Wave and storm-induced changes in the sediment transport of beaches in Boracay Island, Philippines

ABSTRACT

The archipelagic setting of the Philippines and its location along the typhoon belt in the NW Pacific makes its coastal areas vulnerable to erosion due to wave action and storm surges. This study examines the influence of waves and storm surges during the passage of typhoon Haiyan on the sediment transport dynamics along White and Bulabog beaches in Boracay Island, Aklan using a 2D-coupled, hydrodynamic-wave with sediment transport model. Specifically, it also identifies the erosional and depositional areas during fair-weather (SW and NE monsoons) and stormy conditions. During fair-weather conditions, the hydrodynamics in Boracay is primarily governed by the monsoonal wind and wave climate which explains the difference in water level, flow and orbital wave velocities, and sediment transport between White and Bulabog beaches. The island is oriented NW-SE wherein White Beach (Bulabog) faces the southwesterly (northeasterly) winds directly. This results to higher (lower) wind and wave setup in White (Bulabog) beach during SW conditions and the reverse during the NE conditions. Bulabog Beach, however, experiences slightly higher wind and wave setup because of the stronger effect of NE winds than with SW winds on White Beach. Sediment concentrations are slightly higher during the SW monsoon compared to the NE monsoon and this can be possibly due to more sediments transported across the wider shelf. Bulabog has a longer fetch and narrower reef crest which amplified the effects of NE wind waves on the beach. During Haiyan, the cumulative effect of the tides, wind, and waves can be seen in how the two beaches were affected. Haiyan occurred in November with predominantly NE winds, with peak storm winds around Boracay that were southwesterly and coincided with spring low tide. Haiyan produced a storm surge in White Beach but not much in Bulabog and almost equal wave setup in both White and Bulabog. Thus, only the White Beach water level showed an abrupt increase in water level (maximum of 1.2m). This may explain why erosion and accretion patterns occurred along White Beach while Bulabog Beach was stable during Haiyan. The magnitude and direction of bedload and suspended sediment transport follow the prevailing wind (and wave) direction during fair and stormy weather conditions. Bedload transport is nil in White Beach during NE and in Bulabog during SW but occurred in both beaches during Haiyan. However, the counterclockwise motion of the typhoon resulted in more pronounced bedload and sediment transport in White Beach than in Bulabog. In White Beach during SW, erosional areas occurred far from the coast while transport is mostly onshore and depositional at the beach, making the beach relatively stable. Note however, that although erosion occurs during fair weather and stormy conditions on either beach, the wide shelf surrounding the island bears the brunt of erosion and the eroded sediments are transported onshore. Moreover, cross-shore transport is more dominant than longshore transport for both fair-weather and stormy conditions since incoming waves break at a wider angle towards the beach slowing down the longshore current's velocity. The analysis was limited to 14 days hence, the occurrence of long-term erosion on the island cannot be accounted for. Thus, for this study period, both beaches appear to be relatively stable.

Keywords: coastal erosion, sediment transport dynamics, Delft3D, Boracay Island, Haiyan