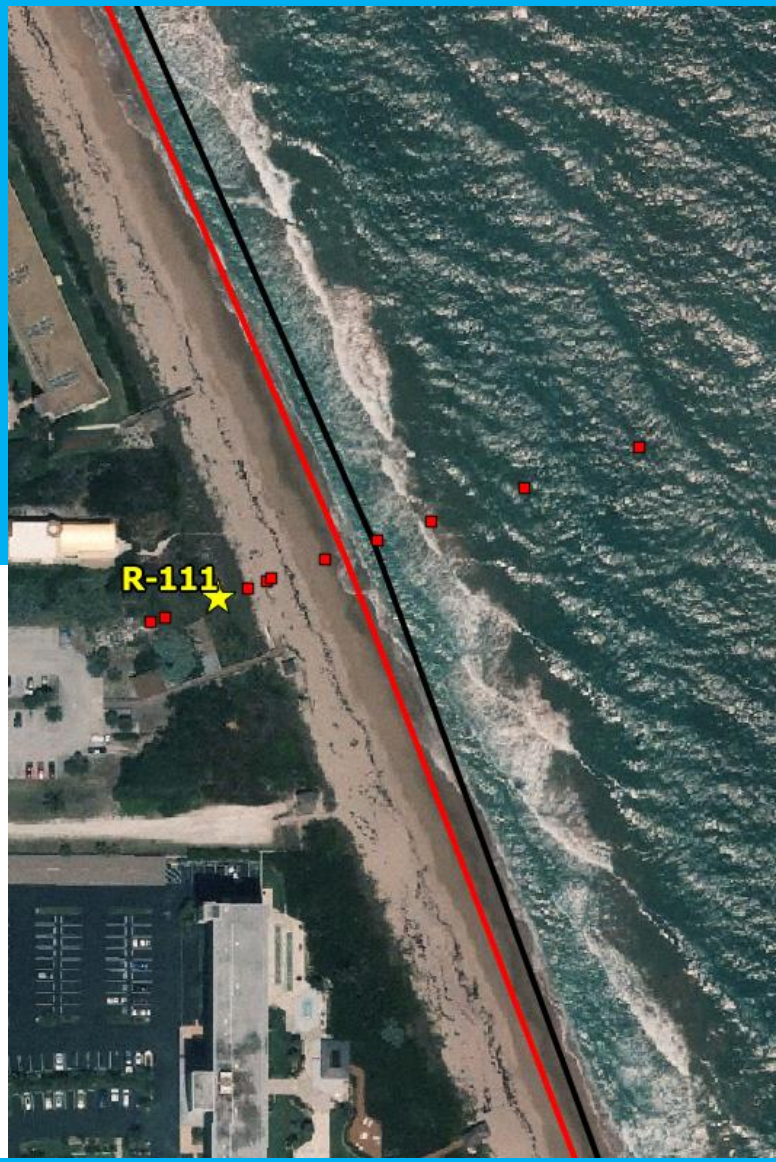




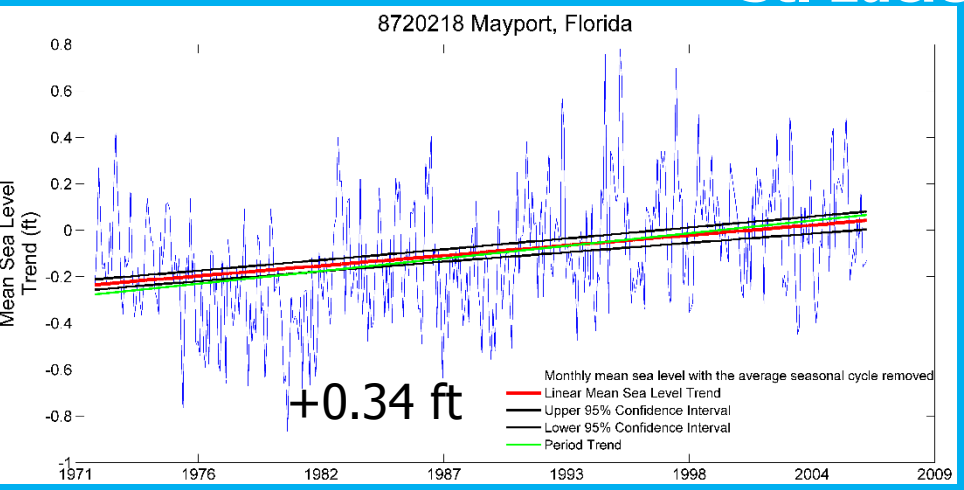
Sea Level Rise Effects on Beaches and Beach Nourishment
St. Lucie County

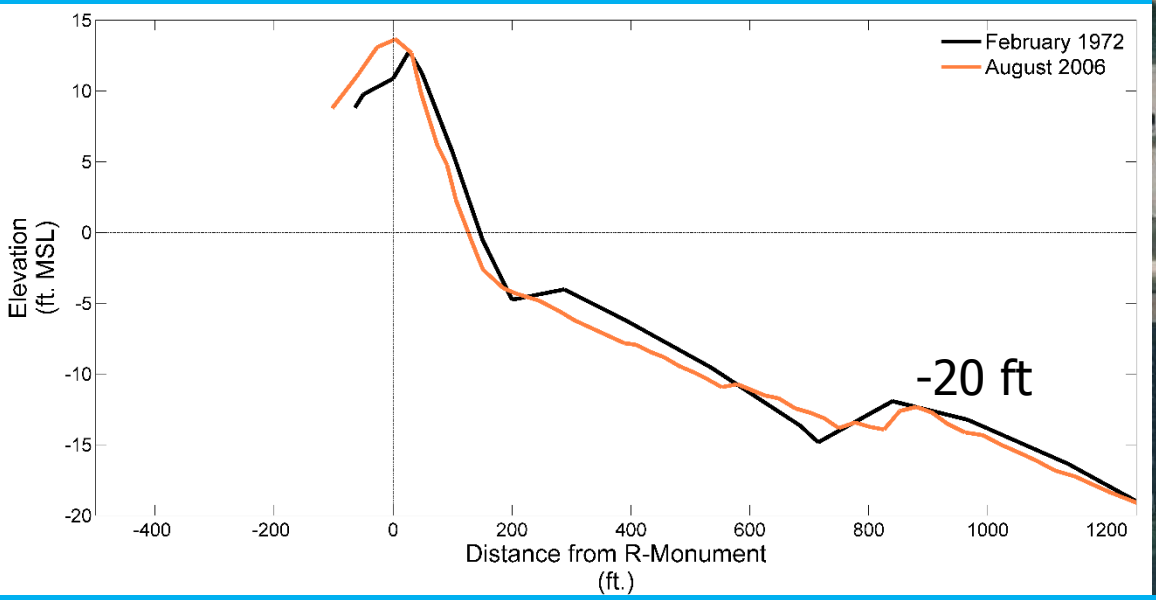


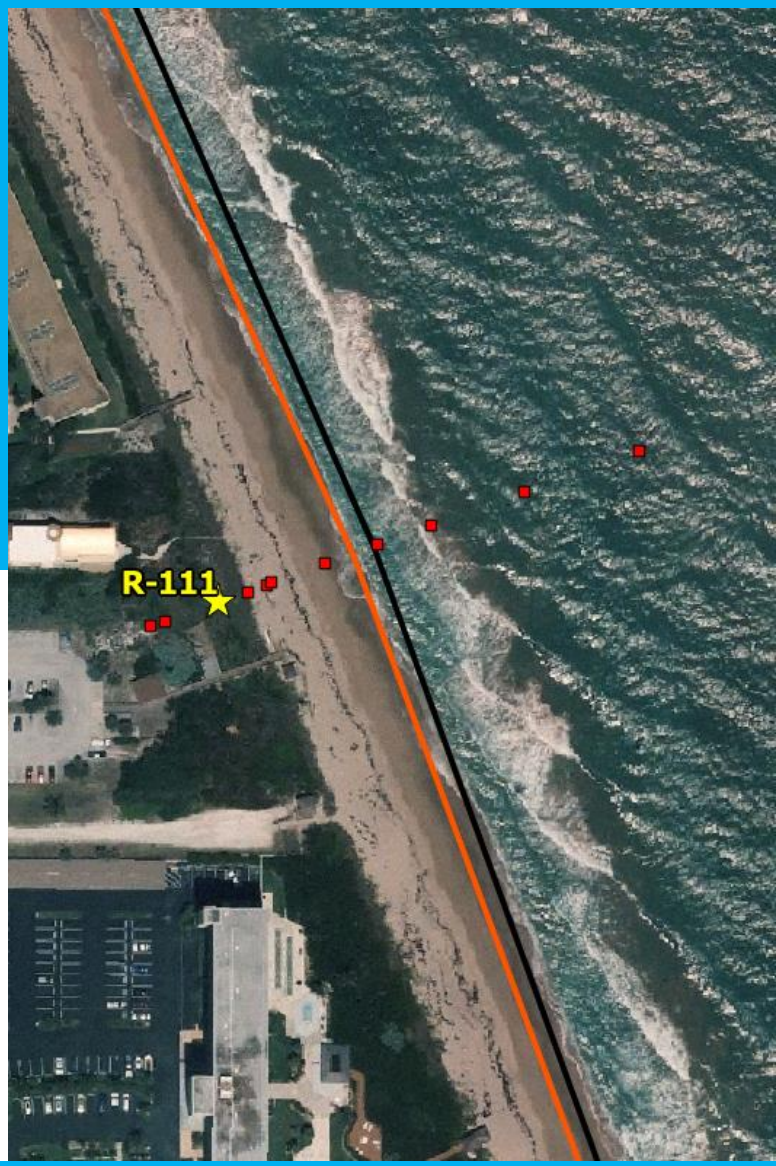




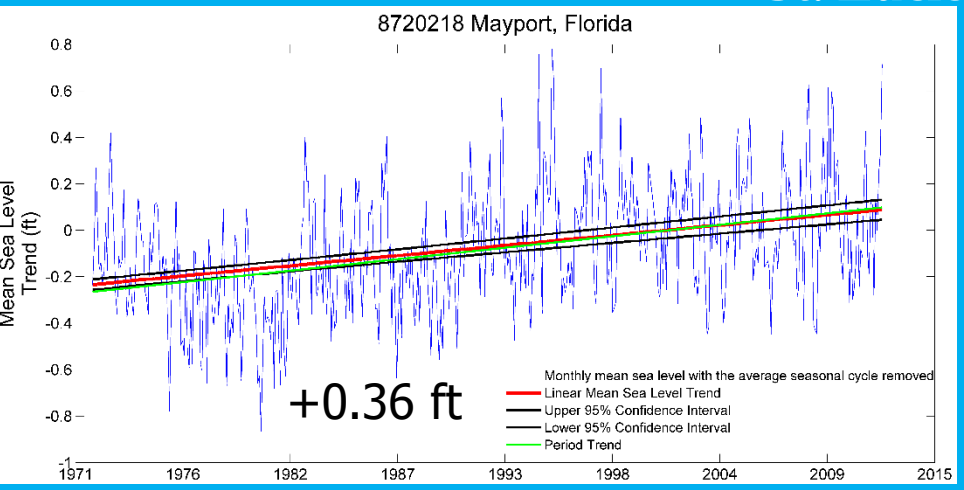
Sea Level Rise Effects on Beaches and Beach Nourishment
St. Lucie County

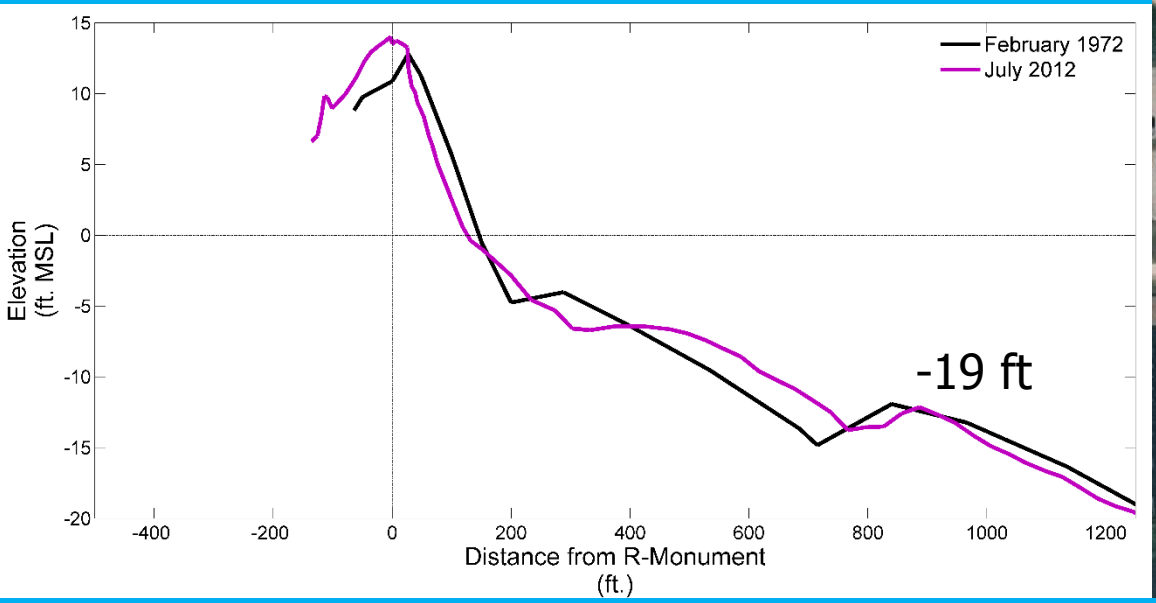


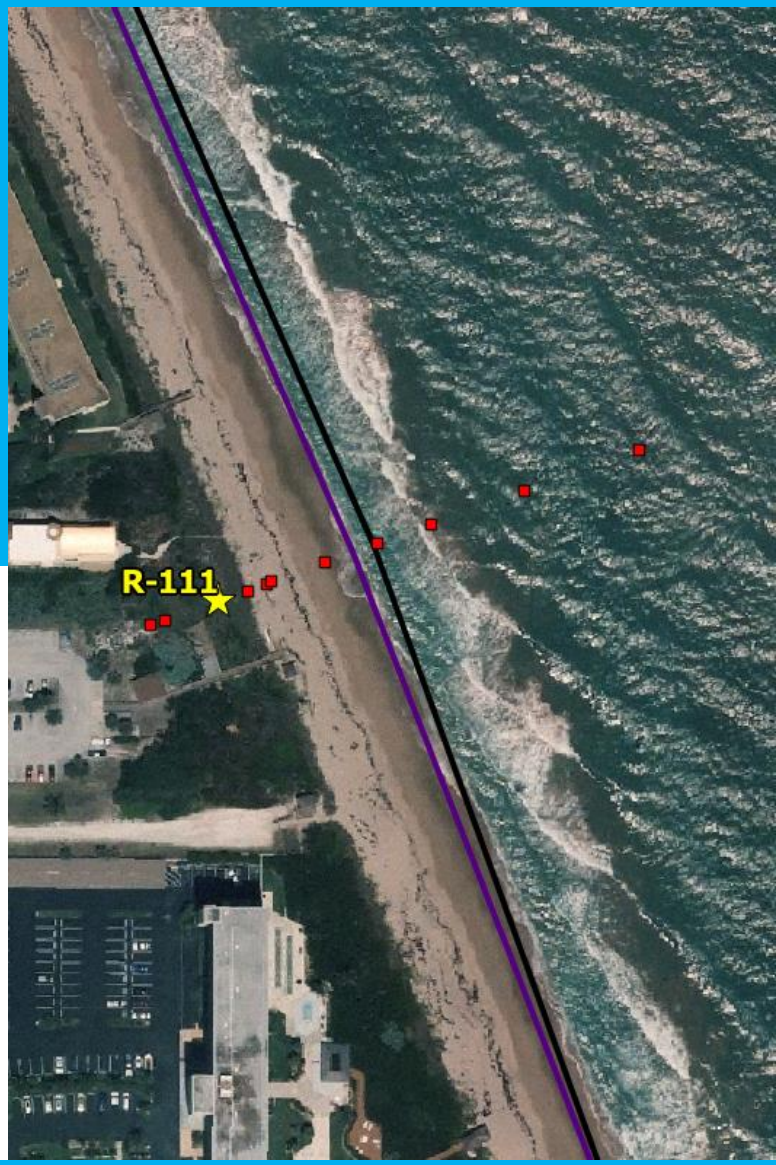


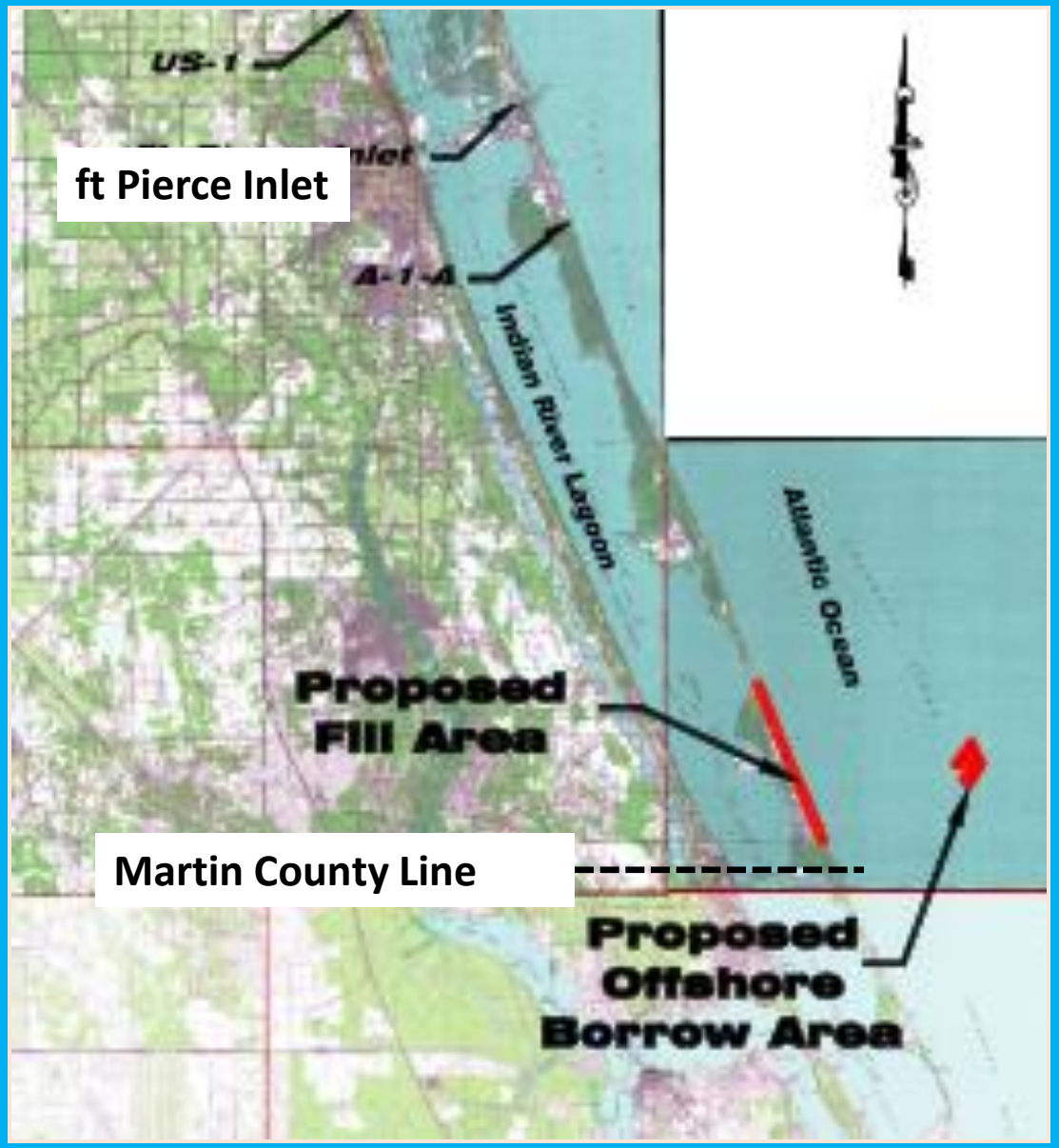


Sea Level Rise Effects on Beaches and Beach Nourishment
St. Lucie County









South County

St. Lucie County

Initial Construction:

682,500 cy

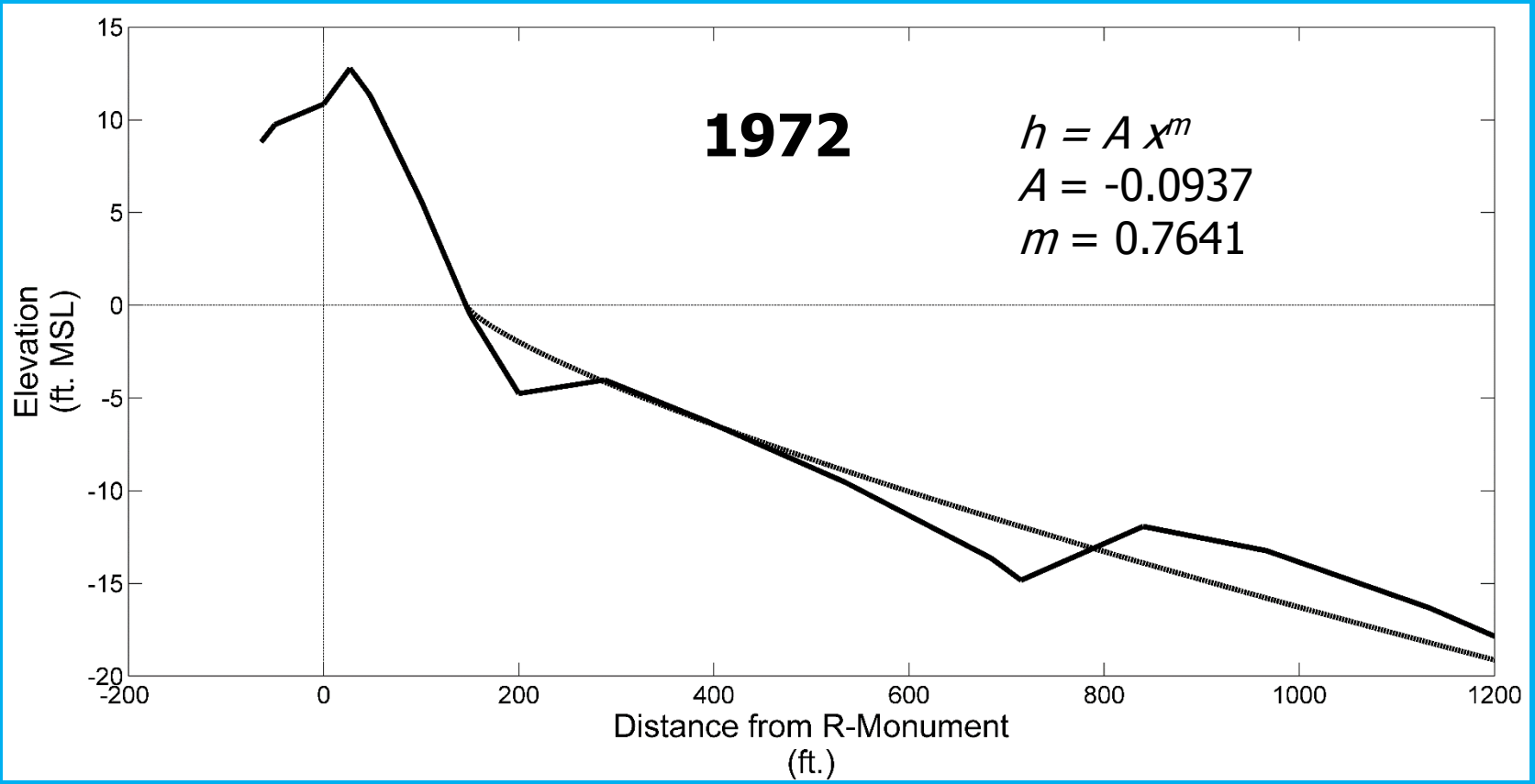
3.4 miles

38.5 cy/ft

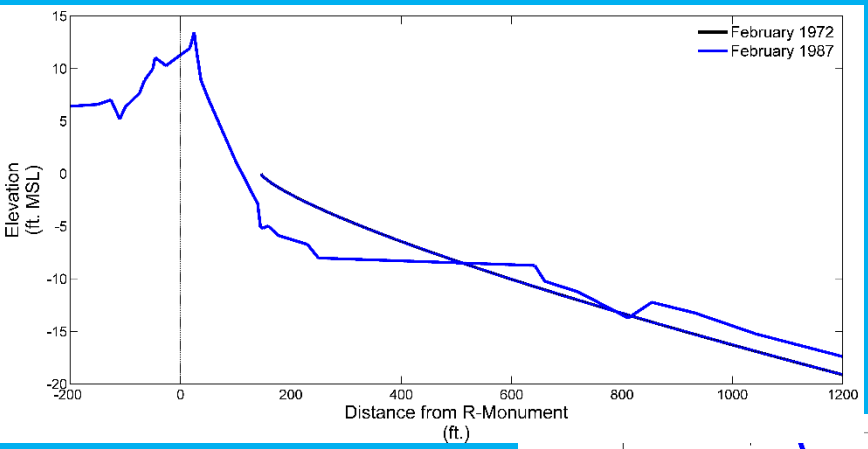
2013

Sea Level Rise

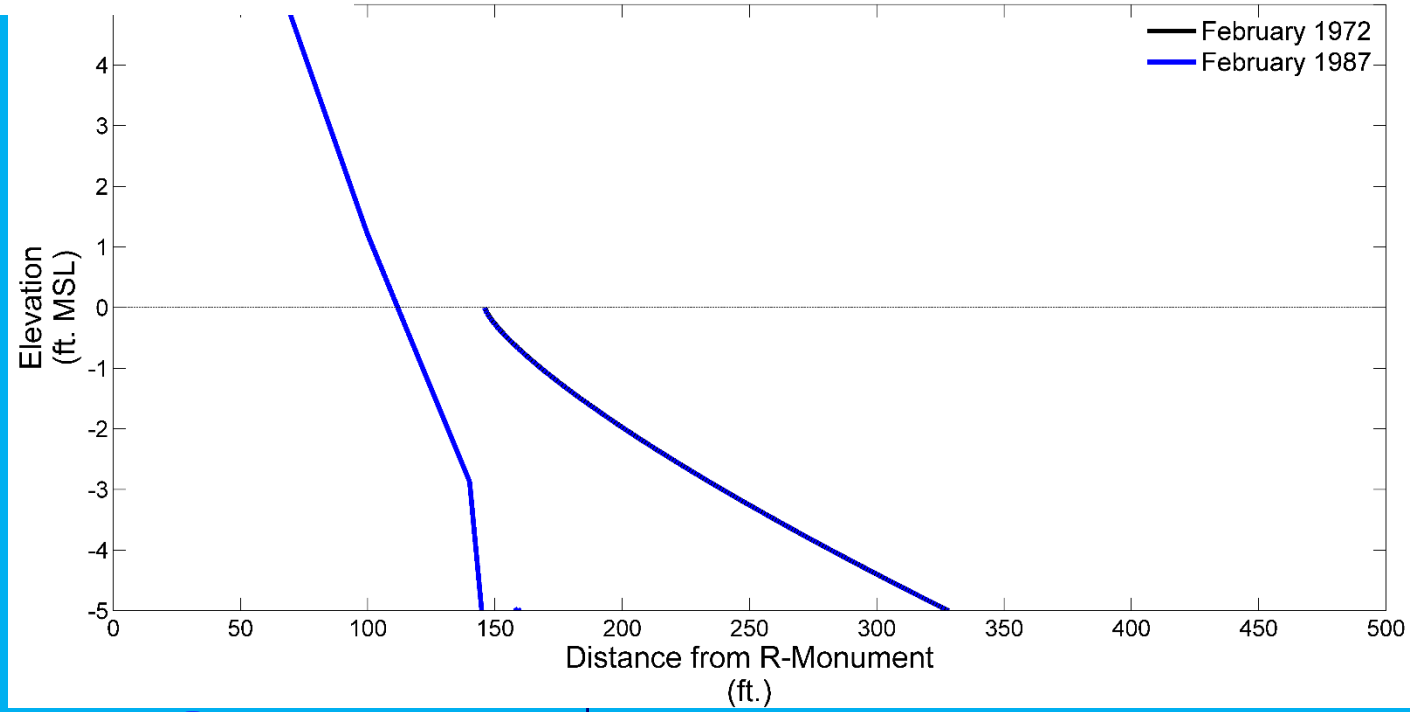
Shoreline Recession: Bruun Rule



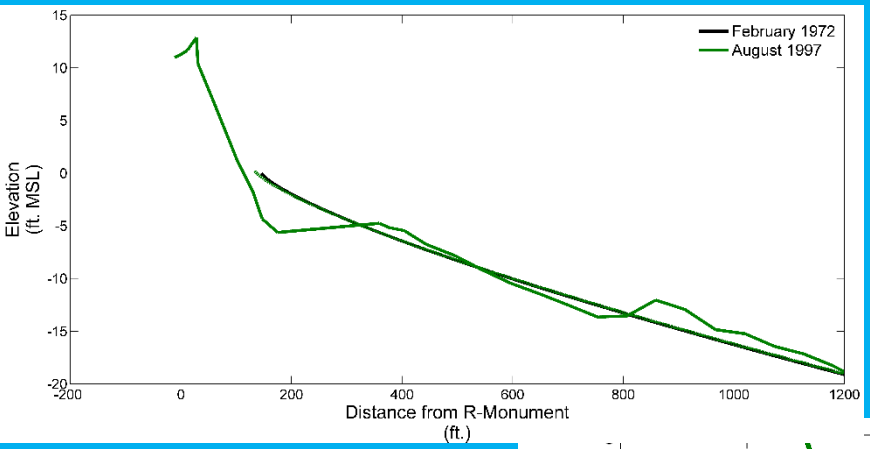
Shoreline Recession: Bruun Rule



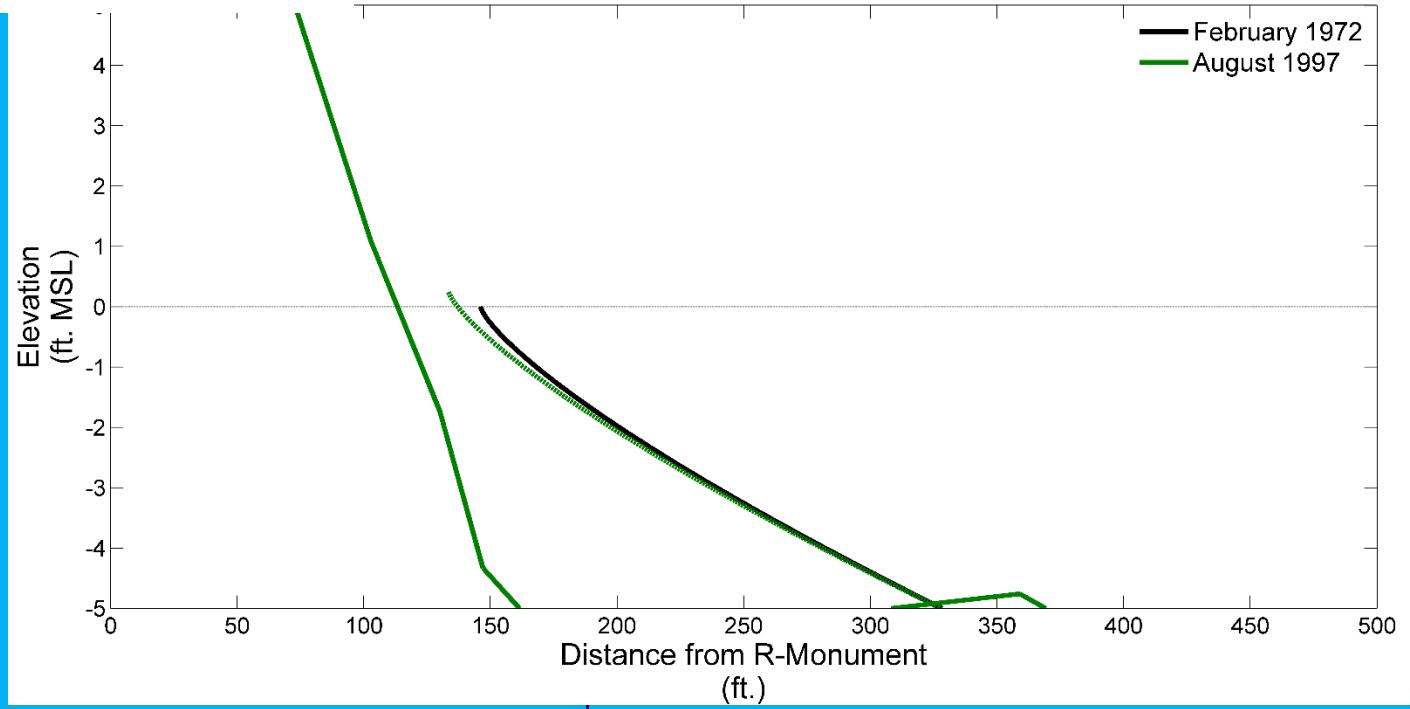
SLR = +0.006
Actual Recession = 34.22
Bruun Recession = 0.30



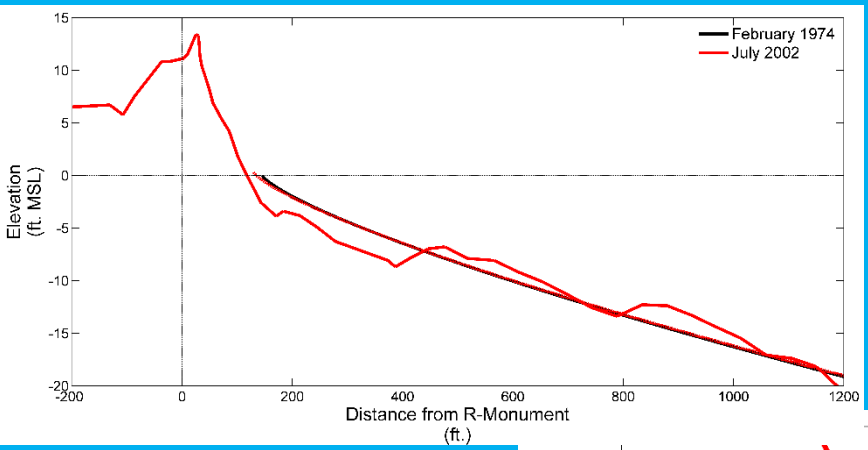
Shoreline Recession: Bruun Rule



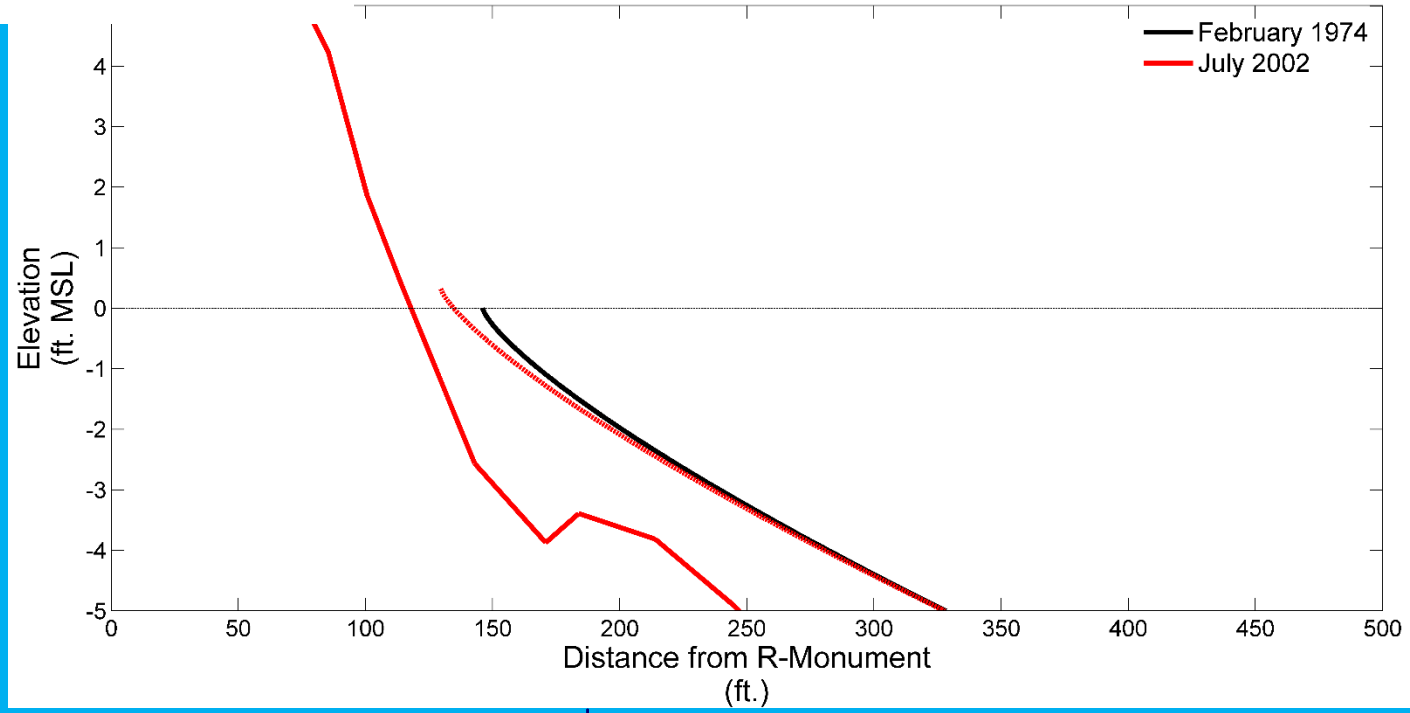
SLR = +0.26
Actual Recession = 32.70
Bruun Recession = 12.68



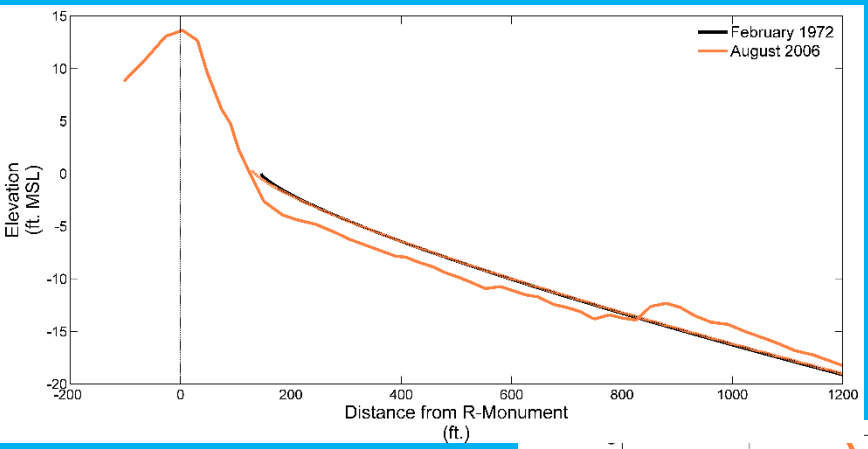
Shoreline Recession: Bruun Rule



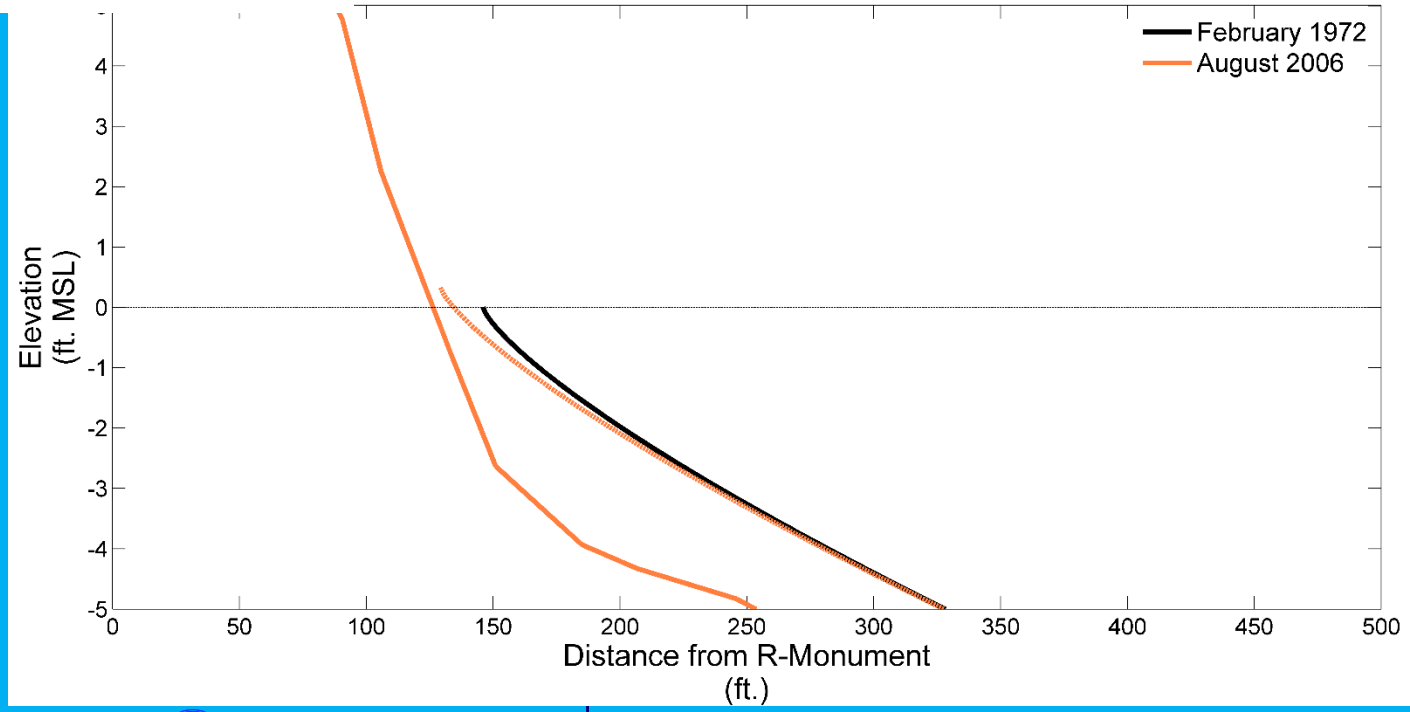
SLR = +0.33
Actual Recession = 28.31
Bruun Recession = 16.54



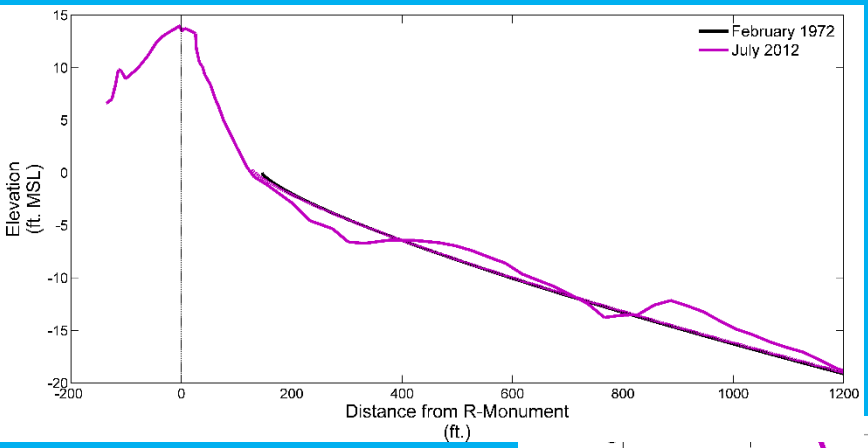
Shoreline Recession: Bruun Rule



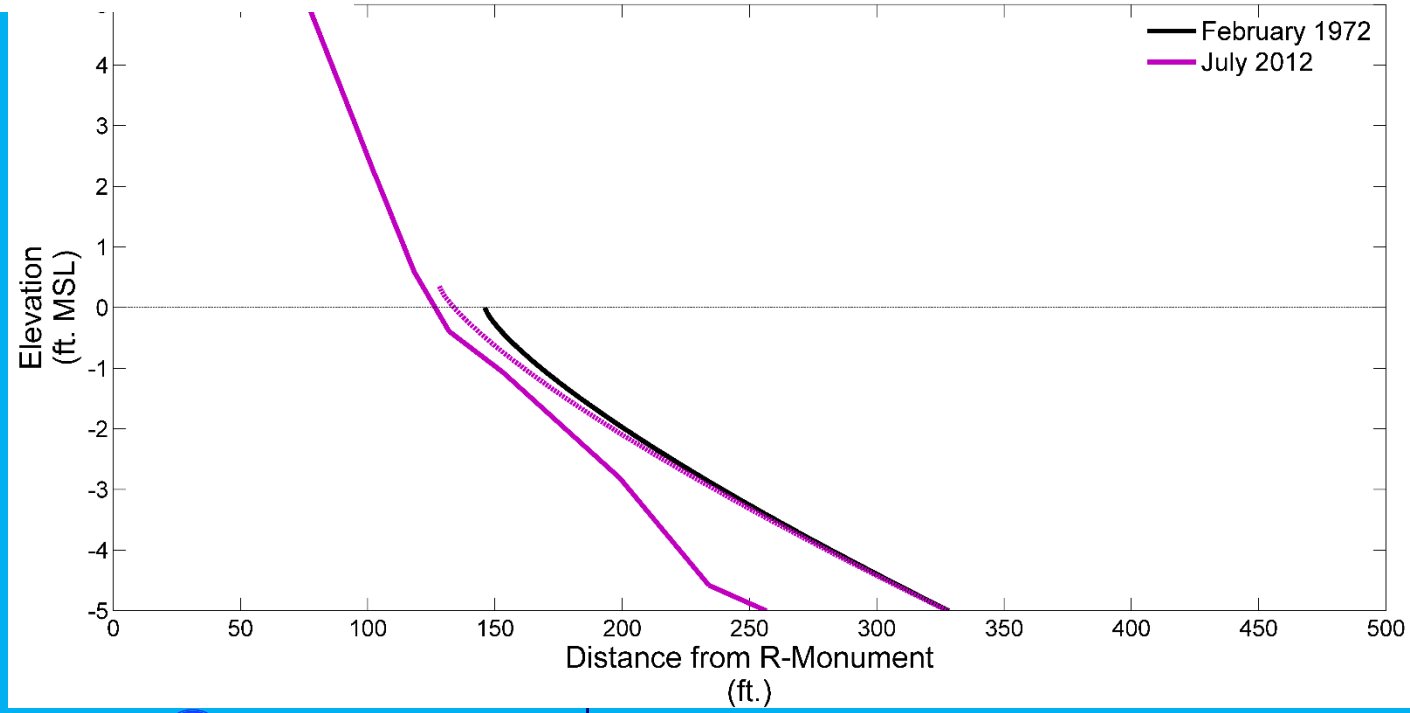
SLR = +0.34
Actual Recession = 19.66
Bruun Recession = 16.91



Shoreline Recession: Bruun Rule

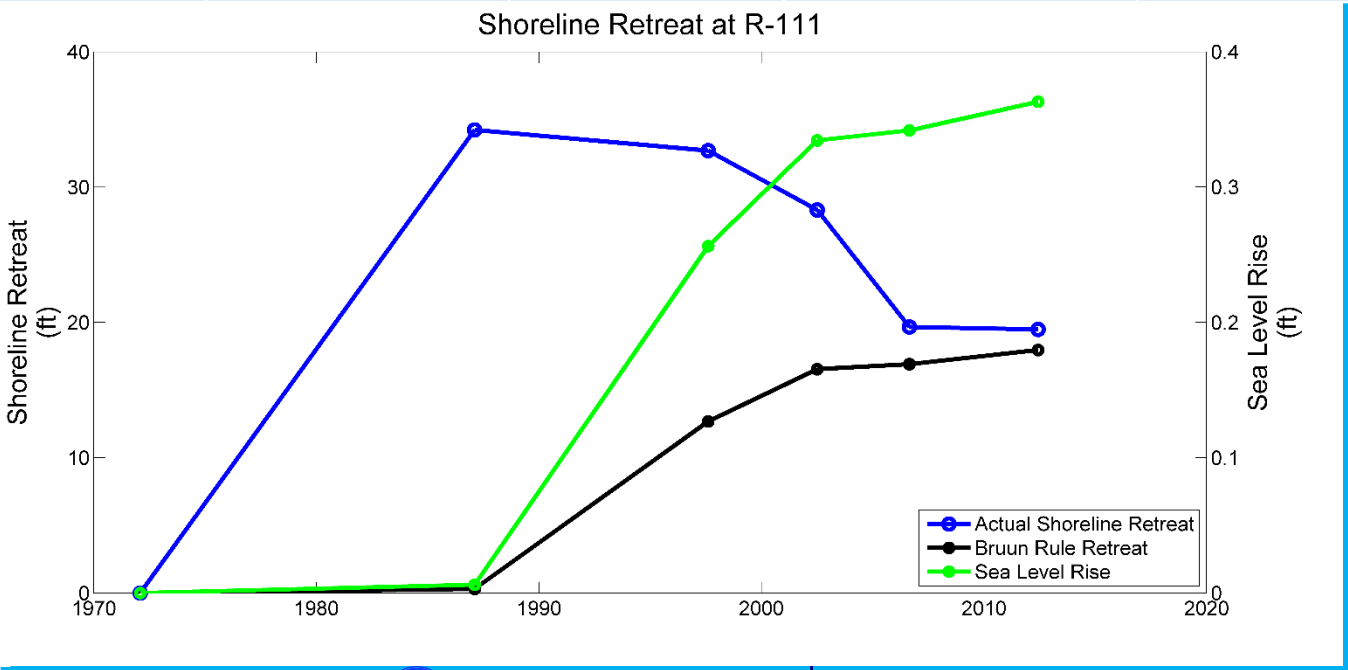


SLR = +0.36
Actual Recession = 19.48
Bruun Recession = 17.95



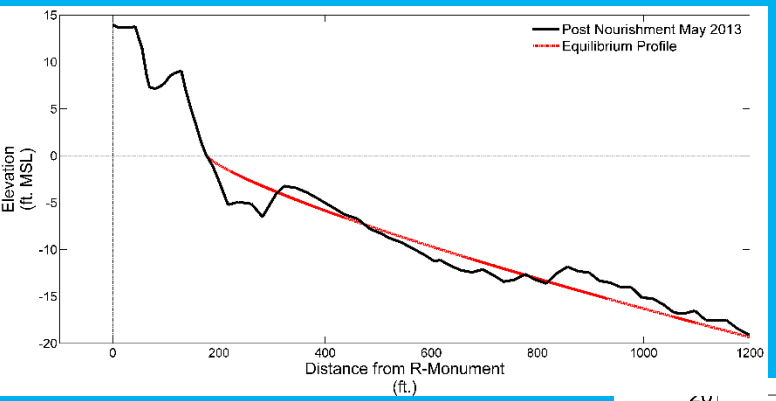
Shoreline Recession: Bruun Rule

Year	Bruun (ft)	Actual (ft)	Difference (ft)	% Error
1987	0.30	34.22	33.92	99
1997	12.68	32.70	20.02	61
2002	16.54	28.31	11.77	41
2006	16.91	19.66	2.75	14
2012	17.95	19.48	1.53	8

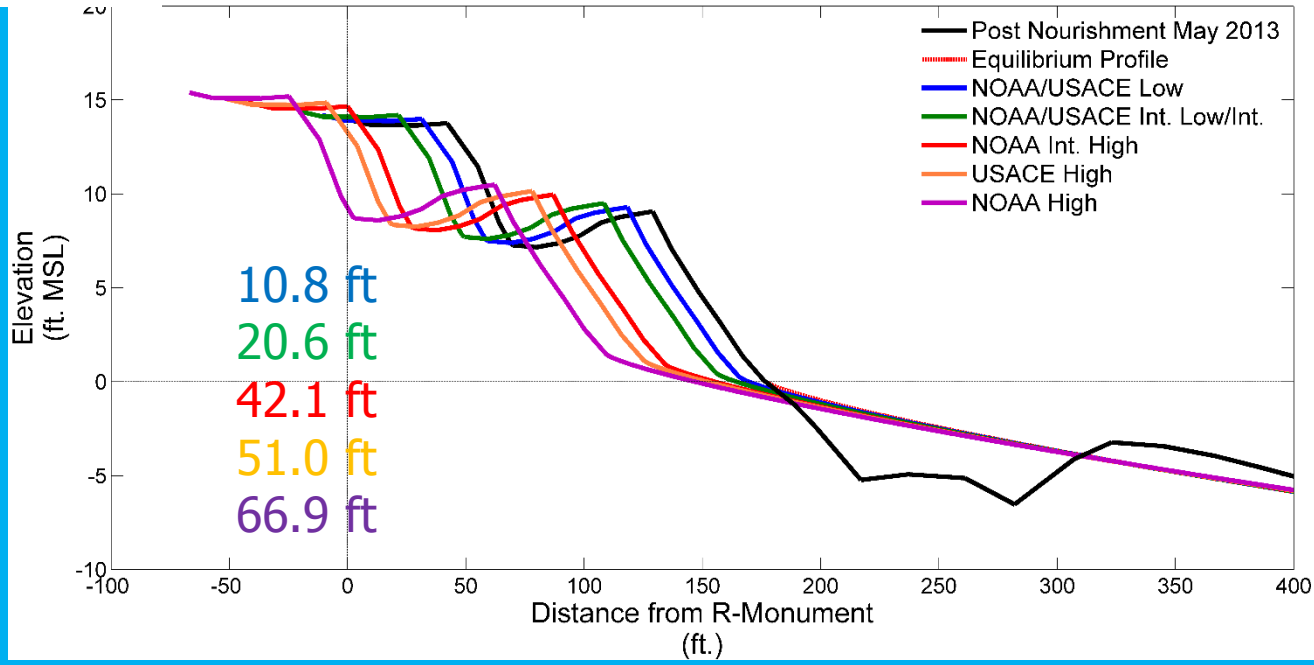


Sea Level Rise - Projections

Shoreline Recession: Bruun Rule



1972 – 2002
30 Year Period
Recession: 28.3 ft
SLR: +0.33 ft



Sea Level Rise

Shoreline Recession: Bruun Rule

- Provides order of magnitude estimate of shoreline recession
- Works best over long, quiet periods
- Does not account for along-shore transport, storm events, localized dynamics
- Good first estimate, but more sophisticated models that account for all relative processes should be used

Sea Level Rise

Effect on Beach Fills – future nourishment

to offset longshore sediment transport gradient & sea level rise

$$\frac{\partial V}{\partial t} = \underbrace{(h_* + B)\frac{\partial R_0}{\partial t}}_{\text{Volume required for present rate of SLR}} + \underbrace{W_*\left(\frac{\partial S}{\partial t} - \frac{\partial S_0}{\partial t}\right)}_{\text{Amount due to the increased SLR rate}}$$

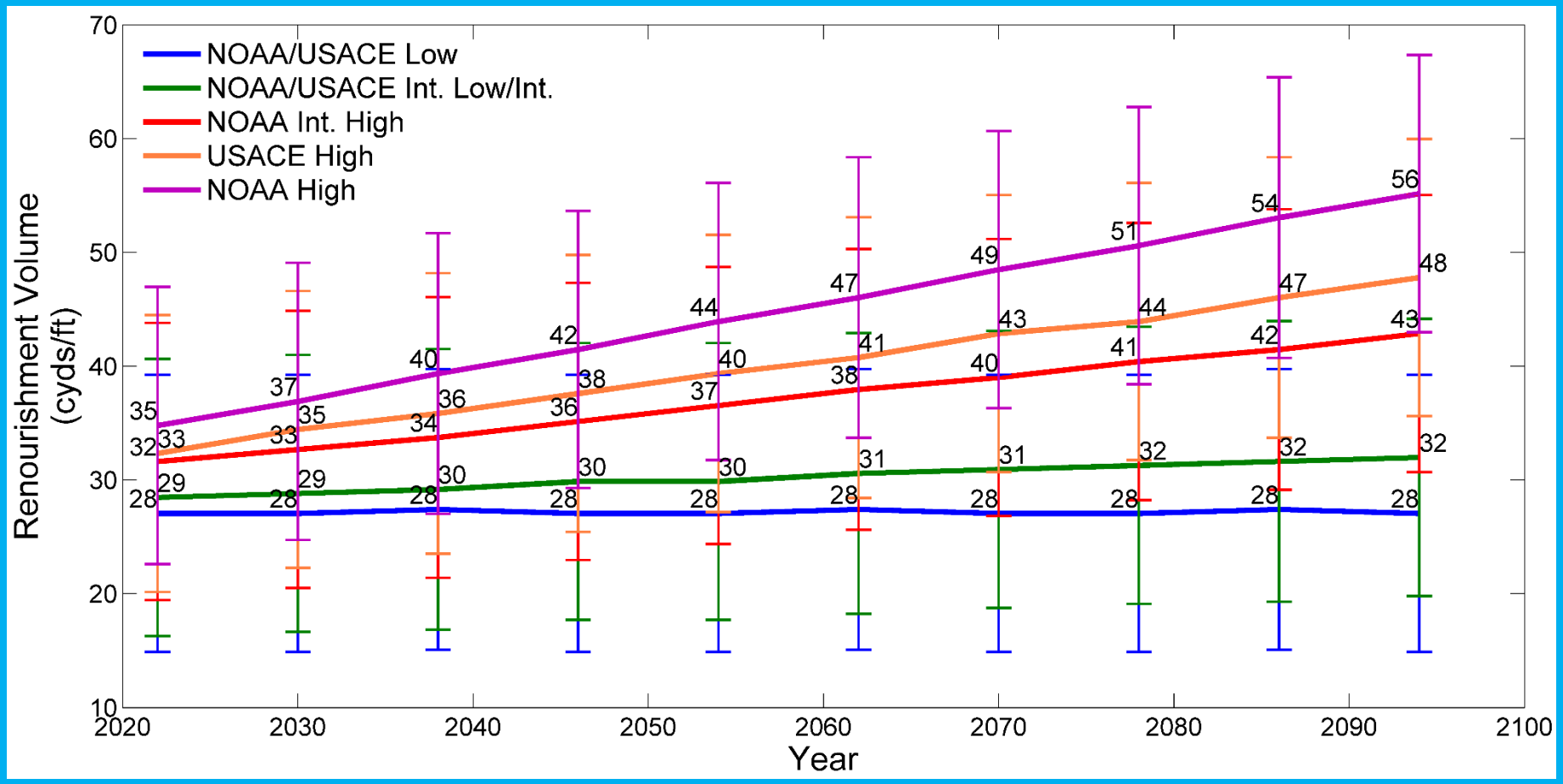
Where

- $\frac{\partial V}{\partial t}$ = Volumetric rate of nourishment addition per unit length of beach (cyds / ft / yr)
- $\frac{\partial R_0}{\partial t}$ = Existing background erosion rate (ft / yr)
- $\frac{\partial S}{\partial t}$ = Rate of sea level rise (ft / yr)
- $\frac{\partial S_0}{\partial t}$ = Existing sea level rise rate (ft / yr)
- W_* = Width of the active beach profile (ft)
- h_* = Depth of closure (ft)
- B = Berm height (ft)

Adapted from: Dean, R.G and Dalrymple, R.A., 2002. "*Coastal Processes with Engineering Applications*". Cambridge: Cambridge University Press, 475 p.

Sea Level Rise – Navarre Beach

Effect on Beach Fills – future nourishment

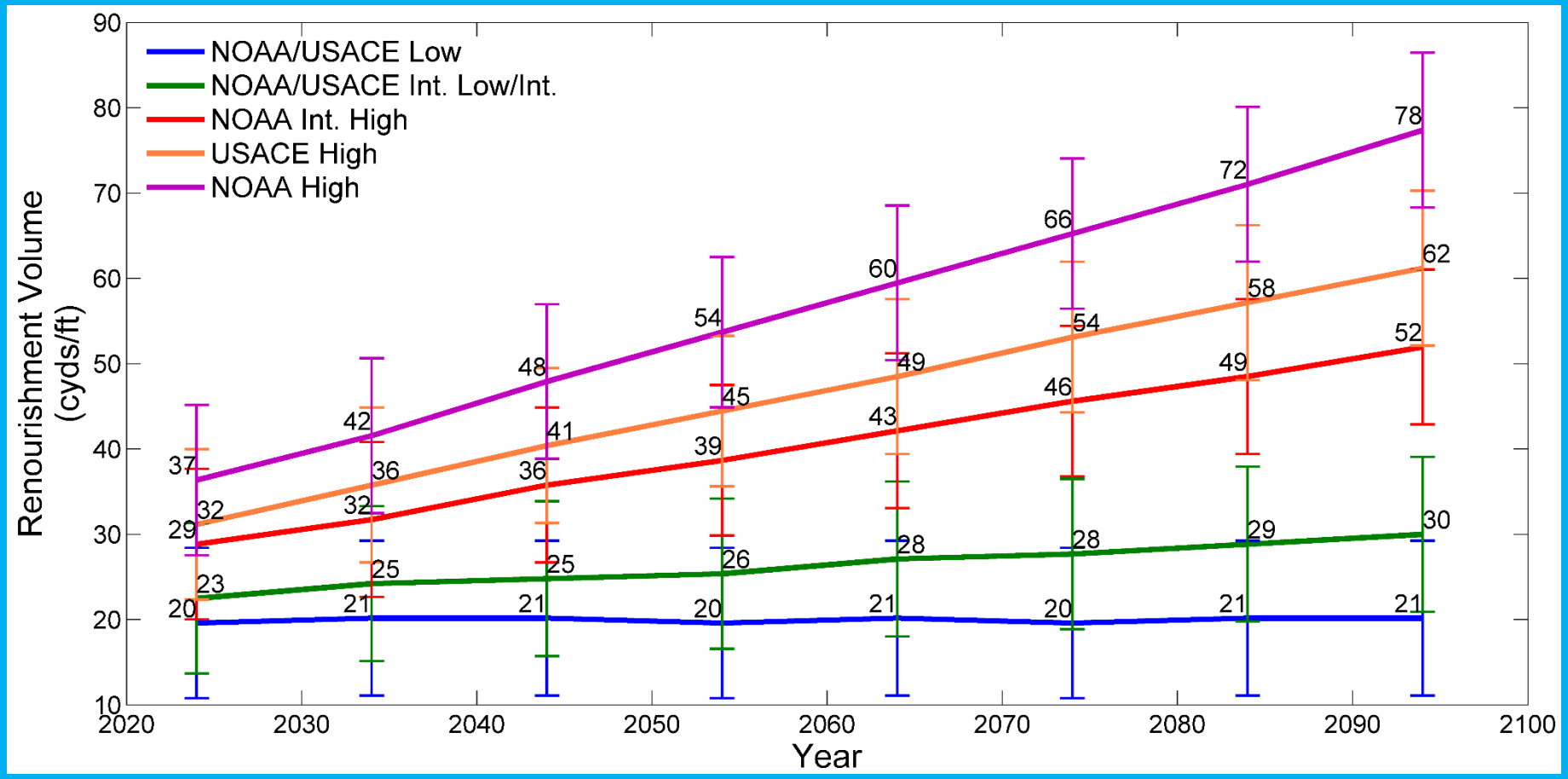


Based on an 8 year renourishment cycle
Background erosion rate of 1.2 ft / yr
Existing Sea Level Rise rate of 0.007 ft / yr

Historic data from: Absalonsen, L. and Dean, R. G., 2010. "Characteristics of the Shoreline Change Along the Sandy Beaches of the State of Florida: An Atlas."

Sea Level Rise – St. Lucie County

Effect on Beach Fills – future nourishment



Based on an 10 year renourishment cycle
Background erosion rate of 0.6 ft / yr
Existing Sea Level Rise rate of 0.008 ft / yr

Historic data from: Absalonsen, L. and Dean, R. G., 2010. "Characteristics of the Shoreline Change Along the Sandy Beaches of the State of Florida: An Atlas."

Conclusions

- **Sea level change is estimated to rise 0.14 feet to 1.45 feet in Florida over the next 30 years**
- **Bruun Rule can be used as order of magnitude estimate. It does not account for along-shore processes**
- **Storm events far exceed the threat of sea level rise (i.e. Ivan ~ = NOAA High Rate for 30 years)**
- **Over the next 30 years, fill quantities needed to offset sea level rise are within range of historical values.**
- **Each case needs to be assessed individually due to wide variation in local shoreline patterns**

Thank you

Questions?