



# Understanding the Long-Term Morphologic Evolution and Sediment Dynamics of the New Pass Ebb-Tidal Delta

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U.S. Army Corps  
of Engineers



Engineering With Nature

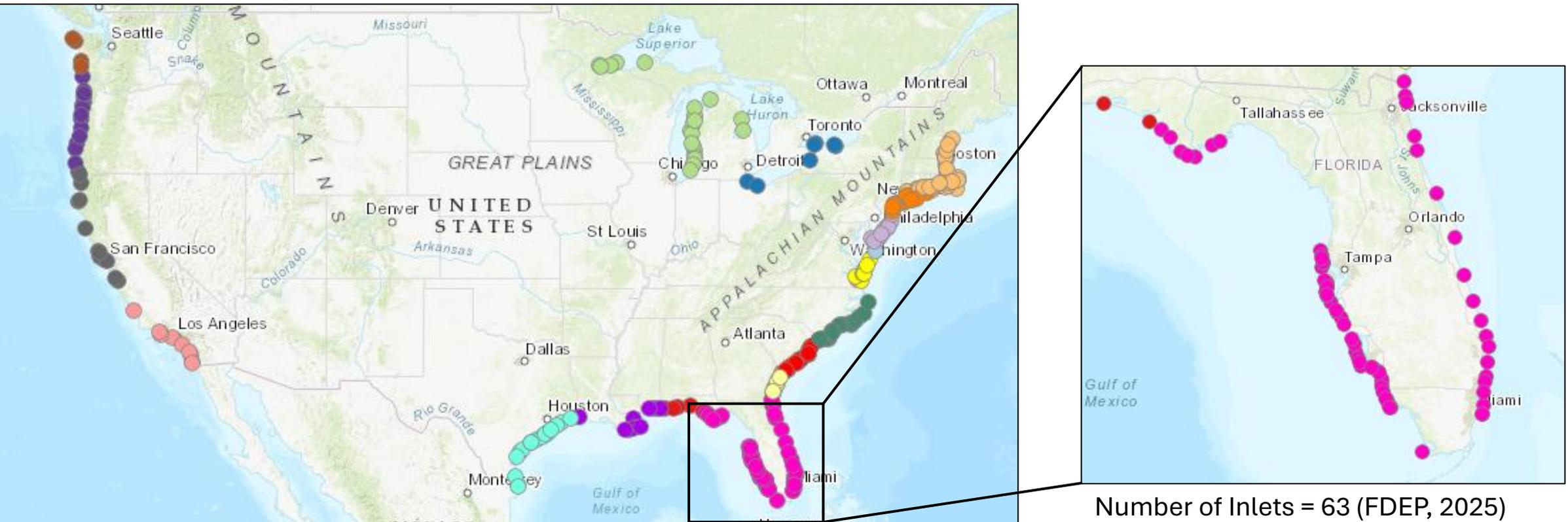


Google Earth 2026



# Motivation

## Tidal Inlets along the Coast of the United States

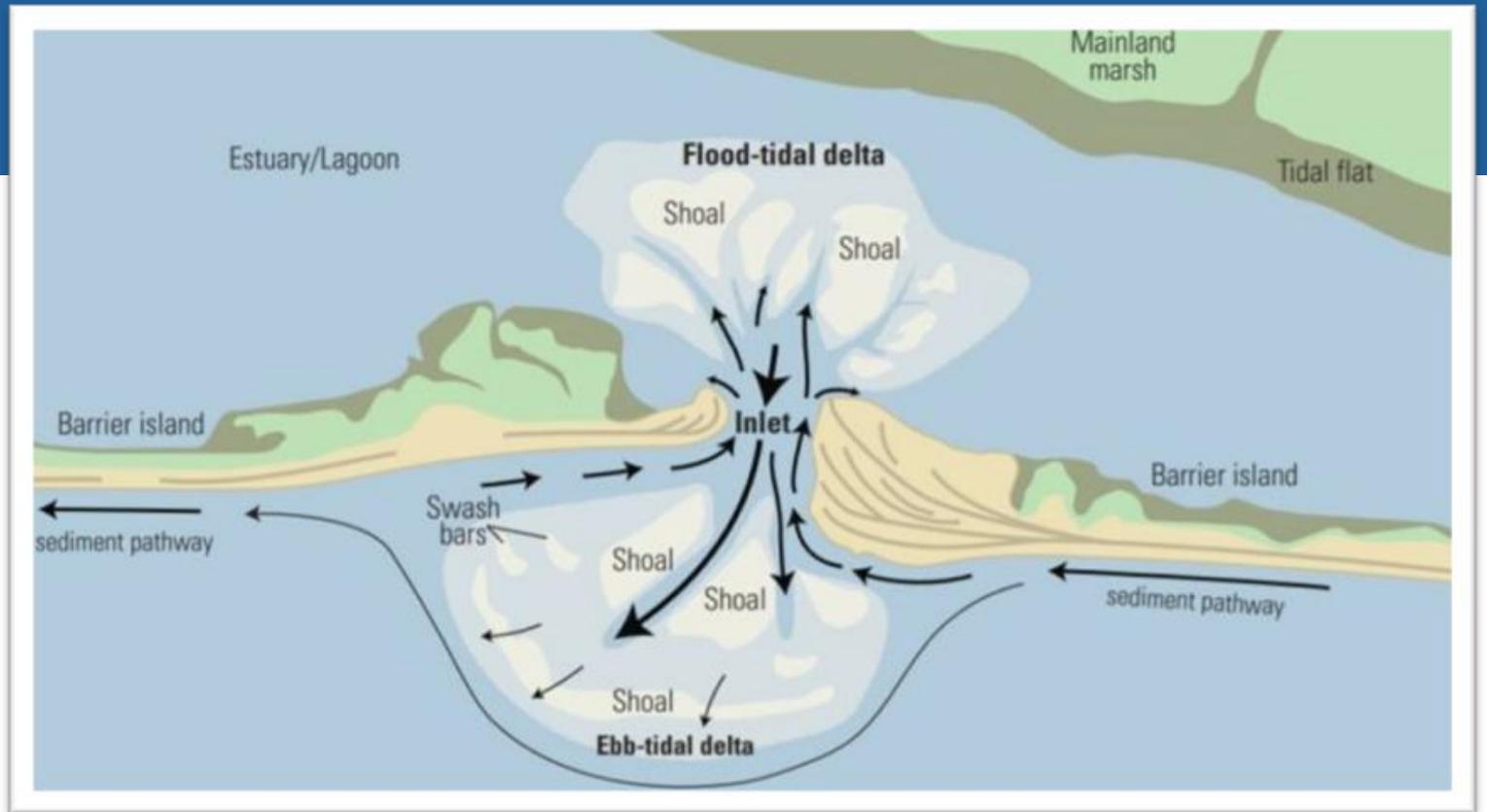
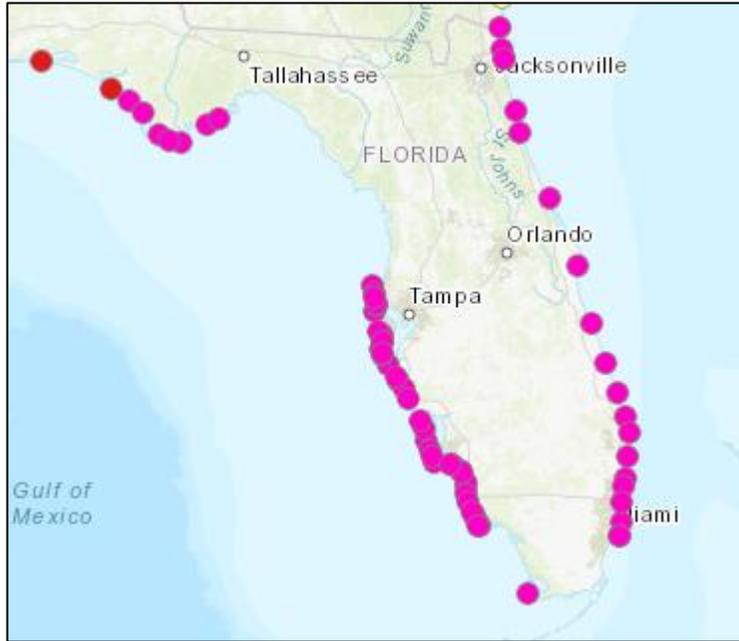


Number of Inlets = 63 (FDEP, 2025)

<https://erdchhl.maps.arcgis.com/apps/webappviewer/index.html?id=07f25730587d433dbfe409226b060cdd>

- **Tidal inlets connect the ocean to adjacent coastal systems, enabling water and sediment exchange**
- **Tidal inlets morphology is controlled by the balance between tidal forcing and wave energy.**
- In Florida, **tidal inlets** are located between **barrier islands.**
- Inlets strongly influence **coastal evolution.**

# Motivation

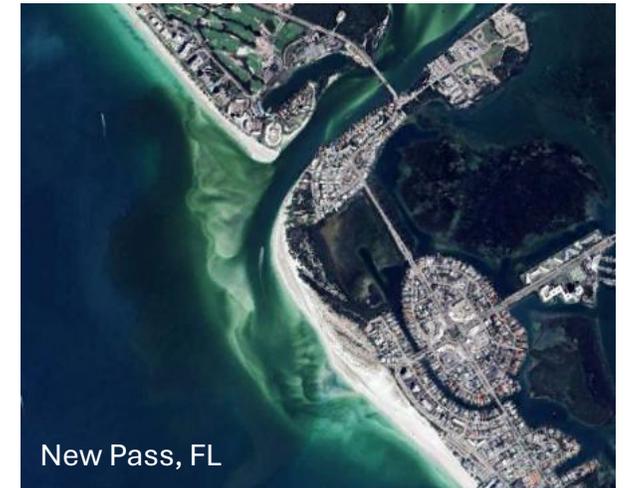


Noreen Buster, U.S. Geological Survey

An **ebb-tidal delta (ETD)** is a large accumulation of **sand** that **forms seaward** of a **tidal inlet**, shaped by the interaction between **tidal currents** and **waves**

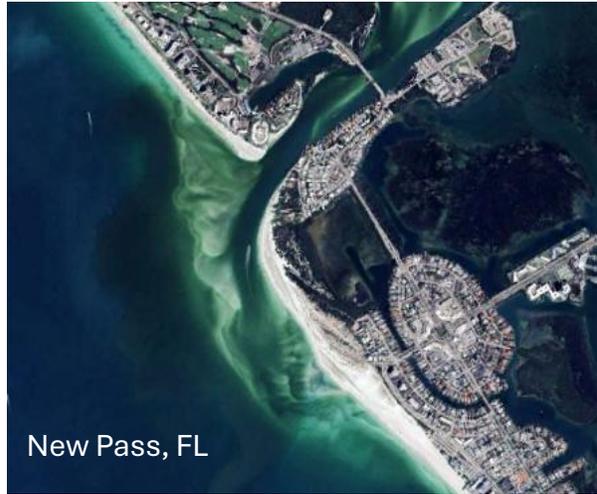


Longboat Pass, FL



New Pass, FL

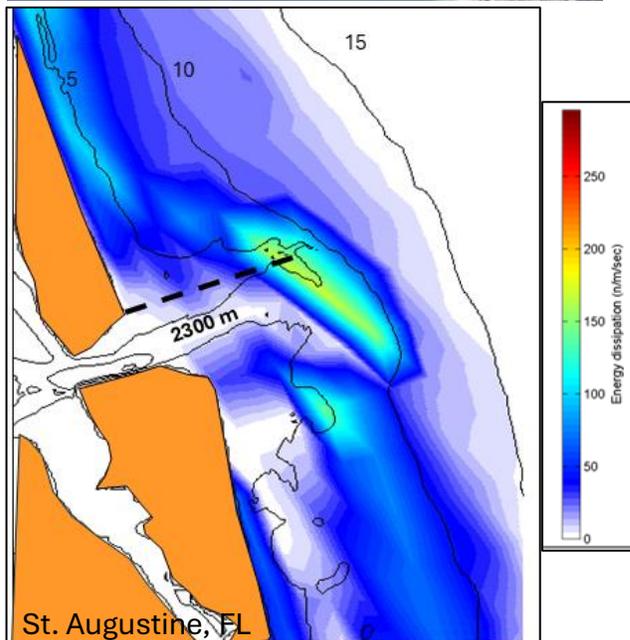
# Why is it important to understand ETD evolution?



- ETDs influence how **sand moves along the coast** by acting as a **sediment sink**.



- ETDs are a **natural sand source** for nearby beaches and **beach nourishment**.

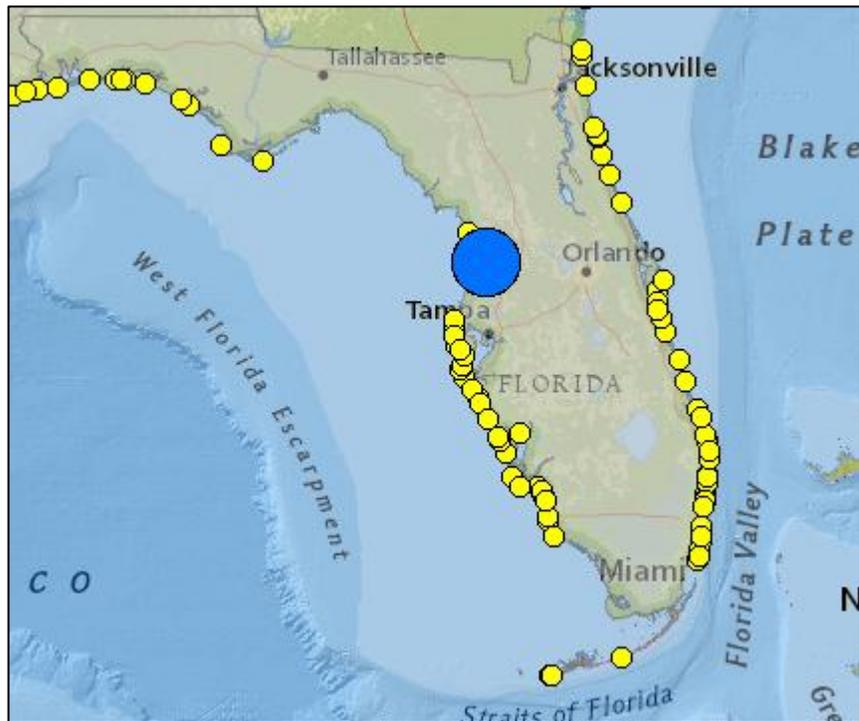


- ETDs **protect the shoreline** by reducing wave energy.



- ETD evolution affects the management of **navigation channels**.

# Beach Nourishment

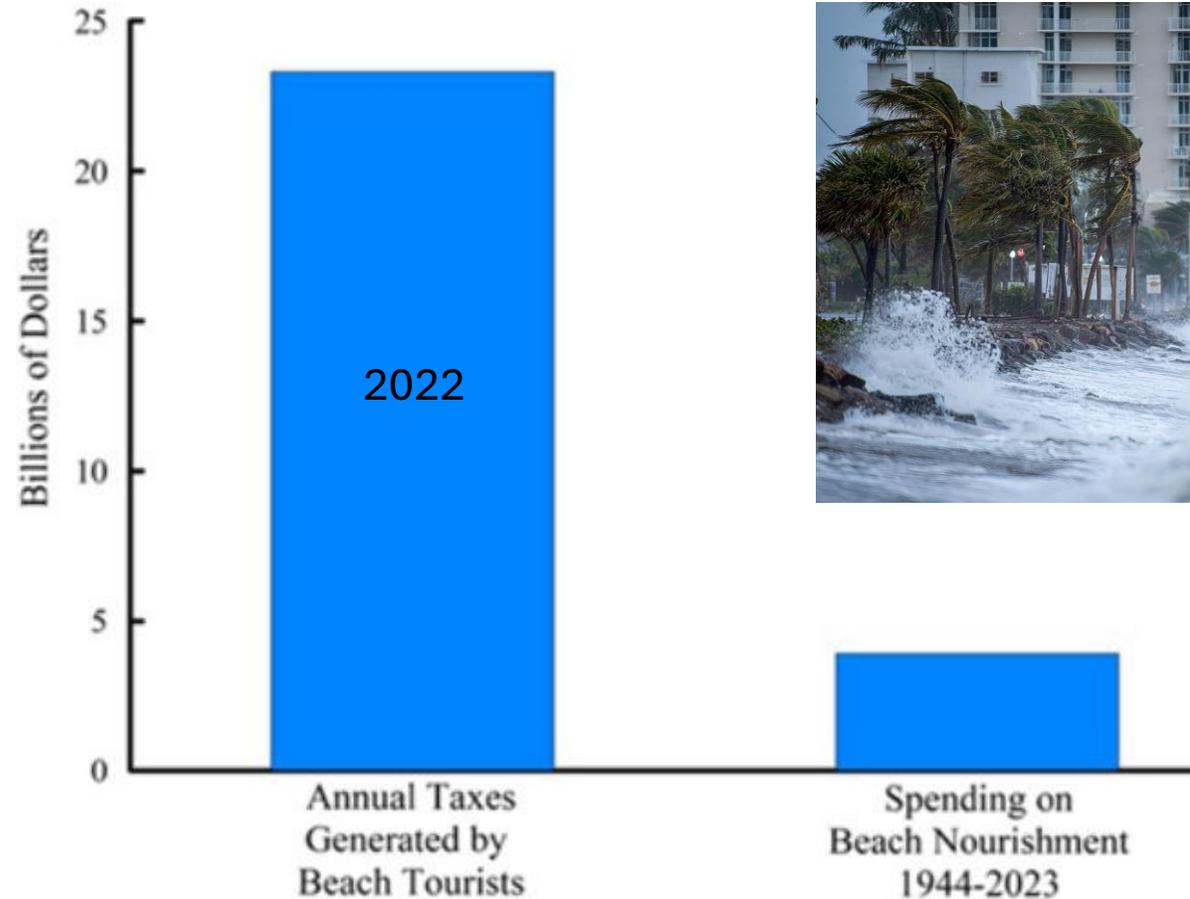


National Beach Nourishment Database

In **Florida**, **ETDs** are an **important source of sediment** for **beach nourishment** projects.

**Beach nourishment projects have two main purposes:**

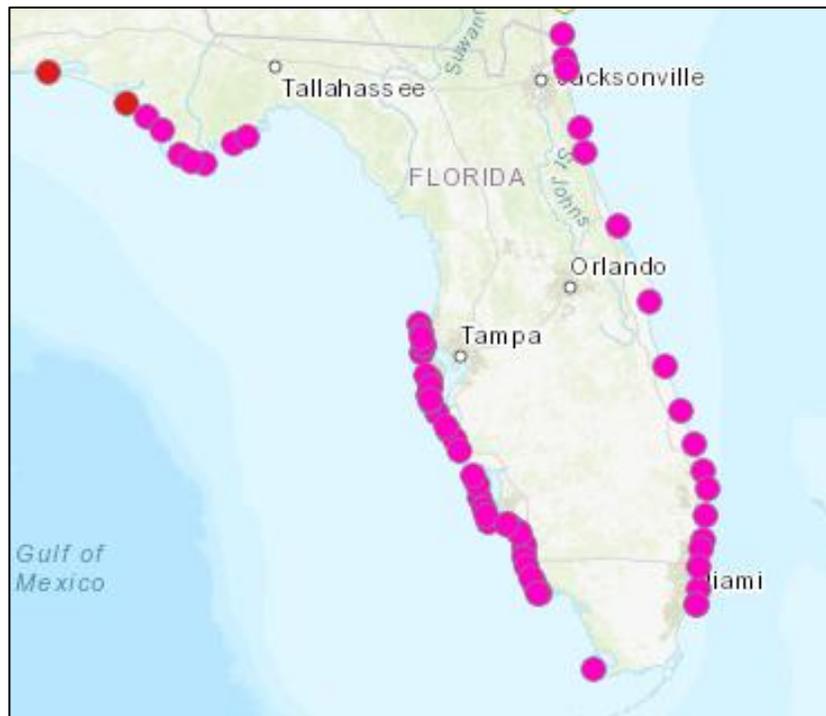
- Coastal storm protection
- Tourism and economic support



# Beach Nourishment

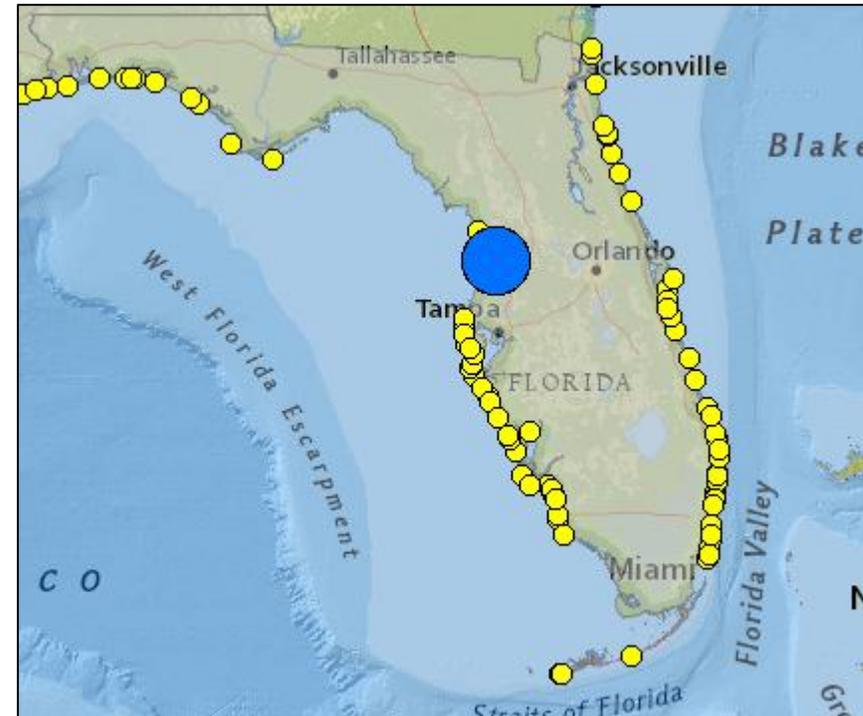
- Because **Florida's beaches** have **great economic importance**, **beach nourishment** and **ETD dredging** will **continue** to be **implemented**.
- **Understanding the long-term morphologic behavior** of the **ETD** is critical for **sustainable sediment management** and **navigation maintenance**.

Inlets



<https://erdchh.maps.arcgis.com/apps/webappviewer/index.html?id=07f25730587d433dbfe409226b060cdd>

Beach Nourishment



National Beach Nourishment Database

# Background

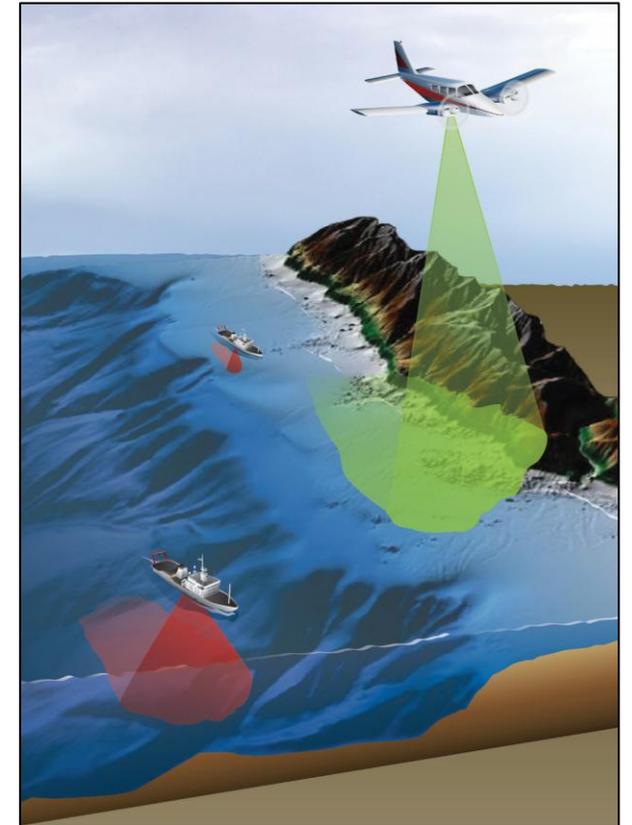
With advances in **technology**, **high-resolution bathymetric data** can now be collected using **modern techniques** including:

- **Airborne LiDAR bathymetry**
- **Single-beam echosounders**
- **UAV**
- **Satellite-derived bathymetry**

Along with these advances, **new methods** have been developed to **improve understanding of ETD morphological evolution**.

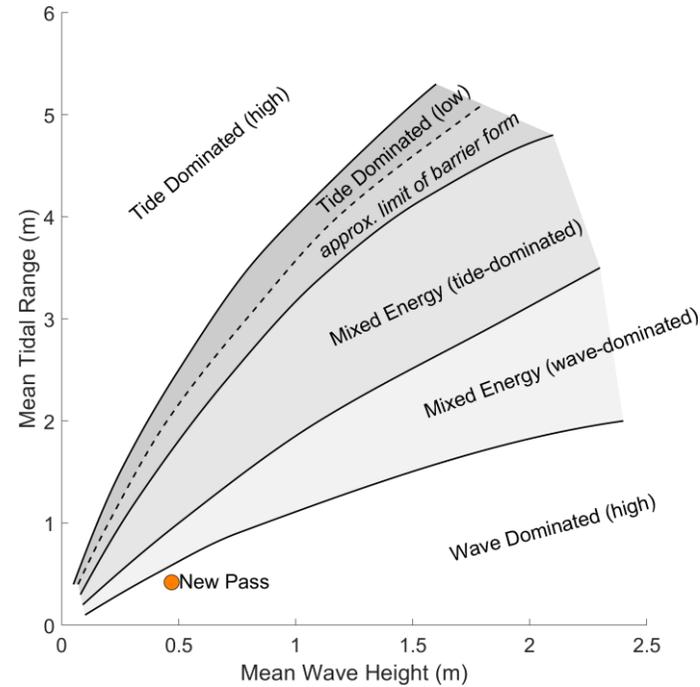
- **ETD volume estimation and temporal variability**  
(Fontolan et al., 2007; Beck & Arnold, 2019; Elias et al., 2022)
- **Shoal migration and sediment deposition**  
(Pearson et al., 2022)
- **Shoreline–ETD interaction**  
(Vos et al., 2019)

## High-Resolution Data Collection

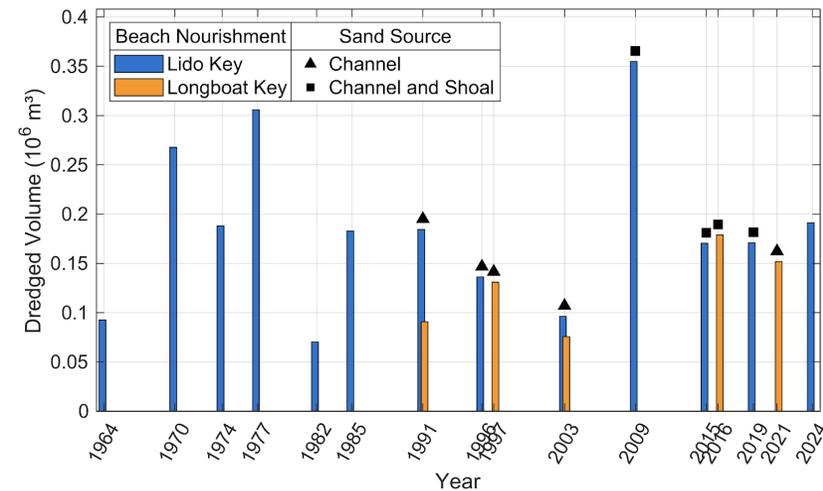


LIDAR magazine

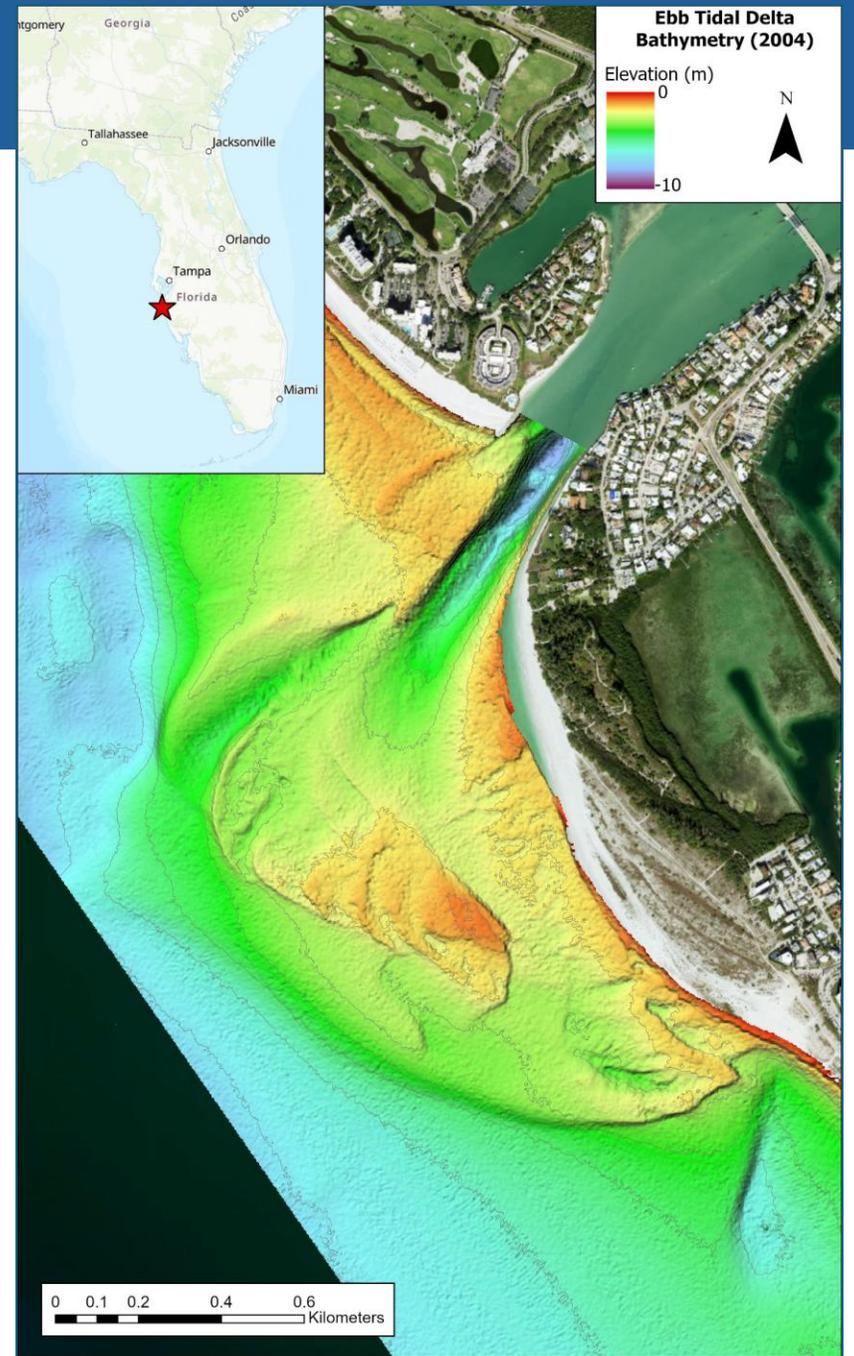
# Study Area - New Pass



**New Pass** is classified as a **wave-dominated inlet** (Davis and Hayes ,1984). However, the **ETD** exhibits **morphological characteristics of a mixed-energy**.

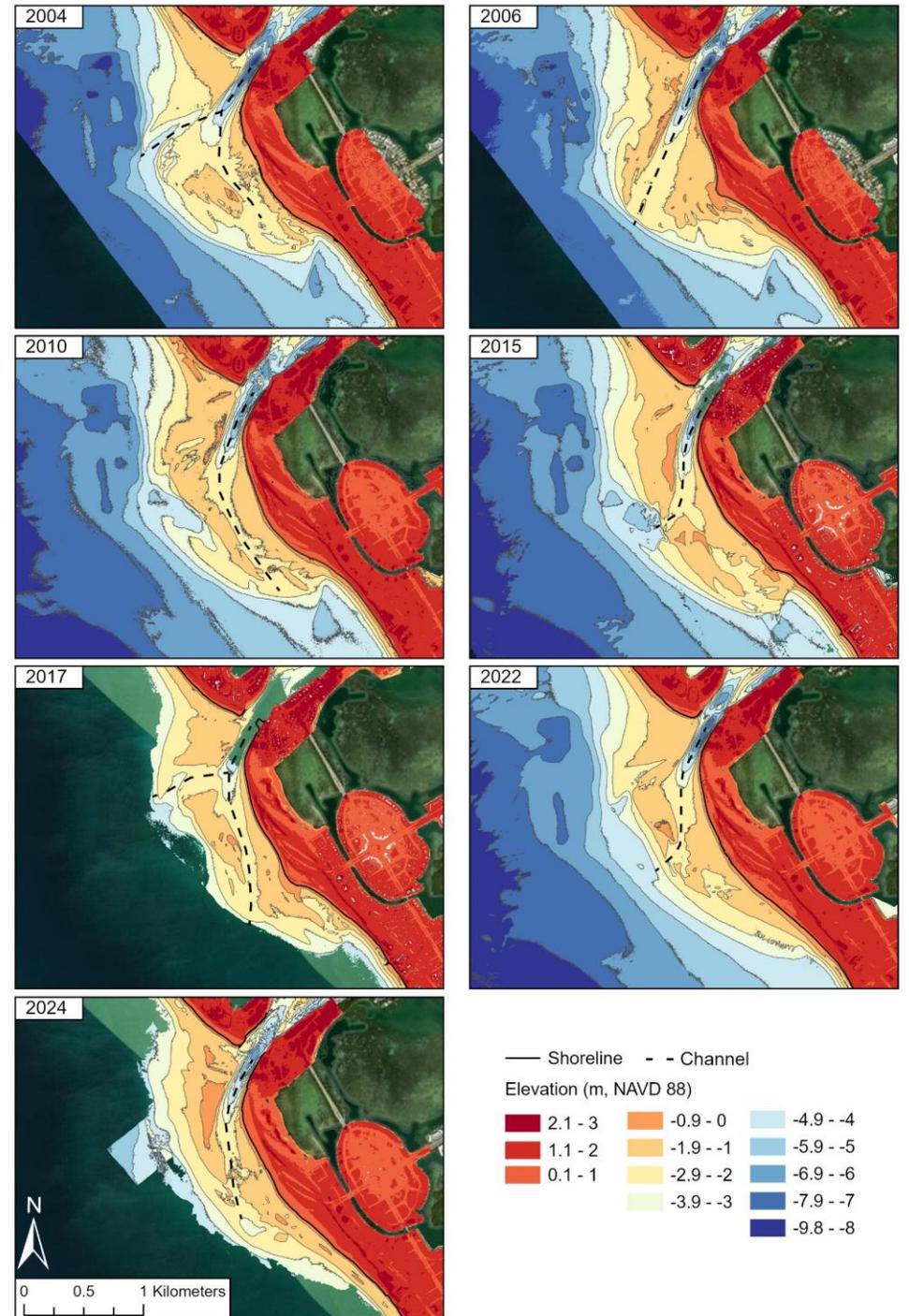


It is strongly influenced by **anthropogenic** processes such as **dredging of the ETD**.



# Methods – Data

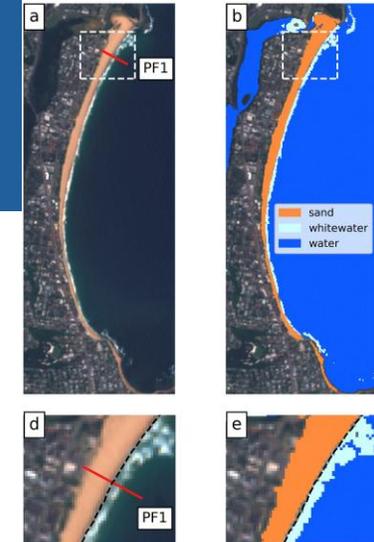
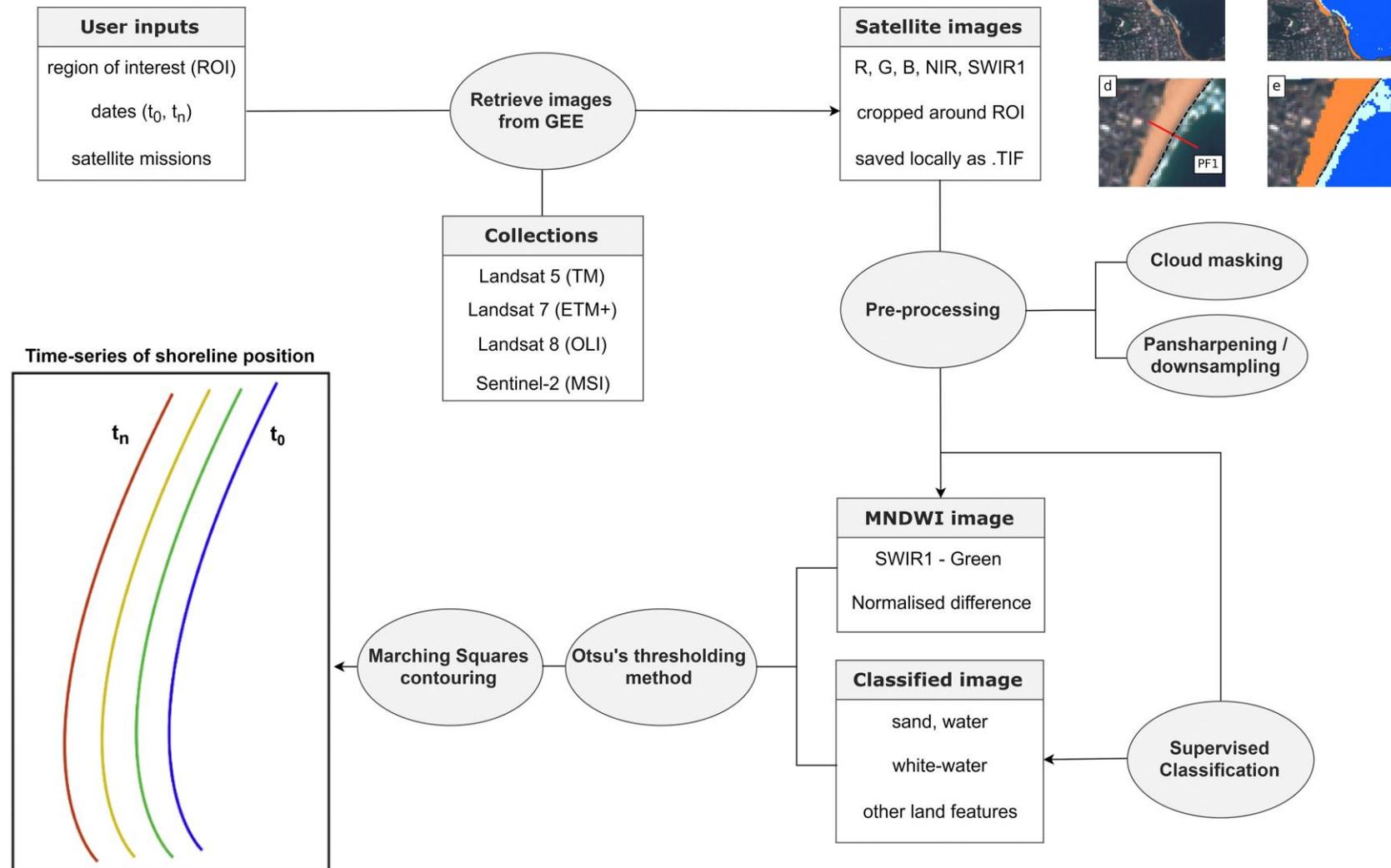
Year	Month	Hurricane	Collected by
2004	September	Pre-Ivan	USACE - JALBTCX
2006	June	Post-Wilma	USACE - JALBTCX
2010	July	-	USACE - JALBTCX
2015	June	-	USACE - JALBTCX
2017	October	-	NOAA - NGS
2022	November	Post-Ian	USACE - JALBTCX
2024	November	Post -Milton	USACE - JALBTCX



# Methods – CoastSat – Shoal Attachment

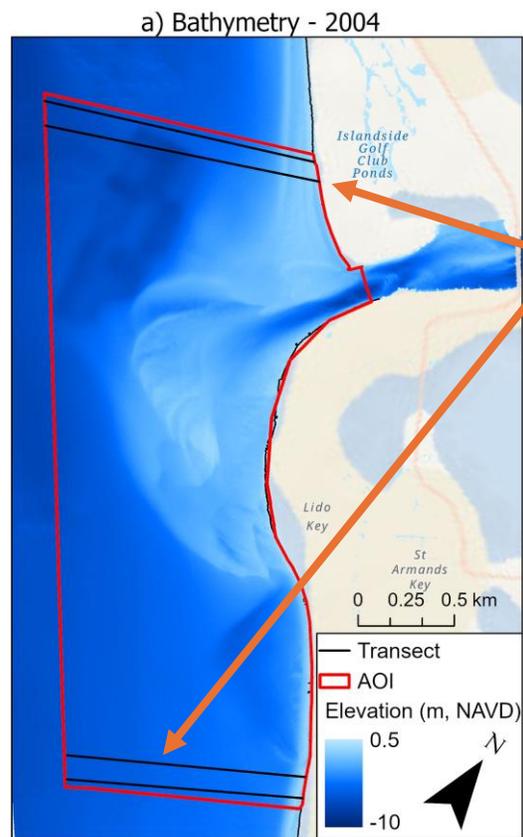
- Use **publicly available satellite imagery** acquired every **5–16 days** (e.g., Landsat and Sentinel-2 missions)
- **Machine-learning algorithms** automatically classify imagery and **extract shorelines**, generating a shoreline shapefile time series
- **Shoreline** time series is **tidally corrected** based on image acquisition time

Vos et al. (2019)



# Methods – ETD Volume Estimation

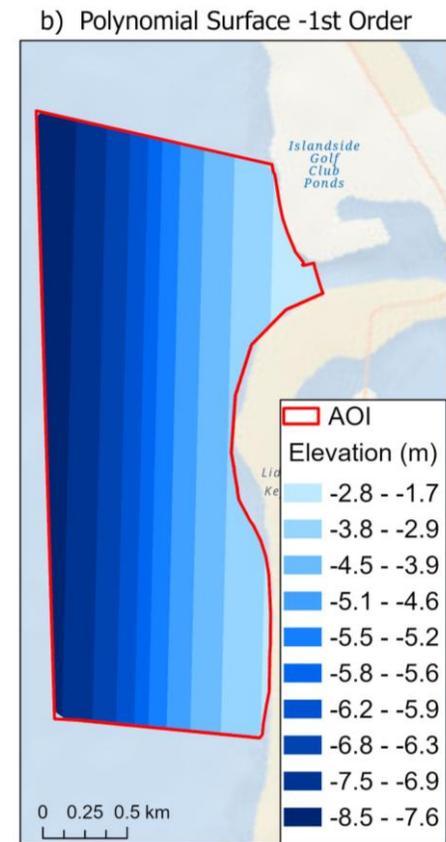
- Methodology used was from **Fontolan et al. (2007)**, and **Beck and Arnald (2019)** - This approach involves generating a **no-inlet bathymetry surface**, which is then used to **calculate the ETD volume** for each DEM.
- Only DEMs with full coverage was used (**2004, 2006, 2010, 2015 and 2022**)



1. Define the area of Interest (**AOI**)

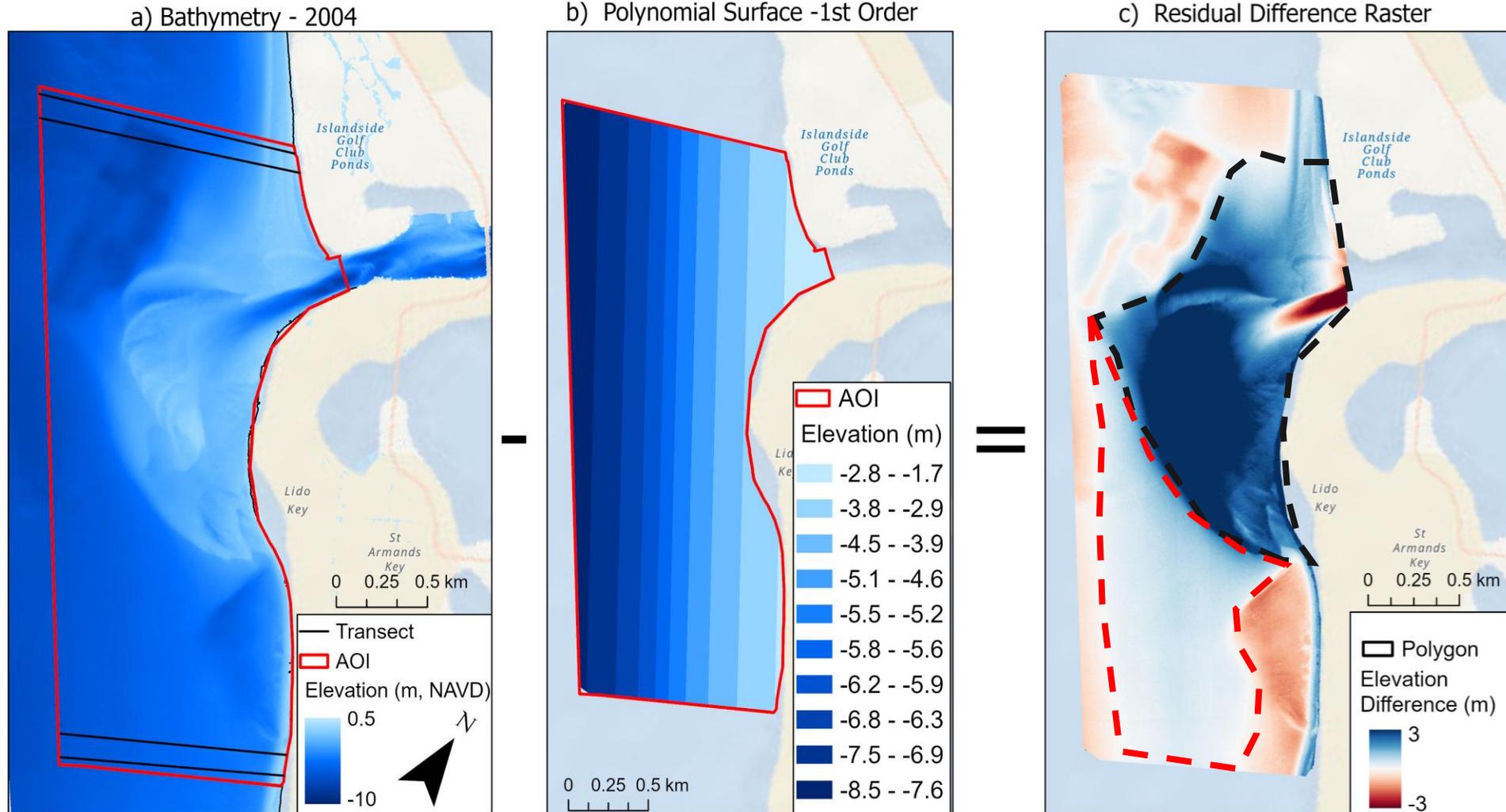
2. 4 **Cross-shore transects** were created – 2 in each side.

3. These **transects** were used to extract **bathymetric profiles** within the **AOI**. These **profiles** were **used** to generate a **polynomial trend surface** covering the **AOI (no-inlet bathymetry surface)**



# Methods – ETD Volume

## 4. Subtract the bathymetry from the trend surface

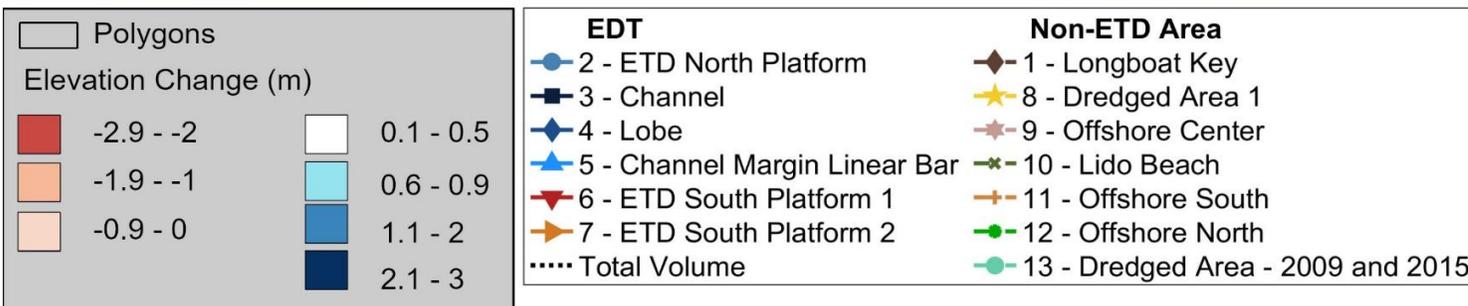
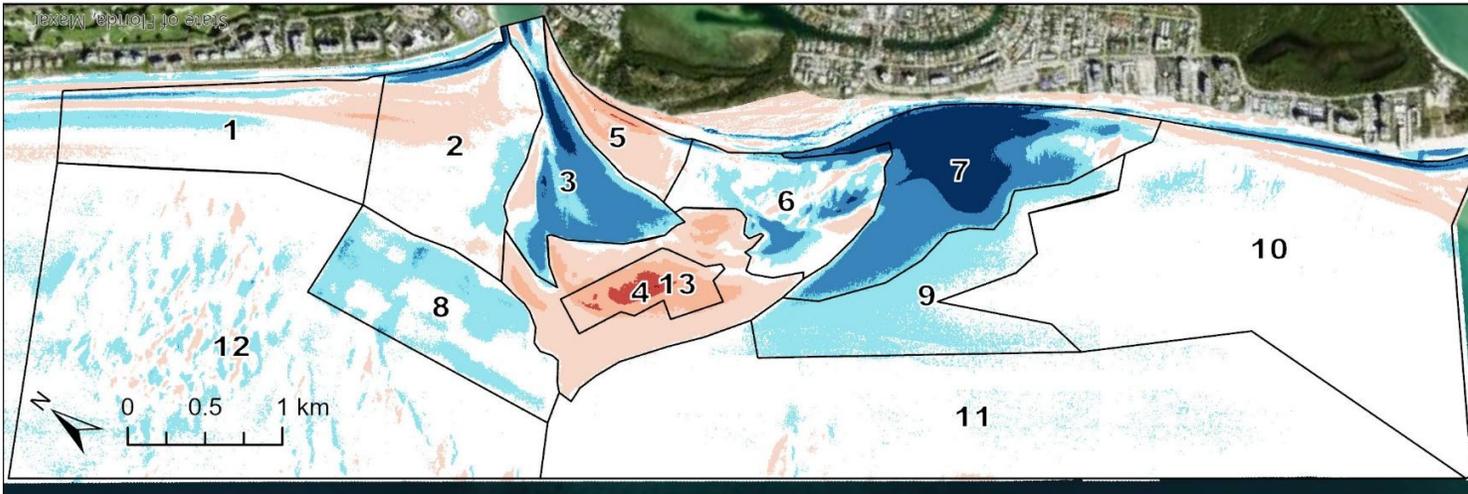


# Methods – ETD Volume

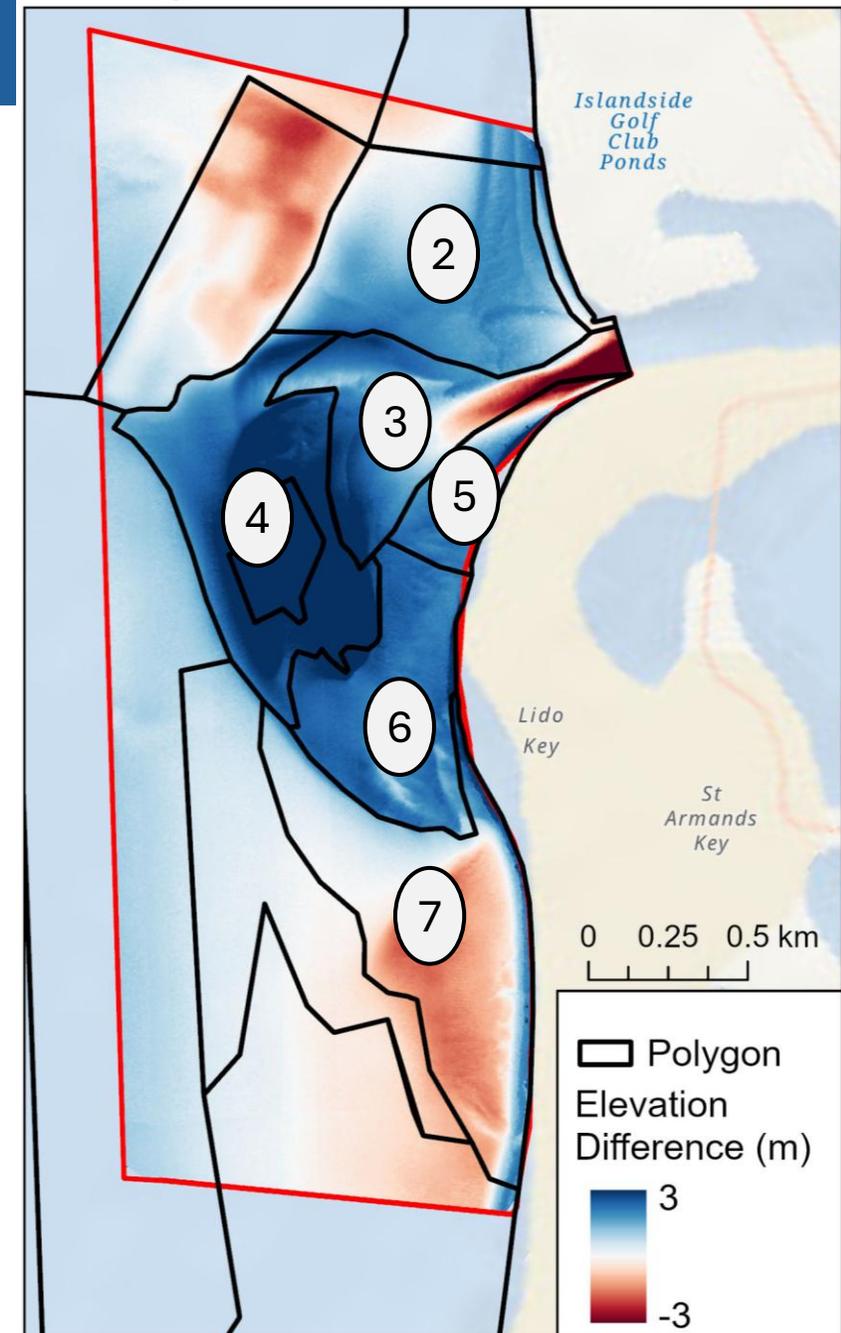
5. The **ETD** was subdivided into distinct **unites** defined by **patterns of deposition and erosion**, as identified from the **difference between the 2004 and 2022 DEMs**

6. **Sum the positive values** within the **ETD units** and multiply by the cell area ( $3 \times 3 \text{ m}$ ) to **calculate the ETD volume**.

a) Elevation Change (2022–2004)



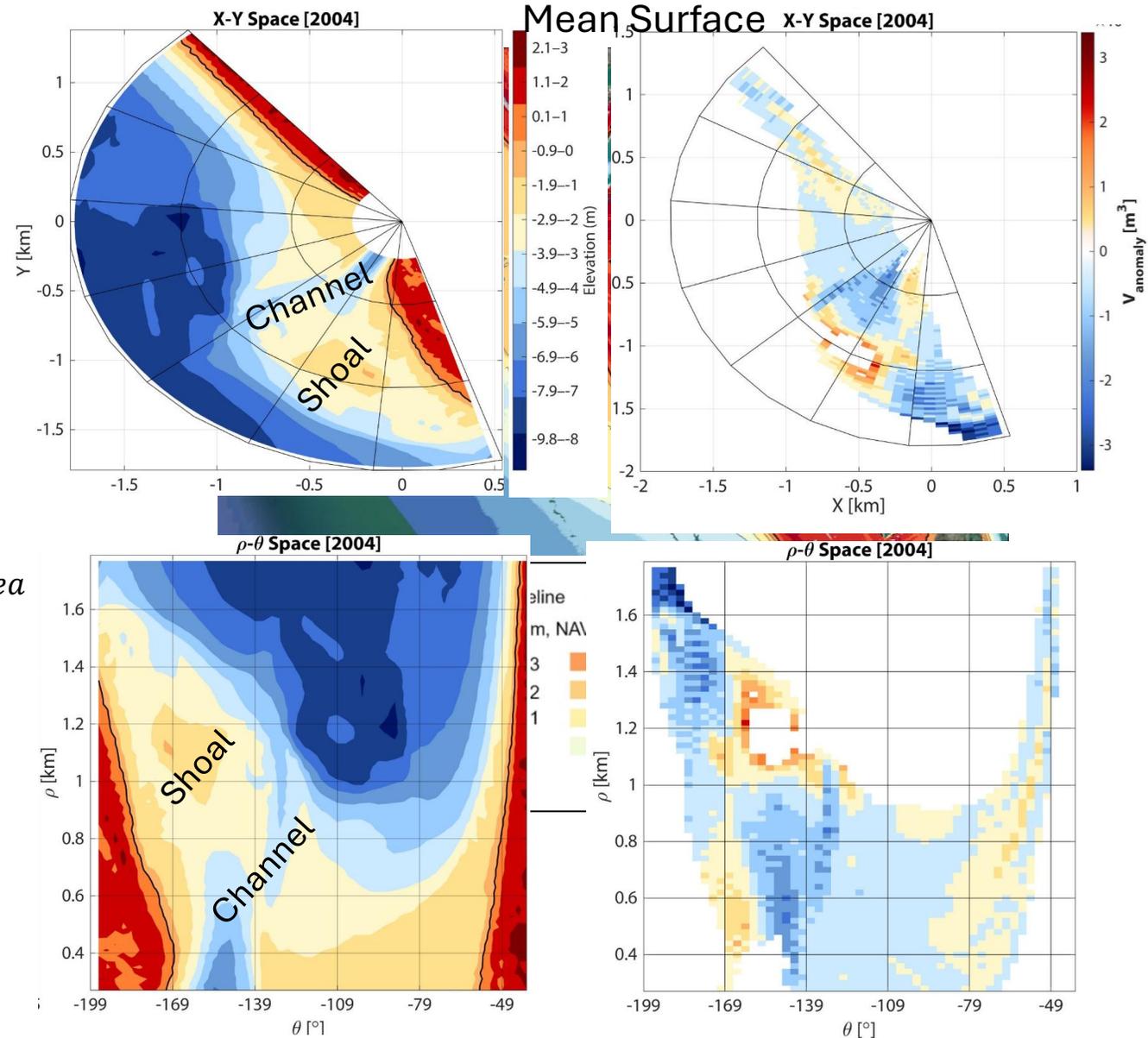
c) Residual Difference Raster



# Methods – Conformal Mapping

Conformal Mapping – angle-preserving spatial transformation

1. Calculate time-weighted mean surface from all surveys
  2. Compute volume anomaly for each survey
- $$V_{anomaly} = (Bathymetry(year) - Mean Bathymetry) * cell\ size\ area$$
3. Conformally map to polar space



# Conformal Mapping

1. Calculate time-weighted mean surface from all surveys

2. Compute volume anomaly for each survey

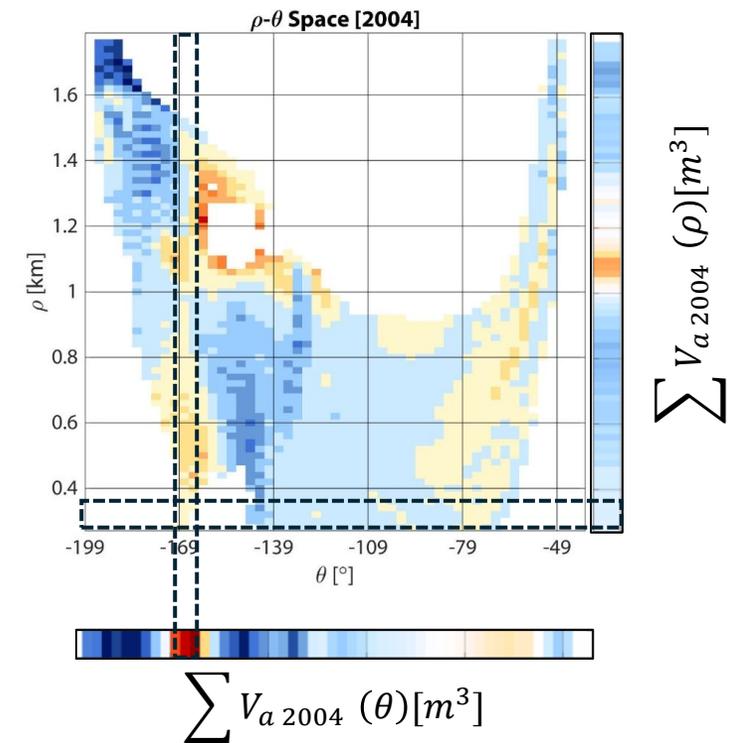
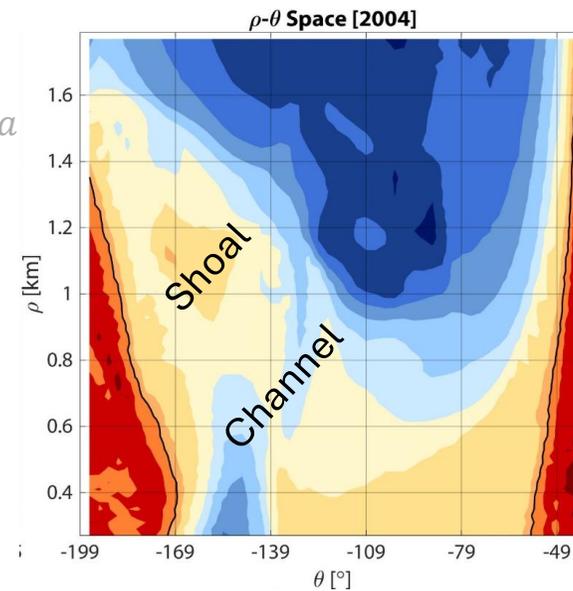
$$V_{\text{anomaly}} = (\text{Bathymetry}(\text{year}) - \text{Mean Bathymetry}) * \text{cell size area}$$

3. Conformally map to polar space

4. Collapse volume anomaly in each dimension for each year.

$$\sum V_{a\ 2004}(\theta)[m^3]$$

$$\sum V_{a\ 2004}(\rho)[m^3]$$



# Conformal Mapping

1. Calculate time-weighted mean surface from all surveys

2. Compute volume anomaly for each survey

$$V_{\text{anomaly}} = (\text{Bathymetry}(\text{year}) - \text{Mean Bathymetry}) * \text{cell size area}$$

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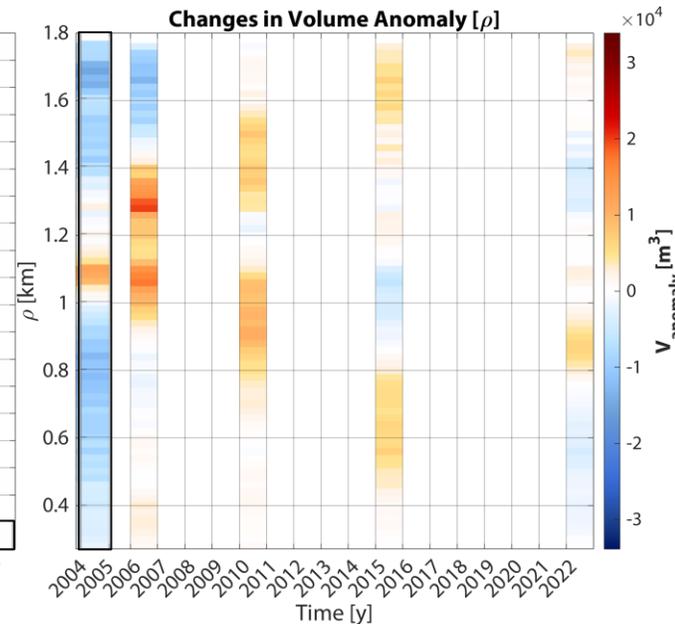
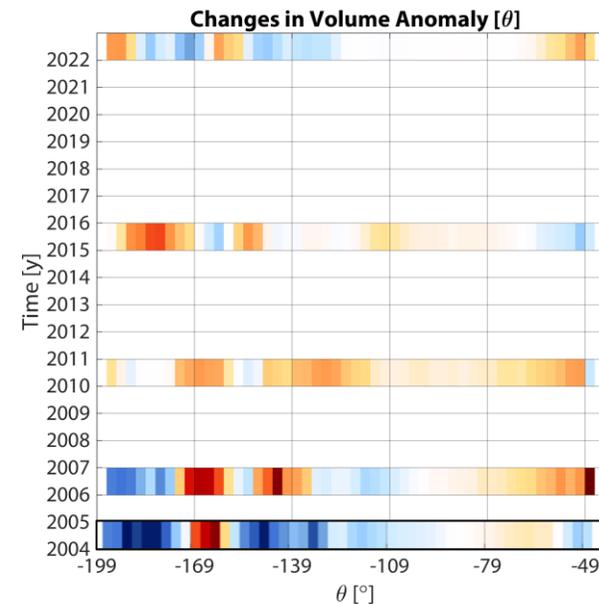
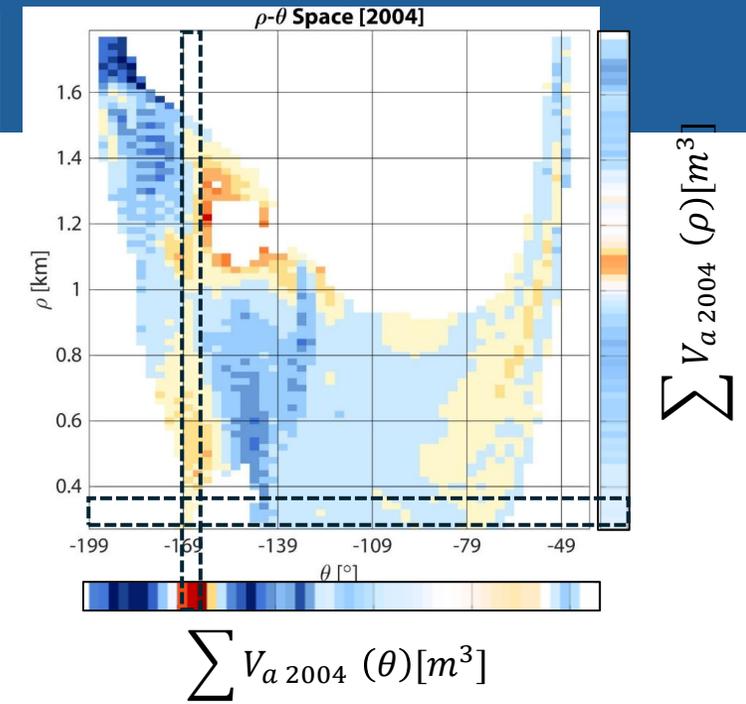
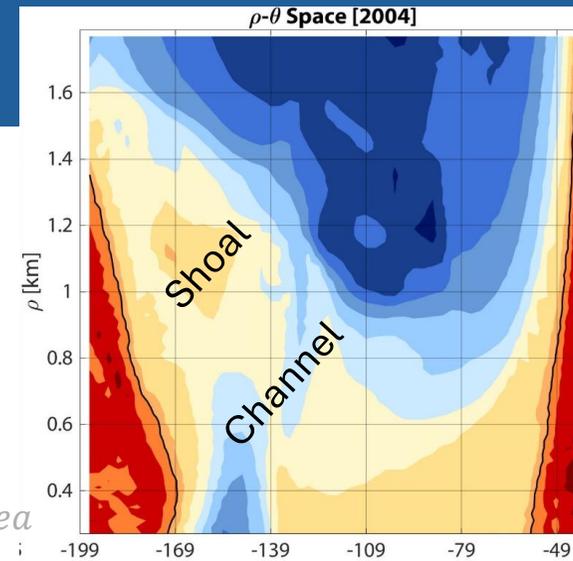
4. Collapse volume anomaly in each dimension for each year

$$\sum V_{a\ 2004}(\theta)[m^3] \quad \sum V_{a\ 2004}(\rho)[m^3]$$

5. Volume anomalies after spatial collapse are plotted as a time stack

( $\theta$ ) Time series of rotation of ETD features

( $\rho$ ) Time series of migration

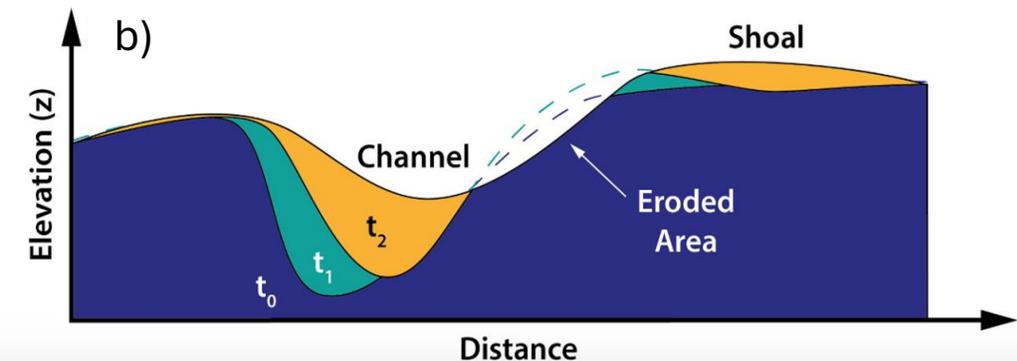
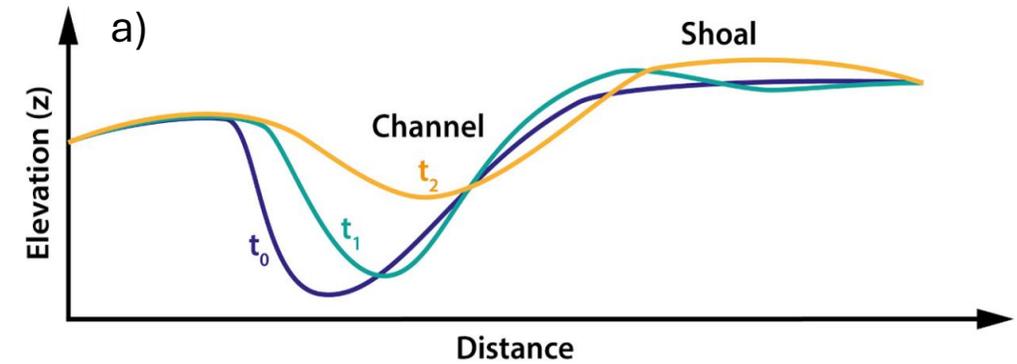
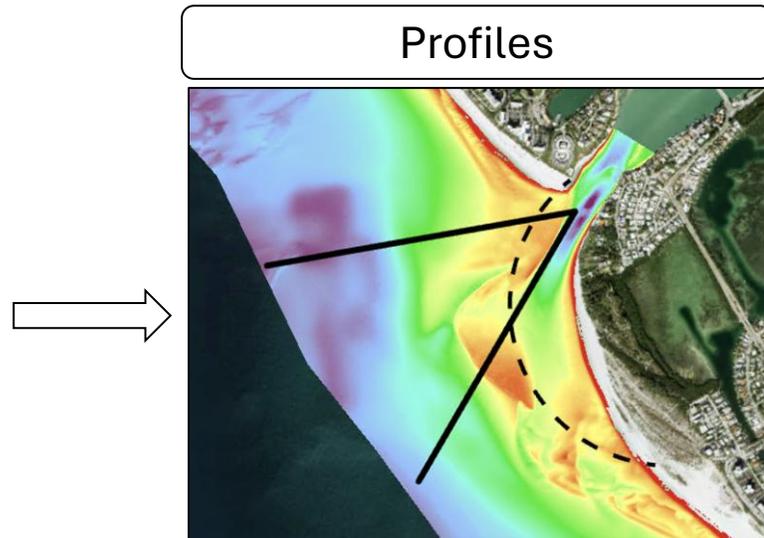


# Methods - Chronostratigraphy

- Helps understand the depositional patterns of sediment over time in the ETD.

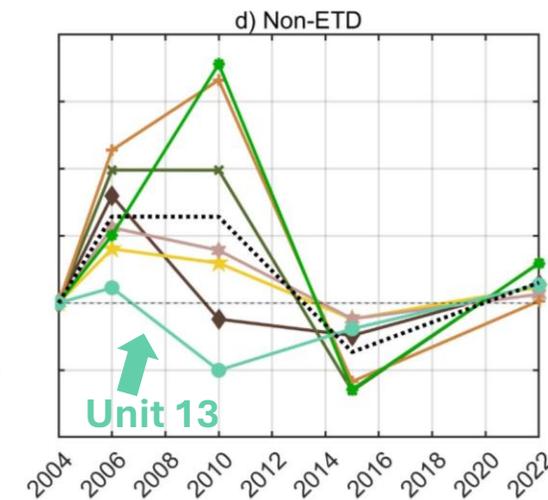
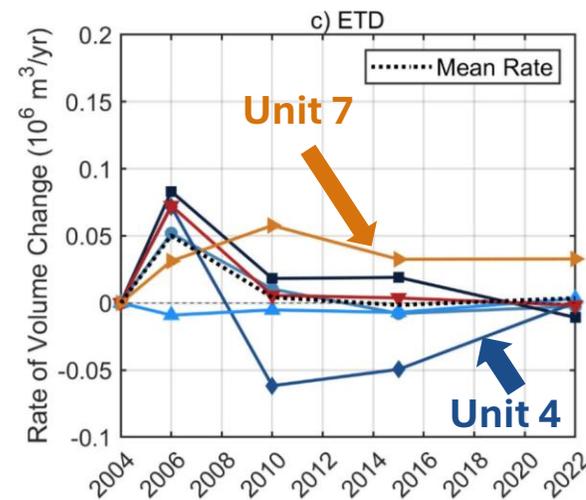
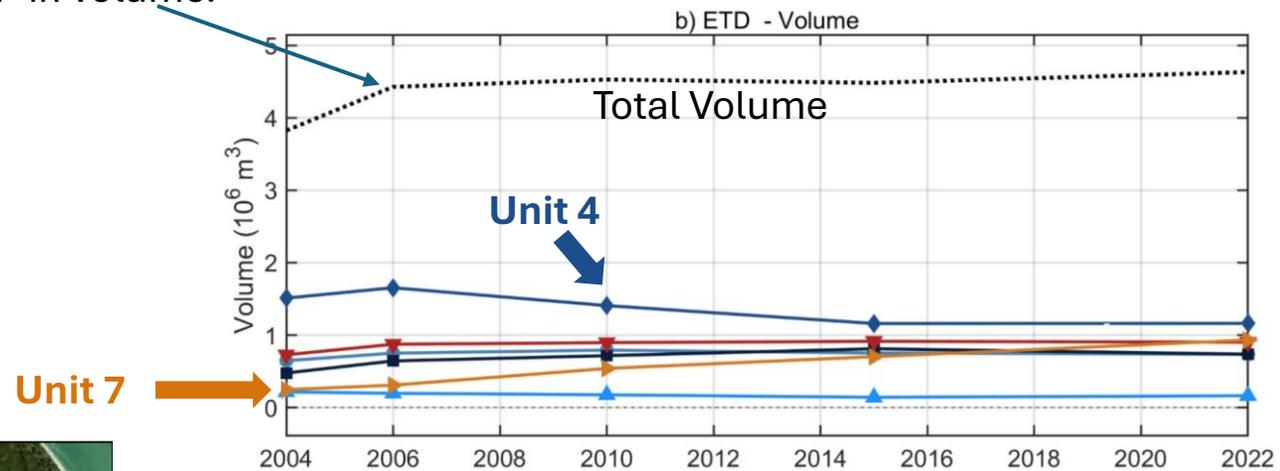
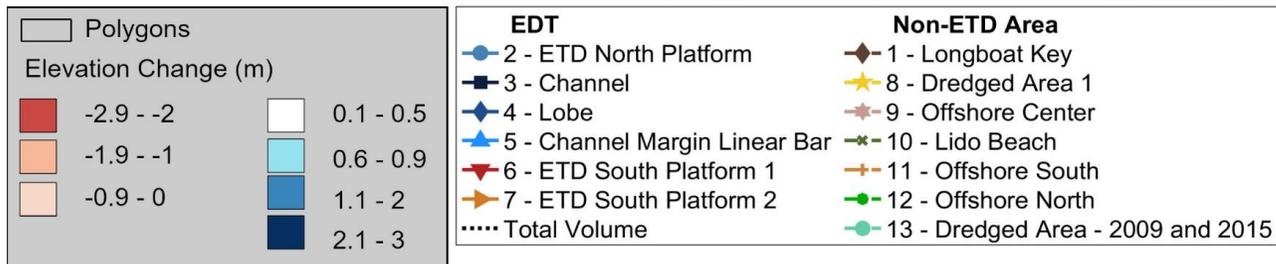
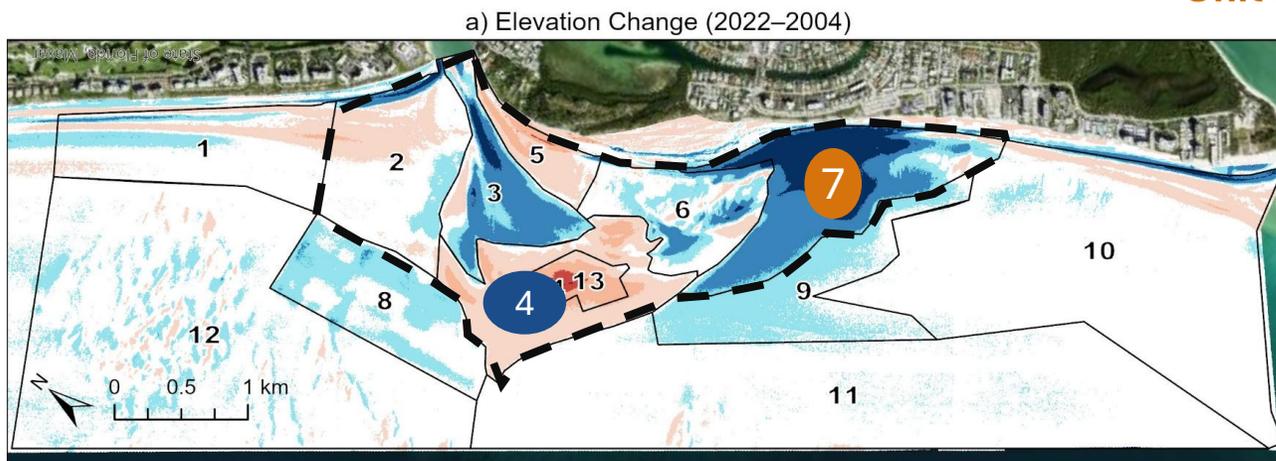


- DEMs
- 2004
- 2006
- 2010
- 2015
- 2017
- 2022
- 2024



# Results – Ebb-Tidal Delta Volume Change

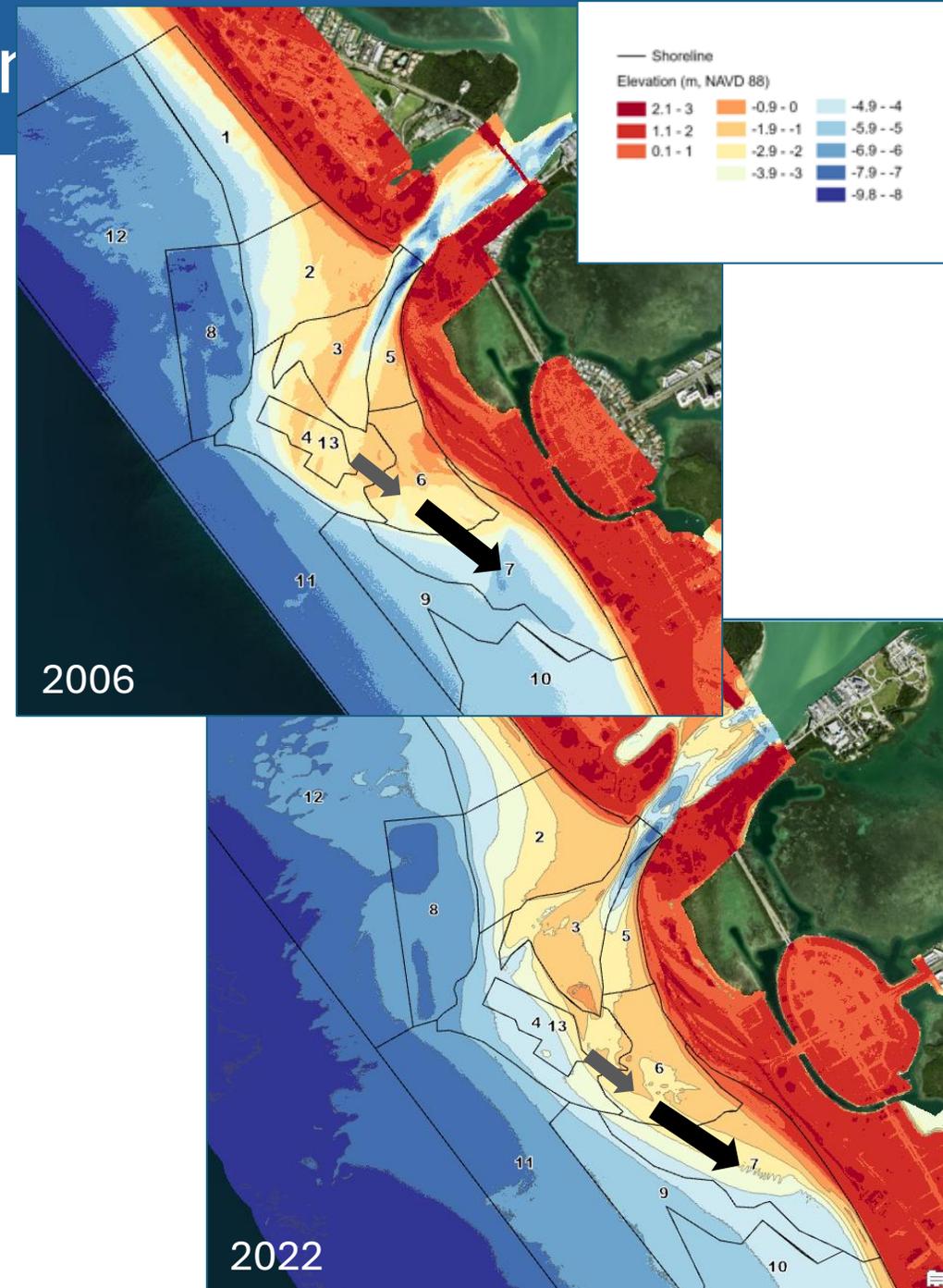
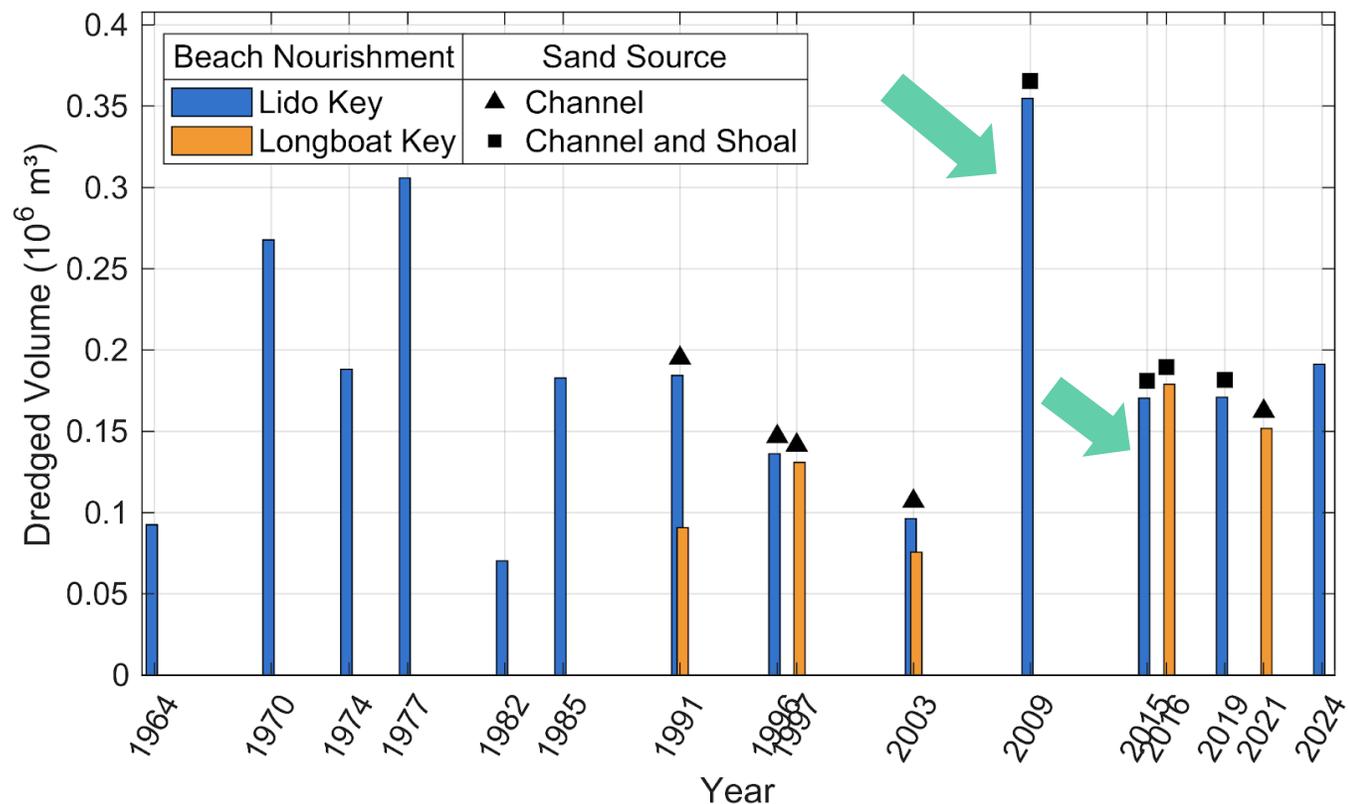
- Over 18 years, the ETD gained approximately **0.83 million m<sup>3</sup>** in volume.
- **Unit 7** gained the most volume = **~0.68 million m<sup>3</sup>**
- **Unit 4** experienced the **largest loss** = **~0.34 million m<sup>3</sup>**
  - Likely linked to **dredging (unit 13)** and **sediment redistribution (unit 7)**



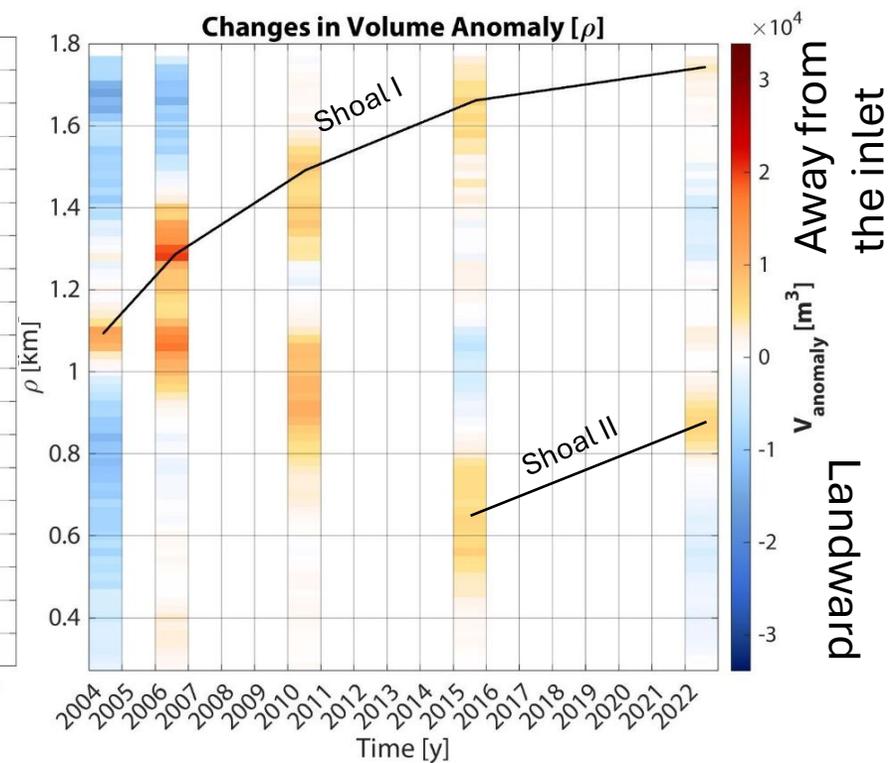
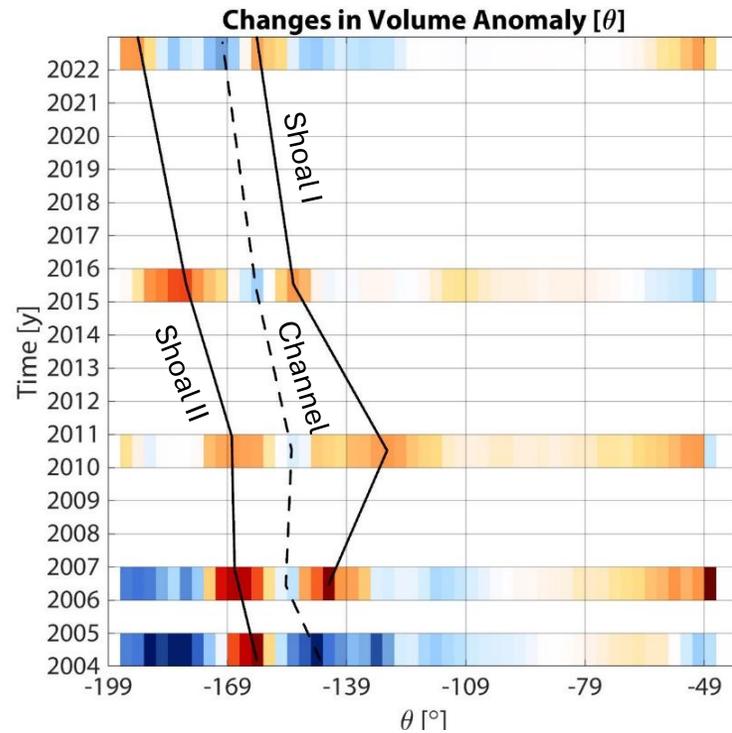
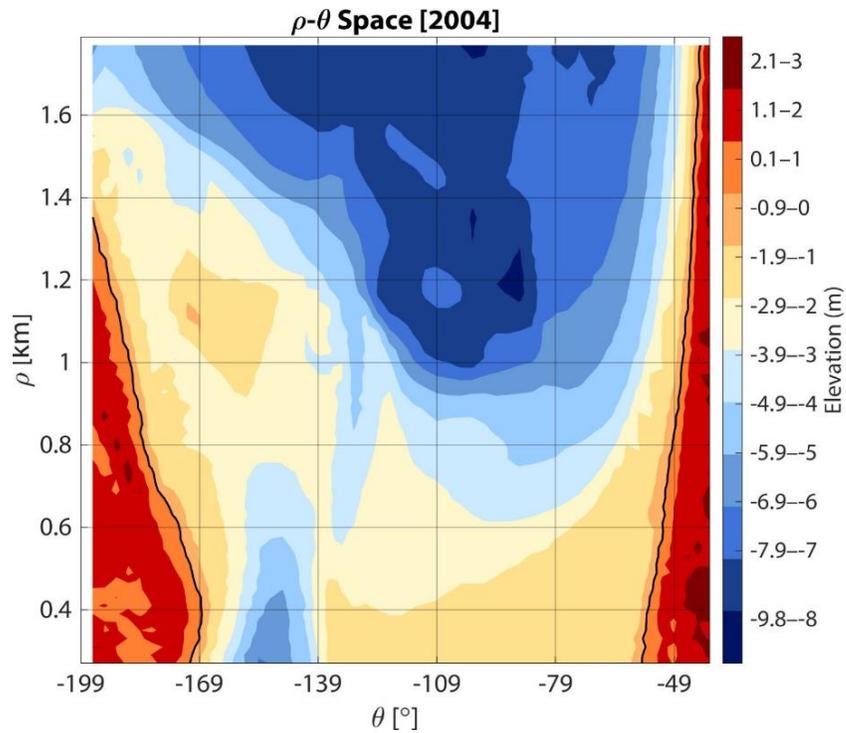
# Results – Ebb-Tidal Delta Volume Change

## Unit 4 – Sediment loss

- Likely linked to **dredging** (2009 and 2015) in **unit 13** and **sediment redistribution** toward **unit 7**.



# Results – Conformal Mapping



- Shoals and the main channel rotated to the southeast, consistent with the longshore current direction.

**Rate of rotation:**

**Shoal I:**  $-0.66^\circ/\text{yr}$

**Channel:**  $-1.33^\circ/\text{yr}$

**Shoal II:**  $-1.82^\circ/\text{yr}$

**Rate of shoal migration away from the inlet:**

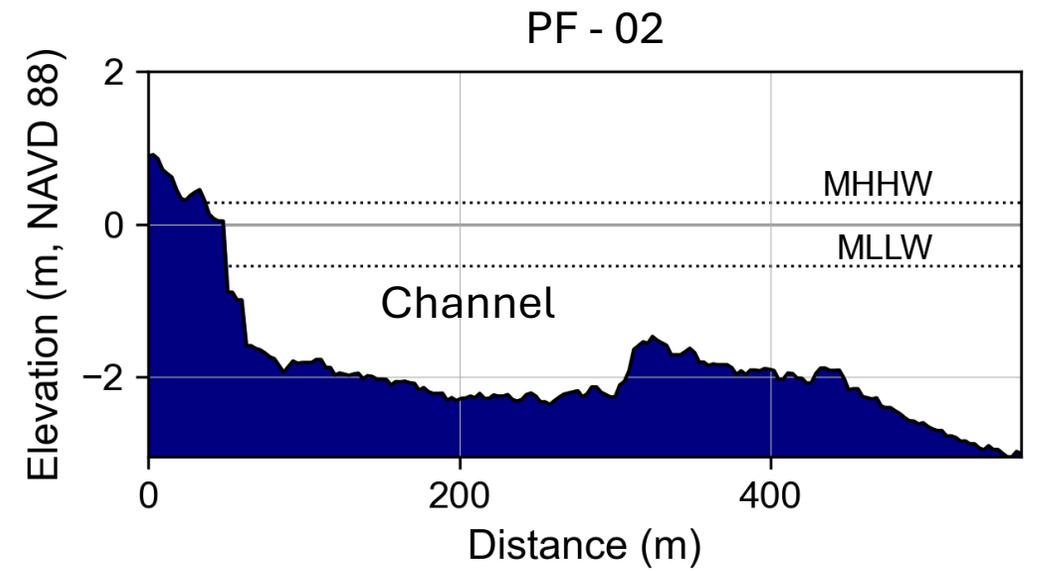
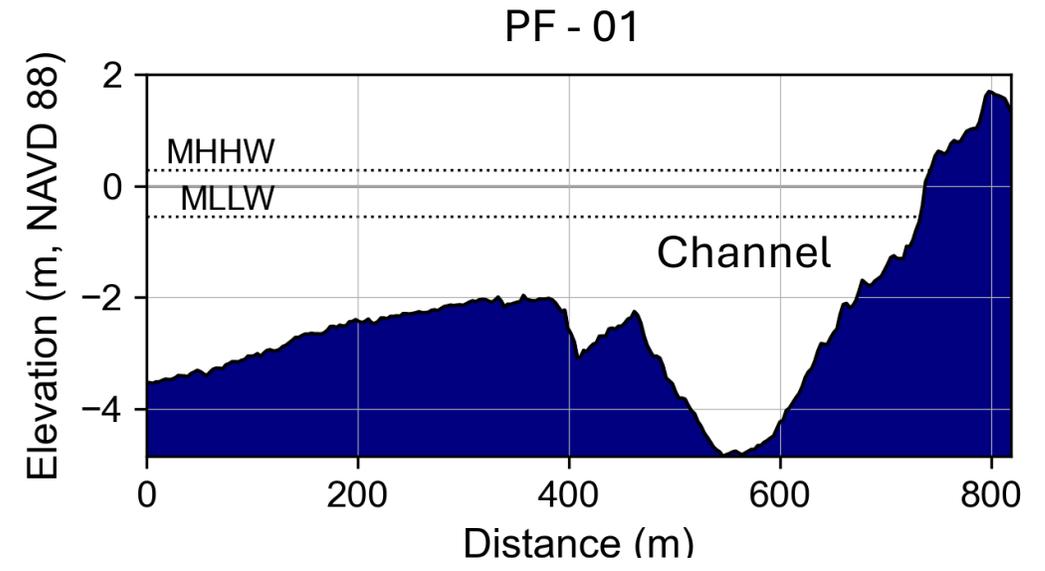
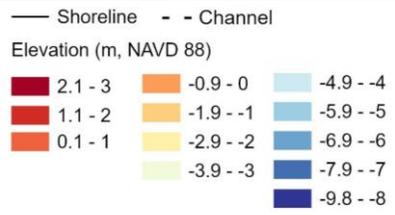
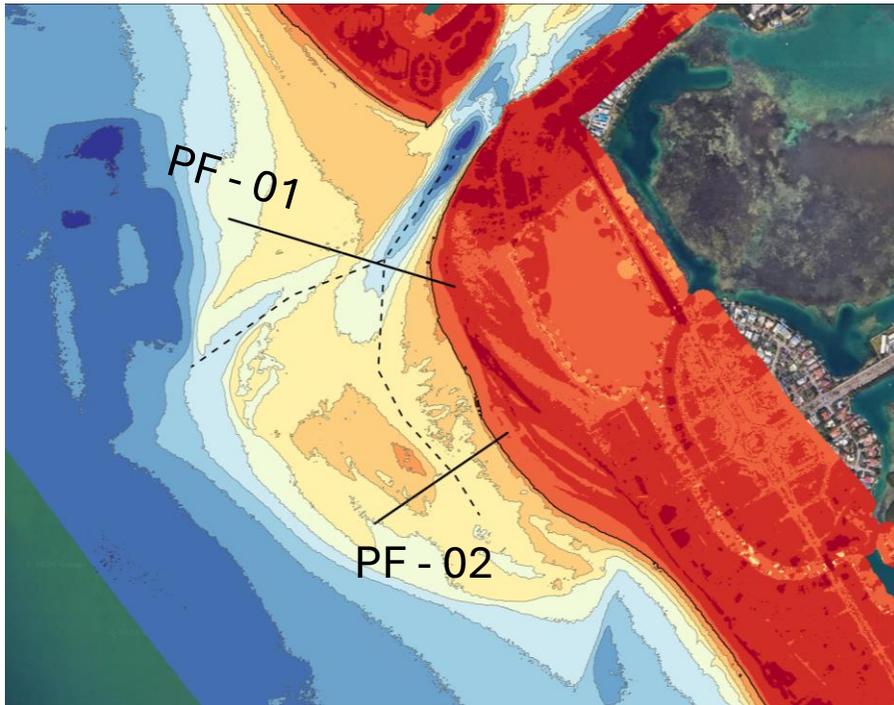
**Shoal I:**  $33.4 \text{ m/yr}$

**Shoal II:**  $42 \text{ m/yr}$

# Results – Chronostratigraphy

■ ≤ 2004

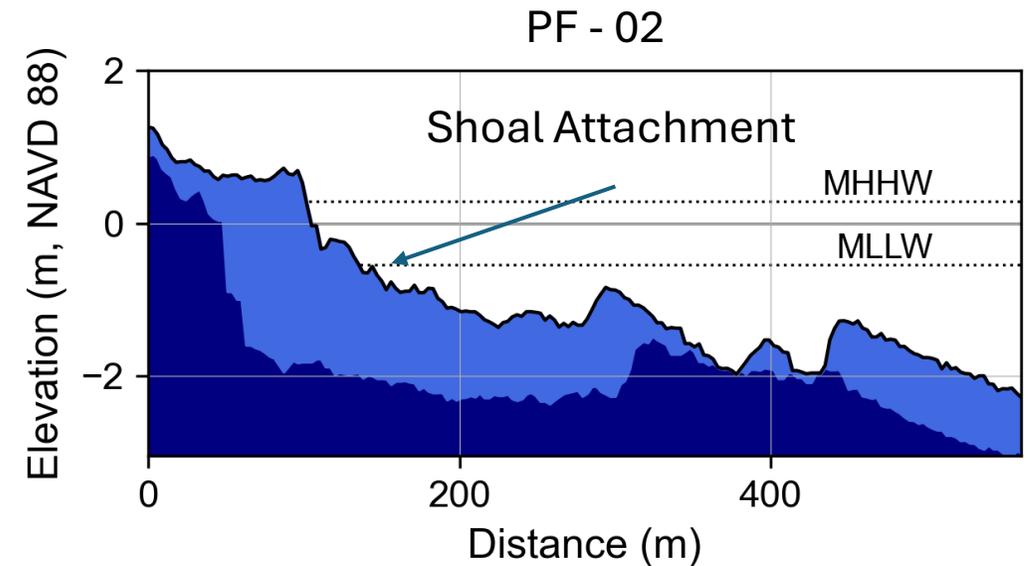
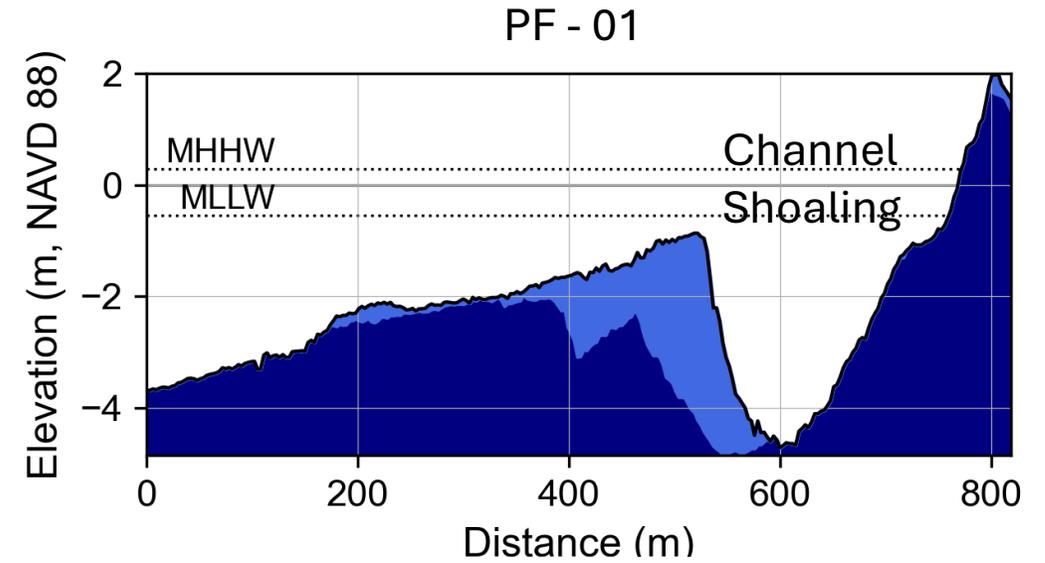
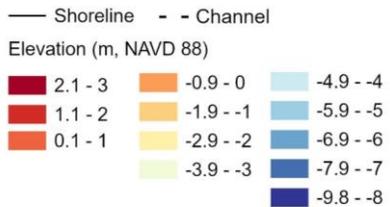
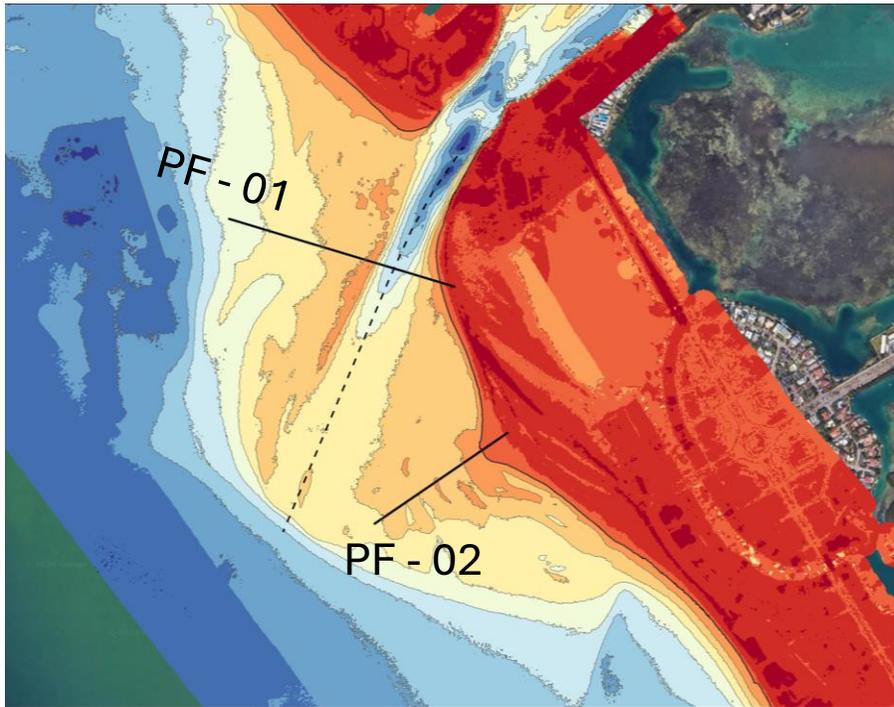
2004



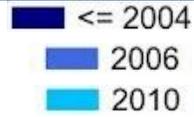
# Results – Chronostratigraphy

≤ 2004  
 2006

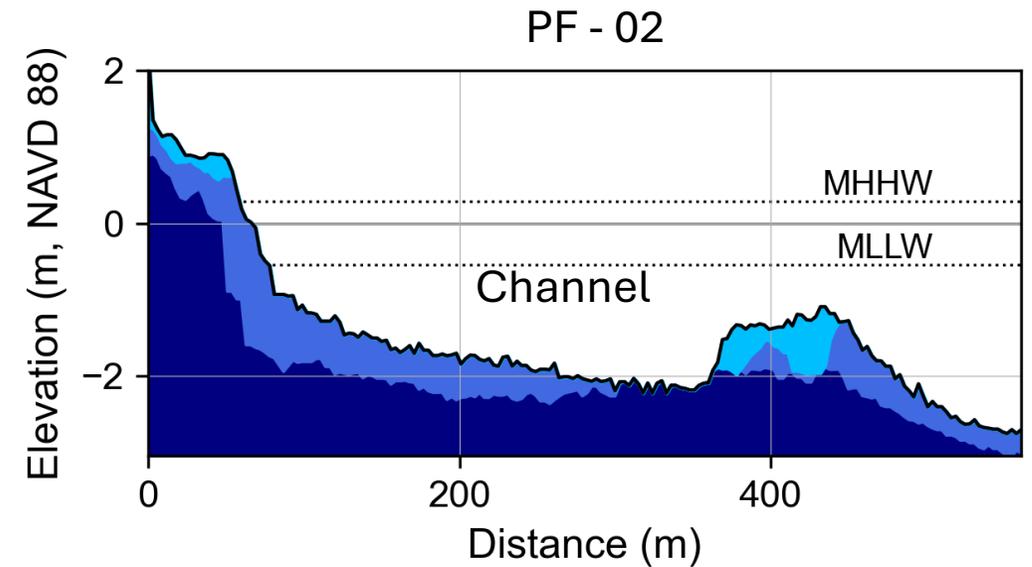
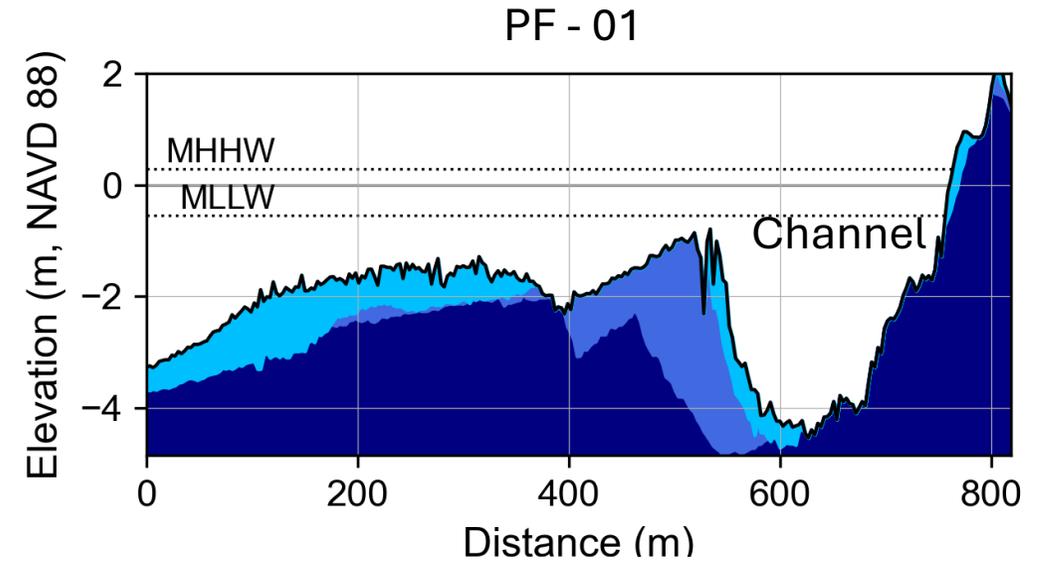
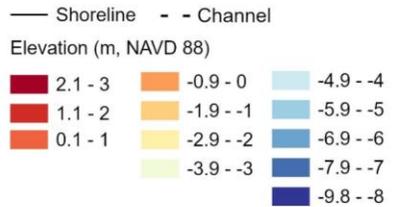
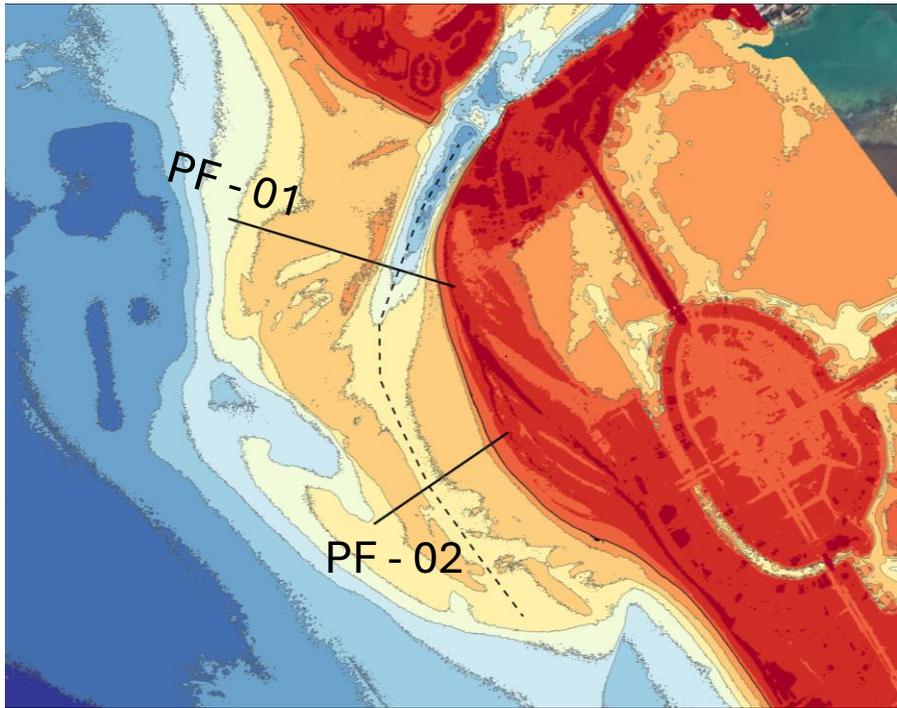
2006



# Results – Chronostratigraphy



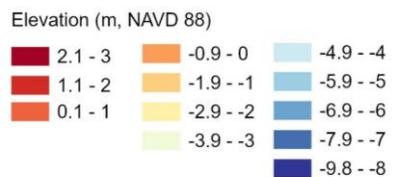
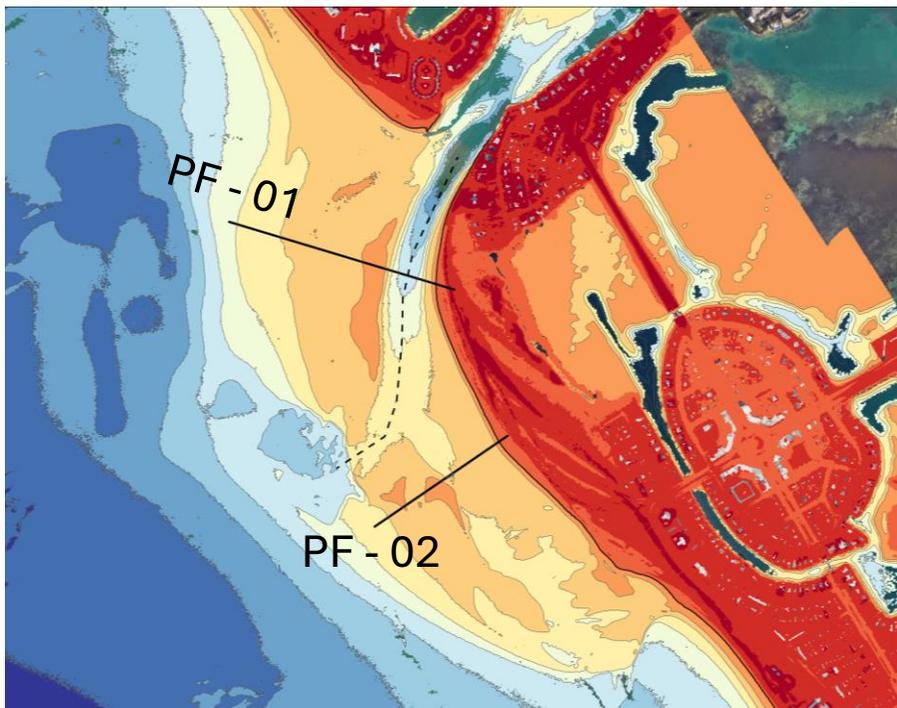
2010



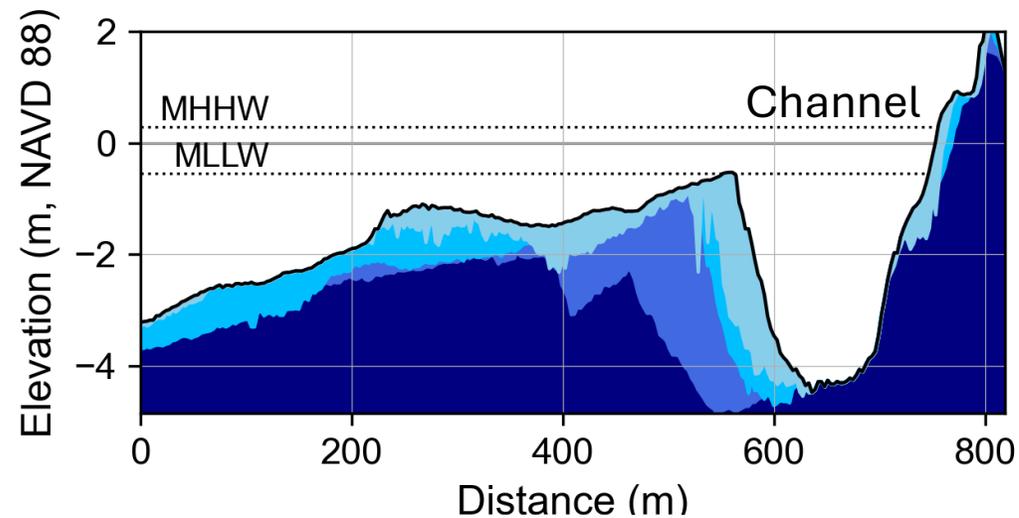
# Results – Chronostratigraphy



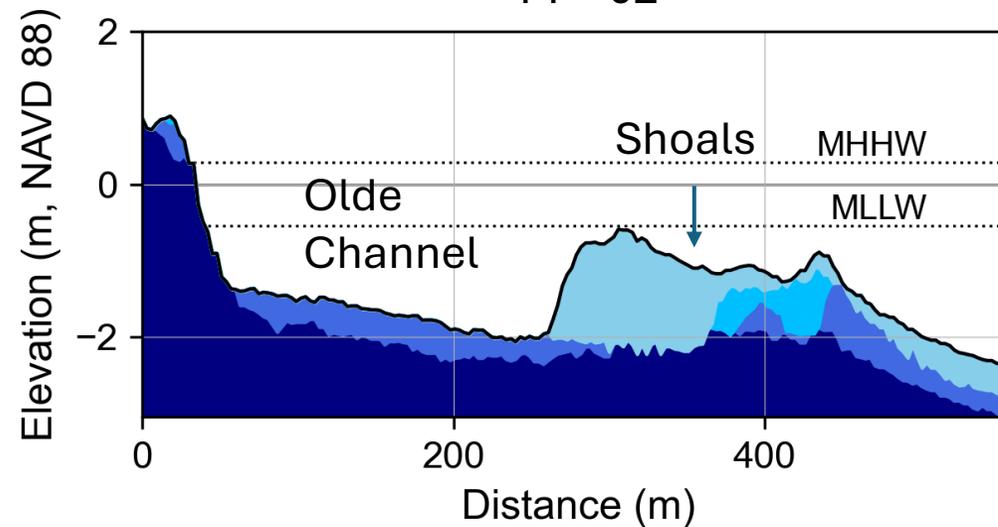
2015



PF - 01



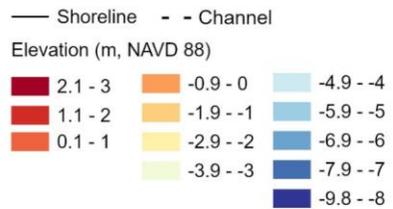
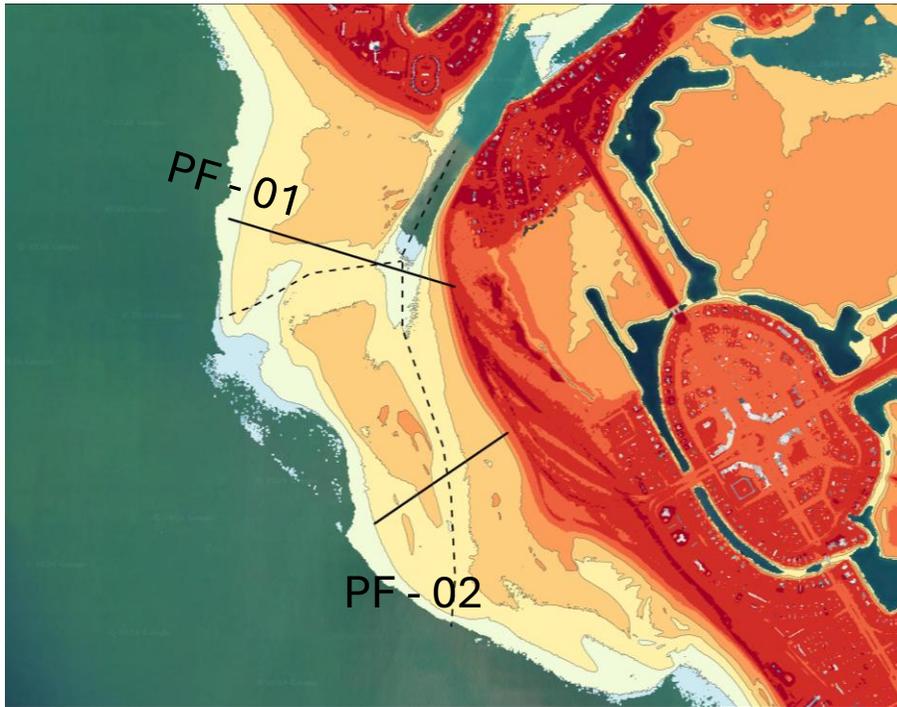
PF - 02



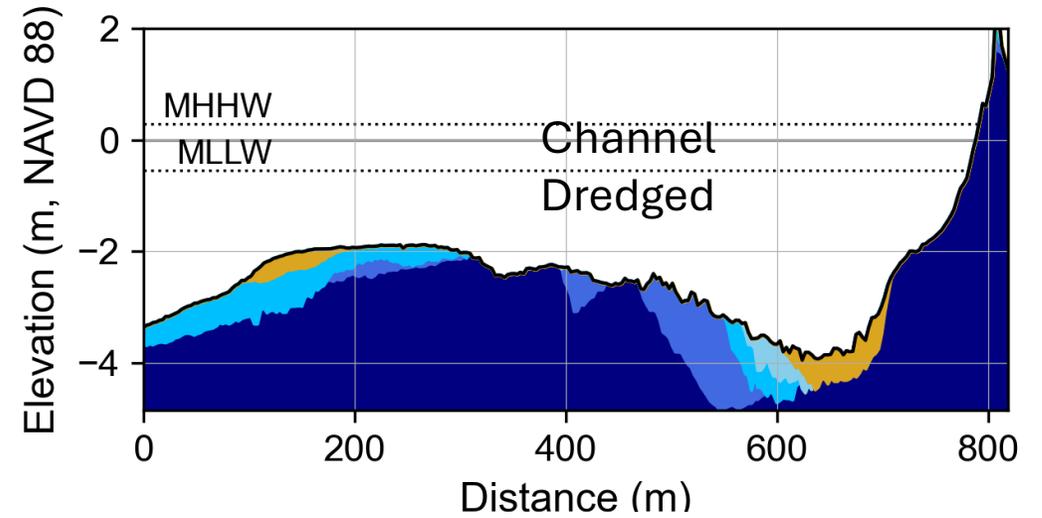
# Results – Chronostratigraphy



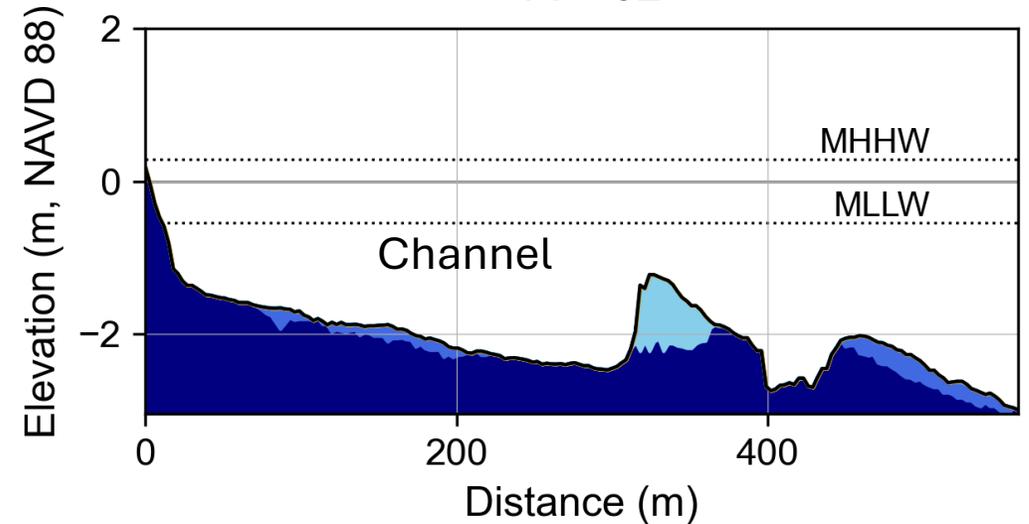
2017



PF - 01



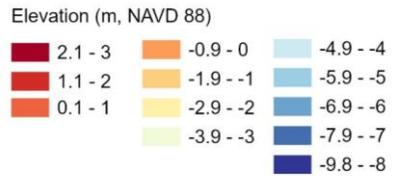
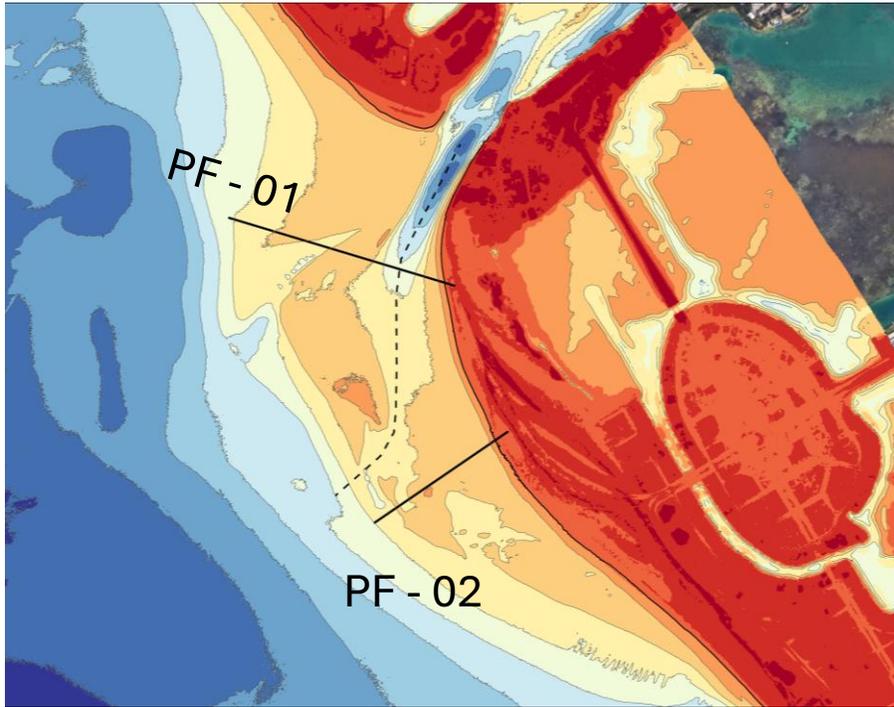
PF - 02



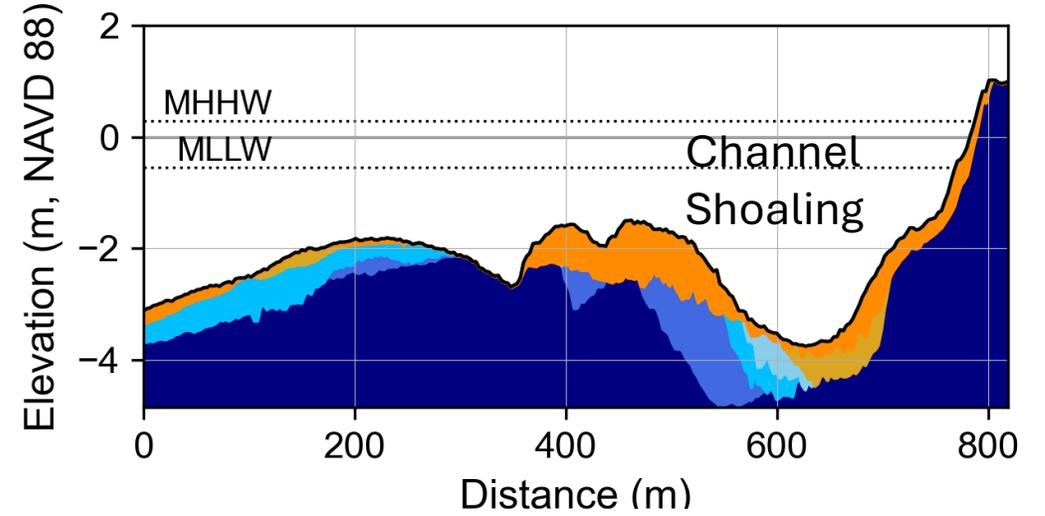
# Results – Chronostratigraphy



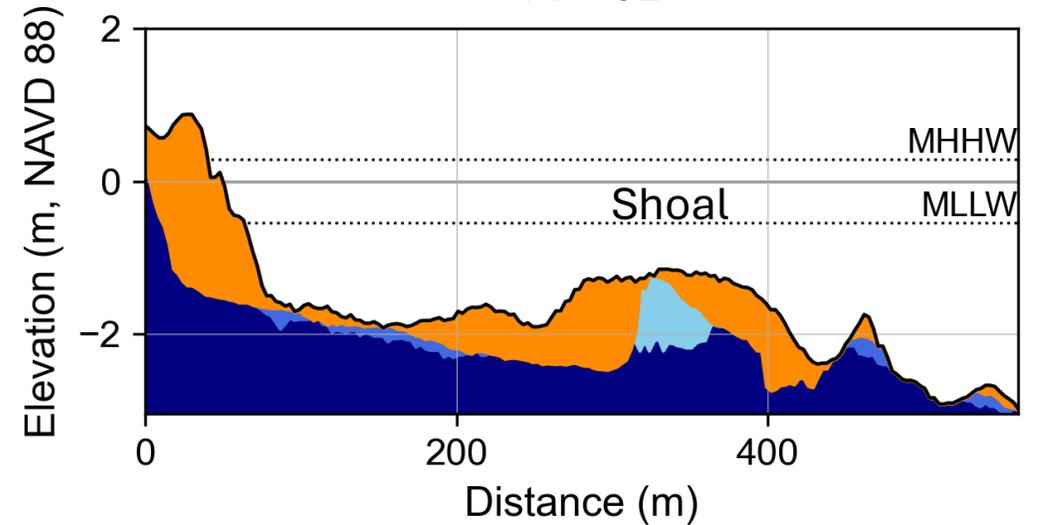
2022



PF - 01



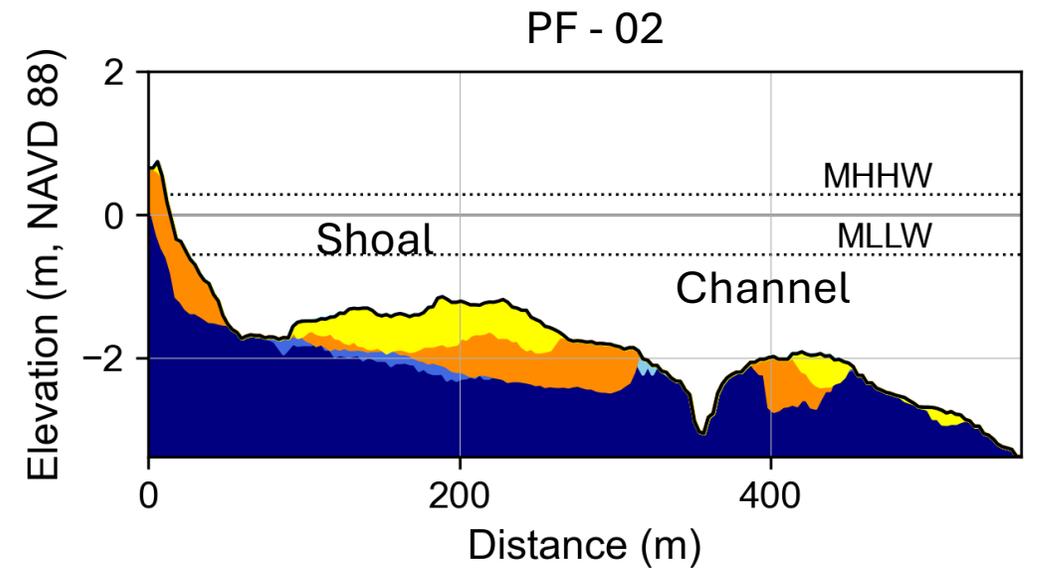
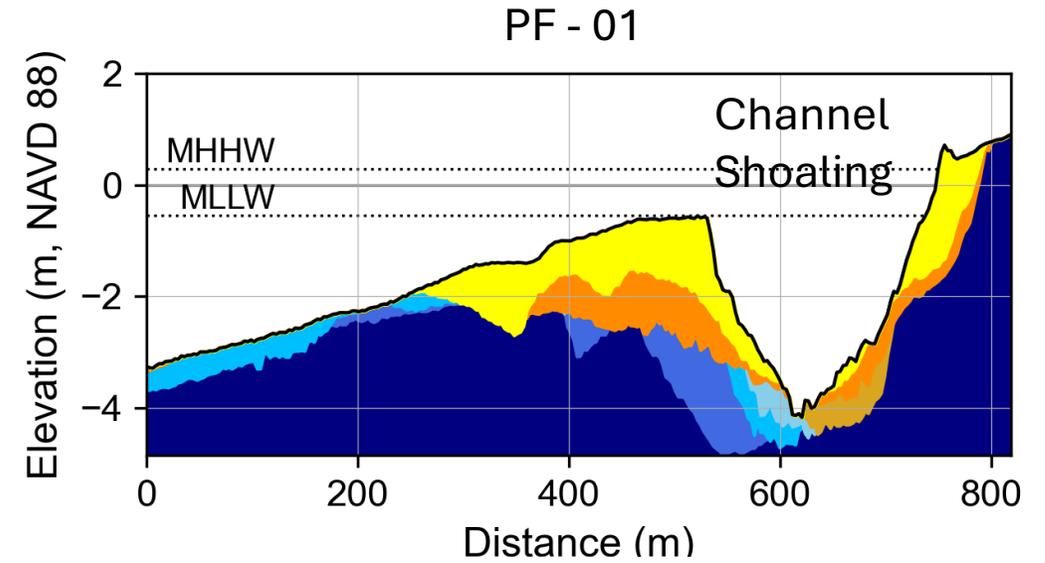
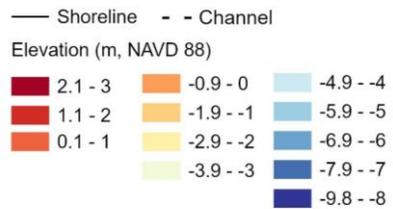
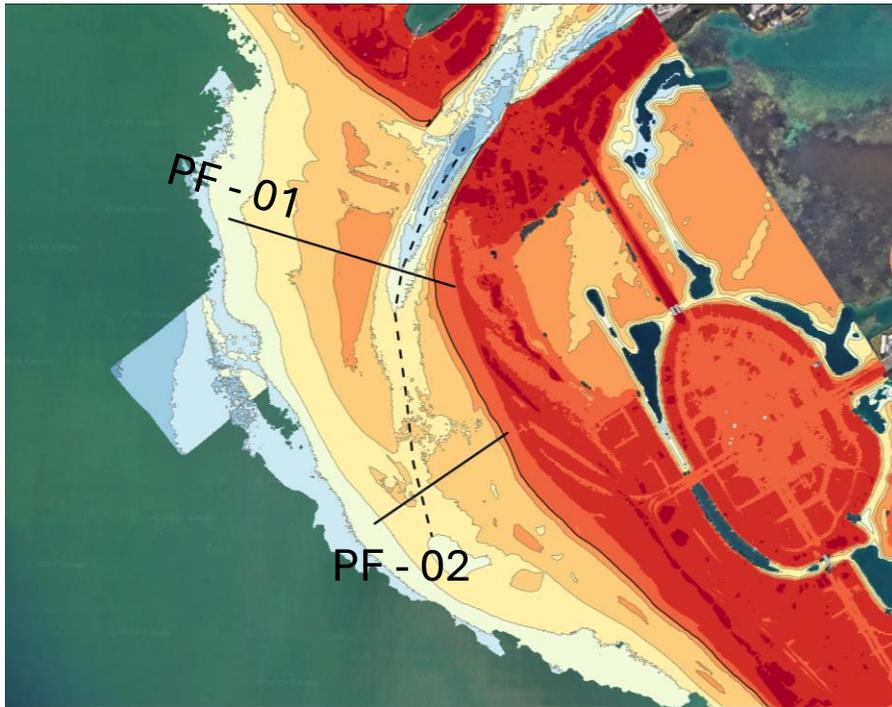
PF - 02



# Results – Chronostratigraphy



2024



# Results – Shoal Attachment

## T01 – T10

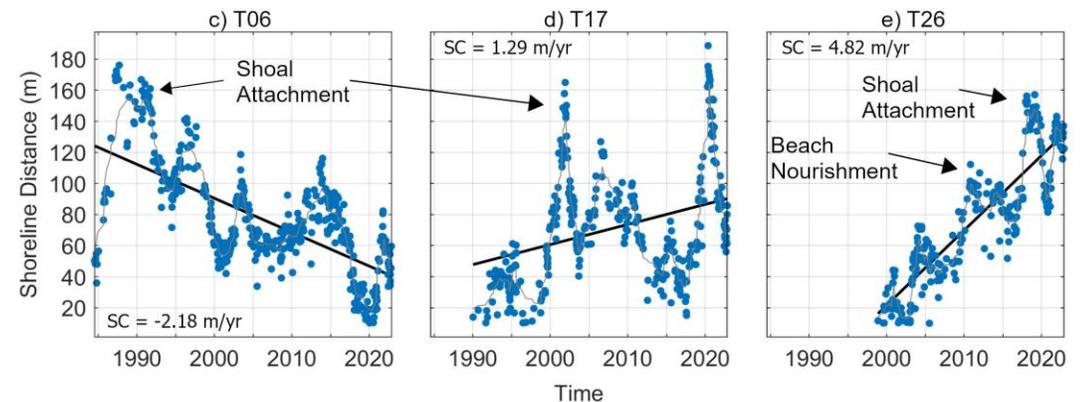
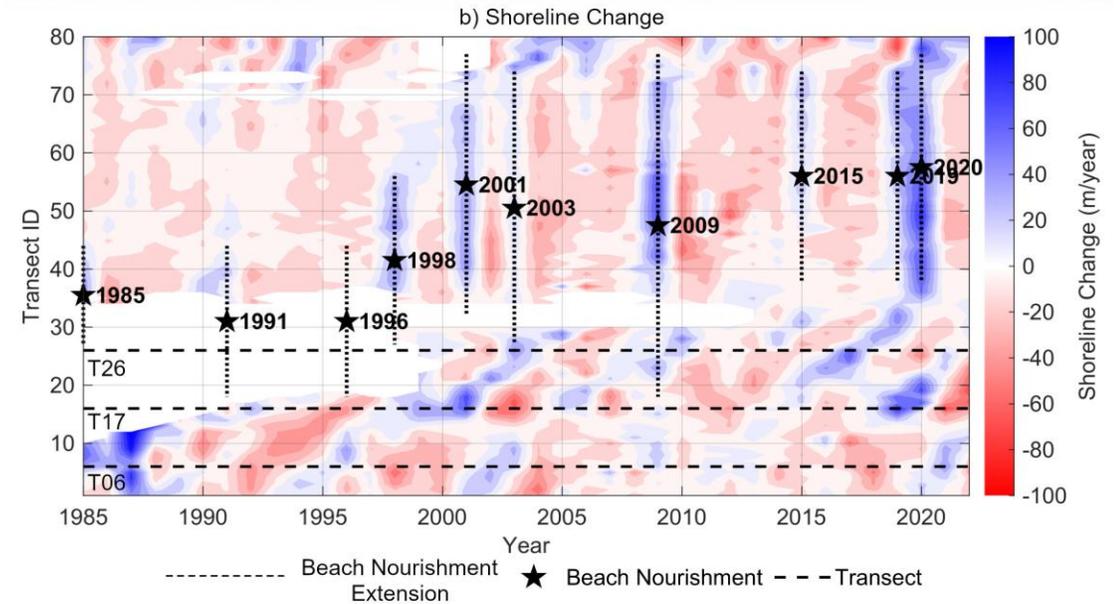
- Five shoal-attachment events were identified (1987, 1996, 2003, 2013, and 2021)
- T06 - Despite these events, this sector experienced persistent shoreline erosion
- Rate of shoreline change: **-2.18 m/yr.**

## T10 – T20

- **4 shoal-attachment events** during the study period (1995, 2001, 2006, and 2020)
- **T17** –rate of shoreline change : **+1.29 m/yr**

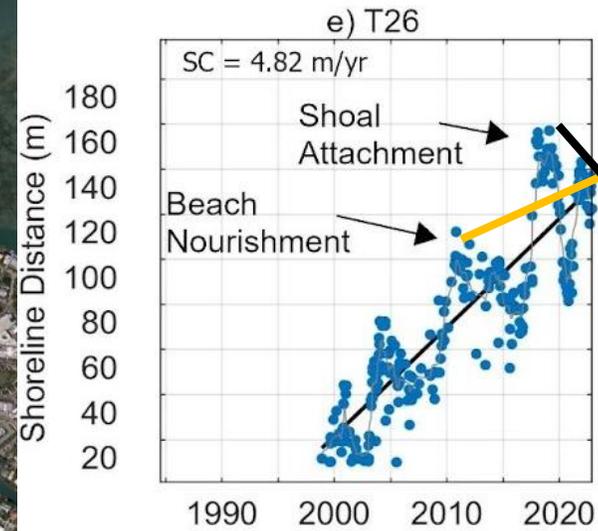
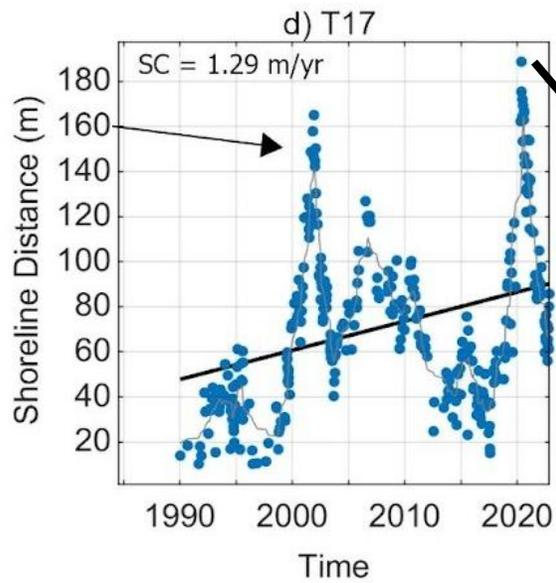
## T20 – T30

- **Two major shoal-attachment events** were recorded (2004 and 2018).
- Shoreline change in this sector was also influenced by **beach nourishment in 2009**
- **T26** – Rate of shoreline change: **+4.82 m/yr**



# Results – Shoal Attachment

**Shoal attachment** is expected to occur approximately every **7 years** and **occurs independently across regions**.



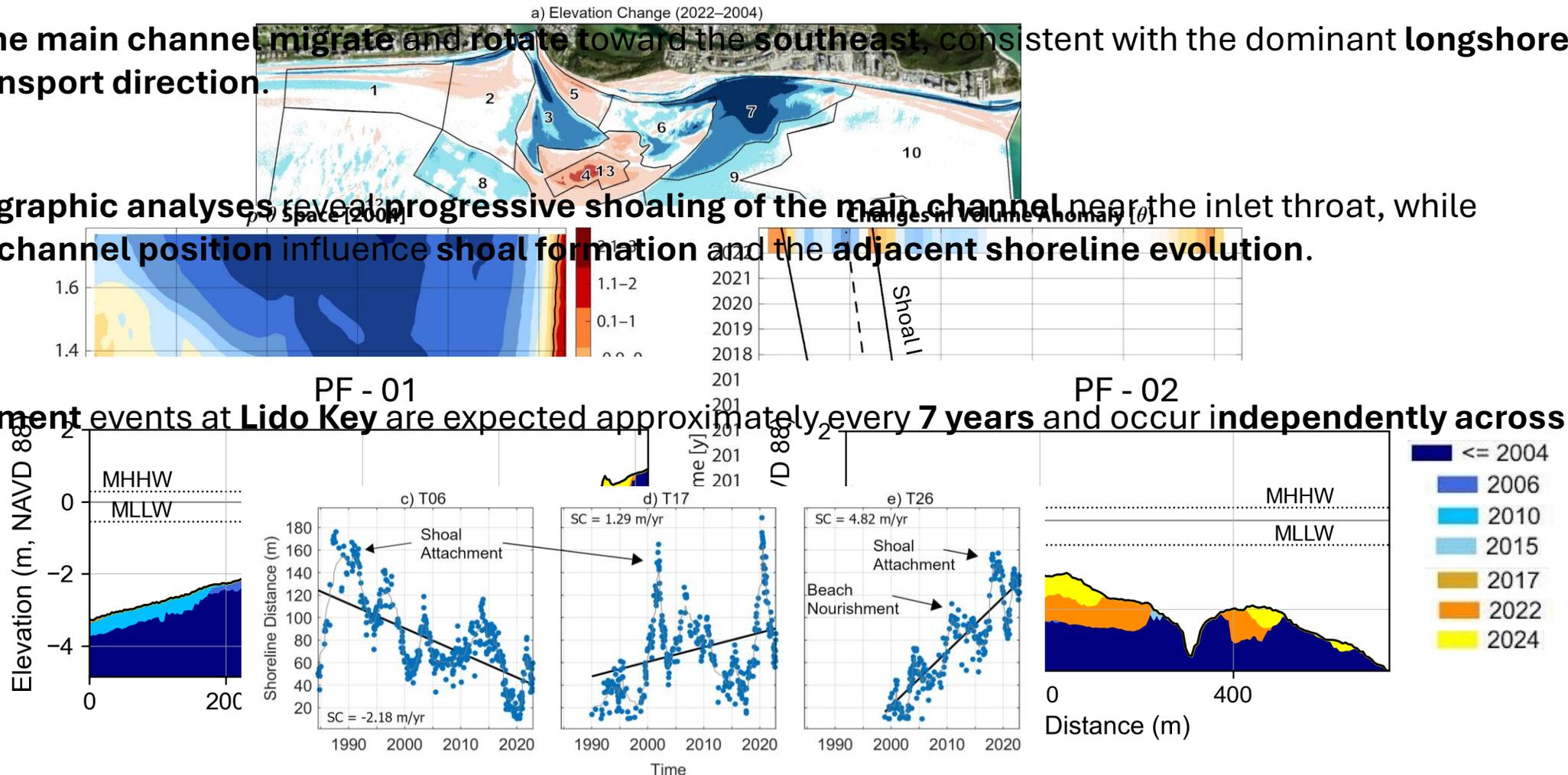
# Conclusion

The **New Pass ETD sediment volume** remains relatively **stable** despite **frequent dredging**, indicating high system **resilience** and **rapid sediment recovery**.

**Shoals and the main channel migrate and rotate toward the southeast**, consistent with the dominant **longshore sediment transport direction**.

**Chronostratigraphic analyses reveal progressive shoaling of the main channel near the inlet throat**, while variations in channel position influence **shoal formation and the adjacent shoreline evolution**.

**Shoal attachment events at Lido Key are expected approximately every 7 years and occur independently across regions.**



# Thank you!

**UF**



U.S. Army Corps  
of Engineers



Engineering With Nature

UF Geomorphology  
Research



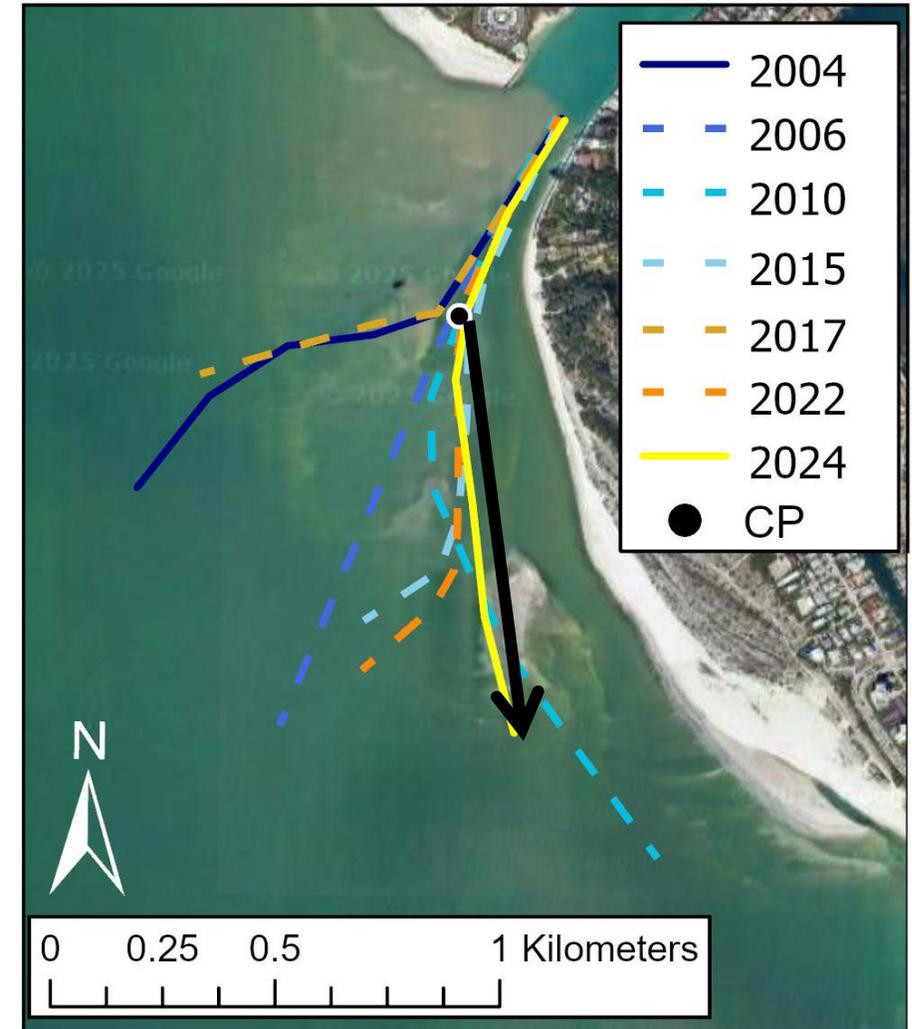
Google Earth 2026



# Methods – Channel Migration / Rotation

- **DEMs** were used to **map the inlet channel** for each year
- When **two channels were present**, the main channel was defined as the one more **orthogonal** to the **inlet entrance**
- The channel was divided into two segments:
  - **0–500 m**: stable, deepest part of the channel
  - **>500 m**: offshore segment, showing migration and rotation (*tail wag*)
- **Channel orientation** was defined by the **azimuth** of a vector from a **fixed control point (CP)** to the **channel endpoint**

a) Channel Location



# Results – Channel Rotation

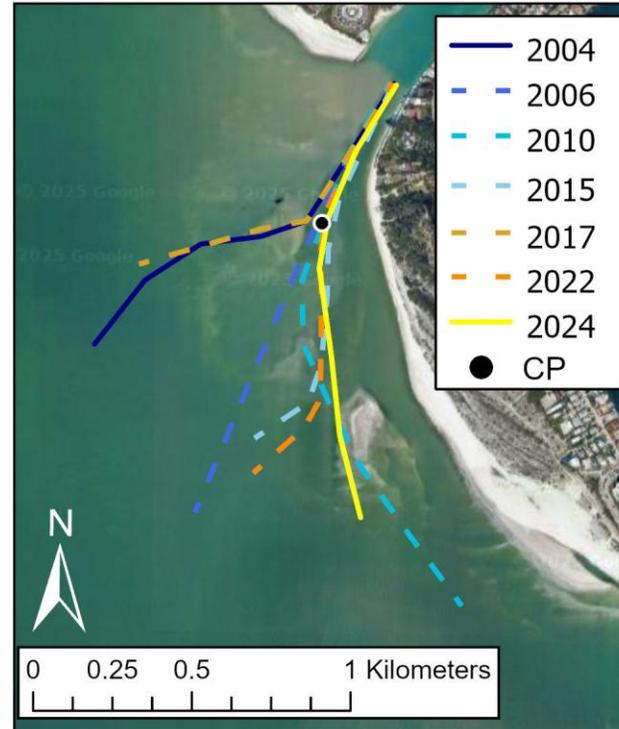
## Inlet mouth – 500 m (CP)

- Minimal positional variability
- Gradual shoaling (2004–2024)

## > 500 m offshore (Tail wag region)

- From the CP, the channel transitions into a tail-wag behavior
- Net channel rotation of **-3.47 °/yr**
- Despite large special migration, channel depth shows limited change

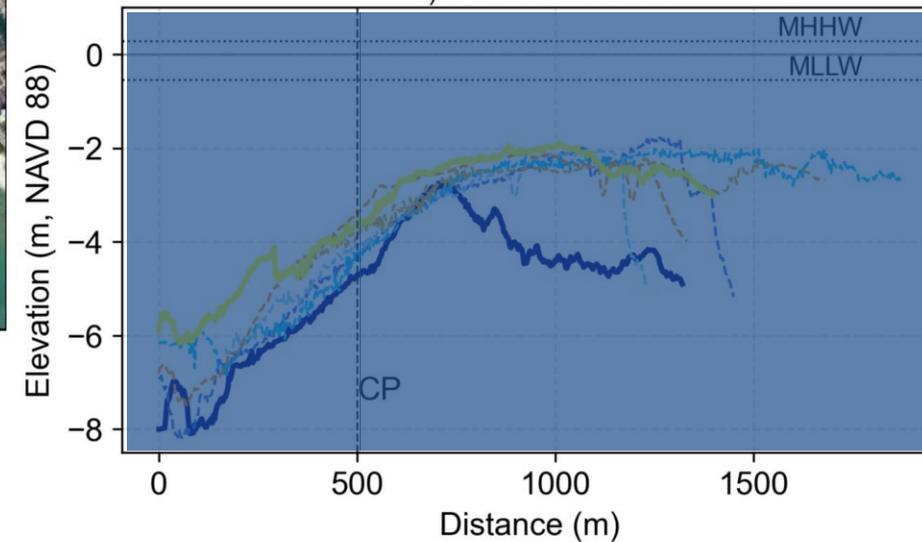
a) Channel Location



b) Table: Channel Azimuth and Annual Rotation Rates

Year	Azimuth (°)	Rate of Change (°/yr)
2004	241.97	
2006	203.17	-19.18
2010	160.00	-10.90
2015	197.28	7.46
2017	257.36	30.04
2022	195.27	-12.42
2024	172.53	-11.37
<b>Net Change</b>	<b>-69.44</b>	<b>-3.47</b>

c) Channel Profile



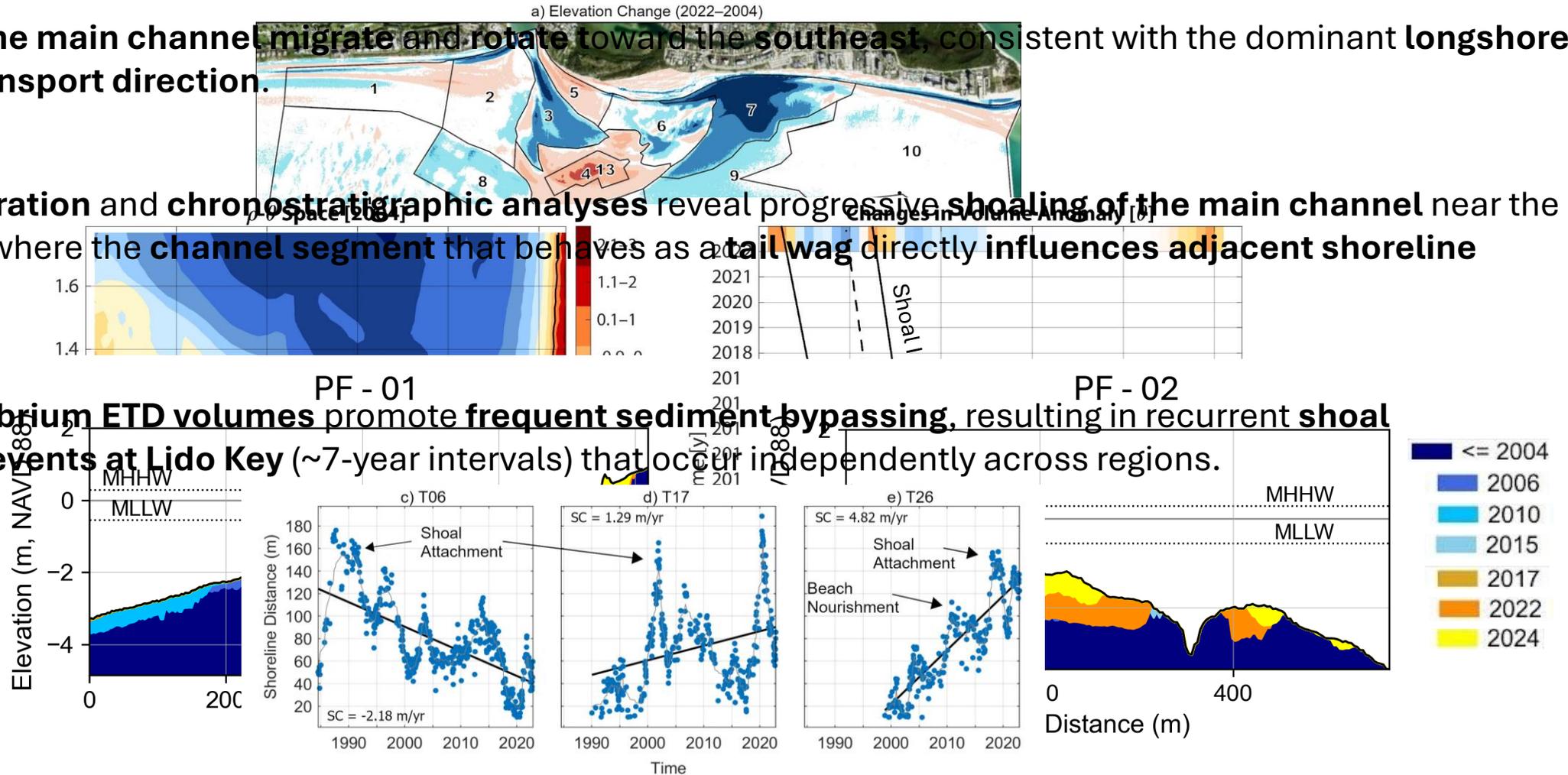
# Conclusion

The **New Pass ETD** remains near **volumetric equilibrium**, despite frequent **dredging** for **beach nourishment** and **navigation maintenance**, demonstrating **high system resilience** and **rapid sediment recovery**.

**Shoals and the main channel migrate and rotate toward the southeast**, consistent with the dominant **longshore sediment transport direction**.

**Channel migration and chronostratigraphic analyses** reveal progressive **shoaling of the main channel** near the inlet throat, where the **channel segment** that behaves as a **tail wag** directly influences **adjacent shoreline evolution**.

A near-equilibrium **ETD volumes** promote **frequent sediment bypassing**, resulting in recurrent **shoal attachment events** at **Lido Key** (~7-year intervals) that occur independently across regions.



# Results – Ebb-Tidal Delta Volume Change

- According to Walton and Adams (1976), the **equilibrium EDT volume** is approximately **5 million m<sup>3</sup>** for New Pass (New Pass volume in 2022 = **4.68 million m<sup>3</sup>** )
- These results suggest that the **New Pass EDT is resilient**, maintaining **near-equilibrium conditions** despite **repeated dredging**.

