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LAKE WASHINGTON SOCKEYE SALMON PRESMOLT STUDIES IN 1981

by

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Introduction

Population estimates of the presmolt sockeye salmon in Lake Washington have been made since 1969 using hydroacoustic techniques. For the past several years these studies have been supported by the Washington State Department of Fisheries and have been reported in annual contract reports. The results provide a valuable long-term forecast of returning adult sockeye salmon and a measure of the combined success of spawning and lake survival. This report gives the results of studies conducted during 1981 on the 1979 year class sockeye salmon.

Materials and Methods

Echo integration techniques for population estimation of sockeye salmon in lakes were pioneered on Lake Washington and are now in widespread use. General principles of hydroacoustic techniques are described in Saville (1977). An extensive dissertation on techniques for juvenile sockeye is given by Nunnallee (1980). The specific techniques used on Lake Washington are described in Thorne et al. (1975). The techniques used on Lake Washington have been very similar the past several years.

The dual beam echosounder described by Ehrenberg et al. (1976) was used for the 1981 surveys. The echosounder was used as a conventional scientific echosounder by collecting data only on the narrow beam

channel with a 20 log R TVG. The frequency of the echosounder is 105 kHz and the transducer beam width is 11 degrees full angle at the -6 dB points on the directivity pattern. A 0.6 msec pulse length and 0.5 second pulse interval were used. The high frequency echo returns were converted to 8 kHz and recorded on a Sony TC 377 analog tape recorder at 7-1/2 IPS.

Both hydroacoustic transects and net tows were conducted from the R/V MALKA. The transect pattern of 16 diagonal transects was run twice as in previous years. Transecting was done the night of March 13 and required 6 hours at the transect speed of 3.5 m/sec.

Midwater trawling procedures were the same as in previous years. A total of 24 net tows was made with a 3-m Isaacs-Kidd midwater trawl the nights of March 11 and 12 in the standard five sampling areas of Lake Washington (Thorne et al. 1975). Estimated volume sampled per 10-min tow at the trawling speed of 4.5 knots was 8,330 m^3. Several tows with higher catches were replicated.

The data were analyzed with a combination of echo integration and echo counting techniques (Thorne et al. 1975). All the data were integrated in 7-m depth intervals from 4 to 60 m and in 2-min time intervals using a Biosonics Model 120 echo integrator (Wirtz and Acker 1980). Echo counts and duration-in-beam measurements (Saville 1977) were made in selected portions and depths in order to scale the echo integration. Fish densities obtained from these measurements were regressed against the corresponding echo integrator outputs to develop a relationship

between density and echo integrator output which was then used to estimate the fish density at all depths and transects. Mean fish densities were calculated for each depth and each of the five sampling areas. The percentage of presmolt sockeye in the corresponding net catches was then used to estimate densities of presmolt sockeye in these depth and area strata. When no net tow was made in a stratum, the mean of the adjacent two strata was used. Total sockeye population was then estimated by multiplying the densities by the corresponding volumes of the strata and summing the numbers from all the strata.

An additional population estimate was obtained from the net tow results as in previous years by assuming a swept volume of 8,330 m^3 per tow. Mean densities of sockeye calculated from the catches and swept volumes were multiplied by the volume of the corresponding strata and summed over the lake as with the acoustic data.

Results and Discussion

The numbers of various fish species caught in the 24 net tows are given in Table 1. Total catch varied from 7 to 85 fish per 10-min tow. The percentage of 1979 year class sockeye in the various depth and area strata is given in Table 2. The numbers of sockeye were slightly greater in the deeper strata, but were well dispersed throughout the lake.

The greater proportion of sockeye and generally larger fish in the deeper strata mandated the use of separate regression relationships between density from echo counts and echo integration for the 4 to 25 m

Table 1. Catches of 1979 year class sockeye salmon (age 1) and other fish in midwater trawls during March 11 and 12, 1981.

Tow #	Area	Depth (m)	Total	CATCH								
				Sockeye			Smelt		Stickle-back	Cottid	Pea-mouth	Other
				0	1	1+	0	1				
1	5	18	12	0	6	0	0	0	6	0	0	0
2		26	58	6	24	0	1	0	12	3	9	3
3		24	42	3	24	0	0	0	10	0	5	0
4		11	22	2	7	0	9	0	1	0	2	0
5	4	14	10	1	5	0	3	0	2	0	0	0
6		22	12	0	7	0	2	0	3	0	0	0
7		28	22	0	12	1	2	0	0	1	6	0
8		35	34	0	15	2	2	0	0	9	5	1
9		28	16	0	12	0	0	0	0	0	4	0
10	3	14	7	1	1	0	4	0	1	0	0	1
11		28	50	0	6	2	0	0	1	0	40	3
12		46	59	0	23	5	0	0	0	23	4	1
13	1	14	17	0	9	0	3	2	1	2	0	0
14		22	24	0	12	0	2	2	8	0	0	0
15		28	21	0	11	0	1	0	0	0	9	0
16	2	14	85	0	9	1	8	0	61	0	6	0
17		22	35	1	3	1	1	1	27	0	1	0
18		28	13	0	4	1	0	0	6	1	1	0
19		35	24	0	18	0	0	2	2	1	1	0
20		36	19	0	16	0	0	2	1	0	0	0
21	3	22	13	1	9	0	0	1	2	0	0	0
22		28	18	0	7	2	0	1	5	0	3	0
23		35	23	0	11	1	2	0	0	0	9	0
24		44	13	0	5	1	2	0	0	3	2	0

Table 2. Percent of sockeye presmolts (1979 year class) from net catches by area and depth (parentheses indicate extrapolated value).

	Area				
Depth (m)	1	2	3	4	5
4-11	(42.5)	(21.5)	(23)	(41)	32
11-18	53	11	14	50	38
18-25	50	9	69	58	56
25-32	52	31	19	63	48
32-39	(65)	79	48	44	--
39-46	--	--	38	--	--
46-60	--	--	39	--	--

strata and the 25 to 60 m strata. The relationship for the deeper strata is illustrated in Fig. 1.

The population estimates of 1979 year class sockeye for each area from each of the two runs and the mean are given in Table 3. The estimates from the two runs were 3.74 and 3.54 million resulting in a mean population estimate of 3.64 million sockeye. The populations of sockeye in each depth and area stratum for both acoustic runs and the net tows are given in Table 4. The population estimate of 1979 year class sockeye from the net tows was 2.93 million. The close correspondence between the two hydroacoustic runs reflects the fairly uniform distribution of fish throughout the lake. The slightly smaller estimate from the net tows may result from either the much smaller sampling power of the net tows or a catching efficiency less than 100%.

Both the hydroacoustic and next estimates are affected by variability in the net sampling process, since the results are required in order to partition the hydroacoustic abundance estimates by species. Often this is a major source of uncertainty in acoustic estimates because of the small sampling power of nets. In this case the problem is lessened by the fairly uniform fish distribution. The relatively small range of 1979 year class sockeye catches (3 to 24 in 24 hauls) and the excellent replication (24 and 24, 12 and 12, 18 and 16) would indicate that the trawling results are a minor source of uncertainty in the 1981 series.

Other sources of variability in the hydroacoustic estimtes are the regression between echo counting and integration, the estimation of

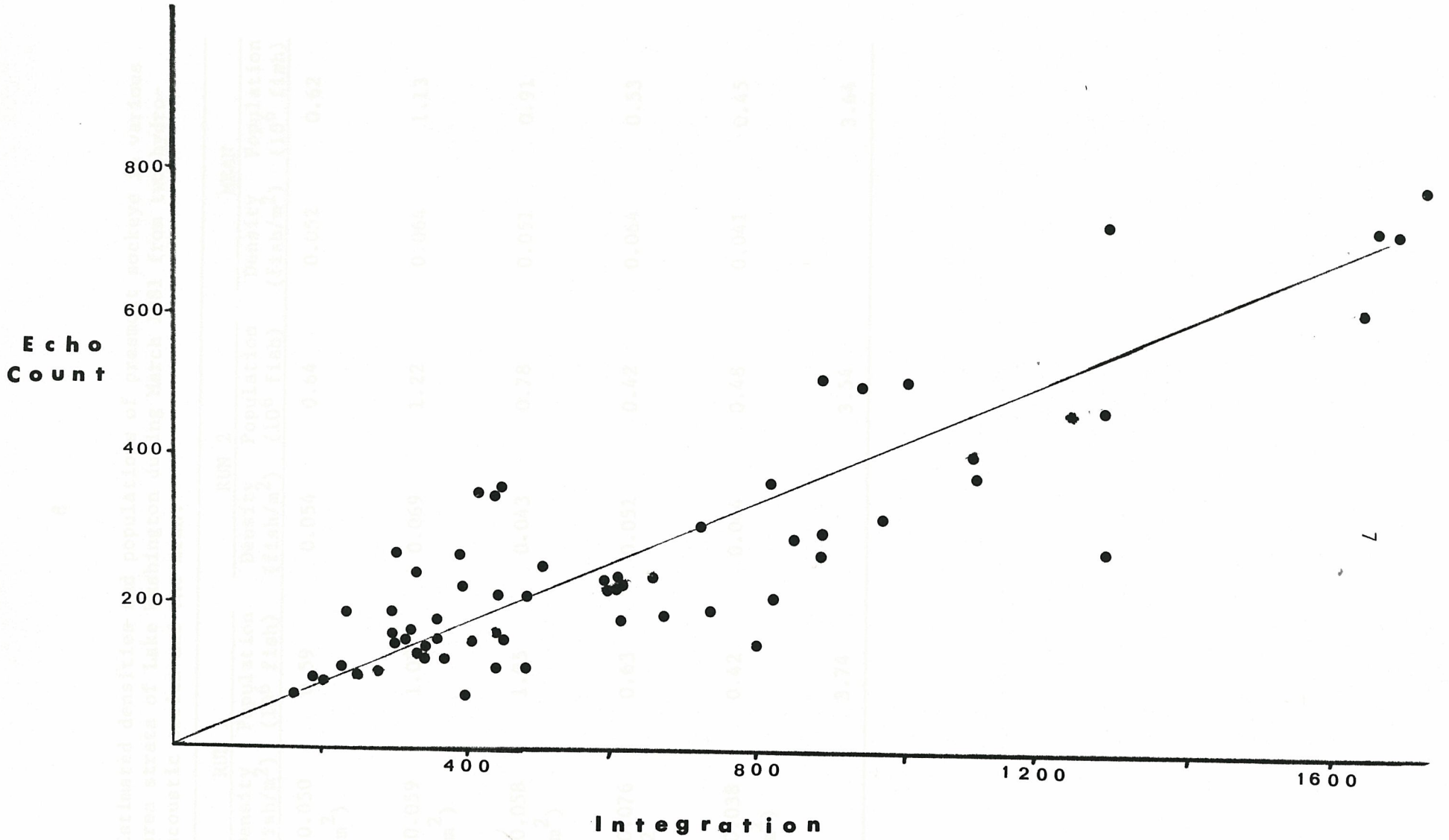

Fig. 1. Relation between estimated fish density from oscilloscope echo counts and echo integration in deeper depth strata of Lake Washington.

Table 3. Estimated densities and populations of presmolt sockeye in various area strata of Lake Washington during March 1981 from two hydroacoustic series and the mean.

	RUN 1		RUN 2		MEAN	
Area	Density (fish/m^2)	Population (10^6 fish)	Density (fish/m^2)	Population (10^6 fish)	Density (fish/m^2)	Population (10^6 fish)
1 ($11.9 \times 10^6 m^2$)	0.050	0.59	0.054	0.64	0.052	0.62
2 ($17.7 \times 10^6 m^2$)	0.059	1.05	0.069	1.22	0.064	1.13
3 ($18.1 \times 10^6 m^2$)	0.058	1.05	0.043	0.78	0.051	0.91
4 ($2.3 \times 10^6 m^2$)	0.076	0.63	0.051	0.42	0.064	0.53
5 ($11.0 \times 10^6 m^2$)	0.038	0.42	0.044	0.48	0.041	0.45
Total		3.74		3.54		3.64

Table 4. Estimates of presmolt sockeye salmon in various depth and area strata from the net tows and the two hydroacoustic runs.

Area	Depth (m)	Presmolt sockeye abundance (thousands) Run 1	Run 2	Net
1	4-18	186	182	88
	18-25	162	162	70
	25-32	240	292	107
	Total	588	637	265
2	4-18	69	83	218
	18-25	32	41	44
	25-32	131	157	47
	32-60	822	940	618
	Total	1054	1222	927
3	4-18	101	117	26
	18-25	140	140	114
	25-32	110	67	86
	32-60	697	458	727
	Total	1049	782	953
4	4-18	138	130	55
	18-25	61	54	47
	25-32	132	110	62
	32-39	296	123	263
	Total	627	416	428
5	4-18	131	124	102
	18-25	151	164	52
	25-32	142	192	200
	Total	424	480	355

sampling dimensions of the acoustic beam, and distributional characteristics of the fish. The correlation coefficients (r^2) for the regression relationships were 0.75 for the deeper strata where the sockeye were most abundant, and 0.36 for the shallow strata. The greater variability of the latter results from a more diverse size and species mix. Both had large sample sizes, 68 and 141.

Procedures for estimating sample volumes are straightforward and extensively studied (Nunnallee 1980) and should be a very minor source of bias. The fish were well dispersed and did not show any indication of anomalous near-bottom distributions which might be missed by the hydroacoustic sampling.

Summary and Conclusions

Population estimates of 1979 year class sockeye salmon in Lake Washington from two hydroacoustic series in March 1981 were 3.54 million and 3.74 million, or a mean of 3.64 million. Bias associated with the estimates should be minor. A corresponding estimate from net tows was 2.93 million. This smaller estimate probably results from either the smaller sampling power of the nets or a catching efficiency less than 100%.

The size of the parent stock of the 1979 year class smolts was estimated at 219,000 fish, including 13,000 taken for enhancement. Assuming that the number of kokanee among the 3.64 million fish is negligible, each sockeye spawner would have produced 16.6 presmolts. Estimated marine survival of Lake Washington sockeye has varied from 5%

to 20% since the 1967 year class, but has averaged about 10%. Applying the average survival to the 1979 year class, a returning adult population of 364,000 fish would be expected in 1983.

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