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### Introduction

In recent decades, coastal dune systems have been significantly diminished and altered due to erosion from environmental and human factors. Naturebased solutions, particularly the use of sand fences, become important for restoring these have ecosystems. These fences help accumulate sediment, rebuild beach-dune profiles, and reduce erosion, especially during storms, enhancing the resilience of these vital coastal areas.

# Study area

We focus on two zones that covers two kilometers of beach: the northern area, in front of Las Dunas campsite, where nature-based solutions have been applied since 2020, and the southern area near La Ballena Alegre campsite, where management



FIGURE 1: The image on the right illustrates the study area, bordered by two seafront campsites. The drone image on the left, captured after Storm Isaak in February 2023, depicts a segment of the beach-dune system adjacent to La Ballena Alegre campsite. The image shows the campsite constraining the dune system from the inland side, leaving limited space for a small foredune, which has been degraded by the movement of users between the campsite and the beach.



Our study assesses the efficacy of sand fences, rope fences and restrictions in mechanical clenning in Sant Pere Pescador beach, located in the Gulf of Roses, Catalonia, Spain (Figure 1).

# Methodology

Data were gathered using drones and high-resolution (10 cm) digital elevation models (DEM), pre and post management measures implemented during the period of 2019 – 2024 (Figure 2).

Installation of 21 sand fences (Figure 2) each 10-15 meters long, 85 cm high, with 60% porosity, oriented NNW. Rope fences were implemented in the northern campsite only, whereas both campsites ceased mechanically cleaning the foredune.

After one year from management initiated, sand fences and rope fences continued in the north. Sand fences were partially halted in the southern campsite, La Ballena Alegre, due to repeated complaints about the Natural Park management criteria. Since then, only maintaining and repairing the sand and rope fences was the main management measure.



FIGURE 2: Chronology of the methodology carried out

# **Preliminary results**

Figure 3 illustrates the dynamic changes in the topography of Sant Pere Pescador beach across the years, highlighting the substantial role of sand fences in sediment accumulation, with increases ranging from 0.4 meters in the south to 1 to 2 meters in the north (Figure 2C). The effectiveness of sand fences has resulted in significant sand retention and accumulation over time. Specifically, these fences have contributed to an average foredune height increase of 1 meter, representing an 80%

FIGURE 3: DEM of the beach in 2019 (A) and 2024 (B), and mean height gain and volume increase in the foredune from 2019 to 2024 using a 5 square meter grid per cell (C).

increase in altitude over four years. Both the minimum and maximum heights have shown substantial growth (Figure 3B). The average height in the southern region rose from 1.9 meters to 2.4 meters (increase of 26%), while the northern area saw a more dramatic rise from 1.4 meters to 2.6 meters increase of 96%).

Additionally, the volume has increased by 79% in all the studied area, especially in the north (Figure 3C). The volume of sand accumulated by each sand fence has been analyzed individually, and it has been determined that each wind barrier has the capacity to generate between 70 and 700 cubic meters.

# Conclusions

The southern foredune has shown the smallest increase in sand accumulation. This limited growth is attributed to the scarce or absent sand fences and rope fences. However, the new morphologies in the foredune that make increase the height at least 40 cm and the volume gained are due to stopping the mechanical cleaning on the foredune.

In contrast, the northern campsite has experienced significant foredune recovery after the dune restoration actions in 2020. Given, the northern campsite demonstrates greater resilience facing storms, while the southern campsite faces a heightened risk of flooding during storm surge periods.



