QUANTIFYING THE WAVE-DRIVEN RECOVERY OF SANDY BEACHES FOLLOWING STORM EROSION

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Following the rapid and destructive impacts of storm erosion, beach recovery is a key natural process of restoration, returning eroded sand to the subaerial beach and rebuilding coastal morphology to continue to support the needs of present-day coastal communities. While more detailed attention in international literature has been given to understanding and predicting beach behaviour under regimes of storm erosion, beaches are for most of the time by nature accretionary features. This paper presents critically important advanced new insight and quantification of recovery processes of sandy beaches by waves.

QUANTIFYING POST-STORM BEACH RECOVERY: A REVIEW

Durations and rates of recovery are synthesised from over 70 studies worldwide in a range of wave climates (from low to high wave energy) and tidal settings (from micro- to macrotidal), with a focus primarily on sandy beach coastlines. A holistic perspective of the different processes and indicators that constitute beach recovery is presented, including those in the subaqueous beach related to the post-storm onshore migration of sandbars and storm deposits in deeper offshore waters, as well as processes in the subaerial beach related to the recovery of subaerial sediment volume, shorelines, berms, and dunes (Figure 1).

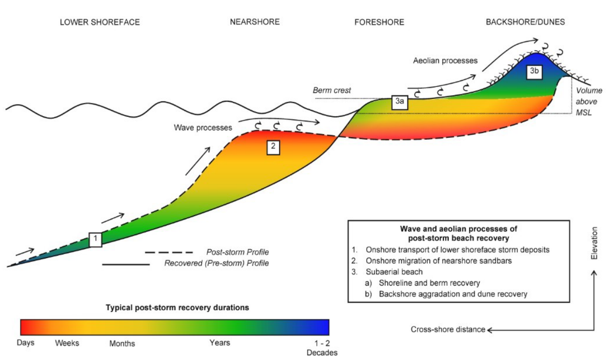

Figure 1 - Quantifying the post-storm recovery of sandy beaches.

SHORELINE RECOVERY: THE ROLE OF SANDBARS AND NEARSHORE WAVES

The onshore return of nearshore sediment back to the shoreline is a primary wave driven process of beach recovery. Shoreline recovery is analysed at Narrabeen Beach, Sydney, following 82 individual storms using a 10-year coastal imaging dataset of daily shoreline and sandbar positions. Shoreline recovery rates are quantified, highlighting temporal variability significantly correlated with parameters related to nearshore wave steepness and sandbar morphodynamics. A new conceptual model is presented in Figure 2, describing phases and rates of shoreline recovery through various stages of onshore sandbar migration following storms, from fully detached storm-deposited sandbar morphology through to complete sandbar welding with the shoreline.

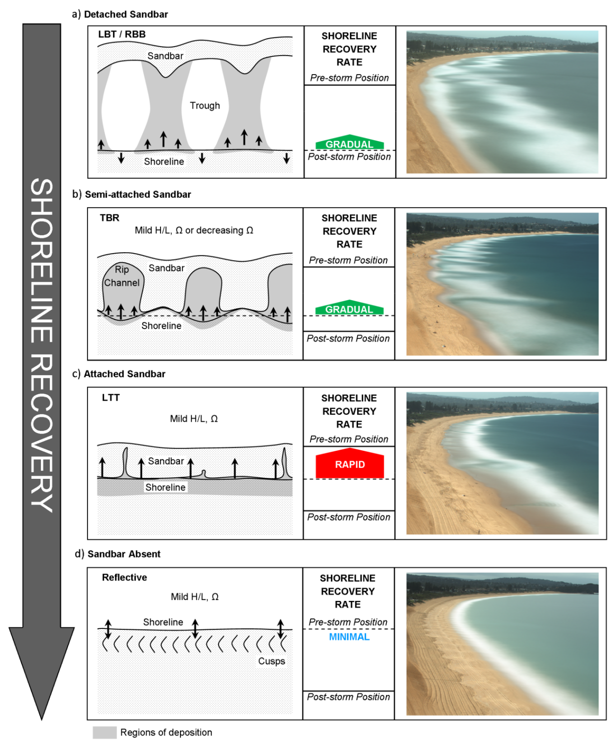

Figure 2 - Conceptual model describing phases and rates of alongshore-averaged shoreline recovery occurring with post-storm onshore migration and attachment of sandbar morphology. Beach states are classified following Wright and Short (1984); LBT = longshore bar and trough, RBB = rhythmic bar and beach, TBR = transverse bar and rip, and LTT = low tide terrace. More rapid shoreline recovery rates are triggered by attached sandbar morphology under nearshore conditions of mild wave steepness/ dimensionless fall velocity.

BERM RECOVERY: HIGH FREQUENCY OBSERVATIONS FROM A CONTINUOUSLY SCANNING LIDAR

After nearshore sediment has returned to the shoreline, swash processes then rework sediment up onto the subaerial beach to rebuild the berm. Following complete removal by a significant storm event, the entire rebuilding of a berm is examined at tide-by-tide timescales, using high resolution (5 Hz) swash and subaerial beach profile measurements obtained from a continuously scanning Lidar. Figure 3 provides an example window of subaerial beach profile changes measured by the Lidar, showing tide-by-tide berm formation and variability over the last 17 days of the recovery period. Tide-by-tide rates of subaerial volume change, berm crest growth and subaerial profile variability are quantified and examined over the complete berm recovery period (including multiple neap/spring tidal cycles). The findings identify behavioural modes of subaerial profile variability throughout berm recovery and provide a classification scheme for distinguishing modes by a given set of swash, nearshore wave and tidal ocean water level conditions (including neap/spring tidal regimes). An example application of a real-time, continuous Lidar beach monitoring system and web interface is provided for Wamberal Beach, Central Coast (Figure 4).

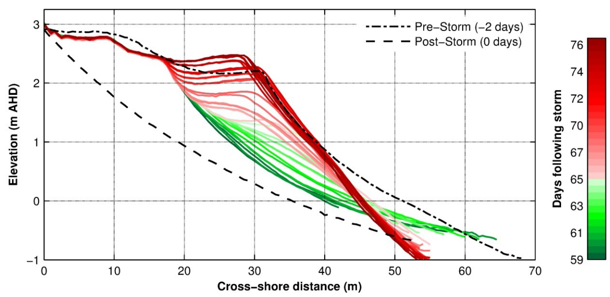

Figure 3 - Tide-by-tide beach profile changes during the final 17 days of berm recovery. Beachface progradation is shown in green from day 59 to 65 leading to the formation of a neap-tide berm. This is followed by significant berm aggradation shown in red from day 65 to 76.

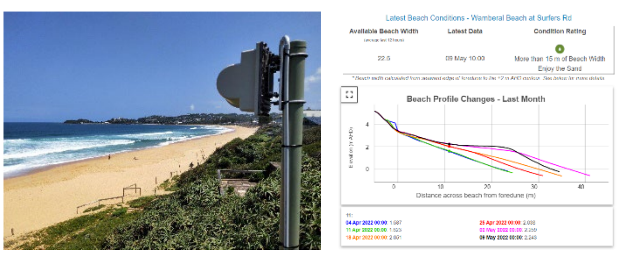

Figure 4 – Application of real-time, continuous Lidar beach monitoring system and web interface. https://mhlfit.net/users/CentralCoast-WamberalBeach

ALONGSHORE VARIABILITY IN BEACH RECOVERY: WITHIN AND BETWEEN EMBAYMENTS

Alongshore variability in subaerial volume recovery on an embayed coastline is evaluated at distinct spatial scales both within and between four closely situated embayments following a significant storm event. The range of variability in net rates of subaerial volume recovery within individual embayments was found to be substantially larger (by a factor of 10) than between embayments. This variability was observed between embayment extremities and also locations spaced only a few hundred metres apart, considered to be driven by subaqueous morphodynamics and alongshore gradients in nearshore wave energy.

IMPLICATIONS AND FURTHER WORK

This study provides advanced behavioural insight, quantification and key driving parameters of wave-driven recovery processes at microtidal, wave-dominated sandy beaches following storm erosion. The findings provide noteworthy opportunity toward developing improved empirical representation of beach recovery processes and indicate strong links between wave-driven processes and morphology during recovery in both the subaqueous and subaerial environment. Additional potential opportunities for further work in this field may include:

- Examining and comparing recovery processes and behaviour at beaches with differing sediment characteristics, tidal range settings and wave climates.
- Advances to numerically model beach recovery (incorporating wave and aeolian processes) following storm events for assessing vulnerability and resilience to storm erosion and coastal inundation as coastlines evolve over timescales of multiple storms, years and decades.
- Developing tools to accurately predict post-storm beach recovery following major storms that support coastal management decision making and interface with the economic, social and ecological values of local coastal communities.
- Engaging and educating coastal communities of beach recovery processes (which may often go unnoticed following the vivid impact and media attention given to storm erosion) toward informing community expectations and perceptions of broader coastal variability and change in post-storm situations.