Conference Paper, Published Version

Furuhata, Hisashi; Tsubaki, Ryota; Tsujimoto, Tetsuro

Water Quality Dynamics in a Tidal River With Groins

WATER QUALITY DYNAMICS IN A TIDAL RIVER WITH GROINS

Hisashi Furuhata[1], Ryota Tsubaki[2] and Tetsuro Tsujimoto[3]

[1] Doctoral Student, Department of Civil Engineering, Nagoya University
Furo-cho, Chikusa-ku, Nagoya, 464-8603, Japan, e-mail: furuhata.hisashi@h.mbox.nagoya-u.ac.jp
[2] Research Worker, Department of Civil Engineering, Nagoya University
Furo-cho, Chikusa-ku, Nagoya, 464-8603, Japan, e-mail: r.tsubaki@civil.nagoya-u.ac.jp
[3] Professor, Department of Civil Engineering, Nagoya University
Furo-cho, Chikusa-ku, Nagoya, 464-8603, Japan, e-mail: ttsujimoto@genv.nagoya-u.ac.jp

ABSTRACT

The purpose of this study is to clarify water quality dynamics in tidal rivers with groins by field observation in tidal reach of the Kiso River. A series of the field observations was performed on the conditions of the neap tide and the spring tide on summer. We measured velocity profiles using Acoustic Doppler Current Profiler and water quality (Salinity, Nutrient, etc.). The results show that water quality dynamics in a tidal river with groins is characterized by two factors, which are materials (nutrient, phytoplankton) transport to river upstream side form coastal zone with salinity intrusion and primary production by phytoplankton in the coastal zone, and the other flow velocity variation due to existence of groins.

Keywords: tidal river, groin, water quality, field observation, Kiso River

1. INTRODUCTION

Eutrophication and dysoxic environment are the major problems in enclosed bays. Historical change of the material flow from the river to the enclosed bay may have significant impact on these problems. In particular, water quality structure of a tidal river, where is to exchange with fresh water and sea water effect on water quality change of coastal zone. We focus on the Kiso River lower reach where is a tidal river. The Kiso River inlets to the Ise bay where is an enclosed bay having water quality problems. In tidal reach of the Kiso River, a series of groins (Figure 1) were constructed in order to protect the levee about one hundred years ago, and embayments (inside of sand bars) have been formed around groins. These landscapes contribute to provide habitat and ecosystem services. Purpose of this study is to clarify water quality dynamics in tidal rivers with

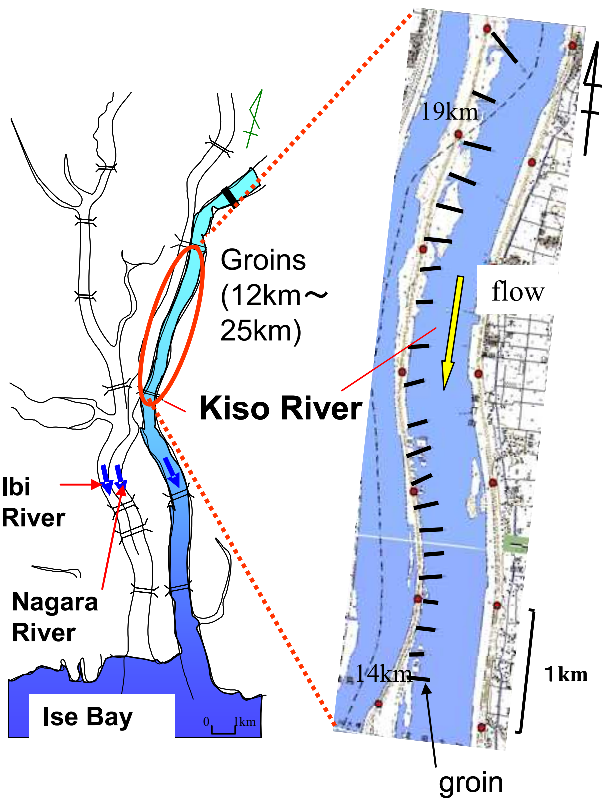


Figure 1 Kiso River

groins by field observation in tidal reach of the Kiso River.

2. SITE DESCRIPTION

The Kiso River flows in the Nohbi plain in the central Japan region. Its catchment area is 5275km^2, length of the river channel is 229km. Tidal reach of the Kiso River is the Kiso River weir (26km) from the river mouth. Figure 2 shows the river bed elevation, the bed slope is 1/5000 and in the lower reach from 9km point, bed slope is averagely flat. As the above mentioned features of the Kiso River lower reach is existence of the groins. This sandwiched area is embayment where is magnitude of velocity lower than main channel. The length of groin is fourth or third part of channel width. There are two types of groins, which are Krippen groin and pile groin (Figure 3). In these days sandwiched area between groins has been dried (temporally submerged or dried by tidal motion) and complex geomorphologic features have appeared. In the region, it has been studied to clarify the function of the physical environment (Kimura et al., 2002). Shinoda et al. (2001) clarified the formation processes of embayments based on the transition of sediment supply. Takeda et al. (2002) showed characteristics of temporal change of water temperature in the embayment due to tidal motion using field observation and numerical analysis. Sumi et al. (2002) estimated water exchanged volume between surface and subsurface water in the sand bar inside of the embayment by numerical simulation. From a viewpoint of habitat of aquatic organism, Mizuno et al. (2005) and Nanbu et al. (2005) clarified the distribution characteristics of *Corbicula japonica*.

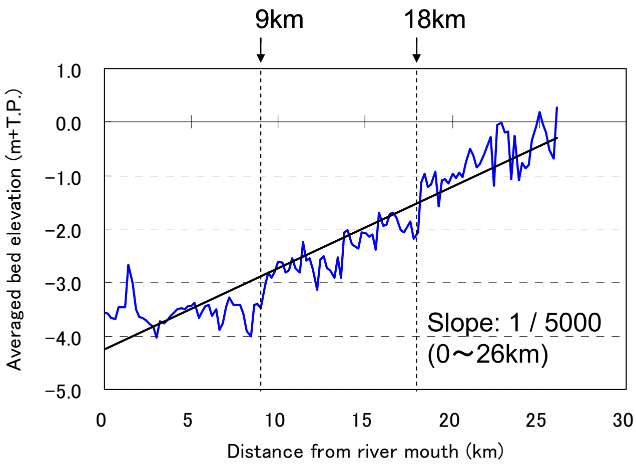
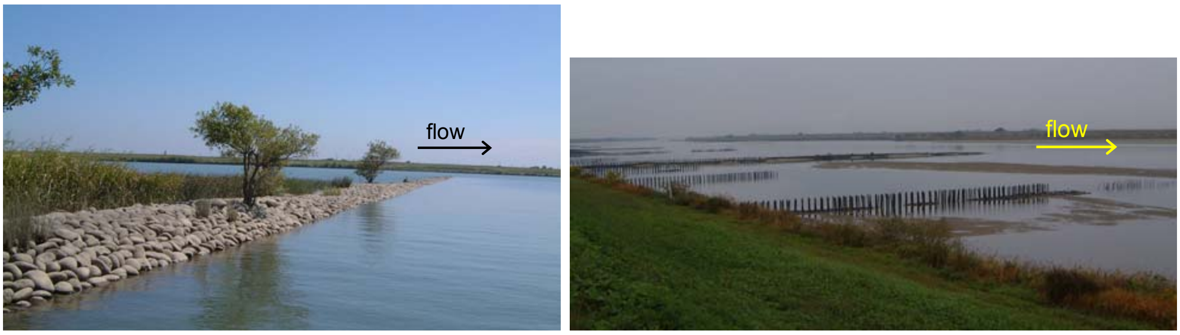


Figure 2 Longitudinal river bed elevation



(a) Krippen groin (16.8km)   (b) Pile groin (15.2km)

Figure 3 Groins in the Kiso River

3. FIELD OBSERVATION

Method

We performed field observation focusing on variation of water quality structure with tide. In particular, we observed the reach where constructed the groins. The reach is located at the 23km from 12km. The field observation was performed twice on the conditions of neap tide and spring tide on summer season. Figure 4 shows the water level (W.L.) then. Tidal range at the neap and the spring tide are 0.8 m and 2.0 m, respectively. In the observations, we measured flow velocity profile using Acoustic Doppler Current Profiler (ADCP) and water quality (salinity, temperature, dissolved oxygen, pH, ORP) using along axis of stream between 8 km and 22 km from the river mouth. Water quality (Temperature, Salinity, etc.) was measured using the multiple water quality meter YSI556MPS（YSI/Nanotech Inc.), and Chlorophyll a was measured using Compact CLW (ALEC ELECTRONICS CO., LTD.). Water samples were taken at water of surface and bottom layer. The samples were brought to laboratory, then later these were analyzed contained nutrient (NO_3-N, NO_2-N, NH_4-N, PO_4-P) using the auto analyzer QuAAtro (BRAN+LUEBBE).

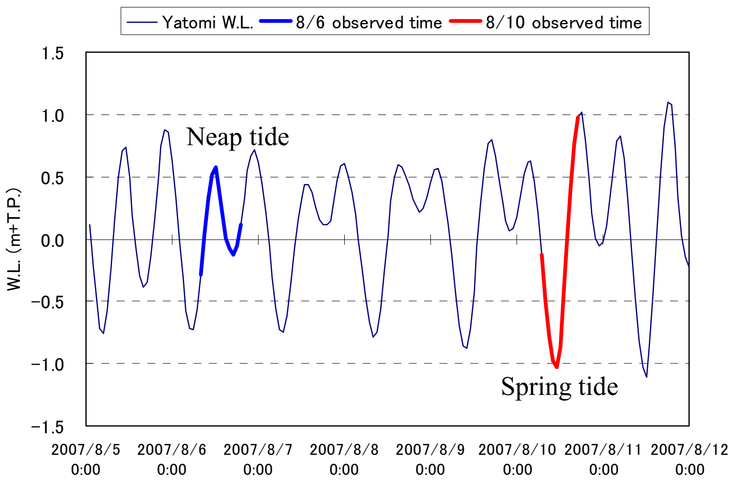


Figure 4 Water level at the observations

Results and Discussion

Figure 5 and 6 show the results of longitudinal flow velocity profiles at the neap and spring tide. It is suggested that velocity magnitude at the spring tide is larger than that of neap tide due to difference of tidal amplitude. The magnitude of depth averaged velocity both tidal conditions are large values in the upstream side because of river bed slope of the upstream from the 12km is steeper than the downstream side. However, the velocity magnitude at the falling tide is little less than that at the rising and the high tide. There are groins in the upstream side from 12 km (Figure 1). Thus it is suggested that the constriction of the river channel due to existence of the groins quicken the flow velocity. The characteristics of velocity profiles at the neap tide are same as the spring tide case. However, standard variation of velocity at the neap tide is larger than that of the spring tide. The river water is well-mixed at the spring tide as against the neap tide.

Water quality structure along longitudinal direction has not so difference between neap tide and spring tide. Figure 7 shows longitudinal profiles of salinity at the high tide. The difference between surface and bottom layer concentrations is large value at the neap tide, and the water at the spring tide is well-mixed between surface and bottom layer. These salinity profiles show that the water in the 8km point at the high tide is affected by salinity intrusion. Figure 8 shows time series of Chlorophyll a concentration with water level. At the spring tide, the maximum value of Chlorophyll a concentration is 40μg/L, so it is indicated that primary production by phytoplankton is active. The peak of Chlorophyll a values are twice in a period of the water level. These indicated that phytoplankton produced in coastal zone was transported from coastal zone to river at the rising tide, after that the phytoplankton was transported from the river to the coastal zone. Nitrate concentrations are low value in the 8 km high tide (Figure 9). And Figure 10 shows Dissolved Oxygen concentration. The DO concentration at the spring tide is larger than that of the neap tide. These water quality distribution are influenced primary production by phytoplankton in coastal zone. Other water quality (NO_2-N, NH_4-N and PO_4-P) distribution around groins is not varied at any time. It is suggested that the existence of groins enhances water mixing.

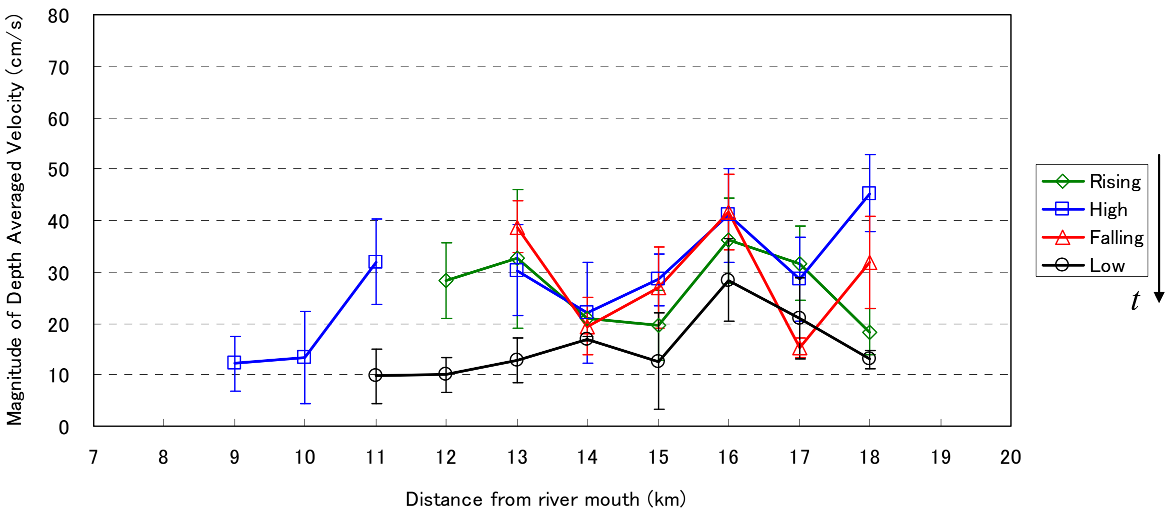


Figure 5 Magnitude of depth averaged velocity distribution at the Neap tide
(error bar represents standard deviation)

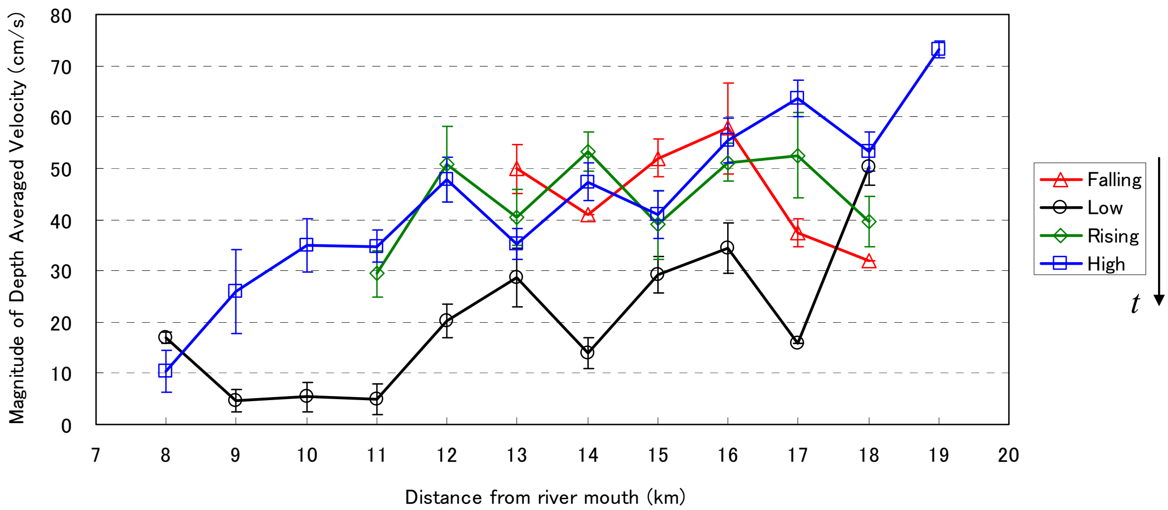


Figure 6 Magnitude of depth averaged velocity distribution at the Spring tide
(error bar represents standard deviation)

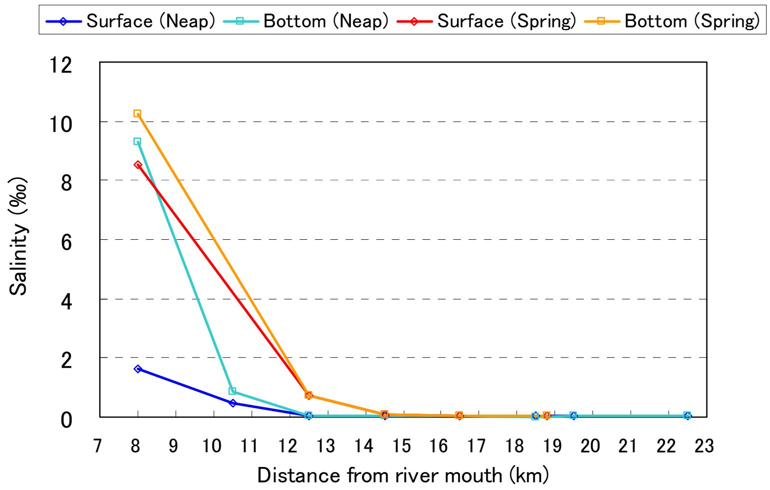


Figure 7 Longitudinal Salinity profiles at the high tide

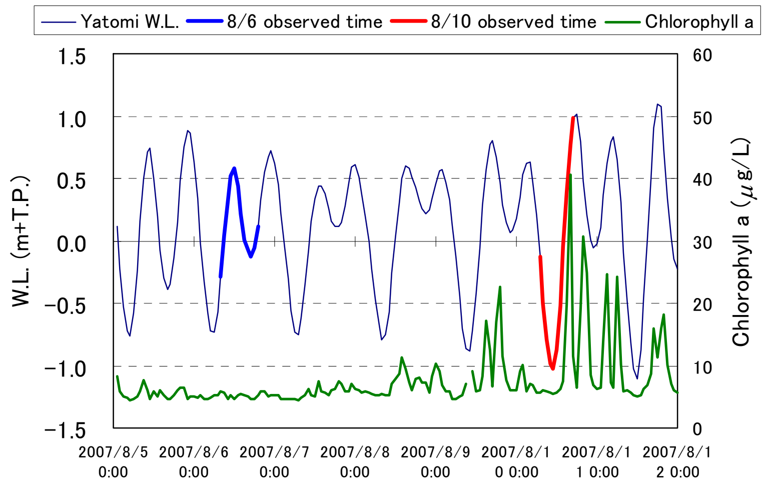


Figure 8 Time series of Chlorophyll a with Water Level

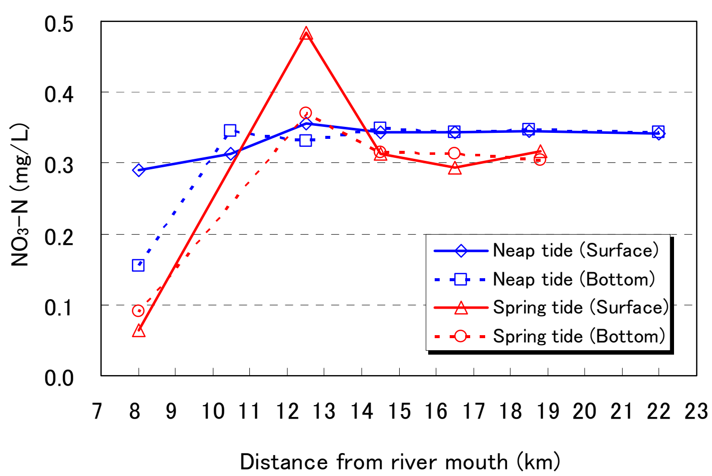
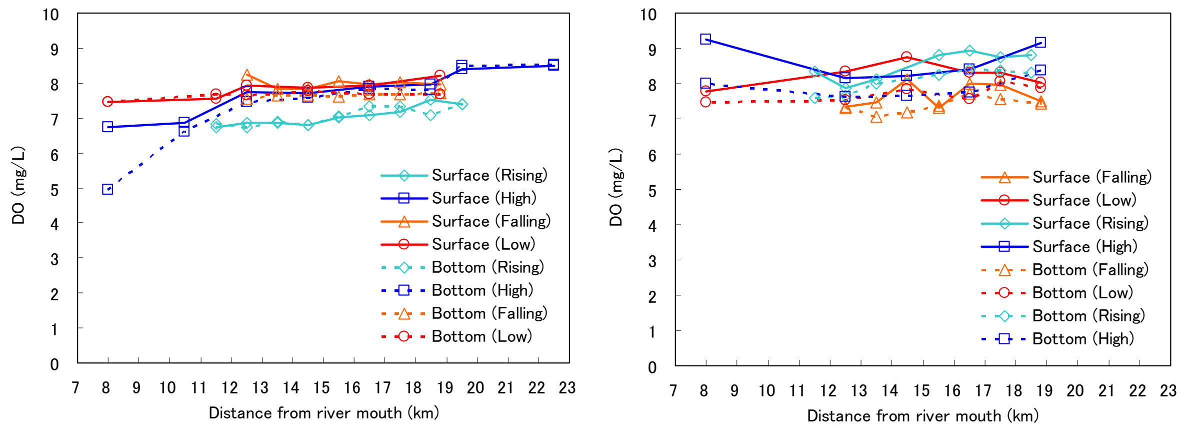


Figure 9 Longitudinal NO_3-N profiles at the high tide



(a) Neap tide (b) Spring tide

Figure 10 Longitudinal Dissolved Oxygen profiles

4. CONCLUSION

In the tidal reach of the Kiso River, following and adverse currents cycle plays major factor of fluid dynamics. The primary production by phytoplankton arises in this area and neighboring coastal area. This primary production plays important aspect of water quality change in this section. Finally, cross-sectional velocity variation due to the existence of groins also has a certain measure of the effect on the fluid dynamics and the water quality change. Further research will be conducted to clarify the quantitative effect of the groins on the water quality change.

ACKNOWLEDGMENTS

This study was performed as part of the outlays for promoting science and technology under the Ministry of Education, Culture, Sports, Science and Technology. We are grateful to the Chubu Regional Bureau Kiso River Downstream River Office, Ministry of Land, Infrastructure and Transport for providing us the data used in this study. We are grateful to Mr. Shionoya supported the field observations.

REFERENCES

Kimura, I., Kitamura, T., Sumi, T., Takeda, M., Onitsuka, K., Sho, K. and Ohtsuka, K. (2002), Cooperative research on morphological evolution and environmental functions of embayed topography formed around spur dikes in the tidal area of the Kiso River, *Advances in River Engineering*, 8, pp.365-370 (in Japanese).

Mizuno, T., Nanbu, R., and Sekiguchi, H. (2005), Population dynamics of the brackish water clam *Corbicula japonica* in Kiso estuaries, Central Japan, *Nippon Suisan Gakkaishi*, 71(2), pp.151-160 (in Japanese).

Nanbu, R., Yokoyama, E., Mizuno, T. and Sekiguchi, H. (2005), Spatio-temporal variations in density of different life stages of a brackish water clam *Corbicula japonica* in the Kiso estuaries, Central Japan, *Journal of Shellfish research*, 24(4), pp.1067-1078.

Shinoda, T., Mizutani, N., Matsuyama, Y. and Tsujimoto, T (2001), Formation process of embayment and feature of riverine environment according topographic history around solid

spur dikes, *Advances in River Engineering*, 7, pp.333-338 (in Japanese).
Sumi, T., Washidu, Y. and Tsujimoto, T. (2002), A study on water interaction between subsurface water in substrate around embayment and surface water in river Kiso, *Advances in River Engineering*, 8, pp.371-376 (in Japanese).
Takeda, M., Kimura, I., Matsuo, N., Yamazaki, Y. and Fujita, A. (2002), Study on water temperature change and its numerical simulation model in Kiso river wando, *Annual Journal of Hydraulic Engineering, JSCE*, 46, pp.1097-1102 (in Japanese).