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ACOUSTIC SURVEYS OF LAKE WENATCHEE AND LAKE OSOYOOS IN 1973

by

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INTRODUCTION

Lake Wenatchee and Lake Osoyoos support two of the most southerly runs of sockeye salmon (*Oncorhynchus nerka*) in the United States and are the principal producers of sockeye salmon in the Columbia River drainage. Biologists of the Washington Department of Fisheries (WDF) have been collecting data on escapements into the lake systems and studying the juveniles to determine fry emergence, growth rates and timing of smolt migrations. After an initial acoustic survey of Lake Wenatchee in 1972 (Nunnallee and Mathisen, 1972), surveys were expanded in 1973 to include both Lake Wenatchee and Lake Osoyoos with funds provided by the Washington Department of Fisheries under a contract with the Fisheries Research Institute. Results of these two surveys are presented in this report.

MATERIALS AND METHODS

The goal of the acoustic surveys was primarily the estimation of the smoltifying population of juvenile sockeye salmon. The quantitative species composition in both lakes was unknown, and net sampling was not feasible because of limited equipment, time and manpower, but the difference in total lake populations between surveys conducted before and after smolt outmigration would furnish an estimate of the juvenile sockeye salmon population. Surveys of Lake Wenatchee were conducted on 27 March and 22 May. Surveys on Lake Osoyoos were conducted on 26 March and 21 May.

The acoustic data collection system used during the four surveys was the same as used during the 1972 survey of Lake Wenatchee except for the addition of an automatic calibration oscillator. Technical descriptions of the components and operational procedures are given in Thorne, Nunnallee, and Green (1972) and Nunnallee (1973). Briefly the system consists of a specially modified, 105 kHz Ross 200A echo sounder with an interface unit so that the acoustic data can be recorded on magnetic tape.

A series of 10 parallel transects spaced approximately 1/2 mile apart were surveyed on Lake Wenatchee in March and May (Figure 1). The transect speed for both surveys was between 2.2 and 2.3 m/sec determined with a Gurley current meter.

A series of 16 transects were surveyed in the three natural basins of Lake Osoyoos (Figure 2), nine of which were located in the Northern Basin. All four acoustic surveys were conducted at night, and each required about 4 hr to complete as transect speeds were between 2.1 and 2.3 m/sec.

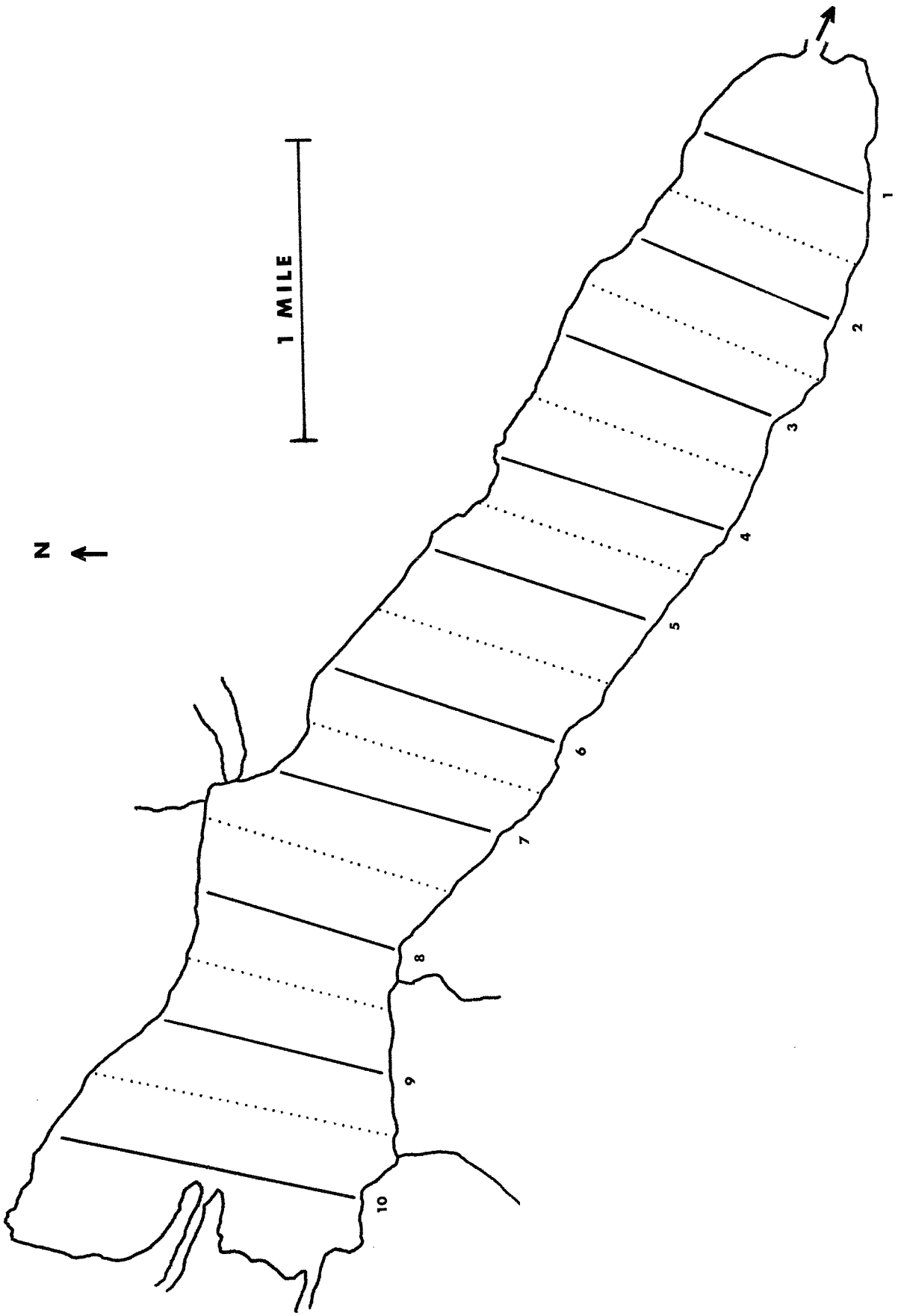

Figure 1. Location of acoustic transects on Lake Wenatchee.

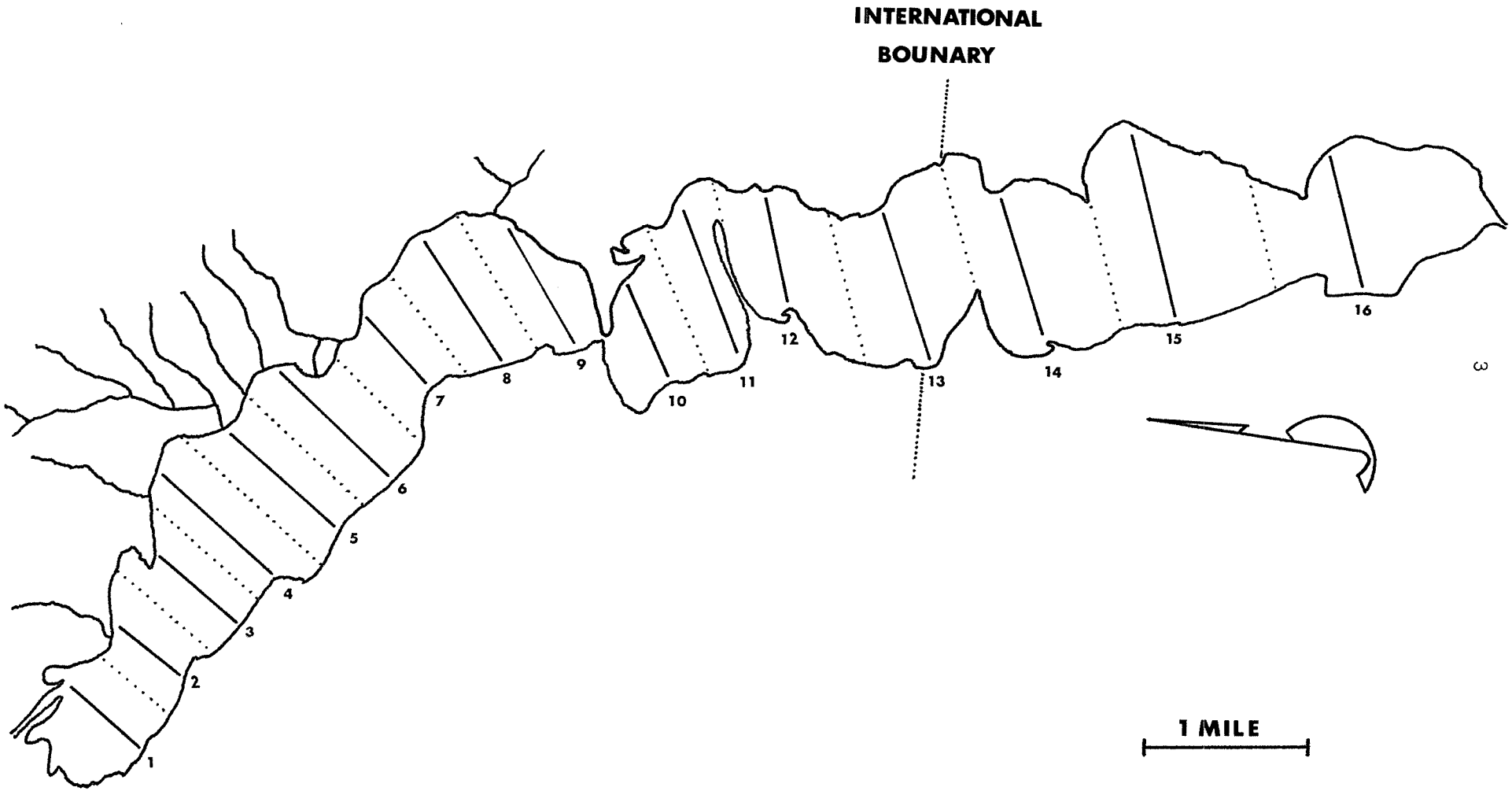

Figure 2. Location of acoustic transects on Lake Osoyoos.

DATA ANALYSIS

The acoustic data analysis techniques have been described elsewhere (Dawson, 1972; Thorne, 1972, Nunnallee and Mathisen, 1972; Traynor, 1973; Nunnallee, 1973) and are similar to the methods applied to the 1972 survey of Lake Wenatchee. Briefly, the basic analysis consists of two stages. The first is analysis of all tapes on a digital echo integration system (Thorne, 1972, 1973; Nunnallee, 1973). The digital echo integrator determines the relative density of fish in pre-specified depth and time cells. Mean densities were determined along each transect for 10-m depth intervals extending from 10 to 70 m. An additional interval from 5 to 10 m was analyzed for the second survey of Lake Osoyoos.

The second step in the analysis is the determination of the constant that converts relative fish densities to absolute. This constant was determined by regression analysis of absolute densities determined from echo counts with an oscilloscope in selected depth and time cells and the corresponding relative densities from the digital echo integrator.

An additional analysis was applied to the data from the 1973 surveys. Measurements of target echo voltages were made with an oscilloscope on about 200 randomly selected yargets for each survey to determine the target strength distribution (Craig and Forbes, 1969). Then the target strength data was used to examine the size distribution of the fish observed during the surveys.

RESULTS

Lake Wenatchee Surveys

The volume of water associated with each depth-transect stratum in Lake Wenatchee is given in Table 1. Volumes were derived from the surface areas of the lakes and the bottom contours determined by the echo sounding. The numbers of fish in the strata were determined from multiplication of the volumes by the acoustically determined mean densities and are presented in Table 2. The total population estimate was 2.42 million fish. The distribution of fish along the long axis of the lake is plotted in Figure 3, while Figure 4 gives the vertical distribution. The results of the target strength analysis are presented as a frequency distribution of target strengths in Figure 5. All targets were greater than -54 dB which theoretically corresponds to a minimum length of about 50 mm.

The estimated abundance of fish in each depth and transect for the May survey is given in Table 3. The total population estimate was 2.33 million. The East-West distribution is plotted in Figure 6, the vertical distribution in Figure 7, and the distribution of target strengths in Figure 8. Thirty percent of the targets were greater than -54 dB and 70 percent were less than -60 dB.

Table 1. Lake Wenatchee volumes in millions of cubic meters by depth

Depth (m)	Transects									
	1	2	3	4	5	6	7	8	9	10
10-20	5.77	10.21	11.72	10.80	8.70	9.46	8.84	7.24	9.92	15.30
20-30	4.50	9.77	11.36	10.50	8.42	9.32	8.17	7.08	9.40	12.20
30-40	3.67	9.02	10.80	10.13	8.05	8.73	7.02	6.68	8.77	8.30
40-50	1.06	7.78	9.83	9.48	7.40	7.76	6.17	5.51	6.70	3.49
50-60		5.90	8.99	8.70	6.83	6.67	5.05	3.68	4.05	0.18
60-70		0.73	2.63	5.83	4.94	3.23	2.09	1.68	0.32	

Table 2. Population size in thousands by depth and transect for Lake Wenatchee, 27 March, 1973

Depth (m)	Transect 1	2	3	4	5	6	7	8	9	10	Total	Percent
10-20	1.39	0.22	4.66	0.17	0.02	1.53	5.07	5.88	10.22	20.20	49.40	2.04
20-30	2.95	4.41	18.18	11.13	9.18	34.48	21.43	29.10	87.42	178.12	396.40	16.37
30-40	19.63	16.51	24.30	17.83	20.53	67.66	71.60	81.50	147.34	319.55	786.45	32.48
40-50	10.21	31.04	42.56	62.66	70.37	118.73	106.74	114.61	126.63	100.86	784.41	32.40
50-60		20.59	44.95	31.23	55.19	56.83	65.65	36.21	48.6	2.32	361.60	14.94
60-70		1.18	5.81	6.18	3.77	4.36	7.09	12.03	2.42		42.80	1.77
Total	34.18	73.94	140.46	129.21	159.05	283.59	277.58	279.32	422.62	621.05	2421.	
Percent	1.41	3.05	5.80	5.34	6.57	11.71	11.47	11.54	17.46	25.65		

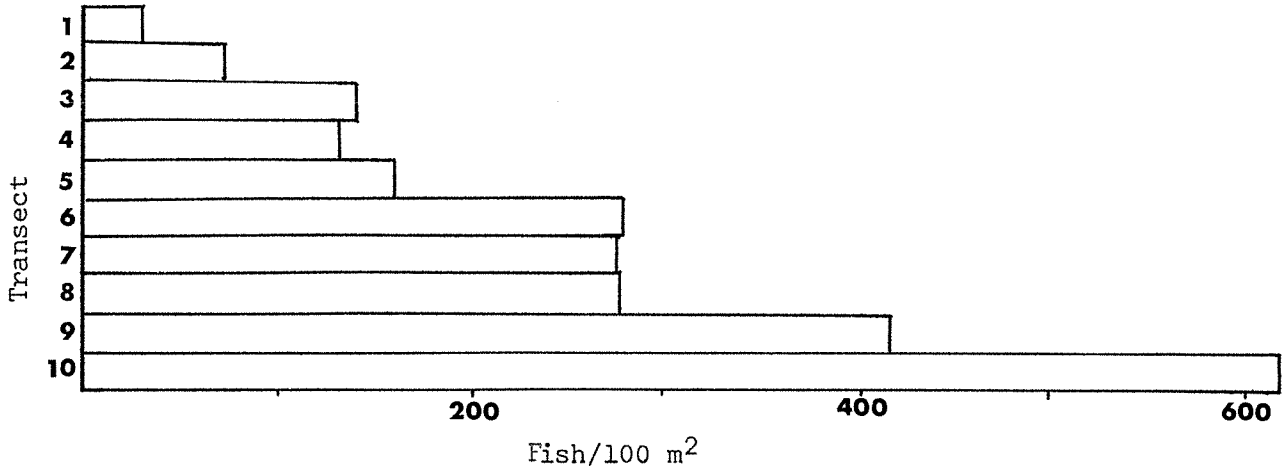

Figure 3. Distribution of fish densities observed along transects on Lake Wenatchee, 27 March 1973.

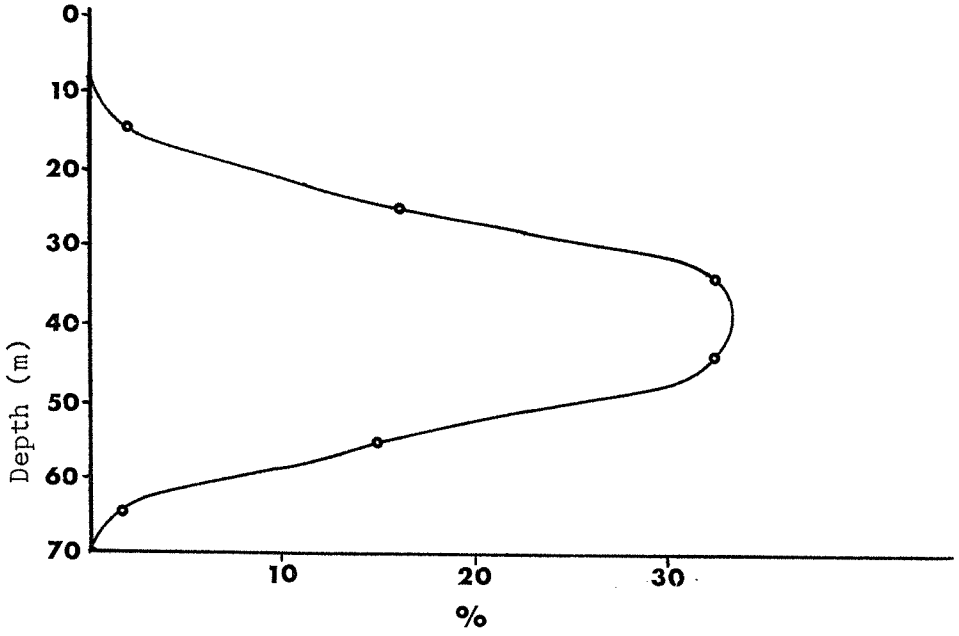

Figure 4. Vertical distribution of fish targets in Lake Wenatchee at night on 27 March 1973.

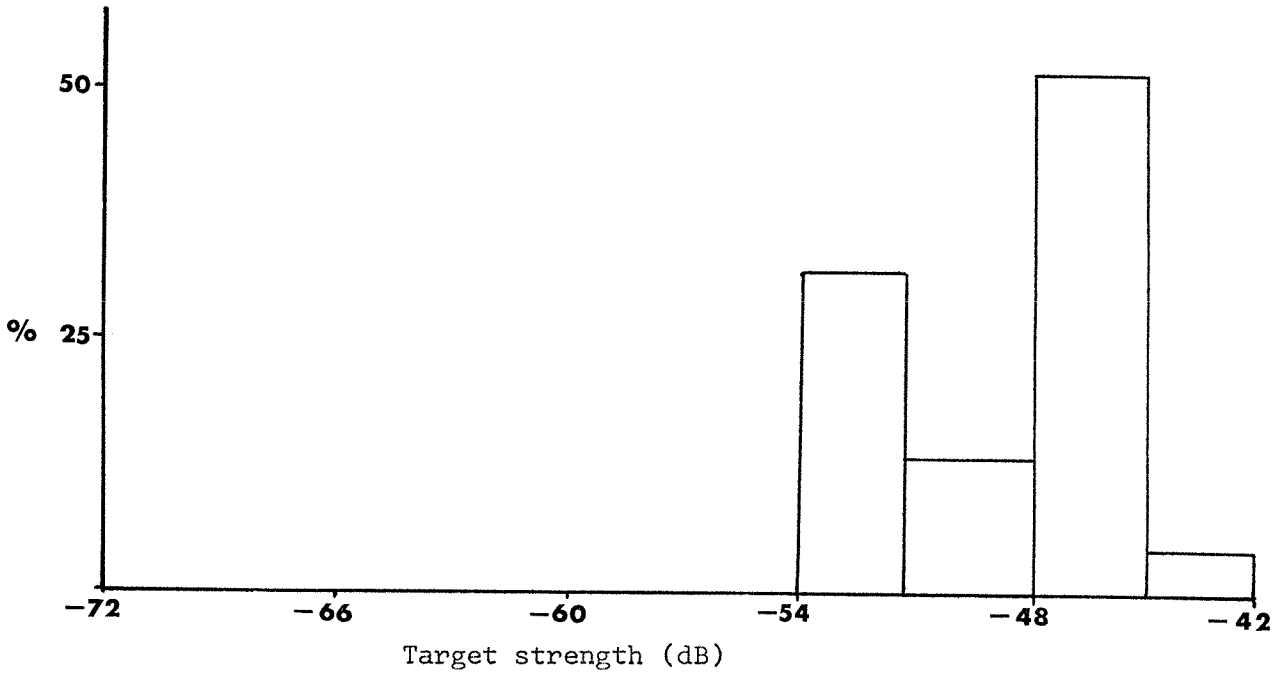

Figure 5. Distribution of target strengths observed during survey of Lake Wenatchee, 27 March 1973

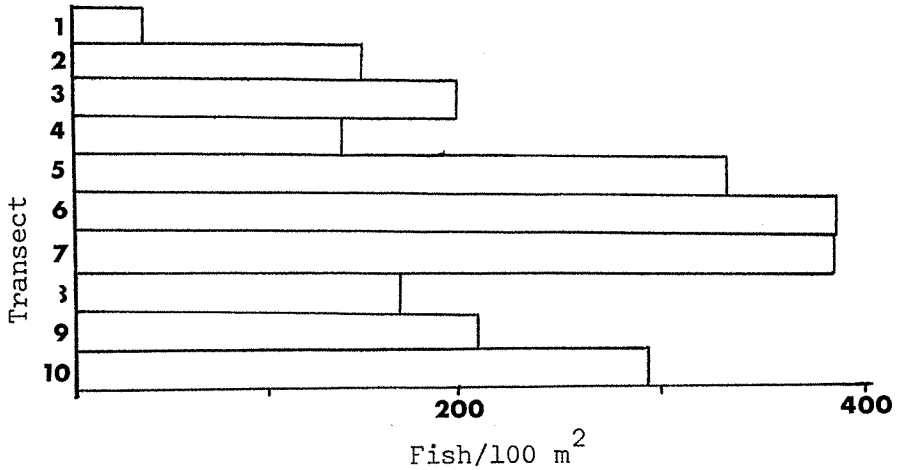

Figure 6. Distribution of fish densities observed along transects on Lake Wenatchee, 22 May 1973.

Table 3. Population size in thousands by depth and transect for Lake Wenatchee, 22 May, 1973

Depth (m)	Transect 1	2	3	4	5	6	7	8	9	10	Total	Percent
10-20	35.3	48.0	92.0	83.8	261.0	289.5	269.6	112.2	139.9	172.9	1504.2	64.68
20-30		46.7	64.0	38.3	52.6	81.6	85.8	46.9	61.9	95.6	573.4	24.66
30-40		14.6	16.5	8.3	15.1	15.2	24.3	7.5	7.1	27.5	136.1	5.85
40-50		12.6	12.6	5.6	12.1	5.0	8.1	3.5	1.7	0.5	61.7	2.66
50-60		25.0	14.2	1.5	1.6	2.3	1.6	0.5	0.2		46.9	2.02
60-70			1.4	0.6	0.6	0.2	0.3				3.1	0.13
Total	35.3	146.9	200.7	138.1	343	393.8	389.7	170.6	210.8	296.5	2325.4	
Percent	1.52	6.32	8.63	5.94	14.75	16.93	16.76	7.34	9.06	12.75		

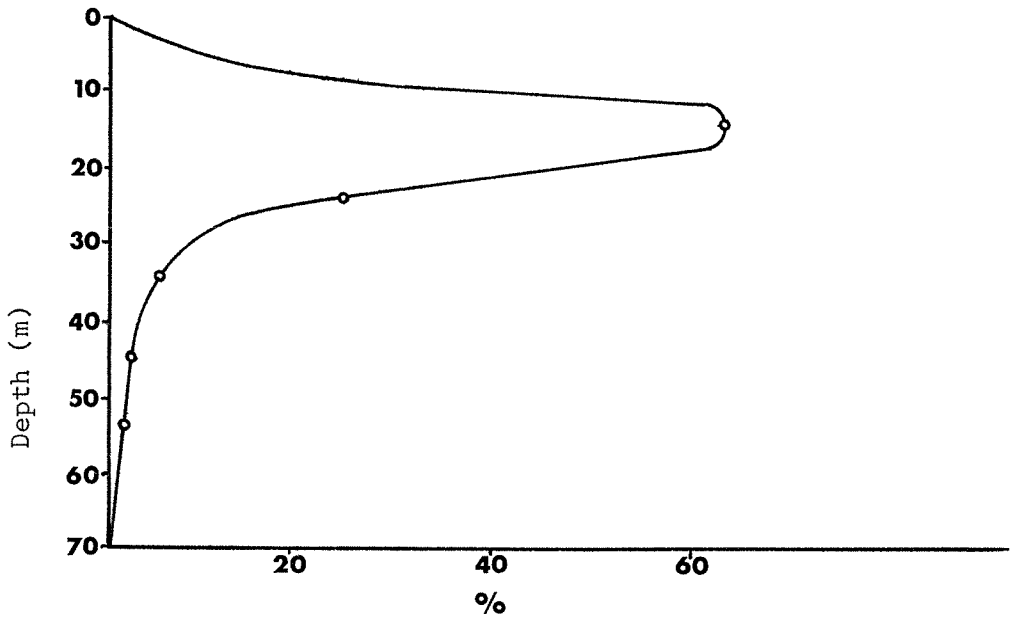

Figure 7. Vertical distribution of fish targets in Lake Wenatchee at night on 22 May 1973,

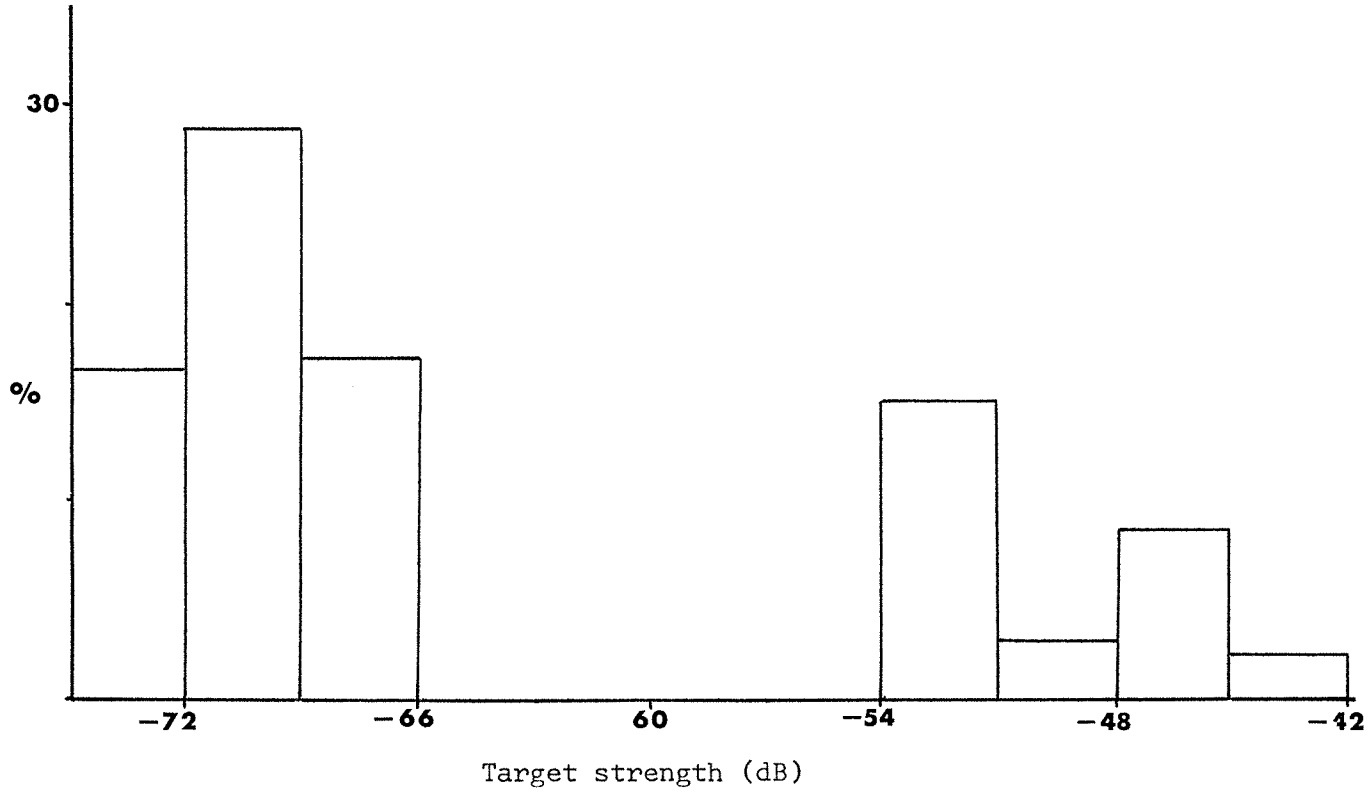

Figure 8. Distribution of target strengths observed during survey of Lake Wenatchee, 22 May 1973.

Lake Osoyoos Surveys

The volumes of water associated with various depth-area strata are given in Table 4 and the population estimates in the corresponding strata for the March survey in Table 5. The total estimate was 2.67 million. Horizontal and vertical distributions are presented in Figures 9 and 10, respectively. The distribution of target strength is shown in Figure 11. Virtually all targets (99.5%) were greater than -54 dB.

The numbers of fish in various strata during May are given in Table 6. The total population estimate was 4.08 million. The distribution of fish densities along the long axis of the lake is given in Figure 12, vertical distributions are summarized in Figure 13, and the distribution of target strengths in Figure 14.

DISCUSSION

Lake Wenatchee

The distribution of fish density along the long axis of Lake Wenatchee shifted toward the outlet at the east end between March and May. The mean depth inhabited by the fish decreased from 40 m to less than 20 m.

The survey of Lake Wenatchee during April 1972 showed a horizontal distribution similar to that observed during March 1973. The vertical distribution observed in April 1972 was intermediate to the vertical profiles observed in March and May 1973.

It is possible that some migration of juvenile sockeye salmon had occurred prior to the April 1972 acoustic survey, but it is considered unlikely that any migration occurred prior to the March 1973 series, since the fish were still deep in the water column.

By late May most juveniles were believed to have left the lake. The May population estimate of 2.33 million fish was only 90,000 less than the March estimate. However, the target strength data indicate a major influx of small fish targets between March and May. These small targets are assumed to be fry entering the lake from the White and Little Wenatchee Rivers. Since only 30 percent of the targets in May were of the larger size category, the difference between the surveys is equal to 1.7 million large targets. This number is probably the best estimate of the outmigrating juvenile sockeye salmon.

Lake Osoyoos

The vertical distribution of fish in Lake Osoyoos also showed a decrease in mean depth between March and May. The shift toward the surface occurred over all parts of the lake but was most pronounced in the deeper northern basin. The horizontal distribution was similar during both months. The proportion in the central and southern basins increased slightly from 3 to 11 percent of the total.

Table 4. Lake Osoyoos volumes in millions of cubic meters by depth

Depth (m)	Stratum 1 (Area 1-4)	2 (Area 5, 6)	3 (Area 7, 8)	4 (Area 9-16)
5-10	8.58	10.49	7.39	16.07
10-20	17.15	20.97	14.78	32.13
20-30	12.30	15.03	8.78	
30-40	6.45	6.45	4.82	
40-50	1.20	3.60	0.77	

Table 5. Population size in thousands by depth and stratum for Lake Osoyoos, 26 March, 1973

Depth (m)	Stratum 1 (Area 1-4)	2 (Area 5, 6)	3 (Area 7, 8)	4 (Area 9-16)	Total	Percent
10-20	242	182	232	88	744	27.83
20-30	793	469	486		1748	65.39
30-40	115	34	31		180	6.73
40-50		1			1	0.04
Total	1150	686	749	88	2673	
Percent	43.20	25.66	28.02	3.29		

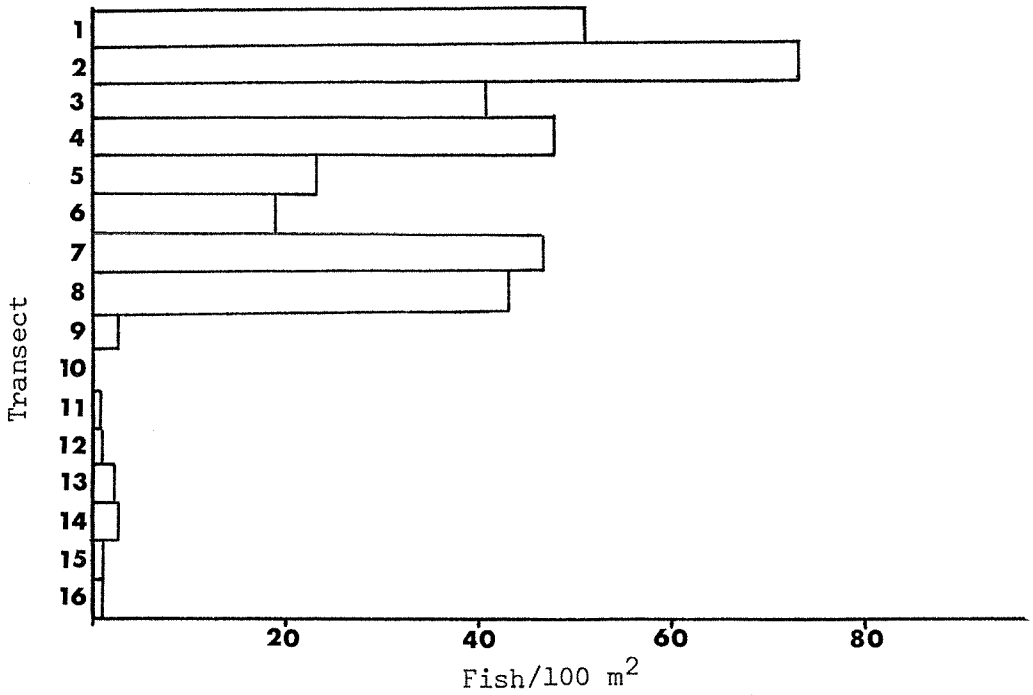

Figure 9. Distribution of fish densities observed along transects on Lake Osoyoos, 26 March 1973

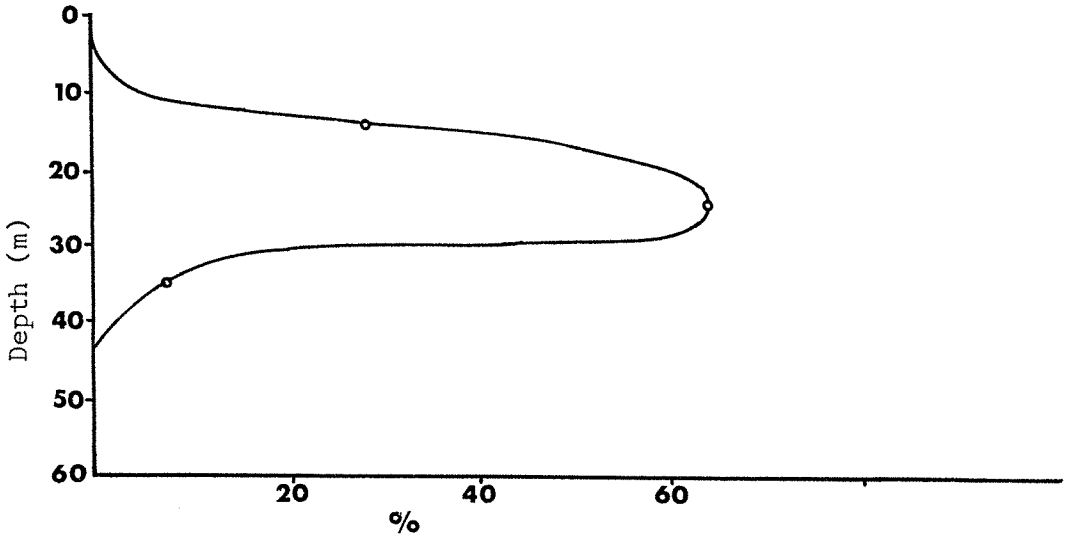

Figure 10. Vertical distribution of fish targets in Lake Osoyoos at night on 26 March 1973.

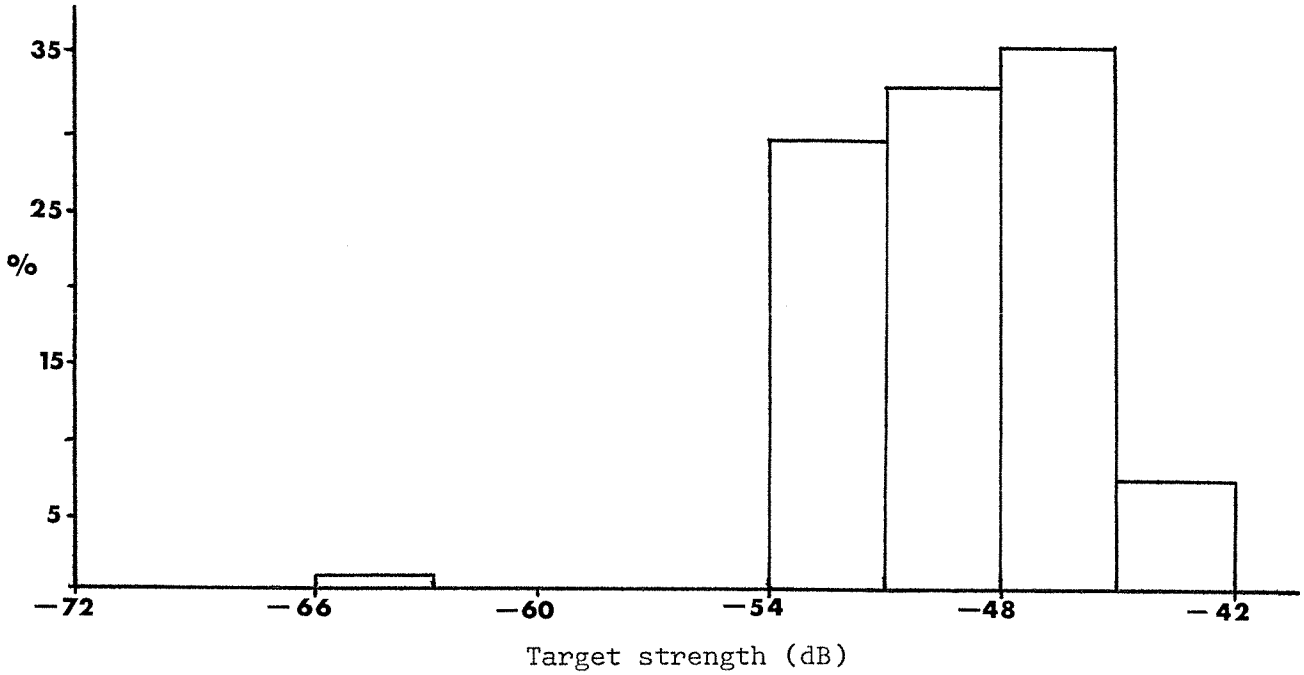

Figure 11. Distribution of target strengths observed during survey of Lake Osoyoos, 26 March 1973.

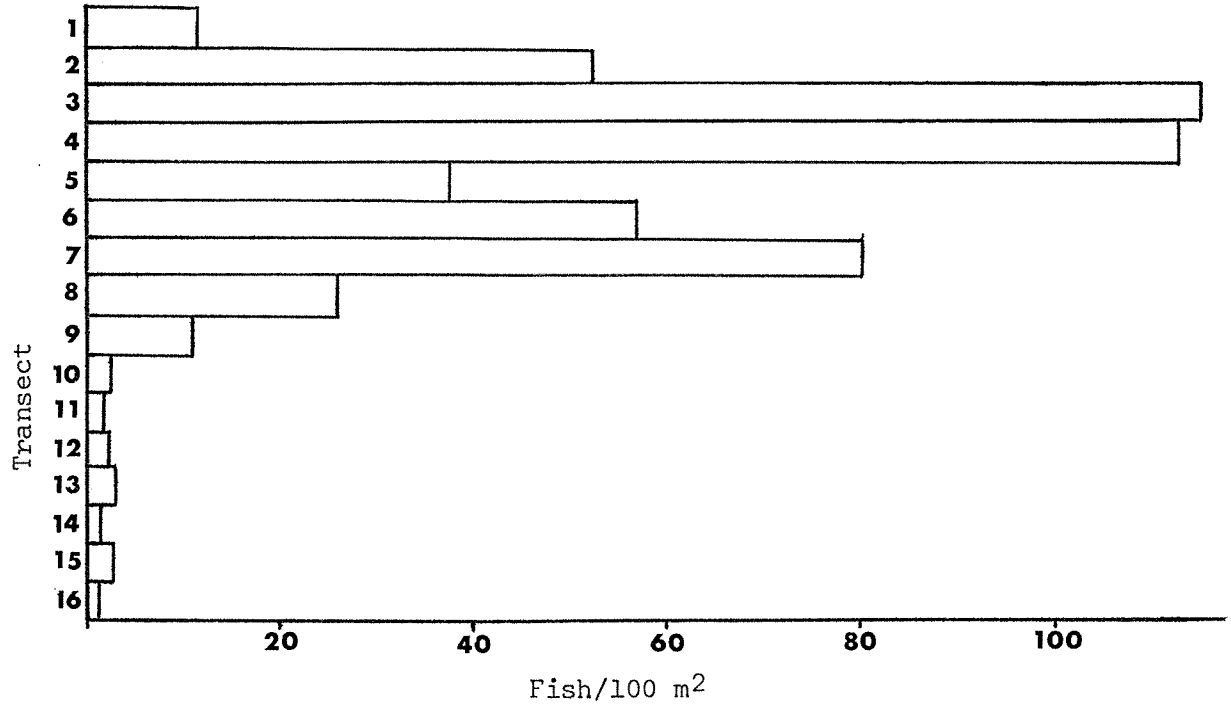

Figure 12. Distribution of fish densities observed along transects on Lake Osoyoos, 21 May 1973.

Table 6. Population size in thousands by depth and stratum for Lake Osoyoos, 21 May, 1973

Depth (m)	Stratum 1 (Area 1-4)	2 (Area 5, 6)	3 (Area 7, 8)	4 (Area 9-16)	Total	Percent
5-10	440	238	119	98	895	21.94
10-20	876	654	473	353	2356	57.76
20-30	244	271	234		749	18.36
30-40	21	18	34		73	1.78
40-50		6			6	.15
Total	1581	1187	860	451	4080	
Percent	38.76	29.10	21.08	11.06		

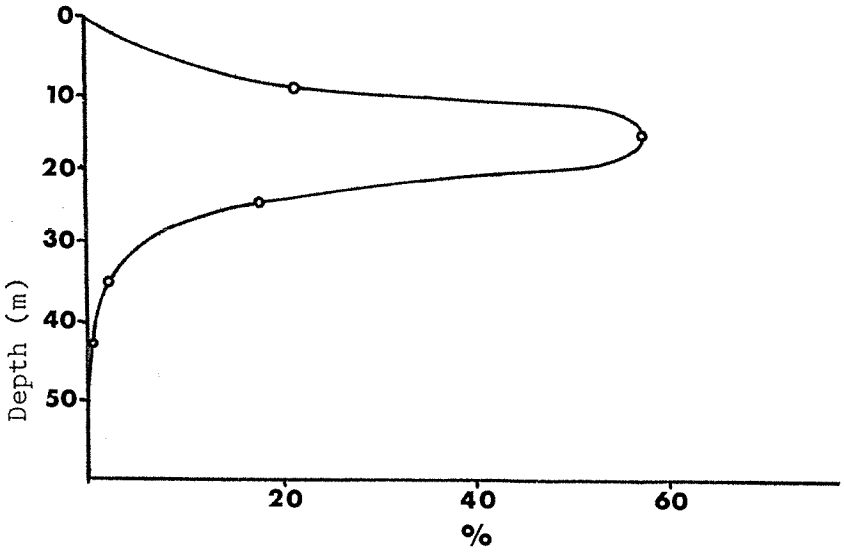

Figure 13. Vertical distribution of fish targets in Lake Osoyoos at night on 21 May 1973.

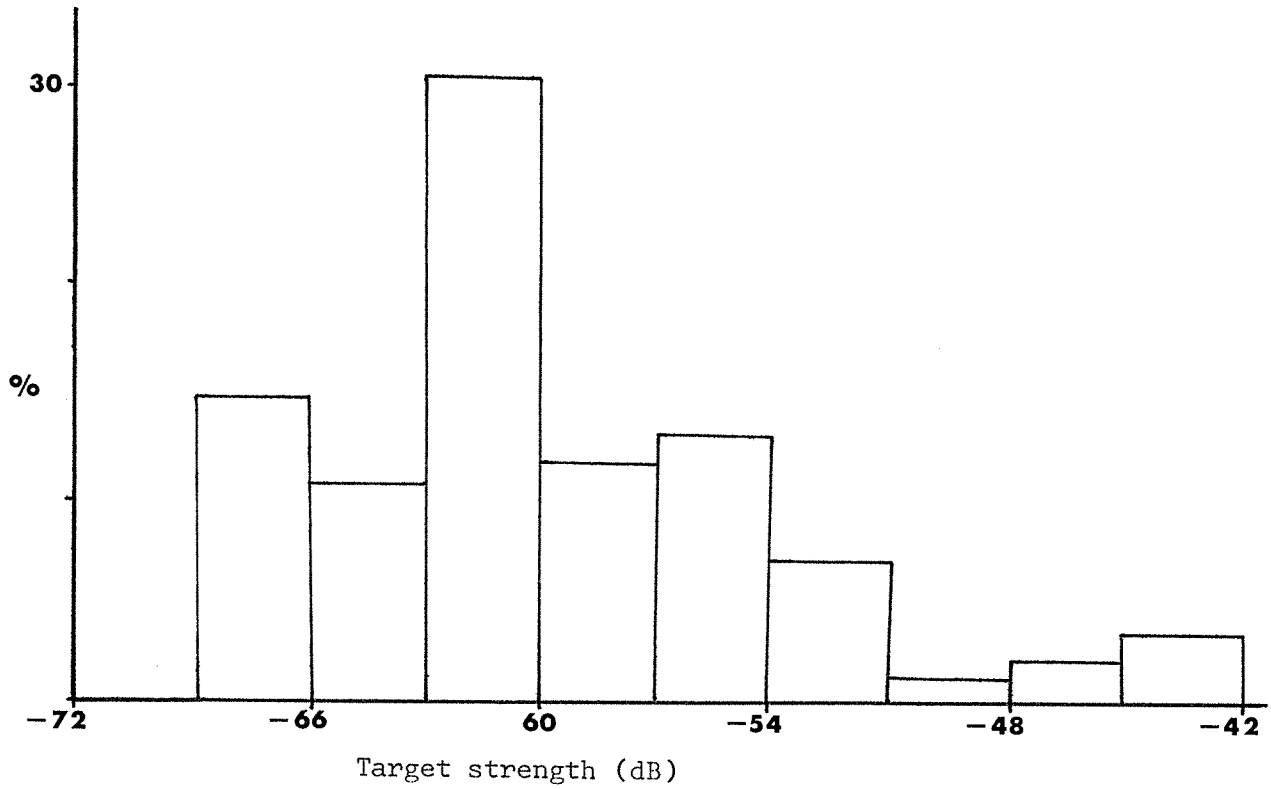

Figure 14. Distribution of target strengths observed during survey of Lake Osoyoos, 21 May 1973.

The population increased by 1.4 million fish from March to May. The target strength distribution indicates recruitment of smaller targets, as in Lake Wenatchee. However, there was no clear separation of large and small size targets in Lake Osoyoos in May. Fourteen percent of the targets were greater than -54 dB, while about 40 percent were greater than -60 dB. Thus, the apparent decrease of large targets is 2.1 million if the dividing point is assumed to be -54 dB, and 1.0 million if -60 dB is assumed.

CONCLUSIONS

The major problem encountered in attempting to assess the size of the outmigrations of Lake Wenatchee and Lake Osoyoos was estimation of population sizes without species composition data. The interpretation of surveys before and after outmigration was complicated by an apparent overlap in the time of lake residency for consecutive year classes. The problem could be minimized with precise information on the timing of migration and recruitment leading to optimal scheduling of the acoustic surveys.

Separation of smolts and fry by target strength analysis appears promising. However, the variability associated with the technique is not completely understood, and further experience and refinement is needed before the technique can be confidently applied.

LITERATURE CITED

Craig, R., and S. Forbes. 1969. Design of a sonar for fish counting. Fisk Dir. Skr. Ser. Havunders, 15:110-219.

Dawson, J. 1972. An acoustical determination of seasonal distribution of juvenile sockeye salmon in Lake Washington. M.S. Thesis, University of Washington, Seattle. 112 p.

Nunnallee, E. 1973. A hydroacoustic data acquisition and digital data analysis system for the assessment of fish stock abundance. Univ. Washington, Fish. Res. Inst. Circ. 73-3. 47 p.

Nunnallee, E., and O. Mathisen. 1972. An acoustic survey of Lake Wenatchee, Washington. Univ. Washington, Fish. Res. Inst. Circ 72-13. 43 p.

Thorne, R. 1972. Hydroacoustic assessment of limnetic feeding fishes. *In* J. F. Franklin, L. J. Dempster, and R. H. Waring (eds.), Proceedings - Research on coniferous forest ecosystems - A symposium, p. 317-322. U.S.D.A. Forest Serv., Portland.

Thorne, R. 1973. Digital hydroacoustic data-processing system and its application to Pacific hake stock assessment in Port Susan, Washington. Fish. Bulletin 71:837-843.

Thorne, R., E. Nunnallee, and J. Green. 1972. A portable hydroacoustic data acquisition system for fish stock assessment. Wash. Sea Grant Publ. 72-4, 14 p.

Traynor, J. 1973. Seasonal changes in the abundance, size, biomass, production and distribution of the pelagic fish species in Lake Washington. M.S. Thesis, Univ. Washington, Seattle. 91 p.