Informational Leaflet 119

FRAZER LAKE SOCKEYE INVESTIGATIONS
1967

By:

Martin F. Eaton
Division of Commercial Fisheries
Research Section
Kodiak, Alaska

April 17, 1968

STATE OF ALASKA
WALTER J. HICKEL - GOVERNOR

DEPARTMENT OF
FISH AND GAME

SUBPORT BUILDING, JUNEAU

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Martin F. Eaton, Fishery Biologist
Alaska Department of Fish and Game
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INTRODUCTION

Frazer Lake is located on Kodiak Island at latitude 57° 15' north and longitude 154° 10' west (Figure 1). The lake is approximately eight miles long and one mile wide covering approximately 5,000 surface acres. The outlet stream is called Frazer River until it reaches a fork about three miles downstream where it enters Dog Salmon Stream which in turn empties into Olga Bay. A 30-foot falls approximately 1/2 mile below the lake outlet blocked salmon passage into the lake until 1962, when fish passage facilities were installed.

In 1951, approximately 200,000 sockeye salmon (Oncorhynchus nerka) eggs were planted in an inlet stream of Frazer Lake in an effort to establish a sockeye run into the system. Annual egg plants continued until 1956 when an estimated 500 progeny of the first plant returned to the base of the falls. Due to inadequate trapping facilities only six sockeye were captured and back-packed over the falls. During the years from 1956 through 1962, returning spawners were trapped at the base of the falls, backpacked over the falls and then released in the stream above the falls to continue their journey to the Frazer Lake spawning grounds.

In 1958, 42 adult sockeye from Red Lake were transported to Frazer Lake to supplement the Frazer Lake escapements. The adult transplants were discontinued until 1961 when they were again initiated and have continued until the present. The transplanted fish were moved from Red Lake in live tanks mounted on the pontoons of a "super cub".

1/ This investigation was financed by the P.L. 89-304 "Anadromous Fish Act" for the period commencing July 1, 1967, under sub-project AFC-8-2, Contract No. 14-17-0007-825.

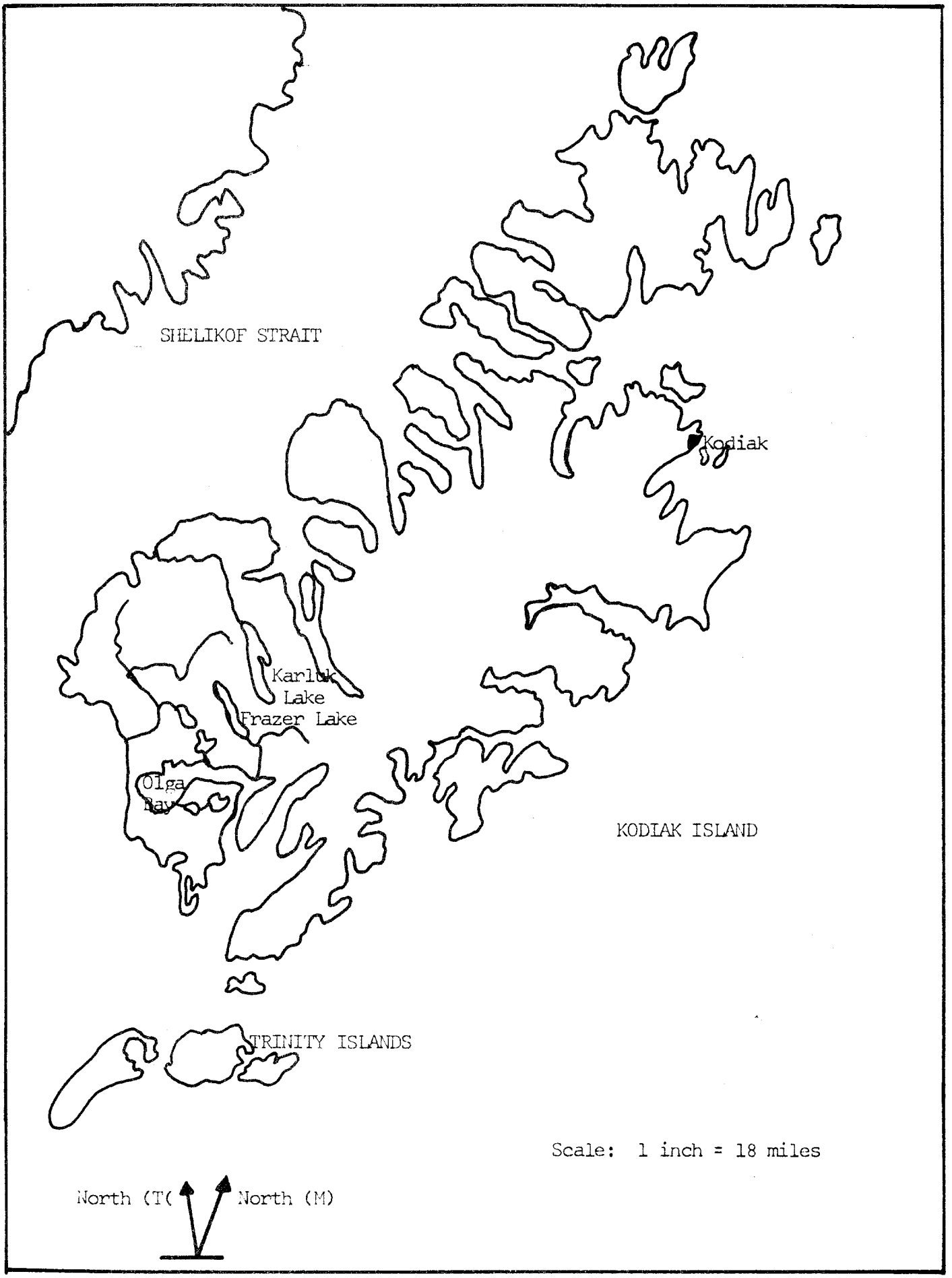


Figure 1. Kodiak Island

Beginning in 1964 a research program was initiated to study the newly introduced sockeye populations. First, extensive spawning ground surveys were made of all inlet streams. The number of spawners were noted, spawning condition, gravel composition and areas of spawning activity recorded (Meehan, Eaton, Gohr, 1965).

The second phase of the program was to construct sampling facilities for smolt and adult sockeye. This was accomplished in 1965 when a smolt weir was constructed a quarter of a mile downstream from the lake outlet and an adult trapping pen was constructed at the exit of the fishpass.

In conjunction with adult and smolt sampling, plankton samples and lake water temperatures are taken every two weeks at specific stations marked with buoys.

In order to determine spawning success and the distribution of sockeye spawners, spawning ground surveys are made during the latter part of July continuing through the middle of August.

Essentially the same procedures and methods have been used to study the newly introduced Frazer Lake sockeye population since 1965. The results of these data have been compiled yearly and published in Alaska Department of Fish and Game Informational Leaflets (Meehan, Eaton, 1965; Eaton, 1966).

In just eleven years starting with the first sockeye return in 1956 until the present, Frazer Lake has had a total accumulated return of 44,132 sockeye salmon (Table 1). The Frazer Lake sockeye run has continually increased every year with the exception of the 1965 return.

Purpose

The Frazer Lake fishpass was constructed primarily for the purpose of establishing a sockeye run which would significantly benefit the commercial fishery. The research program was initiated to study and assess biological and physical factors concerning: (1) productivity of Frazer Lake, (2) freshwater survival of juvenile sockeye, and (3) the effects of adult and juvenile sockeye introduction on a large lake system previously devoid of salmon.

Table 1. -- Frazer Lake escapements and adult transplants, 1956-1967

Year	Escapements 1/	Transplants	Total
1956	6 1/	0	6
1957	165 1/	0	165
1958	71 1/	42	113
1959	62 1/	0	62
1960	440 1/	0	440
1961	273 1/	600	873
1962	1,290	1,800	3,090
1963	2,357	9,500	11,857
1964	8,166	1,800	9,966
1965	5,074	4,000	9,074
1966	11,728	4,728	16,456
1967	14,500	7,334	21,834
Total	44,132	29,804	73,936

1/ Number carried over falls - total escapement unknown.

SMOLT INVESTIGATIONS

Sampling Procedure

Sockeye smolt enumeration commenced on May 13 and was discontinued August 22 when limited numbers indicated termination of the smolt migration. Sampling and enumeration of smolt were performed daily at approximately 9:00 A.M. During the months of June and July, counts were made every night to lessen the chance of smolt mortality.

Water temperature of the outlet stream was taken daily at approximately 9:00 A.M. at the weir site (Figure 2). All species of migrating fish were enumerated daily. All sampled smolts were anesthetized in MS-222 (tricaine methanesulfonate) for a period of one to five minutes. The anesthetized smolts were then placed on a wet sheet of 10 millimeters to the centimeter graph paper and the fork length was marked on the paper by pricking the paper at the fork of the tail with a probe (Meehan, 1966). The techniques and methods for scale removal and recording were the same as described by Eaton (1966).

Some slight modifications in sampling procedure were initiated in 1967 such as increasing the sample size to 300 smolts during the peak migration periods and nightly enumerations. The following are the sampling procedures employed in 1967:

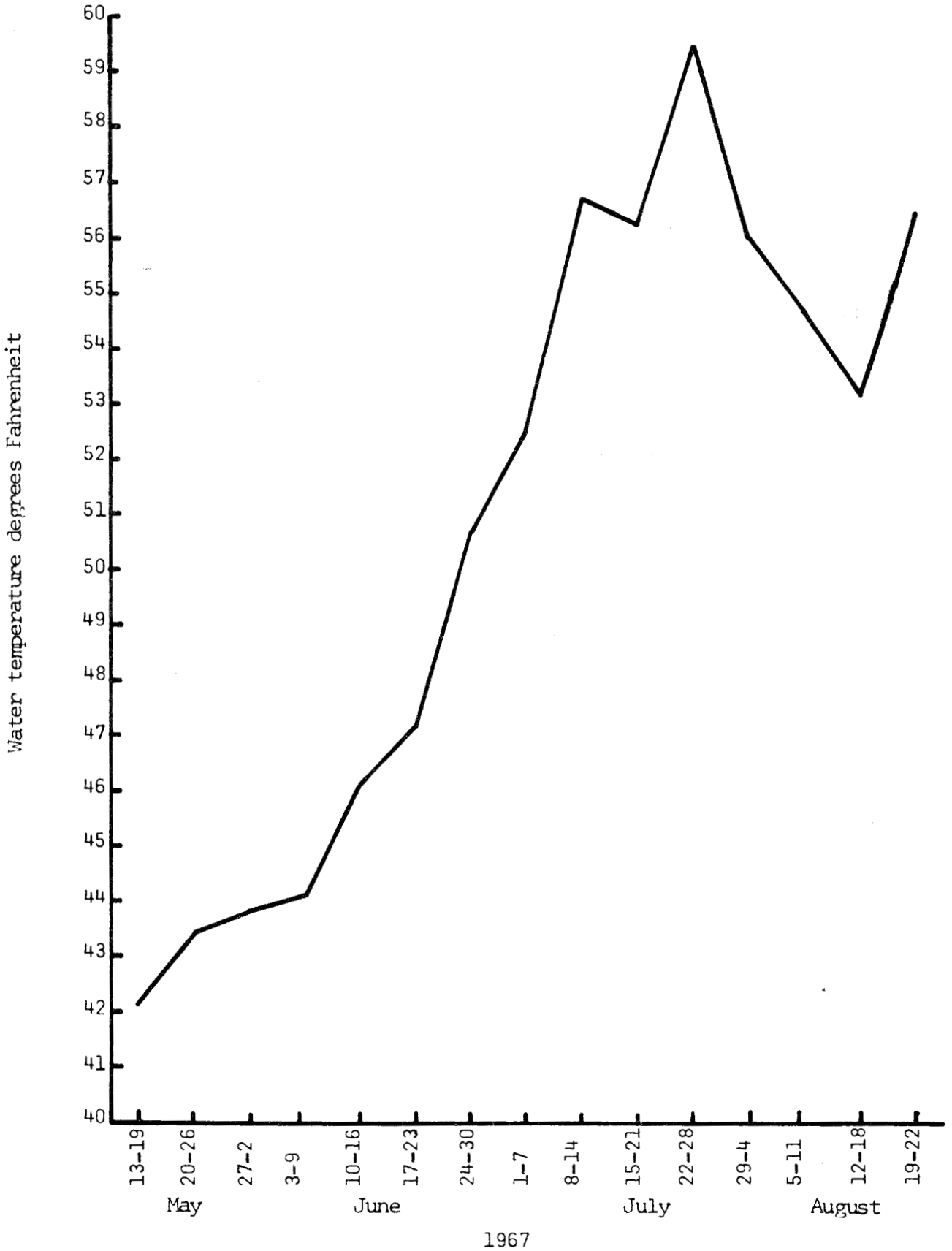
1. Daily enumeration of all species of migrating fish and the recording of any mortality.

2. A seven-day sampling period was used during the smolt seaward migration. During the first five periods, 300 random scales and lengths were taken. Monday through Saturday 45 scales were taken and 35 were taken on Sunday. During the last five sampling periods, 150 random scales and lengths were taken. For convenience sake, 80 scales were taken on Sunday and 35 scales on Tuesday and Friday respectively.

3. Weights were taken each sampling period from five fish in each five millimeter size group for condition factor.

Sampling was discontinued on August 3, but enumeration at the weir continued until August 22. During the 19 day period, only 256 smolt were counted through the smolt weir. Throughout the 1967 smolt migration, 134,124 smolt were enumerated, 1,943 random scales were collected, 1,960 lengths were

Figure 2. Average weekly water temperatures taken at smolt weir daily about 9:00 a.m., Frazer Lake, 1967



recorded and 597 weights were taken.

Timing of Smolt Migration

The weir was completed May 13, the earliest date that the sampling facility had ever been in operation. The first smolt was counted on May 17, four days after opening. Because only 234 smolt were enumerated during the month of May, it is believed that the smolt weir was functioning well before seaward migration commenced. The migration reached its peak during the first two weeks in June when 56,521 smolt were enumerated, or over 1/3 of the total run (Figure 3).

The 1967 smolt migration displayed a rapid increase in smolt passing through the weir in early June and reached a peak the second week of June then proceeded to gradually decline for the rest of the migration period. Migration patterns have constantly changed since sampling was initiated in 1965, but the past two years have displayed tendencies for a shorter and more intensive migration period (Figure 4).

Length-Frequency Distribution of Smolts

The dominant length group during 1967 (145-149 mm) was a decrease of 35 mm from the 180-184 dominant length group of 1966. The mean length group during 1967 consisted of smolts in the 155-159 mm range. A total of 1,960 random lengths were taken throughout the migration period (Figure 5). The largest smolt sampled measured 249 mm, and the smallest smolt measured 118 mm.

Age Class Composition of Smolts and Timing by Age

Random scale samples were collected when possible during each sampling period, however, due to insufficient smolt numbers passing through the weir during the months of May and August, only a few scales were obtained during these months. So few scales were collected in May and August that the first three sampling periods in May and the last three sampling periods in August were each combined into one period.

A total of 1,943 random scale samples were collected for age analysis from the 1967 smolt migration. Age composition was determined for each sampling period by counting the number of random scale samples collected

Figure 3. Timing of smolt migration, Frazer Lake, 1967

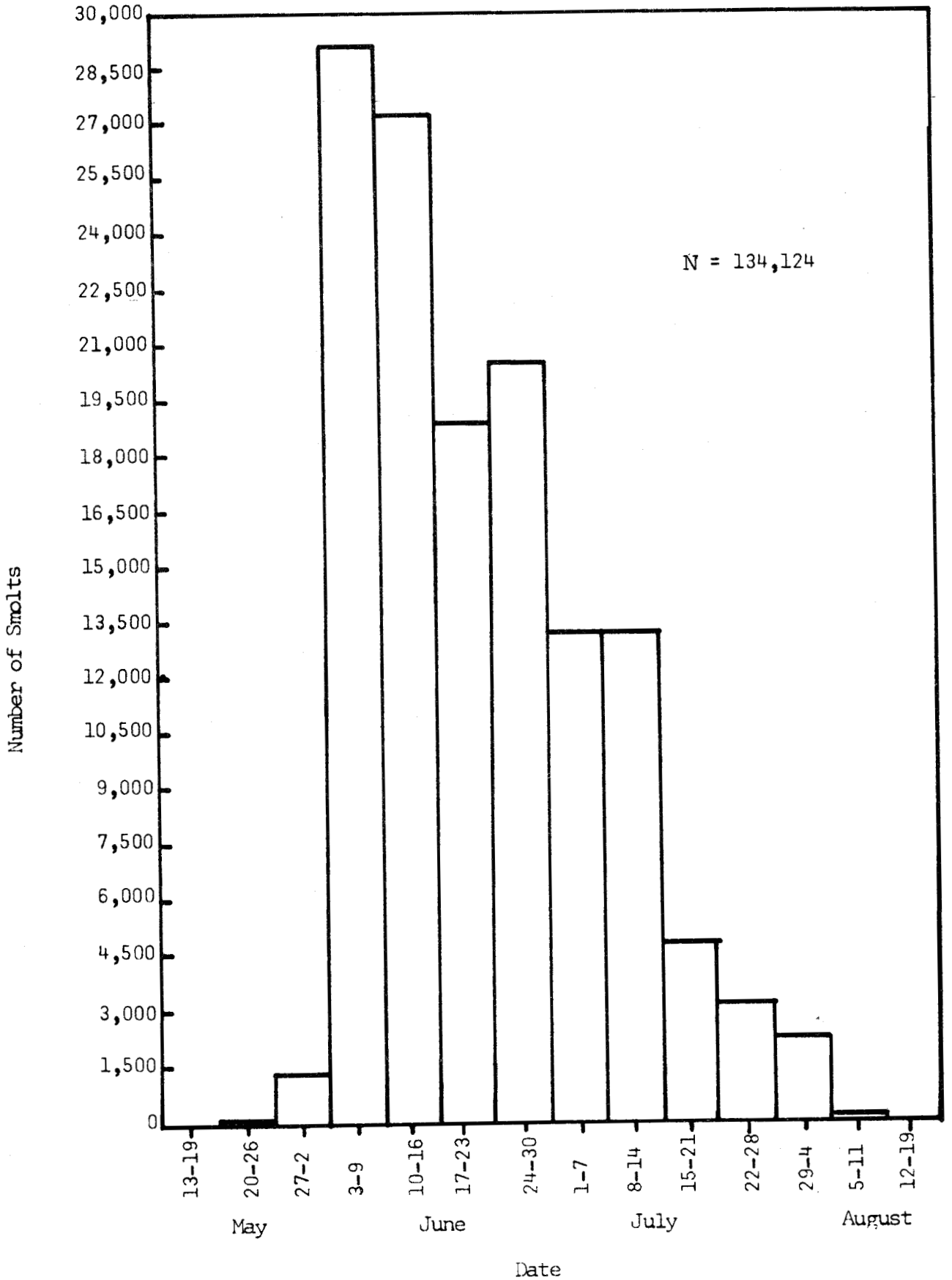


Figure 4. Smolt migration timing, Frazer Lake, 1965, 1966, 1967.

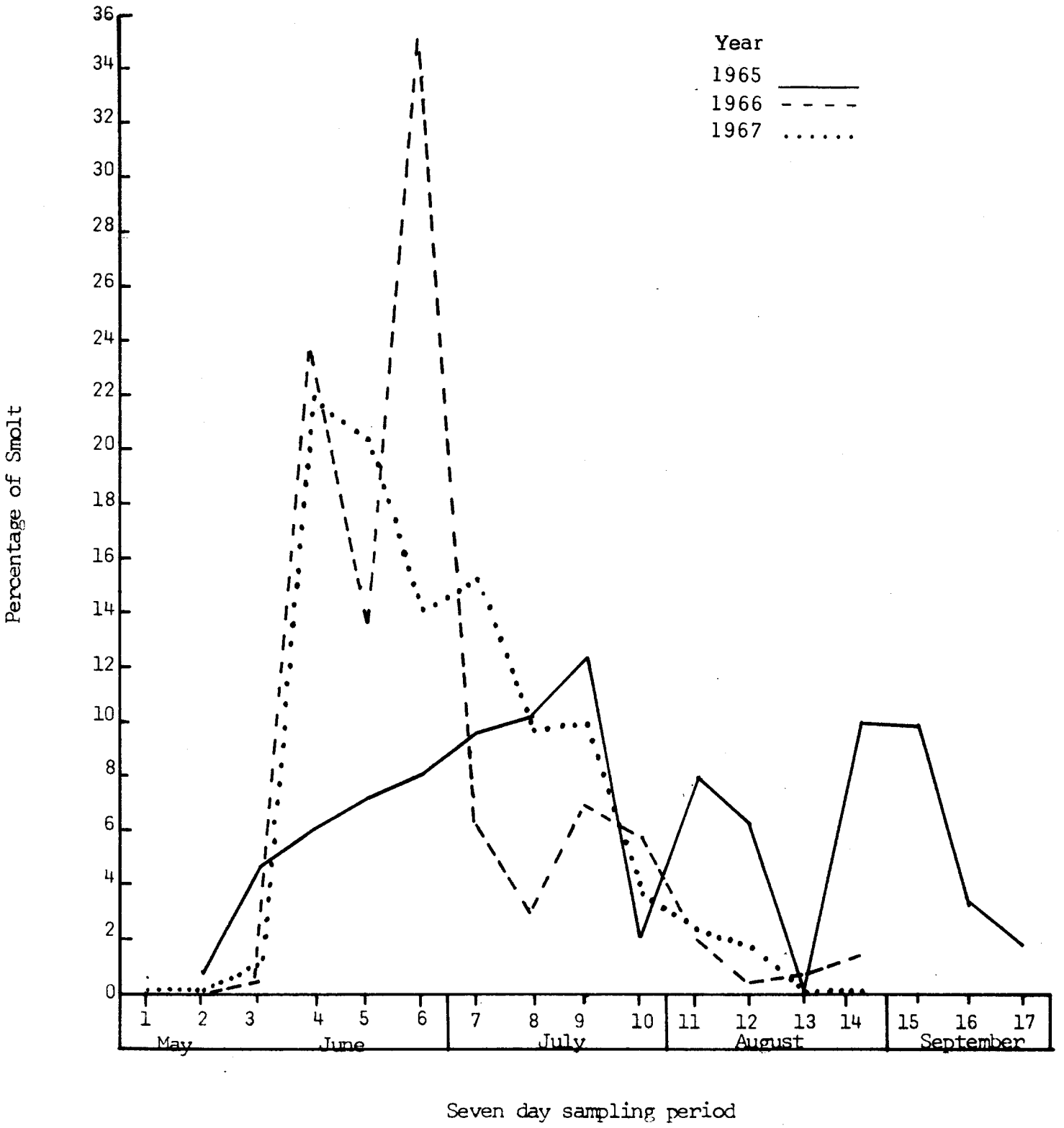
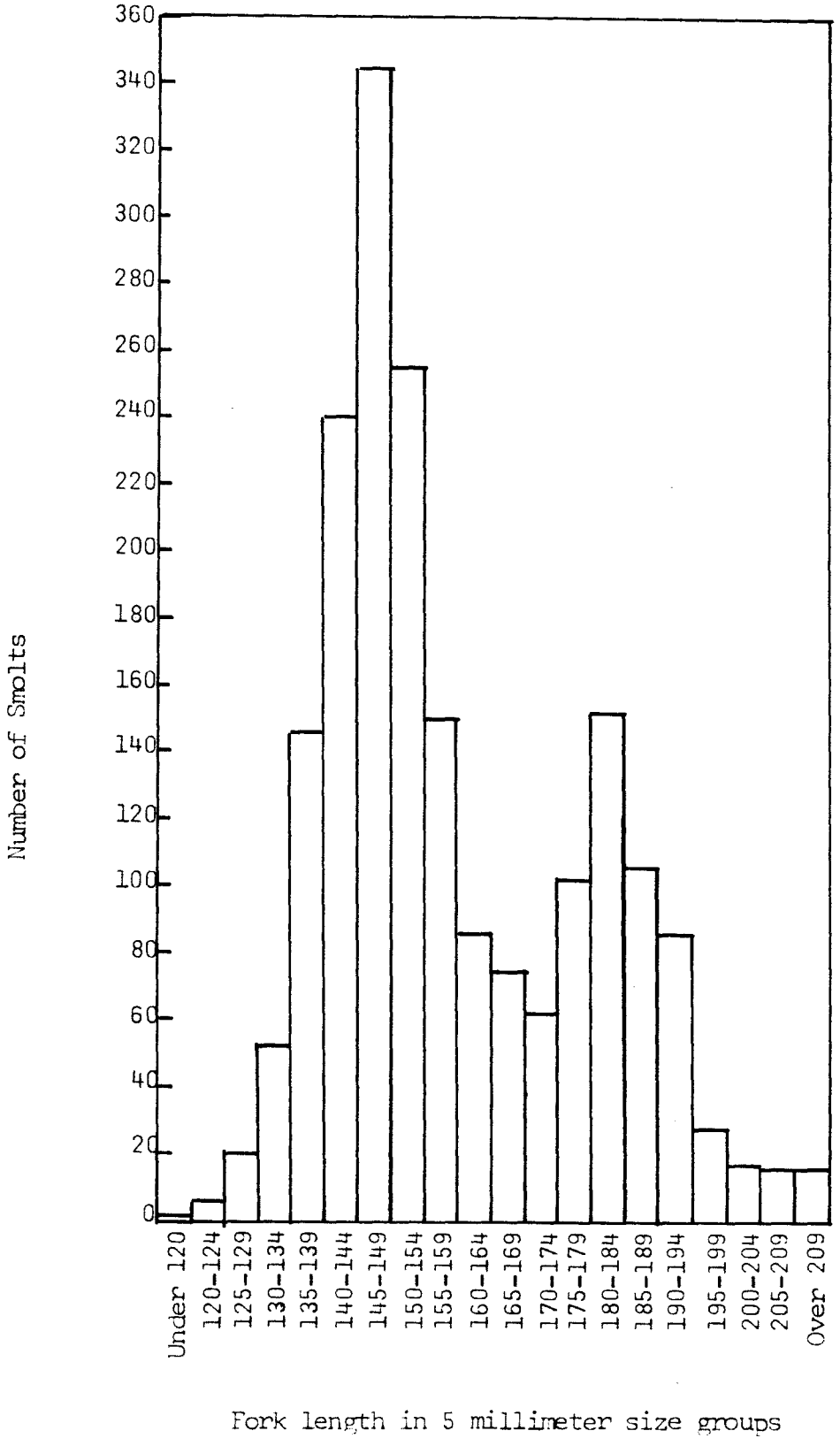


Figure 5. Frequency-distribution, random sample of 1,960 fork lengths, Frazer Lake, 1967



during that period. The sample numbers in each age class was then projected to the total enumeration for that sampling period. Using this method, age composition was calculated for all migrating smolt (Table 2).

Three freshwater age classes comprised the 1967 smolt migration. The age I fish were the dominant age class consisting of 48.4 percent of the migration. Age II fish comprised 43.4 percent and age III fish comprised 8.2 percent of the migration.

In comparing age to length, it was found that all random scales analyzed for smolts 130-134 mm and under were age I fish. Smolts in the 135-159 mm length groups were in the overlap area and included both age I and age II fish. Age II fish were strictly in the 160-169 mm length group. The overlap area between age II and age III was in the 170-204 mm length group (Table 3).

A shift in age composition was noted for the third sequential year. In 1965 the age I fish comprised 6.4 percent of the migration. In 1966 age I fish accounted for 18.3 percent of the smolt migration and in 1967, age I fish were the dominant age class comprising 48.4 percent of the smolt run. After three years of studying age composition, one basic trend is evident. Age I fish have increased in numbers - from the least abundant in 1965 to the dominant age class in 1967 (Table 4).

Age II and Age III fish migrated in greater numbers at the beginning of the migration. Age I and II fish varied in dominance throughout the season; however, greater numbers of age II fish migrated at the beginning and end of migration while age I fish dominated the middle migration period (Figure 6).

The 1967 smolt migrants were the progeny of the 1963, 1964 and 1965 escapements into Frazer Lake. In conjunction with these natural runs, adult transplants and eyed egg plants were also made which have to be included when calculating juvenile sockeye survival.

In 1963, the Frazer Lake escapement was 2,357 sockeye and 9,500 transplanted adult spawners from Red Lake for a total of 11,857. In 1964, the escapement was 8,166 sockeye and 1,800 transplanted adults for a total of 9,966 spawners. In 1965, 719,600 eyed eggs were planted in a tributary stream of Frazer Lake. The escapement was 5,074 and 4,000 spawners were moved from Red Lake for a total of 9,074 sockeye spawners.

The numbers of the three age classes produced by the 1963 parent year have been calculated and the freshwater survival from time of egg deposition

Table 2. Age composition of sampled smolt in relation to weekly smolt enumeration, Frazer Lake, 1967.

Sampling period	Sample size	Sampled number of smolts 1/ age composition			Weekly enumeration	Number of smolt age composition of weekly enumeration		
		I	II	III		I	II	III
May 13-June 2 2/	30	0	20	10	1,492	-	994	498
3-9	252	35	190	27	29,260	4,067	22,063	3,130
10-16	297	168	115	14	27,261	15,402	10,578	1,281
17-23	298	173	100	25	18,911	10,969	6,354	1,588
24-30	299	220	63	16	20,510	15,096	4,307	1,107
July								
1-7	195	139	45	11	13,125	9,371	3,019	735
8-14	147	72	53	22	13,217	6,463	4,758	1,996
15-21	149	66	75	8	4,850	2,149	2,440	261
22-28	148	30	103	15	3,123	634	2,174	315
July 29-Aug. 19 2/	128	39	85	4	2,375	724	1,577	74
Totals	1,943	942	849	152	134,124	64,875	58,264	10,985

Percent age composition relative to total run.

Age 1 $\frac{64,875}{134,124} = 48.4\%$

Age II $\frac{58,264}{134,124} = 43.4\%$

Age III $\frac{10,985}{134,124} = 8.2\%$

100.0%

1/ Roman numeral corresponds to number of annuli or winters in freshwater.

2/ Three sampling periods combined as one period.

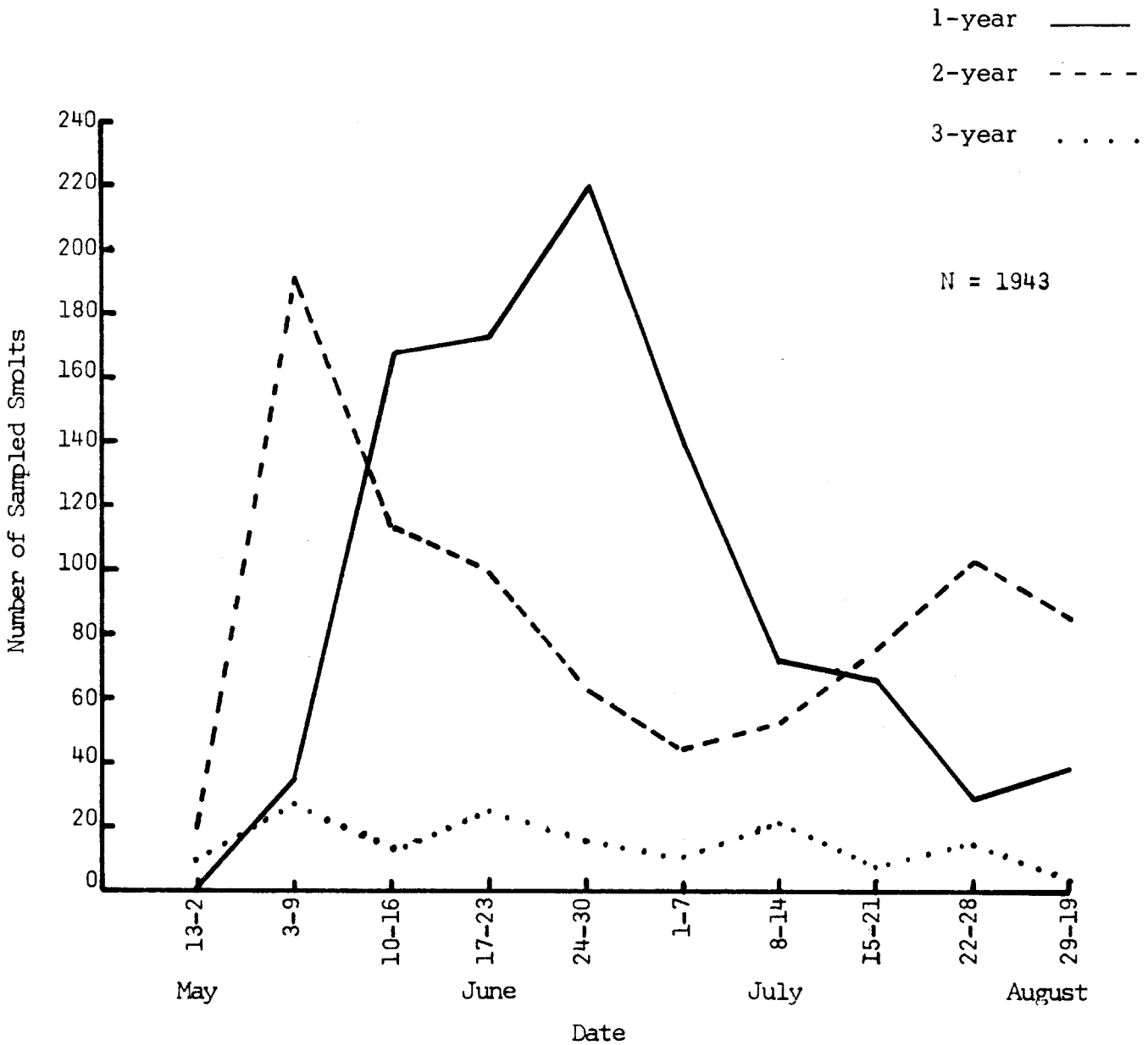
Table 3. Age composition and length of smolts sampled at the Frazer Lake smolt weir, 1967.

Size Group Fork Length mm	Sample Size	Number of Smolts of Age I	II	III
Less than 120	1	1		
120-124	6	6		
125-129	20	20		
130-134	52	52		
135-139	145	140	5	
140-144	239	228	11	
145-149	341	301	40	
150-154	253	162	91	
155-159	149	32	117	
160-164	84		84	
165-169	74		74	
170-174	62		61	1
175-179	101		101	
180-184	151		139	12
185-189	108		79	29
190-194	84		41	43
195-199	27		5	22
200-204	17		1	16
205-209	17			17
210-214	6			6
215-219	5			5
Over 219	1			1
Total	1,943	942	849	152

Table 4. Percent age composition of smolts enumerated at Frazer Lake weir in 1965, 1966, and 1967

Year	Number in migration	Percentage of Age I	II	III	Percent
1965	26,945	6.4	74.2	19.4	100
1966	157,291	18.3	66.3	15.4	100
1967	134,124	48.4	43.4	8.2	100
Total	318,360				

Figure 6. Timing of migration by weekly period as indicated by number of sampled smolt in each age class, Frazer Lake, 1967.



to smolt out-migration estimated (Table 5).

Condition Factor

Every sampling period, five weights were collected in each five millimeter size group to obtain condition factors and mean weights.

The formula $\frac{W x 10^n}{L^3}$ was used in calculating smolt condition factors, when W is the weight in grams and L for length in millimeters.

Condition factors were taken for each age class, and from Table 6 it can be seen that age I fish had the highest average seasonal condition factor of .949. No definite trend is evident as fluctuations occurred in all age classes during the season.

In conjunction with the weights used in calculating condition factor, 597 weights collected were also used to determine mean weights per length group (Table 7).

Smolt Mortality and Predation

Predation was again observed this year by mew gulls (*Larus canus*) and red-breasted mergansers (*Mergus serrator*). These two species were quite plentiful and daily observations were made of their smolt catching techniques.

Weir mortality was less than one percent this year. Most smolt mortality was encountered during the latter part of July when water temperatures in the high 50's made smolt more susceptible to injury on the weir screens. It was believed warm water made smolt more sluggish and they being less vigorous were unable to keep from being swept on the weir screens by the river current.

Three species of salmon, sockeye, chum and king were enumerated at the weir besides rainbow trout, Dolly Varden, stickleback and cottids (Table 8). The 1967 smolt run of 134,124 was somewhat less than the 1966 smolt migration of 157,291, but the migrating smolt were in excellent condition and their size remained unusually large for migrating sockeye smolt.

Table 5. Potential egg deposition to smolt survival for the 1963 Frazer Lake parent year

Number of spawners			11,857
Number of females 1/			5,928
Potential egg deposition 2/			14,820,000
Smolt produced for years:	1965	Age I	1,713
	1966	Age II	104,303
	1967	Age III	10,985
	Total smolt production		117,001

117,001 smolt produced

14,820,000 potential egg deposition = 0.79 percent survival

1/ No sex ratio available 50 - 50 ratio assumed

2/ 2,500 eggs average fecundity assumed

Table 6. Average condition factor by age group for sampled smolts, Frazer Lake, 1967

	Average Condition Factor (K) and Sample Size (n) for Smolts of Age					
	I		II		III	
Date	K	n	K	n	K	n
May 13-19	-	-	.965	2	-	-
20-26	-	-	-	-	-	-
June 27-2	-	-	.952	17	.935	10
3-9	.946	21	.953	42	.934	13
10-16	.972	32	.935	35	.933	11
17-23	.952	25	.911	27	.866	17
24-30	.920	29	.904	29	.904	9
July 1-7	.913	34	.858	22	.820	7
8-14	.901	20	.930	26	.892	15
15-21	.968	15	.936	24	.883	7
22-28	.984	11	.954	26	.916	14
Aug. 29-4	.991	16	.960	27	.890	5
Average for season	.949	203	.932	277	.897	108

Table 7. Mean weights, of sampled smolts Frazer Lake, 1967

5 mm Size groups Fork lengths	Sample size	Mean weight grams
Less than 120	1	16.1
120-124	6	18.8
125-129	19	20.1
130-134	29	21.9
135-139	45	24.9
140-144	47	27.3
145-149	40	30.5
150-154	44	31.8
155-159	41	35.2
160-164	32	39.9
165-169	34	44.5
170-174	31	48.0
175-179	29	51.7
180-184	44	55.0
185-189	43	59.5
190-194	41	64.1
195-199	26	68.8
200-204	15	73.8
205-209	17	78.8
210-214	6	87.4
215-219	7	87.8
Total	597	

Table 8. Total number and mortality of various species of fish trapped by downstream smolt weir, Frazer Lake, 1967

Species	Total number trapped	Mortality Number	Mortality Percent
Sockeye salmon smolt (*O. nerka*)	134,124	1,231	0.9
Dolly Varden char (*Salvelinus malma*)	293	109	47.2
Rainbow trout (*Salmo gairdneri*)	45	0	0
Threespine stickleback (*Gasterosteus aculeatus*)	436	426	97.7
Cottid (*Cottus aleuticus*)	12,099	11,988	99.0
King fry (*O. tshawytscha*)	621	585	94.2
King smolt (*O. tshawytscha*)	30	11	46.6
Chum fry (*O. keta*)	3,552	670	18.8

SUMMARY

1. The smolt weir was operational May 13 and sampling and enumeration of smolts continued until August 22 when numbers of migrating smolt dwindled to the extent that sampling was not feasible.

2. During the first five sampling periods, 300 random scales per period were collected. Random scale samples were decreased to 150 per period during the last five sampling periods.

3. Daily stream water temperatures averaged into weekly water temperatures indicated a minimum water temperature of 42.1^{o} F during the week of May 13 and a maximum water temperature of 59.5^{o} F during the week of July 22.

4. The smolt migration decreased in duration from the two previous years being most intensive during June and July with few smolt migrating in May and August.

5. Mean fork length for 1967 migrating smolt was in the length group 155-159 mm, a decrease of 15 mm from 1966.

6. Three age classes were represented in the 1967 smolt migration with age I fish as the dominant age class consisting of 48.4 percent of the run.

7. Freshwater survival of eggs deposited in the 1963 parent year to out-migrating smolts of age I 1965, age II 1966 and age III 1967 was calculated to be 0.79 percent.

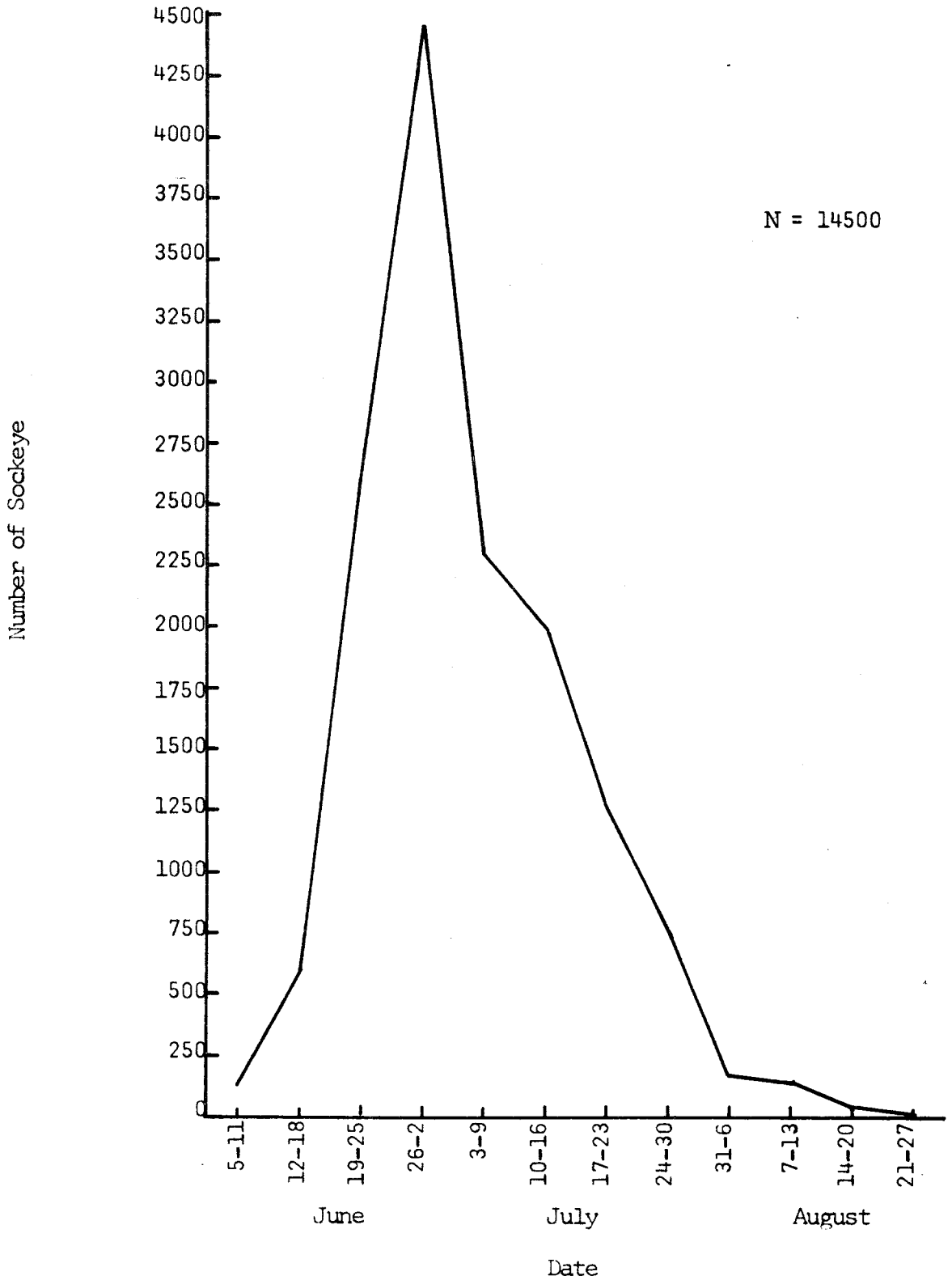
8. A total migration of 134,124 smolts was enumerated in 1967, or 23,167 fewer smolt than 1966.

ADULT INVESTIGATIONS

Fish Enumeration

The 1967 escapement began on June 5 when two sockeye were counted through the trap and continued until August 27 when the last sockeye was counted. The escapement reached its peak during the last week of June when 4,473 sockeye were enumerated (Figure 7).

Figure 7. Migration and timing of sockeye adults, Frazer Lake, 1967



Escapements of pinks and chums were also enumerated through the fishpass (Table 9). As in past years, only salmon were allowed entrance into Frazer Lake.

The sockeye mortality at the fishpass was attributed to injuries received while sockeye were jumping at the falls. Many of these fish that were examined showed no visible external injury, but upon examining the body cavity, internal bleeding was evident. This mortality is to be expected as long as sockeye prefer to jump at the falls before using the fishpass facility.

Sampling Procedure

Two-hundred random sockeye scales were collected during each seven-day sampling period. All the sampled fish were anesthetized in MS-222 (tricaine methanesulfonate). Scales were removed from each fish for later age analysis. Sex was determined by visual observation and a fork length in millimeters was recorded for each sampled fish. Weights were taken from five males and five females in 20 millimeter size groups each period.

Fish were captured by means of a trap placed at the fishpass exit. Fish that were not sampled were individually counted through the trap and allowed to continue their upstream migration.

Age and Size Distribution of Adult Spawners

Analysis of 1,380 sockeye scales collected during the 1967 migration consisted of twelve separate age groups (Table 10, Figure 8). The dominant age group of 2.2 comprised 42 percent of the escapement. Fish spending two years in freshwater accounted for 75.1 percent of the escapement while precocious males (jacks) comprised 2.4 percent. Fish spending three years in saltwater comprised 39.8 percent of the escapement. Males accounted for 49.8 percent of the run while females comprised 50.2 percent for a normal sex ratio.

The dominant length group for males was in the 580-599 mm group while females ranged from 540-579 mm, dominating two length groups (Figure 9).

A total of 1,483 scales were collected, but 103 were unreadable due to regeneration.

Table 9. Species enumeration at fishpass, Frazer Lake, 1967

Species	Number	Known Mortality at Ladder
Oncorhynchus nerka	14,500	144
O. keta	1,081	0
O. gorbuscha	3,829	0
O. kisutch	1	0

Table 10. Age composition and lengths 1/ of male and female sockeye salmon, Frazer Lake 1967 2/

	AGE GROUP 3/												Total or Average
	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	
						Combined Sexes							
Number of Fish	43	943	957	101	232	6,090	4,292	276	73	942	522	29	14,500
Percent of Escapement	0.3	6.5	6.6	0.7	1.6	42.0	29.6	1.9	0.5	6.5	3.6	0.2	100.0
						Males							
Number of Fish Sampled	4	60	62	8	23	274	175	22	6	37	15	2	688
Mean Length	445.3	562.7	617.3	665.2	457.4	568.4	614.7	661.5	450.6	574.8	634.4	676.0	577.3 4/
Percent of Escapement	0.3	4.4	4.5	0.6	1.6	19.9	12.7	1.6	0.4	2.7	1.0	0.1	49.8
						Females							
Number of Fish Sampled	--	29	29	2	--	305	233	4	1	52	36	1	692
Mean Length	--	545.8	599.2	649.0	--	550.5	601.9	654.2	450.0	564.2	598.2	652.0	586.5 4/
Percent of Escapement	--	2.1	2.1	0.1	--	22.1	16.9	0.3	0.1	3.8	2.6	0.1	50.2
						Differences							
Mean Differences	--	16.9	18.1	16.2	--	17.9	12.8	7.3	0.6	10.6	36.2	24.0	16.0 4/
Percent Females Smaller than Males	--	3.0	2.9	2.4	--	3.5	2.0	1.1	0.1	1.8	5.7	3.5	2.6 4/

1/ Fork length measurements were taken to the nearest millimeter
2/ Based on analysis of scales taken from 1,380 fish throughout migration
3/ A number preceding the period represents the number of freshwater annuli. A number after the period represents the number of saltwater annuli. Thus a 2.2 fish is in its 5th year having 2 winters in freshwater and 2 winters in saltwater.
4/ Not weighted by sample size of individual age groups

Figure 8. Age distribution of adult male and female sockeye salmon, Frazer Lake, 1966

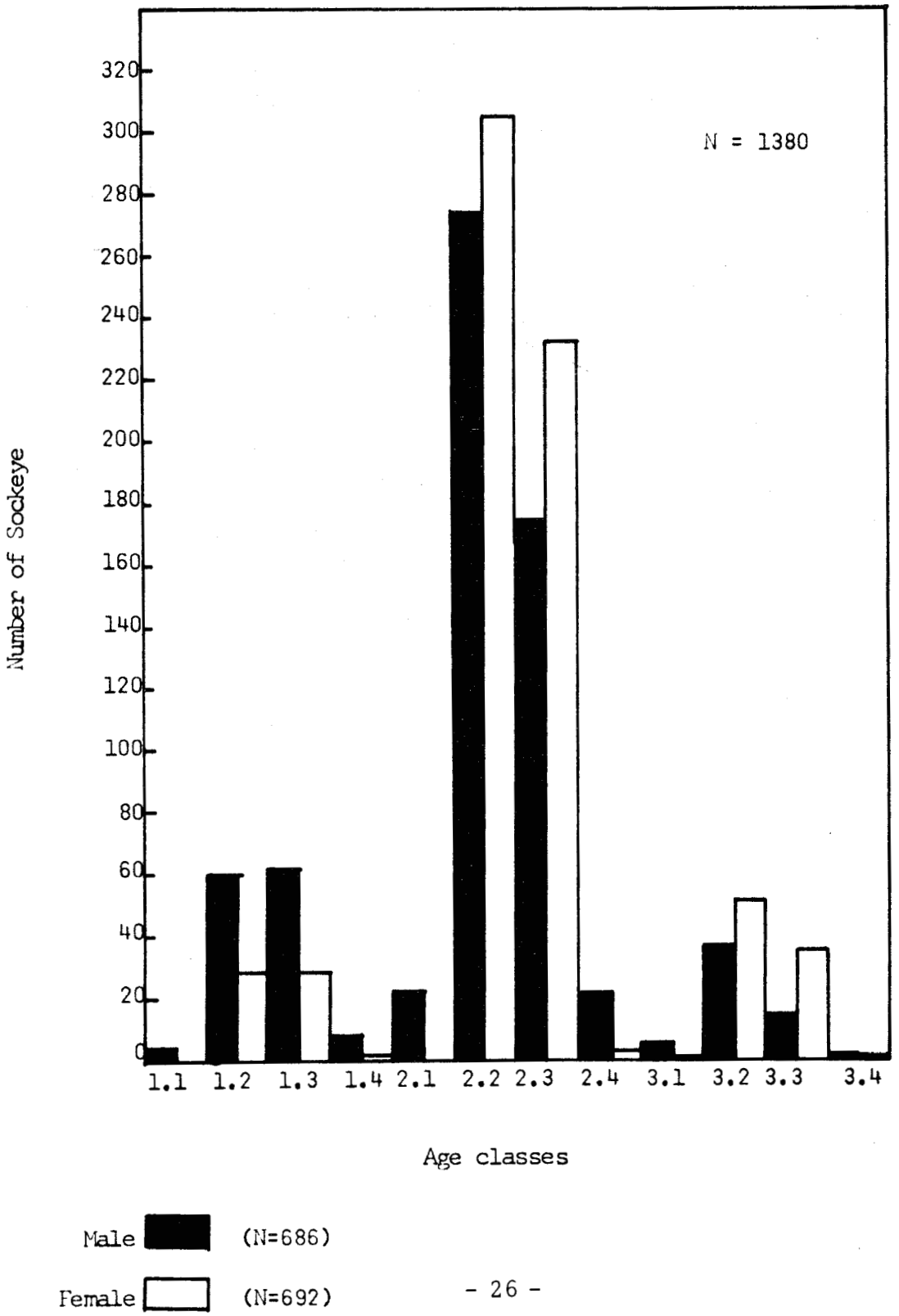
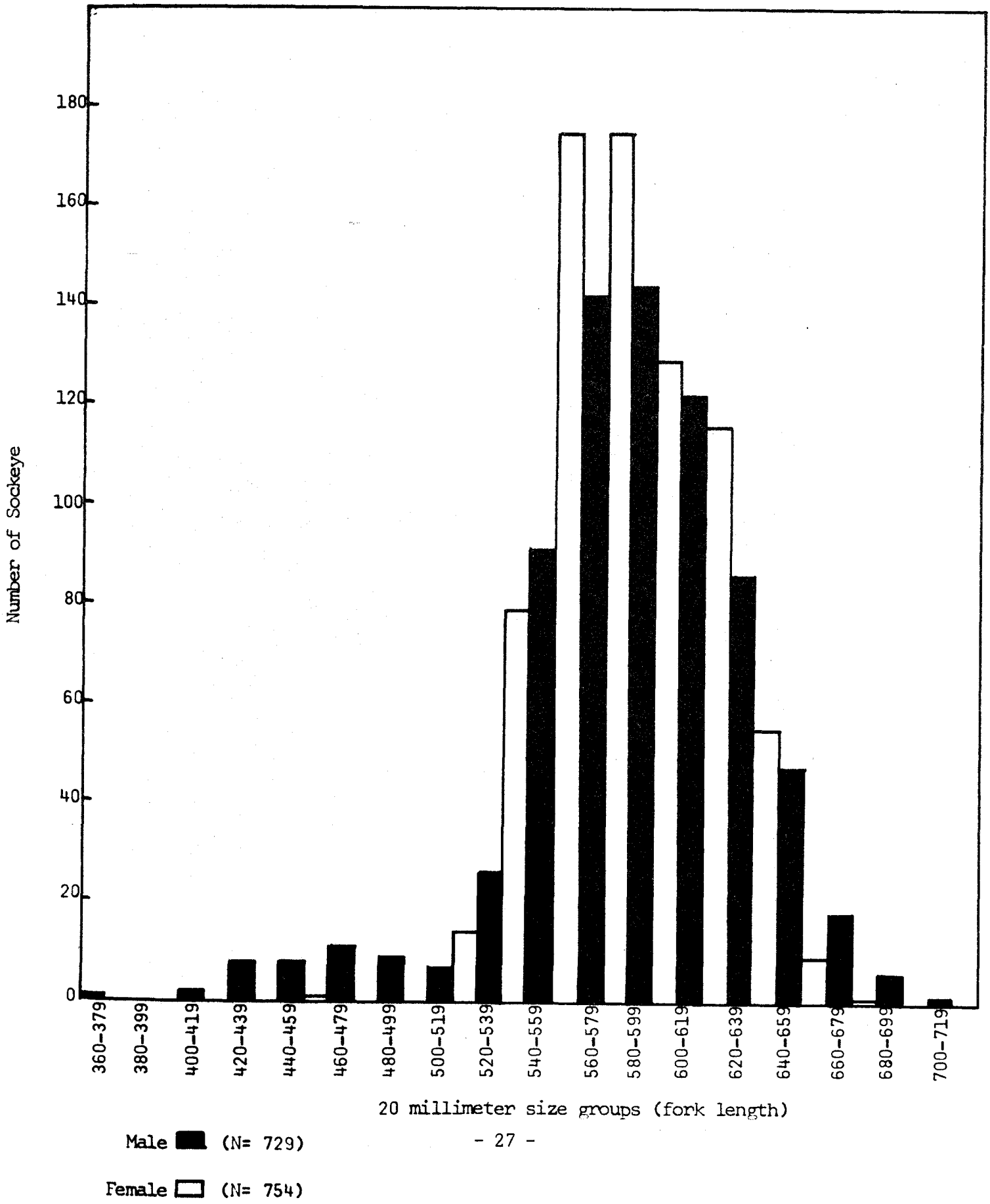


Figure 9. Length-frequency distribution of sockeye salmon escapement, Frazer Lake, 1967.



Condition Factor

A mean condition factor of 1.13 was computed for both male and female sockeye during 1967 (Table 11). There was a general trend for decreasing condition factors as the season progressed. A total of 670 weights were taken throughout the run to obtain average weekly condition factors.

All sampled fish were examined for injuries which were fresh and could probably be attributed to being received while the fish were jumping at the falls. A total of 1,483 fish were examined and of that number, 90 had wounds that they probably received while jumping or 6.0 percent of the run sustained injuries.

LIMNOLOGY

Frazer Lake Water Temperatures

Lake temperatures were taken approximately every two weeks at three stations. The stations were all located in the middle of the lake off streams 7, 12, and 16. The temperatures taken from the three stations were averaged into one mean lake temperature for each sampling period (Figure 10).

The first temperature series was taken on May 15 and at that time, the surface water temperature was recorded at 42° F and the temperature reading at 150 feet was 40° F. Lake surface temperature reached a high of 59° F on August 27.

Plankton Sampling

Since the beginning of the Frazer Lake study in 1965, plankton samples have been collected every two weeks during the field season. Sampling methods consisted of the following steps:

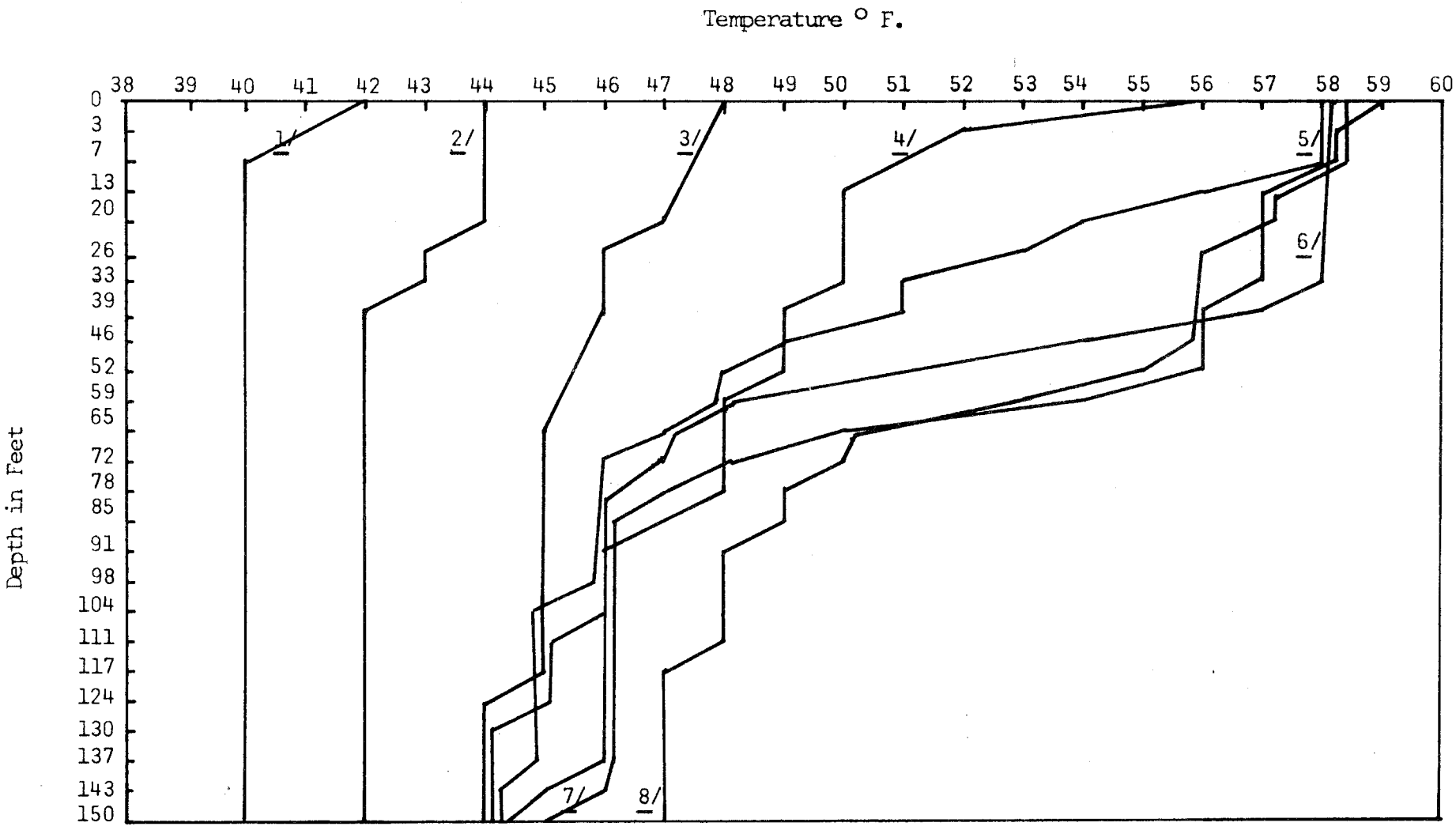
1. Two vertical hauls were made at separate buoy stations located midway in the lake off stream 12.

2. A one-half meter diameter 20 mesh net was lowered vertically until the bottom was reached. Then the depth was noted and the net retrieved.

Table 11. Average weekly condition factors (K) for male and female sockeye salmon, Frazer Lake, 1967.

Average Condition Factor (K) and Sample Size (n)				
	Males		Females	
Date	K	n	K	n
June 5-11	1.22	38	1.21	25
12-18	1.16	57	1.17	32
19-25	1.25	43	1.20	36
July 26-2	1.17	40	1.20	37
3-9	1.13	37	1.09	33
10-16	1.08	40	1.07	34
17-23	1.07	32	1.11	35
24-30	1.01	25	1.06	26
Seasonal	1.13	312	1.13	258

Figure 10. Frazer Lake mean water temperatures, 1967



1/ 5/15/67
2/ 6/1/67
3/ 6/18/67
4/ 7/2/67

5/ 7/13/67
6/ 7/30/67
7/ 8/14/67
8/ 8/27/67

3. Plankton organisms were taken from the bucket and placed in labeled 4-oz. bottles containing 10 percent Formalin.

Analysis of the plankton organisms consisted of the following steps:

1. A one milliliter sample was extracted from the thoroughly mixed bottle and was placed in a Sedgwick-Rafter counting chamber. The power of the microscope was calibrated so that each power corresponded to a certain volume of the one milliliter sample.

2. From each sample, random counts were made of the various planktonic organisms. Ten counts were made if there were few organisms and five counts were made if the organisms were numerous.

3. Organisms were separated in the basic classifications of Cladocerans, Copepods, Rotifers and Phytoplankton. The number counted in each milliliter sample was multiplied by the total volume of the sample which in turn was calculated into organism per square meter.

The purpose of collecting plankton samples is not to arrive at specific plankton densities as they occur in the lake, but rather to establish an index of plankton densities that can be evaluated with smolt production in the lake. It is known that juvenile sockeye are primarily plankton feeders and that they feed mainly on zooplankton (Cladocerans and Copepods). Using an established indexing method, trends in these zooplankton numbers can be plotted yearly. Frazer Lake at the present is a rich and productive lake (Table 12) when compared to other lakes in the Kodiak area; i.e., Ruth Lake on Afognak Island (a treated lake producing large healthy smolt) had an index number in May, 1966 of 3,600 cladocerans and 1,440 copepods per 60 ml sample. Frazer Lake had an index number of 160 cladocerans and 85,000 copepods per 80 ml sample in May, 1966.

After taking plankton samples for two years and plotting their numbers on a graph, it can be seen that numbers of copepods have increased and numbers of cladocerans have decreased (Figure 11).

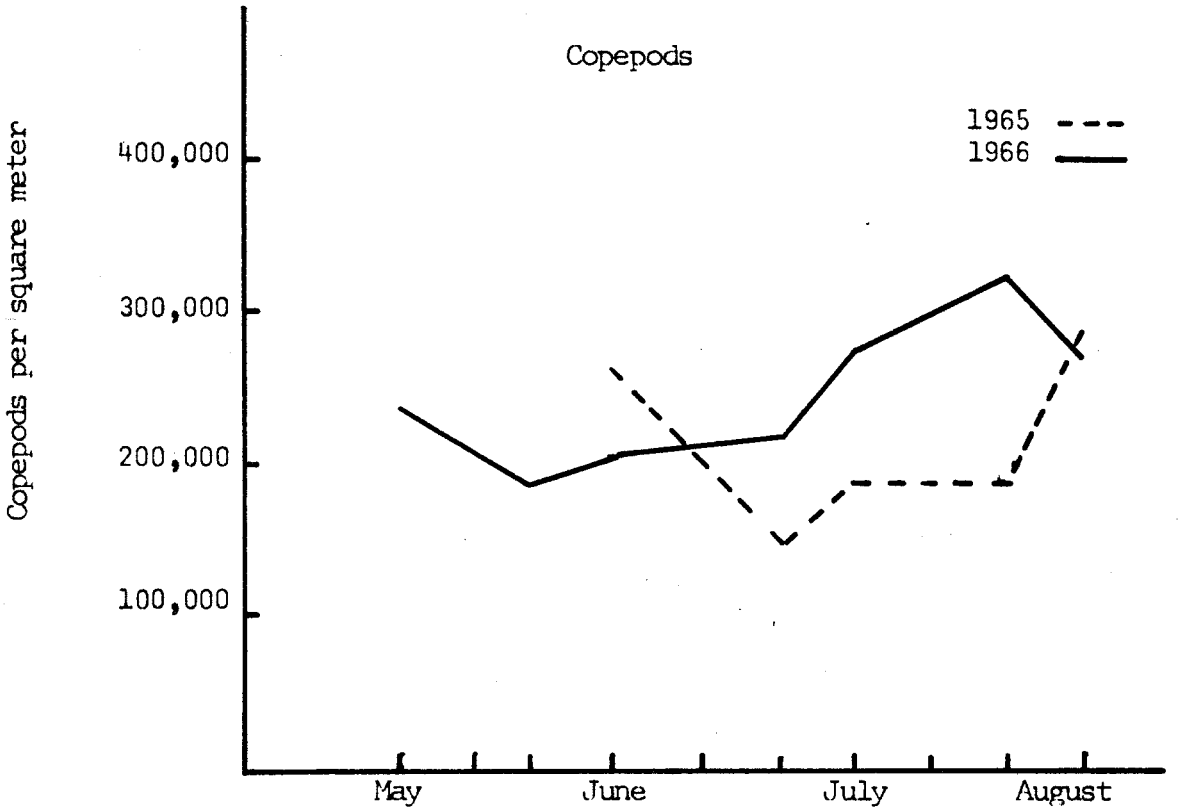
Frazer Lake Tagging

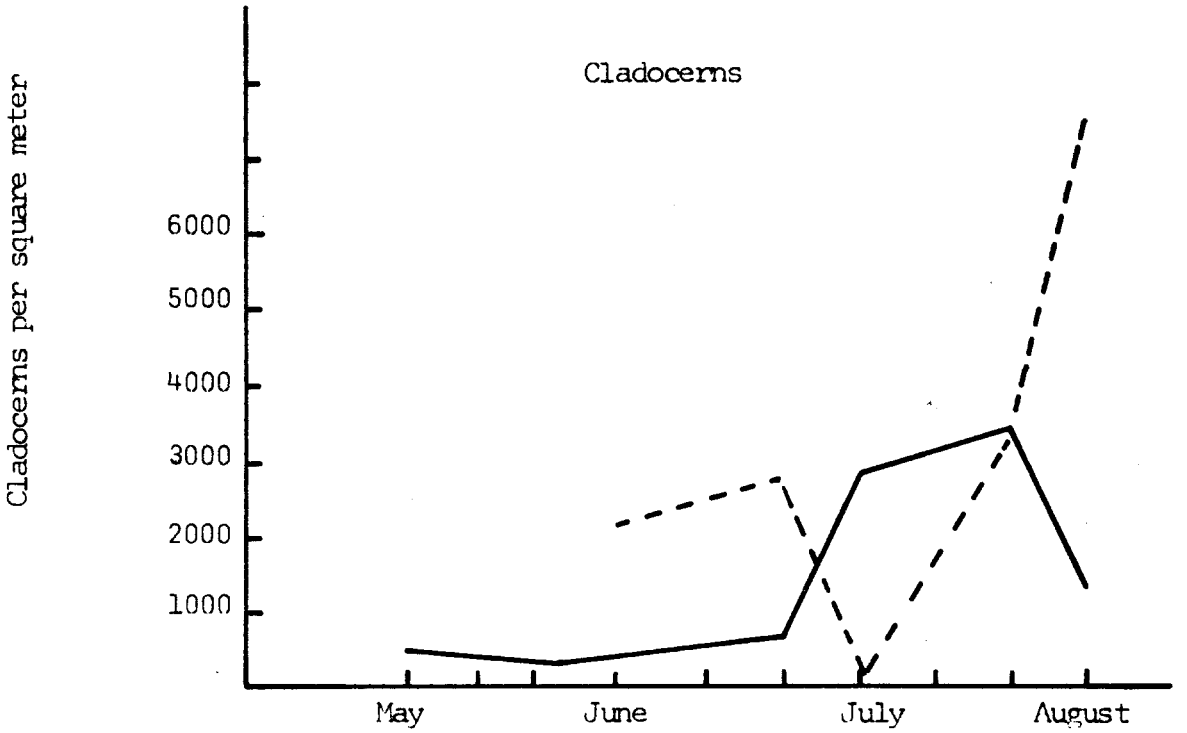
All but a few of the 7,334 fish moved from Red Lake this year were

Table 12. Plankton composition per surface square meter, Frazer Lake, 1965 and 1966.

Date	Average no. of organisms square meter	Cladocerans percent	Cladocerans number	Copepods percent	Copepods number	Rotifers percent	Rotifers number	Phytoplankton percent	Phytoplankton number
				1965					
6/17/65	2,112,500	.4	8,450	24.5	517,562	4.7	99,288	70.4	1,487,200
7/9/65	2,830,250	.4	11,321	10.5	297,176	3.2	90,568	85.9	2,431,185
7/17/65	3,875,850	.0	0	9.6	372,082	1.8	69,765	88.6	3,434,003
8/13/65	2,248,450	.6	13,491	16.8	377,739	3.9	87,690	78.7	1,769,530
8/13/65	2,729,812	1.1	30,028	21.1	575,990	7.1	193,817	70.7	1,929,977
				1966					
5/28/66	754,765	.3	2,264	62.1	468,709	1.8	13,586	35.8	270,206
6/14/66	1,326,040	.1	1,326	28.2	373,943	2.2	29,173	69.5	921,598
6/29/66	1,857,410	.1	1,857	22.2	412,345	1.4	26,004	76.3	1,417,204
7/14/66	2,718,550	.1	2,719	16.0	434,968	1.3	35,341	82.6	2,245,522
7/28/66	2,319,030	.5	11,595	23.6	547,291	3.1	71,890	72.8	1,688,254
8/12/66	2,244,760	.6	13,469	28.6	642,001	2.0	44,895	68.8	1,544,395
8/22/66	1,847,320	.3	5,542	29.1	537,570	1.3	24,015	69.3	1,280,193

Figure 11. Zooplankton densities per square meter, Frazer Lake, 1965, 1966.





tagged with dart tags. After three years of trying to distinguish between Red Lake fish and Frazer fish on the spawning grounds, definite and positive results were obtained this year. During the spawning ground surveys, a total of 685 live tagged sockeye were counted. One tagged male and two tagged females were killed by bears and 73 tagged spawned females were counted. The 73 tagged females are positive proof that some transplanted adult fish will spawn in new areas, such as Frazer Lake. Only a total of 801 tags were observed in the streams or 11.4 percent of the total number tagged. One possible reason for so few tag observations was mainly because of the difficulty in observing the small yellow tags that were used.

In summation, some of the Red Lake fish that were tagged were found to accept and successfully spawn in new spawning areas.

Stream Surveys

Surveys began on July 25 and ended August 18. All inlet streams of Frazer Lake capable of supporting spawning sockeye were surveyed at least once. All the major spawning streams were surveyed twice.

Previously only four streams contained spawning sockeye in any numbers, but this year stream seven had a peak count of 186 sockeye (Figure 12), the first year of reported spawning activity. It is interesting to note that 50 percent of these fish were of Red Lake stock (Table 13).

Stream utilization in order of most utilized to least utilized sockeye streams were 10, 1, 12, 7 and 9. The same order of utilization occurred in 1966 as in 1967 except for the addition of Stream 7 (Figure 12).

Small numbers of chum salmon were observed in most spawning streams, but the greatest chum spawning activity was in front of the smolt weir. An interesting observation was made in Stream 1. Approximately ten small mature pink salmon were observed in August that had never gone to sea. One of these fish was captured and positively identified as a two-year old male by scale analysis. Upon examination of the gonads, they were found to be fully developed and milt was easily extruded when pressure was placed on the abdomen.

Salmon carcasses were collected off the weir screens and spawning condition noted (Table 14). Pink salmon accounted for the majority of the carcasses with sockeye second and chum salmon third.

Another interesting occurrence observed this year dealt with sockeye

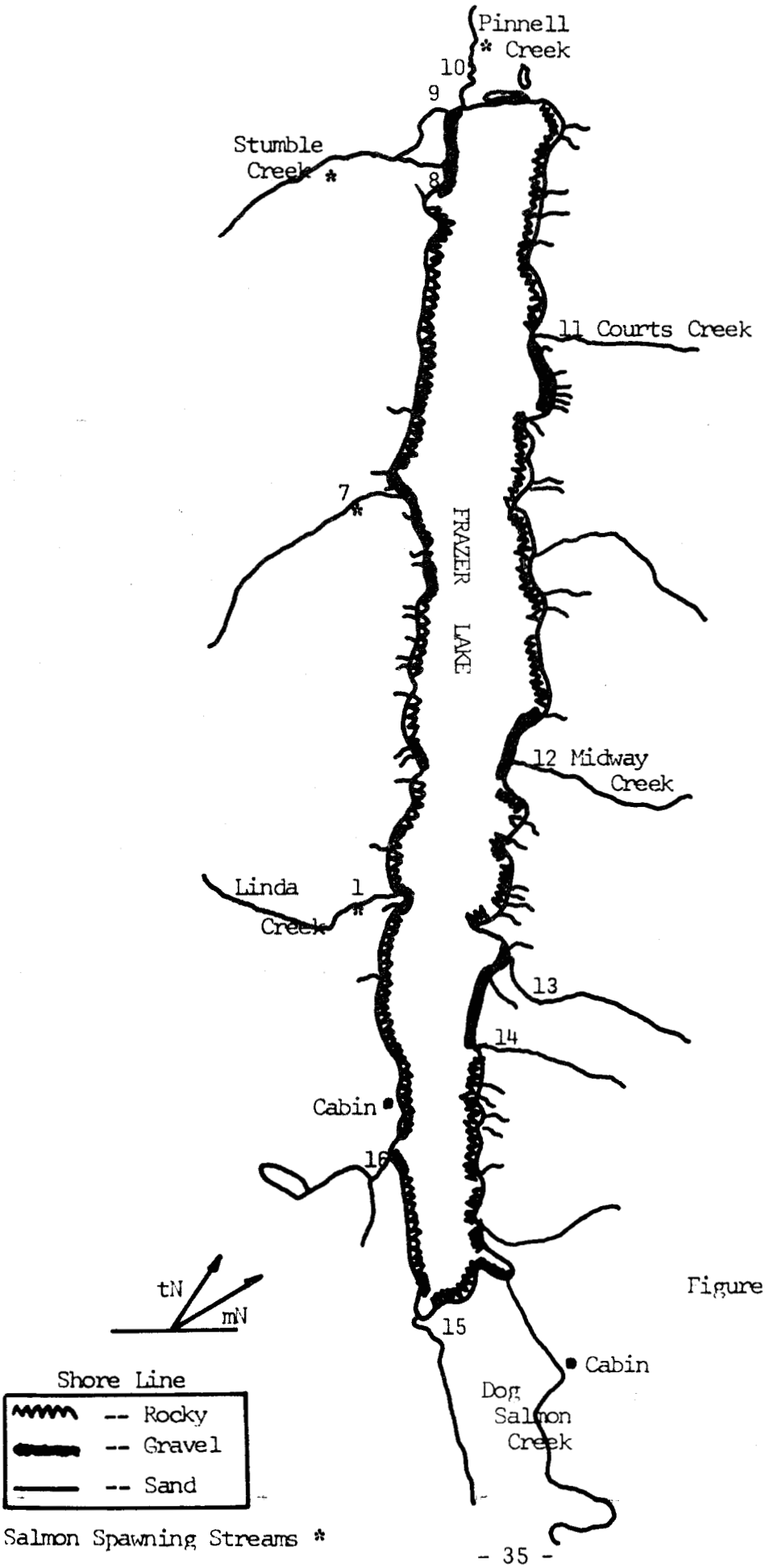


Figure 12. - Map of Frazer Lake and its tributaries.

Scale 1" = 1 mile

Table 13. Sockeye stream and beach surveys, Frazer Lake, 1967

Date	Stream	Temp. of Stream oF.	Live Sockeye		Dead Sockeye																	Total
					Tagged											Untagged						
					Bear Kills			Spawned		Unspawned		Bear Kills			Spawned		Unspawned					
			Tagged	Untagged	M	F	Unknown	M	F	M	F	M	F	Unknown	M	F	M	F				
7/25/67	15	56	2	12										9								23
7/27/67	16	54		5										2								7
7/27/67	7	50	82 1/	100 1/									4									186
7/27/67	13	51																				0
7/27/67	14	53																				0
7/28/67	12	55	12	93								79	53	84	33	33						387
7/29/67	1	58	10	107				2	1			173	140	79	75	180						767
7/31/67	9	57	29	92	1	2						27	7	2	1	1	2	3				167
8/2/67	10	53	206	3644					6		2	100	71	5	129	89	13	23				4288
8/10/67	12	50	36	95				1	5			5	6		24	41						213
8/10/67	7	49	63	35				12	30		3	8	5		18	25		2				201
8/11/67	1	54	157	346					5			18	18		48	114						706
8/15/67	9	59	5	19					2			2	3		2	1						34
8/18/67	10	47	58	504				16	21			60	35	11	733	1076						2554
8/1/67	Below falls			300 1/								158	56		8	13	28	42				605
8/27/67	Frazer Lk. shore		25	163										98 2/								286
7/14-8/23	Smolt weir								3		4					25	13	15				60
Total			685	5515	1	2		31	73		9	930	394	290	1071	1602	56	85				10,444

1/ Estimate

2/ Impossible to determine nature of mortality

Table 14. Adult salmon carcasses examined at the smolt weir, Frazer Lake, 1967

Species and Spawning Condition	Date 7/14	7/16	7/24	7/25	7/26	7/27	7/28	7/29	7/30	7/31	8/1	8/2	8/3	8/4	8/5	8/6	8/7	8/8	8/9	8/10
Sockeye																				
Spawned Female			3				1							1				1		
Unspawned Female				4		2	3	1			3	1		1						
Tagged Spawned Female							1					1								
Tagged Unspawned Female	1						1								1		1			
Dead Male			1		2	1	1							1					2	
Tagged Unspawned Male																				
Sub Total	1		4	4	2	3	7	1			3	2		3	1		1	1	2	
Chum																				
Spawned Female		1	3		3	5	2				1		1							
Unspawned Female				3			2		2		3									
Dead Male			3			1	3	4	4		1		1							
Sub Total		1	6	3	3	6	7	4	6		5		2							
Pink																				
Spawned Female						1				2	2	2	2	7	7	1	6	6	10	10
Unspawned Female							2	2					4	3	1	3	2		3	2
Dead Male								2	2	3	6	5	6	3	9	8	2	4	3	3
Sub Total						1	2	4	2	5	8	7	12	13	17	12	10	10	16	15
Sub Total for all species	1	1	10	7	5	10	16	8	8	5	16	9	14	16	18	12	11	11	18	15

Table 14. Adult salmon carcasses examined at the smolt weir, Frazer Lake, 1967 (Cont.)

Species and Spawning Condition	Date 8/11	8/12	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22	8/23	Total
Sockeye														
Spawned Female	1		1	1	2	3	1	3	2	2	3			25
Unspawned Female														15
Tagged Spawned Female										1				3
Tagged Unspawned Female														4
Dead Male					1				1	2			1	13
Tagged Unspawned Male														0
Sub Total	1		1	1	3	3	1	3	3	5	3		1	60
Chum														
Spawned Female							1	1						18
Unspawned Female														10
Dead Male														17
Sub Total							1	1						45
Pink														
Spawned Female	9	4	13	12	13	25	10	14	22	12	9	3		202
Unspawned Female	2	1												25
Dead Male	3	7	3	4	4	3	7	2	2	8	1			100
Sub Total	14	12	16	16	17	28	17	16	24	20	10	3		327
Total for all species	15	12	17	17	20	31	19	20	27	25	13	3	1	432

spawners below the falls. Approximately 500 sockeye did not ascend the fishpass, but instead chose a small tributary stream located one-half mile below the falls and on the right side of Frazer River facing upstream. The stream is very small, five feet at its maximum width and two feet maximum depth. The stream is not normally surveyed, but bears were observed running along the stream banks. Upon investigation, 60 unspawned sockeye carcasses were counted at the mouth of the stream and scattered along the stream banks were the remains of 214 sockeye that were killed by bears. The majority of these sockeye may have been progeny from the 1962 parent year. In 1962 the fishpass was not yet constructed and fish were hand carried over the falls. Some of these fish were not captured and probably spawned in any available gravel below the falls.

Stocking Program

Beginning the third week in June and continuing until the end of June, 7,334 live sockeye were flown from Red Lake to Frazer Lake. The same method of transport used to move the fish in 1966 was again employed this year; a super cub equipped with two live tanks (capacity 20 fish each) mounted on the floats. The operation was very efficient this year as there were large numbers of fish at Red River and flying weather was good which resulted in the largest number of fish ever moved in the shortest period of time.

In May, 60,000 king fry were flown from Kitoi Bay Hatchery via super widgeon. Richard Marriott, Kodiak Sport Fish Biologist, was in charge of the operation. Two trips were made with approximately 30,000 fry per trip. The fry were transported in collapsible plastic bags which were filled with water, fish, and then oxygen. This method seems to work very well, causing little mortality when moving fry long distances.

In October, 1,190,000 eyed sockeye eggs were flown from Kitoi Bay Hatchery via super widgeon to Frazer Lake. In the first trip, 790,000 eyed eggs were moved and planted in Stream 12. The remaining 400,000 eyed eggs were moved a week later on a second flight and 200,000 eggs each planted in the mouths of Streams 10 and 16 (Table 15).

A new and more efficient method of planting was employed this year. The "redds" were pre-dug in August when stream flows were low. To keep the "redds" from caving in, 55-gallon fuel barrels were cut into three sections, each section a foot high. These sections were buried in the stream until the top of the barrel was level with the stream bottom. The digging of the "redds" is the most time-consuming job when planting eggs and by using pre-dug redds,

Table 15. Introduced species into Frazer Lake, 1967

Date	Species	Development Stage	Location	Number	Method
May	O. tshawytscha	Fry	Lake outlet	60,000	Air transport
June	O. nerka	Adult	Upper end of lake	7,334	Air transport
October	O. nerka	Eyed eggs	Stream 12	790,000	Cylinder
October	O. nerka	Eyed eggs	Stream 10	200,000	Cylinder
October	O. nerka	Eyed eggs	Stream 16	200,000	Cylinder

planting time was cut by a third from previous years.

The actual planting procedure employed this year is as follows:

1. Pre-dug redds were cleaned of silt and leaves.

2. A planting cylinder (smaller diameter than the barrel) was inserted in the pre-dug redd and the space between the outside of the cylinder and the inside of the barrel was filled with gravel to prevent eggs from floating up when the cylinder was removed.

3. The next step was to place fist-sized rocks in the redd bottom so as to create interspace in which the eggs could lay.

4. Four or five double handfuls of eggs were then gently sprinkled among the fist-sized rocks. Next gravel was placed over the eggs until they were covered. When this was completed, another layer of eggs was placed on the covering gravel and this layer of eggs was in turn covered with gravel.

5. After the second layer of eggs was covered, gravel was placed inside the cylinder until it was level with the stream bottom. Then the planting cylinder was gently removed.

6. After all the pre-dug redds were planted with approximately 25,000 eyed eggs each, the barrels were removed from the streambed.

A crew of six men planted 790,000 eyed eggs in about three hours using the pre-dug redd method.

The 1966 eyed egg plant in Stream 9 was examined in May, 1967 for over-winter mortality. Many of these redds were located on dry gravel bars. It was not unexpected, however, considering the plant was made in flood stage and under extremely difficult conditions. It is believed that the 1966 plant was almost a (complete) failure after examination of the excavated redds.

Moser-Olga Bay Fishery

The 1967 commercial fishery commenced on June 26 and was opened for a 3-day fishing period per week. Poor showings of pink salmon forced the Department to close the fishing season after only two open fishing periods. Because of this closure, sockeye escapements into Frazer and Upper Station were higher than in previous years (Table 16). The commercial catch in Moser-Olga Bay was 7,861 sockeye; in Deadman's Bay 559 sockeye; in Portage Bay 395; in the Cape Alitak area 5,412; for a combined total of 14,227. It can be seen from Table 15 that although escapements were larger this year, the total run was smaller than 1966.

SUMMARY

1. Enumeration at the fishpass commenced June 5 and ended August 27. During this period 14,500 sockeye were counted.

2. To determine age composition, 1,380 scales were collected and analyzed. It was found that the sockeye escapement consisted of twelve age groups.

3. Precocious male sockeye comprised 2.4 percent of the escapement.

4. Other salmon species counted through the fishpass included 3,829 pinks and 1,081 chums.

5. Seasonal condition factors for males and females were identical.

6. Lake surface temperatures reached a high of 59° F on August 27.

7. Plankton sampling in 1965 and 1966 indicated an increase in the number of copepods and a decrease in cladocerans in 1966.

8. During June, 7,334 adults were moved from Red Lake to Frazer Lake via a super cub equipped with float mounted live tanks.

9. Observations and recoveries of tagged sockeye transplanted from Red Lake indicated that some adult fish will spawn in the Frazer Lake system.

10. Mature pink salmon (pinks that had never gone to sea) were observed in Stream 1 in August. One was captured for positive identification of sex, age and maturity condition.

Table 16. Escapements and catch, Moser-Olga Bay fishery, 1956-1967 1/

Year	Upper Station Escapement	Frazer Lake Escapement	Combined Catch 3/	Total
1956	185,257	6 2/	91,079	276,342
1957	73,207	165 2/	23,289	96,661
1958	87,848	71 2/	37,779	125,698
1959	92,895	62 2/	24,723	117,680
1960	45,193	440 2/	67,415	113,048
1961	73,884	273 2/	151,003	225,160
1962	39,531	1,290	124,497	165,318
1963	30,270	2,357	54,999	87,626
1964	37,249	8,166	48,055	93,470
1965	22,603	5,074	68,865	96,542
1966	44,931	11,728	69,939	126,598
1967	88,990	14,500	14,227	117,717
Total	821,858	44,132	775,870	1,641,860

1/ Alaska Department of Fish and Game Annual Reports

2/ Number carried over falls - total escapement unknown

3/ Commercial catch figures include sockeye from four minor streams populations that contribute fish to the Olga-Moser Bay fishery

11. In June of 1967, 60,000 king fry were stocked and in October of 1967 approximately 1,190,000 eyed sockeye were planted in Frazer Lake inlet streams.

12. Eggs were planted in pre-dug redds, utilizing a new method which was faster and more efficient than methods used in previous years.

13. The commercial catch of sockeye in the Moser-Olga Bay complex was the lowest it has been in a 12-year period, however, the combined run and catch was smaller than the 1961 and 1962 parent year.

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