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XII CONGRESSO SOBRE PLANEAMENTO E GESTÃO DAS ZONAS
COSTEIRAS DOS PAÍSES DE EXPRESSÃO PORTUGUESA
Zonas Costeiras Inteligentes

MEDIUM-TERM MORPHOLOGICAL EVOLUTION OF THE DOURO SAND SPIT FOLLOWING BREAKWATER CONSTRUCTION

Mahmoud Abouhalima, Luciana das Neves, Hugo Lopes
Francisco Taveira-Pinto, Paulo Rosa-Santos



Douro Estuary

The Douro: Where River, City and Ocean Meet

Originates from Picos de Urbion at elevation of 2080 m.

Has a length of 927 km (195 km in Portugal)

Meets the sea between Porto and Vila Nova de Gaia.

Functions as both an urban waterfront and a navigable waterway.

An Energetic, Changing Estuary

High degree of hydrodynamic activity

River flow can exceed 13,000 m³/s

Tidal range can reach 4 m

Wave heights exceed 8 m in storms

A Historic Gateway Shaped By Navigation

Lower Douro River estuary have historically been shaped by nautical activities

Hazardous to navigation since at least the fifteenth century

Shipwrecks, flooding and channel instability drove repeated engineering proposals

A Managed Estuary, Still in Motion

Quays, walls, and breakwaters sought to improve safety and stabilise the river mouth

Sediment transport estimated to hundred thousands of m³/year

The Cabedelo remains a key element of the estuary's sedimentary system



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Douro Mouth Before Modern Breakwaters

1847–1908

Records of at least 22 wrecks during these decades.

1909

The 1909 floods grounded or sank about 40 larger ships, and fishing boats.

1909–1947

There were at least three dozen shipwrecks resulting in loss of life.



*“Rio Doiro, rio Doiro, rio de mau navegar, dize-me, essas tuas
aguas aonde as foste buscar?”*

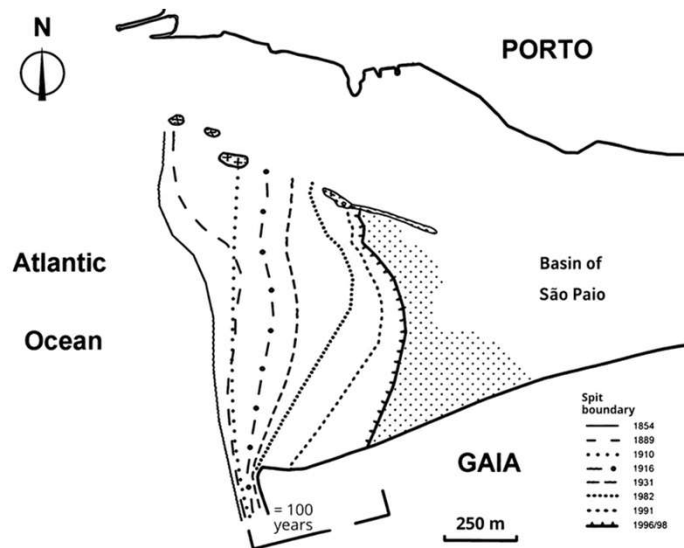
in Miragaia, Cantiga Primeira, Almeida Garrett 1844.



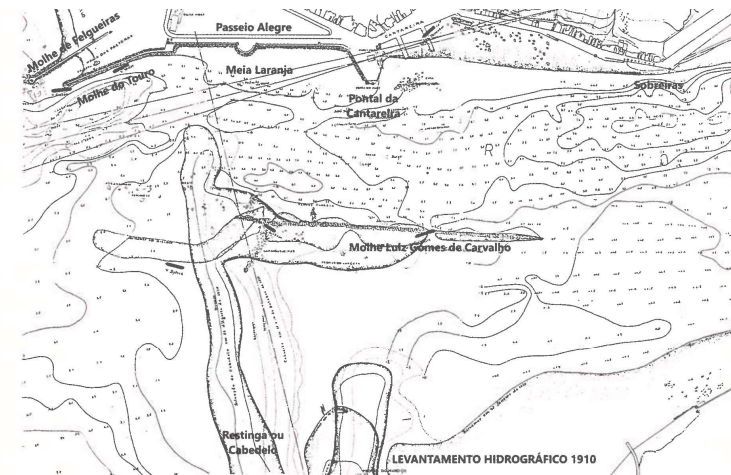
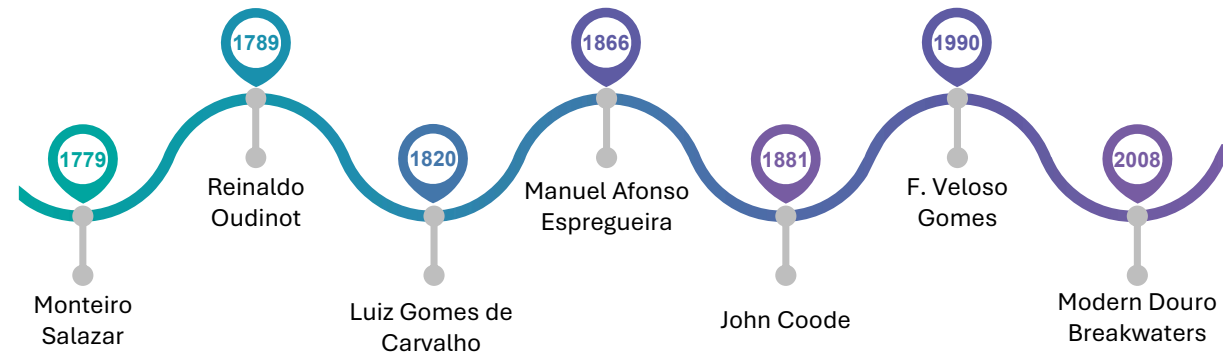
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Projects Along the Estuary



Recuo da restinga de 1854 a 1996 (fonte APDL)



Mapped retreat of the Cabedelo of 600 m between 1854 and 1996. Since the 1980s, the spit became thinner and more fragile.

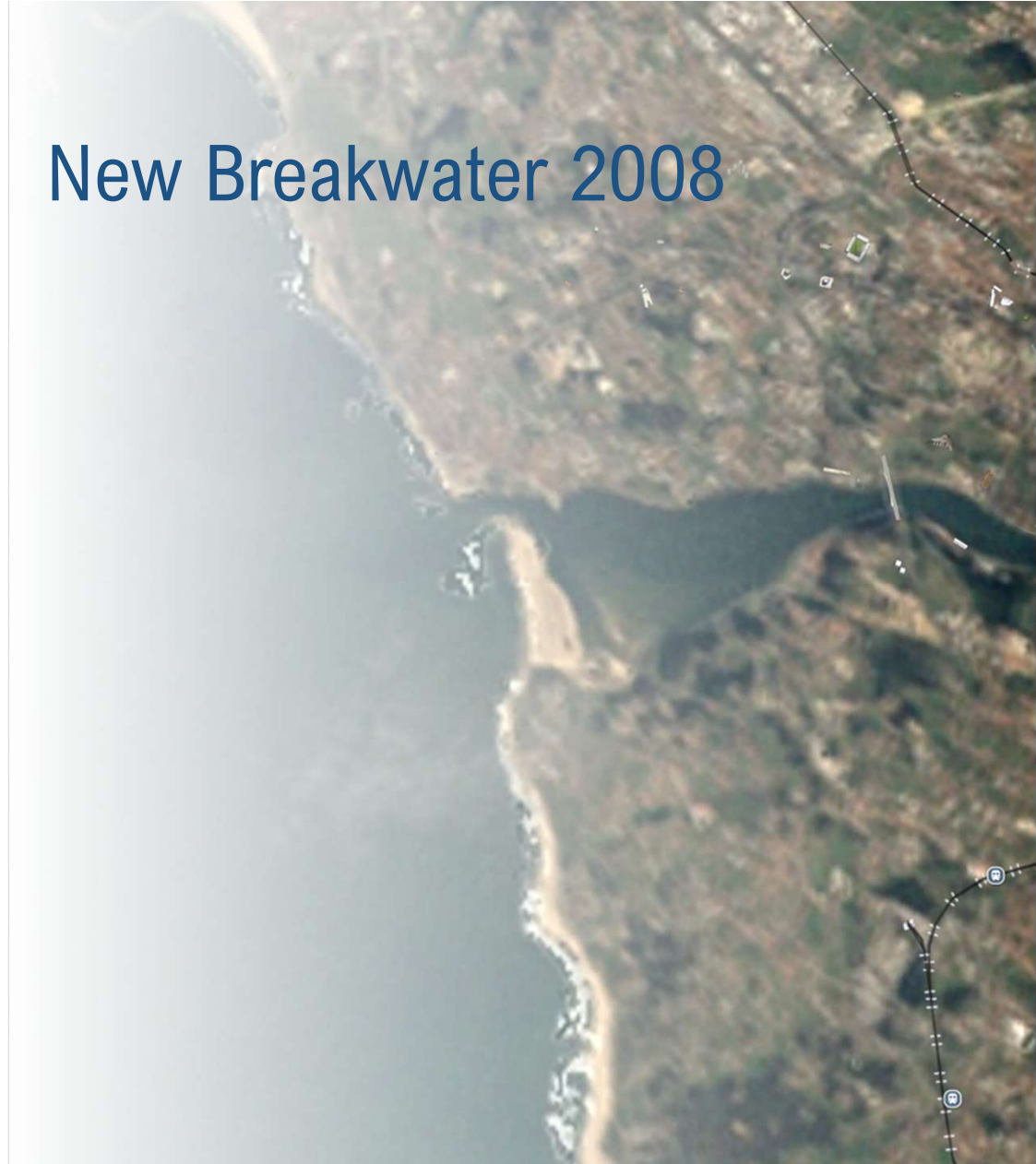


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- Before the construction of the breakwaters, the estuary and the northern river bank were exposed to storms, and navigation was rough due to weather and wave conditions,
- Accretion caused the spit head obstruct of the navigation channel

New Breakwater 2008





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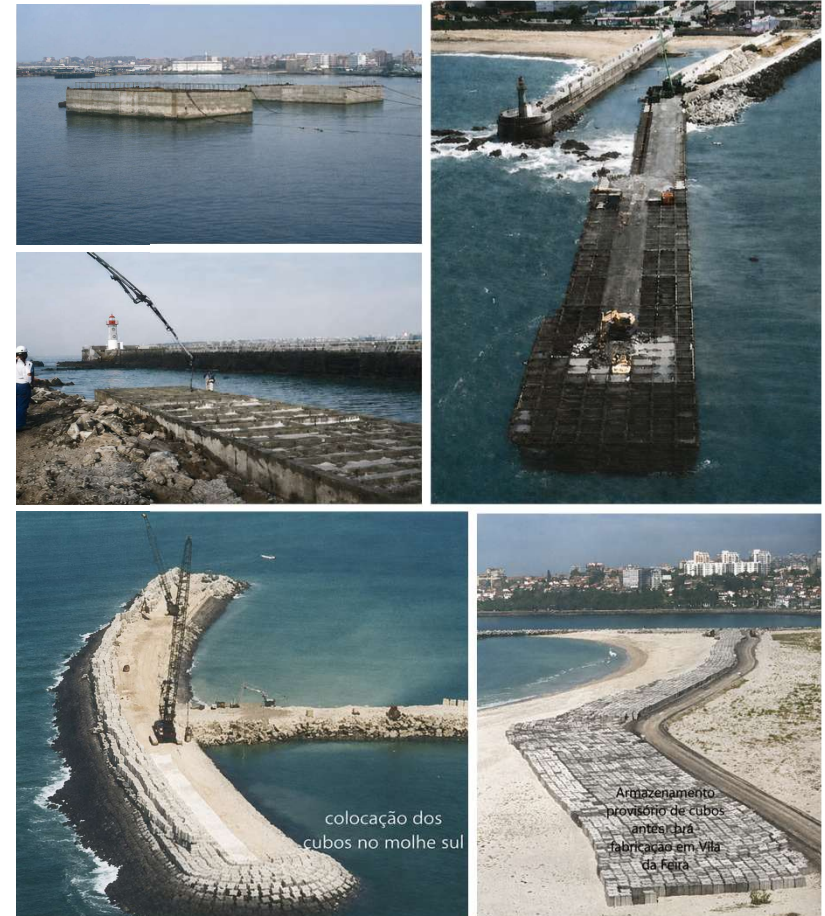
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Objectives:

- Stabilise the Estuary's bank and inlet
- Improve navigation safety
- Reduce the propagation of storm waves into the estuary
- Reduce dredging effort

New Breakwater 2008





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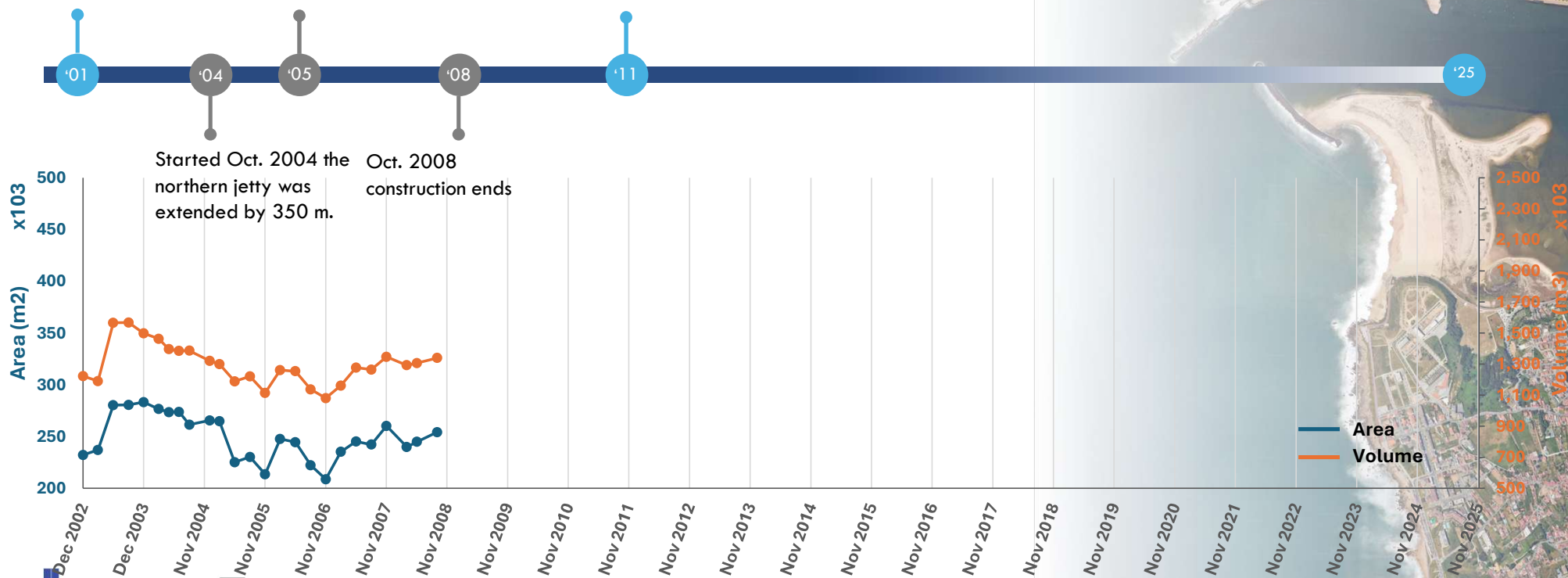
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New Breakwater 2008

Start of surveys
in June 2001

Mar. 2005 started the
construction of a 450 m long
curved breakwater

Two surveys per
year





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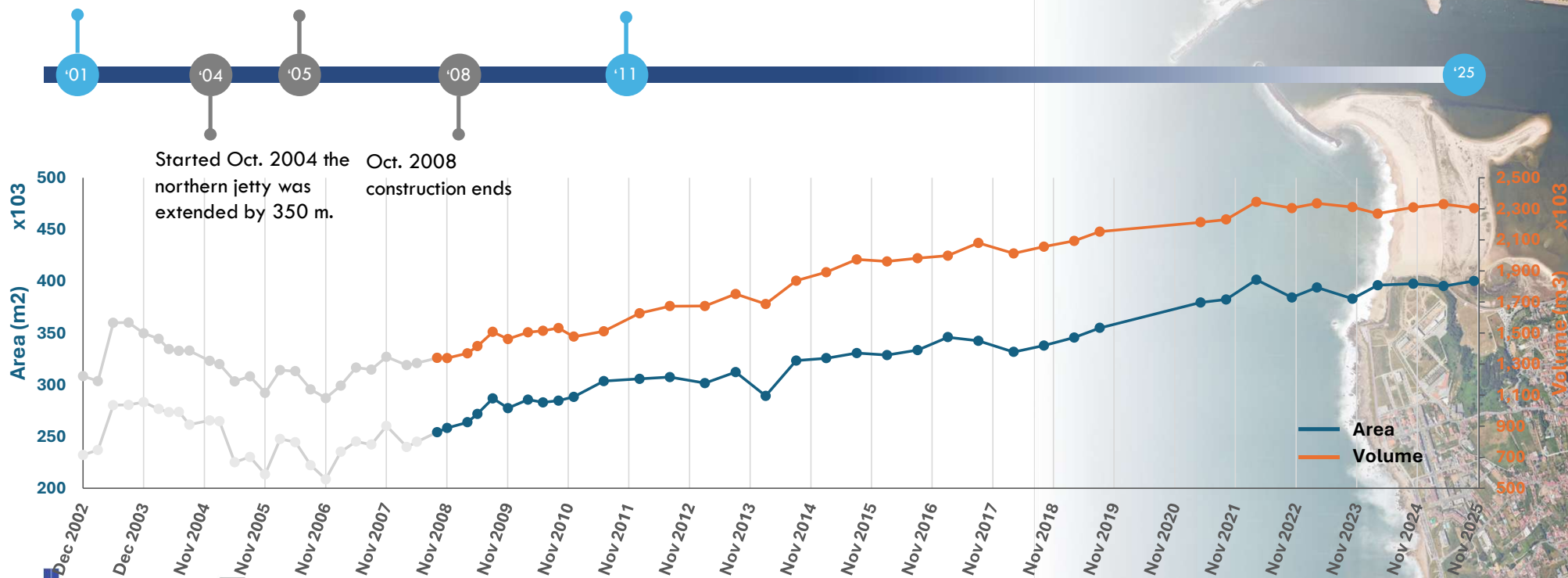
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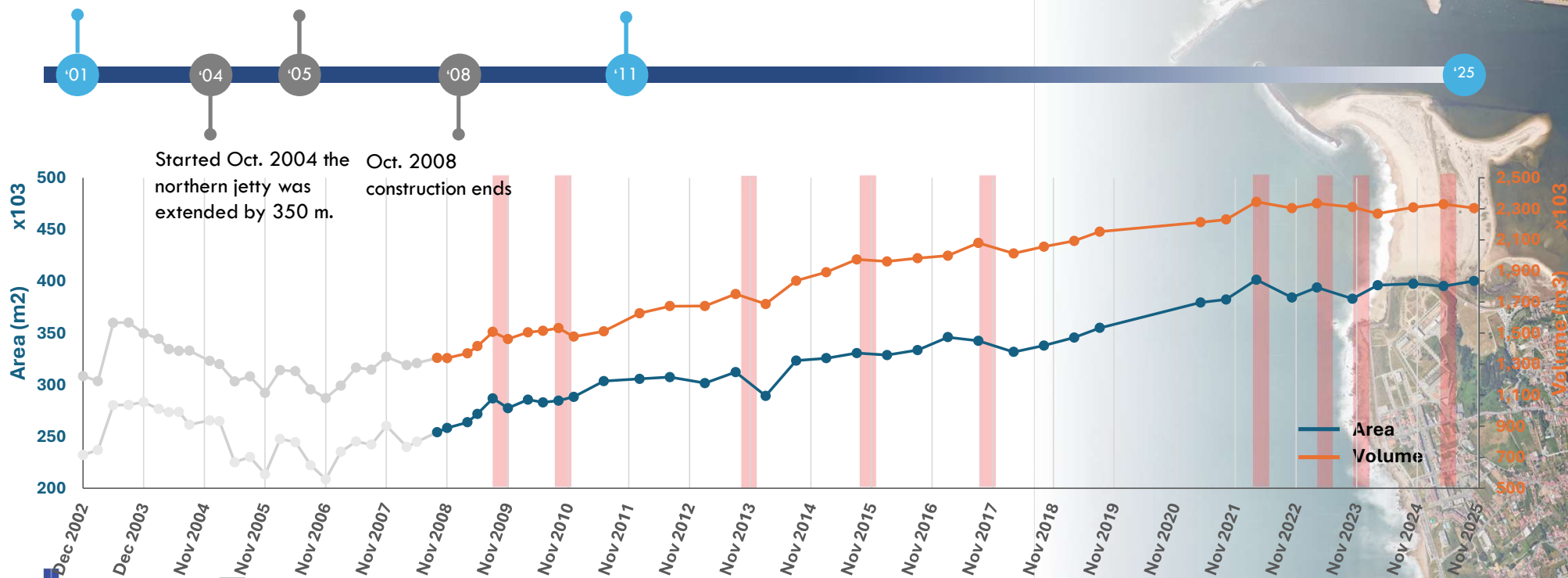
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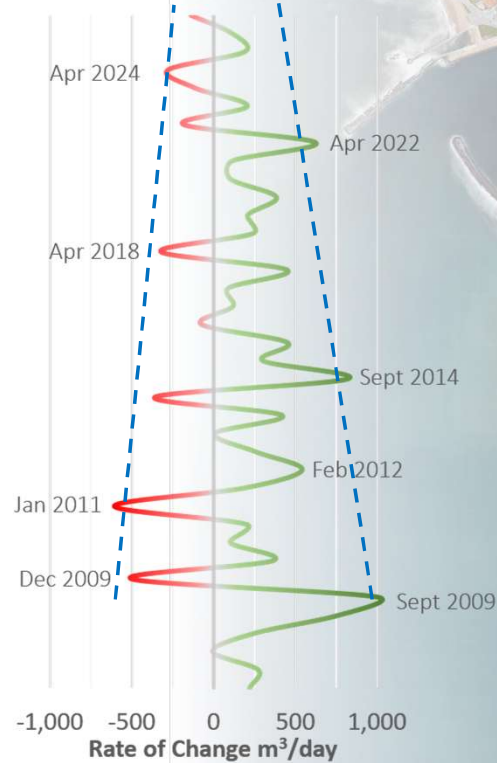
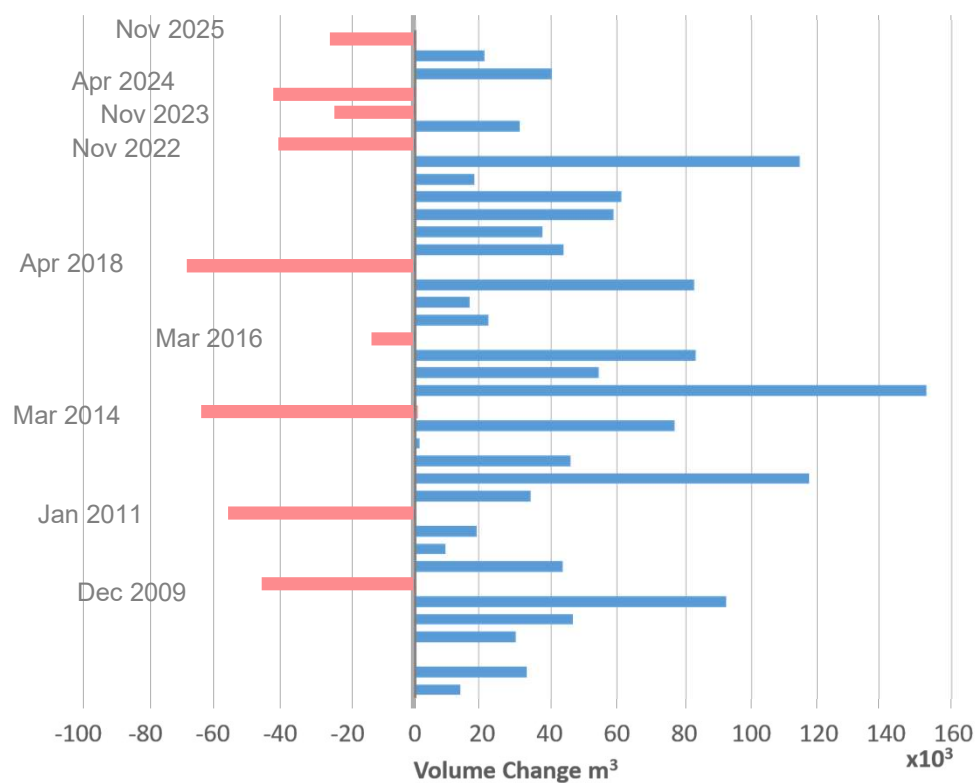




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Sand-Spit Morphology

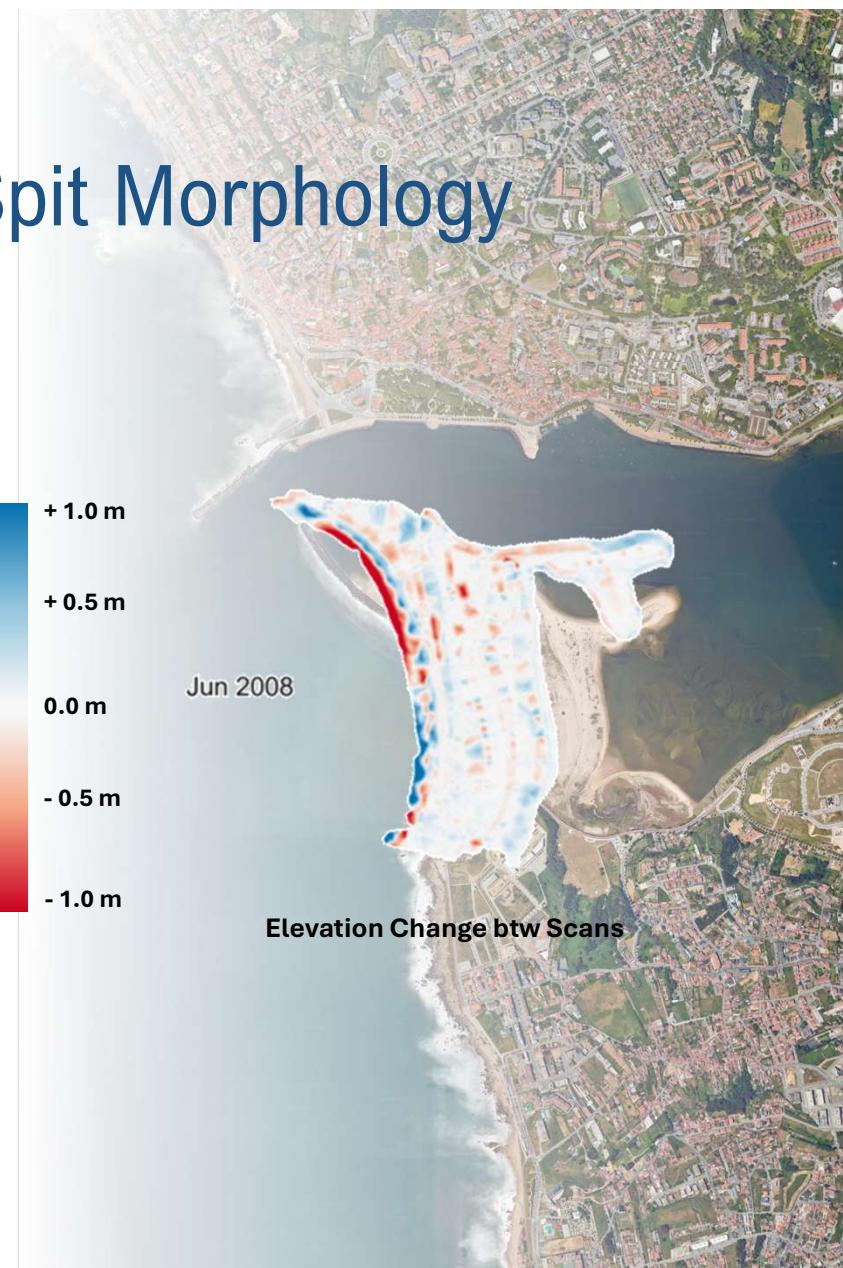
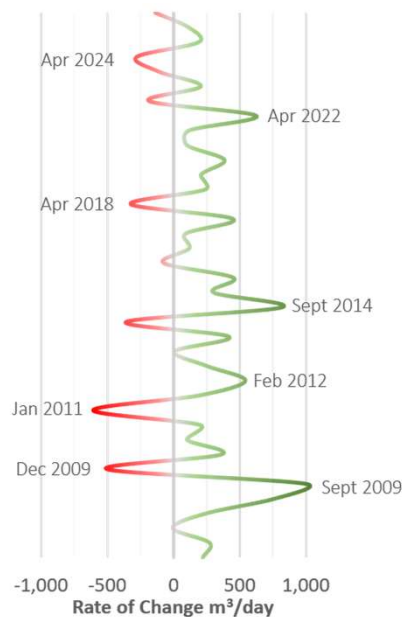
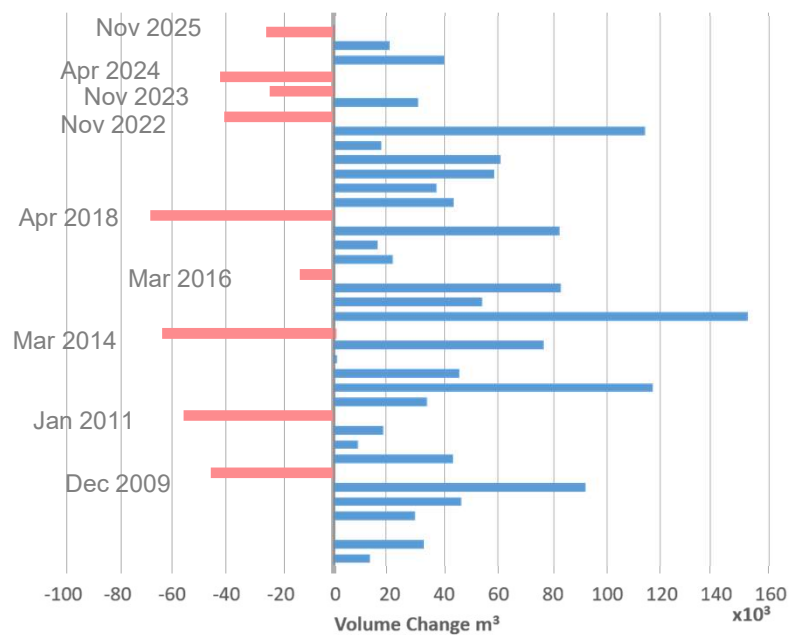




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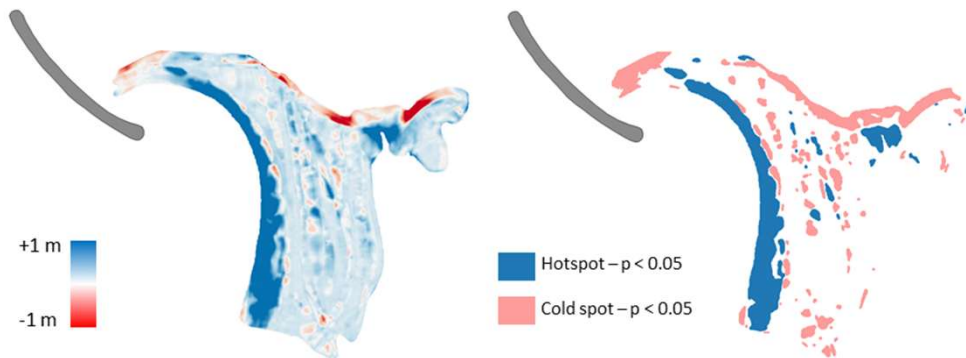


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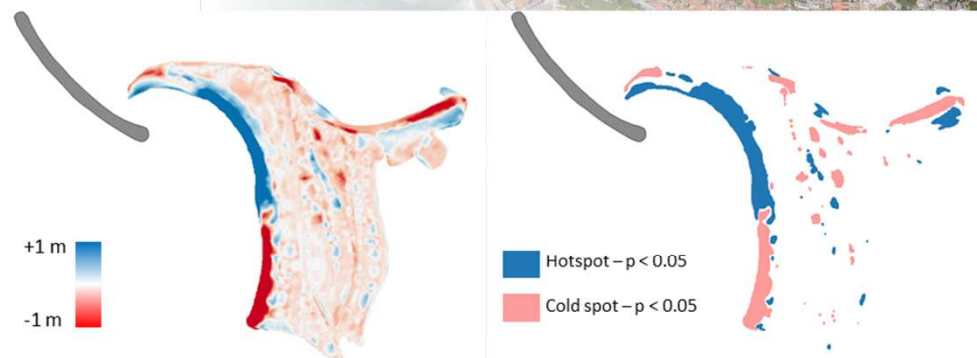
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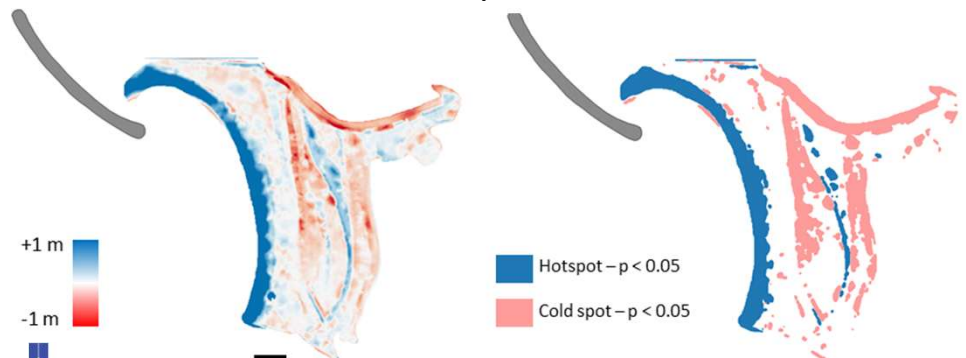
July 2011 to February 2012



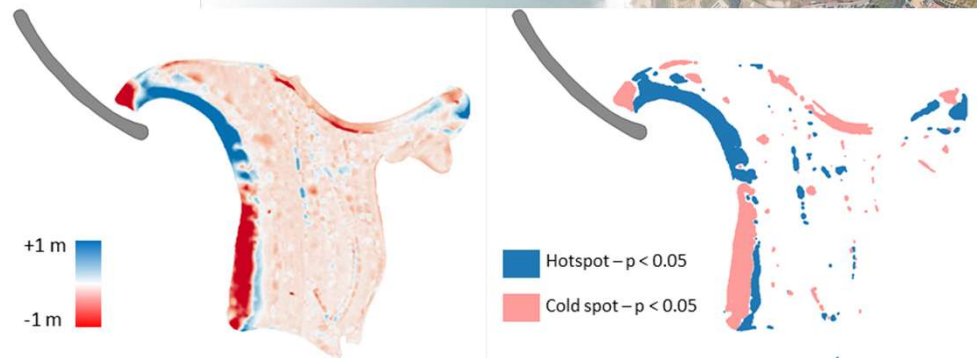
September 2013 to March 2014



March 2014 to September 2014



September 2017 to April 2018



Accretion Periods

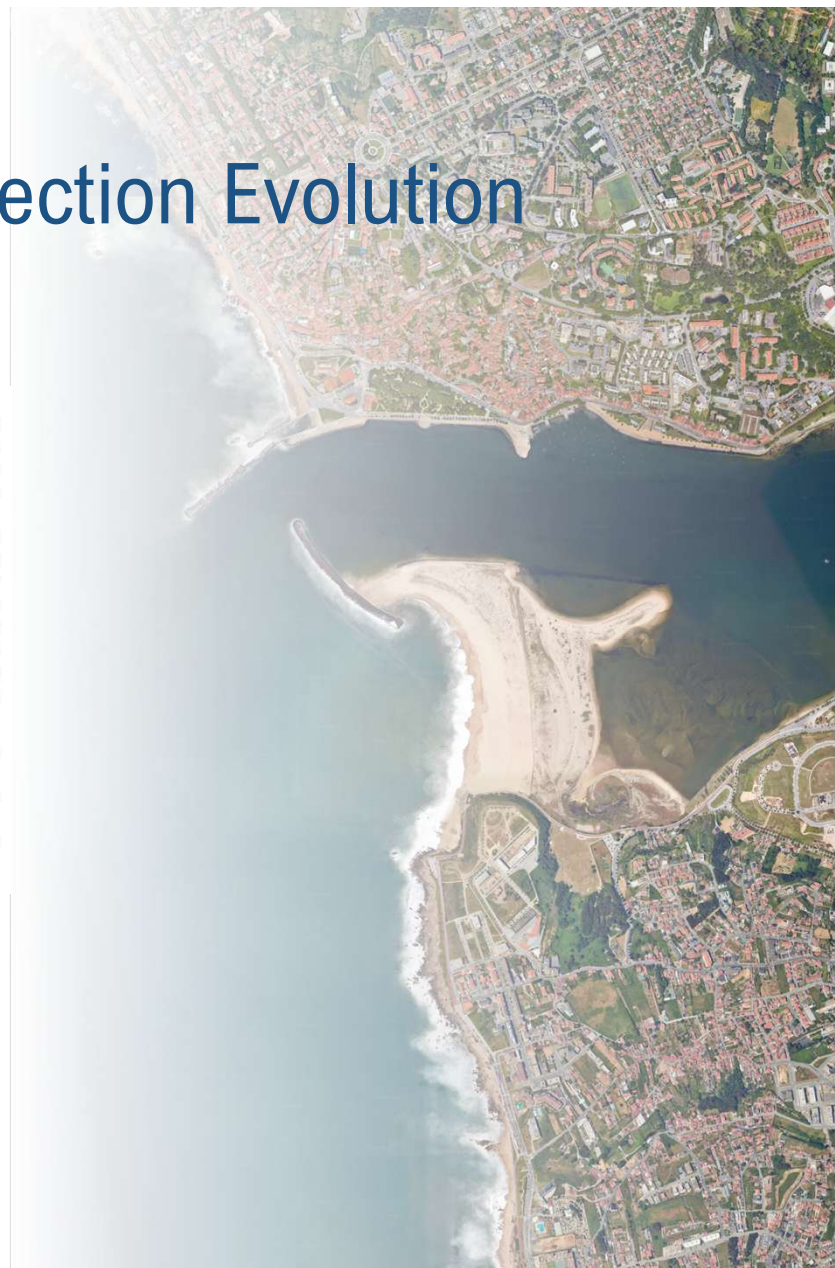
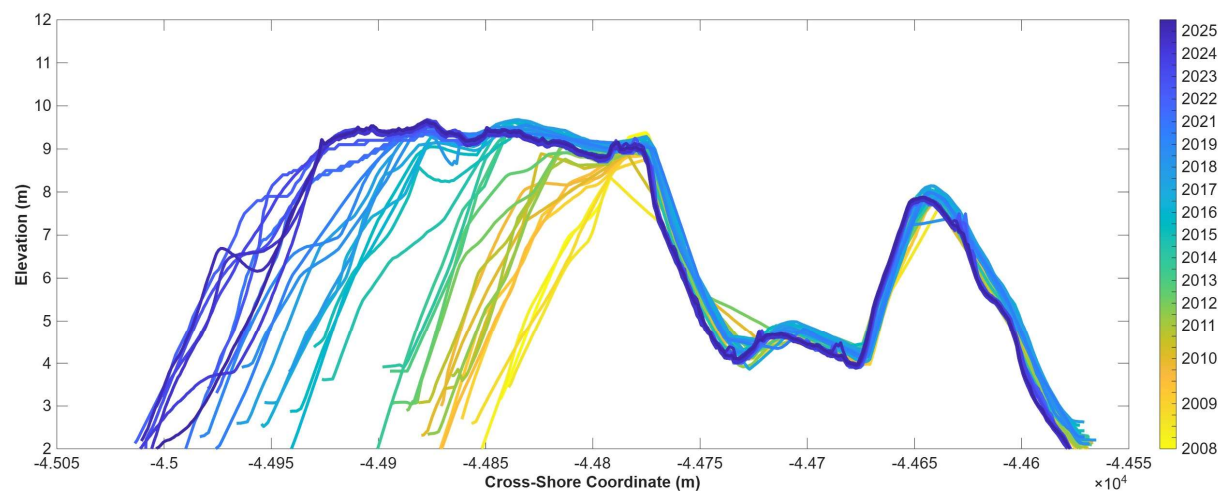
Erosion Periods



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Cross-section Evolution

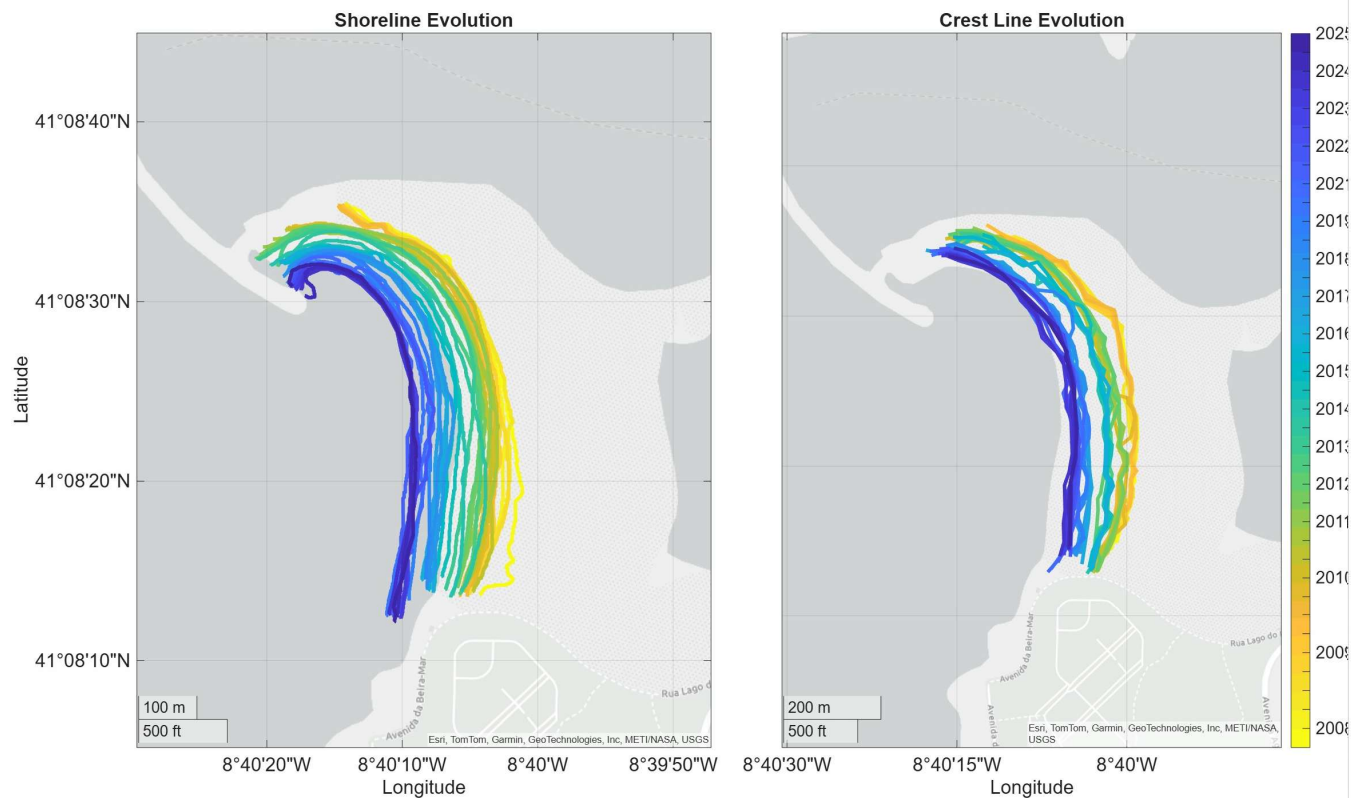




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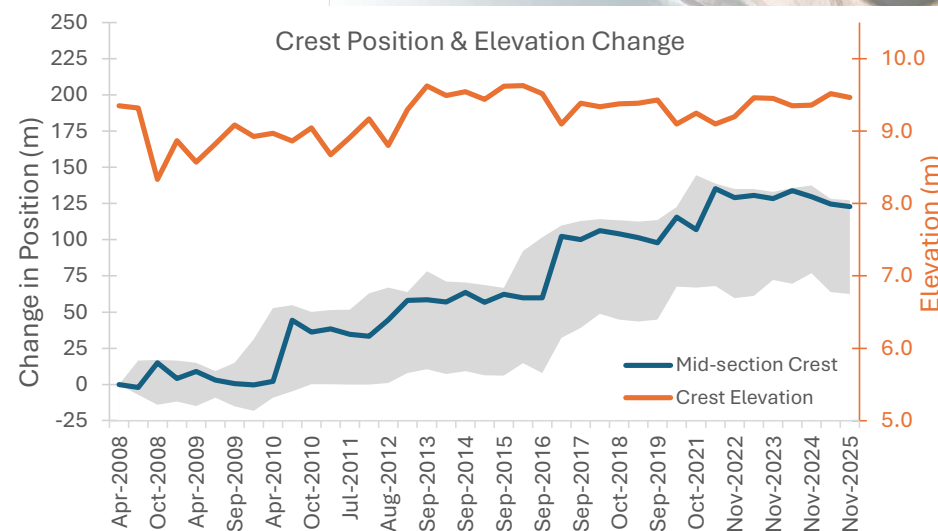
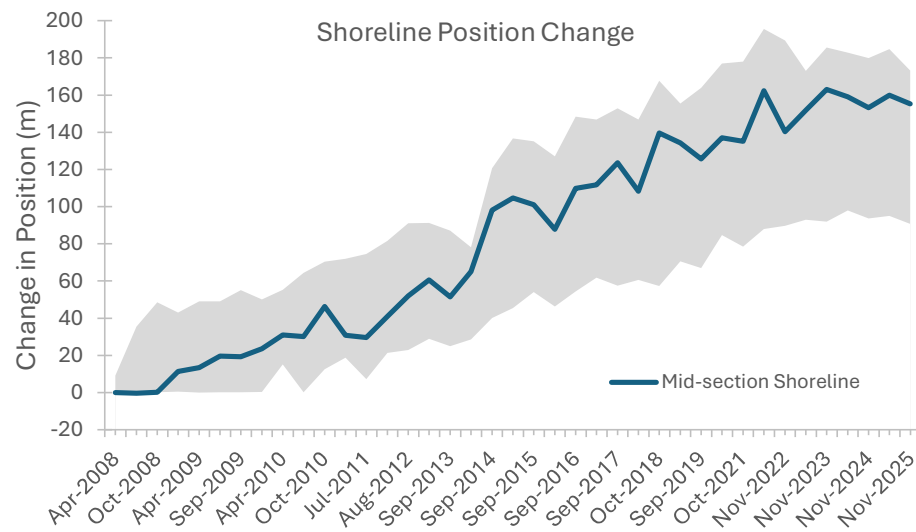
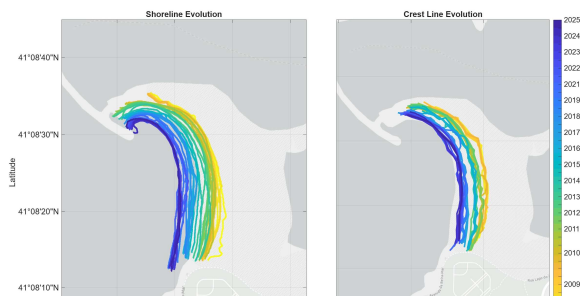
Shoreline & Crest Line Evolution





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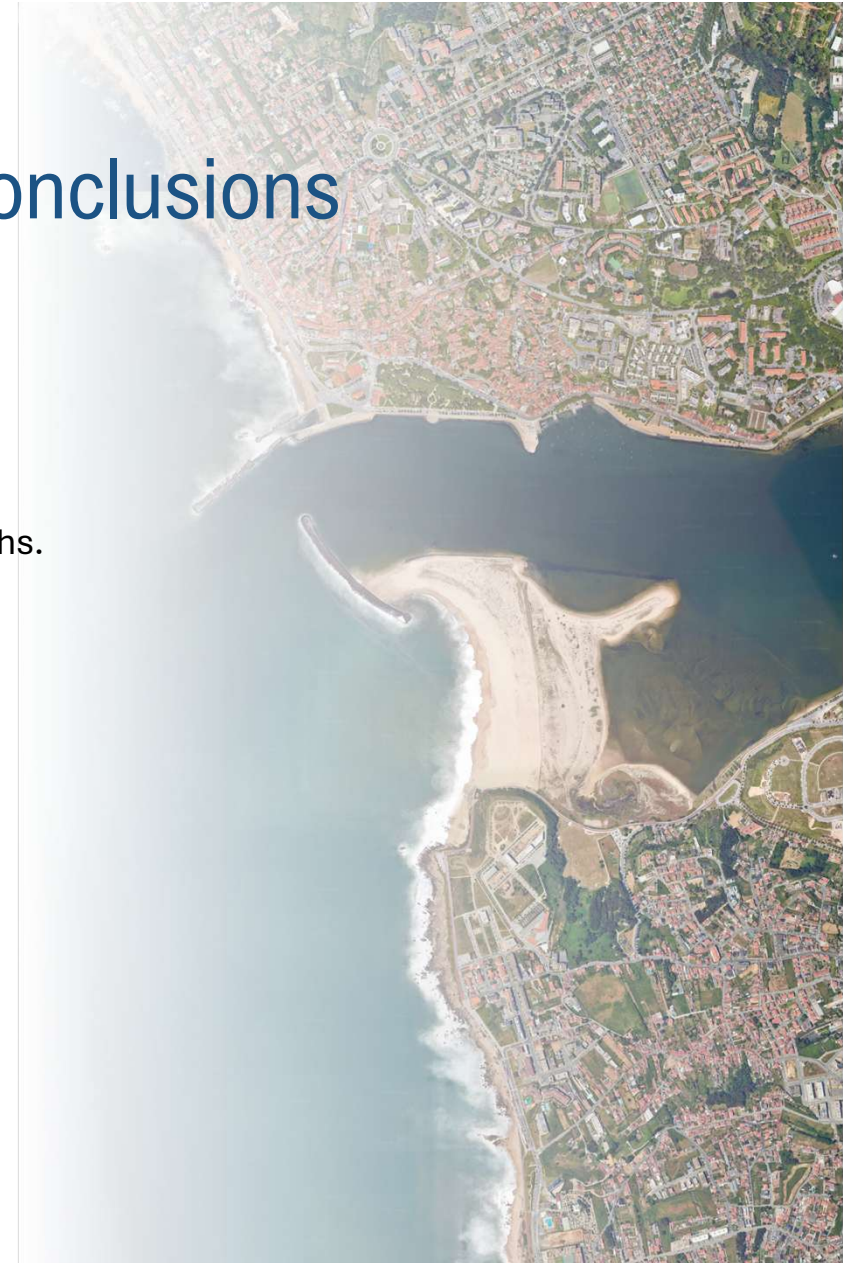


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Conclusions

- ❖ Average gains reached **57,000 m³/year** and **9,000 m²/year**.
- ❖ Storms caused short-term erosion, but the system recovered within months.
- ❖ The shoreline advanced about **160 m**.
- ❖ The dune crest advanced more than **125 m**, in steps.
- ❖ The sand spit remains dynamic but resilient.





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OBRIGADO!

Questions?