



Measured Sea Level Rise vs Beach Erosion

Bathtub Beach/Sailfish Point, FL

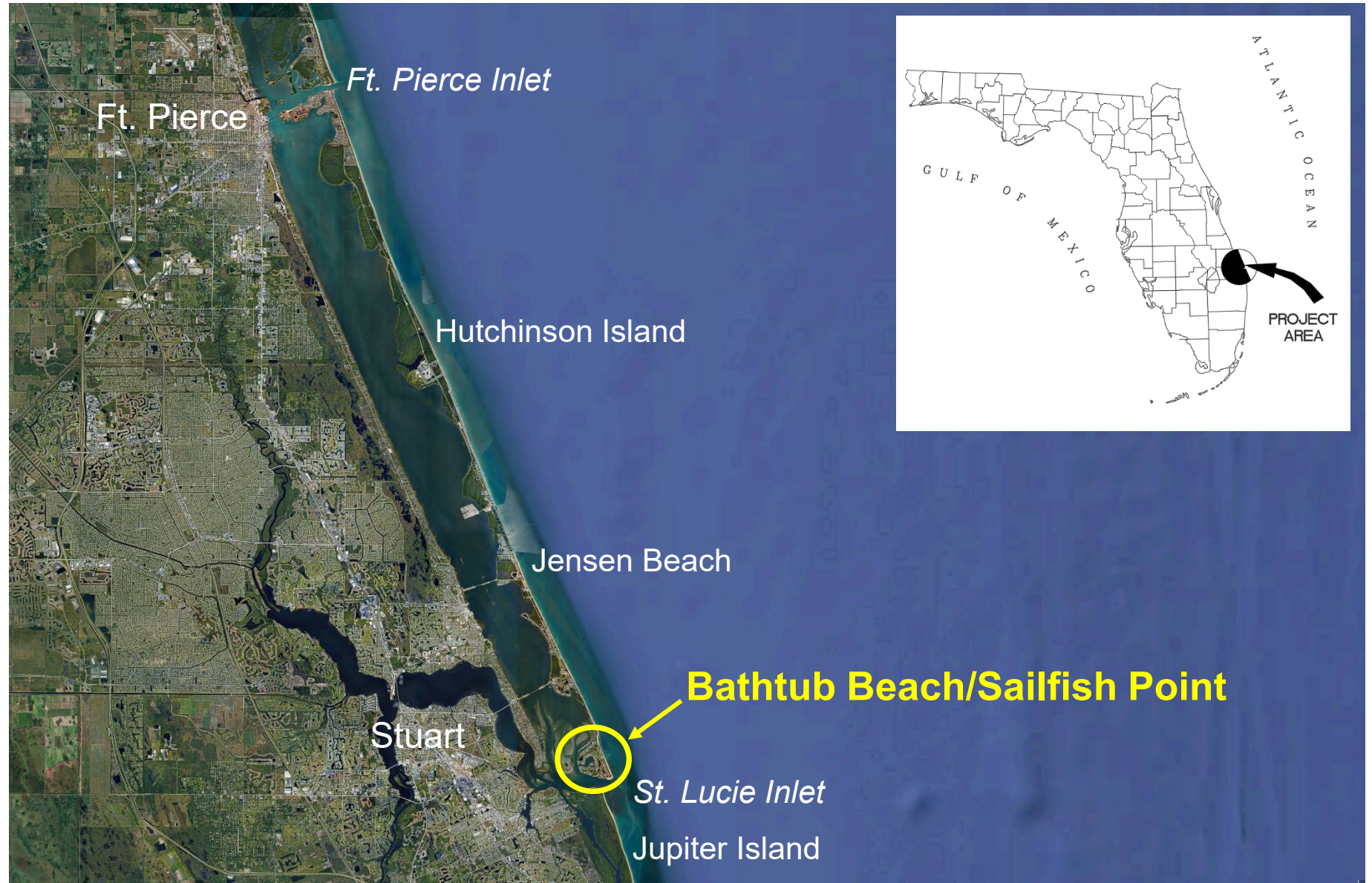
Kevin Bodge, PE, PhD
Steve Howard, PE

Foth Infrastructure &
Environment, LLC

February 5, 2025

Bathtub Reef Beach Park / Sailfish Point

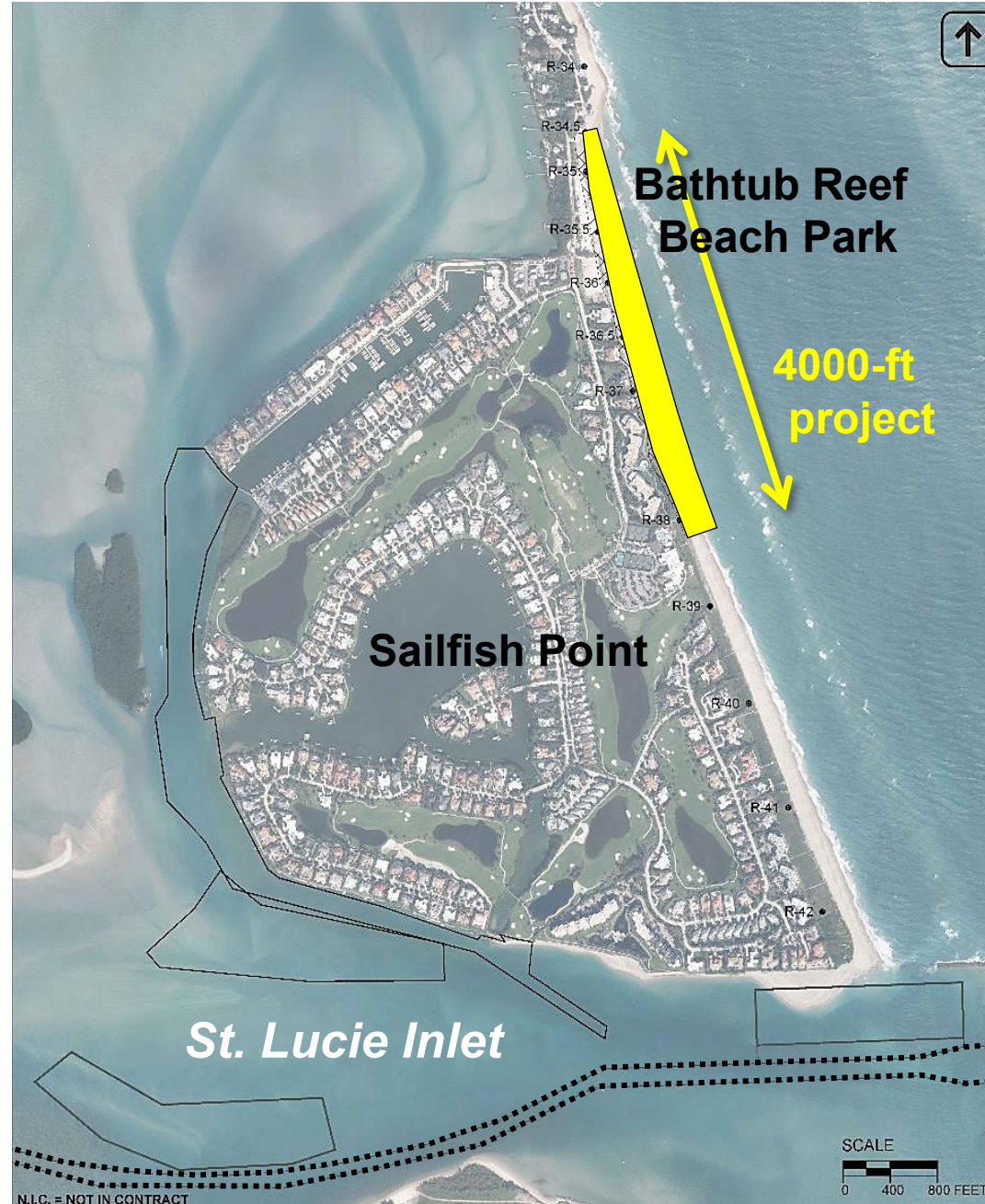
Martin County,
Florida



Bathtub Beach Park / Sailfish Point,

Overview

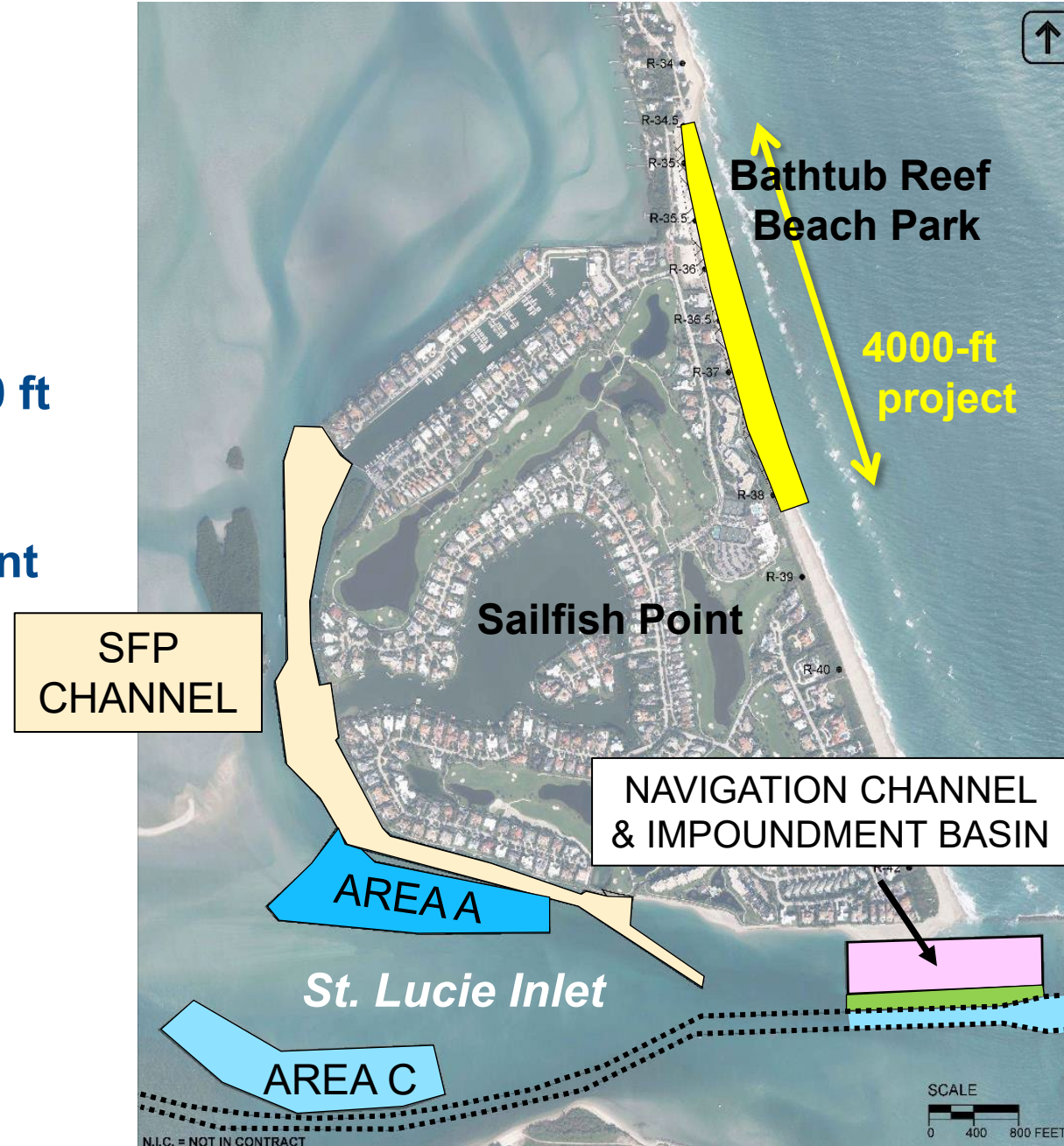
- Renourishes 3500 to 4500 ft of shoreline, 2 to 3 years.
- 150,000 to 250,000 cy/event



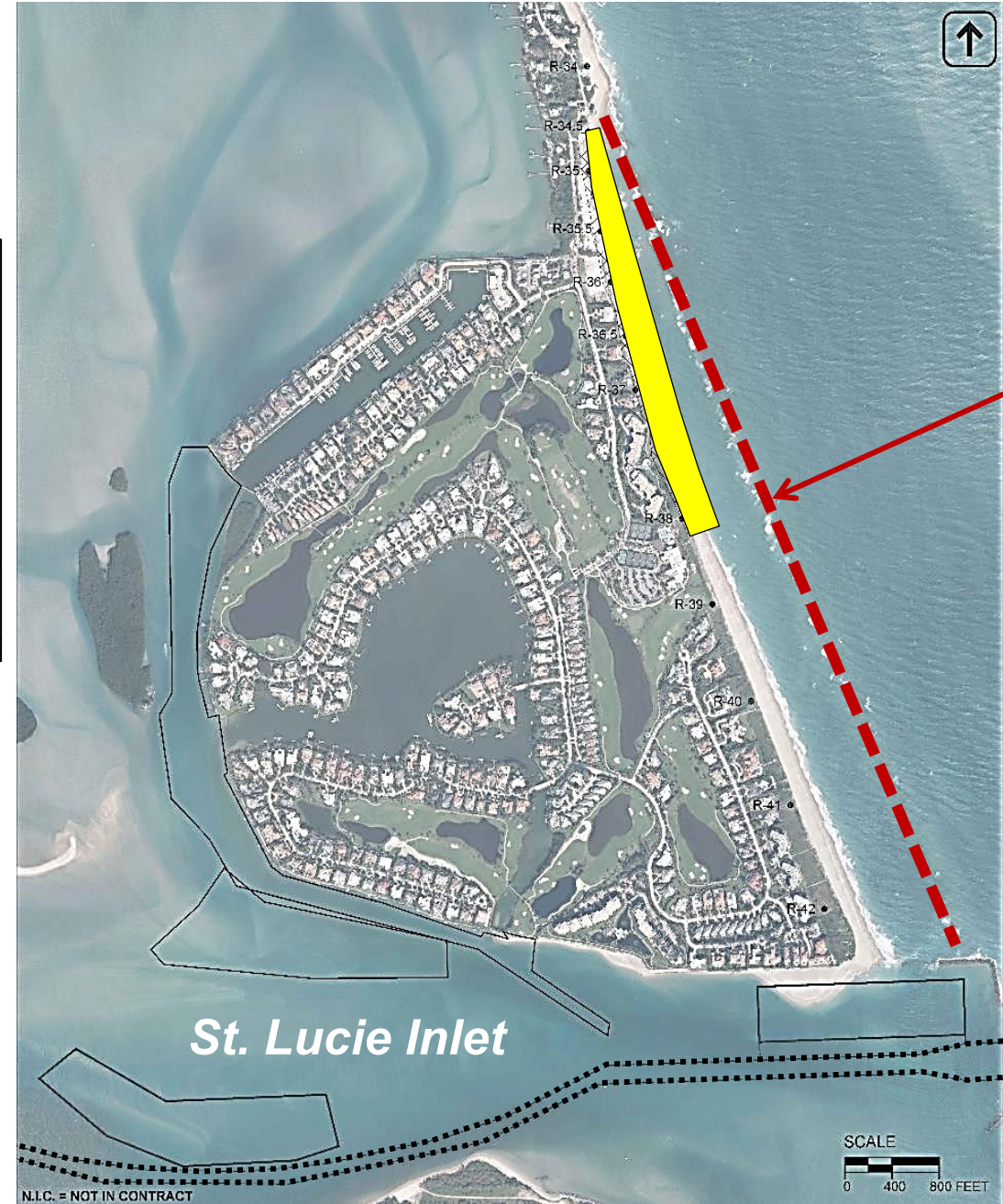
Bathtub Beach Park / Sailfish Point,

Overview

- Renourishes 3500 to 4500 ft of shoreline, 2 to 3 years.
- 150,000 to 250,000 cy/event
- Six borrow areas
 - **2010:** 65,000 cy
 - **2016:** 320,000 cy
 - **2017-18:** 232,000 cy
 - **2021:** 201,000 cy
 - **2024:** 255,000 cy

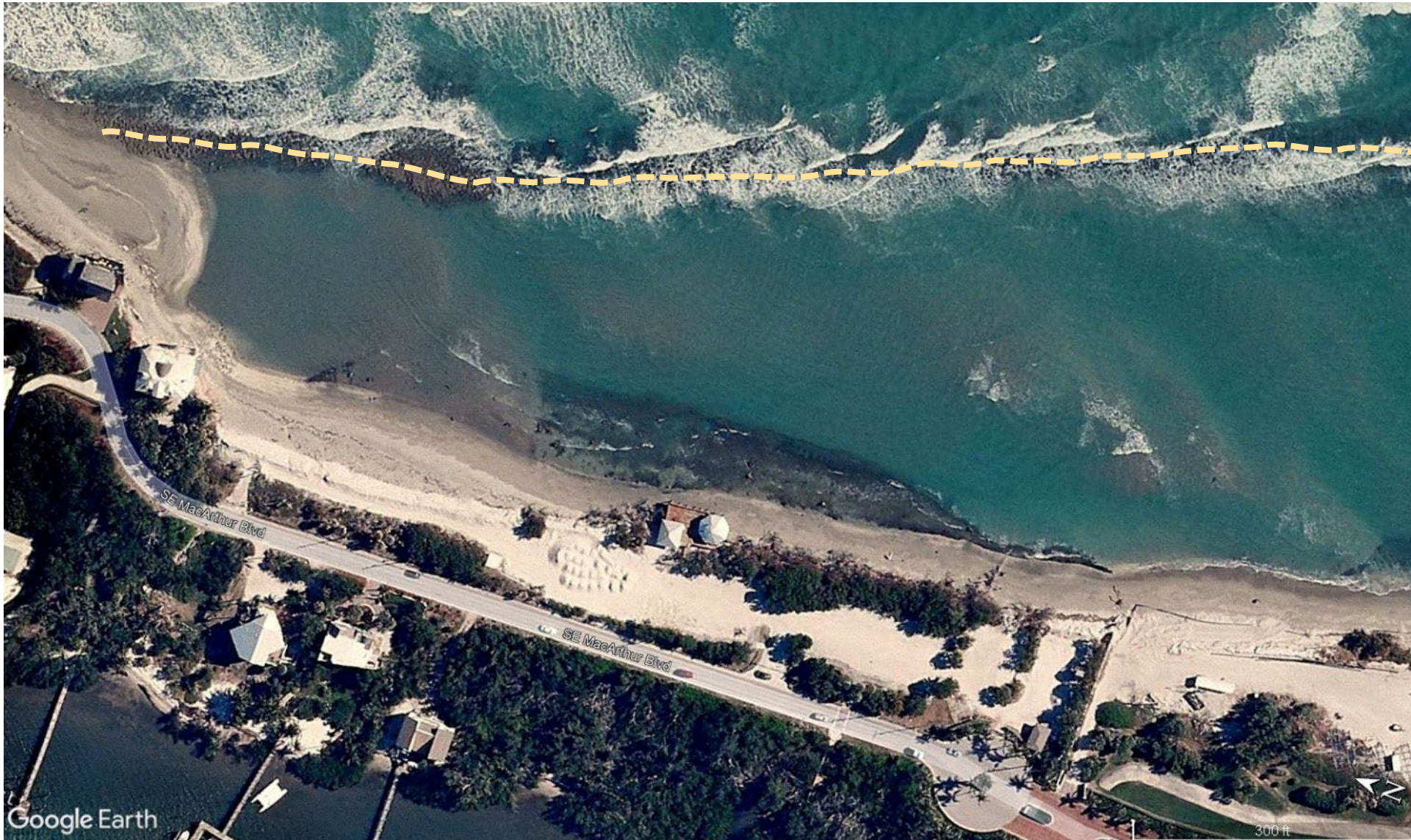


Bathtub Beach Park / Sailfish Point,

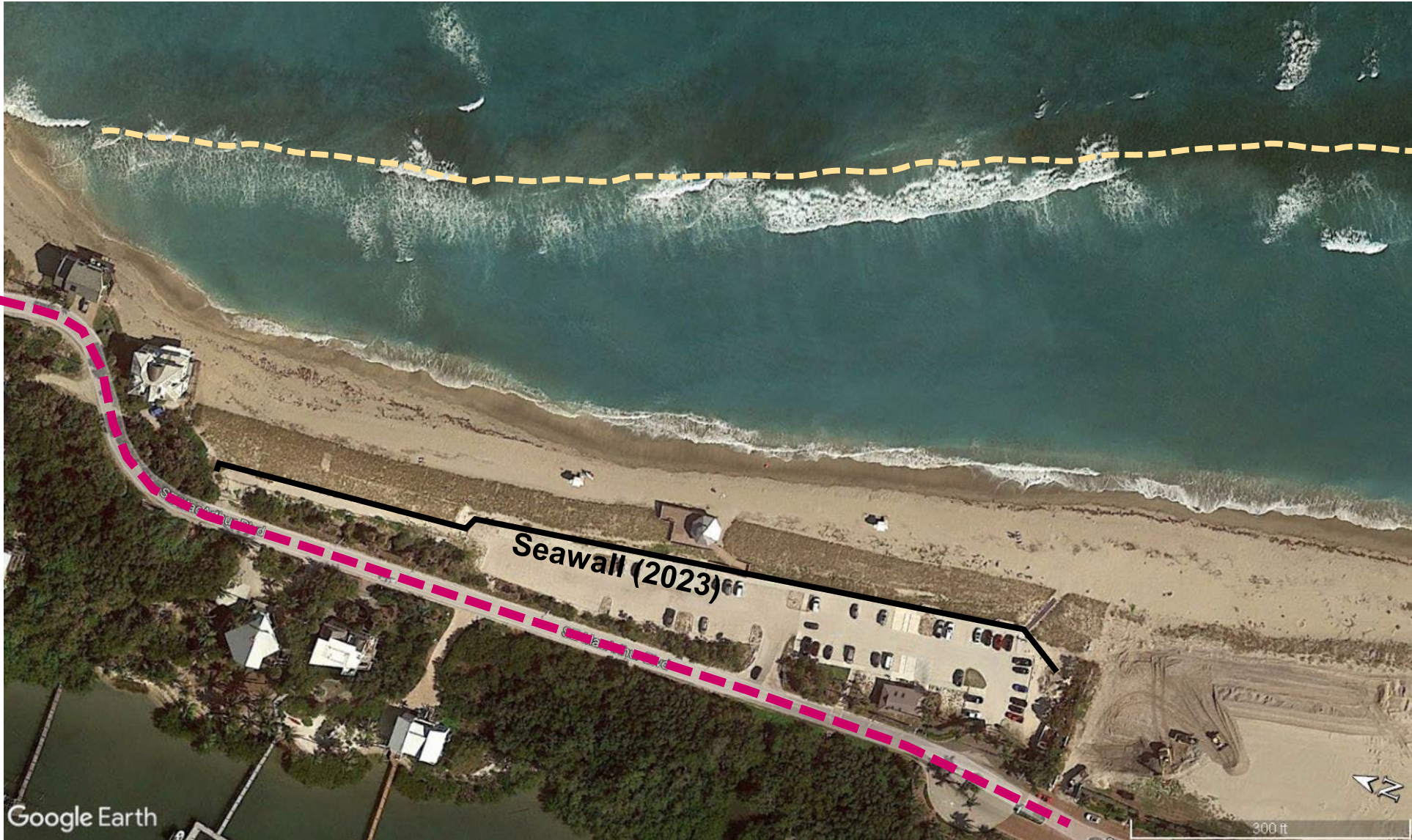


Shallow, shore-parallel reef, 8000-ft long

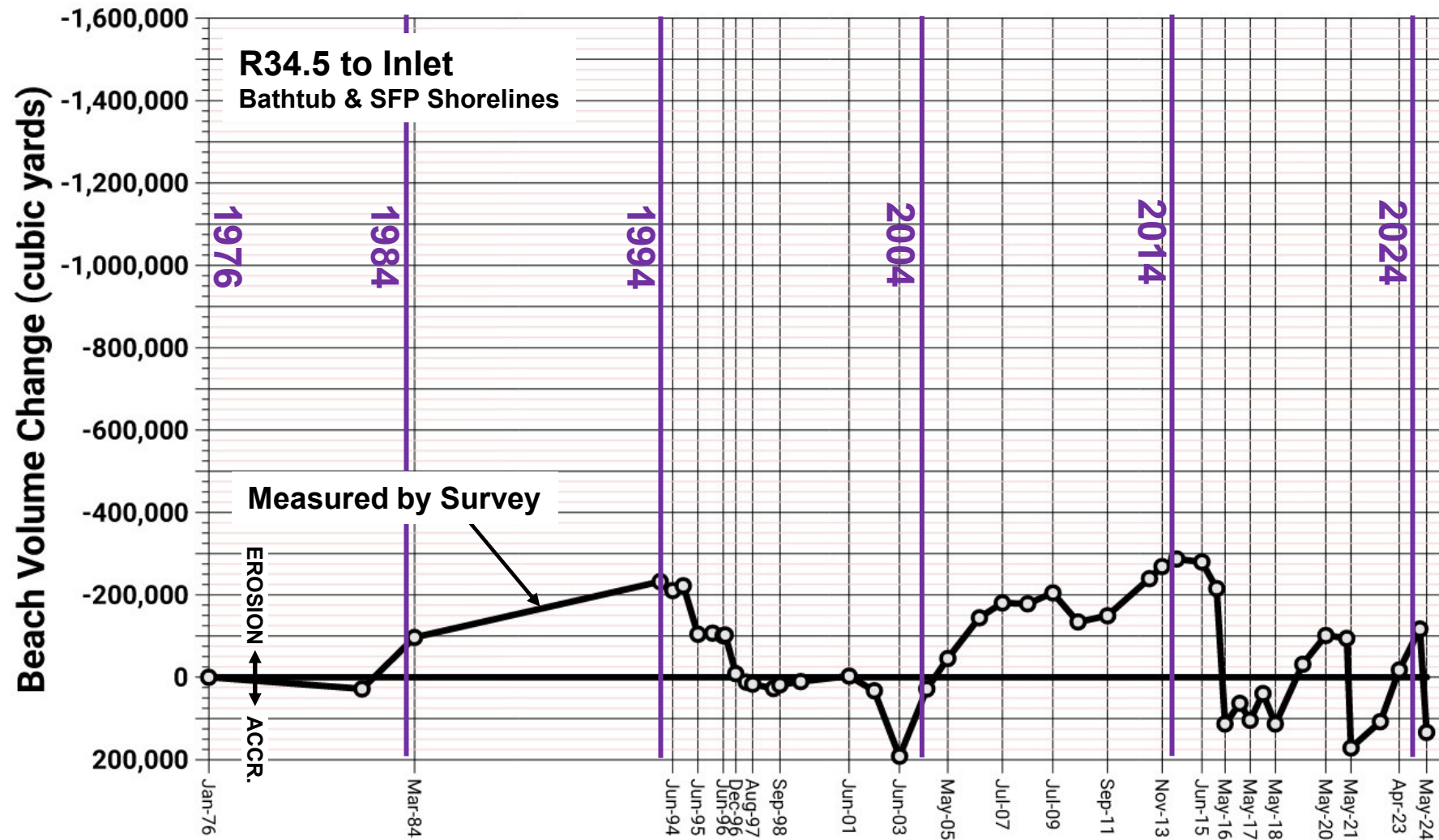
Bathtub Reef Beach Park: 2009



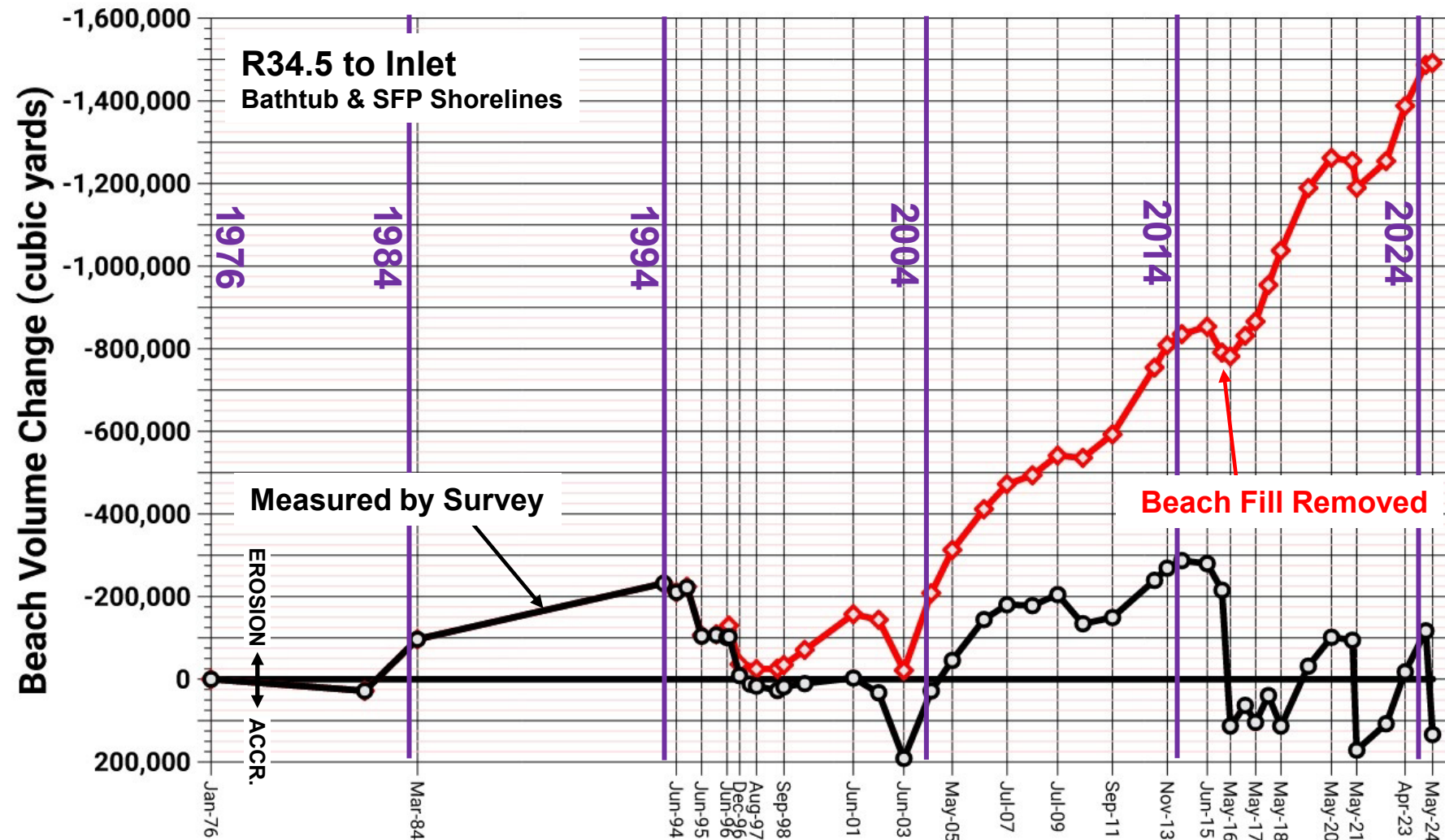
Bathtub Reef Beach Park: 2019



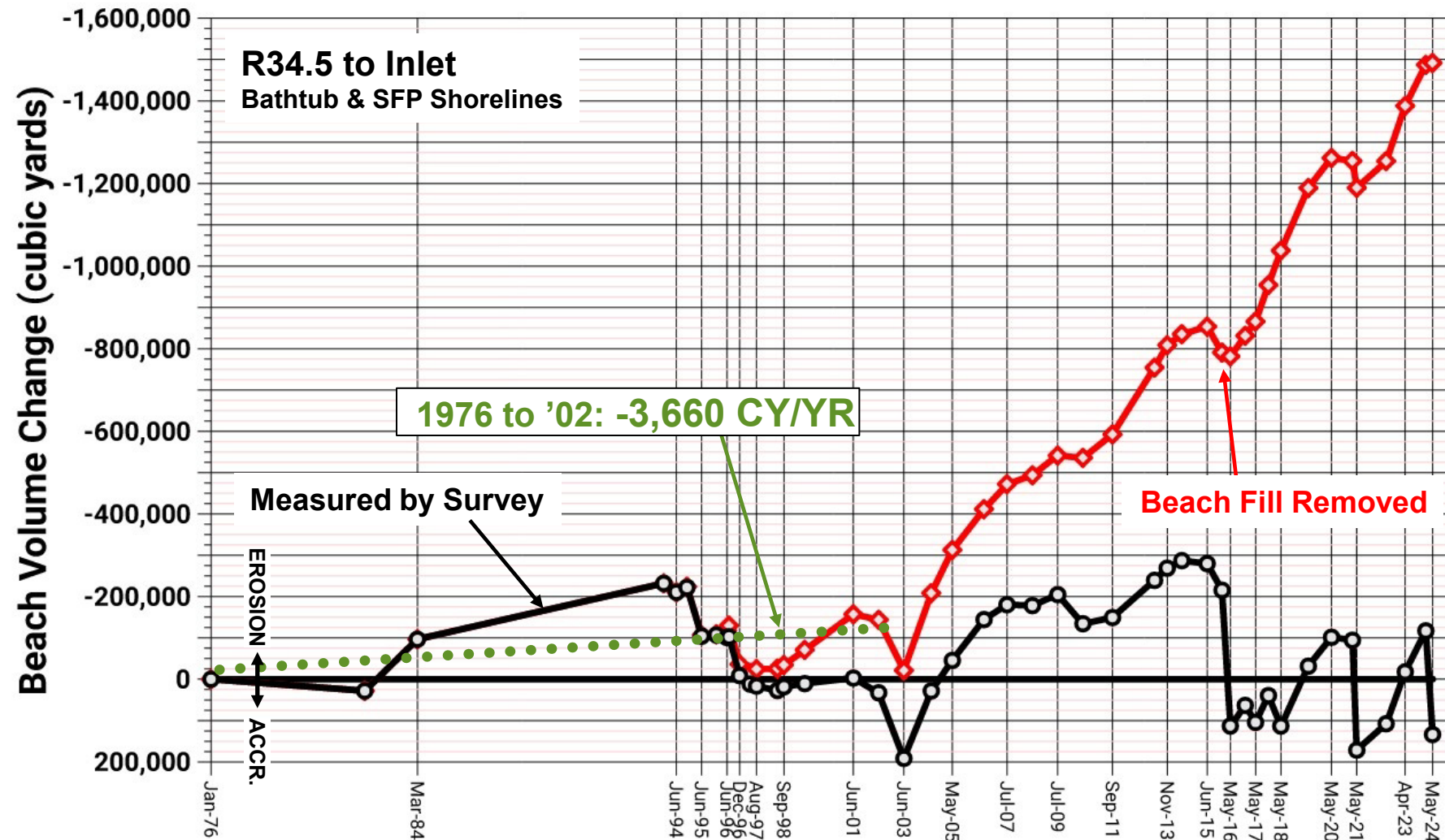
Volume Change: Bathtub Reef to St. Lucie Inlet, 1976 to 2024



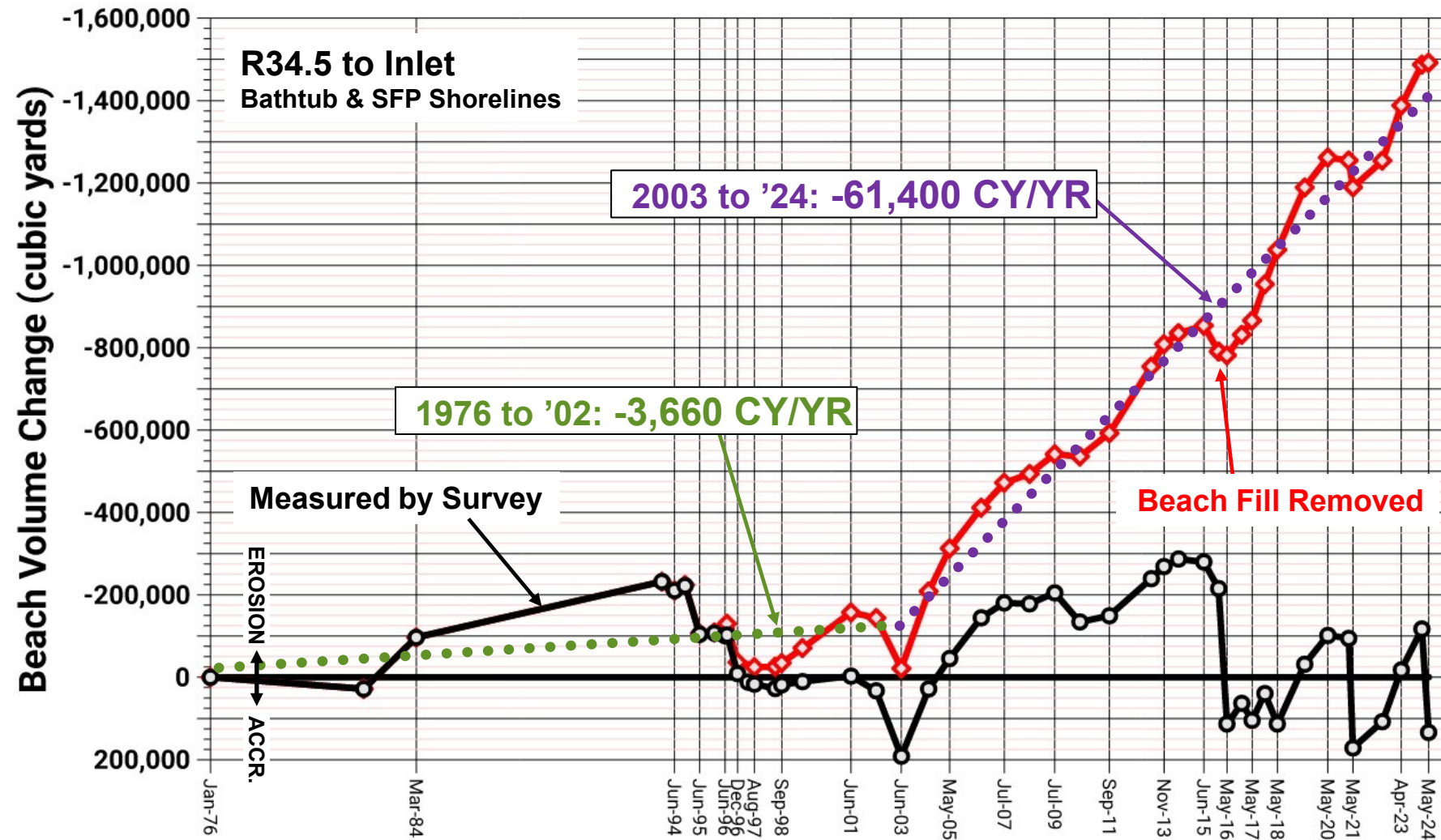
Volume Change: Bathtub Reef to St. Lucie Inlet, 1976 to 2024



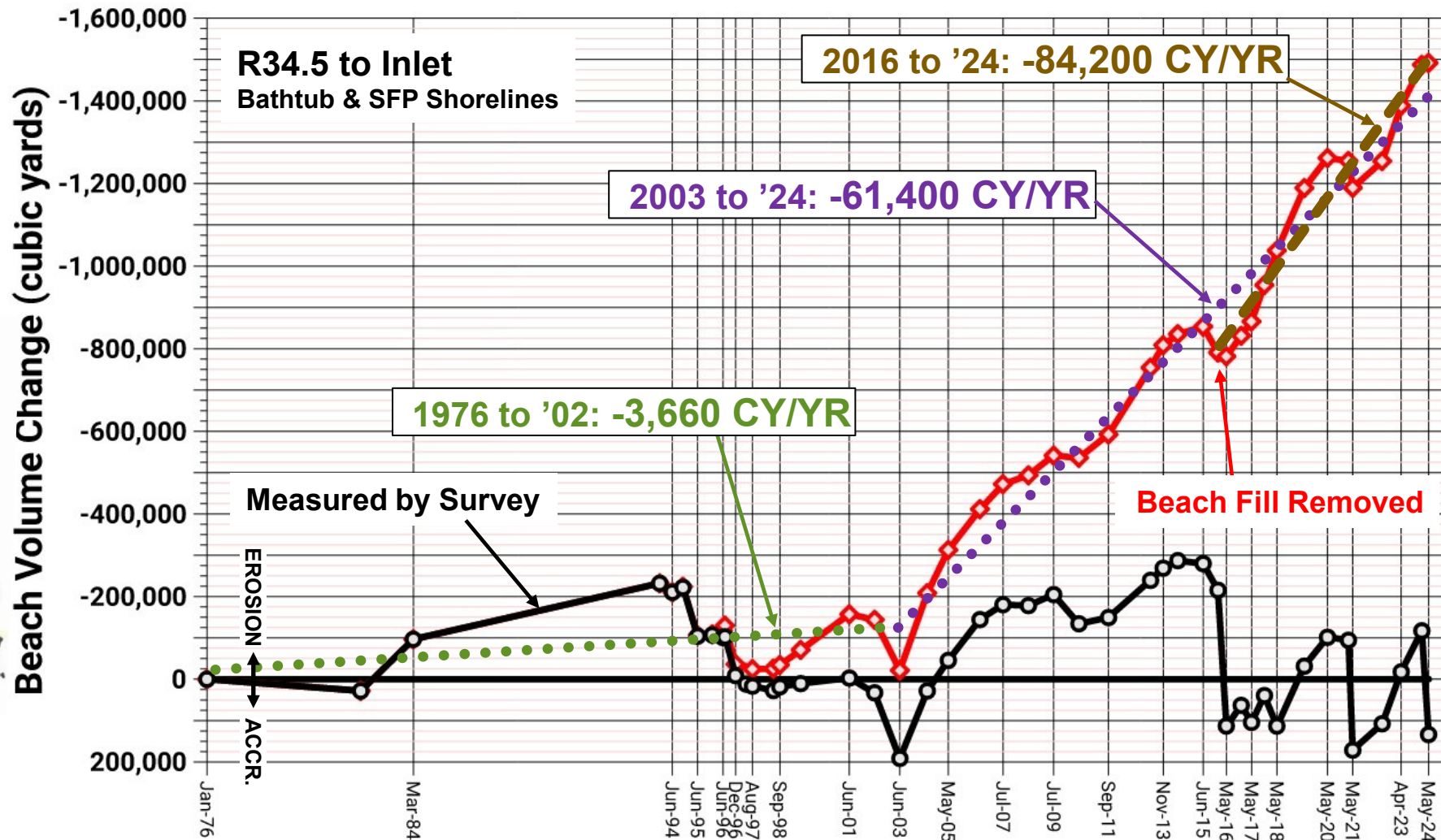
Volume Change: Bathtub Reef to St. Lucie Inlet, 1976 to 2024



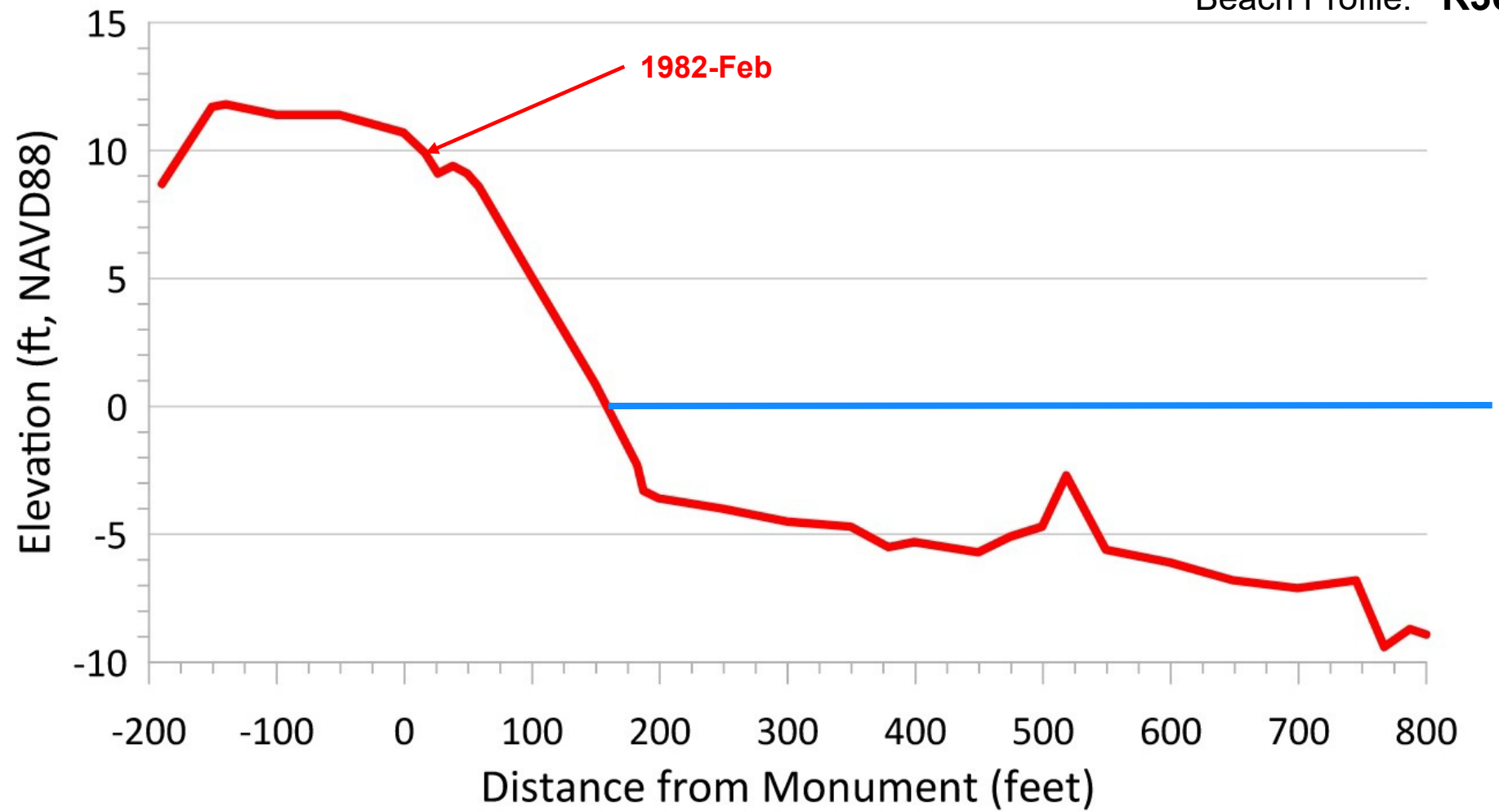
Volume Change: Bathtub Reef to St. Lucie Inlet, 1976 to 2024



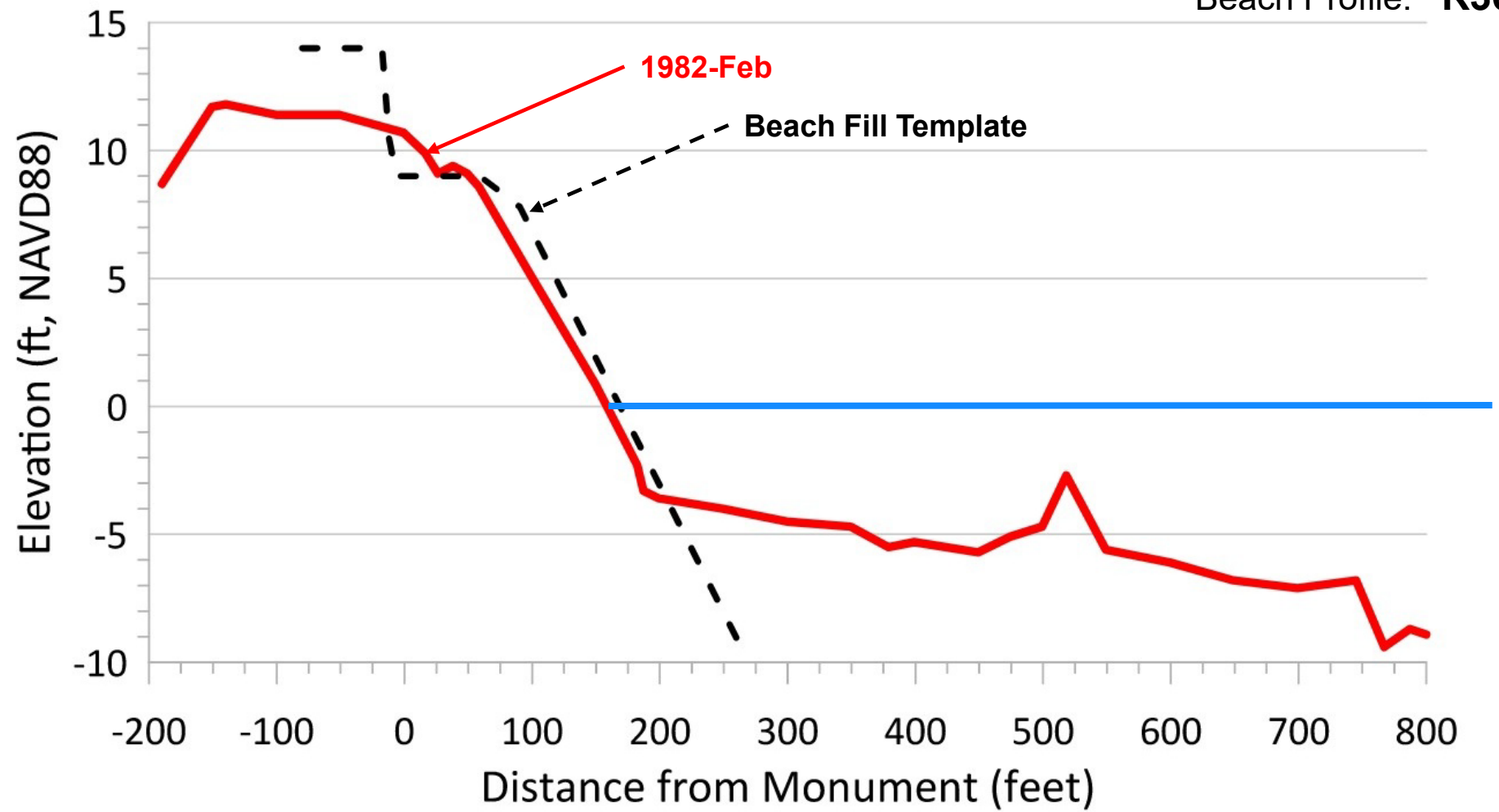
Volume Change: Bathtub Reef to St. Lucie Inlet, 1976 to 2024



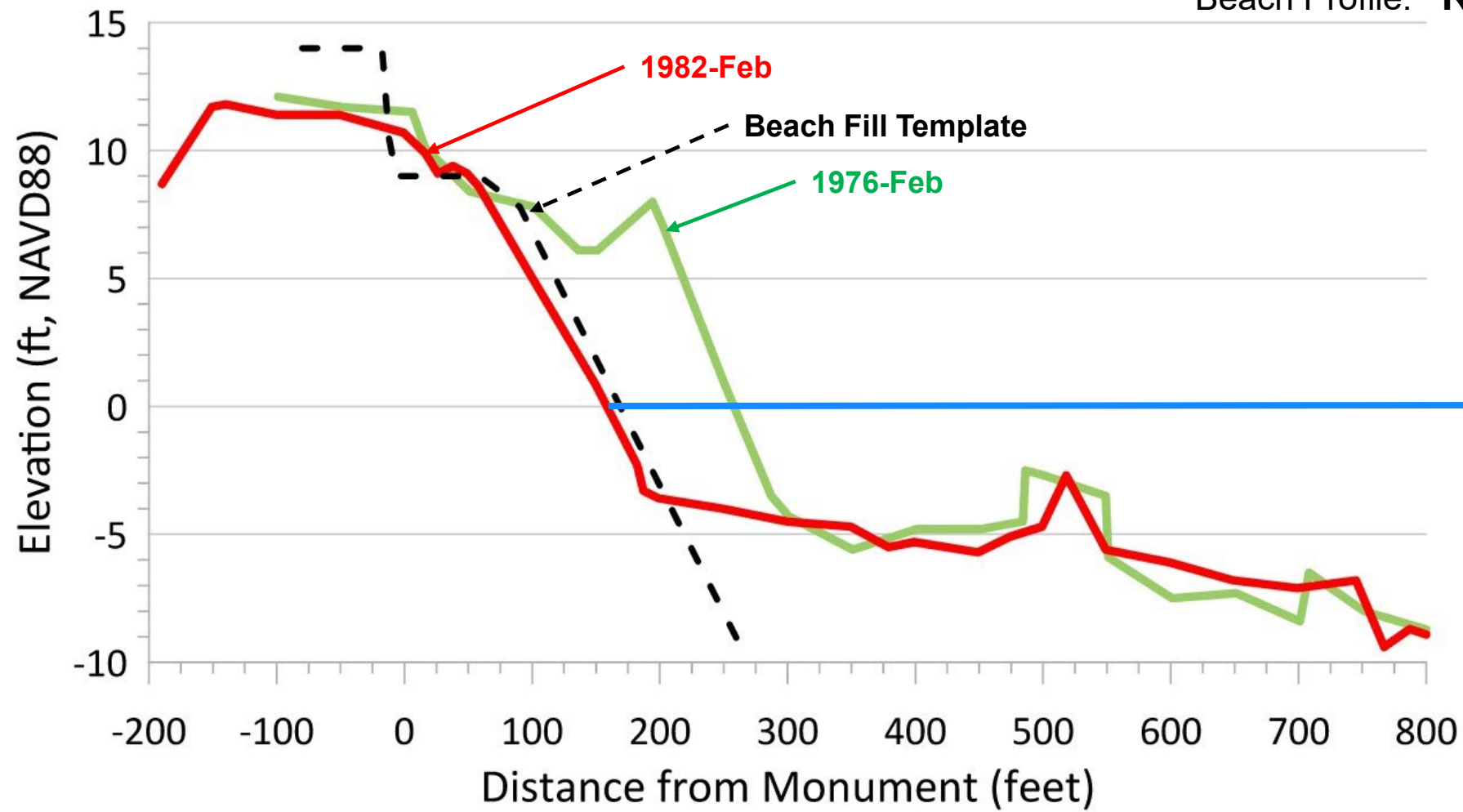
Beach Profile: **R36**

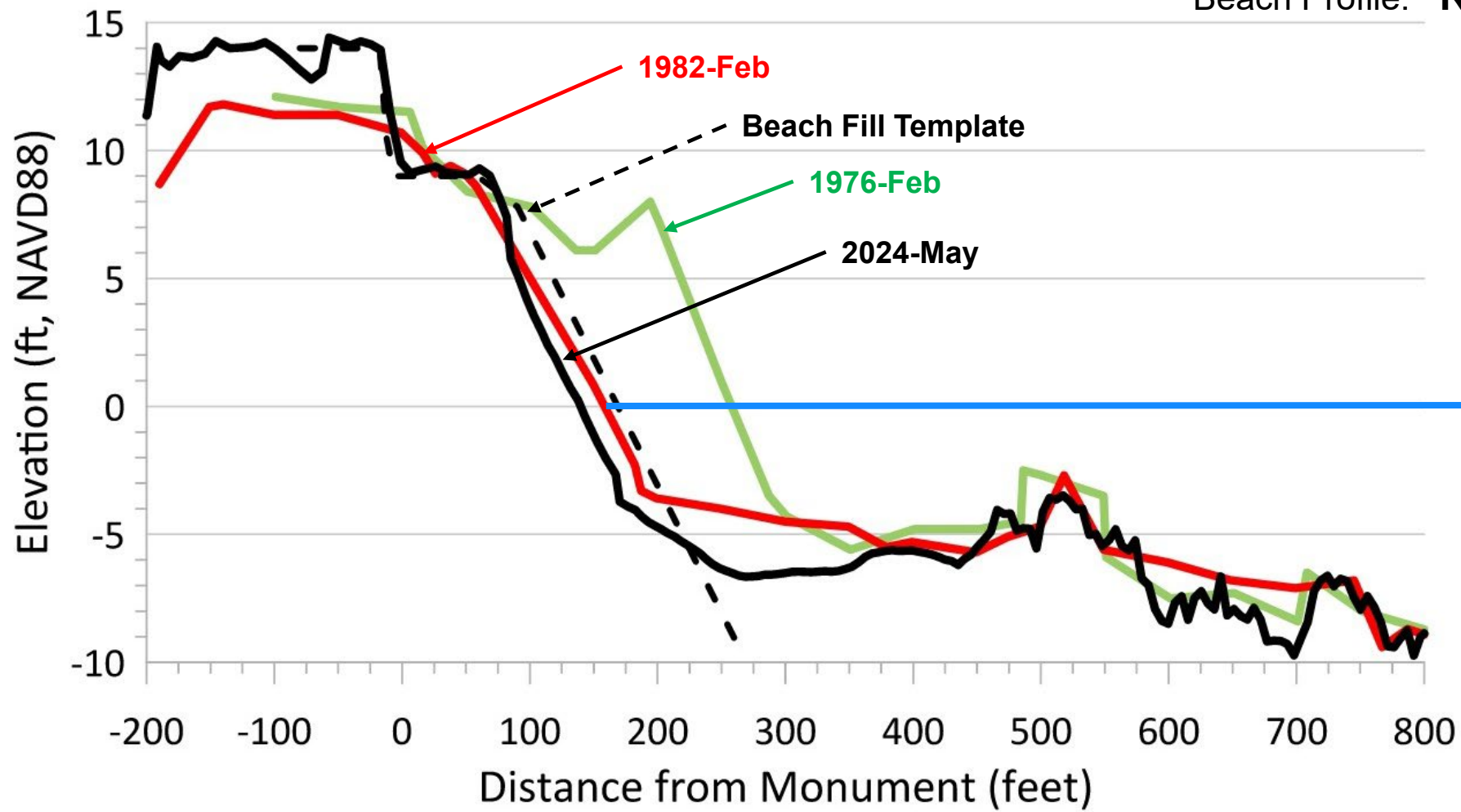


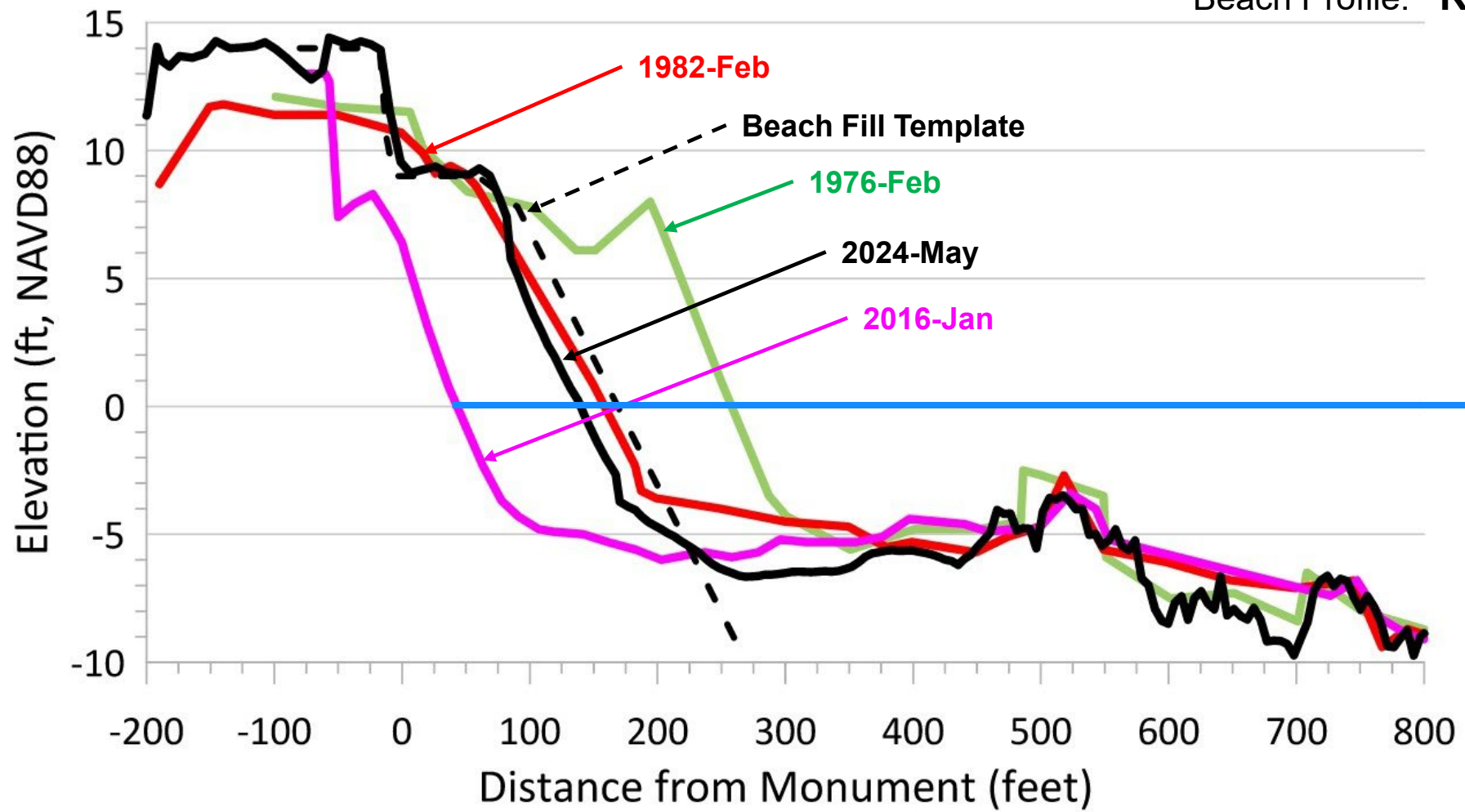
Beach Profile: **R36**

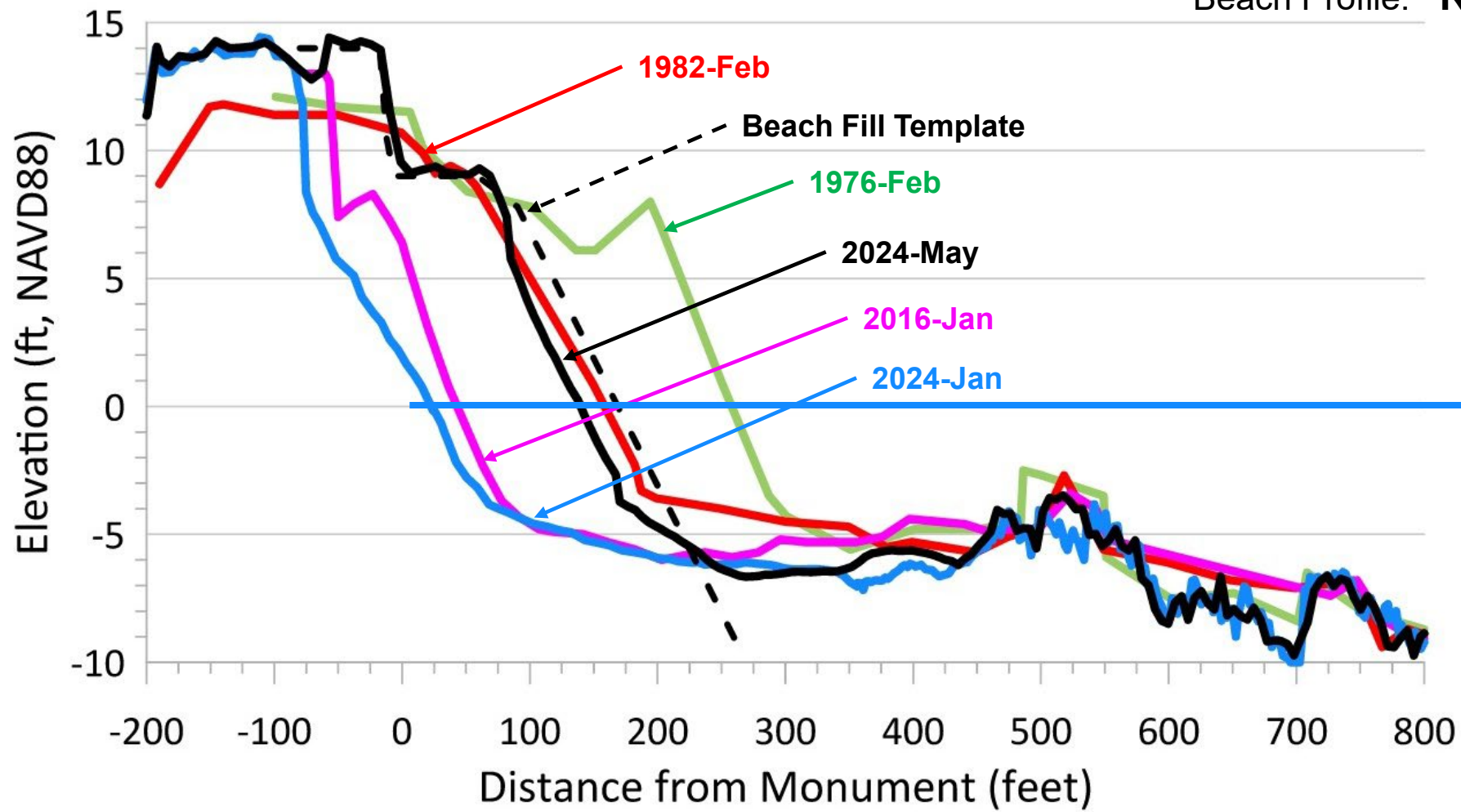


Beach Profile: **R36**



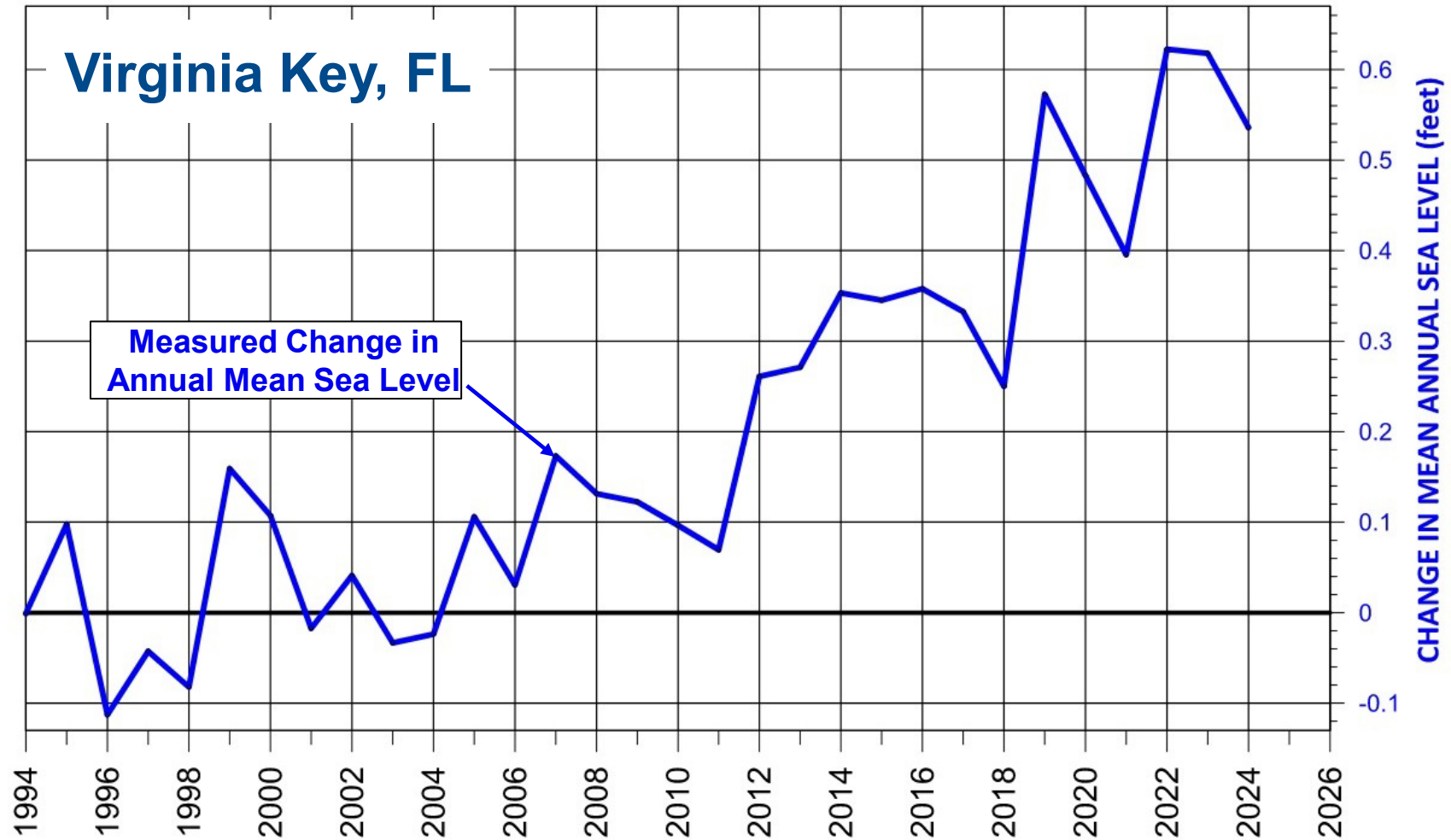






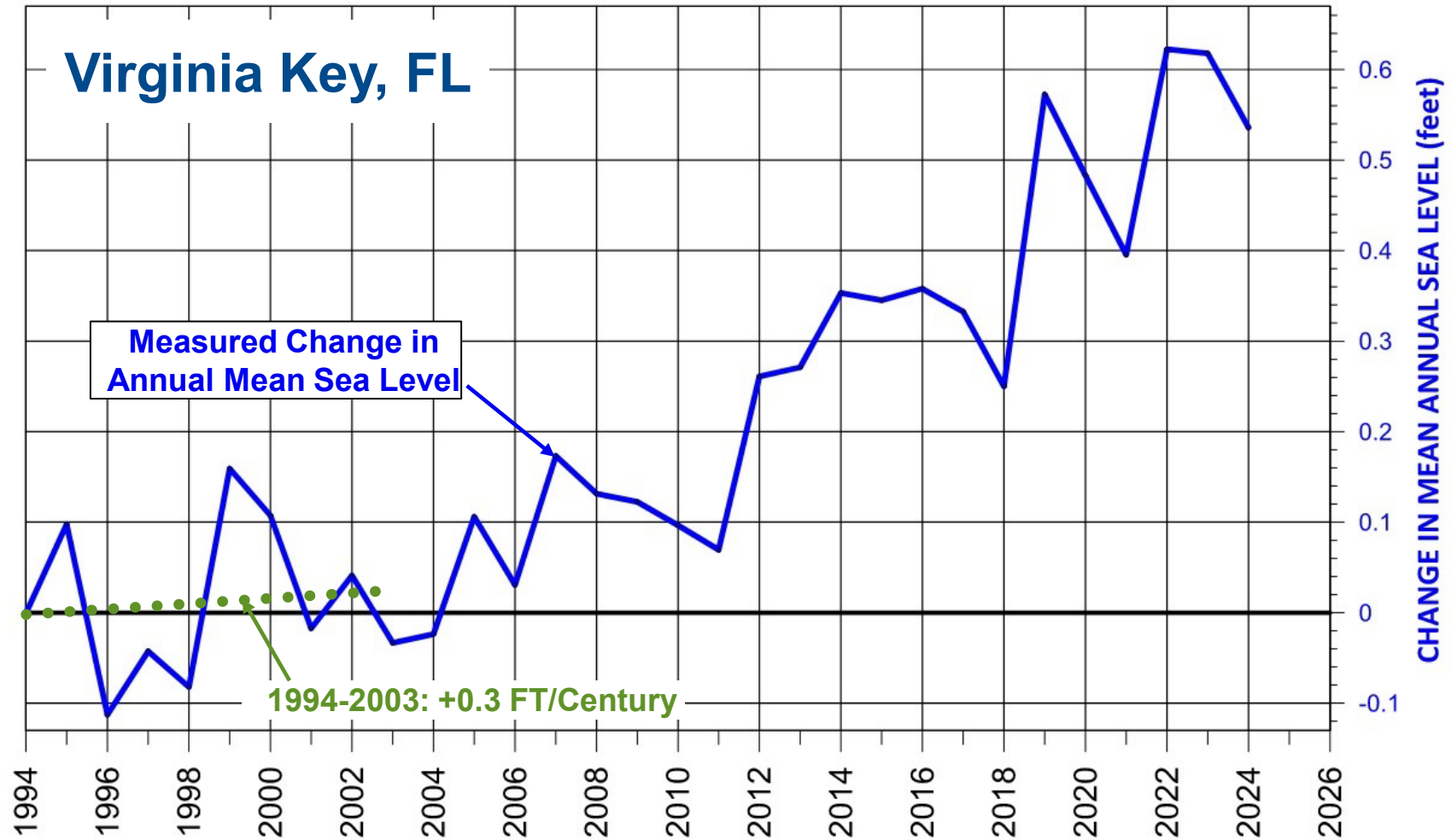
Change in Annual Mean Sea Level

(Measured from 1994 through 2024)



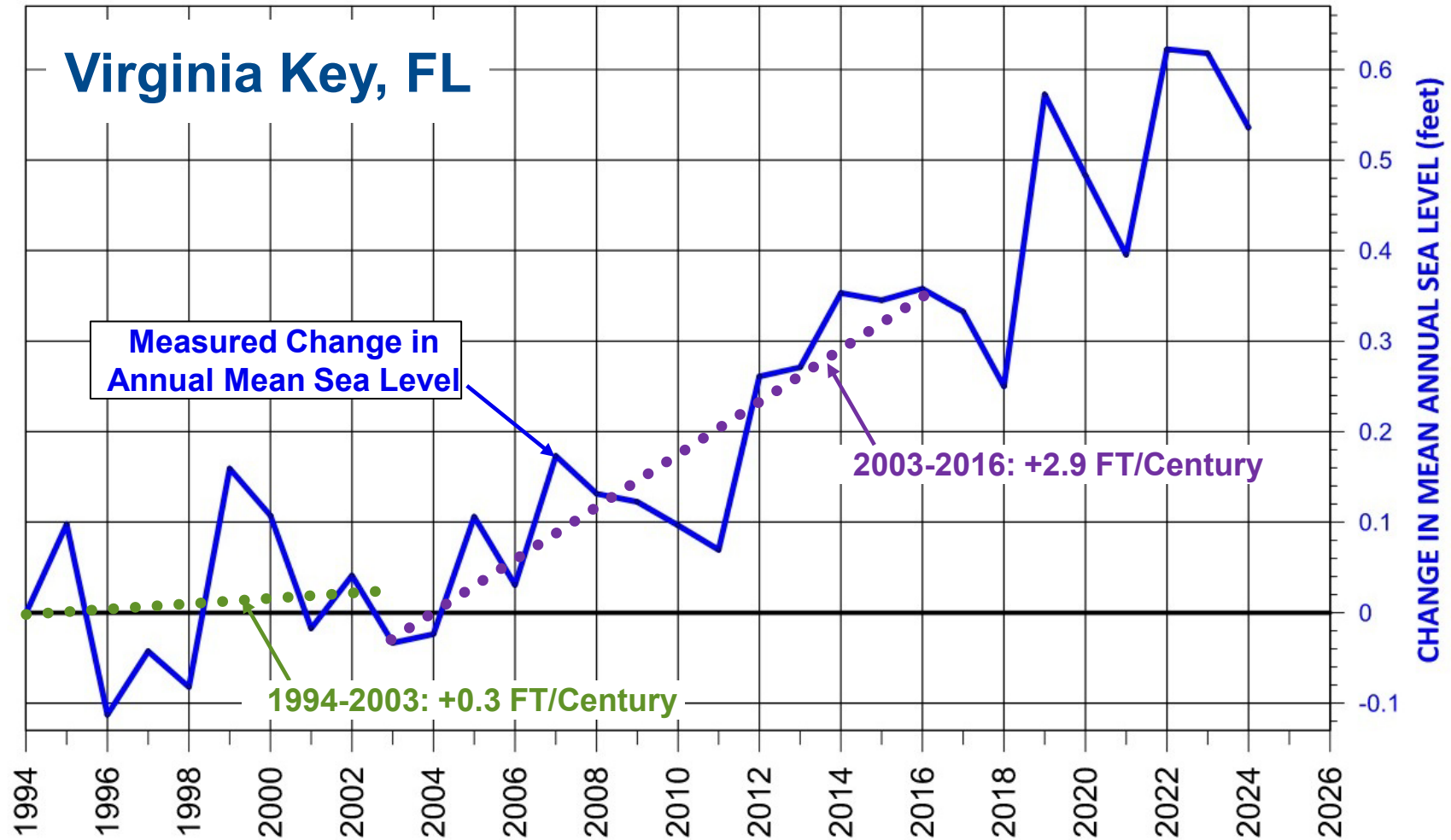
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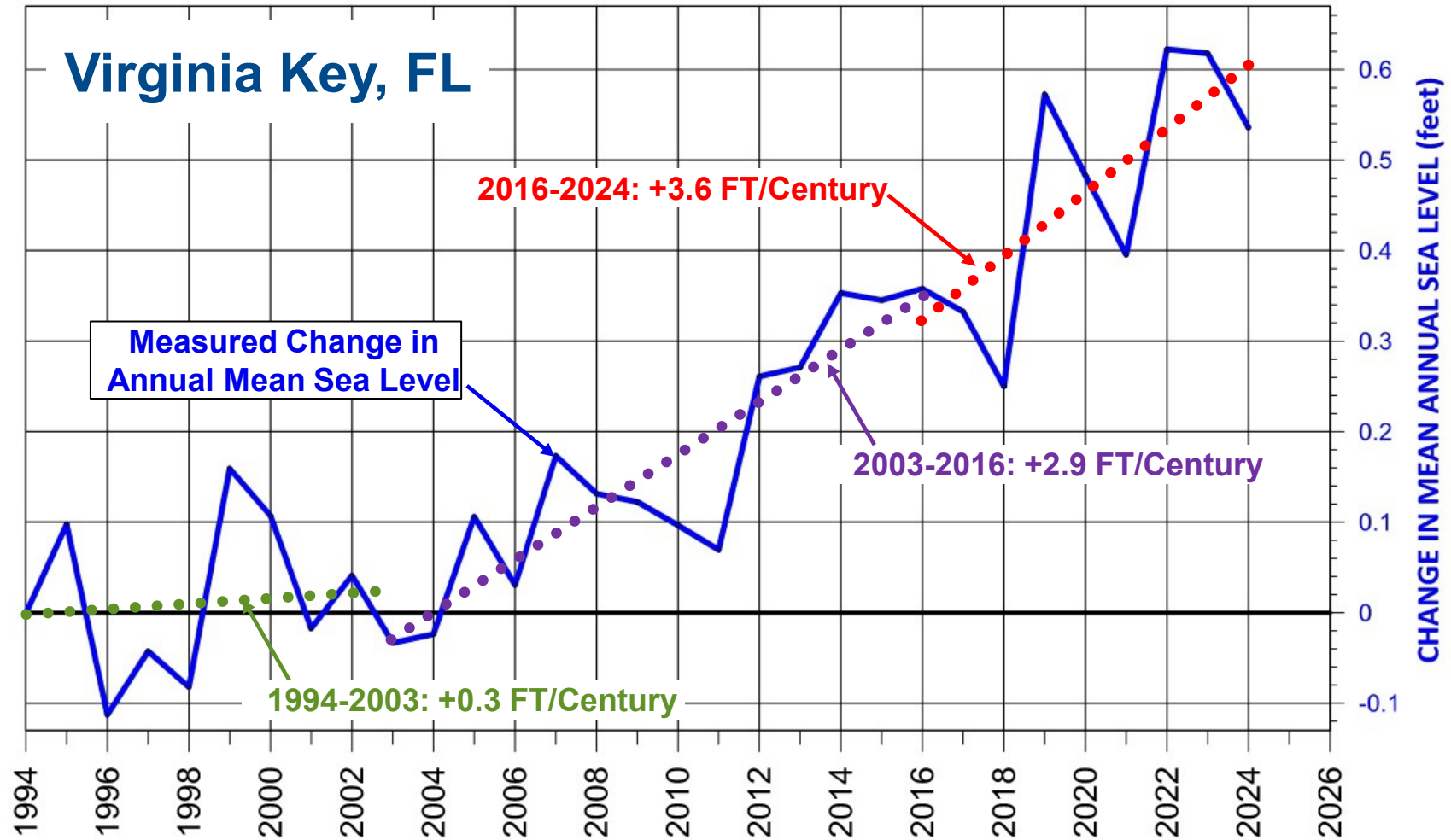
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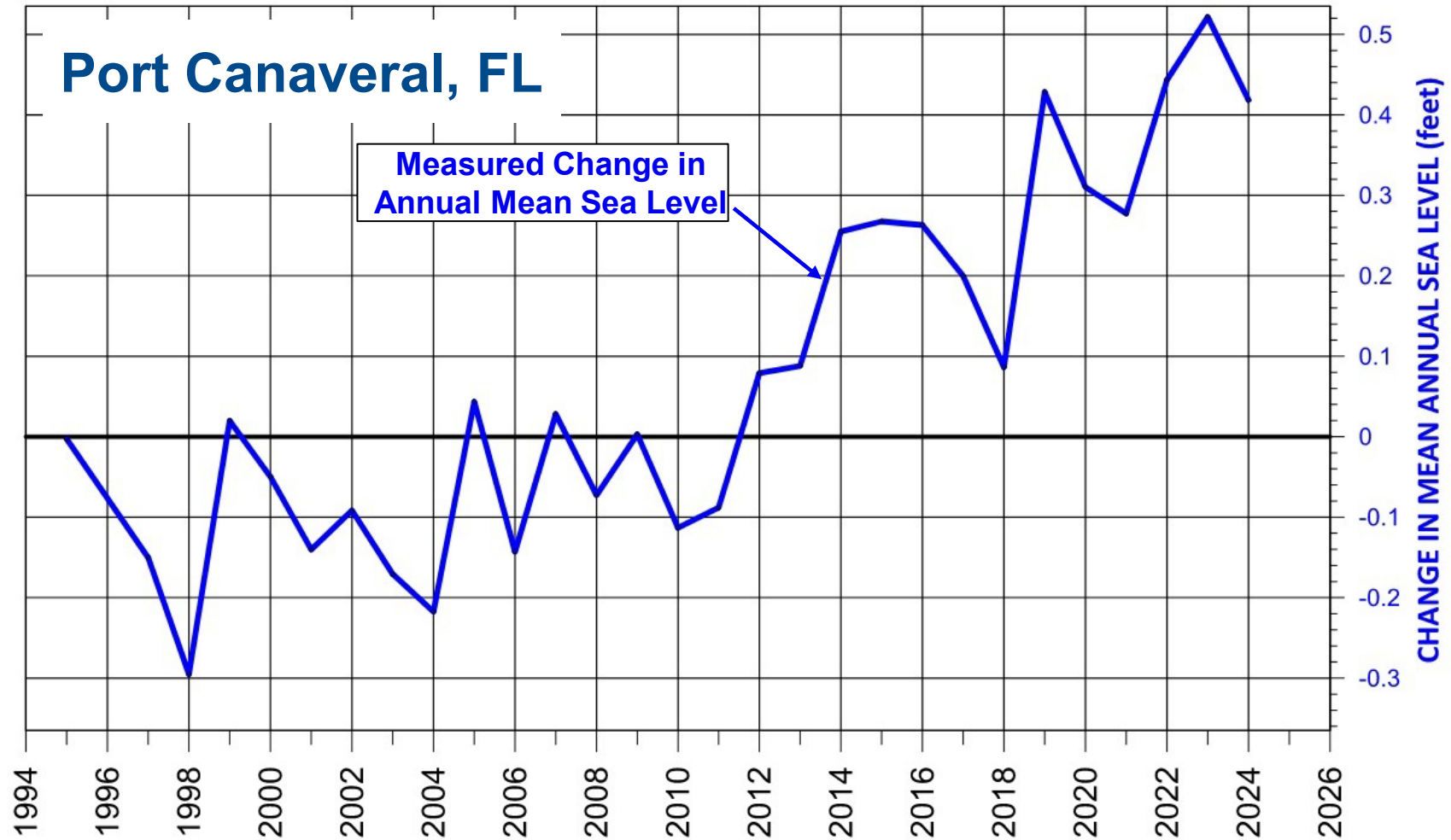
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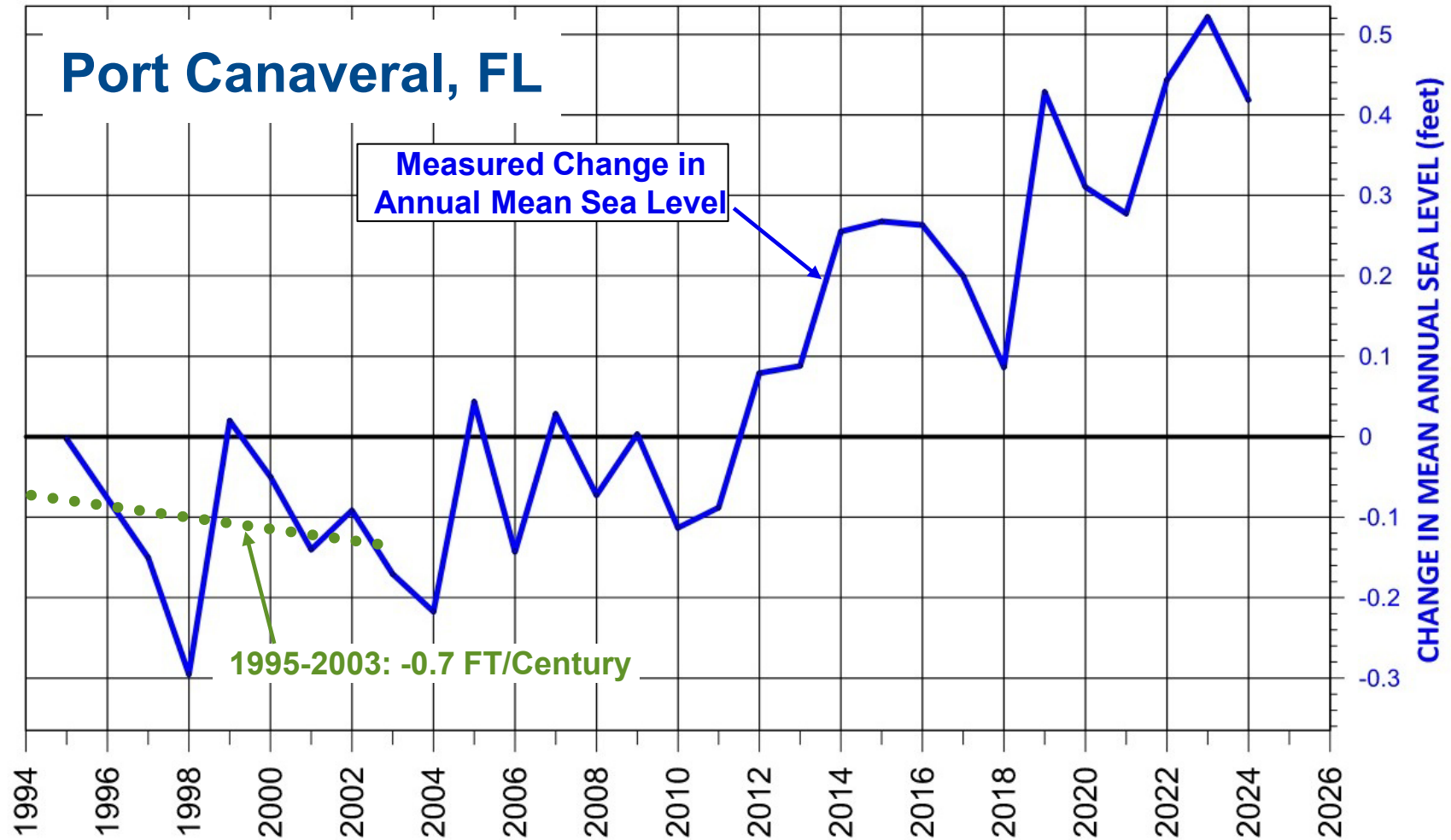
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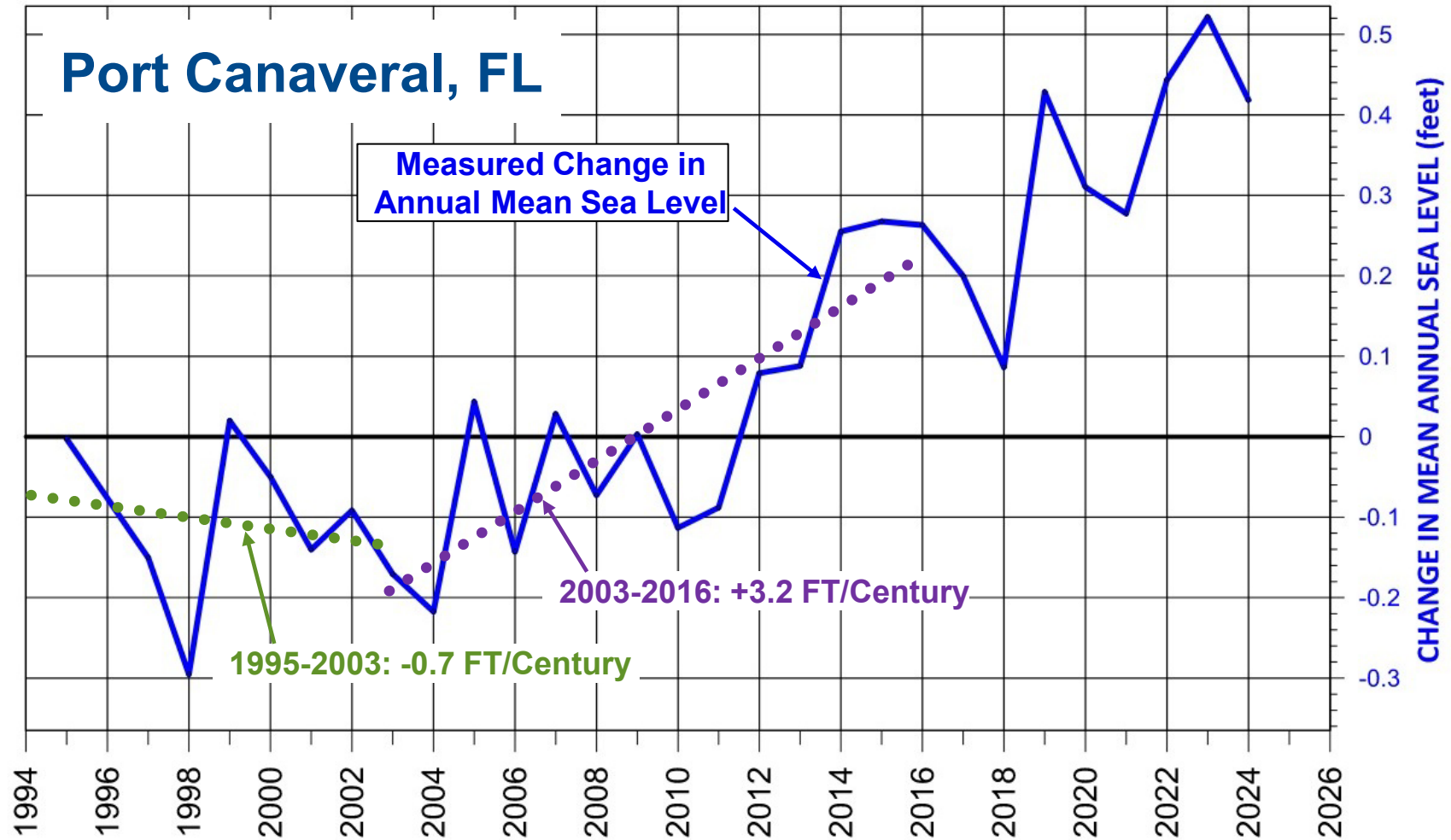
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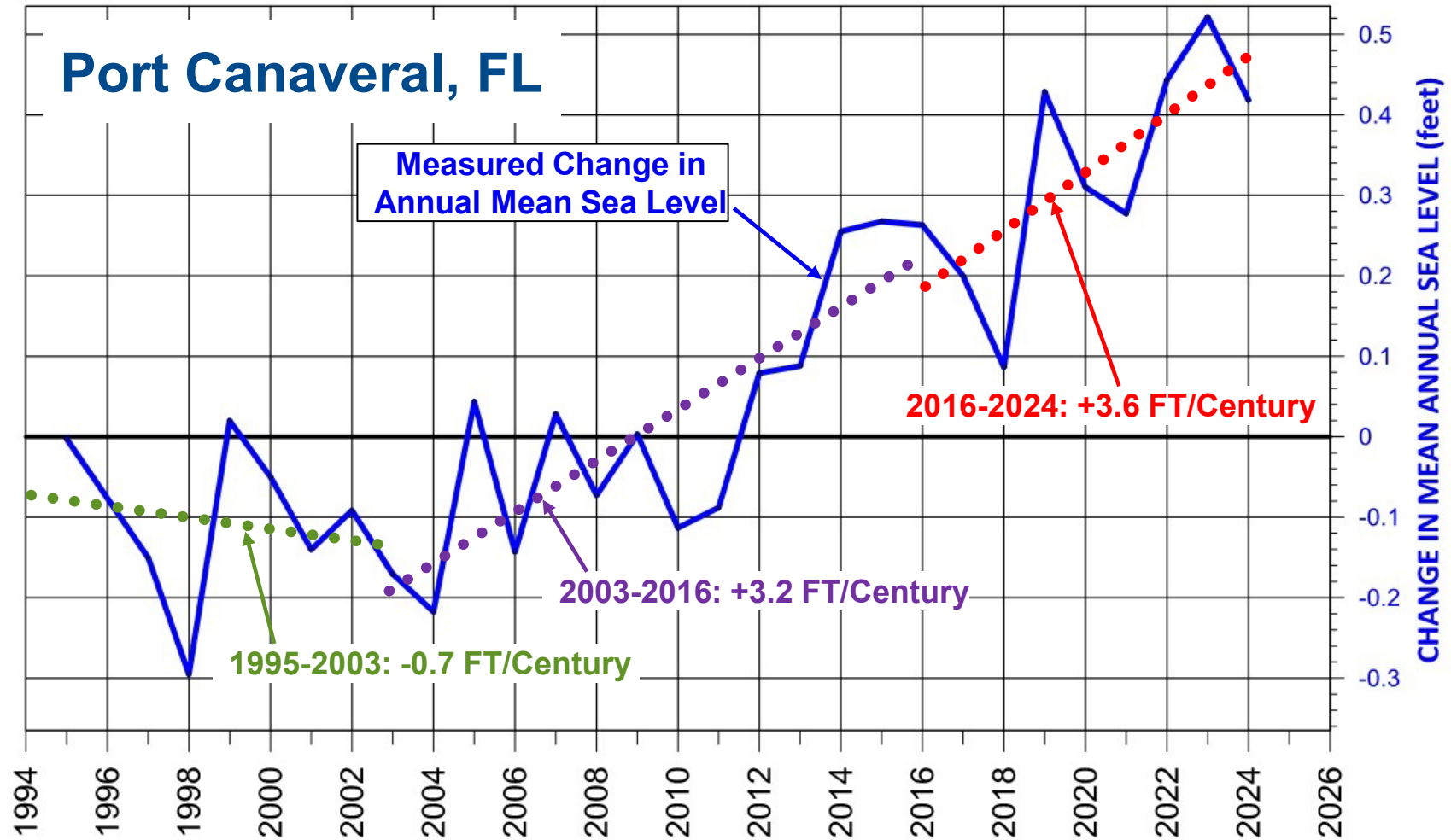
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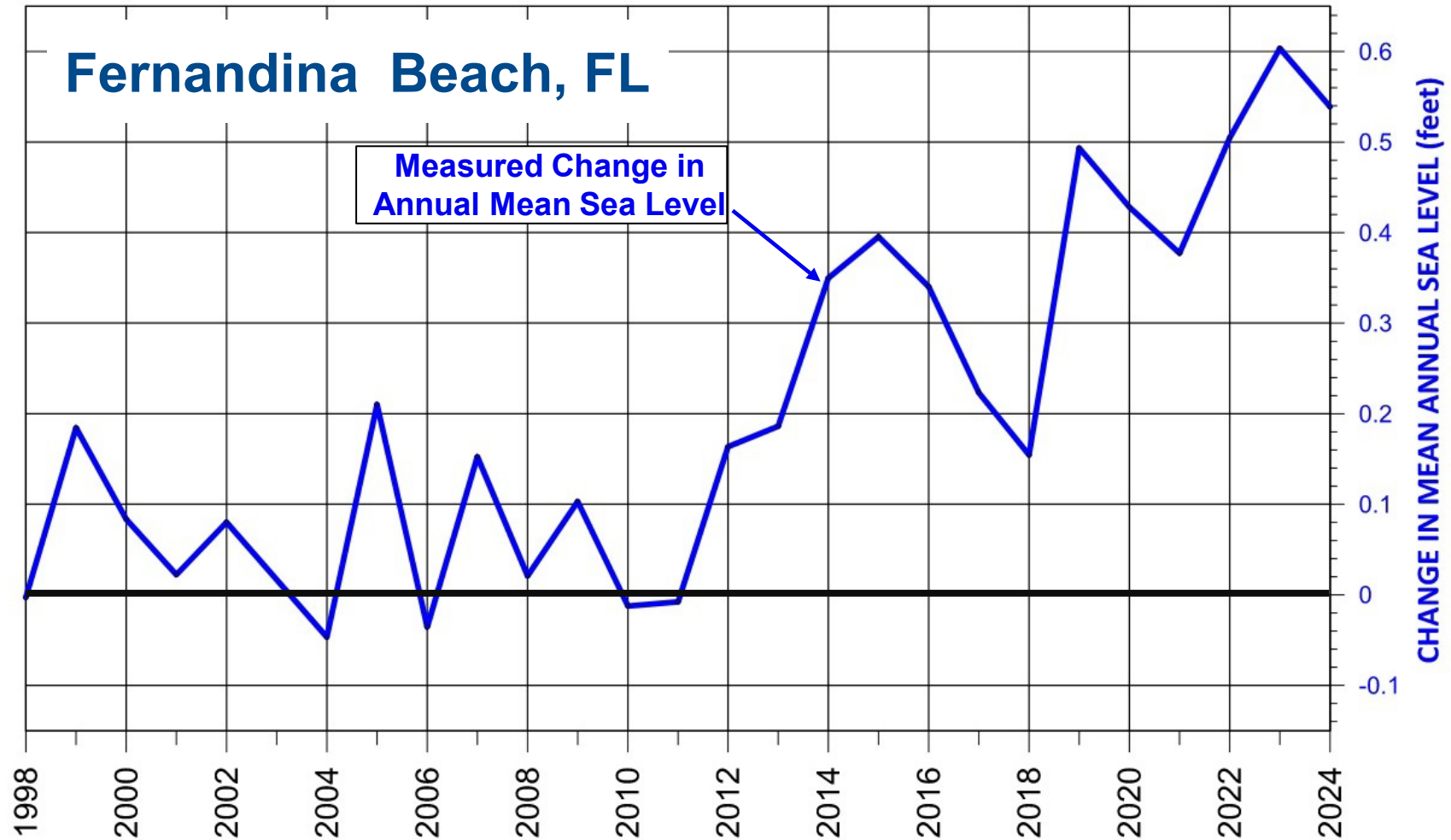
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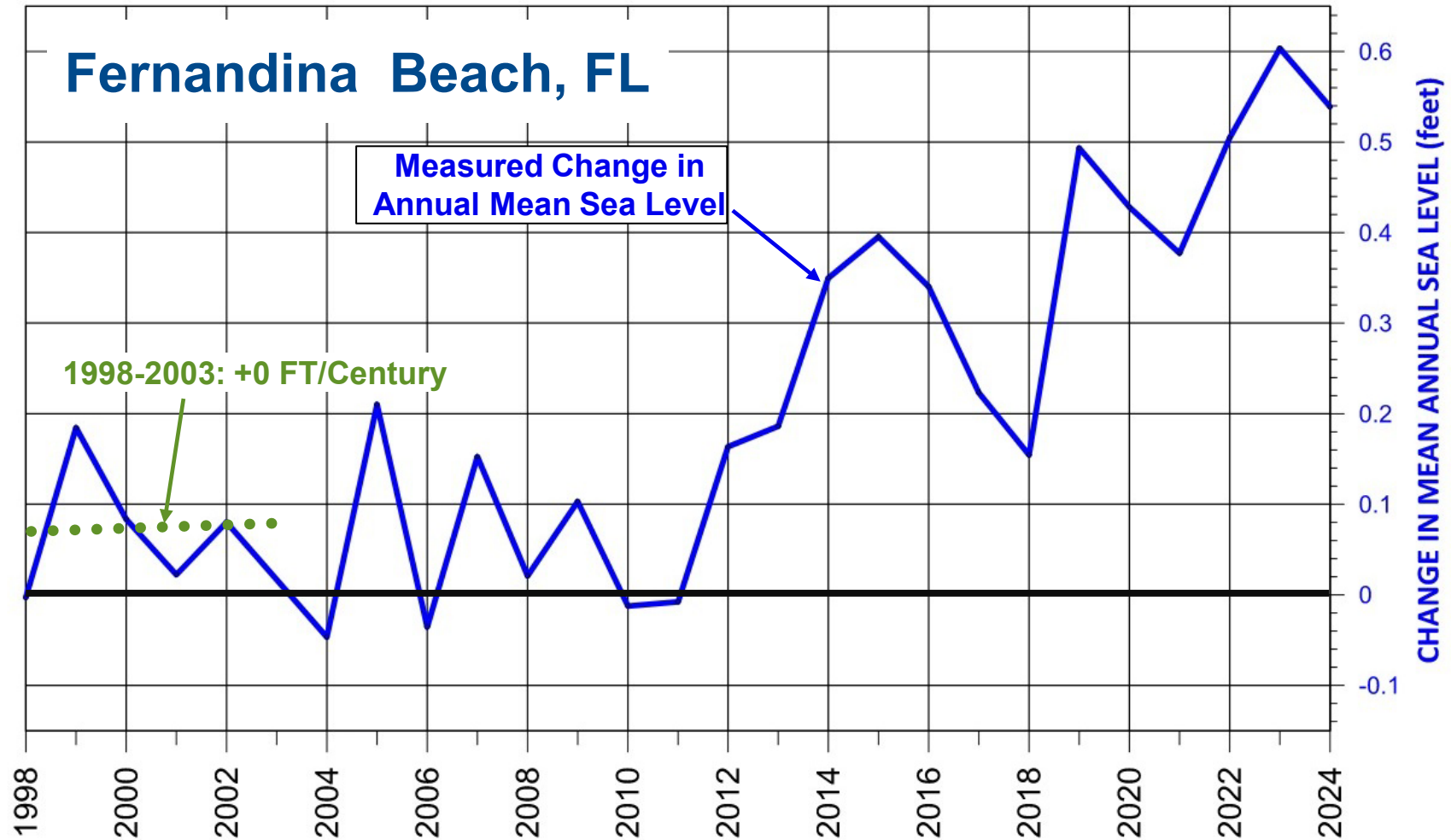
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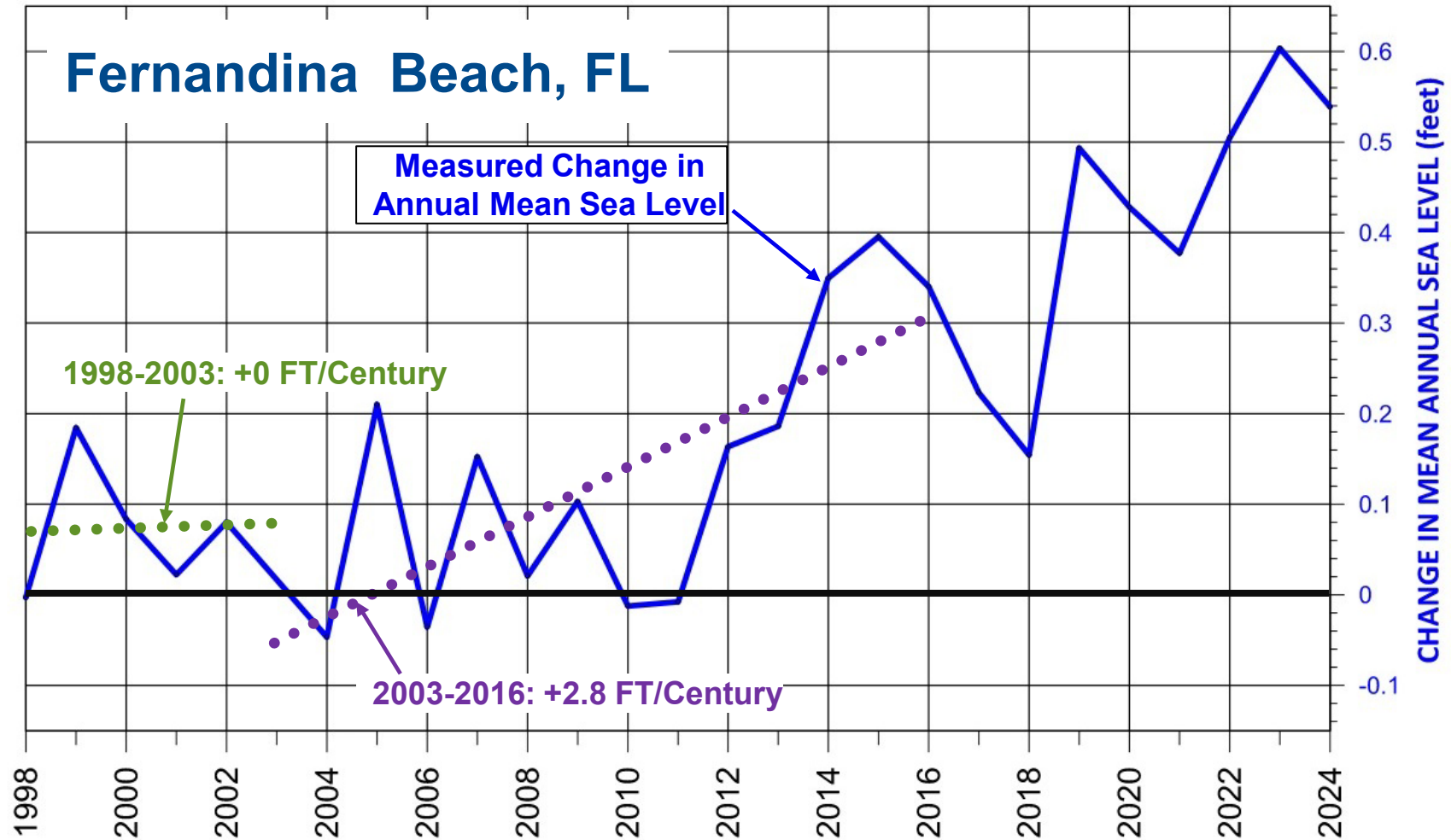
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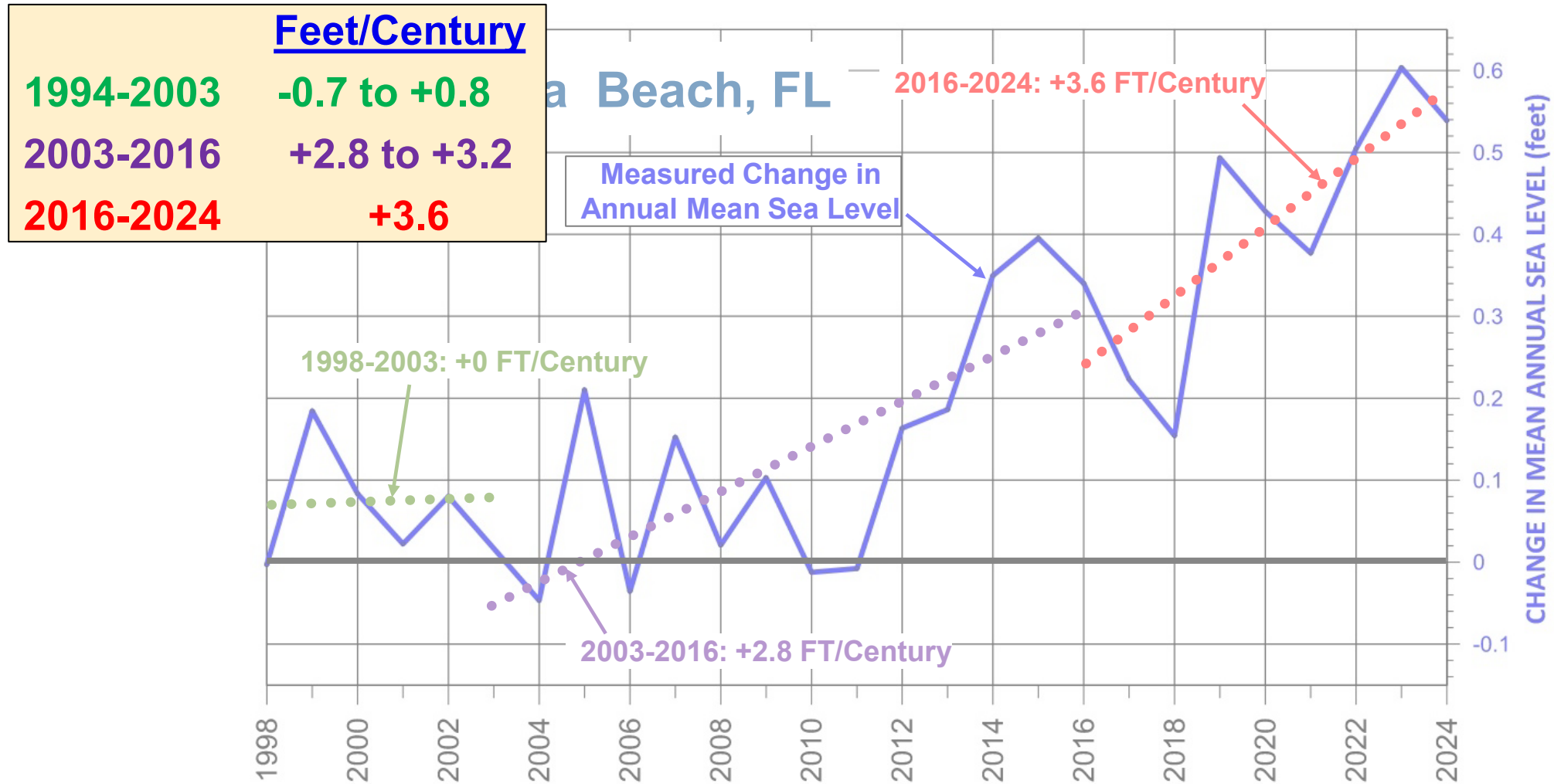
Change in Annual Mean Sea Level

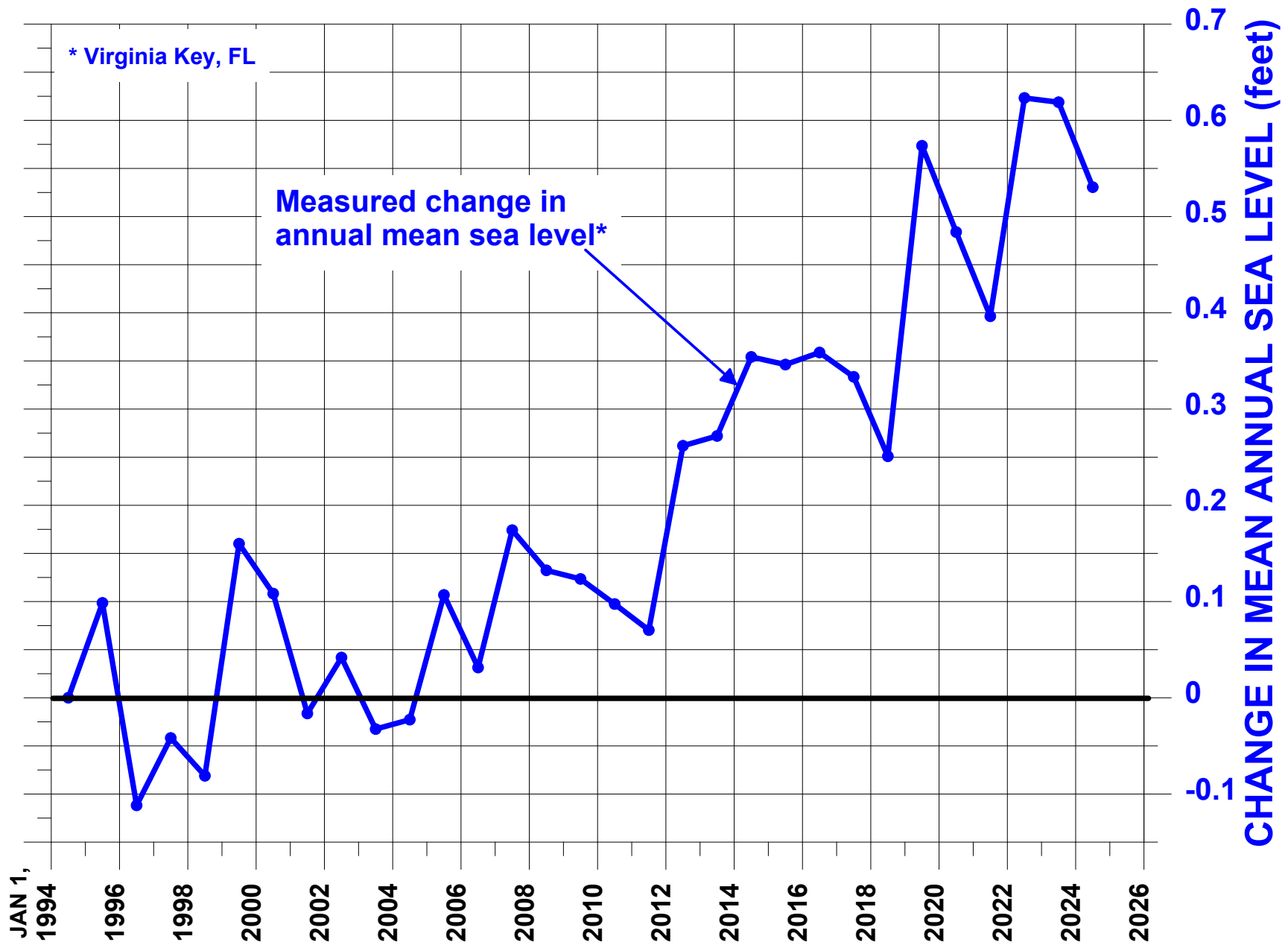
(Measured from 1998 through 2024)



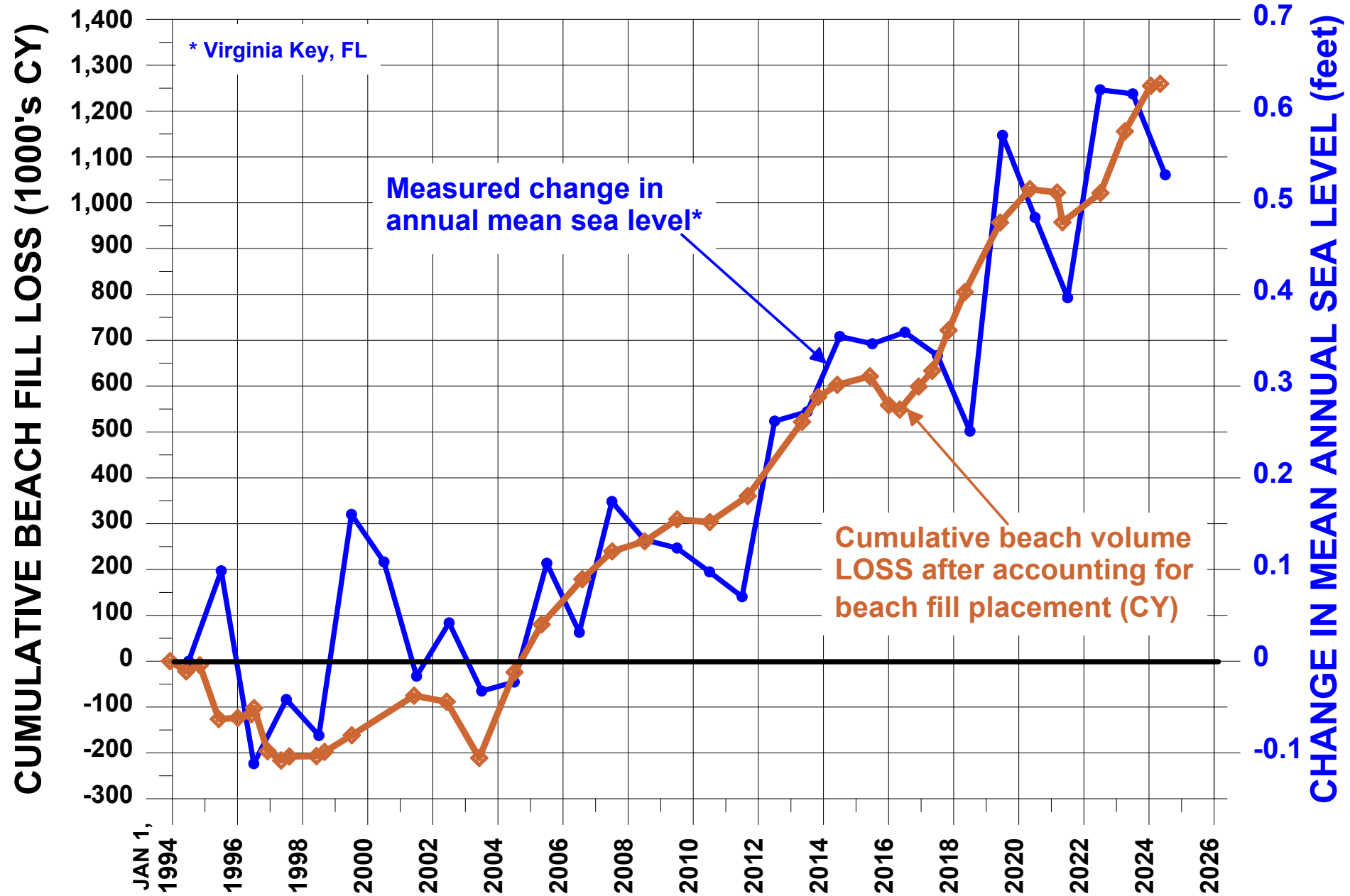
Change in Annual Mean Sea Level

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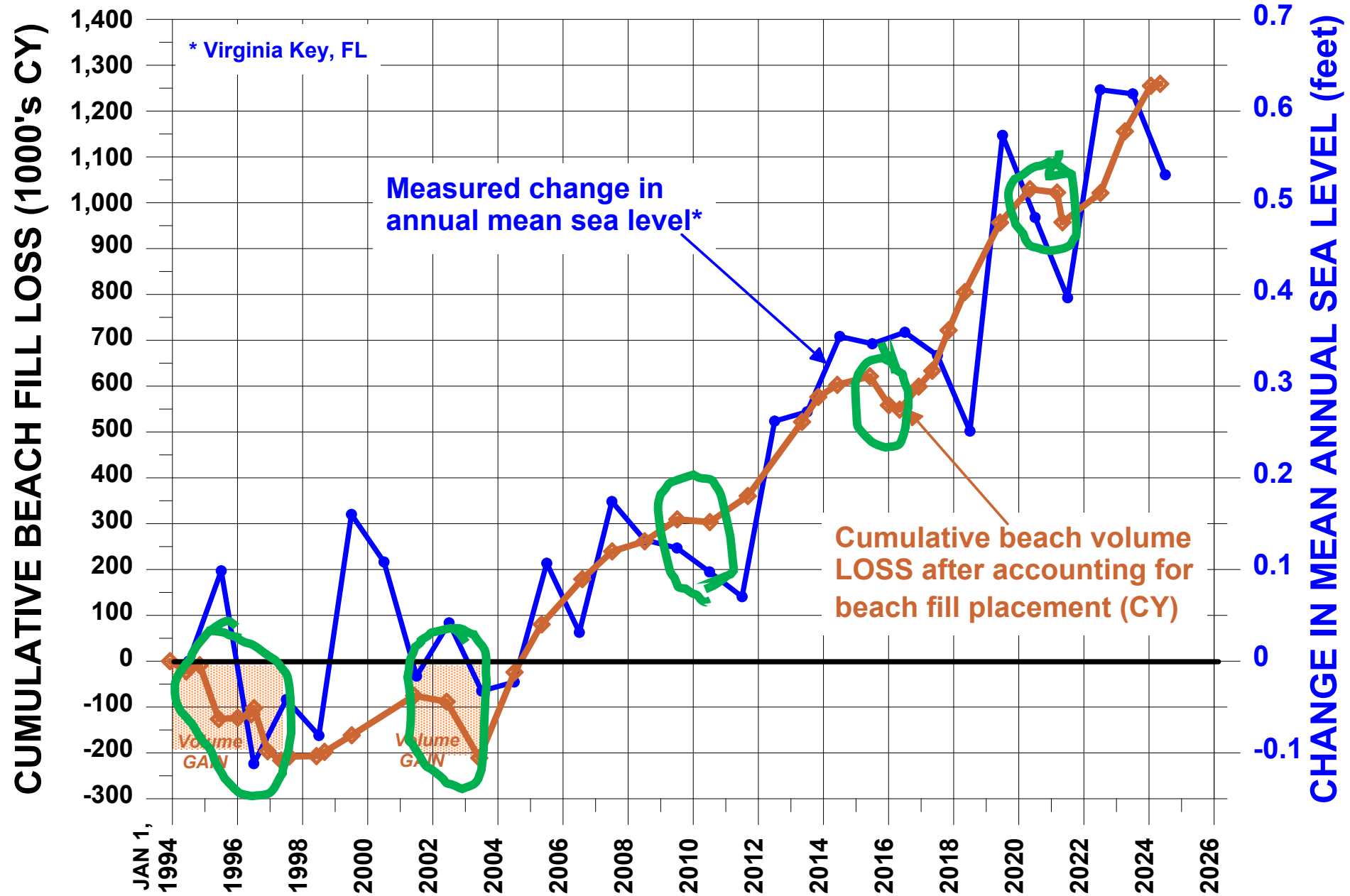




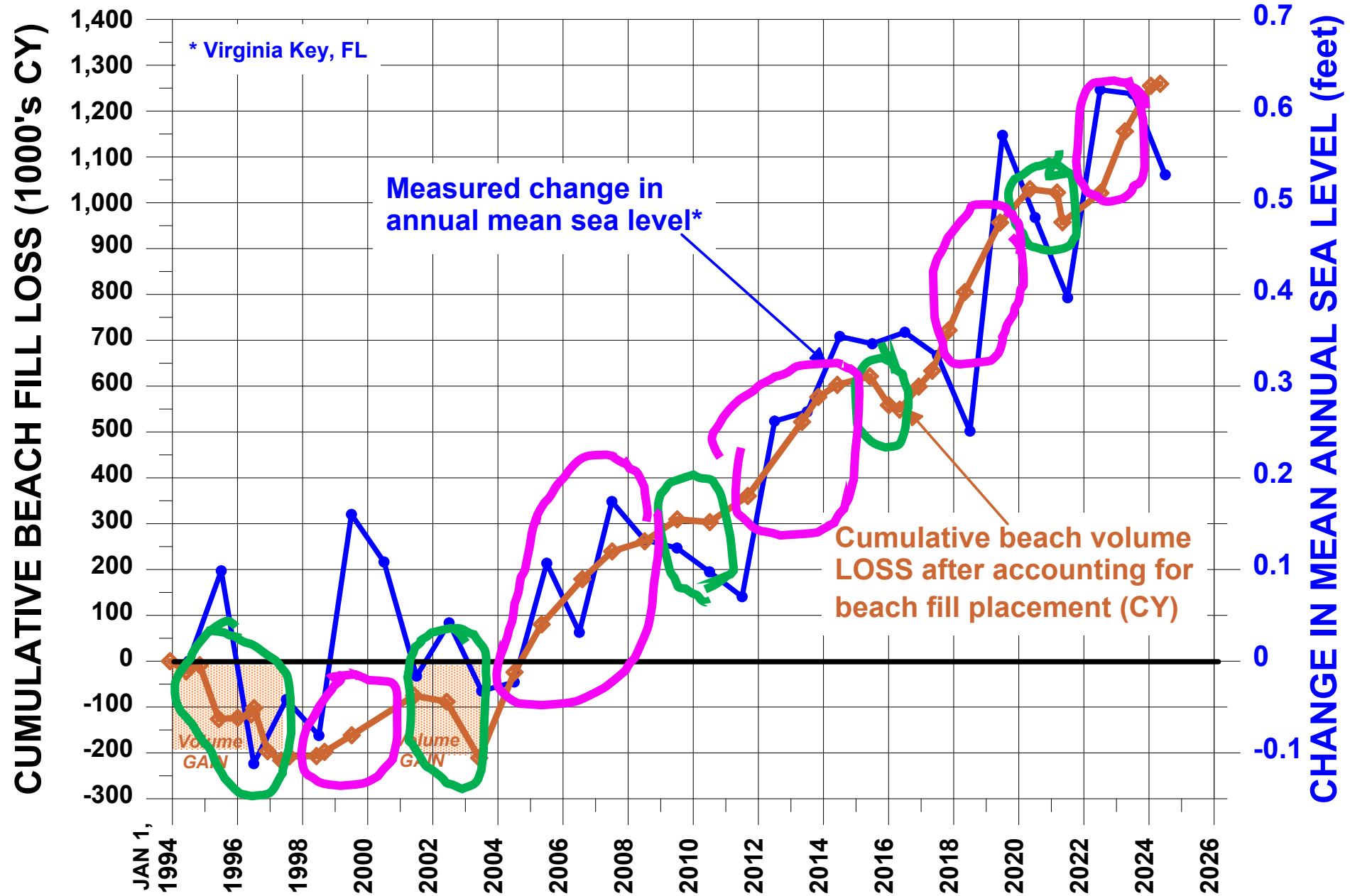
Bathtub Beach / Sailfish Point



Bathtub Beach / Sailfish Point

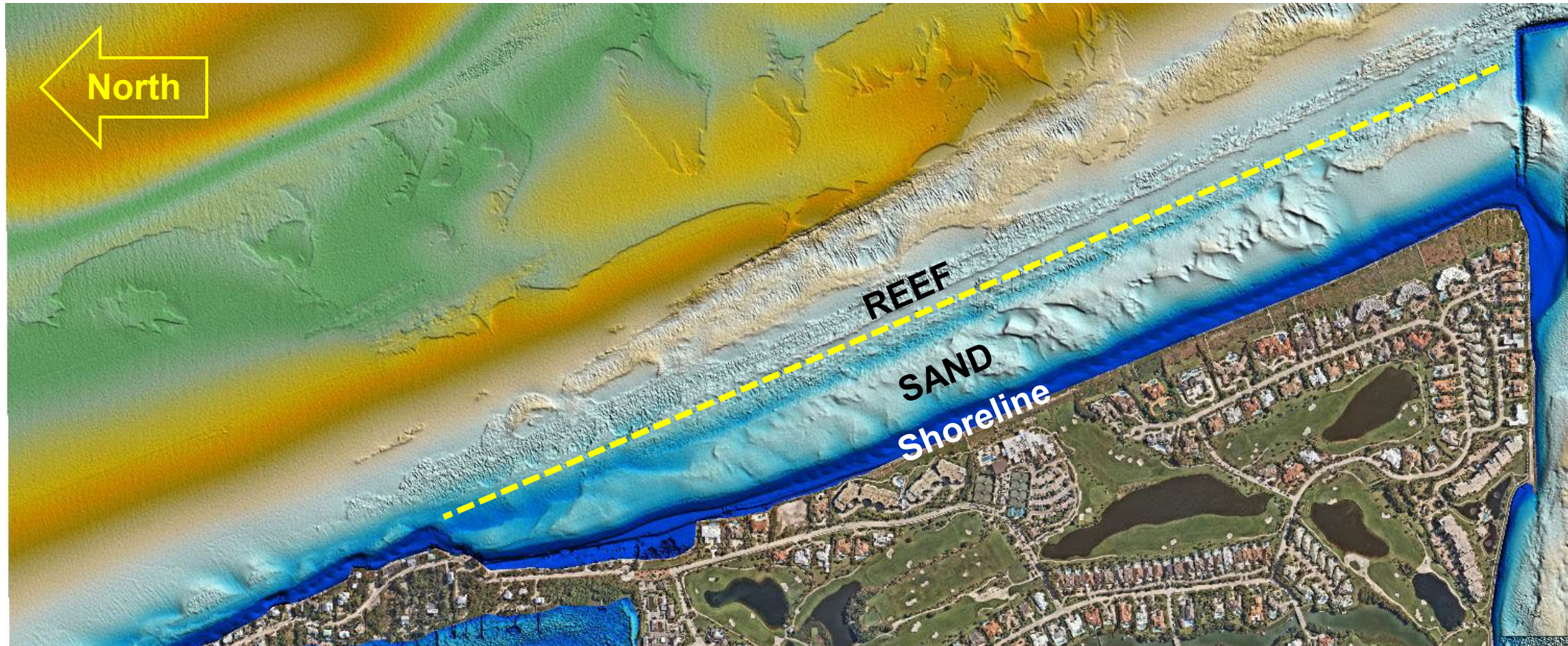


Bathtub Beach / Sailfish Point

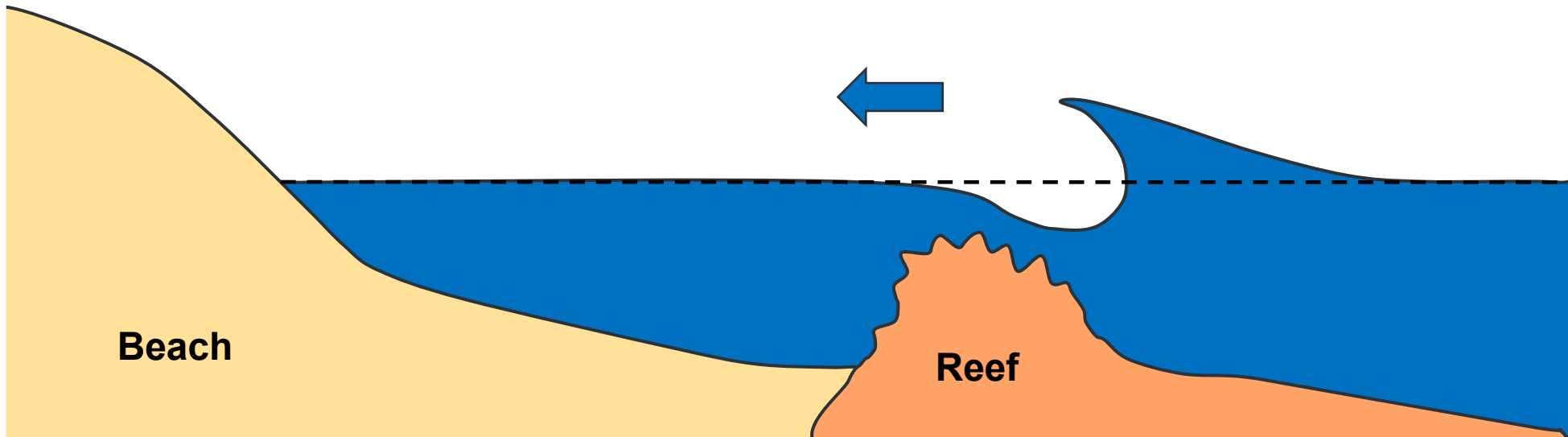


The shallow nearshore reef magnifies the effect of Sea Level Rise.

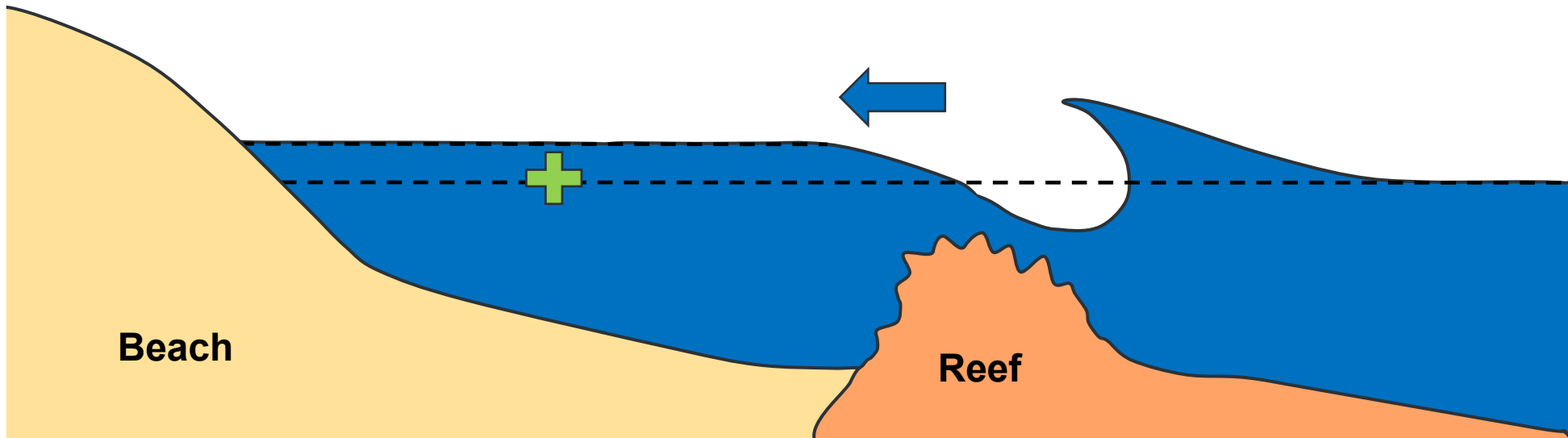
2016 Bathymetric Survey



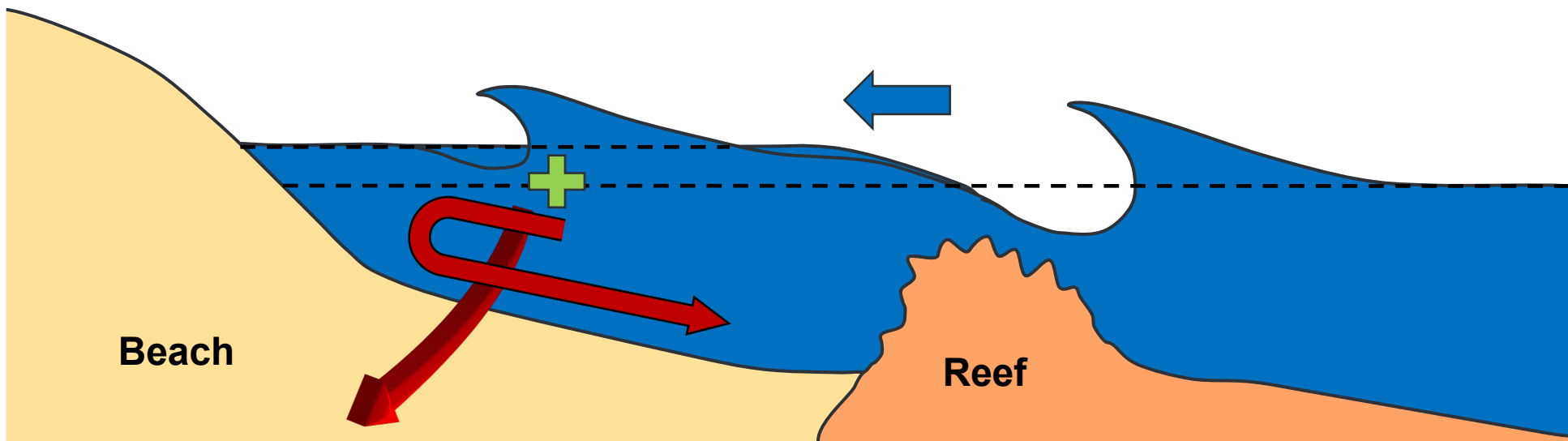
Waves passing over Reef...



Waves passing over Reef... ..increase water level between Beach & Reef.



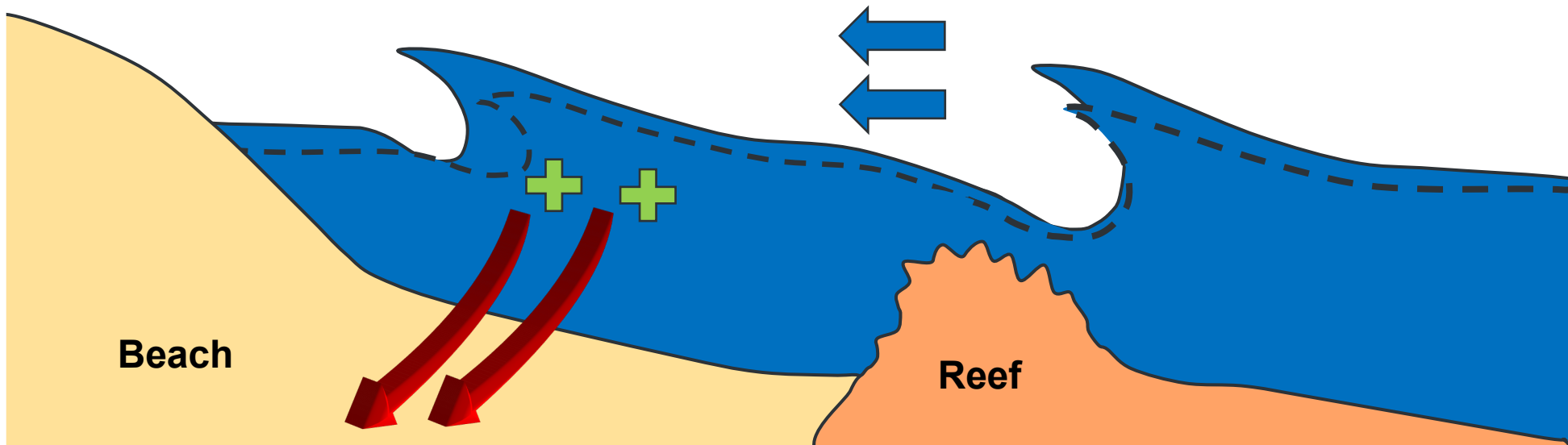
....and waves are transmitted over the Reef – increasing
the energy between the Beach & Reef . . .
. . . and the water & wave run-up return flow is blocked by the reef.



Surf water can't flow out,
it can only flow *south*.

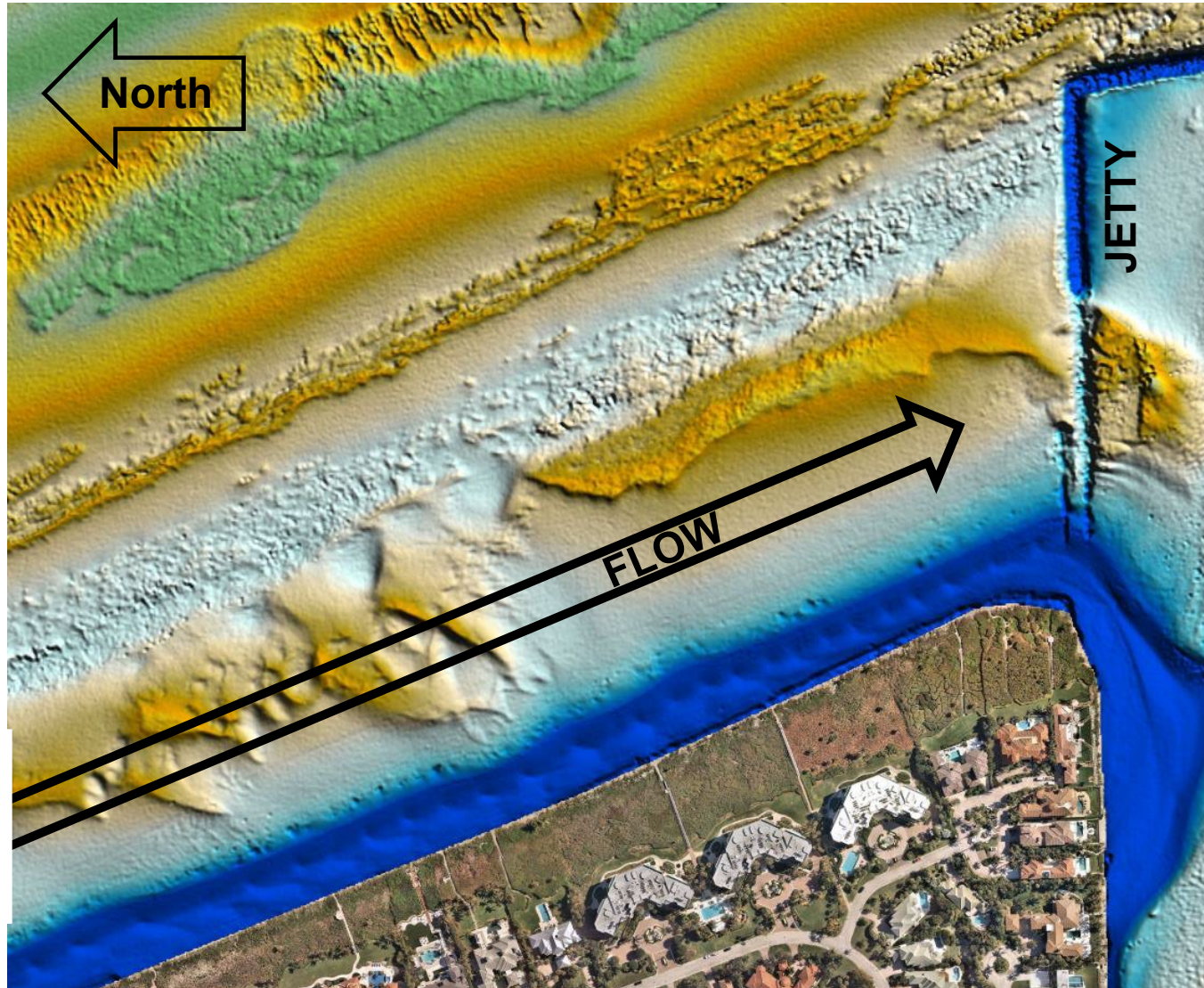
Increased sea level:

More water & waves pass over Reef =
More water & energy trapped between Beach & Reef



South flow of excess
water *increases*

Southward flow of water & energy between Beach & Reef

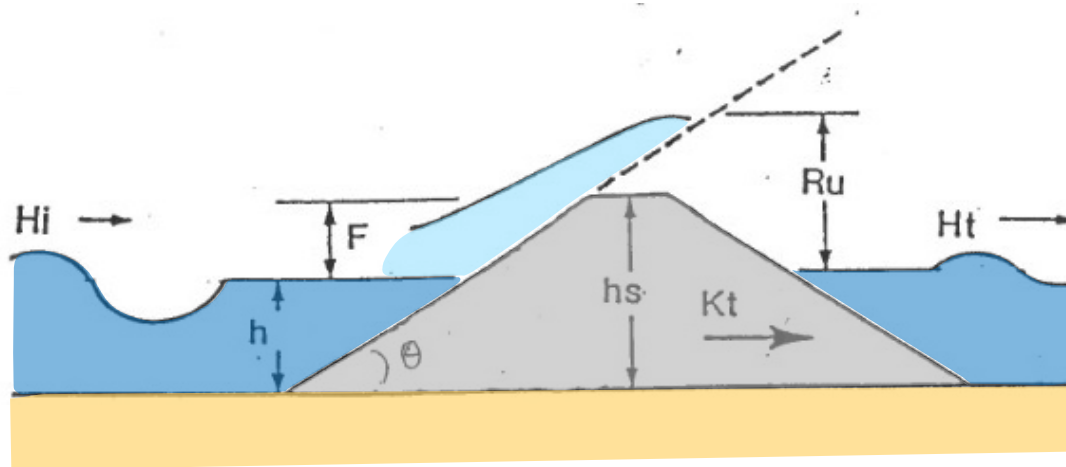


Southward flow of water & energy between Beach & Reef



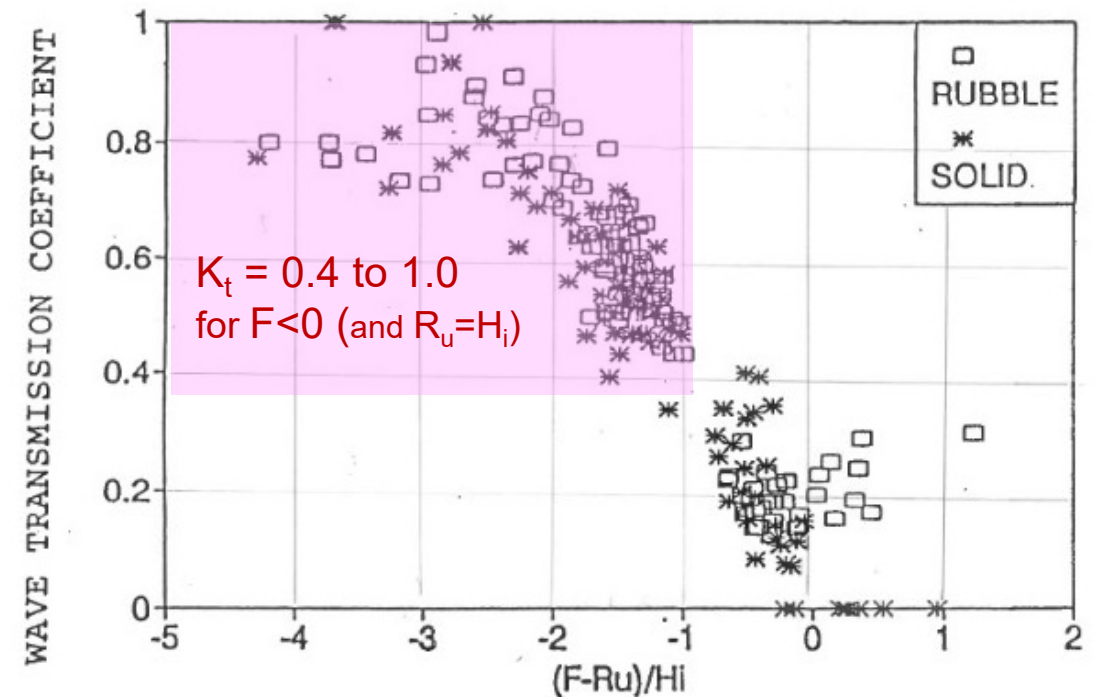
Dec 2020
photo

Wave Transmission Over Submerged Reef



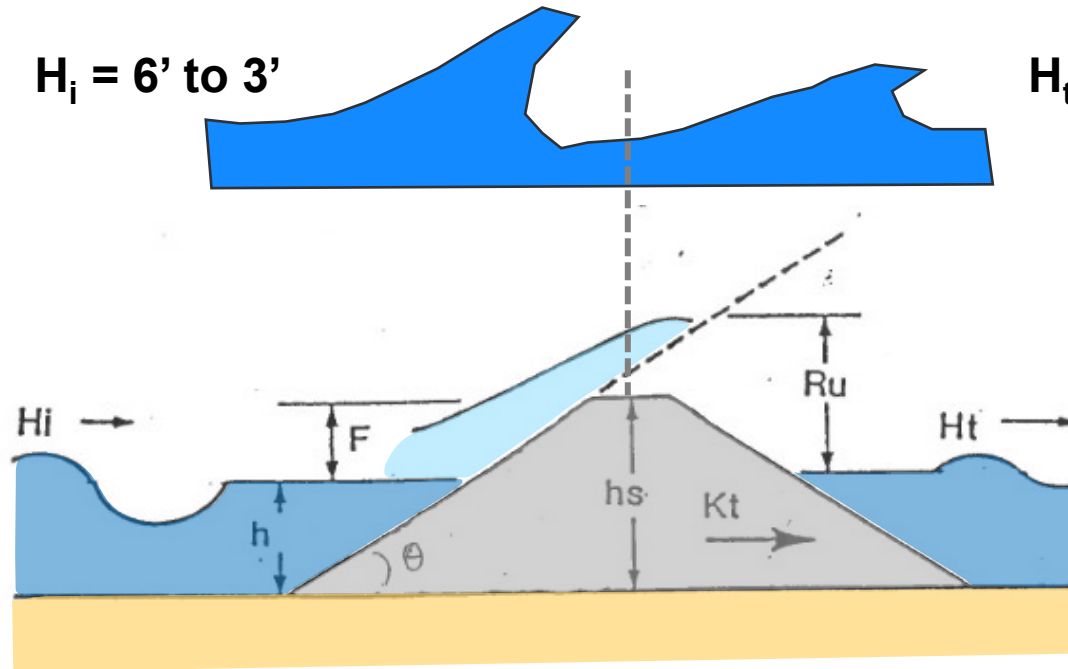
Model Testing of Wave Transmission Past
Low-Crested Breakwaters

Davies & Kriebel, 1992



Freeboard Above Run-Up Elev ÷ Incident Wave H_t

Wave Transmission Over Submerged Reef



With Sea Level Rise of 0.6 feet,
transmitted wave height increases by
+5.3% to +8%.

But, wave energy dissipation \mathcal{D} increases by $H^{5/2} =$
+14% to +21%.

Hence, surf zone volume (between Beach & Reef)
must increase by 14% to 21% greater depth or
width to absorb the increased wave energy.

And that does not account for increased water level
& currents (or that the natural reef is wide).

Wave energy dissipation per unit volume of surf zone:

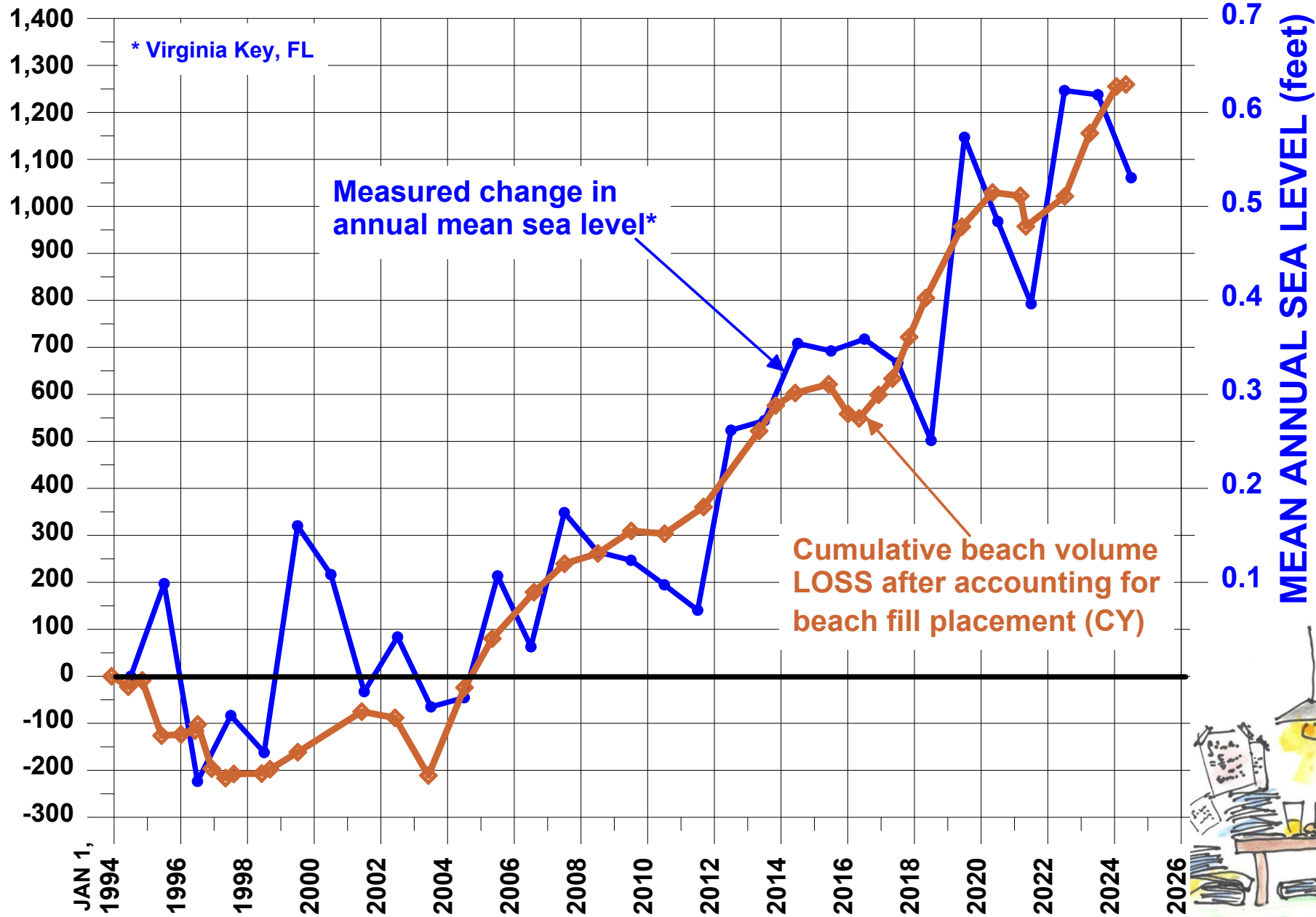
$$\mathcal{D} = -1/h \, d/dx \left(\frac{E}{\rho g} \right)$$

Model Testing of Wave Transmission Past

Low-Crested Breakwaters

Davies & Kriebel, 1992

CUMULATIVE BEACH FILL LOSS (1000's CY)





Measured Sea Level Rise vs Beach Erosion

Bathtub Beach/Sailfish Point, FL

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Foth Infrastructure &
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