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FRAZER LAKE SOCKEYE INVESTIGATIONS, 1970

By

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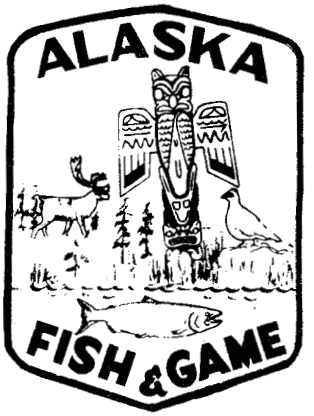

SEPTEMBER 1972

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By

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FOREWORD

By

Roger F. Blackett
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This report was originally prepared in manuscript form in 1970-71 with the intention of summarizing past research assessment conducted during establishment of the Frazer Lake sockeye run, and collation of this information with the 1970 field season data. As the work progressed it became evident from marine survival rates and length-frequency analysis that age interpretations and analysis in previous years of the project were obviously in error for both smolt and returning adult fish.

In the early years of the project, scale cards were pressed in a hand-operated roller press. Many of the scale impressions produced were of such poor quality that they would not even be considered readable by present standards. Also, final age determinations were usually based on a single scale reader's determination without confirmation by other readers. In addition to problems in scale reading technique, the Frazer Lake smolt scales are extremely difficult to interpret some years. This is thought to be due in part to the different development rates of planted fry, eyed-egg plants, and naturally deposited eggs creating different patterns of scale formation.

Considerable time and effort has been spent in refining scale reading techniques, becoming knowledgeable on sockeye scale interpretation, and consultation of scale reading problems with experienced authorities in other agencies. The tedious and time-consuming task of re-reading the thousands of smolt and adult scales collected at Frazer Lake since 1965 was begun in 1971. We have now completed final age readings for smolt and are still in the process of re-reading adult scale samples.

A revision and re-analysis of Frazer smolt data has been necessary after completion of final scale readings. I have revised and rewritten both the smolt and adult investigations sections of Philip Russell's report to incorporate these changes. The results and conclusions, that were falsely drawn from erroneous data, in previous publications stands to be corrected by this publication. Unfortunately, we still can not present revised age analysis data or marine survival rates for sockeye adults until reading of past adult scale samples is completed.

I would like to acknowledge the assistance of Brian Shafford in re-reading and checking my readings of the thousands of Frazer scales that have been examined this past winter. He has also assisted in revision and analysis of smolt data. The delay in publication of this report is regrettable, but I felt it essential that past data and results be corrected before summarization in report form.

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ABSTRACT

This report describes the results of research conducted at Frazer Lake, Kodiak Island, Alaska from 1965-1970. Smolt investigations include timing and age composition of smolt outmigrants; mean length, weight and condition factors; smolt productivity; length frequency analysis; and echo sounding studies. Adult investigations include migration trends; age, length and weight composition of escapement and mean condition factors; and stream and lake surveys to determine spawning area utilization. Limnological investigations include outlet temperatures and lake temperature profiles; plankton analysis; and a profile map of Frazer Lake. The results of fish pass modifications in 1970 are also discussed.

FRAZER LAKE SOCKEYE INVESTIGATIONS, 1970

By

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INTRODUCTION

Frazer Lake, the second largest lake on Kodiak Island, is located at latitude 57°15' North and longitude 154°10' West. The lake is approximately 8 miles long and 1 mile wide, with a surface area of 4,100 acres and a volume of 450,000 acre feet (Appendix Table 1). Drainage from the lake is via the Frazer River which enters Dog Salmon Creek 2.5 miles southwest of Frazer Lake. Dog Salmon Creek flows into Olga Bay at a point approximately 7.5 miles south of the lake outlet. Ten of the tributary streams entering Frazer Lake provide approximately one million square feet of potential spawning area for sockeye salmon (Oncorhynchus nerka) (Appendix Table 2). However, a 30-foot falls located one-half mile below the lake outlet blocked migration into the lake.

From 1951 to 1956 approximately 2,600,000 green sockeye eggs from Karluk Lake were planted in the Frazer Lake system; the first progeny returned in 1956. Until 1962, when a fish pass (Figure 1) was installed at the 30-foot falls that had previously blocked migration into the lake, returning spawners were transported over the outlet falls by backpack. Additional adult sockeye have been introduced into the system by aerial transplants from nearby Red Lake. Natural egg deposition has also been supplemented by eyed-egg and fry plants.

A total of 98,860 sockeye adults have used the fish pass as of 1970. The return of sockeye spawners has increased steadily throughout the years (Table 1). In 1970, an addition to the permanent steeppass structure and construction of a temporary lead greatly improved movement of adult sockeye into the system (Figure 2). The escapement for 1970 was 7,331 fish greater, due to an increased return and improved fish passage, than any previous year. Large concentrations of sockeye adults were not noted below the falls as has been observed in the past.

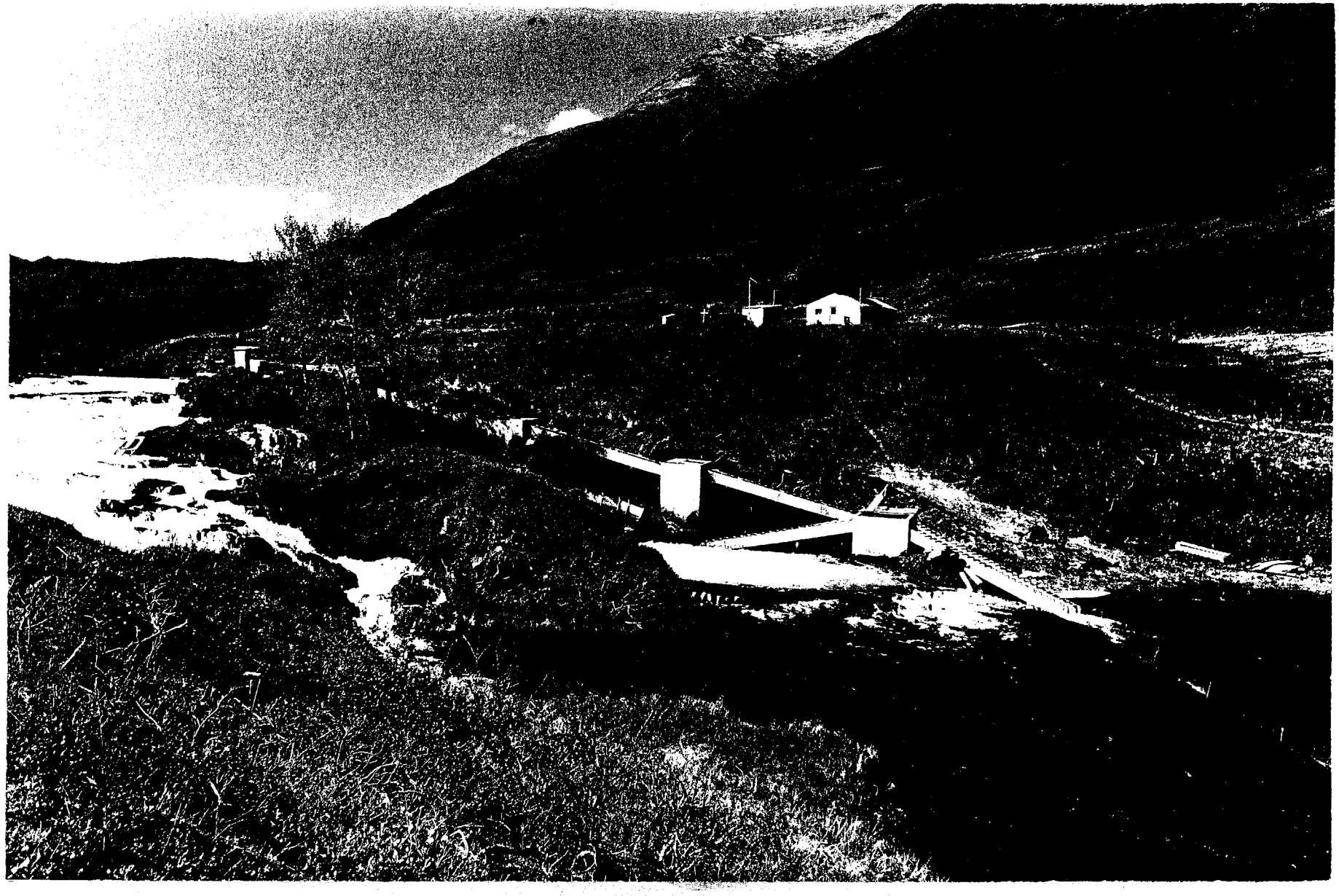


Figure 1. Fishpass installation, Frazer Lake, 1970.

Table 1. Sockeye inmigrants, adult transplants, fry plants and egg plants, Frazer Lake, 1956-1970.

Year	Inmigrants 1/	Adult transplants	Fry plants	Eyed egg plants
1956	6	0	0	500,000
1957	165	0	0	0
1958	71	42	0	0
1959	62	0	0	0
1960	440	0	0	0
1961	273	600	87,000	0
1962	1,290	1,800	0	0
1963	2,357	9,500	0	0
1964	8,166	1,800	0	0
1965	5,074	4,000	0	830,000
1966	11,728	4,728	504,300	600,000
1967	14,500	7,334	0	1,190,000
1968	16,708	30	311,000	3,387,000
1969	13,981	60	599,760	1,963,000
1970	24,039	0	945,000	0
Total	98,860	29,894	2,447,060	8,470,000

1/ Salmon backpacked over the falls, 1956-1961. Inmigrant counts are number of fish actually entering the lake and not total return.

Figure 2. Steeppass addition and temporary lead, Frazer Lake, 1970.

Since 1965, all inmigrant adults and outmigrant smolt have been enumerated and sampled to collect scales for age analysis and record length and weight measurements (in 1969 the smolt weir was inundated by high water preventing effective smolt enumeration and sampling). Streams entering the Frazer Lake system have been surveyed to estimate spawner usage and distribution. Basic climatic and limnological data have also been collected. Thus parameters of survival, growth, age composition and productivity of sockeye are monitored in a large lake system that until the 1950's had been barren of anadromous fish.

The three primary objectives of the Frazer Lake project are: (1) establishment of a major self-sustaining sockeye run of commercial value to the fishing industry; (2) evaluation of the developing productivity of this new run to provide information and insight in developing and rehabilitating other sockeye stocks as well as evaluating the success of the Frazer project, and (3) determine optimum rearing capacity and productivity of the lake to provide guidelines for management of the fishery to attain desirable escapement levels.

Data from 1965 to 1969 has been collated, corrected for errors when evident, standardized, and presented in this report to aid in future analyses and show trends that have occurred in the Frazer Lake system over the last 6 years.

SMOLT INVESTIGATIONS

Sampling procedures

In 1970, sockeye salmon smolt enumeration and sampling at a temporary weir and smolt trap constructed one-fourth mile below the Frazer Lake outlet commenced on May 30 and was discontinued August 22. Weir construction was completed May 9; sockeye smolt were observed in front of the weir May 19 but none entered the smolt trap until May 29 when lanterns were placed over the box and left on all night. During June, July and August enumeration was conducted at night in anticipation of a large outmigration. Sampling and further enumeration of smolt was made at 9:00 a.m. daily.

All species of migratory fish trapped were enumerated and recorded daily. Every week approximately 250 sockeye smolt (usually 35 per day) were sampled at random from the trap. If less than 250 smolt were enumerated during the week then all smolt during that week were sampled. To facilitate handling, all sampled smolt were anesthetized in a MS-222 (tricaine methanesulfanate) solution. Scales for age analysis and fork length measurements recorded to the

nearest millimeter were taken from all sampled smolt. Body weight recorded to the nearest 0.1 gram was taken from five fish in each 5 millimeter length group for each weekly sampling period. Otoliths were taken from weir mortalities when available as an aid in verifying age analysis of scales. Sampling data were recorded for each smolt examined on a standardized age-weight-length form.

The European formula of designating salmon age by number of freshwater winters followed by a decimal and number of winters in saltwater is used throughout this report.

Timing and age composition of outmigrants

In 1970, the smolt outmigration of 44,808 was composed of four freshwater age groups, produced from parent years 1966-1969, consisting of:

0.0	10	(< 0.1%)
1.0	30,500	(68.1%)
2.0	14,150	(31.6%)
3.0	148	(0.3%)

Smolt ages were determined from scale analysis. Age composition of the total smolt enumerated each week was inferred from that week's sample data and projected to estimate the age composition of the year's total smolt migration (Appendix Table 3). Timing of smolt migration in 1970 (Figure 3) was characterized by a peak period of age 3.0 and 2.0 smolt in early June and 1.0 smolt from mid-June to mid-July. A few 0.0 smolt also left the system the end of August but are not shown in Figure 3. The migration began the end of May with the majority of smolt leaving the system during mid-June and completion of migration by the end of August.

In past years, most of the Frazer smolt (55-85%) have migrated at age 1.0 with the exception of the 1966 migration which was primarily (75%) age 2.0 smolt (Table 2). The pattern of outmigration has been generally the same since 1966; a peak migration during June, and then decreasing through mid-July and August. In 1970, the outmigration started earlier than any year previously recorded. In 1965, the outmigration remained at a comparatively steady level throughout the enumeration period (Figure 4).

The migration patterns that were observed in various smolt age classes in 1970, as determined by scale analysis, were generally similar to previous years (Figures 5, 6 and 7). The older and larger smolt have had a tendency to migrate earlier than the younger fish.

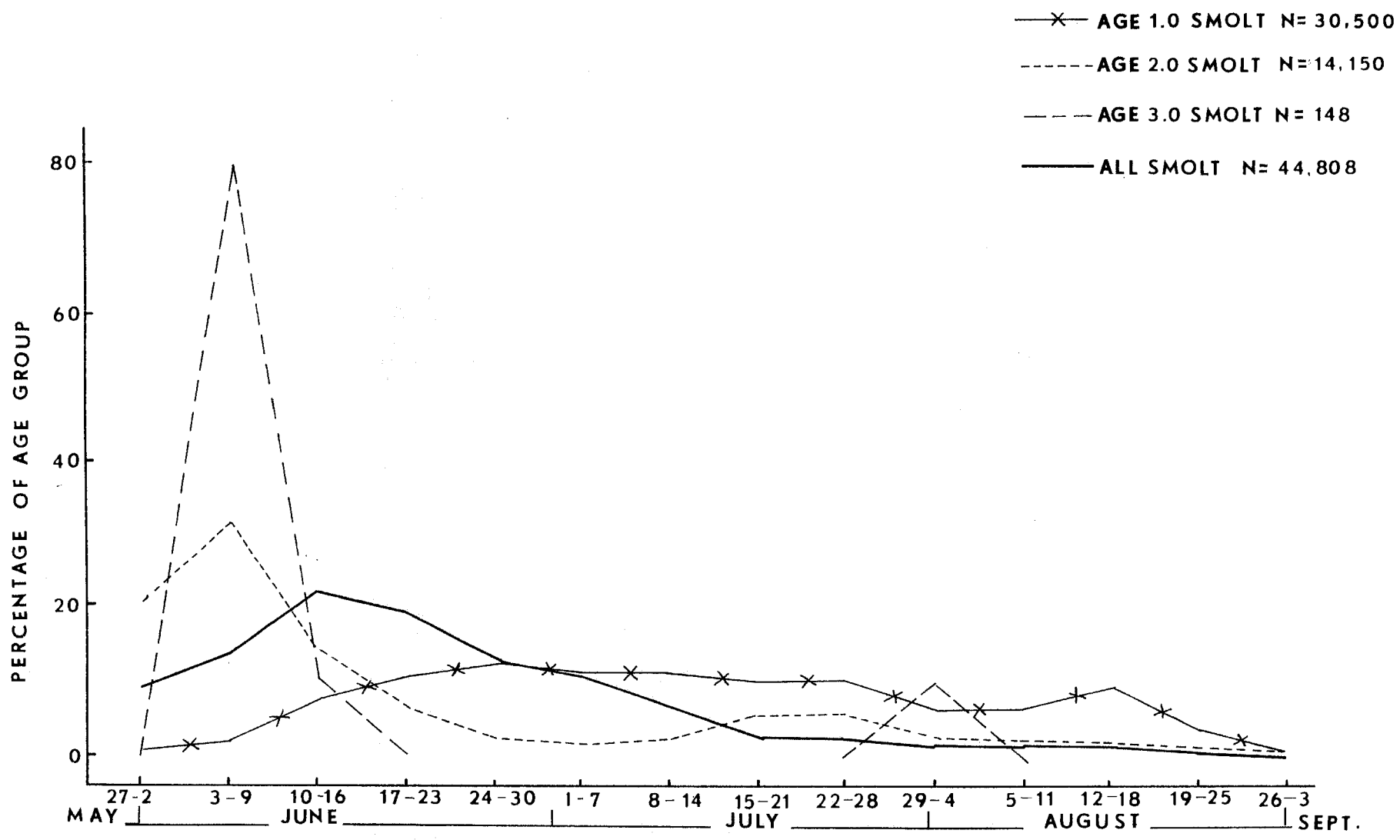


Figure 3. Smolt migration timing by age group, Frazer Lake, 1970. Ten age 0.0 smolt were projected to have migrated between 8/19-9/3 in addition to the age groups shown.

Table 2. Summary of smolt outmigration and age composition, Frazer Lake, 1965-1970.

Year of smolt outmigration	Total number smolts	Age			
		0.0	1.0	2.0	3.0
1965	26,945	43 (0.2%)	20,432 (75.8%)	6,327 (23.5%)	143 (0.5%)
1966	157,291	31 (0.02%)	36,273 (23.1%)	118,832 (75.5%)	2,155 (1.4%)
1967	134,123	0	73,634 (54.9%)	55,674 (41.5%)	4,815 (3.6%)
1968	93,793	0	80,212 (85.5%)	13,253 (14.1%)	328 (0.4%)
1969[1/]	-	-	-	-	-
1970	44,808	10 (0.02%)	30,500 (68.1%)	14,150 (31.6%)	148 (0.3%)

1/ Weir inoperable due to high water conditions.

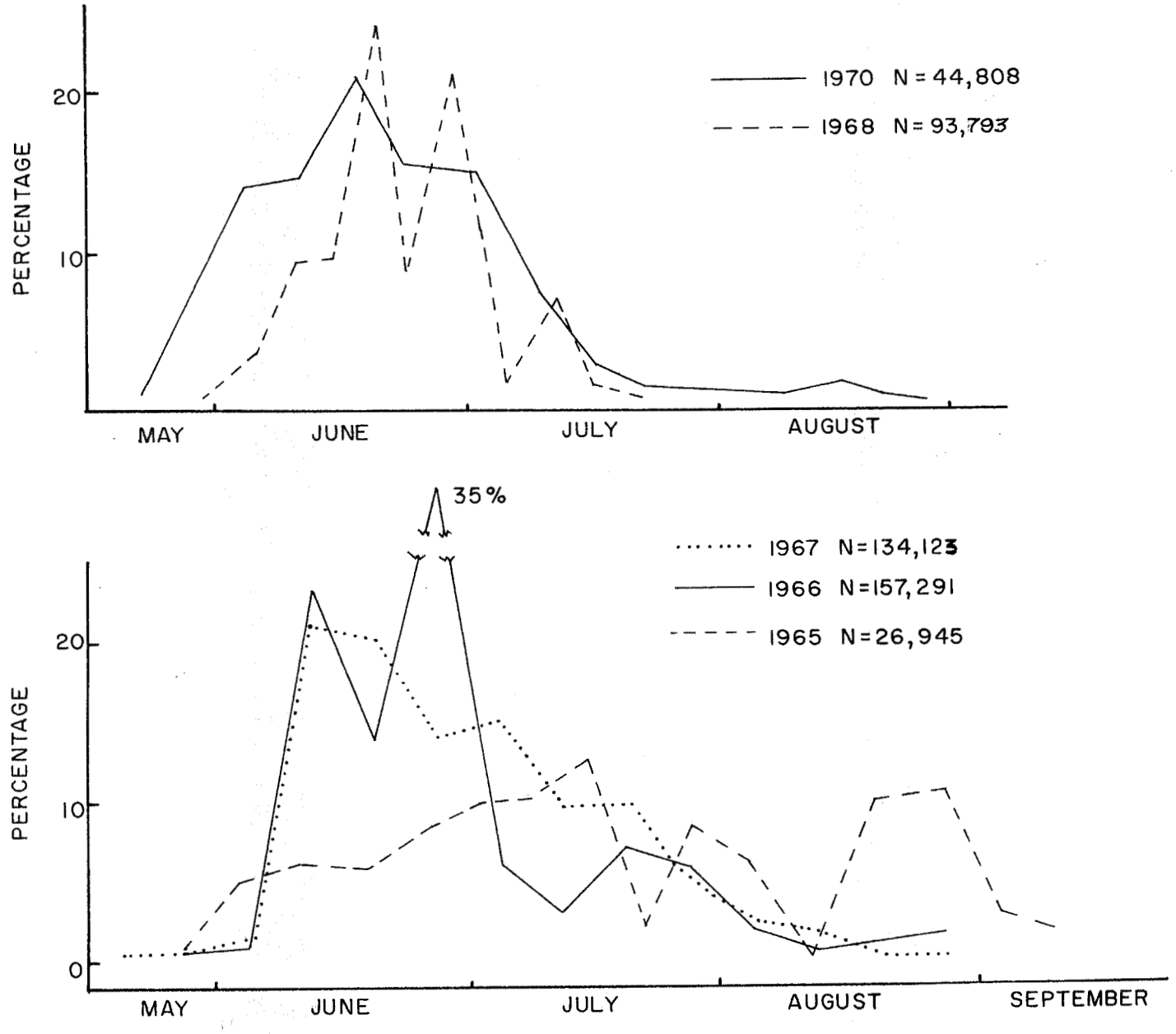


Figure 4. Yearly outmigration of smolt, Frazer Lake, 1965-1970.

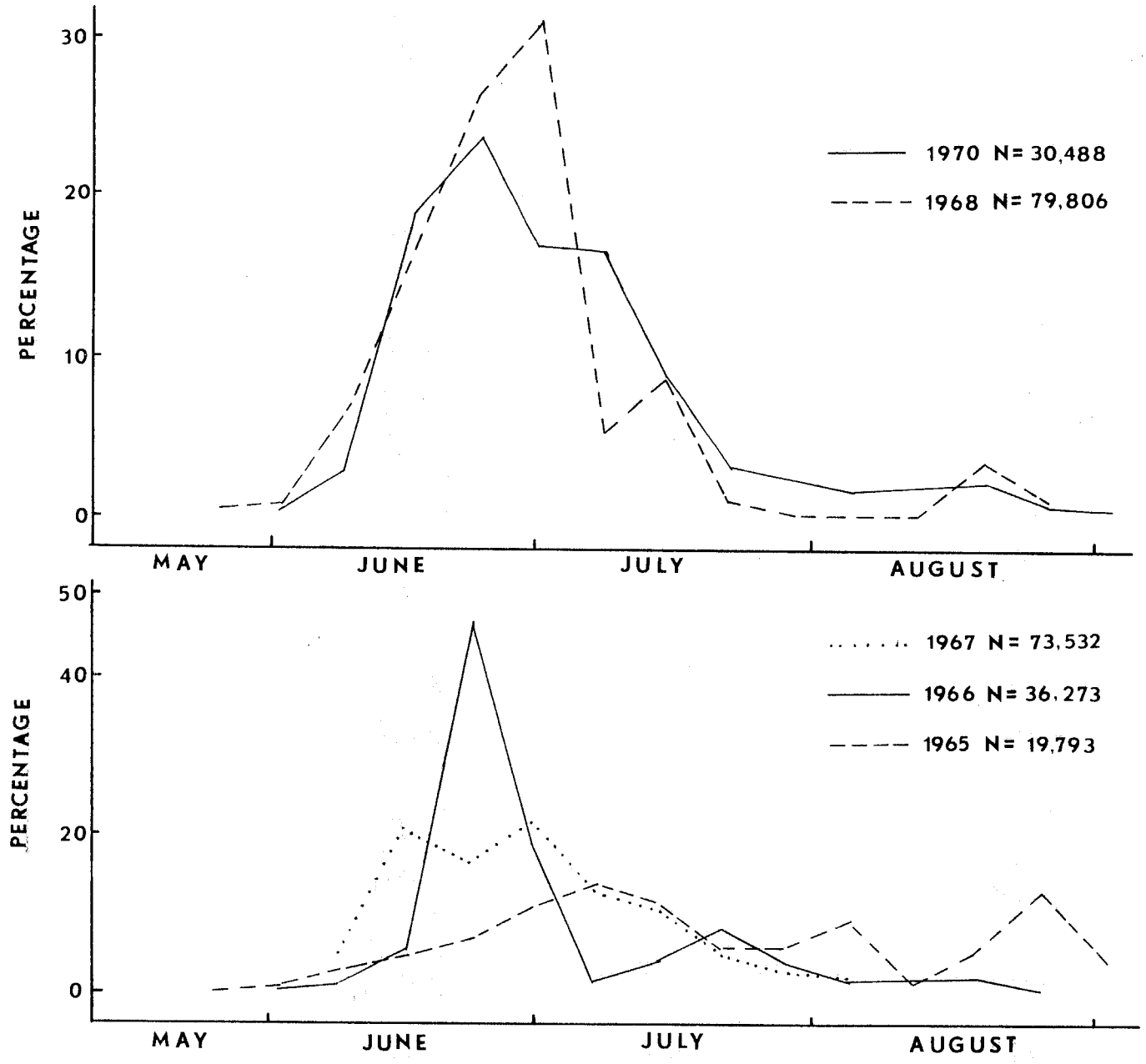


Figure 5. Yearly outmigration of age 1.0 smolt by time period, Frazer Lake, 1965-1970.

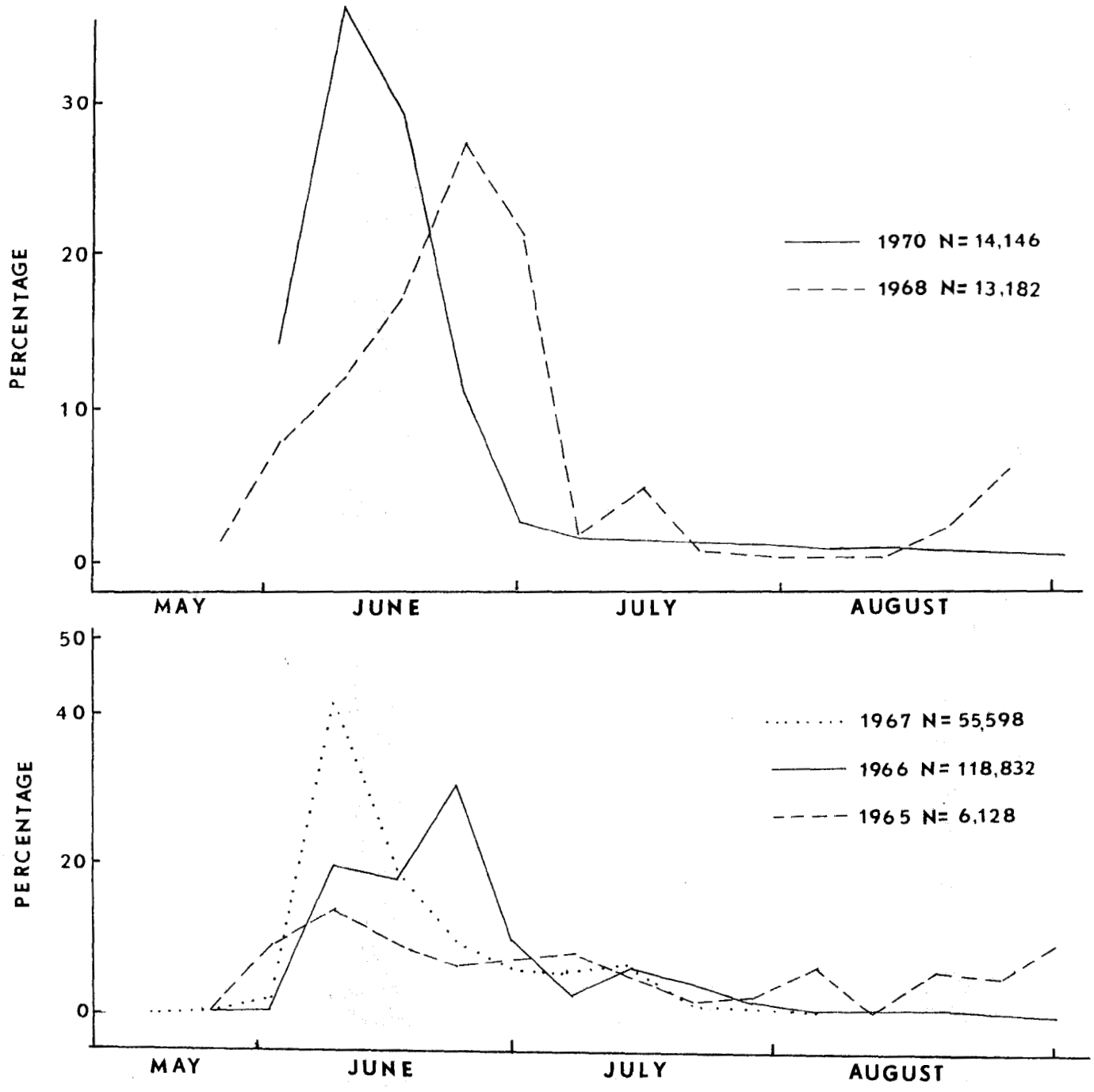


Figure 6. Yearly outmigration of age 2.0 smolt by time period, Frazer Lake, 1965-1970.

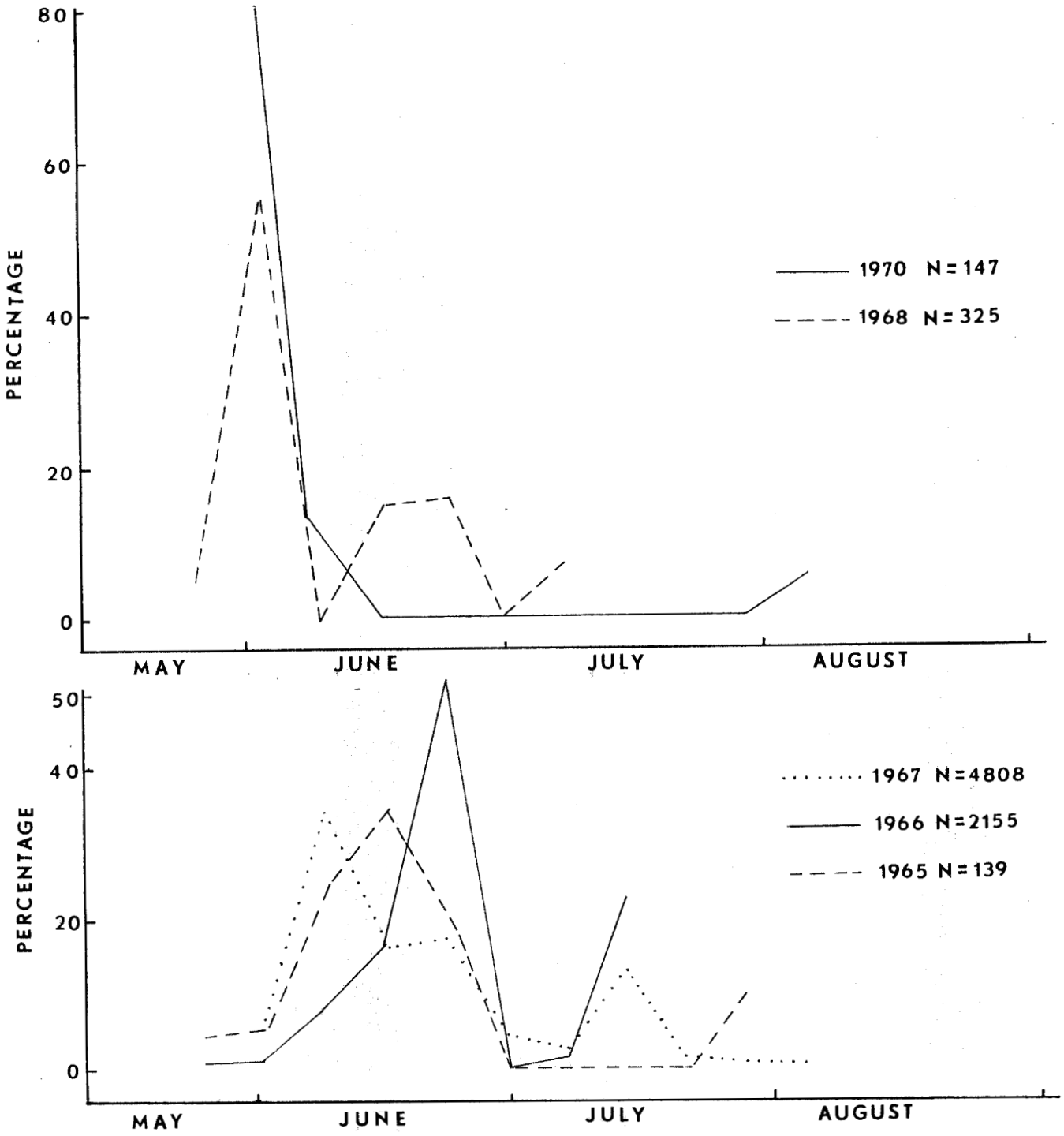


Figure 7. Yearly outmigration of age 3.0 smolt by time period, Frazer Lake, 1965-1970.

Mean lengths, weights and condition factors

Outmigrating smolt were sampled at random throughout the field season for lengths and weights. After aging by scale analysis, mean weights and lengths and respective standard deviations were calculated by sampling periods for the various age groups. Using only smolt which were sampled for both weight and length, mean condition factors were also computed to estimate the relative condition of smolt by the formula:

$$K = \frac{W \times 10^5}{L^3}$$

where:

W = weight in grams
L = length in millimeters

In 1970, age 1.0 smolt averaged 149 mm, 31 grams, with a mean condition factor of 0.93; age 2.0 smolt averaged 180 mm, 54 grams with a mean condition factor of 0.93 (Table 3). Ten age 3.0 smolt averaged 193 mm, 64 grams with a mean condition factor of 0.89. In late August, four 0.0 age smolt were sampled; their mean length was 113 mm, mean weight 12 grams and mean condition factor 0.83.

The mean weights, lengths and condition factors derived from samples taken each year from 1965 to 1970 are summarized in Table 4. Fluctuations in size of smolt are apparent from year to year, however, there is not any indication that smolt size has tended to decrease or increase since 1965 (Figure 8, 9 and 10). It is interesting that years reflecting poor growth (1965, 1967 and 1970) for age 1.0 and 2.0 smolt did not show a similar effect on size of age 3.0 smolt. Possibly the preceding years' growth was sufficient to mask this effect on the older fish. Also, the smaller sample sizes of the age 3.0 fish results in less reliability of data for this age group. Smolt size did decrease from 1968 to 1970 for all age groups, but unfortunately information for 1969, which may have altered the picture, cannot be included.

Frazer Lake smolt, in addition to being large, are also robust fish as indicated by the mean condition factors which have ranged from 0.89 to 0.97 for age groups 1.0 and 2.0 from 1965 to 1970. In nearby Akalura Lake the length of age 1.0 smolt has been approximately 55 to 69 mm less than at Frazer Lake and 80 mm less for the age 2.0 smolt. The growth rate and size of young sockeye in Frazer Lake exceeds that of most all sockeye producing systems (where smolt size data are available for comparison) in the state. The extremely favorable rearing conditions of the lake are capable of supporting far greater densities of young fish. Continued monitoring of smolt productivity, size, and

Table 3. Mean smolt lengths, weights, and condition factors by age and sampling period, Frazer Lake, 1970.

	Age 1.0 Smolt						
Sample period	Mean length (mm)	Standard deviation	Sample size for length	Mean weight (g)	Standard deviation	Sample size for weight	Condition factor
5/30-6/6	133	8.1	13	24.6	3.4	12	1.046
6/7-6/13	138	10.5	87	25.0	5.1	87	0.951
6/14-6/20	145	7.2	181	27.6	3.8	181	0.905
6/21-6/27	145	6.8	224	26.3	5.1	33	0.863
6/28-7/4	145	8.1	228	28.1	5.8	38	0.922
7/5-7/11	143	8.8	216	28.0	6.1	40	0.958
7/12-7/18	149	8.8	205	28.6	6.7	47	0.865
7/19-7/25	152	10.0	164	31.7	6.7	40	0.903
7/26-8/1	153	10.3	167	35.2	7.3	39	0.983
8/2-8/8	158	9.5	114	41.2	10.2	13	1.045
8/9-8/15	159	10.7	160	38.8	9.9	68	0.965
8/16-9/3	162	10.8	119	41.9	8.2	71	0.986
Yearly	149	9.0	1,878	30.9	6.1	669	0.934

Table 3. Mean smolt lengths, weights, and condition factors by age and sampling period, Frazer Lake, 1970 (continued).

	Age 2.0 Smolt						
Sample period	Mean length (mm)	Standard deviation	Sample size for length	Mean weight (g)	Standard deviation	Sample size for weight	Condition factor
5/30-6/6	179	11.3	227	53.6	9.2	221	0.935
6/7-6/13	180	11.0	188	53.7	9.5	188	0.921
6/14-6/20	178	12.9	65	46.5	13.0	65	0.825
6/21-6/27	166	23.0	16	49.6	14.8	10	1.084
6/28-7/4	168	23.6	13	45.3	13.3	11	0.955
7/5-7/11	176	22.6	7	49.2	12.9	6	0.902
7/12-7/18	178	18.9	16	52.1	13.3	13	0.924
7/19-7/25	192	6.8	52	61.6	7.3	21	0.870
7/26-8/1	183	18.4	19	45.8	12.7	5	0.747
8/2-8/8	192	15.3	17	71.7	10.5	4	1.013
8/9-8/15	198	6.6	19	69.4	6.0	13	0.894
8/16-9/3	190	17.3	10	68.9	16.3	9	1.005
Yearly	180	12.4	649	54.0	10.1	566	0.926

Table 4. Mean smolt lengths, weights and condition factors by age, Frazer Lake, 1965-1970.

Year	Mean length (mm)	Standard deviation	Sample size for length	Mean weight (g)	Standard deviation	Sample size for weight	Condition factor
				Age 1.0 smolt			
1965	146	10.8	698	27.2	1.2	238	0.91
1966	153	6.5	542	31.0	4.9	205	0.93
1967	147	6.0	1,196	28.8	5.5	269	0.90
1968	154	9.2	1,517	36.3	7.3	379	0.92
1969[1/]	-	-	-	-	-	-	-
1970	149	9.0	1,878	30.9	6.1	669	0.93
				Age 2.0 smolt			
1965	174	17.5	346	48.0	5.0	65	0.89
1966	180	11.1	1,358	53.1	12.1	488	0.91
1967	177	13.2	680	53.2	11.2	279	0.97
1968	185	11.5	264	62.0	7.6	176	0.94
1969[1/]	-	-	-	-	-	-	-
1970	180	12.4	649	54.0	10.1	566	0.93
				Age 3.0 smolt			
1965	193	-	13	-	-	-	-
1966	193	-	16	-	-	-	-
1967	201	13.0	62	76.4	11.2	48	0.94
1968	200	-	8	-	-	-	-
1969[1/]	-	-	-	-	-	-	-
1970	193	-	10	-	-	-	-

1/ The smolt weir was inoperable in 1969 and the sample data collected is insufficient for inclusion in this table.

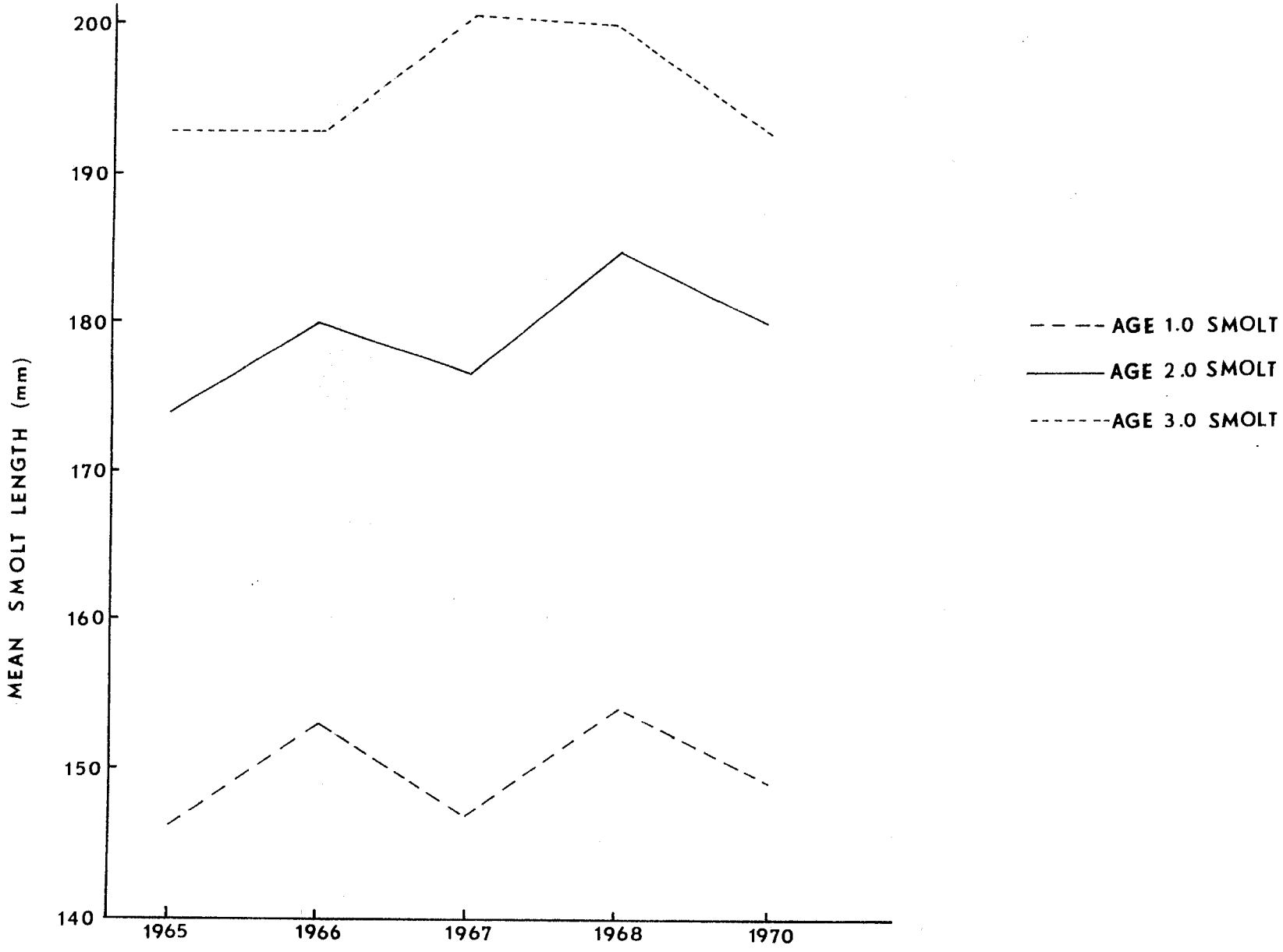


Figure 8. Mean smolt length in millimeters by outmigration year and age group, Frazer Lake, 1965-1970. The 1969 sample is insufficient for inclusion.

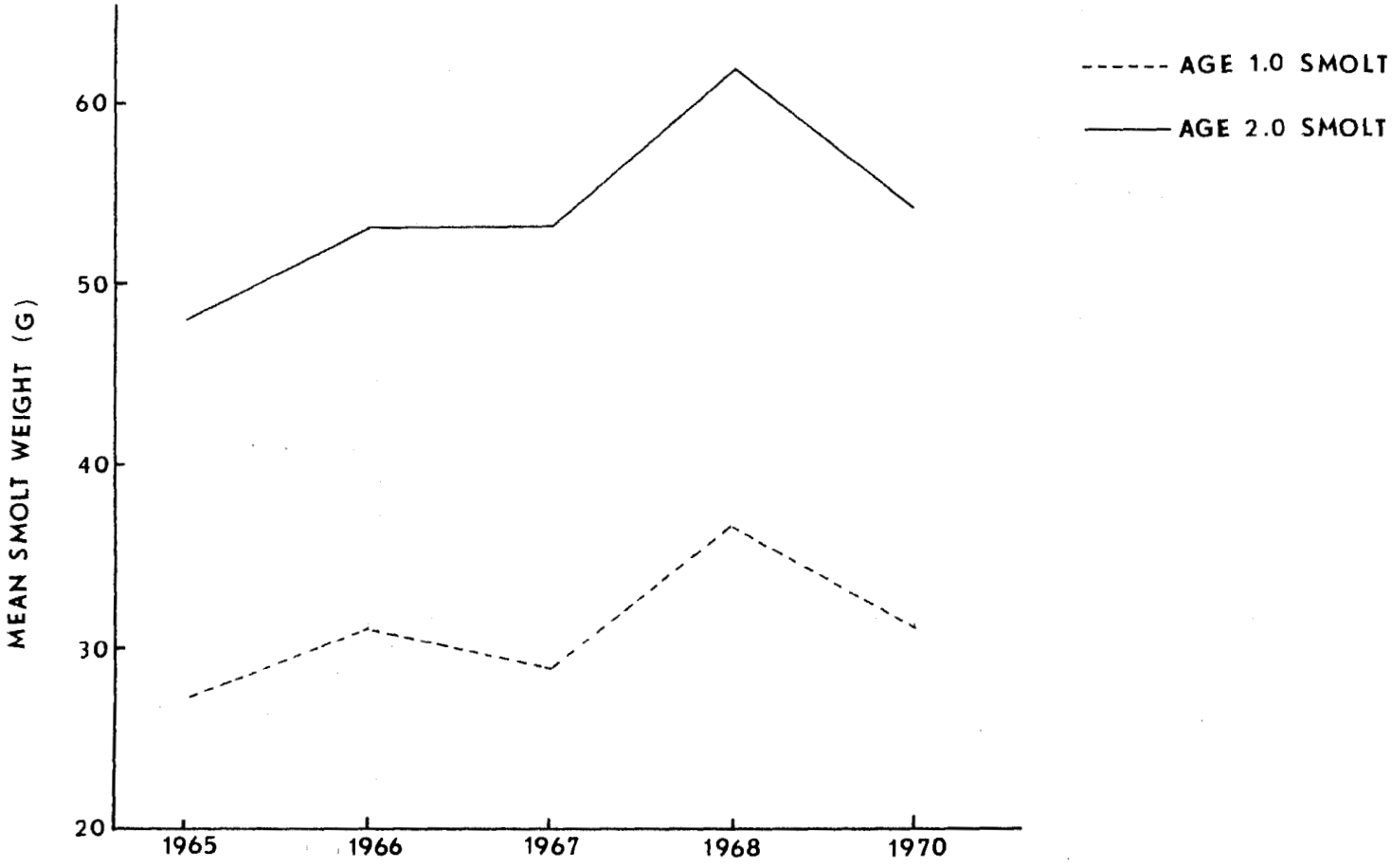


Figure 9. Mean smolt weight in grams by outmigration year and age group, Frazer Lake, 1965-1970. The 1969 sample is insufficient for inclusion.

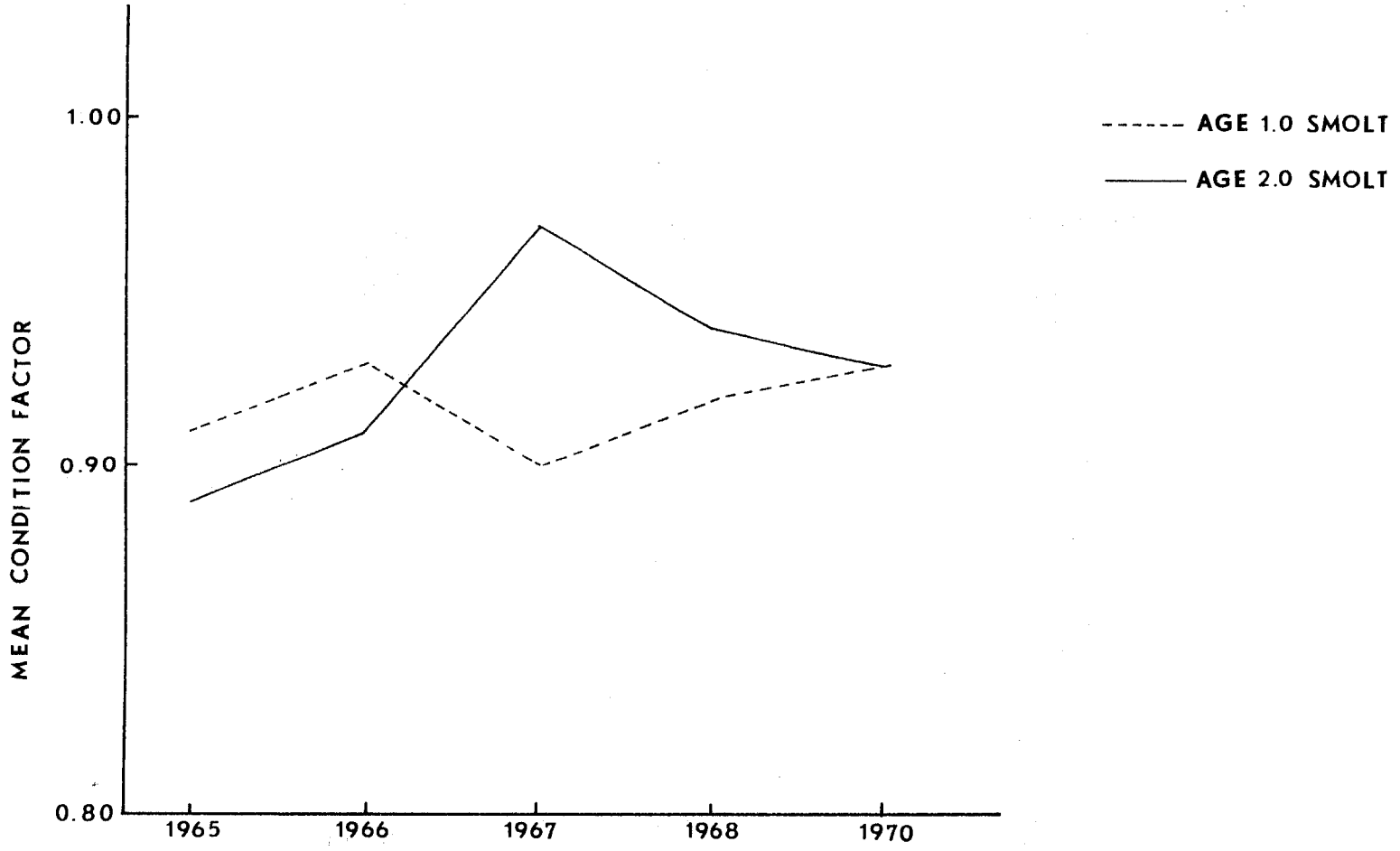


Figure 10. Mean condition factor of smolt by outmigration year and age group, Frazer Lake smolt, 1965-1970. The 1969 sample is insufficient for inclusion.

condition at Frazer Lake as the sockeye run increases should provide an index to optimum rearing capacity of the lake and, in turn, optimum escapement levels to be provided by management of the fishery.

Freshwater survival

Determination of freshwater survival of sockeye from egg to smolt at Frazer Lake is complicated by the various planting methods (eyed-egg plants, fry plants, and spawner transplants) in addition to the natural escapement. There are only 2 parent years, 1963 and 1964, in which the smolt data are complete and that there were no fry or egg plants. Egg to smolt survival rates are assumed to be similar for natural and transplant spawners. Tagging of transplanted fish and observations on spawning areas have not shown any obvious difference related to spawning success of natural and transplant salmon. The known number of smolt produced by parent year is tabulated by year of smolt outmigration in Table 5. The loss of smolt data in 1969 due to high water and weir problems prevents calculation of complete survival rates for parent years 1965 through 1968.

Potential egg deposition at Frazer Lake is estimated for each parent year from the known number of female spawners and an average fecundity (Table 6). The number of fry and eggs planted each year is included in this estimate. The percent survival is calculated from the total number of smolts produced from each parent year's potential egg deposition (Table 7). Freshwater survival from egg to smolt was 0.80 percent for 1963 and 0.61 percent for 1964 parent years. Survival for the 1965 parent year was greater than 0.61 percent (unknown number of age 3.0 smolt produced). When survival rates are calculated by parent year groups for which smolt production figures are relatively complete (Table 8), the rates range from 0.68 percent (parent years 1963-1965) to 0.63 percent (parent years 1962-1965). These rates are minimal since the total number of smolts produced for the 1962 and 1965 parent years is unknown. Overall it would appear that freshwater survival at Frazer Lake has ranged from 0.61 to 0.80 percent with a probable median value of about 0.70 percent. The loss of information on smolt in 1969 was particularly unfortunate as it would have provided complete migration counts for smolt produced from the 1965 and 1966 parent years in addition to 1963 and 1964.

The 1970 smolt migration of 44,808 was the lowest since 1965 and was quite disappointing in respect to the parent years (1966-1968) potential egg deposition which was greater than any previous years at Frazer Lake. The majority of smolt produced may have left the system in 1969 when high water conditions prevented counting. The small outmigration of smolt in 1970 does not necessarily reflect a low egg to smolt survival rate for these productive parent years.

Table 5. Smolt productivity at Frazer Lake by parent and smolt outmigration year.

Parent year	Smolt Outmigration Year[1/]						Total smolts
	1965	1966	1967	1968	1969	1970	
1961	143 (3)	-	-	-	-	-	? (2,3)
1962	6,327 (2)	2,155 (3)	-	-	-	-	8,482+? (1)
1963	20,432 (1)	118,832 (2)	4,815 (3)	-	-	-	144,079
1964	43 (0)	36,273 (1)	55,674 (2)	328 (3)	-	-	92,318
1965	-	31 (0)	73,634 (1)	13,253 (2)	? (3)	-	86,918+? (3)
1966	-	-	0 (0)	80,212 (1)	? (2)	148 (3)	80,360+? (2)
1967	-	-	-	0 (0)	? (1)	14,150 (2)	? (1,3)
1968	-	-	-	-	? (0)	30,500 (1)	? (2,3)

1/ Number of smolts enumerated (age group shown in parenthesis). High water conditions prevented smolt enumeration in 1969.

Table 6. Potential productivity estimates, Frazer Lake, 1956-1970.

Year	Female spawners[1/]	Estimated fecundity[2/]	Fry plants[3/]	Egg plants[3/]	Potential egg deposition[4/]
1956	3	3045	0	500,000	509,135
1957	98	3045	0	0	298,410
1958	57	3045	0	0	173,565
1959	23	3045	0	0	70,035
1960	289	3045	0	0	880,005
1961	451	3045	87,000(R)	0	1,460,295
1962	1,639	3045	0	0	4,990,755
1963	5,928	3045	0	0	18,050,760
1964	4,983	3045	0	0	15,173,235
1965	4,628	2922	0	830,000(R)	14,353,016
1966	8,052	2940	504,300(R)	600,000(R)	24,777,180
1967	11,135	3086	0	1,190,000(R)	35,552,610
1968	9,104	3166	311,000(R)	3,387,000(R)	32,521,264
1969	7,300	3045	599,760(R)	1,963,061(B)	24,791,321
1970	11,173	2823	945,000(B)	0	32,486,379

1/ For years that sample data are available the sample sex ratio is projected to the escapement to determine number of females. For other years a 50 percent female ratio is assumed for the escapement. Includes 50 percent of the sockeye transplanted from Red Lake.
2/ Based upon fecundity studies of Red Lake stock and female age composition at Frazer Lake.
3/ R indicates Red Lake stock; B indicates Becharof stock.
4/ Sum of fry, eyed eggs and estimated natural deposition.

Table 7. Freshwater survival from egg to smolt by parent year at Frazer Lake.

Parent year	Potential egg deposition [1]	Smolts produced	Percent survival
1963	18,050,760	144,079	0.80
1964	15,173,235	92,318	0.61
1965	14,353,016	86,918+ [2]	0.61+ [2]

1/ Calculated as shown in Table 6.

2/ Does not include age 3.0 smolts in 1969 which would increase the survival rate.

Table 8. Freshwater survival of smolt at Frazer Lake by parent year groups.

Parent years	Potential egg deposition	Smolts produced	Percent survival
1962-1965	52,567,766	331,797 [1] [2]	0.63
1962-1964	38,214,750	244,879 [1]	0.64
1963-1965	47,577,011	323,315 [2]	0.68

1/ Does not include age 1.0 smolt migrating from the lake in 1964.

2/ Does not include age 3.0 smolt migrating from the lake in 1969.

Length-frequency analyses

Bimodality exhibited in the length frequency distribution of outmigrating smolt in 1970, 1968, and 1967, and skewed distributions in 1966 and 1965 (Figure 11) suggest that length frequency analyses can be used to detect separate length groups of smolt of a given age at Frazer Lake. Length frequency distributions were computed for each year by weekly sample periods and presented as percentages of the yearly outmigration.

Calculate A and B where

$$A = \frac{n}{X} = \text{Percent of weekly sample}$$

$$B = \frac{\frac{n}{X} N}{\Sigma N} = \text{Percent of total yearly migration}$$

n = number of smolt per length group per week

X = number of smolt sampled per week

N = weekly migration

ΣN = yearly migration

The results are presented in Appendix Tables 4-8 and illustrated in Figures 12-16. Two readily distinguishable size groups of smolt are evident consisting of a large size group appearing early in the year and a smaller size group appearing later in the year. The smaller size group has been the major portion of the outmigration every year except 1966. Growth is also observable as length frequency modes increase throughout the period of outmigration. While the earlier migration of larger smolt is usually short, traces are sometimes evident throughout the year. Age analysis by scale reading indicates that the large size group are primarily age 2.0 smolt and the smaller are age 1.0.

Using only the length frequency data, age distribution was estimated for the two major age groups (Table 9). The age composition determined by length frequency was generally in agreement with the scale analysis except for 1965. The difference between the two methods that year was 15.2 percent for age 1.0 and 14.5 percent for age 2.0. In 1966 and 1970 the differences were less than 1 percent and less than 3 percent in 1968 and 6 percent in 1967 (Table 10). Slight discrepancies exist since age 0.0 and 3.0 smolt are not included in the length frequency analysis while they were detected and recorded in scale reading. Use of length frequency distributions in conjunction with

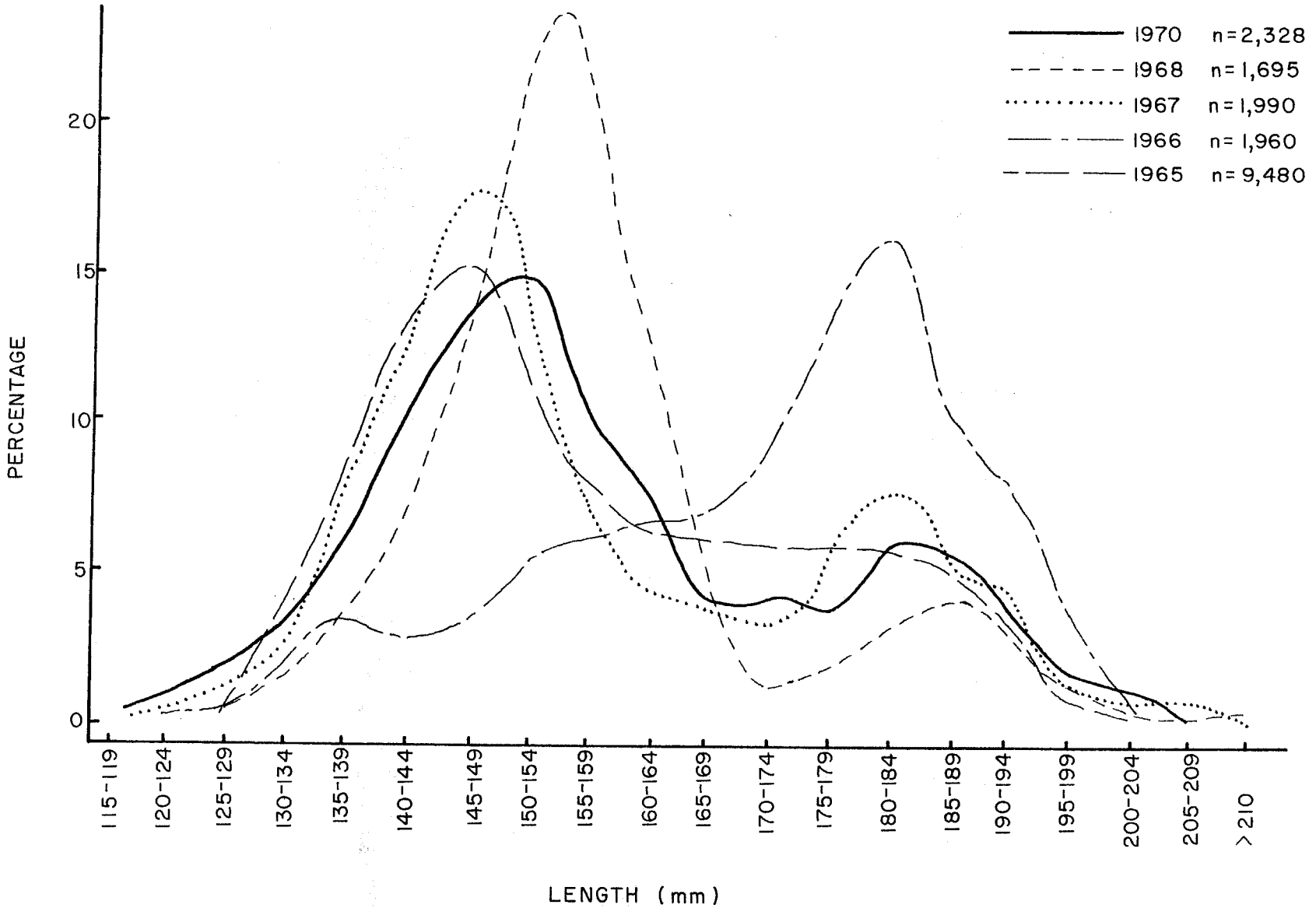


Figure 11. Length frequency of sampled smolt, Frazer Lake, 1965-1970.

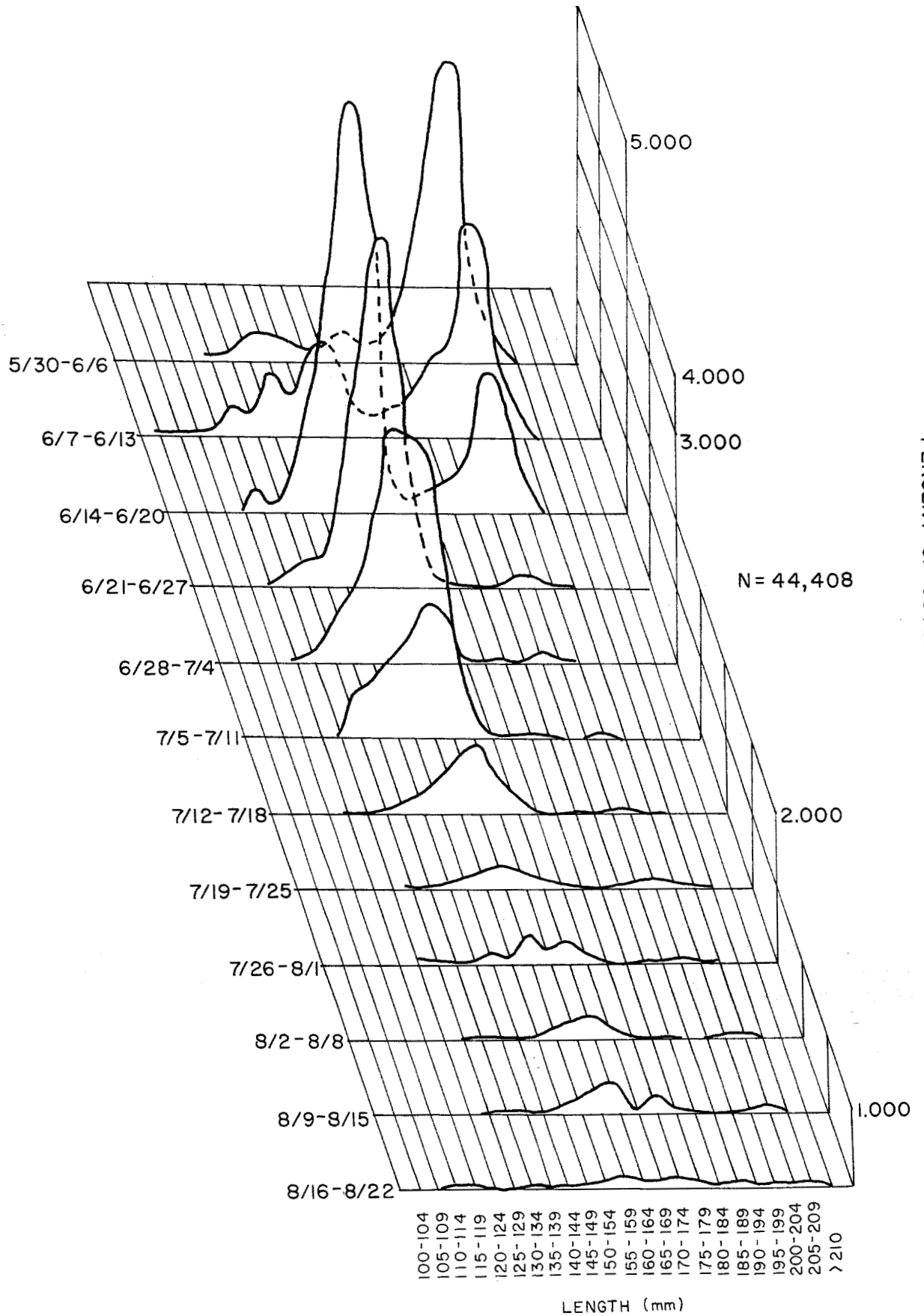


Figure 12. Length frequency of smolt by weekly sample period and percent of total outmigration, Frazer Lake, 1970

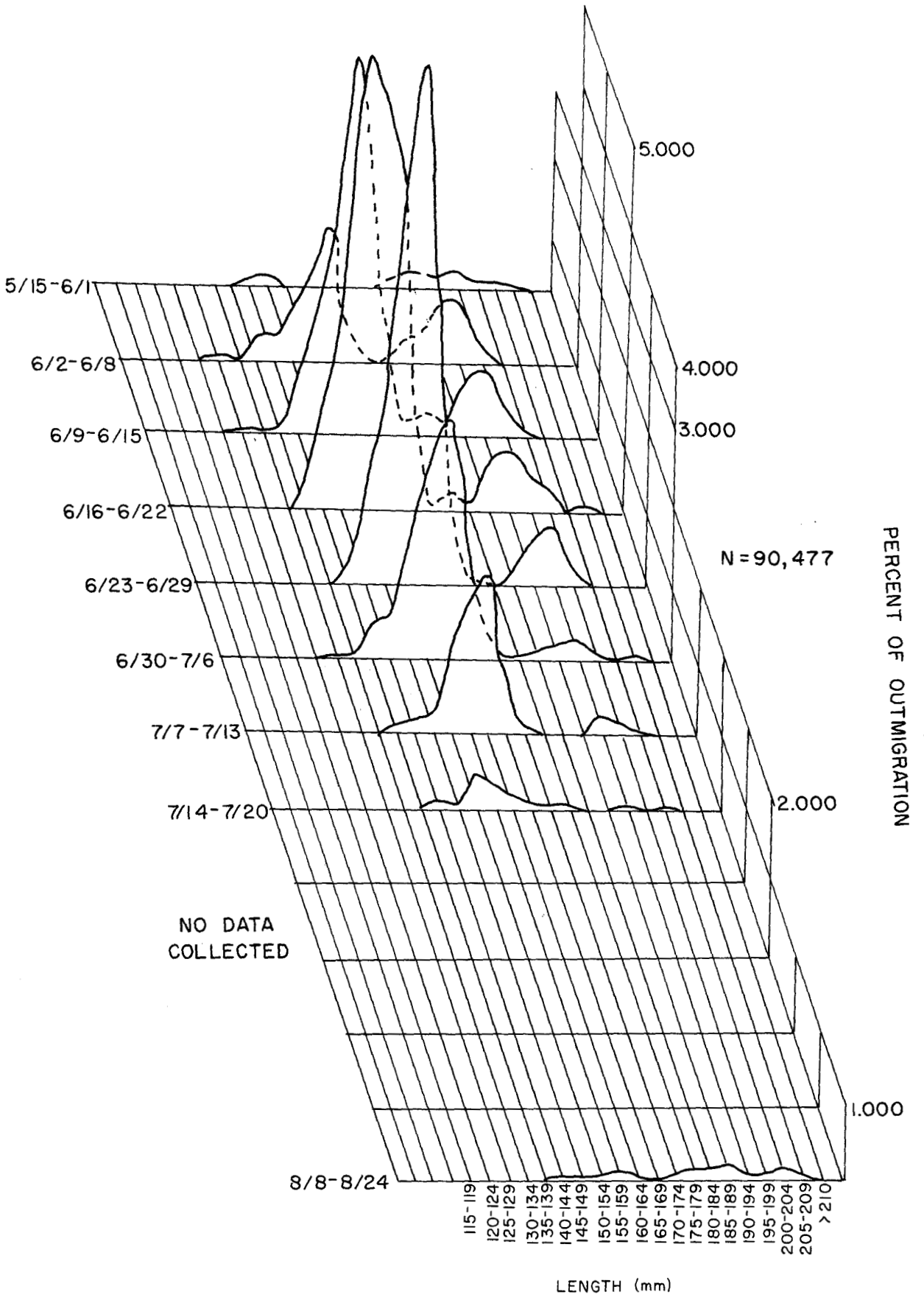


Figure 13. Length frequency of smolt by weekly sample period and percent of total outmigration, Frazer Lake, 1968.

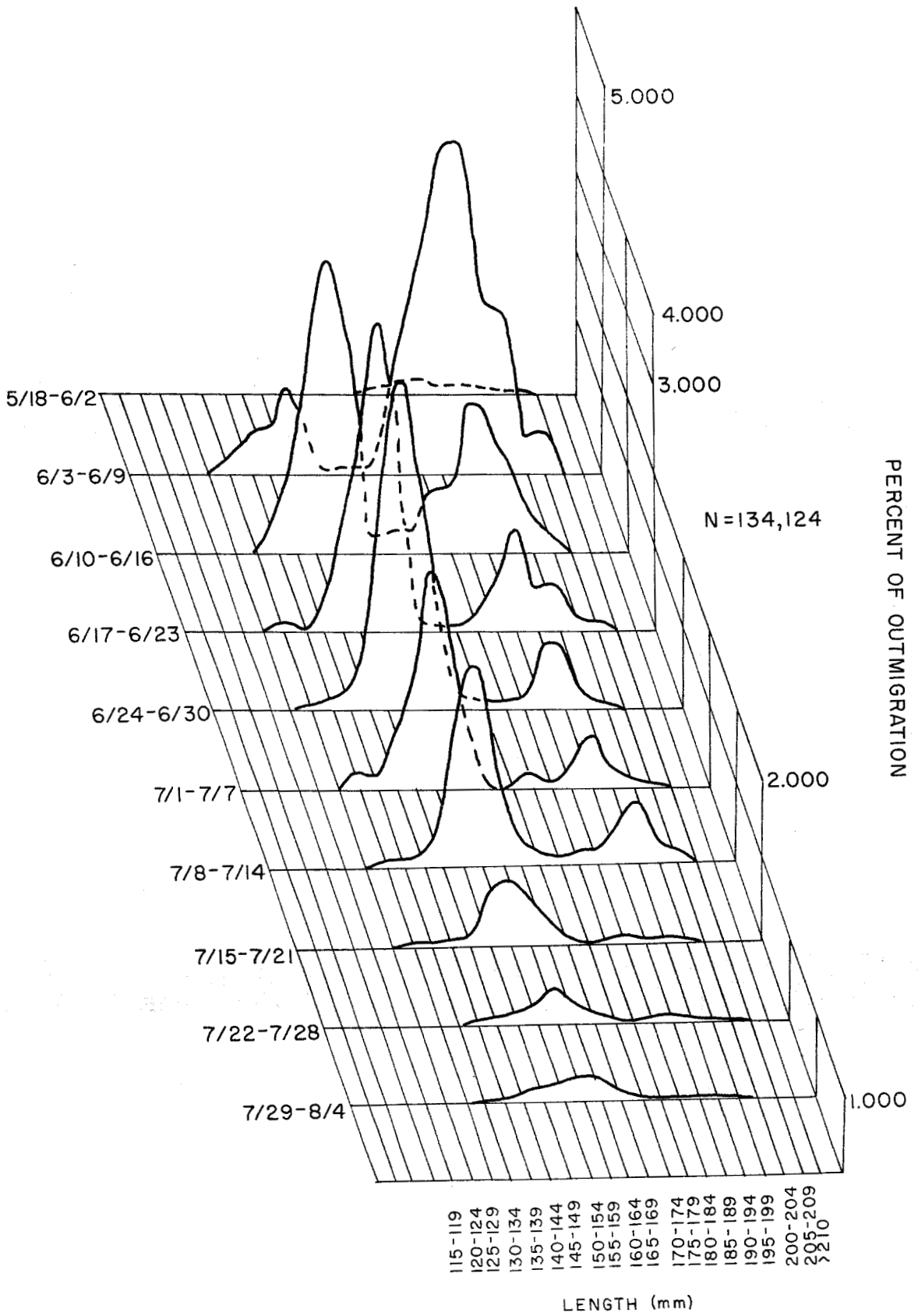


Figure 14. Length frequency of smolt by weekly sample period and percent of total outmigration, Frazer Lake, 1967.

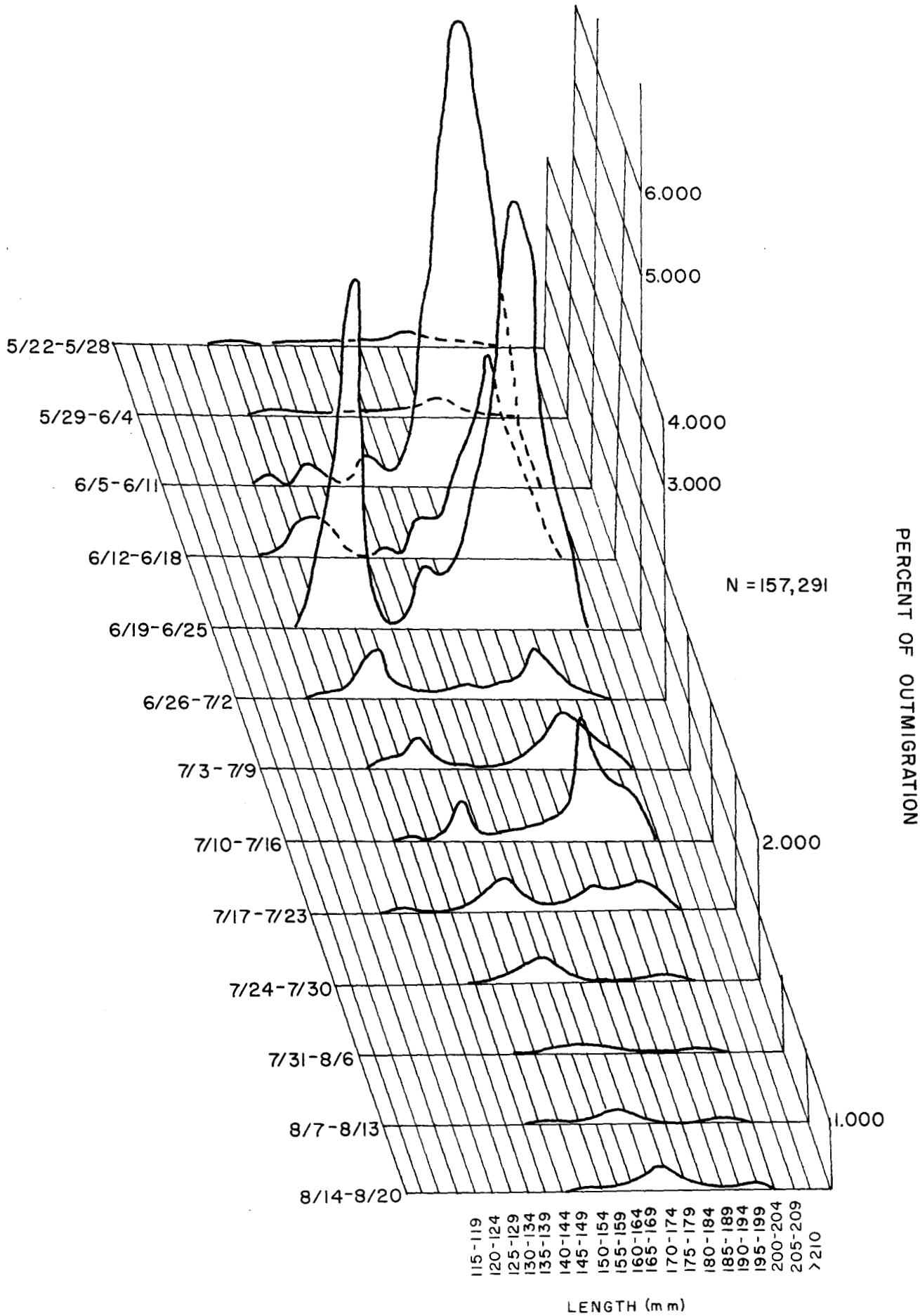


Figure 15. Length frequency of smolt by weekly sample period and percent of total outmigration, Frazer Lake, 1966.

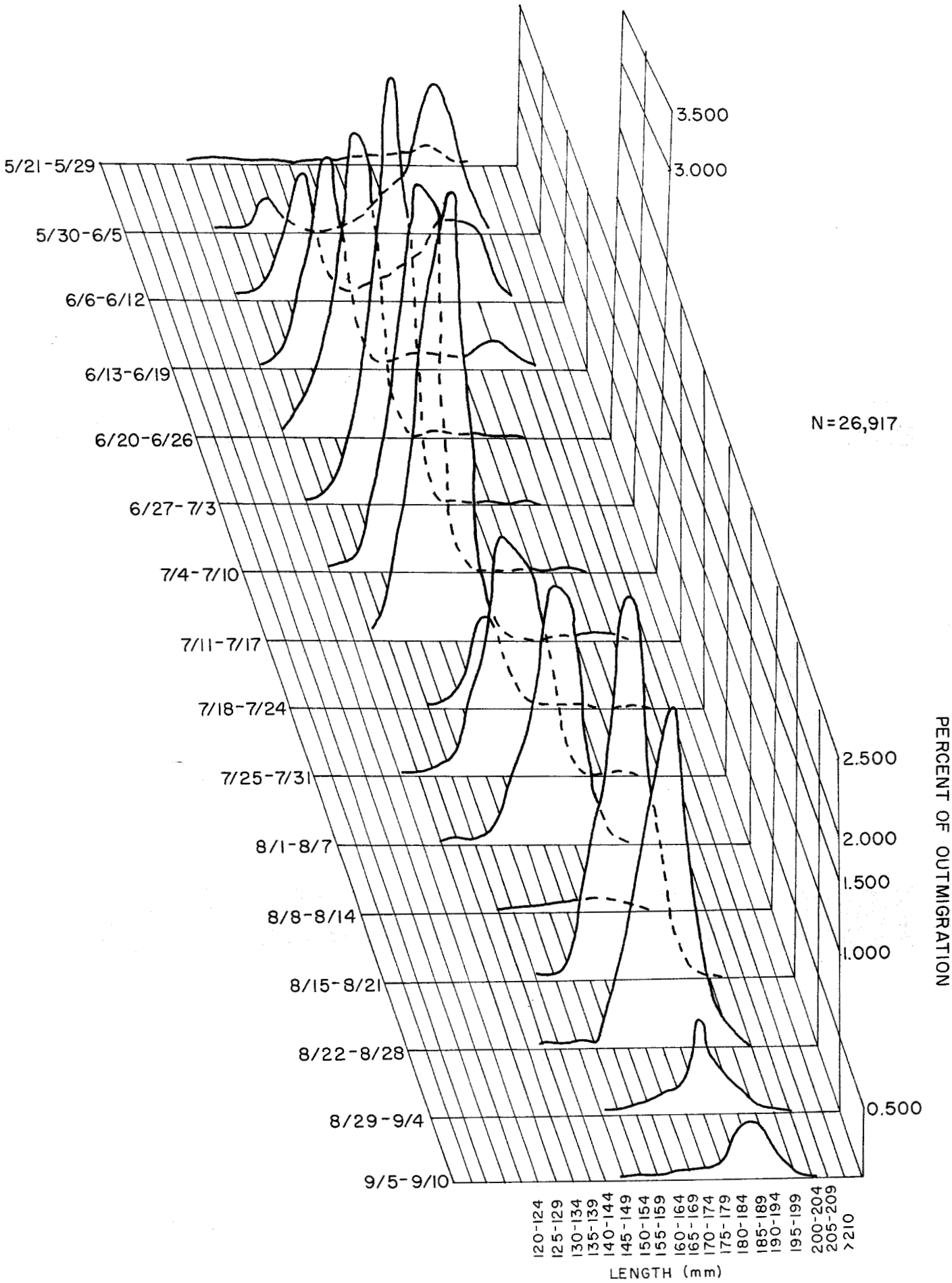


Figure 16. Length frequency of smolt by weekly sample period and percent of total outmigration, Frazer Lake, 1965.

Table 9. Percent age composition of outmigrant smolt estimated by length-frequency analysis, Frazer Lake, 1965-1970.

Year of outmigration	Age (percent of N)			
	n	1.0	2.0	ΣN [1/]
1965	9,480	91	9	26,917
1966	1,960	23	76	157,291
1967	1,990	61	39	134,124
1968	1,695	87	12	90,477
1970	2,328	69	31	44,808

1/ ΣN = Total enumerated outmigrant smolt that were sampled.

Table 10. Comparison of smolt age determinations by length-frequency analysis and scale reading methods, Frazer Lake, 1965-1970.

Year of outmigration	Age 1.0 (%)			Age 2.0 (%)		
	Length frequency	Scale reading	Difference	Length frequency	Scale reading	Difference
1965	91.0	75.8	15.2	9.0	23.5	14.5
1966	23.0	23.1	0.1	76.0	75.5	0.5
1967	61.0	54.9	6.1	39.0	41.5	2.5
1968	87.0	85.5	1.5	12.0	14.1	2.1
1970	69.0	68.1	0.9	31.0	31.6	0.6

scale reading provides a more accurate inference of actual age composition of smolt outmigration than use of either method alone. The relatively good confirmation of age analysis of Frazer smolt by both methods indicates that the age determinations are reasonably accurate.

Yearly migrations (N), as noted in length frequency tables and figures, represents only those migrating smolt that were sampled. Apparent differences between yearly and total migrations will occur as there were periods in some years when samples were not taken.

Echo sounding studies

A high correlation was shown between recorded echo returns and young sockeye distribution at Lake Aleknagik in studies conducted by Pella (1962). A pilot study was conducted at Frazer Lake in 1970 to assess the value of presently available echo sounding equipment in locating and studying lacustrine diurnal movement of smolt. A Ross Dual Sounder model 300/100 was used; it operates at a frequency 190-200 kilohertz with a transducer beam angle of 22^{o}. An initial test for sensitivity was conducted using a sockeye smolt approximately 150 mm in length attached to a light nylon line weighted with a heavy lead sinker. Both smolt and lead weight could be readily detected and distinguished at a depth of 100 feet. Other fish in the lake of a similar size to the sockeye smolt would also be detected and recorded. The majority of echo returns, however, are considered to represent young sockeye due to the distribution patterns and densities observed.

Transects were limited by weather and other work to the nights of May 12, May 13, and August 2. The same transect was run each night using a bright light encased in a wood box 3 feet long. The light placed at the back of the box was visible through two sheets of transparent colored plastic, separated from each other by a quarter of an inch to provide a beam of white light with an angle width of $0^{o}24'$. By maintaining a course where only white light was observed and correcting when the light colored, a relatively consistent transect across the lake could be made for 2 miles at night. The device was set up on Linda Point (B on Figure 17) and allowed a course to be run from there past Midway Creek and Linda Creek.

On May 12 transects were made from 9:10 to 11:35 p.m., and on May 13 from 3:55 to 7:00 a.m. and 7:05 to 11:18 p.m. Before sunset only a few dense echo returns were observable in the deepest part of the transect (Figure 18A); after sunset these returns appeared to disperse into a number of less dense, but still ambiguous returns located at a somewhat lesser depth. Ambiguous patterns also were evident at approximately 50 feet in the Midway Creek area (Figure 18B). As the night progressed, individual echo returns became evident at or near the

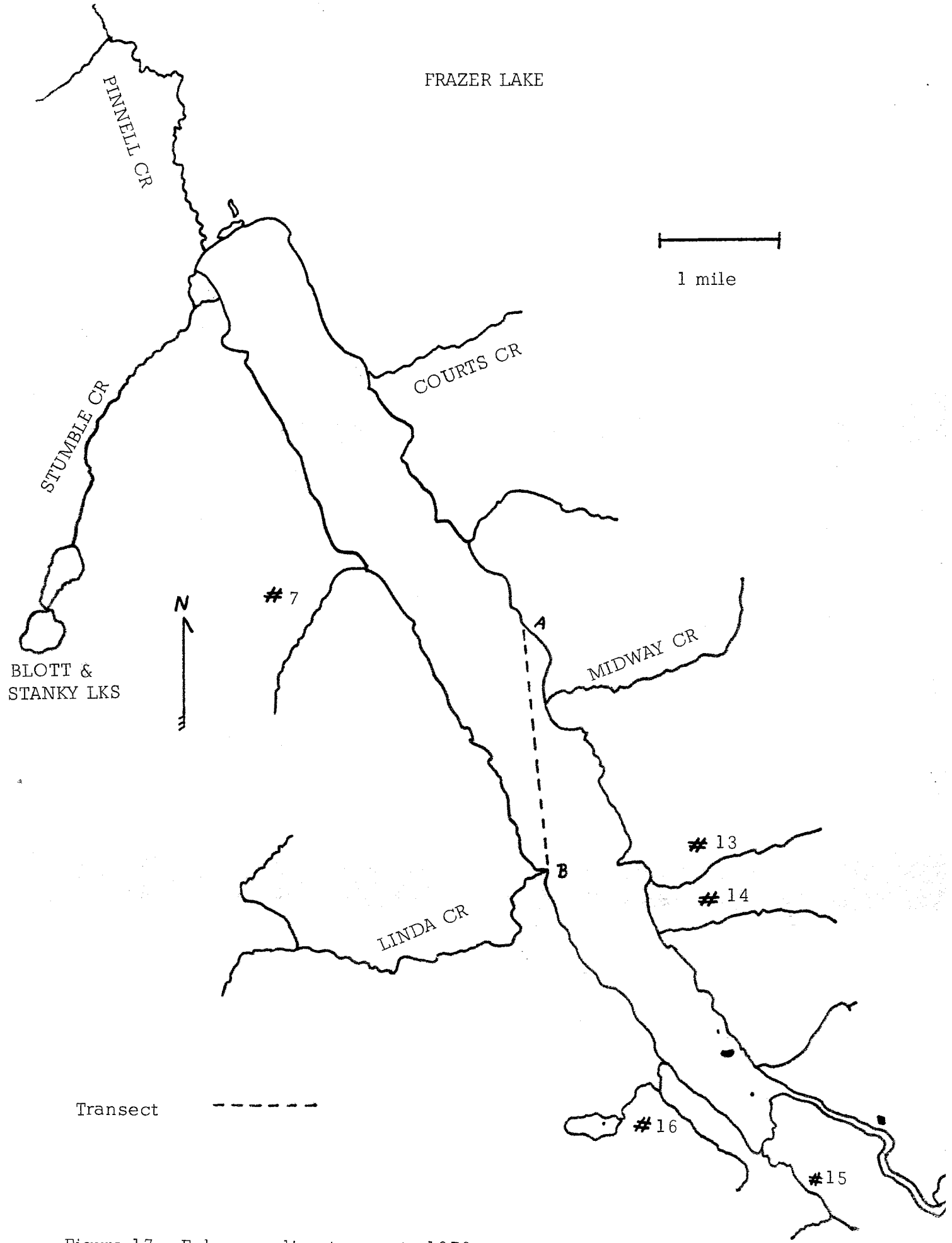
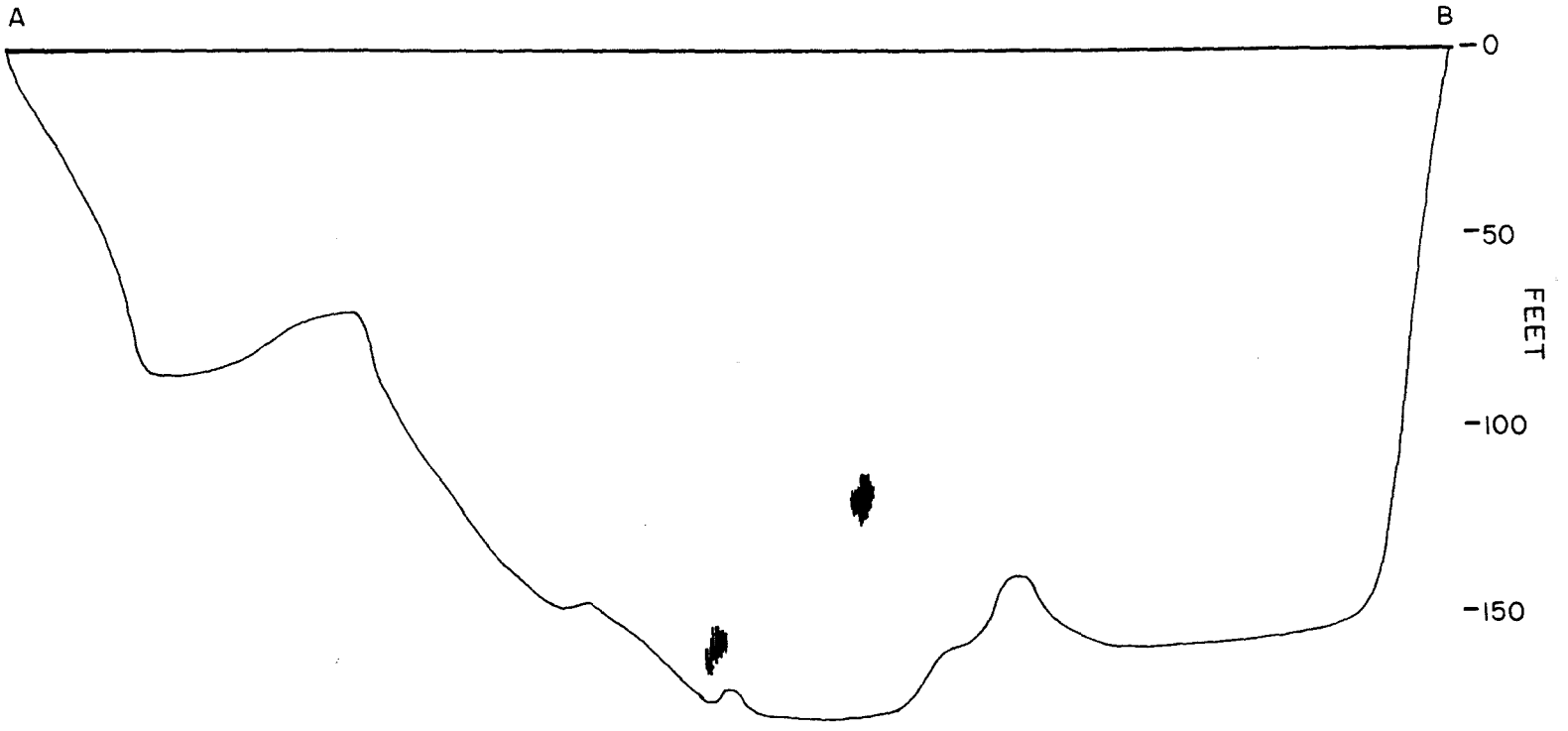
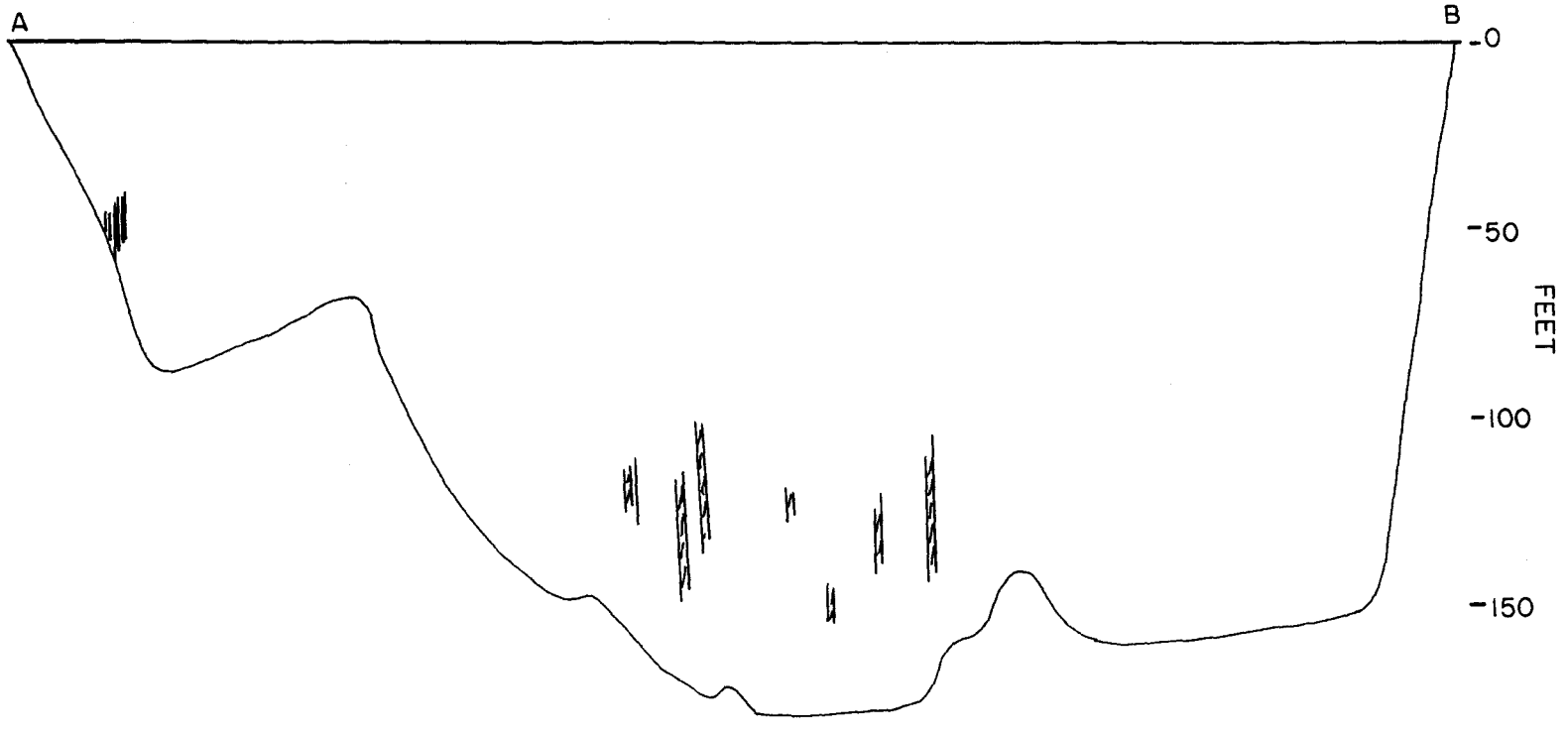


Figure 17. Echo sounding transect, 1970.

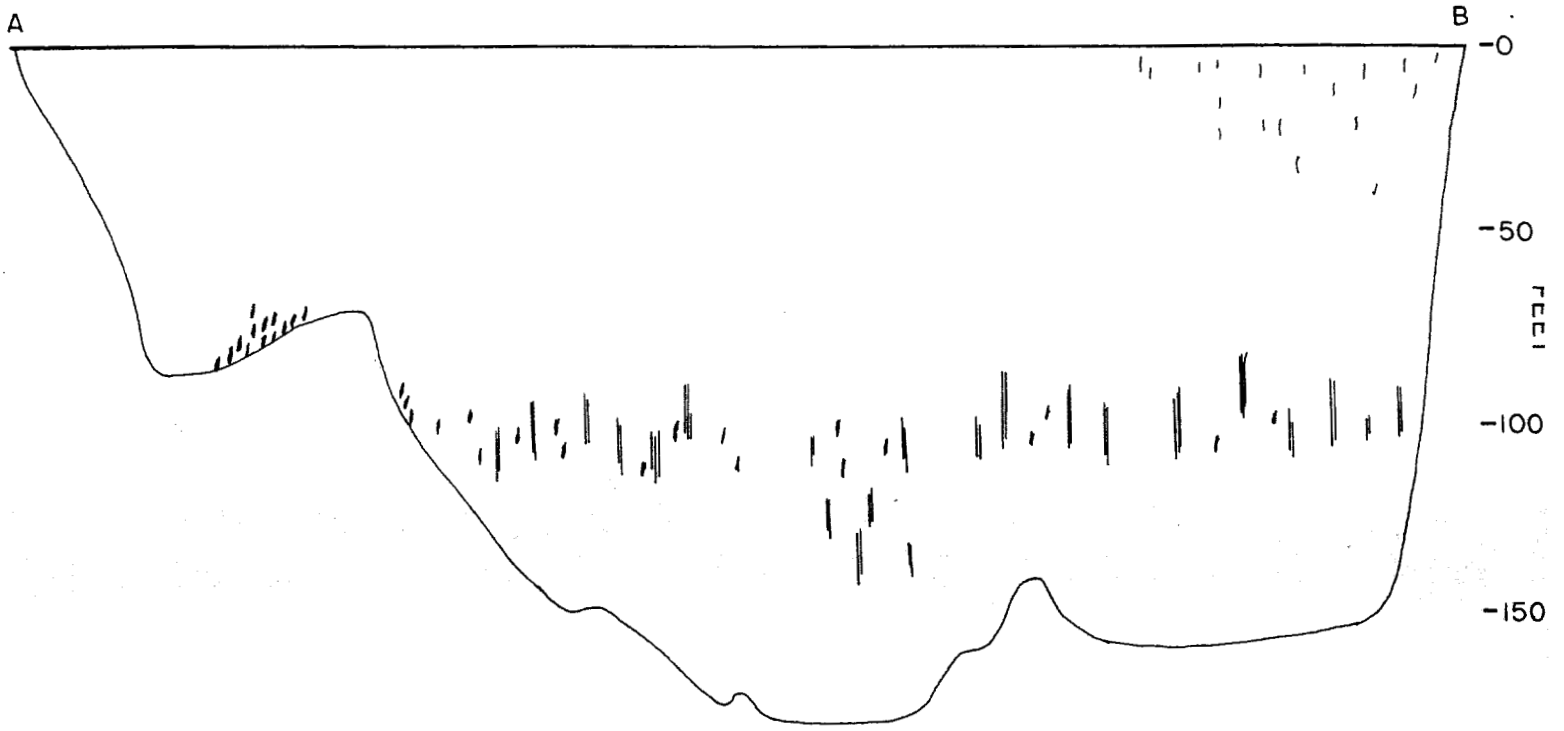


(a) Distribution before sunset and after sunrise.

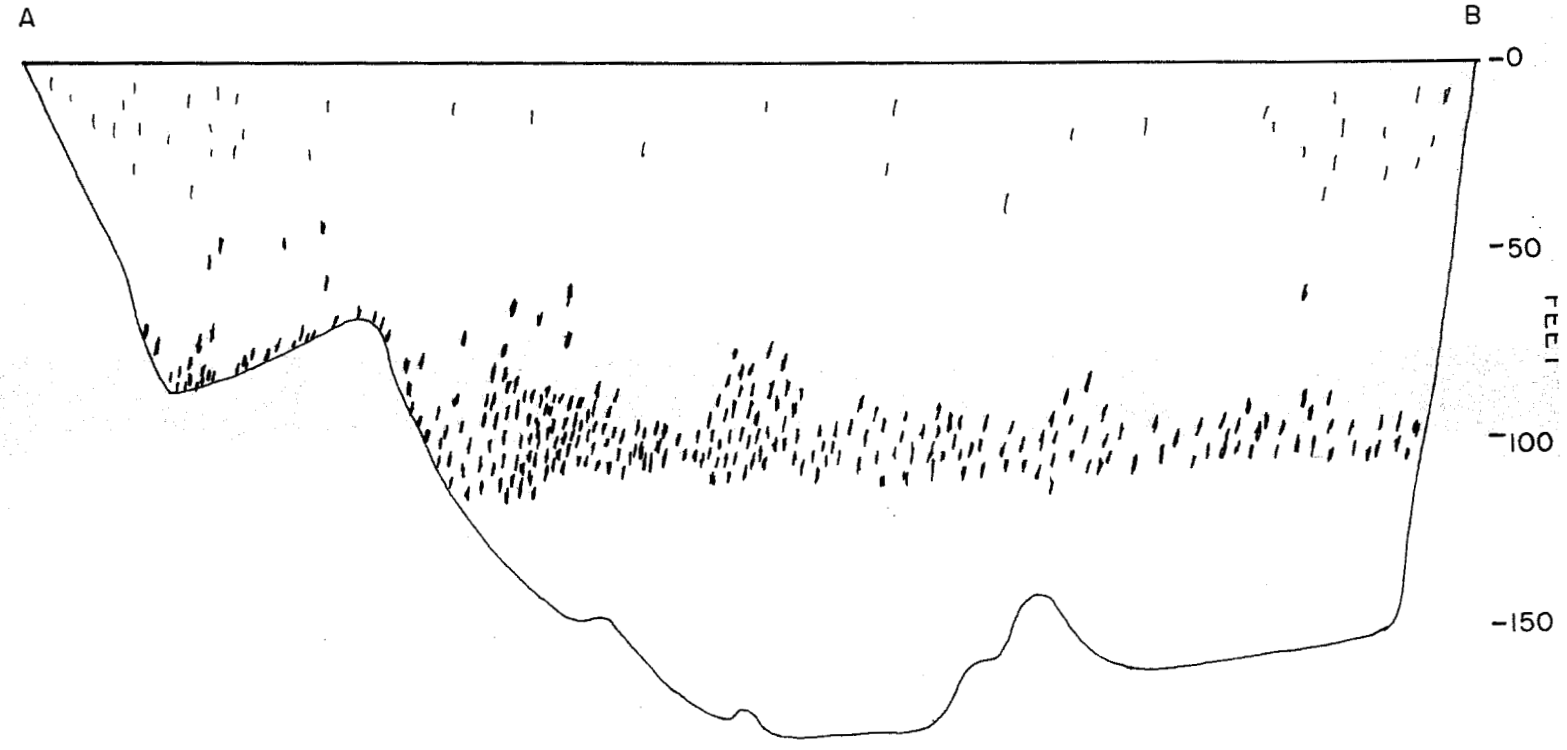


(b) Distribution after sunset and shortly before sunrise.

Figure 18. Distribution of juvenile sockeye, Frazer Lake, May 12-13, 1970.



(c) Distribution after sunset.



(d) Distribution at midnight.

Figure 18. (continued)

bottom in the Midway Creek area and near the surface off Linda Creek, ambiguous returns and some individual echoes were concentrated at a depth of approximately 100 feet across the entire transect (Figure 18C). By midnight a heavy concentration of individual echo returns were located near the bottom of Midway Creek area and at the 100 foot level across the transect (Figure 18D). As the night progressed and the lake illuminated at day break, the individual echo returns appeared to coalesce into ambiguous groups in the reverse manner of the patterns observed as sunlight decreased the evening before (Figures 18C, 18B and 18A, respectively).

It would appear that during the spring young sockeye cluster near the bottom or below the 100' level during the day, and migrate into the upper areas of the lake and away from each other as light leaves the lake. They group back into schools and migrate to darker areas as the lake again becomes illuminated. These observations were very similar to those of Woodey and DeLacy (1970) of young sockeye in Lake Washington. The individual echo returns observed were similar to those determined for a single test smolt.

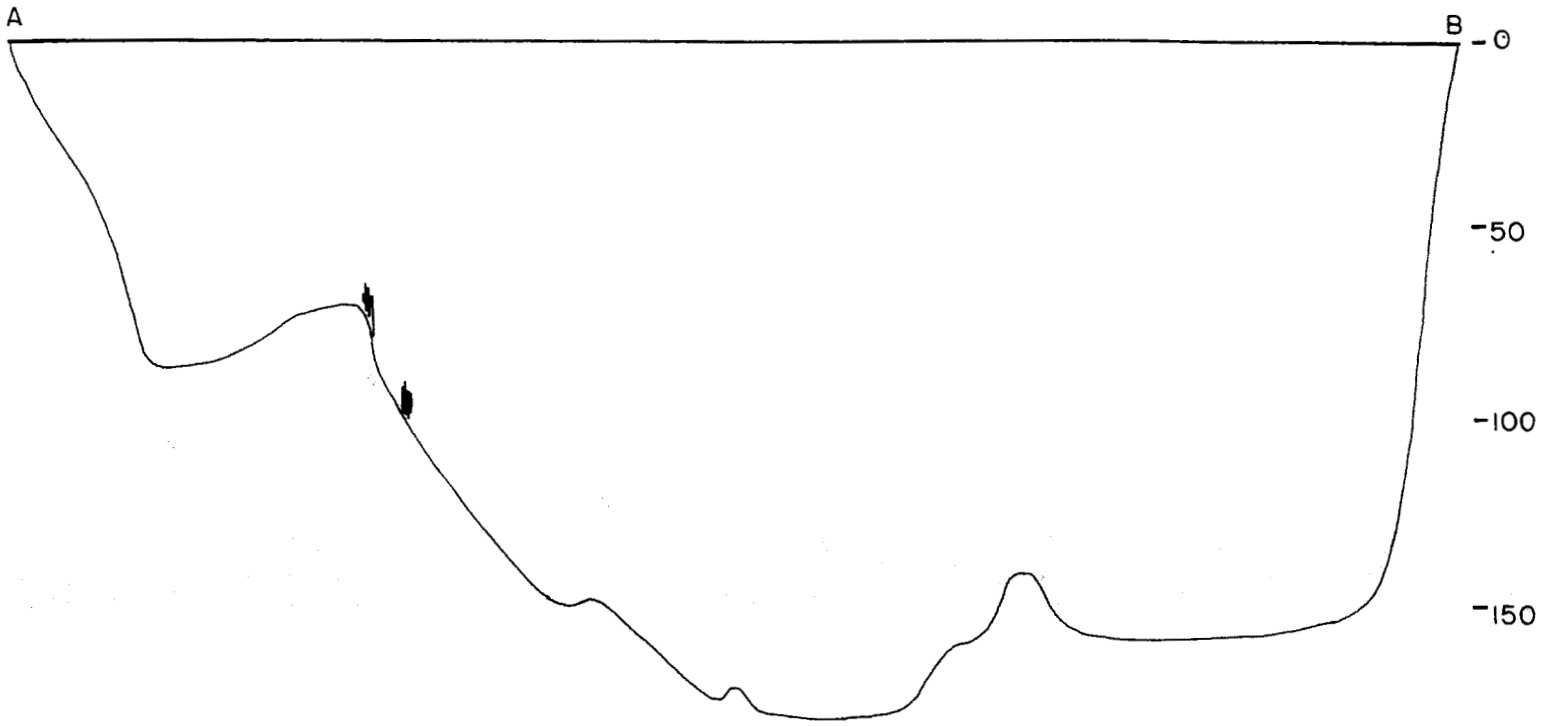
On the night between August 2 and August 3, the same transect was investgated from 9:00 p.m. to 5:40 a.m. Until 11:00 p.m., only a few small ambiguous returns were noted (Figure 19A) at 80 and 100 feet. At midnight, individual echo returns were evident off Linda and Midway creeks (Figure 19B). Prior to sunrise, individual echoes were located at slightly lower depths and ambiguous returns occurred at 40-50 feet (Figure 19C). After sunrise, no echo returns were evident. The abundance of echo returns observed in August was much less than noted in the May investigations and the diurnal movement was similar to that described by Pella (1962) at Lake Aleknagik with sockeye young showing a "diurnal movement into the surface waters of the limnetic zone at night and a movement from these waters at day light".

Echo sounding could provide a means of indexing sockeye abundance in lake rearing areas. Further refinement of echo sounding techniques and determining reliability of indexing will be necessary in future work.

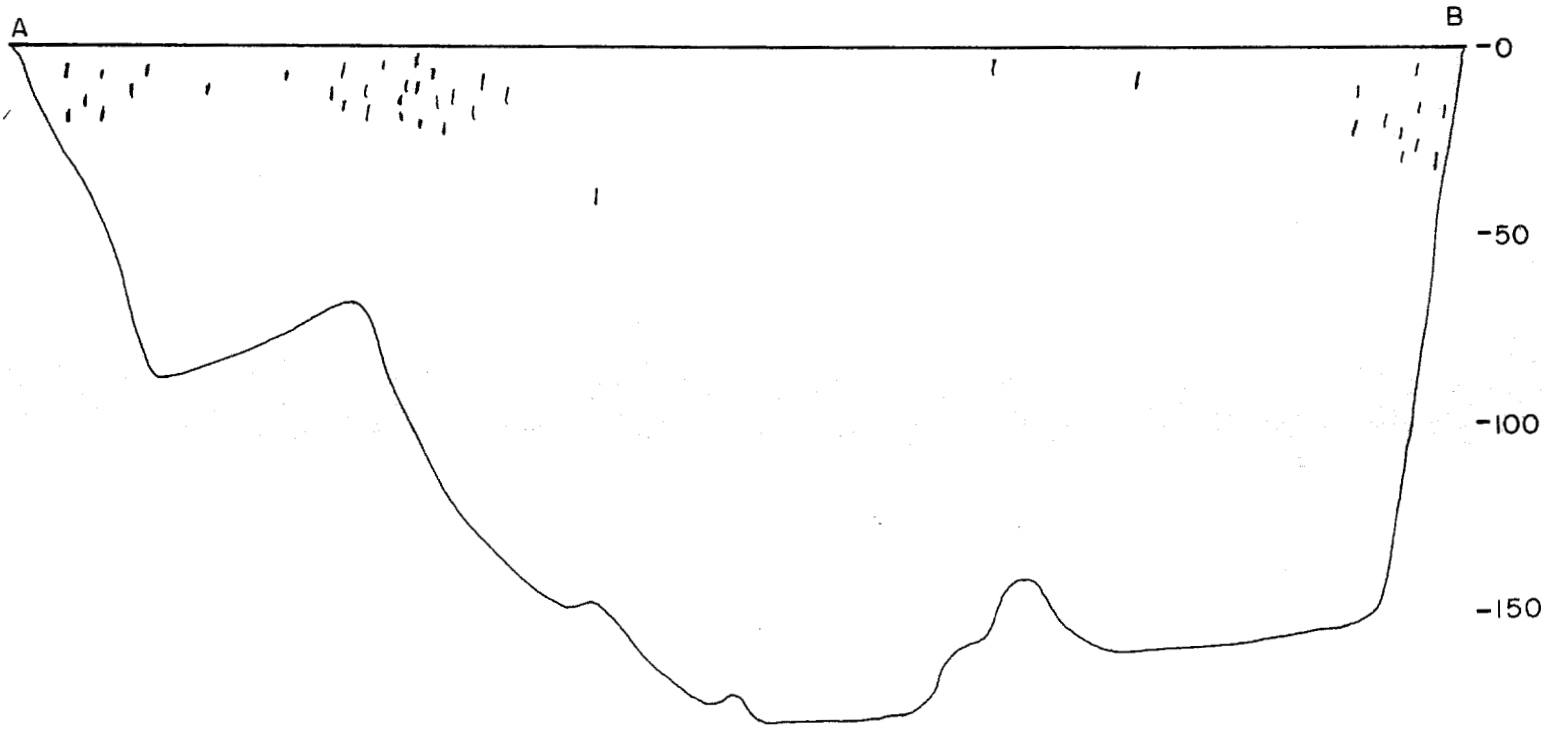
Summary

1. The age composition of smolt in 1970, as determined by scale analysis combined with the aid of length frequency, was 0.3% age 3.0, 31.6% age 2.0, 68.1% age 1.0, and 0.02% age 0.0. The smolt migrated according to age, with older smolt appearing first. Outmigration patterns show similar yearly trends from 1965 to 1970.

2. In 1970, age 0.0 smolt averaged 113 mm and 12 grams; age 1.0 smolt



(a) Distribution shortly after sunset.



(b) Distribution at midnight.

Figure 19. Distribution of juvenile sockeye, Frazer Lake, May 12-13, 1970.

(c) Distribution prior to sunrise.

Figure 19. (continued)

averaged 149 mm and 31 grams; age 2.0 smolt 180 mm and 54 grams; age 3.0 smolt 193 mm and 64 grams. Fluctuations in size of smolt are apparent from year to year, however, there is not any indication that smolt size has tended to decrease or increase since 1965.

3. Freshwater survival of sockeye from potential egg deposition to smolt at Frazer Lake has ranged from 0.61 to 0.80 percent in years that data are available. An overall median value for survival rate is probably about 0.70 percent.

4. Length frequency analysis of smolt provides a quantitative method of determining length distribution parameters that can be used in conjunction with scale reading to infer age composition of smolt outmigrations. Relatively good agreement between length frequency groupings and scale analysis age groups for most all years of the Frazer studies indicates that smolt age determinations are reasonably accurate.

5. Pilot echo sounding studies conducted in Frazer Lake with a dual Sounder Model 300/100 show diurnal migration patterns of young sockeye similar to those observed in Lake Washington and Lake Aleknagik.

ADULT INVESTIGATIONS

Sampling procedures

Adult sockeye were sampled at random at the top of the Frazer Lake steeppass at one week intervals while the inmigration was in progress. Prior to sampling or tagging, adult sockeye were anesthetized in a tank containing a solution of MS-222. Fish sampled were measured from mid-eye to tail-fork to the nearest millimeter, weighed to the nearest 100 grams, sex determined by external features and two or three scales obtained for age determination. Scales were placed on a gummed numbered card, and weight, length and sex recorded on a similarly numbered form. After the field season, ages were determined by scale reading and recorded with length and weight information for each adult sampled. When the number of inmigrants was great enough, 100 adults were sampled each week.

Migration trends

The most important trend observed at Frazer Lake is the continued increase in yearly sockeye escapement which reached a peak of 24,081 in 1970 (Figure 20). Sampling and steeppass mortality amounted to 42 fish

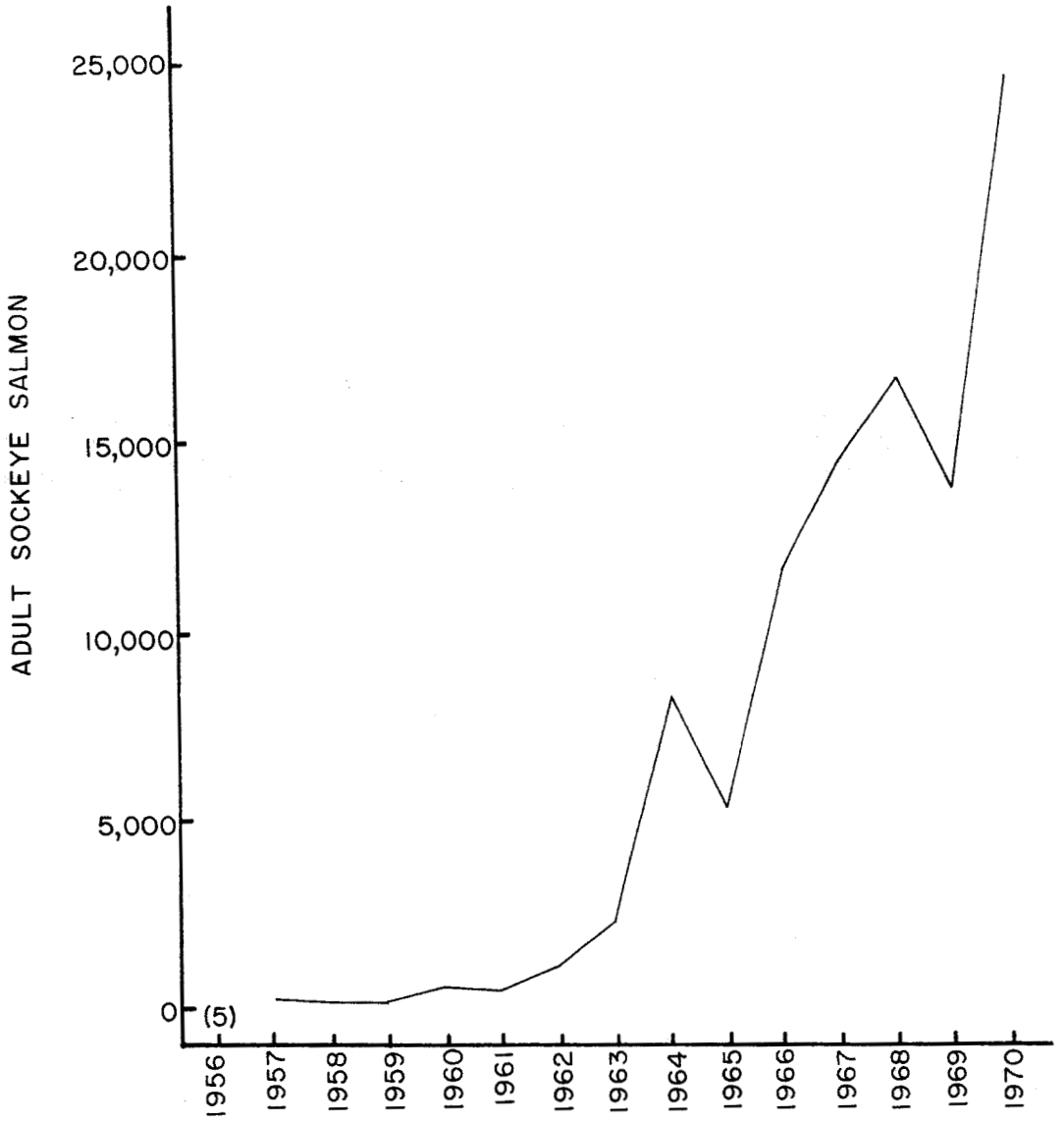


Figure 20. Frazer Lake escapements, 1956-1970.

decreasing actual passage on returning adults into the lake to 24,039. Daily passage was greatest on June 22 (1,913) and July 5 (1,552). Passage rates of over 1,000 fish were recorded on June 26, 29, and 30 and July 2 and 4. The highest previous rate to this was on June 28, 1968 with a count of 1,351. Movement of adults through the fishpass after modification in 1970 was greatly improved over previous years. The area below the new wire lead was clear of sockeye until August when a few adults were noted spawning below the new steeppass section. Observations indicate that adults followed the lead to the entrance of the new steeppass and continued through the steeppass with little delay.

In 1970 it was calculated from the sample sex ratio that 11,173 female adult sockeye and 12,908 males migrated through the steeppass (Table 11). The ratio of female to male inmigrants showed a steady increase from June through August; shifting from 1:4 to almost 5:1 respectively. The ratio of 1:1 during early June coincided with the peak migration period (Figure 21). This shift in sex ratio as the migration progressed has also been evident in previous years.

The majority of adult inmigrants passed through the fishpass during mid-June and July in 1970. With the exeption of 1965 the majority of sockeye in past years also passed through the steeppass by the end of July (Figure 22).

Age, length and weight composition

The majority of adults in the 1970 escapement, as determined by scale analyses, were age 2.2 (19.3% of the males, 25.2% of the females) and 1.2 (18.1% of the males, 23.8% of the females). Six other age classes were represented in the escapement sample. The sample had more (10.2%) adult males returning after one year in the ocean ("jacks") than any previous year since the beginning of sampling in 1965. Age composition by sex of adults sampled at the Frazer steeppass is shown in Figure 23. To give a true perspective of inmigrant age composition, samples were analyzed by weekly periods and these data applied to each weeks' total migration (Appendix Tables 9 and 10), thus weighting sample data for the adult migration in proportion to the actual migration. The sex ratio obtained from the age composition sample differs from that given in Table 11 and is not representative of the sex ratio of the population due to selective exclusion of fish with unreadable scales in age analysis. Age composition, mean mid-eye-to-fork lengths with standard deviation and mean weights with standard deviations for the escapement sample are presented in Table 12. The procedure for measuring adult length in 1970 was changed from previous years; all adults sampled were measured from mid-eye to tail-fork. This measurement is more representative especially for male sockeye where

Table 11. Projected number of adult sockeye by sex and sample period, Frazer Lake, 1970.

Sample period	Sample size	Sample percent females	Sample percent males	Adults enumerated	Projected number female	Projected number male
6/7-6/20	30	20	80	938	188	750
6/21-6/27	100	38	62	4,752	1,806	2,946
6/28-7/4	100	40	60	7,502	3,000	4,502
7/5-7/18	130[1/]	50	50	6,343	3,171	3,172
7/19-7/25	100	57	43	1,540	878	662
7/26-8/1	86	64	36	1,921	1,229	692
8/2-9/8	29	83	17	1,085	901	184
Total	575	--	--	24,081	11,173 (46.4%)	12,908 (53.6%)

1/ Two weeks sampling data combined.

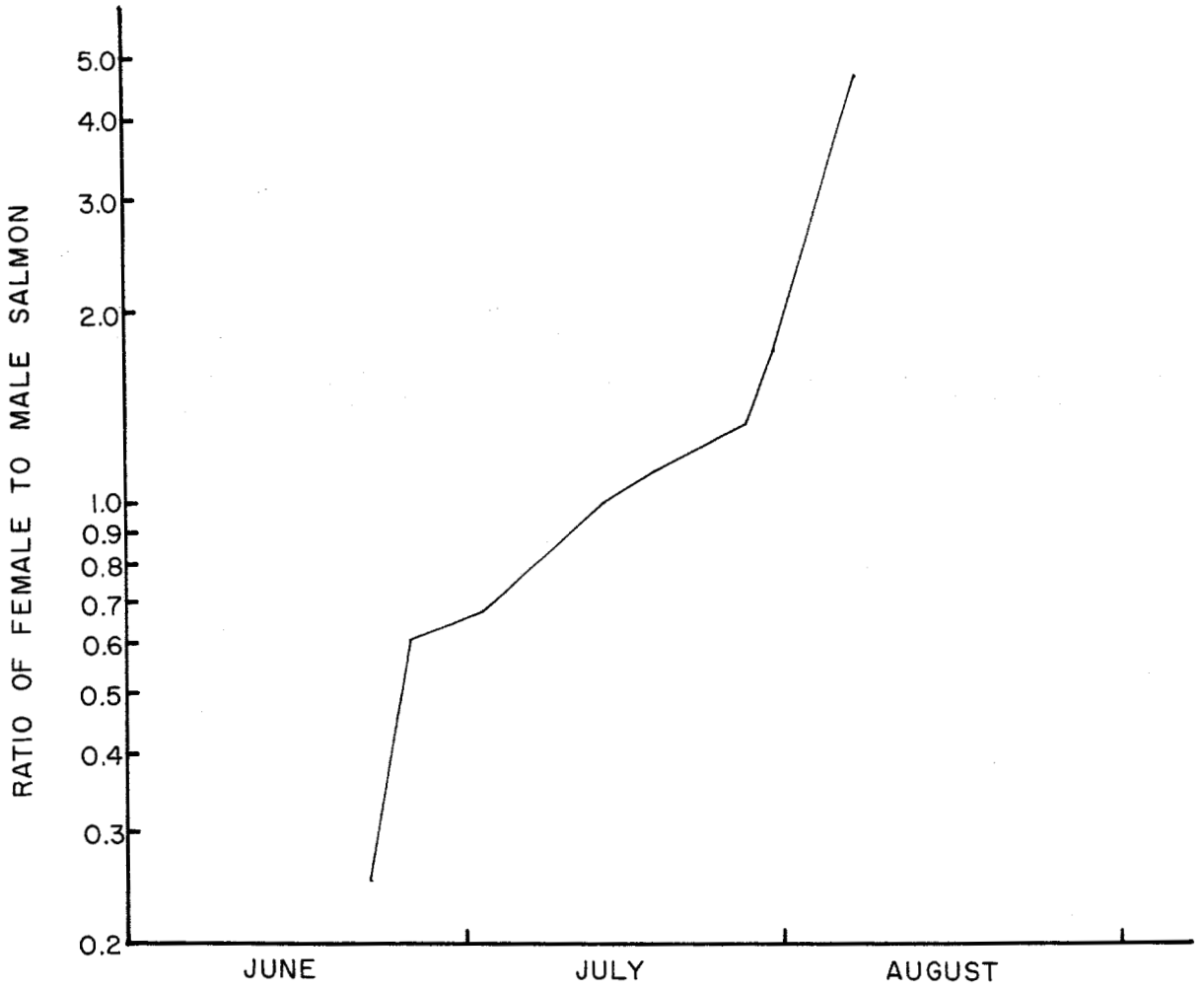


Figure 21. Ratio of female to male adult sockeye, Frazer Lake, 1970.

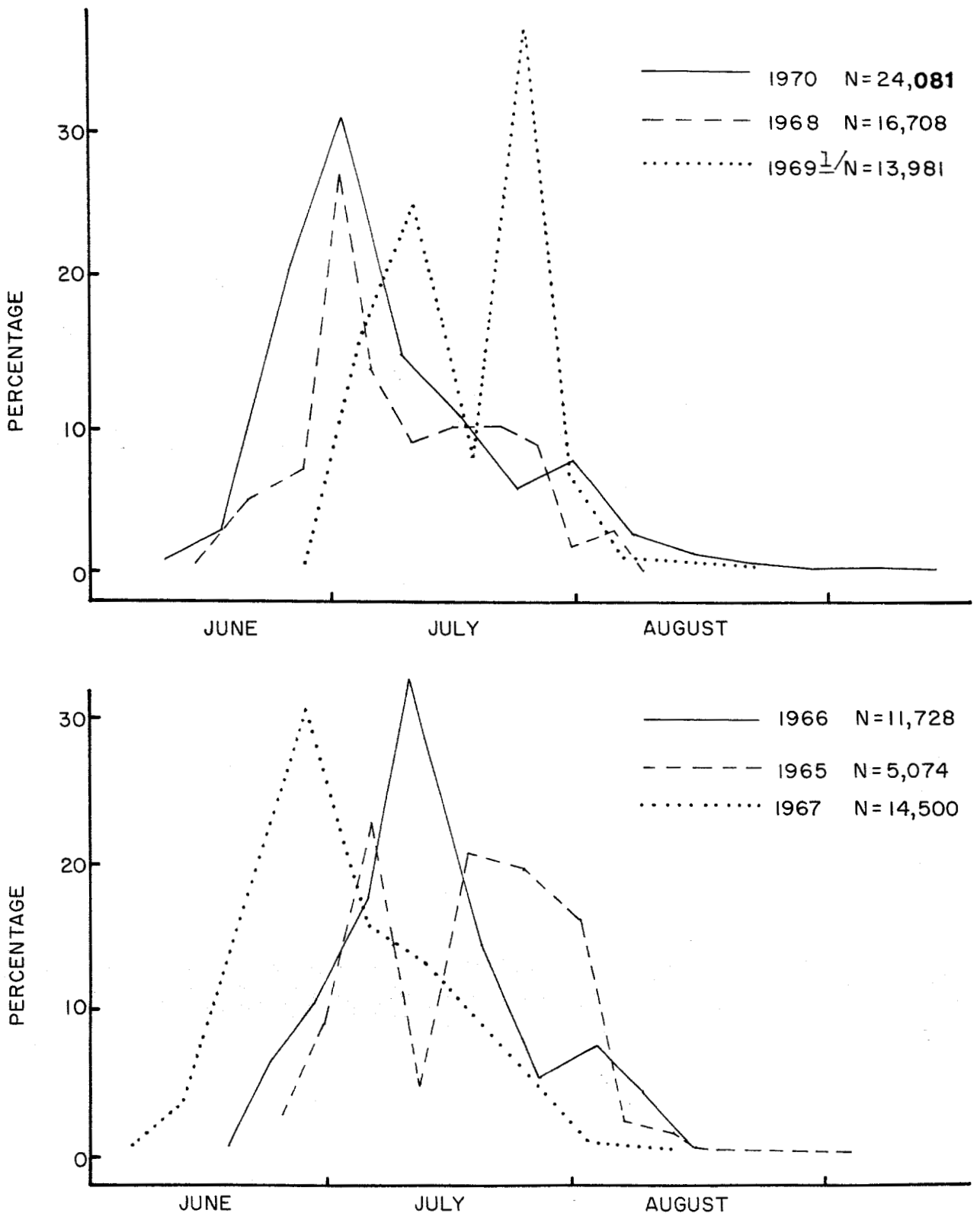


Figure 22. Sockeye salmon escapements, Frazer Lake, 1965-1970.

1/ Fish delayed below ladder and then manually placed in fishpass in late July.

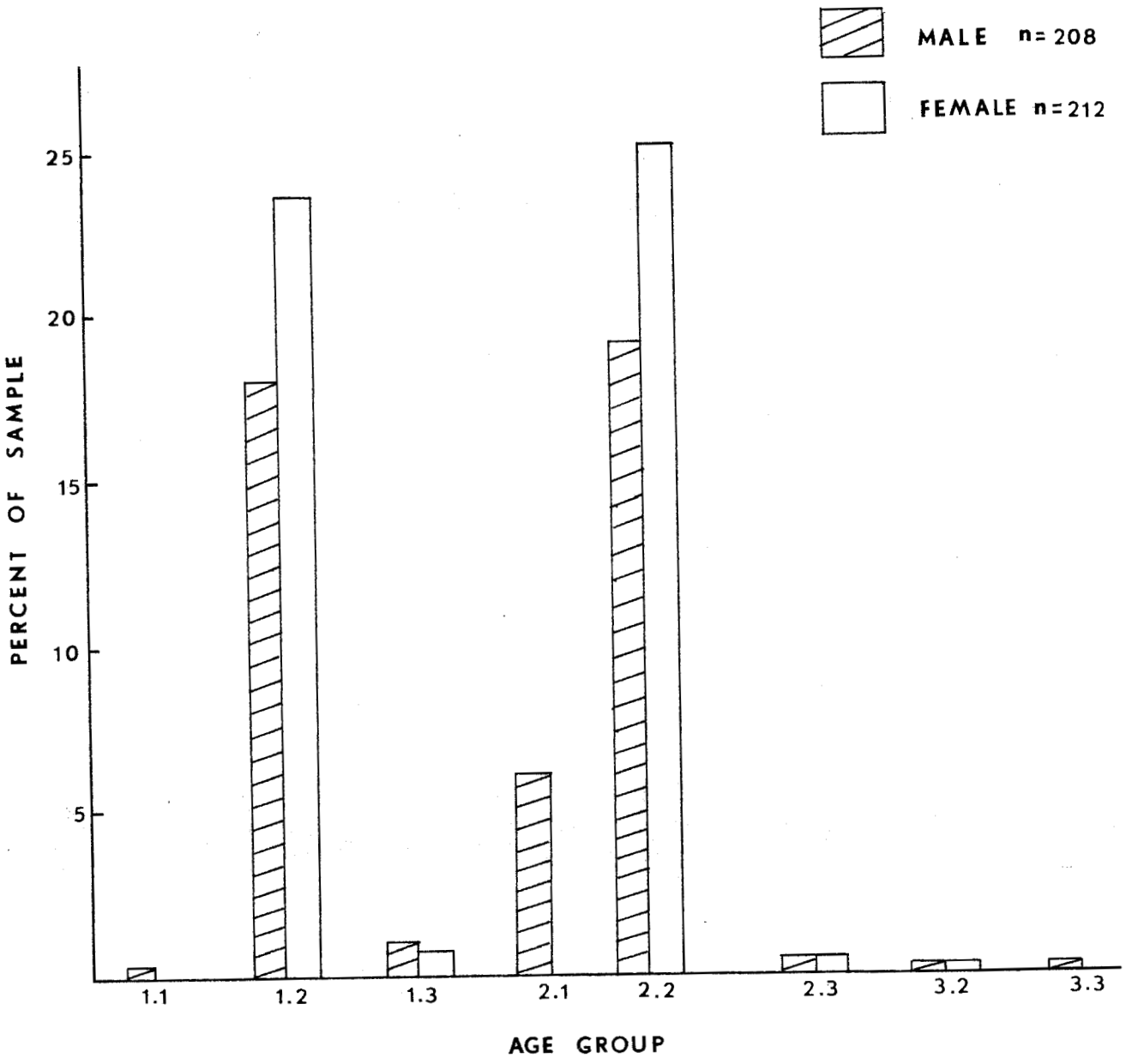


Figure 23. Age composition by sex of 420 sockeye sampled from the Frazer Lake escapement in 1970.

Table 12. Age, weight, and length composition of sockeye sampled from the Frazer Lake escapement in 1970.

Parameter	AGE GROUP 1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	Total or Average
Combined Sexes										
Number of Fish	17	176	7	26	187	4	-	2	1	420
Percent of Sample	4.0	41.9	1.7	6.2	44.5	1.0	-	0.5	0.2	100.0
Males										
Number Sampled	17	76	4	26	81	2	-	1	1	208
Percent of Sample	4.0	18.1	1.0	6.2	19.3	0.5	-	0.2	0.2	49.5
Mean Fork Length (mm) [1]	378.7	511.0	548.0	400.7	511.9	544.0	-	512.0	580.0	502.5
Standard Deviation	21.8	33.9	-	30.1	29.6	-	-	-	-	30.6
Mean Weight (Kg)	0.8	2.0	2.4	1.0	2.0	2.3	-	2.2	3.4	1.8
Standard Deviation	0.1	0.4	-	0.3	0.3	-	-	-	-	0.3
Females										
Number Sampled	-	100	3	-	106	2	-	1	-	212
Percent of Sample	-	23.8	0.7	-	25.3	0.5	-	0.2	-	50.5
Mean Fork Length (mm)	-	500.8	551.3	-	505.3	572.0	-	514.0	-	504.5
Standard Deviation	-	38.5	-	-	25.8	-	-	-	-	32.0
Mean Weight (Kg)	-	1.8	2.3	-	1.9	2.7	-	2.0	-	1.9
Standard Deviation	-	0.3	-	-	0.4	-	-	-	-	0.4
Difference Between Male and Female Means										
Fork Length (mm) [1]	-	10.2	3.3 [2]	-	6.6	28.0 [2]	-	2.0 [2]	-	2.0 [2]
Weight (Kg)	-	0.2	0.1	-	0.1	0.4 [2]	-	0.2	-	0.1 [1]

[1] Mid-eye to tail-fork.
[2] Inversion-female dominance.

maturation causes drastic changes in snout configuration. Data collected from sockeye at Red Lake, which is about five miles west of Frazer Lake and has provided the primary source of eggs and adult transplants for the Frazer Lake project, were used to compute fecundity by means of a regression formula and to convert previous years snout length measurement to mid-eye length (Figure 24). The linear regression formulae for length conversions are:

Male

$$Y = 0.844\,x + 32.002$$

Female

$$Y = 0.854\,x + 41.793$$

Where x = snout-to-fork length in millimeters

Y = mid-eye-to-fork length in millimeters

Mid-eye to tail-fork length measurements of sampled male and female adult sockeye show very similar distributions, with the exception of "jacks" which average approximately 120 mm smaller (Figure 25).

Marine survival

Marine survival of age 1.2, 2.2, and 3.2 salmon in the 1970 escapement that migrated out of the lake as smolts in 1968 was 22.3 percent. Additional adult returns in 1969 and 1971 will increase this favorable marine survival of 1968 smolts even further. Sample expansion of age composition for the 1968 smolt outmigration and the 1970 adult immigration indicates a much greater survival of age 2.0 smolts (81.0%) than age 1.0 smolts (13.0%). Such a high survival rate for a single age class is suspect and additional years data and age analysis are needed for confirmation.

Calculation of marine survival of smolts to adult return and comparison of previous years escapement age composition to the 1970 data are precluded by the necessity of having to re-read thousands of adult scale samples from the earlier years of the Frazer project. The original age readings and age composition analysis from 1965 through 1969 have been in considerable error and require complete revision. This task has been completed for the smolt samples and will hopefully be finished for the adult samples in the near future.

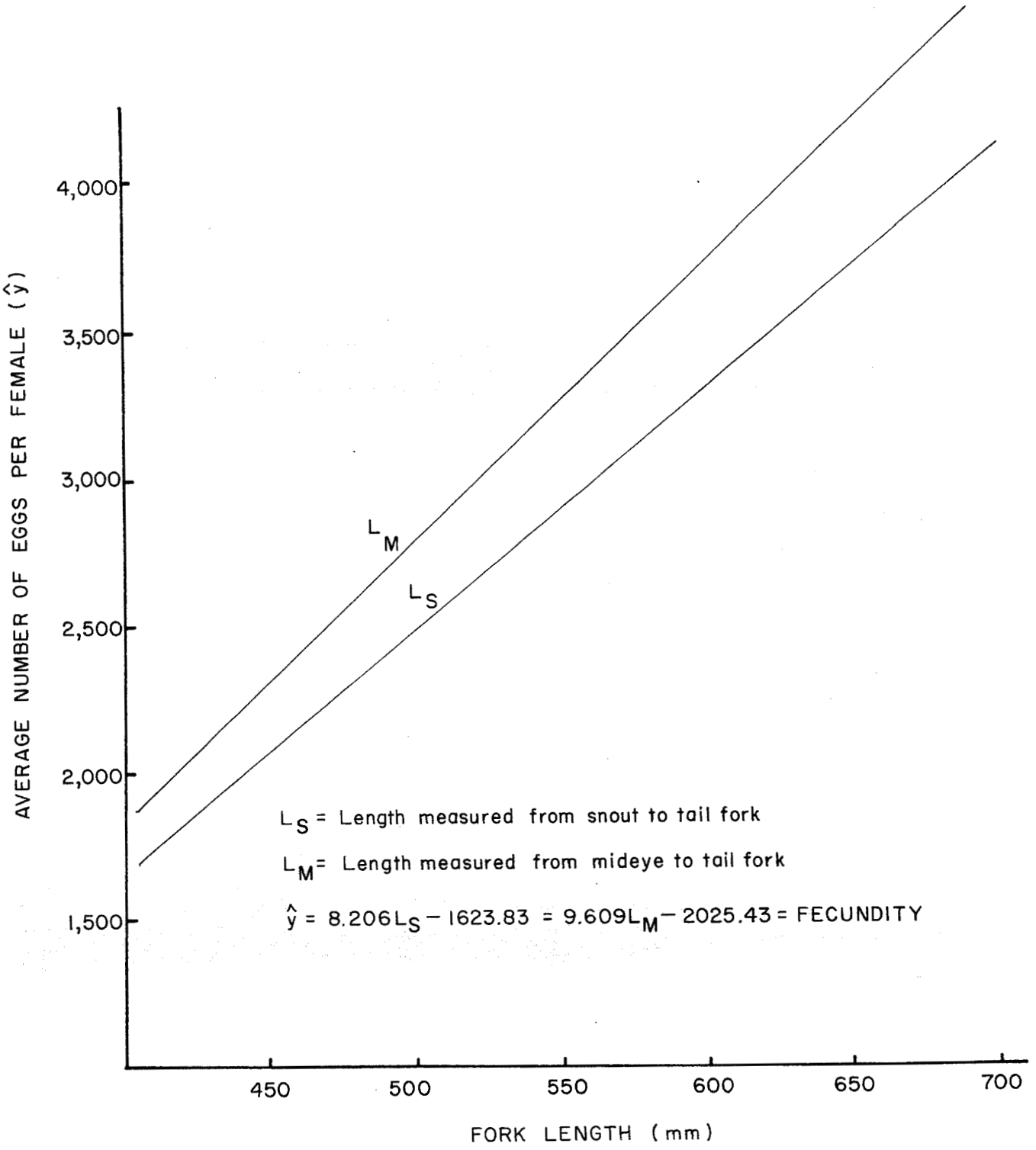


Figure 24. Fecundity relationship to length of adult female sockeye using mideye-to-fork and snout-to-fork measurements.

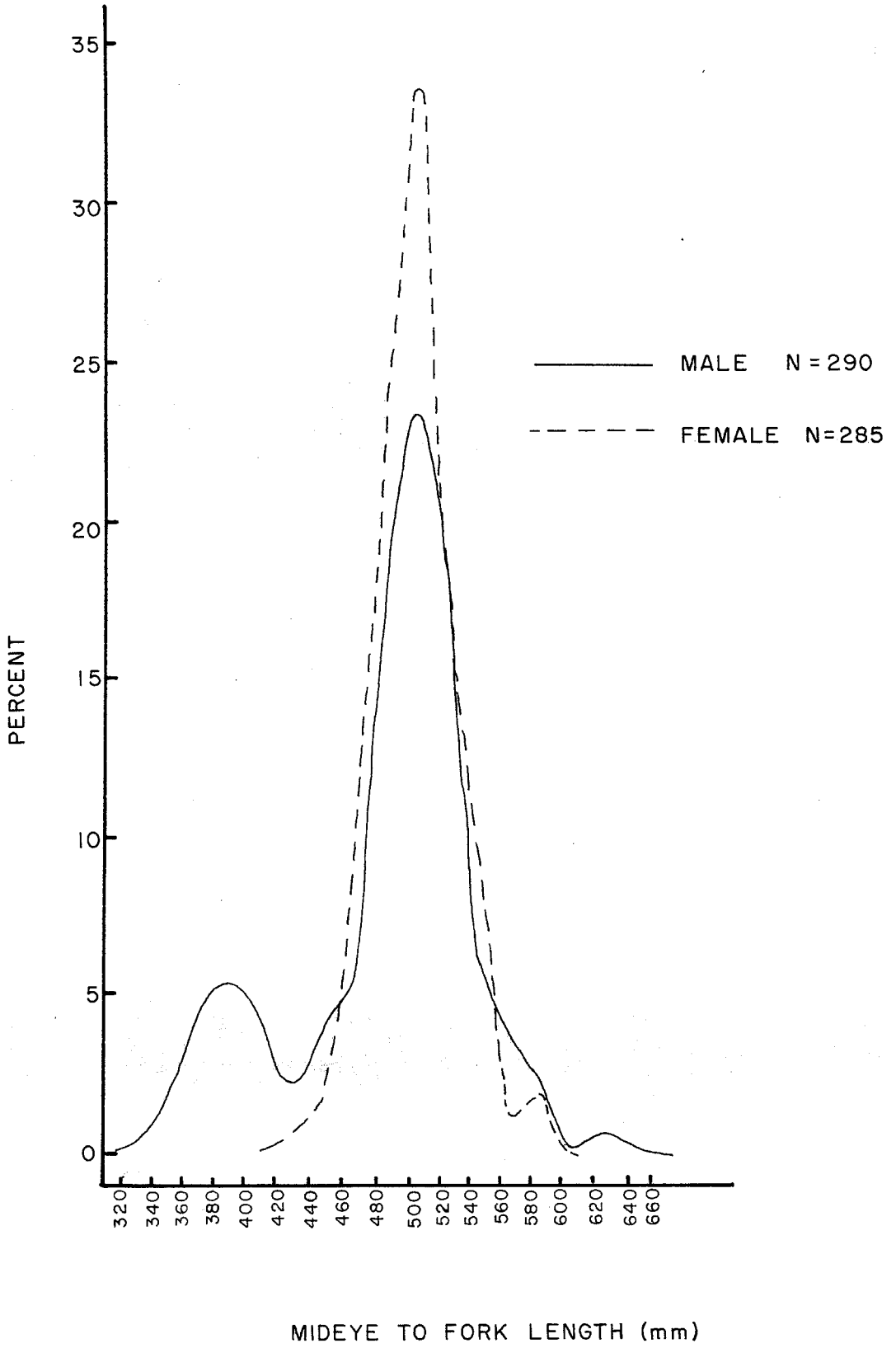


Figure 25. Length-frequency distribution of sampled adult sockeye inmigrants, Frazer Lake, 1970.

Commercial fishery

The return of sockeye to the Frazer River has been primarily in late June and early July and most of the fish are either in the river or off the river mouth before the Alitak and Olga-Moser Bay set gill net fisheries are opened to commercial fishing. Frazer escapements through 1970 are considered to represent most of the adult returns with only a minor contribution to the commercial fishery. As the Frazer run increases in future years it is expected to contribute greatly to the Alitak District fishery as well as districts intercepting the run along the southwest coast of Kodiak Island.

Tagging programs

During the summer of 1970 sockeye were tagged at the top of the steeppass ladder. All tagged fish were first anesthetized using MS-222 and then placed in the water in front of the upper steeppass section by the sampling station. Tagging was conducted to determine if adults were dropping back over the falls after ascending the steeppass and returning through the steeppass more than once. On July 3, 100 adults were tagged with red Dennison flag tags; none were observed going through the steeppass or later during stream surveys in the lake system. On July 5, 100 adults were tagged with yellow Dennison flag tags with the same results as July 3. On July 23, 100 adults were tagged with blue Dennison flag tags; one tag was observed in the steeppass on July 25 and two were recovered in the Olga Bay fishery 1-1/2 miles west of the mouth of Dog Salmon River (one on August 3 and one on August 4). The uncoordinated sluggish movement of anesthetized adults after tagging would make them much more susceptible to being swept over the falls; therefore, it is assumed from this study and previous tagging studies (Eaton, 1966) that very few returning adults are swept back over the falls after passage through the ladder.

Inlet stream and lakeshore surveys

During several foot surveys of stream inlets in 1970, 1,580 adult spawners were noted in Pinnell Creek, 1,267 in Linda Creek and 213 in Midway Creek. All other streams combined had little more than 100 spawners (Table 13). On August 24 ideal weather conditions permitted a complete survey of the lake shore for beach spawning activity; the area 1/2 mile to either side of Midway Creek had the highest concentration of activity while the beach of Number 7 and Number 13 creeks also showed evidence of frequent use as beach spawning areas (Figure 26). The beach in these three areas was composed of heavy gravel on a moderately sloping surface. Because of algae growth on the lake bottom, fresh redds were easily observed. On September 8, 72 adults and 50 fresh redds

Table 13. Summary of sockeye counts and stream surveys, Frazer Lake, 1970.

Stream	Date	Water temp(F°)	Fish Counts: Number Dead Male	Number Dead Female	Number Dead Total	Number live	Total count	Noted Concentrations (tenth-mile sections from mouth)
Pinnell	7/27[1]	-	-	-	0	0	0	-
	8/15	-	-	-	489	1019	1508	21-23(268)[4], 40-55(915)[22][5]
	8/31[2]	-	-	-	-	72	72	First 3 or 4 miles
	9/8 [3]	42°	-	-	0	0	0	
							1580	
Linda	6/27[1]	-	-	-	0	0	0	
	7/12[1]	-	(none in stream; some noted off mouth of creek)					
	7/27[1]	-	-	-	2	50	52	(100 off mouth)
	8/1	48°	124	32	219	867	1086	1(256),5(121),12(102[72]
	8/20	47°	-	-	45	73	118	[8]
	9/2 [3]	-	-	-	1	10	11	
							1267	
Midway	6/27[1]	-	-	-	0	0	0	
	7/27[1]	-	-	-	0	0	0	(250 off mouth)
	8/3	46°	40	44	98	94	192	1(101) [21]
	8/22	44°	-	-	9	10	19	All in first 1/3-mile
	9/2 [3]	-	-	-	0	2	2	
							213	
Stumble	8/10	51°	-	-	58	35	93	[4]
	8/25	49°	-	-	3	1	4	
	8/31[2]	-	(none observed in stream or Blott & Stanky Lakes)				97	

1/ Preliminary surveys, include only first 0.1 mile of stream.
2/ Aerial survey from a Piper Super-cub.
3/ Partial surveys, limited concentrations precluded extensive investigation.
4/ Number of adults observed in indicated sections.
5/ [ ] Average concentration/0.1 mile for entire stream.

Table 13. Summary of sockeye counts and stream surveys, Frazer Lake, 1970 (continued).

Stream	Date	Water temp(F°)	Fish Counts: Number Dead Male	Number Dead Female	Number Dead Total	Number live	Total count	Noted Concentrations (tenth-mile sections from mouth)
Courts	8/7	-	-	-	5	0	5	-
	8/24	42°	-	-	0	0	0	-
							5	
#7	8/4	-	-	-	0	12	12	-
	8/24	43°	-	-	0	0	0	-
							12	
#13	7/27	-	(10 observed near mouth)					-
	8/4	-	-	-	0	4	4	-
	8/24	44°	-	-	0	0	0	-
							4	
#14	8/4	-	-	-	0	1	1	-
	8/24[3/]	45°	-	-	0	0	0	-
							1	
#15	8/9	-	-	-	1	20	21	-
	8/22[3/]	-	-	-	0	0	0	-
							21	
#16	8/7	-	-	-	0	0	0	-
	8/22	44°	-	-	0	1	1	-
							1	
							3201	
Frazer R.	8/18	52°	(no bear kills observed except in immediate vicinity of Falls area)					
Dexter Cr.	8/18	51°	-	-	0	1	1	Creek followed for 1-1/2 miles

3/ Partial surveys, limited concentrations precluded extensive investigation.

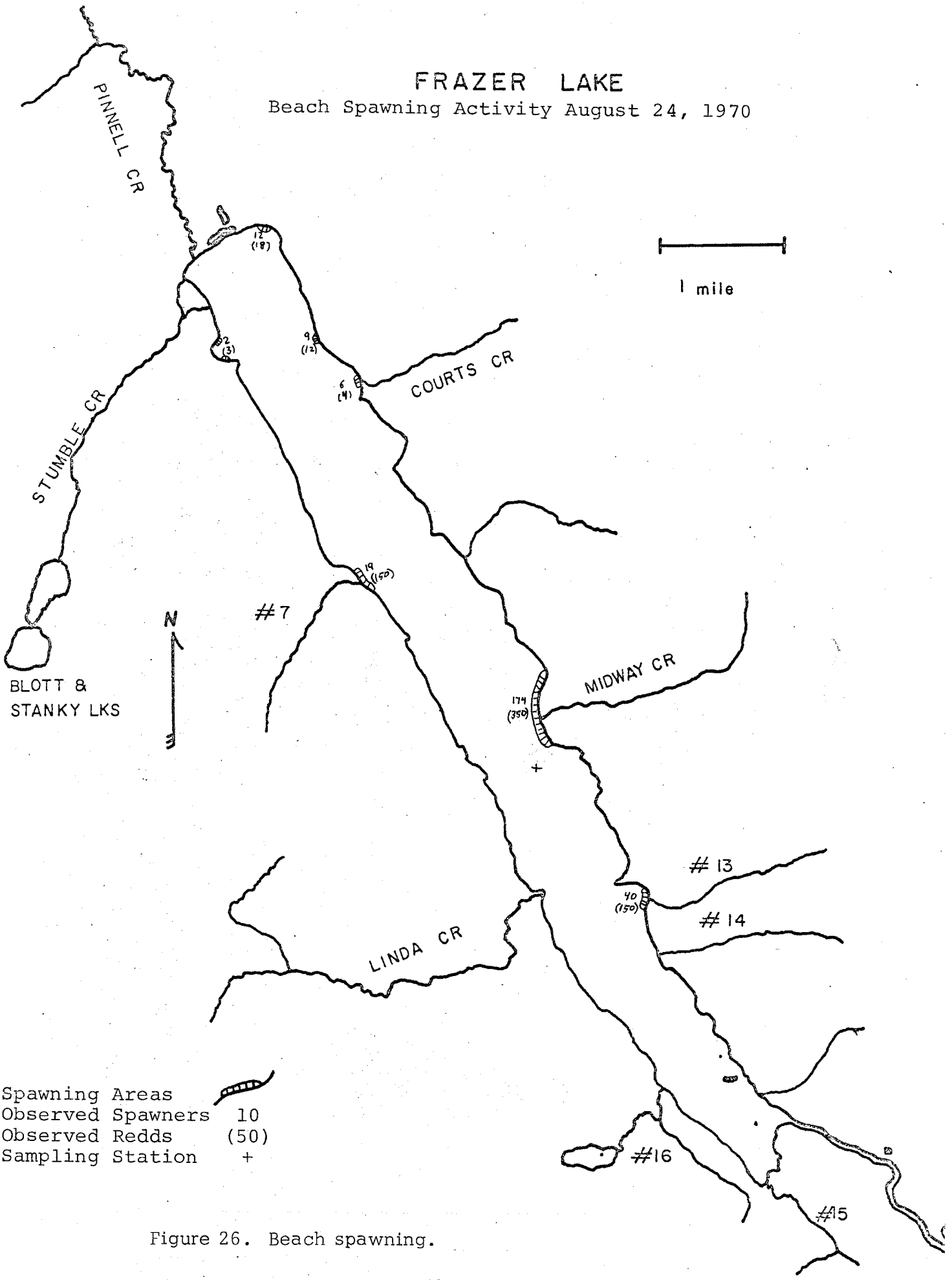


Figure 26. Beach spawning.

were observed near Midway Creek. The dissolved oxygen concentration measured on February 18, 1971 on the lake bottom 1/4 mile north of Midway Creek in close proximity to observed shore spawning areas was 11 ppm at lake bottom under 1.5 feet of ice which was solid to the beach.

For the last 6 years the greatest spawning activity has been in Pinnell Creek with Linda Creek second and Midway Creek third. While the number of spawners has remained fairly consistent in Linda and Midway creeks, the number of observed spawners in Pinnell Creek shows more pronounced variation. In general, major spawning activity in the creeks has been observed within the last week of August and first week of September, with the exception of 1967 when large concentrations were also observed in the three major spawning streams during surveys conducted 2 weeks later (Tables 14 and 15).

During 1970, bear kills of sockeye adults below the Frazer falls were noted only in the immediate vicinity of the falls (especially upstream from the temporary lead below the falls). On August 18, the Frazer River was surveyed downstream to Dexter Creek with no sockeye observed except for a few near the temporary lead. One adult sockeye was noted near the mouth of Dexter Creek, otherwise salmon were not observed in 1-1/2 miles of that creek.

Summary

1. Since 1956 the number of adult sockeye entering Frazer Lake has shown an increase with a peak return of 24,081 in 1970.

2. In 1970, the majority of adults entering the Frazer system were age 2.2. The highest percentage of marine age one "jacks" was noted since the beginning of sampling in 1965.

3. An increase in sockeye spawner survival occurred in 1970 as a result of improved fishpass efficiency due to modifications and temporary lead construction.

4. The majority of spawning activity, as in previous years, occurred in Pinnell, Linda and Midway creeks. Beach spawning activity was noted in numerous parts of the lake with major activity off Midway Creek. No concentrations of spawners were noted below the Frazer falls area as in past years.

Table 14. Summary of survey counts for the three major spawning streams, Frazer Lake, 1965-1970.

Year	Pinnell Creek				Linda Creek				Midway Creek			
	Peak observed	Date	Total observed	Water temp. °F	Peak observed	Date	Total observed	Water temp. °F	Peak observed	Date	Total observed	Water temp. °F
1965	876	8/11	876	46	565	8/9	565	57	46	8/7	46	54
1966	2603	8/3	2918	47	1135	7/27	1304	47	238	7/29	254	48
1967	4288	8/2	6842	53	767	7/29	1473	58	387	7/28	600	55
1968	2196	8/7	2796	54	694	7/31	887	52	285	8/2	353	49
1969	1057	8/18	1189	50	646	7/29	646	49	194	7/27	194	-
1970	1508	8/15	1580	-	1086	8/1	1267	48	192	8/3	213	46

Table 15. Summary of survey counts for the three major spawning streams and beach spawning areas, Frazer Lake, 1965-1970.

Year	Number surveys conducted	Total stream spawners	Total beach spawners
1965	4	1,774	None
1966	17	4,549	247
1967	17	10,444	286
1968	19	4,862	Unknown
1969	13	1,729	315
1970	24[1/]	3,201	342

1/ Does not include six preliminary surveys.

LIMNOLOGICAL INVESTIGATIONS

Water temperatures and profiles

The water temperature of the Frazer River was recorded at 6:00 p.m. every day at the adult sampling station. In 1970, the temperature showed a steady increase from 37° F in mid-May to 52° in early August when it started to decline and reached 50° F by early September. Two pronounced fluctuations in early June and late June were also noted. Various patterns in temperature fluctuation are also evident for the last 6 years. A general rise in temperature in mid-June is evident in all 6 years; for "warm" seasons (1967,1968, 1969) this relatively rapid rise in temperature continued to the end of the month when it leveled off above 55° F. During cold seasons (1965, 1966, 1970) the rise in mid-June peaked during the same week each year, and then decreased during the first part of July, again during the same week, and then rose to stabilize at about 51° F. In 1970 and 1968 a temperature mode appeared during the same week in the first part of June (Figure 27). A relationship between temperature and smolt migration timing has not been apparent at Frazer Lake.

Temperature profiles taken at Frazer Lake from 1965-1968 and 1970 show similarities to river temperature data with warm seasons 1967 and 1968 showing more pronounced temperature gradients than cooler seasons (Figure 28).

Zooplankton analysis

Since 1965, with the exception of 1968, plankton have been sampled each year at Frazer Lake using a 1/2 meter diameter number 20 mesh plankton net, which is lowered into the lake, retrieved, and the sample washed into a bottle and preserved with formalin. The concentration of plankton is determined by finding the number of plankton/cubic meter using the formula:

$$\frac{\frac{i}{n} \cdot \frac{Y}{x}}{V}$$

where i = number of plankton/test cell

n = number of observations per sample

y = volume of sample

x = test cell volume

V = Volume of water strained by tow (for 1/2 meter net = .19635 x depth of tow)

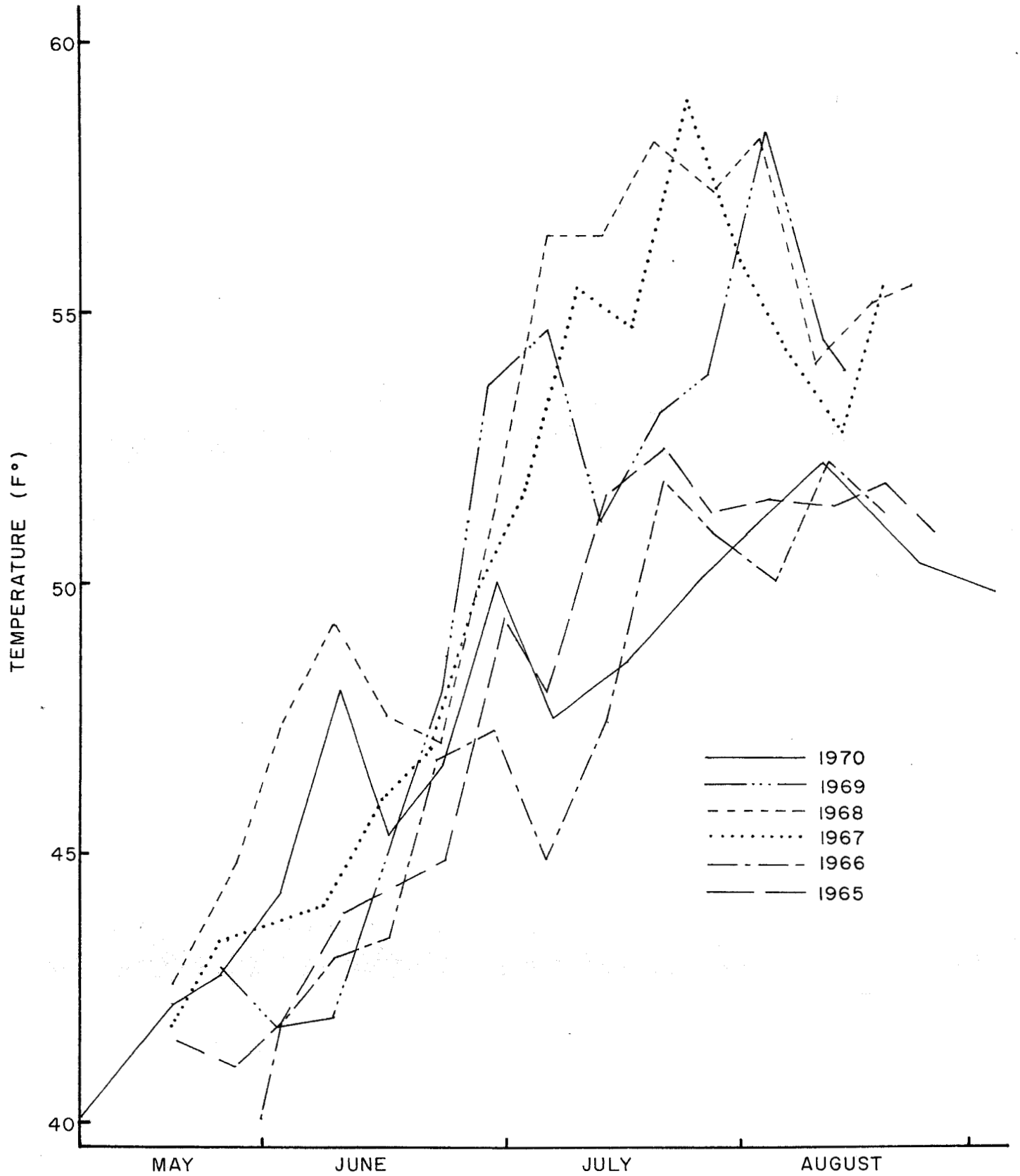


Figure 27. Mean water temperatures, Frazer River, 1965-1970.

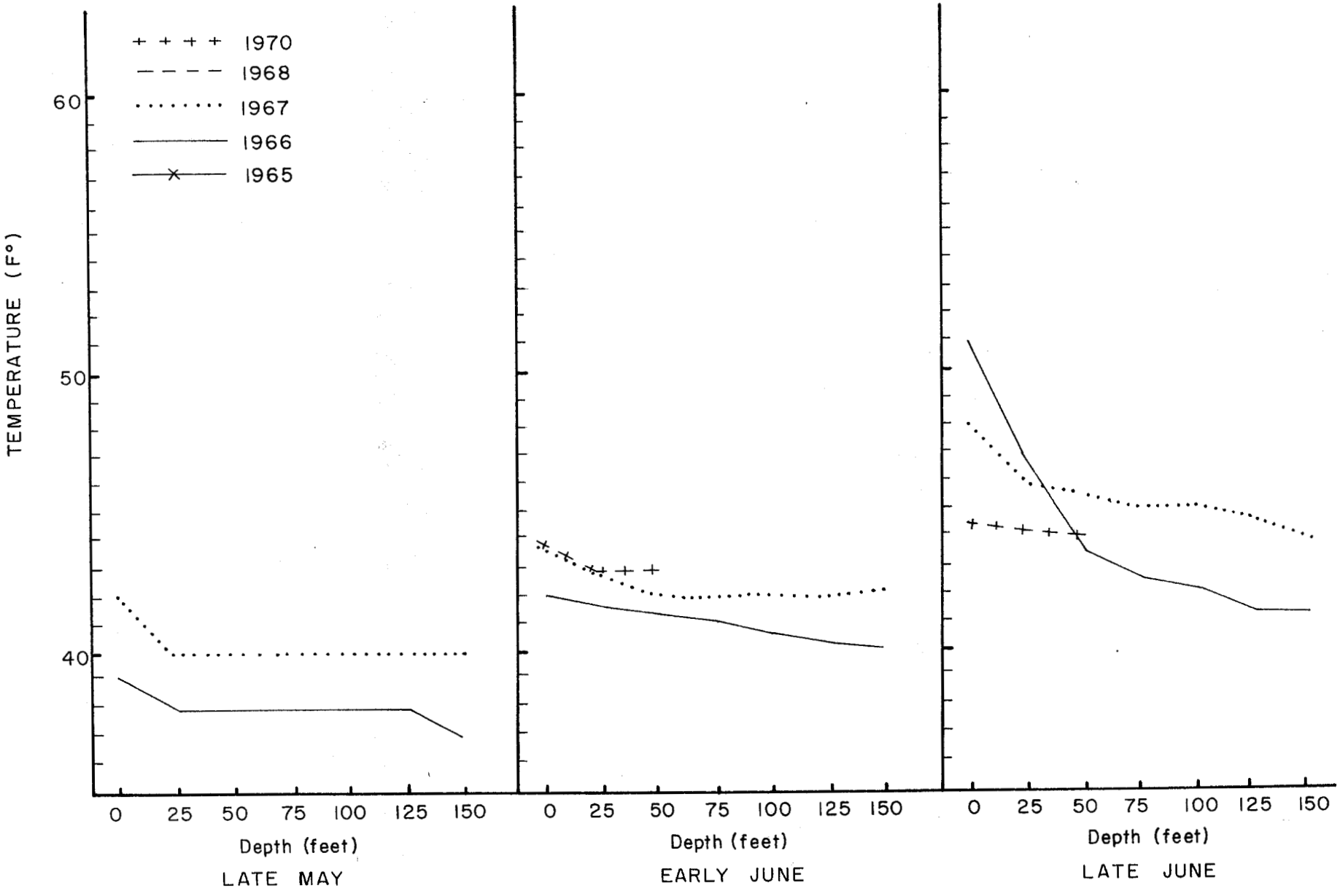


Figure 28. Temperature profiles, Frazer Lake, 1965-1970.

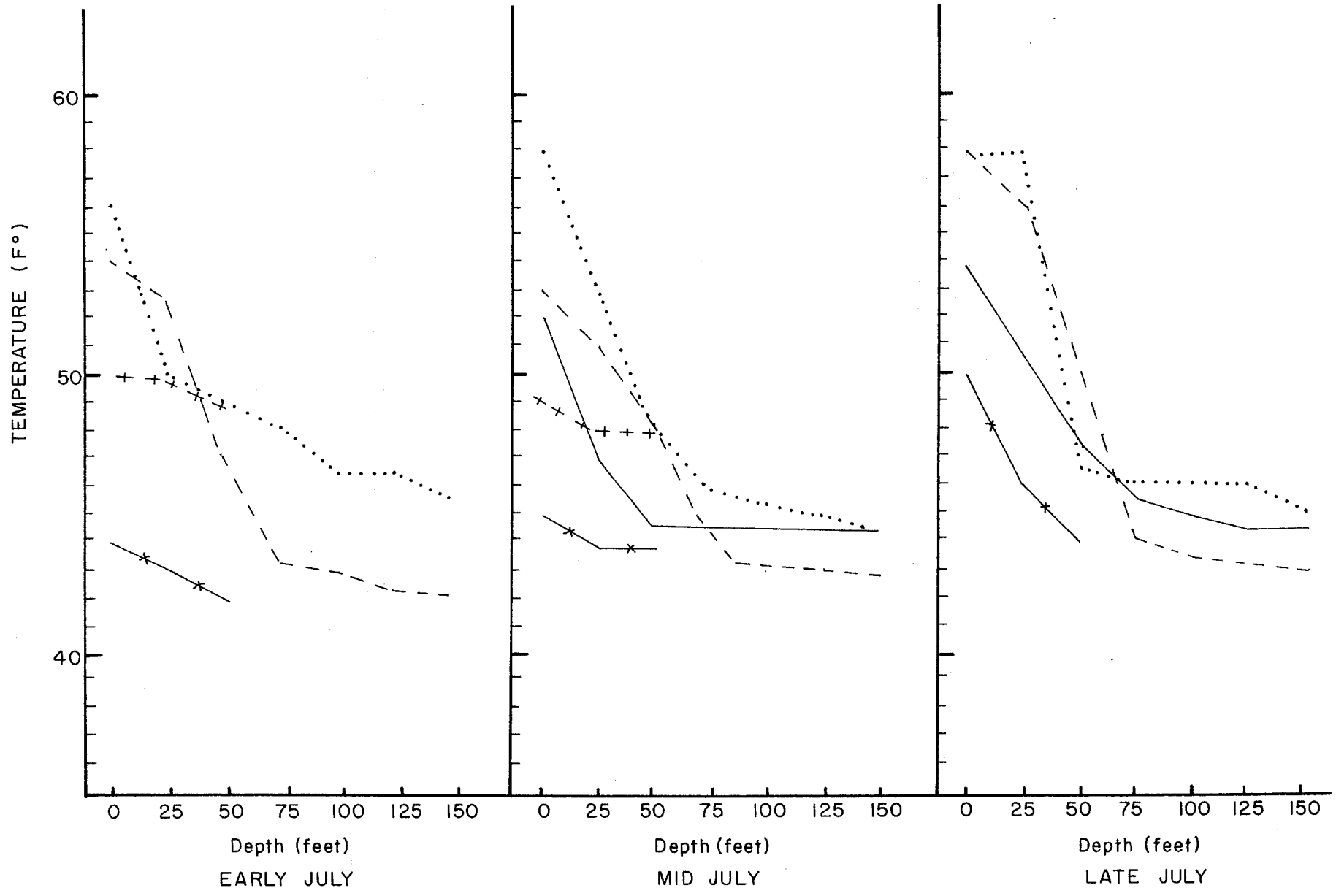


Figure 28. (continued)

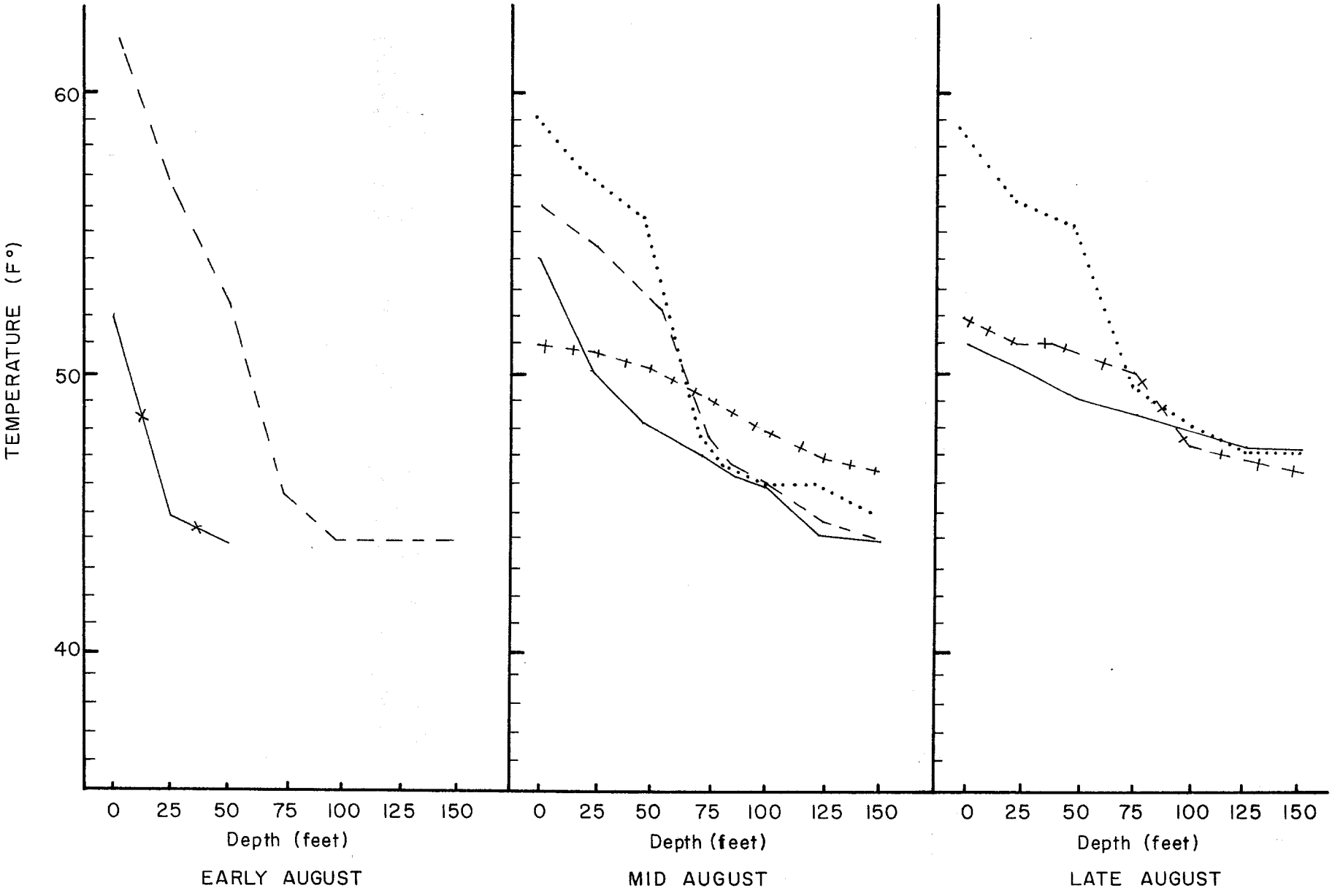


Figure 28. (continued)

Previous years' information which was computed as number of plankton per surface area has been further calculated to give plankton/liter.

The copepod concentration in the Frazer Lake samples has remained fairly constant while the populations of rotifers and cladocerans have been increasing since 1965 (Figures 29, 30, 31).

Frazer Lake profile map

During the summer of 1970, thirty-three transects of Frazer Lake were made at 1/4 mile intervals along the lake at 054° to true North. A number of other transects were also run to clarify profiles where configuration changes rapidly. The project was completed using a Ross Dual Sounder, a transit and portable transceivers. The profiles recorded were used to construct a profile map (Figure 32).

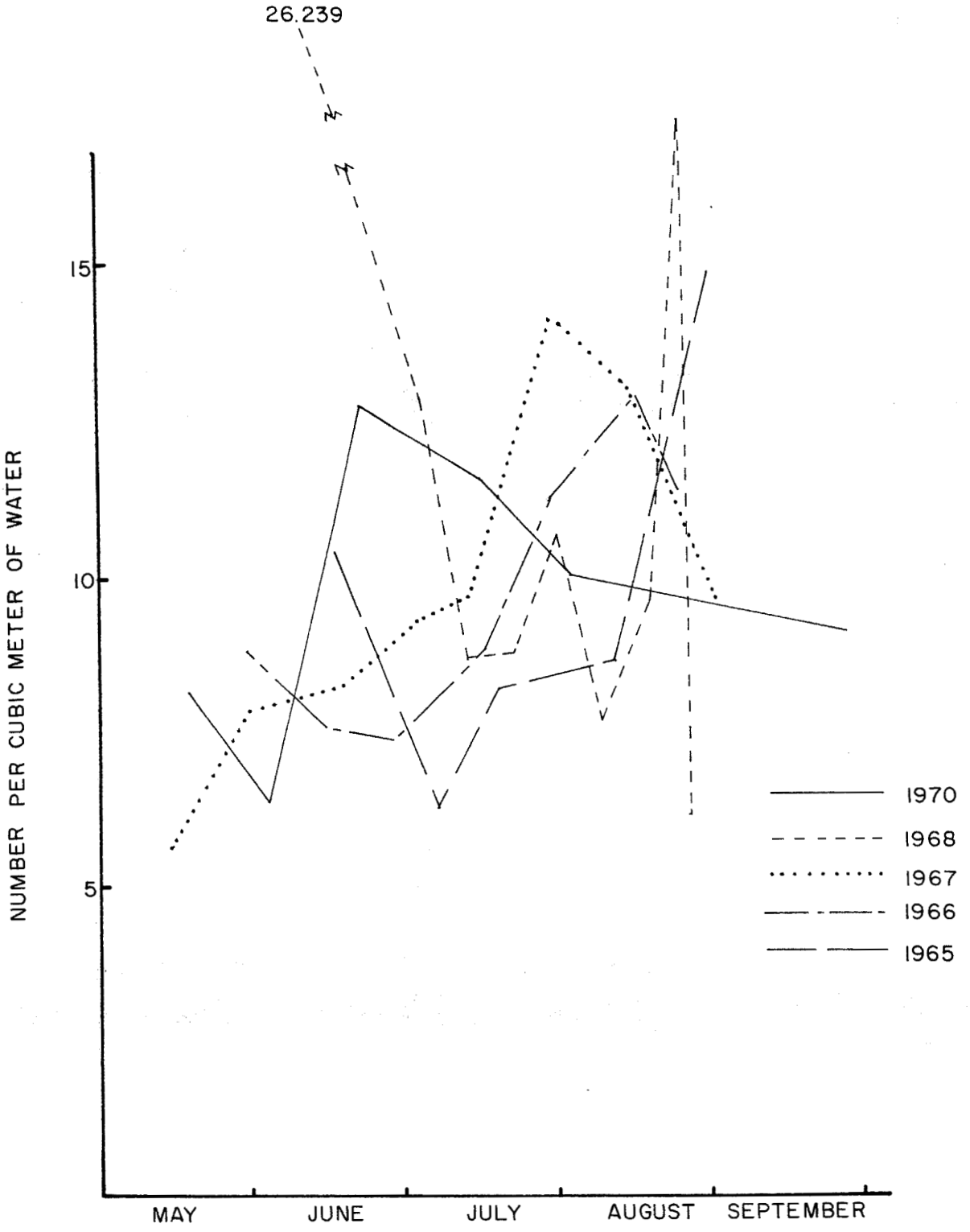


Figure 29. Copepod density indices, Frazer Lake, 1965-1970.

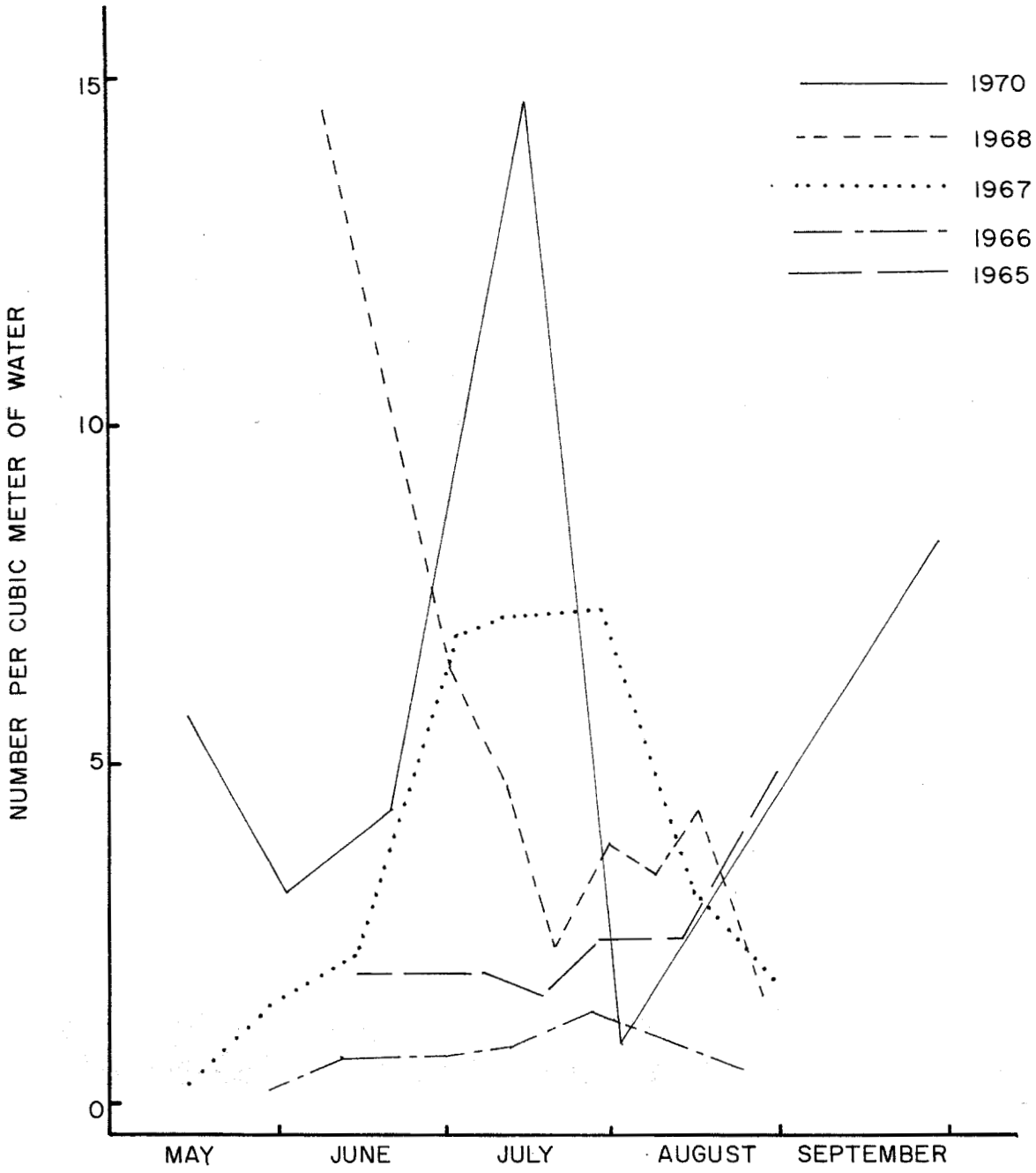


Figure 30. Rotifer density indices, Frazer Lake, 1965-1970.

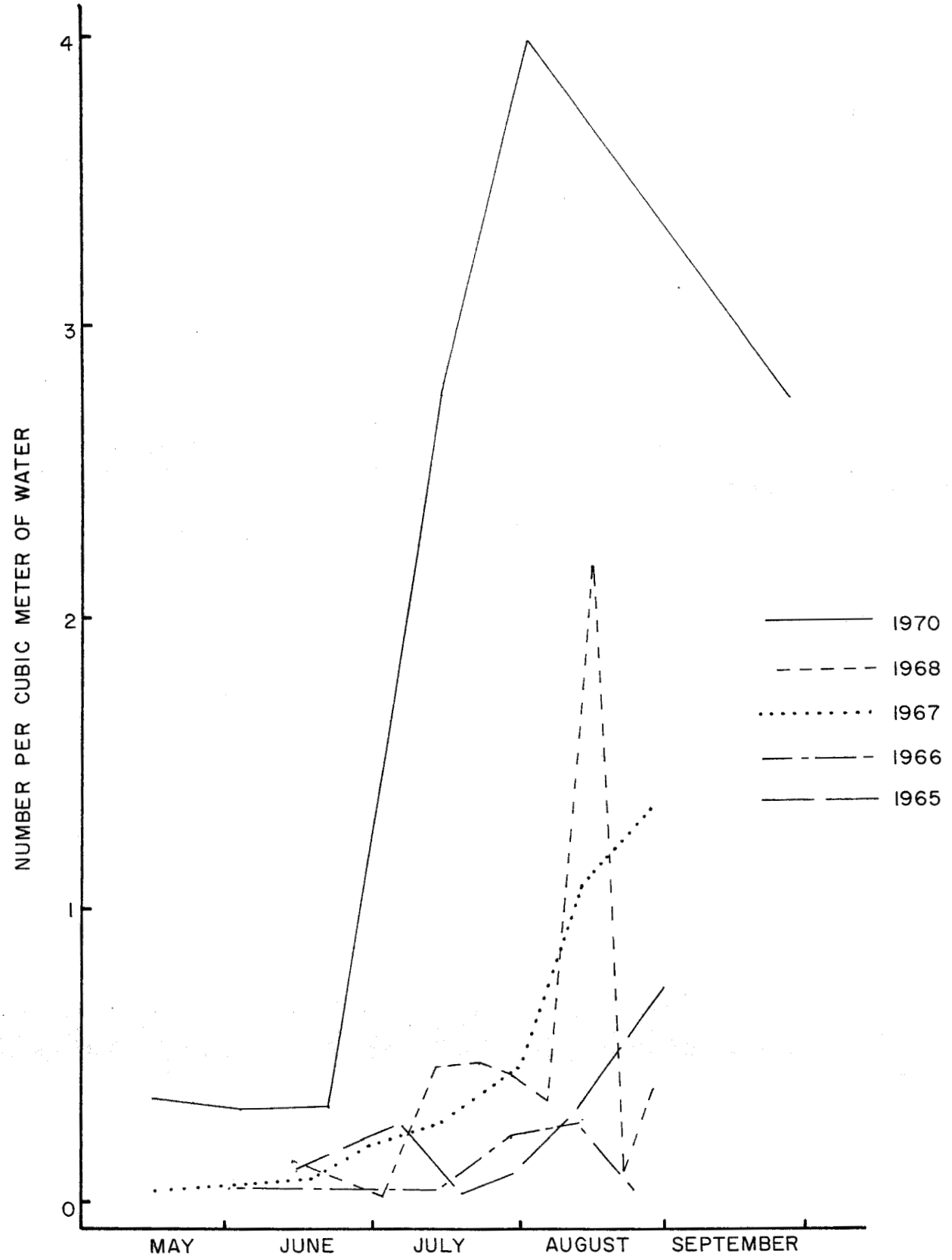


Figure 31. Cladoceran density indices, Frazer Lake, 1965-1970.

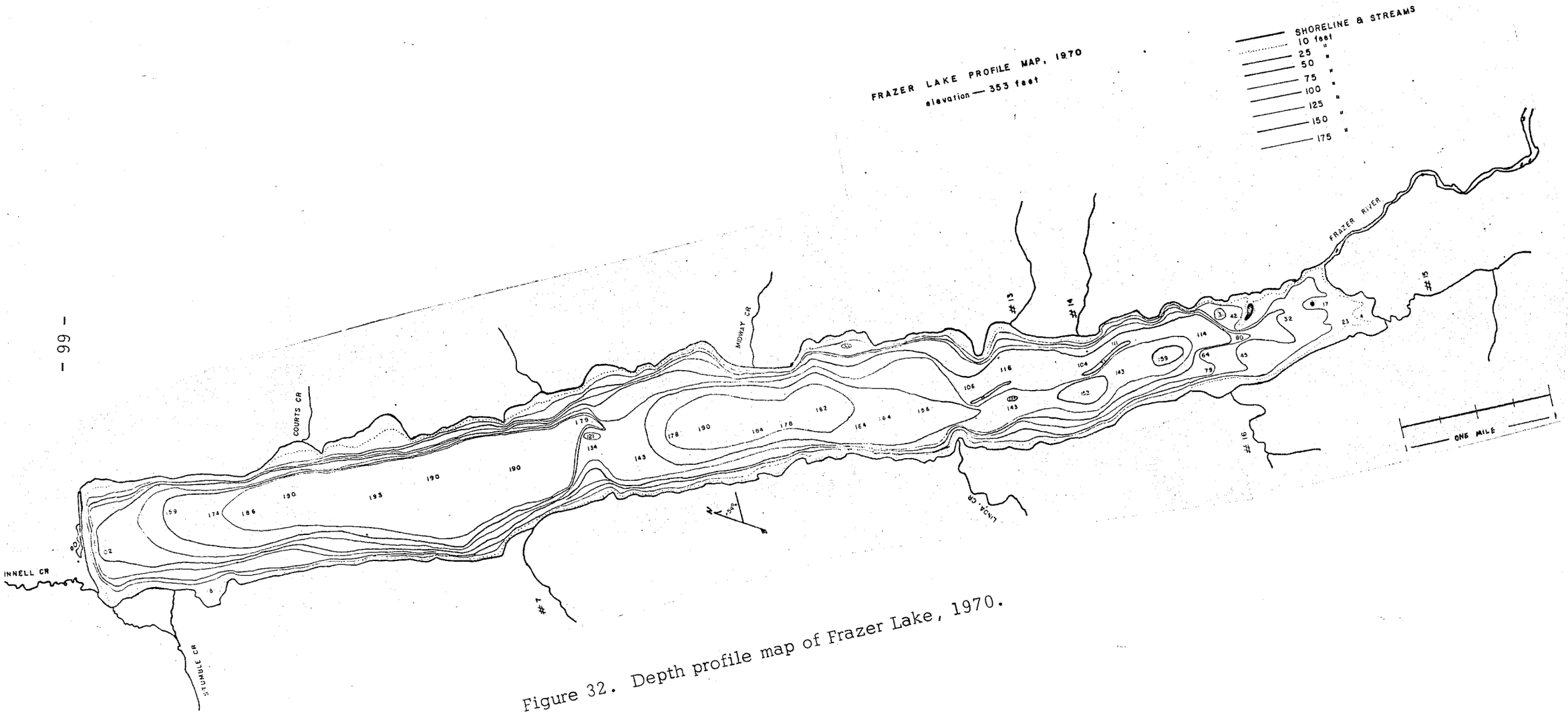


Figure 32. Depth profile map of Frazer Lake, 1970.

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William R. Meehan	1965
Louis A. Gwartney	1968

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COMMEMORATION

The two lakes at the head of Stumble Creek are unofficially named Blott and Stankey lakes after two assistant guides who died as a result of a boating accident at Frazer Lake in November, 1969.

APPENDIX

Appendix Table 1. Calculation of surface area and volume, Frazer Lake

1 mile^2 = 0933 plainimeter units

1 mile^2 = 640 acres

$$\Sigma V = \sum \frac{h}{3} \left(a_1 + a_2 \sqrt{a_1 a_2} \right)$$

h = distance between a_1 & a_2

a_1 = area of upper section

a_2 = area of lower section

Depth	h(ft)	Area (Plainimeter reading) Upper Lake	Middle Lake	Lower Lake	Σa(mile^2)	Σa(acres)	Volume (acre-ft.)
0		2282	2569	1126	6.41	4102.4	
	10						39,445
10		2132	2400	991	5.92	3788.8	
	40						137,628
50		1818	2085	619	4.85	3104.0	
	50						140,719
100		1522	1775	397	3.96	2534.4	
	50						96,655
150		1090	878	59	2.17	1388.8	
	50						27,902
175		829	429	0	1.35	864.0	
	18						5,184
193		0	0	0	0	0	
						Total	447,533

Appendix Table 2. Estimate of potential stream and shore spawning area, Frazer Lake

Stream	Useful length (ft)	Average width (ft)	Area (ft^2)
#15	7392	7	51,744
#16	3696	6	22,176
Linda Cr.	7920	12	95,040
#7	1584	5	7920
Stumble Cr.	13,200	10	130,200
Pinnel Cr.	79,200	8	633,600
Courts Cr.	3168	4	12,672
Midway Cr.	4752	6	28,512
#13	1584	3	4752
#14	1584	3	4752
			991,368 (22.76 acres)
Shoreline area			
#13 Cr.	1584	20	31,680
Midway Cr.	6336	45	285,120
Courts Cr.	528	15	7920
1/3-mile N of Courts Cr.	264	15	3960
1/3-mile NW of Pinnel Cr.	528	10	5280
Bay 1-mile S of Stumble Cr.	1320	15	19,800
#7 Cr.	1584	20	31,680
			385,440 (8.82 acres)

Appendix Table 3. Calculation of smolt outmigration by age group, Frazer Lake, 1970.

Sample period	Sample[1/] Smolt Age 0.0 %	1.0 %	2.0 %	3.0 %	Sample size	Total run	Estimated migration Smolt Age 0.0	1.0	2.0	3.0
5/13-5/26	-	-	-	-	-	17	-	-	-	-
5/27-6/2	-	1.4	93.0	5.6	143	2124	-	30	1975	119
6/3-6/9	-	14.5	85.1	0.4	242	6018	-	873	5121	24
6/10-6/16	-	57.8	42.2	-	244	9933	-	5741	4192	-
6/17-6/23	-	82.3	17.7	-	243	8844	-	7279	1565	-
6/24-6/30	-	93.4	6.6	-	241	5465	-	5104	361	-
7/1-7/7	-	96.0	4.0	-	227	5244	-	5034	210	-
7/8-7/14	-	94.2	5.8	-	223	2871	-	2704	167	-
7/15-7/21	-	85.1	14.9	-	221	1204	-	1025	179	-
7/22-7/28	-	83.9	16.1	-	223	915	-	768	147	-
7/29-8/4	-	85.8	13.4	0.8	134	553	-	475	74	4
8/5-8/11	-	87.7	12.3	-	138	685	-	601	84	-
8/12-8/18	-	93.2	6.8	-	177	689	-	642	47	-
8/19-8/25	4.0	86.5	9.5	-	74	234	9	203	22	-
8/26-9/3	9.1	72.7	18.2	-	11	12	1	9	-	-
					Sum		10	30,488	14,146	147
					Percent		0.02	68.07	31.58	0.33
					Total	44,808	10	30,500	14,150	148

1/The percentage of sample for which age could not be determined is omitted; as a result an expansion is necessary to estimate the number in each age group that composed the total outmigration.

Appendix Table 4. Length frequency of smolt by weekly time period and percent of total outmigration, Frazer Lake, 1970.

Sample period	Length (mm)																		
	120-124	125-129	130-134	135-139	140-144	145-149	150-154	155-159	160-164	165-169	170-174	175-179	180-184	185-189	190-194	195-199	200-204	X	N
5/30-6/6	.06	.06	.24	.37	.24	.18	.24	.49	.24	.42	.92	2.26	3.85	3.79	1.16	.37	0	148	6654
6/7-6/13	.37	.27	.80	.58	1.00	1.27	.53	.27	.37	.43	.90	1.22	2.66	2.60	1.06	.27	.05	280	6661
6/14-6/20	.35	.09	.87	1.84	3.58	5.42	3.58	.52	.18	.26	.35	.61	1.84	1.49	.52	.09	0	247	9673
6/21-6/27	.18	.31	.37	1.89	3.23	4.51	2.56	1.10	.18	.06	.06	0	.18	.18	.06	.06	0	245	6694
6/28-7/4	.18	.53	.94	1.71	3.24	2.95	2.89	1.35	.12	0	.12	0	.18	.12	.12	0	0	246	6495
7/5-7/11	.07	.58	.74	1.18	1.36	1.73	1.54	.74	.11	0	.04	.04	0	0	.15	0	0	225	3706
7/12-7/18	.02	.05	.15	.23	.37	.74	.90	.49	.28	.11	0	.03	.02	.06	.06	.02	.02	226	1552
7/19-7/25	0	.01	.02	.06	.12	.21	.26	.25	.19	.08	.04	.01	.02	.05	.17	.07	.04	234	724
7/26-8/1	.03	.03	.01	.08	.17	.14	.42	.24	.28	.14	.08	0	.01	.01	.08	.02	.01	186	781
8/2-8/8	0	.01	.01	.04	.03	.09	.17	.19	.29	.15	.09	.04	.03	0	.03	.04	.06	135	570
8/9-8/15	0	.01	.05	.05	.03	.13	.26	.36	.45	.10	.26	.06	.05	.02	.02	.07	.11	180	897
8/16-8/22	0	.01	0	.01	.01	.06	.18	.16	.15	.18	.07	.06	.11	.03	.01	.01	.01	140	401
Sample Distribution	20	46	80	151	235	312	350	238	187	94	95	84	140	134	89	37	26	2328[1]	44808
(%)	(.9)	(2.0)	(3.4)	(6.5)	(10.1)	(13.4)	(15.0)	(10.2)	(8.0)	(4.0)	(4.1)	(3.6)	(6.0)	(5.8)	(3.8)	(1.6)	(1.1)		

1/ Fish > 204mm and < 120mm not shown in table, included in sum X.

Appendix Table 5. Length frequency of smolt by weekly time period and percent of total outmigration, Frazer Lake, 1968.

Sample Period	Length (mm)																	X	N
	120-124	125-129	130-134	135-139	140-144	145-149	150-154	155-159	160-164	165-169	170-174	175-179	180-184	185-189	190-194	195-199	200-204		
6/15-2/1	0	0	0	.06	.11	0	0	0	0	0	0	.28	.33	.28	.33	.11	.11	30	1500
6/2-6/8	.08	0	.39	.38	.71	1.03	1.66	.55	.16	0	.24	.39	.63	.63	.24	0	0	89	6353
6/9-6/15	.06	.06	.17	.73	1.68	2.96	5.03	2.96	1.17	.28	.34	.17	.56	.95	.45	.11	0	316	15985
6/16-6/22	0	0	.55	1.51	3.29	6.09	5.61	4.65	1.57	.14	.34	.14	.61	.75	.55	.41	0	384	23780
6/23-6/29	0	0	0	.29	1.23	2.32	5.52	7.05	3.78	.87	.07	0	.22	.65	.87	.29	0	319	20967
6/30-7/6	0	.05	.05	.45	.55	1.66	2.46	3.22	2.01	.70	.10	.10	.15	.25	.30	.05	0	242	11004
7/7-7/13	0	0	0	.13	.26	.34	1.33	1.98	2.20	.86	.09	0	0	0	.26	.13	.04	177	6894
7/14-7/20	0	0	0	0	.11	.05	.48	.42	.26	.21	.05	.05	0	0	.05	0	.05	33	1578
7/18-8/24	0	0	0	0	.01	.05	.05	.08	.01	0	.13	.22	.23	.27	.07	.07	.16	105	1281
Sample distribution	2	2	17	57	126	233	362	349	195	57	30	34	56	75	55	23	16	1695[1]	90477
(%)	(0.1)	(0.1)	(1.0)	(3.4)	(7.4)	(13.7)	(21.4)	(20.6)	(11.5)	(3.4)	(1.8)	(2.0)	(3.3)	(4.4)	(3.2)	(1.4)	(0.9)		

[1] Fish > 204mm and < 120mm not shown in table, included in sum of X

Appendix Table 6. Length frequency of smolt by weekly time period and percent of total outmigration, Frazer Lake, 1967.

Sample period	Length (mm)																
	120-124	125-129	130-134	135-139	140-144	145-149	150-154	155-159	160-164	165-169	170-174	175-179	180-184	185-189	190-194	195-199	200-204
5/18-6/2	0	0	0	0	0	0	0	0	0	.11	.11	.22	.18	.18	.11	.07	.04
6/3-6/9	.25	.51	.68	1.01	.85	0	.17	.17	.76	1.18	1.78	4.06	4.31	2.20	2.03	.42	.51
6/10-6/16	0	.54	1.40	2.74	3.81	2.54	.27	.33	.33	.80	.87	1.94	1.87	1.20	.54	.20	0
6/17-6/23	.09	0	.42	1.48	2.36	2.96	1.99	.19	.14	.14	.32	.74	1.34	.55	.65	.14	.14
6/24-6/30	.05	.10	.35	1.10	3.05	4.20	2.80	.70	.20	.20	.15	.25	.75	.70	.20	.15	0
7/1-7/7	0	.25	.20	.83	1.37	2.74	1.72	.64	0	0	.29	.05	.39	.64	.34	.05	.05
7/8-7/14	0	.07	.07	.26	.66	2.16	2.49	1.05	.39	.26	.13	.20	.20	.59	.85	.26	.20
7/15-7/21	0	.02	.02	.10	.19	.79	.88	.76	.41	.07	0	.02	.14	.05	.07	.05	0
7/22-7/28	0	0	0	.05	.08	.31	.35	.55	.37	.20	.02	0	.08	.11	.08	.05	.02
7/29-8/4	0	0	.01	.01	.20	.23	.39	.42	.42	.19	.07	.04	.03	.01	.03	.03	0
Sample Distribution	6	23	52	142	245	344	267	153	99	70	61	112	152	107	83	28	15
(%)	(0.3)	(1.1)	(2.6)	(7.1)	(12.3)	(17.3)	(13.4)	(7.7)	(5.0)	(3.5)	(3.1)	(5.6)	(7.6)	(5.4)	(4.2)	(1.4)	(0.8)

Appendix Table 6 (continued). Length frequency of smolt by weekly time period and percent of total outmigration, Frazer Lake, 1967.

Sample period	X	N
5/18-6/2	30	1492
6/3-6/9	252	29260
6/10-6/16	297	27261
6/17-6/23	298	18911
6/24-6/30	299	20510
7/1-7/7	195	13125
7/8-7/14	147	13217
7/15-7/21	149	4850
7/22-7/28	148	3123
7/29-8/4	128	2375
Sample Distribution (%)	1990 1/	134124

1/ Fish > 204mm and < 120mm not shown in table, included in sum of X.

Appendix Table 7. Length frequency of smolt by weekly time period and percent of total outmigration, Frazer Lake, 1966.

Sample period	Length (mm)																	
	120-124	125-129	130-134	135-139	140-144	145-149	150-154	155-159	160-164	165-169	170-174	175-179	180-184	185-189	190-194	195-199	X	N
5/22-5/28	0	.01	.01	0	0	.01	.01	.01	.01	.01	.02	.04	.04	.02	.02	.01	149	257
5/29-6/4	0	0	.01	.01	.01	.01	.01	.01	.03	.06	.11	.19	.28	.10	.06	.02	150	1288
6/5-6/11	0	.18	0	.37	.18	0	.37	.37	.18	.91	3.42	6.59	6.59	4.76	2.38	.73	150	43151
6/12-6/18	.09	.43	.52	.43	.09	0	.26	0	.60	.60	1.29	1.98	2.93	1.90	1.47	.43	149	20200
6/19-6/25	0	1.14	2.96	5.00	1.37	0	.23	.91	.68	.91	2.22	2.96	6.14	5.46	2.96	1.13	149	53290
6/26-7/2	.03	.15	.46	.67	.24	.06	.03	.12	.21	.15	.24	.28	.73	.46	.15	.06	147	7011
7/3-7/9	0	0	.22	.25	.40	.15	.09	.06	0	.15	.31	.46	.89	.83	.49	.19	150	7273
7/10-7/16	0	0	.09	0	.18	.62	.13	.09	.13	.18	.35	.49	1.67	.97	.88	.66	149	10294
7/17-7/23	.03	0	0	.03	.21	.47	.59	.44	.09	.09	.24	.50	.41	.50	.53	.12	149	6929
7/24-7/30	0	0	0	.01	.08	.16	.32	.41	.20	.11	.05	.04	.09	.17	.20	.09	147	3085
7/31-8/6	0	0	0	0	.02	.05	.09	.09	.11	.05	.01	.01	.01	.01	.02	.02	145	796
8/7-8/13	0	0	0	0	.01	.02	.04	.09	.22	.20	.12	.11	.01	.01	.04	.02	148	1433
8/14-8/20	0	0	0	0	0	.01	.01	.12	.19	.30	.42	.18	.04	.01	.02	.07	144	2290
Sample Distribution (%)	3 (.2)	16 (.8)	46 (2.4)	62 (3.2)	55 (2.8)	70 (3.6)	95 (4.9)	116 (6.0)	134 (6.9)	137 (7.0)	186 (9.6)	245 (12.6)	303 (15.6)	209 (10.8)	157 (8.1)	70 (3.6)	1960[1]	157291

[1] Fish > 204mm and < 120mm not shown in table, included in sum of X

Appendix Table 8. Length frequency of smolt by weekly time period and percent of total outmigration, Frazer Lake, 1965.

Sample Period	Length (mm)																
	120-124	125-129	130-134	135-139	140-144	145-149	150-154	155-159	160-164	165-169	170-174	175-179	180-184	185-189	190-194	195-199	200-204
5/21-5/29	0	.01	.01	.01	.01	.01	0	.01	.01	.01	.04	.05	.08	.09	.13	.06	.05
5/30-6/5	.04	.05	.10	.29	.19	.07	.03	.03	.09	.16	.28	.38	.77	.93	.80	.33	.05
6/6-6/12	.03	.13	.38	.66	.98	.45	.07	.06	.12	.16	.29	.35	.59	.60	.57	.18	.06
6/13-6/19	.05	.15	.54	1.09	1.61	1.02	.32	.03	.04	.09	.09	.08	.09	.13	.15	.06	.01
6/20-6/26	.10	.26	.08	1.13	2.30	2.21	.84	.12	0	.04	.01	.02	.01	.01	0	0	0
6/27-7/3	.04	.08	.26	.68	2.04	3.26	2.35	.33	.04	.04	.02	.01	0	.02	0	.01	0
7/4-7/10	.03	.10	.38	.99	1.62	2.82	2.78	.78	.16	0	0	.01	.01	0	.03	0	0
7/11-7/17	0	.12	.35	.89	2.21	2.83	3.30	1.80	.55	.06	0	0	.02	.02	.03	.03	0
7/18-7/24	0	.01	0	.04	.08	.24	.58	.60	.26	.04	.01	.01	.01	0	0	.01	0
7/25-7/31	.01	.01	.06	.17	.50	.90	1.78	1.62	1.55	.84	.17	0	0	.01	0	0	0
8/1-8/7	0	.01	.03	.01	.14	.51	.76	1.66	1.99	1.81	.64	.10	.01	0	0	0	0
8/8-8/14	0	0	0	.01	.01	.02	.02	.03	.05	.05	.04	.03	0	0	0	0	0
8/15-8/21	0	0	0	0	.06	.06	.38	.92	1.35	2.62	2.85	1.33	.46	.10	.02	0	0
8/22-8/28	0	0	0	.04	.02	.11	.09	.44	.79	1.58	1.98	2.57	1.47	.35	0	0	0
8/29-9/4	0	0	0	0	0	.03	.03	.07	.18	.24	.36	.73	.41	.38	.05	.01	.01
9/5-9/10	0	0	0	0	0	.01	.02	.02	.05	.05	.10	.28	.47	.47	.26	.01	.01
Sample Distribution (%)	38 (.4)	123 (1.3)	351 (3.7)	702 (7.4)	1261 (13.3)	1413 (14.9)	1176 (12.4)	711 (7.5)	569 (6.0)	559 (5.9)	512 (5.4)	521 (5.5)	512 (5.4)	483 (5.1)	351 (3.7)	123 (1.3)	38 (.4)

Appendix Table 8 (continued). Length frequency of smolt by weekly time period and percent of total outmigration, Frazer Lake, 1965.

Sample period	X	N
5/21-5/29	160	180
5/30-6/5	875	1259
6/6-6/12	927	1620
6/13-6/19	803	1537
6/20-6/26	1138	2228
6/27-7/3	778	2601
7/4-7/10	773	2772
7/11-7/17	778	3367
7/18-7/24	347	545
7/25-7/31	691	2173
8/1-8/7	422	1702
8/8-8/14	59	65
8/15-8/21	496	2726
8/22-8/28	453	2848
8/29-9/4	505	808
9/5-9/10	239	506
Sample Distribution (%)	9480[1/]	26917

1/ Fish > 204mm and < 120mm not shown in table, included in sum of X

Appendix Table 9. Calculation of female inmigrant sockeye by age group and sampling period, Frazer Lake, 1970.

Age group	6/15-6/21 n[1/]	6/15-6/21 N[2/]	6/22-6/28 n	6/22-6/28 N	6/29-7/5 n	6/29-7/5 N	7/6-7/12 n	7/6-7/12 N	7/13-7/19 n	7/13-7/19 N	7/20-7/26 n	7/20-7/26 N	7/27-8/2 n	7/27-8/2 N	8/3-8/9 n	8/3-8/9 N	1970 N	Percent
1.2	-	-	7	401	11	631	1	57	28	1606	22	1263	24	1378	7	401	5737	47.2
1.3	-	-	1	57	-	-	-	-	-	-	2	114	-	-	-	-	171	1.4
2.2	4	229	17	975	19	1091	1	57	20	1147	15	861	17	975	13	746	6081	50.0
2.3	-	-	2	115	-	-	-	-	-	-	-	-	-	-	-	-	115	0.9
3.2	-	-	-	-	-	-	-	-	-	-	-	-	1	57	-	-	57	0.5
All age groups	4	229 (1.9%)	27	1548 (12.7%)	30	1722 (14.2%)	2	114 (0.9%)	48	2753 (22.7%)	39	2238 (18.4%)	42	2410 (19.8%)	20	1147 (9.4%)	12,161	

1/ n= number sampled per period.
2/ N= calculated number of females in escapement.

Appendix Table 10. Calculation of male inmigrant sockeye by age group and sample period, Frazer Lake, 1970.

Age group	6/15-6/21 n[1]	6/15-6/21 N[2]	6/22-6/28 n	6/22-6/28 N	6/29-7/5 n	6/29-7/5 N	7/6-7/12 n	7/6-7/12 N	7/13-7/19 n	7/13-7/19 N	7/20-7/26 n	7/20-7/26 N	7/27-8/2 n	7/27-8/2 N	8/3-8/9 n	8/3-8/9 N	1970 N	Percent
1.1	-	-	3	172	3	172	1	57	5	286	3	172	2	115	-	-	974	8.1
1.2	7	401	15	860	9	516	-	-	18	1032	14	802	11	630	2	115	4356	36.5
1.3	-	-	4	229	-	-	-	-	-	-	-	-	-	-	-	-	229	1.9
2.1	2	114	5	286	8	459	3	172	6	345	2	114	-	-	-	-	1490	12.5
2.2	11	630	22	1262	18	1032	2	114	17	975	8	458	3	172	-	-	4643	39.0
2.3	-	-	-	-	-	-	-	-	1	57	1	57	-	-	-	-	114	1.0
3.2	-	-	-	-	-	-	-	-	1	57	-	-	-	-	-	-	57	0.5
3.3	-	-	1	57	-	-	-	-	-	-	-	-	-	-	-	-	57	0.5
All age groups	20	1145 9.6%	50	2866 24.0%	38	2179 18.3%	6	343 2.9%	48	2752 23.1%	28	1603 13.4%	16	917 7.7%	2	115 1.0%	11,920	

1/ n = number sampled per period.
2/ N = calculated number of males in escapement.

Appendix Table 11. Temperature profiles, Frazer Lake, 1965-1970

Date	Depth (feet) 0	25	50	75	100	125	150	175
	°F							
May								
15/67	42.0	40.0	40.0	40.0	40.0	40.0	40.0	-
28/66	39.0	38.0	38.0	38.0	38.0	38.0	37.0	-
June								
3/70	44.0	43.0	43.0	-	-	-	-	-
20/70	44.5	44.2	44.0	-	-	-	-	-
1/67	44.0	43.0	42.0	42.0	42.0	42.0	42.0	-
18/67	48.0	46.0	45.5	45.0	45.0	44.5	44.0	-
14/66	42.0	41.5	41.2	41.0	40.5	40.2	40.0	-
29/66	51.0	47.0	43.5	42.5	42.0	41.2	41.2	-
July								
2/70	50.0	49.7	49.0	-	-	-	-	-
16/70	49.0	48.0	48.0	-	-	-	-	-
3/68	54.0	52.5	47.0	43.3	43.0	42.3	42.0	-
12/68	53.0	51.3	48.0	44.0	43.0	43.0	43.0	-
20/68	57.0	55.5	48.0	45.0	44.0	43.5	43.0	-
27/68	58.0	56.0	50.0	44.0	43.5	43.3	43.0	-
2/67	56.0	50.0	49.0	48.0	46.5	46.5	45.5	-
13/67	58.0	53.0	48.0	46.0	45.5	45.0	44.5	-
30/67	58.0	58.0	46.5	46.0	46.0	46.0	45.0	-
14/66	52.0	47.0	44.5	44.5	44.5	44.5	44.5	-
28/66	54.0	51.0	47.5	45.5	45.0	44.5	44.5	-
8/65	44.0	43.0	42.0	-	-	-	-	-
17/65	45.0	44.0	44.0	-	-	-	-	-
28/65	50.0	46.0	44.0	-	-	-	-	-
August								
22/70	51.0	50.7	50.3	49.1	48.0	47.0	46.5	46.0
31/70	52.0	51.1	50.7	50.0	47.5	46.9	46.5	46.0
6/68	62.0	56.5	52.5	45.7	44.0	44.0	44.0	-
16/68	56.0	54.5	52.5	47.8	46.0	44.8	44.0	-
14/67	59.0	57.0	55.5	47.5	46.0	46.0	45.0	-
27/67	58.5	56.0	55.0	49.5	48.0	47.0	47.0	-
12/66	54.0	50.0	48.0	47.0	46.0	44.0	44.0	-
22/66	51.0	50.2	49.0	48.5	48.0	47.2	47.0	-
4/65	52.0	45.0	44.0	-	-	-	-	-