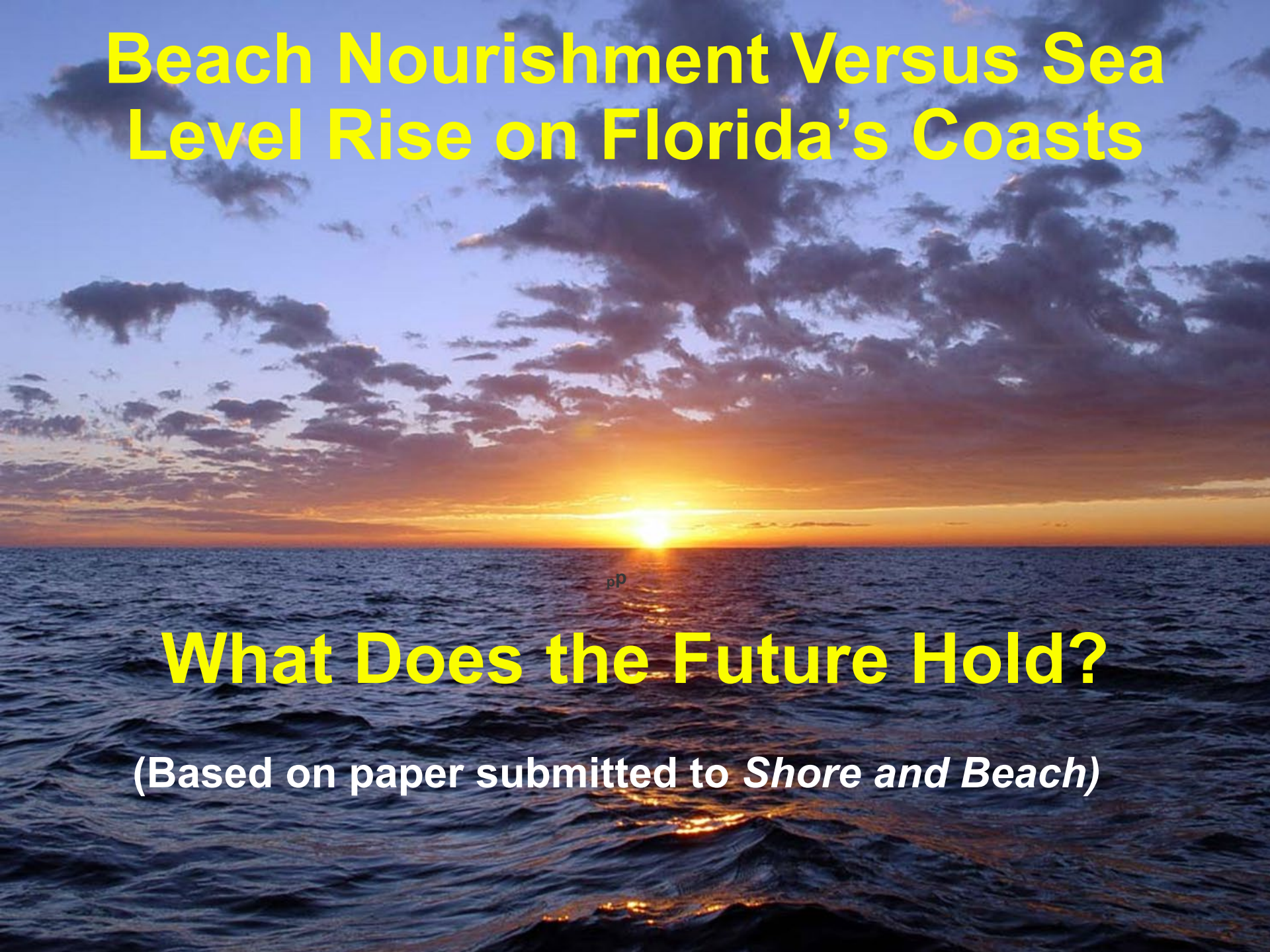
# Beach Nourishment Versus Sea Level Rise on Florida's Coasts



## What Does the Future Hold?

(Based on paper submitted to *Shore and Beach)*

# Before 1970
# Inlets Dominated Shoreline Change

- Inlets modified for navigation removed 250 million $yd^3$ from littoral zone
  (Houston and Dean, 2014)


- But since 1970, few inlets have been modified, shoals largely stabilized, sand is no longer routinely disposed offshore
- Also, inlet management plans are being implemented to bypass sand
- Inlet impacts have been and will further be reduced

# 1970 - 2019
# Beach Nourishment Dominated

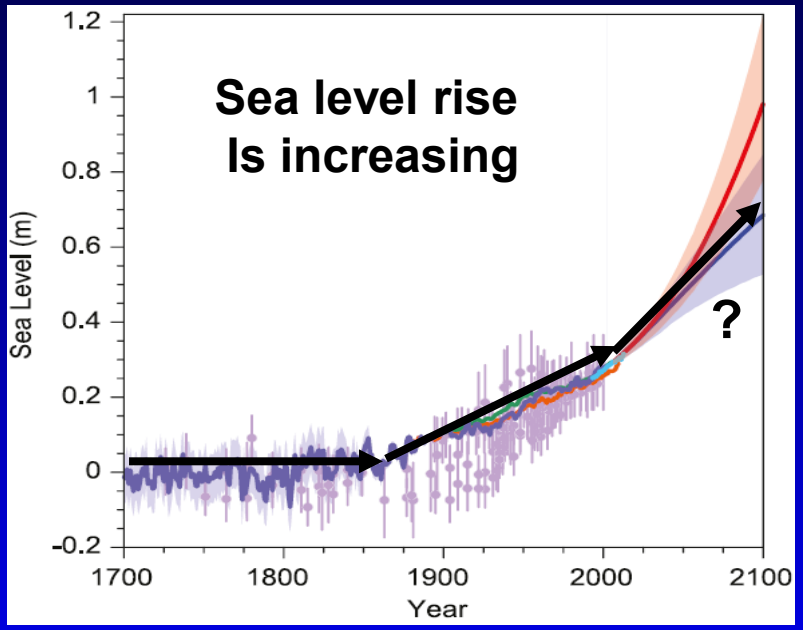
- East coast shorelines accreted 84 ft on average (Houston, 2019)
- Southwest shorelines accreted 102 ft (Houston, 2015)
- Nourishment started late on Panhandle shorelines, but has dominated where placed

- Pensacola Beach eroded 175 ft before 1970
- Accreted 160 ft since nourishment started in 2003

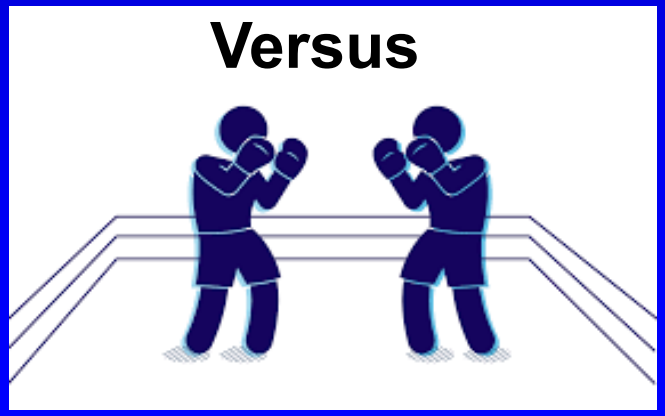
(Absalonsen and Dean, 2010, FDEP, 2019)

# 2020 - 2100
# What Will Happen to Shorelines?

- Will beach nourishment or sea level rise dominate on Florida's 665 miles of sandy coast?



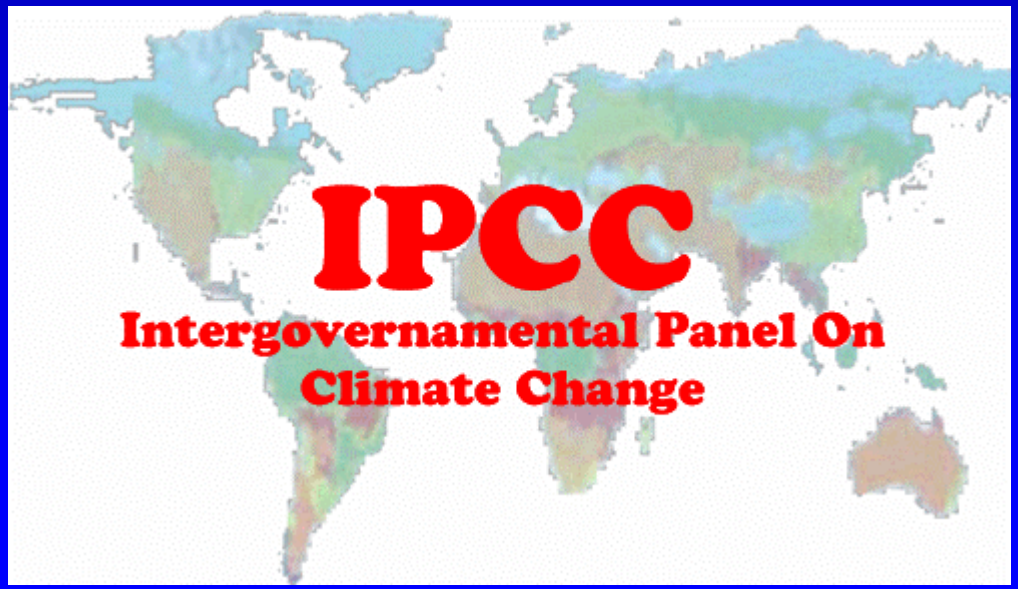

Beach Nourishment




Sea Level Rise

# Tools and Data Used

- Profile equilibrium theory
- Recently documented beach nourishment volumes
- New sea level rise projections of the Intergovernmental Panel on Climate Change (IPCC, 2019)

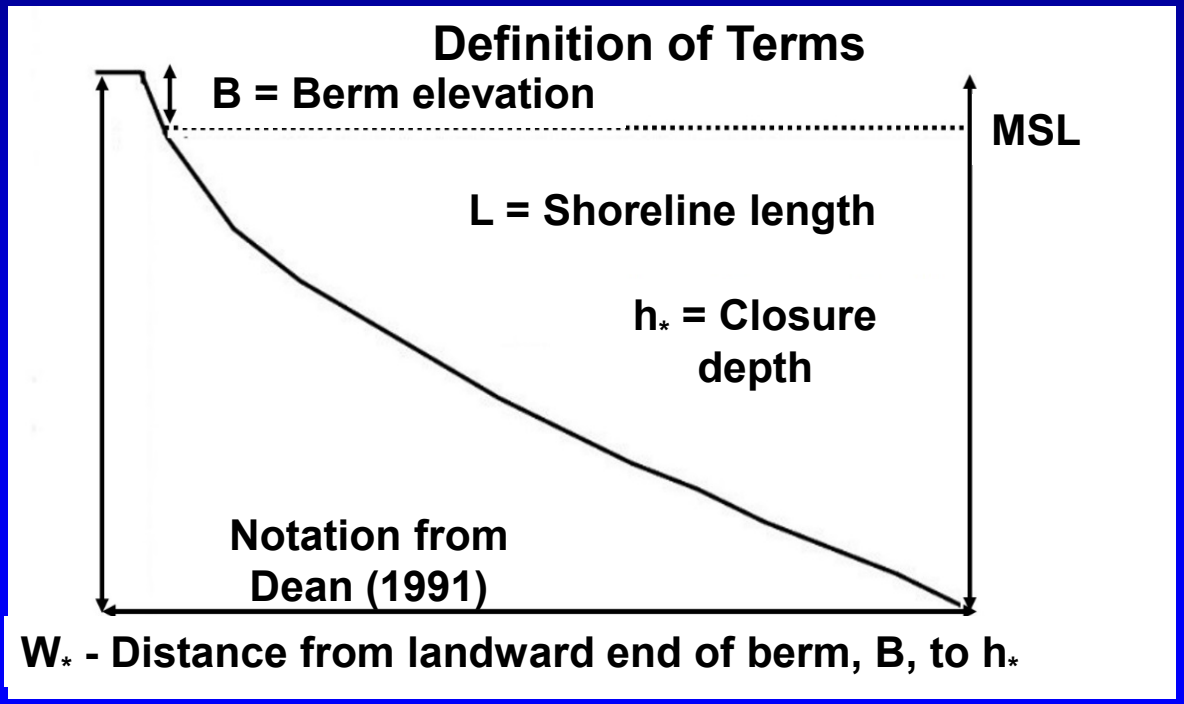


# Equilibrium Profile Theory

- **Shoreline change, $X$, due to adding a beach nourishment volume, $V$,**
  **(Dean and Charles, 1994)**

$$X = \frac{V}{[(h_* + B) * \boldsymbol{L}]}$$

- **Shoreline change due to sea level rise, $S$,** $X = \dfrac{-(S * W_*)}{(h_* + B)}$
  **(Bruun, 1988; Atkinson, 2018)**

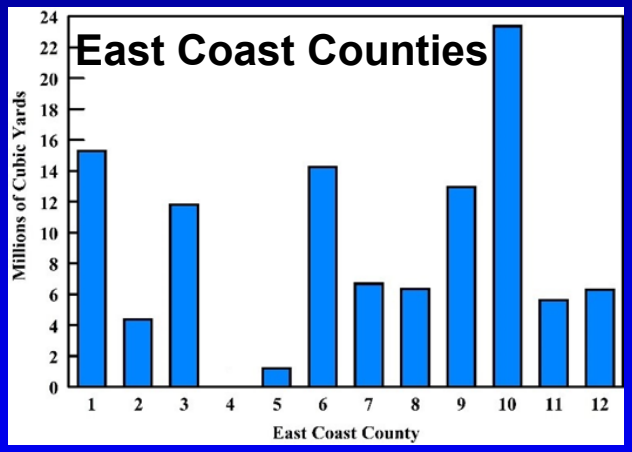


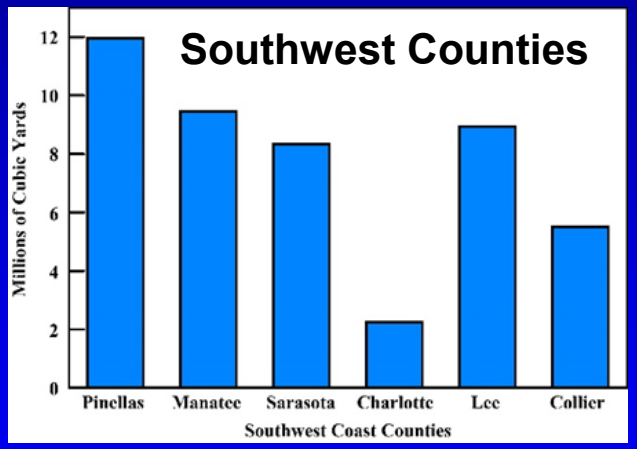

**Need nourishment volume, $V$ , and sea level rise, $S$**

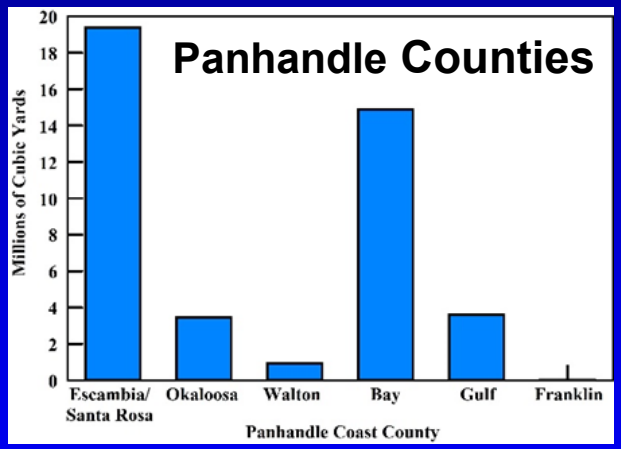
**$h_*$, $B$, $W_*$, $L$ are available**
**(FDEP 2018; Houston and Dean, 2014)**

# Beach Nourishment Data

- 5 new reports on beach nourishment (FDEP, 2018)
- Use rate of nourishment for past 30 yrs as illustrative (1988-2017)



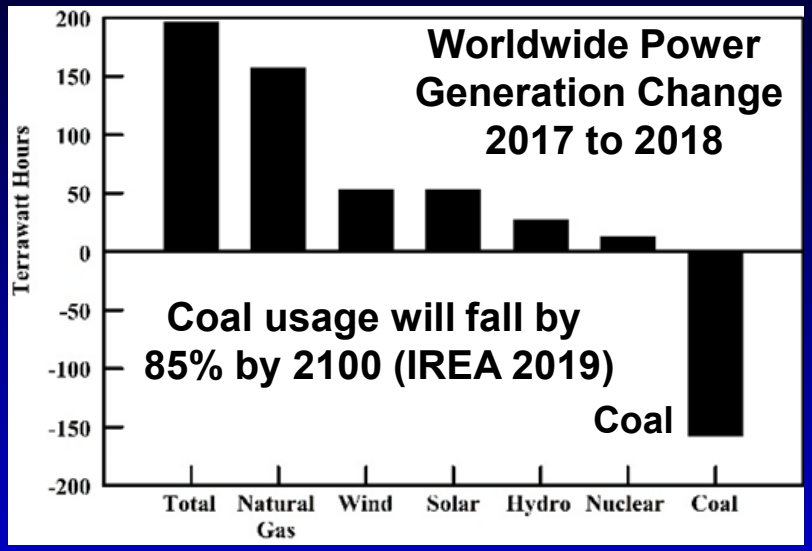




1=Nassau 2=Duval 3=St Johns
4= Flagler 5=Volusia 6=Brevard
7=Indian River 8=St Lucie 9=Martin
10-Palm Beach 11=Broward 12=Dade

**Almost 200 million $yd^3$ placed 1988-2017**

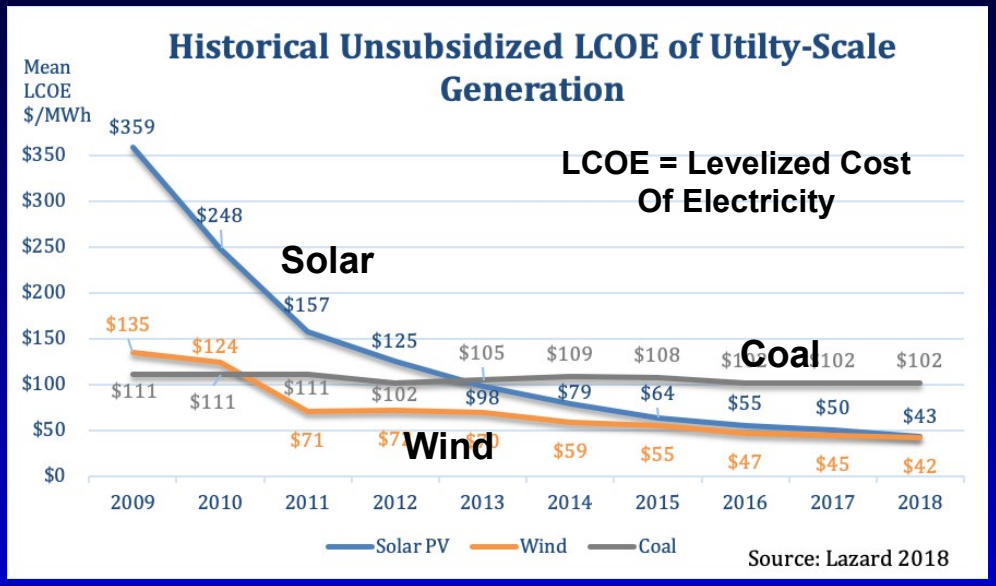
# IPCC Climate Change Scenarios

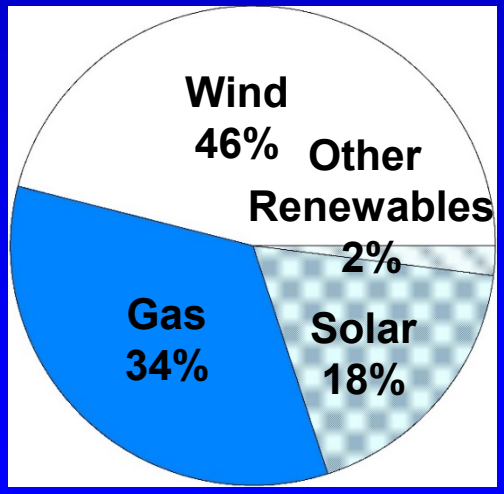
- Scenarios based on future $CO_2$, designated RCP 2.6, 4.5, 6.0, 8.5
- RCP 8.5 assumes world will use 7X more high-$CO_2$ coal by 2100
- "RCP 8.5 with its vast coal consumption is considered **exceptionally unlikely** and should not be a benchmark for policy studies" (Richie and Dowlatabadi, 2017)
- RCP 8.5 also assumes no technological advances by 2100



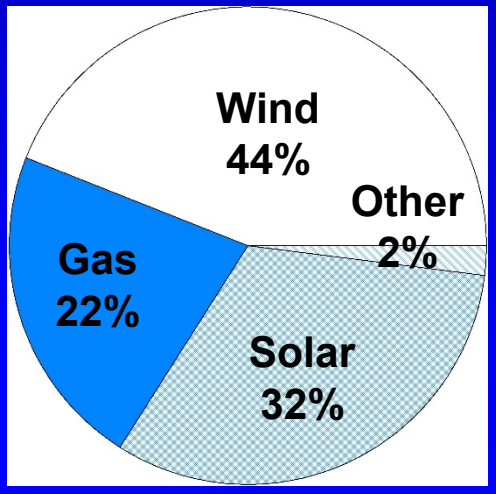
# IPCC Climate Change Scenarios

- However, fracking has made natural gas much cheaper than coal (with 40-45% of $CO_2$ footprint)
- "Unsubsidized wind and solar is now the cheapest provider of energy in most major economies" (IEEFA, 2018)




Power added US in 2019




Planned power added 2020

**RCP 8.5 is "exceptionally unlikely"**

# IPCC Sea Level Projections

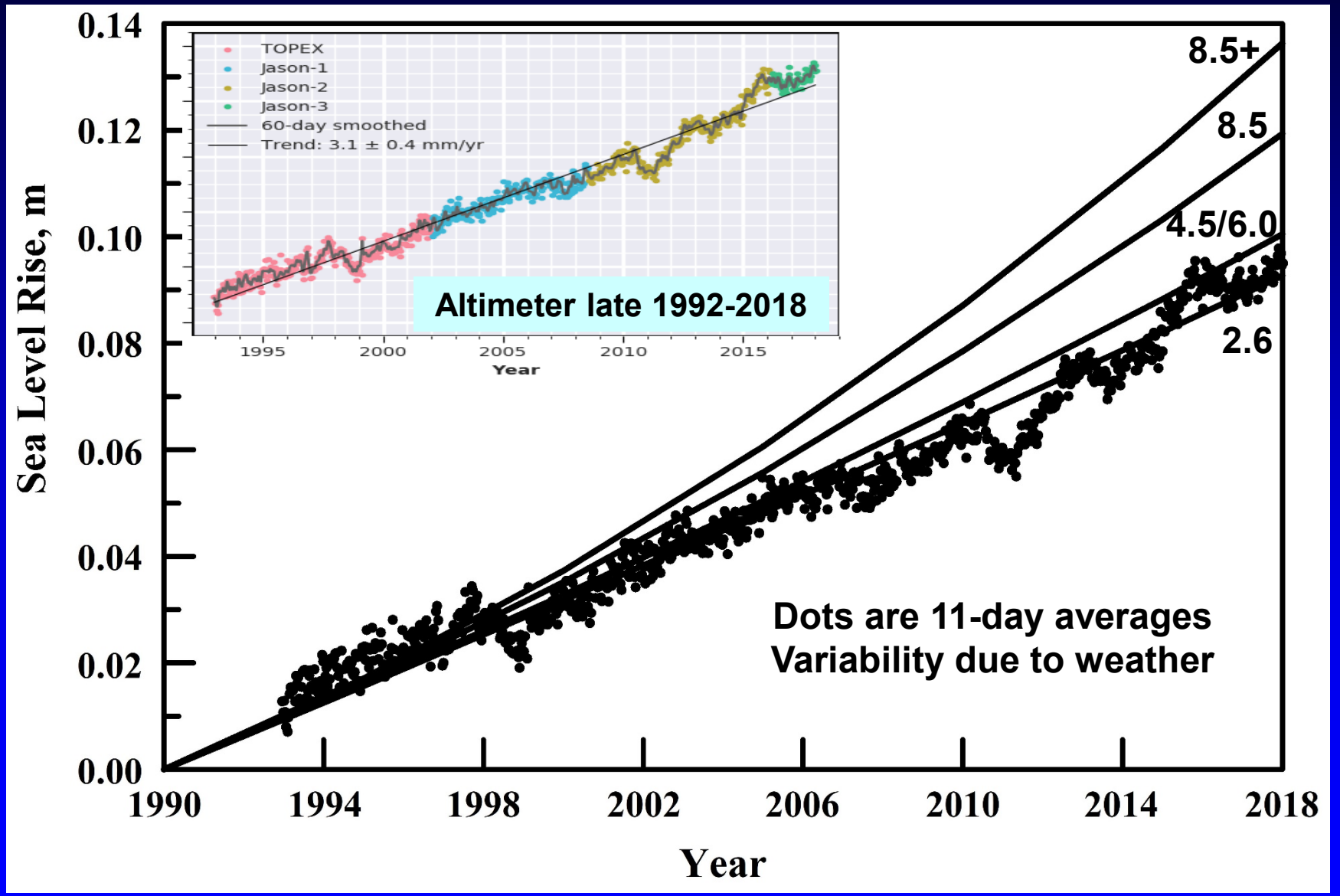
- 71 of the world's experts made IPCC 2013 sea level rise projections
- Later papers claimed new knowledge on ice melting in Antarctica made IPCC projections too low


- IPCC published projections in Sept 2019 that include the latest knowledge on ice melting in Antarctica (IPCC, 2019)

| | 1990-2100 | | | | |
|---|---|---|---|---|---|
| Scenario | RCP 2.6 | RCP 4.5 | RCP 6.0 | + 4 in RCP 8.5 | + 4.7 in RCP 8.5+ |
| Rise (ft) | 1.41 | 1.80 | 1.87 | 2.76 | 3.61 |

RCP 8.5+ is the upper confidence level of RCP 8.5
Only 2.5% chance of occurrence if the "exceptionally unlikely" RCP 8.5 occurs

# IPCC (2019) Vs Satellite Altimeter Data



# Approach

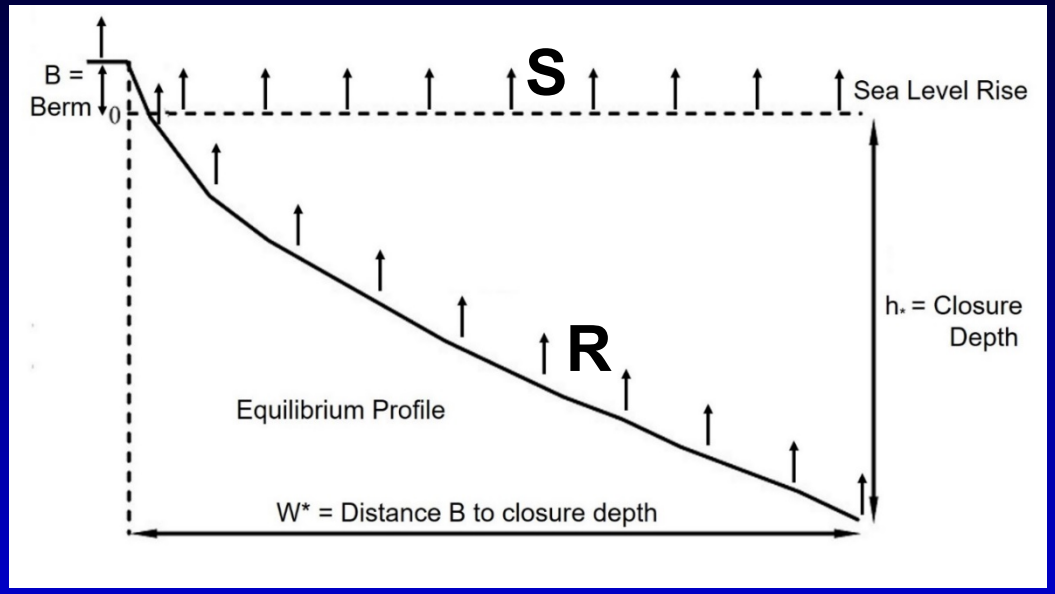
- Assume beach nourishment continues at 1988-2017 rate
- Assume 100% of shoreline will be nourished some day (only ~ 40% has ever been nourished)
- Use projections 2020-2100

| Scenario | RCP 2.6 | RCP 4.5 | RCP 6.0 | RCP 8.5 | RCP 8.5+ |
|---|---|---|---|---|---|
| Rise (ft) | 1.28 | 1.67 | 1.74 | 2.62 | 3.48 |

Projections 2020-2100 (reduces 1990-2100 projection by 3 in)
Include Florida subsidence of 0.5 mm/yr (increases by 1.5 in)

- December 2019 paper says ice melting in Greenland could increase sea level rise by 2-5 inches more than IPCC 2019 estimates (Shepherd et al, 2019)

# Rough Calculation for Entire Coast




From Equation (2)

$R = V/( W_* * L)$

R<S Erosion

R=S Stability

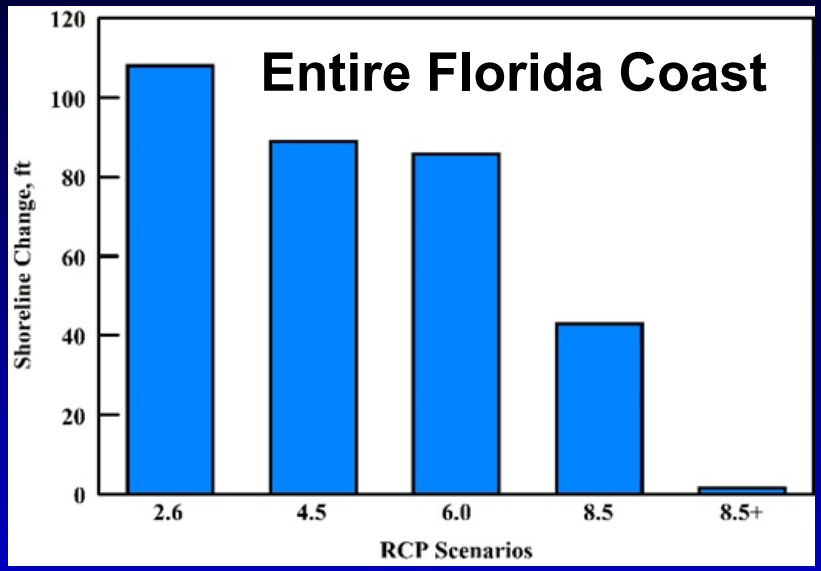
R>S Accretion

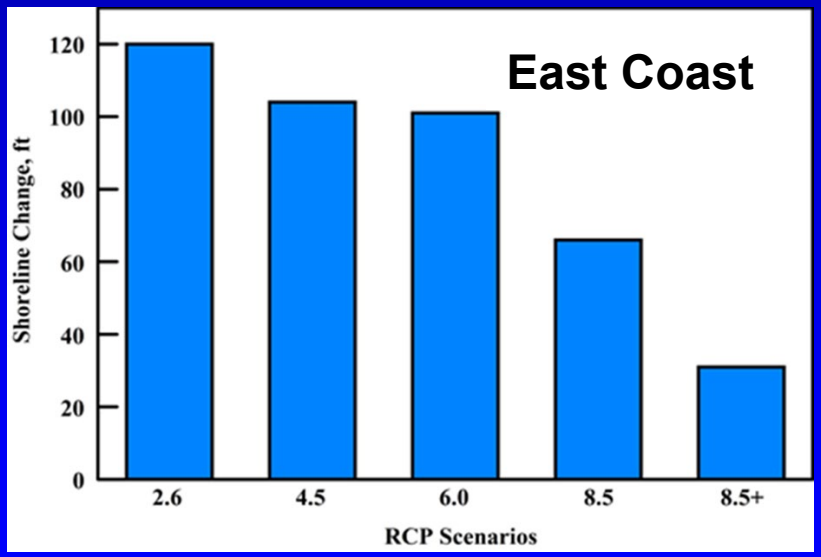
- Placing sand at the 1988-2017 rate from 2020-2100 raises profiles 3.5 ft, which is greater than RCP 8.5+ rise of 3.48 ft
- Much larger rise can be offset if sand placed on only 40% of beaches nourished in the past rather than 100% of beaches

# Shoreline Change 2020 - 2100

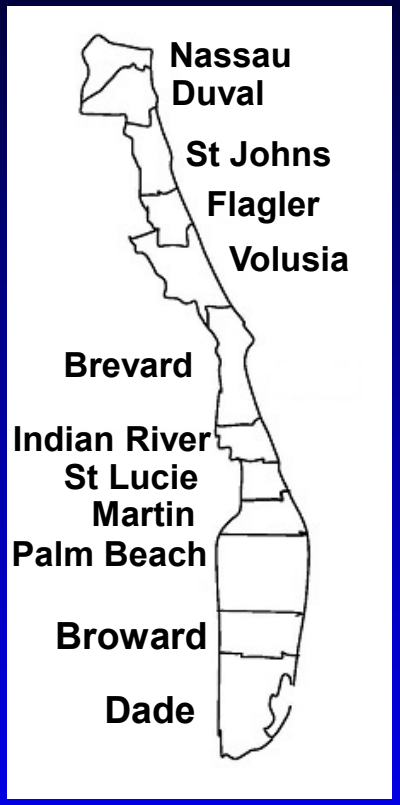
- Total Florida shoreline widens for all scenarios

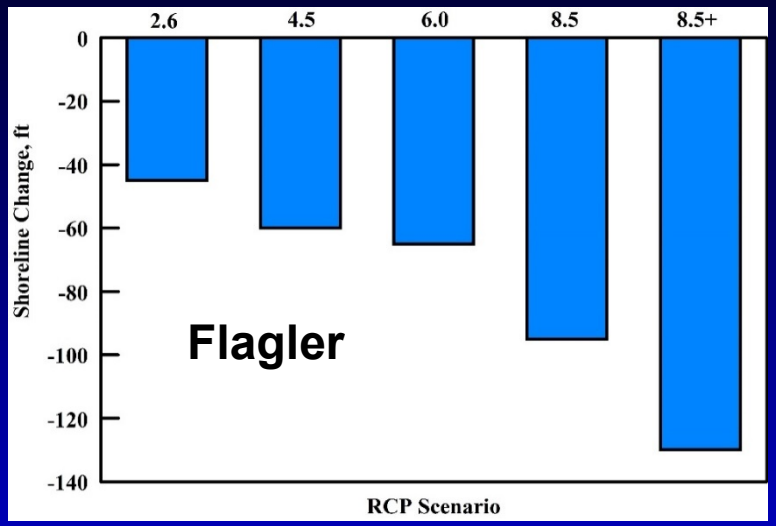
- East coast shorelines widen for all scenarios, but not in all counties



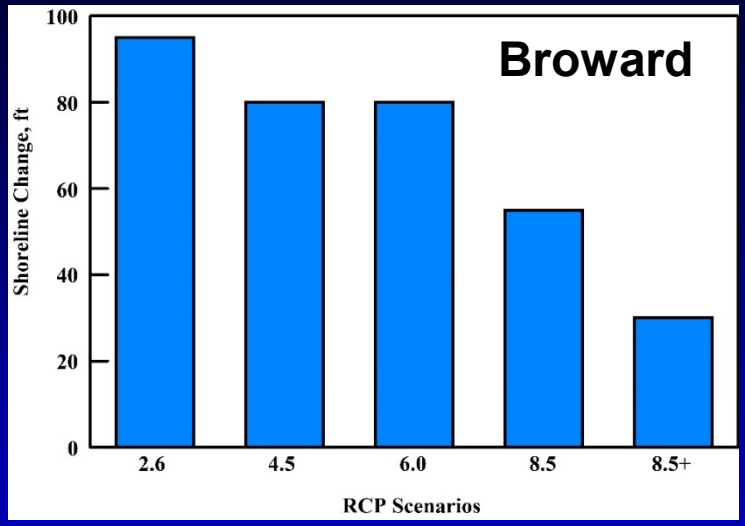



# Shoreline Change East Coast Counties

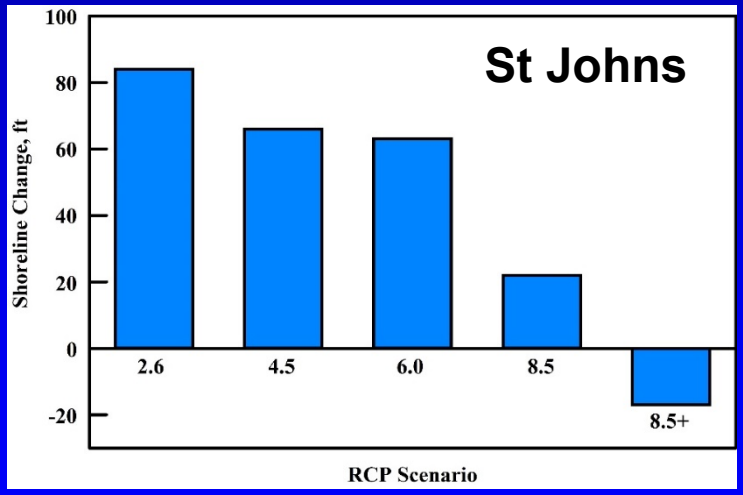



Volusia



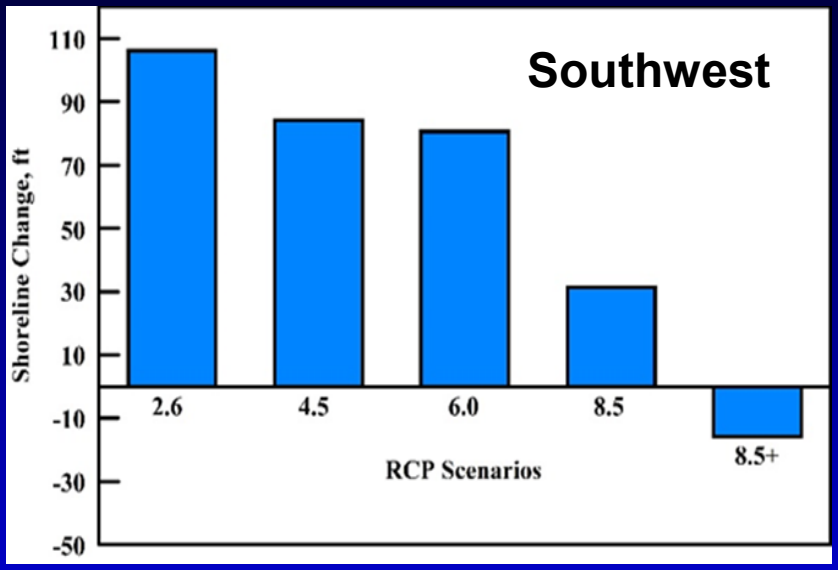

Nassau
Brevard
Indian River
St Lucie
Martin
Palm Beach



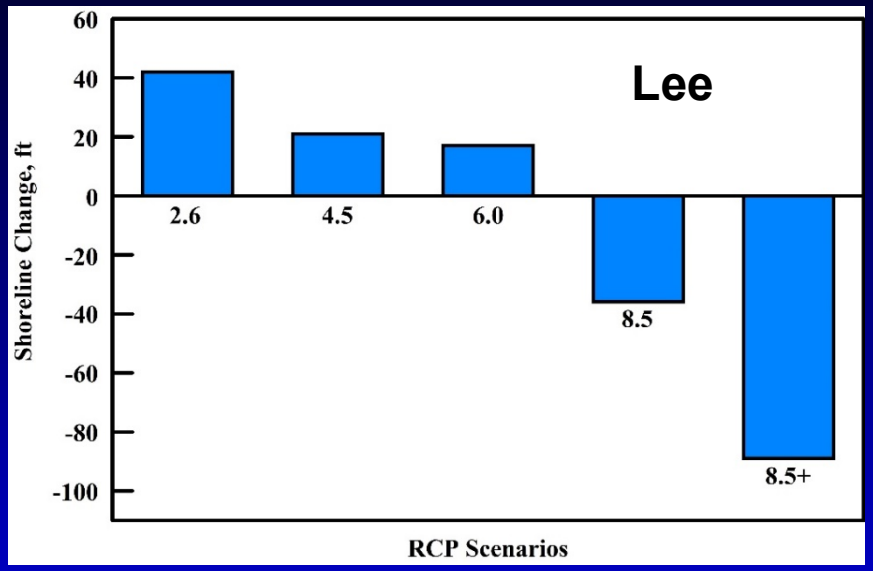

Duval
Dade

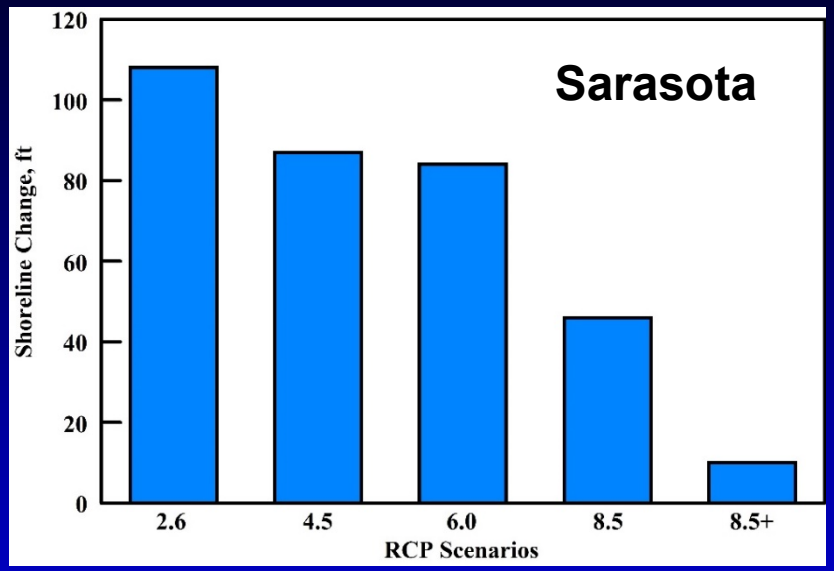
# Shoreline Change Southwest Coast

- Southwest shoreline accretes for all but RCP 8.5+
- Beach nourishment can be increased 10% and it will eliminate recession for RCP 8.5+

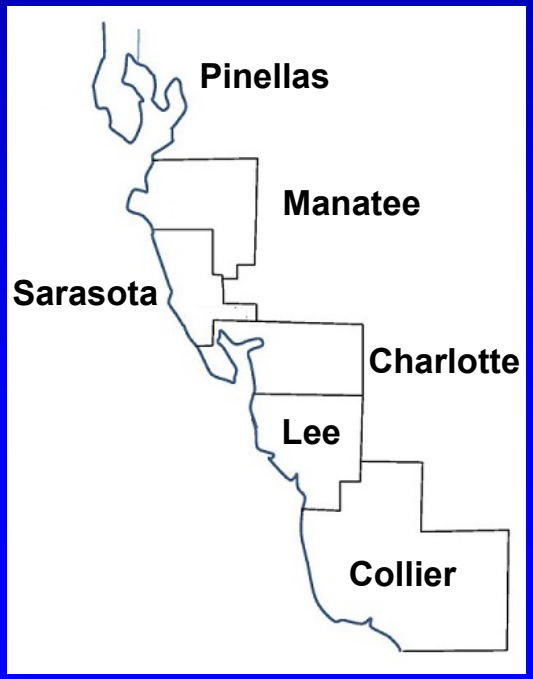


# Shoreline Change Southwest Counties




Charlotte
Collier

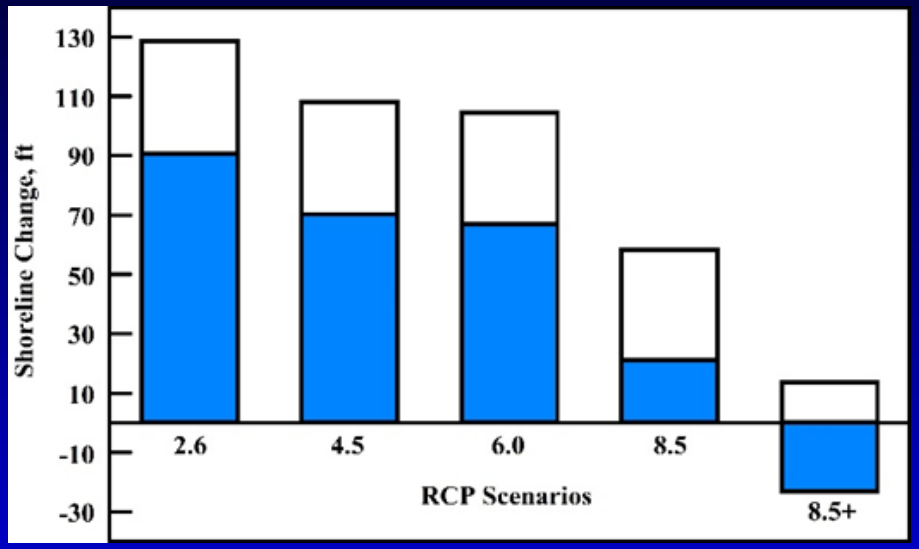



Pinellas
Manatee

# Shoreline Change Panhandle Coast

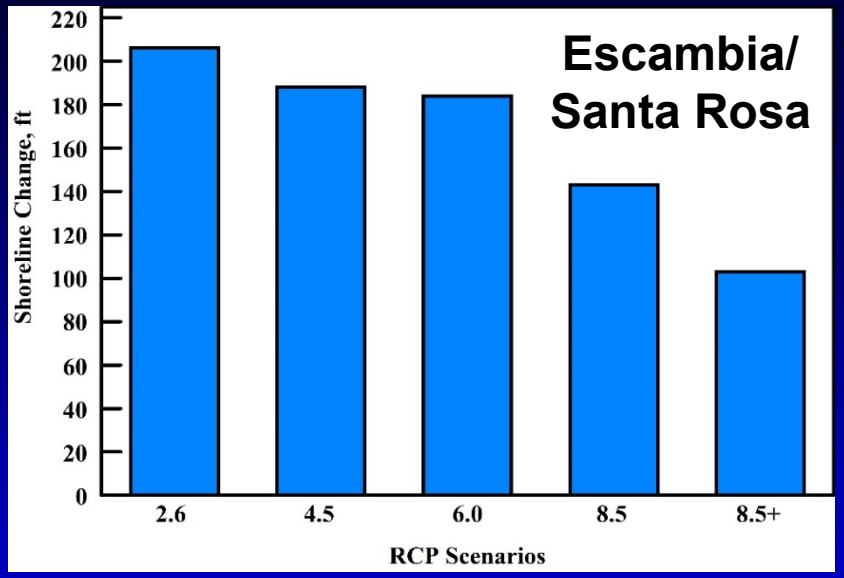
- Shoreline widens for all scenarios except RCP 8.5+
- If Franklin County is not nourished, shoreline widens for all scenarios
- Franklin County shoreline is lightly populated and never nourished

Should it ever be nourished?

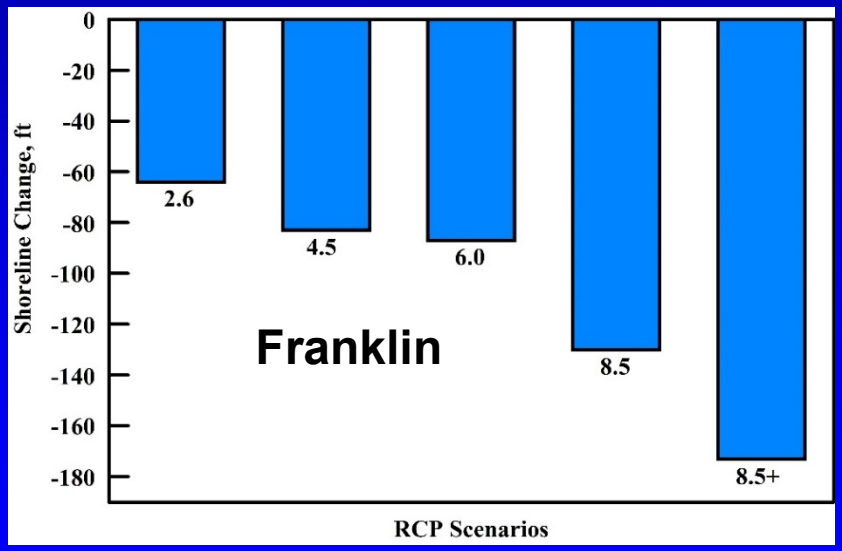



Blue for all counties
White if Franklin County omitted

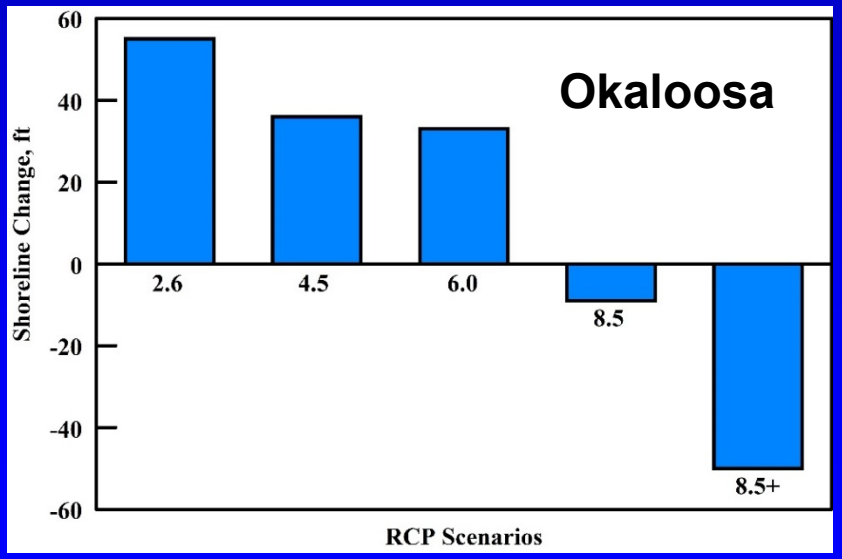
# Shoreline Change Panhandle Counties

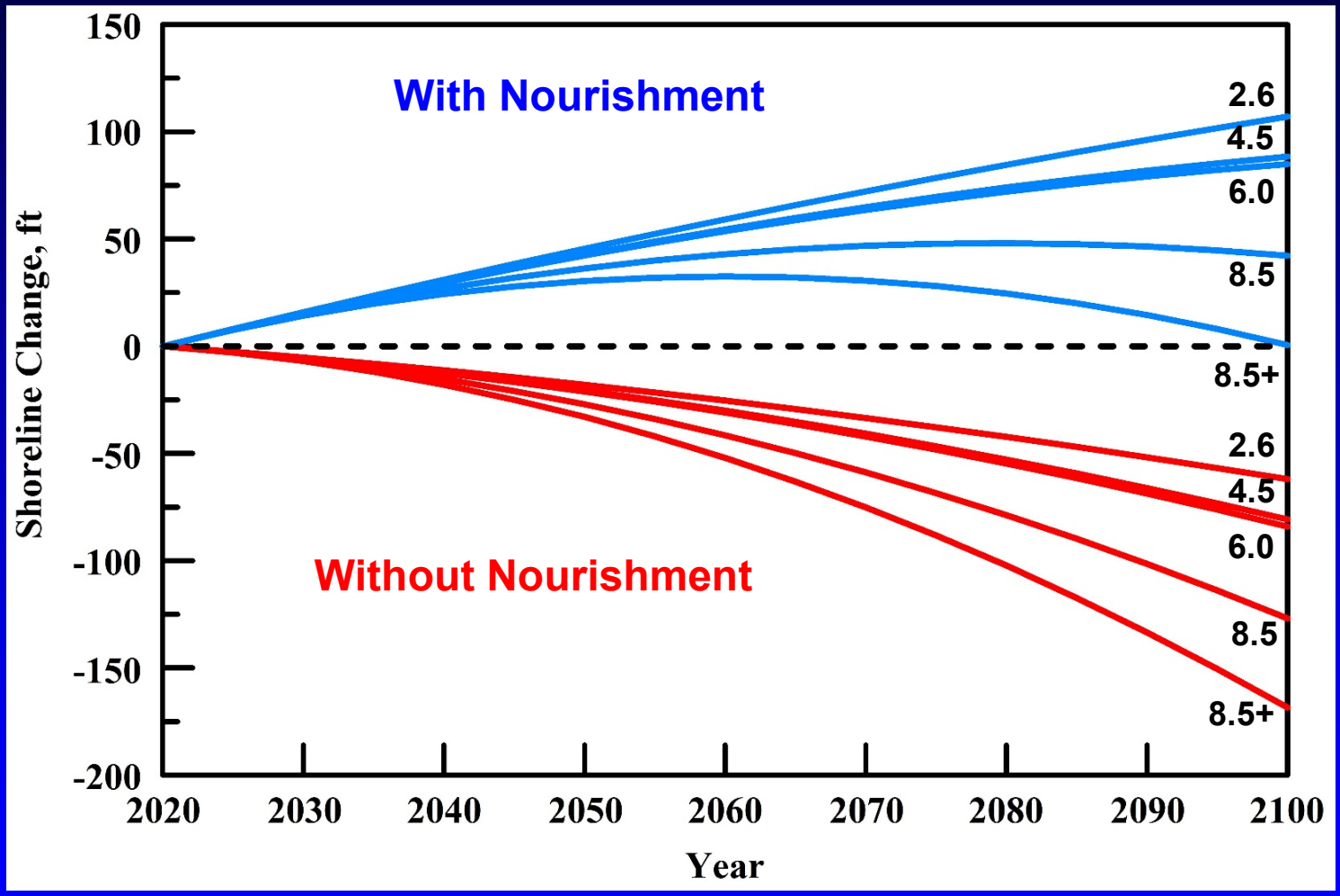

Bay




Walton
Gulf

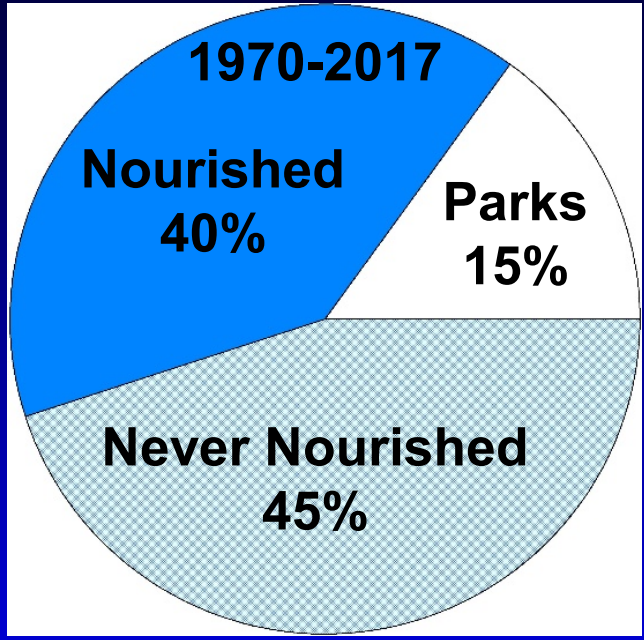


# Value of Beach Nourishment



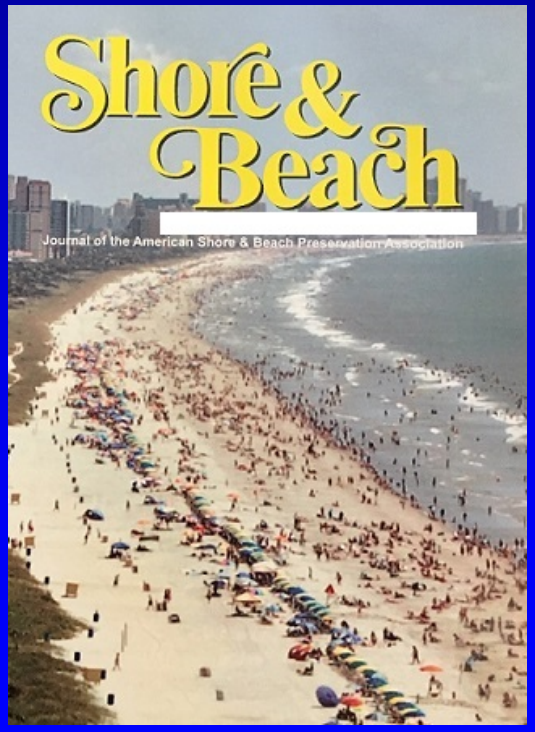
# Is There Enough Sand?

- 60% of shoreline never nourished and some will never be nourished because not economically justified
- Retreat is an option if nourishment is not economically justified
- Suppose
  - Place nourishment to offset RCP 6.0
  - Increase shoreline nourished by 50% over past
- Result
  - Only need 3/4ths the volume of sand for the 80 yrs from 2020-2100 than was used for the 30 yrs from 1988-2017



# Shore and Beach Paper

- Approach gives nourishment rate for which a county has a shortfall or surplus (relative to past rate) in offsetting sea level rise for each IPCC scenario
- Valid for any shoreline where beach nourishment and sea level rise dominate future shoreline change




# Big Challenges I Am Not Addressing

- Back bay areas are low lying and will increasingly flood as sea level rises (e.g., Miami Beach, Key Largo)
- Salinity intrusion will increasingly impact fresh water
- Wetlands will submerge, causing environmental impacts

# Conclusions

- **Beach nourishment is powerful!**
  - Dominated shoreline change 1970-2019
  - Offsets sea level rise 2020-2100 and beyond
- **Nourishment is critical**
  - Without it, beaches will erode for even the most benign scenario



The End