

Sea Level Rise and the Florida Coast



Game Plan

1. Give a background on sea level rise projections
2. Present new IPCC projections, the first since 2013



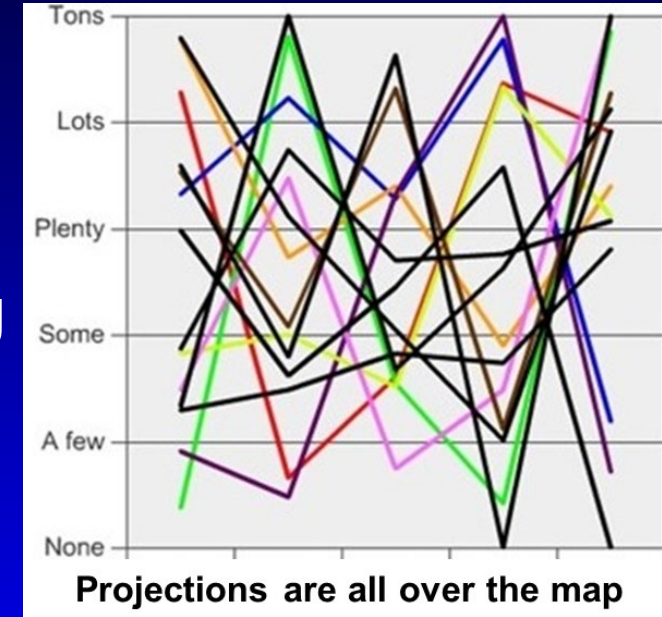
Beach Nourishment vs Sea Level Rise

3. Discuss the future of Florida shorelines given the new IPCC projections

1. Background

Sea Level Rise is a Perplexing Topic

- All US agencies accept IPCC CO₂ and temperature projections
- But, nonsensically they choose sea level rise projections that differ among themselves and with the IPCC

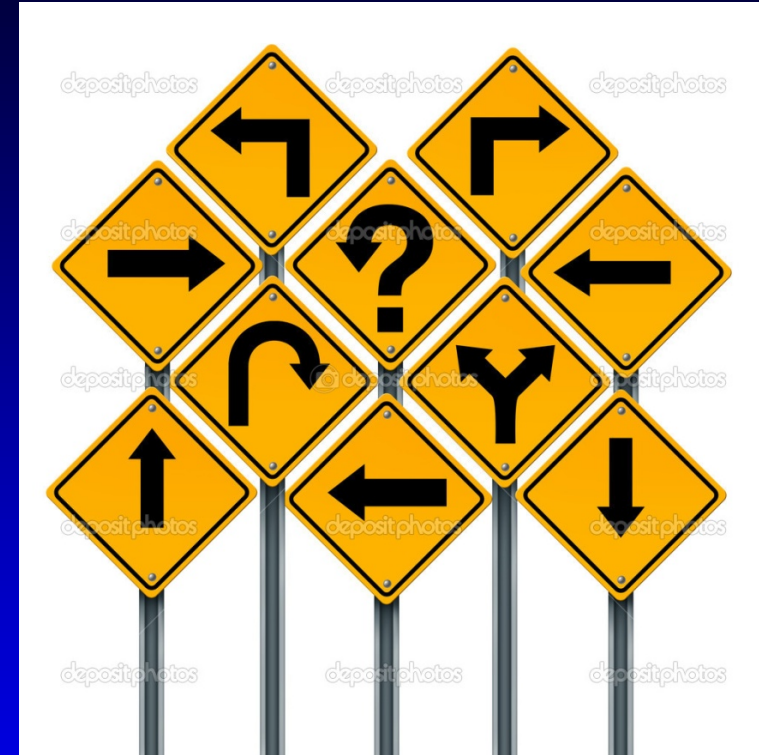


Why Are There Different Projections?

- Agencies seem to believe IPCC projections are not high enough to spur society into action



- Agencies lack expertise, so accept projections from those not expert enough to be IPCC scientific contributors



**Confusion, Lack of Credibility,
Undercutting of the IPCC and
Climate Change**

Expertise is Required in Diverse Areas

1. Thermal expansion

- Water expands when heated
- Requires tremendous supercomputer time

2. Melting mountain glaciers



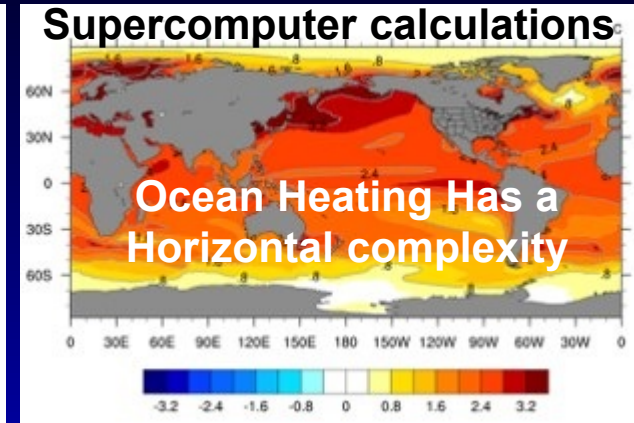
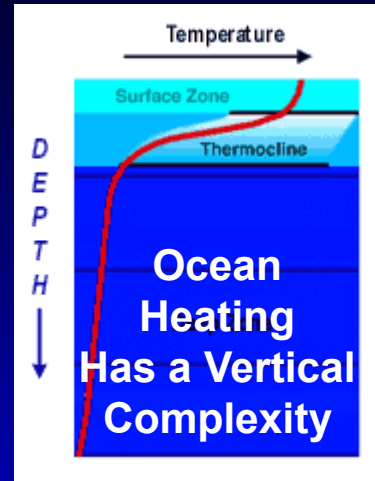
198,000 glaciers



3. Ice Melting Greenland



5. Ice Melting Antarctica



50-yr Temperature Increase

Over 50 mountain glacier experts supported IPCC 2021 projections



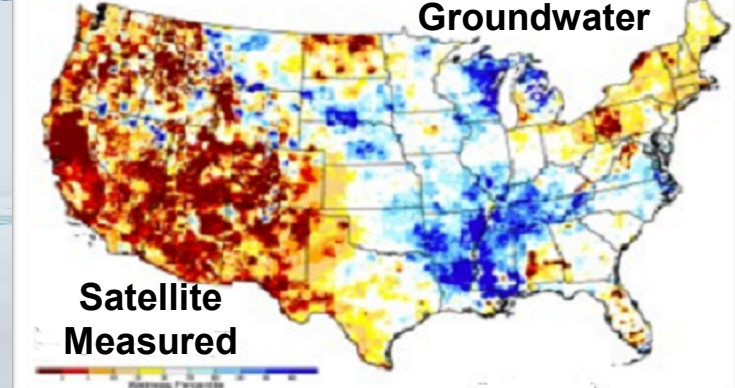
4. Groundwater Extraction

(10 times more groundwater than water than in the Greenland ice sheet)

140 Greenland & Antarctica experts supported IPCC projections

IPCC Has the Expertise

- 92 of the world's experts on all aspects of sea level rise made the 2021 projections
- Supported by thousands of expert scientists
- 1st draft projections were peer reviewed by 750 experts and the 2nd draft by 1279



All Agencies Accept IPCC Warming Scenarios

Scenarios with 2021 projected sea level rises



RCP1.9

1.0- 1.8 C



RCP2.6 Paris Agreement

1.3 - 2.4 C

RCP3.4



RCP4.5

2.1 - 3.5 C

RCP6.0



RCP7.0

2.8 - 4.6 C



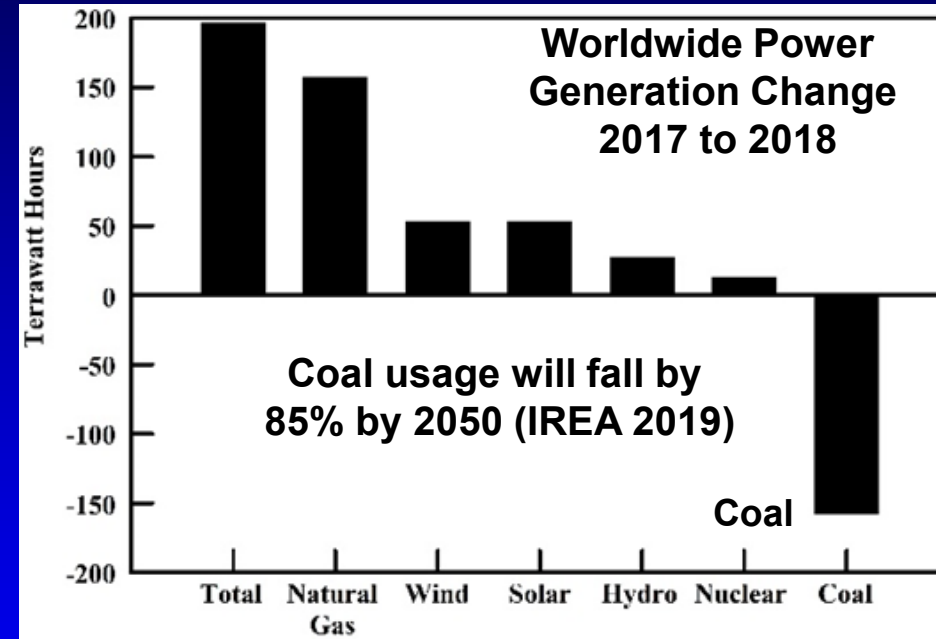
RCP8.5

3.3 - 5.7 C

- Recent study determined that RCP3.4 is the most plausible warming scenario by 2100 (Pielke et al 2021)
- IPCC 2021 says the most likely temperature increase is 3 C

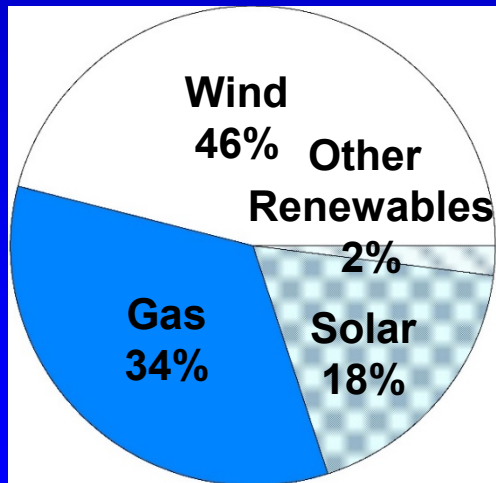
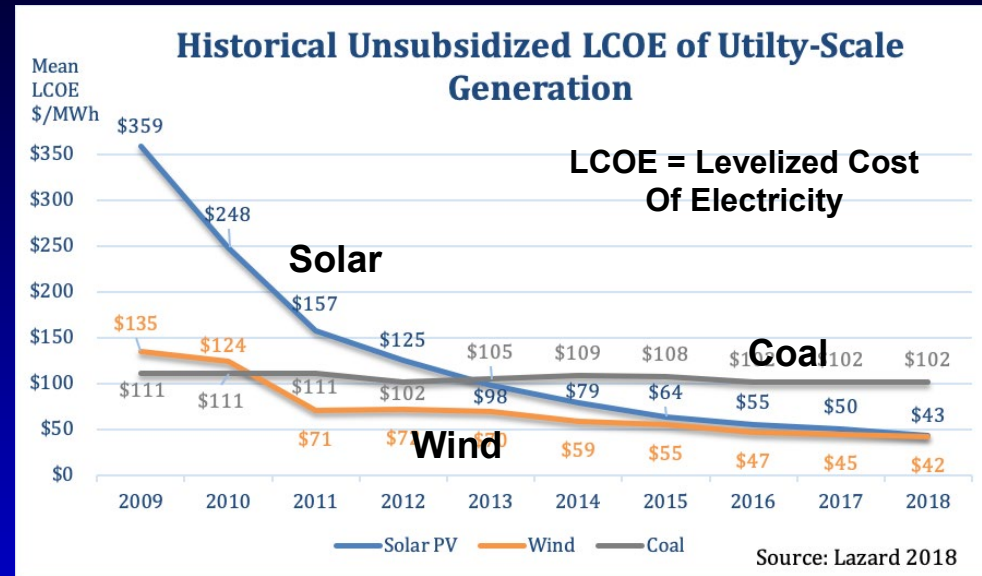
RCP 8.5 “Unlikely”, “Exceptionally Unlikely”

- RCP 8.5 is the “most severe climate scenario and might be so extreme that it's no longer a likely outcome, experts say” (Scientific American 2020)
- “RCP 8.5 with its vast coal consumption is considered exceptionally unlikely” (Richie and Dowlatabadi, 2017; Burgess et al 2021)
- RCP 8.5 assumes world will use 7 times more high-CO₂ coal by 2100
- RCP 8.5 was developed in 2007 and is outdated because it assumes no technological advances by 2100

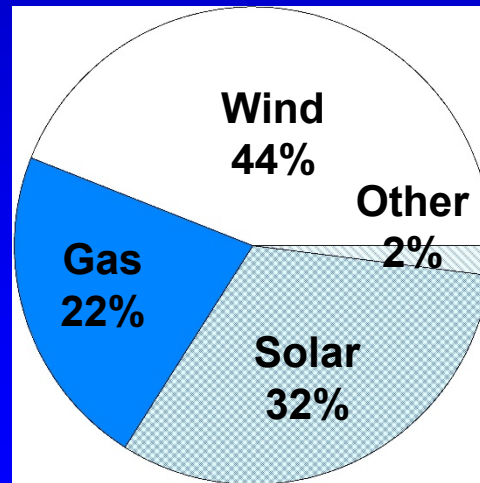


Significant Technological Advances

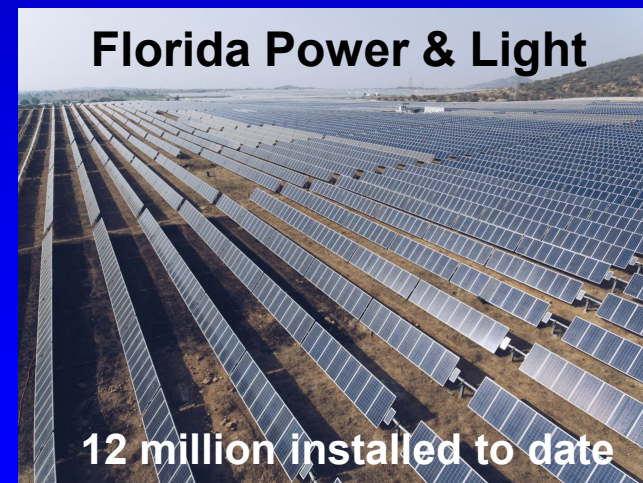
- Fracking made natural gas much cheaper than coal (with 40 - 45% of the CO₂ footprint)
- “Unsubsidized wind and solar is now the cheapest provider of energy in most major economies” (IEEFA, 2018)



Power added US in 2019



Power added US in 2020



Constructing world's largest solar battery system in Manatee County

2. IPCC 2021 Sea Level Projections to 2100

- IPCC scientists worked 8 years since 2013 on their 2021 projections
- All IPCC scientists are climate change believers who want to get society to take action



	2100					
Scenario	1.9	2.6	4.5	7.0	8.5	8.5+
Rise (ft)	1.2	1.4	1.8	2.2	2.5	3.3

- 8.5+ is the upper bound of the “**exceedingly unlikely**” 8.5 scenario making it close to virtually impossible
- IPCC introduced a “low confidence” scenario of catastrophic failure of the Antarctic ice sheet 3.2 (2.7-3.9) ft

IPCC 2021 Versus Compact 2019 Projections

Scenario	1.9	2.6	4.5	7.0	8.5	8.5+	Catastrophic Failure
Rise (ft)	1.2	1.4	1.8	2.2	2.5	3.3	3.2 (2.7-3.9)

Southeast Florida Regional Climate Change Compact 2019

Scenario	Low	Medium	High
Rise (ft)	2.7	6.1	8.6



**The Compact says its low is the 2013 IPCC 8.5 worst case scenario!
("extremely unlikely")**

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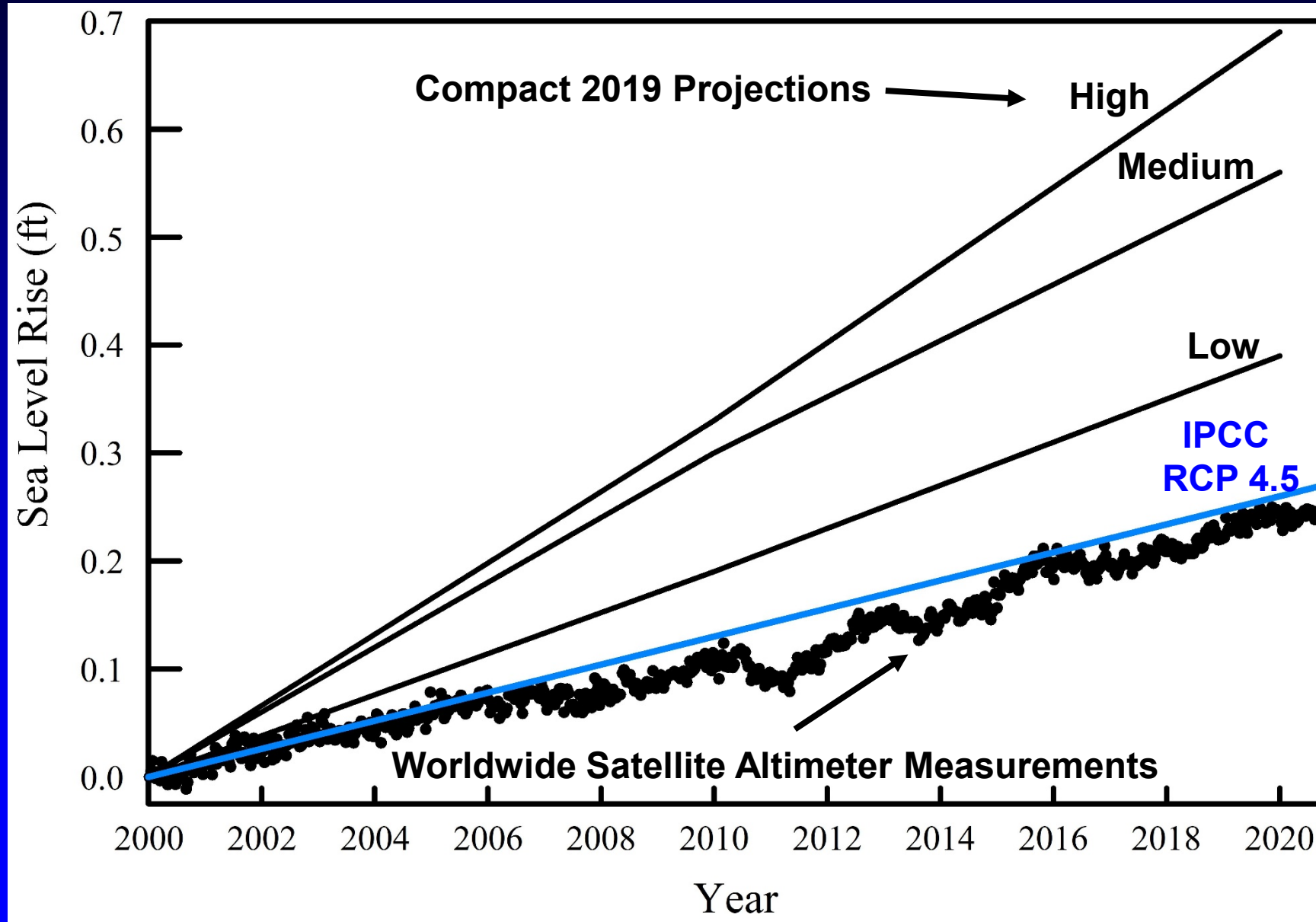
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Realism - Measurements, 2000-2020



Beach Nourishment Has ~ 30-Yr Horizon

- Nourishment decisions can be started, stopped, increased and decreased fairly rapidly
- IPCC (2021) mean projections 2020-2050 in inches

Scenario	1.9	2.6	4.5	7.0	8.5
Rise (in)	5.5	5.9	6.3	7.1	7.5

- There is only a 2-inch difference between the most benign and worst-case scenarios

3. The Future of Florida Shorelines



Beach Nourishment Dominated, 1970 - 2020

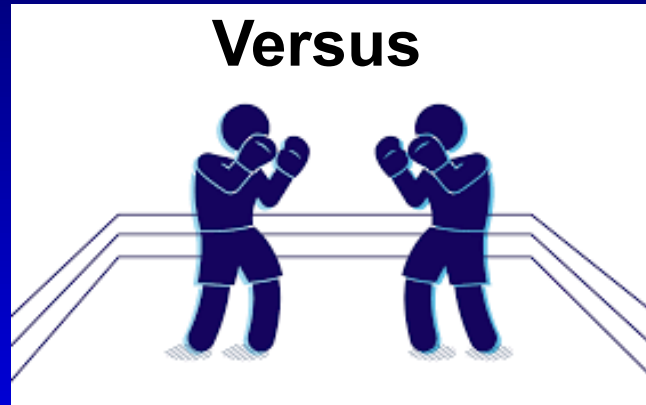
- East and Southwest shorelines accreted 84 and 102 ft on average (Houston 2015, 2019)
- Panhandle nourishment started late, but dominated where placed
- Nourishment sand does not yet = sand removed to modify inlets for navigation (inlets cut, jettied, and sand disposed offshore)
- Sand is placed where economically justified – over 2/3^{rds} of Florida's sandy coast has never been nourished



2020 - 2100

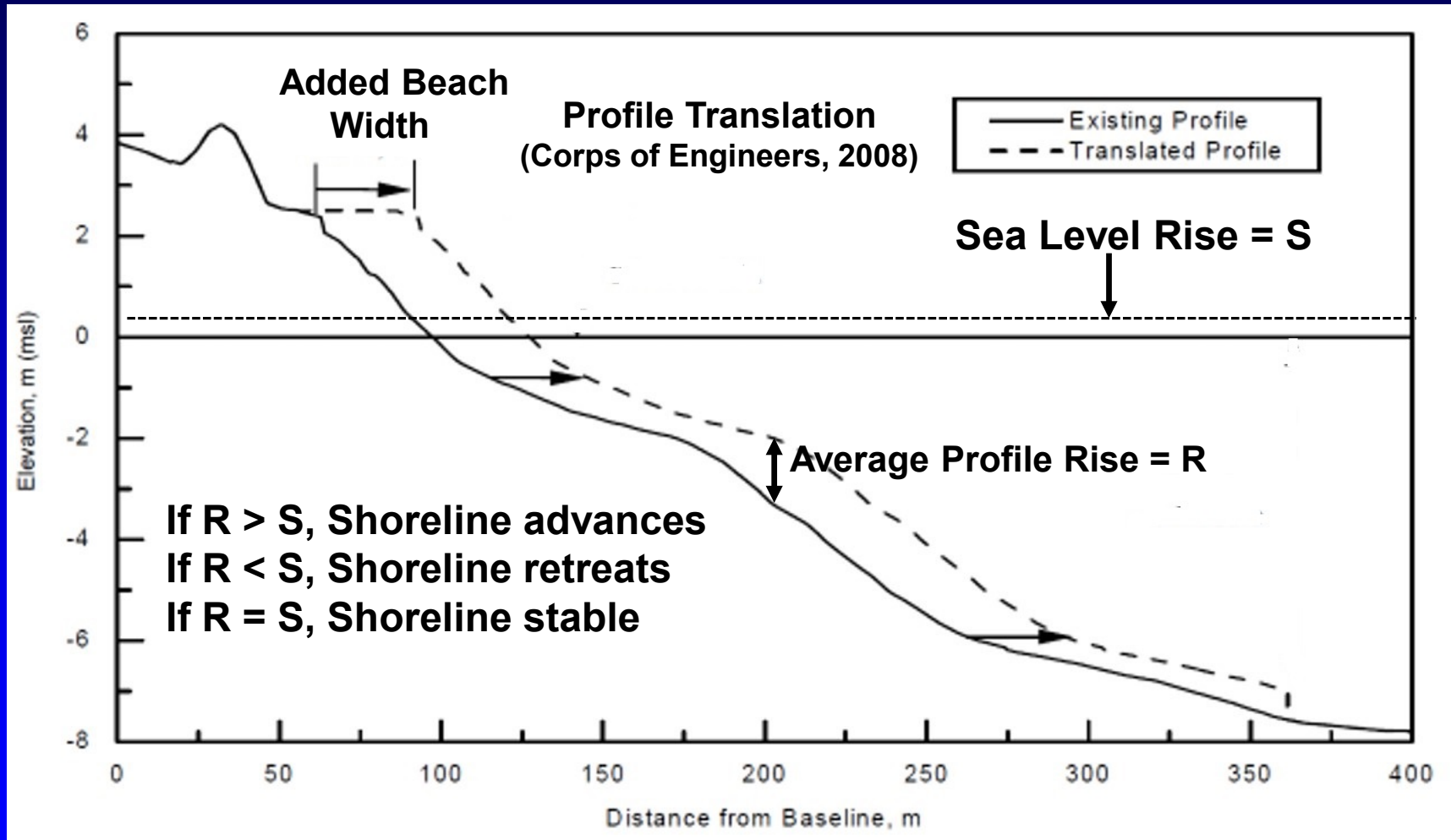
- Will beach nourishment or increasing sea level rise dominate Florida's developed shores?

**Beach
Nourishment**



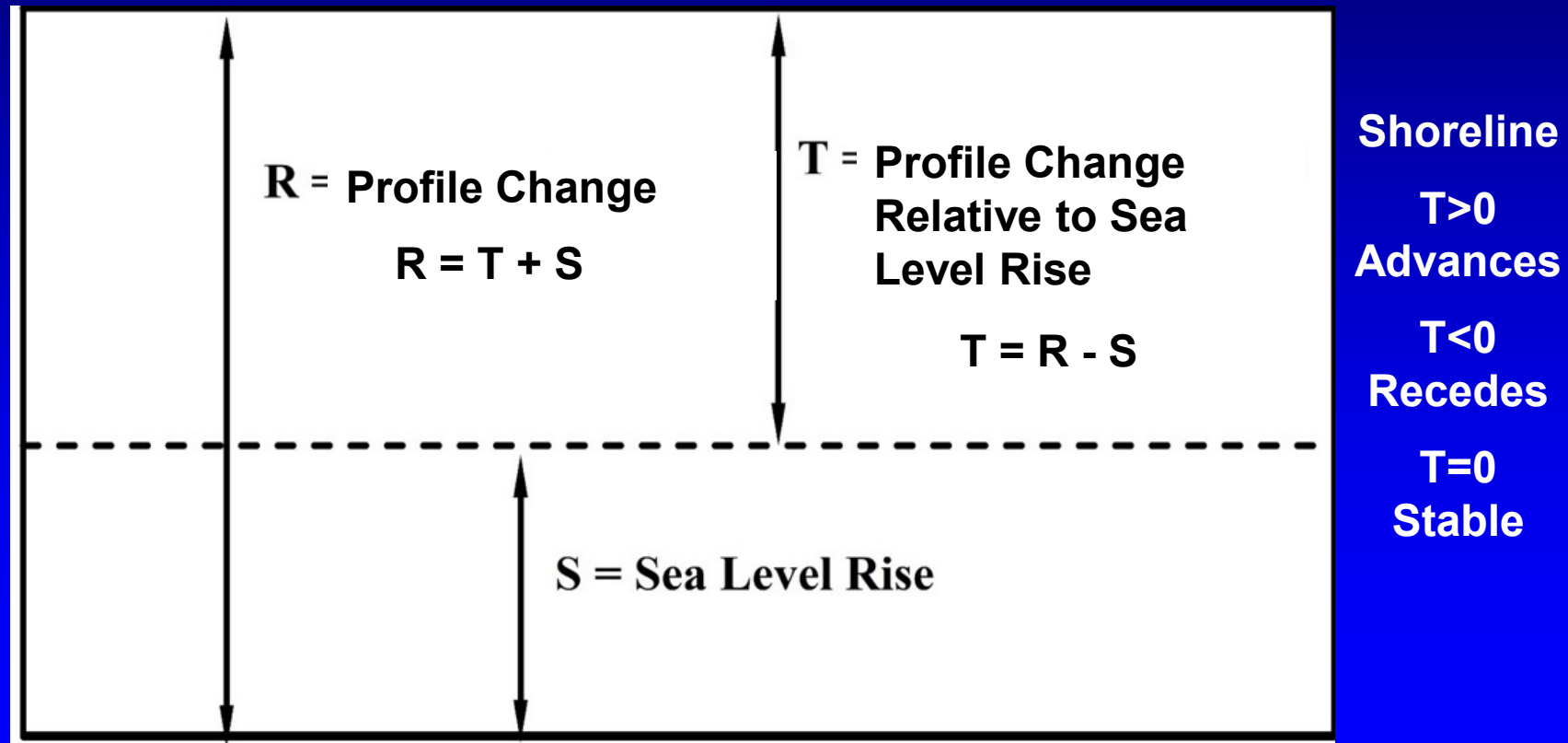
**Sea Level
Rise**

Beach Nourishment Widens the Beach and Also Raises the Profile



Vertical Changes

- Profile change, R , caused by beach nourishment, sand loss to inlets, longshore transport, subsidence, storms, ...
- S is sea level rise and T is the profile change relative to S



Example – Palm Beach County



Palm Beach County, 1989 - 2018

- Most beach nourishment placed during this 30-yr period
- Average FDEP measured shoreline change, X , was + 51 ft
- Sea level rise, S , was about + 0.3 ft

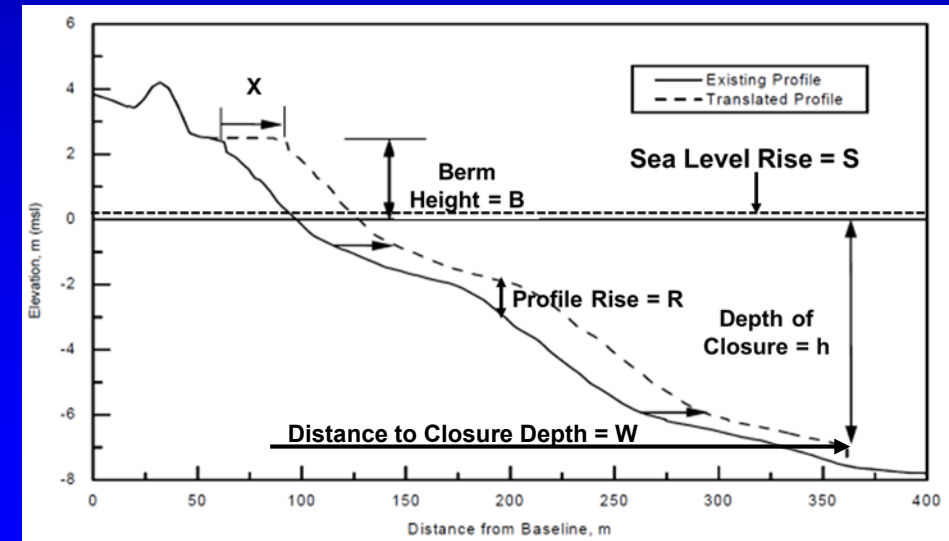
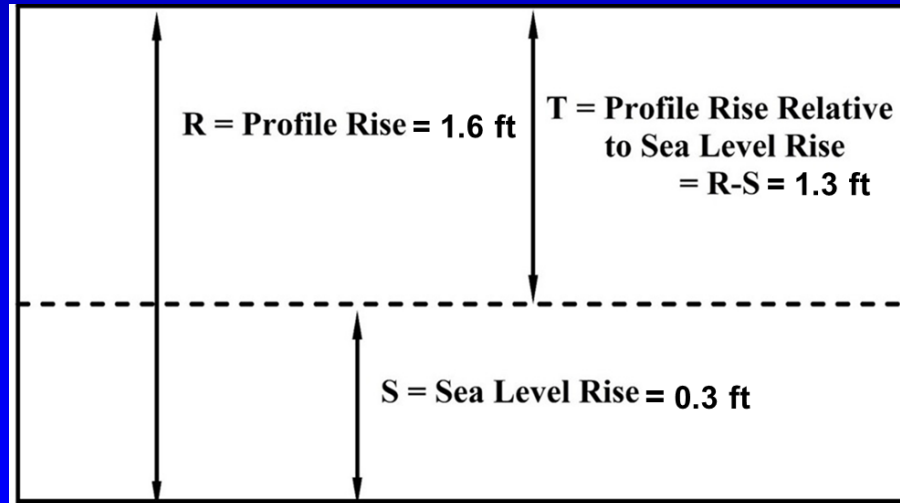


Palm Beach County

- The average rise, T , in a profile relative to sea level rise is the measured shoreline change, X , multiplied by the average profile slope

$$T = X * (h + B) / W$$

- $X = 51$ ft, $h + B = 24.7$ ft, $W = 970$ ft (Houston 2019), $T = 1.3$ ft
- $R = 1.6$ ft ($R = T + S = 1.6$ ft)



Palm Beach County, 30 and 50 Years

- Suppose beach nourishment + other processes of the past 30 yrs continue for the next 30 years to 2050, then **R = 1.6 ft**

Sea Level Rise 2020-2050

Scenario	RCP 2.6	RCP 4.5	RCP 8.5	RCP 8.5+
Rise (ft)	0.6	0.7	0.8	1.0

- For 50 years from 2020-2070, $R = 1.6 \times (50/30) = 2.7 \text{ ft}$

Sea Level Rise 2020-2070

Scenario	RCP 2.6	RCP 4.5	RCP 8.5	RCP 8.5+
Rise (ft)	1.0	1.1	1.4	1.9

80 Years 2020 - 2100

- If beach nourishment + other processes continue at rate of past 30 yrs for 80 yrs to 2100, $R = 1.6 \text{ ft} \times (80/30) = 4.3 \text{ ft}$

Sea Level Rise 2100

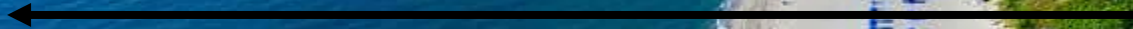
Scenario	RCP 2.6	RCP 4.5	RCP 8.5	RCP 8.5+
Rise (ft)	1.4	1.8	2.5	3.3

- If inlet management eliminates shoal losses (lowered R by 0.5 ft, 1989-2018), $R = (1.6 + 0.5) \times (80/30) = 5.6 \text{ ft}$ by 2100

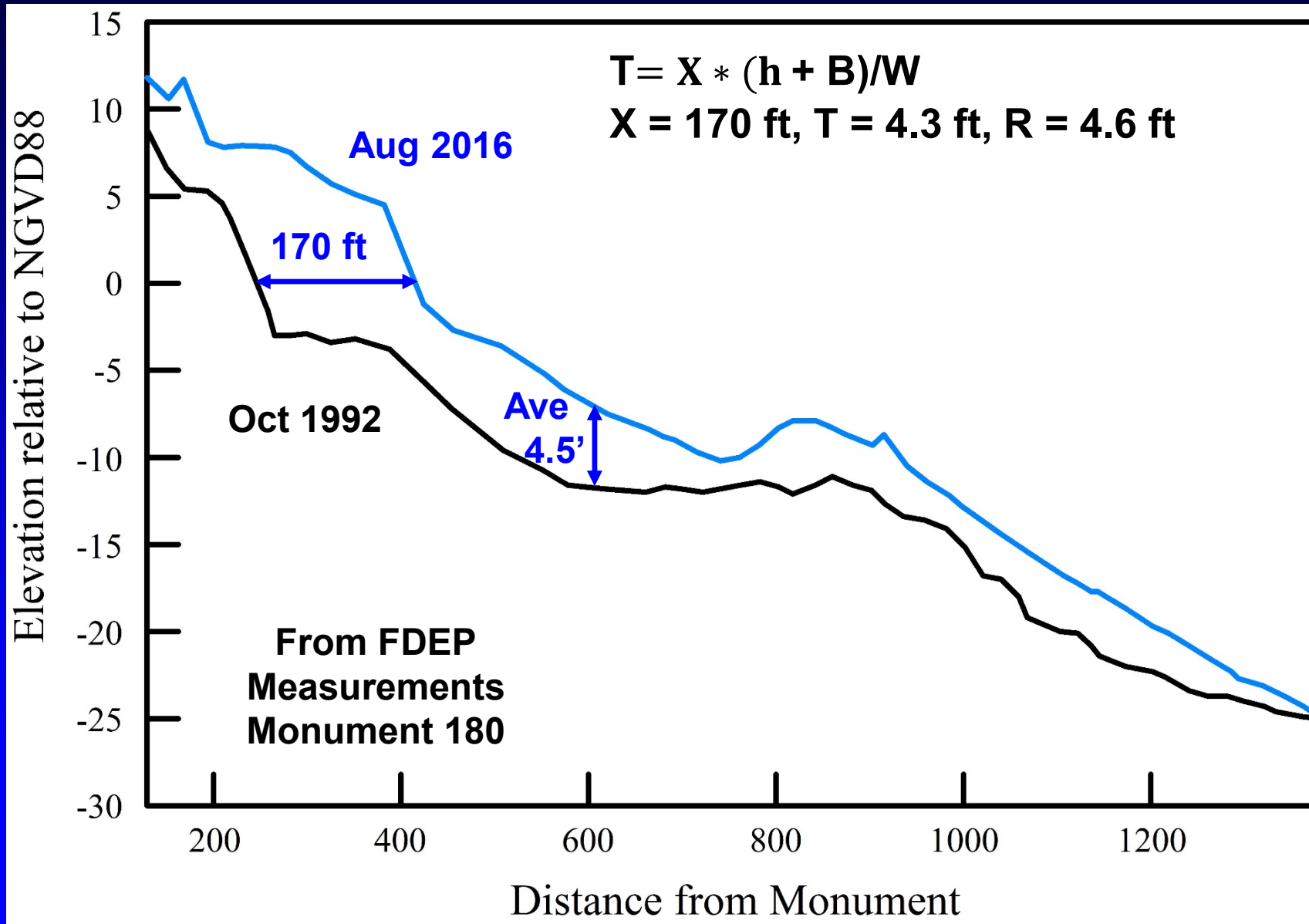


Example – Delray Beach

Profile R180

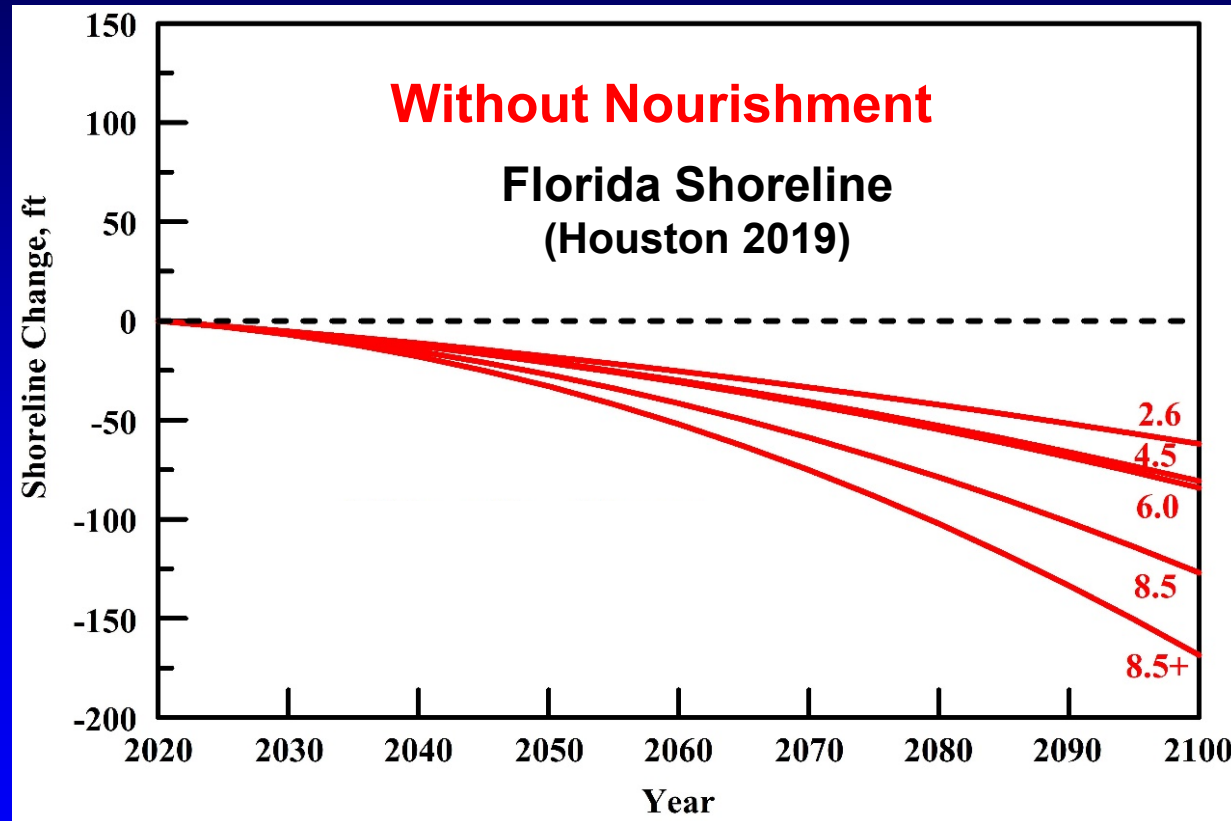


Delray Beach, 24 Years, 1992-2016



Beach Nourishment is Critical

- Sea level rise is relentless, and without beach nourishment all counties will have net shoreline recession

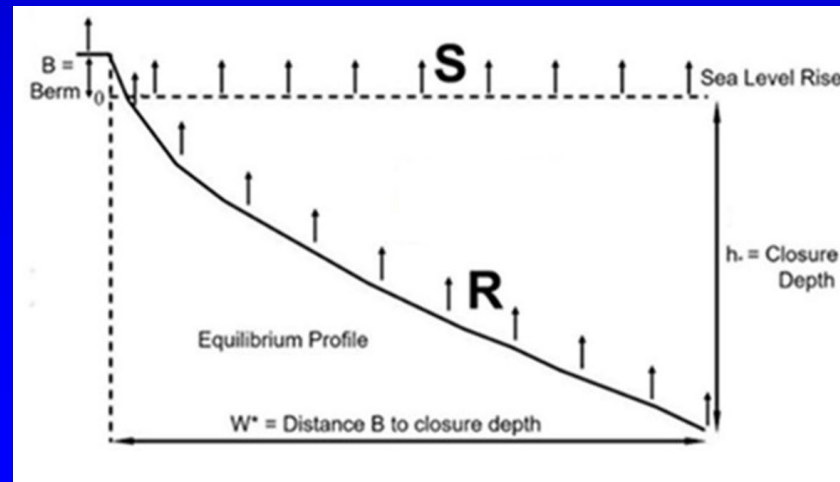


- Nourishment solves sea level rise on developed shores, but retreat may well be the best option for undeveloped shores

How to Determine Results for Any City/County

- Calculate shoreline change, X , from FDEP measured data
- Determine sea level rise, S , during period (Houston 2019)
- Convert shoreline change to vertical movement, T , relative to sea level rise using simple equation
- $R = T + S$ during period, and extend R to 2050, 2080, 2100
- Compare R with IPCC sea level rise, S_{IPCC}

If $R < S_{IPCC}$, increase nourishment



Big Challenges I Am Not Addressing

- Back bay areas will increasingly flood as sea level rises
- Salinity intrusion from rising levels will impact fresh water
- Wetlands will submerge, causing environmental impacts
- Are there sufficient sand sources?



Conclusions

- **Everyone should use IPCC sea level rise projections:** They are THE scientifically legitimate projections
- **Beach nourishment is powerful:** It can raise profiles above sea level to 2100 and beyond, and all Florida beaches will recede without it
- **Sea level rise and climate change are going to cause great problems:** We can defend the shore, but that is only one of many problems



The End

