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Sediment Budget from the Yamakuni River to the Nakatsu Intertidal Flat and the Mechanism of the Morphodynamic Change of the Flat.

Ken-ichi UZAKI [1], Masashi YONEYAMA [2], Shiori OKUMA [1], Akira TAI [3], Yoshito IKEHATA [4], Hiroki IYOOKA [5]
1. Department of Civil and Environmental Engineering, Gunma University
Kiryu City, Gunma, Japan
2. Penta-Ocean Construction Co.Ltd.,
Bunkyo-ku, Tokyo, Japan
3. Institute Advanced Study, Kyushu University
Higashi-ku, Fukuoka, Japan
4. Department of Technology, Nihon-Bunri University
Oita City, Oita, Japan
5. Department of Social Design Technology, Fukuoka University
Jonan-ku, Fukuoka, Japan

ABSTRACT

Sediment movement from the river to the intertidal flat has not been clarified. Erosion of the Nakatsu Intertidal Flat in the Oita Prefecture in Japan was suspected in these days. However, the truth has not been shown. In this study, high precision bottom survey by using the RTK-GPS and the ADCP had been conducted and sediment discharge from the Yamakuni River was estimated. From these results, sediment budget on the flat was discussed. Finaly, numerical simulations of morphodynamic change was conducted in order to estimate the forecasting of future topography and to propose countermeasures for the erosion.

KEY WORDS: Intertidal Flat; Sediment Discharge; Morphodynamic Change; Field Observation; Numerical Simulation

INTRODUCTION

The catch of fish of Nakatsu Intertidal Flat in Oita prefecture in Japan, which is the second largest intertidal flat in Japan, decreased to the half of that in 10 years ago. As the cause of this decrease, the changes of intertidal flat, which are the erosion and the increase of muddy sediments, are suspected. Reasons of these changes are thought to be caused by the expansion of Nakatsu Port, which is located at the middle part of this flat, and by the Heisei weir and the Yabakei Dam of Yamakuni River. However, what is the truth has not been cleared. In general, sediment movement on an intertidal flat and the budget from the river to the flat have not been cleared, so that effective countermeasures to maintain the flat have not been proposed. Today, these uncleared problems are very important because intertidal flats are considered to play an important role on the water quality of inner bay. In this study, the morphodynamic change of the Nakatsu Intertidal Flat and the sediment discharge from the Yamakuni River were observed. In addition, numerical simulations of morphodynamic change were conducted. Results of this study give the truth of erosion/deposition and the mechanism of morphodynamic change of this flat. Furthermore, the method to evaluate the morphodynamic change of intertidal flats are given.

FIELD OBSERVATIONS

Field observations of the bottom topography survey were conducted in spring and in autumn in 2014 and 2015 by using the ADCP and the RTK-GPS (M9 : YSI Nanotek Co. Ltd.). In the nearshore zone, 14 cross-shore measuring lines were set with 500 m span in longshore direction and 4 longshore measuring lines were also set with 500 m span in the offshore zone. Totally, the measuring area was set at 3 km offshore and at about 8 km longshore. Mrophodynamic changes were calculate by using these bottom survey data. Furthermore, data of bottom survey for about 10 years obtained by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), which manages the Nakatsu Port, were also analyzed. In addition, water sampling were also conducted at the Yamakuni River in order to estimate the sediment discharge from the river to the flat. Fig. 1 shows the observation area

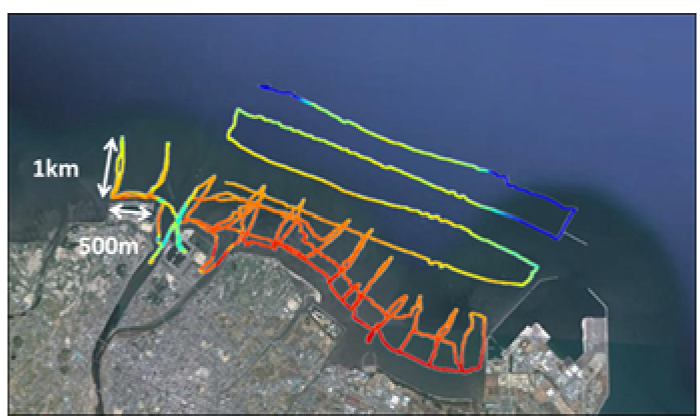


Fig. 1 Observation area and measuring lines.

Fig.2 M9 composed of the ADCP and the RTK-GPS.

and measuring lines. Fig. 2 shows the M9.

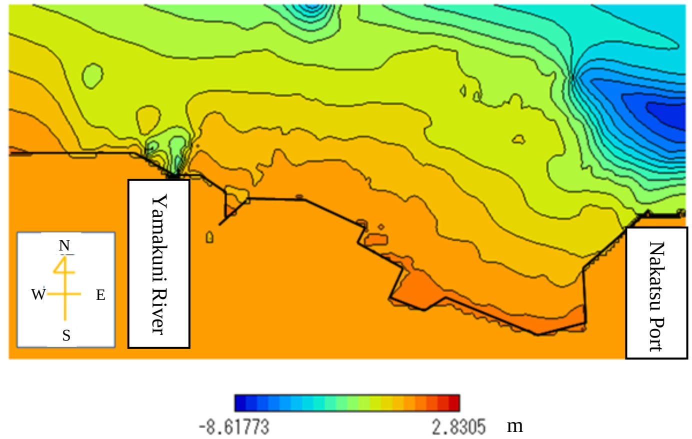
OBSERVATION RESULTS AND DISCUSSION

Two results of observed bottom topography in 2014 and 2015 are shown in Figs.3 (a) and (b), respectively. At the sea route from the rivermouth of Yamakuni River, the dredging of sediments was conducted. Values of dredged sediments were considered in the estimation of total amount of morphdynamic change. The morphodynamic change from 2014 to 2015 is shown in Fig.4. From this figure, we can see the erosion over the almost whole area and it was estimated to be the total amount of about 4,800,000 m^3/year from bottom topographic survey data. From the analysis of AMEDAS data, which is the national climate data, and NOWPHAS data, which is the national wave data network, it is suggested due to the small rainfall and high waves. The sediment discharge from the Yamakuni River was estimated at 142,345 m^3/year. It was estimated by using the water sampling data and the C-Q curve for the suspended load and by using the Ashida-Michiue equation (1972) for the bedload. Fig.5 shows the C-Q curve obtained by using the SS data of water sampling. The morphodynamic change in summer of 2015 was shown to be the deposition of about 190,000 m^3. The sediment discharge from the Yamakuni River was estimated at about 80,000 m^3. The sediment budget of erosion rate and sediment discharge rate was not agreed in both years. It suggests the existence of longshore sediment transport from the northwest of the flat, which will be caused by longshore tidal residual currents from the northwest to the southeast.

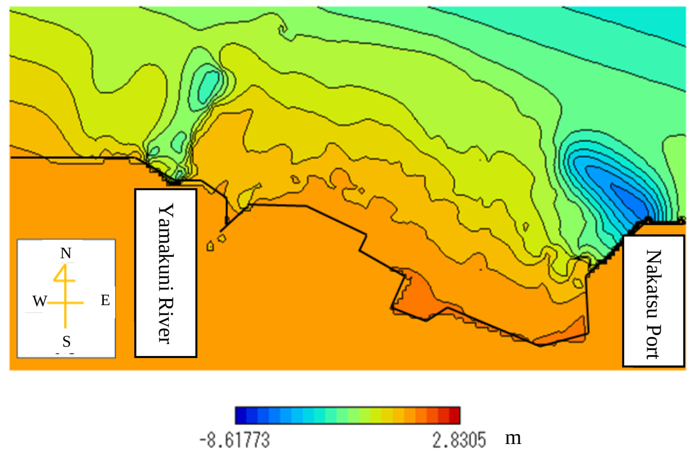
Figs. 6 (a) and (b) show dependences of the erosion/deposition on the rainfall and the significant wave height. Plot data indicate the topography survey data for about 10 years obtained by the MLIT. Each figure shows linear dependence on each factor, so that the multiple regression analysis was applied linearly to the topography survey data for about 10 years obtained by MLIT. The equation was shown in Equ.(1)

$$dh = 5.51\times10^3\, r - 1.11\times107 H_{1/3} + 2.46\times10^6 \quad (1)$$

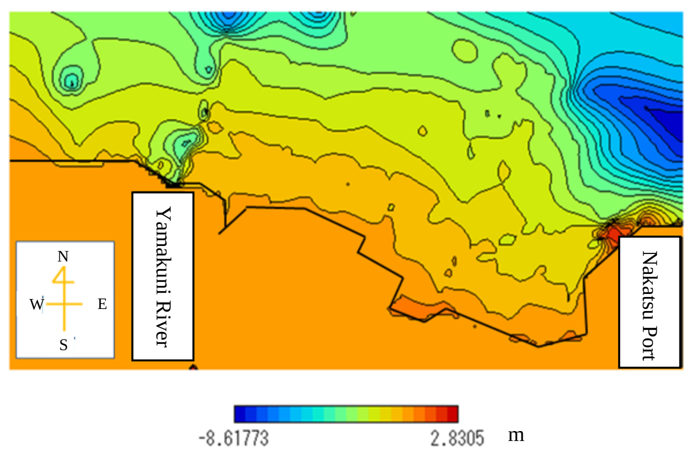
Fig. 7 show the results of the multiple regression analysis. The contour map derived from equ.(1) was well agreed with the plot data.



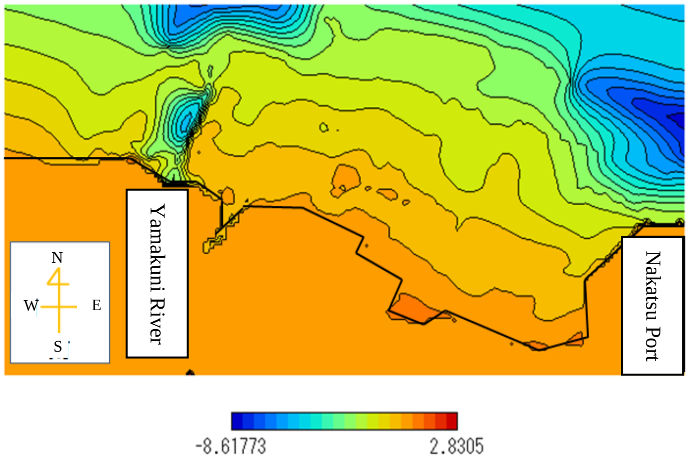
(a) May, 2014.



(b) Sep., 2014.



(c) May, 2015.



(d) Sep., 2015.

Figs. 3 Bottom Topography.

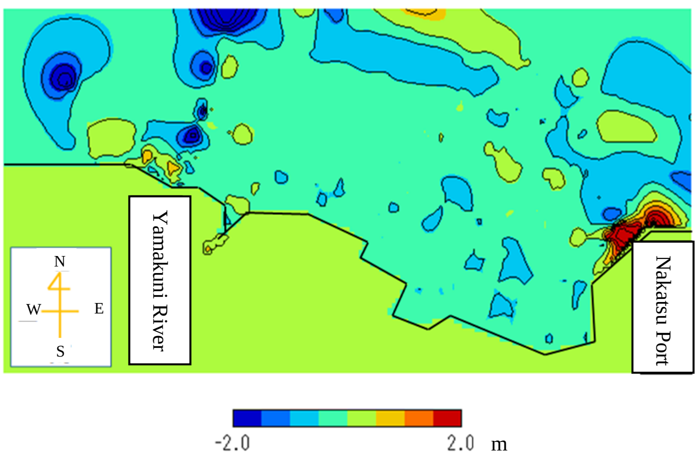


Fig. 4 Morphodynamic change May, 2014 – May, 2015.

NUMERICAL SIMULATIONS

Numerical simulations were conducted by using "WD-POM", which was the three-dimensional morphodynamic change model due to the mud and the sand considering tides and waves. This model was

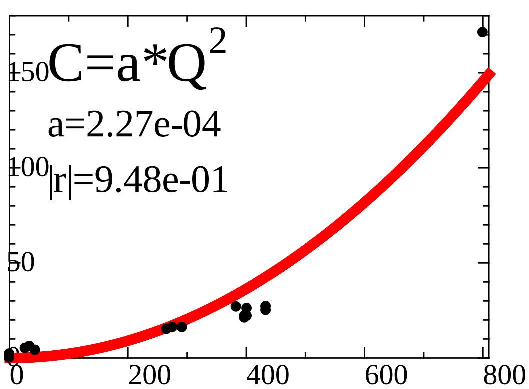
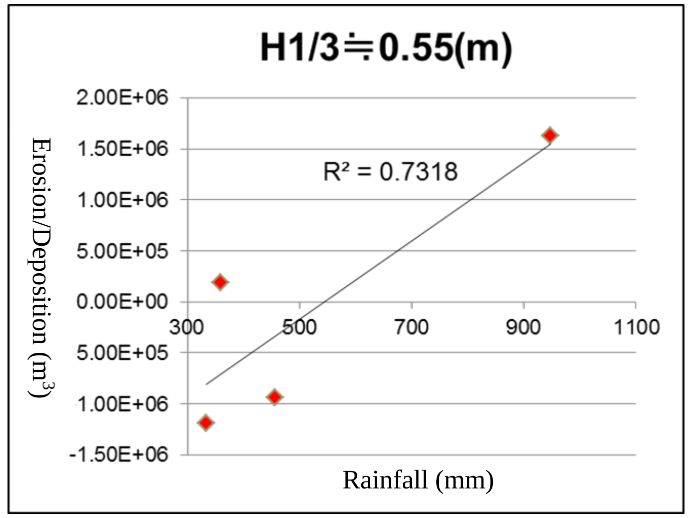
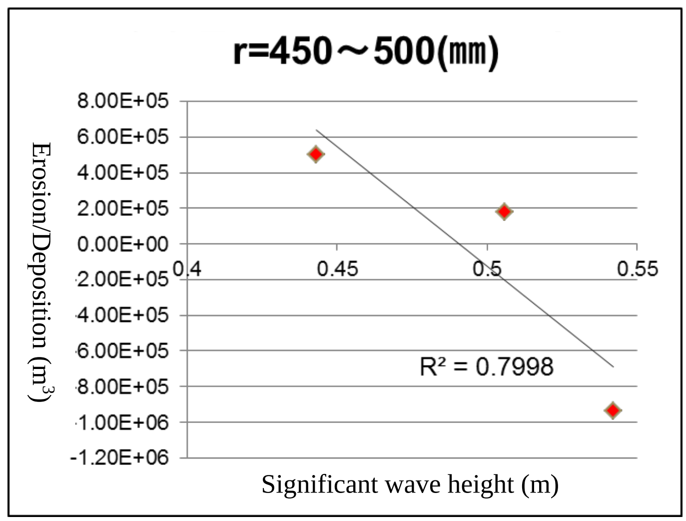


Fig. 5 C-Q curve obtained by the SS data of water sampling.



(a) Dependence of the erosion/deposition on the rainfall.



(b) Dependence of the erosion/deposition on the significant wave height.

Figs. 6 Dependences of the erosion/deposition on two factors.

developed by the authors based on the Princeton Ocean Model. Wave field was calculated by using the energy balance equation, the mud transport by using the advection diffusion equation, the sand transport by using the Bailard model and topography change by using sediment budget equation. Details of this model was summarized in Uzaki et al. (2007). Numerical simulations were conducted by the nesting method. Firstly, the numerical domain was set for the Suo-Nada Sea and secondary for the Nakatsu Intertidal Flat. Figs. 8 shows the numerical domains of the Suo-Nada Sea.

NUMERICAL RESULTS AND DISCUSSIONS

By using this model, longshore tidal residual currents were calculated from the northwest to the southeast due to the unti-clockwise circulation of the Suo-Nada Sea as shown in Fig. 9. Nakajima et al. (2010) and Yagi et al. (2011) also showed such residual currents by using numerical simulations and field observations, respectively. It may

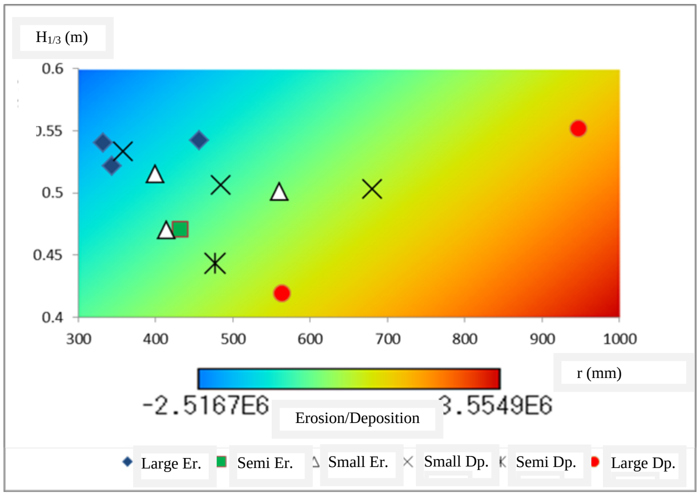


Fig. 7 Results of the multiple regression analysis.

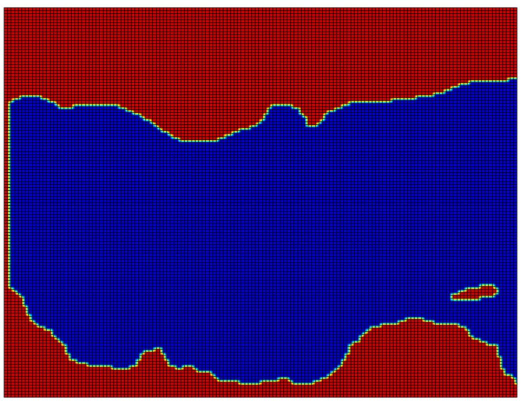


Fig. 8 Numerical domain of the Suo-Nada.

cause the longshore sediment transport on the Nakatsu Intertidal Flat toward the Nakatsu Port. Fig.10 shows coastal currents and tidal currents of the Nakatsu Intertidal Flat at the flood of 21th, June at the ebb tide. Around the rivermouth, a clockwise circulation can be seen. However, the cause of this circulation has not been cleared. This figure shows an example of present simulation progress. In the future work, the forecasting of morphodynamic change of this flat will be made and effective countermeasures will be proposed by using numerical results.

CONCLUSIONS

Field observations of the bottom topographic survey and the water sampling at the Yamakuni River were conducted. From 2014 to 2015, the heavy erosion was observed, which was suggested due to the small rainfall and the high waves. In summer of 2015, the deposition was observed. However, it will be eroded in winter. Results of sediment budget between the erosion/deposition of the Nakatsu intertidal flat and the sediment discharge from the Yamakuni River suggested the importance of longshore sediment transport from the northwest to the southeast. Numerical results indicated the longshore tidal residual currents which was caused the longshore sediment transport along with wind-driven currents and coastal currents due to winter winds. In the future work, the forecasting of morphodynamic change and countermeasures to maintain the flat will be proposed.

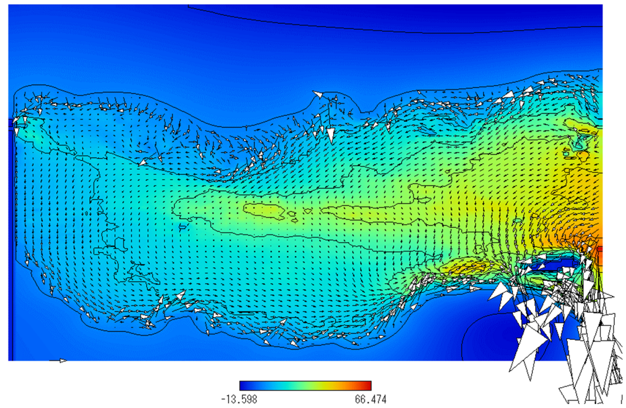


Fig. 9 Numerical result of tidal residual currents of the Suo-Nada Sea.

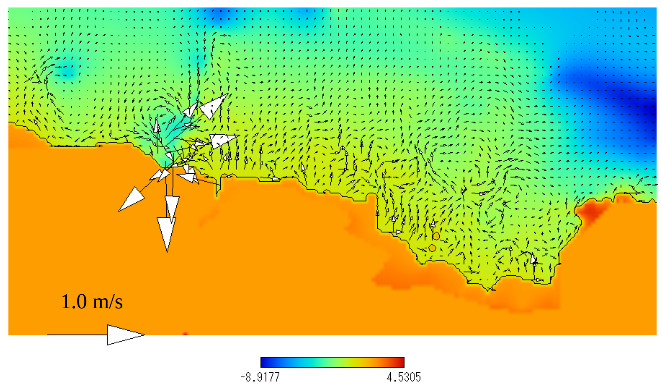


Fig.10 Numerical result of coastal and tidal currents of the Nakatsu Intertidal Flat.

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