

Sea-Level Rise: Science, Legal Issues, and Adaptation for Florida Local Governments



Daytona Beach
May 22, 2015

Thomas Ruppert
Coastal Planning Specialist

Overview

- The Facts and Science of Sea-Level Rise (SLR)
- The Physical Impacts of SLR
- The Legal and Financial Implications for Local Governments
- Adapting to SLR



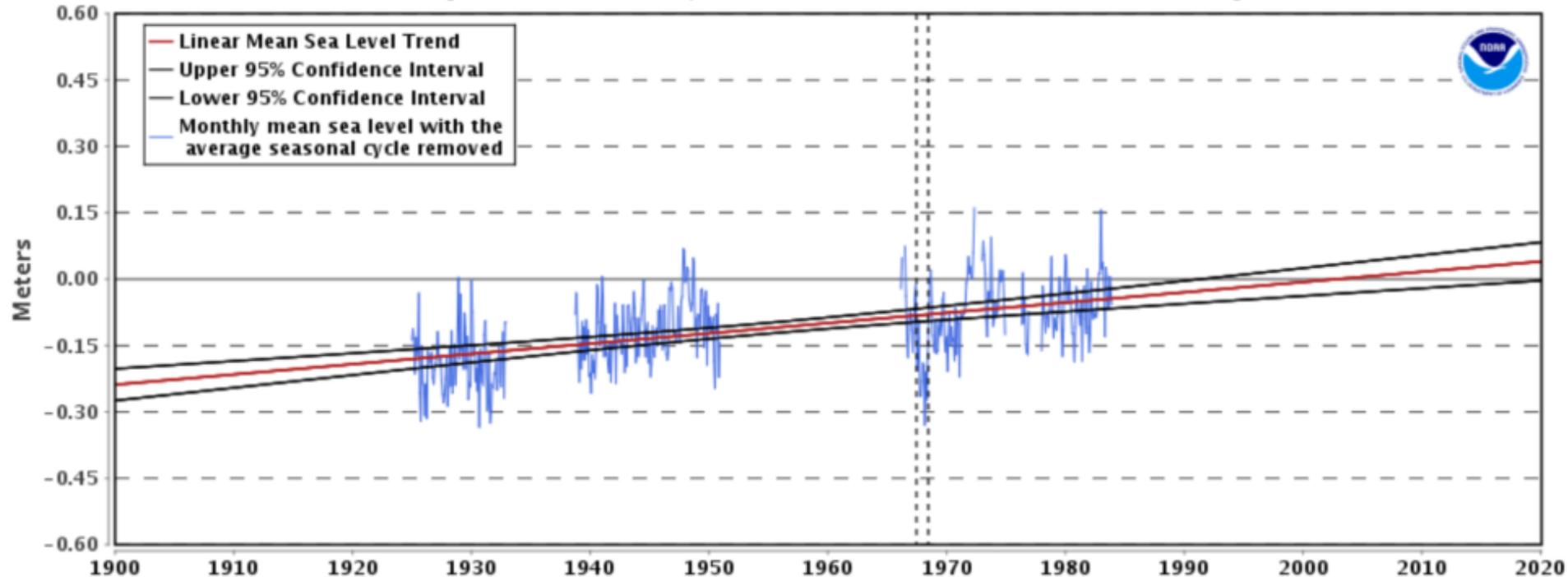
The Facts and Science of Sea- Level Rise (SLR)

Sea Levels Rising: NOAA Tide Gauge Results

Mean Sea Level Trend 8721120 Daytona Beach Shores, Florida

8721120 Daytona Beach Shores, Florida

2.32 +/- 0.63 mm/yr

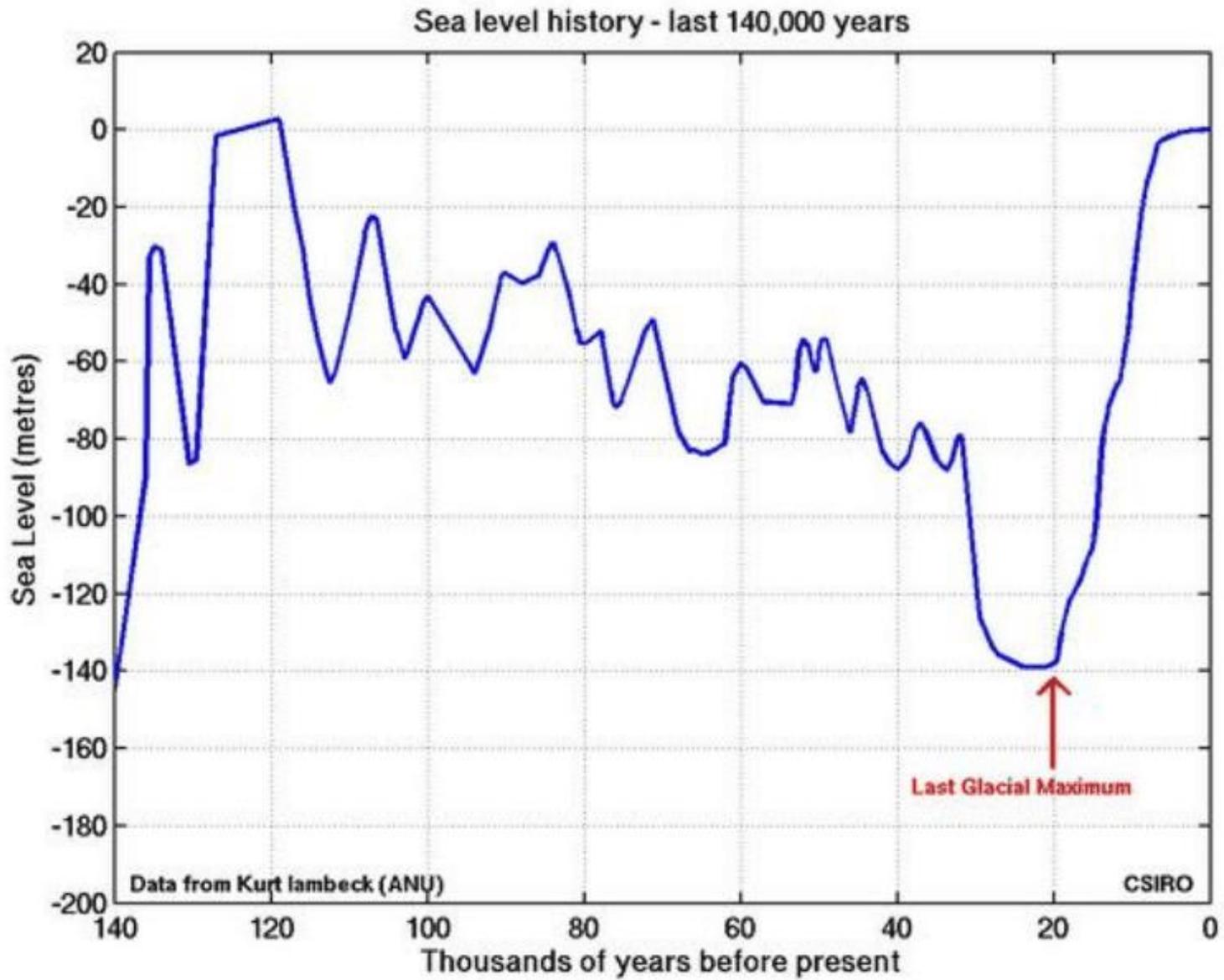


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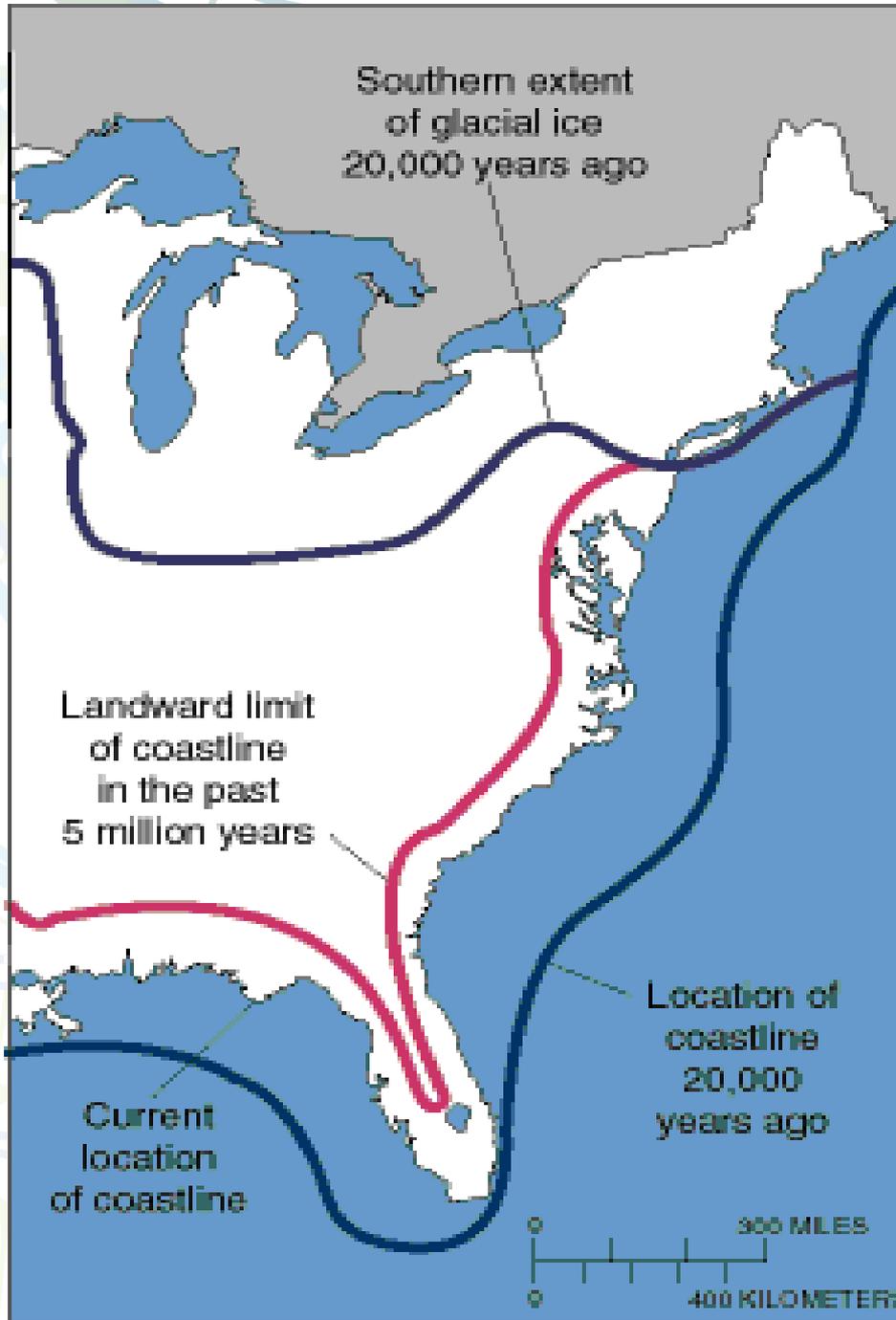
[EXPORT TO CSV](#)

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The mean sea level trend is 2.32 millimeters/year with a 95% confidence interval of +/- 0.63 mm/yr based on monthly mean sea level data from 1925 to 1983 which is equivalent to a change of 0.76 feet in 100 years.

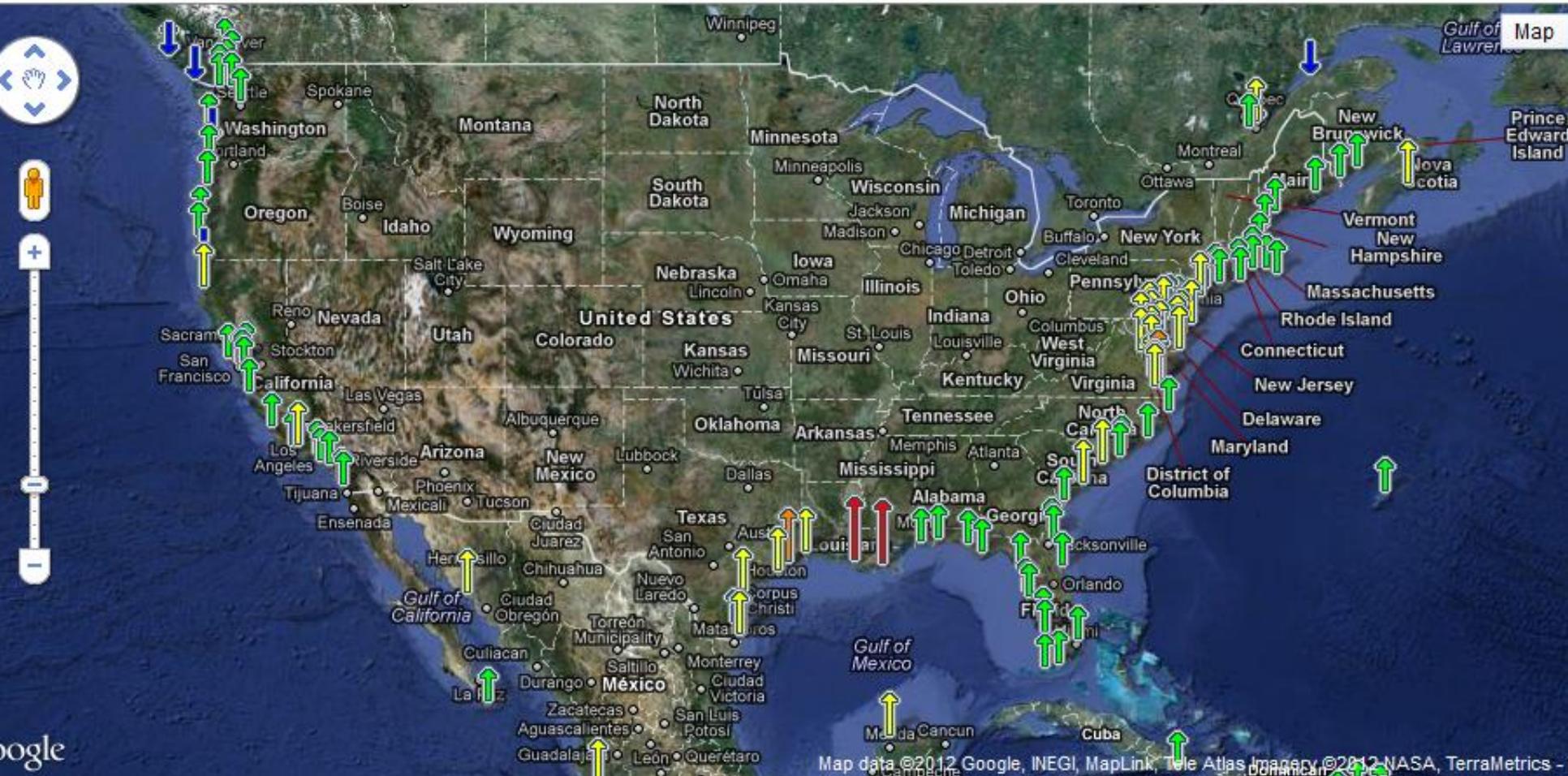


Source: CSIRO, available at http://www.cmar.csiro.au/sealevel/sl_hist_intro.html



Williams, S.J., K. Dodd, and K.K. Gohn. 1997. Coasts in Crisis, U.S. Geological Survey, Circular C-1075.

- East Coast
- West Coast
- Gulf Coast
- Alaska
- Pacific
- Global

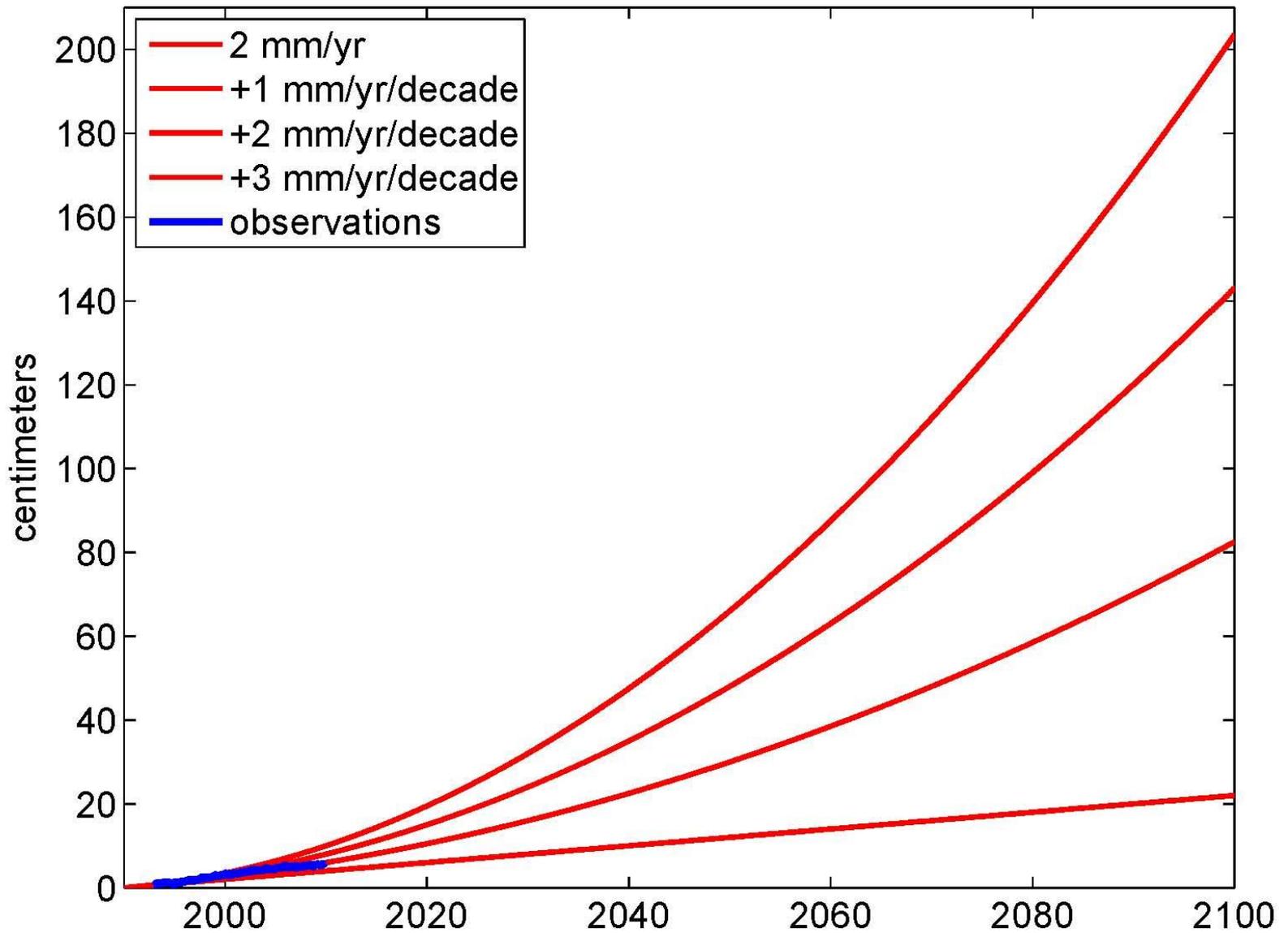


The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow for additional information about that station.

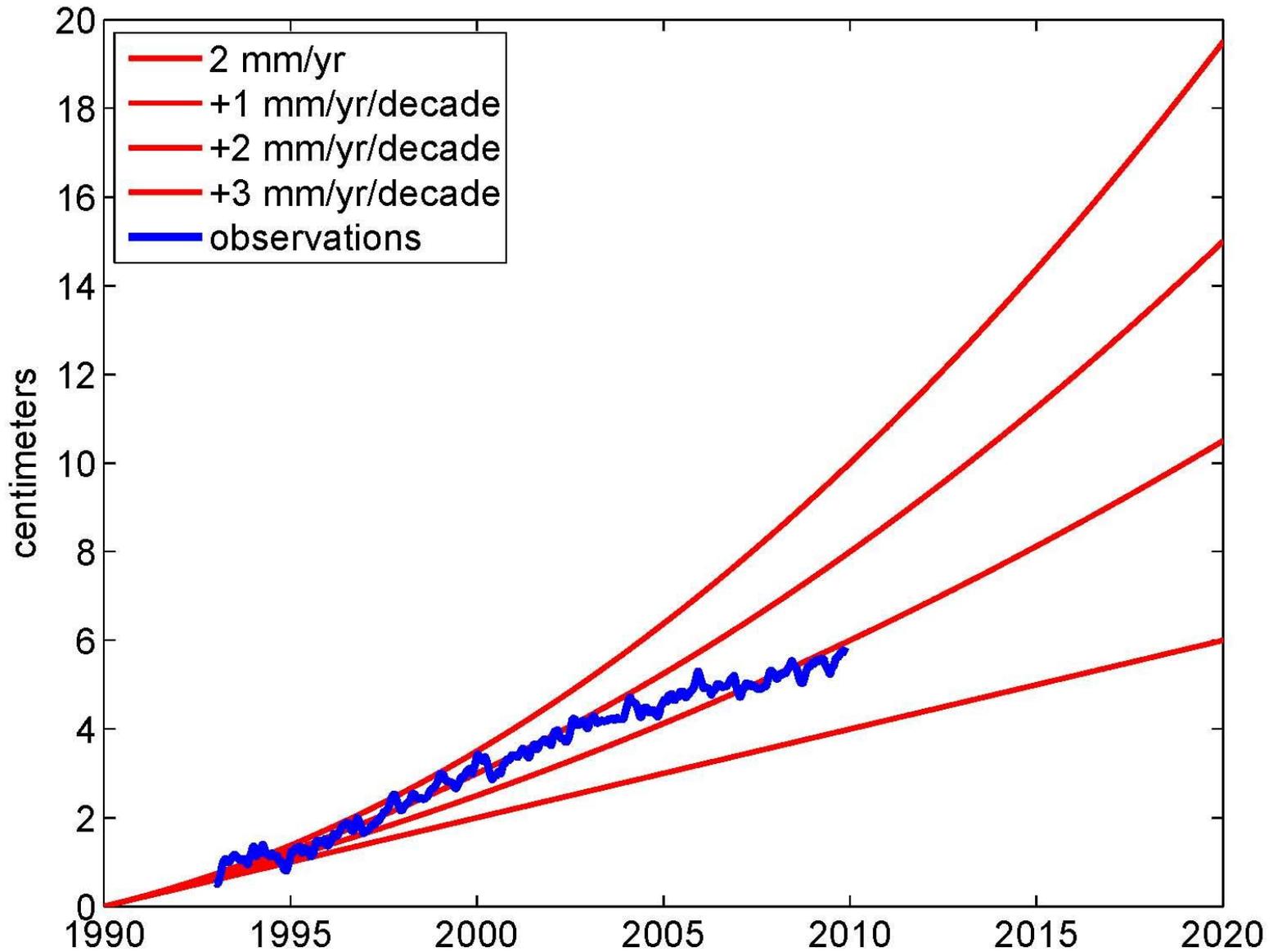
Sea Level Trends					
mm/yr (feet/century)					
■	9 to 12 (3 to 4)	■	3 to 6 (1 to 2)	■	-3 to 0 (-1 to 0)
■	6 to 9 (2 to 3)	■	0 to 3 (0 to 1)	■	-6 to -3 (-2 to -1)
■	-9 to -6 (-3 to -2)	■	-15 to -12 (-5 to -4)	■	-12 to -9 (-4 to -3)
■	-18 to -15 (-6 to -5)				

SLR Predictions

- USACOE
 - 0.5-1.5 meters by 2100 (20 inches to 5 feet)
- SE Florida Climate Compact
 - 2030: 3-7 inches
 - 2060: 9-24 inches
- IPCC AR5 Report (2013)
 - 11 to 39 inches by 2100
- NOAA
 - 1.6 feet to 6.6 feet by 2100



Slide courtesy of Dr. Gary Mitchum, USF



Slide courtesy of Dr. Gary Mitchum, USF

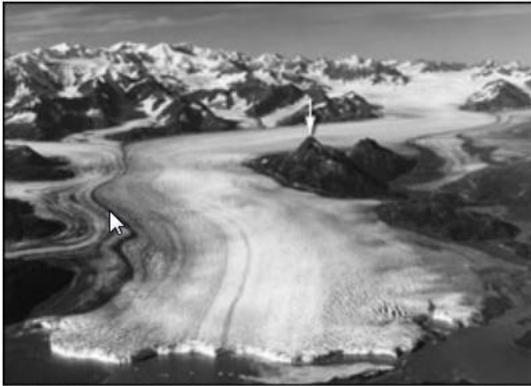
Glacier in 1914



Same Glacier in 2004

Photos from “World View of
Global Warming”





Columbia Glacier c. 1980



Columbia Glacier 2005



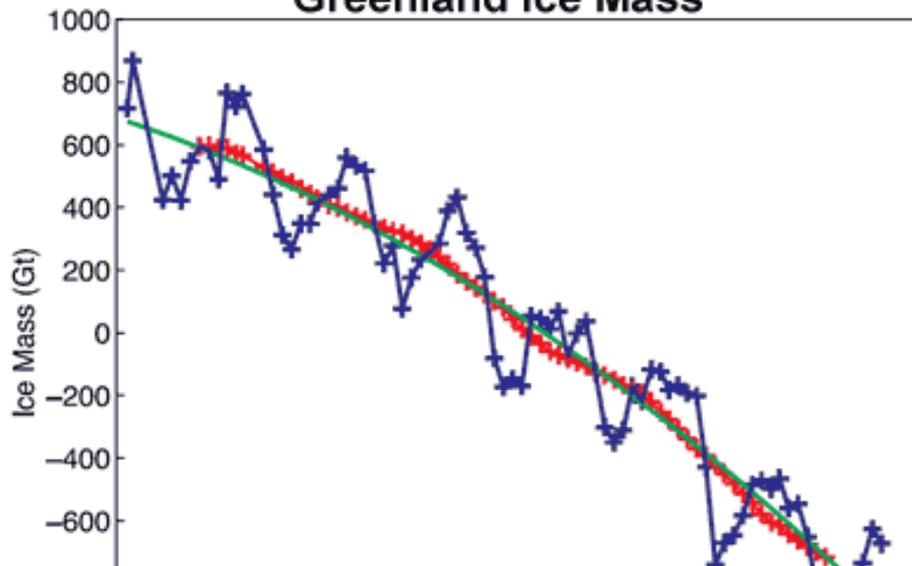
Arapaho Glacier 1898



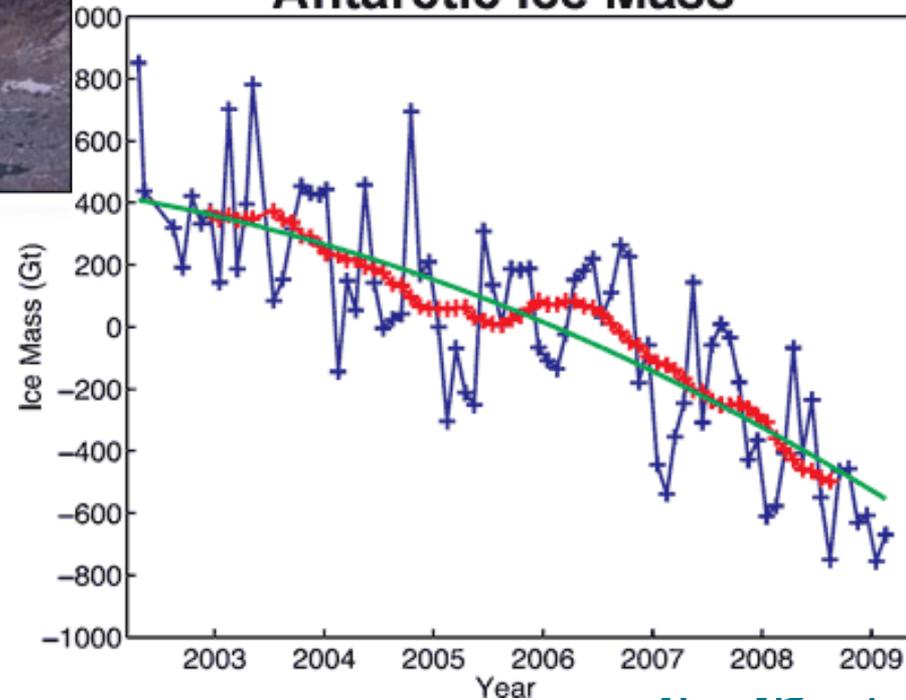
Arapaho Glacier 2003

50% thermal – 50%
new;
now 20-80

Greenland Ice Mass



Antarctic Ice Mass



The background features a stylized, monochromatic illustration of a coral reef. The coral structures are rendered in various shades of blue and green, with intricate patterns of polyps and branching. The overall aesthetic is clean and modern, with a focus on the natural textures and shapes of the reef.

The Physical Impacts of SLR

Florida Sea Grant College Program



Effects on barrier islands

- Increased erosion
- More frequent breaching of barrier islands
- Sand-starved barrier islands migrate landward or lost
- More beach nourishment



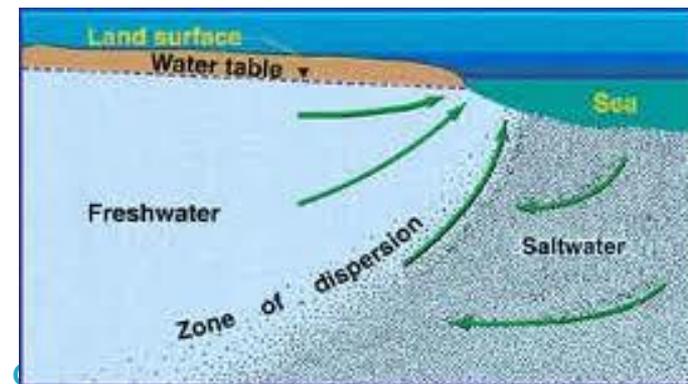
Effects on infrastructure

- Major pop. centers vulnerable and facilities on the water's edge most vulnerable to SLR
- Buildings need to be hardened, elevated or moved
- Salt water stresses building materials, and hydrodynamic pressure from storm surges may undermine foundations



Effects on water supply

- Increased saltwater intrusion into surficial aquifers Pensacola Bay, St. Johns River, south Florida most vulnerable
- SFWMD already spends millions of dollars a year to prevent Miami's aquifer from becoming brackish; need to spend more
- SLR of 6 inches or more = adaptation strategies including alternative water supplies and other advanced water management strategies
- Water and wastewater facilities at low elevations will be subject to more frequent flooding



Effects on beaches

- Further increases in nourishment exacerbating existing sand deficits
- Increased need for sand from outside the US or from inland sand mines, greatly increasing costs
- Pressure to harden shorelines to protect structures, leading to likely loss of habitat for endangered species



Effects on coastal flooding

- Increased coastal flooding.
- Increased risk to gravity-drained areas
- By 2040, 6 to 9 inches of sea-level rise likely to reduce the capacity of flood control systems by 70% in south Florida
- Storm surges penetrate further inland







Effects on Coastal Flooding

“... nuisance flooding ... has increased ... between 300 and 925 percent since the 1960s”

--2014 NOAA study “Sea Level Rise and Nuisance Flood Frequency Changes around the United States”



The Legal and Financial Implications for Local Governments

Florida Sea Grant College Program



Repercussions of Physical Impacts

Why this matters so much to Florida:

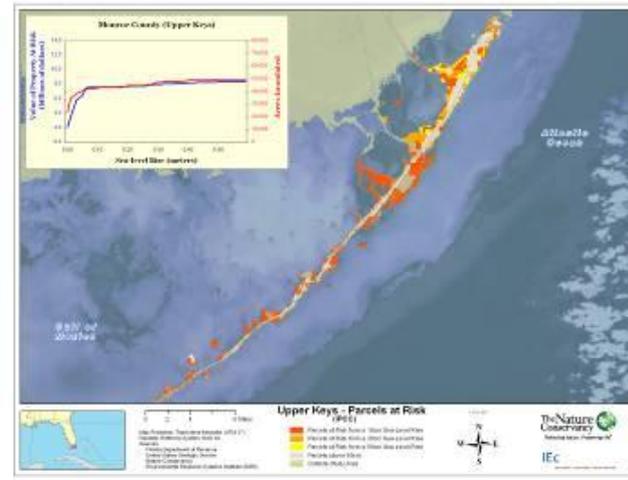
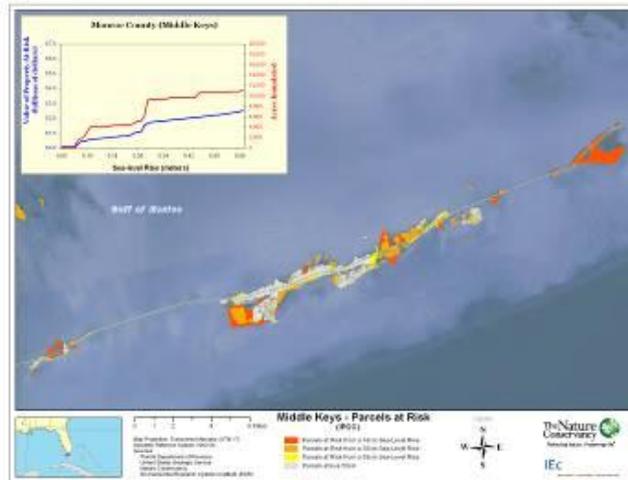
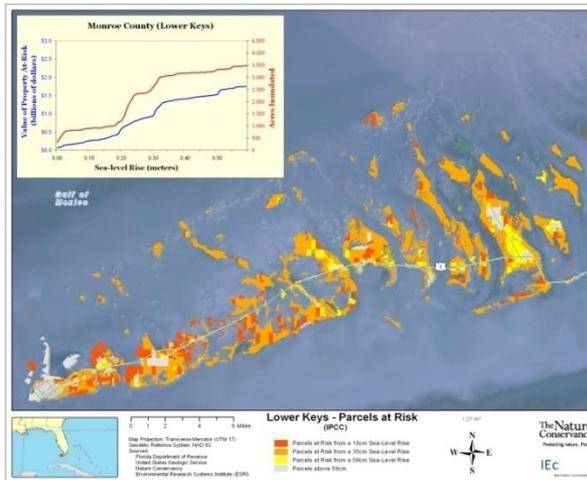
Table 3. Top ten nationally-ranked states, counties and cities for largest total populations living on land less than four feet above local high tide.

Rank	Top 10 States	Top 10 Counties	Top 10 Cities
1	Florida	Miami-Dade, FL	New Orleans, LA*
2	Louisiana*	Broward, FL	New York, NY
3	California	Jefferson, LA*	Hialeah, FL
4	New York	Orleans, LA*	Metairie, LA*
5	New Jersey	Lee, FL	Pembroke Pines, FL
6	Virginia	Pinellas, FL	Cape Coral, FL
7	Texas	Nassau, NY	Miami Beach, FL
8	North Carolina	San Mateo, CA	Plantation, FL
9	South Carolina	Collier, FL	Miramar, FL
10	Massachusetts	Hillsborough, FL	Fort Lauderdale, FL

PROPERTY VALUE AND ACREAGE AT RISK UNDER VARIOUS SLR SCENARIOS (MONROE COUNTY; 30M NED)

SLR Scenario	LOWER KEYS		MIDDLE KEYS		UPPER KEYS		FLORIDA KEYS	
	PROPERTY VALUE AT RISK	ACRES	PROPERTY VALUE AT RISK	ACRES	PROPERTY VALUE AT RISK	ACRES	PROPERTY VALUE AT RISK	ACRES
IPCC 18cm	\$2,610,000,000	11,000	\$753,000,000	4,430	\$7,670,000,000	43,300	\$11,000,000,000	58,800
IPCC 35cm	\$8,790,000,000	49,400	\$1,850,000,000	9,500	\$8,040,000,000	47,500	\$18,700,000,000	106,000
IPCC 59cm	\$11,000,000,000	54,400	\$2,610,000,000	11,200	\$8,330,000,000	49,600	\$21,900,000,000	115,000
Rahmstorf 100cm	\$13,000,000,000	56,300	\$3,530,000,000	12,600	\$10,100,000,000	55,600	\$26,700,000,000	124,000
Rahmstorf 140cm	\$15,800,000,000	58,000	\$6,040,000,000	17,300	\$13,200,000,000	67,100	\$35,100,000,000	142,000

Note: Figures are rounded to 3 significant digits. Entries may not sum to totals due to rounding.



Coastal Erosion
and Solutions
A Primer
2nd Edition

CSE's Coastal Erosion and Solutions

CSE
CIVIL, MARINE & ENVIRONMENTAL ENGINEERING

Protect



Photo : Carlos Frey of the City of St. Pete

Accommodate



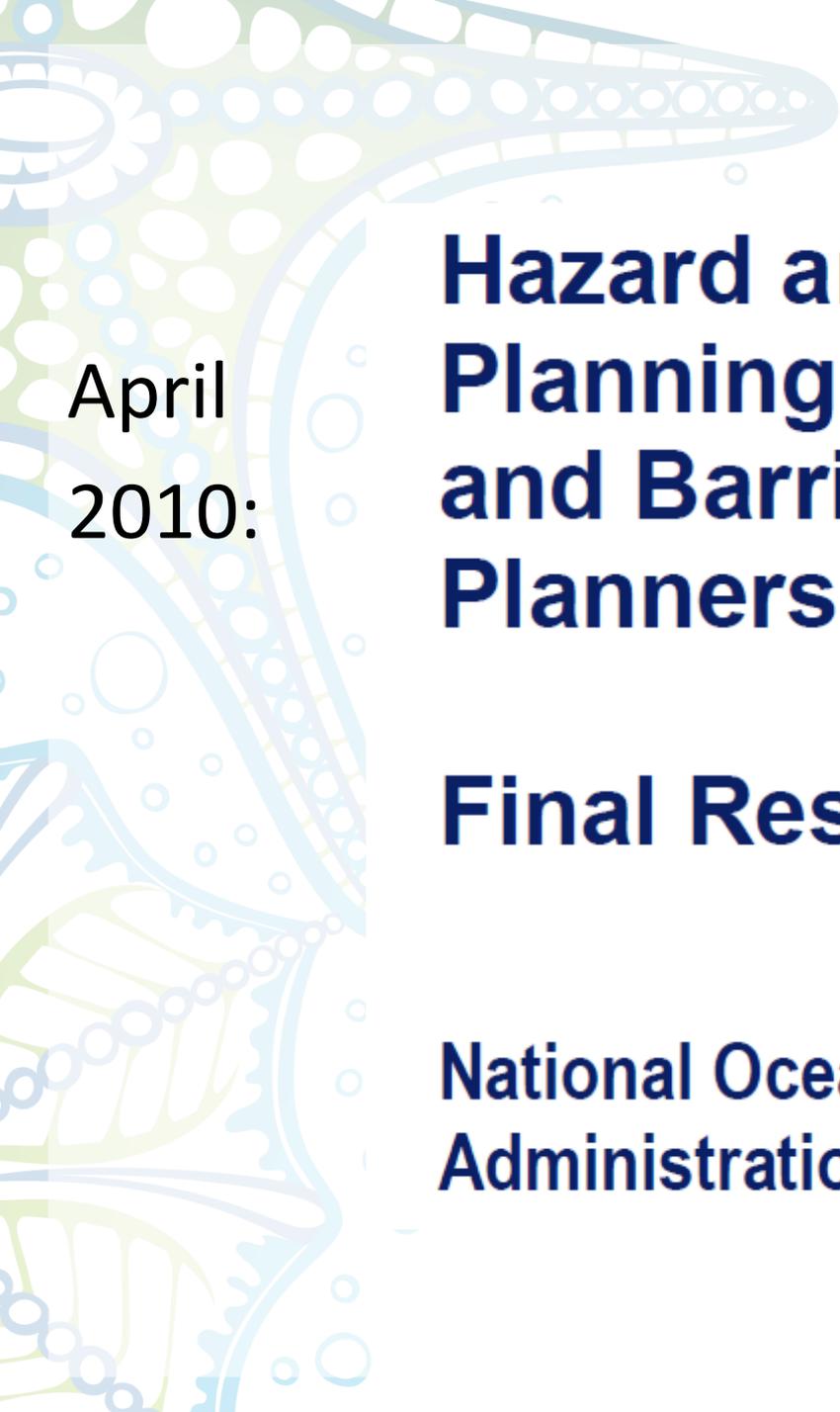


Relocate



Armor/Nourish. Costs

- **Armoring:** Costs vary: \$300-\$4,000 per linear foot
 - Est. for Punta Gorda: almost **\$382 million for bulkhead + \$935 million for fill + \$252 million for salary = \$1.57 billion**
 - DOES NOT consider legal feasibility of backfilling PG to 6 feet above current MHW
 - Typical estimates for armoring cost DO NOT include cost for drainage—a very important and costly consideration
- **Nourishment:** Statewide for 39” of SLR--\$6-\$39 billion; go to Bahamas for sand?
- **Elevation:** \$58/sq. ft. for existing, single-story slab
 - Does not include impacts to roads/neighborhood



April
2010:

Hazard and Resiliency Planning: Perceived Benefits and Barriers Among Land Use Planners

Final Research Report

**National Oceanic and Atmospheric
Administration Coastal Services Center**

We the People

of the United States, in order to form a more perfect Union, establish Justice, insure domestic Tranquillity, provide for the common defence, promote the general Welfare, and secure the Blessings of Liberty to ourselves and our Posterity, do ordain and establish this Constitution for the United States of America.

Article 1

Section 1. All legislative Powers herein granted shall be vested in a Congress of the United States, which shall consist of a Senate and House of Representatives.

Section 2. The House of Representatives shall be composed of Members chosen every second Year by the People of the several States, and the Electors in every State shall have the Qualifications requisite for Electors of the most numerous Branch of the State Legislature.

No Person shall be a Representative who shall not have attained to the Age of thirty Years, and seven Years a Citizen of the United States, and who, when elected, shall not, when he shall be chosen, have seven Years a Citizen of the United States, and who, when elected, shall not, when he shall be chosen, have seven Years a Citizen of the United States, and who, when elected, shall not, when he shall be chosen, have seven Years a Citizen of the United States.

“Takings” in the U.S. Constitution

Representatives and direct Taxes shall be apportioned among the several States which may be admitted into or which shall exist at the Time of the first Meeting of the Congress, according to the Number of free Persons, and three fifths of all other Persons, who in each State shall have the Qualification of Electors in that State, as determined by the Legislature thereof, in the Year 1790. The actual Enumeration shall be made within three Years after the first Meeting of the Congress of the United States, and within every subsequent Term of ten Years, in such Manner as they shall by Law direct. The Number of Representatives shall not exceed one for every thirty Thousand, but each State shall have at least one Representative, and until such Enumeration shall be made, the State of New Hampshire shall be entitled to three, Massachusetts eight, Rhode Island and Providence Plantations one, Connecticut five, New York six, New Jersey four, Pennsylvania seven, Delaware one, Maryland three, Virginia ten, North Carolina five, South Carolina five, and Georgia three.

When vacancies happen in the Representation from any State, the Electors in that State shall fill such Vacancies. The House of Representatives shall choose their Speaker and other Officers, and shall have the sole Power of Impeachment.

Section 3. The Electors in the several States shall have the Qualification, Term, Number, and Mode of Appointment, in each State, as may be directed by the Legislature thereof. The Electors in each State shall have the Qualification, Term, Number, and Mode of Appointment, in each State, as may be directed by the Legislature thereof.

“... nor shall private property be taken for public use, without just compensation.”

Section 4. The Electors in each State shall have the Qualification, Term, Number, and Mode of Appointment, in each State, as may be directed by the Legislature thereof. The Electors in each State shall have the Qualification, Term, Number, and Mode of Appointment, in each State, as may be directed by the Legislature thereof.

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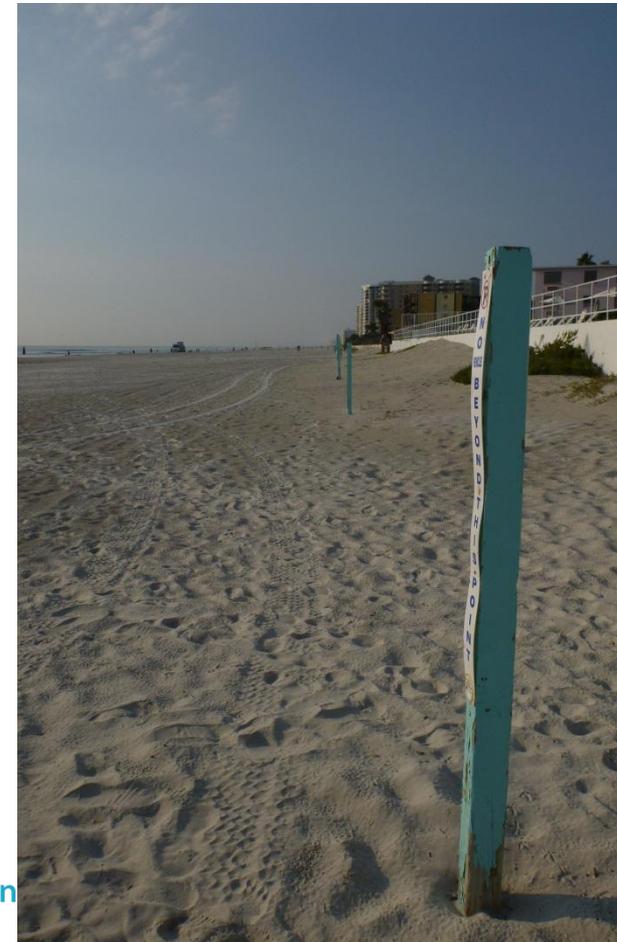
The President of the United States shall be President of the Senate, but shall have no Vote, unless they be equally divided. The Senate shall choose their other Officers, and also a President pro tempore, in the Absence of the Vice President, or when he shall exercise the Office of President of the United States.

The Senate shall have the sole Power to try all Impeachments. When sitting for that Purpose, they shall be on Oath or Affirmation. When the President of the United States is tried, the Chief Justice shall preside: And no Person shall be convicted without the Concurrence of two thirds of the Members present.

Judgment in Cases of Impeachment shall not extend further than to removal from Office, and disqualification to hold any Office of Honor, Trust or Profit under the United States: but the Party convicted shall nevertheless be liable and subject to Indictment, Trial, Judgment, and Punishment, according to Law.

Trepanier Case

- Parking/driving on property after storm
- Beach markers and driving moved landward
- Trial court for County
- Appellate Court:
 - Need proof of customary right
 - *Not* self-evident that a customary right moves with the dry-sand beach
- **LOSS OF LATERAL ACCESS**



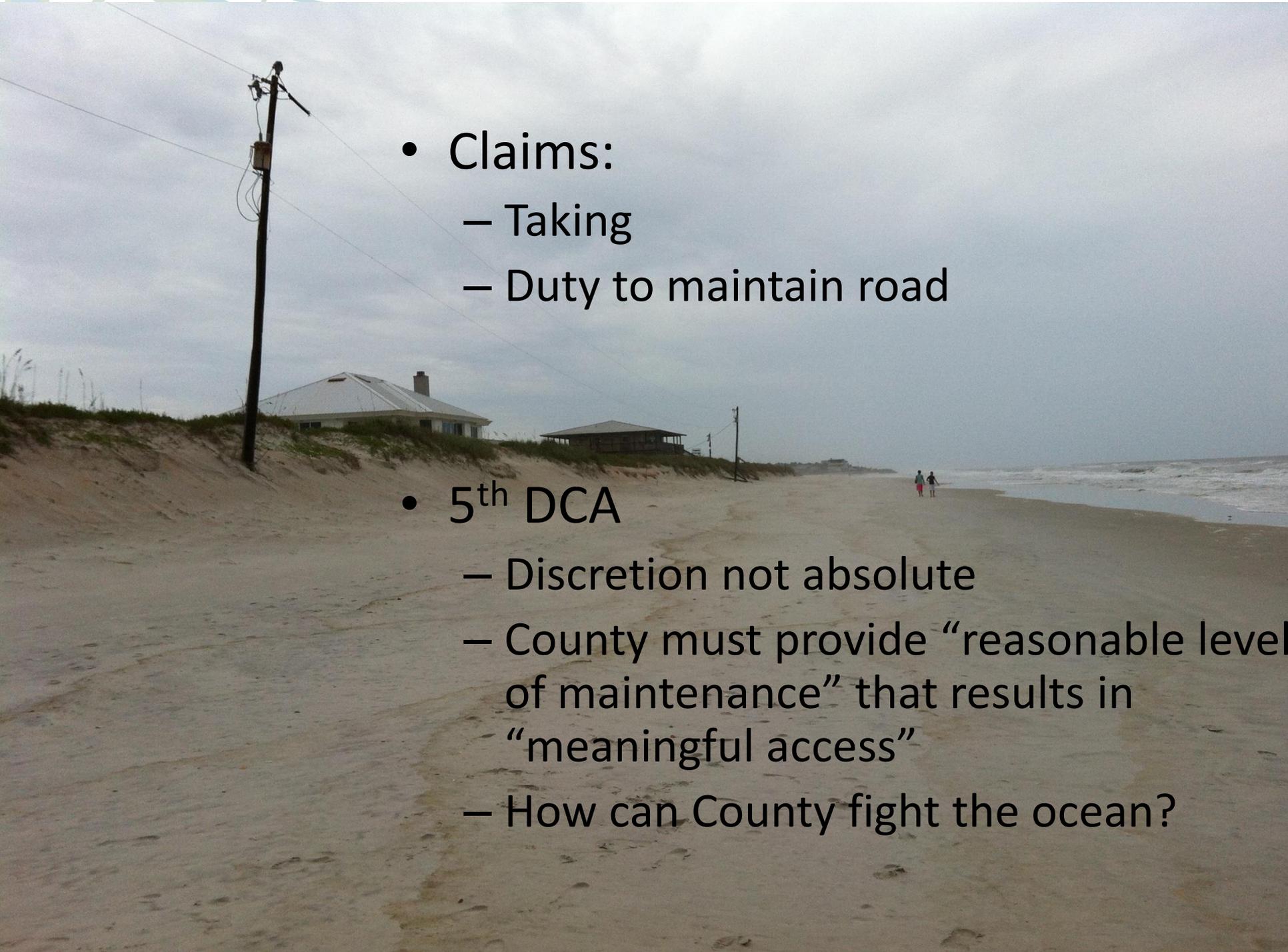
- *Jordan et al. Case*





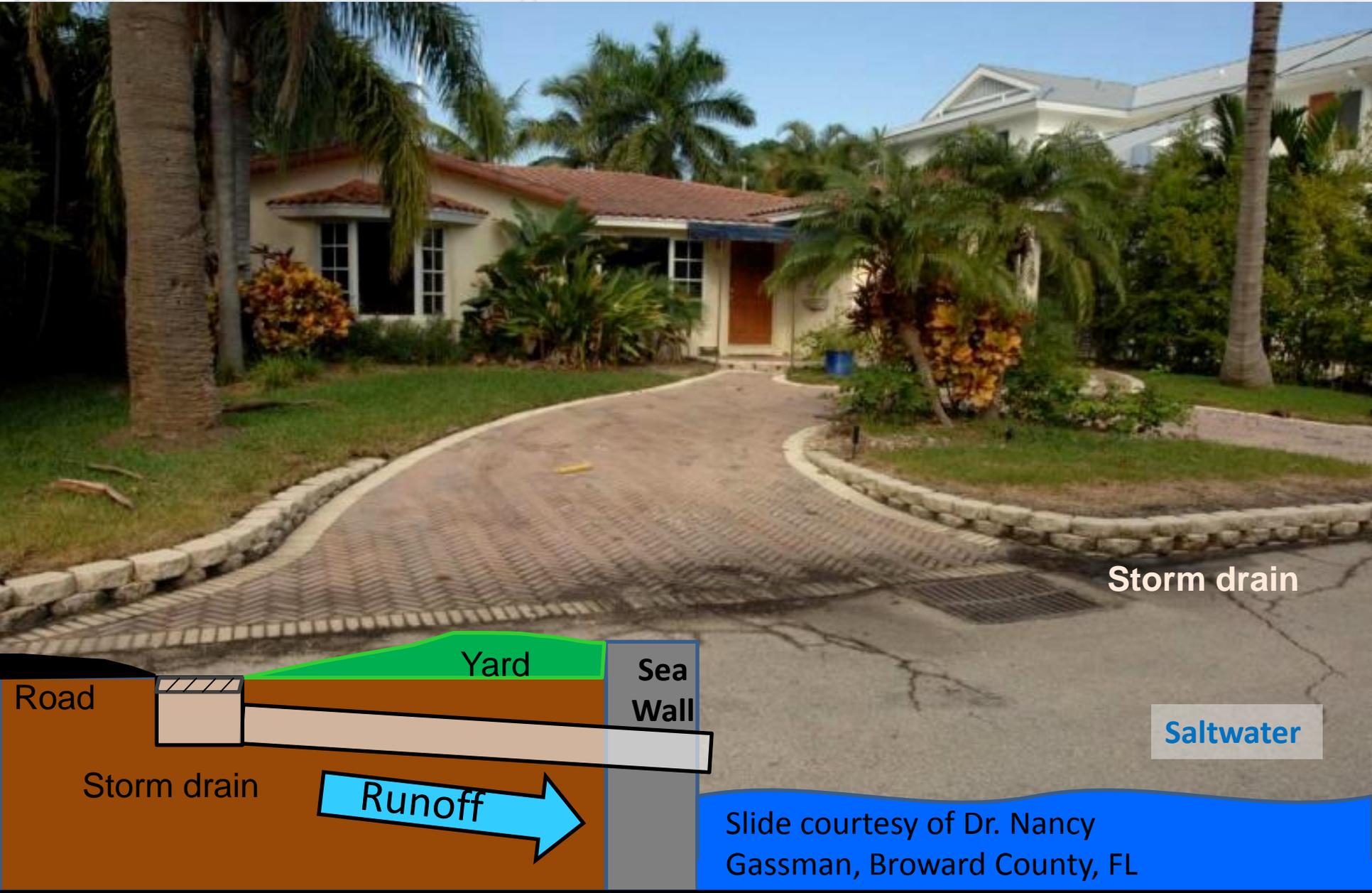


ST JOHNS
ROAD & BRIDGE

- 
- Claims:
 - Taking
 - Duty to maintain road

- 5th DCA
 - Discretion not absolute
 - County must provide “reasonable level of maintenance” that results in “meaningful access”
 - How can County fight the ocean?

Drainage Under Average Tidal Conditions

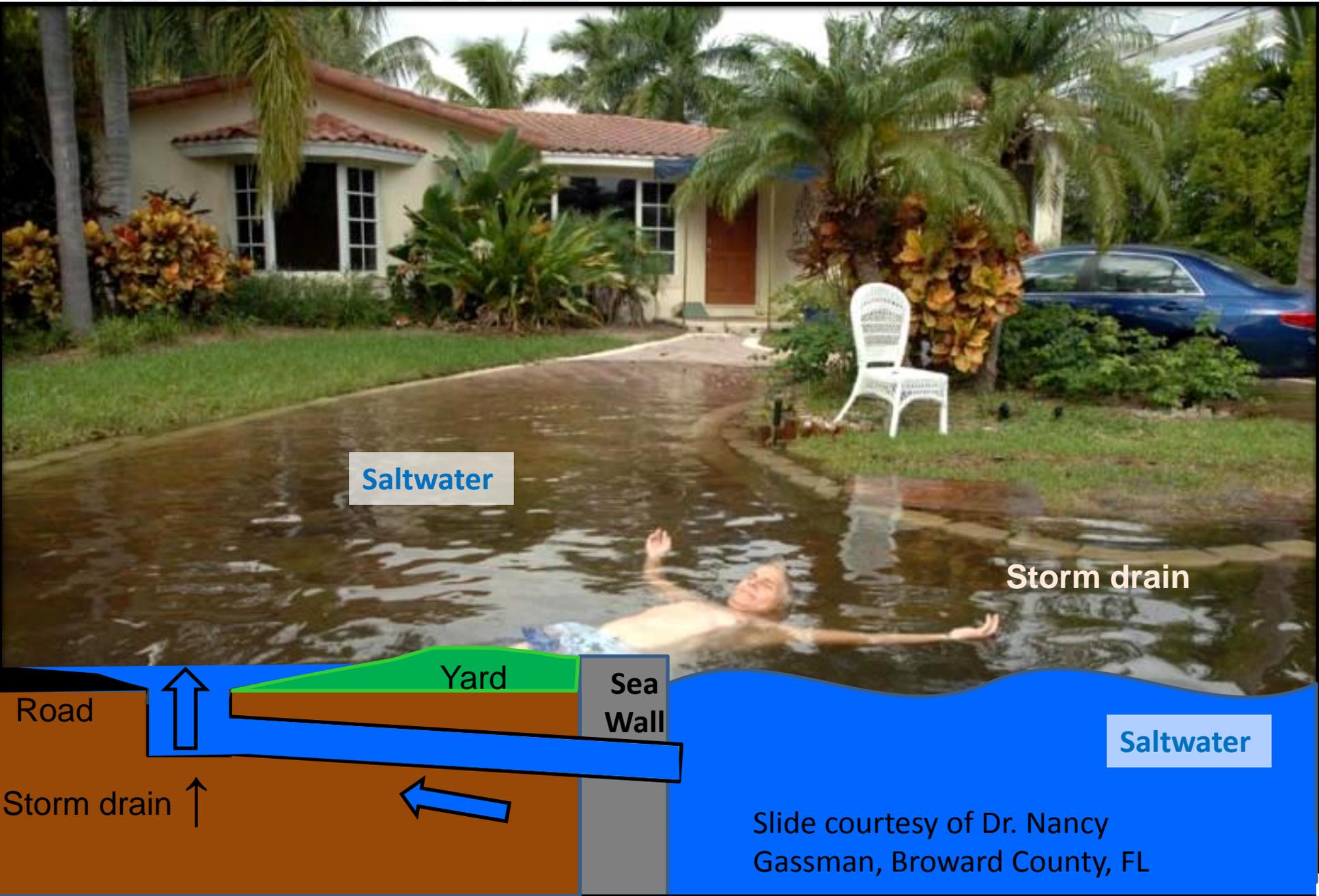


Storm drain

Saltwater

Slide courtesy of Dr. Nancy Gassman, Broward County, FL

Drainage Challenge with Sea Level Rise



Saltwater

Storm drain

Saltwater

Road

Yard

Sea Wall

Storm drain

Slide courtesy of Dr. Nancy Gassman, Broward County, FL

Chicago Flooding: April 2013



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November, 2013 Volume 87, No. 9

Drowning in Place: Local Government Costs and Liabilities for Flooding Due to Sea-level Rise

by Thomas Ruppert and Carly Grimm

- No duty of local gov't to provide drainage
 - As with many services, *authority* or *power* to provide, but not duty (fire, police, etc.)
- However, if provided, duty to maintain arises
 - Maintenance must be done with reasonable care
 - Liability for failure to maintain

Maintenance vs. Upgrade

- Immunity through “planning” vs. “operational” distinction
 - Immunity for planning as this is legislative
 - No immunity for “operations;” always a duty to act with reasonable care
 - But, VA case. . . . “taking” for inaction



Summary of Takings

- Potential loss of lateral public beach access (easement tied to coordinates)
- Untenable situation for local governments for roads: can't maintain but can't abandon
- Planners need to take active role in bringing potential future consequences into current discussions
- Plan for future conditions you know about, or potential for negligence liability



Adapting to the Future

Florida Sea Grant College Program



Resilience

- It's not all just about sea-level rise
 - Coastal flooding, surge, storms, flood insurance, erosion
- Vulnerability assessment, planning, implementation
- Satellite Beach example
 - Studied vulnerability, presented to public, extensive public engagement, moving ahead to implement measures supported by the public



Threat and Hazard Identification and Risk Assessment Guide

Comprehensive Preparedness Guide (CPG) 201

Second Edition
August 2013



NIST Special Publication 1190

Community Resilience Planning Guide for Buildings and Infrastructure Systems

Volume I

Draft for Public Comment

Tools: Vulnerability

- NOAA webinars “Roadmap for Adapting to Coastal Risk”
- U.S. Climate Resilience Toolkit (<https://toolkit.climate.gov/>)



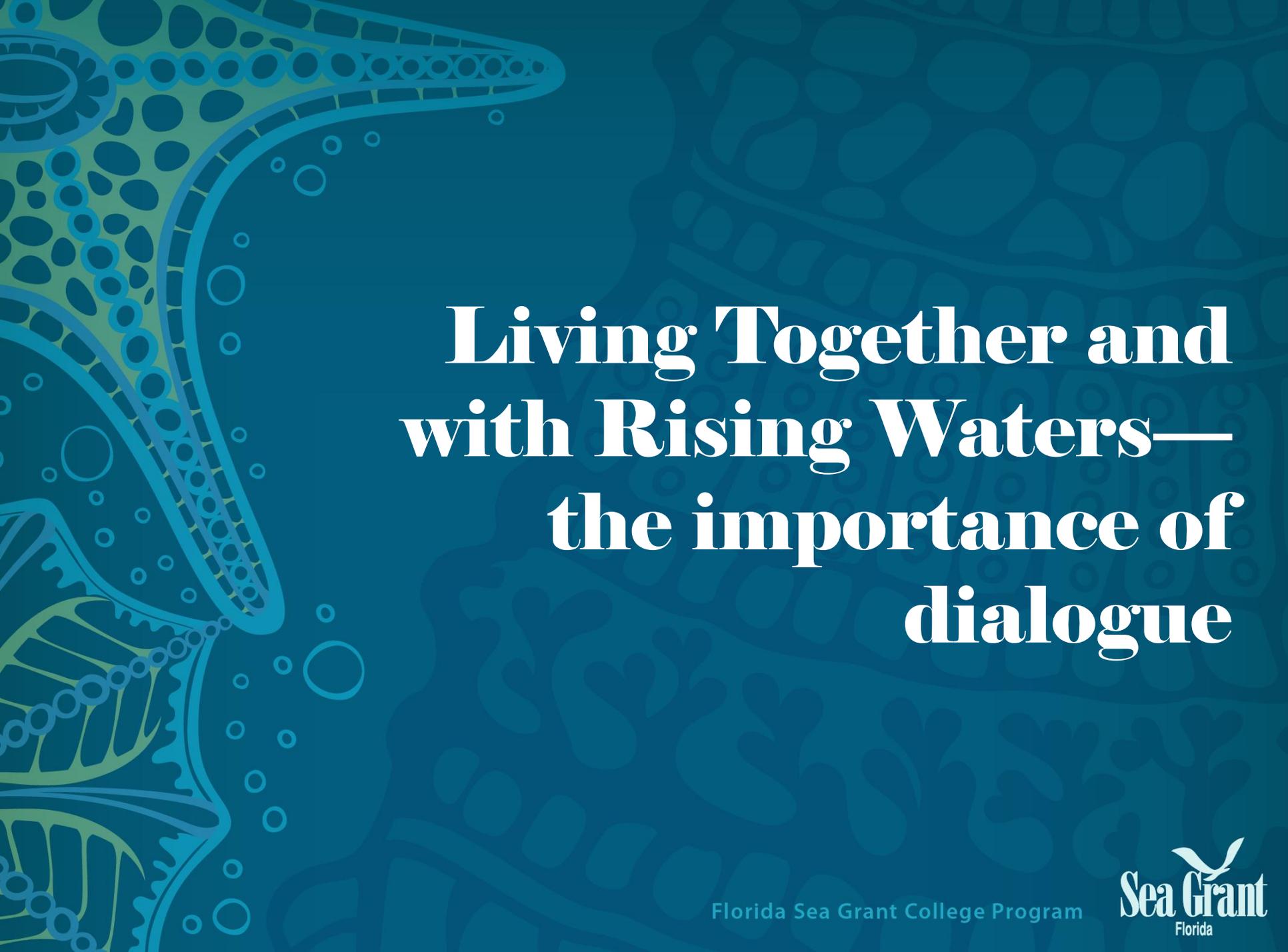
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Tools: Flooding & SLR

- NOAA's "Digital Coast"
 - Data, tools, training
 - "Coastal County Snapshots"—flooding, jobs, and wetland benefits
- NOAA's Coastal Flood Exposure Mapper
- Surging Seas
(<http://sealevel.climatecentral.org/>)
- FDOT-funded "Sketch Tool"
(<http://sls.geoplan.ufl.edu/about/>)

Other Florida Communities' Efforts

- Satellite Beach
- NE Florida's P2R2
- Southeast Florida Climate Change Compact
- Fort Lauderdale
- Monroe County
- Tampa Bay Region
- Sarasota
- St. Petersburg



**Living Together and
with Rising Waters—
the importance of
dialogue**

Is It Fair?



“At least \$80 million, adjusted for inflation, has gone into patching up . . . [Dauphin Island] since 1979 — more than \$60,000 for every permanent resident. That does not include payments of \$72 million to homeowners from the highly subsidized federal flood insurance program.”

Nov. 18, 2012 NY Times article “As Coasts Rebuild and U.S. Pay, Repeatedly, the Critics Ask Why”



Florida's Coastal Hazards Disclosure Law: Property Owner Perceptions of the Physical and Regulatory Environment

- Florida Statute
§161.53



A photograph of a grassy hill under a clear blue sky. A white rectangular marker is placed on the grass, with the text "KATRINA HIGH WATER 2005" printed on it in blue. Three black light poles are visible on the hill behind the marker. In the background, a concrete structure is partially visible on the left, and a tall black pole stands in the center. The foreground shows a field of dry, brownish grass with several young trees supported by stakes.

KATRINA HIGH WATER 2005

Bay St. Louis officials oppose Hurricane Katrina high-water markers on highway

Published: Saturday, July 23, 2011, 9:00 PM



By The Associated Press

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Bay St. Louis, Miss., officials want **high-water markers** placed by the state at Mississippi Highway 603 and Interstate 10 camouflaged so they no longer commemorate the tragedies of **Hurricane Katrina** in 2005.



The **Sea Coast Echo** reports there are two high-water markers at the intersection, one facing north and the other facing south on Mississippi 603. They were placed there following Katrina to commemorate the area's comeback from the killer storm. In Katrina, water ran up the roadway so

REASONABLE INVESTMENT-BACKED EXPECTATIONS: SHOULD NOTICE OF RISING SEAS LEAD TO FALLING EXPECTATIONS FOR COASTAL PROPERTY PURCHASERS?

THOMAS RUPPERT*

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Florida's Coastal Hazards Disclosure Law: Property Owner Perceptions of the Physical and Regulatory Environment



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JULY 2012

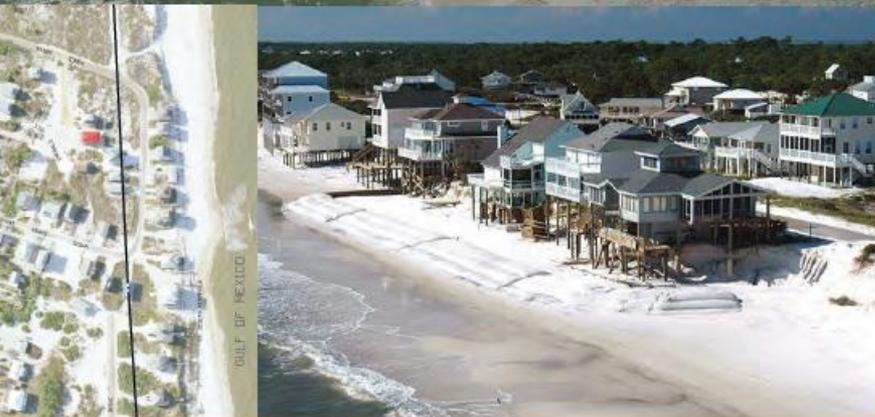
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Conservation Clinic
UNIVERSITY OF FLORIDA



Southeast
Climate Consortium



Florida
Climate Institute



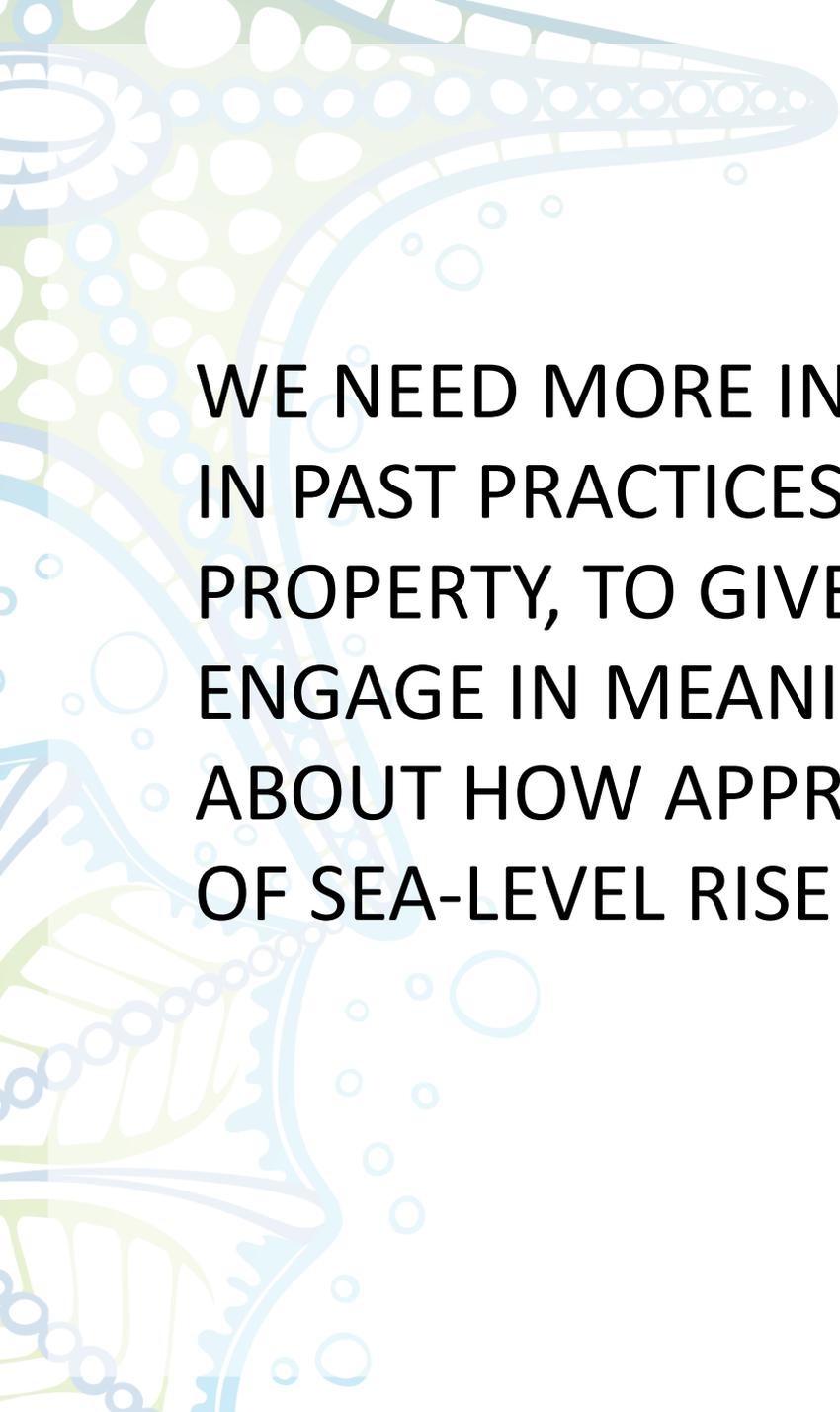






Is It Fair? -- Reprise

- When there's loss, who should pay?
- Why?
- What if it requires changing the law?
 - Is it a taking?
- Should the law evolve?
 - When? Why? By what method?



WE NEED MORE INFORMATION, GROUNDED
IN PAST PRACTICES AND IDEAS ABOUT
PROPERTY, TO GIVE US THE ABILITY TO
ENGAGE IN MEANINGFUL DISCUSSION
ABOUT HOW APPROACH THE CHALLENGES
OF SEA-LEVEL RISE

“At the center of today’s debate [about property] . . . Lies a collective failure on our part to think clearly and intently about the institution [of property], how it works, why it exists, and many shapes it can take, in terms of landowner rights and responsibilities. . . . In operation, [the right to property] is less an individual right than a tool society uses to promote overall social good. Important truths about this arrangement have largely passed from our collective memory. We need to regain these truths.”

-Eric Freyfogle, *On Private Property: Finding Common Ground on the Ownership of Land*

“...when [our current idea of property] emerged in the nineteenth century, it was greeted with considerable dissent and resistance. Far from being timeless, our image of ownership reflects the dominant values and aspirations of the industrial, frontier era. Lawmakers of that era revised ownership norms to help them achieve the development goals that then prevailed.”

-Eric Freyfogle, *On Private Property: Finding Common Ground on the Ownership of Land*

“[A] foolish man . . . built his house on sand. The rain came down, the streams rose, and the winds blew and beat against that house, and it fell with a great crash.”

Matthew 7: 26-27

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