SHORELINE EVOLUTION AND ESTIMATION OF LONGSHORE SEDIMENT TRANSPORT ON NHA TRANG COAST, VIETNAM

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1. INTRODUCTION

Nha Trang coast with 4.3 km in length is located in Khanh Hoa province which is situated in the south central region of Vietnam. This coast is of vulnerability to natural hazards. Strong northeast monsoon and typhoons have caused severe erosion in recent years. Therefore, it is of crucial importance for coastal communities to know if shoreline is advancing, retreating or stable as well as to get an understanding of sediment transport process. In this study, the change of shoreline positions is extracted from continuous images of coastal camera surveillance system together with applying of one-line model for estimating longshore sediment transport rate.

2. STUDY AREA

Nha Trang coast is an arc-shaped beach located in the central area of Nha Trang city as shown in small figure of Fig. 1. The prevailing wind directions in this region are northeast and east-southeast. Cai River was considered as the principal source of the sediment to the north of this coast. However at the Cai River mouth, the development of sand spit, which was accreted by this river, cannot be observed in recent years (Viet et al., 2014). Besides, this area is characterized by the protrusion of beachside hotel and concrete blocks playing a role simiar to a groin at the north of this coast. Therefore, it can be observed that there is no sediment transport from this river to the coast over the last years.

This study focuses on the most serious erosion area which is the area on the right side of hotel located approximately 350m to the southwest of the Cai River mouth (Fig.1).

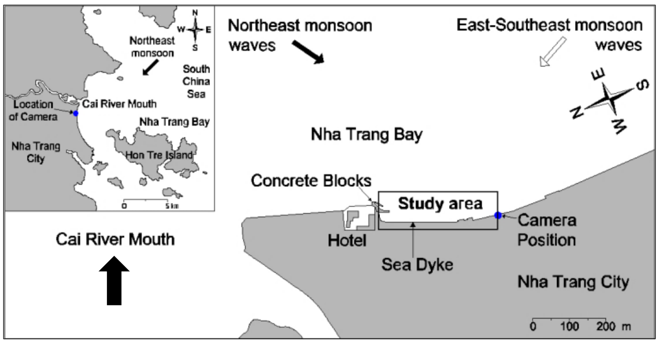

Fig. 1 Study area

3. DATA COLLECTION AND ANALYSIS

Images have been taken in every second by the camera system on this coast since May 2013. This study utilizes time-averaged images which are results of the combination of images taken in each 15 minutes interval. In order to ignore the influence of sea level change, all time-averaged images in this analysis were collected at the time when tidal level was 0. Shoreline positions $y_s(x, t)$ were detected in every 5m in longshore direction and then corrected with sea level. The definition of x-axis and y-axis were performed based on sea dyke position. The positive direction of x-axis and y-axis in this analysis is southward and seaward, respectively (as shown in Fig. 2).

The one-line model, which are discussed extensively by Hanson et al. (1989), has been applied for the simulation of shoreline change and estimation of longshore sediment transport. In this model, longshore sand transport is assumed to occur uniformly over the beach profile down to depth of closure. In this study area, cross-shore transport as source or sink of sand on the landward or seaward side, respectively, can be neglected. The differential equation of one-line model can be obtained as follows (Larson et al., 1997):

$$\frac{\partial y_S}{\partial t} + \frac{1}{D}\frac{\partial Q}{\partial x} = 0 \qquad (1)$$

Where Q: longshore sediment transport rate, x: longshore position, y_S: the shoreline position, t: time, D: the total of depth of closure (D_C) and height of berm (D_B).

Equation (1) can be converted as the following integral equation:

$$\int_0^x \frac{\partial Q}{\partial x} dx = -D\int_0^x \frac{\partial y_S}{\partial t} dx \qquad (2)$$

The definition of x-axis can be seen in Fig. 2 and $Q_{x=0}$ is equal to 0. The equation to estimate longshore sediment transport rate for this analysis can be simplified as follows:

$$Q = -D\int_0^x \frac{\Delta y_S}{\Delta t} dx \qquad (3)$$

Shoreline of the study area was modeled by using uniform spatial in x-axis direction with each 1m in length of grid for the distance 310m. The simulations of sediment transport were carried out for the period from Jun 2013 to May 2014 using a one-month step (∆t). In addition, wave data of many coastal regions in Vietnam is unavailable. Therefore, the values of the depth of closure (D_C=5m) and the height of berm (D_B=3m) are assumed.

4. RESULTS AND DISCUSSION

4.1. Shoreline change: Fig. 2 shows shoreline change of about 310m in length of study area. As a whole, the shoreline evolution is classified into two types: advance (solid lines) or retreat (dashed lines). Shoreline retreated from the end of September 2013 and reached to the position of the sea dyke in December. And then, the most severe erosion occurred and extended to the first two months of next year. In the remaining periods, the advance of shoreline can be observed. The beach on the close side of hotel has more significant erosion than the beach on the far side.

In order to get a detailed view of coastal morphology change, the beach is divided into 4 regions (Fig. 2) and the temporal variation of shoreline position at some longshore positions of each region is shown in Fig. 3. From June to September 2013, the advance of shoreline can be observed

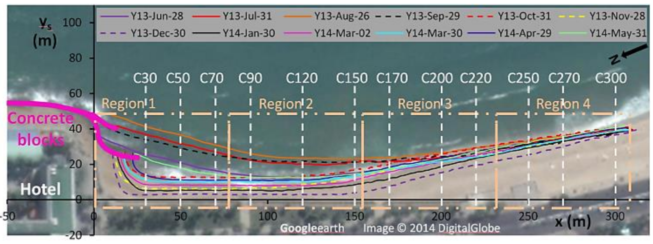

Fig. 2 Shoreline change

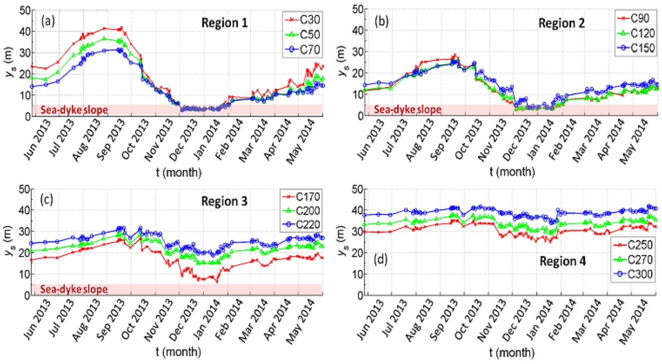

Fig. 3 Temporal variation of shoreline position

in all regions, but there were differences between regions. Shoreline advanced more than 10m in region 1 and region 2 while about 4m is the advance of shoreline in region 3. However, from the end of September to the next 3 months, shoreline retreated remarkably to sea dyke by about 30m in region 1, 20m in region 2 and 7m in region 3. As shown in Fig. 3, the beach is backed by the sea dyke. The shoreline reached to sea-dyke slope in the beginning of December and the coastline was stable until the end of January 2014. The concave shape of the beach can be observed during this period.

From the February to May 2014, gradual recovery of the beach can be observed; shoreline advanced nearly 6m in region 1 and region 2, and about 3m in region 3. In region 4, this study has identified a stable trend of shoreline from Jun 2013 to May 2014.

4.2. Longshore sediment transport rate: Table 1 shows relationship between shoreline change and characteristics of wind and wave on Nha Trang coast. It can be said that the variability status of shoreline in the study area is characterized by the variation of wind direction and wave conditions. In the south central region of Vietnam, high waves induced by the northeast monsoon with strong winds can be observed from September to December. Therefore, there was longshore sediment transport from the north to the south in this period. It can be seen clearly in Fig. 4. Especially, the longshore sediment transport rate to the south in October is the largest. As a result, shoreline retreated remarkably from the end of September to October.

From January to February, high waves are occasionally observed in this region and storm intensity decreases gradually. Shoreline advanced slightly, but in general its shift was still remained around the bottom of sea-dyke slope. Hence, the northward longshore sediment transport rate was small and the severe erosion was still observed in these months.

In the southeast of this coast, offshore is large islands as obstacles to wind and wave (Fig. 1). Besides, wind speed during the east-southeast monsoon period tends to be lower than the northeast monsoon period. Thus, calm waves are

Table 1. Relationship between shoreline change and the characteristics of wind and wave

Prevailing wind direction (N, E, S, W)		↙	↙	↙	↙	↖	↖	←	←	←	↙	↙	↙
Wave conditions		High waves		Calm waves							High waves		
Year	2013					◆	◆	◆	◆	◆ ¤	¤	¤ ✧	¤ ✧
	2014	¤ ✧	¤ ✧	◆	◆	◆							
Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

◆ Shoreline advance ¤ Shoreline retreat or reach to sea dyke ✧ The most severe erosion

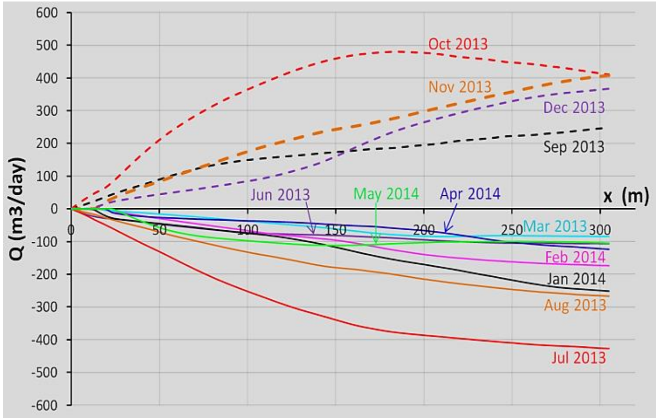

Fig. 4 Longshore sediment transport rate

dominant in this period. As as result, the beach was accreted gradually as well as sediment was transported from the south to the north between March and August. Especially, the longshore sediment transport rates to the north in July and August were larger than other months, so there was the significant advance of shoreline.

5. CONCLUSION

The change of shoreline positions on Nha Trang coast was extracted from the analysis of camera images. The northeast monsoon waves with high waves have caused longshore sediment transport from north to south. Thus, severe erosion can be observed in this period before seeing the recovery of the beach with the northward longshore sediment transport during the remaining periods.

ACKNOWLEDGEMENT

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