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LAKE WASHINGTON SOCKEYE SALMON STUDIES

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Richard E. Thorne and James J. Dawson

Final Report
Service Contract No. 545
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CONTENTS

	Page
INTRODUCTION	1
MATERIALS AND METHODS	1
Data Acquisition System	1
Survey Procedure	1
Data Analysis: Adult Salmon Surveys	3
Data Analysis: Juvenile Salmon Surveys	7
RESULTS AND DISCUSSION	7
Adult Salmon Surveys	7
Juvenile Salmon Surveys	10
LITERATURE CITED	15

LIST OF TABLES

Table No.		Page
1	Estimates of large fish in Lake Washington from June 17 to December 14 based on target strength thresholds of -44dB and -38dB	8
2	Estimates and 95% confidence intervals of 1972 year class sockeye salmon, 1972 year class longfin smelt and sticklebacks in Lake Washington based on acoustic surveys from April 1973 to March 1974	11
3	Summary of presmolt estimates for the 1970 and 1971 year classes of juvenile sockeye salmon in Lake Washington	14

LIST OF FIGURES

Figure No.		Page
1	Locations of transects over Lake Washington during surveys of adult sockeye salmon	2
2	Locations of transects over Lake Washington during surveys of juvenile sockeye salmon	4
3	Locations of trawl sampling stations on Lake Washington	5
4	Typical echo counting threshold for discrimination between large and small fish targets	6
5	Estimates of large fish in Lake Washington based on thresholds of -44dB and -38dB, cumulative tower counts from the Cedar River, and removals by Indian and sport fisheries from June to December 1973	9
6	Estimates of the 1972 year class of juvenile sockeye salmon in Lake Washington from April 1973 to March 1974 based on net catches and acoustic surveys	12

LAKE WASHINGTON SOCKEYE SALMON STUDIES

INTRODUCTION

The sockeye salmon populations in Lake Washington have been studied for several years by the Fisheries Research Institute through acoustic assessment methods developed under the Sea Grant Program. Considerable indirect support has been provided by the Washington Department of Fisheries, and recently also direct financial support under a contract for the period 1 July 1974 to 30 June 1975. The results of population studies of both adults and juveniles during the past year are described in this report under the terms of the contract.

MATERIALS AND METHODS

Data-Acquisition System

The same data-acquisition system was used in both studies of adult and juvenile sockeye salmon. The basic components are a Ross 200 A Fineline echo sounder having a frequency of 105 kHz and a pulse length of 0.6 msec, and equipped with a transducer producing a circular beam pattern of approximately 8^{o} full angle at 6 dB down. The data from echo sounding are converted from 105 kHz to 5 kHz by chopper and filter circuits and recorded by a standard stereophonic tape recorder. The system is described in detail in Thorne et al. (1972).

Survey Procedure

Eight surveys of the adults were conducted from 17 June to 14 December, in the pattern illustrated in Fig. 1. Three were conducted on successive nights with replicated transects, and the others on individual nights with single runs.

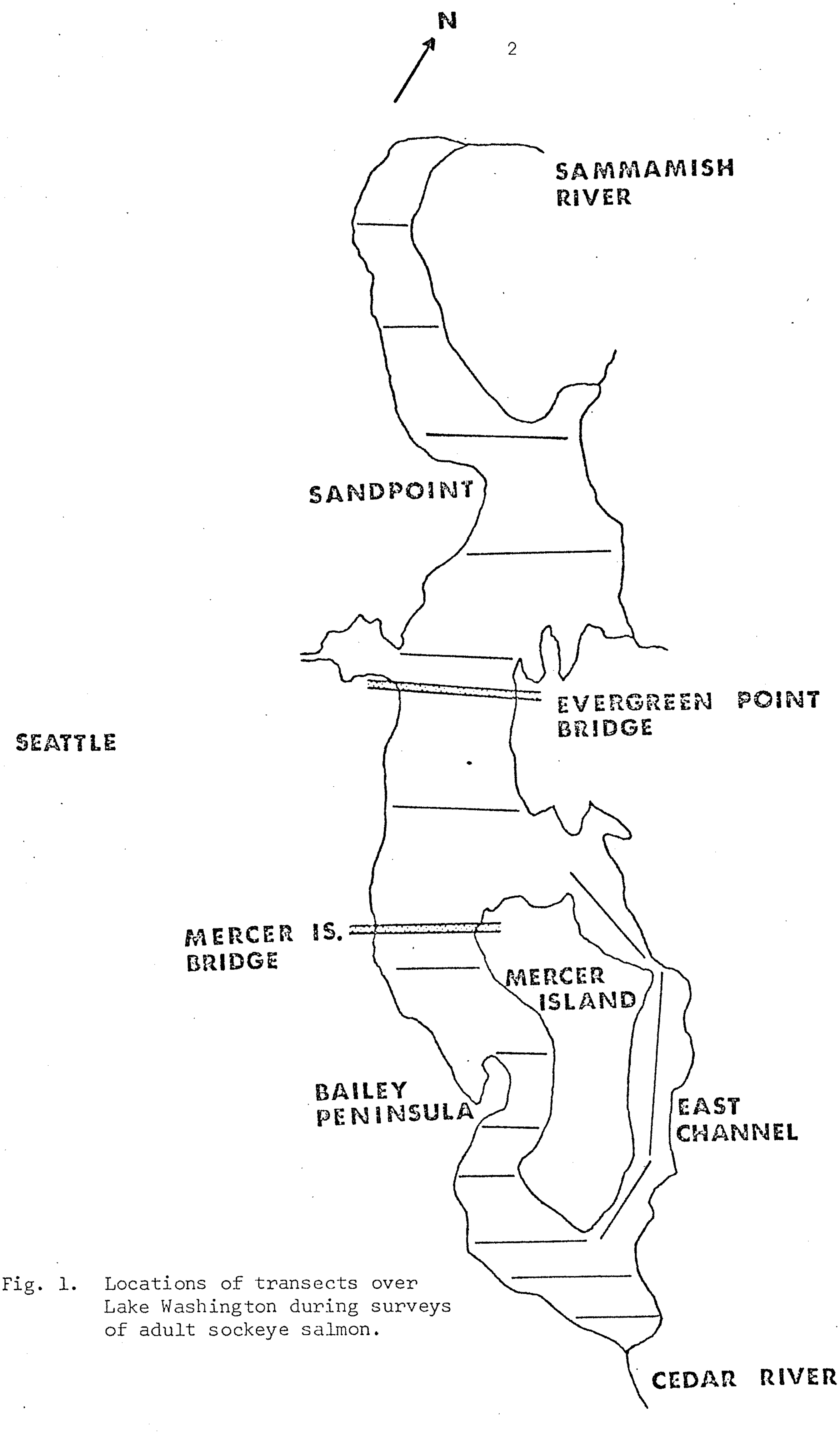

Fig. 1. Locations of transects over Lake Washington during surveys of adult sockeye salmon.

Five surveys of the juveniles were made between April 1973 and March 1974, in the pattern illustrated in Fig. 2. Data on species composition were obtained by midwater trawling with a 3-m Issacs-Kidd trawl from the RV *Commando*. Three to five depths in each of five sampling areas were sampled with replicate hauls (Fig. 3).

Data Analysis: Adult Salmon Surveys

The magnitude of an echo from a fish is a function of its length. The magnitudes of echoes from fish surveyed in Lake Washington were analyzed through the technique of target strength measurement developed by Craig and Forbes (1969). The distribution of target sizes obtained is analogous to a length-frequency distribution of the fish sampled. Based on these distributions, a threshold was established for the echoes associated with the adult salmon. Counts were made at two different thresholds (-44dB and -38dB) for evaluation of the sensitivity of the technique. A typical threshold is shown in Fig. 4. The threshold level decreased in proportion to depth; therefore, the effect of depth was corrected for by use of the threshold with the 20 log R Time-Varied-Gain of the sounder.

The area sampled by the sounder was estimated from the average number of insonifications per target, the average boat speed, and the sounder pulse repetition rate (Thorne and Dawson, 1974). The number of large fish per square meter of surface area in each transect was 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 areas.

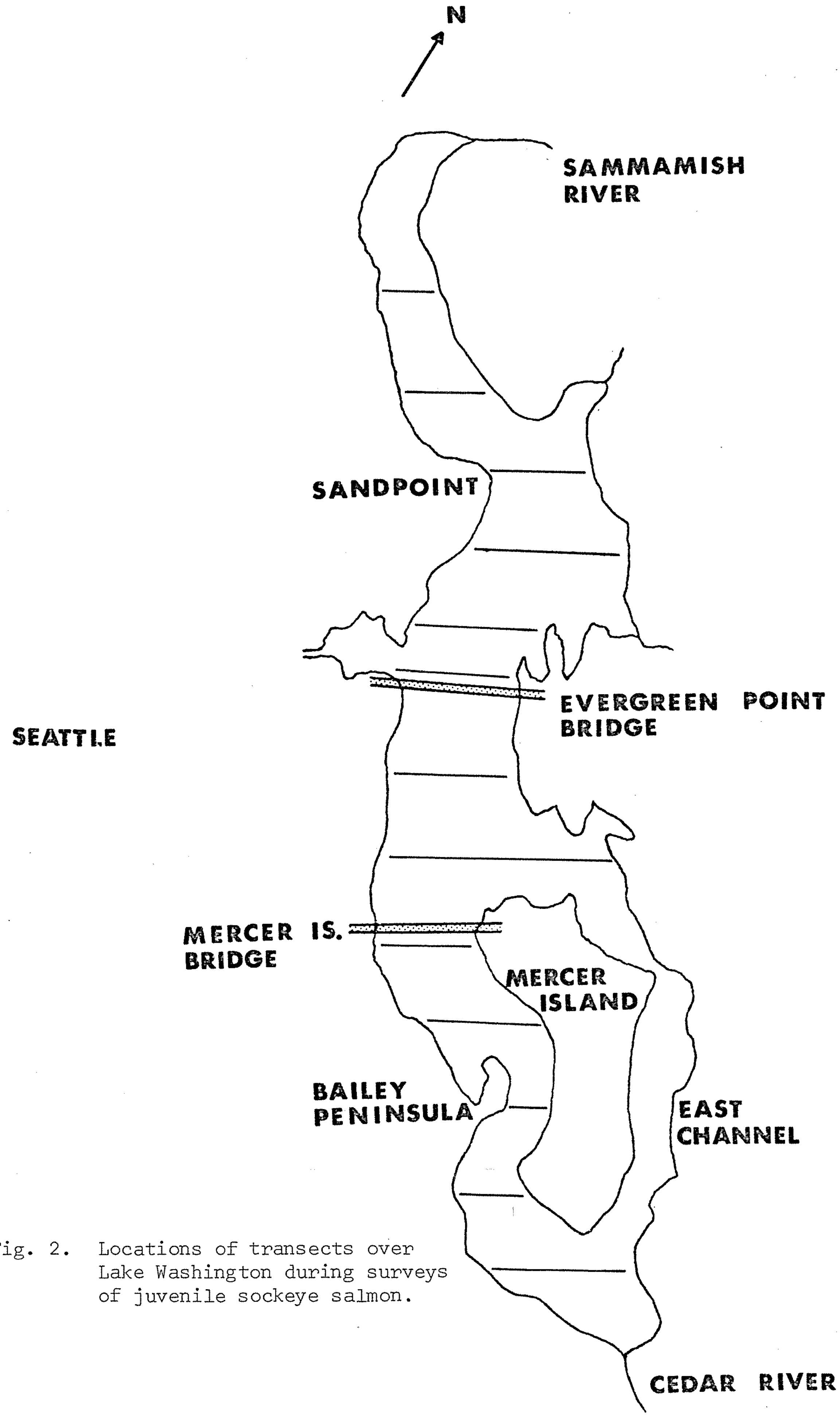

Fig. 2. Locations of transects over Lake Washington during surveys of juvenile sockeye salmon.

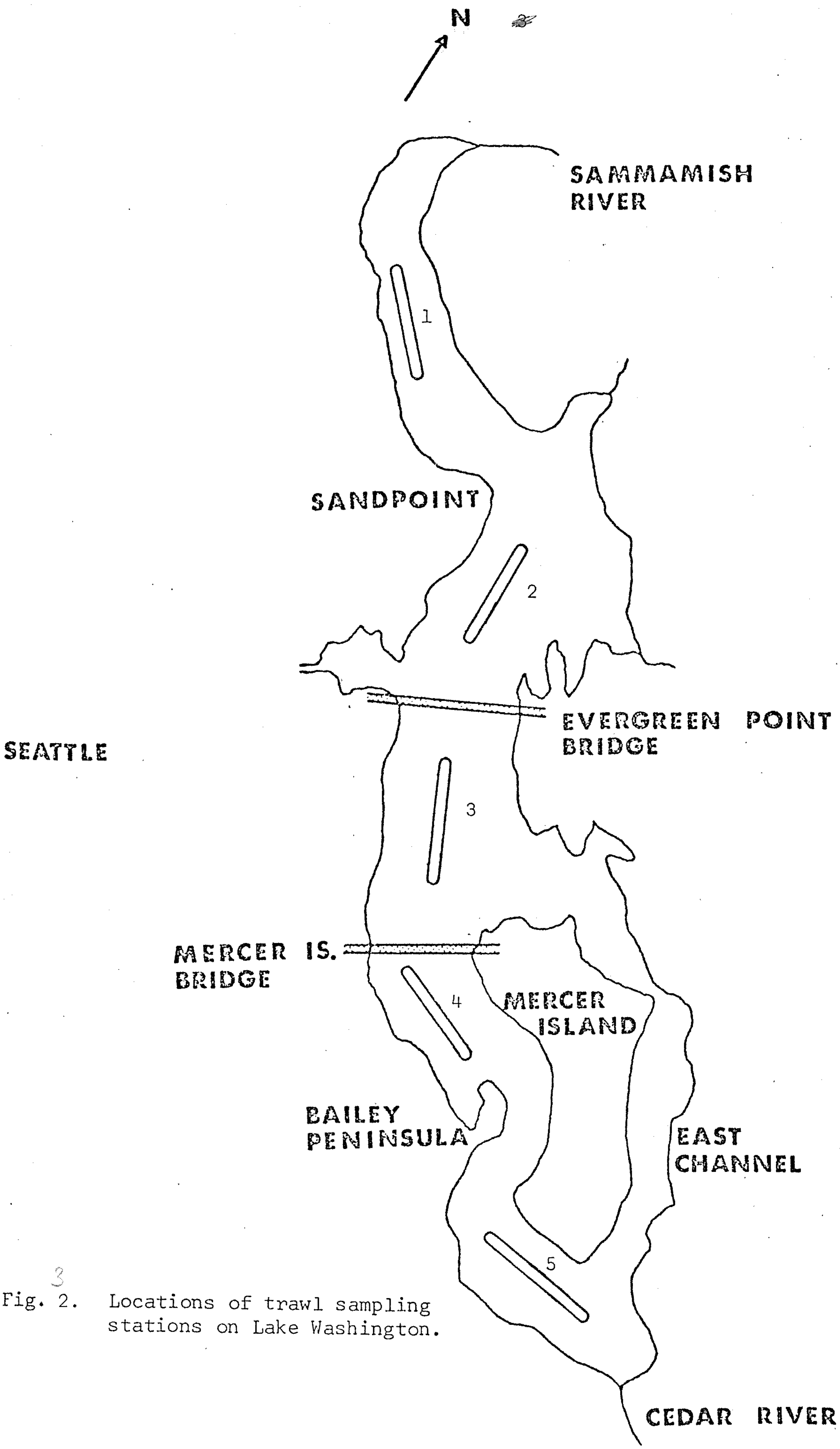

Fig. 2. Locations of trawl sampling stations on Lake Washington.

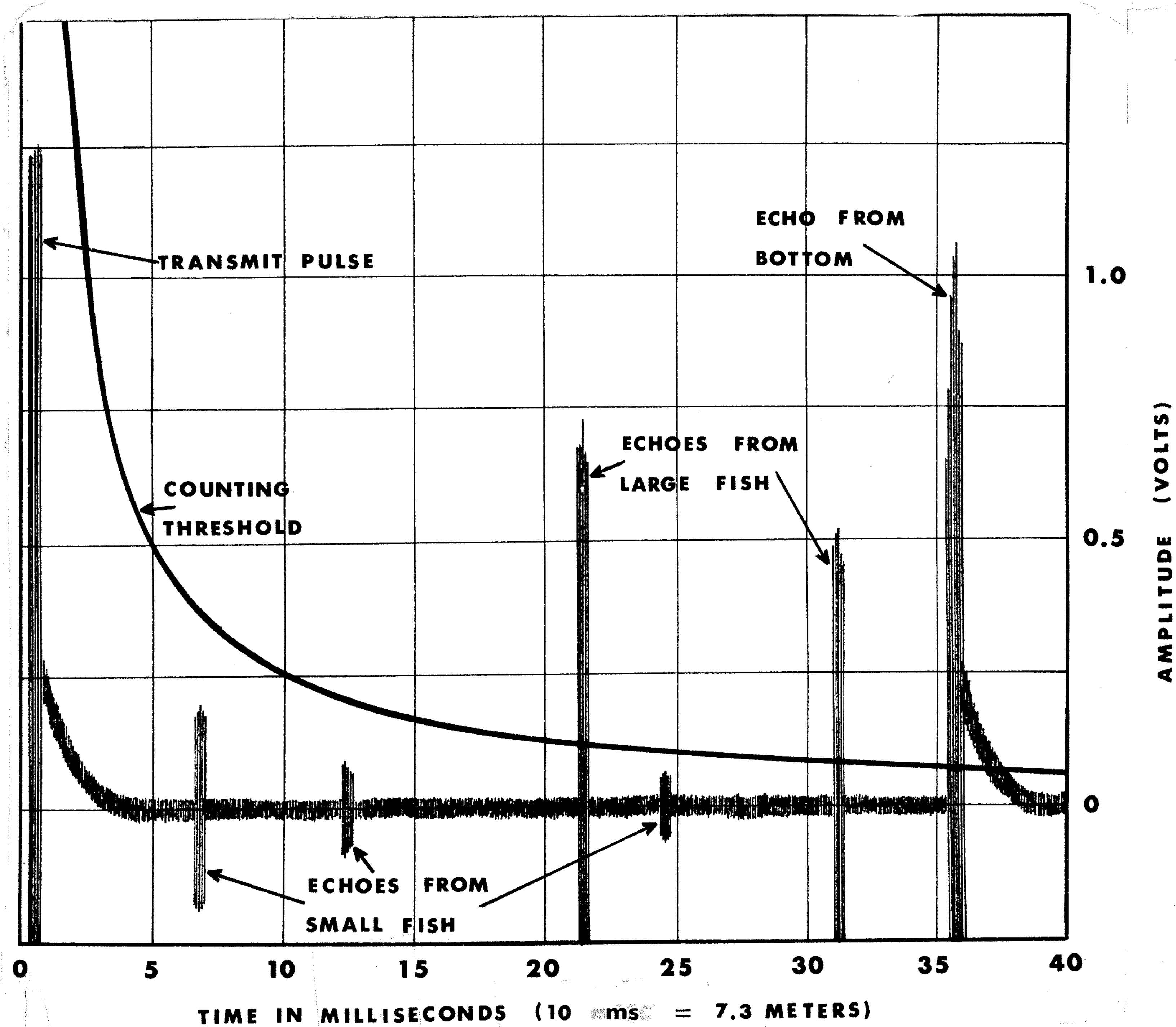

Fig. 4. Typical echo counting trheshold for discrimination between large and small fish targets.

Data Analysis: Juvenile Salmon Surveys

The analytical technique used on the previous year class was applied. Briefly, fish signals stored on magnetic tape are integrated by use of a specialized computer system (Nunnallee, 1973). The resulting relative densities are calibrated against densities determined from oscilloscope counts. The acoustic estimates of density and the data on species composition from the hauls are processed in another computer program for calculation of population sizes and 95% confidence intervals for each sampling area by species and year class. The procedures are detailed in Traynor (1973).

RESULTS AND DISCUSSION

Adult Salmon Surveys

The estimates of large fish in Lake Washington based on the two counting thresholds are shown in Table 1. There were no data from one of the two-night surveys, September 13 and 17, because of equipment failures. The estimates are plotted in Fig. 5 with the estimates of fishery removals and the cumulative tower counts provided by WDF personnel. The initial estimate from the June 17-18 series based on the -44dB threshold was 70,000 fish. Since the sockeye salmon in the lake at this time numbered only about 10,000, the initial estimate primarily represented the larger resident fish in the lake. The estimates based on the -44dB threshold increased rapidly to 375,000 on July 13 and to 385,000 on August 2-3. Recruitment to the lake was virtually complete by the early August series. Since the fishery removals prior to 2 August were similar in magnitude to the June background count of resident fish, the 385,000 estimate is in excellent agreement with

Table 1. Estimates of large fish in Lake Washington from June 17 to December 14 based on target strength thresholds of -44dB and -38dB

Date	Population estimates -44dB	Population estimates -38dB
June 17-18	70,000	30,000
July 2	175,000	166,000
July 13	375,000	326,000
August 2-3	--	326,000
September 27	--	183,000
October 10	--	143,000
December 14	--	31,000

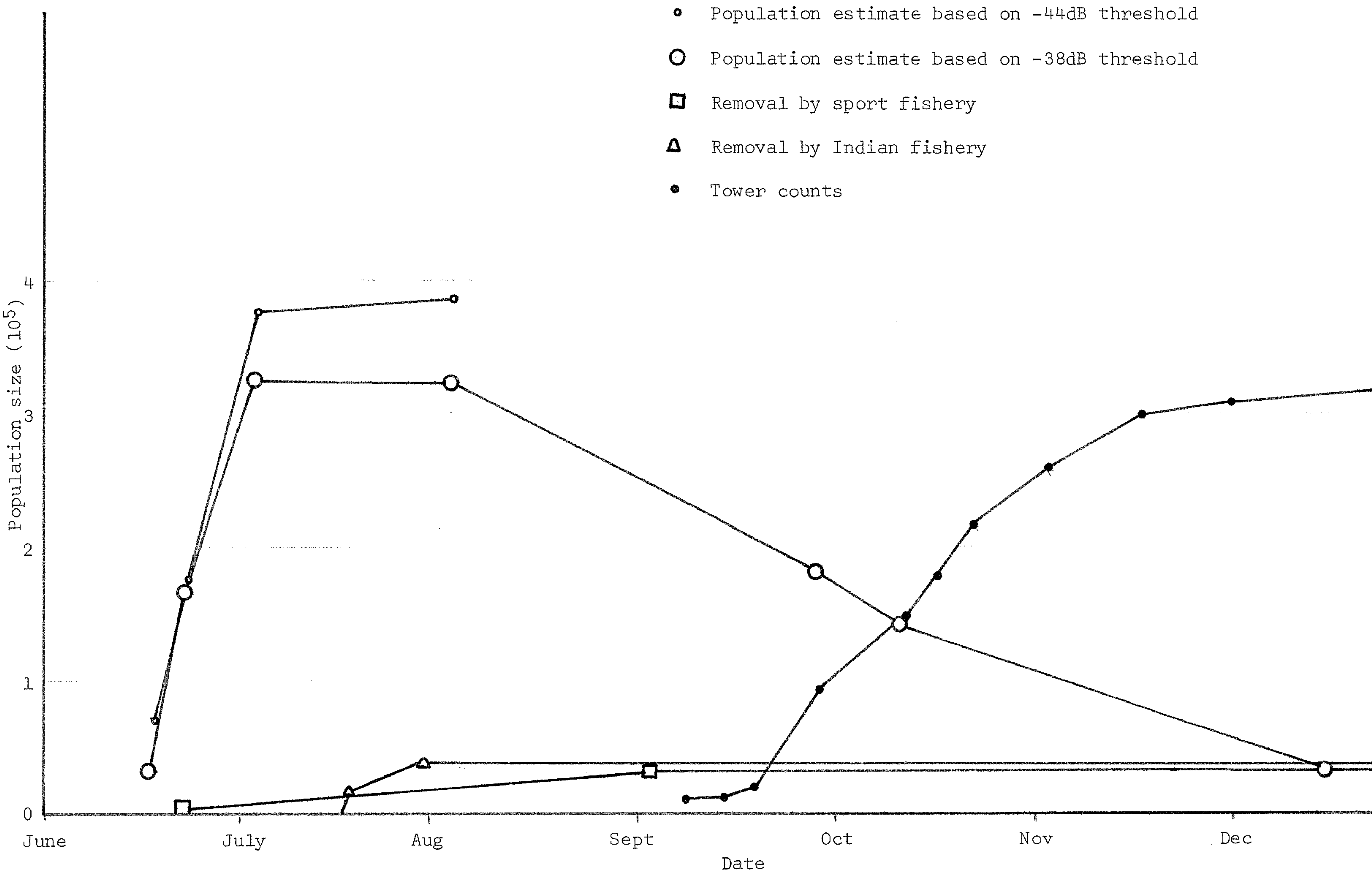

Fig. 5. Estimates of large fish in Lake Washington based on thresholds of -44dB and -38dB, cumulative tower counts from the Cedar River, and removals by Indian and sport fisheries from June to December 1973.

the total run size of 390,000 estimated from the fishery data and river tower counts. The -44dB threshold was not used in analysis of data from later series because of increasing interference from the rapidly growing juveniles.

As a result of the higher threshold most of the resident fish were not included in the estimate and the June 17-18 estimate was reduced by 40,000 to 30,000. However, the subsequent adult salmon estimates were also lowered slightly more than had been expected from the decrease in the resident fish component. For example, the August estimate was lowered by 59,000, and numbers were clearly underestimated in subsequent series in comparison with the data from the tower counts. The differences may have resulted from decreased accuracy in the estimated sampling volume associated with the higher threshold. The low estimates in late September and October may also have been caused by distributional changes, as generally at this time the sockeye salmon are congregated in the extreme southern portion of the lake in shallow water.

Juvenile Salmon Surveys

Acoustic estimates and confidence intervals are presented in Table 2 for the 1972 year class of sockeye salmon and the 1972 year class smelt and sticklebacks. Sticklebacks were the most numerous species during all five series. The juvenile sockeye salmon estimates are illustrated in Fig. 6, along with the corresponding estimates based solely on trawl catches with catching efficiency of the net assumed at 100 percent. The net haul and acoustic estimates are in unusually poor agreement for the January and March series, apparently because of unusual distributional patterns. It appears from the echograms that densities were high in areas not sampled by the trawl.

Table 2. Estimates and 95% confidence intervals of 1972 year class sockeye salmon, 1972 year class longfin smelt and sticklebacks in Lake Washington based on acoustic surveys from April 1973 to March 1974

	Population estimates (millions of fish)					
	Sockeye		Smelt		Sticklebacks	
Date	Mean	C.I.	Mean	C.I.	Mean	C.I.
4/73	0.45	0.16	0.39	0.12	0.64	0.21
10/73	2.00	0.53	1.62	0.44	2.98	0.88
11/73	4.41	1.89	1.50	0.64	6.94	2.67
1/74	5.22	3.02	2.05	1.17	5.23	2.13
3/74	3.58	0.98	0.78	0.22	4.32	1.22

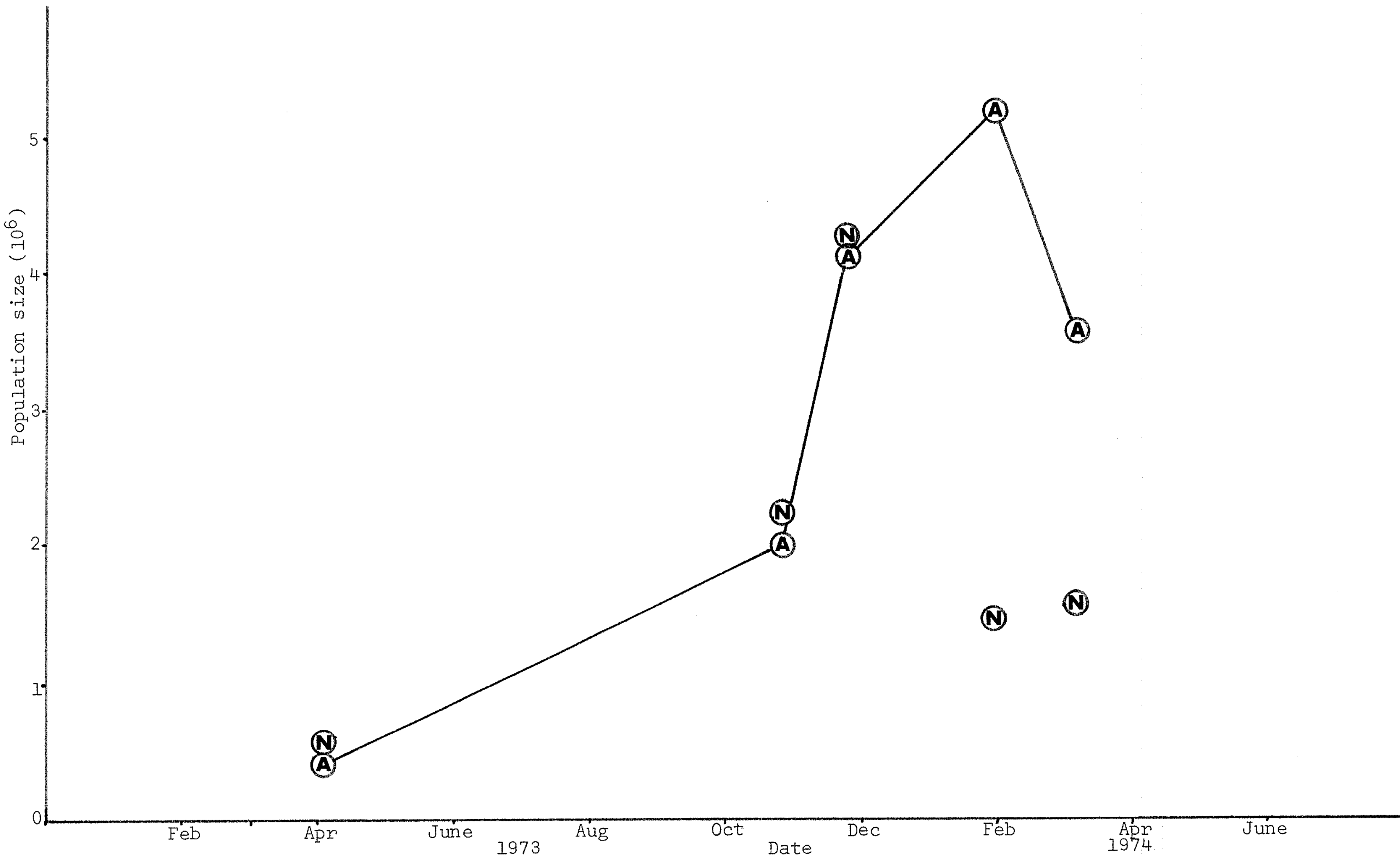

Fig. 6. Estimates of the 1972 year class of juvenile sockeye salmon in Lake Washington from April 1973 to March 1974 based on net catches and acoustic surveys.

Distinctly differing density patterns were shown by the echograms made during trawling and those taken during the acoustic surveys. The densities in the trawl areas were not representative of the densities in that portion of the lake over which they were extrapolated, and the resulting estimates were low. The acoustic sampling provided a much better population estimate partly because of the much greater sample size.

Acoustic assessment of Lake Washington juvenile sockeye salmon in the past generally indicated no significant recruitment nor mortality after November; thus the results of the November, January, and March surveys should have been similar. An examination of the echograms revealed some gear problems during the January acoustic survey; electrical noise was present during three transects and may account for the 20 percent increase observed in this survey. The estimate of 3.6 million in March has the highest precision and is probably the best estimate of the population size at outmigration.

Acoustic estimates are available on the numbers of juveniles since 1969, and information is available on the magnitudes of adult returns for the first three year classes surveyed (1967, 1968, and 1969); and from these data, marine survival rates were calculated. Except for the first estimate on the large 1967 year class, the results agree well with the 10 percent marine survival rate observed of sockeye salmon in the Canadian Pacific area (Foerster, 1968). Based on this information a return of 360,000 would be expected from the 1972 year class in Lake Washington. For convenience, the presmolt estimates for the 1970 and 1971 year classes are also summarized in Table 3.

Table 3. Summary of presmolt estimates for the 1970 and 1971 year classes of juvenile sockeye salmon in Lake Washington

		Population estimate (millions)		
		Acoustic		
Year class	Date	Mean	C.I.	Net haul
1970	March 1972	2.0	1.3-2.7	3.0
1971	December 1972	2.6	2.0-3.2	2.7
	February 1973	1.7	1.0-2.4	1.7
	April 1973	1.8	1.2-2.4	1.2

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