ESTIMATING DEPTH OF CLOSURE FROM VIDEO-CAMERA IMAGES ANALYSIS, A CASE STUDY OF NHA TRANG COAST, VIETNAM

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1. INTRODUCTION

In the central of Vietnam, coastal erosion reaches alarming level with the disappearance of several beaches. Nha Trang Coast is also not an exception of severe erosion. In order to observe morphological change, a video-camera monitoring system was employed on this coast. Thanh et al. (2015) utilized time-averaged images from this system for analyzing the mechanism of shoreline seasonal variation. In this study, longshore sediment transport rate is estimated based on analyzing depth of closure from width of surf zone that was extracted from time-averaged images.

2. STUDY AREA

Locating approximately 300 km to the northeast of Ho Chi Minh City, Nha Trang Coast located in the central of Nha Trang City, Khanh Hoa Province, Vietnam. This study focuses on the right side of Cai River mouth where the most severe erosion on Nha Trang Coast has been observed in recent years (Fig. 1).

Nha Trang Coast is characterized by seasonal variation of shoreline with the retreat of shoreline during the northeast monsoon period and the advance of shoreline during the non-monsoon period (Thanh et al., 2015). Besides, in his study, wave data from a station located approximately 30 km to the east of this coast was used for evaluation of longshore sediment transport rate. However, it is noted that the influence of wind speed and wave intensity from southeast to this coast in the non-monsoon period may be weakened by some large islands in the southeast of Nha Trang Coast such as Hon Tre island that can be seen as obstacles. Thus, estimation of longshore sediment transport rate from analyzing seasonal characteristics of breaking waves, which are characterized by the width of surf zone in time-averaged images, is more reliable.

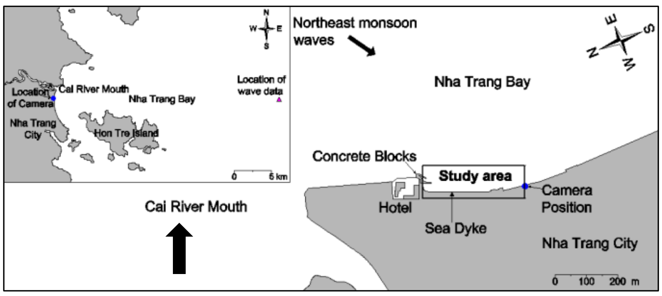

Fig. 1 Study area

3. DATA COLLECTION AND ANALYSIS

This study analyzes fifteen-minute time-averaged video images from 26th May 2013 to 30th January 2015. The time-averaged images were selected at the time when tidal level is equal to 0 every day to ignore influence of sea level change. After that, these time-averaged images were rectified with projective transformation from pixel coordinates into real-world coordinates as seen in Fig. 2. In the surf zone, the intensity signal is the result of a mixture of the breaking and nonbreaking waves. Therefore, the surf zone in the fifteen-minute time-averaged images will be the average of the area-weighted contributions arising from the breaking and nonbreaking areas. According to Fig. 2, the surf zone can be seen as the area of white patterns that are formed due to the presence of white foam induced by breaking waves. Furthermore, at the distance of longshore positions less than 230 m from the hotel is scarcely identified with breaker patterns in the challenging case of energetic waves. In this analysis, the investigation of surf zone is limited in the distance of x greater than 230 m (red rectangle). In fact, in order to find proper identification of wave breaking is difficult. In general, the locations of breaking in the surf zone correlate with the increased intensity values, i.e., the high intensity signals are associated with active wave breaking. Thus, in this analysis, maximum gradient of imaging intensity was identified as the breaking point to distinguish water pixel and breaking point pixel.

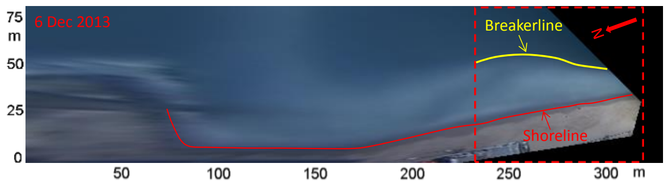

Fig. 2 Projected time-averaged image and breaker line extraction

4. RESULTS AND DISCUSSION

4.1. The width of surf zone: Fig. 3 shows relationship of temporal variation between breaking point and shoreline position from x ≥ 230 m to x ≤ 290 m. According to Fig. 3, during the non-monsoon period, the advance or the recovery of shoreline can be observed; and the breaking point is very close to the shoreline position, namely, the width of surf zone is very small in this period. However, in the northeast monsoon period, the coastal erosion occurred; and the breaking point tends to move away from the shoreline, i.e., the width of surf zone in this period is wider than that in the non-monsoon period. Thus, there is the periodic variation of shoreline and the surf zone for corresponded seasons in the study area of Nha Trang Coast. Besides, the wider surf zone is characterized by the period of energetic waves. Average width of the surf zone in the northeast monsoon period is about 21.1 m while average width of surf zone in the non-monsoon period is about 4.8 m.

4.2. Estimation of depth of closure: According to Kraus et al. (1998), definition of the depth of closure (D_C) can be understood in various ways, depending on research objectives, involving critical depth, depth of active profile, depth of active sediment movement, maximum depth of beach erosion, seaward limit of nearshore eroding wave processes, and seaward limit of constructive wave processes. Depth of

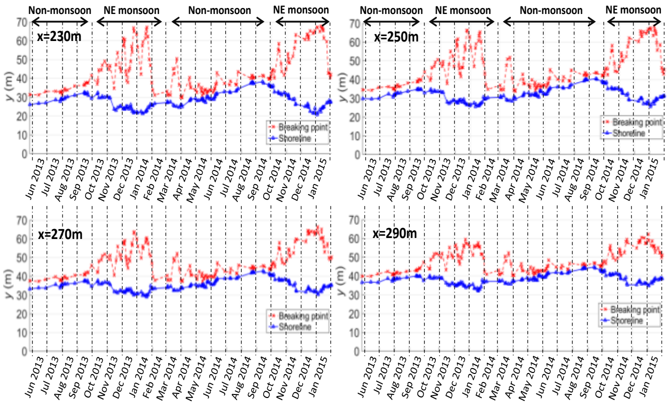

Fig. 3 Temporal variation of breaking point (red line) and shoreline position (blue line)

closure, D_C, can be assumed as a function of breaking wave height:

$$D_c = a\, H_b \tag{1}$$

where wave height at breaking is given by

$$H_b = \gamma\, h_b \tag{2}$$

in which h_b is breaking depth and γ is breaker index.

Besides, the following equation correlates the beach slope, $tan\beta$, with the breaking depth (h_b) and the average width of surf zone ($\overline{W}$):

$$tan\beta = \frac{h_b}{\overline{W}} \tag{3}$$

Combining equation (1) with equation (2) and (3), depth of closure can be obtained:

$$D_c = a\, \gamma\, tan\beta\, \overline{W} \tag{4}$$

The resulting depth of closure for corresponded seasons can be expressed as follows:

$$\frac{D_{c(NE)}}{D_{c(Non)}} = \frac{\overline{W}_{NE}}{\overline{W}_{Non}} \tag{5}$$

where the average width of surf zone in the northeast monsoon period ($\overline{W}_{NE}$ = 21.1 m) and in the non-monsoon period ($\overline{W}_{Non}$ = 4.8 m). Besides, the depth of closure for the northeast monsoon period ($D_{c(NE)}$), which is determined based on wave data analysis (Thanh et al., 2015), is equal to 7.0 m. Therefore, the depth of closure for the non-monsoon period ($D_{c(Non)}$) is equal to 1.6 m.

4.3. Longshore sediment transport rate: Using the calculated depth of closure in the analysis of the width of surf zone, longshore sediment transport rate Eq. (6) in the study area of Nha Trang Coast was identified (Fig. 4).

$$Q(x) = -(D_C + D_B)\int_0^x \frac{\Delta y_s}{\Delta t}\, dx \tag{6}$$

where D_B is height of berm (D_B is equal to 2 m), x is longshore position, y is shoreline position on the cross-shore direction, t is the time. Here, the result of temporal variation of shoreline position ($\Delta y_s/\Delta t$) is obtained by the extraction of the continuous camera images.

In addition, longshore sediment transport rate, which was determined based on seasonal values of depth of closure from wave data analysis (Thanh et al., 2015), also showed in Fig. 4. It is sure that there were the difference of longshore sediment transport regime between two monsoons: from north to south for the northeast monsoon season and vice versa for the non-monsoon season. In addition, significant difference of longshore sediment transport rate between two approaches can be observed in the non-monsoon period. Longshore sediment transport rate in the non-monsoon period were overestimated by using values of D_C for corresponded seasons in the case of performing analysis of wave data. Judging from these results, it is necessary to estimate D_C based on investigating the width of surf zone which can be obtained from time-averaged images analysis.

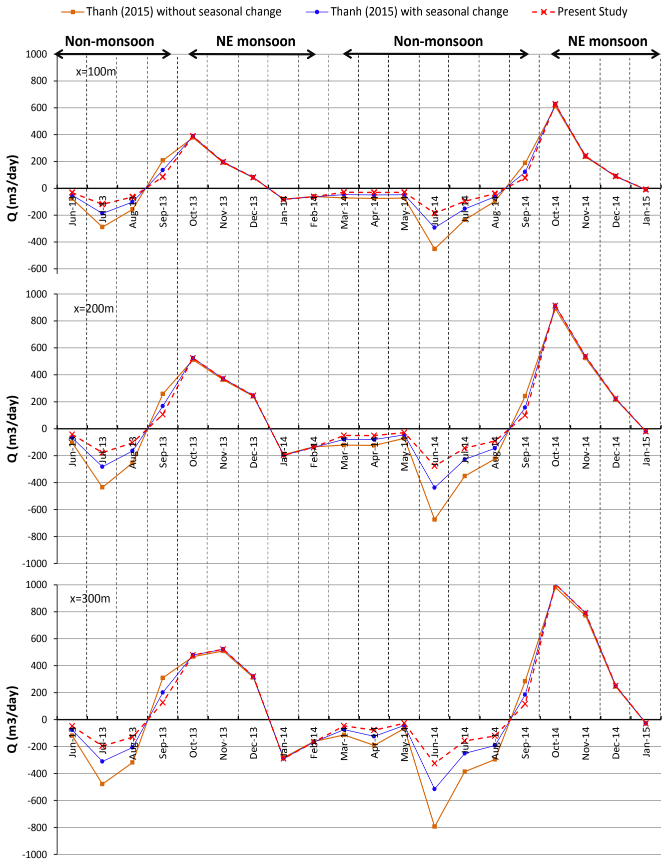

Fig. 4 Longshore sediment transport rate

5. CONCLUSION

The width of surf zone, which characterizes for breaking wave conditions on Nha Trang coast, was investigated from the analysis of camera images. The average width of surf zone in the northeast monsoon period with the dominance of high waves is wider than that in the non-monsoon period with calm waves. In this paper, the depth of closure for corresponded seasons is expressed as a function of seasonal variation of the width of surf zone.

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