STUDY ON MECHANISM OF SHORELINE CHANGE IN SHICHIRI-MIHAMA IDA BEACH USING WEB CAMERA IMAGES

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Image analysis using Web camera can be very useful tool to clarify the mechanics of beach deformation because it allows time domain analysis of shoreline changes. The purpose of the present study is to extract shoreline from the video images using image processing and investigate the relationship between shoreline change and waves. New method to detect shoreline in images has been proposed and it has been demonstrated to detect shoreline more stable than exiting CCD model. Results reveal that the shoreline tends to advance if the significant wave height is ranged between 1m and 2m, whereas it tends to retreat if the significant wave height is larger than 3m. Furthermore, the image analysis revealed that presence of artificial reefs reduces the retreat of shoreline during storm.

Keywords: WEB camera system, image processing, shoreline change,

INTRODUCTION

Shichirimihama Beach is a gravel beach about 20 km long, located along Route 42 in southern part of Mie Prefecture, Japan. Kumano River is recognized as the major source of Shichirihama beach material. During the period of rapid economic growth in Japan, many dams were constructed in Kumano River, and also large amounts of material had been dredged from this river, resulting supply of materials to beaches has been reduced and the shoreline retreated as corollary. Because of the restrictions on the collection of material from Kumano River, Ojigahama Beach, located on the right side of Kumano River, has gradually recovered. In contrast, the erosion in Ida coast of the southern end of Shichirimihama beach, which is located in the left side of Kumano River, is still vulnerable to erosion due to the constructing of breakwaters in Udono Port which locates adjacent to Kumano river. Hence various measurements such as beach nourishment and construction of artificial reefs have been adopted, but the situation has not been improved yet. The field survey of 2012, there are many concrete block subsided due to the shoreline retreated. Hence it is important to investigate the characteristics of the shoreline changes behind artificial reef over a long period of time in order to consider effective coastal erosion measures in the future. This study aims to investigate the characteristics of shoreline change by analyzing the shoreline data extracted from a Web camera system installed in Shichirimihama Ida coast associated with wave data.

IMAGEPROCCESING

Because waves play as an external force on shoreline movement, mechanism of shoreline change should be analyzed with wave condition, which changing continuously over time. And due to continuously data collection potential, a Web camera is one of the most effective technique for regularly collecting shoreline data over long period. In this case, a reliable method to detect shoreline from image is required.

In this study, in addition to the existing CCD method (Suzuki et al, 2008) which has been applied for many sandy beaches, this study proposes a new method to detect shoreline from image. At first, RGB image data collected by the Web camera system in Ida Coast were used as an input data to examine the applicability of the CCD method. As a result, there still have room of improvement for images that have been taken with the bad weather such as rain. In consideration of the features of the image in such a case, we have proposed a new image processing method.

Camera system in Shichirimihama

The Web camera installed on the seawall behind the Shichirimihama Ida coast, and the images have been stored in the PC installed at the office of Kumano maintain branch of Kisei National Highway Office, Ministry of Land, Infrastructure and Transport through a dedicated optical cable. Then this data are transferred to Nagoya University using the internet in private sector. Every day, the camera has operated from 6:00 to 18:00, image is recorded for 5 minutes at each frame with the interval of one second (See Fig.1). And the average of 300 images at one frame has been used as one input data of image processing.

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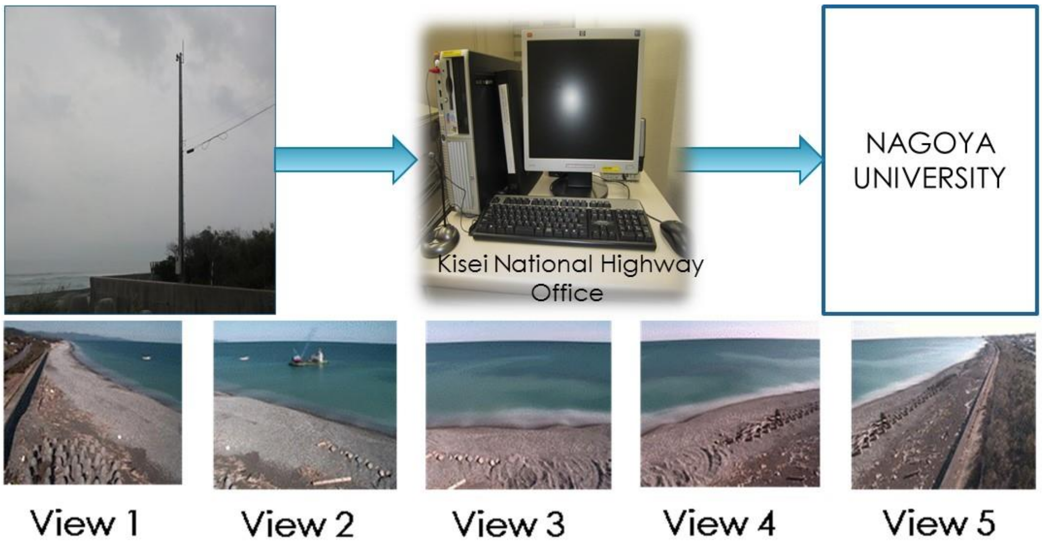


Figure 1. General of WEB system

Applicability of CCD method

The CCD technique is extracting the shoreline by using the difference on intensity of a red color and a blue color between sea surface and beach. Figure 2 illustrates the composition of colors along the cross-shore section moving from land to sea. Figure 2 shows that the difference between the intensity of the blue and red colors increase when proceeds to the sea side. In the wave breaking zone, all colors have almost same intensity, indicating white color is dominant in this area. In the CCD method, this wave breaking position and an empirical surf zone width (called K value) are used to determine the position of shoreline. For Shichirimihama Beach, it was found that K = 0.81.

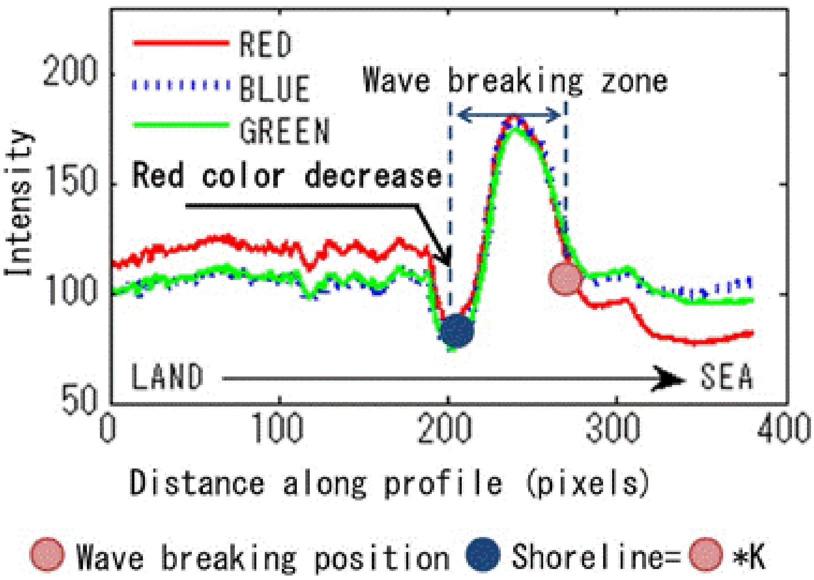
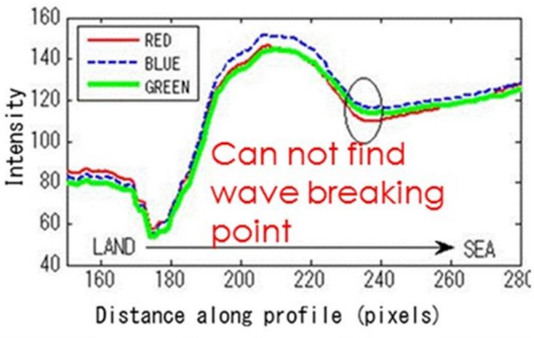
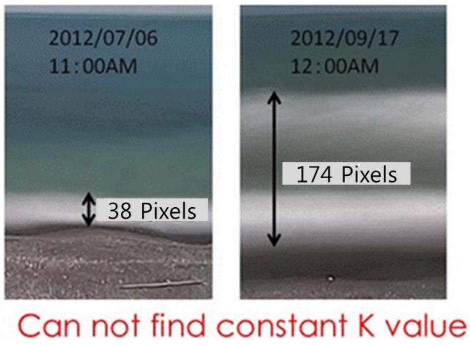


Figure 2. Principle of CCD method and new method

However, as shown in Figure 3a, in rainy weather condition, the difference of the blue sea and red beach is not clear, so it is hard to find the position of breaking point, hence it is difficult to extract shoreline correctly. This is a common problem even in cloudy weather. Due to high effective wave energy dissipation of beach slope, or permeability of the gavel beach, waves off to the beach almost breaking near the shoreline. On the other hand, as illustrated in Figure 3b, in typhoon and cyclones weathers, wave breaking occurs very far from the coast, hence finding a constant K value for specific coast is a very tough task. Moreover Shichirihama Ida coast is facing to the east direction and it contributes more difficult to extracting shoreline by CCD method with images taken in the early morning because of sun light. Therefore, in the present study, a new shoreline detection method is proposed considering all mentioned factors.



(a)

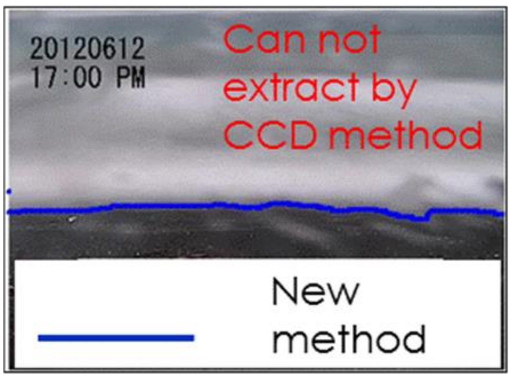


(b)

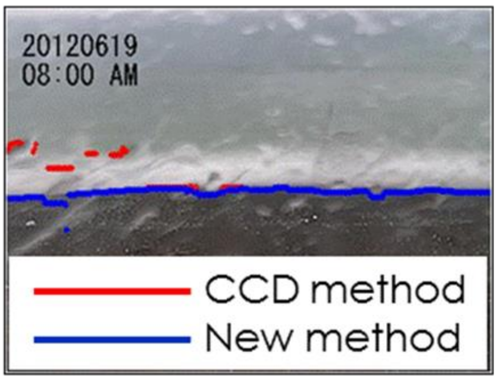
Figure 3. Wave breaking point and wave breaking zone under different weather condition

Principle of new method

In this study, the shoreline rather than the surf zone was detected with paying attention to change in color tone of the beach itself. As shown in Figure 2, on land side of the surf zone, intensity of the red decreases approaching to the sea and it drops suddenly near the shoreline. This trend has been confirmed as a common characteristic for all images despite of weather condition. So shoreline can be detected by finding the position at which the intensity of red color drops abruptly. An example of an output shoreline detected by this method is shown in Figure 4a by a blue dot line. The red line in the same figure shows the result of the shoreline detected by the CCD method. Figure 4a shows an image taken under cloudy weather condition. Under this condition, white color spread over sea surface, thus the wave breaking point could not be detected, then shoreline could not be extracted by the CCD method. However, there is a clear difference in the color tone between the sea surface and beach, and the change in intensity of red color can be clearly identified, so it was possible to detect shoreline by the new method. Figure 4b illustrates an image under rainy weather. Rain drops on camera screen reflect as white color on output image, results locally change of wave breaking zone width, hence a constant K value over image cannot be found for the CCD method. However similarly to the case of cloudy weather in Figure 6a, shoreline can be extracted stably by the present method.



(a)



(b)

Figure 4. Comparison of CCD method and new method

CHARACTERISTIC OF SHORELINE CHANGE

In this section the characteristic of shoreline obtained by the new method will be analyzed associated with wave condition. The shoreline was extracted with the new method is the maximum run up position. In Ida coast, the HF radar wave observation system has been carried out by Mie Prefecture. Therefore, it is possible to analyze the relationship over time of the incident wave changes and shoreline behavior. However, there were many missing data due to system problem, so wave data observed by the GPS buoy system if NOWPHAS at Owase with 20 minutes time interval were used instead of HF radar wave data.

Wave characteristic

Obtained wave data shows that waves approaching to the coast from E, ESE, SE directions dominates over other direction, indicating to generate the northward long-shore current. Waves off to the coast can be divided into three groups according to the wave height: less than 1m wave high, from 1m to 2m wave high, and larger than 2m wave high. Therate of occurrence are 35%, 40%, and 15% respectively. Wave period also can be divided into 3 groups: less than 8s, from 8s to 10s, and larger than 10s with the occurrence rate of 40%, 40%, 10%, respectively.

Shoreline change

Shoreline change of 6 points, P1, P2, P3, P4, P5, and P6 obtained from 1st June 2012 to 30th June 2013 will be analyzed to investigate the relationship between wave conditions and shoreline change (See Figure 5). Among these locations, P1 and P2 locate in the area without artificial reef and P3 throughP5 are in the area behind artificial reefs, P6 is located behind the gap of two adjusting artificial reefs.

•Relationship between shoreline change and incident waves:

In Shichirimihama Ida coast, there is a tendency that a shoreline forwards from June to July. As shown in Figure 9, in this period the incident wave with a height about 1~2m is dominating. In addition, the shoreline change is relatively small when incident wave height is around 1m. On the other hand, temporary shoreline retreat was confirmed when the wave height is larger than 3m. If there is no high wave off to the coast, a shoreline recovery to the original position in almost one week after retreat.

In the early state of a period from August 2012 to October 2012, higher waves than 4m off to the coast result in large amount of shoreline retreat. In the later part, dominating wave condition is about 1m of wave height, then it is observed that the shoreline gradually recover although intermittently 3m height wave off to the coast make some temporary shoreline retreat. From November 2012 to June 2013 low wave energy condition causes the shoreline gradually forward.

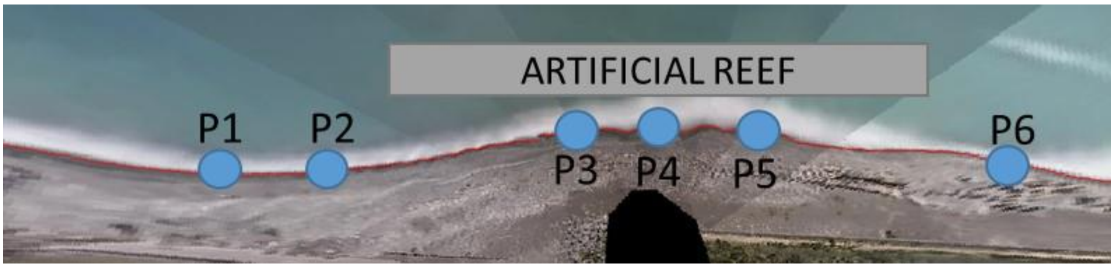


Figure 5. Location of artificial reef on study area

•Shoreline change during typhoon:

As mentioned above, shoreline retreats in high wave energy condition occur during typhoon. In this section, Typhoon 201217 will be taken for analyzing the shoreline behavior during typhoon. Between 28th September 2012 and 1st October 2012, Typhoon 201217 has affected all around Japan, after passing through the main island of Okinawa islands in the 29th September, the typhoon hit to Aichi Prefecture at 19 o'clock 30th September. According to the Japan Meteorological Agency at 17:06 30th September, the typhoon hit Mie Prefecture and caused 134cm tide level. This is the highest tide level of Mie Prefecture up to now. Figure 7 shows the behavior of shoreline during storm, the small V-shape variations indicate the fluctuation caused by astronomical tidal change in a day. As shown in Figure 7, the height of maximum 11m wave results in the largest shoreline retreat during period of study. Figure 8 shows change in the shoreline of about one month before and after including Typhoon 201217. In Figure 8, the shoreline shows a recovery trend after a peak of the storm has passed, but there is a period in which the wave height is greater than 2m, hence the shoreline cannot recover after two weeks. Shoreline is confirmed back to the original position on the early of November 2012.

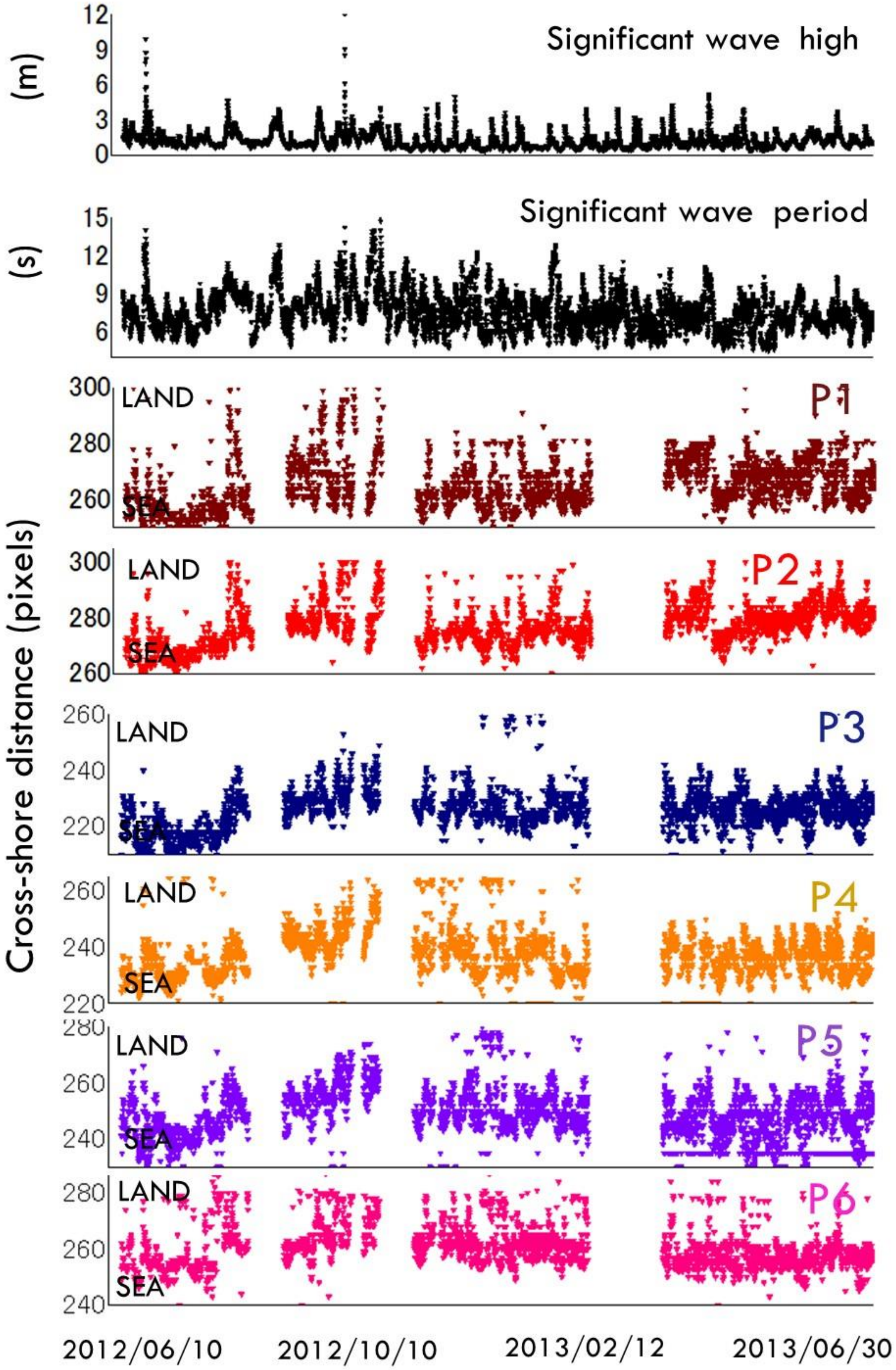


Figure 6. Shoreline change in the period from June 2012 to June 2013

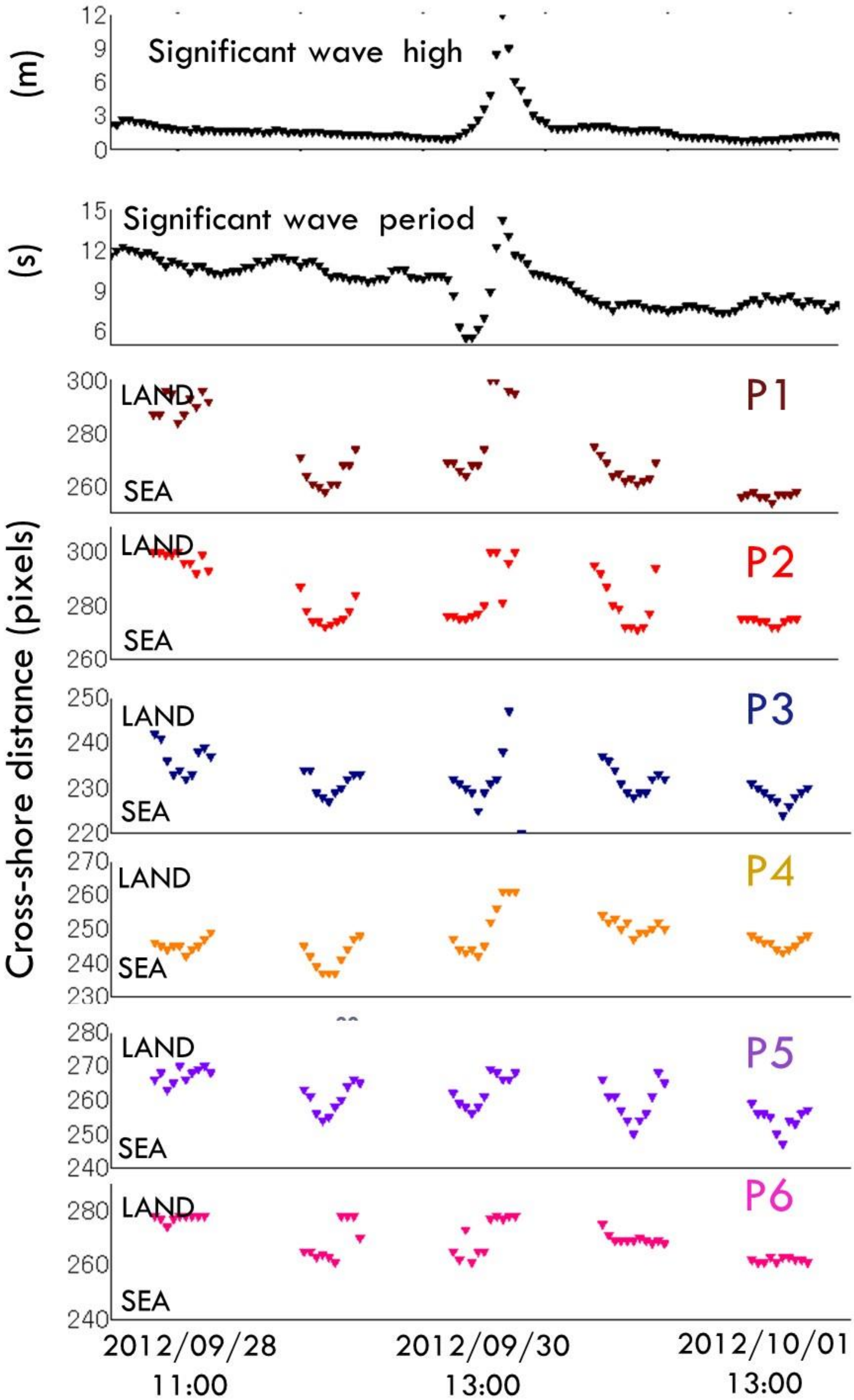


Figure 7. Shoreline change during storm

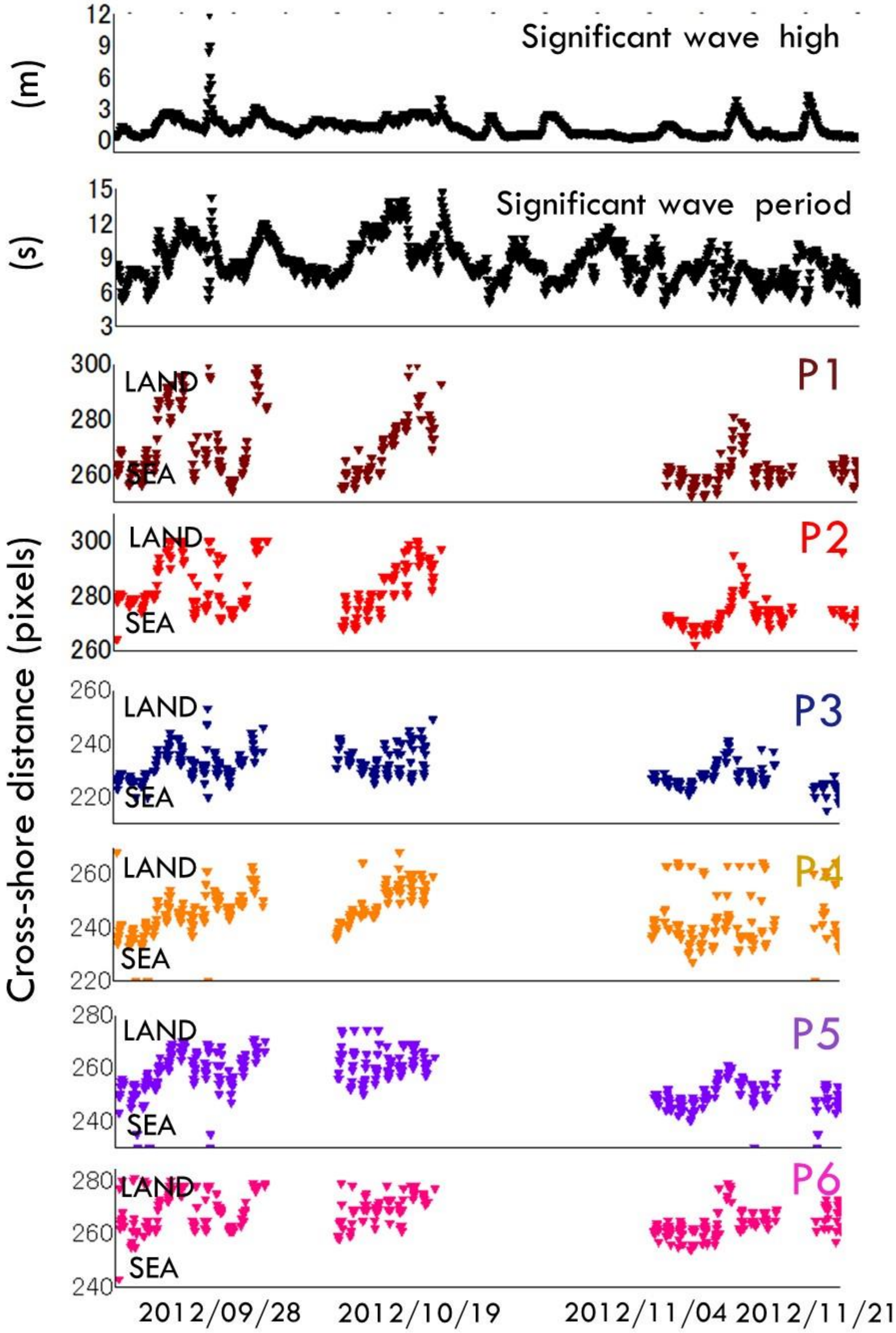


Figure 8. Shoreline change recovery after storm

•Relationship between shoreline change and artificial reefs:

The range of fluctuation is very large at the locations P1, and P2 and they are larger than those of P3, P4, P5, and P6 (Figure 6). During a typhoon, the points located on the area behind artificial reef (P3, P4, P5, P6) show less retreat than points located on the area without artificial reef (Figure 7). In addition, the beach at P3, P4, P5, P6 also recovered faster than P1 and P2 after the typhoon passed (Figure 8). Thus, the important role of artificial reef on reducing the shoreline retreat caused by typhoon has been confirmed.

CONCLUSIONS

This study investigates characteristics of shoreline change by analyzing the image data collecting by WEB camera system in associate with local wave data. Image processing results show that the new method can extract shoreline more stable than the CCD method. According to this study in Shichirimihama Ida coast, the shoreline forwards when the significant wave height is ranged between 1m and 2m, whereas retreats if the significant wave height is larger than 3m. Moreover, the image analysis shows that presence of artificial reefs also reduces the retreat of shoreline during typhoon.

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