MORPHOLOGY CHANGE INDUCED BY THE TOHOKU 2011 TSUNAMI AND ITS RECOVERY PROCESS AT THE NARUSE RIVER MOUTH

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1. INTRODUCTION

The 2011 Tohoku Earthquake and Tsunami is considered the biggest catastrophy happened in Japan in the last recent decade. Many coastal and estuarine regions were devastated overwhemingly which resulted in the dissappearance of sandspits at river mouths and severe erosion along the coast. Naruse River mouth is one of the river mouths that its sandspit was destructed entirely by the tsunami and recovery showed an unsufficient process. However, recently an artifical sandspit had been implemented to reform the previous sandspit before the tsunami and it has become quite stable lately.

In the past, the studies of changes and recovery process of morphology after the tsunami in the Sendai Bay area were multiple; namely, Tanaka et al. (2012), Tappin et al. (2012) and Udo et al (2012). Among them, Tanaka et al. (2012) reported the remarkable changes of coastal and estuarine areas in Miyagi prefecture such as beach erosion and breaching, sand barriers and sandspits' disappearance. Many detailed researches were done to investigate morphology change before and after the tsunami of Naruse River mouth. Kawamura and Tanaka (2003) was one of the very first studies discussing the morphology variation of Naruse River mouth prior to the 2011 Tsunami. After the tsunami occurred, the urgency of understanding the impact and recovery of the river mouth rose subsequently. Min Roh et al. (2015), by using aerial photographs and river mouth cross-sectional data on pre- and post- tsunami discussed about the recovery process and morphological changes at Naruse River mouth. This study, furtherly, made a relationship between measured cross-sectional areas near the river mouth and the tidal prism. Hoang et al. (2017) made a comprehensive study of the morphological variation at the esturies located in Miyagi Prefecture including Naruse River mouth area

With the update of aerial photographs during the period after Tsunami along with the recent implementation of artifical upstream sandspit. It is vital to investigate the latest morphology change of Naruse River mouth and compare to its previous variation before and straight after the tsunami.

2. STUDY AREA

2.1 Study area

Naruse River mouth is located in Higashi Matsushima City having the river length of 89 km and catchment area of 1133 km^2. The noticeable features of the river mouth are the upstream sediment deposit and downstream sandspit at the entrance respectively as shown in Figure 1. The river mouth is categorized as class A which water resources and protection against natural extreme disasters are managed by the national government. The present of existing jetties at the river mouth have the function of maintaining the river's shipping and navigation path.

2.2 Data collection

This study utilized main source of aerial photographs and data provided by Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and Higashi Shiogama City Office

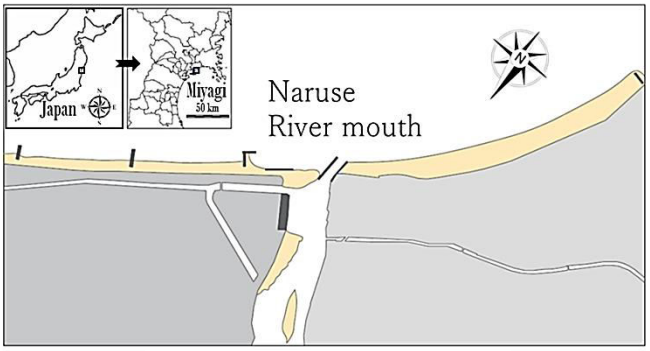

Figure 1: Study Area

along with some imagery data from Google Earth Database and GPS data from field trip. The period of observed data is from 2002 to October, 2018.

3. RESULTS AND DISCUSSION

3.1 Naruse River mouth morphology variation before and after the Tsunami

During almost 10 years before the 2011 Tohoku Tsunami, the morphology upstream sediment deposit and sandspit were moderately stable and their variation is very slight. However, after being hit by the 2011 Tsunami, entire downstream sandspit was faded away as the consequence that waves are able approach upstream furtherly and dig up the sediment near left bank's embankment to transport upstream, while due to wave diffraction, huge amount of sediment goes into Kitakami canal and affect negatively the fishing port. This leads to the significant reduction of the upstream deposit afterwards (Figure 2)

During 6 years after the tsunami, the sandspit was not able to recover as a result of insufficient supply from surrounding sandy coasts. Both longshore sediment transport direction are obstructed by a left side T-headland and jetty on the right side. In the meanwhile, Naruse River is not a large catchment area and the sandpsit is restrained by wave's interaction. Therefore, the upstream deposit had been stable

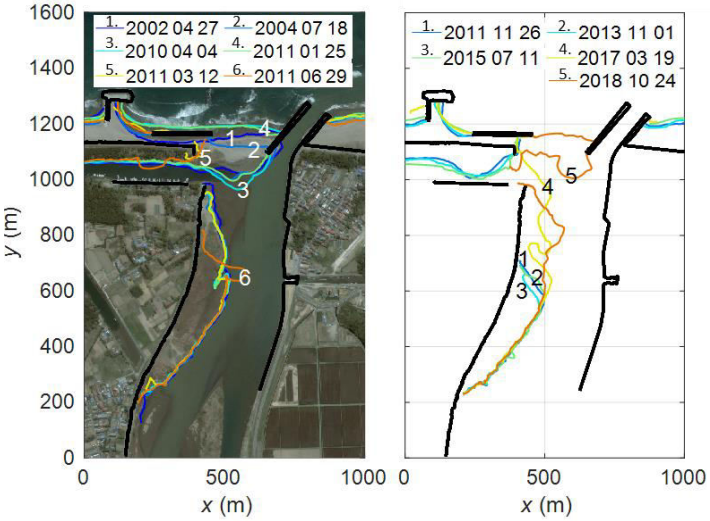

Figure 2: Shoreline position (2000-2018)

Key words: Naruse River mouth, 2011 Tohoku Tsunami, recovery process, sandspit, aerial photographs
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Figure 3: Left: Definition of river mouth quantities, Right: Artifical sandspit (2018/03/19)

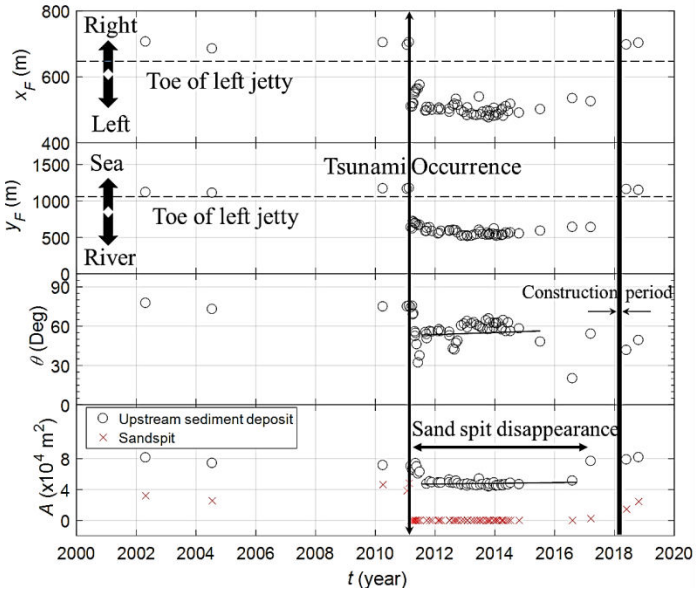

Figure 3: Analysis of Naruse River mouth quantities

and its orientation with wave incident has minor variation.

The morphology of Naruse River mouth remained till the end of 2017 when an artificial sand spit was created in the period from 19th February, 2018 to end of March, 2018 in regard to a project of reformation of the sandspit by clearance sediment inside Kitakami Canal. The construction was successful and the renewed sandpsit has stayed steady lately. However, the response of the sandspit over river mouth impacts has not yet been evaluated overall until more observation and investigations are made.

3.2 Analysis of Naruse River mouth characteristics

To examine the river mouth variation quantitatively, several quantities of river mouth are defined and discussed thoroughly consisting of area of downstream sandspit (A_1) upstream sediment deposit (A_2), the farthest point in longshore direction where it gives the minimum river mouth width (x_F,y_F) as well as orientation of upstream sediment deposit (θ) (Figure 3).

Figure 4 shows evidently the farthest location is influenced by the existence by the upstream sandspit. When the downstream sandspit presents, the minimum river mouth with is almost equal to distance between two jetties; whilst during the period the sandspit was lost, the minimum river mouth width was dependent on the upstream sediment deposit.

The orientation of upstream sediment deposit reflects minor changes till 2017 because a stable angle between approaching wave and its shoreline and afterwards, the angle was reducing since the sediment fulfilled the Kitakami canal and sediment was transported further upstream. The area value also stated the disappearance of the sandspit and its recovered amount after the construction. However, the upstream sediment deposit indicated more important details which straight after the tsunami, its area had not reduced yet but then lost a tremendous amount owing to scoured sediment by waves. And on which the canal entrance was obstructed by sediment, subsequent sediment transported towards the upstream sediment deposit resulting on the rise in its magnitude from late 2016.

4. CONCLUSION

The 2011 Tohoku Tsunami was responsible for a significant change in morphology at Naruse River mouth. The tsunami flushed away the sandspit and let waves approach further into the river mouth and scour the sediment on the upstream sediment deposit. The recovery showed no progress till the implementation of artificial sandspit in 2017 which reform the previous downstream sandspit. The characteristics of prior morphology of Naruse River mouth has been recovered as being in the past.

5. ACKNOWLEDGENEMT

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