Informational Leaflet 138

1968 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

By:

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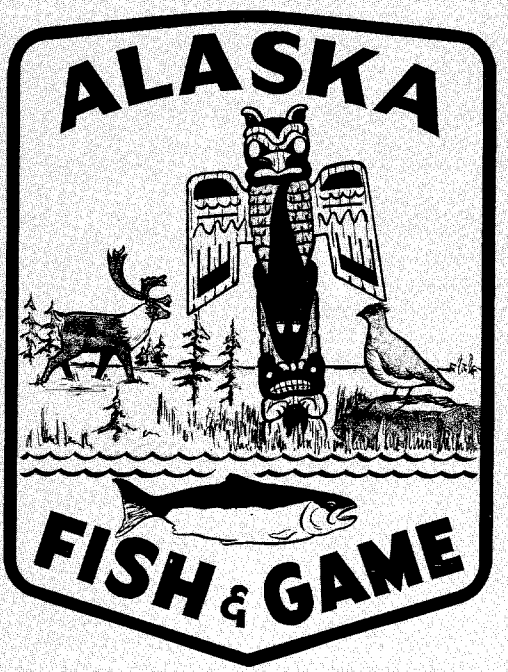
December 31, 1969



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CORRECTIONS FOR INFORMATIONAL LEAFLET #138

Page 81, Table 3:

1968 - Outmigration should be 2,295,023

Percent outmigration should be 37.5

Averages - Outmigration should be 1,584,474

Percent outmigration should be 54.9 3/

Footnote 3/ should read: "Note that the average 54.9% ....."

1968 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

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

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October 1969

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1968 KVICHAK RIVER SOCKEYE SALMON (Oncorhynchus nerka) SMOLT STUDIES [1/]

By

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I. INTRODUCTION

Since 1955 the Kvichak River smolt index has been conducted to provide an index of the relative abundance of sockeye salmon (Oncorhynchus nerka) smolt leaving Iliamna Lake. The index, which has been obtained for the past fourteen years, has been used to predict the magnitude (and age composition) of the adult sockeye salmon return to the Kvichak River. It is also used to evaluate the production of smolt from the various levels of adult escapement.

Despite the amount of expended effort on this project, the index has proven to be unreliable as a source of information on which to predict adult sockeye salmon returns to the Kvichak River. This unreliability may be due to a number of factors. One of the foremost problems is river ice preventing the fishing of a fyke net. Coupled with this, in many years a large proportion of the smolt apparently migrated down the river beneath this ice. Other problems are an irregular river bottom contour, two channels at the site of operations, variations from year to year in water level and turbidity, and the net avoidance exhibited by the smolt. The last factor also varies with the size and condition of the fish.

However, the index has added information on the population dynamics of the Iliamna Lake system sockeye. This, plus the need for comparative year to year data, has necessitated the continuation of the index project.

In order to improve the outmigration estimates, a federally funded program was initiated in 1965, using funds from the Commercial Fisheries Research

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1/ This investigation was financed by the Commercial Fisheries Research and Development Act (P.L. 88-309) for the period commencing July 1, 1966, under sub-project 5-5-R-1, Contract No. 14-17-0007-374.

and Development Act (P.L. 88-309). The main objective under this program was to devise methods and procedures to obtain total yearly outmigration estimates. The history of this program will be discussed in Total Smolt Outmigration Estimate section of this report.

All the data presented in this report was collected and compiled by personnel of the Alaska Department of Fish and Game, and Mr. O. E. Kerns of the Fisheries Research Institute who provided much valuable assistance on the methods and procedures of operating the index project.

II. CONTINUATION OF THE INDEX PROJECT

A. Methods and Procedures

This year a standard 4' x 4' fyke net was fished in the same location and at the same depth as it has been each year since 1955. Fishing the fyke net began on May 14 and ended on June 14. Twenty-four hour sampling was initiated on May 19. All fishing time that was lost was due to ice or algae.

One change that was initiated this year, during photo-calibration, was the use of a lever system to pull the photo-tunnel and cod end free of the water.

B. Results and Discussion

1. Ice Interference, Climatological and Hydrological Data

Loss of fishing time due to ice and algae interference was minimal in 1968. In total 18 hours were missed.

As in the past, weather observations were made twice daily. The station was located one mile below the Iliamna Lake outlet (Figure 1). Water temperatures ranged from a low of 39° F to a high of 47° F. The mean seasonal temperature was 42° F. The water temperature, on June 19 at the beginning of the outmigration, had an average of 39.5° F based on the day's two temperature readings.

This year's water depth data was obtained from the United States Geological Survey who operated a gauging station on the Kvichak River. The station was located approximately 1/2 mile downstream from the lake outlet. The data is presented in Table 1 along with the other hydrological and climatological data gathered by personnel of the Alaska Department of Fish and Game.

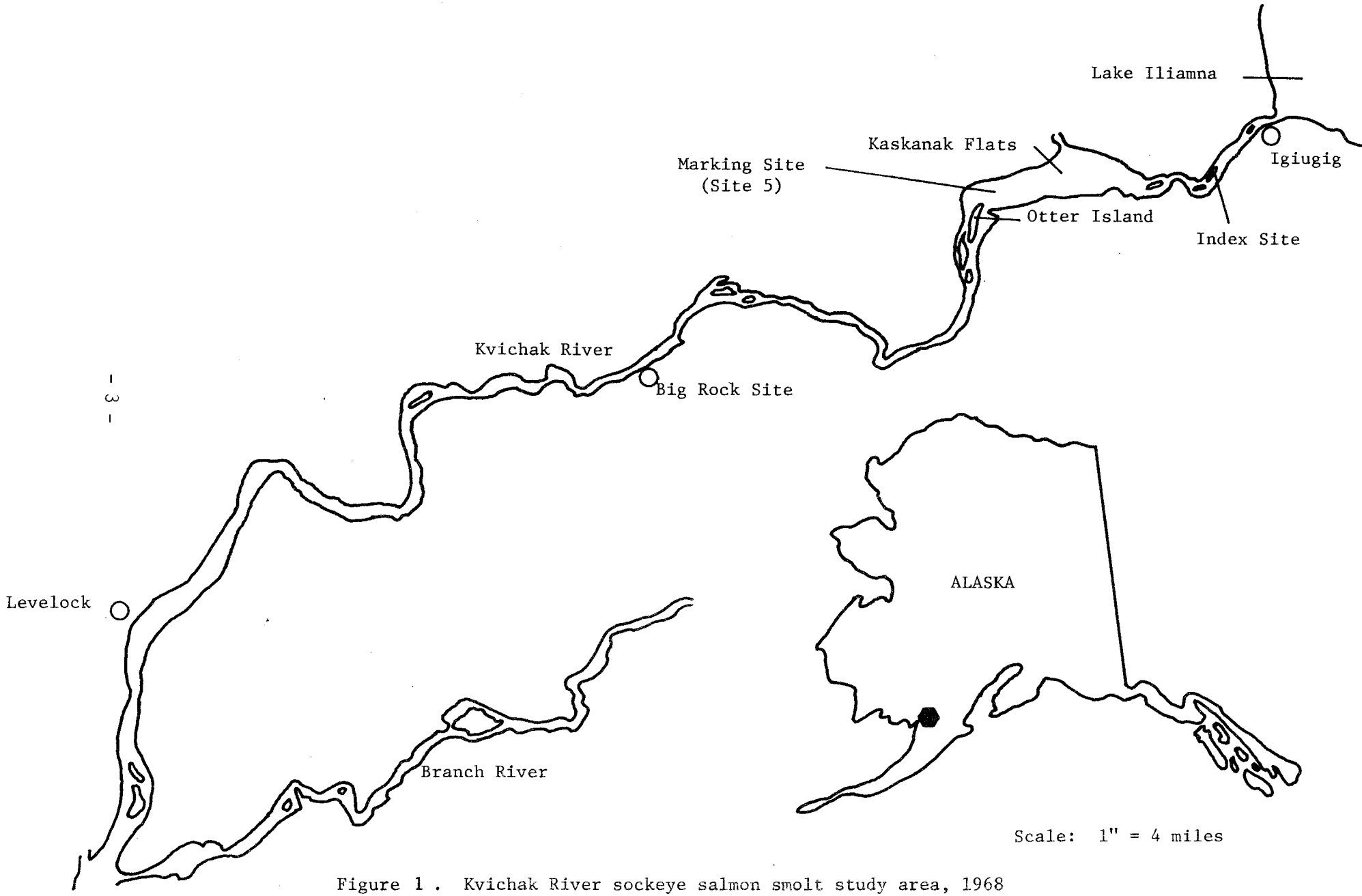

Figure 1 . Kvichak River sockeye salmon smolt study area, 1968

TABLE 1. Climatological and stream observations - Kvichak River 1968, May 13-June 12.

Date	Sky 9am	Sky 8pm	Precipitation 9am	Precipitation 8pm	Precipitation Amt.	Wind Dir - Vel 9am	Wind Dir - Vel 8pm	Air Temp. °F 8pm Max	Air Temp. °F 8pm Min	Water Temp. °F 9am	Water Temp. °F 8pm	Water Guage 1/ 8pm	9am Turbidity	Remarks
5/13	1	1	0.00	0.00	0.00	-	-	-	-	-	-	21.62	-	Max - Min Broken
14	3	4	0.00	0.00	0.00	N5	S18	-	39	39	40	21.66	A	
15	4	4	0.00	0.00	0.00	S6	SE10	-	-	39	-	21.68	A	
16	4	-	0.00	-	-	NE9	-	-	39	39	39	21.10	A	
17	-	3	0.00	0.00	0.00	-	NW13	-	41	-	39	21.20	A	
18	4	3	0.00	-	-	NW5	NW10	-	43	38	37	21.10	A	Heavy Ice - pm
19	2	3	0.00	0.00	0.00	NW12	S5	57	-	39	40	21.12	A	
20	1	-	0.00	-	-	N7	-	66	-	40	-	21.16	A	
21	1	2	0.00	0.00	0.00	N7	SW15	59	-	40	42	21.26	A	Water gauge out
22	1	3	0.00	0.00	0.00	N12	N4	56	44	42	41	21.18	B	Heavy Ice - am
23	-	-	-	-	-	-	-	-	-	-	-	21.52	-	
24	2	4	0.05	0.17	0.22	SW14	S12	60	45	41	40.5	21.24	A	
25	4	1	0.30	1.00	1.30	N8	NW12	-	47	40	39	21.40	C	
26	2	1	0.10	0.60	0.70	NW17	NW7	-	47	41	40	21.54	A	
27	2	3	0.00	0.00	0.00	NW4	NW6	56	45	41	42	21.40	A	
28	1	2	0.00	0.00	0.00	S7	S16	60	52	42	42	21.44	A	
29	4	4	0.05	0.00	0.05	S17	SE13	44	41	41	41	21.50	B	
30	4	3	0.00	0.04	0.04	SE22	SE17	44	42	40	41	21.64	B	
31	-	4	-	-	0.19	-	SE8	-	40	-	41	21.56	-	
6/ 1	1	1	0.28	0.00	0.28	N7	E3	55	56	41	42	21.67	A	
2	3	3	0.00	0.05	0.05	SE4	SE6	57	50	42	42	21.68	A	
3	1	3	0.00	0.04	0.04	NE3	NE11	56	49	42	43	21.76	A	
4	1	-	0.00	-	-	NE6	-	56	-	42	-	21.70	A	
5	2	4	0.00	0.00	0.00	NE2	NE9	62	52	43	43	21.64	A	
6	4	1	0.01	0.39	0.40	E5	SE5	52	50	43	43	21.44	A	Heavy Hail - pm
7	2	2	0.00	0.00	0.00	N17	N6	62	34	43	44	21.72	A	
8	3	1	0.00	0.00	0.00	N7	N5	60	38	44	44	21.26	A	
9	2	3	0.00	0.00	0.00	N7	NW9	67	39	44	44	21.24	A	Very Light Rain
10	2	3	0.00	0.75	0.75	NE7	S17	71	38	45	46	21.52	A	
11	2	2	0.05	0.00	0.05	SW5	N4	75	41	46	47	21.76	A	
12	1	4	0.00	0.00	0.00	N6	NW6	70	43	47	47	21.40	A	

Codings:

Sky

0. No observation made
1. Clear sky, cloud cover not more than 1/10
2. Cloud cover not more than 1/2 sky
3. Cloud cover more than 1/2 sky
4. Complete overcast
5. Fog or thick haze

Turbidity

A. Clear
B. Partly Cloudy
C. Cloudy
D. Debris

1/ Data taken from U.S.G.S. records of the gauging station on Kvichak R. Readings were taken at 1330 hrs. Above an arbitrary datum. Data questionable.

2. Index Net Catch and Photocounter Calibration

a. Index Catch

This year's expanded 24-hour index net catch, presented in Table 2, is the largest on record with a total of 6,123,683 smolt. Fishing with the photo-electric counters began on May 22 at 0100 hours. The major peaks of the outmigration occurred on May 23-24, and 25-26. Each of the peaks represented over one million smolt with the 25-26 peak nearing two million. Together they represented 50 percent of the total expanded catch. Figure 2 graphically shows their magnitude as compared with the remainder of the outmigration. They are also shown in comparison to the 1963 outmigration which previously was the largest outmigration on record (Figure 3).

The 1968 catch for the index hours totaled 2,295,023 and represented 37.48 percent of the total catch.

The 24-hour index catches were derived as described in the Alaska Department of Fish and Game Informational Leaflet No. 83.

b. Photo-Electric Counter Calibrations

The method used for the calibration of the photo-electric counters was the same as in the years past with the exception of the aforementioned lever which was used to pull the photo-tunnel and cod end free of the water. It was significantly helpful during the periods of high outmigration when the cod end was extremely heavy with smolt.

The daily conversion ratios for numbers of smolt per photo-electric count ranged from 11.89 to 17.11. This compares favorably with 1967's figures but is large when compared with past figures such as 1965 when the range was 3.22 to 10.00. However, contrary to past data, the highest number of fish per count occurred during a period when smolt passage rates were low (ranging from 47 to 900 fish per minute). Both low and high figures in this range experienced more than 19.4 fish per count. The lowest fish per count recorded was 12.93 with a passage rate of 99 fish per minute. The reason for this could not be determined. The crew conducting the calibrations had sufficient experience in the procedure of calibrating the counters and turbidity was non-existent on the dates in question (5/27-28, and 6/1-2). The only reasonable explanation seems to be the counters were malfunctioning due to a variance in the power supplied by the batteries or variances in the temperatures in which the counters were operating. The data is presented in Table 3.

This year, in addition to index hour calibrations, non-index hour calibra-

TABLE 2 . Kvichak River red salmon smolt expanded twenty-four hour index catch by period, 1968.

Date	1200-2200	2200-2300	2300-2400	0000-0100	Index Hour Total	0100-1200	Daily Total	Accumulative Total
5/17-18	0	0	0	0	0	0	0	0
5/18-19	0	0	0	0	0	0	0	0
5/19-20	16,101	46,222	29,684	13,147	89,053	2,486	107,640	107,640
5/20-21	186,435	41,396	70,963	9,285	121,644	17,949	326,028	433,668
5/21-22	313,919	66,745	27,361	1,891	95,997	6,551	416,467	850,135
5/22-23	195,192	26,568[1/]	26,568[1/]	15,754[2/]	68,890	31,286	295,368	1,145,503
5/23-24	578,729	154,745	12,306	284,684	451,735	164,603	1,195,067	2,340,570
5/24-25	187,915	56,607	2,127	10,558	69,292	64,386	321,593	2,662,163
5/25-26	115,909	160,188	596,996	253,338	1,010,522	735,975	1,862,406	4,524,569
5/26-27	439,452	92,550	133,947	27,010	253,507	124,465	817,424	5,341,993
5/27-28	175,031	8,583	1,709	2,654	12,946	33,961	221,938	5,563,931
5/28-29	15,704	2,128	0	0	2,128	5,807	23,639[3/]	5,587,570
5/29-30	2,527	0	17	286	303	1,433	4,263[3/]	5,591,833
5/30-31	489	3,134	1,516	118	4,768	4,264	9,521[3/]	5,601,354
5/31-6/1	2,132	303	388	691	1,382	21,869	25,383[3/]	5,626,737
6/1-2	247,067	20,224	19,180	3,251	42,655	718	290,440	5,917,177
6/2-3	2,047	2,598	4,523	1,834	8,955	611	11,613[4/]	5,928,790
6/3-4	578	377	551	0	928	2,784	4,290	5,933,080
6/4-5	48,038	17,965	28,798	5,080	51,843	50,493	150,374	6,083,454
6/5-6	4,984	0	0	0	0	2,984	7,968[5/]	6,091,422
6/6-7	317	0	131	559	690	3,028	4,035[5/]	6,095,457
6/7-8	1,557	26	7	3	36	1,150	2,743	6,098,200
6/8-9	4,241	781	940	1,461	3,182	5,748	13,171	6,111,371
6/9-10	792	98	1,037	57	1,192	1,254	3,238	6,114,609
6/10-11	26	0	2	0	2	150	178	6,114,787
6/11-12	40	0	764	360	1,124	2,885	4,049	6,118,836
6/12-13	1,812	74	48	854	976	118	2,906	6,121,742
6/13-14	6	5	188	1,080	1,273	662	1,941	6,123,683
TOTALS	2,541,040	701,317	959,751	633,955	2,295,023	1,287,620	6,123,683	
PERCENT	41.49	30.56	41.82	27.62	37.48	21.03	100.00	

1/ Average of total catch for 2200 and 2300 hrs.
2/ Average of 2200 and 0200 hrs.
3/ Expanded day's catch determined by using average of index calibrations of 5/27-28 and 6/1-2.
4/ Expanded day's catch determined by using average of index calibrations of 6/1-2 and 6/4-5.
5/ Expanded day's catch based on average index calibration of 6/4-5.

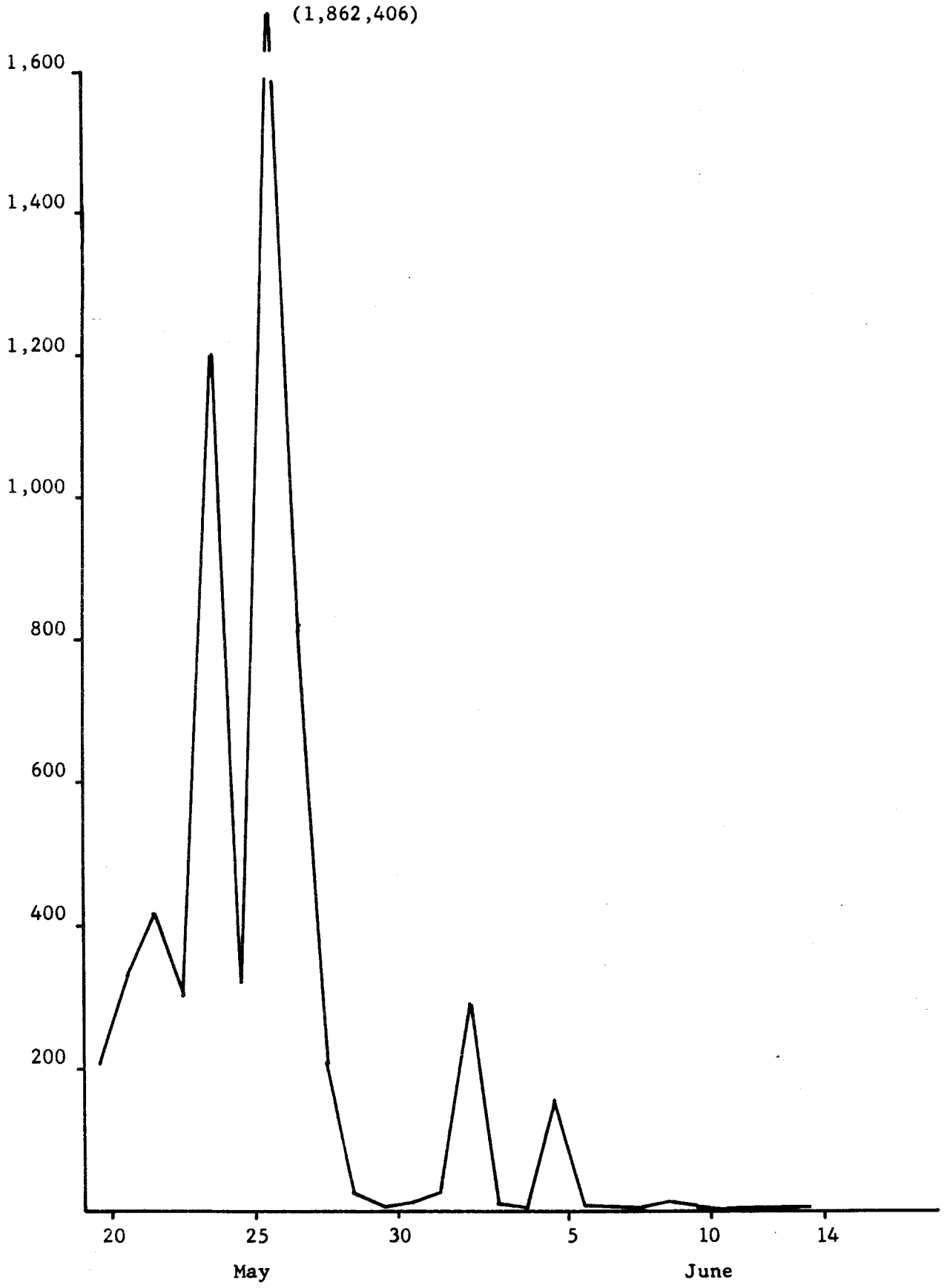

FIGURE 2. Daily fyke net catches, Kvichak River, 1968.

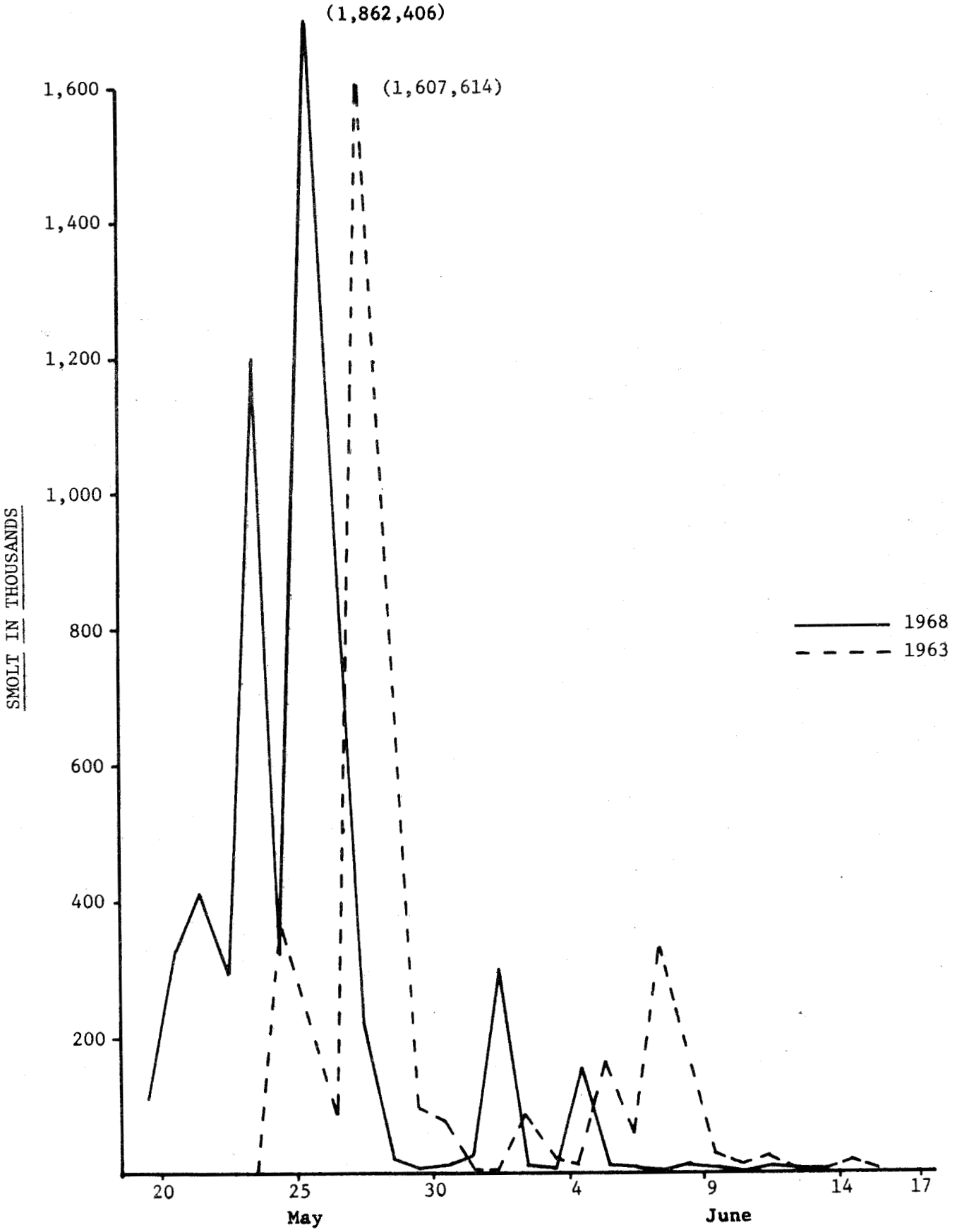

Figure 3 . Daily fyke net catches, Kvichak River - 1963 and 1968

Table 3. Kvichak River sockeye salmon smolt photo-counter calibrations, 1968.

Date	Hour	Fishing Time	Weight	Fish per Pound	Total Fish	Counts	Counts per Minute	Fish per Minute	Fish per Count	Daily Totals Fish/Count [1]
5/23-24	0000	0.37	61.4	48	2,947	210	567.57	7,964.9	14.03	14.03
5/24-25	2200	7.00	26.0	57	1,482	87	12.43	211.7	17.00	
	0000	4.50	17.4	54	940	69	15.33	208.9	13.60	15.32
5/25-26	2300	2.17	58.4	50	2,920	210	96.77	1,345.6	13.90	
	2300	0.66	55.6	45	2,502	170	257.58	3,790.9	14.72	
	2300	0.66	62.4	48	2,995	210	318.18	4,537.9	14.26	
	0000	0.75	79.8	48	3,830	260	346.67	5,106.7	14.73	
	0000	0.66	43.6	47	2,049	140	212.12	3,104.5	14.63	
	0000	0.33	40.4	49	1,980	130	393.94	6,000.0	15.23	
	0000	0.92	62.2	44	2,737	200	217.39	2,975.0	13.68	
	0000	0.17	69.2	45	3,144	240	1,411.76	18,494.1	13.10	14.28
5/26-27	2200	1.78	47.6	48	2,285	200	112.36	1,283.7	11.42	
	2200	1.00	23.4	54	1,264	100	100.00	1,264.0	12.64	
	2200	1.38	41.2	54	2,225	204	147.83	1,612.3	10.91	
	2200	0.60	25.8	51	1,316	107	178.33	2,193.3	12.30	
	2200	1.35	42.8	53	2,268	211	156.30	1,680.0	10.75	
	2200	0.82	22.6	52	1,175	101	123.17	1,432.9	11.63	
	0000	1.93	31.4	53	1,664	105	54.40	862.2	15.85	
	0000	5.97	53.2	48	2,553	200	33.50	427.6	12.77	
	0000	18.78	21.2	54	1,145	82	4.37	61.0	13.96	12.47

Table 3. Kvichak River sockeye salmon smolt photo-counter calibrations, 1968 (Continued).

Date	Hour	Fishing Time	Weight	Fish per Pound	Total Fish	Counts	Counts per Minute	Fish per Minute	Fish per Count	Daily Totals Fish/Count 1/
5/27-28	2200	9.35	27.8	55	1,529	100	10.70	163.5	15.29	
	2200	13.58	22.8	59	1,345	104	7.66	99.0	12.93	
	2200	22.27	27.6	59	1,628	100	4.49	73.1	16.28	
	2300	21.00	15.2	65	988	50	2.38	47.0	19.76	
	0000	3.00	8.2	57	467	25	8.33	155.7	18.68	16.59
6/1-2	2200	7.50	26.5	68	1,802	100	13.33	240.3	18.02	
	2200	17.00	30.0	67	2,010	129	7.59	118.2	15.58	
	2200	2.20	30.5	65	1,982	102	46.36	900.9	19.43	
	2200	5.75	24.0	62	1,488	102	17.74	258.8	14.59	
	2300	4.17	23.2	62	1,438	96	23.02	344.8	14.98	
	2300	3.50	26.4	76	2,006	100	28.57	573.1	20.06	17.11
6/3-4	2200	37.00	4.0	74	296	22	0.59	8.0	13.45	13.45
6/4-5	2200	10.00	25.5	58	1,479	110	11.00	147.9	13.44	
	2200	4.00	40.0	59	2,360	202	50.50	590.0	11.68	
	2200	3.00	16.0	62	992	100	33.33	330.7	9.92	
	2200	5.00	41.8	61	2,550	207	41.40	510.0	12.32	
	2200	5.25	18.0	62	1,116	100	19.05	212.6	11.16	
	2200	10.00	32.0	62	1,984	155	15.50	198.4	12.80	11.89
								Seasonal Average		14.25 2/

1/ Figures represent an arithmetic mean of calibrations for that period.
2/ Represents arithmetic average of all photo-counter calibrations taken during the index hours.

tions were taken. These are presented in Table 4. They were not, however, used to expand the daily index catch because of the disparity between passage rates of fish and fish per count, and for the sake of comparability between the year to year data. In the past, daily calibration averages were derived nearly entirely on the basis of the nighttime index hour calibrations.

3. Length and Weight of Smolt by Age Group

Thirty-three one pound and four two pound samples were taken throughout the season to determine the length and weight by age group. Table 5 and Figure 4 show the weighted length frequencies of the smolt index catch. The age class separation point was determined by reading the scales of the fish, which by length, bracketed the separation. By the use of this method it was determined that the index net catch consisted of 89.41 percent Age II smolts and 10.59 percent of Age I smolts. They averaged 104.5 mm and 87.9 mm respectively.

Age II smolt averaged 9.2 grams while Age I smolt averaged 5.5 grams. This was arrived at by averaging by lengths the weight samples taken throughout the season. The sample represented 680 individual smolt. The samples measuring 93 mm (the age class separation point) were divided in half with one half being accorded to each age class.

III. DISCUSSION AND COMPARISON WITH PAST DATA

As previously stated, the 1968 Kvichak River sockeye smolt index catch is the largest on record. The 5,475,362 Age II smolt were progeny of the 1965 escapement of 24,360,000 adults. The Age I smolts totaled 648,321 individuals and were progeny of the 1966 adult escapement of 3,775,184.

The Age II smolt estimate is the largest index on record with a total of 164.2 points with one index point equal to 33,340 smolt. The Age I smolt totaled 19.4 index points. This places the Age I smolt just slightly higher than the 14 year average of 646,070 for the index project (1955-1968). This, however, is a higher production figure than other years with similar brood year escapements. For previous years' data refer to Appendix A, Tables 1 through 7.

To summarize, the 1968 Kvichak River sockeye smolt index catch is the largest on record. This is a result of the 1965 brood year production of Age II smolt. The Age I smolt production of the 1966 escapement was only slightly higher than the 14 year average but was considerably higher than past brood year productions from escapements of similar magnitude. Loss of fishing time due to ice and algae interference was minimal.

Table 4. Kvichak River sockeye salmon smolt non-index hour photo-counter calibrations, 1968.

Date	Hour	Fishing Time	Weight	Fish per Pound	Total Fish	Counts	Counts per Minute	Fish per Minute	Fish per Count	Daily Totals Fish per Count
5/23-24	1600	1.50	45.6	50	2,280	200	133.33	1,520.0	11.40	
	1600	2.95	54.0	49	2,646	210	71.19	895.9	12.60	
	1600	17.75	41.0	48	1,968	170	9.58	110.9	11.58	11.86
5/25-26	1500	6.00	13.6	59	802	84	14.00	133.7	9.55	
	1600	13.28	6.4	57	365	32	2.41	27.5	11.41	
	1600	7.75	1.4	56	78	1	0.13	10.1	78.00	32.99
5/26-27	1500	3.90	45.6	54	2,462	200	51.28	631.3	12.31	
	1600	8.00	10.8	50	540	47	5.88	67.5	11.49	
	1600	2.08	23.2	57	1,322	105	50.48	635.6	12.59	
	1600	10.08	48.8	53	2,586	202	20.04	256.5	12.80	
	1600	1.40	50.6	49	2,479	210	150.00	1,770.7	11.80	
	1600	2.67	44.8	50	2,240	208	77.90	839.0	10.77	11.96
5/27-28	1500	2.80	70.0	52	3,640	212	75.71	1,300.0	17.17	
	1500	5.50	31.8	55	1,749	103	18.73	318.0	16.98	
	1600	2.80	25.0	52	1,300	102	36.43	464.3	12.74	15.63
6/1-2	1400	1.00	51.5	50	2,575	182	182.00	2,575.0	14.15	
	1400	4.00	31.5	59	1,858	130	32.50	464.5	14.29	
	1500	1.50	24.4	51	1,244	99	66.00	829.3	12.56	
	1500	5.33	24.0	51	1,224	103	19.32	229.6	11.88	
	1500	9.83	22.8	46	1,049	105	10.68	106.7	9.99	12.57

TABLE 5. Weighted smolt length frequency, Kvichak index site, 1968.

Length in mm.	Occurrence	Length in mm.	Occurrence
75	1,503	103	279,222
77	99	104	371,095
78	2,688	105	301,273
79	9,596	106	208,285
80	6,767	107	246,778
81	5,499	108	237,311
82	40,030	109	232,179
83	28,591	110	307,642
84	33,913	111	226,760
85	57,140	112	134,182
86	36,056	113	105,615
87	27,103	114	204,231
88	59,975	115	108,150
89	54,452	116	44,611
90	90,030	117	30,551
91	83,692	118	96,454
92	78,254	119	49,877
93	65,866	120	97,844
94	78,218	121	45,052
95	156,625	122	8,843
96	138,640	123	1,206
97	180,538	124	9,039
98	235,774	125	7,214
99	279,693	126	61
100	328,830	128	128
101	297,997	132	61
102	392,450		

TOTAL - 6,123,683

Age I - 648,498
Percent - 10.59
Average Length - 87.9
Average Weight - 5.5

Age II - 5,475,185
Percent - 89.41
Average Length - 104.5
Average Weight - 9.2

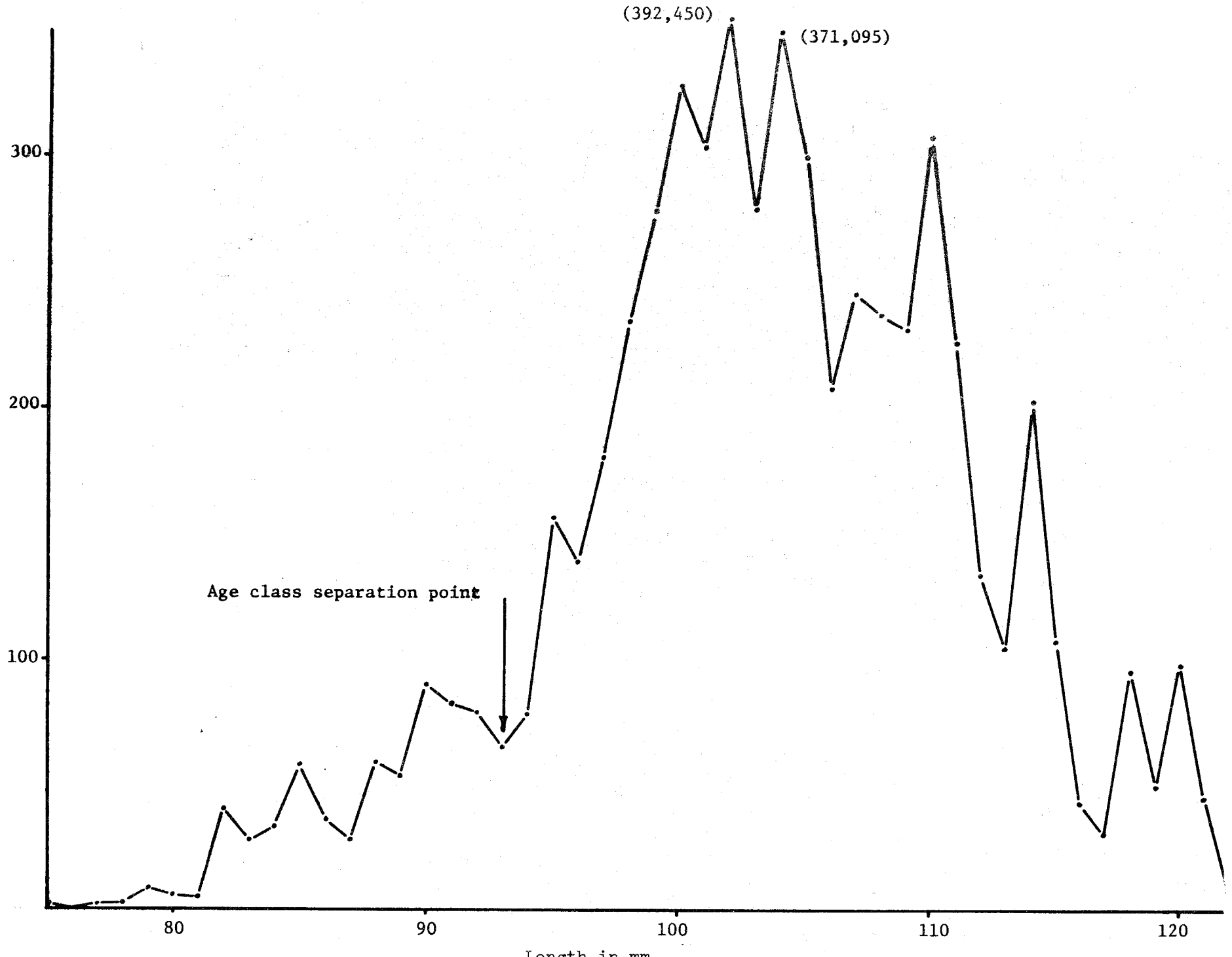

Figure 4. Weighted length frequencies of smolt, Kvichak River, 1968

IV. TOTAL SMOLT OUTMIGRATION ESTIMATE

A. Methods, Procedures and Results of 1968 Mark-Recovery Program

In 1968 the outmigration estimate was to be based on a mark-recovery program. The marking site (shown on Figure 1) was located at the downriver end of Kaskanak Flats approximately 12 miles downstream from the Iliamna Lake outlet. The recovery site was located at Big Rock which is 25 miles downstream from the outlet[1/]. The rationale for the mark-recovery requirements was as follows:

The preliminary 1970 forecast is for an inshore return of 54.783 million 5_3 and the 1971 forecast is for 8.217 million 6_3. This is a total of approximately 63 million adults. The Japanese high seas fishery had a catch amounting to 15 percent of the inshore return in 1960 and 35 percent in 1961. Applying these figures to the 1970 and 1971 returns, yields a total adult population of 8.217 + 54.783 = 63.000 5_3 and 2.875 + 8.217 = 11.092 6_3 or 74.092 Age II adults. Using an average survival of 14.1 percent for Age II Ugashik smolt would yield an outmigration of 525 million Age II smolt. The 1970 preliminary inshore forecast is for 2.336 million 4_2 adults and 1971 for 1.401 million 5_2 adults. Using the same high seas catch ratios, yields .350 + 2.336 = 2.686 4_2 and .490 + 1.401 = 1.891 5_2 or 4.577 Age I adults. Using an average Ugashik survival of 7.7 percent for Age I smolts, yields an outmigration of 60,000,000 Age II smolt. The combined estimated smolt outmigration for 1968 would be 585 million smolt. Realizing the inadequacy of data and the possibility of large errors, we used a high estimate to determine mark and recapture sample sizes. We then anticipated an outmigration in 1968 of 500,000,000 - 1,000,000,000 smolt.

Using Robson and Regier (1964) at $1-\alpha = 0.95$ and $p = 0.10$ we assumed that we would have to mark between 300,000 and 500,000 fish and recover 900,000. Of course, these relationships are based on ideal conditions. Since the conditions in the field are seldom ideal and the preliminary estimate of outmigration size was at best an educated guess, we attempted to double the marking and mark between 600,000 and 1,000,000 fish.

Normally, if we wish to insure adequate marking, we would set a certain minimum number of minutes for each hour during which fish would have to be

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1/ Refer to the 1966 Bristol Bay Red Salmon Smolt Studies, Alaska Department of Fish and Game Informational Leaflet No. 102 for the factors influencing the choice of the recovery site.

marked. However, analysis of data from 1963 has shown that during peak hours the number of fish that should be marked will exceed both an hour's marking and holding capacity. Additionally, the first part of any school passing the site will have no, or too few, marked fish in it. With these complications in mind a tentative marking schedule was set up. Obviously, adjustments would have to be made in the field by the crew leader and supervisors based on actual observations and mechanical considerations.

The total marking goal of 600,000 - 1,000,000 fish was simply a general guideline to give crew and supervisors some idea of what they were aiming for. It was based on a minimum level of .1 percent of the total population forecast. This number must then be reduced to daily and hourly goals. Although the proportion of fish that should be marked varies with population size, we assumed that any significant population passing the site in an hour is large enough for the .1 percent goal to hold. If only 50,000 fish passed the site (this includes all channels of the river) we should mark about 10 percent of them. However, any inaccuracy in estimating this small a segment of the total population would not seriously affect the season's total.

In 1963 an estimated 113,338 Age I and 4,116,093 Age II smolt passed through the index net for a total estimated catch of 4,229,431. The Age I smolt produced a total return (inshore and high seas) of 504,000 4_2 and 5_2 and the Age II smolt produced 52,151,000 5_3 and 6_3. Again, using average Ugashik survivals of 7.7 percent for Age I and 14.1 percent for Age II, the 1963 outmigration is estimated to have been 6,545,000 Age I and 369,865,000 Age II for a total of 376,410,000. In other words, by rough guess, the index net captured about 1.1 percent of the outmigration. If we presume the mortality rates are generally right, the 1963 index catch was representative of the proportion taken from a large outmigration, the 1970 preliminary forecast is correct, and the net at Otter Island is about as effective as the index net, then the Site 5 net should have caught about 5-10 million smolt. We would have had to mark a minimum of 10-20 percent of the catch to achieve our upper goal of 1,000,000 and 6-12 percent to achieve our lower goal of 600,000. Initially we planned to use 13 percent of the catch, or eight fishing minutes out of the hour as our goal.

The 13 percent was the proportion of marked fish that should have been introduced into the population at any given time. Instantaneous capture and release was not feasible, particularly in view of the number of fish we were anticipating. To partially correct this condition it was proposed to stockpile marked fish in the hours of low outmigration.

Accordingly, the catch from the first eight minutes of each hour was to be marked and released as soon as possible. After that had been accomplished, the stockpiling of marked fish was started until 30,000 fish had been accumulated.

The live box in which the marked fish were placed consisted of three separate compartments, each containing approximately 10,000 fish. Then, whenever heavy migrations occurred, the compartments were to be opened one at a time and the fish released into the outmigration. These releases were to be spaced one hour apart for the duration of the heavy outmigration. Heavy migrations were defined as 1,000 fish per minute passing through the net. If this occurred during an afternoon hour, the compartments emptied were to be refilled as soon as possible.

Three colors and two color combinations were employed to mark the fish. The colors used were red, green and yellow. The combinations were red-green and yellow-green. The total amount of dye used was 129.5 pounds. Each color or combination was to be used every fifth day. The word "day" refers to 1200 hours of one date to 1200 hours of the next date. This provided consistency with the index site. When one color was expended before the day ended the next scheduled color was used with all of the other colors being moved up one day in the schedule. This change was to be noted on the marking form.

The marking procedure was as follows: After having fished the first eight minutes of the hour, the counts on the count paks were recorded on the fyke net log. Then with a man on each side of the marking box netting fish with dip nets and one man spraying, the fish were marked. The procedure was to have one man dip some smolt, have them marked and immediately released. During this time, the other man would net some smolt and have them ready to be marked. This procedure was followed during periods of heavy outmigration. When periods of low outmigration occurred, only one man dipped smolt. The smolt that were caught in the fyke net during the remainder of the hour were allowed to pass through the marking box via the release chute. The netting in the dip nets was shallow, forming a dish-like depression, thus keeping the smolt spread over the net to allow them to be adequately marked. During periods of heavy outmigration, marking was initiated as soon as sufficient numbers of smolt were present in the holding pens. This was to prevent overcrowding and thus unnecessary mortality. The marking box is shown in Diagrams 1 and 2.

Enumeration of the marked smolt through the use of photo-electric counts proved unfeasible due to faulty gear design. After the smolt entered the net and passed through the photo-tunnel, they were funneled down to a six-inch diameter hose which led to the marking box. It was at the point of funneling that the fault appeared. Apparently the funnel created a circular type current which recycled a portion of the smolt back through the photo-tunnel, thus having them registered twice on the count pak (Diagram 3). This resulted, in many cases, in less than one fish per count. This, plus erratic behavior of the photo-electric gear itself completely negated any facsimile of accuracy of

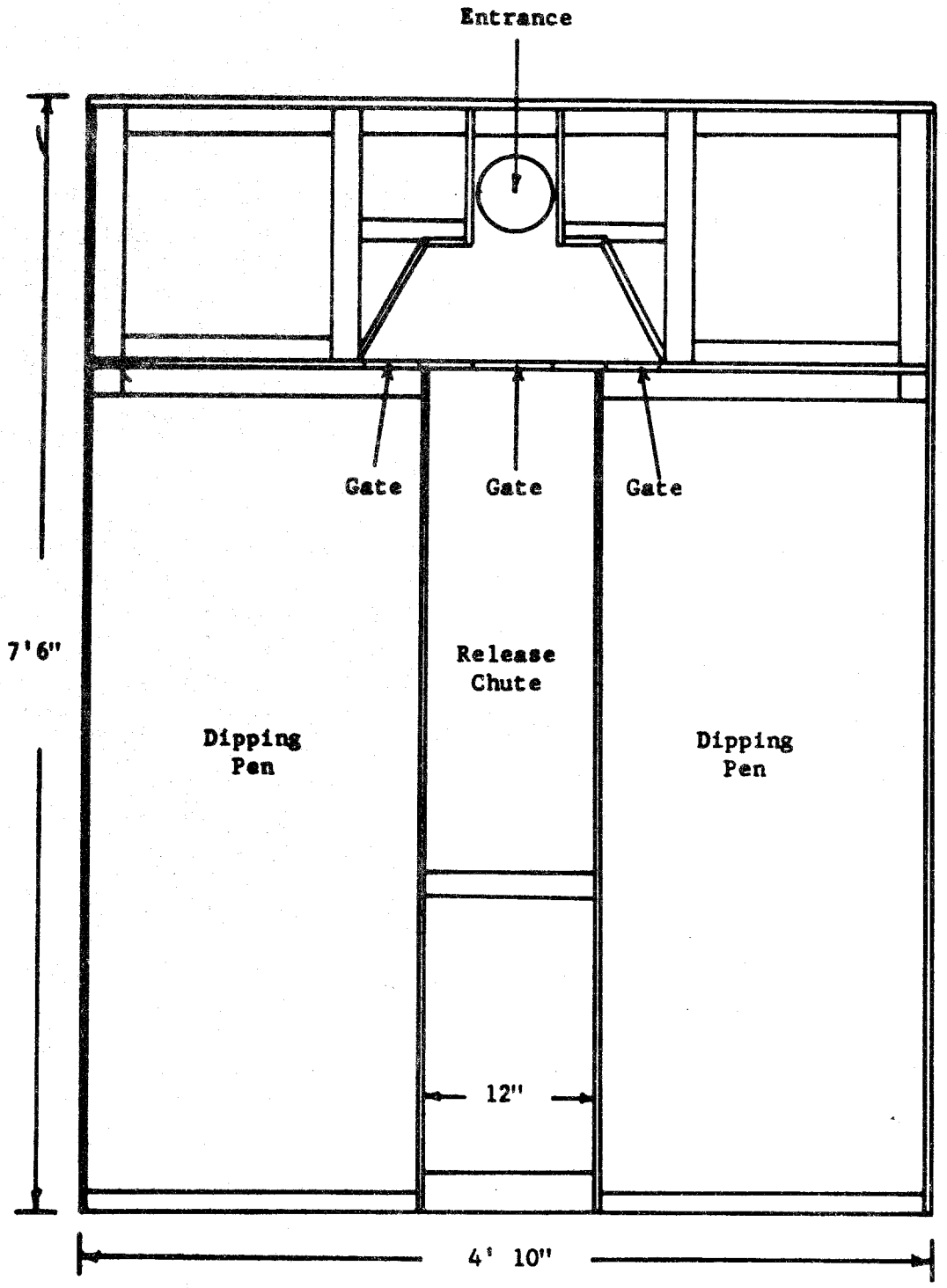

DIAGRAM 1. Smolt marking box, top view.

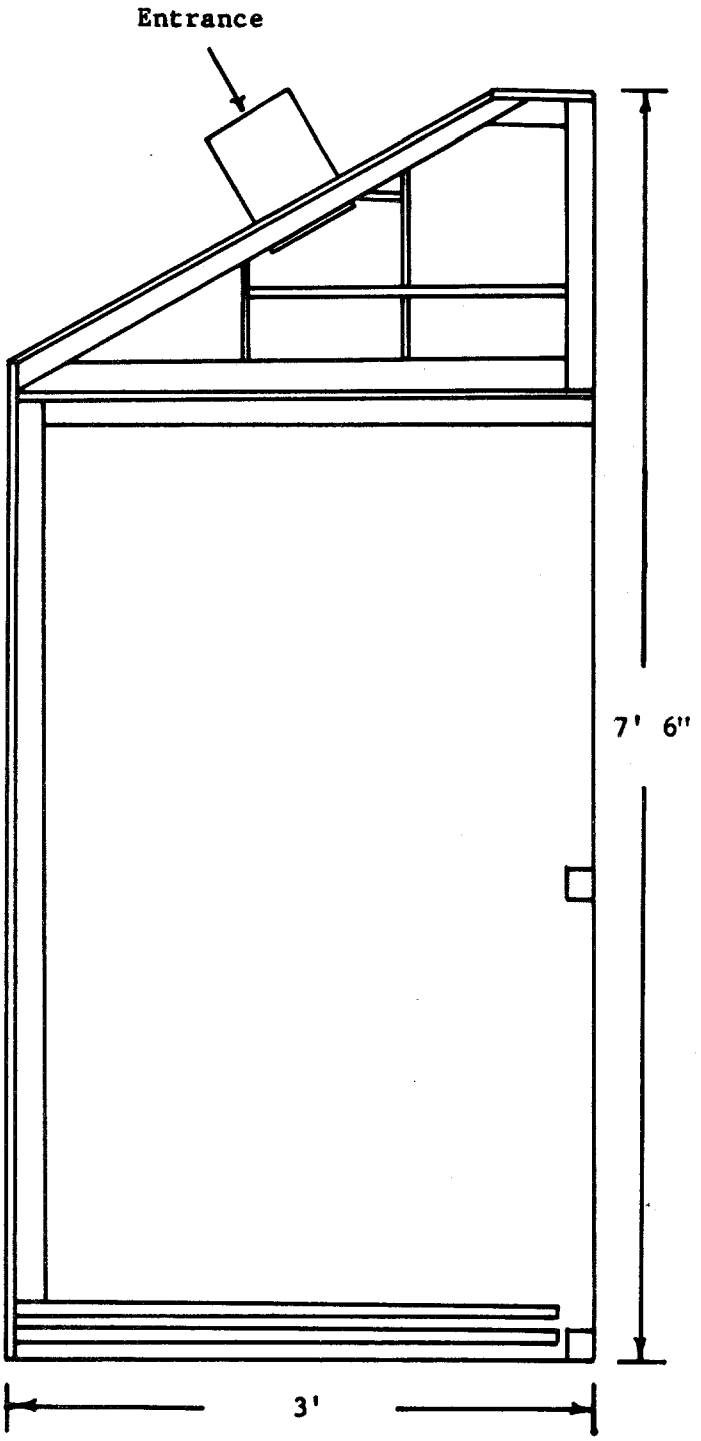

DIAGRAM 2. Smolt marking box, side view with side panel removed.

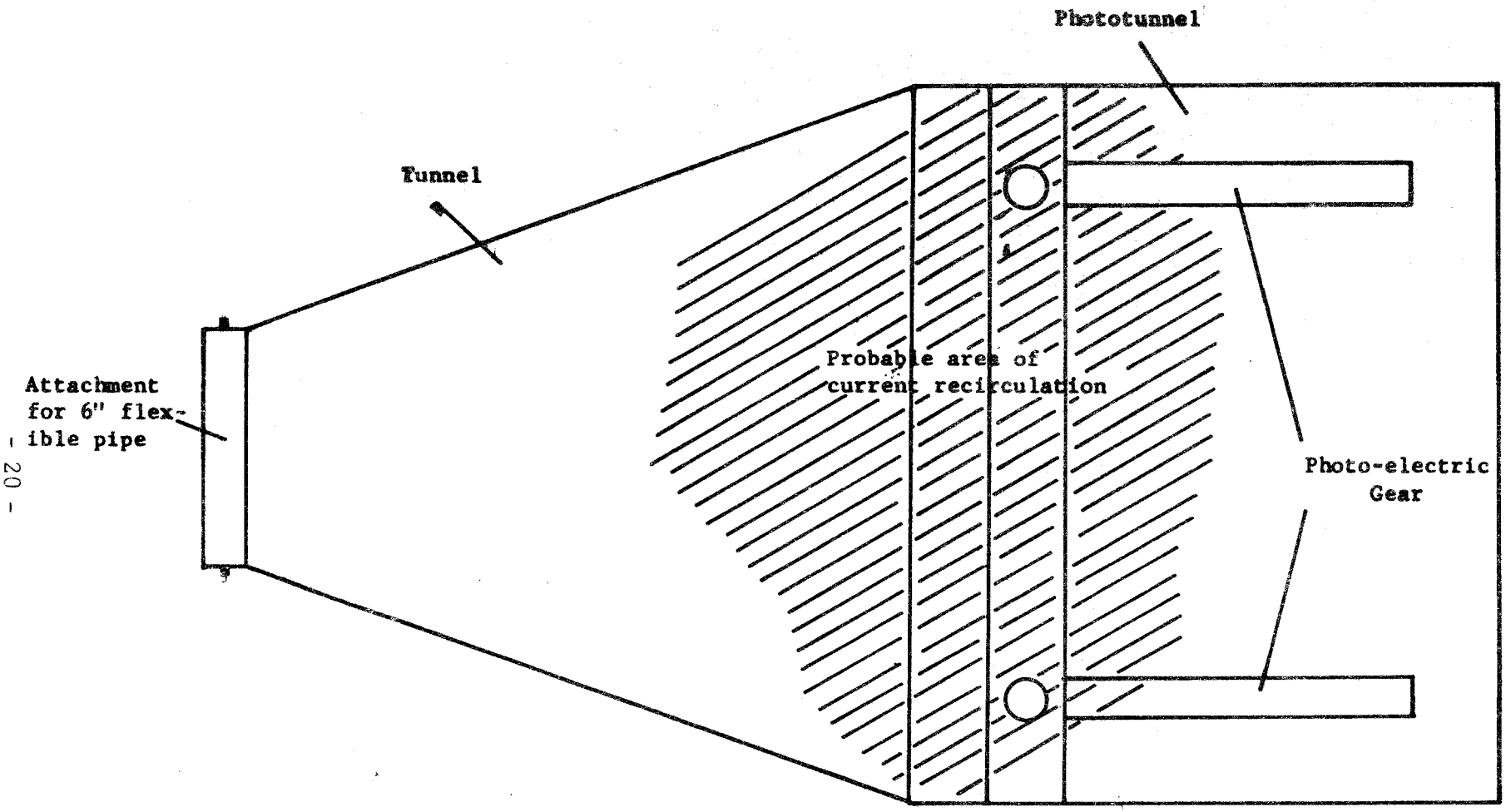

DIAGRAM 3. Phototunnel and funnel showing area of probable current recirculation.

photo counts. Diagram 3 shows the photo-tunnel, funnel and the probable area of recirculation.

Two alternative methods of enumeration of marked smolt remained. These were 1) the total number of tallied dips multiplied by the average number of smolt per dip, and 2) compressor time multiplied by the average number of smolt per dip. In this scheme the compressor time was tallied in terms of two men dipping and one man dipping. These two factors were then divided by the average time per dip to arrive at total numbers of dip per unit time for each method. The resulting two figures were then each multiplied by the average number of smolt per dip, and then added to arrive at the total marked smolt.

In both cases the total number of marked smolt were in the area of 900,000. In method number one, the total dips was 9,423. The average number of fish per dip was 97.2. Thus:

Total marked smolt = 9,423 x 97.2 = 915,916

The average number of smolt per dip was arrived at by tests conducted by the marking crew. These tests were conducted as follows: The crew would mark smolt, keep them isolated in a live box, and record the number of dips taken. Then a total weight of smolt, and smolt per pound was obtained. The resultant total number of smolt (total weight x smolt per pound) was then divided by the number of dips taken. These averages ranged from 158 to 43 smolt per dip.

In method two the figures used were as follows:

Two man compressor time = 9.0 hrs. = 32,400 seconds
One man compressor time = 3.2 hrs. = 7,920 seconds
Total compressor time = 12.2 hrs. = 40,320 seconds
Average time per dip = 4.4 seconds

Smolt marked during 2-man compressor time =

$$\frac{32,400 \text{ seconds}}{4.4 \text{ seconds per dip}} \times 97.2 \text{ smolt per dip} = 715,745$$

Smolt marked during 1-man compressor time =

$$\frac{7,920 \text{ seconds}}{4.4 \text{ seconds per dip}} \times 97.2 \text{ smolt per dip} = 174,960$$

Total marked smolt = 890,705

It should be emphasized that these two figures (915,916 and 890,705) are only estimates of the total marked smolt. These two figures, however, fall within the upper limits of the estimated number of marked smolt necessary for a total population estimation.

In conjunction with the marking program, a mortality study was conducted on marked smolt from May 28 to June 4. The procedure was to mark the smolt and immediately deposit them in a holding box situated alongside the marking skiff. The holding box consisted of three boxes in tandem, with the box used for the control sample being situated at the upstream end. The results of the study are shown on Table 6.

In addition to the mortality study a mark retention study was also conducted. These retention studies were conducted on three different occasions during the smolt season, twice after a twelve hour holding period and once after a six day period. In each case the fish were found to have a minimum of two or three dyed spots to a maximum of one-third to one-half of the fish being colored. To detect the dye imbedded on the smolt, a small, hand held, ultra-violet light unit was used.

Also conducted was a smolt predation study. In accordance with Migratory Bird Treaty Act of 1918, a bird collecting permit, #1A-68-16, was obtained. The collecting device was a .410 gauge shotgun using No. 8 shot. The species collected were mew and glaucous-winged gulls, and arctic terns. Table 7 shows the results of the study. It was noted that birds showed no feeding habits selective toward the area downstream of the fyke net. Observations indicated that the marked smolt had little or no trouble reorienting themselves after being released. With their behavior patterns being normal, it is doubtful that they would attract more than normal attention from either the birds or predacious fish. The only factor that might produce increased predator selectivity would be the pigment imbedded in the smolt. No predatory species of fish were collected at the marking site. However, predatory species of fish were collected at the north side of the Iliamna Lake outlet. Four arctic char (Salvelinus alpinus) ranging from 20 inches to 24 inches in length, and two rainbow trout (Salmo gairdneri) measuring 19 inches and 28 inches made up the sample. The stomach contents are shown on Table 8. Their presence was, however, noted around and below the fyke net site. This, however, is not extraordinary as it is a known area of congregation for these fish during the smolt outmigration.

The mark recovery effort at Big Rock was conducted with a modified Mason's migrant dipper. Because of late arrival of the blueprints of the dipper from the U.S.F.W.S. and the lack of time for construction in Anchorage, the dipper used in the recovery effort was not in use until June 1.

The recovery unit consisted of two 24 ft. by 2 ft. by 30" wide styrofoam

TABLE 6

MORTALITY STUDY ON MARKED vs. UNMARKED SMOLT, KVICHAK RIVER, 1968

Sample No.	Date Collected Hr.	Marked Number[2]	Marked Date-Observation Time Time Lapse (Hrs.)	Marked Number Dead	Marked Percent	Unmarked Number[2]	Unmarked Number Dead	Unmarked Percent	Remarks
1	5/28 0420	960[1]	5/28-1500 10.7	0	0.00	—	—	—	No control collected due to lack of fish.
2	5/28 2040	1,218	5/29-1745 21.1	42	3.44	1,200	0	0.00	
3	5/29 0141	240	5/30-1600 40.3	10	4.17	240	4	1.67	
4	5/29 2118	1,120	5/30-1600 18.7	7	0.63	1,120	3	0.27	
5	6/2	240[1]	6/3-1745 40.7	—	—	240[1]	6	2.5	Portion of marked smolt escaped.
6	6/2	240	6/3-1745 39.3	0	0.00	240	6	2.5	
7	6/4 0058	240[1]	6/4-1700 16.0	2	0.83	240[1]	0	0.00	Not included because of same control group used as in No. 6.
8	6/3 2355	160	6/10-1355 158.0	5	3.13	160	5	3.13	
9	6/4 2317	160	6/10-1350 133.5	0	0.00	160	0	0.00	
Total		3,138		64		3,120	18		

Percent Mortality = 2.04 Percent Mortality = 0.58

Percent Mortality Due to Marking = 1.46

1/ These figures not used in estimating mortality due to marking due to reason cited in remarks column.

2/ These figures arrived at by using number of fish per dip as cited on page

TABLE 7

RESULTS OF THE STOMACH ANALYSIS OF MEW GULLS
GLAUCOUS-WINGED GULLS, AND ARCTIC TERNS
COLLECTED ON THE KASKANAK FLATS, KVICHAK RIVER, 1968

Species	Number Collected	Stomach Contents
Mew gull (Larus canus)	6	No food
Glaucous-winged gull (Larus glaucescens)	2	No food
Arctic tern (Sterna paradisaea)	1	Small fish and Plecoptera
	1	1 smolt
	1	No food
	1	No food
	1	Aquatic insects

It is noteworthy that a step of the collecting procedure was overlooked. The stomachs were not perforated to permit the penetration of formalin to stop the digestive processes. Some food items could have been lost.

TABLE 8

STOMACH CONTENTS OF THE ARCTIC CHAR AND RAINBOW TROUT
COLLECTED AT ILIAMNA LAKE OUTLET, 1968

Species	Number Collected	Stomach Contents
Arctic char (Salvelinus alpinus)	1	4 sockeye smolt
	1	3 sticklebacks (?), several hundred Tendipedidae (Diptera) larvae
	1	17 acquatic snails
	1	1 fish vertebral column, approx. 4" in length
Rainbow trout (Salmo gairdneri)	1	1 sockeye smolt
	1	No food

filled pontoons decked over the rear. The enclosure, basket, and louver section were built of steel angle iron, plywood and wood. The lead consisted of a pipe frame and knotted nylon netting. The trap was held in position in the river with a combination of two shore lines and two anchor ropes. When positioned, it was about 75 feet offshore.

The power source to revolve the basket was a 1/2 horsepower variable speed electric motor. This was connected via an A drive belt, to a Boston Gear Reductor with a reduction ratio of 60 to 1. Using 3/4 pitch chain and 12 and 96 tooth gears power was transferred from the gear reductor to the axle on which the basket revolved. Mechanically, this proved to be effective and the basket was able to revolve at 1 RPM with a speed of 4,000 RPM on the electric motor. Electricity to run the motor was provided by a 9 HP Briggs and Stratton engine with an Everlite 3500 watt generator.

To examine for marked fish a plywood shelter was built on the decked over portion of the pontoons. Within this were housed two fiberglassed examination troughs and two 100 w. long-wave ultra-violet lamps for examination purposes and all the electronic gear which consisted of the photo counters and the Simrad unit. Also incorporated in this was a water pump to supply a steady regulated flow to the examination troughs.

On the offshore side of the pontoons were attached two 6 ft. by 3 ft. by 3 ft. deep live boxes. The upstream box served as a receiver for the fish that were flumed out of the dipper basket. The current, which entered through a screened over aperture, then would motivate the fish to swim through a photo-tunnel which connected to the downstream live box. On the photo-tunnel was mounted the photo-heads which were to count the fish. (To check the accuracy of the counters, other than calibration, hand talliers were to be used by the men examining for marked fish). Out of this last box the fish were to be dipped out with a net and put into the examination troughs.

In addition to this we used a Simrad unit in an attempt to determine the diurnal movements of the schools of passing smolt. The transducer was placed in the middle of the river, on the bottom, with the face plate facing the surface of the river. In this way vertical movements could be detected on the recorder tape and give us an idea on the effectiveness of the migrant dipper at different periods of a 24-hour period. However, no 24 hour recordings were made because of the lack of smolt in the river after the unit was in operation.

The failure of the dipper to capture fish in sufficient numbers was due primarily to difficulties in assembling and anchoring this complex piece of equipment. The problems resulted in the dipper not being fully operational

until June 1. At that time 92 percent of the recorded seasonal catch had already been made at the index site.

Another problem which made it impossible to test the dipper even on the remaining part of the outmigration after June 1 hinged on the lack of mobility of the dipper and a behavioral pattern of the smolt. This behavior pattern was only observed for a short period of time at low migration levels, but could affect future sampling. Smolt were observed to migrate in a 50-foot wide band down the middle of the river for a period of eight consecutive hours on the dates of June 1 at 2100 hours and extending to 0500 hours on June 2. This pattern was determined by observations made on the jumping action on the surface of the river. The fish seemed to be following the swiftest section of the river. The width of the river at Big Rock is approximately 400 feet.

This was contrary to one of the basic assumptions of the sampling scheme, that being that the smolt would randomly distribute themselves across the river, thus insuring a random sample of the passing outmigrants. Had this been the case, it was felt the dipper would have caught smolt as they were observed in the enclosure prior to the time the dipper was in operation. During the period of operation, pink salmon fry and rainbow trout up to 150 mm in length were captured in appreciable numbers, thus illustrating the fact that the trap was working effectively. As there were insufficient numbers of smolt captured, neither length frequency nor scale samples were taken.

Before or in conjunction with any further sampling at Big Rock studies should be done on the vertical and lateral distribution of smolt as related to velocity, turbidity and whether they are passing in daylight or darkness. It is possible that a dipper operation would require more than a single piece of gear and greatly expanded leads.

B. Review of the 1967 Mark-Recovery Program

In 1967 a mark-recovery program was conducted under the direction of Mr. Steve Pennoyer and Mr. Donald Stewart. Through literature research and contact with other scientists it was thought that a mark-recovery program utilizing a mechanical method of sampling offered the most feasible method of obtaining a total population estimation. Other fields such as electronics had at yet not evolved sufficiently enough to be of value in this type of program. Following is a symposium of their methods, procedures, and results.

"Originally two approaches to obtaining an estimate of the total outmigration were planned. One was labeled the volumetric method and was based on estimates of smolt passage rate expressed in catch per volume of water versus total flow. Catches were to be made with a mobile trap propelled by

two outboard motors. This trap and its operation were described in detail in in earlier progress report, the trap was not usable due to smolt avoidance".

"The second method was mark-recovery utilizing compressed air and a fluorescent pigment to mark the smolt. The marking technique was described in a previous progress report. Numbers of fish marked by date, color of dye, times of capture and release, and recovery percentages are shown in Table 9. This project was done in cooperation with the U.S. Fish and Wildlife Service who were attempting to recover marked smolt in the Bristol Bay estuary for racial identification. To increase the number of marked fish in the population, 18,489 additional fish were marked on June 11 and 12 for which no recovery effort was made."

"In conjunction with the marking phase (conducted at the index site) of the mark-recapture experiment, studies directly related to the success of such a method of smolt population estimation was conducted."

"First of all, an attempt to evaluate short term mortalities incurred due to marking, was conducted by actual study in the field and research of literature pertaining to juvenile salmonid mortalities due to the marking technique."

"In addition to the short term mortality study, records of immediate mortalities after marking were maintained from May 27 - June 9. From May 26 - June 9 the marking procedure was to mark all smolt and hold one hour before releasing to allow any excess dye to slough off by water action. At the time of release, numbers of mortalities and general condition of fish were recorded. Eighty-five thousand and sixty-two (85,062) smolt were marked (Table 10) during the above period with a total mortality of 350 smolt or 0.4 percent of the total number marked. Immediate mortality, therefore, can be termed insignificant."

"The same dye as used by Phinney (granular form) was employed under a constant 100 p.s.i. In order to keep resultant mortality data of the two groups as unbiased as possible, the following procedure was used with the exception of number two for the control group."

(1) Smolt were taken from the live tank by dip net and weighed until 5 pounds were obtained.

(2) Weighed smolt were placed in a fiberglass marking trough and marked in the same manner, i.e., gun held approximately 18 inches from smolt and three complete passes with the gun to assure good dye coverage.

Table 9

RED SALMON SMOLT
TAGGING DATA - KVICHAK RIVER
1967

Date	Color	Time of Capture	Time of Release	Number Of Fish	Number Recovered[1]	% Recoveries	Total Recoveries	% Marked
May 26	Red	2200		960				
27	Green	2200	2400	2,162				
	"	2300	2400	286				
28	Red-Green	2100	0115	1,295				
	"	0000	0115	986				
29	Red	2200	2330	6,202				
30	Green	2222	2305	15,688	1	.006	11,842	.01
31	Red-Green	2007	2325	4,908				
	"	2300	0115	5,876	2	.018	108	1.85
June 1	Red		2400	5,278	6	.114	8,183	.07
2	Green	2100	2300	11,092				
	"	2300	0100	1,346	7	.056	22,328	.03
6	Red-Green	2200	immed.	14,796	18	.122	22,686	.08
7	Red	1200	1430	7,762				
	"	1500	1645	5,656				
	"	2100	2300	2,752	22	.078	27,849	.08
	"	2300	2355	6,363				
	"	2317	0050	5,563				
8	Green	2100	0025	3,948	1	.025	8,354	.01
9	Red-Green	1931	2053	4,993				
	"	2000	2105	4,208	11	.103	11,238	1.00
	"	2400	0215	1,435				
11	Red	2200	2253	5,091				
12	"	0645	0803	8,199				
	"	1031	1105	5,199				
Total				132,044	68	.06[2]		

1/ Generally 6 to 24 hours following mark-release, unless later tag recoveries made. In no case were periods of time over 36 hours used.

2/ This percentage derived exclusive of 18,489 fish marked on June 11 and 12 for which no recovery effort was made.

Table 10

IMMEDIATE MORTALITIES AND CONDITION OF SMOLT ATTRIBUTED TO HANDLING AND MARKING, KVICHAK RIVER, 1967[1/]

Date	No. of Smolt Marked	Mortalities	Condition[2/]
5/27	2,447	20	Good
5/28	2,281	86	Good
5/29	6,202	-[3/]	Good
5/30	15,688	-[3/]	Good
5/31	10,784	44	Good
6/1	5,278	30	Good
6/2	12,439	113	Good
6/6	14,796	15	Good
6/7	28,096	41	Good
6/8	3,948	1	Good
6/9	4,993	0	Good
Total[4/]	85,062	350	

Percent Mortalities = 0.4%

1/ Smolt were held one hour before release to allow excess dye to slough off.

2/ Condition was described as good if no erratic movements such as "finning", frequent surfacing or "bellying" up occurred.

3/ On 5/28 and 5/29 dead smolt sank to the bottom of the holding tank making enumeration impossible with large numbers of live smolt present - usually smolt were held against the tail gate of the live tank making enumeration possible.

4/ This total excludes marked smolt and mortalities occurring on 5/28-29.

(3) Smolt were then flushed from the marking trough into a 30 gallon galvanized tub and transported as fast as possible (average 5 minutes) to the divided live tank for future observation.

"The control group of fish was handled in the same manner as the marked group except for marking."

"The live tank mentioned in item three above measured 4' x 4' x 8' and was divided into two equal compartments, one for the marked group of smolt and one for the control group."

"The frame was constructed of 2" x 4"'s and covered with 1/4 mesh knotless nylon netting. To prevent predation by birds during the testing period, a top fabricated of 2 x 2's for the frame and covered with 1/4 mesh knotless nylon netting was used."

"The live tank was situated in approximately 3.5 feet of water with a current velocity of 1.5 - 2 feet per second. This is probably less current than experienced by marked smolt in the outmigration population. However, this location was selected as the least likely spot to be bothered should a heavy ice flow occur."

"In comparing the above to other studies (Scidmore, 1961) reports that the compressed air technique was used for marking eight lots of brown trout ranging from 4.5 to 6.0 inches. In this study both granule and powder-like material was applied at pressures ranging from 100-200 p.s.i. Observations were conducted for 197 days. Although some loss of fish occurred during this time, Scidmore states that, 'In no instance did the loss of fish appear to be attributable to the marking technique of the marking materials.' The loss of fish was attributed to difficulties with the water supply."

"Also, (Phinney, 1967) reports that 'Mortality directly attributable to marking was negligible.' In this group of experiments, different air pressures (p.s.i.) were used for application of the pigment, which is a solid solution of fluorescent dye in a melamine-sulfonamide-formaldehyde resin that is commonly used in manufacturing textile coatings, printing inks, paints, and paper coatings. He further states that the pigment is slightly soluble in acetone and many other ketones, but insoluble in water, formaldehyde, and in aliphatic and most aromatic hydrocarbons."

"Several size groups of age-0 and age-I sockeye, coho, pink salmon and rainbow trout were marked. Total mortality was 10 percent in each of the marked groups and 7.5 percent in the unmarked control group."

"In summary, the above discussion suggests that immediate and, in fact, long-range mortality rates (Phinney, 1967), (Scidmore, 1961) are insignificant due to mass-marking of young salmonids with fluorescent pigment applied at pressures between 70 - 120 p.s.i."

"The short-term mortality experiment was carried out during an 11 day period (June 11 - June 22) using a random five-pound sample of marked red salmon smolt (350). This is also true for the control group."

"The first day of the experiment, four observations at different times were made. The second and third day, two observations were made. From the third day to the end of the test, observations were made, but no mortalities occurred until the last day."

"As can be seen in Table 11of the marked group, a total of 156 mortalities were recorded during the test or 44.6 percent of the total number marked. Of special interest is that of the total mortality, 79.4 percent occurred during the first 13 hours of the 11-day test."

"Again referring to Table 11, one can see that the control group suffered a 26.6 percent mortality (93 smolt) of the total, during the test and of the total mortality, 55.9 percent occurred in the first 12 hours of the test."

"By the above, we might conclude then that mortalities attributed to marking is 18 percent. However, it must be kept in mind that this was not a repetitious test, no assessment of mortality due to fungus or starvation was made if any exists, and the stream condition, i.e., temperature and velocity were different than conditions that normally marked fish in the outmigration would experience."

"Considering our test and previous tests by other individuals and agencies, we felt 18 percent is extremely high to attribute to marking. Repetitious tests and more refined methods of experimentation will be conducted in 1968 and hopefully denounce the findings of this year's single experiment."

"The mark recovery effort was situated in the canyon above Big Rock, some 30 miles downriver from Lake Iliamna and 27 miles below the index marking site (Figure 1). Men and gear for this site were flown in to Iguigig on May 15 and ferried downriver by boat on May 16, 17, and 18. A seven-man camp was established in the canyon."

"The primary recovery gear was a tow net with a nine foot square opening and no wings. The net was towed by two skiffs powered with 33 and 40 h.p. outboard motors (one on each). Measurement of velocity relative to the current at a time when the net was being towed properly showed 3.5 feet per

Table 11

RESULTS OF SHORT TERM MORTALITY OF MARKED AND UNMARKED RED SALMON SMOLT, KVICHAK RIVER, 1967[1/]

Marked			Unmarked		
Date	Observation Time	Mortalities	Date	Observation Time	Mortalities
6/11	1540	5	6/11	1605	2
"	2140	85	"	2140	39
"	0340	39	"	0400	13
"	0940	2	"	1000	6
6/12	0400	18	6/12	0400	6
"	1000	0	"	1000	0
6/13	0400	5	6/13	0400	0
"	1000	0	"	1000	1
6/22	1500	2	6/22	1500	26
Total		156	Total		93
Mortality = 44.6%			Mortality = 26.6%		

Mortality attributed to marking = 18.0%

1/ A total of 350 marked red salmon smolt and 350 unmarked smolt were used for this test.

second. However, this was probably a maximum and not an average. It was difficult to hold the skiffs even and considerable yawing occurred with resultant variations in towing velocity."

"A floating live box was attached to the terminal end of the tow net by a section of rubber hose. The fish collected in this box were transferred to live tanks around the anchored mark recovery skiff or dipped directly from the floating live box for examination. Net loads were weighed and poured down a fiberglassed trough under a 100-watt long-wave ultra-violet light. Number of fish per pound was determined and used to expand cumulative weight of net loads less the weight of the fish to yield total fish examined per sample."

"Towing commenced on May 28 and was terminated on June 10. During this period 177,658 fish (Table 12) were examined for marks and 68 marked fish were recovered. As can be seen in Table 12, towing success was extremely variable. All of the marked fish were recovered in 18 tows with a total catch of 97,776. Forty-two tows with a catch of 79,882 yielded no marked fish. As shown in Table 13 the percentage of marked fish in the successful tows was also quite variable (.01-1.85). Seasonally .06 percent of the fish marked May 26-June 9 were recovered. No recovery effort was made on June 5 and 6 since no fish were marked at the index site on June 3, 4 and 5."

"The tow net operation required a minimum of three men and the mark-examination at least two. It was, therefore, impossible to operate on a 24-hour basis. Normally a twelve-hour gap occurs in the outmigration at the index site during daylight hours. An attempt was made to coordinate recovery effort with periods of migration and thus achieve complete coverage. This, however, proved very difficult since the hours of migration at Big Rock varied from day to day. On some days peak migration seemed to occur in the middle of the night and on others mid to late afternoon. This is illustrated by the fact that some color groups were first recorded at the recovery site in as little as seven hours after release, while others took up to 18. (Some groups were first recorded in the catches in longer intervals from release, but this was always when the first part of the day's outmigration was missed.) Individual recoveries varied from seven hours after release to 106 (Table 12). However, it is likely that both the 63 and 106 hour recoveries were mistaken identifications of color code due either to one color of a combination being scraped off or unwanted dye particles not being completely washed out of the spray cannister. The other 66 recoveries averaged 17.2 hours from mark-release to recovery."

"A tidal reversal occurs at Big Rock and tidal influence is felt as far upriver as the upper end of Otter Island. Smolt migration is, therefore, subject to tidal changes for some 16 miles or 60 percent of the distance from the

Table 12

RED SALMON SMOLT
MARK-RECOVERY DATA - KVICHAK RIVER, BIG ROCK
1967

Date	Times	Catch	Catch/Min	Recoveries: Red #	Red Hrs. Out	Green #	Green Hrs. Out	Red-Green #	Red-Green Hrs. Out	No. Per Pound	Remarks
May 28	2130-	83	-							69	Fyke Net
29	0130-	32	-							-	Trap
	2135 (8 min)	537	67.1							88	Net Twisting
	2300-2318	1,011	56.2							79	
30	0030-	22	-							-	
	1400-	0	0							-	
	1500-	0	0							-	Downstream
	2135-2147	-	-							-	Net Twisted
	2215-2245	1,817	60.6							77	No Surface Activity
	2320-2335	-	-							-	Tow Rope Broke
31	0045-0115	1,917	63.9							83	
	0140-	-	-							-	Net Twisted
	0200-0214	20	1.4							-	Not Examined
	0310-0325	0	0							-	Little Fish Activity
	2120-2205	11,842	263.2			1	23			86	1st Activity @ 1830
	2245-2300	7,105	473.7							-	Water Turbid
	2337-	-	-								Bad Set Damaged Net
June 1	0210-0225	1,810	120.7*							85	*Net Plugged Dumped ½
	0308-0313	7,094	1,418.8*							79	* " " " "
	0420-0423	0	-							-	
	2108-2123	108	7.2					2	22-20	83	
	2258-2340	430	10.2							86	
2	0029-0128	365	6.2							73	
	0256-0345	0	-							-	
	1525-1555	1,378	45.9							84	Heavy Smolt Activity
	1629-1644	6,296	419.7	1	16					80	Otter Is - Index
	1703-1725	1,454	66.1	2	17					92	
	2043-2143	0	-							-	
	2250-2315	50	2.0							-	Not Examined

Table 12(Continued)

RED SALMON SMOLT
MARK-RECOVERY DATA - KVICHAK RIVER, BIG ROCK
1967

Date	Times	Catch	Catch/Min	Recoveries						No. Per Pound	Remarks
				Red		Green		Red-Green			
				#	Hrs. Out	#	Hrs. Out	#	Hrs. Out		
June 2	2329-2353	433	18.0	3	24					76	
3	0030-0100	697	23.2							81	
	0150-0215	5,773	230.9							82	
	0405-0425	983	49.2							84	
	0450-0455	0	-							-	
	0520-0530	2,430	243.0							81	
	1705-1743	2,781	73.2			2	18-16			79	
	1925-	-									Bad Tow
	1950-2000	0	-							-	
	2005-2025	0	-							-	
	2147-2247	1,233	20.6							90	
4	0007-0022	3,741	249.4			2	25-23			87	
	0040-0050	4,740	474.0			2	25-23			82	
	0205-0220	1,615	107.7							82	
	1235-1305	1,462	48.6							84	
	1707-1734	5,888	218.1							92	
	1800-	4,272								87	Water Turbid
	1914-1944	310	10.3							-	
7	1100-1130	11,066	368.9			1	106-104	11	13	91	
	1335-1350	943	62.9					1	15	82	
	1638-1653	6,931	462.1					2	18	96	
	1708-1723	2,723	181.5							89	
	2114-2141	435	16.1	1	7			2	23	87	
8	1131-1201	3,311	110.4	13	21-11			1	37	93	
	1424-1454	14,810	493.7	5	24-14					95	
	1657-1712	3,183	212.2	1	26-16					92	
	1853-1908	2,226	148.4							92	
	2053-2108	2,700	180.0							86	

Table 12(Continued)

RED SALMON SMOLT
MARK-RECOVERY DATA - KVICHAK RIVER, BIG ROCK
1967

Date	Times	Catch	Catch/Min	Recoveries						No. Per Pound	Remarks
				Red		Green		Red-Green			
				#	Hrs. Out	#	Hrs. Out	#	Hrs. Out		
9*	0900-	8,850								92	Catch Partially Released
	1300-1330	6,110	203.7	2	47-37			1	63	94	
	1600-	3,159								88	
	1800-	8,354				1	18			91	
	1900-	5,960								86	
	2200-	1,861								82	
10**	0900-	11,238						11	12-7	91	
	1330-	959								82	
	1702-1732	0								-	
	2030	3,110								81	

* Times of tows for June 9-10 were kept in crew leader's notebook and will not be available until he returns to Alaska on January 8, 1968.

** A few tows were made on June 11-12, but catches were either 0 or not examined.

Table 13

KVICHAK RIVER
TOW SUCCESS
1967 RED SALMON SMOLT OUTMIGRATION

Tows in Which Marks Recovered # Fish	# Marks	% Marks	Tows with No Mark Recovery # Fish
11,842	1	.01	83
108	2	1.85	32
6,296	1	.02	537
1,454	2	.14	1,011
433	3	.69	22
2,781	2	.07	1,817
3,741	2	.05	1,917
4,740	2	.04	20
11,066	12	.11	0
943	1	.11	7,105
6,931	2	.03	1,810
435	3	.69	7,094
3,311	14	.42	0
14,810	5	.03	430
3,183	1	.03	365
6,110	3	.03	0
8,354	1	.01	1,378
11,238	11	.10	0
			50
			697
			5,773
			983
			0
			2,430
			0
			0
			1,233
			1,615
			1,462
			5,888
			4,272
			310
			2,723
			2,226
			2,700
			8,850
			3,159
			5,960
			1,861
			959
			0
			3,110
Totals 97,776	68	.07 N=18	79,882 N=42

index site to Big Rock. It seems probable that the stage of the tide when the smolt reach the lower end of Kaskanak Flats plays a major role in migration timing. If tidal action in this stretch of river was better understood, it might be possible to predict times of peak daily migration at Big Rock."

"As was mentioned in the July 1967 progress report, there was a general lack of mixing of marked fish. The schools apparently maintained their cohesiveness from the index site. Better than one-half of the recoveries were made in three tows with 69.4 percent of the tows representing 44.9 percent of the catch containing no marked fish. In 1967 marked fish were generally released in groups at the marking site on the assumption that in over 27 miles of river, multiple channel areas, and tidally affected stretches, the fish would mix. Apparently this assumption is unwarranted and future operations will have to take this into account."

"The overall recovery rate of only .06 percent is not very great, but evaluation of the mark-recovery method should not be based on this. As mentioned above, the fishing effort did not always cover the day's migration and the marked fish tended to arrive in groups, e.g., on June 7 twelve marked fish were recovered on the first tow of the day. It is probable that segments of the migration with large proportions of marked members were missed altogether. Also, due to problems with the gear, greenness of the crew and lack of any knowledge of daily migration timing, fishing prior to June 1 was extremely inefficient. From June 1 - 10, the mark-recovery success was .08 percent. It is probable that this proportion could have been doubled even with present crew and methods by some modification of live boxes and examination techniques."

"It is still felt that mark-recovery offers the best chance of obtaining a total outmigration estimate in the Kvichak 2/. Some modifications in methods and gear will be necessary and are being worked on. Among these:

1. Tow Net: The tow net is generally unsatisfactory for mark-recovery for the following reasons:

   a. Scaling of fish and removal of pigment. This is fairly serious with this form of gear. Fish tend to jam in the

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2/ Note: This does not represent current thinking since electronic means of counting may now be available.

throat of the net and often had to be poured into the live box. This could possibly be corrected, but it would probably mean using a more powerful means of propulsion to increase water velocity through the net and even when the fish didn't jam considerable scaling occurred.

b. Operation of the tow net on a 24-hour basis would require a six man crew.

c. It is nearly impossible to maintain a fishing schedule around the clock that will expose all segments of the run to an equal chance of capture. Even within a single run variations in velocity and course occur.

d. Handling of the catch from a tow net operation is difficult and at high passage rates the small live box is quickly jammed.

For these reasons we have been investigating other forms of capture gear. The migrant dipper downstream migrant trap seems to offer some promise. It is a motor driven fishwheel apparatus developed by the U.S. Fish and Wildlife Service, Montlake Laboratory, for use at low current velocities. It may be possible to work a photo-counter apparatus into the design to eliminate one portion of the handling.

2. Live box and examination. Presently too much time is consumed and the fish handled too often from tow net to examination trough. It is hoped that with the migrant dipper capture, counting, and holding gear can all be incorporated into one design. A raft with two examination troughs and the live tank would be situated off the back of the dipper.

3. Examination trough. More room is needed and a mechanical water supply would be desirable. It may prove advantageous to build a glass section into the trough with a mirror underneath to detect fish marked on one side only.

4. As discussed before the marking site will be located at Otter Island next year and marking will be conducted on a 24-hour basis.

5. Modification of mark-capture gear will be made employing a simulated version of the standard fyke net now in use on the Kvichak River.

a. The capture device will be of the same dimensions as the fyke net, but will be fabricated of an aluminum frame

covered with 1/4 mesh hardware cloth rather than cotton or nylon webbing. This will facilitate the cleaning of the gear, in that hardware cloth cleans easier of algae and debris than does cotton or nylon, and the amount of time involved in removing and placing the gear in the water will be greatly reduced. The reason for reduction in time is that the standard fyke net has to be collapsed in the water, then manually horsed aboard the skiff; also, much time is consumed in the setting of a fyke net. The new gear will be fished from a stationary platform, i.e., suspended between two styrofoam filled pontoons. When setting or taking the gear from the water, it will involve only letting out line attached to a hand operated winch or retrieving line with the winch respectively.

b. An alternate method of capturing smolt is under consideration should the above gear be hampered by long periods of ice interference. Using such gear, the marking operation could be moved downstream to an ice-free location and continue to mark. Specifications for this gear have been drawn up and submitted to different firms for price estimates.

6. Problems arose this year when dye accumulated too much moisture and would clog the nozzle of the sand blasting gun. This event resulted with uneven distribution of dye on smolt and prolonged periods of time out of water. We hope to circumvent this problem by filling several different cannisters at one time at the living site which will offer a dry environment as compared to filling the cannisters at the site of marking which is often quite damp.

7. Handling of smolt to be marked this year was also a problem and we feel probably contributed to the high mortality of marked smolt in the short term mortality study.

   a. We hope to reduce handling time this year by incorporating a photo-electric counter at the terminus of the capture gear. By doing this, we can calibrate as done at the index site to arrive at numbers of smolt marked rather than the netting and weighing method used this year.

8. Mortality and predation studies were inadequate this year in that tests were not repetitious and methods not refined enough. Observations made this year and the use of SCUBA gear will greatly enhance 1968 studies."

C. Differences in Age Composition Between the Index and Site 5 Fyke Net Catches, 1968

Toward the end of the outmigration, differences in the age composition were noted between the two fyke net sites (Figures 5 and 6). It was also reported by the crew leader of the mark site that some of the largest catches were obtained after the index site catches were in the final decline. Consequently, it is planned to fish Site 5 again in 1969 to obtain more information in order to further evaluate the index fyke net catches.

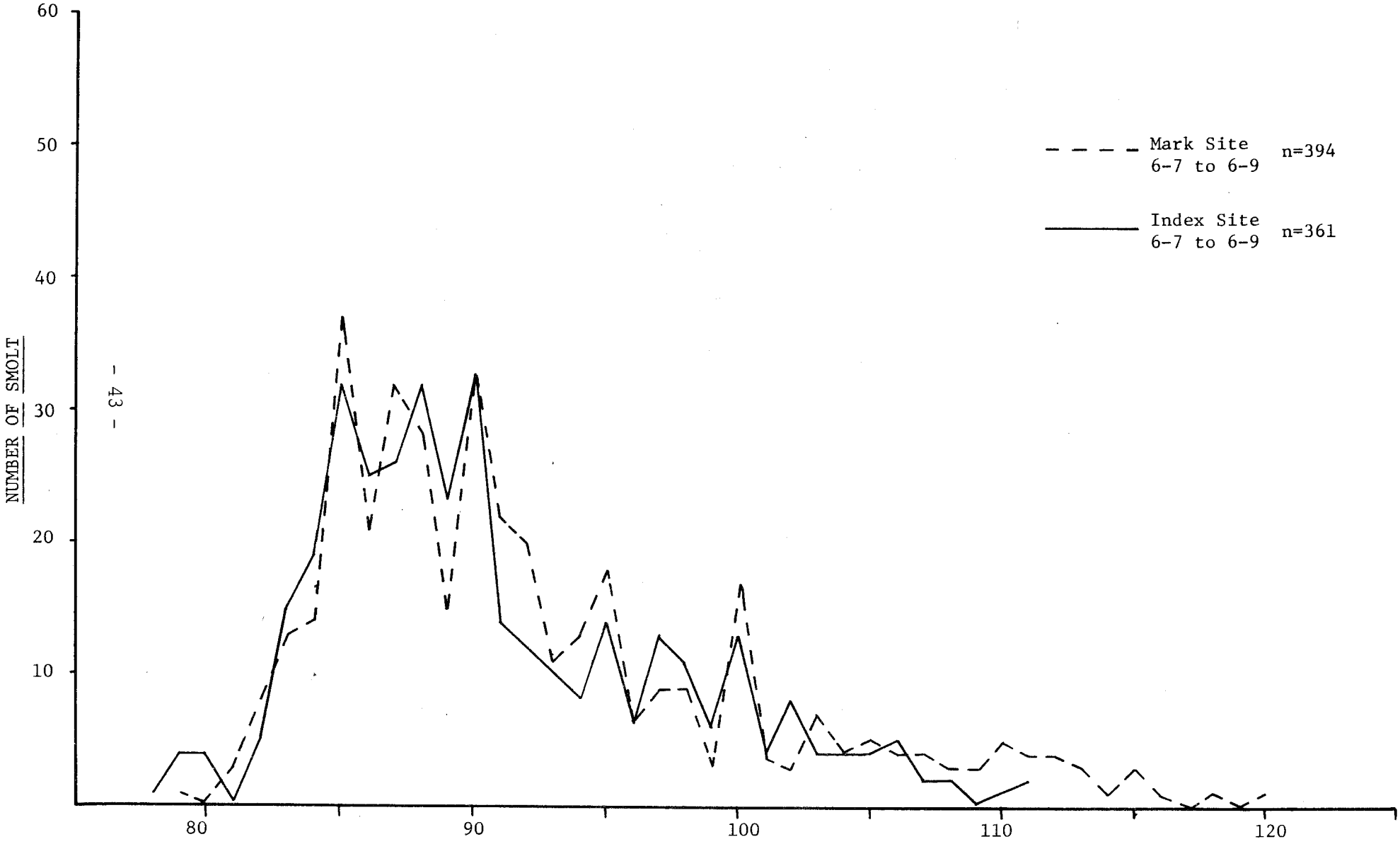

Figure 5 . Comparison of Mark and Index Site fyke net catches, June 3-6, Kvichak River, 1968.

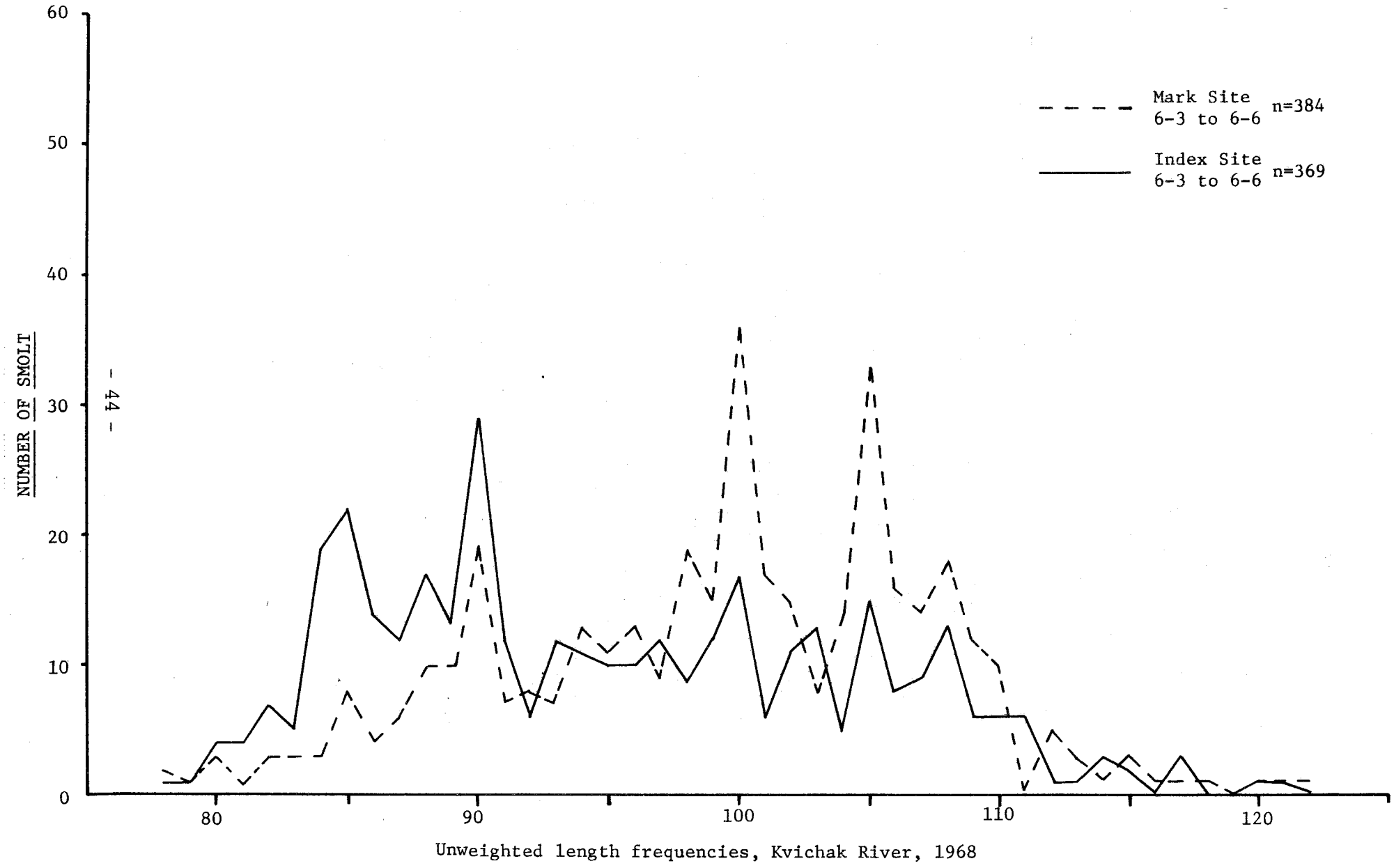

Figure 6 . **Comparison of Mark and Index Site fyke net catches, June 6-9, Kvichak River, 1968.**

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ABUNDANCE, SIZE AND AGE OF SOCKEYE SALMON SMOLT FROM THE UGASHIK RIVER LAKES SYSTEM, 1968

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I. INTRODUCTION

The Ugashik sockeye salmon (Oncorhynchus nerka) smolt enumeration and sampling program conducted annually since 1956, except 1966, was continued during 1968.

Data obtained from this program is used to estimate the size, age composition, average lengths and weights by age class of the total smolt outmigration. These estimates are used in prediction of future adult run size and calculation of optimum escapement for the system. The 1968 outmigration was the progeny of the 1965 brood year escapement of 996,612 and the 1966 brood year escapement of 704,436.

Field work was under the supervision of the writer with Michael L. Nelson, Assistant Area Biologist, assisting with the program design. Participants in the program were Jerome J. Sexton, Robert C. Hansen, Herbert T. Ertheridge III and John F. Ratterman.

II. METHODS AND PROCEDURES

Ugashik River program designs, fyke netting procedures and methods for collecting field data are discussed in Nelson, 1965. Modifications of the sampling design in used during the 1968 study were as follows: (1) fishing a 24-hour schedule one out of three nights, (2) collecting 10 extra scale samples from smolt between 100 and 120 millimeters in length, for age group separation, (3) collecting 20 extra scale samples during nights of large smolt outmigrations, and (4) fishing the random schedule two out of every three nights as well as during nights of heavy outmigrations.

Further, the fyke net sampling design was modified to allow the use of a floating smolt live box which replaced the standard cod-end as fished in

previous years. The floating live box was used only on the index net site.

A smolt live box made of three-eights inch marine plywood and covered with fiberglass was used at the index net (Site No. 4) in place of the standard fyke net cod-end (Figure 1). This live box was patterned after the design discussed by Craddock 1961, but was modified to allow the use of two aluminum weighing baskets in divided compartments (Figure 2). A partition in front of the weighing baskets was fitted with a sliding door which allowed the alternate use of the weighing basket.

A flexible six-inch diameter rubber tube was used to carry the trapped smolt from the fyke net to the floating live box. A desirable catch per weighing basket was between 10-30 pounds, as catches in excess of 30 pounds were difficult to lift from the floating box. In addition, smolt were compacted in the baskets during weighing, and with catches larger than 30 pounds, smolt were noted to be less active upon release than with catches released weighing less than 30 pounds. The use of the live box and baskets facilitated handling and, it was felt reduced immediate mortalities by a reduction in scaling.

Fyke netting was conducted between May 13 and June 24 with the index net being fished between 10 p.m. and 1 a.m. and the random scheme between 9 p.m. and 2 a.m.

III. RESULTS

The total seasonal smolt catch during the three index hours from Site No. 4 was 439,587 and equal to 145.93 index points (Table 1). An index point is based upon the 1958 smolt catch of 301,231 which was assigned the base value of 100 index points.

Index net catches in 1968 were divided into two major outmigration peaks (Figure 3). Peak catches occurred on May 23 and June 2.

Total smolt caught during the random sampling scheme was 641,719 (Table 2). The majority of smolt were captured in Site No. 3 of the random sampling scheme (Table 1, Appendix B).

Twenty-four hour sampling was conducted during 13 days of the 23-day smolt season. Data collected indicated that 56.0 percent of the smolt outmigration occurred during the three index hours, and 68.5 percent occurred during the five random sampling hours (Table 3).

Smolt samples were collected and divided into seven sampling periods to determine age, weight and length for the total outmigration (Tables 4 and 5).

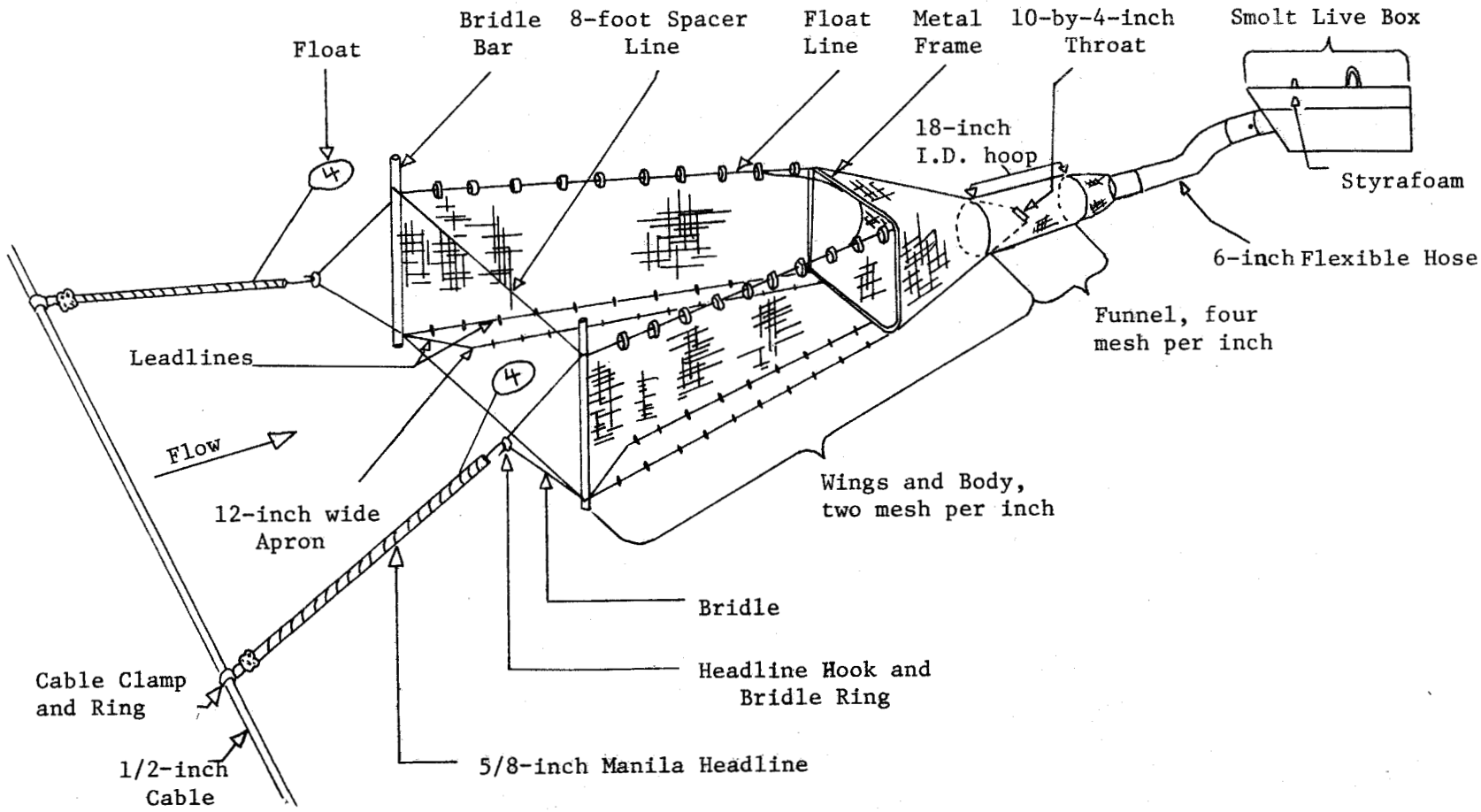

FIGURE 1. Nylon fyke net and live box used to sample sockeye salmon smolt, Ugashik River, 1968.

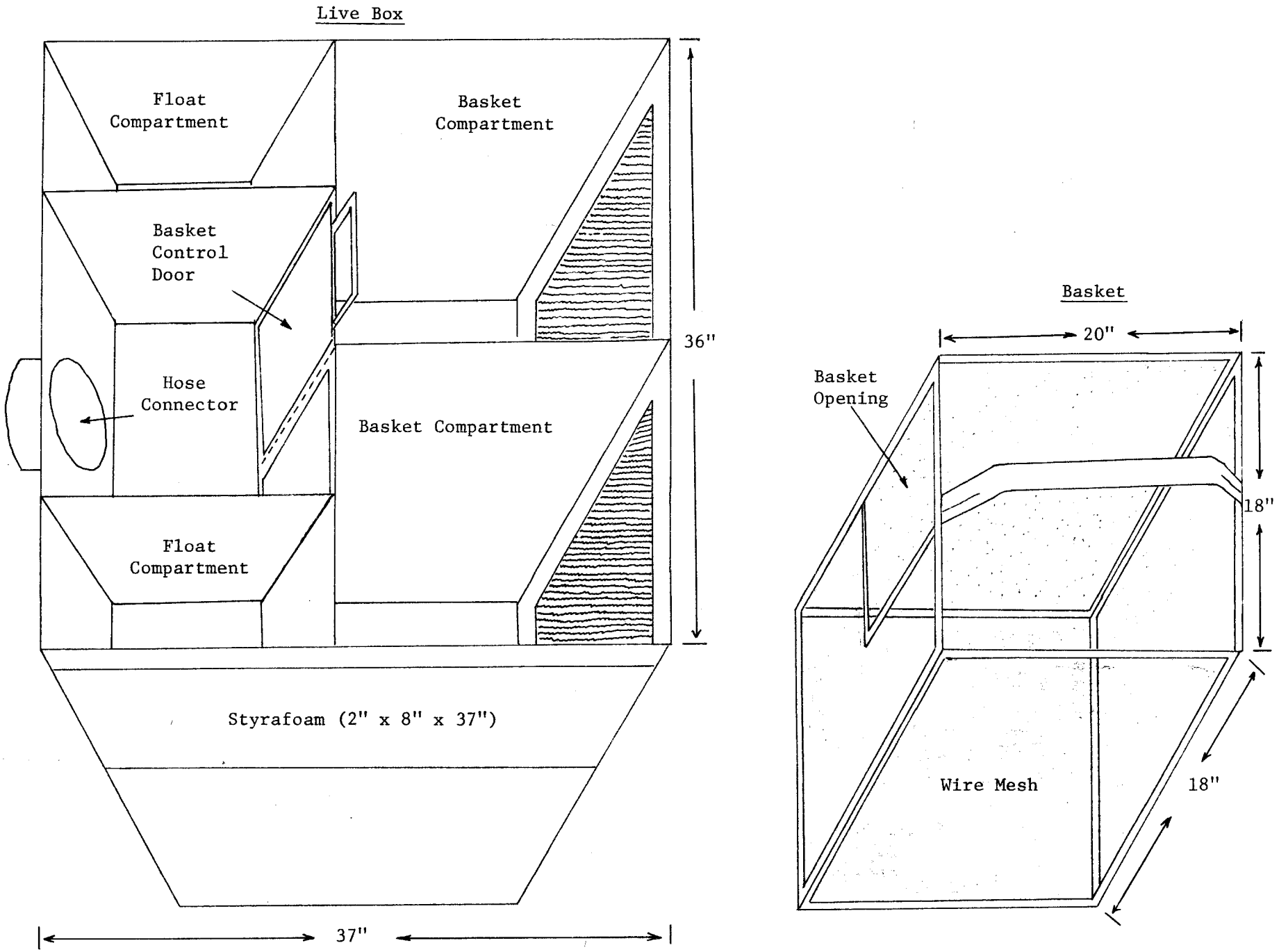

FIGURE 2. Smolt live box and weighing basket used to sample sockeye salmon smolt, Ugashik River, 1968.

TABLE 1. Ugashik River sockeye salmon smolt catch in index net by hour and day, 1968.

Date	Index Hours			Total Index Catch		Index Points[1/]	
	2200-2300	2300-2400	2400-0100	Daily	Cumulative	Daily	Cumulative
May 13	42	53	24	119	119	0.04	0.04
14	11	19	14	44	163	0.02	0.06
15	11	79	83	173	336	0.06	0.12
16	1,235	518	456	2,209	2,545	0.73	0.85
17	74	152	382	608	2,153	0.20	1.05
18	71	89	74	234	3,387	0.08	1.13
19	248	512	227	987	4,374	0.33	1.46
20	72	670	476	1,218	5,592	0.40	1.86
21	560	1,034	490	2,084	7,676	0.69	2.55
22	2,185	2,786	2,746	7,717	15,393	2.56	5.11
23	45,556	31,552	10,855	87,963	103,356	29.20	34.31
24	9,603	12,235	4,148	25,986	129,342	8.63	49.94
25	9,176	7,927	13,111	30,214	159,556	10.03	52.97
26	4,715	7,643	5,886	18,244	177,800	6.06	59.03
27	18,231	17,665	8,812	44,708	222,508	14.84	73.87
28	553	1,233	824	2,610	225,118	0.87	74.74
29	433	433	112	978	226,096	0.33	75.07
30	31	21	8	60	226,156	0.02	75.09
31	24	76	64	164	226,320	0.05	75.14
June 1	4,786	3,702	1,386	9,874	236,194	3.28	78.42
2	12,343	44,181	13,972	70,496	306,690	23.40	101.82
3	4,892	11,040	13,792	29,724	336,414	9.87	111.69
4	10,105	8,260	5,915	24,280	360,694	8.06	119.75
5	482	5,512	9,805	15,799	376,493	5.24	124.99
6	3,450	6,458	5,315	15,223	391,715	5.05	130.04
7	329	580	707	1,616	393,332	0.54	130.58
8	98	316	342	756	394,088	0.25	130.83
9	17	35	62	114	394,202	0.04	130.87
10	0	5	8	13	394,215	0.00	130.87
11	4,504	4,617	4,979	14,100	408,315	4.68	135.55
12	5,579	4,279	3,701	13,559	421,874	4.50	140.05
13	88	1,001	970	2,059	423,933	0.68	140.73
14	196	697	707	1,600	425,533	0.53	141.26
15	810	832	564	2,206	427,739	0.73	141.99

(Continued)

TABLE 1. (Con't)

Date	Index Hours			Total Index Catch		Index Points[1/]	
	2200-2300	2300-2400	2400-0100	Daily	Cumulative	Daily	Cumulative
June 16	2,015	996	562	3,573	431,312	1.19	143.18
17	272	693	511	1,476	432,788	0.49	143.67
18	318	335	366	1,019	433,807	0.34	144.01
19	67	182	68	317	434,124	0.11	144.12
20	312	342	730	1,384	435,508	0.46	144.58
21	308	794	1,245	2,347	437,855	0.78	145.36
22	1,123	228	104	1,455	439,310	0.48	145.84
23	0	2	4	6	439,316	0.00	145.84
24	19	169	83	271	439,587	.09	145.93
Total	144,944	179,953	114,690	439,587	439,587	145.93	145.93
Percent	32.97	40.94	26.09	100.00			

1/ One index point = 3,012.32 smolt.

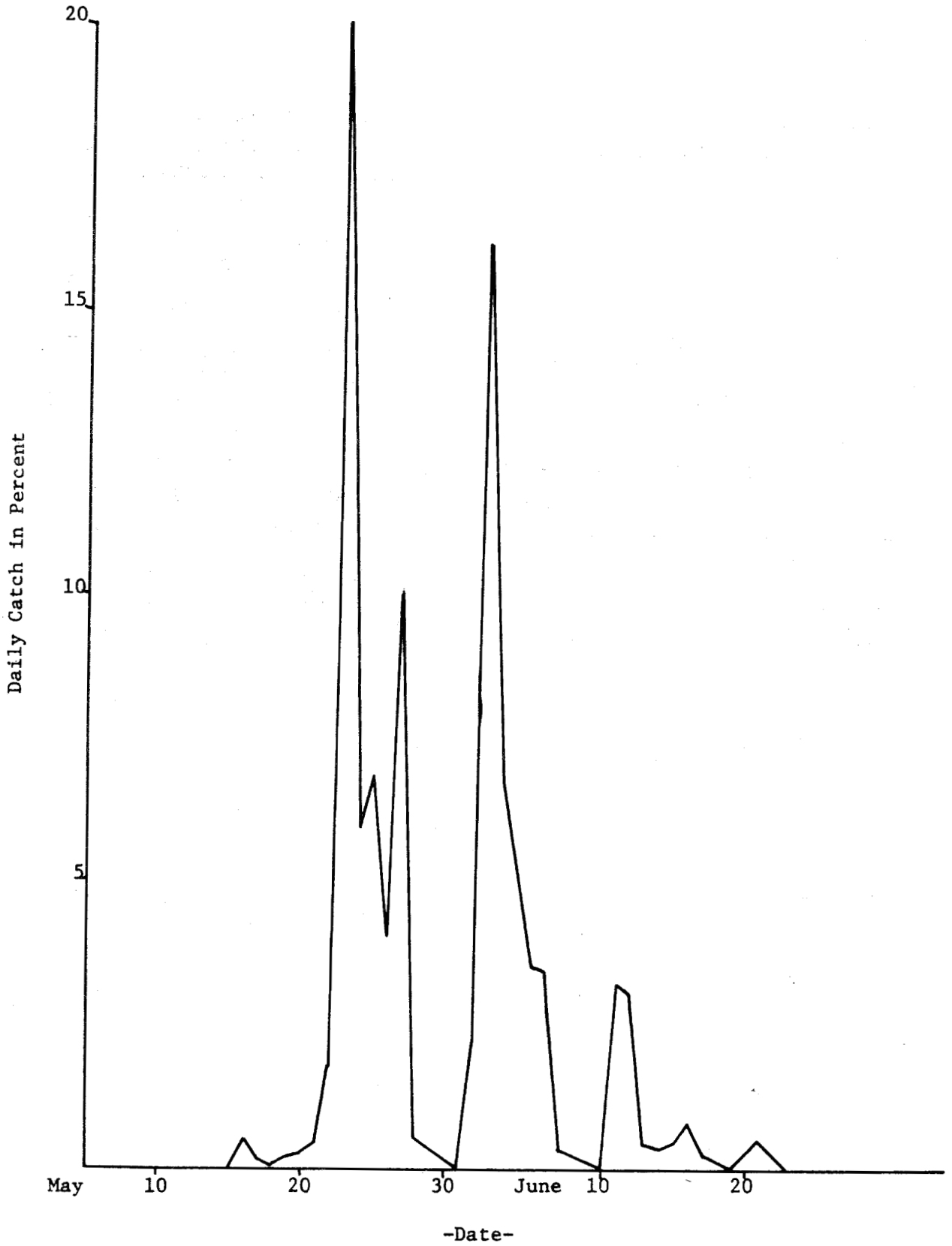

FIGURE 3. Daily index net catches of sockeye salmon smolt in percent of total index catch, Ugashik River, 1968.

TABLE 2. Ugashik River sockeye salmon smolt catches in the random sampling scheme by fishing site, 1968.

Date	Random Sampling Sites 1	2	3	4	5	Total Catch
May 13	1	5	26	53	15	100
14	10	15	5	11	6	47
16	136	1,360	228	185	183	2,092
17	8	11	22	750	345	1,136
19	29	640	1,436	1	294	2,400
20	390	1,927	929	134	71	3,451
22	15	48	2,084	2,185	1,980	6,312
23	10,872	10,770	108,477	10,855	3,516	144,490
24	10,665	3,657	7,005	4,148	10,734	36,209
25	8,644	2,864	5,489	1,311	10,722	29,030
26	27,051	24,591	46,245	7,643	488	106,018
27	9,905	247	6,241	18,231	14,886	49,510
28	1,646	13,700	1,925	57	216	17,544
29	2	4,106	2,209	112	325	6,754
31	83	95	907	30	1	1,116
June 1	19,278	5,607	252	4,786	94	30,017
2	2,014	2,240	6,794	95	1,725	12,868
3	2,297	2,648	21,254	11,040	13,369	50,608
4	1,136	2,763	9,572	13,510	7,786	34,767
6	7,532	379	5,087	6,458	1,821	21,277
7	1,056	1,511	2,443	61	254	5,325
9	277	235	1,487	17	6	2,022
10	130	1	139	8	0	278
12	142	1,286	6,567	3,701	738	12,434
13	921	2,300	1,644	1,241	163	6,269
15	148	291	1,628	412	144	2,623
16	2,804	6,578	10,985	138	190	20,695
18	382	986	224	318	1	1,911
19	9	173	433	67	23	705
21	214	2,803	754	1,245	780	5,796
22	26	3	207	9	14	259
24	38	413	186	19	0	656
Total	107,861	94,253	252,884	88,831	70,890	614,719
Percent	17.55	15.33	41.14	14.45	11.53	100.00

TABLE 3 . Ugashik River sockeye salmon smolt catch in index net over 24-hour period, 1968.

	Time Period									
Date	2200 to 2300	2300 to 2400	2400 to 0100	0100 to 0200	0200 to 0330	0330 to 0500	0500 to 0630	0630 to 0800	0800 to 0930	0930 to 1100
May 17-18	74	152	382	147	220	14	22	4	1	0
May 20-21	72	670	476	0	0	2	0	0	0	1
May 23-24	45,556	31,552	10,855	5,350	648	19	2	0	1	0
May 26-27	4,715	7,643	5,886	11,099	43,373	2,138	6,783	2,985	1,274	778
May 29-30	433	433	112	25	11	1	0	0	0	0
June 1-2	4,786	3,702	1,386	278	21	1	0	1	0	1,558
June 4-5	10,105	8,260	5,915	4,499	1,007	3	0	0	0	0
June 7-8	329	580	707	61	4	0	2	2	1	1
June 10-11	0	5	8	1	1	0	0	0	0	0
June 13-14	88	1,001	970	312	26	2	2	0	4	0
June 17-18	272	693	511	138	11	1	0	0	0	0
June 19-20	67	182	68	96	22	1	1	0	0	0
June 22-23	1,123	228	104	9	9	0	0	0	0	2
Totals	67,620	55,101	27,380	22,015	45,353	2,182	6,812	2,992	1,281	2,340
Percent	25.23	20.56	10.22	8.22	16.92	.81	2.54	1.12	.48	.87

TABLE 3. Ugashik River, 1968 (Con't).

Date	Time Period 1100 to 1230	1230 to 1400	1400 to 1530	1530 to 1700	1700 to 1830	1830 to 2000	2000 to 2100	2100 to 2200	TOTAL
May 17-18	0	347	40	8	74	1,605	184	35	3,309
May 20-21	0	0	3	0	0	1	0	23	1,248
May 23-24	1	0	0	0	1	0	551	68	94,604
May 26-27	44	4,614	1,195	909	873	2,582	1,830	878	99,599
May 29-30	0	0	0	0	0	0	0	2	1,017
June 1-2	1,758	59	768	55	6	3	1,190	95	15,667
June 4-5	0	0	0	0	0	83	2	8	29,882
June 7-8	0	0	0	186	40	296	22	7	2,238
June 10-11	0	0	0	0	0	0	196	1,114	13,25
June 13-14	0	2	2	0	0	0	0	3	2,412
June 17-18	0	0	0	105	1,233	1,540	1,051	9,198	14,753
June 19-20	0	1	0	1	0	0	2	12	453
June 22-23	5	0	0	0	0	0	0	0	1,480
Totals	1,808	5,023	2,008	1,264	2,227	6,110	5,028	11,443	267,987
Percent	.68	1.87	.75	.47	.83	2.28	1.88	4.27	100.00

TABLE 4 . Ugashik River sockeye salmon smolt sampling data, 1968.

Period No.	Date	Index Smolt Catch	Percent of Season's Total	No. of 1 lb. Samples Measured	No. of Fish Measured	No. of Scales Read
1	May 13-22	15,393	3.50	15	999	179
2	May 23-26	162,407	36.95	13	814	200
3	May 27-31	48,520	11.04	11	640	158
4	June 1-5	150,173	34.16	14	1,010	226
5	June 6-10	17,722	4.03	9	567	129
6	June 11-15	33,524	7.62	15	1,094	151
7	June 16-24	11,848	2.70	23	1,603	171
	Totals	439,587	100.00	100	6,727	1,220

TABLE 5. Age, length and weight of sockeye salmon smolt by sampling period from the Ugashik River system, 1968.

Period No.	Date	Mean Length in mm. of Age Group		Mean Weight in gr. of Age Group		Percentage of Age Group	
		I	II	I	II	I	II
1	May 13-22	93.9	110.4	6.8	9.9	90.6	9.4
2	May 23-26	93.8	110.0	6.7	10.1	89.1	10.9
3	May 27-31	94.2	113.7	6.8	11.5	90.5	9.5
4	June 1-5	91.7	113.2	6.2	10.8	97.2	2.8
5	June 6-10	92.3	118.1	7.9	12.4	90.1	9.9
6	June 11-15	91.2	117.3	6.2	10.9	98.6	1.4
7	June 16-24	91.7	116.9	6.5	11.0	99.1	0.9
Season's Weighted Totals		92.8	112.6	6.5	10.7	93.1	6.9

Note: Age groups I and II denote number winters in freshwater.
Season total weighted by index catch.

Size composition was determined from 6,727 smolt contained in 100 one-pound samples while the age composition was determined from 1,220 smolt scales (Table 5).

The average length and weight of Age I smolt were 92.8 millimeters and 6.5 grams respectively. Age II smolt averaged 112.6 millimeters in length and 10.7 grams in weight (Table 5). Average lengths of Age II smolt were equal to the 10-year average of 112.6 millimeters, but their average weight of 10.7 grams was less than the 10-year average of 11.8 grams (Table 5). The weighted seasonal percentages of Age I and Age II smolt were 93.1 and 6.9 respectively (Table 5).

The total estimated smolt outmigration for 1968 derived from the methods discussed by Nelson, 1965. The outmigration of 42,205,912 smolt was the largest outmigration estimate on record (Table 4, Appendix B).

IV. DISCUSSION AND COMPARISON WITH PAST DATA

An adult escapement of 400-500,000 sockeye salmon appears optimal for the Ugashik system. Past data indicates that survival to smolt stage expressed as smolt per spawner, is the greatest when escapement levels are within this range (Figure 4). The average number of smolt produced from the two adult escapements that exceeded 1,000,000 spawners (1960 and 1965) was 9.7 smolt per spawner, while the average smolt per spawner produced from escapements that were less than 500,000 was 30.4 (Table 5, Appendix B). The exceptional production of Age I smolt from the 1966 escapement of 704,000 spawners is as yet unexplained.

Smolt produced from escapements that ranged between 220-700,000 were larger in size than smolt produced from the large escapements in 1960 and 1965 (Table 5, and 5, Appendix B) indicating that nursery area carrying capacity may be a limiting factor to smolt production. The poor smolt production from the 1965 escapement of 996,612 cannot be explained from the climatological data available.

If fry produced from large escapements have higher than normal mortalities due to the depletion of availble food in the nursery areas, then the ensuing year's smolt production may have a higher survival rate due to less competition. This may be the factor increasing survival from egg to smolt that has occurred after both large escapements in 1960 and 1965. In both years (1961 and 1966) following a large escapement, the number of smolt produced per spawner increased significantly in comparison to other yearly productions (Table 5, Appendix B).

Other factors that may limit the number of smolt produced are limited

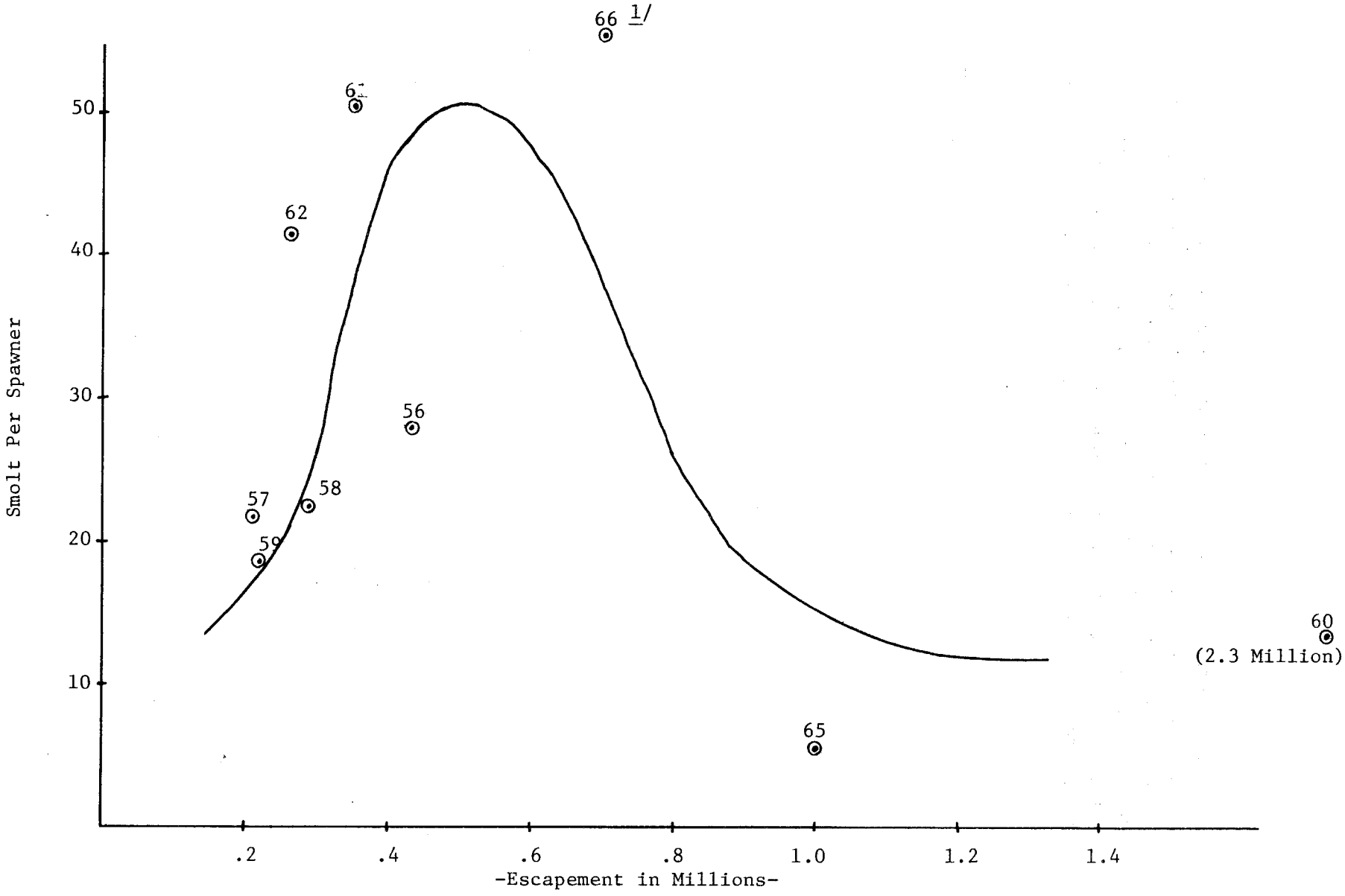

FIGURE 4. Smolt production from sockeye salmon escapements in the Ugashik lake system, 1956-66. (Reproduction curve is fitted by eye to 3-year moving averages of the paired escapement-return data, ordered to size of escapement.)

1/ Does not include Age II smolt.

spawning areas, gravel compaction from siltation, superimposition, adverse weather and predation. Any one or a combination of the aforementioned factors may limit smolt production in a given year, and may cause higher than average fry mortalities from a large escapement. It is difficult to assess the many variances that occur in this system which affect the yearly smolt production, since there are no monitoring programs at present except smolt sampling.

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NAKNEK RIVER SOCKEYE SALMON SMOLT STUDY, 1968

By

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I. INTRODUCTION

The 1968 season completed the thirteenth year of sockeye salmon (Oncorhynchus nerka) smolt studies on the Naknek River. The program was originally developed by the U.S. Fish and Wildlife Service in 1956 under the direction of Herbert W. Jaenicke, Fishery Research Biologist. In 1959 the basic program methods and procedures were established with minor alterations since that time. In 1966 the project was transferred to the Alaska Department of Fish and Game and operated by the Division of Commercial Fisheries under the supervision of Angus D. Robertson, Fishery Biologist. In 1967 the project was initially supervised by Angus D. Robertson with the author assisting from June 1 until project termination. The 1968 smolt project was under the supervision of the author. The crew consisted of project crew leader Daniel Gralian and Fish and Game Aid Cress Lundstrom.

II. METHODS AND PROCEDURES

In 1968 the program commenced on May 23 and terminated on July 11. On August 10 and 12 the index net was fished for a 9 hour period each night to determine the magnitude of the outmigration of what is normally a late period in the season.

Throughout the season smolt were trapped in standard fyke nets 4 feet wide and varying from 4 to 7 feet in depth. As the season progressed the river depth increased until, in some sites, the 7 foot net was required. The nets were suspended from a cable laid across the river bottom 8-3/4 miles below the outlet of Naknek Lake. During the 1968 season a smolt live box was used in place of cod end on the index net. The live box afforded a more accurate measurement of the outmigration and lowered mortality.

In 1957 and 1958 the entire river width was fished to determine the most productive sites. Six sites in the main channel of the river are now fished on a random schedule during the peak outmigration hours of 2100-0600. Data obtained from 1957 and 1958 indicate that 88.34 percent of the entire outmigration passed

within these 6 sites. The most productive of the 6 sites was used as an index.

A 3 day work schedule was employed throughout the season. On the first day the 6 sites were fished in a random order, with each site fishing 90 minutes. The first day's schedule was repeated on the second day. However, the index site was fished for 24 hours. When fishing the random nets the forty samples are obtained utilizing the following scheme: Ten (10) of the samples are obtained from the random net that is fished from 2100-2230 hrs. The following ten (10) are obtained from the net that is fished from 2230-2400 hrs. The remaining twenty (20) samples are taken in the same manner from the random nets fished from 0000-0130 hrs. and 0130-0300 hrs. When the index net is being fished all forty (40) samples are taken from this net (i.e., twenty prior to and twenty following 2400 hrs.) This scheme results in all of the sites being sampled throughout the season. Scales, weight and length data were taken from each smolt sampled. Scales were aged at the end of the season by the author and project crew leader.

III. RESULTS

A. Weather Data

Naknek River weather observations made by Herbert W. Jaenicke during the years 1956 to 1965 reveal that 90 percent of the smolt outmigrated when the mean water temperature was between 51° F and 55° F. These temperatures are considerably higher than in other major rivers of Bristol Bay where water temperatures are between 36° F and 41° F during outmigration.

In 1968 the peak of the Naknek outmigration occurred when mean water temperatures were between 50° F and 54° F (Table 1).

B. Index Catch

Indices of annual smolt abundance have been obtained since 1959 through randomized and index sampling.

In 1968 the index was conducted from May 27 to July 12. The index catch for this period was 93,258 (Table 2). The peak catches occurred on the sampling periods of June 5-6 and June 8-9, and were 18,556 and 13,984 respectively.

During the seasons sampling, 16.43 percent of the total catch occurred between the hours of 0000-0130. The catches occurring between the hours of

TABLE 1. Mean water and air temperature by day, Naknek River, 1968 1/

Date	Mean Water Temp. °F	Mean Air Temp. °F	Date	Mean Water Temp. °F	Mean Air Temp. °F
May 21	50°	*	June 17	58°	50°
22	50°	47°	18	*	*
23	50°	42°	19	56°	*
24	45°	50°	20	58°	52°
25	*	*	21	56°	50°
26	50°	*	22	*	*
27	46°	45°	23	56°	49°
28	47°	50°	24	54°	48°
29	48°	46°	25	57°	50°
30	49°	41°	26	56°	50°
31	48°	46°	27	55°	52°
June 1	50°	50°	28	59°	59°
2	51°	48°	29	59°	61°
3	50°	50°	30	58°	63°
4	50°	52°	July 1	59°	54°
5	51°	51°	2	59°	53°
6	51°	50°	3	59°	53°
7	*	*	4	59°	52°
8	54°	52°	5	62°	65°
9	55°	49°	6	61°	62°
10	56°	50°	7	60°	*
11	57°	57°	8	60°	55°
12	57°	55°	9	60°	54°
13	58°	52°	10	*	*
14	59°	52°	11	61°	54°
15	57°	51°	12	60°	54°
16	58°	51°	13	60°	*
			14	60°	*

1/ Water temperatures are recorded six times a day.
* Not recorded.

Table 2. Naknek River index net catches of sockeye salmon smolt by 90 minute periods, May 27-July 11, 1968.

	May 27-28	May-June 30-1	June 2-3	June 5-6	June 8-9	June 11-12	June 14-15	June 17-18
2100-2230	58	0	5	757	3,375	211	286	19
2230-2400	161	25	240	1,038	315	1,617	418	221
0000-0130	207	42	820	2,061	236	348	747	282
0130-0300	146	89	646	2,907	1,103	1,298	722	510
0300-0430	25	44	490	2,341	1,948	1,208	711	3,151
0430-0600	28	15	1,575	2,841	1,360	136	632	1,882
0600-0730	56	9	157	811	1,042	315	622	205
0730-0900	32	13	133	850	1,729	19	440	98
0900-1030	0	7	56	275	710	23	141	541
1030-1200	0	6	61	73	525	3	29	1,602
1200-1330	0	11	23	38	128	8	117	1,896
1330-1500	0	1	23	31	83	5	90	1,960
1500-1630	0	1	15	60	54	0	412	855
1630-1800	0	0	15	9	475	2	655	185
1800-1930	1	2	46	1,116	470	1,361	1,643	210
1930-2100	1	3	80	3,348	431	3,409	847	505
Totals	715	268	4,385	18,556	13,984	9,963	8,512	14,122

Table 2. Naknek River index net catches of sockeye salmon smolt by 90 minute periods, May 27-July 11, 1968. (Cont'd)

	June 20-21	June 23-24	June 26-27	June 29-30	July 2-3	July 5-6	July 8-9	July 11-12	Total	Percent
2100-2230	263	0	282	153	1	132	36	2	5,580	5.98
2230-2400	165	207	1,483	754	14	684	29	220	7,591	8.14
0000-0130	559	256	539	1,070	670	7,067	119	296	15,319	16.43
0130-0300	351	245	309	1,476	407	285	118	94	10,706	11.48
0300-0430	180	36	623	635	666	22	3	114	12,197	13.08
0430-0600	75	14	17	87	403	2	1	100	9,168	9.83
0600-0730	34	27	4	37	2	0	0	1	3,322	3.56
0730-0900	36	0	34	28	0	0	0	2	3,414	3.66
0900-1030	35	0	3	3	0	0	0	0	1,794	1.92
1030-1200	68	0	1	0	0	0	0	0	2,368	2.54
1200-1330	24	0	0	37	0	0	0	0	2,282	2.45
1330-1500	24	0	0	0	0	0	0	0	2,217	2.38
1500-1630	2	0	0	2	0	0	0	0	1,401	1.50
1630-1800	5	0	0	0	0	0	0	0	1,346	1.44
1800-1930	6	215	3	0	1	0	0	0	5,074	5.44
1930-2100	2	585	0	0	267	0	1	0	9,479	10.17
Totals	1,829	1,585	3,298	4,282	2,431	8,192	307	829	93,258	100.00

0000-0430 accounted for 40.99 percent of the total index catch.

C. Outmigration Estimate

In 1968 the smolt outmigration peaked June 4-7 when 41 percent of the season's random catch was made. This time period encompassed the only Age II catch peak. The Age I smolt catches reflected two peaks, the first occurring June 5 with the second on June 38 (Figure 1 and Table 3).

The start of outmigrations in the past 12 years has ranged from May 23 to June 9. The end of the outmigration has varied from June 17 to July 20. Smolt continue to migrate from Naknek Lakes throughout July, August and September (Jaenicke). However, the migration is insignificant compared to that occurring during the main outmigration period. In 1968 the index net was fished for two days in August and caught 0.12 percent of the total season's catch of Age I smolt and 0.02 percent of the total season's catch of Age II smolt (Table 3 and Table 4).

The 1968 total smolt outmigration estimate was obtained by the following procedure:("sampling period" refers to the period 2100-0600)

1) Determine the seasonal average 90-minute catch per fishing site per sampling period.

   Total season catch = 224,576

   No. of sites fished (each site fished for 90 minutes per sampling period) = 6

   No. of sampling periods fished during the season = 34

   Therefore, the seasonal average 90-minute catch per fishing site per sampling period is given by

   (224,576) / ((34)(6)) = 1,100 smolts.

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

   Average 90-minute catch per fishing site per sampling period = 1,100 (from Step 1)

   No. of sites fished = 6

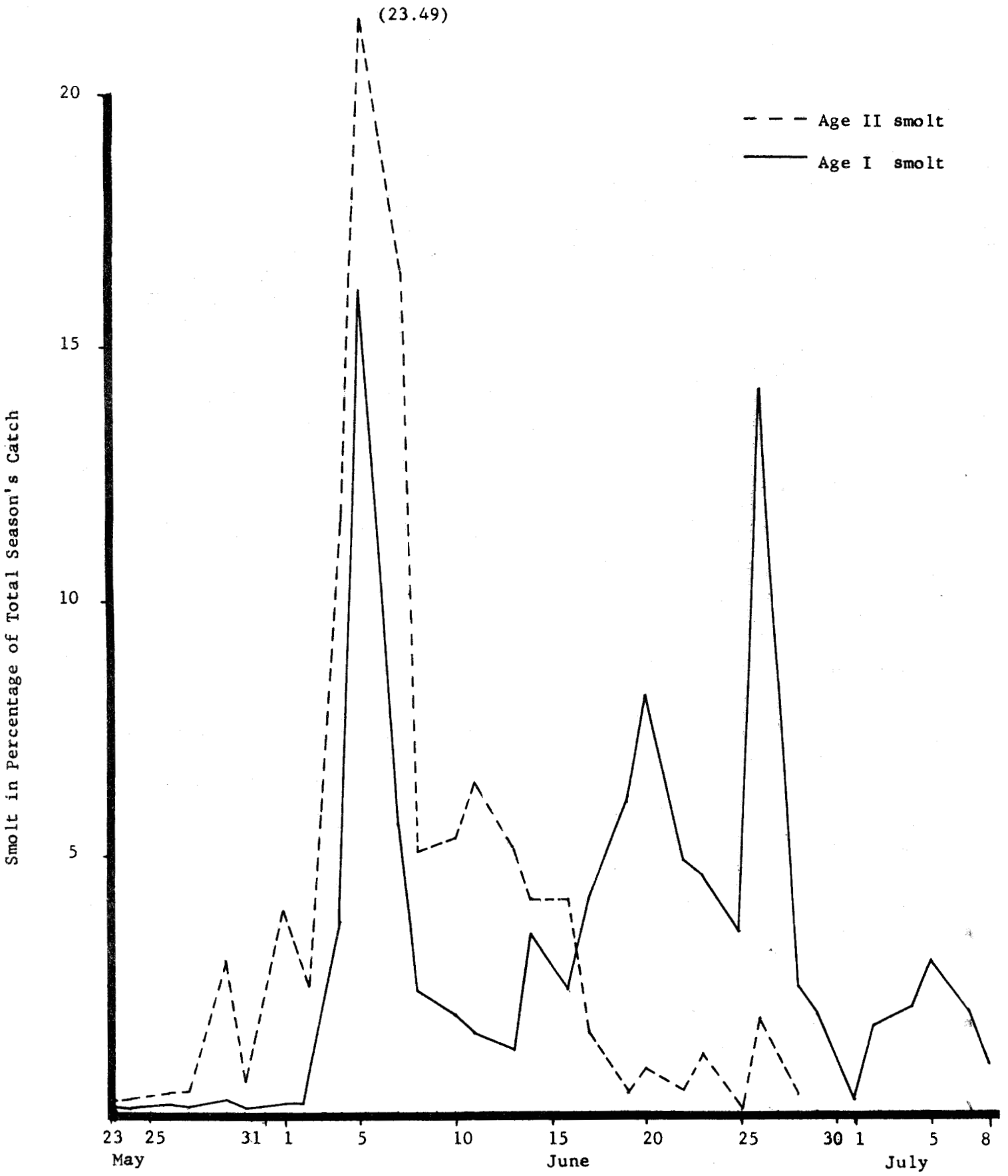

Fig. 1 Daily catches of sockeye salmon smolt in percent of total season's catch from the Naknek River, 1968.

TABLE 3. Naknek River random sampling catches of sockeye salmon smolt by fishing site, 1968

Date	Sites						Total	Percentage of Daily Total
	1	2	3	4	5	6		
May 23	15	227	35	9	1	67	354	0.16
24	124	29	122	2	66	69	412	0.18
26	42	351	80	0	6	5	484	0.22
27	13	285	27	28	93	4	450	0.20
29	1,472	1,036	861	423	138	405	4,335	1.93
30	29	369	268	25	72	0	763	0.34
June 1	0	0	4,405	1	718	24	5,148	2.29
2	660	416	2,207	5	35	0	3,323	1.48
4	2,269	1,254	15,799	258	151	6	19,737	8.79
5	2,712	33,258	6,891	1,037	1,885	177	45,960	20.47
7	108	22,016	2,973	816	61	263	26,237	11.68
8	109	2,576	3,481	1,102	1,305	7	8,580	3.82
10	2,160	4,604	608	1,055	303	64	8,794	3.92
11	4,954	96	3,138	348	298	819	9,653	4.29
13	91	3,122	5,156	277	489	3	9,138	4.07
14	154	689	6,899	747	89	0	8,578	3.82
16	253	26	3,793	3,710	19	2	7,803	3.47
17	555	4,049	510	509	270	5	5,898	2.63
19	230	3,570	787	1,901	100	0	6,588	2.93
20	0	7,188	1,228	180	0	9	8,605	3.83
22	0	2,810	1,954	150	76	0	4,990	2.22
23	1,777	2,784	1,100	14	2	88	5,765	2.57
25	811	574	1,294	503	107	46	3,335	1.49
26	950	13,050	1,320	133	0	3	15,456	6.88
28	890	0	1,485	0	209	112	2,696	1.20
29	200	398	23	1,070	78	3	1,772	0.79
July 1	54	95	21	28	6	0	204	0.09
2	648	576	254	14	21	72	1,585	0.71
4	71	0	1,673	0	213	5	1,962	0.87
5	1,089	932	0	285	370	0	2,676	1.19
7	0	1,011	208	127	201	4	1,551	0.69
8	461	6	349	1	30	20	867	0.39
10	0	190	58	75	49	77	449	0.20
11	6	67	258	94	3	0	428	0.19
Totals	22,907	107,654	69,265	14,927	7,464	2,359	224,576	100.00
Percent	10.20	47.94	30.84	6.65	3.32	1.05	100.00	

TABLE 4. Naknek River sockeye salmon smolts, mean weight in grams, 1968

Date	Age I		Age II		Age III	
	% of Total Season's Catch	Mean Weight	% of Total Season's Catch	Mean Weight	% of Total Season's Catch	Mean Weight
May 23	0.09	17.2	0.20	17.2	0.58	19.9
24	0.00	00.0	0.22	17.7	2.90	23.4
26	0.10	11.8	0.31	14.6	0.00	00.0
27	0.01	5.4	0.33	17.4	0.50	20.0
29	0.23	14.0	2.90	17.5	9.36	22.7
30	0.06	11.8	0.54	15.3	0.41	23.6
June 1	0.13	11.7	3.84	15.4	2.79	19.6
2	0.17	8.0	2.48	13.6	0.00	00.0
4	3.73	9.6	12.81	12.2	0.00	00.0
5	16.13	7.3	23.49	10.0	24.83	20.5
7	5.66	5.4	16.50	8.7	0.00	00.0
8	2.31	9.9	5.06	9.3	0.00	00.0
10	1.89	6.9	5.35	10.9	4.75	18.4
11	1.56	6.8	6.44	10.1	0.00	00.0
13	1.23	8.7	5.20	10.6	29.63	17.4
14	3.47	7.0	4.21	9.6	0.00	00.0
16	2.31	7.6	3.68	10.8	21.07	25.7
17	4.14	8.5	1.51	10.4	3.18	34.6
19	6.58	8.7	0.39	10.0	0.00	00.0
20	8.13	8.7	0.85	10.2	0.00	00.0
22	4.85	9.0	0.39	10.1	0.00	00.0
23	4.66	8.8	1.13	10.0	0.00	00.0
25	3.51	8.3	0.01	8.7	0.00	00.0
26	14.18	9.0	1.82	10.1	0.00	00.0
28	2.47	8.9	0.32	9.5	0.00	00.0
29	1.86	8.7	0.00	9.8	0.00	00.0
July 1	0.21	9.1	0.00	13.9	0.00	00.0
2	1.71	9.4	0.00	00.0	0.00	00.0
4	2.06	9.9	0.00	11.0	0.00	00.0
5	2.89	9.8	0.00	00.0	0.00	00.0
7	1.67	10.2	0.00	00.0	0.00	00.0
8	0.94	10.7	0.00	00.0	0.00	00.0
10	0.48	11.1	0.00	00.0	0.00	00.0
11	0.46	11.2	0.00	00.0	0.00	00.0
Aug 10	0.01	16.9	0.01	16.3	0.00	00.0
12	0.11	16.7	0.01	16.8	0.00	00.0
	100.00		100.00		100.00	

No. of subsites 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 given by

(1,100) (6) (6) = 39,600 smolts.

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

Estimated average migration past the sampled section of the river during a 90-minute period within a sampling period = 39,600 (from Step 2)

No. of 90-minute periods in a sampling period = 6

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

(39,000) (6) = 237,600 smolts.

4) Estimate the average migration past the entire width of the river at the sampling location per sampling period.

Estimated average migration past the sampled section of the river each sampling period = 237,600 (from Step 3)

Estimated 1/ proportion of migration occurring within the section of the river presently sampled = 88.34%

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

(237,600) / .8834 = 268,960 smolts.

5) Estimate the average daily migration past the sampling location.

Estimated average migration past the entire width of the river at the sampling location per sampling period = 268,960 (from Step 4)

Estimated 2/ proportion of daily migration occurring during the sampling period (2100-0600) = 70.87%

1/ Derived from 1957-1958 data when whole river width was sampled by net sites 7 - 12.

2/ Average index net catch for 8 year period (averaged 70.8% of total catch during hours of 2100 - 0600).

Therefore, the estimated average daily migration past the sampling location is given by

(268,960) / (.7087) = 379,511 smolts.

6) Estimate the total seasonal migration past the sampling location.

Estimated average daily migration past the sampling location = 379,511 (from Step 5)

No. of days fished in 1968 = 49

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

(379,511) (49) = 18,596,039 smolts.

D. Age, Weight and Length Data

Age, weight and length data was collected from 1,380 smolt. The mean weight and length by day and for the season was calculated for each age group (Tables 4 and 5).

The final mean weights and lengths (by age class) for the season were derived by multiplying the mean data (weight or length) for an age class, for a day, by the percentage of the total season's catch for that day for that age class.

Table 1, Appendix C, summarizes ages, weights and lengths for the years 1957 through 1968. The average weight and length for Age I smolt was 8.4 grams and 99 mm. The Age II smolt averaged 11.1 grams in weight and 108 mm. in length. Age I smolt were 1 gram lighter than the previous 11 year average and 3 mm. shorter.

The Age II smolt averaged 1.5 grams lighter and 5 mm. shorter than the 11 year average.

IV. DISCUSSION

In 1968 the Age I smolt were the progeny of the 1966 adult escapement of 1,016,445 and comprised 41.2 percent (7,661,568) of the total smolt outmigration. The Age II smolt outmigration was the largest recorded for a 13 year

TABLE 5. Naknek River Sockeye salmon smolt, mean length in millimeters, 1968

Date	Age I		Age II		Age III	
	% of Total Season's Catch	Mean Length	% of Total Season's Catch	Mean Length	% of Total Season's Catch	Mean Length
May 23	0.09	122	0.20	124	0.58	130
24	0.00	000	0.22	124	2.90	136
26	0.10	105	0.31	117	0.00	000
27	0.01	91	0.33	125	0.50	130
29	0.23	113	2.90	124	9.36	135
30	0.06	107	0.54	121	0.41	142
June 1	0.13	111	3.84	121	2.79	132
2	0.17	98	2.48	116	0.00	000
4	3.73	105	12.81	110	0.00	000
5	16.13	96	23.49	106	24.83	135
7	5.66	94	16.50	105	0.00	000
8	2.31	106	5.06	105	0.00	000
10	1.89	92	5.35	108	4.75	130
11	1.56	97	6.44	106	0.00	000
13	1.23	98	5.20	106	29.63	130
14	3.47	94	4.21	105	0.00	000
16	2.31	97	3.68	107	21.07	144
17	4.14	99	1.51	106	3.18	160
19	6.58	100	0.39	106	0.00	000
20	8.13	100	0.85	106	0.00	000
22	4.85	101	0.39	105	0.00	000
23	4.66	100	1.13	105	0.00	000
25	3.51	100	0.01	104	0.00	000
26	14.18	101	1.82	106	0.00	000
28	2.47	101	0.32	105	0.00	000
29	1.86	101	0.00	109	0.00	000
July 1	0.21	99	0.00	118	0.00	000
2	1.71	103	0.00	000	0.00	000
4	2.06	103	0.00	109	0.00	000
5	2.89	104	0.00	000	0.00	000
7	1.67	104	0.00	000	0.00	000
8	0.94	106	0.00	000	0.00	000
10	0.48	105	0.00	000	0.00	000
11	0.46	106	0.00	000	0.00	000
Aug 10	0.01	124	0.01	122	0.00	000
12	0.11	122	0.01	123	0.00	000
	100.00		100.00		100.00	

period. The Age II's were the progeny of the 1965 escapement of 717,798 and comprised 56.7 percent (10,543,954) of the 1968 outmigration (Table 2, Appendix C).

Relative size of smolt outmigration and age composition for the years 1956-1968 are given in Table 3, Appendix C. The production of smolt by brood year for a 10 year period is given in Figure 2.

Based on the smolt production figures of the last 10 years the optimum escapement goal should be held in the range of 700,000 to 1,000,000 adults. The exception of this range would be 1961 which had an escapement of 351,078.

This escapement produced a return of 1,712,737 (exclusive of the 1968 inshore return) for a return per spawner relationship of 4.88. However, the largest returns experienced since 1953 have had escapements of 799,167 (1954) and 828,381 (1960). These escapements produced returns of 2,939,867 and 3,555,616 respectively for return per spawner relationships of 3.68 (1954) and 4.29 (1960).

V. SUMMARY

1. 1968 concluded the thirteenth consecutive year of smolt enumeration on the Naknek River. The project was initiated by the U.S. Fish and Wildlife Service in 1956. The Alaska Department of Fish and Game assumed responsibility for the project in 1966.

2. Sampling began on May 23 and terminated July 11.

3. An index net was fished August 10 and 12 to determine the magnitude of the outmigration during late summer. The numbers of smolt caught were insignificant.

4. Six fishing sites on the main channel of the river were fished on a random schedule during the peak outmigration hours of 2100-0600. An index site was fished 24 hours on every second day of sampling.

5. The peak period of outmigration was between June 4 and June 7.

6. The total 1968 smolt outmigration was 18,596,039.

7. The 1968 outmigration was the second largest in thirteen consecutive years. The 1965 outmigration of 24,700,000 was the largest.

8. The Age II smolt outmigration (the progeny of the 1965 adult escape-

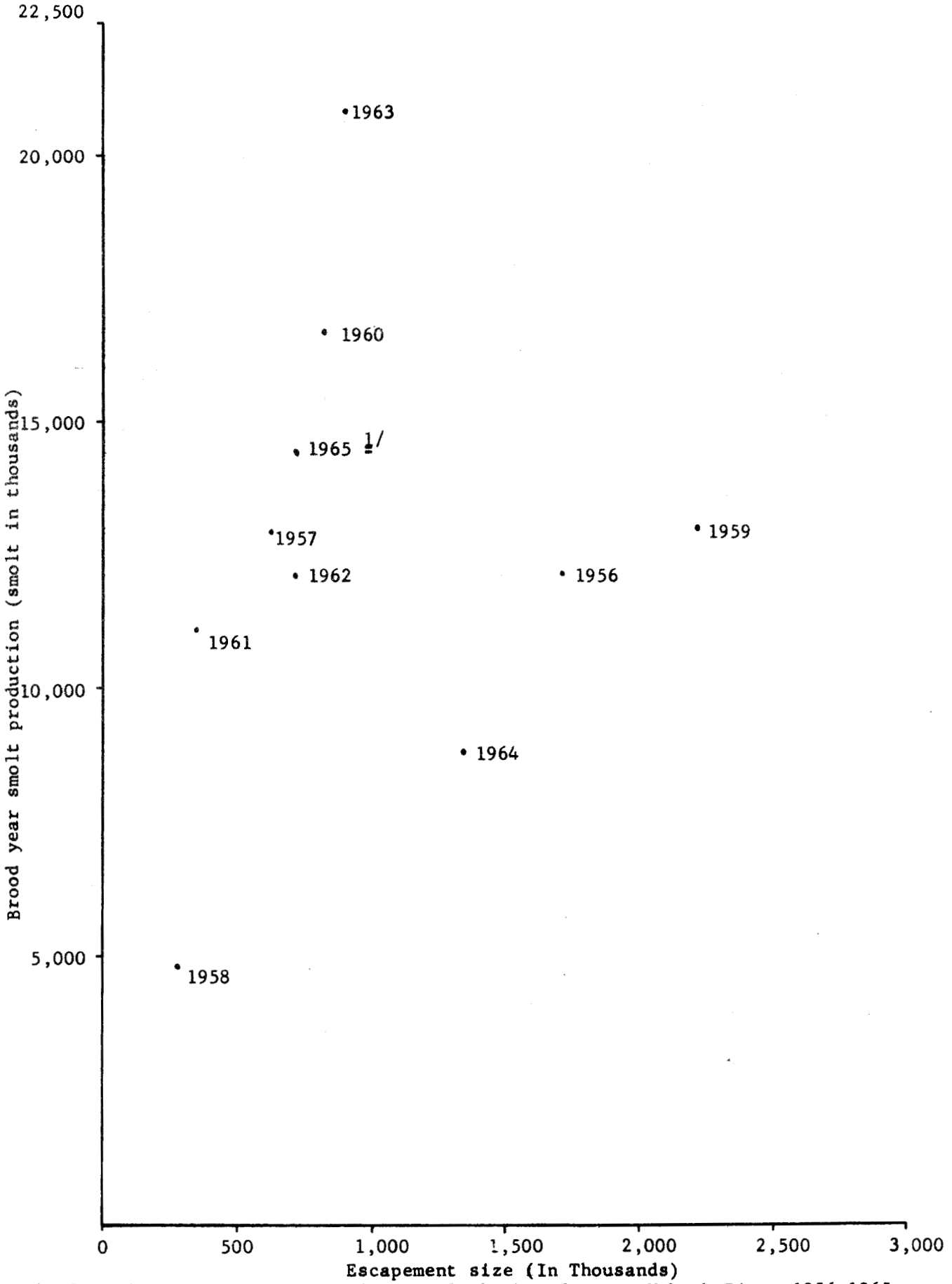

Fig.2 Production of sockeye salmon smolt by brood year, Naknek River 1956-1965

1/ Figure does not include Age III smolt.

ment of 717,978) was the largest on record, (10,543,954).

9. Based on the smolt production figures for the past ten years the optimum escapement range appears to lie between 700,000 and 1,000,000.

10. Age, weight and length data was determined from 1,380 smolt. Age I smolt comprised 41.2 percent of the outmigration and averaged 99 mm. in length and 8.4 grams in weight. Age II smolt comprised 56.7 percent of the outmigration and averaged 108 mm. in length and 11.1 grams in weight. Both Age I and Age II smolt were smaller than the 11 year average for Naknek River outmigrants.

LITERATURE CITED

Jaenicke, Herbert W. 1966. Timing, Age, Condition, and Abundance of Red Salmon Smolts from the Naknek River System, Alaska, 1956-1965. U.S. Bureau of Commercial Fisheries, Auke Bay, Alaska. Unpublished Manuscript. 40 pp. plus tables and Appendix.

APPENDIX A

TABLE 1 . Dates and water temperatures at beginning of peak smolt outmigration, Kvichak River, 1955-1968.

Year	Beginning Date of Peak Outmigration	Water Temperatures in Degrees Fahrenheit
1955	June 4	38°
1956	June 1	36°
1957	May 28	42°
1958	May 22	45°
1959	May 26	42°
1960	May 26	41°
1961	May 23	36°
1962	June 1	37°
1963	May 24	36°
1964	June 1	38°
1965	May 24	41°
1966[1/]	-	-
1967	May 26	40°
1968	May 25	40°

1/ Date of peak outmigration not known for certain.

TABLE 2. Kvichak River 24-hour sockeye salmon smolt catches average lengths and weights, 1955-1968.

Outmigration	AGE I Number	AGE I Percent[2]	AGE I Average Length	AGE I Weight	AGE II Number	AGE II Percent[2]	AGE II Average Length	AGE II Weight	Total Number	Total 24-Hour Index[1]
1955	18,198	7	89 mm	-	241,780	93	109 mm	-	(259,978)[3]	7.8
1956	30,287	39	92 mm	-	47,373	61	116 mm	-	(77,660)[3]	2.3
1957	22,287	72	96 mm	7.3 g	8,654	28	120 mm	14.4 g	30,907	0.9
1958	3,267,274	98	84 mm	4.6 g	66,679	2	114 mm	-	3,333,953	100.0
1959	85,916	3	80 mm	-	2,777,960	97	99 mm	7.6 g	(2,863,876)[3]	85.9
1960	61,400	10	91 mm	6.3 g	552,603	90	108 mm	10.3 g	(614,003)[4]	18.4
1961	26,038	72	92 mm	6.8 g	10,126	28	117 mm	13.1 g	(36,164)[3]	1.1
1962	1,130,820	94	82 mm	4.3 g	72,180	6	110 mm	9.9 g	1,203,000	36.1
1963	113,338	3	83 mm	4.8 g	4,116,093	97	98 mm	7.5 g	4,229,431	126.9
1964	458,122	22	87 mm	5.2 g	1,603,464	78	108 mm	9.8 g	2,061,586	61.8
1965	64,377	4	90 mm	6.8 g	1,748,178	97	109 mm	11.3 g	1,812,555	54.4
1966	252,384	92	94 mm	7.4 g	23,377	8	114 mm	12.6 g	275,761	8.3
1967	2,866,214	93	86 mm	5.9 g	222,528	7	118 mm	14.2 g	3,088,742	92.6
1968	648,321	11	88 mm	5.5 g	5,475,362	89	104 mm	9.2 g	6,123,683	183.6
Fourteen-Year Averages	646,070	44	88 mm	5.9 g	1,211,883	56	110 mm	10.9 g	1,857,950	55.7

1/ One index point = 33,340 smolt.

2/ Numbers of Age I and Age II fish derived from rounded-off season percentages except in 1963, 1964, 1965 and 1966 when rounded percentages were derived from numbers of smolts obtained by weighting length frequency distribution by daily catches.

3/ 24-hour index catch estimated by ratios with years of actual 24-hour fishing and from visual observations of smolt migration outside the 3-hour index period.

4/ 24-hour index catch estimated from ratios with the 3-hour index period catch obtained during only 2 days of actual 24-hour fishing.

TABLE 3. Percent of sockeye salmon smolt outmigration occurring during index hours (2200-0100), Kvichak River, 1955-1968.

Year	Outmigration[1/]	Percent Outmigration During Index Hours (2200-0100)
1955	259,978	82.3%
1956	77,660	82.3
1957	30,907	82.3
1958	3,333,953	57.4
1959	2,863,876	57.4
1960	614,003	74.1
1961	36,164	82.3
1962	1,203,000	25.1
1963	4,229,431	32.6
1964	2,061,586	38.3
1965	1,812,555	46.9
1966	275,761	39.5[2/]
1967	3,088,742	30.1
1968	6,123,683	34.8
Averages	1,857,950	54.7[3/]

1/ The methods used to expand the 3-hour index catches to 24-hour catches for the years 1955, 1956, 1959, 1960 and 1961 are explained in the 1964 smolt report.

2/ This figure is nearly meaningless since ice flow precluded any estimate of comparative migration by period.

3/ Note that the average 56.2% migration during the index hours is probably high as the percent for three of the four years showing 82.3% was assumed on the basis that 82.3% of the smolt in 1957 migrated during the index hours. Sampling was not on a 24-hour basis for the years, 1955, 1956, 1959, 1960 and 1961.

TABLE 4. Kvichak River 3-hour sockeye salmon smolt catches, 1955-1968, (3-hour index catches).

Year of Outmigration	Age I		Age II		Total Number	Total 3-Hr. Index[1/]
	Number	Percent	Number	Percent		
1955	14,971	7	198,897	93	213,868	6.4
1956	24,916	39	38,970	61	63,886	1.9
1957	18,306	72	7,119	28	25,425	0.8
1958	1,874,512	98	38,255	2	1,912,767	57.4
1959	49,292	3	1,593,781	97	1,643,073	49.3
1960	45,478	10	409,305	90	454,783	13.6
1961	21,420	72	8,330	28	29,750	0.9
1962	283,328	94	18,085	6	301,413	9.0
1963	41,424	3	1,339,379	97	1,380,803	41.4
1964	173,919	22	616,623	78	790,542	23.7
1965	34,009	4	816,212	96	850,221	25.5
1966	100,199	92	8,713	8	108,912	3.3
1967	864,650	93	65,081	7	929,731	27.9
1968	252,452	11	2,042,571	89	2,295,023	68.8
Fourteen-Year Averages	271,348	44	514,380	56	785,728	21.1

1/ One index point = 33,340 smolt.

TABLE 5. Parent escapement and corresponding sockeye salmon smolt production, Kvichak River, 1952-1966.

Year of Spawning	Escapement In Thousands	24-Hour Index Smolt Produced			24-Hour Index Smolt Per Spawner x 10^3		
		Age I	Age II	Total	Age I	Age II	Total
1952	5,970		241,780			40	
1953	321	18,198	47,373	65,571	57	148	205
1954	241	30,287	8,654	38,941	126	36	162
1955	250	22,253	66,679	88,932	89	267	365
1956	9,443	3,267,274	2,777,960	6,045,234	346	294	640
1957	2,964	85,916	552,603	638,519	29	186	215
1958	535	61,400	10,126	71,526	115	19	134
1959	680	26,038	72,180	98,218	38	106	144
1960	14,630	1,130,820	4,116,093	5,246,913	77	281	358
1961	3,706	113,338	1,603,464	1,716,802	30	433	463
1962	2,581	458,122	1,748,178	2,206,300	178	677	855
1963	339	64,377	24,818	89,195	190	73	263
1964	957	252,384	222,528	474,912	264	233	497
1965	24,326	2,866,214	5,475,362	8,341,576	118	225	343
1966	3,775	648,321			172		
Averages	4,714	646,067	1,211,986	1,932,511	131	216	357

TABLE 6. Dates of sampling and peak periods of sockeye salmon smolt outmigration, Kvichak River, 1955-1968.

Year	Date	Number of Days	Date	Number of Days	Percent of Total Catch
1955	5/28-6/27	31	6/4-9	6	94%
1956	5/24-7/4	42	6/1-9, 14-16	12	88
1957	5/28-7/24	58	5/28-6/6	10	84
1958	5/10-7/5	56	5/22-6/3	13	80
1959	5/23-6/28	36	5/26-6/2	8	98
1960	5/18-6/19	33	5/28-6/4	8	80
1961	5/23-6/20	29	5/23-6/2	11	81
1962	5/27-7/4	39	6/2-15	14	88
1963	5/16-6/16	32	5/24-29, 6/7-9	9	86
1964	5/19-6/22	35	6/4-12	9	84
1965	5/17-6/14	28	5/24-30	6	91
1966	5/18-6/17	31	6/4-11	8	97
1967	5/17-6/17	31	5/26-6/6	12	80
1968	5/17-6/14	28	5/24-27, 6/1-6/5	9	76
Averages		36		10	86

TABLE 7. Parent escapement and corresponding percent of Age II sockeye salmon smolt produced, Kvichak River, 1952-1965.

Year	Escapement	Percent Age II Smolt Produced[1/]
1952	5,970,000	10 - 15% [2/]
1953	321,000	72%
1954	241,000	22%
1955	250,000	75%
1956	9,443,000	46%
1957	2,964,755	87%
1958	534,785	14%
1959	680,000	73%
1960	14,630,000	78%
1961	3,705,849	93%
1962	2,580,884	79%
1963	338,760	27%
1964	957,120	47%
1965	24,360,000	66%

1/ Based on 24-hour index catches.

2/ Estimated on basis of 2-ocean returns in 1956 and 5_2 fish in 1957 vs. 5_3 fish in 1957 and 6_3 fish in 1958.

APPENDIX B

TABLE 1. Ugashik River sockeye salmon smolt catches in the random sampling scheme by fishing site in percent, 1958-1968.

Year	Random Sites				
	1	2	3	4	5
1958	1.81	27.04	17.69	52.83	.63
1959	2.40	5.74	46.39	37.07	8.40
1960	7.97	4.54	28.11	54.70	4.68
1961	1.29	10.64	20.96	56.83	10.28
1962	7.62	9.93	46.50	29.31	6.64
1963	7.61	10.65	31.42	29.43	20.89
1964	8.61	9.59	24.74	47.02	10.04
1965	0.54	7.59	26.59	43.45	21.83
1967	7.45	7.80	25.12	52.39	7.24
1968	17.55	15.33	41.14	14.45	11.53
10-Year Average	6.28	10.88	30.87	41.75	10.22

TABLE 2. Average length and weight of Ugashik River sockeye salmon smolt by freshwater age group, 1958-1968.1/

Year of Seaward Migration	Age I		Age II	
	Length	Weight	Length	Weight
1958	93.0	6.4	112.0	11.7
1959	90.0	6.1	120.0	13.5
1960	90.0	6.6	108.0	11.0
1961	90.0	6.7	112.0	12.2
1962	88.0	6.1	112.0	12.3
1963	89.8	6.1	104.3	9.6
1964	92.2	6.9	118.3	12.7
1965	93.7	6.9	114.1	12.5
1967	87.5	6.0	113.1	12.2
1968	92.8	6.5	112.6	10.7
Mean Average	90.7	6.4	112.6	11.8

1/ Weighted by index catch.

TABLE 3. Ugashik River sockeye salmon escapements and smolt produced, 1956-1966.

Brood Year	Ugashik River Escapement	Millions of Smolt Produced			
		Age I	Age II	Age III	Total
1956	425,295	11.4	0.4	.01	11.9
1957	214,802	2.5	2.2	--	4.7
1958	279,546	3.3	3.0	--	6.3
1959	219,228	0.8	3.2	--	4.0
1960	2,304,200	13.5	18.1	--	31.6
1961	348,639	15.6	2.0	--	17.6
1962	255,426	8.0	2.6	--	10.6
1963	388,254	1.0	-- 1/	--	1.0 1/
1964	472,770	-- 1/	2.4	--	2.4 1/
1965	996,612	2.7	2.9	--	5.6
1966	704,436	39.3	-- 2/	--	

1/ No outmigration estimates for 1966.

2/ The Age II smolt from the 1966 escapement will not leave freshwater until 1969.

TABLE 4. Comparative age, length, index net catches and outmigration estimates of sockeye salmon smolt from the Ugashik River system, 1956-1968.

Year of Seaward Migration	Age I		Age II		Index Points	Index Net Catch	Outmigration Estimate
	Percent	Mean Length in mm.	Percent	Mean Length in mm.			
1956	11.0	--	89.0	--	--	--	--
1957	4.0	--	96.0	--	--	--	--
1958	98.1	93.0	1.9	112.0	100.0	301,232	11,659,905
1959	87.3	90.0	12.7	120.0	36.5	109,982	2,887,002
1960	59.7	90.0	39.3 1/	108.0	75.1	226,317	5,503,646
1961	20.4	90.0	79.6	112.0	52.3	157,441	3,802,079
1962	80.7	88.0	19.3	112.0	103.1	310,616	16,692,089
1963	46.3	89.8	53.7 1/	104.3	305.2	919,451	33,750,496
1964	80.1	92.2	19.8 1/	118.3	68.1	205,145	9,990,048
1965	28.8	93.7	71.2	114.1	57.4	172,893	3,640,115
1967	52.5	87.5	47.5	113.1	30.9	93,068	5,137,063
1968	93.1	92.8	6.9	112.6	145.9	439,587	42,205,912
Average	55.2	90.7	44.7	112.6	97.5	293,573	13,526,836

Note: Age Group I and II denotes number winters in freshwater.
Age and length weighted by index catch.

1/ 1.0 percent Age III in 1960; 0.1 percent Age III in 1963 and 1964.

TABLE 5. Ugashik River sockeye salmon escapement, smolt outmigration estimate, smolt per spawner and average length and weight of smolt by freshwater age group and brood year, 1956-66.

Brood Year	Escapement in Millions	Outmigration Estimate In Millions	Smolt Per Spawner	Age I		Age II	
				Length	Weight	Length	Weight
1956	.43	11.9	28.0	93.0	6.4	120.0	13.5
1957	.21	4.7	21.9	90.0	6.1	108.0	11.0
1958	.28	6.3	22.5	90.0	6.6	112.0	12.2
1959	.22	4.0	18.2	90.0	6.7	112.0	12.3
1960	2.30	31.6	13.7	88.0	6.1	104.3	9.6
1961	.35	17.6	50.5	89.8	6.1	118.3	12.7
1962	.26	10.6	41.5	92.2	6.9	114.1	12.5
1963	.39	1.0 1/	- 1/	93.7	6.9	- 1/	- 1/
1964	.47	2.4 1/	- 1/	- 1/	- 1/	113.1	12.2
1965	1.00	5.6	5.6	87.5	6.0	112.6	10.7
1966	.70	- 2/	55.8 3/	92.8	6.5	- 2/	- 2/
Average	60.09	11.5	28.6	90.7	6.4	112.6	11.8

1/ No smolt samples or total outmigration estimates since smolting was not conducted during 1966.

2/ Age II smolt from the 1966 escapement will not leave freshwater until 1969.

3/ Partial estimate. Based on Age I smolt.

APPENDIX C

TABLE 1 Average fork lengths and weights, Naknek River sockeye salmon smolts, 1957 - 1968 1/

Year of Seaward Migration	Age I			Age II		
	% Age Class	Length mm.	Weight Grams	% Age Class	Length mm.	Weight Grams
1957	57.9	111	13.1	42.1	112	13.1
1958	96.4	91	6.9	3.6	114	11.3
1959	80.5	97	8.2	19.5	106	10.1
1960	53.1	99	8.8	46.6	109	11.9
1961	77.8	103	10.8	22.2	113	13.8
1962	48.6	105	10.4	51.4	112	12.5
1963	40.6	98	8.1	58.5	114	12.8
1964	31.1	97	7.7	68.8	110	11.0
1965	59.6	99	8.4	40.0	114	13.0
1966	33.8	106	10.6	66.2	118	14.2
1967	43.5	113	13.1	56.2	119	14.7
1968	41.2	99	8.4	56.7	108	11.1
Mean Average	55.3	102	9.5	44.3	112	12.5

1/ Age III smolt not included.

TABLE 2. Production of sockeye salmon smolt by brood year, Naknek River, 1956-1966 [1/]

Brood Year	Escapement	Smolts Produced at Age I	II	III	Total
1956	1,722,595	9,698,033	2,430,770	20,074	12,148,877
1957	634,645	10,034,717	3,118,182	0	13,152,899
1958	278,118	3,553,121	1,246,008	0	4,799,129
1959	2,231,807	4,336,639	8,461,579	134,108	12,962,326
1960	828,381	8,000,637	8,717,000	7,228	16,724,865
1961	351,078	6,049,747	4,973,098	88,951	11,111,796
1962	723,066	2,248,013	9,878,527	0	12,126,540
1963	905,358	14,741,194	6,098,025	25,399	20,864,618
1964	1,349,604	3,114,885	5,284,965	390,517	8,790,367
1965	717,798	4,096,836	10,543,954		14,640,790
1966	1,016,445	7,661,568			
1967	755,640				
1968	1,023,222				

1/ Production from 1954 and 1955 brood years were only partially sampled in 1956 and 1957.

TABLE 3. Sockeye salmon smolt outmigrations, Naknek River, 1956-1967.

Year of Seaward Migration	Number at Age			Total
	I	II	II	
1956	5,064,000	936,000	-	6,000,000
1957	1,760,401	1,280,015	-	3,040,416
1958	9,698,033	362,167	-	10,060,200
1959	10,034,717	2,430,770	-	12,465,487
1960	3,553,121	3,118,182	20,074	6,691,377
1961	4,366,639	1,246,008	-	5,612,647
1962	8,000,637	8,461,579	-	16,462,216
1963	6,049,747	8,717,000	134,108	14,900,855
1964	2,248,013	4,973,098	7,228	7,228,339
1965	14,741,194	9,878,527	88,951	24,708,672
1966	3,114,885	6,098,025	-	9,212,910
1967	4,096,836	5,284,965	25,399	9,407,200
1968	7,661,568	10,543,954	390,517	18,596,039