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Acoustic monitoring of water atmosphere in Lake Biwa
琵琶湖における水質環境の音響モニタリング

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1. Introduction

Interest to warming of the climate system rises. Now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level [1].

There is acoustic tomography as technique to observe global scale marine warming and to be observed increasing water temperature and heat-balance.

In Lake Biwa, increasing lake water temperature and concern for affect to the ecosystem are reported [2].

Relationship with increasing lake water temperature and climate change of global scale, we need to watch this changes carefully. It is important that observation of continued lake water temperature and maintenance of observation system in future.

Water observation in Lake Biwa has been enforced at 49 points once a month since 1979 by ship. We suggest construction of observation systems which acoustic tomography are applied for observing increase lake water temperature. We begin disputation of basic study to use these systems.

In Lake Biwa, the speed of sound becomes faster than ion-exchanged water from the instrumentation in the winter season. We suggested that revised affect by contained various ions as salinity conversion values to a lake in equation for the speed of sound in case of water temperature estimation [3].

On this salinity conversion values, amount of chloride ion in particular is pointed out with being essential when we know derivation of the water, extent of contamination. There are three kinds of origins as follows, 1) Sea water pours into a lake whirled up between ground, 2) Life drain and industry drain it of water as contamination by human activities, 3) There are hot springs and a case by affect of a volcano [4].

The thermocline where there is it between warm cortex and the cold depths, and water temperature change is suddenly generated exists in Lake Biwa from summer to autumn. On this account there is the period when cortex and alligation of the depths liquid are not generated. Therefore, as for the cortex and the water of the depths liquid, there are many strange cases.

I enforced instrumentation of speed of sound and water temperature in the time when thermocline existed in the north basin of Lake Biwa at autumn season. We describe correction by salinity conversion values to do so that accuracy estimates water temperature from speed of sound in peculiar characteristic thermocline entity by this report in autumn.

2. Information about Lake Biwa

2.1 Feature of the topography

Lake Biwa has boundary length 241 km, area 670.3 km^2, and it is the greatest depth of the water 103.8 m, mean depth of the water 41.2 m (mesotrophic lake) [5].

2.2 Interior flow

In study of Lake Biwa, as for the circular currents, search was done in 1925, and three kinds of entity were estimated in 1927. It is reported that character of geostrophic current, and consistency distribution of lake water (water temperature) reflects circular currents afterwards.

2.3 Water temperature structure

The Lake water temperature structure changes with atmospheric temperature change of the four seasons in Lake Biwa. I show value of the typical month data in Table.1 from water temperature mean value of 2000 from 1971 that the Shiga fisheries experimental station measured. As for the depth of the water are managed with 10 m unit, water temperature is managed with 0.1 degrees unit.

Table.1 Value of average year of water temperature.

Depth	Water Temparature (℃)			
(m)	March	June	Sep.	Dec.
0.5	7.3	20.8	24.7	11.1
10	7.0	16.6	23.9	11.3
20	7.0	11.2	13.4	11.2
30	7.0	8.9	9.6	11.0
40	7.0	8.0	8.4	9.5
50	7.0	7.6	7.8	8.2
60	7.0	7.4	7.5	7.7
75	6.9	7.2	7.2	7.4

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2.4 The quality of the water

Observation was done in June 1999, about the major ions in the north basin of Lake Biwa. As a result there are Na^+ 8.2, Ca^{2+} 12, Mg^{2+} 2.2, K^+ 1.6, SO_4^{2-} 10, Cl^- 9.7 (unit: mg/L), each instrumentation point, and it is reported that it is almost homogeneity [6].

3. **Equation for the speed of sound**

Del Grosso reports equation for the speed of sound includes seawater on the basis of experimental result as polynomial and shows it in expression 1.

$$C=1402.392+Ct+Cp+Cs+Cstp \quad (1)$$

As for the framing of this expression, *Ct* as for temperature, *Cp* as for pressure, *Cs* as for saline matter section, *Cstp* depending on become the section that they are related to mutually.

Lake Biwa water includes a very small amount of various ions. I adopt equation for the speed of sound, which Del Grosso examined by experiment analysis with pure water (DG equation) for this purpose by this disputation.

4. **Experiment**

I adopt for instrumentation-measured the speed of sound by framing same as former report. I selected the two instrumentation places of into Makino and Adogawa, but these are the places the same as former report. Instrumentation of this time proofreads sound-speed meter using ion-exchange water, too, and it is comparing instrumentation with ion-exchange water.

4.1 Thermocline

I selected the autumn season when thermocline existed, and circular current developed and enforced the instrumentation in Lake Biwa on November 2nd, 2008. Depth of the water 20 m neighborhood can identify thermocline.

4.2 Sound-speed measurements

There was the case that drift was recognized by affect of flow and transmitting pulse amplitude thought about in sound-speed meter in thermocline neighborhood. The instrumentation results of all layers became value to be faster than pure water and done account value in DG equation. I was different from the value that the speed of sound calculated thermocline to a boundary in difference of measured value, and 0.5 m/s, became 2 m/s fast value to depth below thermocline.

5. **Conclusion**

The speed of sound became fast instrumentation effect than pure water with all layers. I think that I need to revise it in DG equation in estimation of water temperature with that purpose.

I tried to demand the salinity conversion values reduced property, which revised sound-speed difference in DG equation when thermocline existed in this time. I show the results in Fig.1.

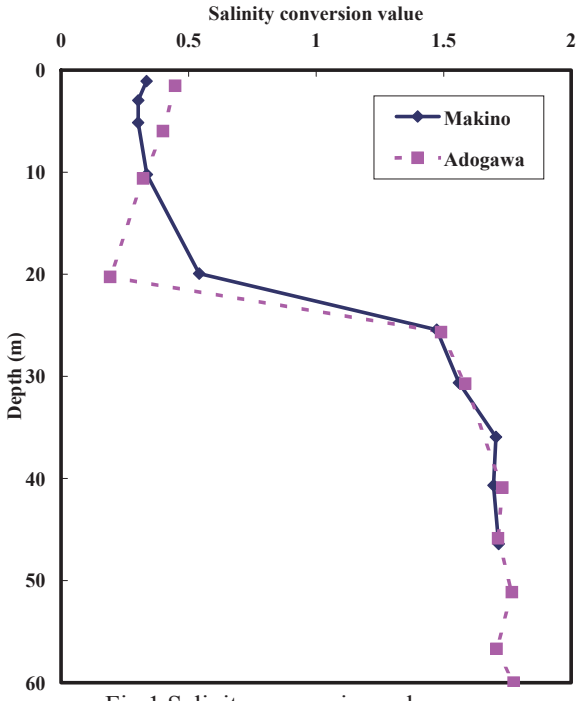

Fig.1 Salinity conversion values

It was different in salinity conversion values reduced property with thermocline greatly to a boundary. I am more inconsiderably than salinity conversion values reduced property measured with depth below thermocline for the winter season. But it was low value in the part, which was shallower than thermocline (there is a little sound-speed difference with pure water).

Lake water of the top and bottom layers does not mix it that thermocline is formed.

I will analyze lake water by sampling and, about this phenomenon, do validation of ion concentration in future. I want to do disputation necessary for water temperature estimation between the phases which thermocline exists in furthermore.

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