MEASUREMENT OF VERTICAL DISTRIBUTION OF VELOCITY AND SALINITY IN MITOGUCHI CHANNEL, LAKE JUSAN

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ABSTRACT

Hydrodynamic information is essential for developing a predictive water quality model in Lake Jusan. The lake is connected to the sea by the Mitoguchi channel. Saline water and freshwater exchange through this channel, and it take dominant effect on the water quality behavior in the lake. Detail information about parameters of velocity and salinity distribution in the channel is very important to achieve a good result of numerical modeling. Field observation was carried out by deploying continuous point measurement devices to measure the both parameters. Spatial measurements by using ADCP and water quality device are also performed to verify vertical distribution. The result shows that both parameters are only distributed vertically. The distribution is changed due to flood and tidal conditions. For the velocity, even it is distributed vertically, but its direction from the bottom to the surface is uniform. By using this information, a better result of numerical simulation could be achieved.

Keywords: Mitoguchi channel, vertical current distribution, salinity distribution

1. INTRODUCTION

Lake Jusan is brackish lake, located in northwestern part of Aomori prefecture, Japan. The lake is connected to Japan Sea by the Mitoguchi channel (Fig. 1). The lake is wide shallow lake which has an average depth of 0.9 m and a surface area of 18.06 km^2. The Mitoguchi channel is a man-made canal, 180 m wide and protected from blockage by longshore transport by two jetties; 389 m and a 337 m long in north and south side, respectively (Sasaki and Sato, 2006). There are some rivers flowing into the lake, but only three of them are dominant, they are Iwaki River, Yamada River and Toriya River which have catchments areas of 1996 km^2, 267 km^2 and 106 km^2, respectively.

The lake has the third biggest production of Yamato sijimi (*Corbicula japonica*), a species of bivalve that is an important resource in fisheries in Japan, usually cooked as an ingredient of soup. In 2008, the amount of 8900 ton of bivalve stays in the lake. The population of bivalve fluctuates yearly (Fig. 2), but the parameters which are responsible for it have not been clearly understood.

The bivalve life depends much on appropriate water quality, and hydrodynamic condition. They can not move to feed, but water flow brings food to them. Hydrodynamic information in the lake is essential for developing a predictive water quality model for the lake. A 3-dimmensional hydrodynamic model is sufficient to simulate the circulation structure in the lake. To obtain precise results, a set of boundary condition data is needed. The objective of this study is to measure the characteristic of flow velocity and salinity distribution in Mitoguchi channel, and to obtain sufficient data for boundary conditions of numerical simulations.

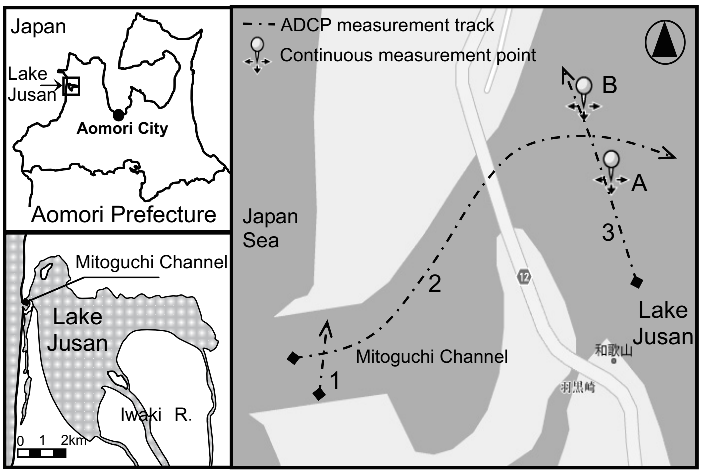

Figure 1- Location of study and lay out of measurement in Mitoguchi Channel

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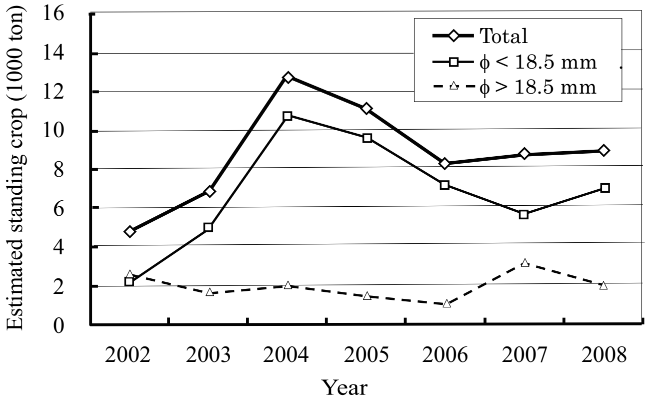

Figure 2- Fluctuation of total sijimi in Lake Jusan (measurements were done in every Aug. or Sept.)

2. FIELD OBSERVATION

Two kinds of observations were conducted; continuous and spatial observation. Both consist of velocity and salinity measurement. The objective of continuous measurement is to obtain a set of data that will be applied in the computational simulation as boundary condition data. The spatial measurement will be used to verify the vertical distribution of both parameters.

For continuous observation, devices were deployed at point A and B to figure out the horizontal distribution. Meanwhile, to catch the vertical distribution, several devices were installed at each point that located vertically at fixed distance, measured from bottom (Fig. 3 and Table 1). All devices were set to record the data at 10 minute intervals and the period of measurements start from 10 July to 25 October, 2009.

The spatial measurements were conducted by using portable water quality meter (AAQ1183, Alec Electronics Co. Ltd) and ADCP (Acoustic Doppler Current Profiler) to measure vertical distribution of salinity and velocity, respectively. Salinity measurement was carried out in the same location as the continuous measurement points, meanwhile the velocity measurement was performed at several tracks as shown in Fig. 1. The spatial measurements were carried out two times on July 10th and August 10th, 2009.

During the first spatial measurement, there was a storm with high intensity rain and strong wind. The water elevation in the lake was high and the tide elevation might be effected by the storm. In Mitoguchi channel, it was clearly observed that water flew from the lake to the sea. The contrast condition happened on the second measurement: it was calm and sunny day.

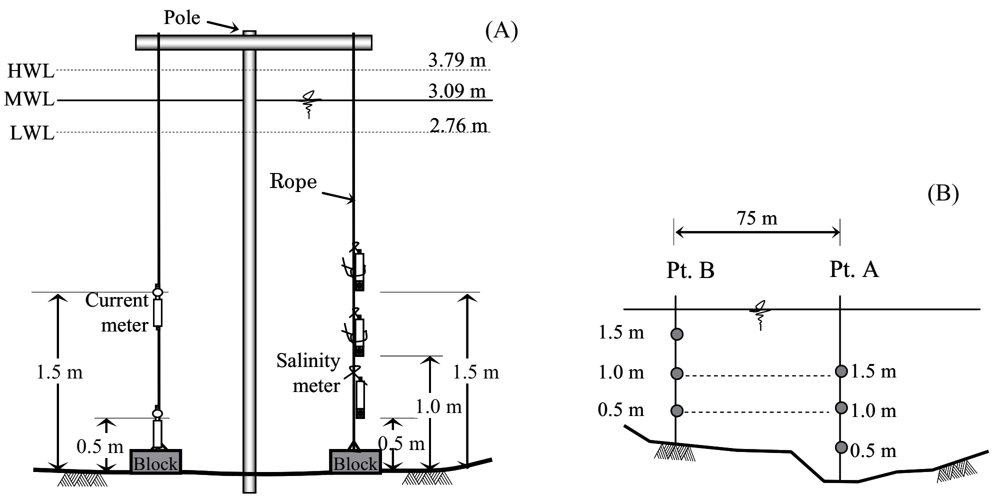

Figure 3- Measurement setup. (A) Sketch of installation of salinity meters and current meters at Point A. (B) Sketch of cross section between point A and point B

Table 1- Instrumentation in Mitoguchi Channel

Location	Device	Type	Elevation from bottom (m)
Point A	Current meter	COMPACT-EM, Alec Electronics Co. Ltd.	0.5 and 1.5
	Salinity meter	COMPACT-CT, Alec Electronics Co. Ltd.	0.5, 1.0 and 1.5
Point B	Salinity meter	COMPACT-CT, Alec Electronics Co. Ltd.	0.5, 1.0 and 1.5

3. RESULTS AND DISCUSSION

River discharge and tidal condition

Conditions of river discharge, water level in the lake and tide in the sea have effects on the flow characteristics in the Mitoguchi channel (Fig. 4). During the measurement, several floods occurred, and four of them were big with peaks over 400 m^3/s. Flood continue for more than 2 days. Stormy wind is one of the characteristics of Lake Jusan (Umeda et al, 2007). The wind plays big effect on tide elevation. In some cases, especially during flood, high tide occurred and it seemed not because of lunar tide. These phenomena observed clearly in several flood events.

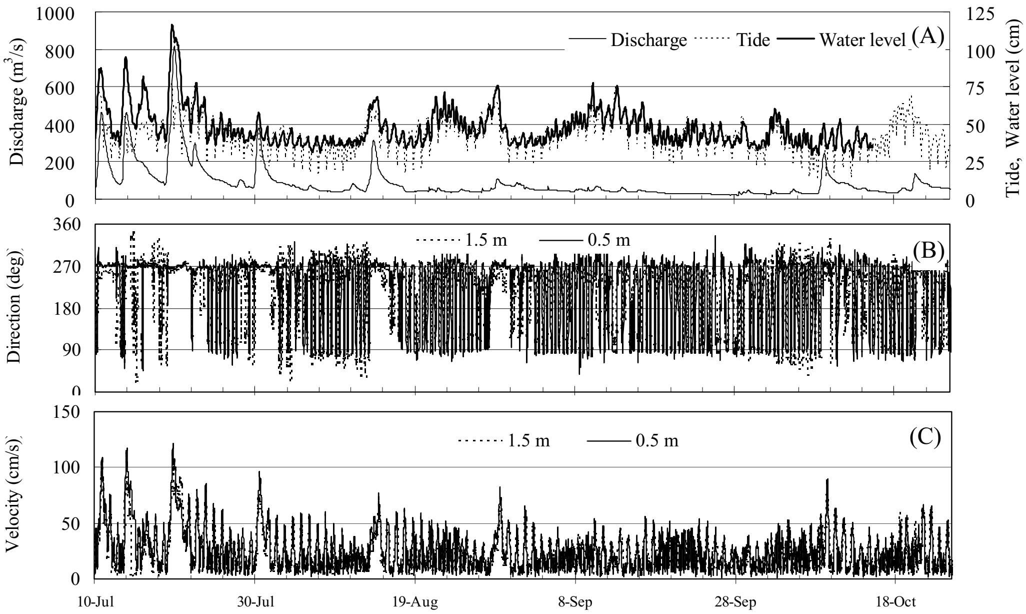

Figure 4- (A) Condition of river discharge, tide and water level in the lake during continuous measurement period. (B) Flow direction at point A on 0.5 m and 1.5 m, clockwise start from the North. (C) The magnitude of velocity at point A

Velocity distribution

In order to make clear the effect of river discharge and tidal condition on the distribution of velocity and salinity, the analysis will be focused on two cases: during flood and low river discharge. Considering the availability of spatial data, the period of 10-12 July and 9-11 August are chosen as flood and low discharge cases, respectively (Fig. 5).

Direction of current is controlled by the differences between water level in the lake and tidal elevation in the sea. When water level is higher than tide, water flows to the sea even in the flood tide condition. During flood, the current mostly flows to the sea. In some cases, because the flood occurred during the storm, sea water flew to the lake even as low velocity. During low discharge, the current controlled totally by tide.

In vertical direction, velocity in the lower surface, 0.5 m, always smaller than that in the upper surface, 1.5 m (Fig. 5.B). This distribution was well captured by spatial measurement ADCP (Fig. 6). Compare to the continuous data, the ADCP data looks very realistic. From both data, it shows that the current flows in the same direction from the bottom until surface.

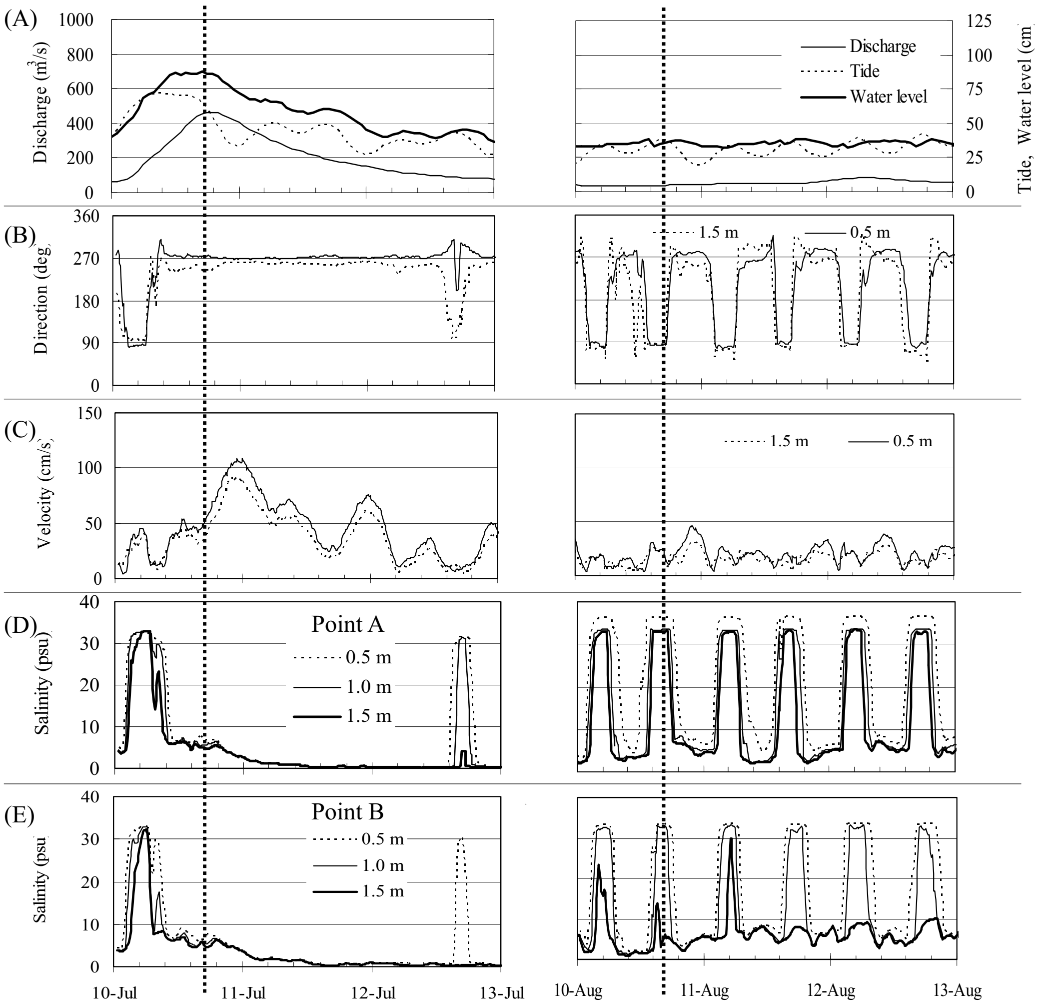

Figure 5- Profiles of velocity and salinity with river discharge and tidal conditions for flood and low discharge cases. The vertical dot line indicates the time of spatial measurement for both velocity and salinity.

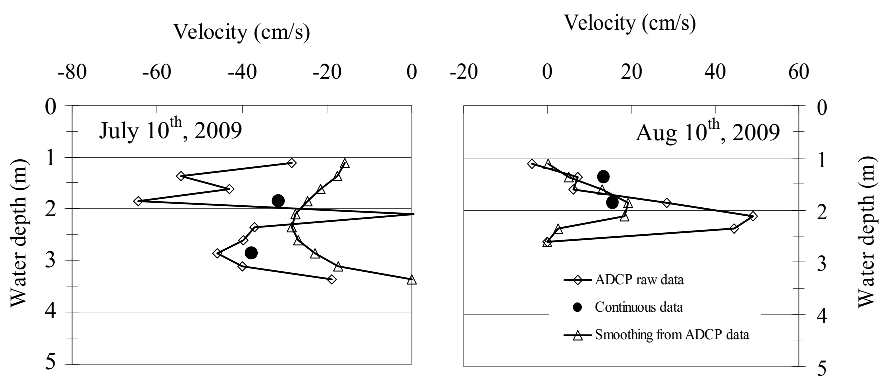

Figure 6- Comparison between vertical velocity distribution measurement by using ADCP and continuous point measurement data..

Salinity distribution

Water depth at point A is 0.5m deeper than point B, therefore 1.0 m at A is the same elevation with 0.5 m at B, and also for 1.5 m at A and 1.0 m at B as well (Fig 3.B). Fig. 7 shows that on the same elevation, point A and B has similar salinity even it fluctuates due to river discharge and tidal level. Comparison of spatial and continuous data shows that the vertical distribution exactly already captured by continuous measurement data (Fig 8). Furthermore, the figure gives a proof that salinity is not distributed horizontally across Mitoguchi channel.

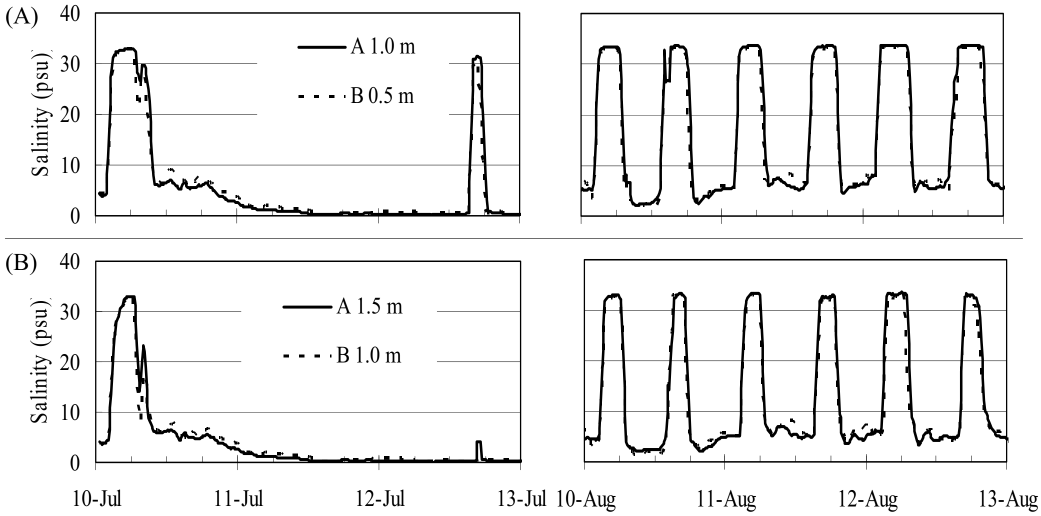

Figure 7- Comparison of salinity data at point A and B during flood and low discharge cases. (A) Point A 1.0 m and point B 0.5 m. (B) Point A 1.5 m and point B 1.0 m.

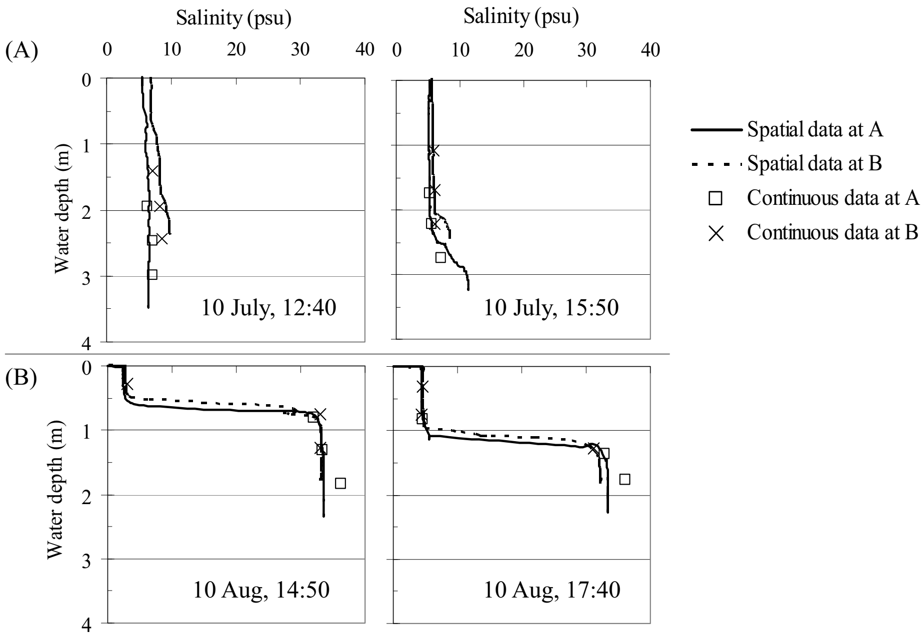

Figure 8- Comparison of salinity data at point A and B during flood and low discharge cases. (A) Point A 1.0 m and point B 0.5 m. (B) Point A 1.5 m and point B 1.0 m.

4. CONCLUSIONS

Field measurements were conducted in Mitoguchi channel to investigate the horizontal and vertical distribution of velocity and salinity. Both parameters are distributed vertically. Behaviors of both parameters during river flood and low discharge have been characterized. For the velocity, even it is distributed vertically, the direction from the bottom to the surface is uniform. The highest concentration of salinity occurs in the bottom and distributed vertically. All of these information are detail, therefore it is sufficient to be applied as boundary condition data in order to simulate the hydrodynamic behavior in Lake Jusan.

5. ACKNOWLEGEMENTS

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6. REFERENCES

Konishi E. (2009). Research on water environment in a shallow brackish lake, Jusan Lake in Aomori Perfecture, Master Thesis, Civil Dept., Tohoku Univ. Japan (in Japanese)

Sasaki M, Sato M. (2006). Topographical change of Iwaki River Mouth in the early 1900's. Vietnam-Japan estuary workshop, Hanoi, Vietnam.

Umeda M, Tanaka H, Sasaki M. (2007). Field measurements on brackish water environment in Lake Jusan, Japan. Japan-Vietnam estuary workshop, Hochiminh, Vietnam,