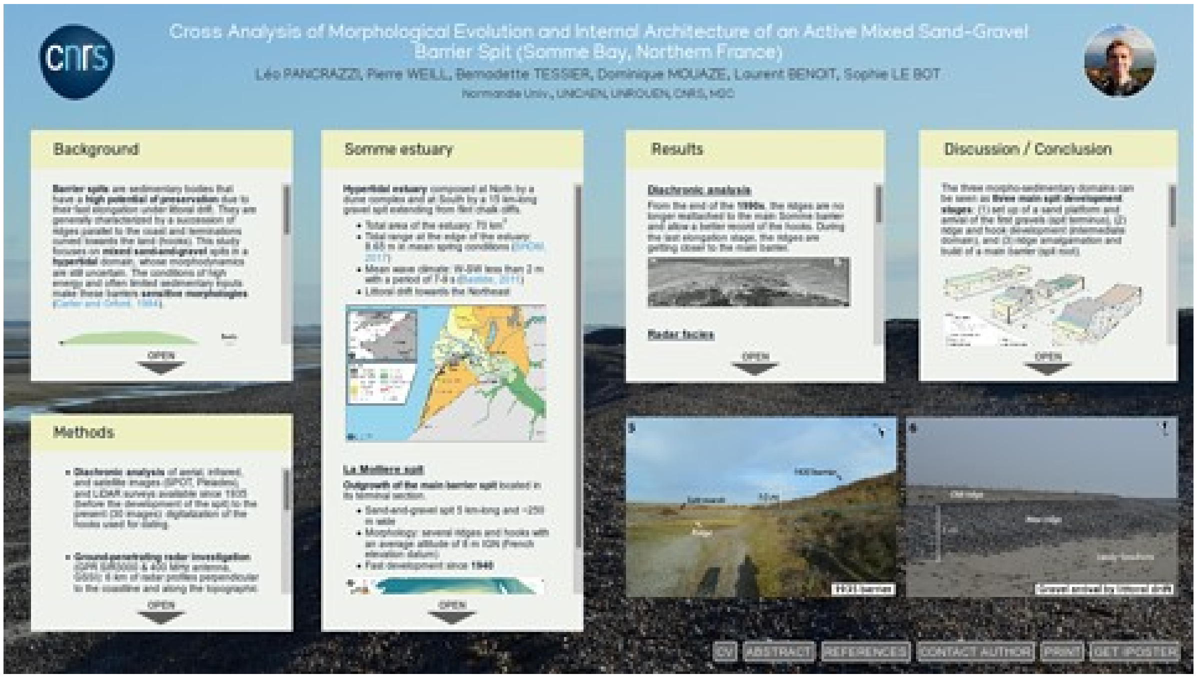
Cross Analysis of Morphological Evolution and Internal Architecture of an Active Mixed Sand-Gravel Barrier Spit (Somme Bay, Northern France)



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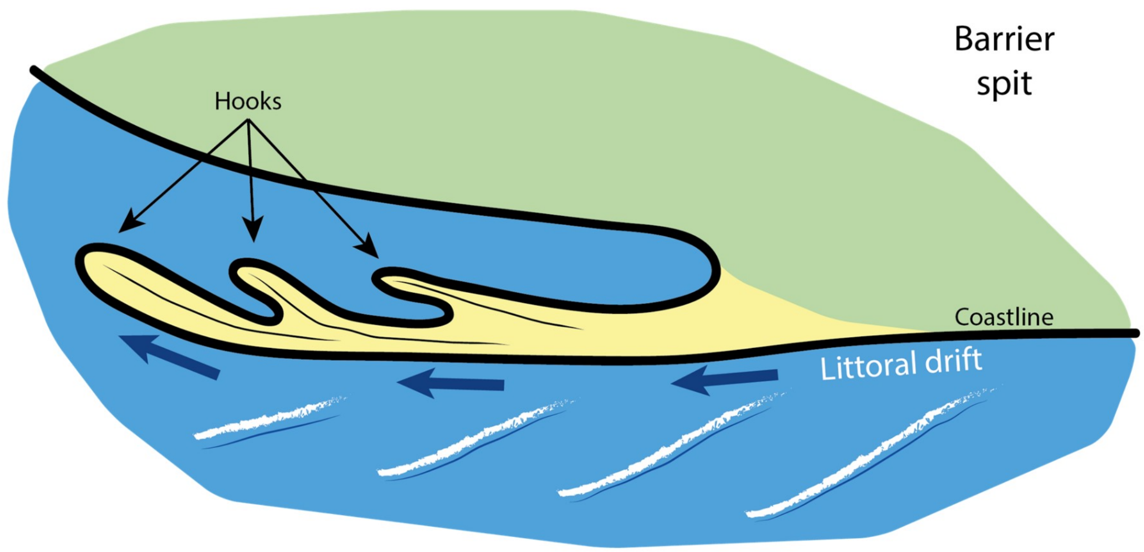
BACKGROUND

Barrier spits are sedimentary bodies that have a **high potential of preservation** due to their fast elongation under littoral drift. They are generally characterized by a succession of ridges parallel to the coast and terminations curved towards the land (hooks). This study focuses on **mixed sand-and-gravel** spits in a **hypertidal** domain, whose morphodynamics are still uncertain. The conditions of high energy and often limited sedimentary inputs make these barriers **sensitive morphologies** (Carter and Orford, 1984).



Objectives

- Characterize the different structures and build a **synthetic depositional and stratigraphical model** specific to coarse-grain spits in the hypertidal domain.

- Associate the multi-decadal morphological evolution of a gravel spit with its sedimentary architecture to better understand the **forcings controlling its morphodynamics**.

METHODS

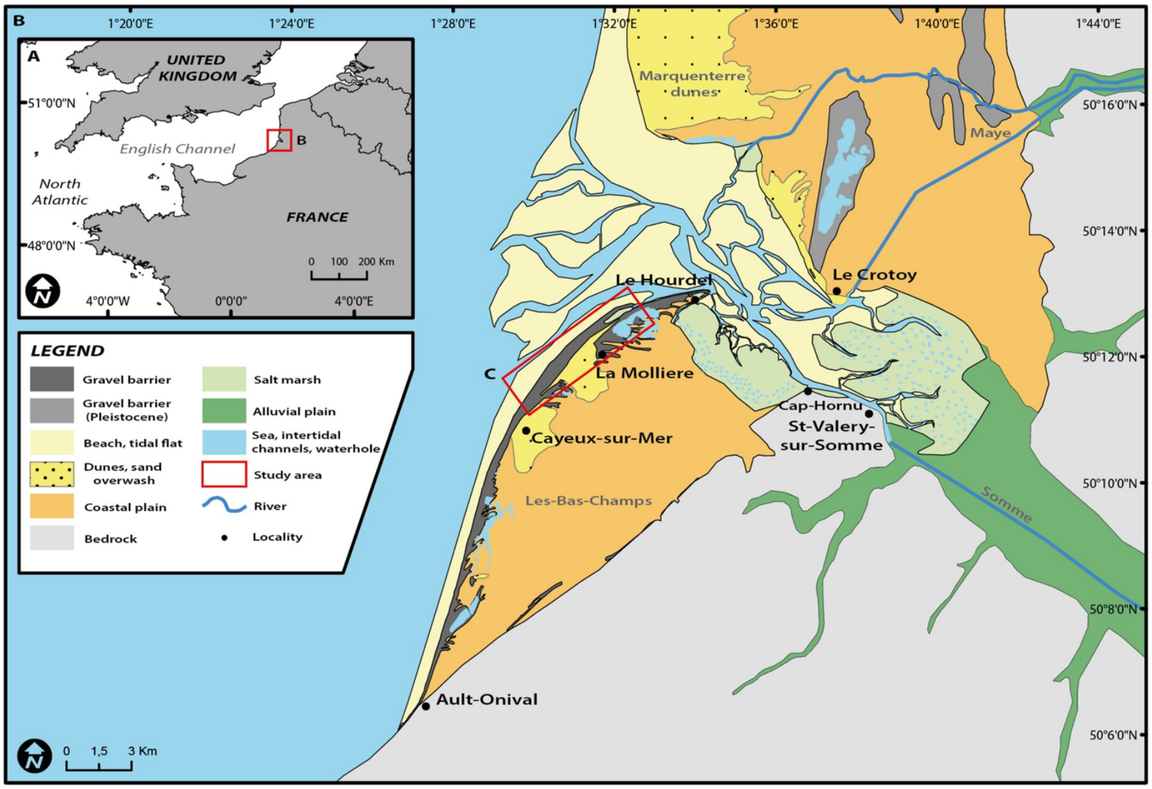
- **Diachronic analysis** of aerial, infrared, and satellite images (SPOT, Pleiades), and LiDAR surveys available since 1935 (before the development of the spit) to the present (30 images): digitalization of the hooks used for dating.

- **Ground-penetrating radar investigation** (GPR SIR3000 & 400 MHz antenna, GSSI): 6 km of radar profiles perpendicular to the coastline and along the topographic ridges of the spit.

SOMME ESTUARY

Hypertidal estuary composed at North by a dune complex and at South by a 15 km-long gravel spit extending from flint chalk cliffs.

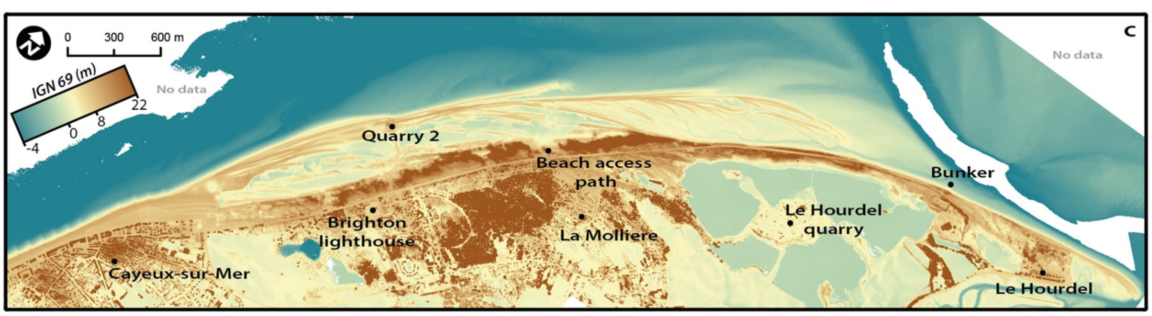
- Total area of the estuary: 70 km^2
- Tidal range at the edge of the estuary: 8.65 m in mean spring conditions (SHOM, 2017)
- Mean wave climate: W-SW less than 2 m with a period of 7-9 s (Bastide, 2011)
- Littoral drift towards the Northeast



La Molliere spit

Outgrowth of the main barrier spit located in its terminal section.

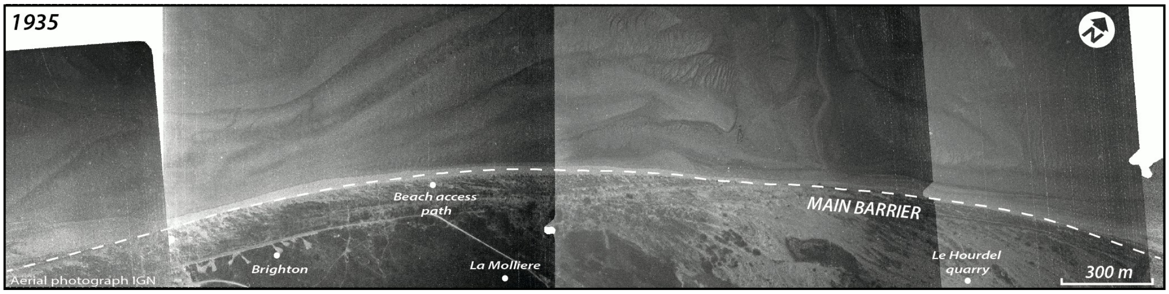
- Sand-and-gravel spit 5 km-long and ~250 m wide
- Morphology: several ridges and hooks with an average altitude of 8 m IGN (French elevation datum)
- Fast development since **1940**



RESULTS

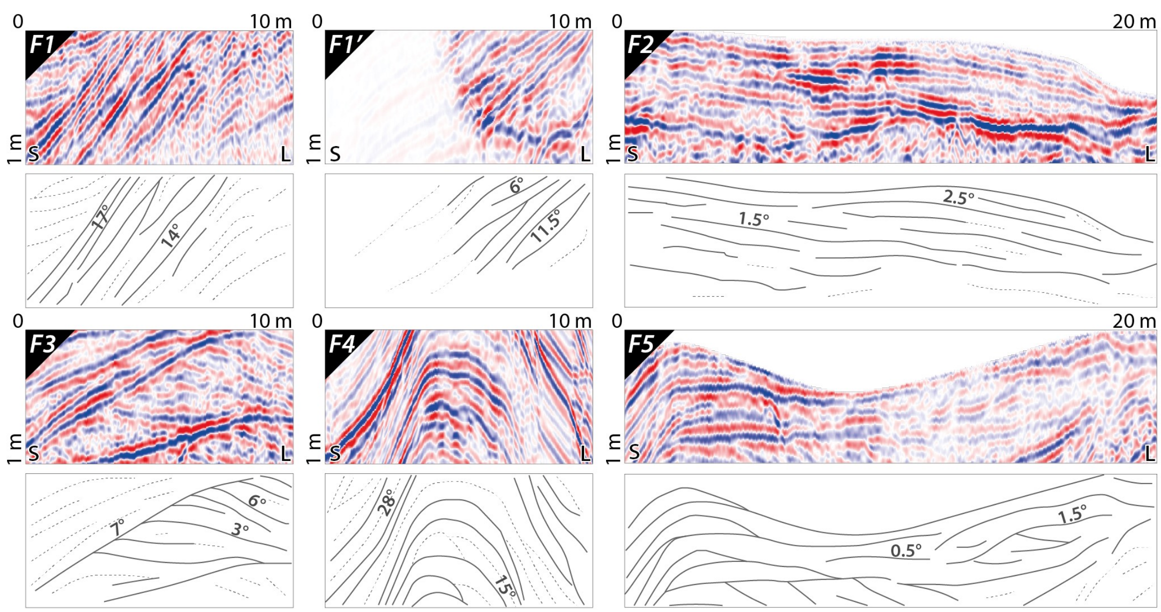
Diachronic analysis

From the end of the **1990s**, the ridges are no longer reattached to the main Somme barrier and allow a better record of the hooks. During the last elongation stage, the ridges are getting closer to the main barrier.



Radar facies

Five main radar facies have been characterized and associated with different sedimentary bodies: F1 beach face, F2 washover fans, F3 berms, F4 ridge core deposits, and F5 overtopping deposits

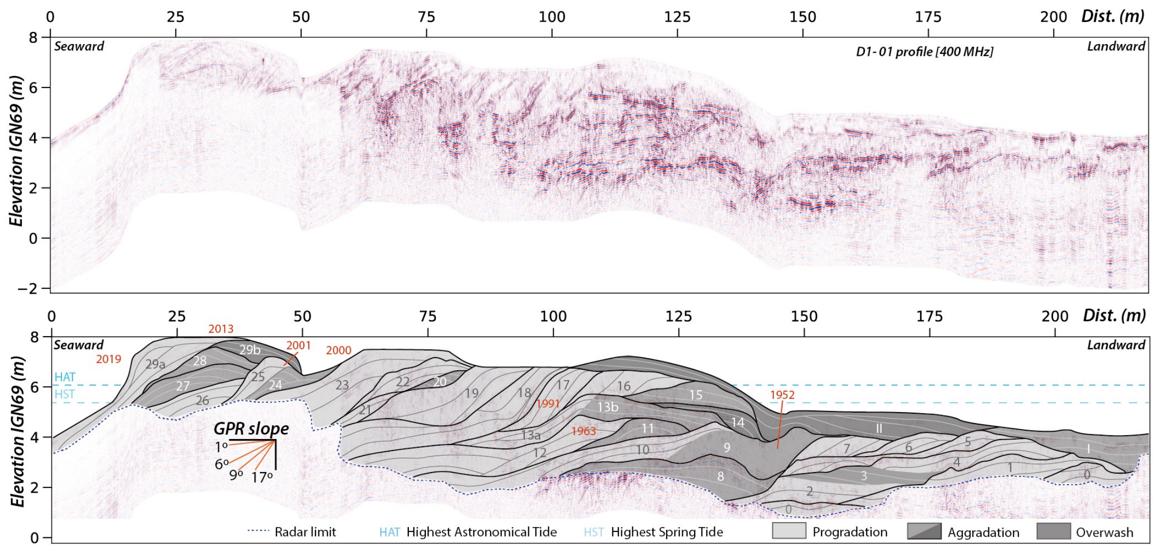


(Left: Seaward; Right: Landward)

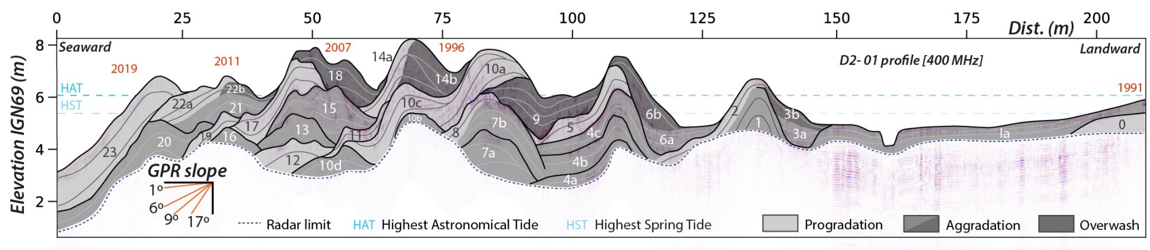
Morpho-sedimentary domains

The internal architecture associated with the three morpho-sedimentary domains of the spit (spit root, intermediate domain, and spit terminus) are illustrated by **three representative GPR profiles**. The different sedimentary bodies are classified in terms of progradational (F1), transgressive (F2), and aggradational (F2, F3, F4, F5) deposits.

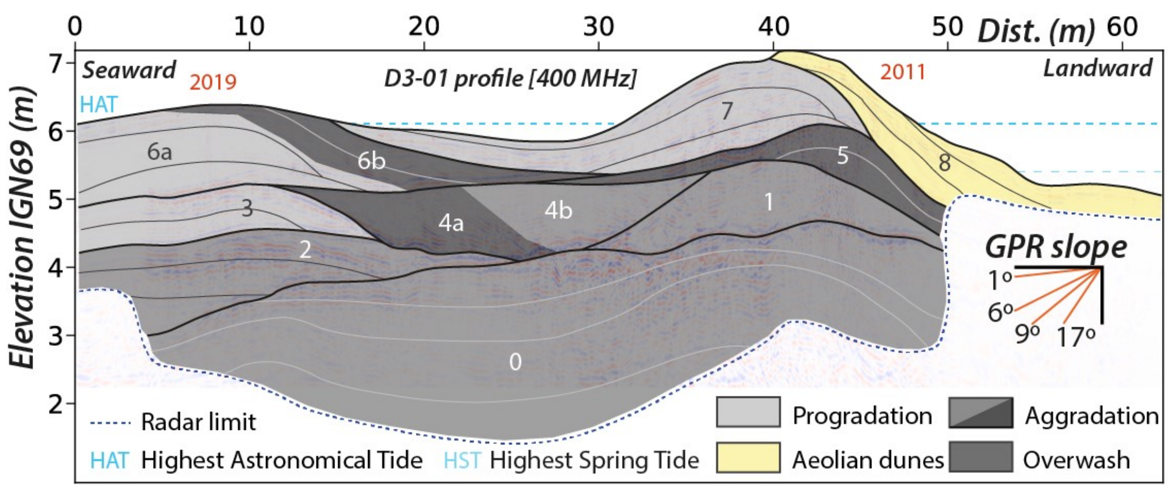
- **Spit root (GPR line D1-01)**: mainly progradational geometries with an aggradational stage dated between 1963 and the 1980s



- **Intermediate domain (GPR line D2-01)**: mixed aggradational, progradational, and transgressive geometries

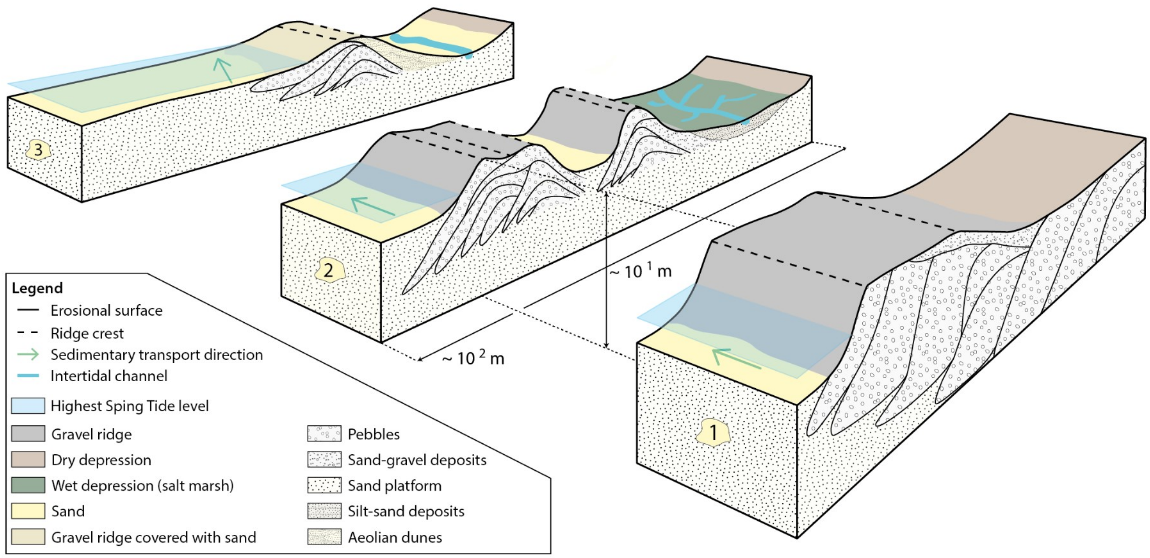


- **Spit terminus (GPR line D3-01)**: similar to D2-01 but with low slope geometries and aeolian dunes facies



DISCUSSION / CONCLUSION

The three morpho-sedimentary domains can be seen as **three main spit development stages**: (1) set up of a sand platform and arrival of the first gravels (spit terminus), (2) ridge and hook development (intermediate domain), and (3) ridge amalgamation and build of a main barrier (spit root).



Conclusion

- The characterization of **various sedimentary bodies** makes it possible to go back to the **hydro-sedimentary processes** occurring during the development of the spit.

- The **amalgamation** of the ridges and their structures increase, as the chronological markers are being tightened, from landward to seaward and from downdrift to updrift. This fact can be explained by the **migration updrift of the fulcrum point** of the spit (Ashton, 2016).

- The **cross-shore component of the oblique wave action** is predominantly recorded in the **updrift** part of the spit with progradational geometries, while the **longshore component** is predominantly recorded in the **downdrift** part of the spit where the aggradational geometries are associated with the development of the ridges over the sand platform.

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Research

Currently working on a PhD in coastal sedimentology. The main goal of this PhD is to study the dynamics and the internal structures of sand-and-gravel coastal barriers. Two different approaches will be used : 1) geophysical ivestigation with GPR and 2) flume experiments with heterogeneous sediments.

Main study areas : Baie of Somme (English Channel, Northern France) and Santa Cruz estuary (Patagonia, Southern Argentina)

Referees

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ABSTRACT

Morphodynamic evolution of coastal barriers and the way it is recorded in the internal structure are still revealing many uncertainties. Coastal spits have a high potential of preservation due to their fast elongation under littoral drift, and are thus suitable for this kind of study. Compared to sandy spits, gravel and mixed spits are understudied. Yet these coarse-grained coastal barriers are sensitive sedimentary bodies due to the high energy conditions they are usually associated with and to often scarce sediment supply. The present study focus on the relationships between multi-decadal morphological evolution of a mixed sand and gravel spit in the bay of Somme (Northern France) and its sedimentary architecture. A geophysical survey using a 400 MHz GPR GSSI antenna have been performed on the Molliere spit, a fast-growing secondary spit developing along the main 15 km-long Somme barrier spit. The development of this sedimentary body starts in the 1940s and allows a morpho-stratigraphical approach, thanks to the cross analysis of aerial photographs and GPR profiles. The spit is 5 km long and is composed of several ridges, sometimes with hooks at the tip. A synthetic depositional and stratigraphical model specific to gravel spits is proposed, based on radar profiles and aerial photographs analysis, differentiating three contrasting morpho-sedimentary units. The Unit 1, at the spit root, is characterized by mainly progradating structures that can be assimilated to a beach ridge. The Unit 2, in the central part of the spit, is characterized by individual ridges with a core structure reflecting a longshore development, topped by an aggradating unit associated to a cross- shore-dominated dynamics. The third unit, at the spit terminus, is also mainly characterized by longshore dynamics, but interfering with sand bank dynamics due to the proximity of the Somme estuary and the development of the spit platform. Larger-scale GPR prospecting, especially in older coast sections, will be necessary to understand how this fast secondary spit development (decadal to centennial time scale) is integrated into the longer-term (millennial) construction dynamics of the main Somme spit.

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