FRI-UW-7507
June 1975

LAKE WASHINGTON SOCKEYE SALMON STUDIES
1974-1975

by

James J. Dawson and Richard E. Thorne

Final Report
Service Contract No. 590
Washington State Department of Fisheries
For the period July 1, 1974 - June 30, 1975

Approved

Submitted June 30, 1975

Robert L. Burgner
Director

INTRODUCTION

Due to increased interest in and demands on the Lake Washington adult sockeye, the need for accurate and rapid assessment of juvenile and adult sockeye salmon has become more critical. The Fisheries Research Institute has been conducting acoustic surveys of juvenile sockeye since 1969 and of the adults since 1971. Considerable direct and indirect support has been provided throughout much of this period by the Washington Department of Fisheries, including financial support under a contract for the period July 1, 1974 to June 30, 1975. The results of population studies of both adults and juveniles during the contract period are described in this report under the terms of the contract.

MATERIALS AND METHODS

Field Equipment

The echosounder and associated peripherals composing the data acquisition system were the same as those used the previous year in the Lake Washington sockeye salmon studies. A 105 kHz Ross echosounder transmitting through a narrow beam transducer was coupled to a tape-recording unit via an interface box. All data were routinely recorded on magnetic tape for later analysis by oscilloscope or computer. Details of the gear and operational techniques are described in Nunnallee (1973, 1975).

All acoustic surveys were made from a 6-meter outboard skiff with a side-mounted transducer. A hull-mounted transducer was used for acoustic data collection during trawling operation from the RV *Commando*.

Survey Procedure

Ten surveys of the adults were conducted from June 17 to July 29 to document the period of recruitment into the lake. The transect pattern used the previous year proportioned effort toward the expected southern bias of adult sockeye; this pattern appeared satisfactory and was used again in 1974. All surveys were run during complete darkness and at a boat speed of 6 to 8 knots.

Surveys of juvenile sockeye salmon were made on November 14, 1974 and March 4, 1975, over a pattern of 12 evenly spaced orthogonal transects similar to those used the previous year. Again, all surveys were done at night. Data on species composition were collected on November 4-5, 1974 and February 25-26, 1975, in the same standardized sampling locations as last year (Fig. 1). The gear and techniques used and the sampling depths were also unchanged.

Data Analysis: Adult Salmon Surveys

Targets recorded on magnetic tape were counted using thresholds established the previous year for Lake Washington adult sockeye. Target counts over thresholds representing large and medium plus large fish were summarized for each transect.

As depth distribution of adult sockeye during the survey period was quite uniform and narrow, a sampling area rather than a sampling volume was calculated. The area sampled by the sounder was estimated from the average number of insonifications per target over all depths, the average boat speed, and the sounder pulse repetition rate (Thorne and Dawson 1974*a*). The numbers of medium and large fish combined and of large fish only per m^2 of surface area in each transect were determined by dividing the average number of echoes per pulse by the sampling area of the echo sounder. Total numbers in the transects were calculated by extrapolation of the values found over the surface area.

Data Analysis: Juvenile Salmon Surveys

The acoustic data from the juvenile salmon surveys were analyzed using digital echo integration techniques as during the previous two years (Thorne and Dawson 1974*b*). Echo integration measurements were made within several depth strata between 5 and 60 m and along each transect. The integration values were converted to fish densities through regression against a range of densities determined from oscilloscope counts. Separate regressions were necessary for deep and shallow depth strata because of vertical changes in target sizes. Total species estimates were made in each of the five sampling areas. Then the data on species composition from the net hauls made 7 to 10 days earlier were used to apportion the population by species and year class.

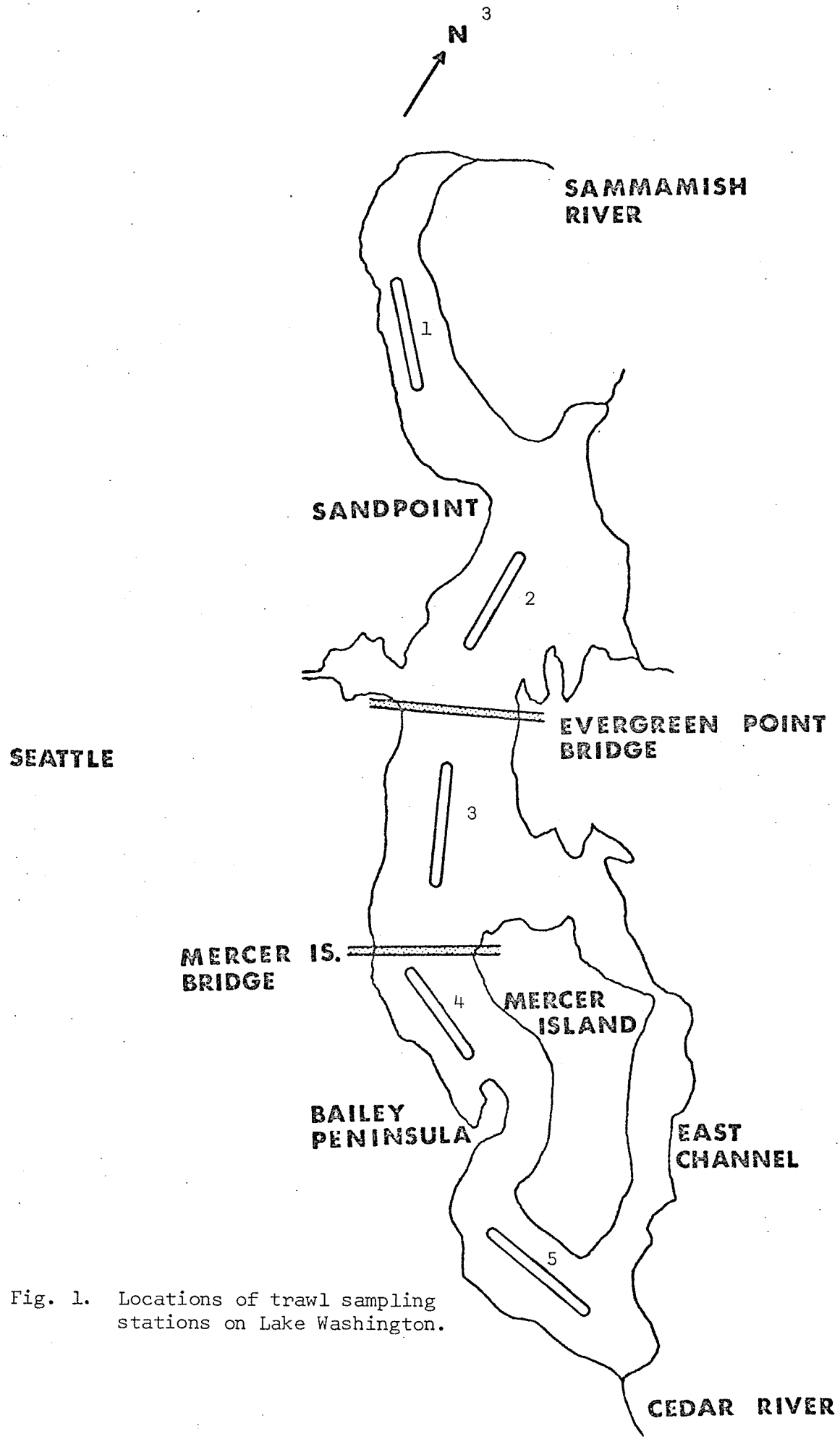

Fig. 1. Locations of trawl sampling stations on Lake Washington.

RESULTS AND DISCUSSION

Adult Salmon Surveys

The estimates of fish in Lake Washington based on the two counting thresholds are shown in Table 1. The estimate of medium plus large targets, based on a -44dB threshold, increased rapidly to a level varying between 170,000 and 200,000 except for a value of 353,000 on July 26. The estimate of large targets, based on a -38dB threshold, reached a level of about 130,000 by the July 8 survey and remained about that level except for a value of 199,000 on July 26.

Table 1. Results of 1974 Lake Washington adult sockeye salmon surveys

Date	Counts above threshold -44	Counts above threshold -38	Population estimate based on threshold -44	Population estimate based on threshold -38
June 17	52	22	53,200	22,480
June 26	131	67	111,290	52,150
June 29	105	70	97,950	62,150
July 2	132	85	115,610	84,500
July 4	219	131	173,630	111,930
July 8	168	106	204,020	136,040
July 12	174	112	179,720	120,640
July 16	197	138	165,810	121,660
July 26	295	169	353,240	199,090
July 29	205	136	190,880	130,640

The estimates of June 17 were treated as "background counts" or counts of resident fish and are removed from the values plotted in Fig. 2. The values estimated on July 26 are considerably higher

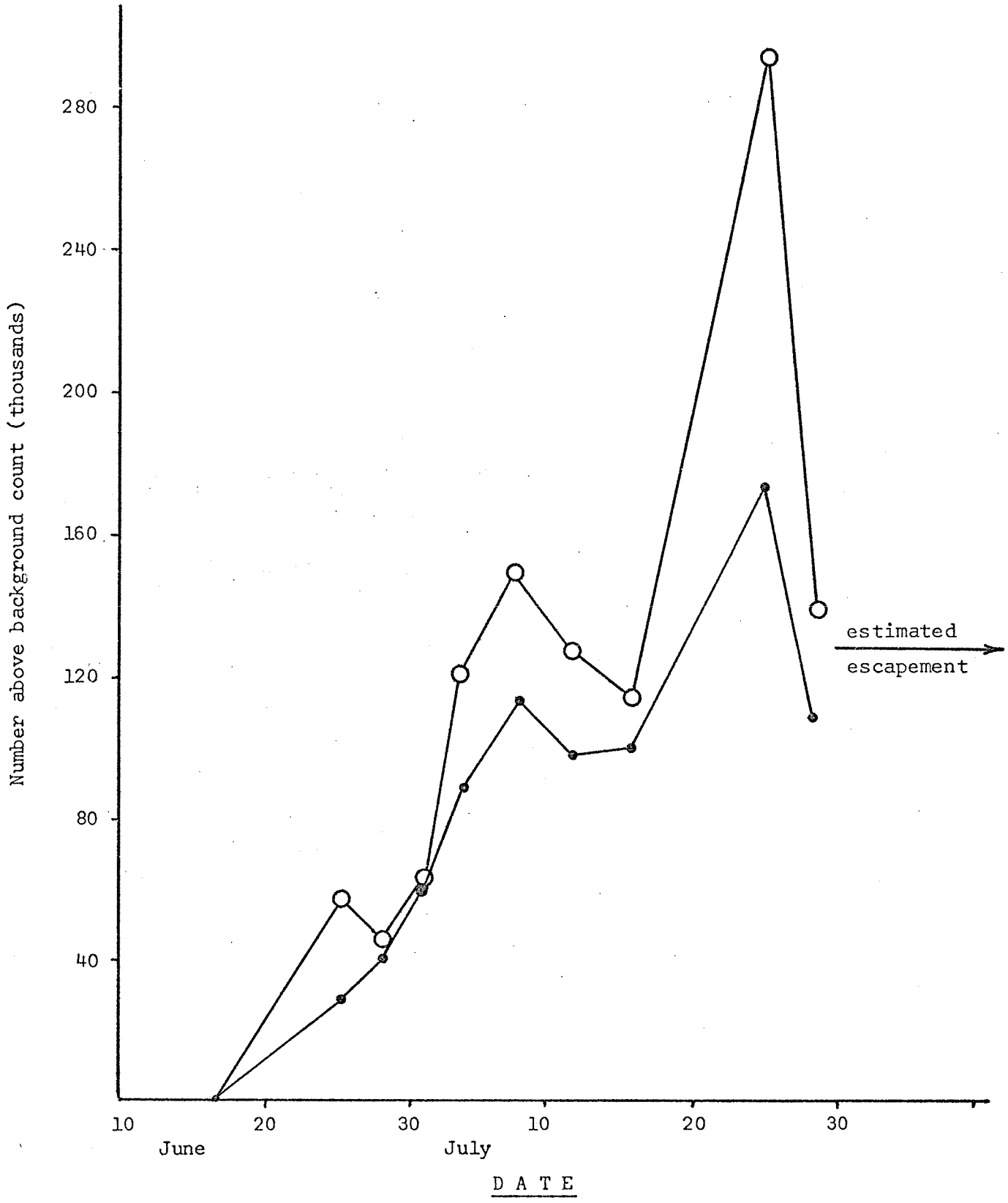

Fig. 2. Estimated increases in populations of large fish (closed circles) and medium plus large fish (open circles) in Lake Washington from June 17 to July 29, 1974.

than the other values. Since data from lock counts indicate that recruitment is virtually complete by July 8, the discrepancy is probably a result of either unusual sampling variability associated with single night surveys or an undetected change in the data acquisition equipment. The final estimate of 137,000 medium plus large fish and 108,000 large fish was made on July 29 and agrees extremely well with the Washington State Department of Fisheries' total 1974 Lake Washington basin escapement of 126,000 adult sockeye salmon (WDF, personal communication). The Indian gill net fisheries catch of 5,200 sockeye and the sport catch of 6,400 (FRI estimate, Mason Bryant) were for the most part removed before the final acoustic estimate.

One additional survey of adult sockeye was completed on July 30, 1974 using a wide-angle transducer. Targets were counted over four thresholds, -44, -38, -35, and -32dB, for comparison with the previous night's survey using the narrow beam transducer. The corresponding population estimates were 166,000, 141,000, 101,000, and 57,000 fish. Of these estimates, the first two compare with 191,000 and 131,000 for the equivalent thresholds from the series with the narrow beam transducer (Table 1). The estimates from the two thresholds of the wide-angle series are in much better agreement with each other, probably because of both increased sampling volume and better definition of the respective sampling volumes associated with the two thresholds. Unfortunately, no background estimates are available for the wide-angle transducer. If one applies the background estimate from the narrow beam to the wide-angle series, one obtains estimates of 113,000 and 119,000 adult sockeye salmon from the two thresholds.

Juvenile Salmon Surveys

Results of acoustic and net haul estimates of the 1973-year-class juvenile sockeye salmon in each of the five sampling areas and the total lake are presented in Table 2. Examination of the horizontal distributions in November reveal a southward shift in the population between the net and acoustic series. However, the total lake estimates for the two techniques are in good agreement, suggesting that the use of species composition information from the net series 10 days earlier did not cause appreciable error in the acoustic results. The horizontal distributions for the February-March series were very similar, with the acoustic estimate slightly lower in all five areas.

Sockeye salmon of the 1973 year class are the progeny of 309,000 spawners. Data from previous year classes in Lake Washington suggest that a production of about six-million smolts would be expected from this number of spawners under normal conditions (Thorne et al. 1974).

However, unfavorable runoff conditions in the Cedar River were expected to reduce the production (Jim Ames, WDF, personal communication), and both the acoustic and trawl estimates are well below this value.

Comparison of the November and the February-March series suggests a 50 percent decline in the population between the series. While not unreasonable, the implied mortality is greater than that observed for the previous three year classes (Thorne et al. 1974; Thorne and Dawson 1974*b*).

The precision of the estimates is difficult to evaluate because of the number of factors affecting the results. Other studies have demonstrated fairly high precision associated with acoustic estimates of total fish populations (Croker 1974). The major problem associated with the acoustic estimates on Lake Washington continues to be the determination of species composition. As indicated in Table 2, the juvenile sockeye salmon represent only about one-third of the Lake Washington limnetic population. The sampling problem the past year was compounded by difficulties in precisely determining the net position, combined with distribution of fish in unusually narrow depth layers.

Table 2. Acoustic and net haul estimates and percent species composition of 1973-year-class juvenile sockeye salmon in five sampling areas and total Lake Washington

Series	Area	Acoustic estimate (millions)	Percent of total acoustic estimate	Net estimate (millions)	Percent of total net estimate	Percent 1973-year sockeye
November	1	0.020	0.5	0.070	1.6	1.8
	2	0.811	20.0	2.096	49.3	42.8
	3	1.595	39.3	1.606	37.8	53.7
	4	0.661	16.3	0.253	5.9	28.1
	5	0.969	23.9	0.229	5.4	27.8
Total		4.06		4.25		32.5
February-March	1	0.108	5.6	0.285	11.3	25.4
	2	0.799	41.2	0.937	37.0	52.6
	3	0.839	43.2	1.004	39.7	41.5
	4	0.095	4.9	0.112	4.4	12.2
	5	0.100	5.2	0.195	7.7	12.4
Total		1.94		2.53		33.0

The other major source of potential error in the estimates is distribution of the juveniles near the bottom in the shallower areas of the lake, where they are not accessible to either the net or the acoustic equipment. This problem has been noted occasionally in past years during the period October to December when the juveniles are deep in the water column, but has not been noted in the February-March period. However, the distribution of the juvenile sockeye this year in February-March was considerably deeper than any previous year. The low numbers in areas 4 and 5 are unusual and may result from near-bottom distributions.

The uncertainty associated with the presmolt estimate this year indicates a need for a greater level of effort. In the past, the frequent acoustic and net sampling surveys conducted throughout the year under the Sea Grant Lake Washington studies have provided background information which has greatly aided interpretation of the presmolt estimates. With the decrease of the Sea Grant project, this support is no longer available. As an alternative, it is recommended that three surveys be conducted in the January to March period when mortality is a negligible factor. This would provide six estimates, three acoustic and three net, which would allow a better evaluation of the precision of the estimates.

Both the unusually large decline between the November and the February-March series and the unusually deep distribution in February-March suggest that the latter result may be an underestimate. However, it is unlikely that the uncertainties are sufficiently large to account for the difference between the presmolt estimate and that expected from the spawning stock. Assuming that the decline between the two series was in reality only half that seen in the estimates, and applying the historical marine survival data for the stock, it is predicted that the subsequent run will be similar in magnitude to the parent run.

ACKNOWLEDGMENTS

Support for these studies was also provided by the Sea Grant Sockeye Salmon Management Project and the Analysis of Ecosystems, Coniferous Biome Program of the National Science Foundation, under the direction of Dr. Robert L. Burgner.

LITERATURE CITED

Croker, T. R. 1973. Acoustic estimation of the density and abundance of fish in Lake Quinault, Washington. M.S. Thesis, Univ. Washington, Seattle. 105 pp.

Nunnallee, E. P. 1973. A hydroacoustic data acquisition and digital data analysis system for the assessment of fish stock abundance. Circ. No. 73-3, Fish. Res. Inst., Univ. Washington, Seattle. 47 pp.

Nunnallee, E. P. 1975. An operators' manual for the hydroacoustic data collection system. Washington Sea Grant Tech. Rep. 75-1. 28 pp.

Thorne, R. E., and J. J. Dawson. 1974*a*. An acoustic estimate of the escapement of sockeye salmon (*Oncorhynchus nerka*) into Lake Washington in 1971. J. Fish. Res. Bd. Canada 31:222-225.

Thorne, R. E., and J. J. Dawson. 1974*b*. Lake Washington sockeye salmon studies. Final Report, Contract No. 545, Washington Dep. Fish. (FRI-UW-7410). 15 pp.

Thorne, R. E., J. J. Dawson, J. J. Traynor, and Robert L. Burgner. 1974. Population studies of juvenile sockeye salmon in Lake Washington with the use of acoustic assessment techniques. EIFAC Symposium on Methodology for the Survey, Monitoring, and Appraisal of Fishery Resources in Lakes and Large Rivers, Aviemore, Scotland, May 1974. 19 pp.