SALINITY DISTRIBUTION CHANGE DUE TO MORPHOLOGICAL DEFORMATION INDUCED BY THE 2011 TSUNAMI

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1. INTRODUCTION

Effects of the Great East Japan Tsunami on fish populations and ecosystem recovery has been studied by Ito et al (2016), the distribution and abundance of bivalve can be affected by variations of salinity and depth of the water.

Tanaka et al. (2013) investigated morphological characteristics of estuary after the 2011 Tsunami. Their result showed that the Natori river mouth was severely eroded by the 2011 tsunami, and the water depth is now significantly deeper than before the tsunami. However, there are signs that many damaged areas of coastlines and river mouths are recovering.

On the other hand，studies have been conducted to investigate the spatial and temporal variations of salt intrusion in the estuary. Gong et al. (2014) suggests that salt transport controls the intrusion of salt water, and also influences the transport of sediment and nutrients. Yoon et al. (2015) concluded that in the tidally-dominated estuary, freshwater discharge is the primary environmental factor controlling the salinity during high river condition. Numerical modeling has apparently become the prevailing method because of its convenience, and its results frequently provide high-resolution views of phenomena such as spatial and temporal variations.

The objective of this study is to investigate the salt transport mechanisms and the factors that have influence on salinity distribution in this area. This paper applies a numerical model, which can provide more detail results in space and time, to the salt intrusion and salinity distribution process. Several observation datasets were collected for model calibration and verification. Once the validation showed good results in estimating salt intrusion, it is demonstrated that the modified model can be applied to analysis and prediction of salt intrusion in the Natori River mouth.

2. STUDY AREA

The Natori River flows through the Sendai Plain and ends by draining into Sendai Bay. The river length is 55 km; catchment area 424.3 km^2; and yearly averaged discharge: 17.32 m^3/s. The river's estuary is located on Japan's east coast, and faces the Pacific Ocean.

In the first two years after the tsunami, the shoreline changes very frequently in estuary area, scouring and accumulation often occur. After two years of recovery, the shoreline gradually stabilized and obvious sediment deposition can be seen inside the river channel.

3. METHODOLOGY

3.1 Data collection

The river discharge used in this study was derived from 2 stations (Hirose bridge, Natori bridge) located on two branches upstream of the Natori River respectively. The water level data used for the calibration is derived from two downstream stations (Fukurobara, Yuriagedaini); The tidal level is the observation data from Sendai port. Salinity data began to observe in 2014, the basic observation point St.A, which located around the Yuriage Bridge, St.B in the downstream of St.A; and St.C which located in the upstream but in the deep water. The numbers of observation points vary depending on the year.

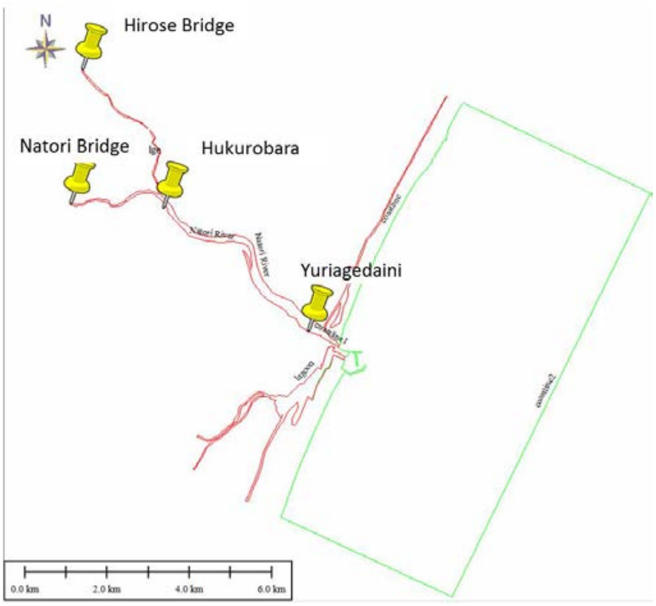

Fig. 1 the Natori river and stations

3.2 Numerical model setup

The EFDC model domain covers the Natori Estuary and upstream to the two branches. Curvilinear grids are used over the entire domain. Use of 15 sigma layers was adopted in the vertical direction. At the two upstream boundaries, river discharges are specified with an inflowing salinity of 0. The east coastal open boundaries are forced by water elevation obtained from the Sendai port, while the inflowing salinities are specified by 35 ppt.

Key words: Salinity Distribution, Estuary, Morphological Change, Tsunami
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4. MODEL CALIBRATION

The hydrodynamic model is calibrated by comparing the modeled water elevations to measurements conducted during March and April 2016 and January 2015 in the Fukurobara and Yuriagedaini station. And the salinity model is calibrated by comparing with observed data gained from St.A in 2016 and from St.A,B,C respectively in 2015.

The model skill is evaluated by two index: RMS and Nash-Sutcliffe Efficiency Coefficient. Overall, the modeled results can be considered as acceptable and the model was used for the following studies.

	Location	RMS	Nash-Sutcliffe
		Water level	
2015	Fukurobara	0.086m	0.798
	Yuriagedaini	0.191m	0.646
2016	Fukurobara	0.186m	0.367
	Yuriagedaini	0.197m	0.68
		Salinity	
2016	St.A	6.828	0.534
2015	St.A	3.585ppt	0.815
	St.B	3.701ppt	0.641
	St.C	2.453ppt	-0.805

Table 1 Index values from comparison of model results with observations

5. DISCUSSION

5.1 Topographic changes caused by the tsunami

At the front of the estuary, the bottom elevation of cross-section which near the lagoon area in 2010 and 2015 is depicted in Fig.2. A severe erosion can be seen in the lagoon area. In addition, during the morphological restoration after the tsunami, the sediment deposition inside channel caused the current river mouth section to appear wider and shallower than before the tsunami. This kind of change may cause more saltwater to flow into the river, exacerbating salt intrusion in the estuary.

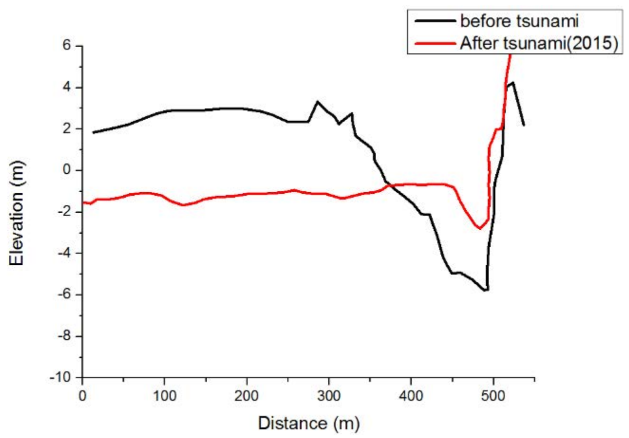

Fig. 2 The elevation changes at the bottom-section of Natori River mouth before and after Tsunami

5.2 The response of salt intrusion to changes in morphology

From the model results in 2009 and 2015, The distributions of salinity in the vertical directions within a distance from estuary to the upstream are shown in Fig. 3.

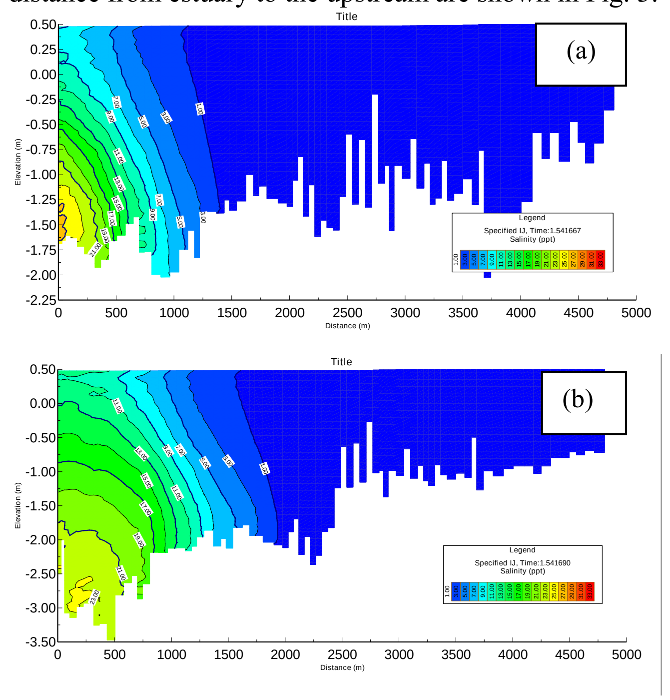

Fig. 3 Vertical salinity distribution before (a) and after (b) the tsunami during flood period

6. CONCLUSIONS

Before the tsunami, the salinity isohaline is almost vertical. However, an angle was formed between the salinity isohaline and horizontal direction in 2015. Compared with before the tsunami, the maximum salt intrusion length also increased.

Acknowledgments

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