ANALYSIS OF BATHYMETRY CHANGE AROUND GROYNE SYSTEM ON ISHINOMAKI COAST

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ABSTRACT

Coastal protection has been an interesting case to study. Groyne, as mean of coastal protection structures, has been applied in many cases in the world. In Japan, it is applied to protect sediment deposition in Ishinomaki Coast and also others coastal. The purpose of this study is to analyze influence of groyne system on Ishinomaki Coast using bathymetry data sheet from 1990 to 2006. Analyzing using standard deviation presents how significant sea bed level change to mean elevation. Using Least Square Method, it can also represent changing bottom rate along those years.

1. INTRODUCTION

Uncontrolled coastal change is one of problem in coastal area. Erosion and deposition rate in some area occurs rapidly, thus requires hydraulic structure for protection. There is various type of construction for this purpose, such as groyne. Groyne has been used in Ishinomaki coast to protect its coastline from severe sediment transport of its bed material which is sandy clay. Furthermore, past construction of breakwater for harbor in nearby area has affected the mechanism of sediment movement. Since 1990 to 2001, seven groyne has been constructed along Ishinomaki Coast. The construction purpose is to manage sediment transport problem along the coast. From previous study, it is concluded that westward movement of longshore sediment is predominant along Ishinomaki Coast (Mochizuki et al., 1990 and Inoue et al., 2002). In long-term prediction, it can be caused severe deposition around Nobiru Coast.

The previous study has already discussed about morphological change based on bathymetry data sheet 1990 to 2002 due to breakwater and also river mouth influence (Takahashi et al, 2005). However, since the final groyne was finished constructed in the end of 2001, the effect of this construction was not evaluate clearly.

2. STUDY AREA

Ishinomaki coast is one of sandy coast in Japan. It is located around 40 km northeast Sendai Port. Its coastline length is approximately 12 km. Ishinomaki Industrial Port is located on the eastern side of the study area, whereas the western side is bounded by Miyato Island as seen in Figure 1. The construction had been started in 1991 when groyne nos. 6,7 was constructed. Following the year, groyne no. 4 was constructed in 1993 and groyne no. 5 in 1994. Miyagi Prefectural Government program to overcome erosion problem was still conducted continuously, along with groyne no. 3 was constructed in 1997, and no. 2 in 1999. Finally, the groyne construction planning has been done in 2001. Groyne no. 1 was installed near Naruse River mouth area.

3. FIELD MEASUREMENT

The measurement has been performed by government from 1990 to 2006, in the winter season, using echosounding and leveling. From this survey it was obtained depth measurement point that was used for further bathymetry analysis along the period. Figure 1 shows field measurement area. Bathymetry surveying has been

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conducted beyond the depth of closure in this coastal area. The measurement area covered 11,6 km in longshore direction and 10 m in spatial interval. Moreover, it is also applied in approximately 600 m in cross shore direction, and 0.2 km spatial interval.

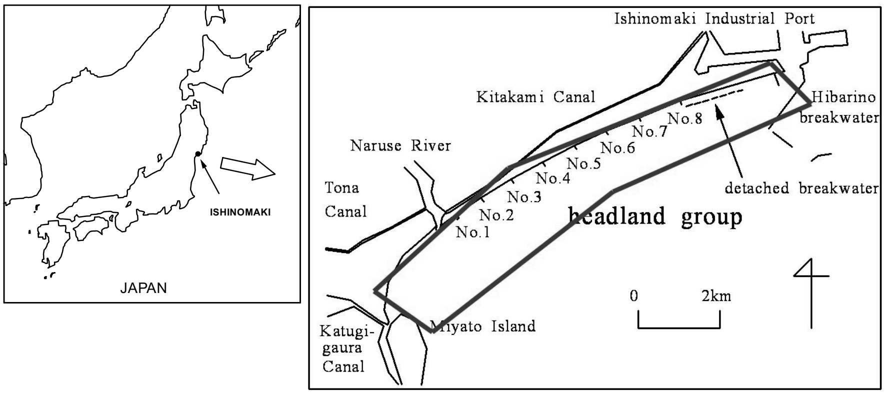

Figure 1: *Ishinomaki Coast, location of groyne system construction and field measurement area*

4. RESULT AND DISSCUSSION

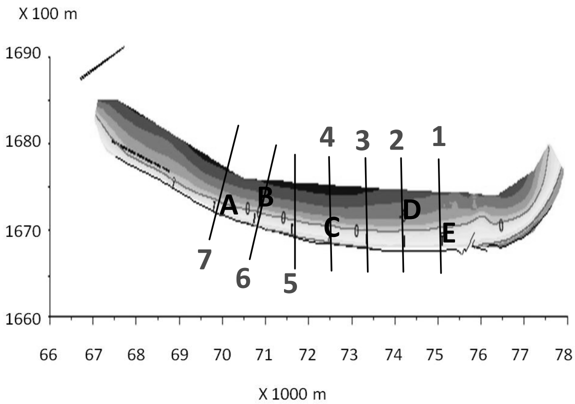

Figure 2: *Cross section location for the analysis*

Analyses of bathymetry change around groyne system conclude comparison of sea bed change for each year, standard deviation, and changing bottom rate analysis using least square method. Mean elevation analysis is one of requirement to generate standard deviation and least square method. These analyses applied in the cross shore direction as shown in Figure 2. The locations of groyne construction are also confirmed in this figure. Comparison of sea bed deformation profile in 1990 to 2006 for each year is shown in Figure 3. It will be difficult to make comprehensive discussion regarding only from comparison analysis.

Therefore, further analysis using comparison result is conducted to understand morphological behavior.

Average Bathymetry

Average bathymetry is the requirement to analyze standard deviation and changing bottom rate. It also presents sea bottom level in relatively stable condition. From 1990 to 2006 bathymetry data sheet, the range value of average bathymetry elevation is 4 m in land to -10 m in deeper area.

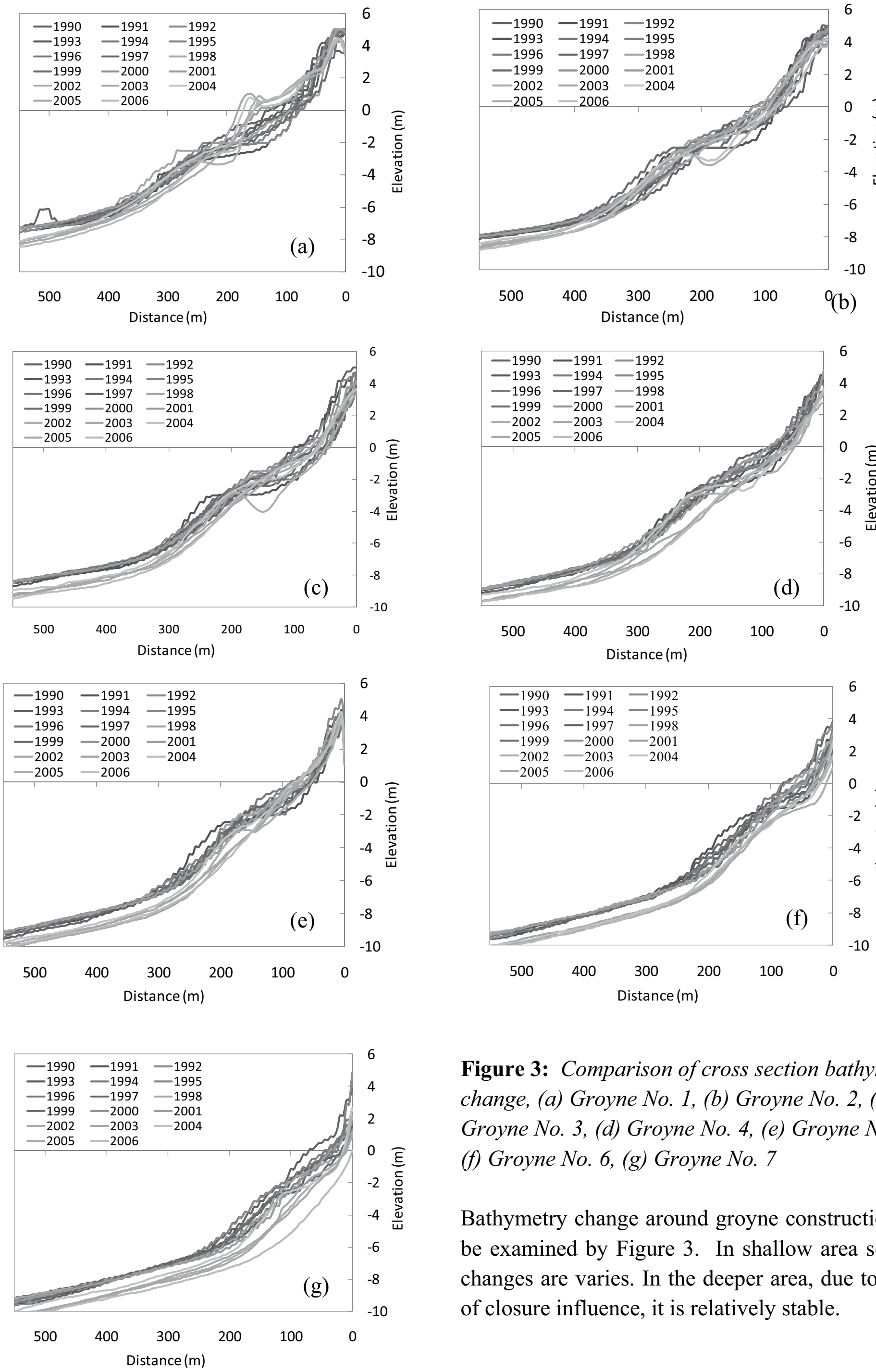

Figure 3: *Comparison of cross section bathymetry change, (a) Groyne No. 1, (b) Groyne No. 2, (c) Groyne No. 3, (d) Groyne No. 4, (e) Groyne No. 5, (f) Groyne No. 6, (g) Groyne No. 7*

Bathymetry change around groyne construction can be examined by Figure 3. In shallow area sea bed changes are varies. In the deeper area, due to depth of closure influence, it is relatively stable.

Standard Deviation

Standard deviation represents how significant sea bed change to mean elevation. Figure 4 shows correlation of standard deviation with sea bed elevation. Regarding to this result, it can be seen that deeper area (TP = -7m) has less variation. Theoretically, it represents this area is influenced by depth of closure. Otherwise, in shallow area (TP = -2 ~ 6m), it shows the largest fluctuation. Sediment movement activity in beach area is the major influence in this phenomenon.

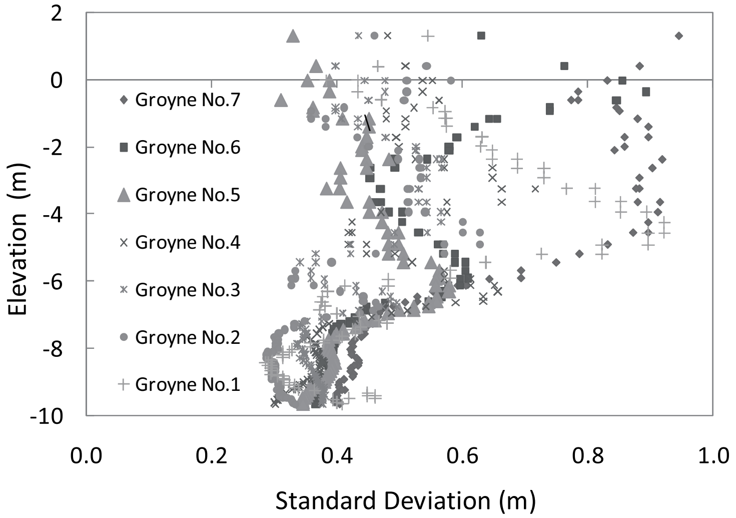

Figure 4: *Standard deviation around groyne system (data sheet 1990 – 2006)*

Trend Analysis

Least square method is one method to examine trend analysis. In coastal case it can be used to understand changing rate of bottom elevation. Using this method, sea bed deformation in meter peryear can be calculated. The locations of measuring point are pointed in Figure 2.

Trend analysis derived from least square method expresses changing rate of bottom elevation as slope or gradient. Using one variable and linier function, the prediction is given by the following equation:

$$Y = aX + b \quad (1)$$

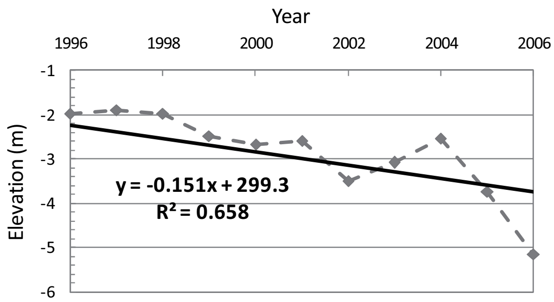

Figure 5: *Trend analysis using Least Square Method in cross section A*

Suppose year is independent variable (X) and elevation is a value of the dependent variable (X) as shown in Figure 5. The R-square as correlation coefficient determines goodness-of-fit of the regression. The R-square takes value from -1.00 to +1.00. The strong correlation is indicated by value closer to |1|.

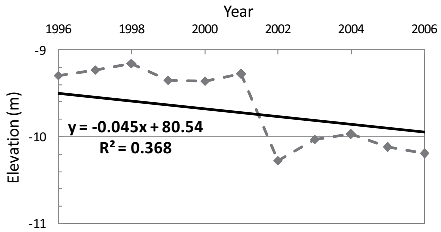

Figure 6: *Trend analysis using Least Square Method in cross section B*

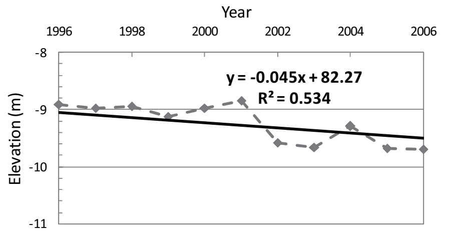

Figure 7: *Trend analysis using Least Square Method in cross section C*

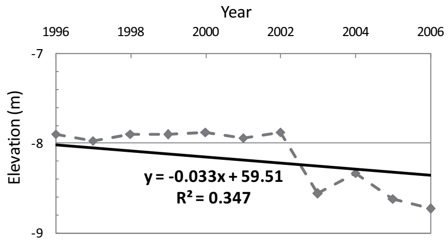

Figure 8: *Trend analysis using Least Square Method in cross section D*

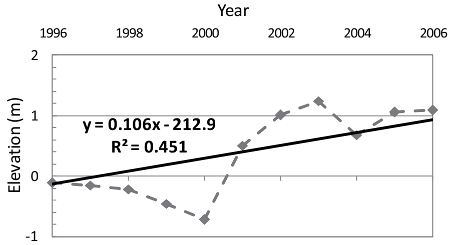

Figure 9. Trend analysis using Least Square Method in cross section E

From figures above it can be examined that erosion occurred in cross section A, B, C and D. In the other side, the trend raising indicates sediment deposition settles in cross section E.

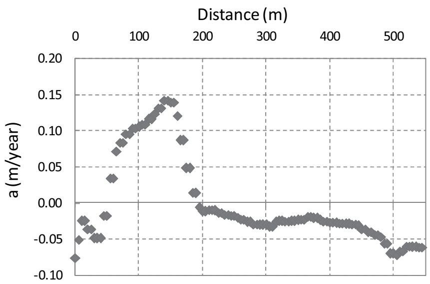

Figure 8: *Changing rate of bottom elevation analysis using Least Square Method in groyne no.1*

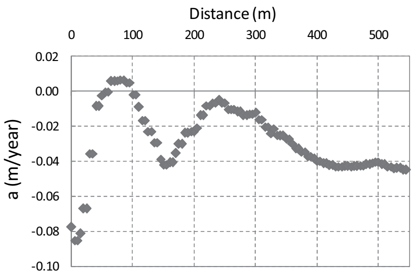

Figure 9: *Changing rate of bottom elevation analysis using Least Square Method in groyne no.2*

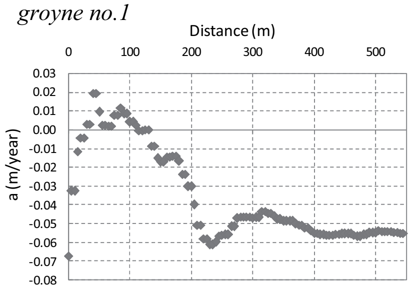

Figure 10: *Changing rate of bottom elevation analysis using Least Square Method in groyne no3*

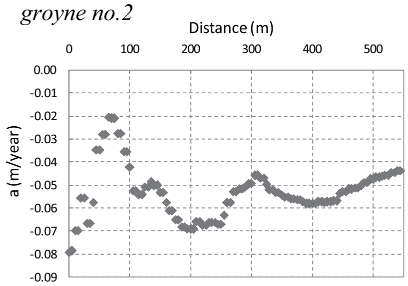

Figure 11: *Changing rate of bottom elevation analysis using Least Square Method in groyne 4*

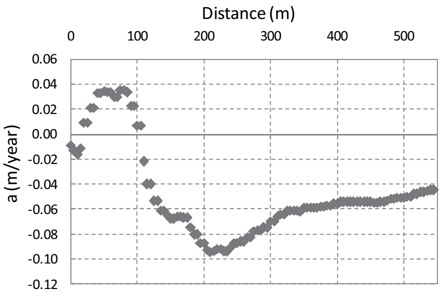

Figure 12: *Changing rate of bottom elevation analysis using Least Square Method in groyne no5*

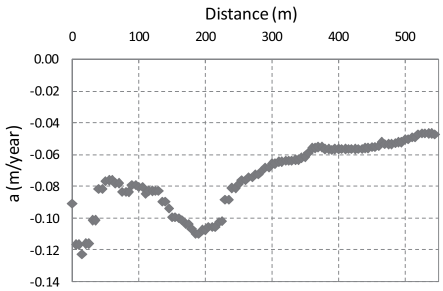

Figure 13: *Changing rate of bottom elevation analysis using Least Square Method in groyne no 6*

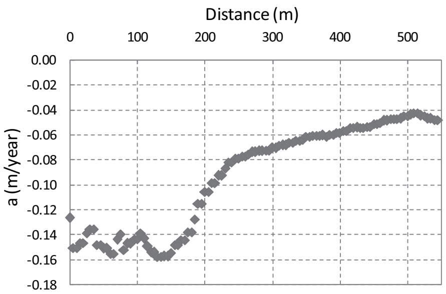

Figure 14: *Changing rate of bottom elevation analysis using Least Square Method in groyne no 7*

The positive value represents deposition occurrence, otherwise the negative value explains depth of erosion in that section.

The maximum deposition reaches 0.15 m/year occurred around groyne no. 1 until distance 200 m and the 0.16 m severe erosion occurred around groyne no. 7 until distance 150 m from shoreline.

5. CONCLUTION

Bathymetry change around groyne system on Ishinomaki Coast can be examined using several methods. Standard deviation shows that sea bed formation has less variation in elevation TP = -7 m to the deeper area. The most variation of sea bed formation is located in shallow area, until elevation TP = -6 m. It gives interpretation that sediment movement activity becomes the main cause in this phenomenon. Trend analysis carried out using least square method represents changing rate of bottom elevation in meter peryear. Positive value indicates occurrence of deposition. Otherwise, negative value presents depth of erosion in representative area. Correlation coefficient regarding the least square method is much smaller than 1. It is indicates that raw data process should be enhanced to acquire a more accurate result

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