



1977 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

Edited by:
Henry Yuen

1978

ADF&G TECHNICAL DATA REPORTS

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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.

1977 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

A summary of data collected from sockeye salmon
(Oncorhynchus nerka) smolt programs on the Kvichak,
Naknek, and Wood Rivers

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1978

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1977 KVICHAK RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

Studies to determine the age composition and relative magnitude of the sockeye salmon smolt (Oncorhynchus nerka) outmigration in the Kvichak River have been conducted annually since 1955. This information on smolt production is used for forecasting the age composition and magnitude of subsequent adult returns. Prior to 1973, only an index of the outmigration was determined using a 4 x 4 ft. fyke net. Although the index program has provided information on the dynamics of the smolt populations, it was not a reliable forecast tool. In 1965, attempts were begun to improve the index and to develop a sampling method that would provide a total outmigration estimate. Experiments were conducted utilizing underwater sonar equipment during 1969 (Parker 1974) and 1970 (Russell 1972). A new sonar site was selected for the 1973 season and the program has returned to this location through 1977 (Parker 1974). Figure 1 shows the sampling sites for the years 1971-72 and 1973-77. Although the program has remained in the same location for 5 years, significant changes were made in the design, installation, and operation of the sonar system beginning in 1976 (Randall 1977).

After more than 20 years of continuous operation, the outmigration index program was discontinued in 1977. The index site was retained, however, as the primary site for collection of smolt for age, weight and length data.

MATERIALS AND METHODS

Installation and operation of a sonar counting system was similar to that used in 1976 (Randall 1977). The system consists of three 10.5 ft. plastic ladder assemblies, or arrays, each of which is outfitted with 14

sonar transducers. Each transducer comes outfitted with 330 ft. of electronic cable. The transducers are attached to the arrays and their cables are gathered together into three separate bundles which are connected to a single control unit housed in a tent on the riverbank where the entire system is monitored (Figure 2). Each array is rigged with an independent anchoring system and, after being positioned in the river channel, is submerged to the bottom for actual operation.

The system functions as a biomass counter and is designed to register one count for the biomass equivalent to 10 smolt passing over the sonar gear. The system is monitored continuously 24 hours per day. Every 15 minutes counts are electronically totaled for each array and recorded on paper tape.

Total counts are multiplied by 10 fish per count to estimate numbers of smolt passing over the three arrays. No satisfactory technique for field calibration of the sonar gear has been developed thus far, therefore, the theoretical 10 fish/count expansion is used.

Since wind, rain, snow, boats, etc. can cause false counts on the system, the counts recorded by the control unit must be adjusted as needed. Known false counts are simply deducted from the printed counts. If false counts become continuous or occur simultaneously with true smolt counts, the entire system is disabled until the source of the false counts has passed. Counts during missed time are estimated by linear interpolation. The control unit will print out the number of seconds the system is disabled. Since there is a 0.2 to 7.8% error in the internal mechanical clock that records the disable time; an adjustment is made in the printed time.

Each array covers a section of the river approximately 12 ft. across. The counts from each array are expanded to estimate the number of smolts outmigrating in sections of the river not covered by the sonar gear. A sonar transducer aimed across the river was used to determine the horizontal distribution of the smolt. The equipment electronically divides the river into 12 equal segments and records the number of targets per segment. This year the river was 393 ft. wide. Sonar records indicated that 90 ft. on the west bank and 27 ft. on the east bank were not utilized by smolt. Figure 2 illustrates the position of the arrays in the remaining 276 ft. Expansion factors for the center and eastern sectors were calculated by dividing the length of the sector by 12 ft. The west (offshore) sector was divided into two sub-sectors. Counts for the western 40 ft. subsector were estimated to be equal to the counts on the offshore array and counts for the eastern 93 ft. subsector were estimated to be 40% of the counts on the offshore array (Figure 3 and Table 2).

The counting rate of the system is adjusted each season depending on river velocity. Water velocities are measured with a gurley meter over each array. Since the control unit is adjusted for the velocity of the center array, linear adjustments of the offshore and inshore counts are made for the differences in river velocity over these two arrays.

Due to rising river levels, adjustments of sonar counts had to be made of the accompanying changes in water velocities over the three arrays. The control unit was originally set for 5.02 fps on May 21 (average velocity over the center array on that date). Water velocity were measured again on June 14 with significant changes observed over all three arrays. Using June 2 as the midpoint of the sonar operation season, counts prior to this date were adjusted according to velocities on May 21 and the counts for the second half were adjusted relative to velocities measured on June 14. Average velocities ranged from 4.11 to 5.09, 5.02 to 5.20, and 5.18 to 5.30 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, expansion for unsonified areas, etc. is presented in Figure 3.

Samples from fyke net catches were used to determine mean lengths, weights and age composition of the outmigration. A standard 4 x 4 ft. fyke net was fished in about four ft. of water in approximately the same location as the index site of previous years. During each 5-day sample period throughout the season, 300 smolts were collected. Thirty smolt were collected at a time during 10 randomly selected hours in each 5-day sample period. Because smolt tend to outmigrate during the hours of darkness, more sampling was done at night. If no samples were collected during any sample hour, they were collected at the next sampling hour. At the end of the season, the smolt samples were pooled into 300 fish sample size instead of 5 day sample period. As a result there were four sample periods between 5 to 8 days each (see Table 3). Mean weights were estimated with a length-weight regression formula, $W = aL^b$, and corrected (Pieraar and Richer 1968). Estimated age composition of the total outmigration is weighed by the sample size of each of the four sample periods.

RESULTS

Climatological and Hydrological Observations

Weather and river conditions were recorded at the Barge Island field station from May 17 until June 14 (Table 1). Air temperatures were above average for this time of year. Although water temperatures in the lake were below average early in the season, a rapid warming trend was observed.

The average water temperature during the 29-day sampling period was 6.2° C. Due to a warm winter, Lake Iliamna had never received a complete cover of ice and when this program started, the lake was virtually ice-free. Warm air temperatures in May and June and a heavy accumulation of snow at higher elevations produced unusually high water levels in the river. The river began to rise on June 5 and by the end of sampling season had risen more than 0.5 ft.

Outmigration Estimate

The sonar counting system was in operation between May 20 and June 14 with only minor interruptions.

Timing of the outmigration in 1977 approximated "normal" for the first time in the past 3 years. Almost 66% of the total outmigration occurred between May 28 and June 7 with the peak falling on May 29-30 (Table 3). The total outmigration for the season was more than 215 million smolt. The majority of the outmigration were age 2 smolt from the 1974 escapement of 4.4 million spawners (Table 3). Total production of age 2 smolt appropriates 53 smolt per spawner and is much higher than that from 1969. Both 1969 and 1974 are comparable in that they immediately precede the peak year in the existing 5-year sockeye salmon production cycle of the Kvichak River system.

Production of Age 1 smolt from the 1975 peak year escapement of 13.1 million adults in 1975 amounted to over 82,000,000 smolt.

Age-Weight-Length

A total of 1,239 smolt were collected from this season's outmigration to determine age, weight and length. The estimated age composition of the total outmigration was 38.2% Age 1 and 61.8% Age 2 smolt (Table 3). The mean weight by age class was 5.5 g for Age 1 smolt (19 year average = 6.1) and 10.1 g for Age 2 smolt (20 year average = 11.3 g). The mean length by age class for the season was 86 mm for Age 1 smolt and 106 mm for Age 2 smolt. These compare with a 23 year mean of 89 mm and 110 mm for Age 1 and Age 2 smolt, respectively. The mean length of this year's Age 1 smolt is larger than the mean from other peak years. The mean length of Age 1 smolt from 1958, 1962, 1967 and 1972 is 83 mm.

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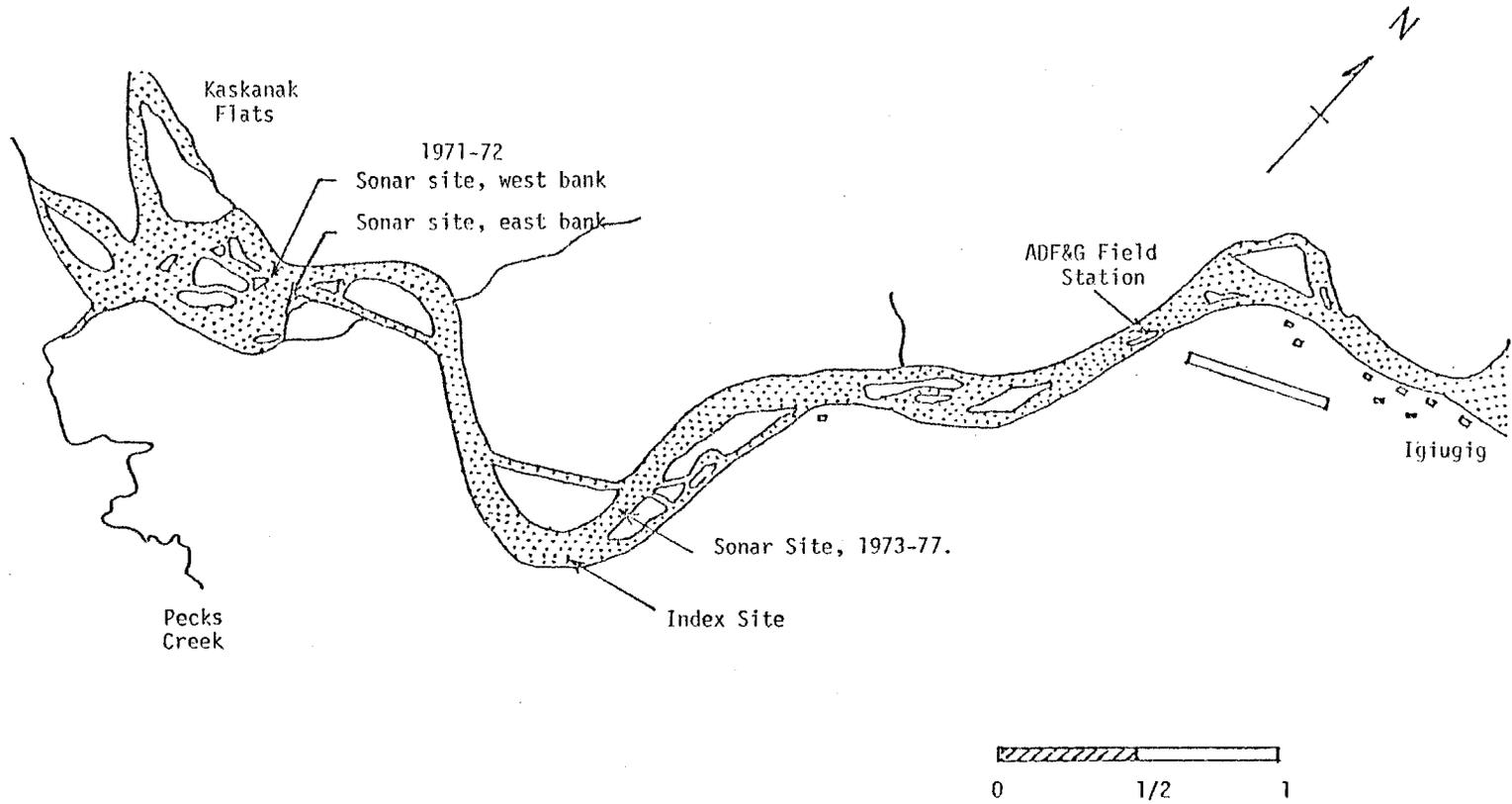


Figure 1. Kvichak River sampling sites, 1971-72 and 1973-77.

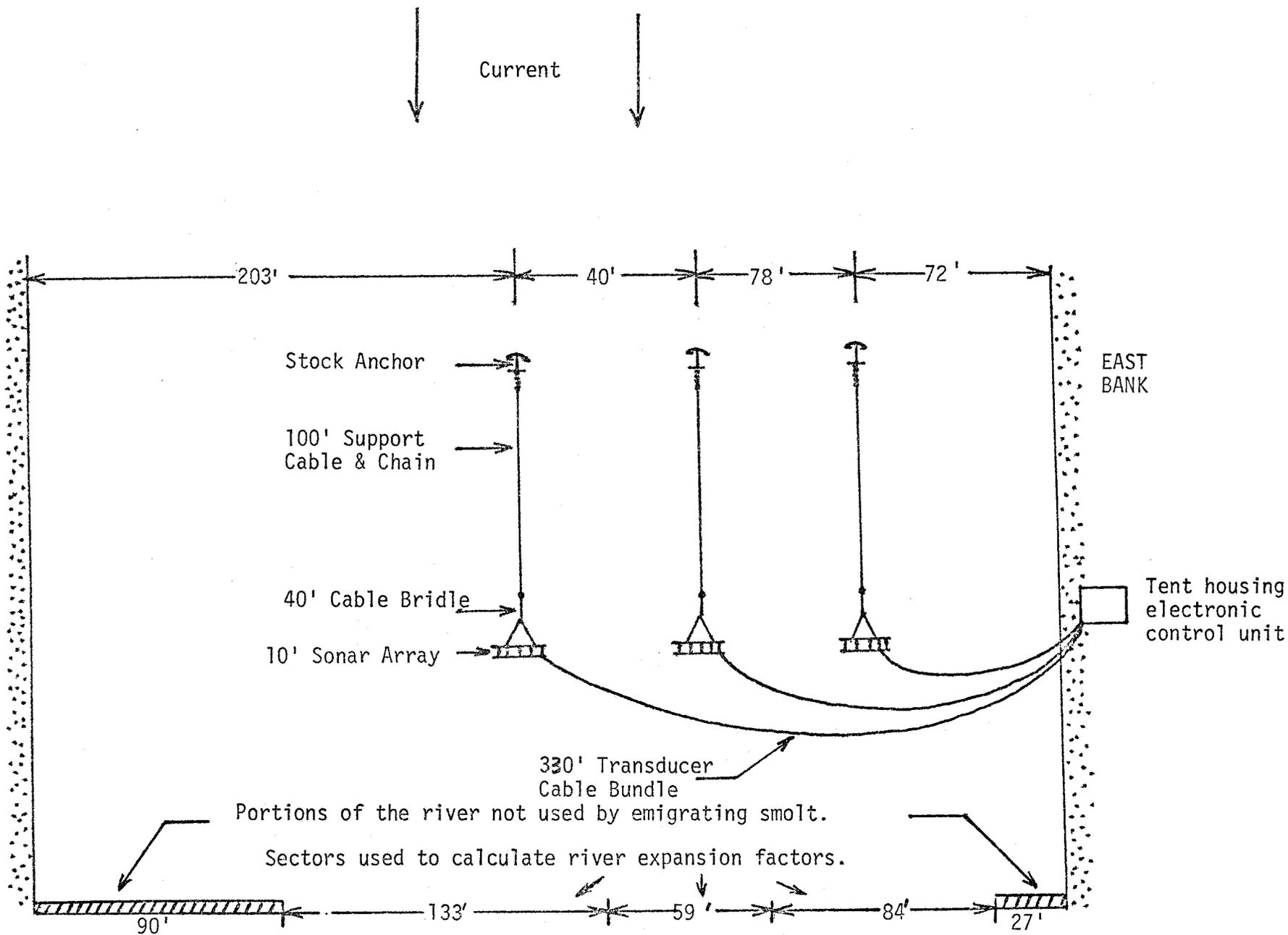


Figure 2. Sonar equipment placement in the Kvichak River, 1977.

Day's Outmigration (I + C + O) = 15,559,775

Hour	Adj. Page	Disable Time (Sec.)	Inshore				Center				Offshore			
			Actual	Adj. Log	Missed Time	Final Adj.	Actual	Adj. Log	Missed Time	Final Adj.	Actual	Adj. Log	Missed Time	Final Adj.
13	42	0	1510	0	0	1510	3632	0	0	3632	1018	0	0	1018
14		141	766	0	0	766	3074	0	141	3173	1271	0	141	1322
15		96	303	0	96	311	553	0	96	500	931	0	96	956
16		1202	14	5	1202	13	1053	14	1202	1554	501	15	1202	847
17		773	132	0	773	160	461	0	773	506	1140	0	773	1439
18		2303	345	0	2303	1007	171	0	2303	499	1204	0	2303	2002
19	43	1028	1471	0	1028	2053	2466	0	1028	3442	2004	0	1028	2495
20		33	2099	0	33	2110	3582	0	33	3615	3602	0	33	3635
21		202	5029	105	202	5193	5600	0	202	6024	2495	0	202	2642
22		236	5779	0	236	6395	10694	0	236	11431	7026	0	236	8221
23		0	3632	0	0	3632	10710	0	0	10710	6622	0	0	6622
24		0	3762	0	0	3762	6002	0	0	6002	1574	0	0	1574
1	44	0	11260	0	0	11260	12546	0	0	12546	1470	0	0	1470
2		0	14202	0	0	14202	12497	0	0	12497	1442	0	0	1442
3		0	3929	0	0	3929	10590	0	0	10590	1469	0	0	1469
4		0	3969	0	0	3969	15871	0	0	15871	3172	0	0	3172
5		0	2156	0	0	2156	6706	0	0	6706	3266	0	0	3266
6		0	405	0	0	405	4050	0	0	4050	6770	0	0	6770
7	45	0	1560	0	0	1560	1649	0	0	1649	3065	0	0	3065
8		102	306	0	102	315	2100	0	102	2242	1572	0	102	1617
9		0	2370	0	0	2370	1587	0	0	1587	2717	0	0	2717
10		0	2660	0	0	2660	1671	0	0	1671	2116	0	0	2666
11		0	3357	0	0	3357	1750	0	0	1750	2234	0	0	2234
12		0	3113	0	0	3113	1420	0	0	1420	3556	0	0	3556

	Total (i) =	76,271		Total (c) =	133,517		Total (o) =	69,649
Outmigration:	Total adjusted counts	x	velocity correction	x	fish/count	x	river expansion =	total
Inshore (I) :	76,271	x	.02		15	x	7.00	= 4,377,955
Center (C) :	133,517	x	1.00		10	x	4.92	= 6,531,086
Offshore (O) :	69,649	x	1.00		10	x	6.43	= 4,462,734

Figure 3. Sample of completed daily outmigration estimate.

1
8
1

Table 1. Climatological and stream observations, Kvichak River, May 17 - June 14, 1977.

Date	Sky		Wind Direction-Velocity (MPH)		Air Temp. °C		Water Temp. °C		Precipitation (inches) 24 hrs.	Water Level 1/ (ft.) 0800	Turbidity 0800
	0800	2000	0800	2000	Max.	Min.	Max.	Min.			
5/17	-	4	-	NE5	17	-	4.5	-	-	-	2
18	3	3	NE5	NE5	8	6	4.5	4.0	.43	-	2
19	4	2	S5	NE5	10	1	3.5	3.0	.02	-	1-2
20	3	2	NE5	calm	11	1	4.5	3.5	.02	-	1-2
21	5	1	calm	calm	14	-1	4.0	3.5	.01	-	1-2
22	2	3	SW10	S5	14	0	4.5	4.0	.00	.02	1
23	3	2	N5	NE10	13	2	6.5	4.5	.03	.04	1
24	3	2	NE5	calm	12	1	5.5	-	.33	.00	1
25	3	2	calm	SW15	16	0	5.5	5.0	.00	.02	1
26	4	3	S5	SW5	9	1	5.0	-	.00	-.04	1
27	3	3	S5	NE5	14	-2	6.0	4.5	.00	.01	1
28	3	1	NE5	calm	18	2	6.0	5.5	.00	-.06	1
29	3	4	SW5	NE5	15	3	5.5	-	.00	.04	1
30	4	3	SW5	calm	16	4	6.0	5.5	.09	.00	1
31	2	2	SW5	W5	18	5	6.5	6.0	.02	-.04	1
6/1	1	2	S10	NW5	24	4	7.0	6.5	.06	-.02	1
2	2	3	S10	NW5	25	5	8.0	7.0	.00	-.05	1
3	2	1	S20	S20	18	3	7.5	7.0	.00	-.20	1
4	2	3	S20	S20	19	2	7.0	6.5	.00	-.12	1
5	4	4	S15	calm	11	4	7.0	6.5	.00	.01	1
6	4	4	calm	calm	15	4	7.0	6.5	.00	.13	1
7	4	4	calm	NE10	15	4	7.0	6.5	.00	.21	1
8	4	4	NE15	NE10	12	8	7.5	7.0	.17	.27	5
9	4	4	calm	NE5	13	8	7.5	7.0	.21	.26	5
10	3	3	NE10	NE15	18	7	9.0	7.5	.10	.28	5
11	4	4	NE15	NE10	16	8	8.5	8.0	.01	.35	5
12	5	4	NE5	S10	16	8	8.5	8.0	.35	.34	1
13	4	1	SW5	NE10	20	7	9.5	8.0	.25	.42	1
14	1	1	NE10	NE15	20	4	9.5	8.5	.01	-	1

1/ Denotes water level above that of base level set on 5/20/77.

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 2. Kvichak River daily sockeye salmon smolt counts by array, 1977. 1/

Date (1200-1200)	Inshore Array	Center Array	Offshore Array	Total
5/20-21	122	4,583	2,713	7,418
21-22	268	6,432	4,935	11,635
22-23	971	9,638	6,579	17,188
23-24	122,844	63,574	39,528	225,946
24-25	42,626	38,204	19,077	99,907
25-26	17,227	40,559	25,002	82,788
26-27	26,727	51,820	29,085	107,632
27-28	16,205	77,080	54,065	147,350
28-29	73,856	200,155	98,096	372,107
29-30	77,583	292,299	128,464	498,346
30-31	31,013	54,885	35,057	120,955
5/31-6/1	76,271	133,517	69,649	279,437
1-2	123,859	130,016	76,652	330,527
2-3	80,300	88,311	52,134	220,745
3-4	27,409	42,184	25,521	95,114
4-5	16,311	90,825	61,683	168,819
5-6	21,782	85,728	63,997	171,507
6-7	30,006	126,348	58,233	214,587
7-8	10,494	50,257	39,859	100,610
8-9	17,576	29,332	21,574	68,482
9-10	25,748	39,700	31,178	96,626
10-11	29,802	51,261	45,057	126,120
11-12	19,649	41,393	33,765	94,807
12-13	1,220	17,069	27,303	45,592
13-14	1,398	16,538	24,370	42,306
Total	891,267	1,781,708	1,073,576	3,746,551
Percent of total	23.8	47.6	28.6	

1/ Counts include interpolations for missed time, expansions for unsonified areas between arrays and adjustments for water velocity differences. (from Figure 3).

Table 3. Kvichak River sockeye salmon smolt outmigration by day and age class, 1977.

Date (1200-1200)	Age 1 Smolt		Age 2 Smolt		Total Outmigration	
	Number	Percent	Number	Percent	Number	Percent
5/20-21	26,379	6.4	385,787	93.6	412,166	0.2
21-22	42,155	6.4	616,522	93.6	658,677	0.3
22-23	61,801	6.4	903,845	93.6	965,646	0.4
23-24	819,007	6.4	11,977,980	93.6	12,796,987	6.0
24-25	357,748	6.4	5,232,072	93.6	5,589,820	2.6
25-26	296,972	6.4	4,343,218	93.6	4,640,190	2.2
26-27	1,676,774	27.9	4,333,170	72.1	6,009,944	2.8
27-28	2,059,718	27.9	5,322,783	72.1	7,382,501	3.4
28-29	5,742,869	27.9	14,840,891	72.1	20,583,760	9.6
29-30	7,628,534	27.9	19,713,883	72.1	27,342,417	12.7
30-31	1,897,836	27.9	4,904,442	72.1	6,802,278	3.2
5/31-6/1	5,337,003	34.3	10,222,772	65.7	15,559,775	7.2
1-2	6,373,927	34.3	12,208,952	65.7	18,582,879	8.6
2-3	4,715,995	34.3	9,033,261	65.7	13,749,256	6.4
3-4	2,001,661	34.3	3,834,086	65.7	5,835,747	2.7
4-5	3,431,616	34.3	6,573,096	65.7	10,004,712	4.7
5-6	3,528,930	34.3	6,759,495	65.7	10,288,425	4.8
6-7	9,479,359	75.5	3,076,084	24.5	12,555,443	5.8
7-8	4,552,790	75.5	1,477,396	24.5	6,030,186	2.8
8-9	3,181,513	75.5	1,032,411	24.5	4,213,924	2.0
9-10	4,512,472	75.5	1,464,312	24.5	5,976,784	2.8
10-11	5,889,694	75.5	1,911,225	24.5	7,800,919	3.6
11-12	4,385,445	75.5	1,423,091	24.5	5,808,536	2.7
12-13	2,129,522	75.5	691,037	24.5	2,820,559	1.3
13-14	1,967,579	75.5	638,486	24.5	2,606,065	1.2
Total	82,097,299	38.2	132,920,297	61.8	215,017,596	100.0

1977 NAKNEK RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

This was the twenty-second year that the Naknek River sockeye salmon (Oncorhynchus nerka) smolt study has been conducted. There were two objectives in this years program: to obtain an estimate of the magnitude and age composition of the sockeye salmon smolt outmigration in the Naknek River and to prepare for the transition from fyke net sampling to sonar counting. This second objective includes site selection for the sonar gear and feasibility tests for use of the 1972 model Bendix sonar smolt counters (which were designed for the Kvichak River).

MATERIALS AND METHODS

A standard 4 x 4 ft. fyke net was fished during the 1977 season. The net was attached to a cable stretched across the river bottom at a location approximately 8-3/4 miles below the outlet of Naknek Lake.

In 1957 and 1958, the entire river was sampled to determine the most productive sites. Data obtained from this effort indicated that 88% of the outmigration passed within the six sample sites used until 1976. The most productive individual site (no. 4) had been used as an index site (McCurdy 1972) and in 1977 this was the only site fished.

The index net was fished daily between 2200 and 0400 hours with an average of 4.8 hours of active fishing time per day. There were daily age-length-weight sampling through June 10, after which, samples were collected every other night. Sample periods were reorganized into 300 smolts per sample period.

The 1972 model Bendix smolt counter (Parker 1974) was installed upstream of the traditional smolt site (Figure 1).

RESULTS

Outmigration Estimates

The sample schedule was initiated on May 20 and terminated June 23. During this period 60,349 smolt were captured. A peak in the outmigration occurred between June 24 and June 30 (Figure 1).

The magnitude of the 1977 outmigration is estimated to be between 2.06 and 4.42 million with a point estimate of 3,223,885 smolt. This estimate was obtained first by converting the 1977 catch data into units comparable to past year's data (steps 1-4 below) before calculating for outmigration as in past years.

1. Convert 1977 daily catches (Table 4) to "catch/90 minutes."
2. Calculate the 1977 seasonal outmigration trend of "catch/90 minutes" using polynomial regression analysis (Figure 3) and interpolate from the outmigration curve the "catch/90 minutes" for the 8 days when no catch data were available.
3. Tally the 1977 daily "catch/90 minutes" to obtain estimated "total random catches" of 17,737 smolts from site 4.
4. Correlate "total random catches" from site 4 with the "total season catch" using data from 1966 through 1976 (Figure 4). The 1968 data were not included since it was outside one standard error of the mean. Using the estimated 1977 "total random catch" of 17,737, the estimated 1977 "total season catch" would be 58,564 (S.E. = 21,755) from the above linear regression analysis. The remaining calculations using the "total seasonal catch" follow Van Valin (1969).
5. Calculate the seasonal average random catch per 90 minute set:

Total season catch = 58,564

Number of sites fished = 6

Number of sampling days fished during the season = 35

Therefore, the seasonal average catch per 90 minute set is derived by $58,564 / (6 \times 35) = 279$

6. Estimate the average migration past the sampled section of the river during a 90 minute period within a sampling period.

Average catch per 90-minute period = 279

Number of sites fished = 6

Number of sites for which the migration is estimated from the catch at each fishing site = 6

Therefore the estimated average migration past the sampled section of the river during a 90-minute period within a sampling period is derived by:

$$279 \times 6 \times 6 = 10,044$$

7. Estimate the average migration past the sampled section of the river per sampling period.

Number of 90-minute periods within a sampling period = 6

Therefore, the estimated average migration past the sampled section of the river per sampling period is derived by:

$$10,044 \times 6 = 60,264$$

8. Estimate the average migration past the entire width of the river at the sampling location per sampling period. Estimated proportion of migration occurring within the section of the river presently sampled = 88.34 percent.

Therefore, the estimated average migration past the entire width of the river at the sampling location per sampling period is derived by:

$$60,264 / .8834 = 68,218$$

9. Estimate the average daily migration past the sampling location. Mean proportion of daily migration occurring during the sampling period = 74.06%, derived by adding the percentage of the total season's index catch for the hours 2100-0600, for years 1966 through 1975, except for 1968.

Therefore, the estimated average daily outmigration past the sampling location is derived by:

$$68,218 / .7406 = 92,111$$

10. Estimate the total seasonal migration past the sampling location.

$$\text{Number of days fished} = 35$$

Therefore, the estimated total seasonal migration past the sampling location is derived by:

$$92,111 \times 35 = 2,223,885$$

With a standard error of 21,755 in the estimated total season catch, the estimated total seasonal migration could be anywhere between 2,056,840 and 4,425,674 smolt.

Age-Weight-Length

The age composition of the outmigration estimate was 10.2% Age I smolt (328,836) and 89.8% Age II smolt (3,895,048). No Age III smolt were observed. Table 1 gives the age composition by date.

A total of 1,178 smolt were sampled to estimate lengths and weights by age class (Tables 2 and 3). Age I smolt averaged 91.6 mm in length (22-year average = 100.1 mm) and 7.2 g. in weight (22-year average = 9.2 g.). Age II smolt averaged 112.9 mm in length (22-year average = 112.7 mm) and 11.9 g. in weight (22-year average = 12.6 g.).

Sonar Counts

Sonar counts from 1977 are presented in Table 4 and Figure 1. The insensitivity of the equipment which was designed for the Kvichak River, prevented the gear from adequately counting smolt in the Naknek River.

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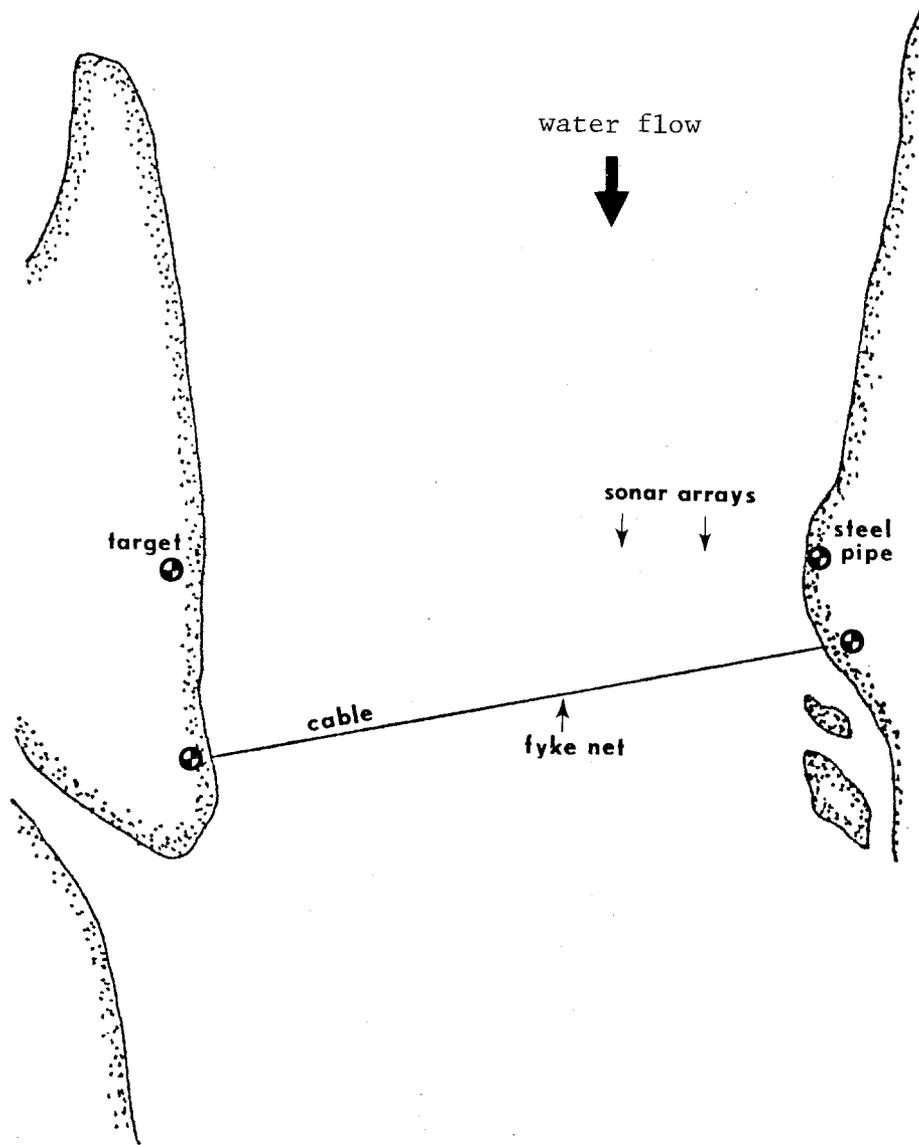


Figure 1. Sonar arrays and fyke net placement in the Naknek River, 1977. Sonar arrays were initially 107 and 202 ft. from the steel pipe on the east shore, in line with target on opposite shore. On June 7, the arrays were moved to 122 and 205 ft. from the east shore, where the stream bottom was more level. The fyke net was 240 feet from the east shore the entire season.

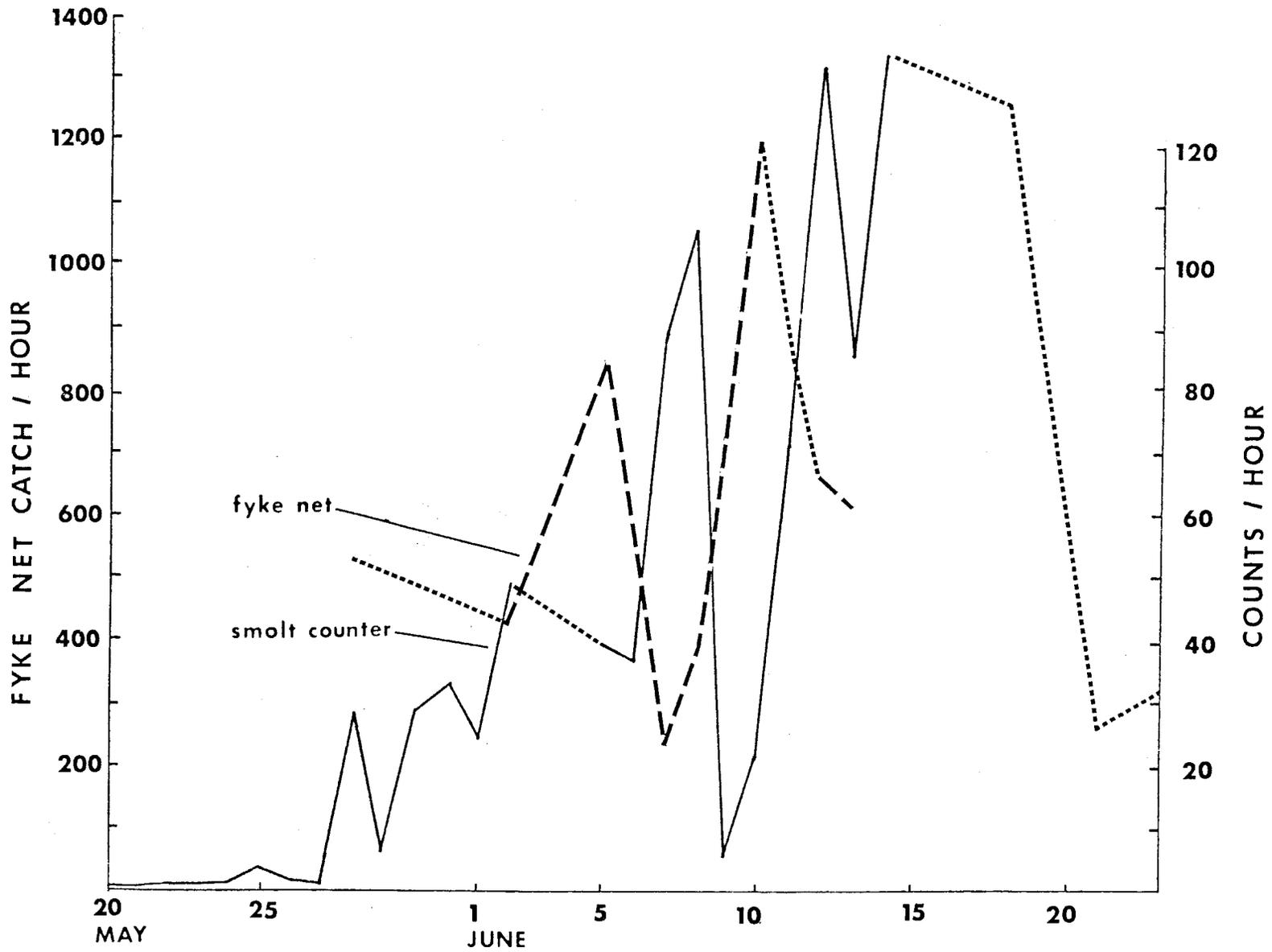


Figure 2. Fyke net catches and sonar counts of outmigrating sockeye salmon smolt, Naknek River, 1977.

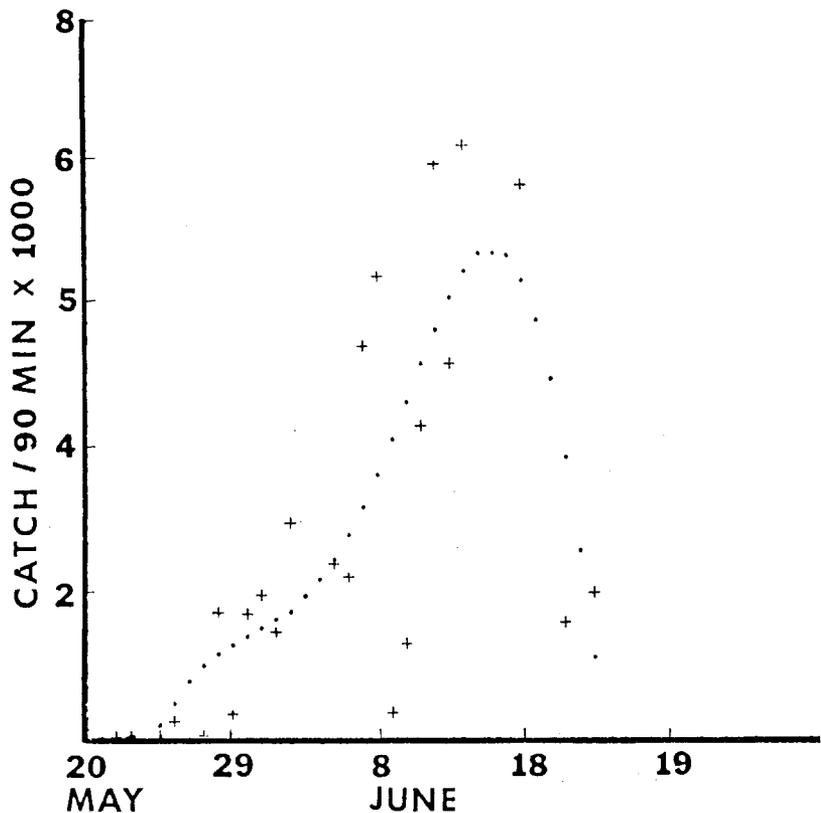


Figure 3. Sockeye salmon smolt outmigration trend of daily "catch/90 minutes", Naknek River, 1977. $y = 2364.04 - 1911.41x + 486.61x^2 + 51.31x^3 + 2.65x^4 - .06x^5 + .001x^6$

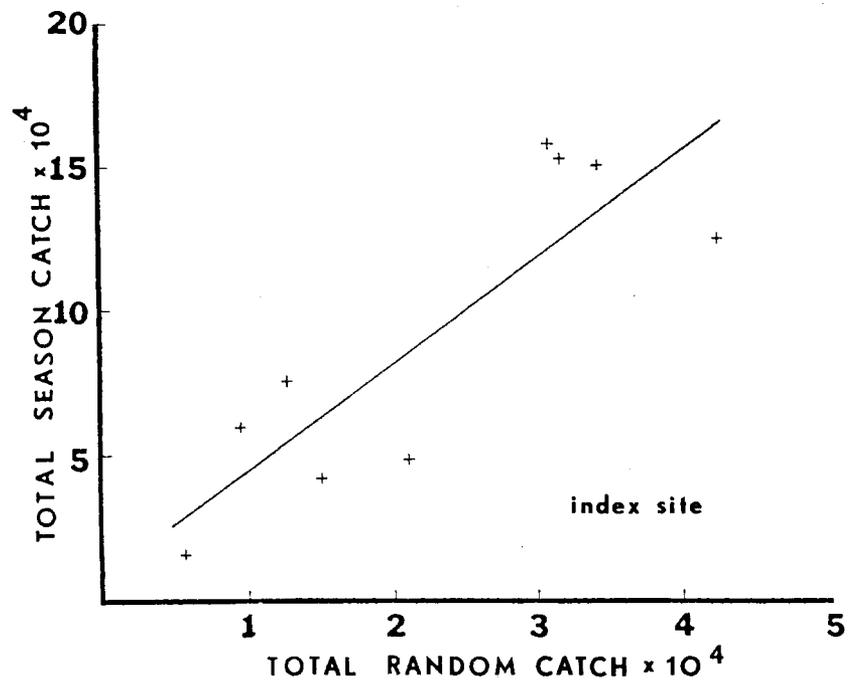


Figure 4. Correlation of total season fyke net catch of sockeye salmon smolts with total index site fyke net catch, Naknek, 1966 through 1976. $y = 2.91 + 6784.43x$. $r^2 = .85$

Table 1. Estimated smolt outmigration by age class and sample period, Naknek River, 1977.

Date	Age I		Age II		Total
	n	%	n	%	
May 20-May 24	535	4.7	10,841	95.3	11,376
May 25-May 29	13,280	8.7	139,373	91.3	152,654
May 31-June 7	96,992	8.3	1,071,584	91.7	1,168,576
June 8-June 12	193,015	14.8	1,111,139	85.2	1,304,154
June 13-June 23	166,648	10.5	1,420,476	89.5	4,223,884
Totals	470,470	11.1	3,753,413	88.9	4,223,884

Table 2. Sample size, mean weight (g) and variance of sockeye salmon smolt by age class and sample period, Naknek River, 1977.

Period	Age I			Age II		
	n	\bar{x}	s^2	n	\bar{x}	s^2
May 20-May 24	4	9.15	1.68	82	11.98	2.87
May 25-May 29	22	8.11	3.16	230	12.55	12.58
May 31-June 7	25	6.99	1.40	275	11.56	2.15
June 8-June 12	44	6.96	1.03	256	11.86	3.61
June 13-June 23	25	6.74	0.90	215	11.72	2.96
Totals	120	7.20		1058	11.87	

Table 3. Sample size, mean length (mm) and variance of sockeye salmon smolt by age class and sample period, Naknek River, 1977.

Period	Age I			Age II		
	n	\bar{x}	s^2	n	\bar{x}	s^2
May 20-May 24	4	99.75	32.26	82	113.05	84.09
May 25-May 29	22	92.95	69.89	230	118.29	93.08
May 7-June 7	25	91.84	37.33	275	114.01	61.84
June 8-June 12	44	91.59	18.40	256	111.00	112.57
June 13-June 23	25	88.60	19.45	215	108.00	102.01
Totals	120	91.55		1058	112.92	

Table 4. Index net catches and sonar counts sockeye salmon, Naknek River, 1977.

Date	Fyke Net Catches			Sonar Counts		
	Total Catch	Hours Fished	Catch/90 min.	Total Counts	Hours Counted	Counts/hr.
May 20	2	2	1.5			
21	5	2	3.8			
22	30	3.17	14.2			
23	25	4	9.4			
24	40	4	15.0			
25	145	4	54.4			
26	59	4	22.1			
27	15	4.5	5.0			
28	1,577	5.5	430.1	315	6	52.5
29	284	5.5	77.5			
30	1,418	5.0	425.4			
31	1,801	5.5	491.2			
June 1	1,337	5.5	364.6			
2	2,461	5.0	738.3	217	5.0	43.4
5	1,987	5.0	596.1	762	9.0	84.67
6	2,031	5.5	553.9	337	6.0	56.17
7	6,254	7.0	1340.1	116	5.0	23.20
8	6,326	6.0	1581.5	158	4.0	39.50
9	277	5.0	83.1	444	6.0	74.0
10	1,078	5.0	323.4	601	5.0	120.2
11	3,906	5.5	1065.3			
12	7,258	5.5	1979.5	398	6.0	66.33
13	4,280	5.0	1284.0	310	5.0	62.0
14	7,497	5.5	2044.6			
18	7,603	6.0	1900.8			
21	1,326	5.0	397.8			
23	1,327	4.0	497.6			

1977 WOOD RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

The Wood River Smolt Project was initiated in 1951 to obtain an abundance index of the 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 returns was extremely variable and of little value in forecasting the magnitude of future runs.

A more representative smolt outmigration estimate was needed for forecasting adult returns and evaluating the potential of various management options. Sonar smolt enumeration equipment, therefore, was purchased, and a program was initiated in 1975 to estimate total smolt outmigration. This project was continued in 1977 with the same objectives of estimating number, size, and age composition of the smolt emigrating from the Wood River system.

The outmigration estimates obtained in 1975 and 1976 (Krasnowski 1977) with the sonar gear were still an index of the numbers of smolt passing down the river. The sonar equipment is designed to count at a rate of five smolt per count (Krasnowski 1976) and, through an oversight, the counts were not multiplied by this factor. If the factor had been used, the resulting outmigration estimates would have been increased five-fold. Such estimates would be very high and possibly unrealistic. Therefore until a method of calibrating the sonar equipment, (i.e., determining how many fish a count actually represents) is developed the factor of five will not be used. The estimated daily counts over the sonar arrays will be expanded to estimate for the entire width of the river and for the time the equipment was not operated. These expanded counts will be used as an index of the total outmigration of smolt during the period sampled.

METHODS AND MATERIALS

The same four transducer arrays and electronic control unit were used in 1977 as in 1976 (Krasnowski 1976 & 1977). An attempt was made to place the arrays in the same locations as 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 a distance of 131 feet from the south bank.

With a few minor changes, the sampling design and data collection procedures were the same as described by Krasnowski (1977). The arrays were installed in the river on May 29 and the counter was operated intermittently at night until June 10 when the last ice flowed down the river. The random daily counting schedule was then started on June 10-11 and continued until August 7-8. The sonar gear was operated 75 hours (25 randomly selected 3 hour blocks) per 5-day sample period. Array I was operated during all the 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.

River velocity was measured with a pygmy gurdy meter on 46 occasions during the season. Because the river depth was unusually high, the measurements could not be taken at the standard location, behind Array I, established in 1975. The measurements were taken at three specified locations and comparative readings were taken behind Array I and the other three arrays when possible.

Lake depth at the 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 on the sonar counter. Daily air and water temperatures were also recorded at the ADF&G cabin.

The velocity model used in 1976 to estimate hourly velocity factors for adjusting the hourly sonar counts (Krasnowski 1977) could not be applied to the 1977 velocity data. Although the daily mean river depth and daily mean lake depth relationship in 1977 was similar to that found in 1976, the river velocity data were so variable that the model did not fit. There was also no direct relationship among the velocity measurements over the individual arrays. A correction factor to adjust the hourly counts for each array was calculated from the average velocity across the river per 5-day period divided by the 4.5 feet per second velocity setting on the counter.

Hourly counts from each of the four arrays were adjusted by the velocity correction factor. The sum of the adjusted hourly counts (referred

to as corrected counts in 1977) was expanded in proportion to the river not sonified by the arrays, giving hourly expanded counts. Expanded counts for hours when the gear was not operated were obtained by linear interpolation. Hourly expanded counts and interpolated expanded counts were summed by sample day (noon to noon) to give daily total expanded counts, which is an index of the total daily outmigration.

Approximately 300 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. Because of difficulties experienced in 1976 in obtaining adequate samples using a sampling scheme with times selected randomly throughout the day, a revised sampling scheme with times selected randomly from 2100 to 0300 each night was used in 1977. The sampling goal was 60 fish per night although on some nights more fish were sampled than on other nights to yield the 300 smolt needed per 5-day sample period. During the sample period, June 30 to July 5, adequate samples could not be obtained even though sampling effort was increased every night of the sample period.

Fork lengths and scale samples were taken from each smolt. Weights were taken from approximately 30% of the smolt. The mean lengths and variances for the seasons were calculated using a formula for stratified samples (Cochran 1963). Mean Age I smolt weights for each sample period were calculated, using a formula which results in an unbiased estimate of mean weight from the mean length and variance, the length-weight relationship, and correction factors (Pienaar and Ricker 1968). There were not enough Age II smolt weights in each sample period to calculate mean weights by sample period. Instead, a seasonal mean weight was calculated, using Pienaar and Ricker's equation, from the mean length for the season and a length-weight relationship based on all Age II smolts weighed.

RESULTS

Climatological and Hydrological Observations

Daily water and air temperatures at the ADF&G cabin during the smolt outmigration are presented in Table 1. The maximum and minimum seasonal water temperatures were 15.5°C (July 20) and 4.5°C (June 9). The maximum and minimum air temperatures were 30°C (June 17 and June 30) and 0°C (July 3).

Table 2 lists the mean river velocity (over all arrays), river and lake depth gauge measurements for 1976 and 1977. More fluctuations in the fixed depth gauge measurements were observed during 1977 than in 1976 (ADF&G

unpublished data). Depth gauge measurements were also 3.12 ft higher in the lake and 2.11 ft higher in the river during 1977. Nevertheless, a close correlation between daily lake and daily river depth gauge measurements was observed in both years.

Age-Weight-Length

Table 3 lists the mean lengths for Age I and II smolt by sample period. The weighted mean lengths for the season of Age I and Age II smolt were 70.48 and 98.06 mm respectively. Mean weights for Age I smolt by sample period are listed in Table 4. The seasonal mean weights for Age I and Age II smolt were 3.45 and 9.30 g respectively.

Total Expanded Counts (Outmigration Index)

The total expanded counts for 1977 were 14,659,792 (Table 5). Age I smolt comprised 82.9% (12,149,484 expanded counts) of the outmigration. Age II smolt comprised 17.1% (2,510,308 expanded counts) with the majority of the Age II smolt (87%) emigrating during the early part of the season (June 10-25). Total expanded counts by day are plotted in Figure 1. The outmigration peaked earlier in 1977 than in 1976 (Krasnowski 1977), June 20-21 and July 15-16 respectively.

The emigrating smolts distributed themselves more evenly over the four sonar arrays in 1977 than in 1976, but, the majority of the total adjusted (for river velocity only) counts were still recorded by Array I. Of a total of 1,877,732 adjusted counts in 1977, 36% were recorded by Array I, 24.37% by Array II, 20.83% by Array III, and 18.8% by Array IV.

Table 6 summarizes the sonar outmigration indices (seasonal total expanded counts) for all the years this program was operated. Table 7 relates these smolt outmigration indices to the brood year escapements. The two brood year escapements, 1972 and 1973, from which both Age I and II smolt have been indexed, produced 19.8 and 13.3 total expanded counts per spawner, respectively.

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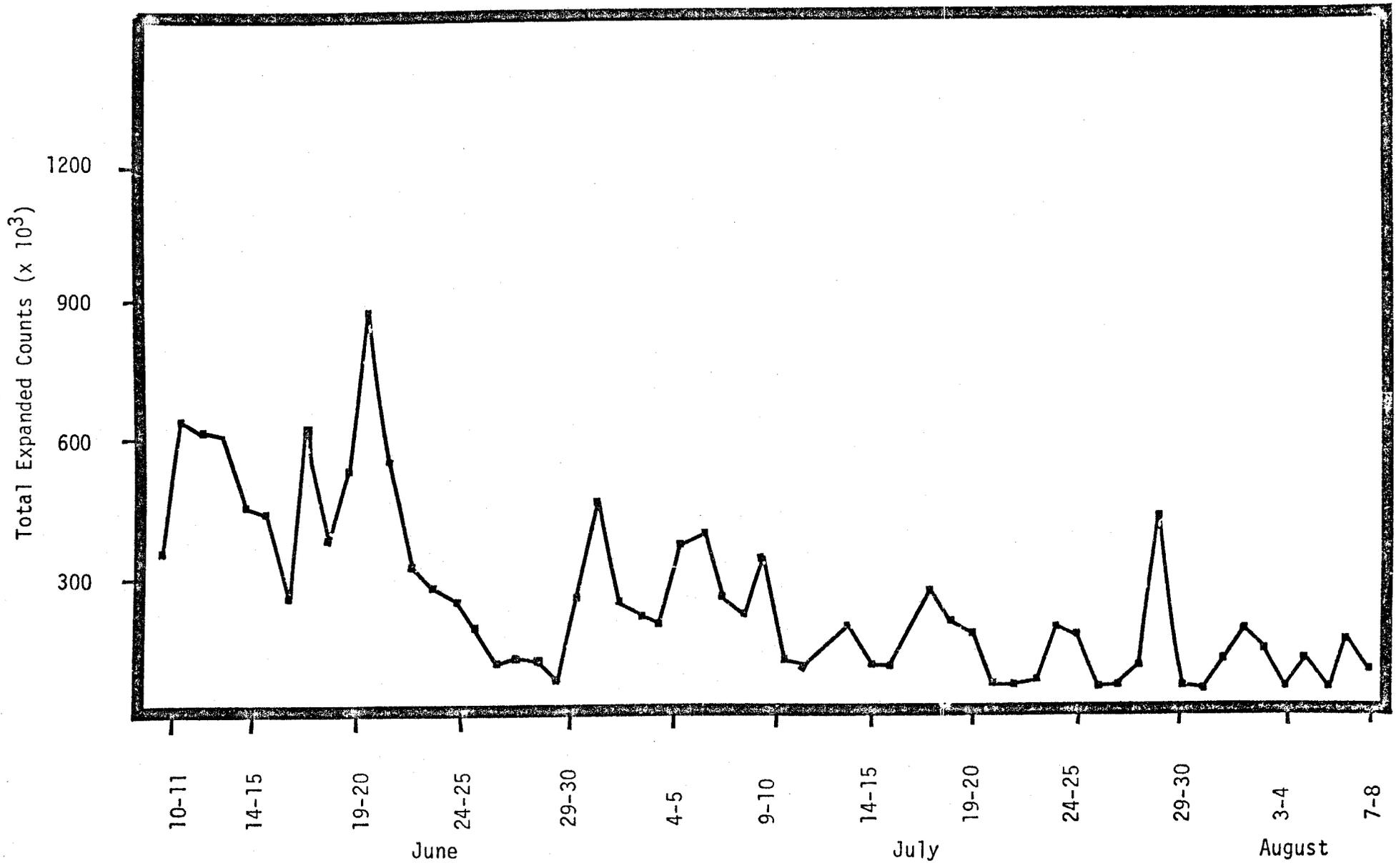


Figure 1. Daily total expanded counts of sockeye salmon smolt, Wood River, 1977.

Table 1. Water and air temperatures, ADF&G cabin, Wood River, 1977.

Date	Water Temp. (°C)	Air Temp. (°C)		Date	Water Temp. (°C)	Air Temp. (°C)	
		Max.	Min.			Max.	Min.
6/9	4.5	12	8	7/9	7.5	20	10
6/10	5	15	7	7/10	9.5	22	11
6/11	5	15	8	7/11	10	23	4
6/12	5	12	11	7/12	9	18	9
6/13	5.5	22	6	7/13	10	20	4
6/14	6	24	1.5	7/14	9	18	1
6/15	6	19	9	7/15	11	23	8
6/16	5.5	21	10	7/16	10.5	22	5
6/17	5	18	8	7/17	10	26	7
6/18	6	30	12	7/18	11	27	4
6/19	6	21	7.5	7/19	14	27	7
6/20	7	22	4	7/20	15.5	27	6
6/21	7	28	4	7/21	14	20	9
6/22	6	26	10	7/22	13	26	10
6/23	6.5	21	8	7/23	12	23	7
6/24	8	26	6	7/24	10	18	16
6/25	8	22	7	7/25	11	19	10
6/26	6.5	23	9	7/26	9	14	10
6/27	7	29	10	7/27	7	14	15
6/28	7	29	5	7/28	9	11	17
6/29	6	28	7	7/29	11	17	12
6/30	7	30	7	7/30	11	19	12
7/1	11	26	8	7/31	12	18	9
7/2	11	23	4	8/1	11	23	10
7/3	11	22	0	8/2	11	17	12
7/4	11.5	24	5	8/3	11	17	12
7/5	9.5	14	9	8/4	10.5	19	8
7/6	8	17	10	8/5	10	18	10
7/7	6.5	18	10	8/6	10	18	11
7/8	6.5	18	11	8/7	11	17	11
				8/8	12	16	12

Table 2. Seasonal sample sizes, means and variances of velocity, river and lake depth gauge measurements in 1976 and 1977, Wood River.

Year	River Velocity (fps)			Depth gauge measurements (ft)					
				River			Lake		
	n	\bar{x}	s^2	n	\bar{x}	s^2	n	\bar{x}	s^2
1976	28	4.55	0.16	60	8.12	1.68	60	1.87	0.68
1977	37	4.81	1.28	58	10.23	2.95	59	4.99	1.62

Table 3. Sample sizes, mean lengths (mm), and variances for Age I and Age II sockeye salmon smolt by sample period, Wood River, 1977.

Sample Period	Age I			Age II		
	n	\bar{x}	s^2	n	\bar{x}	s^2
June 10-15	183	64.21	74.3	106	96.41	92.2
June 15-20	203	71.41	115.8	94	99.47	120.3
June 20-25	234	70.40	94.7	65	98.08	80.6
June 25-30	249	63.63	23.8	6	95.00	39.2
June 30-July 5	19	65.63	38.1	0	-	-
July 5-10	281	67.70	72.4	14	97.93	34.3
July 10-15	288	74.05	70.1	24	99.38	109.0
July 15-20	255	77.87	79.7	20	98.60	57.0
July 20-25	292	73.45	85.2	14	99.21	37.5
July 25-30	256	70.31	76.0	2	112.00	71.9
July 30-August 4	271	81.18	102.6	12	109.08	32.9
August 4-8	280	88.28	70.9	16	105.50	52.9
Season total	2811	70.48 ^{1/}	0.06	373	98.06 ^{1/}	0.30

^{1/} The mean lengths used in calculating the season totals are weighted by the total expanded counts for each sample period (Table 5).

Table 4. Sample period and seasonal total mean weights (g) for Age I sockeye salmon smolt, Wood River, 1977. 1/

Sample Period	Mean Weight (g)
June 10-15	2.25
June 15-20	3.09
June 20-25	3.40
June 25-30	2.20
June 30-July 5	2.55
July 5-10	3.23
July 10-15	3.87
July 15-20	4.39
July 20-25	4.46
July 25-30	3.89
July 30-August 4	6.02
August 4-8	6.94
Season Total	3.45 <u>2/</u>

1/ Sample sizes for the Age II smolt were too small to calculate length-weight relationships by sample period. Seasonal total mean weights for Age II smolt was 9.30 g.

2/ The season total mean weight is derived by weighting each sample periods mean weight by the total expanded counts for that period (Table 5).

Table 5. Total expanded counts of sockeye salmon smolt by age class and sample period, Wood River, 1977.

Sample Period	AGE I		AGE II		Total
	No.	%	No.	%	
June 10-15	1,700,286	63.3	985,790	36.7	2,686,076
June 15-20	1,520,159	68.4	702,296	31.6	2,222,455
June 20-25	1,744,656	78.3	483,513	21.7	2,228,169
June 25-30	608,835	97.6	14,971	2.4	623,806
June 30-July 5 ^{1/}	1,319,338	96.5	47,852	3.5	1,367,190
July 5-10	1,424,530	95.3	70,255	4.7	1,494,785
July 10-15	665,416	92.3	55,511	7.7	720,927
July 15-20	864,754	92.7	68,098	7.3	932,852
July 20-25	559,948	95.4	27,000	4.6	586,948
July 25-30	756,462	99.2	6,100	0.8	762,562
July 30-Aug. 4	552,033	95.8	24,202	4.2	576,235
August 4-8	433,067	94.6	24,720	5.4	457,787
Total	12,149,484	82.9	2,510,308	17.1	14,659,792

^{1/} The sample size for this period was too small to determine the age composition. An average of the percentages from the preceding and following sample periods was used.

Table 6. Summary of Wood River total expanded smolt counts by age class, 1975, 1976 and 1977 (Number of Counts x 10⁶).

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

Table 7. Summary of Wood River total expanded smolt counts from brood year escapements. (Number of counts x 10⁶).

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	-	-

EDITOR'S NOTE:

During 1977, migrating smolt were also sampled at the Ugashik, Egegik, Nuyakuk and Igushik Rivers to obtain smolt scale samples from the major sockeye salmon producing systems in Bristol Bay that did not have a smolt enumeration project. These scale samples were to be 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.

A single 4 by 5 ft. standard winged fyke net was fished in the Ugashik River during the evenings of May 21,22, and 23. A single collapsible 4 by 4 ft. winged fyke net was fished in the Egegik and Nuyakuk Rivers. Fishing took place during the evenings of May 27,28 and 29 in the Egegik River, whereas, the Nuyakuk River was fished during the evenings of June 18,19 and 21. The Igushik River was sampled during the evening with a 100 ft. long beach seine periodically from June 3 through June 25. Captured smolt in all cases were measured for fork length, weighed to the nearest 0.1 gram, and sampled for scales.

Age, sample size, length and weight data from the smolts sampled are:

River System	Age	Sample Size	Fork length (mm)		Weight (g)	
			Average	Range	Average	Range
Ugashik	1	346	92.33	72-105	7.98	3.8-18.6
Ugashik	2	216	111.86	89-132	15.22	6.0-26.9
Egegik	1	11	110.00	90-123	11.31	8.4-15.6
Egegik	2	238	115.50	102-136	13.25	8.6-22.5
Nuyakuk	1	240	69.32	51-78	2.73	1.3-4.6
Nuyakuk	2	47	69.89	64-79	3.68	2.7-5.0
Igushik	1	333	67.59	54-90	4.29	1.2-7.3
Igushik	2	25	86.2	73-109	6.28	3.3-11.8

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