FOREDUNE GUIDED REMOBILIZATION EXPERIMENTS ALONG THE SOUTHWEST COAST OF FRANCE

Alexandre Nicolae Lerma, Bruno Castelle, David Rosebery, Cedric Bouchet, Julie Billy, Bruce Ayache, Olivier Burvingt, Nicolas Robin

FOREDUNE GUIDED REMOBILIZATION EXPERIMENTS ALONG THE SOUTHWEST COAST OF FRANCE

ALEXANDRE NICOLAE LERMA[1,2], BRUNO CASTELLE[3], DAVID ROSEBERY[2,4], CEDRIC BOUCHET[2,4], JULIE BILLY[1], BRUCE AYACHE[1,2], OLIVIER BURVINGT[3], NICOLAS ROBIN[5]

1. *BRGM, Regional Direction Nouvelle- Aquitaine, Pessac, France.* *a.nicolaelerma@brgm.fr ; j.billy@brgm.fr ; b.ayache@brgm.fr*
2. *Observatoire de la Côte Nouvelle Aquitaine (OCNA), Pessac, France.*
3. *Univ. Bordeaux, CNRS, Bordeaux INP, EPOC, UMR 5805, F-33600 Pessac, France* *bruno.castelle@u-bordeaux.fr ; olivier.burvingt@u-bordeaux.fr*
4. *ONF, Office National des Forêts, 75570 CEDEX 12 Paris, France* *david.rosebery@onf.fr ; cedric.bouchet@onf.fr*
5. *CEFREM, Université de Perpignan Via Domitia, 52 Avenue Paul Alduy, Perpignan* *nicolas.robin@univ-perp.fr*

Abstract: This contribution presents the response of experimental management methods implemented along 2 km stretch of the southwest coast of France with the objective to restore aeolian dynamics and foredune mobility to promote quasi alongshore-uniform landward foredune migration. The analysis based on eight airborne LiDAR campaigns and several morphometric indicators shows that the alongshore and temporal variability of foredune evolution depends on natural dynamics and contrasted managed strategies. These experiments offer new perspectives and guidelines for coastal dune managers in areas where chronic erosion threatens fixed dune systems.

Introduction

Coastal dunes are iconic landscapes providing outstanding ecosystem services such as reserve of biodiversity; barrier against flooding hazards; buffer zone mitigating coastal erosion. In the recent history (last centuries), foredunes have been usually managed to provide safe areas for human activities and settlements. Thus, current coastal dune landscape, including morphology and vegetation distribution, is often inherited from several centuries of management (Arens et al., 2013), especially along the French Atlantic coast (Bossard and Nicolae Lerma 2020; Robin et al., 2021). Coastal dune stabilization has often resulted in large, high and alongshore-uniform dune fields (Nordstrom, 2015), limiting beach-dune sediment exchange and reducing biodiversity (Pye et al., 2014). In chronically eroding sectors with re-shaped coastal dunes, dune remobilization can be seen as an efficient management strategy to help the dune to migrate landwards and maintain while also driving vegetation rejuvenation. However, in southwest France this has only been addressed at a single site, not affected by chronic erosion and only through localized foredune notching (Castelle et al., 2019). Foredune notching has been used to stimulate sand transport from the beach to

the dune but the effects remain relatively local (10 m to 100 m) and with contrasted results, which prevents the elaboration of large-scale remobilization strategies. Since 2014, the French National Forest Management Office (ONF) started new management methods adapted to address the issue of dunes vulnerability to marine erosion. This contribution presents the response of experimental management methods implemented along 2 km stretch of the southwest coast of France (Figure 1a). The objective is to restore Aeolian dynamics and foredune mobility, with the main goal consisting in promoting quasi alongshore-uniform landward foredune migration. The analysis is based on pluriannual LiDAR surveys and synchronous ortho-photographs, documenting morphological and vegetation response to natural forcings and management interventions over the last decade.

Sites and Method

The study site is one of the five sites forming a network of surveyed remobilized coastal dune system along the Aquitanian coast, southwest France, where innovative and adaptive management actions are tested.

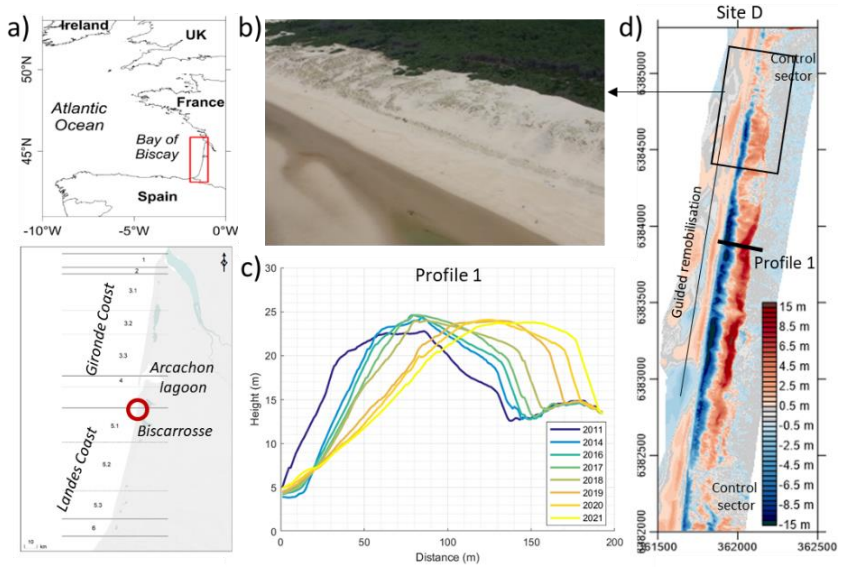

Figure 1. a) Site location, b) oblique photograph of the beach-dune system (spring 2020), c) Temporal evolution along a cross shore profiles, d) 2011-2021 DTM difference plot at site

Eight airborne LiDAR campaigns from the "Observatoire de la Côte de Nouvelle-Aquitaine" (OCNA) database were used. Data were acquired in spring in 2011,

during fall in 2014, and annually at the same period since 2016. LiDAR Digital Terrain Models (DTMs), were used (1-m gridded spatial resolution) to calculate beach and/or dune volume changes. Several morphometric indicators were computed in order to analyze the alongshore and temporal variability of the foredune (e.g. dune foot location, dune front slope, maximum elevation, centroid position, back dune location). The study area was segmented into 6 sectors (Figure 2) with contrasted experiments and interventions on the dunes. Morphological and vegetation responses were compared between sectors and relative to adjacent control areas (fixed dunes).

Results

The study site suffered from chronic erosion over the last decades (>2 m/yr). With the outstanding winter of 2013-2014 further eroding the dune front along the study area by 15-20 m, a guided remobilization strategy was set up. Implemented management actions mainly consisted in manual and/or mechanic dune scarp clipping. Punctually, sand trapping or branch cover have been used in order to control unplanned morphologic evolutions. The primary aims were to: (i) re-establish a quasi alongshore-uniform sand transfer from the beach to the dune, (ii) allow for a smooth beach-dune interface slope and an aerodynamic shape of the dune, (iii) limit winter dune volume loss caused by marine erosion. Figure 1d shows the 2011-2021 DTM difference of a 3.5-km dune system and Figure 1c shows the temporal evolution at a cross-shore profile in the managed area.

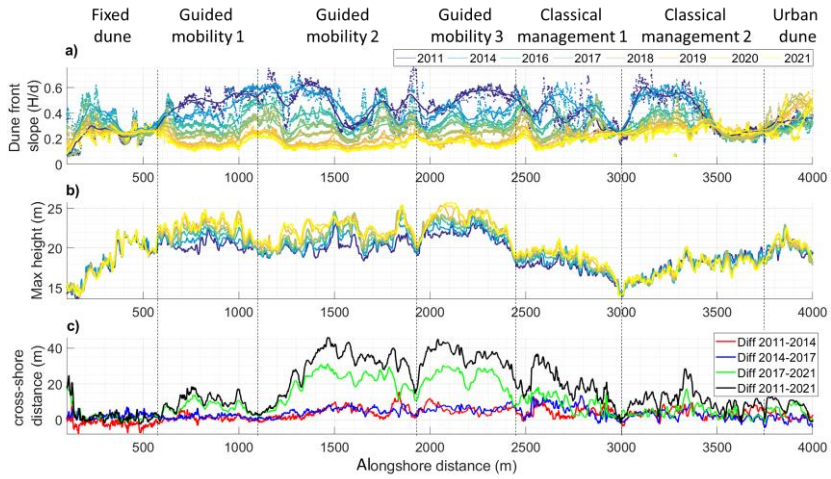

Figure 2. Time evolution of the alongshore distribution in a) dune front slope b) maximum dune height and c) cross-shore barycenter location relative to shoreline location (6 m NGF official levelling network in mainland France)

After 6-7 years, the scarped dune front observed in 2014 (average slope around 0.5 peaking at 0.7), has been largely flattened (by between 0.3 and 0.1, see Figure 2a) through punctual and localized mechanic dune scarp clipping and thus free evolution. Dune shape was substantially modified allowing the growth of an incipient foredune and conferring an aerodynamic profile to the dune. In average, the foredune raised by 2.1 m between 2014 and 2021 (Figure 2b) along the mobilized sector ($600 < x < 3000$), with a landward migration (lee foot) of 20 to 40 m, and a landward shift of the dune centroid position by approximately 20 m (Figure 2c). At guided mobility sectors ($600 < x < 2450$, Figure 2) foredune volume increased by +67 m^3/m between 2014 and 2021. In comparison, at the northern (Fixed dune, $0 < x < 600$) and southern control sectors (Classical management 2 and Urban dune $3000 < x < 4000$), foredune presents lower gain with +36 and +21 m^3/m respectively.

Conclusion

Original management strategies have been tested to drive foredune remobilization at a site affected by multidecadal chronic erosion. By restoring natural Aeolian dynamics through a limited intervention, a large and reasonably alongshore uniform inland migration of the foredune was observed. This migration also maintains the coastal dune system and provides a smoother beach-dune interface. These experiments offer new guidelines for coastal dune managers in areas where chronic erosion threatens fixed dune systems and perspectives for large-scale dune management plan.

Acknowledgements

The authors are grateful to all the co-funders of the OCNA project.

References

Arens, S. M., Mulder, J. P., Slings, Q. L., Geelen, L. H., & Damsma, P. 2013. Dynamic dune management, integrating objectives of nature development and coastal safety: Examples from the Netherlands. *Geomorphology*, 199, 205-213.

Bossard, V., & Nicolae Lerma, A. 2020. Geomorphologic characteristics and evolution of managed dunes on the South West Coast of France. *Geomorphology*, 367, 107312.

Castelle, B., Laporte-Fauret, Q., Marieu, V., Michalet, R., Rosebery, D., Bujan, S., Lubac B., Bernard J-B., Valance A., Dupont P., Ould El Moctar A., Narteau, C. 2019. Nature-based solution along high-energy eroding sandy coasts:

preliminary tests on the reinstatement of natural dynamics in reprofiled coastal dunes. *Water*, 11(12), 2518.

Nordstrom, K. F. (2015). *Coastal dunes*. Coastal environments and global change, 178-193.

Pye, K.; Blott, S.J.; Howe, M.A. 2014. Coastal dune stabilization in Wales and requirements for rejuvenation. *J. Coast. Conserv* 18, 27–54.

Robin, N., Billy, J., Castelle, B., Hesp, P., Nicolae Lerma, A., Laporte-Fauret, Q., Marieu V., Rosebery D., Bujan S., Destribat B., Michalet, R. 2021. 150 years of foredune initiation and evolution driven by human and natural processes. *Geomorphology*, 374, 107516.