RELIABILITY OF BOTTOM TOPOGRAPHY OBTAINED BY ULTRASONIC ECHO-SOUNDER (*)

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In 1950, he was apponted to his present post at the Fishing Boat Laboratory, where he is engaged in basic echo-sounding research, and applications to the fishing industry.

He obtained the degree of Doctor of Technology in 1956 by presenting a thesis on ultrasonic propagation in the sea. He has also published many papers on his studies.

Mr. NISHIMURA is engaged in basic research into echo-sounding and fish-finding equipment and its application, at the Fishing Boat Laboratory, Fisheries Agency, under the direction of Dr. HASHIMOTO.

After graduating from Tohoku University in 1949, he was engaged in research into electrification of the fishing industry in 1950. He is carrying out research into ultrasonic propagation and field experiments in echo-sounding at sea. He is also supervising the equipment of fishing boats with ultrasonic transducers.

ABSTRACT

In this paper the authors give a comparison between an echo-survey of the topography of an artificial lake and an actual survey by triangulation made before the valley was filled with water. Accurate results were obtained using a high frequency and a narrow beam angle.

(*) This experiment was made with the co-operation of the Tokyo Electric Power Co. Inc., in September 1954, at a power plant along the Saikava River.

INTRODUCTION

For echo sounding or for research into the boundary conditions of artificial fish nests or *apartment houses* (*) by the ultrasonic echo sounder, it is necessary to obtain the true shape of the sea bottom by echo sounder.

We have already noted that when an echo sounder which transmits only broad-beamed ultrasonic signals is used, it is very difficult to obtain the true shape of a sloping or undulating sea bottom owing to the sounding error (**). However, if we use an ultrasonic wave of 15 to 3 centimetres in wave length, both the transducer and other apparatus become large and heavy, and they are not suitable for mounting on a small craft used for survey of shallow waters, lakes or swamps.

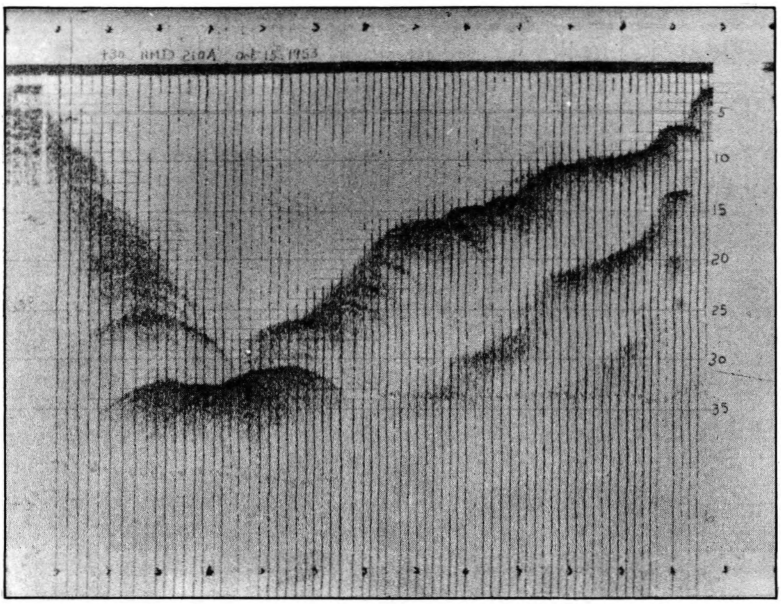


FIGURE 1

Echo-sounding record at steep inclination.

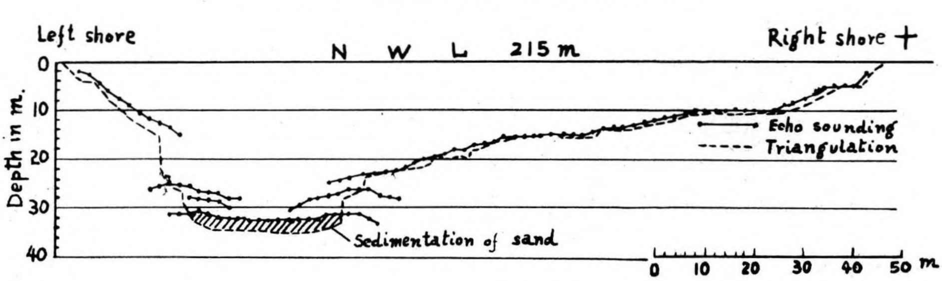


FIGURE 2

Comparison between echo-sounding record and true shape.

(*) In Japan there are artificial breeding grounds in rocks or wrecks on the sea bed. These last few years, hollow concrete structures have also been used for the purpose. They are one cubic metre in volume and include several apertures for the fish to build their nests in.

(**) T. HASHIMOTO and M. NISHIMURA : *Tech. Rep. of Fishing Boat*, No. 5, 1954, p. 155.

It is necessary, consequently, to use high-frequency ultrasonic waves, such as of 200 kc, and we can easily obtain a transducer with sharp directivity which can be used in small craft.

This paper reports the results of the experiment made to obtain a cross section of the underwater valley in an artificial lake along the Saikawa River in Nagano Prefecture, to compare the shape of the section surveyed by the triangulation before the lake was filled with water, with that obtained by echo sounder after it was filled.

ECHO SOUNDING BY TRANSDUCER WITH WIDE BEAM ANGLE

We had tried a similar experiment using echo-sounders with transducers of wide beam angle in November 1953 at an artificial lake of the Yanaizu power plant along the Tadami River. Details of results have already been published (*). Here we show again one of the above results obtained by 50 kc with a half-power beam angle of 22° in figures 1 and 2 for comparison. Figure 1 shows the cross section of the valley obtained by an echo-sounder and figure 2 illustrates a comparison between the shapes obtained by triangulation and echo-sounding.

It is clear that the shape obtained by echo-sounder is almost the same as that obtained by triangulation, in the case of the cross section where the slope is not so steep as the right hand bank in figure 2, but at the steep slope on the left bank or at the step-like shape, the echo-trace seems very odd, as shown in figure 1, and the shape obtained by this record is very different from the true shape of the valley.

METHOD AND APPARATUS

In this experiment, the triangulation was at first made at a cross section of the underwater valley of the Saikawa river, and figure 3 shows the survey-map location where the experiment was made. The slopes of both banks of the valley were steep and there was a masonry revetment (to separate the waterway from the main flow of the river) on the right-hand side of the valley 10 metres below the water line. The experiment was mainly made around this revetment. The width and height of the revetment were respectively 6.2 metres and 2.8 metres and the inclination on the right side of the revetment.

The echo-sounding was made along this cross section after the water was admitted. A steel wire covered with plastic with signs marked every metre was extended between the two bench marks used for triangulation on the right and left banks. The continuous echo-sounding was made travelling along this wire by a small boat fitted with a sounding apparatus. Signs were marked on the recording paper at intervals of 1 metre from the original point to the right bank by means of a rope tied between the two bench marks.

The apparatus used in this experiment was an experimental echo-sounder which could transmit and receive both 100 and 200 kc frequencies

(*) T. Hashimoto and M. Nishimura : *Tech. Rep. of Fishing Boat*, N° 5, 1954, p. 155.

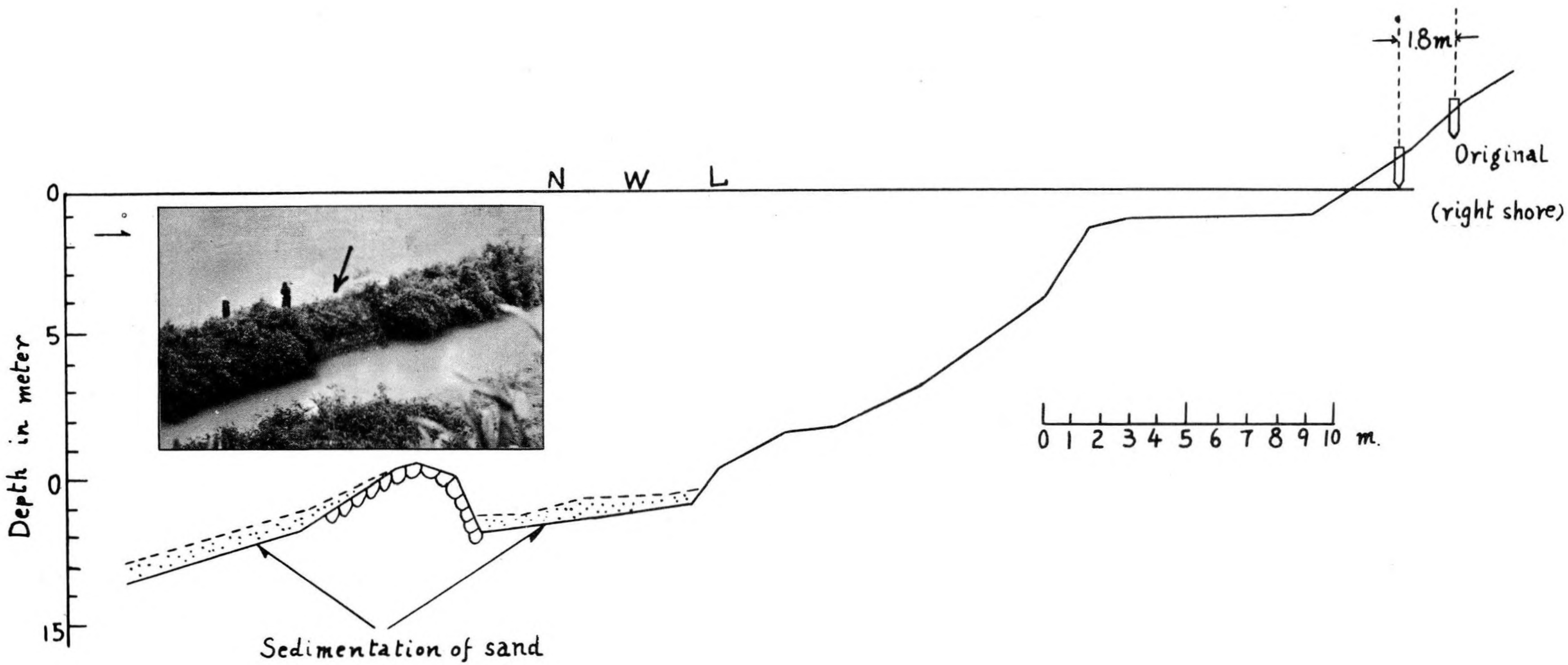
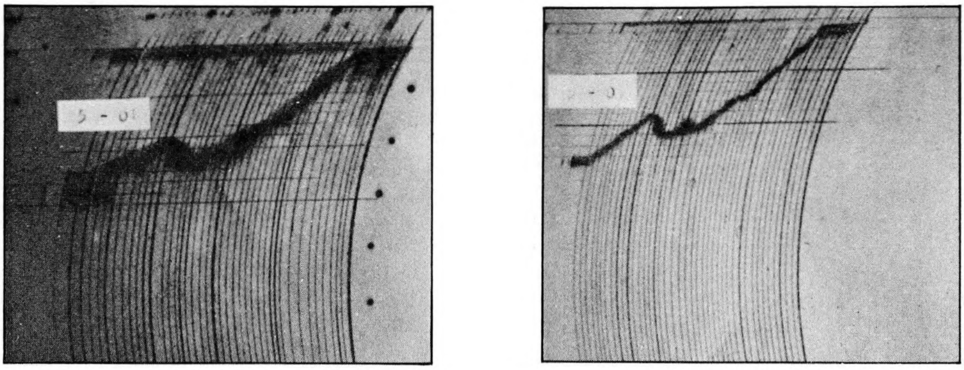


FIGURE 3
Cross section of the underwater valley obtained by triangulation.



A
(16°, 100 kc)

B
(3.3°, 200 kc)

FIGURE 4
Echo-sounding records.

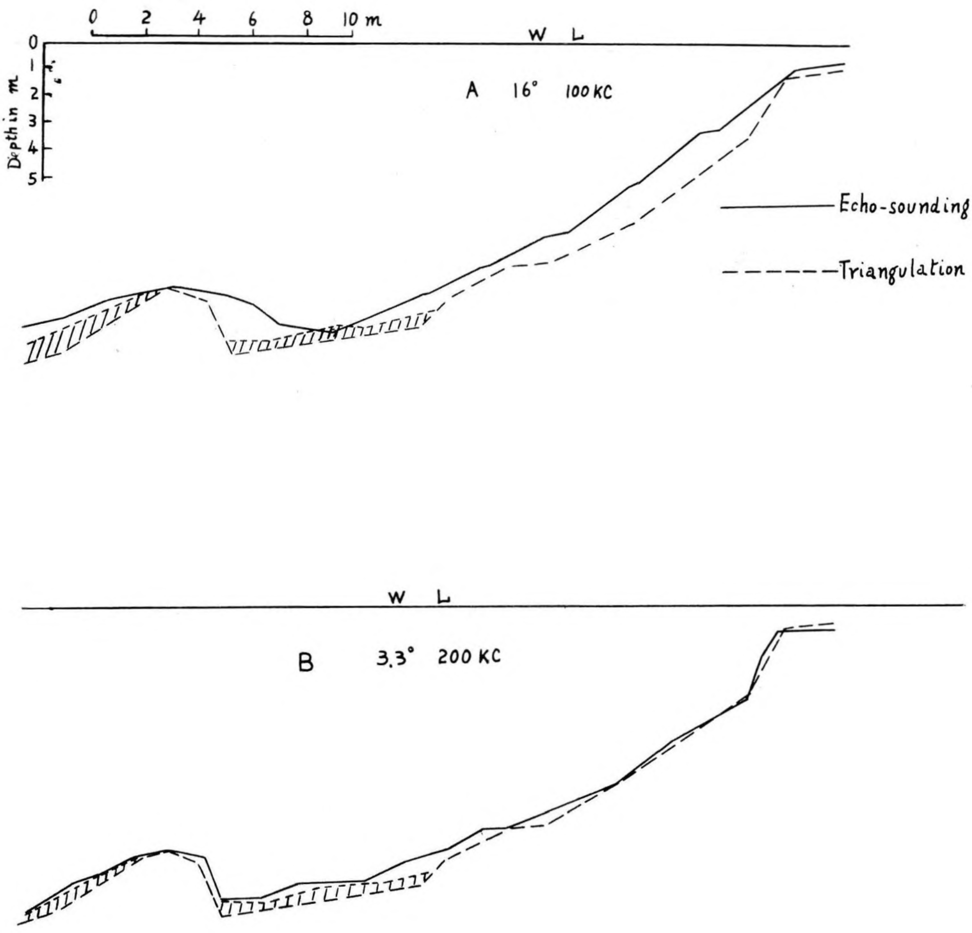


FIGURE 5
Comparison between echo sounding and triangulation.

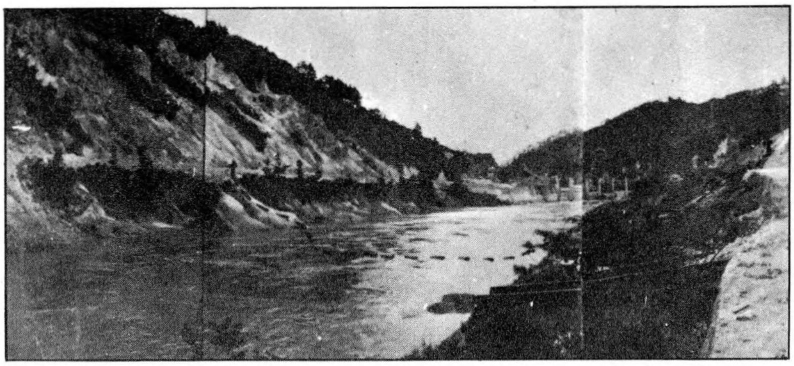


FIGURE 6
Picture of artificial lake before filling.

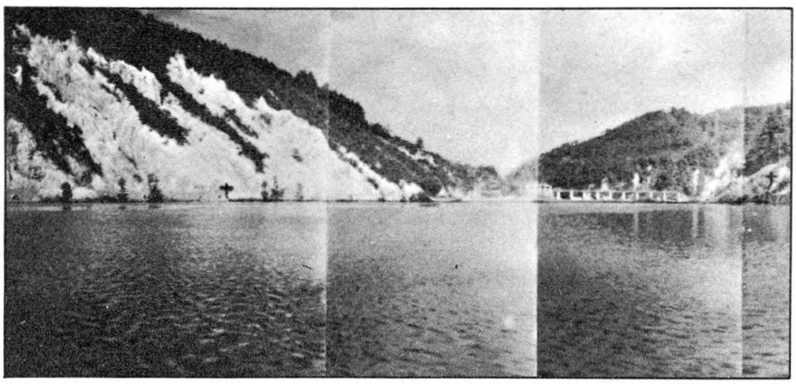


FIGURE 7
Picture of artificial lake after filling.

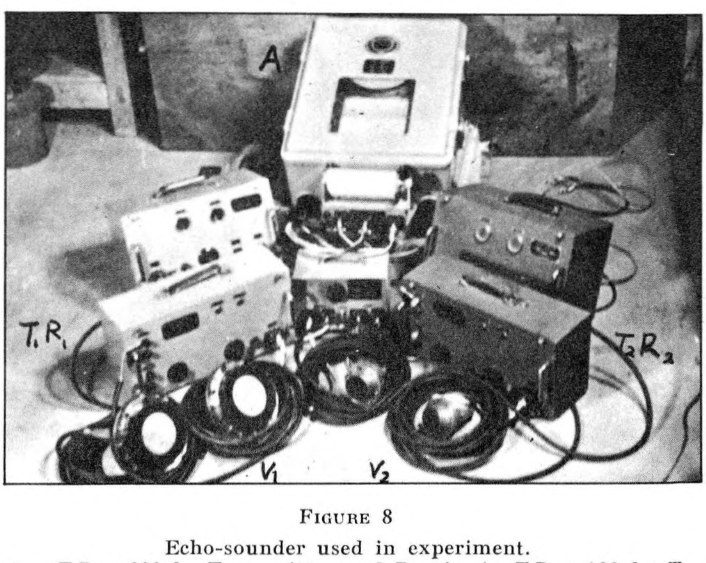


FIGURE 8
Echo-sounder used in experiment.
(A : Indicator, T_1R_1 : 200 kc Transmitter and Receiver); T_2R_2 : 100 kc Transmitter; V_1 : 200 kc Transducers; V_2 : 100 kc Transducers.

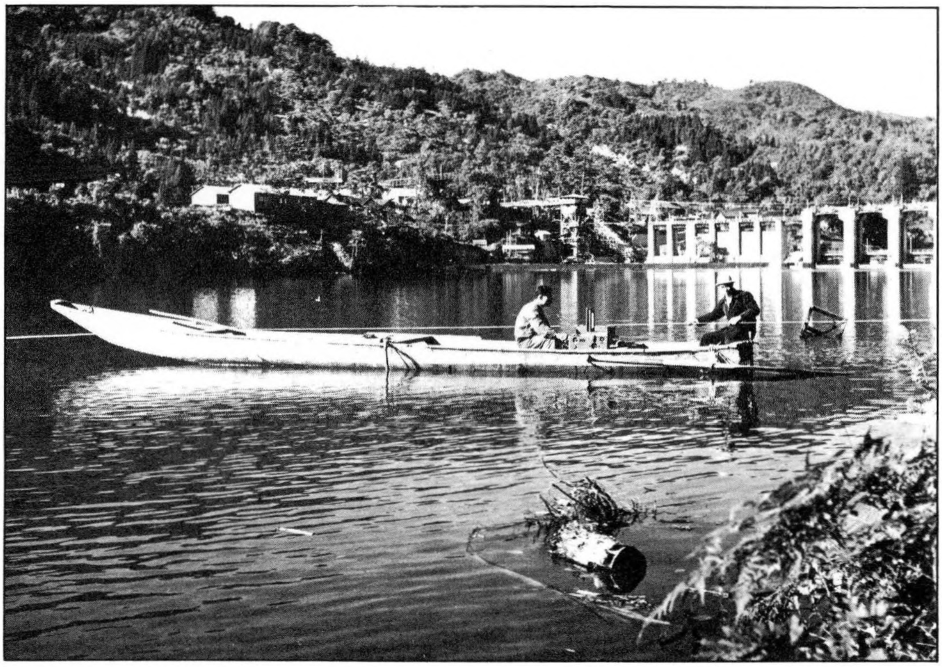


FIGURE 9
Scene of echo-sounding in artificial lake.

by changing the transducers. The sounding range of this echo-sounder was 50 metres and recording system was of a circular type (rotating type) with wet recording paper, and the beam angles of the transducer were 16° and 3.3° respectively.

RESULTS

The results of the echo-sounding obtained by using the transducer at half-power with 16° and 3.3° beam angles are shown in figure 4 (A and B), and in figure 5. Figure 4 is the echo-sounding record and figure 5 shows the echo-sounding shape compared with the true shape obtained by triangulation. When the beam angle is 16° (100 kc) as shown in figure 5A, the shape of the revetment is distorted and it is difficult to obtain the true shape with the record, but on the other hand when the beam angle is 3.3° the width of the revetment is only 20 centimetres longer than the true width as shown in figure 5B.

CONCLUSION

From the results of these experiments we may conclude as follows :

1) To have a sharp beam angle, it is best to use high frequency ultrasonic waves, such as of 200 kc, because the transducers become compact and echo-sounding is easy in shallow waters, lakes or swamps, even from a small craft, since the mounting of the sounding apparatus is simplified.

2) It is possible not only to obtain the true shape of the sea bottom but also to detect schools of fish swimming quite near the artificial fish nest or *apartment houses* by echo sounder, if we use an apparatus with a sharp beam angle such as 3.3° at half-power, since the error of the echo trace is not so large as when a broad beam angle is used, even on sloping or steep bottoms.