



## **The morphological changes of headland-bay beaches in northeast coast of Taiwan**

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An equilibrium in beach morphology is achieved through interactions between the constantly changing coastal processes and the adjustment of beach sediments. Due to the nature of the headlands, it could be easier for sediments in bay beaches to reach a steady-state equilibrium. Even if the beaches experience severe erosion during a stormy season, the beach could normally recover to its original state after the season.

Because of its geographical location, the Northeast coast of Taiwan is often affected by typhoons during the summer and fall seasons. With seasonal changes in wave condition, rainfall, and storm surges, the beaches experience severe erosion in the typhoon season. For this study, we observed three headland-bay beaches in the Northeast coast of Taiwan: Jinshawan, Wai'ao, and Xiao'ao. Among them, Jinshawan beach had been eroded since 1988 due to the construction of a harbor located in the northern part of the beach that interrupts the local current system. The beach sand from Jinshawan had moved northward and filled up the harbor. Even when a fifty-meter breakwater was removed in 2004 and after the beach was replenished with sand dredged from the harbor, the beach has never return to its original state before the harbor construction. On the other hand, in the south side of Wai'ao beach, the Wushi port was completed in 2001. The north breakwater of the Wushi harbor then served as a newly structure-controlled headland. Thus, the morphology Wai'ao beach has changed tremendously, and since then, the shoreline position has adjusted according to the artificial headland. Xiao'ao is a small natural bay beach just next to the north of Wai'ao.

By using satellite images and RTK-GPS, we interpreted historical records of the three beaches' shoreline changes from 2000 to 2016 and monitored the beach profiles every two months since 2016 (Jinshawan) and 2017 (Xiao'ao, Wai'ao).

The results show that Jinshawan's shoreline has remained in a steady-state equilibrium since the removal of the breakwater. Meanwhile, the northern part of the shoreline of Wai'ao retreated for about 50 to 60 meters between the years 2000 and 2005, and the southern part of the shoreline advanced with sand accumulating from year 2010 and on. Compared to Wai'ao, the shoreline of Xiao'ao appeared to have experienced little change over the years. In terms of seasonal changes, all three beaches generally saw their shorelines advance, with berms forming during the spring and early summer. Shorelines will retreat, and berms will disappear after the typhoon season, normally starting from mid-summer to the fall. There is not much difference between the natural bay beach and the structure-controlled beach. The beach recovery process may be completed within a year. Even with the removal of breakwater in the Jinshawan case, or the construction of the harbor breakwater in the Wai'ao case, the new steady-state equilibrium beach could be reached in just a few years.