



1978 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

Edited by:  
Charles P. Meacham

1980

## ADF&G TECHNICAL DATA REPORTS

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The primary purpose of these reports is presentation of data. Description of programs and data collection methods is included only to the extent required for interpretation of the data. Analysis is generally limited to that necessary for clarification of data collection methods and interpretation of the basic data. No attempt is made in these reports to present analysis of the data relative to its ultimate or intended use.

Data presented in these reports is intended to be final, however, some revisions may occasionally be necessary. Minor revision will be made via errata sheets. Major revisions will be made in the form of revised reports.

1978 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

A summary of data collected from sockeye salmon  
(Oncorhynchus nerka) smolt programs in Bristol Bay,  
including Kvichak and Wood Rivers

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1980

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# 1978 KVICHAK RIVER SOCKEYE SALMON SMOLT STUDIES

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## INTRODUCTION

Data on age composition, size, and numbers of Kvichak River sockeye salmon (Oncorhynchus nerka) smolt migrating to sea are used by the Alaska Department of Fish and Game in forecasting part of the age composition and numbers of subsequent adult returns to the Bristol Bay fisheries and in evaluating the effects of different escapement levels on smolt production. From 1955 to 1973 an index of the smolt outmigration was derived from fyke net catches. Although these outmigration indices have provided information on fluctuations in the smolt populations, they were not reliable in forecasting the magnitude of salmon runs back to the Kvichak River. Sonar equipment was introduced in 1969 to obtain a total outmigration estimate (Russell 1972; Parker 1974a). Beginning in 1971 these total outmigration estimates have replaced the outmigration indices (Russell 1972; Paulus and McCurdy 1972; Parker 1974a and 1974b). Collection of age and size data and sonar enumeration of emigrating Kvichak River smolt were continued in 1978.

## METHODS AND MATERIALS

Installation and operation of the sonar counting system was similar to that of 1976 (Randall 1977). The system consisted of three 10.5 ft. plastic ladder assemblies, or arrays, each of which had 14 sonar transducers. Each transducer had 330 ft. of electronic cable. The transducers were attached to the arrays and their cables gathered together into three separate bundles which were connected to a single control unit housed in a tent on the riverbank, where the entire system was monitored. Each array was independently anchored and, after being positioned in the river channel, was submerged to the bottom for actual operation.

The system functions as a biomass counter and was designed to register one count for a biomass equivalent to 10 smolt (Parker 1974a). The system was monitored 24 hours per day. Every 7.5 to 60 minutes, counts were electronically totaled for each array and recorded on paper tape. Total counts were

multiplied by 10 fish per count to estimate smolt passing over the three arrays.

Known false counts, caused by wind, rain, snow, boats, etc., were subtracted from the counts printed on the paper tape. The normal procedure, however, was to disable the entire system when a known source of false counts appeared (e.g., boat, ice). Counts during missed time were estimated by linear interpolation. The control unit printed out the number of seconds the system was disabled. As the error in the internal mechanical clock that recorded the disable time was a negligible 0.2%, it was ignored.

Each array covered a section of the river approximately 12 ft. across. The counts from each array were expanded to estimate the number of smolt outmigrating in sections of the river not covered by the sonar gear. A sonar transducer with a 2° beam was aimed across the river from both sides of the river to determine the horizontal distribution of the smolt. The control unit for this side scanning sonar logged the returning echos into 12 individual counters depending on distance from the sending unit. The width of the river at the sonar site changes with river discharge and in 1978 the river was 342 ft. wide. Sonar records indicated that 40 ft. on the west bank and 20 ft. on the east bank were not utilized by smolt. Figure 1 illustrates the position of the arrays in the remaining 282 ft. The total daily counts were expanded to estimate the total daily outmigration based on the distribution of sonar counts over the three sonar arrays (Figure 2). These expansion factors were 8.1, 5.0, and 5.4 for the western, center, and eastern sector respectively.

The counting rate of the system is adjusted each season depending on river velocity. Water velocities were measured with a Gurley meter over each array at the start of the season. Since the control unit was adjusted for the velocity of the center array, linear adjustments of the offshore and inshore counts were made for the differences in river velocity over these two arrays. The control unit was set for 5.40 feet per second (fps), as measured on May 19. Average velocities ranged from 4.80, 5.40, and 4.80 fps over the inshore, center, and offshore arrays, respectively. A sample of a completed daily outmigration estimate with the adjustments for disable time, velocity differences, and expansion for unsonified areas was presented by Randall (1977).

Samples from fyke net catches were used to determine mean lengths, weights, and age composition of the outmigrating smolt. A standard 4 x 4 ft. fyke net was fished in about 4 ft. of water in approximately the same location as the index site of previous years. Thirty smolt were collected for age, length, and weight data at 0300, 0900, 1500, and 2100 hours daily. Because the estimated age proportion was 90% age II and 10% age I, the smolt age samples were pooled into sample sizes of 150 fish or more which allowed detection of a 5% change in the age composition at the 95% confidence limit (Snedecor and Cochran 1967). As a result there were four sample periods between 2 to 8 days each. Estimated age composition of the total outmigration was weighted by the outmigration estimate of each of the four sample periods.

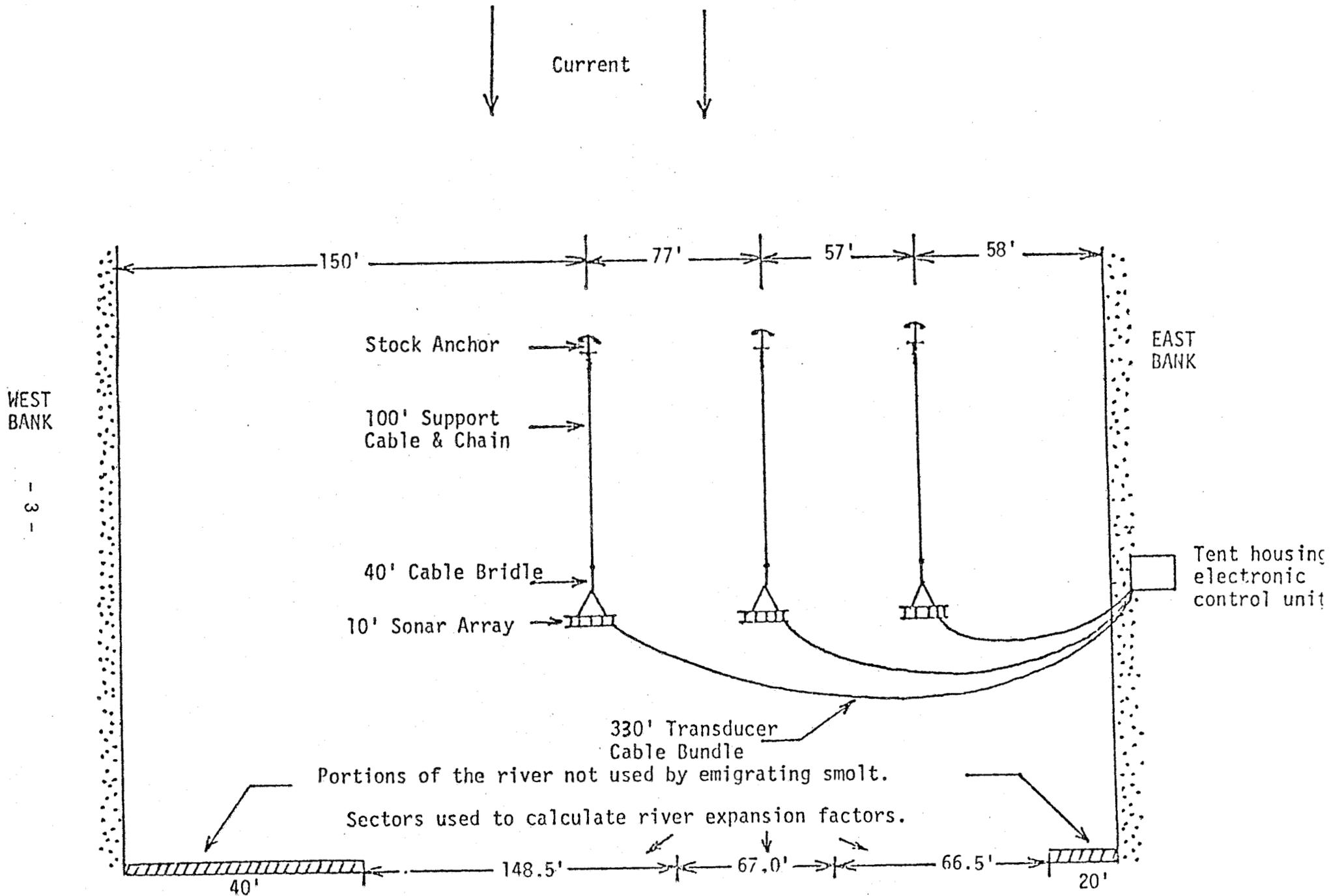


Figure 1. Sonar equipment placement in the Kvichak River, 1978.

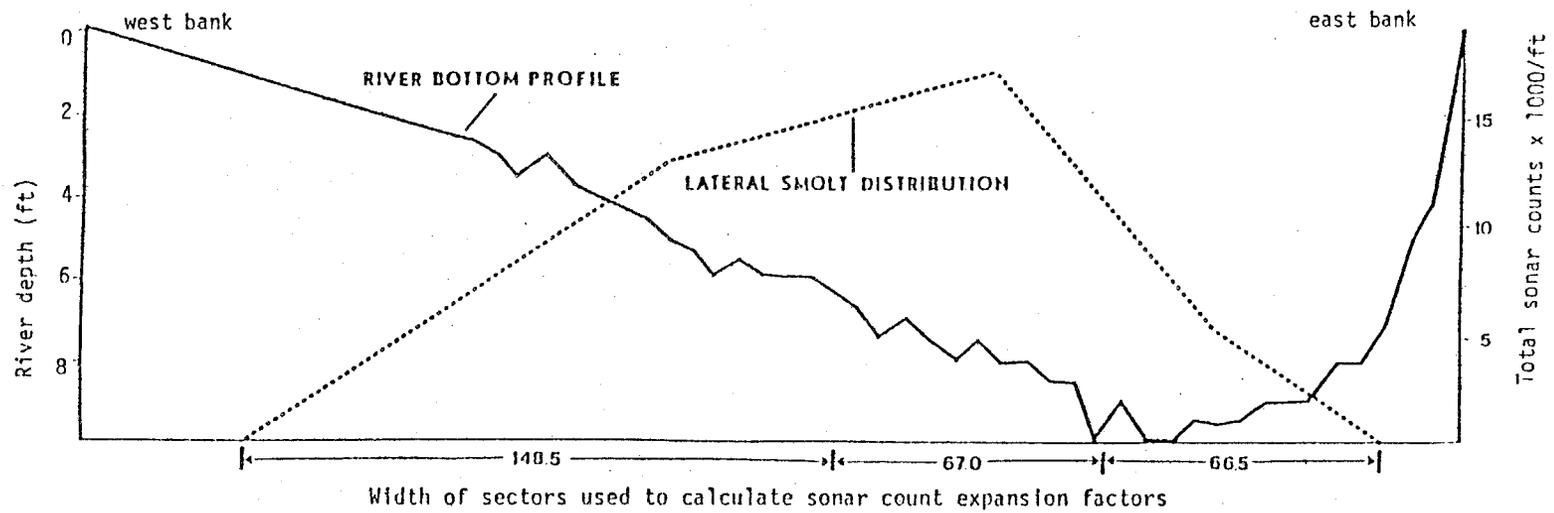


Figure 2. Lateral smolt distribution and river bottom profile at sonar site, Kvichak, 1978.

Length and weight data were not pooled because of significant differences between samples as few as 1 day apart. Estimated mean length and weight for the entire outmigration was obtained by summing the daily mean lengths and weights, each weighted by the corresponding daily outmigration estimate.

## RESULTS

### Outmigration Estimate

Nearly 4.3 million smolts were counted in 1978 with the center array recording the largest count of 2.1 million, followed by the offshore array with 1.6 million, and the inshore array with 620.8 thousand (Table 1).

Timing of the outmigration was the earliest since the Kvichak smolt studies began in 1955. An expanded count of about 15.4 million smolt were counted between May 18 and 19, the first night of sampling, and when the study ended on June 9, over 248.2 million smolt had been counted (Table 2). The peak of the outmigration occurred between May 23 and 24. An additional estimated 21.6 million smolt (8%) emigrated before the smolt project began on May 18. Thus a total of 269.8 million smolt is estimated to have emigrated down the Kvichak River (Table 2).

The majority of the smolt, i.e., 238.5 million, counted were age II smolt from the 1975 peak year escapement of 13.1 million spawners (Table 3). The remaining 31.3 million age I smolt were the progeny of 2.0 million adults spawning in 1976.

### Age-Weight-Length

A total of 852 smolt was measured to determine mean weight and length and a total of 1,221 smolt was collected to determine age. Daily mean weights and lengths were calculated (Table 4). The estimated age composition of the total outmigration was 12% age I and 88% age II smolt (Table 5). The predominance of age II smolt is typical of smolt outmigrations from peak year escapements (e.g., 1963, 1968, 1973, and 1978).

Mean weight in 1978 was 6.0 g for age I smolt and 7.8 g for age II smolt (Table 5). The long term average weight is 6.1 g (19 years) and 11.3 g (20 years) for age I and II smolts. Mean length was 88.1 mm for age I smolt and 96.9 mm for age II smolt (Table 5). The long term average length is 89 mm (23 years) for age I smolt and 110 mm (23 years) for age II smolts.

Table 1. Kvichak River daily sockeye salmon smolt counts by array, 1978<sup>1/</sup>

Date	Inshore	Center	Offshore	Total
May 18	46,191	148,702	79,401	274,294
19	14,582	70,036	77,355	161,973
20	11,496	25,976	28,953	66,425
21	25,275	156,684	173,730	355,689
22	59,623	300,713	175,249	535,585
23	171,996	311,746	182,000	665,742
24	76,300	279,353	322,582	678,235
25	71,726	273,901	196,268	541,895
26	64,212	182,151	78,914	325,277
27	5,765	29,802	40,702	76,269
28	1,359	5,194	25,652	32,205
29	21,294	116,051	112,459	249,804
30	18,076	88,887	44,736	151,699
31	6,169	52,688	16,599	75,456
June 1	13,013	29,015	10,390	52,418
2	1,885	6,314	697	8,896
3	4,349	9,437	2,409	16,195
4	440	2,231	678	3,349
5	4,531	6,521	1,420	12,472
6	1,159	2,088	353	3,600
7	747	2,694	506	3,947
8	364	1,396	139	1,899
9	226	952	190	1,368
Total	620,778	2,102,532	1,571,382	4,294,692
Percent of total	14.4	48.9	36.9	100.0

<sup>1/</sup> Counts less false counts plus interpolation for missed time, beginning at noon and ending at noon the following day.

Table 2. Expanded Kvichak River daily and cumulative sockeye salmon smolt outmigration, 1978.

Date	AGE I			AGE II			Total counts	Accum. counts
	No. counts	%	Accum. counts	No. counts	%	Accum. counts		
May 18	1,730,144	11.25	4,158,599	13,648,913	88.75	32,806,729	15,379,057	39,965,320 <sup>1/</sup>
19	1,100,152	11.25	5,250,751	8,678,981	88.75	41,465,710	9,779,133	46,744,461
20	443,084	11.25	5,701,835	3,495,436	88.75	44,981,146	3,938,520	50,682,981
21	2,426,975	11.25	8,128,810	19,146,138	88.75	64,127,284	21,573,113	72,256,094
22	3,435,168	11.25	11,563,978	27,099,663	88.75	91,226,947	30,534,831	102,790,925
23	4,159,553	11.25	15,723,531	32,814,255	88.75	124,041,202	36,973,808	139,764,733
24	3,716,861	9.09	19,440,392	37,172,703	90.91	161,213,905	40,889,564	180,654,297
25	2,844,367	9.09	22,284,759	28,446,795	90.91	189,660,706	31,291,162	211,945,459
26	1,625,518	9.09	23,910,277	16,256,971	90.91	205,917,671	17,882,489	229,827,948
27	787,950	16.76	24,698,227	3,913,423	83.24	209,831,094	4,701,373	234,529,321
28	364,407	16.76	25,062,634	1,809,859	83.24	211,640,953	2,174,266	236,703,587
29	2,502,789	16.76	27,565,423	12,430,320	83.24	224,071,273	14,933,109	251,636,696
30	1,430,986	16.76	28,996,409	7,107,115	83.24	231,178,388	8,538,101	260,174,797
31	909,289	22.03	29,905,698	3,218,215	77.97	234,396,603	4,127,504	264,302,301
June 1	622,305	22.03	30,528,083	2,202,785	77.97	236,599,388	2,825,170	267,127,471
2	131,347	28.77	30,659,430	325,193	71.23	236,924,581	496,540	267,584,011
3	245,848	28.77	30,905,278	608,680	71.23	237,533,261	854,528	268,438,539
4	52,239	28.77	30,957,517	129,334	71.23	237,662,595	181,573	268,620,112
5	185,905	28.77	31,143,422	460,273	71.23	238,122,868	646,178	269,266,290
6	53,383	28.77	31,196,805	132,167	71.23	238,255,035	185,550	269,451,840
7	59,577	28.77	31,256,382	147,502	71.23	238,402,537	207,079	269,658,919
8	27,998	28.77	31,284,380	69,317	71.23	238,471,854	97,315	269,756,234
9	20,760	28.77	31,305,140	51,399	71.23	238,523,253	72,159	269,828,393
TOTAL		11.60	31,305,140		88.40	238,523,253		269,828,393 <sup>1/</sup>

<sup>1/</sup> Includes 21,586,271 smolt thought to outmigrate prior to May 18 of which 11.25% or 2,428,455 are Age I and 88.75% or 19,157,816 are Age I. Total expanded count was 248.2 million smolt.

Table 3. Kvichak sockeye salmon parent escapement and corresponding smolt production, 1956-1976<sup>1/</sup>

Brood year	Escapement	Age Proportion			Total	Age Proportion			Smolt per spawner
		Age I	Age II	Age III		Age I	Age II	Age III	
1956	9,443,318	3,267,274	2,777,960	0	6,045,234	0.54	0.46	0	0.640
1957	2,842,810	85,916	552,603	0	638,519	0.13	0.87	0	0.225
1958	534,785	61,400	10,126	0	71,526	0.86	0.14	0	0.134
1959	680,000	26,038	72,180	0	98,218	0.27	0.73	0	0.144
1960	14,630,000	1,130,820	4,116,093	0	5,246,913	0.22	0.78	0	0.359
1961	3,705,849	113,338	1,603,464	0	1,716,802	0.07	0.93	0	0.463
1962	2,580,884	458,122	1,748,178	0	2,206,300	0.21	0.79	0	0.855
1963	338,760	64,377	23,377	0	87,754	0.73	0.27	0	0.259
1964	957,120	252,384	222,528	0	474,912	0.53	0.47	0	0.496
1965	24,325,926	2,866,214	5,475,362	0	8,341,576	0.34	0.66	0	0.343
1966	3,775,184	648,321	541,017	0	1,189,338	0.55	0.45	0	0.315
1967	3,216,208	594,327	298,282	0	892,609	0.67	0.33	0	0.278
1968	2,557,440	185,356 <sup>2/</sup>	5,959,383 <sup>2/</sup>	0		0.03	0.97	0	
1969	8,394,204	85,723,430	67,004,325	0	152,727,755	0.56	0.44	0	18.194
1970	13,935,306	570,750	189,138,158	4,925,610	194,634,518	0.00	0.97	0.03	13.967
1971	2,387,392	4,987,961	33,767,464	0	38,755,425	0.13	0.87	0	16.233
1972	1,009,962	4,021,849	5,784,036	0	9,805,885	0.41	0.59	0	9.709
1973	226,554	9,848,495	2,927,804	0	12,776,299	0.77	0.23	0	56.394
1974	4,433,844	99,890,123	132,920,297	0	232,810,420	0.43	0.57	0	52.508
1975	13,140,450	82,097,299	238,523,253	0	302,620,552	0.27	0.73	0	23.030
1976	1,965,282	31,305,140							

<sup>1/</sup> For the years 1956 through 1967 production values are indices only; since 1969 production values are actual estimates of smolt numbers.

<sup>2/</sup> From brood year 1968, the Age I smolt production value is an index whereas the Age II smolt production value is an estimate of total abundance.

Table 4. Sample size, mean length (mm), mean weight (g), and variance for sockeye salmon smolt by age class and sample period, Kvichak River, 1978.

Date	Age I					Age II				
	Mean length	Variance	Mean wt.	Variance	N	Mean length	Variance	Mean wt.	Variance	N
May 19	91.00		6.10		1	106.07	33.067	9.88	2.56	29
21	83.11	17.361	5.14	0.61	9	90.81	11.962	6.53	0.62	21
22	92.13	105.839	6.98	4.20	8	100.68	57.173	8.85	3.43	62
23					0	105.93	62.478	9.83	3.66	30
24	92.50	0.500	6.40	0.72	2	94.83	33.085	7.49	2.21	107
25	91.00		6.50		1	98.97	39.677	8.21	1.79	29
26	84.40	36.971	5.48	1.15	15	94.57	22.112	7.45	1.28	44
27	89.25	18.250	5.45	0.23	4	99.15	93.575	8.07	4.83	26
29	90.56	8.796	6.47	0.54	16	93.93	22.509	7.05	1.36	73
30	87.77	13.859	5.51	0.57	13	97.79	54.432	7.85	2.83	47
31	88.78	19.242	6.19	0.83	18	94.56	25.360	7.59	1.71	100
June 1	88.52	14.962	6.03	0.59	21	92.92	15.264	6.86	0.65	38
3	87.19	16.772	5.88	0.89	27	98.74	44.621	8.00	2.56	62
4	89.00	11.000	6.41	0.80	15	96.38	38.437	7.89	1.58	42

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Table 5. Comparative age, length, weight, and outmigration estimate of sockeye salmon smolt.

Year of seaward migration	% of out-migration	Age I		% of out-migration	Age II		% of out-migration	Age III		Outmigration estimate (No. of smolt) <sup>1/</sup>
		Length (mm)	Wt. (g)		Length (mm)	Wt. (g)		Length (mm)	Wt. (g)	
1955	7	89.0		93						260,068
1956	39	92.0		61	116.0					77,660
1957	72	96.0	7.3	28	120.0	14.4				30,907
1958	98	84.0	4.6	2	114.0					3,333,953
1959	3	80.0		97	99.0	7.6				2,863,876
1960	10	91.0	6.3	90	108.0	10.3				614,003
1961	72	92.0	6.8	28	117.0	13.1				36,164
1962	94	82.0	4.3	6	110.0	9.9				1,203,000
1963	3	83.0	4.8	97	98.0	7.5				4,229,431
1964	22	87.0	5.2	78	108.0	9.8				2,061,586
1965	4	90.0	6.8	96	109.0	11.3				1,812,555
1966	92	94.0	7.4	8	114.0	12.6				275,761
1967	93	86.0	5.9	7	118.0	14.2				3,088,742
1968	11	88.0	5.5	89	104.0	9.2				6,123,683
1969	52	92.5	4.7	48	109.3	10.6				1,135,344
1970	38	90.8	6.0	62	110.2	11.0				483,638
1971	94	89.9	5.8	7	111.0	11.1				91,682,813
1972	1	80.0	4.2	99	106.0	10.0				67,575,075
1973	3	85.6	5.1	97	97.1	8.3				194,126,120
1974	9	95.5	8.3	79	111.0	13.1	0.12	123.5	17.5	42,714,923
1975	63	97.7	8.4	37	121.9	16.4				15,632,531
1976	97	88.2	5.8	3	120.8	14.2				102,817,927
1977	38	86.0	5.5	62	106.0	10.1				215,017,596
1978	12	88.1	6.0	88	96.9	7.8				269,828,393

<sup>1/</sup> Index values only from 1955 through 1979. Outmigration estimate from sonar enumeration, 1971-1978.

## Climatological and Hydrological Observations

Weather and river conditions were recorded at the sonar site from May 19 through June 9 (Table 6). Air and water temperatures were significantly warmer than in past years (Table 7). The average air and water temperatures during the 21 day sampling period were 9.7 and 7.6° C, respectively. At the start of this project the lake and river were virtually ice-free. Water levels in the river were lower than in past years. The river began to rise on May 23 and by the end of the sampling season had risen more than 0.2 ft.

## DISCUSSION

Sonar estimates of the total smolt outmigration have been made since 1971. Several years of data exists to initiate assessment of the Kvichak smolt project in terms of its goals to: (1) forecast the return of adults based on the number and age composition of the smolt outmigrants and (2) to determine the affects of different parental escapement levels on smolt production.

### Forecasting of Adult Returns

Five years of data exists from which the smolt outmigration and subsequent adult return can be studied. There is no clear relationship between the return of 4<sub>2</sub> and 5<sub>2</sub><sup>1/</sup> adults and the age I smolt (Figure 3). Estimated survival from the age I smolt to the 4<sub>2</sub> and 5<sub>2</sub> adult range from a low of 1% to a high of 16%. The 5<sub>3</sub> and 6<sub>3</sub> returns from the age II smolt are more predictable, although smolt to adult survival range from 4% to 25% (Figure 4). Environmental factors (weather, predation, food supply) probably affect the smaller age I smolt more than the larger age II smolt resulting in more variable age I smolt survival rates.

### Production of Smolt from Parental Spawners

Seven years of data exists from which the relationship between numbers of parental spawners and subsequent smolt production can be examined. The number of smolt per parental spawner range from a low of 9.7 to a maximum of 56.4 with no clear relationship between the two (Figure 5). An analysis of parental escapement characteristics such as sex composition and fecundity may clarify this relationship.

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1/ Gilbert-Rich Formula - Total years of life at maturity (large type) - year of life at outmigration from fresh water (subscript).

Table 6. Climatological and stream observations, Kvichak River, May 18-June 19, 1978.

Date	Sky		Wind Direction-Velocity (MPH)		Air Temp. °C		Water Temp. °C		Precipitation (inches)	Water Level 1/ (ft.)	Turbidity
	0800	2000	0800	2000	Max.	Min.	Min.	Max.	24 hrs.	0800	0800
5/19		3		SW10	13	8		6.0	.10	8.97	1
20	4		SW15		14	1	5.0		0	8.94	1
21	5	4	SW4	SW2	12	0	5.5	6.0	.01	8.93	1
22	4		SW8		8	6	5.5		.05	8.96	1
23	4		calm			6	6.0		T	9.11	1
24	3	4	NE10	SW5	7	6	6.0	7.0	.23	9.19	1
25	2	2	NE3	calm	17	1	6.5	7.0	.02	9.08	1
26	2	4	calm	SE5	14	9	7.0	8.0	.40	8.98	1
27	4	4	NE10	N4	10	4	7.7	7.7	.38	8.98	1
28	4	2	SW12	NE10	14	7	7.0	6.5	.12	9.16	2
29	4	1		NE15	14	8		7.5	.04	9.21	1
30	3	4	NE4	NE4	18	5	7.0		T	9.19	1
31	3	2	NE5	NE5	15	5	7.5		.20	9.20	1
6/1	1	2	calm	SW4	17	3		8.0	0	9.22	1
2	3	1	NE5	calm	17	0	7.5	8.0	0	9.18	
3	2	3	SW5	calm	19	1	8.0	9.0	T	9.17	1
4	2		calm	SW10	15	5		8.5	0	9.18	1
5	4	4	NE3	NE2	11	6	8.5	9.0	.18	9.18	1
6	4	4	SE5	calm	22	3		9.3	.06	9.13	1
7	1	1	NE7	calm	21	5		11.0	0	9.12	1
8	2	4	NE4	SW10	25	3	8.5	10.5	T	9.18	1
9	4			NE3						9.18	1

1/ Depth of inshore half of center array 9.18 corresponds to tower staff gauge of 1.9'

Sky codes: 1-clear sky, cloud covering not more than 1/10 of sky.

2- cloud covering not more than 1/2 of sky.

3- cloud covering more than 1/2 of sky.

4- complete overcast.

5- fog.

Turbidity codes:

1- clear

2- light turbidity

3- medium turbidity

4- heavy turbidity

5- glacial

6- ice covered

Table 7. Water temperatures (°C) during smolt studies, Kvichak River, 1964 to 1978.

Year	Date		Water Temperature		Mean
	Start	End	Minimum	Maximum	
1964	5/18	6/14	0.0	5.6	5.5
1965	5/17	6/11	0.0	8.9	4.4
1966	5/16	6/26	0.0	1.1	4.7
1967	5/17	6/20	1.1	9.4	6.9
1968	5/12	6/12	3.3	8.3	5.4
1969	5/16	6/18	0.3	7.8	3.9
1970	5/13	6/7	2.8	1.1	6.8
1971	5/17	6/20	1.1	3.3	2.4
1972	5/18	6/18	0.6	5.0	2.9
1973	5/15	6/14	2.9	8.9	4.9
1974	5/13	6/9	3.0	8.0	6.2
1975	5/17	6/15	2.0	8.0	3.8
1976	5/18	6/19	2.0	9.5	3.9
1977	5/17	6/14	3.0	9.5	6.4
1978	5/19	6/9	5.0	11.0	7.6

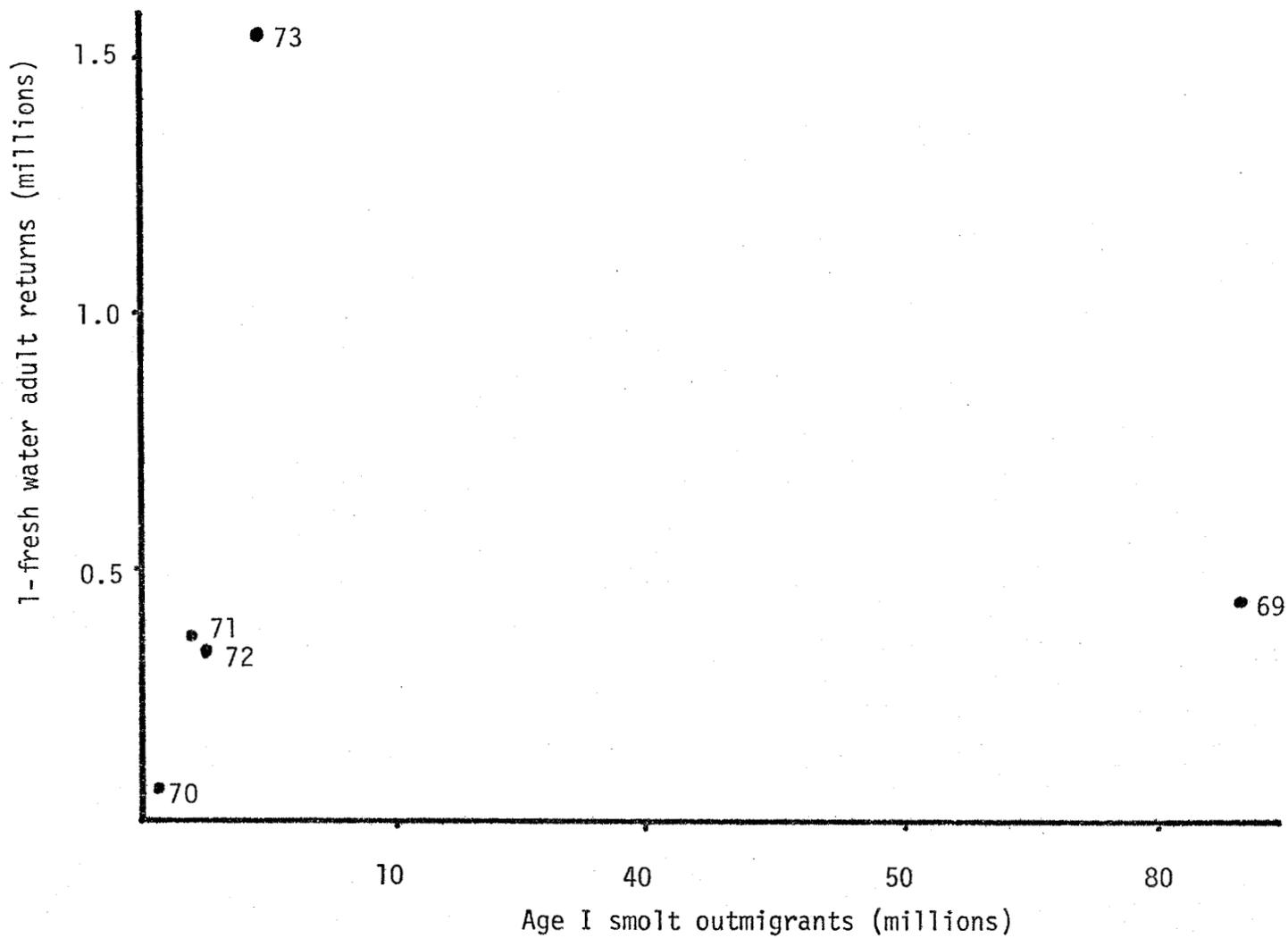


Figure 3. Age I smolt outmigration by year of outmigration and 1-fresh water adult returns, Kvichak River.

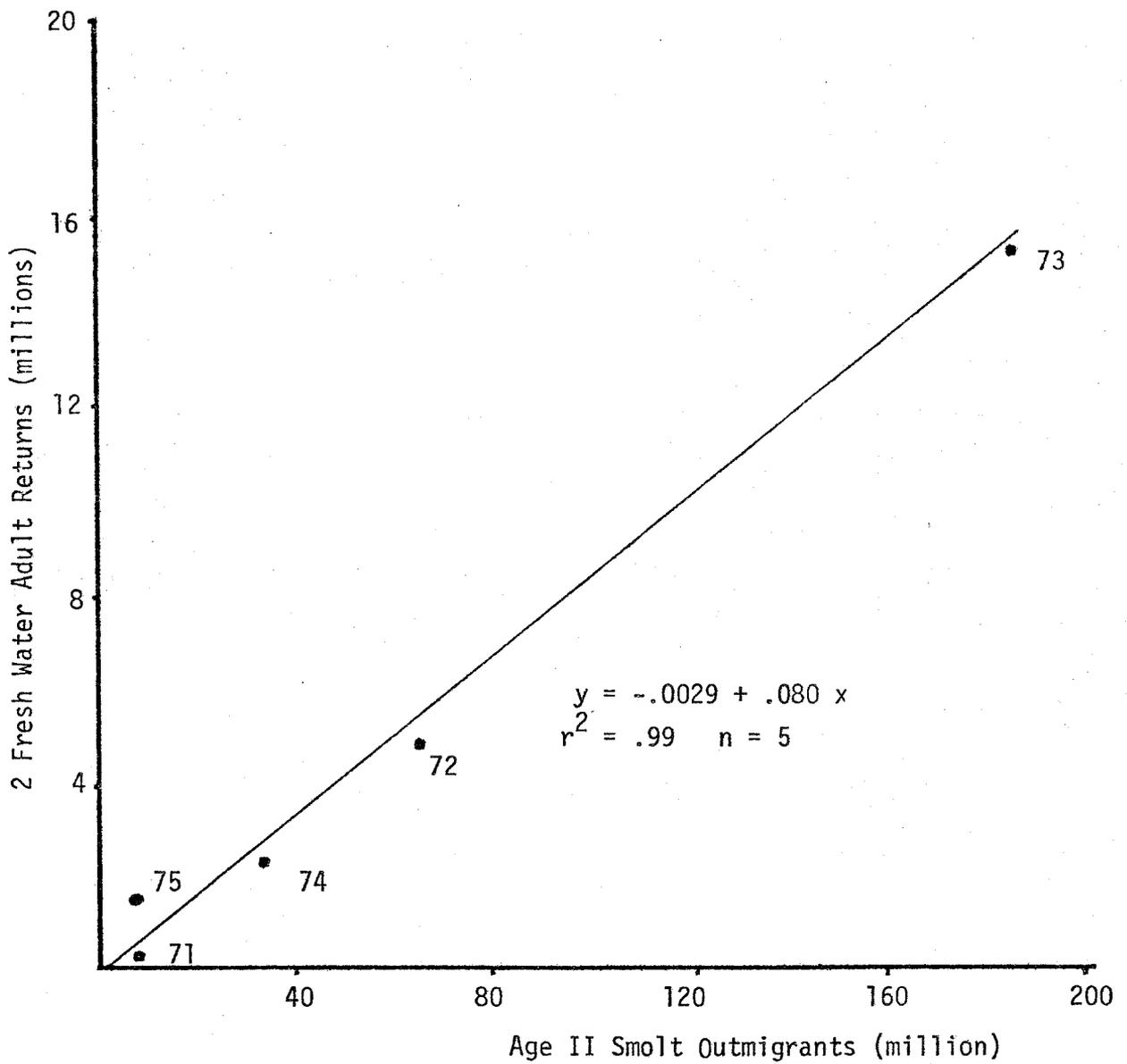


Figure 4. Age II smolt outmigration by year of outmigration and 2-fresh water adult returns, Kvichak River.

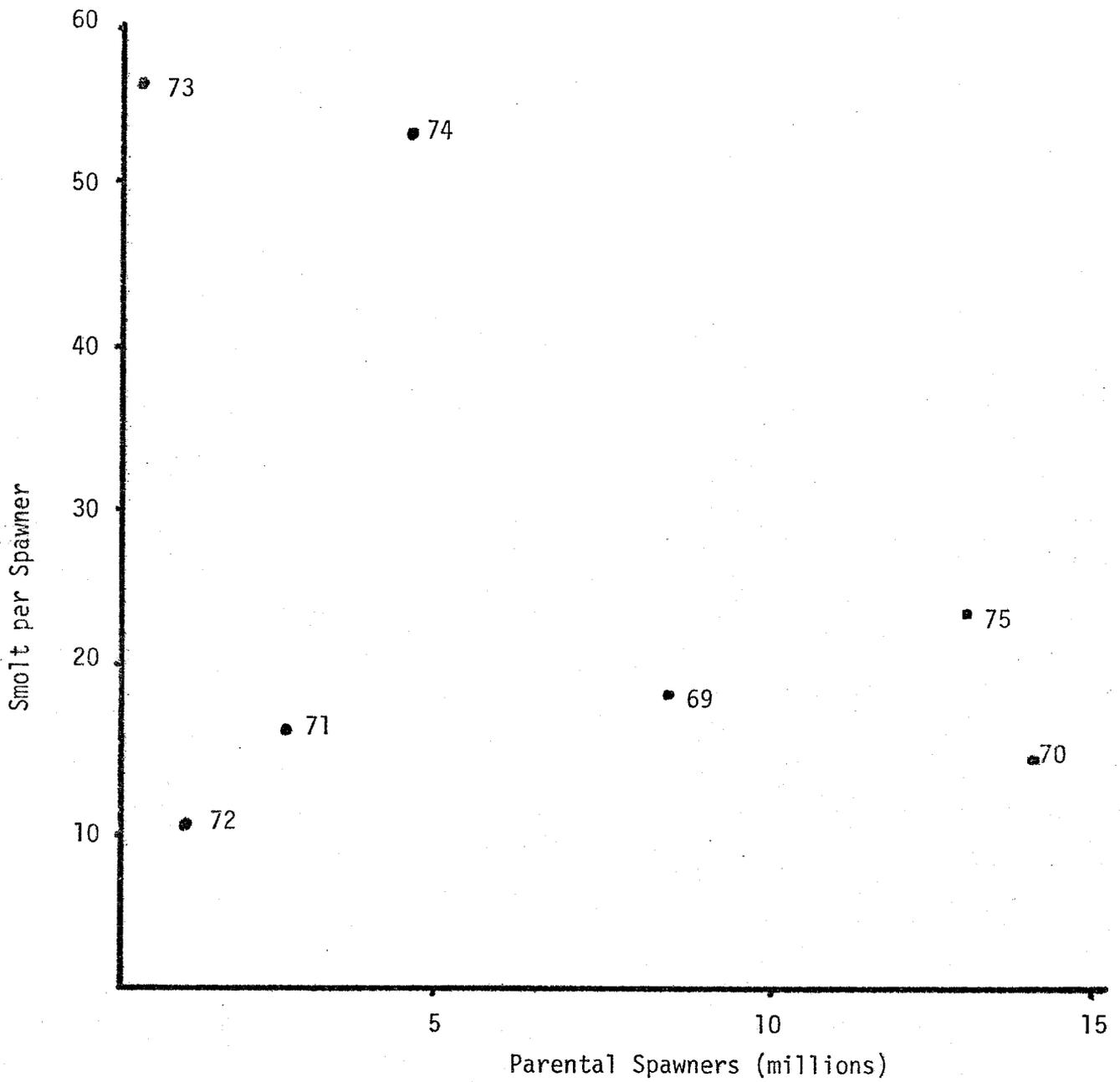


Figure 5. Relationship between number of parental spawners and subsequent smolt produced per spawner by brood year.

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# 1978 WOOD RIVER SOCKEYE SALMON SMOLT STUDIES

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## INTRODUCTION

The Wood River Smolt Project utilizing fyke nets was initiated in 1951 to obtain an abundance index of annual sockeye salmon smolt outmigration. Various programs designed to determine this index were operated until 1971 (excepting 1968). The index program was discontinued in 1971 because the relationship between this abundance index and the eventual adult return was extremely variable and of little value in forecasting the magnitude of future runs. There was also no clear relationship between escapement and the smolt production index.

A more accurate and precise smolt outmigration estimate was needed for forecasting adult returns and evaluating the potential of various management options recently initiated in the Wood River Lakes. Sonar smolt enumeration equipment therefore was purchased in 1975. The project has been continued through 1978 with the same objectives of estimating number, size and age composition of the smolt emigrating from the Wood River system. During 1978, an additional objective was added to the project. Calibration of the Wood River sonar smolt counter was researched in order to insure that it was counting as designed at the rate of 5 smolt per count and to answer questions raised by Newcome (1978).

The outmigration estimates published for 1975 and 1976 (Krasnowski 1977) for the Wood River Smolt Project were not estimates of total smolt migration, but were only an index of the numbers of smolt passing down the river. The sonar equipment was designed to count at a rate of 5 smolt per count, and through an oversight, the counts were not multiplied by this factor. Newcome (1978) published expanded sonar counts for the 1977 Wood River sockeye salmon outmigration and redefined the published 1975 and 1976 outmigration estimates as expanded sonar index counts. The present report will summarize the 1978 data and expand the 1975 through 1978 sonar index counts to actual smolt outmigration estimates.

## METHODS AND MATERIALS - 1978

The same four transducer arrays and electronic control units were used in 1978 as were used in 1976 and 1977 (Krasnowski 1976, 1977; and Newcome 1978). An attempt was made to place the arrays in the same locations as were used in 1976. The actual positions of Array I, II, III, and IV from the north bank were: 69, 112, 148, and 204 feet, respectively. This put Array IV at a distance of 131 feet from the south bank.

With a few minor changes, the sampling design and sonar data collection procedures were the same as described by Krasnowski (1977). The arrays were installed in the river on May 28 and the counter was operated during index hours (2100 to 0300) only through June 1st. A random daily counting schedule was started on June 2 and continued until July 22. The sonar gear was operated 75 hours (25 randomly selected 3 hour blocks) per 5-day sample period. Array I was operated during all sampling hours. Arrays II, III, and IV were operated in a random sequence for 15-minute intervals within each hour, and these 15-minute counts were expanded to yield hourly counts for each array. Between July 22 and August 11, the sonar counter was monitored during index hours only.

River velocity was measured with a pygmy gurlly meter on 93 occasions during the season. Velocity measurements usually were made behind array number I, as was accomplished during 1975 and 1976. Velocity measurements were taken periodically behind the other three arrays.

Lake depth at the Alaska Department of Fish and Game (ADF&G) cabin, near the outlet of Lake Aleknagik about a mile upriver from the sonar site, was measured four times daily. River depth at the sonar site was measured every 15 minutes during periods of sonar counting. Daily air and water temperature data was also recorded at the ADF&G cabin.

The velocity model used in 1976 to estimate hourly velocity factors for adjusting the hourly counts (Krasnowski 1977) could not be applied to the 1978 velocity data. First, the river velocity data were so variable that the model did not fit, and second, not enough river velocity - river depth paired data points were collected to adjust for tidally influenced periods. Sonar counts during time periods of no tidal influence on velocity were adjusted through the use of a correction factor calculated by dividing the average velocity during these time periods (per 5 day sampling schedule) by the 4.5 feet per second (fps) velocity setting on the counter which was maintained throughout the season. Sonar counts during tidally influenced time periods were estimated by extrapolation between non-tidally influenced counts. Lastly, all sonar counts per 5 day sampling period were expanded by interpolation across the entire width of the Wood River and for time periods not counted.

Smolt were collected for age-weight-length analysis during each 5-day sample period. The samples were collected with a beach seine near the outlet of Lake Aleknagik and with a fyke net fished 1/4 mile below the sonar site in the Wood River. Fork lengths and scale samples were taken from each smolt. Weights were taken from only a few of the smolt, but all smolt were examined for presence of the parasite Triaenophorus crassus.

During late July a floating fyke net was fished immediately behind sonar array number I. Comparative fyke net catch and sonar count data during night-time hours (midnight to 0200 h) were collected on 16 occasions in an attempt to calibrate the sonar counter.

## RESULTS

### Climatological and Hydrological Observations

Daily water and air temperatures at the ADF&G cabin during the smolt outmigration were measured (Table 1). The maximum and minimum seasonal water temperatures were 16° C (August 2 and 7) and 5° C (May 28 through June 1). The maximum and minimum air temperatures were 33° C (August 2) and 1° C (June 4).

### Biological Sampling

Mean lengths for age I and age II smolt were calculated by sample period (Table 2). The weighted mean lengths for the season of age I and age II smolt were 75.8 mm and 87.6 mm, respectively. Estimated infection rate of age I and age II sockeye salmon smolt by T. crassus was calculated (Table 3). Overall, about 15% of the age I smolt and 40% of age II smolt were infected by the parasite.

### Total Expanded Counts (Outmigration Index)

The total expanded counts for 1978 were 10,997,100 (Table 4). Age I smolt comprised 84.7% (9,320,000 expanded counts) of the outmigration. Age II smolt comprised 15.3% (1,677,100 expanded counts) with the majority of the age II smolt emigrating during the early part of the season.

Sonar outmigration indices (seasonal total expanded counts) for all the years this program was operated are presented in Table 5 whereas, Table 6 relates these smolt outmigration indices to appropriate brood year escape-ments.

Table 1. Water and air temperatures taken at the ADF&G sonar site, Wood River, 1978.

Date	Water temp. (°C)	Air temp. (°C)		Date	Water temp. (°C)	Air temp. (°C)	
		Max.	Min.			Max.	Min.
5/28	5.0	--	--	7/ 5	8.0	17.5	10
5/29	5.0	18	18	7/ 6	8.5	19	9
5/30	5.0	18	18	7/ 7	9.0	22	11
5/31	5.0	18	18	7/ 8	8.0	11	10
6/ 1	5.0	20	9	7/ 9	8.0	15	10
6/ 3	6.0	22	2	7/10	8.0	27	11
6/ 4	---	22	1	7/11	7.5	15	11
6/ 5	---	--	--	7/12	8.0	12	5
6/ 6	5.5	13	7	7/13	6.4	24	3
6/ 8	5.5	22	3	7/14	7.5	12	12
6/ 9	5.5	18	5	7/15	10.8	17	11
6/10	5.5	14	7	7/17	10.0	19	11
6/11	5.5	22	5	7/18	8.5	19	11.5
6/12	6.0	24	7	7/19	9.0	13	10
6/13	6.0	9	6	7/20	9.0	13	10
6/14	---	--	--	7/21	8.5	11	9
6/15	5.2	15	6	7/23	9.0	22	10
6/16	5.2	12	4	7/24	10.0	18	9
6/17	5.5	11	3	7/25	11.0	22	9
6/18	5.5	11	3	7/26	12.0	21	10
6/19	5.5	12	4	7/27	12.0	30	5
6/20	6.0	29	0	7/28	15.0	29	13
6/21	7.0	20	4	7/29	13.0	31	9
6/22	7.0	16.5	9	7/30	13.0	28	7
6/23	6.5	10	7	7/31	14.0	25	12
6/24	7.0	22	4.5	8/ 1	13.0	28	8
6/25	7.0	21	3	8/ 2	16.0	33	10
6/27	7.0	20	5	8/ 3	14.0	30	11
6/28	8.5	28	8	8/ 4	12.0		
6/29	9.5	29	5	8/ 5	13.0		
6/30	10.0	20	8	8/ 6	14.0		
7/ 1	8.5	15	7	8/ 7	16.0		
7/ 2	7.5	12	9	8/ 8	13.0		
7/ 3	8.0	13	10	8/ 9	14.0		
7/ 4	7.0	15	9				

Table 2. Sample sizes, mean lengths (mm), and variance of length for Age I and Age II sockeye salmon smolt sampled by sample period, Wood River, 1978.

SAMPLE PERIOD	AGE I			AGE II		
	n	$\bar{x}$	$s^2$	n	$\bar{x}$	$s^2$
May 29 - June 2 <sup>1/</sup>	104	70.2	127.7	231	85.4	53.3
June 2 - June 7 <sup>1/</sup>	67	70.4	125.4	73	83.7	42.3
June 7 - June 12 <sup>1/</sup>	227	74.2	75.7	91	85.9	96.0
June 12 - June 17 <sup>1/</sup>	266	77.6	72.3	95	85.3	72.3
June 17 - June 22 <sup>1/</sup>	235	72.6	42.3	50	85.9	90.3
June 22 - June 27 <sup>1/</sup>	361	76.8	84.6	38	86.8	228.0
June 27 - July 2 <sup>1/</sup>	123	74.5	39.7	14	95.4	70.6
July 2 - July 7 <sup>1/</sup>	130	76.8	59.3	52	98.2	148.8
July 7 - July 12 <sup>2/</sup>	338	81.0	56.3	1	99.0	-
July 12 - July 17 <sup>2/</sup>	212	79.9	60.8	0	-	-
July 17 - July 22 <sup>2/</sup>	350	86.7	44.9	0	-	-
July 22 - July 27 <sup>3/</sup>	173	89.2	38.4	0	-	-
July 27 - August 1 <sup>3/</sup>	49	77.3	126.6	0	-	-
August 1 - August 6 <sup>3/</sup>	66	89.7	182.3	0	-	-
August 6 - August 11 <sup>3/</sup>	68	83.3	225.0	1	104.0	-
May 29 - August 11		75.8	90.8		87.6	100.2

- <sup>1/</sup> Lengths estimated from smolt captured by beach seine at Mosquito Point at the outlet of Lake Aleknagik.
- <sup>2/</sup> Lengths estimated from smolt captured by beach seine (Mosquito Point) pooled with smolt samples captured by fyke nets in the Wood River 1/4 mile downstream from the sonar site.
- <sup>3/</sup> Lengths estimated from smolt captured by fyke net in the Wood River 1/4 mile downstream from the sonar site.
- <sup>4/</sup> The season total mean length is derived by weighting each sample period's mean length by the total expanded counts for that period (Table 4).

Table 3. Sample sizes and estimated infection rate of *T. crassus* for Age I and Age II sockeye salmon smolt by sample period, Wood River, 1978.

Sample Period	Age I		Age II	
	n	% T.C.	n	% T.C.
May 29-June 2 <sup>1/</sup>	108	13.5	264	35.6
June 2-June 7 <sup>1/</sup>	80	20.0	80	53.8
June 7-June 12 <sup>1/</sup>	86	21.5	72	44.6
June 12-June 17 <sup>1/</sup>	101	28.0	19	37.2
June 17-June 22 <sup>1/</sup>	110	43.8	9	11.0
June 22-June 27 <sup>1/</sup>	149	9.5	32	31.0
June 27-July 2 <sup>1/</sup>	84	17.7	14	7.0
July 2-July 7 <sup>1/</sup>	198	20.6	41	39.0
July 7-July 12 <sup>2/</sup>	466	17.2	14	57.1
July 12-July 17 <sup>2/</sup>	373	11.5	1	100.0
July 17-July 22 <sup>2/</sup>	302	6.6	3	66.6
July 22-July 27 <sup>3/</sup>	180	6.6	0	-
July 27-August 1 <sup>3/</sup>	49	0.0	0	-
August 1-August 6 <sup>3/</sup>	66	0.0	0	-
August 6-August 11 <sup>3/</sup>	68	2.7	1	100.0
May 29-August 11		15.1 <sup>4/</sup>		40.5 <sup>4/</sup>

- <sup>1/</sup> T.C. infection estimated from smolt captured by beach seine at Mosquito Point at the outlet of Lake Aleknagik.
- <sup>2/</sup> T.C. infection estimated from smolt captured by beach seine (Mosquito Point) pooled with smolt samples captured by fyke net in the Wood River 1/4 mile downstream from the sonar site.
- <sup>3/</sup> T.C. infection estimated from smolt captured by fyke net in the Wood River 1/4 mile downstream from the sonar site.
- <sup>4/</sup> The season total mean infection rate of *T. crassus* is derived by weighting each sample period's mean infection rate by the total expanded counts for that period (Table 4).

Table 4. Total expanded counts of sockeye salmon smolt by age class and sample period, Wood River, 1978.

Sample Period	Age I		Age II		Total No. (thousands)
	No. (thousands)	%	No. (thousands)	%	
May 29-June 2 <sup>1/</sup>	101.1	29.0	247.6	71.0	348.7 <sup>4/</sup>
June 2-June 7 <sup>1/</sup>	312.9	50.6	305.5	49.4	618.4
June 7-June 12 <sup>1/</sup>	693.5	54.4	581.3	45.6	1,274.8
June 12-June 17 <sup>1/</sup>	544.2	80.0	11.1	20.0	555.3
June 17-June 22 <sup>1/</sup>	495.2	92.4	40.7	7.6	535.9
June 22-June 27 <sup>1/</sup>	816.8	82.1	178.1	17.9	994.9
June 27-July 2 <sup>1/</sup>	520.9	85.7	86.9	14.3	607.8
July 2-July 7 <sup>1/</sup>	884.7	82.8	183.8	17.2	1,068.5
July 7-July 12 <sup>2/</sup>	1,328.2	97.9	28.5	2.1	1,356.7
July 12-July 17 <sup>2/</sup>	1,376.4	99.7	4.1	0.3	1,380.5
July 17-July 22 <sup>2/</sup>	371.7	97.5	9.5	2.5	381.2
July 22-July 27 <sup>3/</sup>	642.9	100.0	0.0	0.0	642.9 <sup>4/</sup>
July 27-August 1 <sup>1/</sup>	461.0	100.0	0.0	0.0	461.0 <sup>4/</sup>
August 1-August 6 <sup>3/</sup>	391.1	100.0	0.0	0.0	391.1 <sup>4/</sup>
August 6-August 11 <sup>3/</sup>	379.4	100.0	0.0	0.0	379.4 <sup>4/</sup>
<b>Total</b>	<b>9,320.0</b>		<b>1,677.1</b>		<b>10,997.1</b>

- <sup>1/</sup> Age composition estimated for smolt captured by beach seine at Mosquito Point at the outlet of Lake Aleknagik.
- <sup>2/</sup> Age composition estimated from smolt captured by beach seine (Mosquito Point) pooled with the smolt samples captured by fyke net in the Wood River 1/4 mile downstream from the sonar site.
- <sup>3/</sup> Age composition estimated from smolt captured by fyke net in the Wood River 1/4 mile downstream from the sonar site.
- <sup>4/</sup> Total counts for these five day periods was estimated from average index counts (2100 to 0300 hour counts).

Table 5. Summary of Wood River total expanded smolt counts by age class, 1975, 1976, 1977, and 1978 (number of counts x 10<sup>6</sup>).

Year of outmigration	Age I	Age II	Total
1975	5.59	1.18	6.77
1976	20.28	0.96	21.24
1977	12.15	2.51	14.66
1978	9.32	1.68	11.00

Table 6. Summary of Wood River total expanded smolt counts from brood year escapements (number of counts x 10<sup>6</sup>).

Brood year	Escapement	Age I	Age II	Total
1972	0.43	-	1.18	-
1973	0.33	5.59	0.96	6.55
1974	1.71	20.28	2.51	22.79
1975	1.27	12.15	1.68	13.83
1976	0.82	9.32		

### Sonar Calibration and Outmigration Estimates

During late July the number of smolt collected by fyke net fished behind array number I (Table 7) and when divided by the sonar count of smolt during the same period averaged 5.82 smolt per sonar count. It was concluded that the sonar counter was counting as designed, i.e., at a rate of essentially 5 smolt per sonar count. Consequently, data summarized in Tables 5 and 6 have been expanded by a factor of 5 to provide actual estimates of the smolt outmigration from Wood River between 1975 and 1978 (Tables 8 and 9).

### 1973 Brood Year Age I Marine Survival Estimates

A total of 1.140 million 5<sub>2</sub> and 0.201 million 4<sub>2</sub> Wood River system sockeye returned from the 1973 brood year escapement. Since the Wood River system sockeye are virtually 100% 4 and 5 year old fish, the resulting return from the Age I 1975 smolt outmigration will total about 1.341 million adult sockeye salmon. The outmigration estimate for this age class was 27.950 million smolt and marine survival is estimated at 4.8%.

Table 7. Wood River smolt sonar calibration data, 1978.

Date	Time	Minutes fyke net fished	Number of smolt	Total adjusted sonar indices	Smolt/catch	Incidental catch
7/24	2400-2415	15	809	823	0.983	
	2415-2430	15	766	427	1.794	
	2430-2445	15	338	119	2.840	
	2445-0100	15	176	42	4.190	
	0100-0115	15	134	62	2.161	1 Stickleback, 1 Lamprey
	0115-0130	15	117	35	3.343	1 Stickleback, 1 Lamprey
	0130-0145	15	103	34	3.029	
	0145-0200	15	126	16	7.875	
7/25	2400-2415	15	449	261	1.720	
	2415-2430	15	386	113	3.416	
	2430-2445	15	486	120	4.050	
	2445-0100	15	290	28	10.360	
	0100-0115	15	154	13	11.850	
	0115-0130	15	385	38	10.130	
	0130-0145	15	752	80	9.400	
	0145-0200	15	947	59	16.050	
Average					5.820	

Table 8. Summary of Wood River smolt outmigration by age class from 1975 to 1978 in millions.

Year of outmigration	Age I	Age II	Total
1975	27.95	5.90	33.85
1976	101.40	4.80	106.20
1977	60.75	12.55	73.30
1978	46.60	8.40	55.00

Table 9. Summary of Wood River smolt outmigration resulting from brood year escapements in millions and smolt production per spawner.

Brood year	Escapement	Age I	Age II	Total smolt	Smolt production per spawner
1972	0.43	-	5.90	-	-
1973	0.33	27.95	4.80	32.75	99.24
1974	1.71	101.40	12.55	113.95	66.64
1975	1.27	60.75	8.40	69.15	54.45
1976	0.82	46.60	-	-	-

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# 1978 BRISTOL BAY SPECIAL SOCKEYE SALMON SMOLT STUDIES

Summarized by

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## INTRODUCTION

Since the spring of 1977, samples of migrating sockeye salmon smolt have been collected at the Ugashik, Egegik, Nuyakuk, and Igushik Rivers to obtain age, weight, and length information and scale samples from the major sockeye salmon producing systems in Bristol Bay that did not have smolt enumeration projects. The 1977 scales have been examined for pattern recognition and used in conjunction with data obtained from the smolt enumeration projects on the Naknek, Kvichak, and Wood River systems to test the feasibility of using smolt scales as standards for separating returning adult Bristol Bay sockeye salmon in mixed stock fisheries in 1979 and 1980. Smolt from the same four river systems sampled in 1977 were again sampled in 1978. Additionally, Naknek River smolt were also sampled this year because the Naknek smolt enumeration project there was discontinued.

## METHODS AND MATERIALS

A single collapsible 4 ft. by 4 ft. winged fyke net was fished in the Ugashik, Egegik, Naknek, and Nuyakuk Rivers. Fishing was conducted in the Ugashik River during the evenings of May 23, 24, and 25, and in the Egegik River during the evenings of May 19 and 22. Fishing took place at night in the Naknek River on June 1, and in the Nuyakuk River on June 18 and 19. The Igushik River was sampled during the evening of June 17 with a 100 ft. long beach seine.

Fork length and scale samples were collected from all smolt captured at each special smolt sampling location. Weight samples to the nearest 0.1 gram were taken from all smolt captured in the Ugashik, Egegik, Nuyakuk, and Igushik Rivers, whereas weights were taken from only one-half of the smolt collected from the Naknek River.

## RESULTS

### Scale Analysis

Identification of different stocks of smolt by polynomial discriminant analysis of scale characteristics was undertaken using smolt samples collected in 1977. Results are summarized in Table 1. Overall accuracies in classifying group membership of age I smolt ranged from 70.8% for eastside Bristol Bay samples to 74.7% for westside samples. Overall accuracy decreased to 65.4% when all Bristol Bay age I smolt were classified in a 7-group analysis (Table 2). Only eastside Bristol Bay age II smolt were classified as there were insufficient westside age II samples to allow analysis. Overall accuracy of classifying age II smolt was 56.0% (Table 1). These classification accuracies may be put into perspective by the fact that in a 4-group analysis, chance alone would account for only 25% accuracy. In a 7-group analysis, chance alone would account for only 14% accuracy.

### Age, Weight, and Length Analysis

Table 3 lists sample sizes and length and weight statistics for each age class at each river. Conforming to historic data, the eastside Bristol Bay smolt were larger than the westside smolt, and age II smolt dominated in eastside river systems while age I smolt dominated in westside river systems.

There was little variation between the size of the Ugashik smolt collected in 1978 and those collected 15 years previously. Only a meager data base exists for Egegik River smolt, but it appears that those smolt outmigrating in 1978 were slightly larger than average. Similarly, 1978 outmigrating Naknek smolt were noticeably larger than average for that system. Smolt from the Nuyakuk and Igushik Rivers were slightly larger than those collected in 1977.

It should be noted that since these samples were collected over relatively short periods of time, the age composition of the samples may not be representative of the overall age composition of the migrating smolt in these systems.

Table 1. Classification matrices for Bristol Bay smolt, 1977.

1977 AGE I SMOLT

<u>East Side</u> Group (n)	Predicted Group Membership %			
	Kvichak	Naknek	Egegik	Ugashik
Kvichak (50)	64.0	26.0	0	10.0
Naknek (50)	16.0	72.0	0	12.0
Egegik (21)	4.8	0	81.0	14.3
Ugashik (50)	14.0	10.0	4.0	72.0

Overall Accuracy = 70.8%

West Side

Group (n)	Igushik	Wood	Nuyakuk
Igushik (50)	70.0	28.0	2.0
Wood (50)	34.0	58.0	8.0
Nuyakuk (50)	4.0	0	96.0

Overall Accuracy = 74.7%

1977 AGE II SMOLT

East Side

Group (n)	Kvichak	Naknek	Egegik	Ugashik
Kvichak (50)	56.0	22.0	18.0	4.0
Naknek (50)	24.0	42.0	18.0	16.0
Egegik (50)	16.0	18.0	58.0	8.0
Ugashik (50)	10.0	12.0	10.0	68.0

Overall Accuracy = 56.0%

Table 2. Classification matrix for grouped 1977 Bristol Bay Age I smolt.

Group (n)	Predicted Group Membership						
	Kvichak	Naknek	Egegik	Ugashik	Igushik	Wood	Nuyakuk
Kvichak (50)	58.0	24.0	0	8.0	6.0	2.0	2.0
Naknek (50)	10.0	62.0	0	10.0	2.0	14.0	2.0
Egegik (50)	4.8	4.8	76.2	14.3	0	0	0
Ugashik (50)	12.0	4.0	8.0	60.0	4.0	6.0	6.0
Igushik (50)	4.0	0	0	2.0	68.0	22.0	4.0
Wood (50)	8.0	4.0	6.0	4.0	26.0	48.0	4.0
Nuyakuk (50)	0	4.0	0	0	4.0	0	92.0

Overall Accuracy = 65.4%

Table 3. Age, weight, and length statistics for sockeye salmon smolt captured during spring 1978 at the Ugashik, Egegik, Naknek, Nuyakuk, and Igushik Rivers.

System	Dates	Age	Sample size	Fork length (mm)		Weight (g)	
				Average	Variance	Average	Variance
<u>Eastside</u>							
Ugashik	May 23, 24, 25	1	115	89.5	77.2	6.4	4.0
		2	244	115.4	48.1	13.7	3.5
Egegik	May 19, 20, 21, 22	1	43	103.6	20.8	10.1	1.6
		2	263	122.5	51.2	15.5	2.5
		3	15	130.1	46.8	18.5	6.5
Naknek	June 1	1	112	95.7	19.5	8.3	1.3 <sup>1/</sup>
		2	127	105.0	37.9	11.0	2.7 <sup>2/</sup>
<u>Westside</u>							
Nuyakuk	June 18, 19	1	285	75.5	20.8	4.3	.4 <sup>3/</sup>
		2	65	84.7	25.8	5.8	.9 <sup>4/</sup>
Igushik	June 17	1	339	69.8	62.1	3.1	.9 <sup>5/</sup>
		2	1	83.0	-	0.0	0.0 <sup>6/</sup>

- <sup>1/</sup> Weights based on a 69 fish subsample.  
<sup>2/</sup> Weights based on a 80 fish subsample.  
<sup>3/</sup> Weights based on a 50 fish subsample.  
<sup>4/</sup> Weights based on a 10 fish subsample.  
<sup>5/</sup> Weights based on a 49 fish subsample.  
<sup>6/</sup> No weight sample available.

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