FIELD OBSERVATIONS OF SHORELINE CHANGE BY FREQUENCY-BANDED WAVE ENERGY FLUX AND FORESHORE SHAPE

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1. Introduction

The correlation between longterm shoreline change and wave forcing has been the subject of many research works. When considering the effects of wave period, researchers often divide the spectrum into two parts, one characterized by the peak period and a second for the low frequency motion less than approximately 30 s.

In this paper, we analyzed the relation between shoreline change and wave energy flux by dividing the wave forcing into six energy bands. Furthermore, we consider the foreshore shape and relative starting location of the shoreline position in our analysis of the shoreline recession rate.

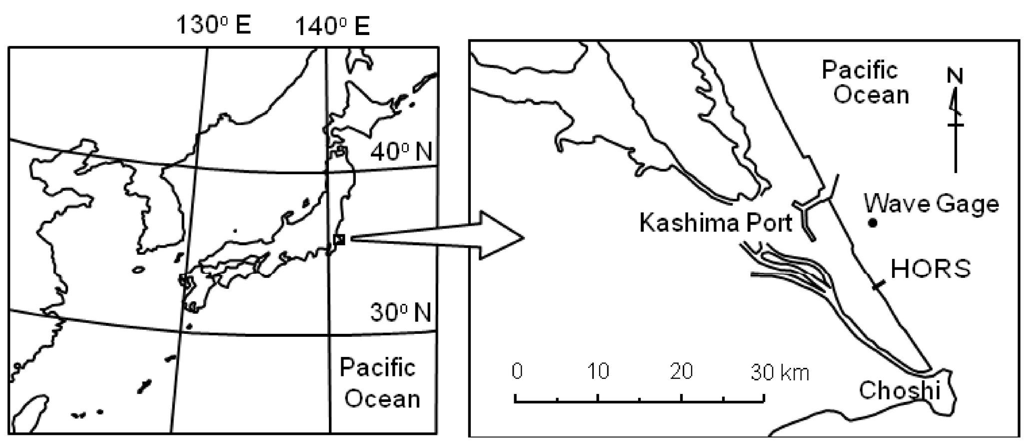
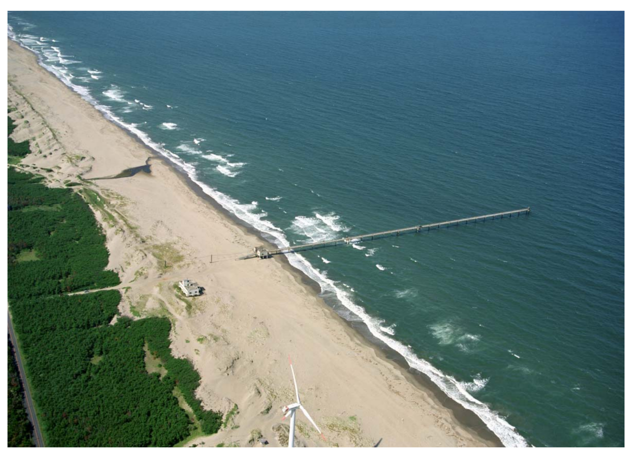


Figure 1. Location of Hazaki Oceanographical Research Station (HORS).



Picture1. Hazaki Oceanographical Research Station (HORS).

2. Data Description and Method

Beach profile data were obtained at Hasaki Oceanographical Research Station (HORS, Fig. 1, Pic. 1), which conducts field measurements of various phenomena in the nearshore zone on the Hasaki coast of Japan. HORS has a 427 m long pier, which is located perpendicularly to the shore. The cross-shore distance along the pier is defined relative to the reference point of HORS, and the seaward side is set as being positive. An ultrasonic weave gage (USW) sensor was mounted at a water depth of 23.4 m offshore of the Port of Kashima (Fig. 1). In this study, the beach profile data and wave data from Jan. 2001 to Dec. 2005 were used. During the investigation period, the averaged offshore significant wave height and period were 1.65 m (varied from 0.37 m to 6.49 m) and 8.51 s (varied from 4.88 s to 17.2 s), respectively.

The shoreline position was defined at the cross-shore location where the elevation is equal to the high water level, D.L., +1.25 m. Figure 2 shows the fluctuation of the shoreline position. Relatively small erosion events occurred seasonally from the end of February to March and were mostly caused by large atmospheric depressions. Moreover, large beach erosion events occurred during the typhoon season, which is from the end of August to September. During the rest of the year, the shoreline retained its position or moved seaward.

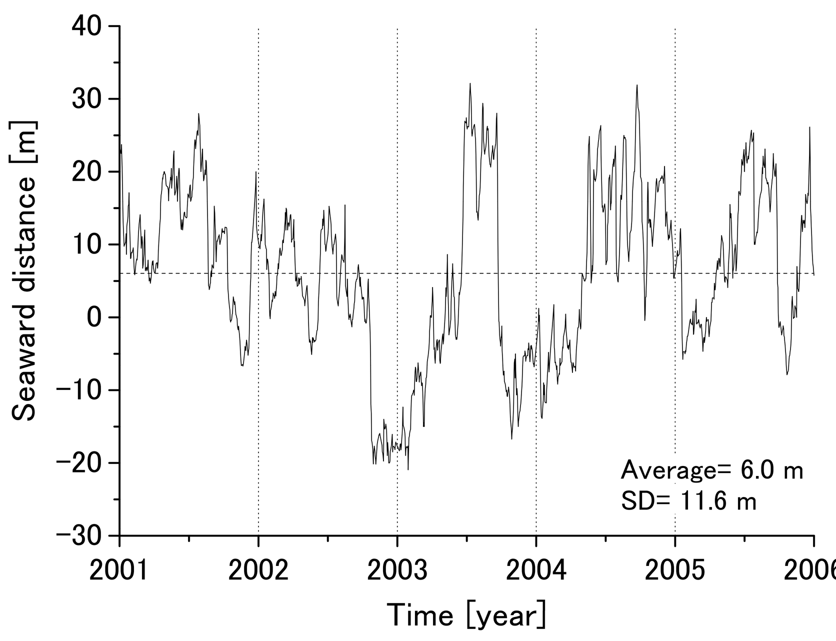


Figure 2. Fluctuation of shoreline position.

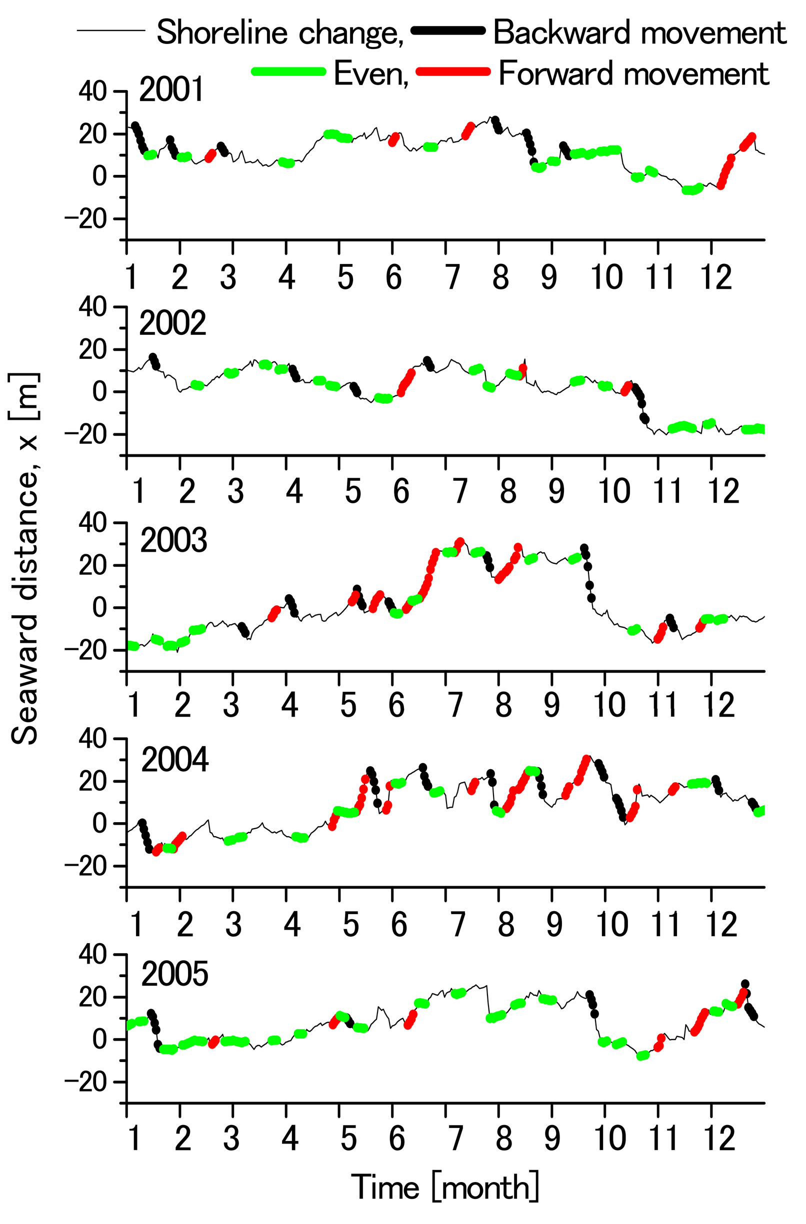


Figure 4. Time series data of Shoreline position (solid line). Bold black line: Backward movement events; Green line: Even events; Red line; forward movement events.

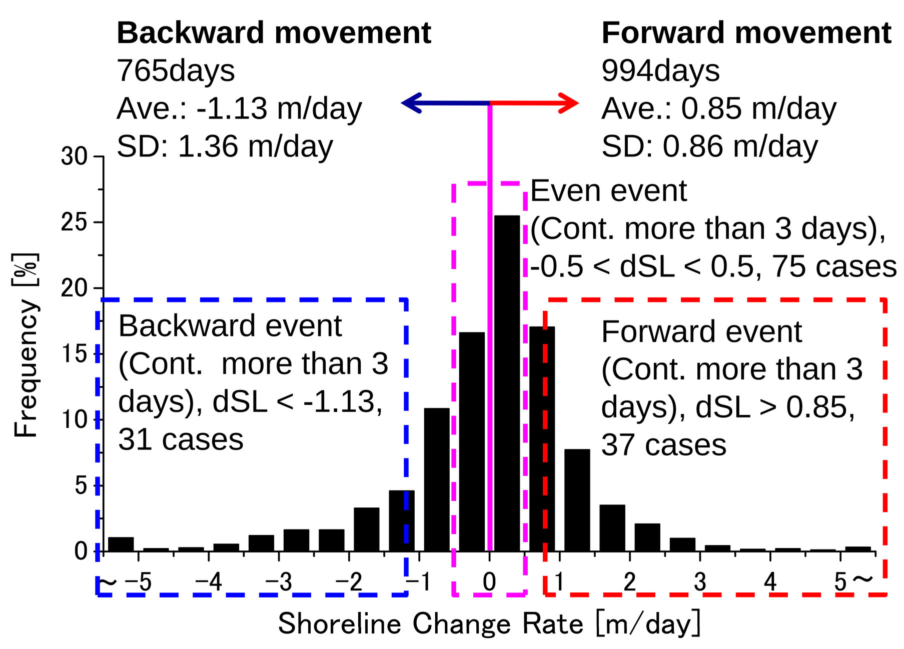


Figure 3. Histogram of shoreline change rate.

Figure 3 shows the histogram of shoreline change rate (dSL). The averaged rates during the backward movements (negative values) and forward movements (positive values) are -1.13 m/day and 0.85 m/day, respectively. Here, backward events (dSL < -1.13 m/day), forward events (dSL > 0.85 m/day), and even events (-0.5 m/day < dSL < 0.5 m/day) are detected from the data. The numbers of these events are 31, 37 and 75, respectively (Fig. 4).

The offshore wave energy flux was calculated by using the offshore wave data (see, Fig. 1). In this analysis, we calculate the each frequency-band of offshore wave energy flux was calculated as follows. Ef1: T > 32.0 s, Ef2: 16.0 s > T > 25.6 s, Ef3: 10.7 s > T > 14.2 s, Ef4: 8.0 s> T > 9.8 s, Ef5: 4.3 s > T > 7.5 s, Ef6: T > 4.1 s. Also, the total energy flux was calculated by using Hs and Ts (Ef).

3. Results and Discussions

(a) Relationship between the shoreline position and frequency-banded wave energy flux:

Figure 5 shows the relationship between the shoreline position and the wave energy flux (Ef: calculated by using Hs and Ts) for each event. The solid line in the figure is used to distinguish the backward movement (shoreline retreat) from the data using the discrimination analysis, and this line has a predictive skill of 89.5 %. However, it seems that the separation between forward (accretive) movement and even (no erosion/accretion) events are harder to define.

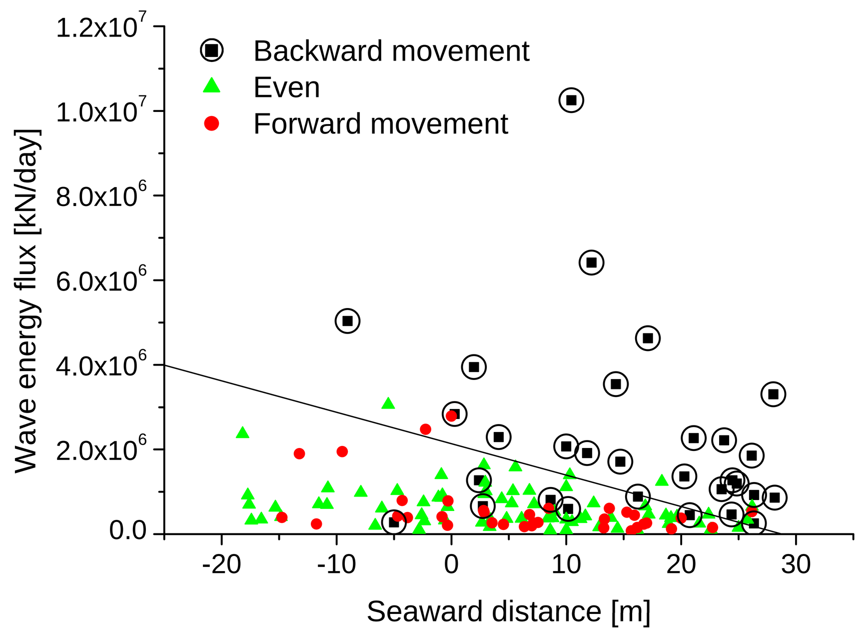


Figure 5. Relationship between the significant wave of energy flux (EF) and the shoreline position (solid line: discrimination line)

By using frequency-banded wave energy fluxes, the predictive skills were calculated in the same way as Fig. 5. The figure of the skills (Fig. 6) indicates that the skills are high at Ef1 (T > 32 s) and Ef3 (10.7 s > T > 14.2 s), where the spectrum densities are most energetic. From these results, it is possible to separate shoreline erosion events from shoreline advance events and shoreline neutral events by using frequency-banded wave energy fluxes.

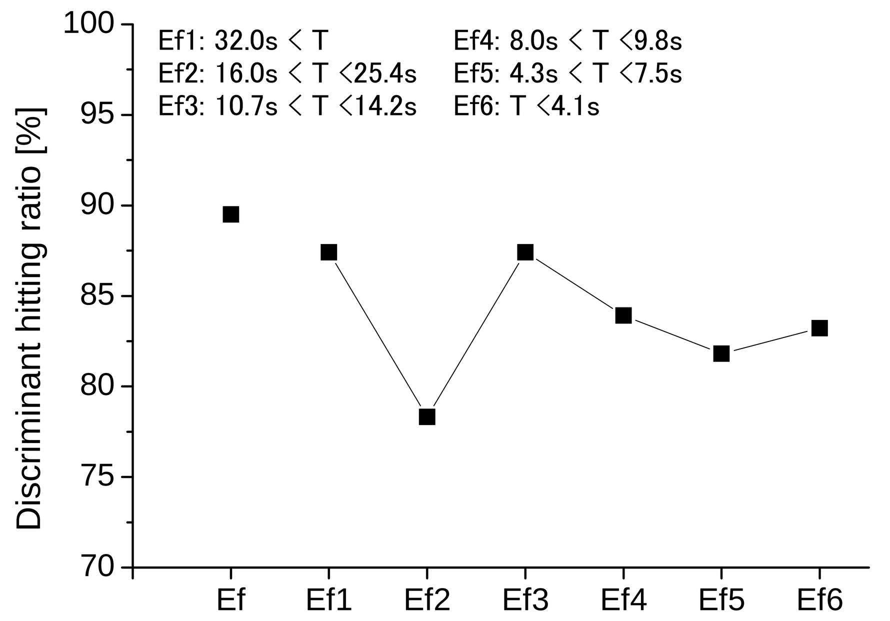


Figure 6. Predictive skills of backward movement events by using frequency-banded wave energy flux

(b) Relationship between backward events and foreshore shape:

We turn our attention to large events with backward (erosion) movement speed faster than -3.0 m/day. For these cases, all of the starting shoreline positions of the events were located seaward of x = 20 m and the 69 % of them include berm erosion (Fig. 7).

Table 1 shows the averaged shoreline position and backward speed of with and without berm shape. With the berm shape, the shoreline located relatively offshore and the backward speed increased 1.6 times compared to without the berm shape. These results reveal that both the shoreline position and foreshore shape affect shoreline backward movement speed.

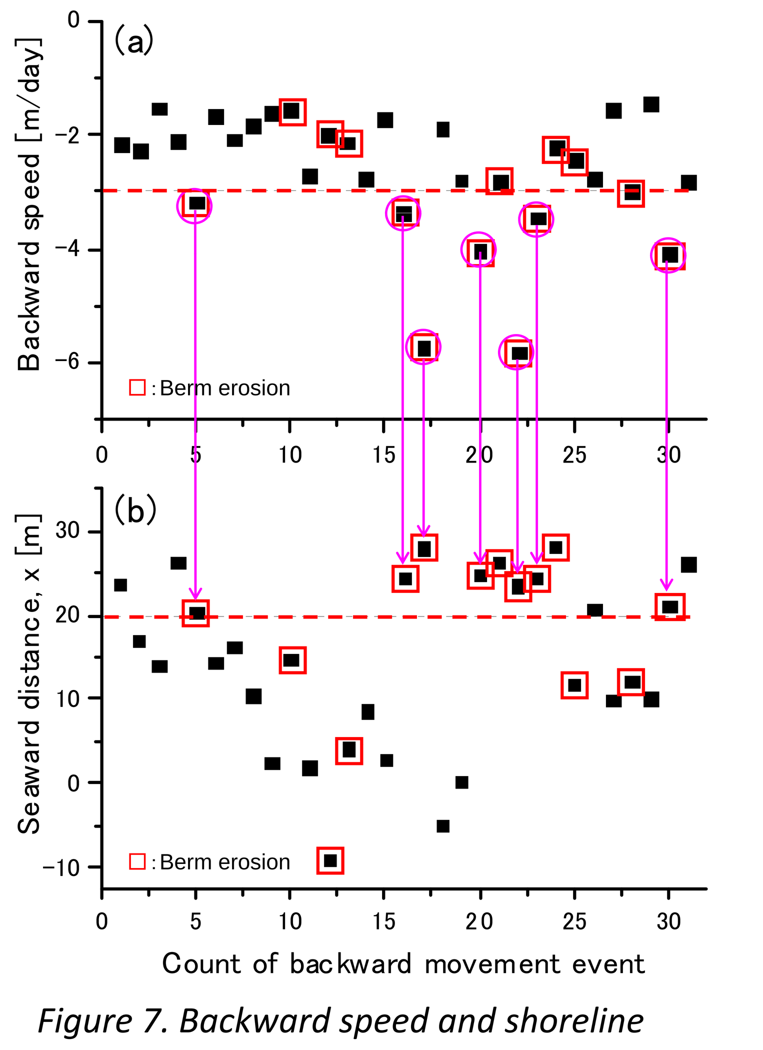


Figure 7. Backward speed and shoreline position of each backward movement events

Table. 1. (a) Sahoreline speed of each backward movement events, (b) Shoreline position of the each event.

	With berm shape: Ave. (SD)	Without berm shape: Ave. (SD)
(a) Shoreline position, x [m]	18.2 (10.6)	11.8 (9.35)
(b) Backward speed, [m/day]	-3.3 (1.3)	-2.1 (0.50)

4. Conclusions

- shoreine erosion events can be separated from shoreline advance and shoreline neutral events by using Ef (wave energy flux calculated using Hs and Ts), Ef1 and Ef3 (frequency-banded wave energy flux; the spectrum densities are high). The predictive skills are over 85 %.
- For the estimation of the shoreline change rate, we need to consider not only wave conditions but also shoreline position and foreshore shape (berm shape).

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