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ABUNDANCE, SIZE, AGE AND SURVIVAL OF RED SALMON SMOLTS FROM THE UGASHIK LAKES SYSTEM, BRISTOL BAY, 1964

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INTRODUCTION

A red salmon (Oncorhynchus nerka) smolt enumeration and sampling program was initiated at the outlet of Lower Ugashik Lake in 1955 for the purpose of providing an annual estimate of the relative abundance of smolts migrating to sea.

Further refinement of the sampling program was begun in 1958 when a random sampling scheme was employed to give an estimate of the total smolt outmigration from the Ugashik Lakes system.

The Alaska Department of Fish and Game assumed responsibility for the smolt program in 1963 and has continued the program in 1964.

Information gained from the seaward migrant studies is used in determining forecasts of adult salmon returns. In addition, the smolt studies provide valuable information for the eventual determination of optimum escapement levels for the Ugashik Lakes system.

The life history of the red salmon allows the separation of fluctuations in abundance into those that occur in freshwater, at sea and as a result of the coastal fishery. The number of seaward migrants as related to the number of parent spawners gives a direct means of measuring the production of young in terms of freshwater survival to the smolt stage. Marine survival rates reflect the success of the seaward migrants' ability to survive to the adult stage of development.

This report is a summary of the data obtained in 1964. Procedures used in determining abundance, size, age and survival of Ugashik River smolts are fully discussed.

OBJECTIVES

The primary objective of the Ugashik smolt program is to measure the abundance of red salmon smolts migrating seaward from the Ugashik Lakes. Other objectives are as follows: (1) to study the diurnal and nocturnal fluctuations and seasonal timing of the migration; (2) to determine the size and age composition of the run; (3) to measure the condition factor of the smolts; (4) to determine the relationship between escapement levels and smolt

production, and (5) to determine the freshwater and marine survival of each brood year.

DESCRIPTION OF THE AREA

The Ugashik Lakes system, which lies on the northwest side of the Alaska Peninsula, is composed of two large lakes which cover 160 square miles in area (Figure 1; Jaenicke, 1963). Both lakes are located on the west side of the Aleutian Mountain Range on a broad glacial plain that averages 10 feet above sea level (U.S. Army Corps of Engineers, 1957).

The smolt sampling site is located on the Ugashik River, 150 yards below the outlet of Lower Ugashik Lake (Figure 2).

The Ugashik River, which drains a basin of approximately 1,000 square miles, is 297 feet wide at the sampling site and has a flow which varies from 1,873 to 4,435 cubic feet per second, as determined from readings taken from May 14 to June 20, 1964.

The annual average precipitation recorded at King Salmon, the nearest Weather Bureau Station, over a period of 17 years is 23.5 inches. The average annual snowfall is about 42.0 inches while the mean annual temperature is 42.2° F. (Mertie, 1938).

Escapements of red salmon over a 9-year period have varied from 214,802 in 1957 to 2,304,200 in 1960. The average escapement during the period 1956 through 1964 was 545,351 (Alaska Department of Fish and Game, 1965).

METHODS

Fyke Net Design

Fyke nets constructed of 1/2 inch mesh nylon webbing in the wings and body and 1/4 inch mesh webbing in the tunnel were used to trap the smolts (Figure 3). The nets were hung from steel frames 4 feet wide and either 4 or 5 feet deep and were preceded by two 10-foot long lead-in wings (Figure 3). The two wings were held open by the force of the river current and two spacer lines between the wings allowed the net to fish an 8-foot wide section of the river.

The body of the net funnels from the frame to a 4" x 10" rectangular aperture at the throat (Figure 3). A second aperture of the same dimensions was located in the detachable cod-end. A heavy duty zipper facilitated emptying the catch from the cod-end.

Fyke Netting Procedure

Fyke nets were suspended at five standard fishing sites across the

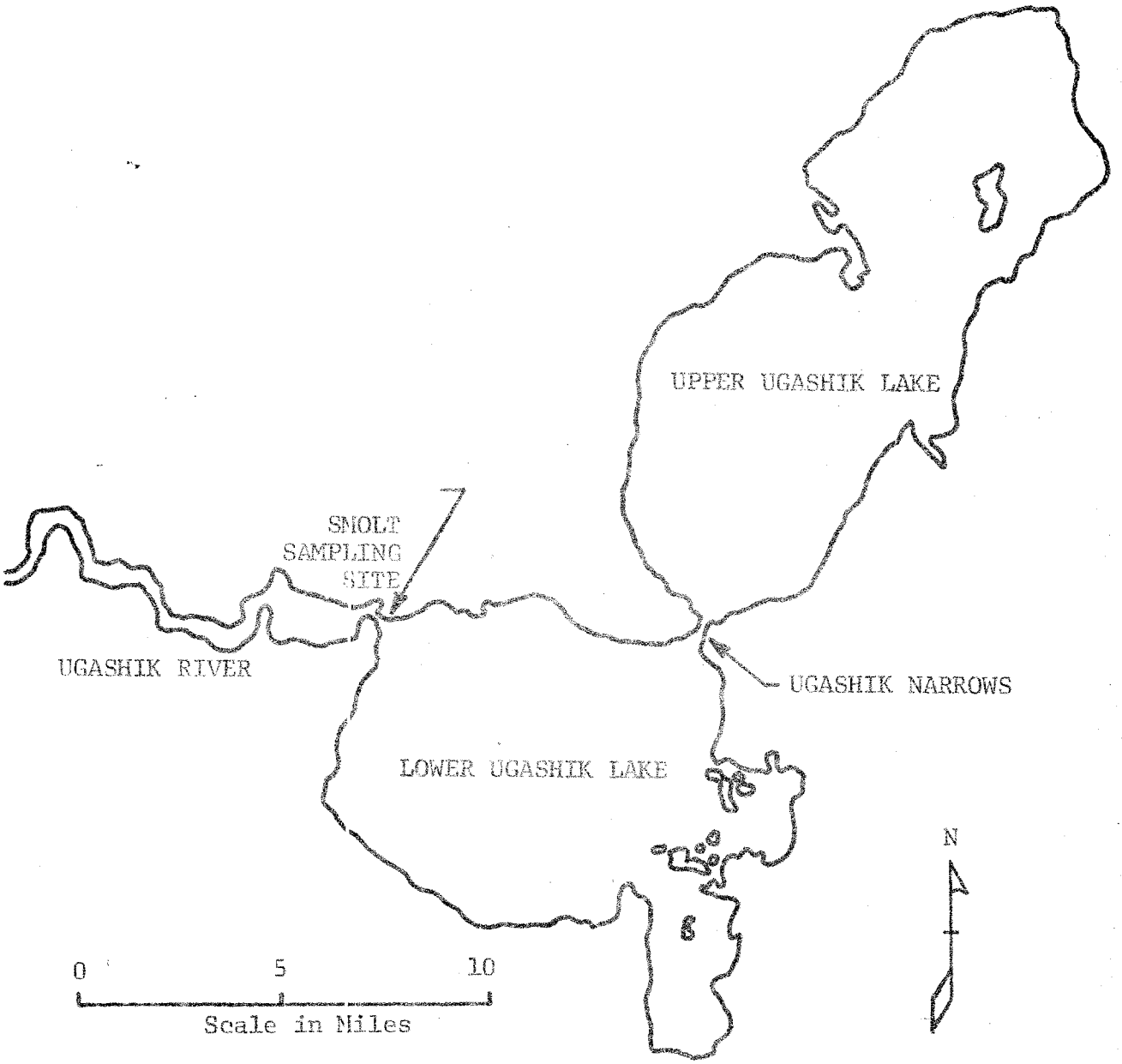

Figure 1. Ugashik Lakes system, Bristol Bay, Alaska.

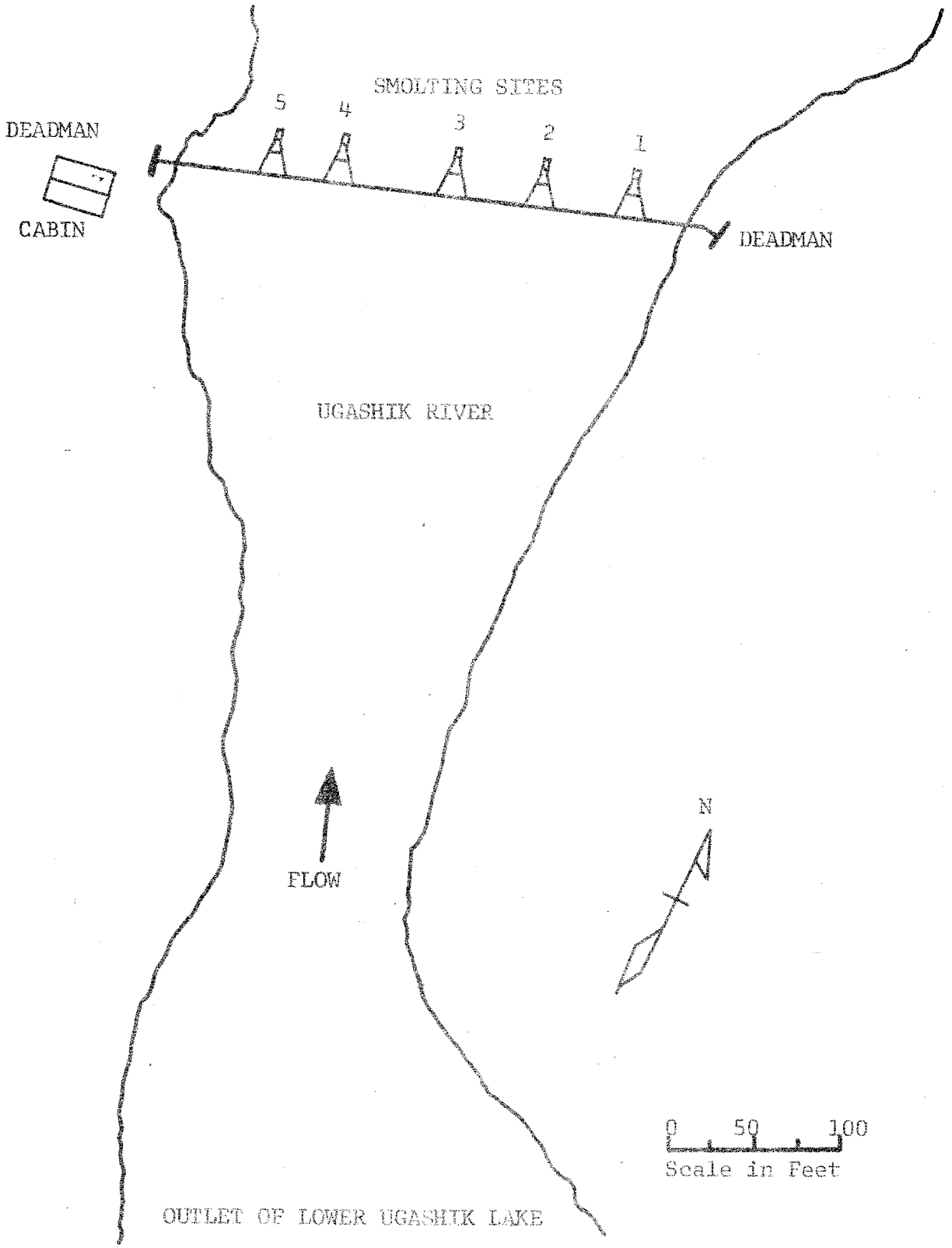

Figure 2. Ugashik River red salmon smolt sampling sites.

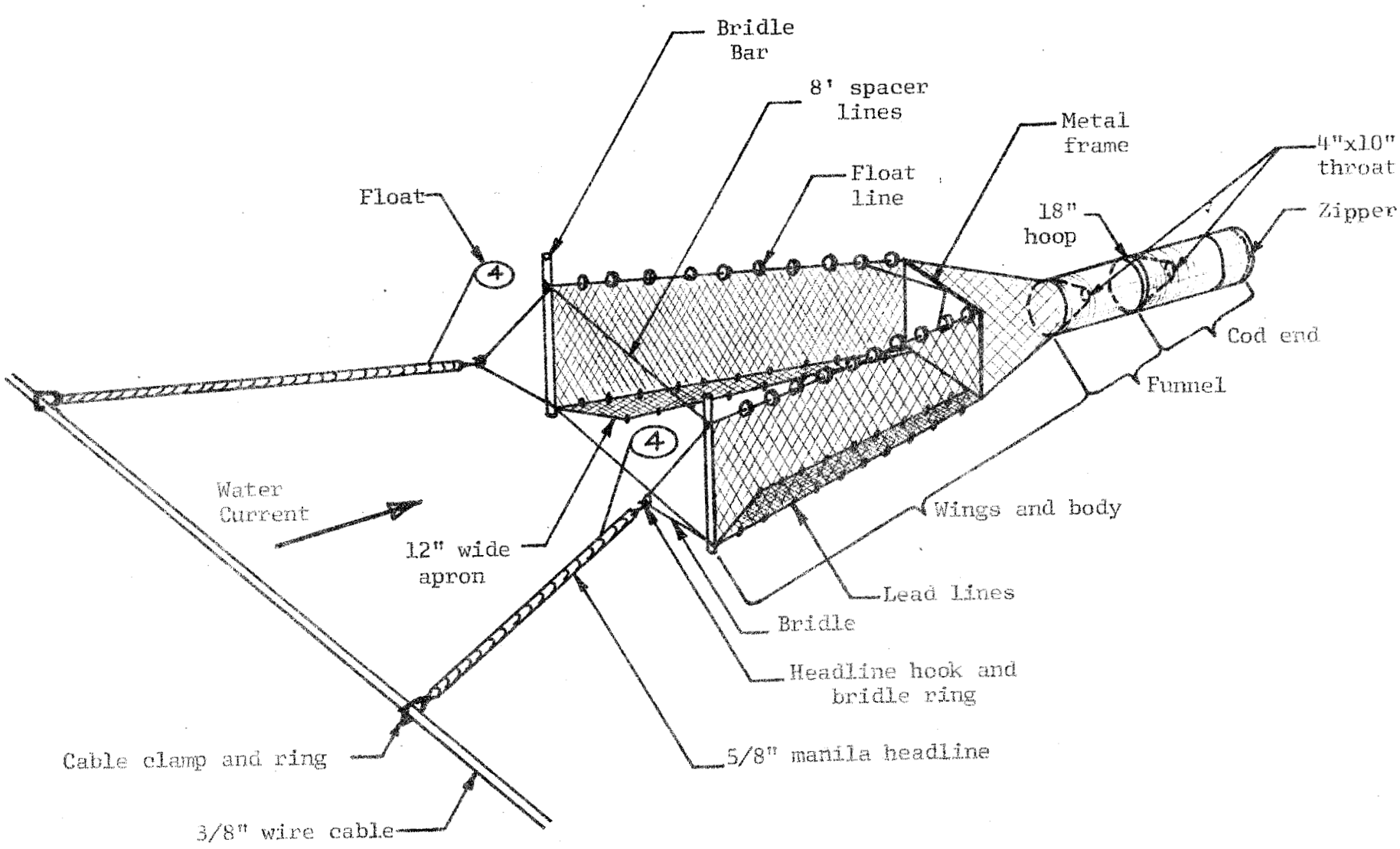

Figure 3. Nylon fyke net used to sample red salmon smolts, Ugashik River, 1964.

river along a 3/8 inch wire cable which was secured to each bank by "dead-men" (Figure 2). A pair of manila headlines were tied to the cable at each fishing site. Numbered floats tied to the trailing ends of the headlines served to identify each site.

To sample the catch, the cod-end was detached by removing a single locking pin. An empty cod-end was immediately put in place before the net was lowered back into the water. This procedure was always followed except during extremely heavy runs of smolt. When the runs were heavy, the cod-end was left off for a few minutes to clear the net of smolt. The time the net did not fish was later interpolated to derive the catch for the missed fishing periods.

If the catch was small, the smolts were counted by hand and returned immediately to the river. If the catch was over 5 pounds, they were placed in a large wire mesh weighing basket immersed in a tub of water. The weighing basket was then removed from the tub and hung on a spring balance of 60-pound capacity suspended from a weighing stand in the skiff. The total catch in pounds and tenths of pounds was then recorded from each cod-end check during each night's fishing schedule. When the catches were weighed, a 1-pound sample count was made in order to convert total weight into numbers of fish. All fish were released at the fyke net site except those specimens needed for length, weight and age analysis.

Sampling Design

In 1956 a single fyke net site was established at the lake outlet. All smolt taken in this index net yielded a daily smolt index which was totaled for the entire season.

The index catch for the years 1958 through 1963 was derived by fishing the index net for a 6-hour period from 8 p.m. to 2 a.m. In 1964, the index fishing period was reduced from a 6-hour to a 3-hour period. The number of fishing hours was reduced primarily to limit the numbers of fish that were being handled during each night's fishing schedule. In comparing the revised 3-hour index catch with the 6-hour catch, it was found that over 65 percent of the smolt were caught during the revised index period (Table 1). It is felt that the reduction in the number of hours fished by the index net will have no adverse effects on the index data.

In 1958 a random sampling scheme using more nets and sites was established to derive an estimate of the total outmigration of smolts. The index net, site number 4 in the random sampling scheme, was fished in a method similar to that of the previous two years to maintain continuity with the previous methods of indexing.

The random sampling method, which employs the use of five fishing sites located across the entire width of the river, was continued without major modification (Figure 2).

Each of the five net sites in the random fishing scheme was fished for a period of 1 hour, between 9 p.m. and 2 a.m. during 4 days of each 5-day period. The 24-hour index schedule was fished on the fifth day of each period. On any sampling day each site was fished only once during the 5-hour period. Specific combinations of fishing sites and time periods were sampled only once every 5 sampling days.

Estimates of the total outmigration of smolts between 9 p.m. and 2 a.m. were derived by applying the average catch per set to the total number of possible sets as follows:

$$\hat{x} = \bar{x}ab$$

where $\hat{x}$ = estimate of total number of smolts

$\bar{x}$ = average catch per 1 hour fishing period

a = width of river at sampling station (280 feet)[1/] divided by width of fyke net opening (8 feet)

b = total number of sampling periods (5 per day)

Investigations in previous years indicated that there was considerable variation in the timing of the smolt outmigrations in the Ugashik Lakes system (Jaenicke, 1963). In some years, large numbers of smolts left the Lower Ugashik Lakes outside the sampling hours. To show the relationship between the diurnal and nocturnal migrations, the index net was fished continuously for 24 hours every fifth day throughout the season. The 24-hour sampling was conducted at the index site because past data has shown that this site consistently caught the most fish (Jaenicke, 1963). During the peak of the migration, several additional 24-hour counts were conducted to obtain a better representation of the migration peak. The random sampling nets were not fished during nights when the 24-hour fishing schedule was in effect.

The estimate of the total number of smolts in the outmigration was then adjusted upward to include the migration between 2 a.m. and 9 p.m. as follows:

$$x = \frac{y}{\hat{x}} = \frac{100.00}{x}$$

where x = estimate of total number of smolts

1/ The river at the sampling location is 297 feet wide; however, a 17 foot shallow section extending outward from the left bank is situated out of the main current in an eddy. Past visual observations indicate that smolts do not migrate downstream in this section; consequently, the effective width of the migration path is assumed to be 280 feet.

y = percent smolts migrating between 9 p.m. and 2 a.m.

$\hat{x}$ = estimate of total number of smolts migrating between 9 p.m. and 2 a.m.

Collection of Biological and Physical Data

A representative sample of smolts was saved from each cod-end catch of the index net each sampling night. The smolts were placed in plastic containers which were later transferred to a divided live pen. At the conclusion of each night's fishing schedule a 1-pound sub-sample of smolts was taken for each hour that the index net fished. These fish were anethetized in MS-222 (Tricaine methanesulfonate), measured (snout to tail-fork), and returned to the water unharmed.

Individual length, weight and scales were taken from 20 fish from each night's peak hour catch of the index net. Weights were taken on a Ohaus triple beam balance and recorded in grams to the nearest tenth. Lengths were recorded in millimeters, and scales were taken from each fish and placed on microscope slides for later reading.

Condition samples were taken approximately every third night during the early and later portion of the smolt outmigration and every night during the peak of the migration.

Air and water temperatures, water level, precipitation, wind direction and velocities were determined daily with a maximum-minimum air thermometer and pocket thermometer, water gauge mounted in the river, rain gauge and a Dwyer wind meter, respectively.

General weather observations and water color were recorded daily, while the river flow in cubic feet per second was recorded once per week.

OUTMIGRATION RESULTS

Timing of Outmigration

The beginning of heavy seasonal migration of red salmon smolts from the Ugashik Lakes system was delayed until the lake outlet water temperature reached 38° - 39° F. on May 25. Past records indicate a significant correlation between the beginning of the seasonal migration and water temperatures at the lake outlet (Table 2). Figure 4 shows the relationship between the water level and water temperature at the lake outlet in 1964.

Breakup of lake ice on Lower Ugashik Lake occurred on May 24, which is approximately two weeks later than the normal breakup date for this lake system. Shortly after breakup and the resultant rise in water temperature the heavy seasonal migration of smolts began. Total seasonal catches were comparable for each hour of the three hour index period (Table 3). The year-

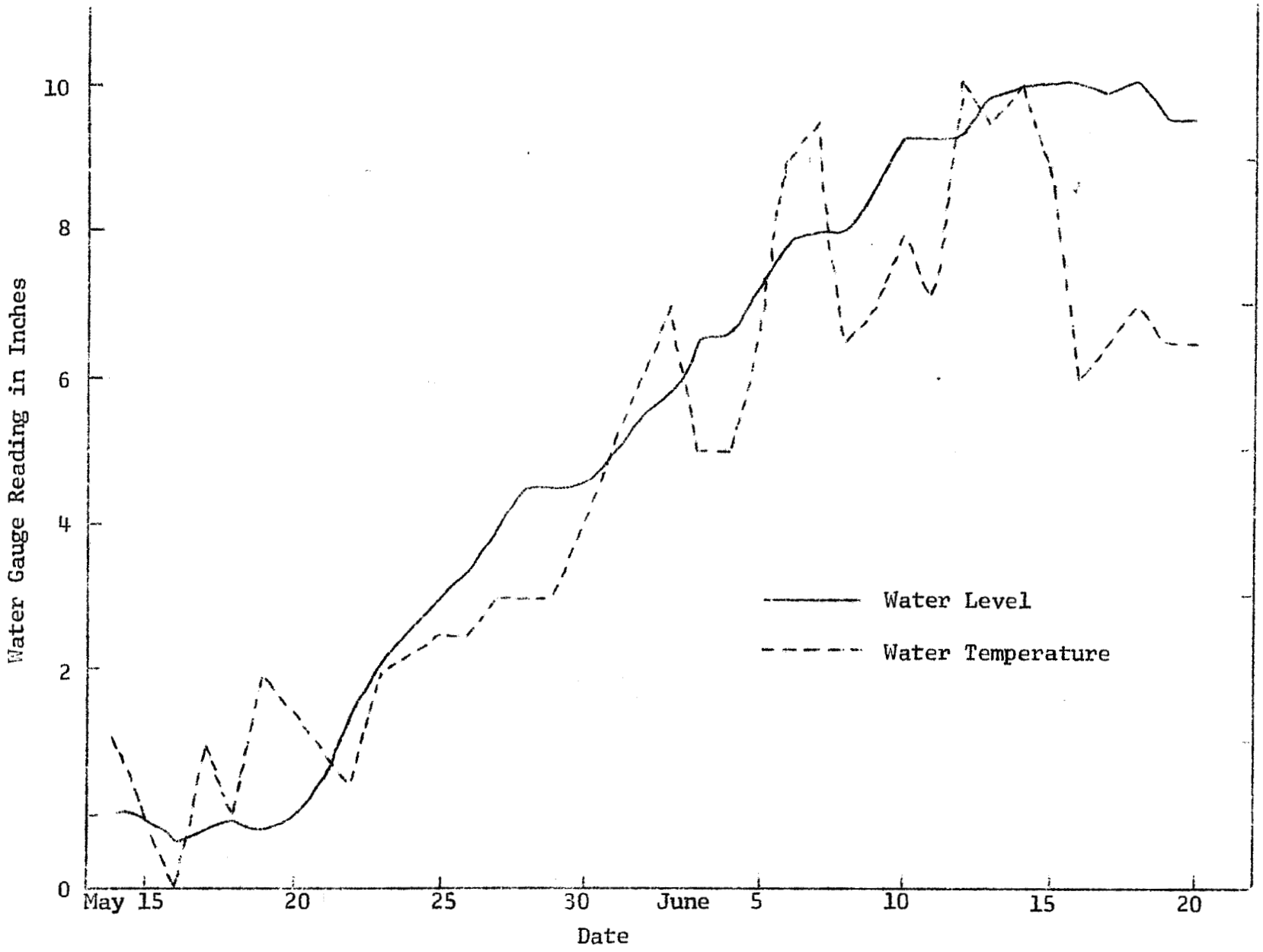

Figure 4. Ugashik River water level and water temperature, 1964 (water level measured in inches and tenth of inches from a fixed bench mark).

to-year consistency in the proportion of the index catches to total catches is a good indication of the reliability of the index sampling method for the Ugashik River (Bureau of Commercial Fisheries, 1958-1961; Jaenicke, 1963; and Nelson and Jaenicke, 1965).

The 24-hour sampling counts conducted throughout the season revealed that over 37 percent of the smolts were taken during the index hours, 10 p.m. through 1 a.m. and that 62 percent of the smolts were taken during the random sampling hours, 9 p.m. through 2 a.m. (Table 4).

The daily index net catches indicated an erratic migration pattern (Figure 5), which was similar to those in the past. Peak index catches occurred at intervals throughout the season, with the largest catch on June 7, when over 34,000 smolts were caught (Table 3 and Figure 5).

Field operations were discontinued on June 20 because of the small number of smolt caught during the preceding days.

Abundance of Smolt

The total index net catch of red salmon smolts during the index hours for the entire season was 205,145 (Table 3 and Figure 6). Using 1958 as the base year with the assigned value of 100.00 index points, the 1964 season index net catch was equivalent to 68.10 index points (Tables 3 and 8). Figure 6 shows in graph form the relative magnitude of the smolt index catch and total outmigration estimate in the Ugashik River system from 1958 through 1964.

The random sampling smolt catch for the entire season was 138,612 (Table 5). The majority of the fish taken in the random sampling nets were caught in site numbers 3 and 4. Site 4 caught 47.0 percent of the random catch while site 3 caught 24.7 percent (Table 5).

Applying the method of determining estimates of total outmigration discussed earlier under Sampling Design, the estimate of the total smolt outmigration for 1964 was calculated to be 9,990,048 (Table 8). Both the index smolt catch and the total outmigration estimate are compared in Figures 6 and 7.

Size and Age Composition

Length frequencies, weight and age data were grouped into 5-day periods extending from May 15 through June 20. The number of smolts caught in the index net, percentage of the season's catch by period, number of samples taken, number of fish measured and the number of scales read are shown in Table 6.

Size composition was determined from length measurements of 4,047 smolts contained in 69 1-pound samples. Age determination was based on readings of 510 scales contained in 26 scale samples (Table 6).

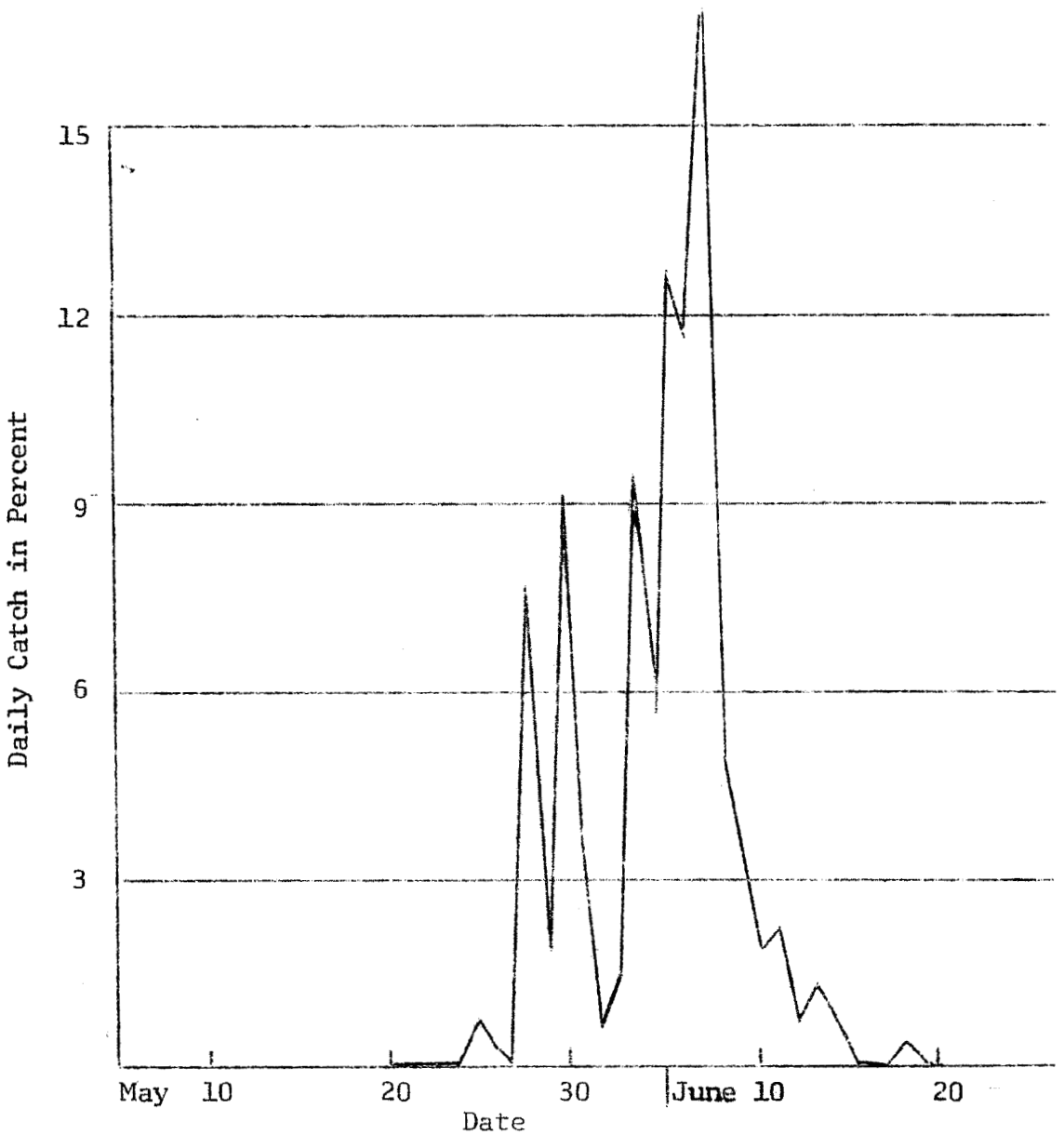

Figure 5. Daily index net catches of red salmon smolt in percent of total index catch, Ugashik River system, 1964.

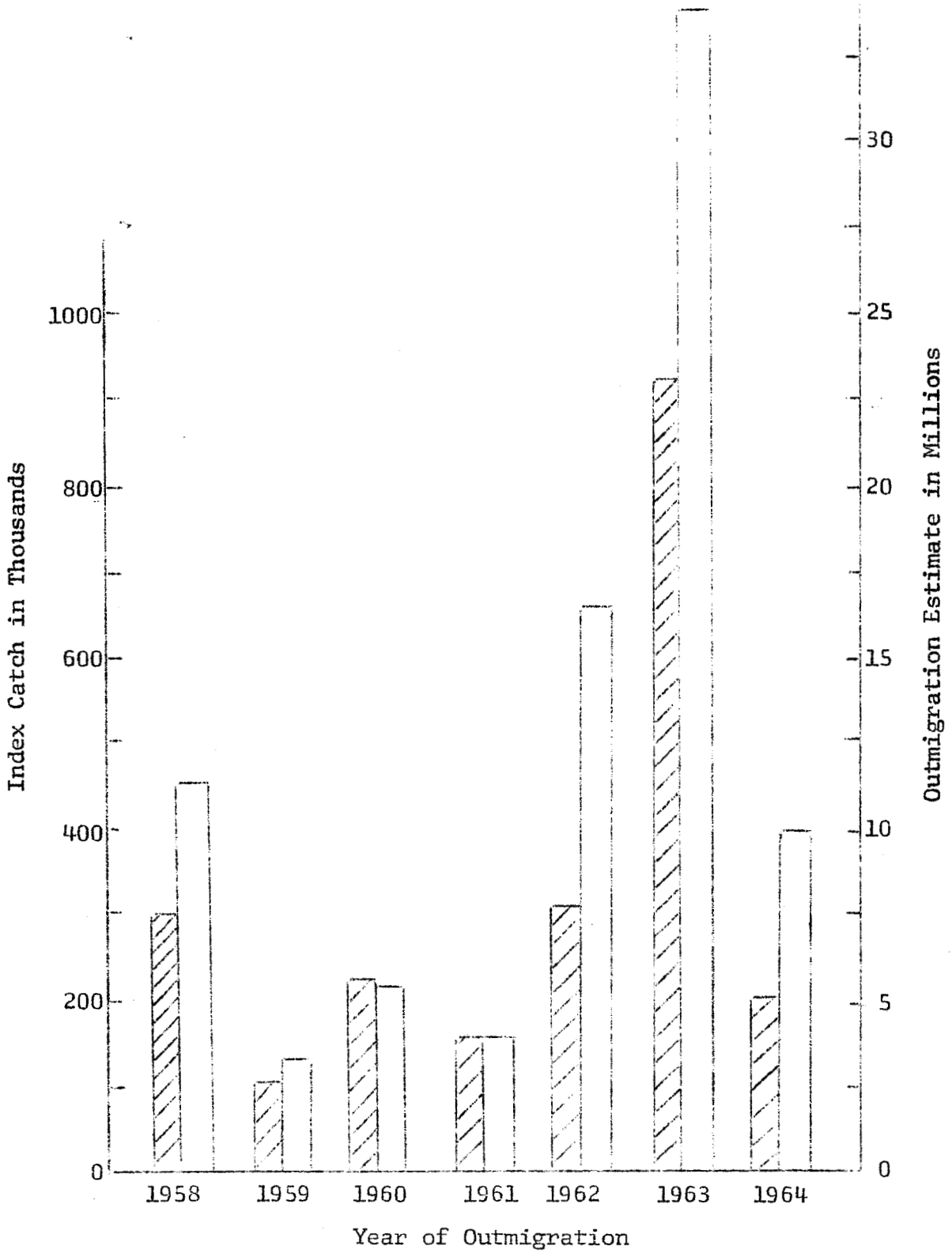

Figure 6. Relative magnitude of red salmon smolt catches in the index net scheme and total outmigration estimates, 1958-1964.

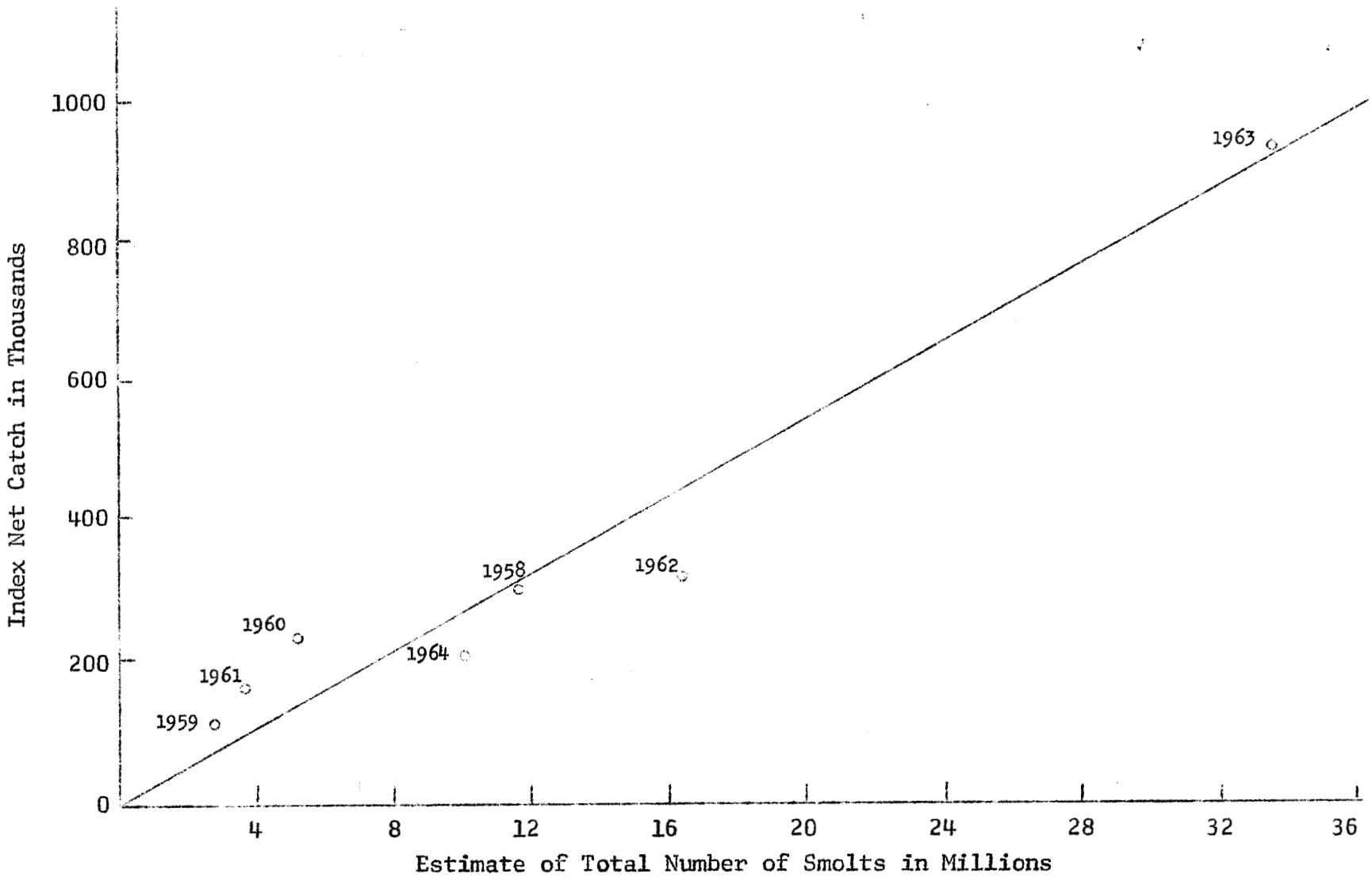

Figure 7. Annual index net catch and estimates of the total smolt outmigration, Ugashik River, 1958-1964.

The season's unweighted length frequency is shown in Figure 8.

The percentage and mean length and weight of each age group were calculated for each period and for the entire season (Table 7). Age I smolts (fish in their second year of life) comprised 80.14 percent of the total run and averaged 92.2 mm. in length and 6.9 grams in weight; Age II smolts (fish in their third year of life) comprised 19.80 percent of the run and averaged 118.3 mm. in length and 12.7 grams in weight (Table 7).

Table 8 summarizes the comparative age, length, index points, index net catches and outmigration estimates for the years 1956 through 1964.

Condition Index of Smolt

The condition index of the 1964 smolt run was calculated on the basis of weight per fish of a given length. Ten 2 to 3-pound condition samples were taken randomly throughout the season. Fish were measured in millimeters and collected in 3 mm. groupings. Each group of fish was weighed in grams and average weight per fish was calculated (Table 9).

The average length and weight of both smolt age groups, as compared to the previous 6 years, is shown in Table 10. The 1964 smolt were larger and weighed considerably more than the 7-year mean average (Table 10).

The relationship between the length and weight of the 1964 smolt migration is shown in Figure 9.

Smolt Production Versus Escapement Levels

The 1964 smolt run originated from the adult spawning escapements of 348,639 in 1961 and 255,426 in 1962.

The 1962 spawning escapement of 255,426 produced 80.1 percent of the outmigration, and the remainder were derived from the 1961 escapement. The number of smolts arising from specific brood years has varied from 4.0 million smolts from a parent 1959 escapement of 219,228 to 31.6 million smolts from a parent 1960 escapement of 2,304,200 (Table 11).

The smolt production from the various escapement levels indicates that an increase in adult escapement will result in an increase in the number of smolts produced. The range of adult escapements to the Ugashik River system has been under 500,000 fish with the exception of the large escapement in 1960 (Table 11). The lack of escapements in the intermediate range makes analysis of the smolt-escapement relationship difficult, however the data suggests that the lower range of optimum adult escapement for the Ugashik River system is near 500,000 fish.

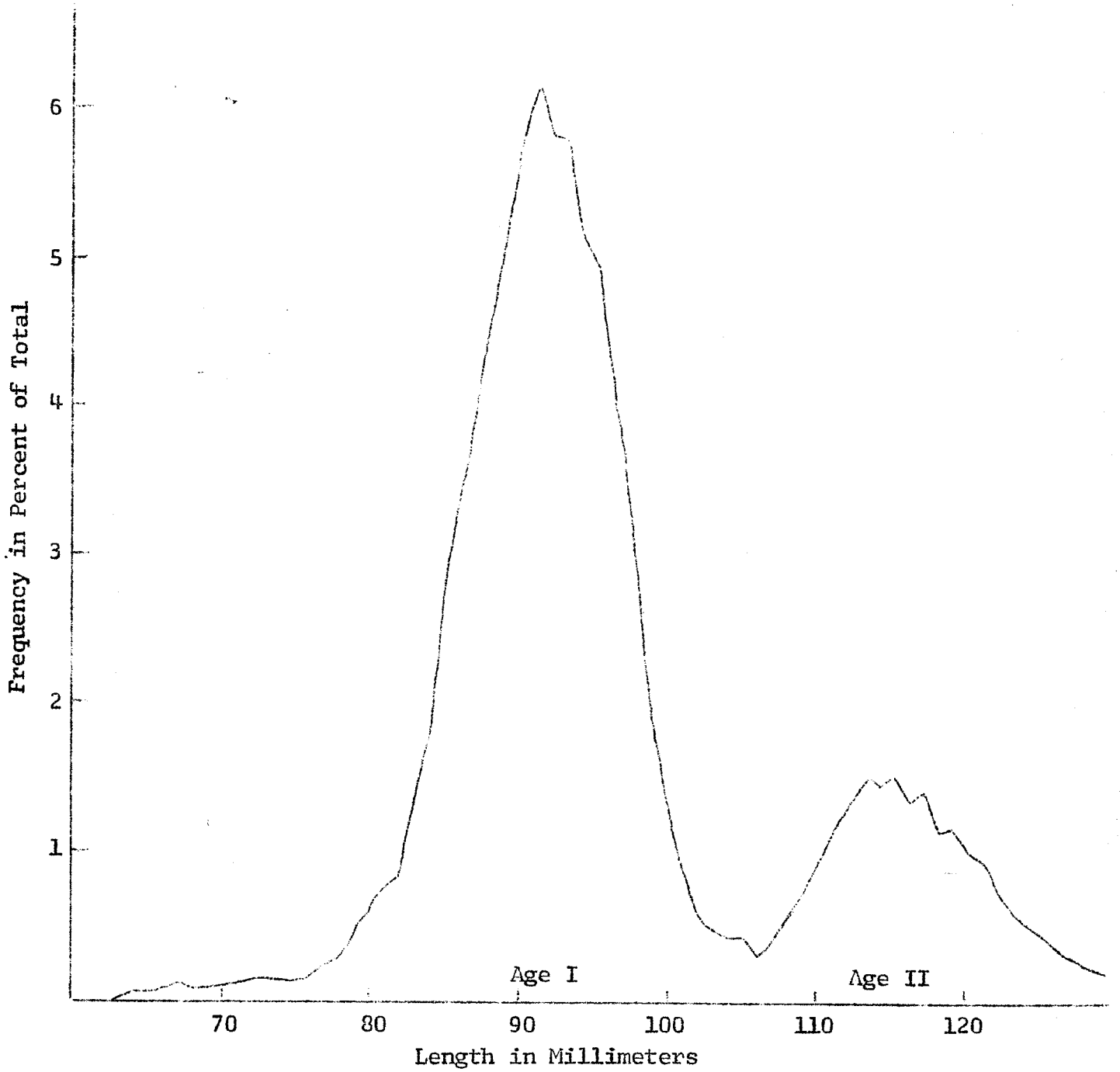

Figure 8. Season's unweighted length frequency of red salmon smolt from the Ugashik River system, 1964. (Frequencies smoothed by moving averages of threes).

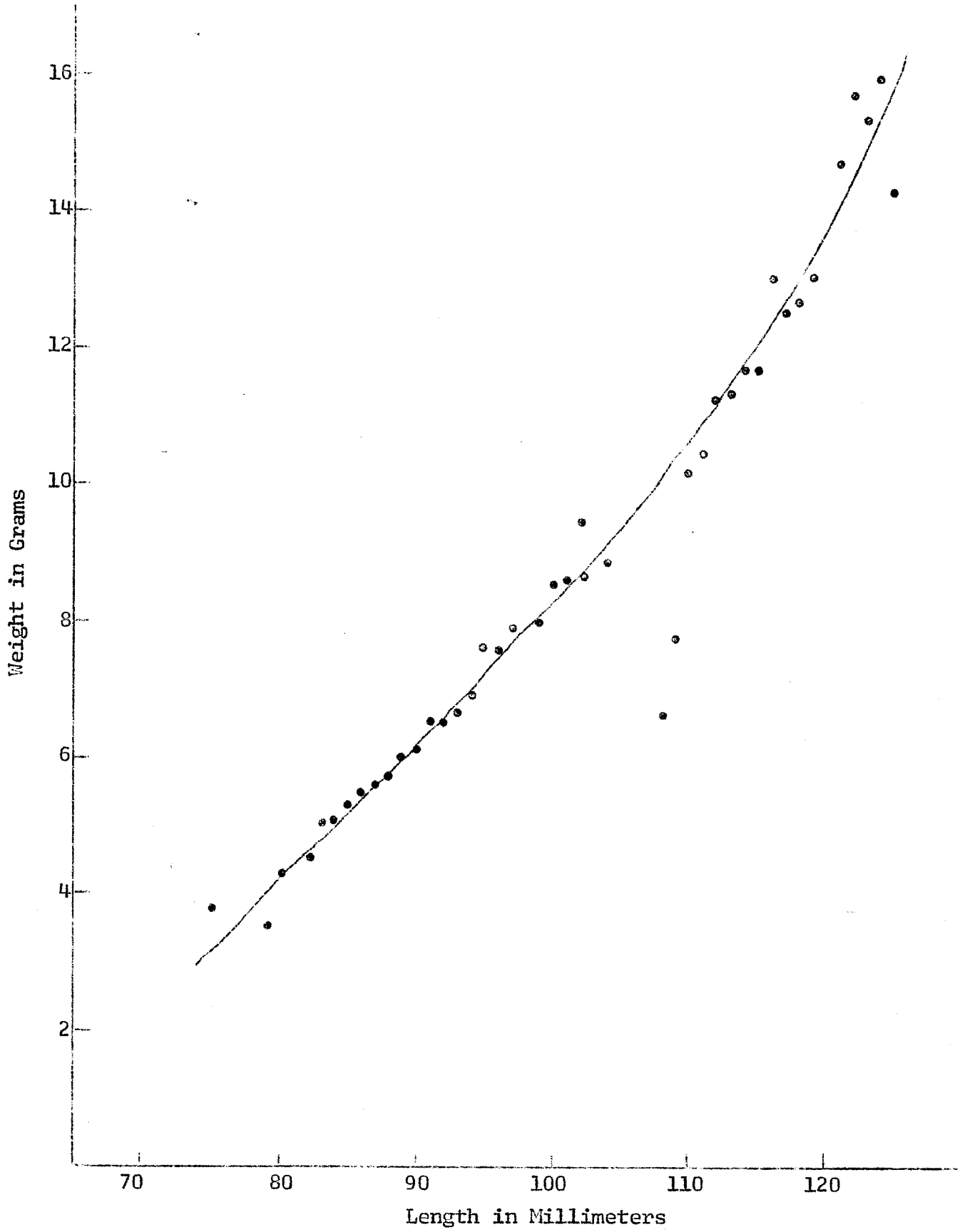

Figure 9. Length-weight relationship of red salmon smolt from the Ugashik River system, 1964.

SURVIVAL

Determination of freshwater and marine survival rates is useful in predicting the number of adult salmon that will return from spawning escapements and in determining optimum escapement levels.

Freshwater Survival

Freshwater survival rates to the smolt stage of development in the Ugashik River system can be determined for the brood years, 1956 through 1959.

Potential egg deposition for each brood year is shown in Table 12. The female red salmon runs to the Ugashik system have always fluctuated between small and large ocean fish (Table 12). Therefore, the egg potential was estimated for each group of fish rather than for the female run as a whole. The average egg fecundity of small and large fish used in Table 12 was 3,420 and 4,170 respectively (Horton and Olsen, 1962). In the absence of egg fecundity data from the Ugashik system, it was felt that the figures used were the best available.

Freshwater survival by brood year from the egg to the smolt stage is shown in Table 13. The range of survival rates has varied from 0.77 to 1.82 percent (Table 13). The limited data suggests that larger escapements of adult fish not only produce more smolt but they produce a higher freshwater survival to the smolt stage. The low freshwater survival of the large escapement in 1960 suggests that the optimum escapement may have been exceeded. However, lack of escapements of intermediate sizes make comparisons difficult.

Considerable variability was found in comparing freshwater survival levels of the Ugashik River system with other ranges of survival levels in other areas. At Babine Lake in the upper Skeena River system in British Columbia, freshwater survival ranged from 0.95 to 5.19 percent over a 6-year period. (Department of Fisheries, 1964). Survival rates at Lakelse Lake in British Columbia over a 7-year period ranged from 1.00 to 4.90 percent (Canada, Fisheries Research Board, 1957).

Marine Survival

Marine survival rates from the smolt to the adult stage of development in the Ugashik River system can also be determined for the brood years, 1956-1959.

Total mortality in the marine environment is controlled by oceanic conditions and the length of time the salmon spend in the ocean.

Marine survival by brood year is shown in Table 13. The percent smolt to adult survival for the Ugashik system shows considerable variation which is difficult to interpret. One possible answer may be that during certain years environmental conditions may be especially conducive to good survival or vice versa. Another factor which undoubtedly has an effect on marine survi-

val is the Japanese high seas fishery. In addition to the Japanese catch there is a drop-out factor which affects a large number of fish. A drop-out is considered a fish which falls from the gear as a dead fish or subsequently dies because of its encounter with the fishery gear. No attempt was made to correct the marine survival figures for the catch and drop-out factor of red salmon by the high seas fishery because of the difficulty in determining the specific origin of the fish in the catch.

The 1958 and 1959 brood year returns and final marine survival will not be completed until 1965 and 1966. The number of 7-year-old fish that return in 1965 will complete the 1958 brood year return. In the past, less than one percent of the returns to the Ugashik system have been 7-year-old fish (Bureau of Commercial Fisheries, 1958-1963). The 6-year-old fish returning in 1966 could increase the marine survival rate for the 1959 brood year, since one to 16 percent of the returns in the past have been 6-year fish (Bureau of Commercial Fisheries, 1958-1963).

The marine mortality of the Ugashik system runs, as derived from the data in Table 13, ranges between 69.86 and 91.34 percent. This range corresponds closely to the average marine mortality of 64 to 95 percent as discussed by Ricker (1962) for red salmon in different areas of Canada, Alaska and the Kamchatka Peninsula in Russia.

Effects of smolt size on marine mortality are shown in Table 14 and Figure 10. In general, survival increases as the size of the smolts increase. The highest marine survival by freshwater age group for the Ugashik system was for the 1956 brood year (Table 14). However, the survival rate for the 1956 brood year is somewhat atypical as the Age I smolt show a higher marine survival than the Age II group.

The geometric mean of the marine survival rates for the Ugashik system for Age I smolt is 8.04 percent while the Age II smolt average 15.24 percent (Table 14). The highest survival in the Age I and II smolt classes correspond with the largest sized smolt in both age groups (Table 14).

Similar studies conducted on the Babine River system in British Columbia show a 4-year average marine survival of 4.88 percent for the Age I smolt group (Ricker, 1962). The lower survival rate for the Babine smolt may be explained by the difference in average smolt size. The Babine Age I smolt average 82 mm. in length while the Ugashik smolt average 91 mm.

Studies conducted on the Karluk River system on Kodiak Island, Alaska show an 8-year average marine survival rate of 27.40 percent for Age II smolt (Ricker, 1962). Again, the lower marine survival rate of the Ugashik Age II smolt may be explained by average smolt size. The Karluk smolt average 132 mm. in length while the Ugashik smolt average 113 mm.

Total Survival

Total survival of red salmon from the Ugashik River system reflects the relationship between the egg potential and the adult return.

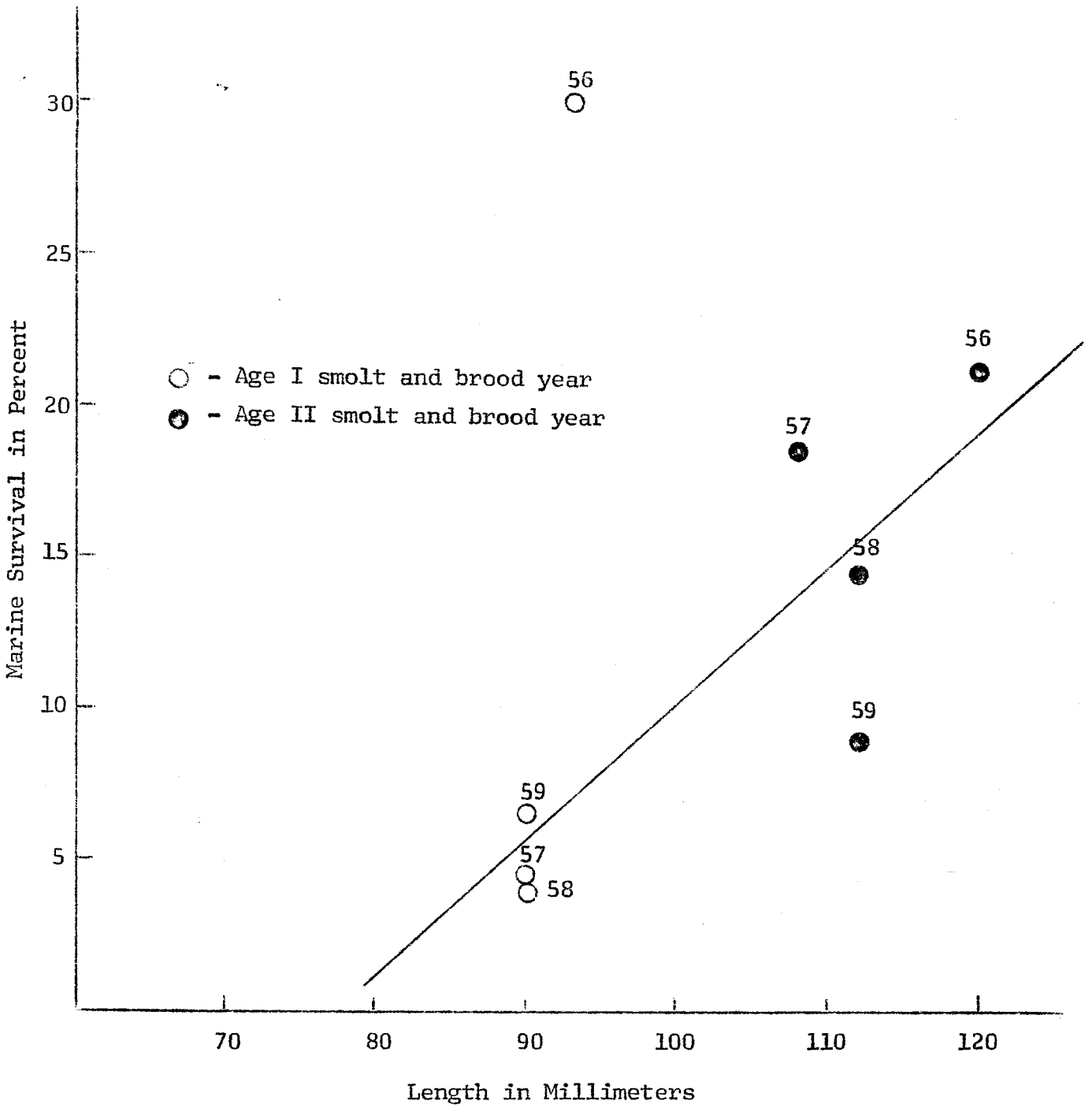

Figure 10. Marine survival of red salmon smolts by freshwater age group in the Ugashik River system, 1956-1959.

Total red salmon survival rates for the brood years 1956-1959 have varied from 0.07 to 0.46 percent (Table 13). The limited data suggests that total survival is greater for larger escapements. This is not surprising in view of the increased freshwater and marine survival rates with increased spawning escapements.

The geometric mean of the red salmon total survival for the Ugashik system of 0.14 percent corresponds closely with the Skeena system average of 0.24 percent (Department of Fisheries, 1964).

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APPENDIX

TABLE 1. COMPARISON OF THE ORIGINAL AND REVISED INDEX NET CATCHES OF RED SALMON SMOLT IN THE UGASHIK RIVER SYSTEM, 1958-1964

Year of Seaward Migration	Original 6-Hour[1/] Smolt Index Net Catch	Revised 3-Hour[2/] Smolt Index Net Catch	Percent of Migration During 3-Hour Period	Revised[3/] Index Points
1958[4/]	451,352	301,232	66.74	100.0
1959	183,763	109,982	59.85	36.5
1960	354,173	226,317	63.90	75.1
1961	264,696	157,441	59.48	52.3
1962	460,103	310,616	67.51	103.1
1963	1,250,319	919,451	75.53	305.2
1964	314,110[5/]	205,145	-	68.1
Average	468,359	232,883	65.31[6/]	84.5[6/]

Data Source: Nelson and Jaenicke, 1965

1/ The original 6-hour index period ran from 8 p.m. - 2 a.m. during 1958-1963

2/ The revised 3-hour index period runs from 10 p.m. - 1 a.m.

3/ One index point = 3,012.32 smolts

4/ Base year; assigned value of 100.0

5/ Interpolation derived by using 3-hour catch and geometric average percent

6/ Geometric mean

TABLE 2. WATER TEMPERATURE AND DATE OF UGASHIK RIVER SMOLT MIGRATION PEAKS, 1960-1964

Year	Beginning Date of Migration Peak	Ugashik River Water Temperatures, °F
1960	May 22	40°
1961	May 15	39°
1962	May 14	41°
1963	May 16	38°
1964	May 25	38°

Data Sources: Jaenicke, 1963; Nelson and Jaenicke, 1965

TABLE 3: UGASHIK RIVER RED SALMON SMOLT CATCH IN INDEX NET BY HOUR AND DAY, 1964

Date	Index Hours			Total Index Catch		Index Points1/	
	10-11 p.m.	11 pm.-12 mn.	12 mn.-1 am.	Daily	Cumulative	Daily	Cumulati
May 15	0	0	0	0	0	0.00	0.00
16	0	1	1	2	2	0.00	0.00
17	0	1	0	1	3	0.00	0.00
18	0	0	0	0	3	0.00	0.00
19	0	0	0	0	3	0.00	0.00
20	1	0	0	1	4	0.00	0.00
21	0	0	0	0	4	0.00	0.00
22	0	0	1	1	5	0.00	0.00
23	10	19	73	102	107	0.03	0.03
24	-	-	-	-	107	0.00	0.03
25	191	851	875	1,917	2,024	0.64	0.67
26	317	302	140	759	2,783	0.25	0.92
27	5	125	151	281	3,064	0.09	1.01
28	2,802	6,944	6,093	15,839	18,903	5.26	6.27
29	2,218	1,022	690	3,930	22,833	1.31	7.58
30	1,020	7,238	10,795	19,053	41,886	6.33	13.91
31	544	2,360	4,456	7,360	49,246	2.44	16.35
June 1	144	822	419	1,385	50,631	0.46	16.81
2	99	943	2,055	3,097	53,728	1.03	17.84
3	8,598	6,401	4,527	19,526	73,254	6.48	24.32
4	1,298	3,399	7,055	11,752	85,006	3.90	28.22
5	4,077	7,474	14,571	26,122	111,128	8.67	36.89
6	14,394	7,797	1,947	24,138	135,266	8.01	44.90
7	24,622	6,194	4,053	34,869	170,135	11.58	56.48
8	3,192	4,939	2,082	10,213	180,348	3.39	59.87
9	4,005	2,318	1,102	7,425	187,773	2.47	62.34
10	1,768	1,697	656	4,121	191,894	1.37	63.71
11	1,168	2,577	1,056	4,801	196,695	1.59	65.30
12	1,044	207	646	1,897	198,592	0.63	65.93
13	981	1,191	514	2,686	201,278	0.89	66.82
14	864	811	531	2,206	203,484	0.73	67.55
15	79	48	64	191	203,675	0.06	67.61
16	0	4	26	30	203,705	0.01	67.62
17	2	3	6	11	203,716	0.00	67.62
18	153	662	468	1,283	204,999	0.43	68.05
19	35	4	12	51	205,050	0.02	68.07
20	41	12	42	95	205,145	0.03	68.10
Total	73,672	66,366	65,107	205,145	205,145	68.10	68.10
Percent	35.91	32.35	31.74	100.00			

1/ One index point = 3,012.32 smolt

TABLE 4. UGASHIK RIVER RED SALMON SMOLT CATCH IN INDEX NET OVER 24-HOUR PERIOD, 1964

Time Period	Date May 17-18	May 22-23	May 28-29	June 2-3	June 5-6	June 7-8	June 9-10	June 12-13	June 17-18	Total	Percent
10-11 p.m.	0	0	2,802	99	4,077	24,622	4,005	1,044	2	36,651	15.23
11-12 mn.	1	0	6,944	943	7,474	6,194	2,318	207	3	24,084	10.01
12 mn.-1 am.	0	1	6,093	2,055	14,571	4,053	1,102	646	6	28,527	11.85
1-2 am.	1	0	9,566	728	5,319	6,737	706	184	4	23,245	9.66
2-3:30 am.	0	0	44,471	54	8,662	403	224	363	0	54,177	22.51
3:30-5 am.	0	0	2,065	0	6	13	59	28	0	2,171	.90
5-6:30 am.	0	0	12	181	220	23	5	3	0	444	.19
6:30-8 am.	0	0	0	5	106	8	0	3	0	122	.05
8-9:30 am.	0	0	141	71	1,218	7	33	4	1	1,475	.61
9:30-11 am.	0	0	0	121	329	1	1	481	0	933	.39
11 am.-12:30 pm.	0	0	2	0	221	7	6	27	0	263	.11
12:30-2 pm.	0	0	0	0	1,172	2	11	6	2	1,193	.50
2-3:30 pm.	2	0	0	0	743	663	134	96	0	1,638	.68
3:30-5 pm.	0	2	2	1,253	390	759	296	0	0	2,702	1.12
5-6:30 pm.	0	5	0	3	768	1,119	12	1	0	1,908	.79
6:30-8 pm.	0	5	0	2,433	878	348	18	30	0	3,712	1.54
8-9 pm.	0	1	403	9,485	4,169	4,928	1,395	423	0	20,804	8.65
9-10 pm.	0	17	1,103	13,544	11,728	8,798	764	639	4	36,597	15.21
Total	4	31	73,604	30,975	62,051	58,685	11,089	4,185	22	240,646	100.00

TABLE 5. UGASHIK RIVER RED SALMON SMOLT CATCHES IN THE RANDOM SAMPLING SCHEME BY FISHING SITE, 1964

Date	Random Sampling Sites 1	2	3	4	5	Total Catch
May 15	0	3	0	0	0	3
16	0	2	1	0	0	3
18	1	1	7	0	1	10
19	1	0	0	0	0	1
20	0	1	22	0	0	23
21	0	0	1	0	0	1
23	2	0	19	19	33	73
25	24	585	214	2	682	1,507
26	27	147	1,331	302	41	1,848
27	27	65	1	151	2	246
29	17	97	363	2,218	245	2,940
30	1,027	193	3,979	10,795	2,295	18,289
31	9,395	3,596	1,092	2,360	677	17,120
June 1	20	4,031	415	435	82	4,983
3	1,023	863	1,302	26,285	4,559	34,032
4	340	432	1,901	3,399	0	6,072
5	0	2,654	20,714	5,399	1,320	30,087
6	3	434	368	1,947	683	3,435
8	6	20	511	3,192	1,022	4,751
9	0	11	49	3,896	1,190	5,146
10	2	5	42	764	429	1,242
11	0	37	510	2,577	4	3,128
13	9	6	1,210	132	211	1,568
14	0	3	7	531	363	904
15	0	0	3	79	30	112
16	1	60	7	26	2	96
18	8	0	130	662	47	847
19	4	14	85	4	1	108
20	1	34	0	0	2	37
Total	11,938	13,294	34,284	65,175	13,921	138,612
Percent	8.61	9.59	24.74	47.02	10.04	100.00

TABLE 6. UGASHIK RIVER RED SALMON SMOLT SAMPLING DATA, 1964

Period No.	Date	Index Smolt Catch	Percent of Season's Total	No. of 1 lb. Samples Measured	No. of Fish Measured	No. of Scales Read
1	May 15-26	2,783	1.36	4	219	70
2	May 27-31	46,463	22.65	14	759	100
3	June 1-5	61,882	30.16	15	825	100
4	June 6-10	80,766	39.37	15	949	100
5	June 11-15	11,781	5.74	15	923	100
6	June 16-20	1,470	.72	6	372	40
	Total	205,145	100.00	69	4,047	510

TABLE 7. AGE, LENGTH AND WEIGHT OF RED SALMON SMOLTS BY SAMPLING PERIOD FROM THE UGASHIK LAKES SYSTEM, 1964

Period No.	Date	Mean Length in mm. of Age Group		Mean Length in gr. of Age Group		Percentage of Age Group		
		I	II	I	II	I	II	III
1	May 15-26	93.21	113.59	5.82	11.21	46.67	53.33	-
2	May 27-31	94.26	118.20	6.72	13.13	74.57	25.43	-
3	June 1-5	93.40	118.60	6.89	12.58	75.88	23.88	.24
4	June 6-10	90.41	117.36	7.15	12.08	86.72	13.07	.21
5	June 11-15	90.10	123.09	6.27	15.57	90.14	9.75	.11
6	June 16-20	90.91	124.90	5.72	15.10	94.86	5.14	-
Season's Weighted Total		92.21	118.26	6.90	12.68	80.14	19.80	.06

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

TABLE 8. COMPARATIVE AGE, LENGTH, INDEX NET CATCHES AND OUTMIGRATION ESTIMATES OF RED SALMON SMOLT FROM THE UGASHIK RIVER SYSTEM, 1956-1964

Year of Seaward Migration	Age I		Age II		Index Points	Index Net Catch	Outmigrati Estimate
	Percent	Mean Length in mm.	Percent	Mean Length in mm.			
1956	11.0	-	89.0	-	-	-	-
1957	4.0	-	96.0	-	-	-	-
1958	98.1	93.0	1.9	112.0	100.0	301,232	11,659,905
1959	87.3	90.0	12.7	120.0	36.5	109,982	2,887,002
1960	59.7	90.0	39.3 1/	108.0	75.1	226,317	5,503,646
1961	20.4	90.0	79.6	112.0	52.3	157,441	3,802,079
1962	80.7	88.0	19.3	112.0	103.1	310,616	16,692,089
1963	46.3	89.8	53.7 1/	104.3	305.2	919,451	33,750,496
1964	80.1	92.2	19.8 1/	118.3	68.1	205,145	9,990,048
Average	54.2	90.4	45.7	112.4	84.3 2/	318,598	12,040,752

Data Sources: Jaenicke, 1963; Nelson and Jaenicke, 1965.

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

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

2/ Geometric mean

TABLE 9. CONDITION INDEX OF RED SALMON SMOLT FROM THE UGASHIK RIVER SYSTEM USING 3 MM. LENGTH GROUPS, 1964

Mid-Point of 3 mm. Groupings	Grams Per Fish						Mean Average
	May 22-26	May 27-31	June 1-5	June 6-10	June 11-15	June 16-20	
70	-	-	-	-	3.35	2.56	2.96
73	2.70	-	-	-	4.04	-	3.37
76	-	3.70	-	3.65	4.84	3.85	4.01
79	-	4.32	4.10	4.35	4.25	3.83	4.17
82	4.05	-	4.92	5.18	4.86	4.58	4.72
85	4.67	5.91	5.44	5.82	5.30	5.11	5.38
88	5.23	6.84	5.94	5.98	5.81	5.69	5.92
91	5.96	5.50	6.39	6.82	6.00	5.91	6.10
94	6.45	6.73	7.13	6.95	6.92	7.16	6.89
97	7.05	7.78	7.21	7.85	7.56	8.65	7.68
100	7.88	8.45	7.44	7.01	8.18	8.26	7.87
103	8.25	11.44	9.09	9.35	8.62	-	9.35
106	8.38	9.65	9.36	10.15	9.31	-	9.37
109	10.01	10.90	10.00	10.65	9.10	-	10.13
112	10.91	11.47	10.32	10.35	10.75	-	10.76
115	11.16	12.88	11.35	12.03	12.48	-	11.98
118	12.46	14.54	14.12	13.05	13.07	14.32	13.59
121	15.19	12.68	13.81	15.57	14.63	15.29	14.53
124	17.14	15.29	15.73	14.74	15.01	15.63	15.59
127	-	15.74	15.30	15.28	16.71	-	15.76
130	-	-	-	-	17.96	-	17.96
133	-	-	19.90	-	18.46	-	19.18

TABLE 10. AVERAGE LENGTH AND WEIGHT OF UGASHIK RIVER RED SALMON SMOLTS BY FRESHWATER AGE GROUPS, 1958-1964 1/

Year of Seaward Migration	Age I		Age II	
	Length	Weight	Length	Weight
1958	93.0	6.4	112.0	11.7
1959	90.0	6.1	120.0	13.5
1960	90.0	6.6	108.0	11.0
1961	90.0	6.7	112.0	12.2
1962	88.0	6.1	112.0	12.3
1963	89.8	6.1	104.3	9.6
1964	92.2	6.9	118.3	12.7
Mean Average	90.4	6.4	112.4	11.9

Data Source: Nelson and Jaenicke, 1965

1/ Weighted by index catch

TABLE 11. UGASHIK RIVER RED SALMON ESCAPEMENTS AND SMOLTS PRODUCED, 1956-1962

Brood Year	Ugashik River Escapement	Millions of Smolts Produced			
		Age I	Age II	Age III	Total
1956	425,295	11.4	0.4	.01	11.9
1957	214,802	2.5	2.2	-	4.7
1958	279,546	3.3	3.0	-	6.3
1959	219,228	0.8	3.2	-	4.0
1960	2,304,200	13.5	18.1	-	31.6
1961	348,639	15.6	2.0	-	17.6
1962	255,426	8.0	1/	-	-

Data Source: Nelson and Jaenicke, 1965

1/ The Age II smolts from the 1962 escapement will not leave freshwater until 1965.

TABLE 12. PRELIMINARY EGG POTENTIAL IN MILLIONS BY SMALL AND LARGE ADULT RED SALMON IN THE UGASHIK RIVER SYSTEM, 1956-1961

Brood Year	Spawning Escapement	Percent Females	No. Females	Percent Females		No. Females		Av. Egg Fecundity		Egg Potential, Millions		
				Small	Large	Small	Large	Small	Large	Small	Large	Total
1956	425,295	52.0	221,153	90.9	9.1	201,028	20,125	3,420	4,170	687.5	83.9	771.4
1957	214,802	53.0	113,845	54.8	45.2	62,387	51,458	"	"	213.4	214.6	428.0
1958	279,546	53.1	148,512	64.1	35.9	95,196	53,316	"	"	325.6	222.3	547.9
1959	219,228	61.3	134,280	52.9	47.1	71,034	63,246	"	"	242.9	263.7	506.6
1960	2,304,200	52.2	1,202,792	99.5	0.5	1,196,778	6,014	"	"	4,093.0	25.1	4,118.1
1961	348,639	67.3	234,775	6.8	93.2	15,965	218,810	"	"	54.6	912.4	967.0

Data Source: B.C.F., 1958-1963; Horton and Olsen, 1962; Kerns, 1963; A.D.F.G., 1965.

Note: "Small" designates fish that have spent 1 or 2 winters in ocean; "Large" designates fish that have spent 3 or more winters in ocean.

TABLE 13. PRELIMINARY FRESHWATER AND MARINE SURVIVAL OF RED SALMON SMOLTS FROM THE UGASHIK RIVER SYSTEM, 1956-1961

Brood Year	Spawning Escapement	Egg Potential (Millions)	Smolts Produced (Millions)	Freshwater Survival % Egg to Smolt	Total Adult[1/] Salmon Return	Marine Survival % Smolt to Adult	Total Survival % Egg to Adult
1956	425,295	771.4	11.9	1.54	3,575,144	30.14	0.46
1957	214,802	428.0	4.7	1.10	527,438	11.26	0.12
1958	279,546	547.9	6.3	1.15	591,382[2/]	9.37	0.11
1959	219,228	506.6	4.0	0.79	346,347[2/]	8.66[2/]	0.07[2/]
1960	2,304,200	4,118.1	31.6	0.77			
1961	348,639	967.0	17.6	1.82			
AVERAGE	631,952	1,223.2	12.7	1.14[3/]		12.85[3/]	0.14[3/]

Data Sources: B.C.F., 1958-1963; A.D.F.G., 1964a, 64b and 65; Nelson and Jaenicke, 1965

1/ Includes both catch and escapement

2/ Preliminary (see text for explanation)

3/ Geometric mean

TABLE 14. PRELIMINARY MARINE SURVIVAL OF RED SALMON SMOLTS BY FRESHWATER AGE GROUP IN THE UGASHIK RIVER SYSTEM, 1956-1959

Brood Year	Millions of Smolts Produced		Mean Length in mm.		Total Adult Return 1/ by Freshwater Age		Marine Survival % Smolt to Adult	
	Age I	Age II	Age I	Age II	Age I 2/	Age II 3/	Age I	Age II
1956	11.4	0.5	93	120	3,485,037	90,107	30.47	21.37
1957	2.5	2.2	90	108	119,713	407,725	4.75	18.85
1958	3.3	3.0	90	112	146,148	445,234 4/	4.45	14.71 4/
1959	0.8	3.2	90	112	50,310 4/	296,031 4/	6.49 4/	9.09 4/
AVERAGE	4.5	2.2	91	113			8.04 5/	15.24 5/

Data Sources: B.C.F., 1958-1963; A.D.F.G., 1964a, 64b; Nelson & Jaenicke, 1965.

Note: Age group I and II denotes number winters in freshwater. Age III smolts included with Age II.

1/ Includes both catch and escapement

2/ Includes Age 0 fish

3/ Includes Age III fish

4/ Preliminary (see text for explanation)

5/ Geometric mean

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