

Final Report

“The **sand pillows** that
lull the **sea**”



Problem:



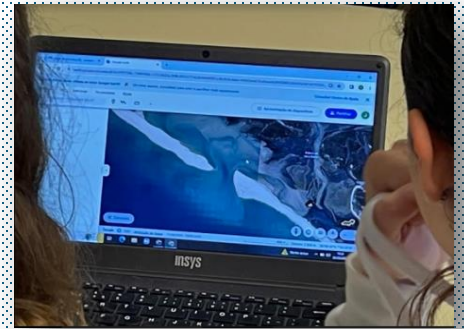
Do the sandbanks in coastal areas adapt to the rise in sea level, a consequence of Climate Change?









Context...

On a global scale.

- There is a natural tendency for a slight rise in the average sea level, as we are currently in an interglacial period. However, anthropogenic activities are responsible for emitting a large amount of greenhouse gases, which promote global warming and consequently the melting of polar ice caps and thermal expansion of the oceans, leading to the rise in the average sea level.





Context...

-  The **Coastal systems** are transitional zones between **terrestrial and marine environments**.
-  They serve as **buffers** between dynamic marine and terrestrial agents.
-  Their shapes and dimensions result from **the competition between these marine and coastal agents**.
-  The **current rise in mean sea level**, on the order of 2-3 mm/year, a reflection of **global warming versus climate change**, is countered by the formation of **sandy deltas** at the mouths of **tidal inlet bars**, forming flood and ebb deltas with dimensions and shapes that adjust to this rise in mean sea level.
-  The size of the deltas also reflects the dominance of flood or ebb phases at the inlet, a consequence of the **hydrodynamic balance** of the sea and the coastal system.
-  **Case in study: São Luís tidal inlet bar**, integrated into the barrier island system of **Ria Formosa**.



Context...

 During the flood tide phase, the flood delta forms within the Ria Formosa to dampen the entry of currents into the lagoon system;

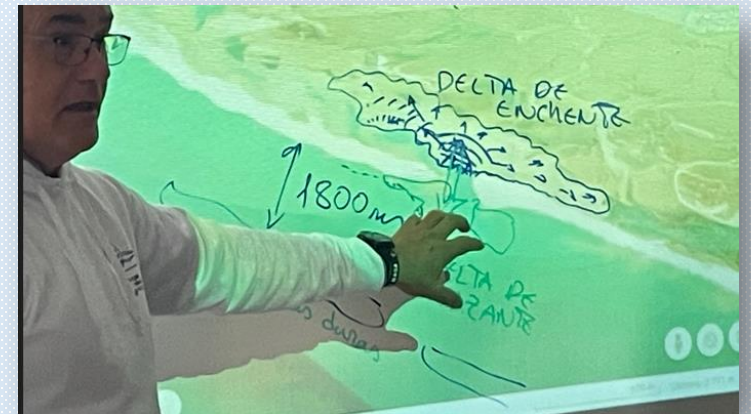
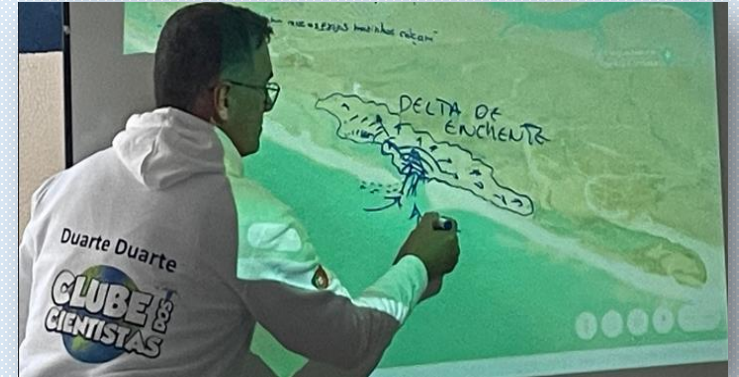
 During the ebb tide phase, the ebb delta forms within the sea to dampen the currents coming from the Ria Formosa into the sea;



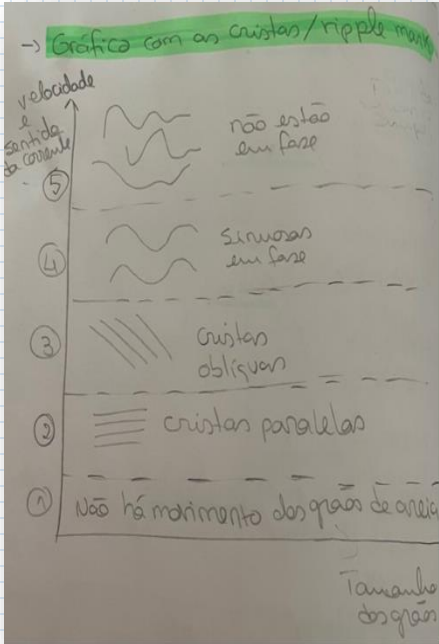
How we did our investigation...

1st Phase at School:

- **We understood** the hydrodynamic processes (tides and currents) and the processes inherent to sediment transport (energy transfers to natural clasts/sand grains).
- **We studied** the formation of sedimentary environments, flood and ebb deltas that emerge at the tidal inlets of the lagoon coastal system (case study: São Luís Inlet Bar).



We built a model with a **graph of the crests of ripple marks on sand pillows (deltas)**, where we had the variation of the speed and direction of the sea current, depending on the size of the sand grains.



We replicated the action of a very weak current on the sediment, unable to move and transport it (**Board 1**). With the increase in current energy, part of it is transferred to sediment transport, leading to the formation of small straight-crested ripples (**Board 2**). When currents are of greater magnitude, the sandy nature of the delta bottoms dissipates more energy from the water, forming ripples with oblique crests (**Board 3**) and ripples with in-phase sinuous crests (**Board 4**) and out-of-phase sinuous crests (**Board 5**).



Second Phase: We

conducted a field trip to São Luís Inlet Bar to observe in situ the physical and sedimentary processes, and the sedimentary environments, previously explored in the scientists'





Flood Delta Dunes

(with sinuous crests out of phase)

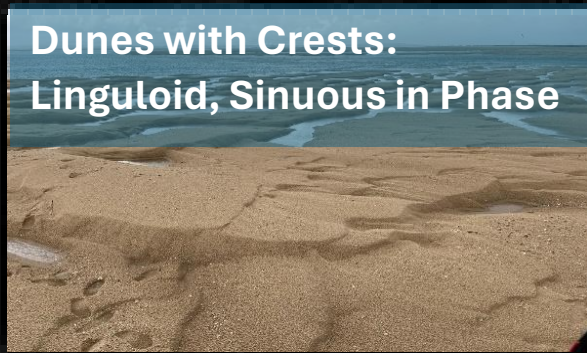


We went to discover the bottom forms (*ripple marks* and dunes) of the sand pillows and to understand the importance of their crests in the flood delta.





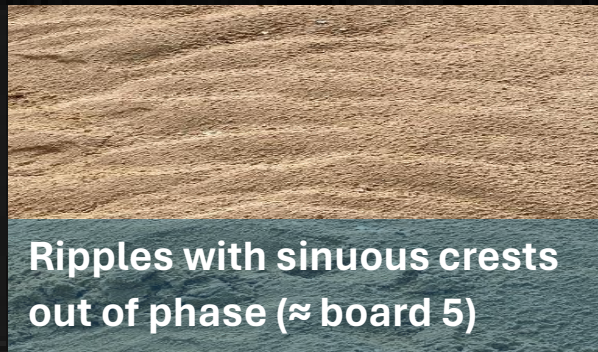
Sinusoidal Crest Dunes in Phase



Dunes with Crests:
Linguloid, Sinuous in Phase



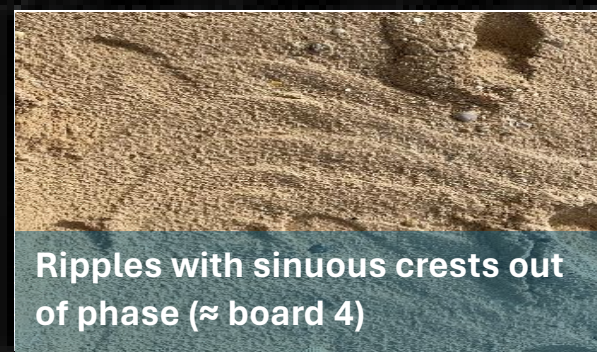
Sand dunes



Ripples with sinuous crests
out of phase (\approx board 5)



Flood dunes with sinuous
crests out of phase



Ripples with sinuous crests out
of phase (\approx board 4)

Ripples with sinuous crests out of phase
(\approx board 5)

Parallel crest ripples in phase, on dune backs (\approx board 2)

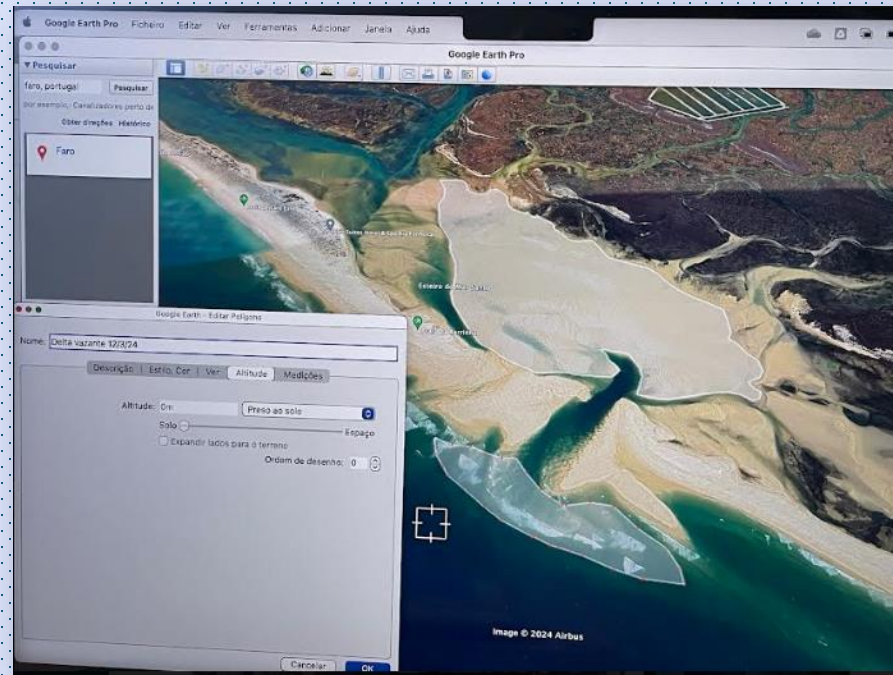


Flood dunes with sinuous crest in phase

Ripples with parallel crests in phase (\approx Board 2)

Third Phase -Having understood the processes in theoretical and natural contexts, we selected several satellite images (Google Earth®) from different time periods (2013 and 2024), in which we identified the morphologies and dimensions of the deltas, their areas and perimeters, as well as the flood and ebb dunes that comprise them.





Satellite images



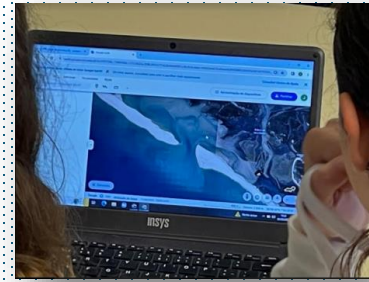
Satellite images



DISCUSSION OF RESULTS AND FINAL CONSIDERATIONS

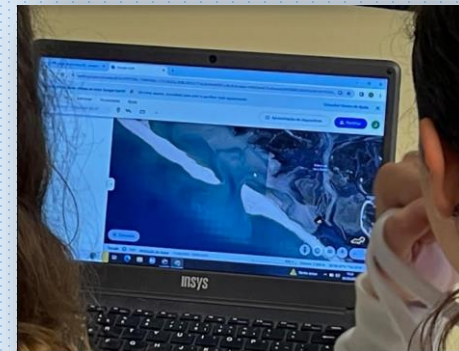
Comparing the deltas of 2013 and 2024 from São Luís Inlet, Ria Formosa:

- the **deltas adjusted to the natural migration of the inlet**. In 2013, the inlet was more to the east, and by the end of that year, a new inlet was artificially opened near the last inhabited building, causing the initial inlet to close. After this intervention and up to 2024, the inlet migrated back to the east.
- the **area of the flood delta nearly doubled** (from 255,820 m² to 501,111 m²), while **the area of the ebb delta halved** (from 181,946 m² to 72,631 m²), leading us to suggest that flood deltas **are a defense mechanism** within the Ria Formosa against the advance of the sea.
- The deltas, here referred to as **SAND PILLOWS**, are **dynamic structures** formed by water currents. The **flood delta** is a **megaform** that reflects **hydrodynamics** and results from the entry of seawater into the lagoon system during the flood phase. This flood delta **dissipates the energy of the seawater entering the lagoon system, LULLING IT...**



CONCLUSIONS

- The **flood delta** is always larger than the **ebb delta** at this inlet, indicating that in addition to the dominance of the flood tide, **the sea is also in a transgressive phase**, suggesting that the **balance of forces of the flood currents clearly surpasses those of the ebb currents**.
- **Flood deltas** serve as a natural defense to dampen tidal currents, **functioning as PILLOWS THAT LULL THE SEA**. The shape of the delta resembles a pillow, and its function seems to be to calm the sea...
- **The bottom forms that make up the deltas** reflect the **sand transport** and **its ability to dissipate the energy of the currents** in the delta. We identified in the flood delta bottom forms: **megadunes, dunes, and ripples**.



We're making a difference!!!

Meeting with the Mayor of Faro to present our ideas and establish partnerships, with the aim of promoting actions/suggesting measures that we can all adopt in these coastal environments, such as:

- Avoiding trampling on vegetation and dune environments (natural sand reserve that feeds longshore drift and deltas).
- Promoting activities to replenish sand removed from the beach road in Faro by restoring it to the dunes.
- Protecting and planting dune plants (which help retain sand in the dunes). If this is not possible, installing fences on the dunes.
- Promoting artificial beach nourishment with sand that is "lost" in deeper areas of the sea.



Ongoing Actions...

- Production of podcasts/short awareness videos/theater plays/flyers and dissemination on social media... ongoing

- Organization of lectures for students, teachers, staff, and parents, within the school setting. Specifically:

✓ Lecture "The Poles and Climate Change," held on April 10th, 2024, to raise awareness among students in our group about the consequences of climate change.

✓ Lecture "The Marine Pillows That Lull the Sea," to be held on April 24th, 2024, to disseminate the results of our project and raise awareness among the entire educational community about the consequences of climate change. To raise awareness about the importance of dune sands in minimizing the impacts of climate change, particularly in mitigating the rise in average sea levels.



Ongoing actions...

- Dissemination of this study through participation in student conferences/events organized by entities, as they occur/regional and national conferences, among others.
- Promotion of our work on the school and municipality's social media platforms,
- Promotion of our work in local/regional newspapers.



The SDGs (Sustainable Development Goals) very evident in our project...

