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An Acoustic Survey of Salmon Juveniles in the Okhotsk Sea during the Autumn of 1996

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An Acoustic Survey of Salmon Juveniles in the Okhotsk Sea during the Autumn of 1996

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ABSTRACT

We made a survey on salmon juveniles, including trawl sampling and acoustic investigation, on the board of R/V Kaiyo-maru, in the north western North Pacific around the Kuril Islands and in the Okhotsk Sea during October and November of 1996. The detected echoes of juveniles were weak, about –32dB to –43dB, but we were able to extract the signals from fish with the single echo processing system attached to the echo sounder KJ-2000 (Kaijo Co.). Though we must admit there are some shortcomings, the acoustic survey in the Okhotsk Sea revealed that salmon juveniles can be detected by the echo sounder. The analysis of apparent fish swimming speed calculated with the single echo processing system suggested the possibility that salmon juveniles make small groups. The vertical distributions of detected juveniles shows that 90 percent of detected fish are in the zone shallower than 40 m, and 2.8 percent of them are detected in deeper water than 70 m, where water temperature was 1°C to 4°C.

INTRODUCTION

We made an acoustic survey on salmon in the northern North Pacific in January of 1996, and found that we can detect them with a qualitative echo sounder FQ-72 (Furuno). The vertical and horizontal distribution of salmon from the acoustic data was discussed in Sakai *et al.* (1996).

National Research Institute of Far Seas Fisheries (NRIFSF), Fisheries Agency of

Japan, has made an investigation into the distribution of chum salmon juveniles in western North Pacific Ocean near the Kuril Islands and Okhotsk Sea, from October to November of 1996. We tried to detect salmon juveniles, the target strength of which was supported to be much small than of adults, with echo sounder during survey.

In this paper, the word "juvenile" means salmon which came down to the sea in the spring or summer, and "adult" means immature and mature on ocean stage.

Materials and Method

The outline of the acoustic survey

In this survey, we made a series of acoustic survey with quantitative echo sounder, KJ-2000 (Kaijo Co.) on fisheries research vessel Kaiyo-maru, Fisheries Agency of Japan. We collected data continuously on magneto optical disks and colour recording papers. The frequency was 38kHz, the maximum range 100 m, and the pulse duration 1.2 msec.

We only analysed data collected in the several trawl stations in Okhotsk Sea, for three reasons; because (1) we could not catch any juvenile on the Pacific waters with trawl net, (2) the data when the ship speed was relatively slow was selected to avoid noise made by the ship itself (this condition was satisfied only at the trawl stations), and (3) we removed data collected in rough sea condition. By these reasons, the data of only five stations illustrated in **figure** 1 could be taken to analyse.

Analysis of the data

Looking at colour- and wet- recording papers, we were able to detect some echoes on them. However, the intensity of signals from salmon juveniles was so weak, that it is difficult to count signals of fish directly from recording papers.

The quantitative echo sounder KJ-2000 contains dual-beam and split-beam system. It also has the *single echo processing system*, the details of which was introduced by Furusawa *et al.* (1993). It enables us to extract single fish echoes with information concluding its range from transducer, target strength of fish (in the unit of dB), the position of detected fish towards the echo sounder. The target strength (here after, TS [dB]) is already transformed to remove the effect of the beam pattern of the transducer. We used this system to extract weak signals from juveniles.

At the same time, we can get the navigation information including ship speed. Hence, when single-echo data are collected in several continuous pings, *apparent* fish speed can be calculated.

Results and Discussion

252 signals were extracted by the single echo processing system. Some of them are from continuous pings. When the continuous data have about the same range, two way of interpretation is possible. They are signals showing the movement of single fish, or they are from two or three different individuals making groups.

Separation of juvenile echoes from adults

Because we caught salmon in various size of fork length, it is natural to deduce that both of adults and juveniles were detected with the echo sounder. Then we must separate the signals into those from adults and from juveniles. Regarding magnitudes of TS is useful for this purpose, for TS varies with body length. But target strength of single fish also varies in complicated way with incident angle of the sound. Miyanohana (1995) suggests that maximum TS of fish of length L cm in dorsal aspect can be described by the equation,

$$TS_{\max} = 20 \log L - 60.0.$$

We applied this equation to the mean length of juveniles, and the mean length about 25 cm derived the value about -32. However, The value of TS_{max} only means maximum TS in dorsal aspect, so essentially we can not separate signals from juveniles and weak ones from adults, for the acoustic patterns of fish itself. Here this equation was taken to separate the signals of salmon adults from juveniles as the best possible way.

Speeds of migration and schooling habit of salmon

As has been mentioned, if signals of single echo at about the same depth are collected in continuous pings, *apparent* fish speed can be calculated from fish position and ship speed. The speeds of fish calculated from single echoes are from 1.1 to 14.7 m/s (the effect of water current was not considered). Migration speed of salmon in the ocean is at the range of about a fork length par second (1 FL/s) to 8 FL/s, mostly about 1 or 2 FL/s (Ichihara *et al.* 1975, Ogura and Ishida 1995). In this case, salmon might swim very fast because the ship and the net chased them. The laboratory experiments suggests salmon juveniles can swim at the speed of more than fifteen times of fork length par second (15 FL/s) for several seconds (Ohkuma *et al.* 1995). Here we take the criterion of 15 FL/s as maximum speed, in order to judge if the apparent fish speeds are reasonable or not. Then the limit of swimming speed for juveniles of 25 cm becomes 3.75m/s, and even for the fish of 50 cm, 7.5m/s. These estimation shows that the upper values that we have got here seem to be too high for swimming speed of salmon. In the analysis, the speed of

3.75 m/s for juveniles was taken as the fastest speed beause the mean length of juveniles is about 25cm.

Table 1 shows the number of signals extracted by single echo processing system. There was 52 sets of signals in continuous pings for juveniles. But 30 of them were not taken as the continuous data from single fish, because the apparent swimming speeds derived from them are too fast. They are supported to be the signals from different individuals. The number of all signals of juveniles is 226, and sets of signals in three continuous pings are 5. Thus 199 juveniles were detected. The results also shows that we detected 28 pairs and 2 groups of three juveniles among 199 individuals by echo sounder. This suggests the possibility that salmon juvenile make small groups.

Vertical distribution of salmon detected

Figure 2 shows appearance rate of salmon individuals by the sections of 5 meters down to 100m. The number of individuals is not provided because we need to correct the effect of beam spreading which increases swept volume in deeper zone. The depth of the transducer attached to the hull was about 5 m. We can not utilize the data of several meters from a echo sounder for mechanical restriction, and fish might escape from a running ship. So we can not find fish in shallower zone.

Figure 2 indicates most of detected fish is in the depth of 15 m to 40m. 90 percent of all are found in the depth shallower than 40 m. Fish found at deepest depth is at 97.1 m.

The acoustic survey made in the Pacific Ocean in January of 1996 suggests that the limit of low temperature of salmon habitation is considered to be 4°C (Sakai *et al.* 1996). The depth where the water temperature becomes below 4°C was 53 to 69 m in the stations we analysed here. Some signals are in deeper place than theses depths. Mainly their echoes are found in the nighttime, when DSL appears on echograms. But some signals appear at such depths in daytime, and we have no biological information about deeper zone than about 60 m where the trawl net reached. So identification of the signals is impossible here.

Conclusion

1. Acoustic survey for salmon juvenile made in the Okhotsk Sea revealed that salmon juveniles can be detected by echo sounder.
2. The possibility that salmon juvenile make small schools is suggested by the analysis of apparent swimming speed of detected fish calculated with the single

echo processing system.

3. According to the vertical distributions of detected fish, 90 percent of them are in shallower zone than 40 m. On the other hand, 2.8 percent of them are detected in deeper water than 70m, where water temperature was 1°C to 4°C.

We must admit that these conclusion contain many problems. Probably we were not able to separate echoes of juvenile from those of adults completely. As concerns the discussion on swimming speed, this survey was made on the Okhotsk sea where the sea condition is relatively severe, then almost always the research vessel rolled and pitched. Rolling and pitching of the ship greatly affects the measurement of angle of fish with echo sounder. Errors in the angle make errors in position of fish, which lead to wrong estimations in swimming speed of fish. We also admit that we neglected the effects of water current on the estimation of them. These shortcomings derive from the fact that we could not collect acoustic data very carefully, because we did not have time and hands enough to make the acoustic survey properly besides the biological and oceanographic investigations.

The confirmation of these conclusions need more careful and precise survey.

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References

Furusawa,M., Y.Takao, K.Sawada 1993 Versatile Echo Sounding System Using Dual Beam. *Nippon Suisan Gakkaishi* 59(6), 967-980.

Ichihara,T., T.Yonemori, H.Asai 1975 *Bull. Far. Seas Fish. Lab.* 13, 63-77.

Miyanohana,Y., K.Ishii, M.Furusawa 1986 Measurement and Analysis of Dorsal

Aspect Target Strength of Fish *J. Marine Acoustic Soc. Japan* 13, 169-175.

Ogura,M., and Y.Ishida 1995 Homing behavior and vertical movements of four speceis of Pacific salmon in the central Bering Sea *Can. J. Fish. Aquat. Sci.* 52, 532-540.

Ohkuma,K., S.Sasaki, A.Wada, C.Toshima 1995 *Abstracts for the Meeting of the Japanese Society of Fisheries Science, April, 1995* 247, p.56.

Sakai,J., Y.Ueno, Y.Ishida, K.Nakayama 1996 Vertical Distribution of Salmon Determined by an Acoustic Survey in the North Pacific Ocean in the winter of 1996. *NPAFC*, Doc.214.

Table 1. numbers of signals extracted by single echo processing system.

	Adults	Juveniles	Total
Number of signals	26	226	252
Number of sets of signals at about the same range in continuous pings	10	52	62
Number of sets of signals in continuous pings from single fish	7	22	29
(Sets in three continuous pings from single fish, included in the data just above)	(1)	(5)	(6)
Number of individual fish detected	18	199	217

Number of schools detected	3	30	33
(Schools of three fish, included above)	(0)	(2)	(2)

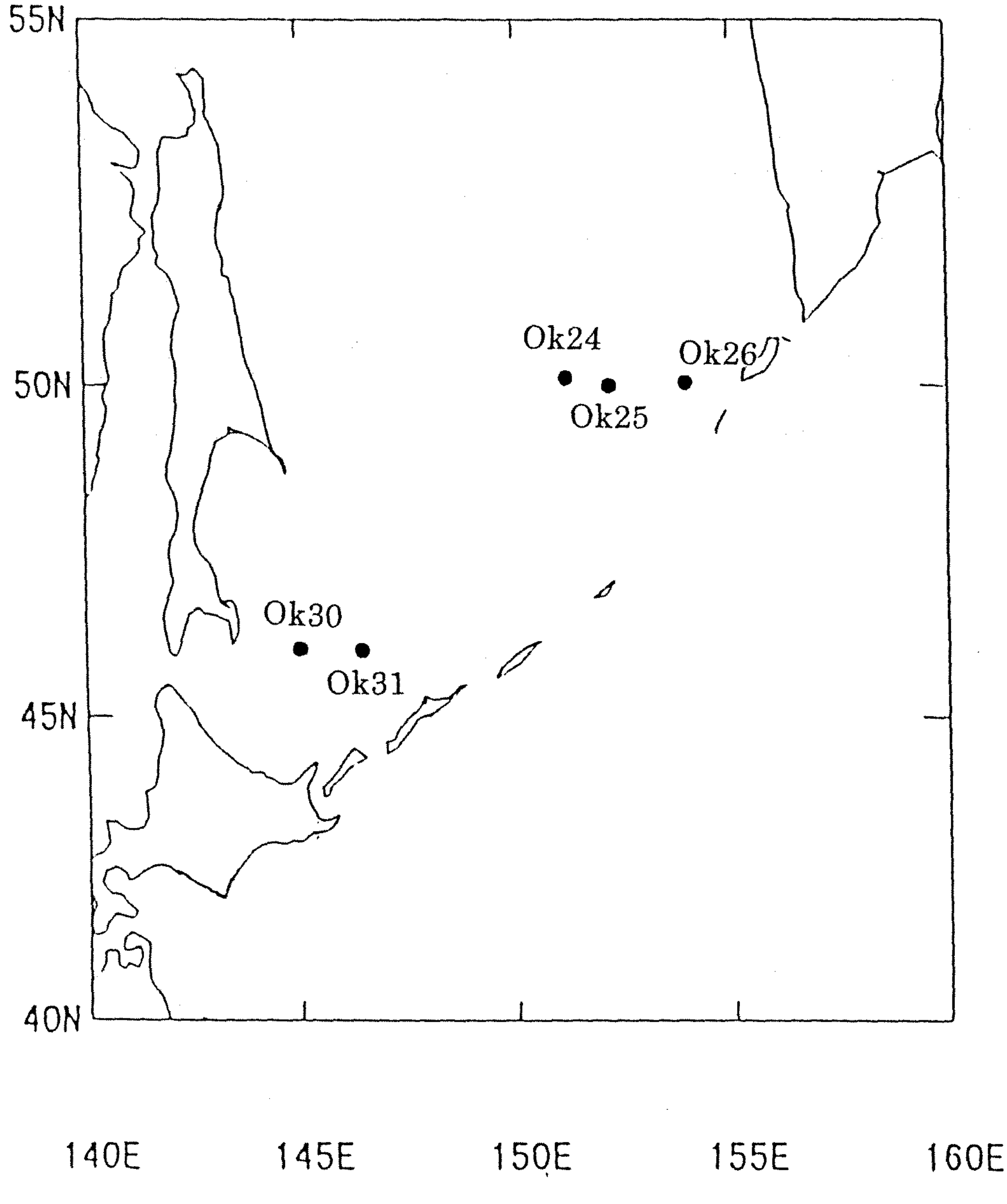

Figure 1. Trawl stations at which acoustic data analysed were collected.

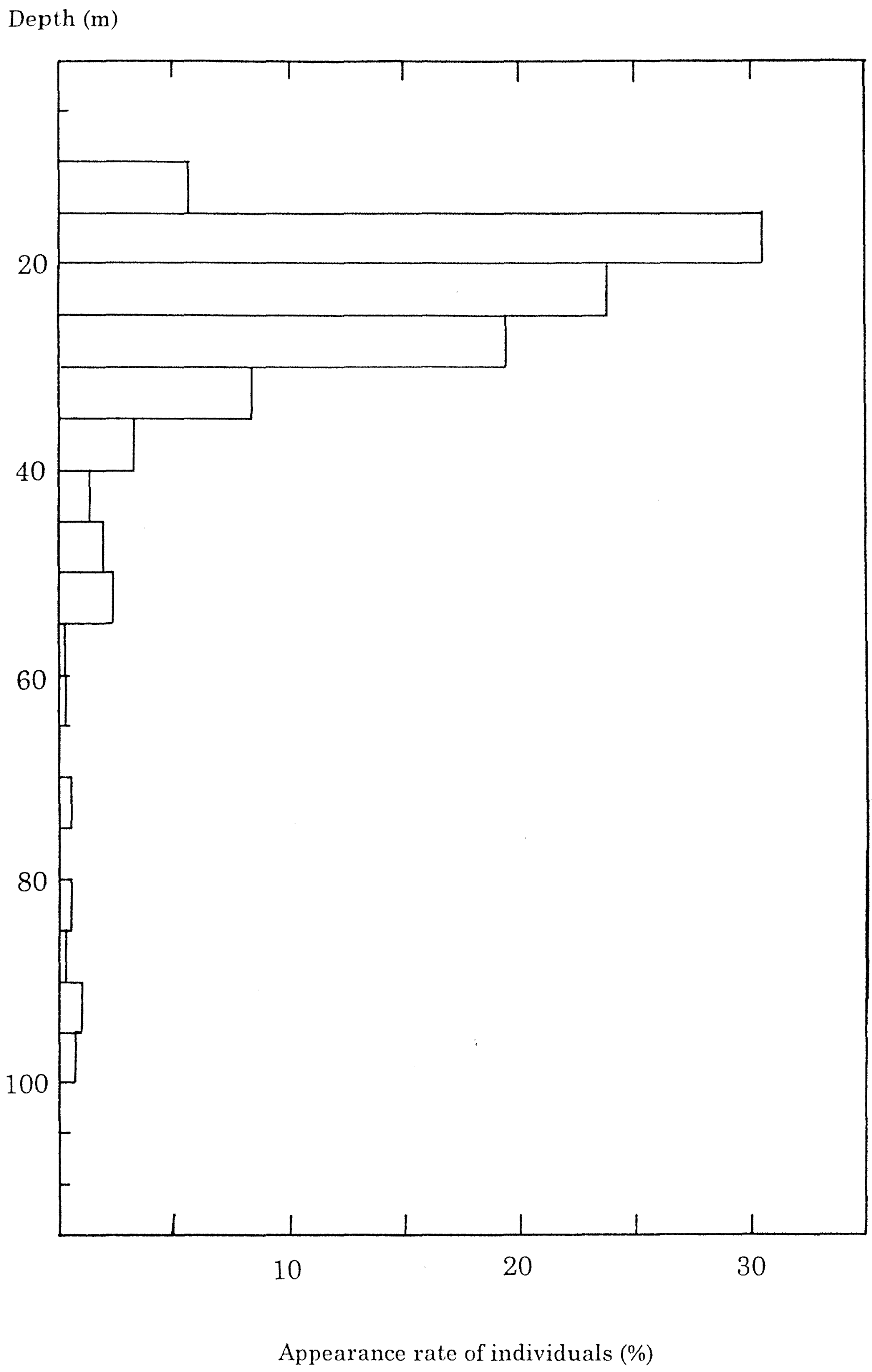

Figure 2. Appearance rate of fish calculated from the number of individuals.