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RECENT MORPHOLOGICAL CHANGE AT THE NARUSE RIVER MOUTH, JAPAN

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Abstract: The Naruse River mouth showed stable topography at least for these 46 years. However, sediment deposit occurred in July 2002, which caused difficulty in ship operation going in and out of a port located in the river mouth. In addition, the behavior of the morphology of the river mouth after the flushing of the sand spit on the left-hand side has never been observed for these 50 years. In this paper, characteristic morphological change at the Naruse River mouth is shown with the use of aerial photographs and morphological maps. Furthermore, time-variation of water-level in the river mouth is compared with tidal variation. From this analysis, it can be concluded that the river mouth closure has occurred just before the flushing of the sand bar in July 2002.

Key words: Sand spit, River mouth closure, Naruse River, Harmonic analysis

1. INTRODUCTION

Sand spit at a river mouth prevents waves and salt water from intruding into a river. However, excessive development of sand spit causes serious problems such as water level rise during a flood and difficulty of navigation through a river mouth. To maintain a river mouth, it is important to understand the river mouth morphology behavior responding to waves, tide, river flow and construction of structures around a river mouth.

The Naruse River mouth has been stable at least for these 46 years, with two jetties at the river mouth and fully developed sand spit on the left-hand side of the mouth. However, sediment deposit between the jetties, observed in July 2002, caused difficulty in navigation in the mouth. Although sediment deposit between the jetties, as well as the sand spit on the left-hand side of the jetties, was flushed during a flood in July 2002, the sand spit did not recover to its equilibrium state. After the flood, the sand spit tends to migrate into the river. There is still concern about the difficulty in ship operation and water level rise during a flood caused by inward migration of the sand spit.

2. STUDY AREA

The mouth of the Naruse River is located on Ishinomaki Coast, Japan as shown in Fig.1. The catchment area is 1,133km^2, and the length of mainstream is 89km. The Nobiru water level station is located in the river mouth about 0.5km upstream from the mouth. The river mouth is characterized by two training jetties along with fully developed sand spit on the left-hand side of the river mouth, as seen in Photo 1.

The constructions of Naruse-churyu Weir, Korie Weir and Miyatoko Dam are principal events in the recent years in the river basin that might have affected sedimentary environment including the morphology of the river mouth. On the other hand, as an event in the coastal

area, the construction of eights headlands from 1990 to 2000, for preventing erosion of the coast, should be pointed out (Sato et al., 1998).

Almost all of the aerial photographs, which have taken since May 1956 to May 2002, show very stable topography of the river mouth as seen in Photo 1.

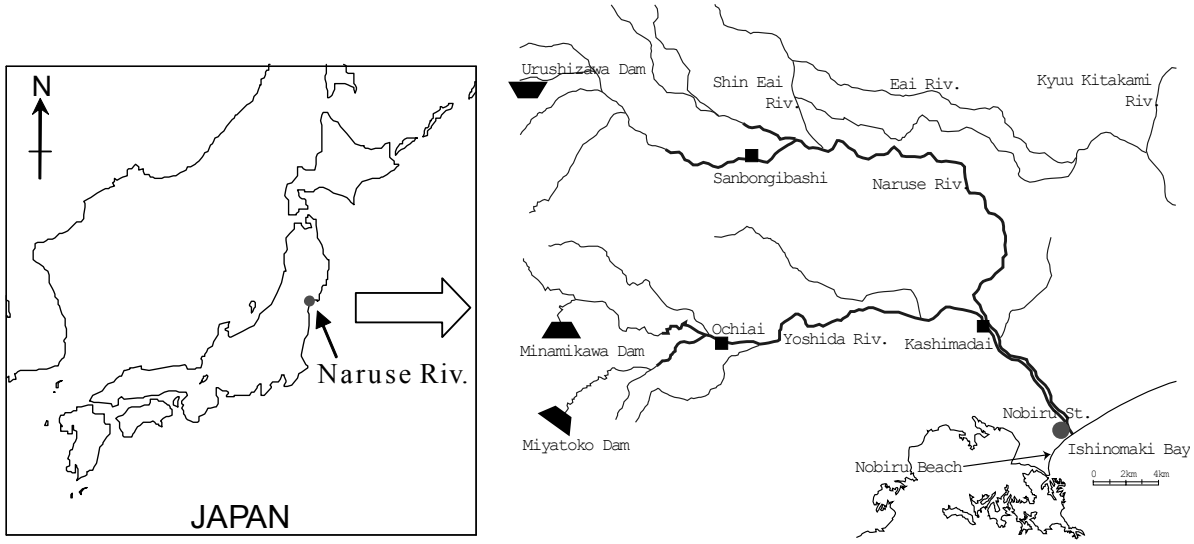

Fig. 1 Location of Naruse River mouth

3. MORPHOLOGICAL CHANGE AT THE RIVER MOUTH

3.1 SEDIMENT DEPOSIT BETWEEN THE JETTIES IN 2002

Photo 2 shows the sediment deposit observed between two jetties in July 2002. Considerable amount of sediment deposit can be seen on the right-hand side of the river between the jetties, by which almost half of the river mouth width was closed. Such a severe river mouth closure has never been observed for these several decades up to present.

Photo 1 Naruse River mouth in 1998

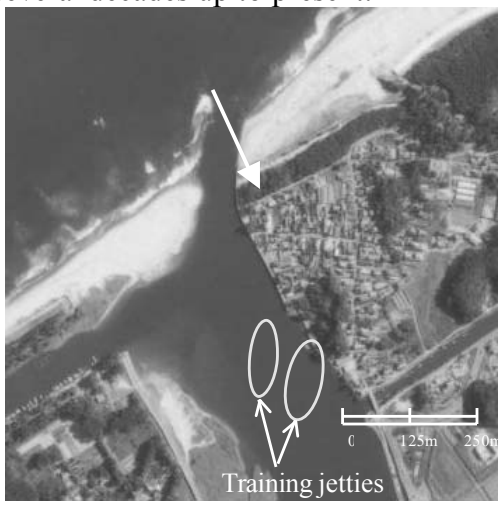

Photo 2 Sediment deposit between jetties(Jun.14, 2002)

3.2 MORPHOLOGICAL CHANGE AFTER THE FLOOD IN 2002

The sand bar between the jetties and the sand spit on the left hand-side were flushed during a flood in July 2002 as shown in Photo 3, in which one of the eight headlands can be seen on the right hand-side of the photograph.

After the flood, the sand spit migrated into the river, as seen in Photo 4. The migrating sand spit caused difficulty of ship operation around the port in the river mouth. Another

concern is destruction of the river bank and the port in the river mouth caused by waves propagating through the gap between the sand bar and jetties and over the sand bar.

Although the flush of the sand spit was observed during a flood in August 1986, which is one of the greatest floods in recent years, the sand bar has recovered to its equilibrium state in a while after the flood at that time.

Photo 3 Flushing of the sand bar (Nov.7,2002)

Photo 4 Migration of sand bar into the river (Jul.27,2002)

River mouth topography similar to Photo 4 can be seen in Photo 5, which was taken in 1952 after two extremely big floods in 1947 and in1948. In this photograph, the sand bar on the left-hand side of the river migrated inside of the river and the river mouth between the jetties was closed completely.

Photo 6 shows stable topography of the river mouth in 1956. In Photo 6, the sediment deposit between the jetties is not seen and the sand spit on the left-hand side of the river is fully developed, as same as Photo 1. It is supposed that sediment deposited inside the jetties was removed artificially, because there was no big flood between 1952 and 1956.

Photo 5 Naruse River mouth in October 1952

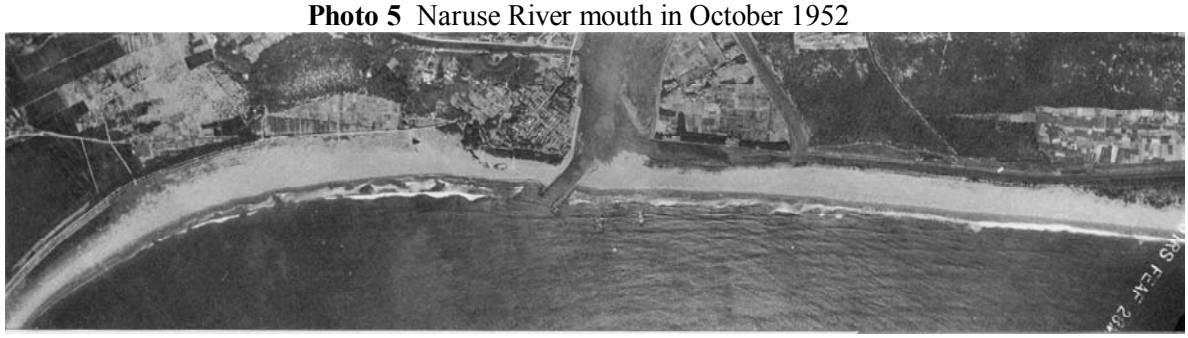

Photo 6 Naruse River mouth in June 1956

Fig. 2 shows the shoreline change around the river mouth in 1952, 1989 and 2002. The sand spit on the left-hand side of the river in 1952 and 2002 are thinner and showing inward migration, as compared to the stable shoreline in 1989.

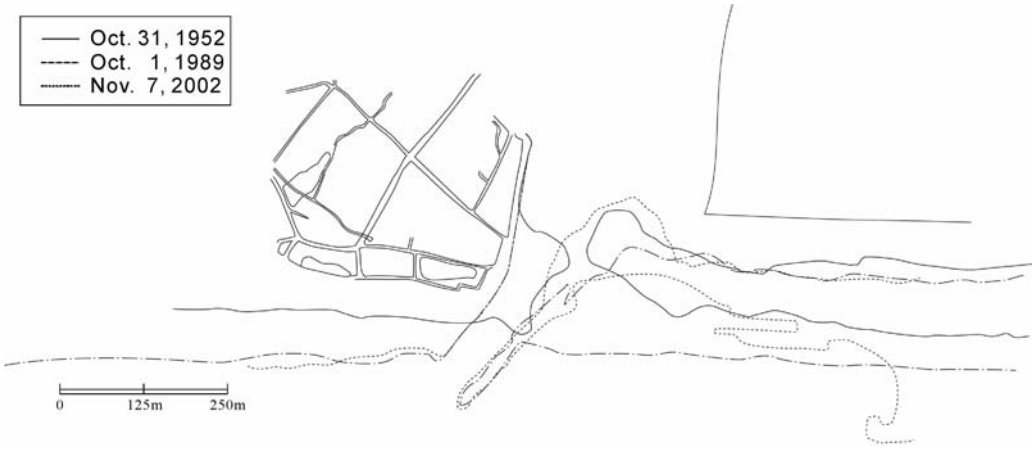

Fig. 2 Shoreline around the river mouth

4. RELATIONSHIP BETWEEN WATER LEVEL IN THE MOUTH AND TIDE

4.1 MEASURED WATER LEVEL VARIATION

Fig. 3 shows time-variation of water level at the Nobiru measuring station, tidal variation at Ayukawa Port and the discharge of the Naruse River. In this figure, the water level S.P.+0.0m is mean sea-level of Shiogama bay (Shiogama peil). The water level at the Nobiru station is corrected based on the lowest water level when the discharge is negligibly small. Fig. 3(a) is about three weeks before the sediment deposit was observed (Period 1). Figure 3(b) is the period just before the sand bar flushing (Period 2), whereas Fig. 3(c) is immediately after the flushing of the sand bar (Period 3). Each Period has similar tidal variation, changing from neap to spring tide.

Tanaka et al. (1996) reported that phase difference and amplitude reduction can be observed in a river mouth as compared to tidal variation when a mouth is almost closed. Similar to Tanaka et al.'s (1996) observation, the phase difference between water level and tide level can be seen in Fig.3 from 6th to 10th in July. The difference seems to be caused by the river mouth closure, because river discharge is rather small. Meanwhile, the differences of the water level from 21st to 22nd on June, from 3rd to 4th on July, and from 10th to 12th on July are caused by increase in the river discharge.

The relationship between water level and tidal level is shown in Fig.4(a). To remove the effect of the river discharge, the relationship is plotted only for the period when the river discharge is smaller than $40m^3/s$. Fig. 4(b) is the relationship while tide level is lower, i.e., the tidal level is lower than S.P.+0.25m.

Temporal variation of correlation coefficient for these three periods is shown in Fig.5. The coefficient is smallest during Period 2 immediately before the flushing of sand spit. This trend is more clearly observed during lower tide. Therefore, it is concluded that the river mouth closure was occurred just before the flushing of the sand spit.

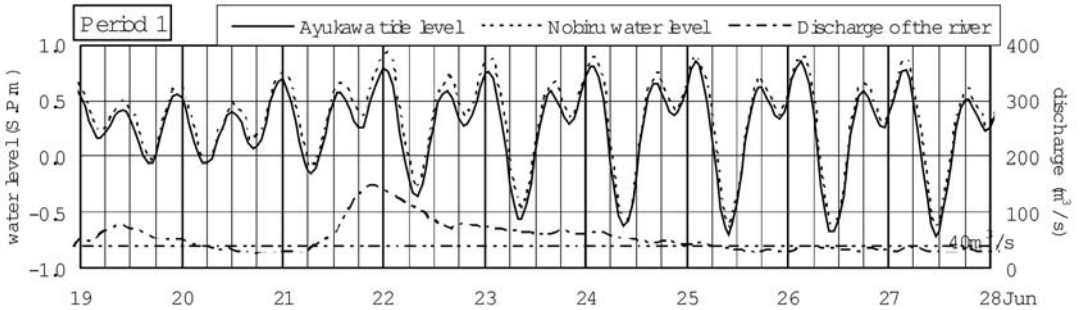

Fig. 3(a) Time-variation of water level and tide level
(Period 1: 3 weeks before the river mouth closure)

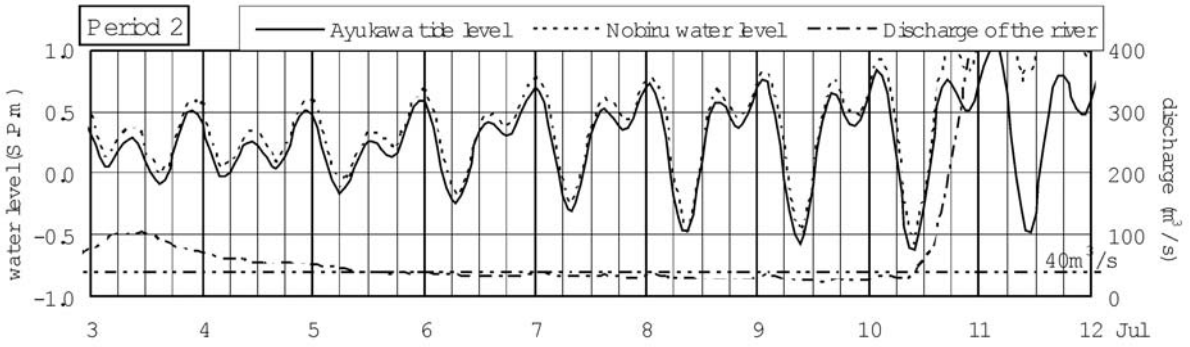

Fig. 3(b) Time-variation of water level and tide level
(Period 2: Just before the flushing of the sand bar)

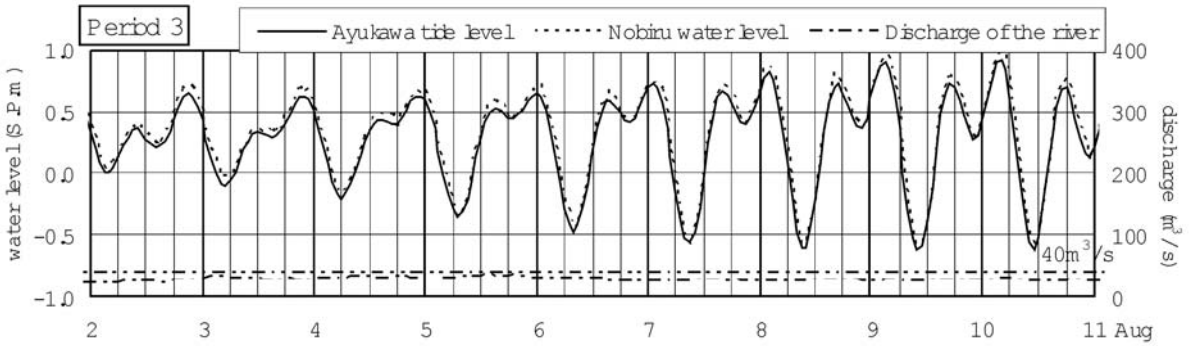

Fig. 3(c) Time-variation of water level and tide level (Period 3 : After the flushing of the sand bar)

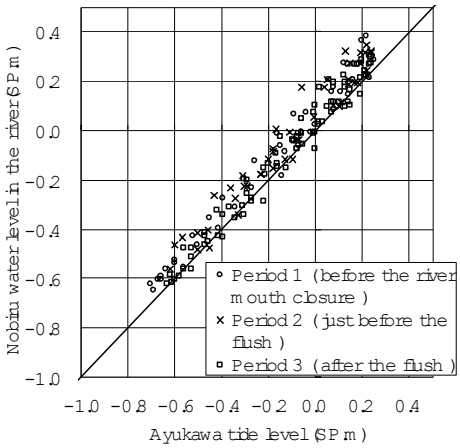

Fig. 4(a) The relationship between water level and tide level

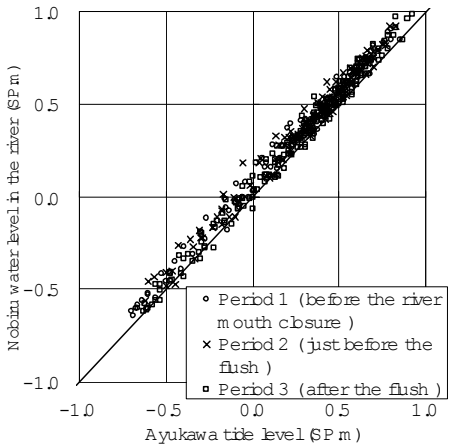

Fig. 4(b) The relationship between water level and tide level

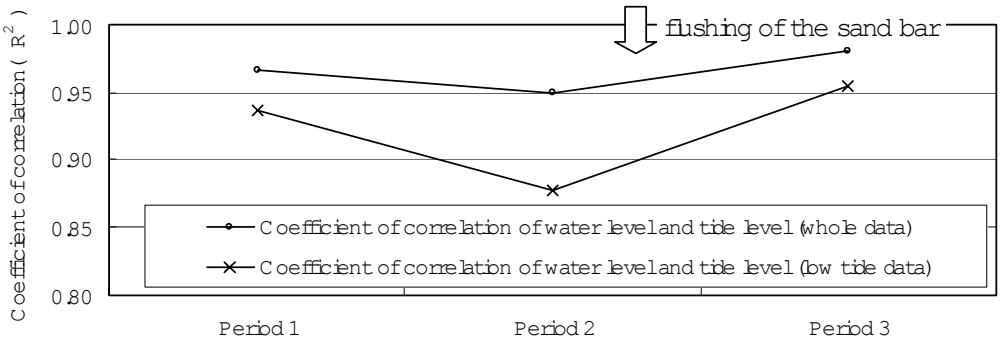

Fig. 5 Coefficient of correlation between water level and tide level

4.2 HARMONIC ANALYSIS

Harmonic analysis is applied to the time-variation of the water level and tidal level for the three periods. Fig. 6 and 7 show the amplitude difference and phase difference between water level in the mouth and tidal level, respectively. In these figures, M2, K1, S2 and O1 denote principal lunar semi-diurnal tide, luni-solar diurnal tide, principal solar semi-diurnal and principal lunar diurnal tide, respectively. Although the amplitude difference is very small in Fig.6, remarkable phase difference can be seen in Fig.7, especially for M2, K1 and S2 during Period 2 just before the flushing. From this analysis, it is concluded that the river mouth closure has occurred immediately before the flushing of the sand bar.

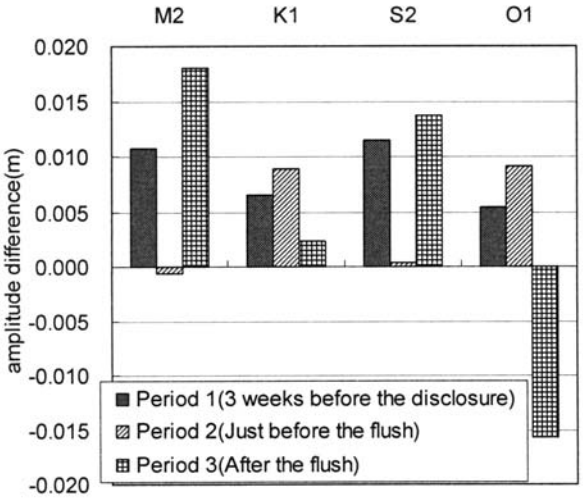

Fig. 6 Amplitude difference between water level and tide level for principal tidal constituents

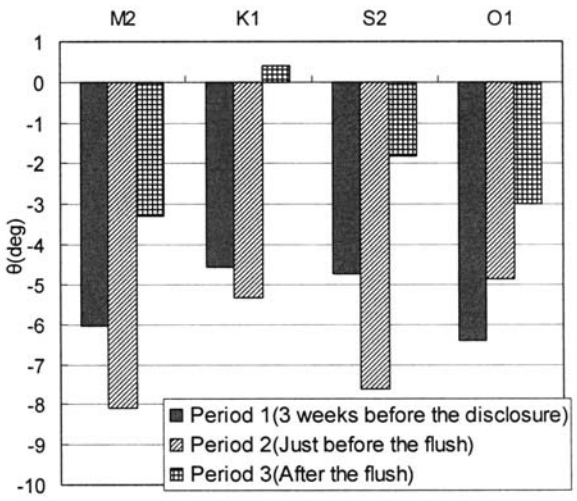

Fig. 7 Phase difference between water level and tide level for principal tidal constituents

5. CONCLUDING REMARKS

In the present study, characteristic morphological change at the Naruse river mouth is shown with the use of the aerial photographs. Furthermore, time-variation of the water level in the river mouth is compared with that of variation at Ayukawa Port, and harmonic analysis is applied to these two water level data. From the present analysis, it can be concluded that the river mouth closure has occurred just before the flushing of the sand bar in July 2002.

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