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KARLUK LAKE SOCKEYE SMOLT ENUMERATION, 1983

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BY

TONY CHATTO
FISHERY BIOLOGIST

FINAL REPORT

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PREFACE

In 1982 the Alaska Department of Fish and Game (ADF&G) and the U.S. Fish and Wildlife Service (USFWS) entered into a memorandum of agreement to work cooperatively on the restoration of the Karluk Lake sockeye salmon run. The goal is to restore the Karluk sockeye returns to a level where annual escapements of 0.8 - 1.0 million fish can be realized. In support of this effort during FY 1983 the USFWS - Kodiak National Wildlife Refuge (KNWR) conducted a study to determine the number and age structure of sockeye salmon smolts leaving Karluk lake. This report outlines the results of the 1983 smolt study.

INTRODUCTION

The Karluk river drainage is approximately 611 Km^2 and contains the largest lake on the Kodiak Archipelago. All five species of pacific salmon (Onchorynchus sp.), plus steelhead/rainbow trout (Salmo gairdneri), Dolly Varden (Savelinus malma), and arctic charr (S. alpinus) utilize the drainage for spawning and/or rearing. Karluk river is approximately 38.6 kilometers long and is fed by the 40 Km^2 area of Karluk lake. The lake in turn is fed by numerous lateral and terminal tributaries (figure 1).

The Karluk drainage contains critical fresh-water fisheries habitat which, for it's size historically supported one of the most productive sockeye salmon populations for Alaska. Although the commercial harvest from the late 1800's to the early 1920's ranged between 1 and 4 million fish annually, it was not until 1921, when a counting wier was installed in the Karluk river, that the acutal escapement numbers were determined. From 1921 and 1950 total annual returns ranged from 1 to 5 million fish. Returns from 1950 to the present have fluctuated between

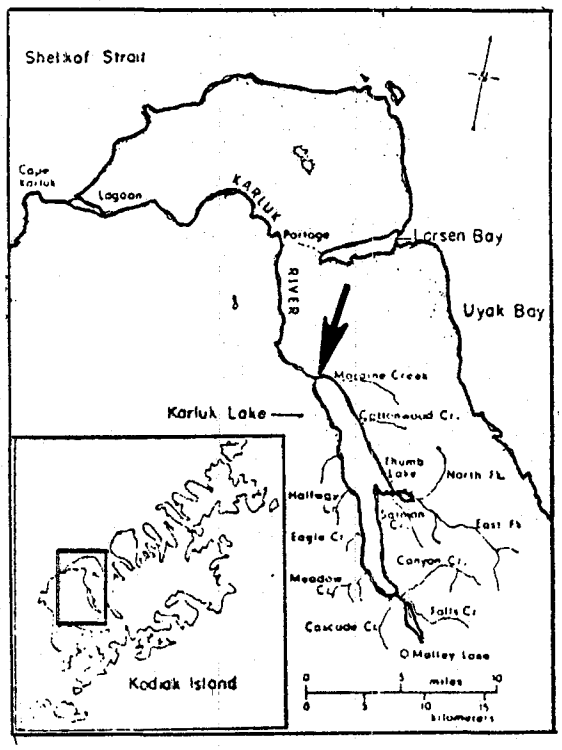

Figure 1. Karluk river/lake, arrow depicts 1983 smolt trapping location North end Karluk lake.

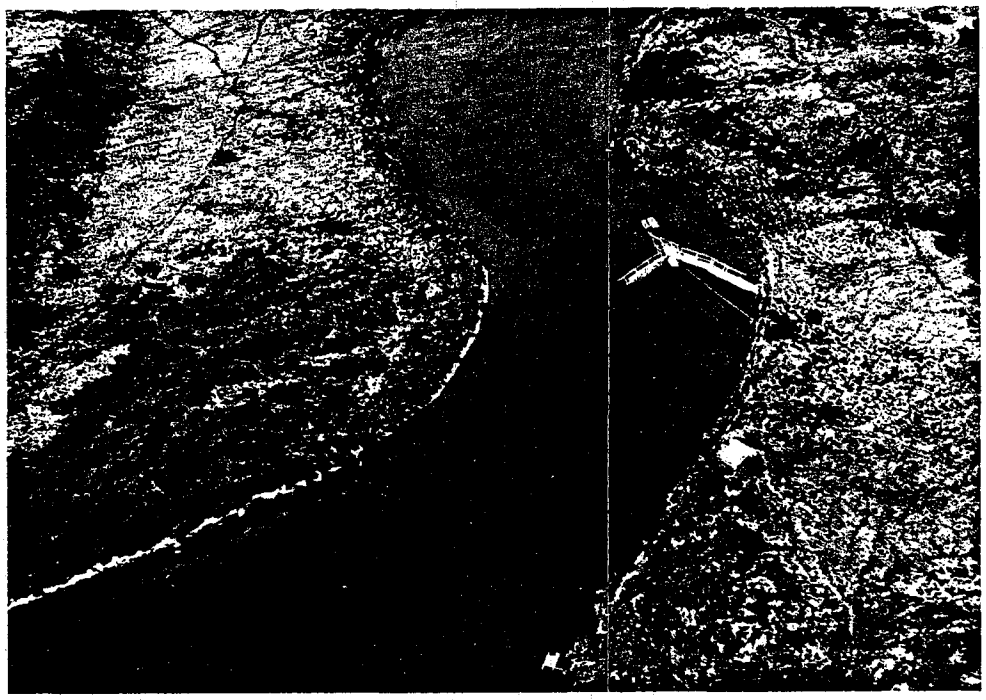

Figure 2. Karluk river smolt trap May - June 1983.

0.2 and 0.8 million fish. One exception was the return of 0.95 million fish in 1962. Recent 1981-83 returns have been less than 0.48 million fish.

Smolt production from escapement into the Karluk system has been estimated by several investigators. Barnaby (1944) marked smolts and examined returns in the fishery from 1925 to 1940. Data was provided where estimates on the total numbers and age structure of smolts could be estimated during those years. Gard and Drucker (1961-68) employed Karluk river fyke net catches to estimate the age structure and numbers of smolts leaving the lake from 1961-68. ADF&G has used sonar gear annually on the Karluk river since 1979 to estimate numbers, age, and timing of outmigrant smolts. ADF&G smolt estimates since 1979 have ranged from 2.0 to 0.8 million fish.

Although sonar gear is being utilized in some Alaskan Bristol Bay streams with a fairly reliable measure of accuracy (Mecham. pers comm) the magnitude of the Karluk smolt migration, less than 2.0 million fish, unfortunately appears to be below the threshold level of accurate measurement utilizing sonar gear (Kail-pers comm). Therefore, during 1983, a stratified mark-recapture method for estimation of Karluk salmon smolt numbers leaving the lake was proposed. Unfortunately, projected equipment delivery for field use precluded the use of purse seine gear in time for the 1983 migration and a alternative method was utilized to determine smolt numbers leaving the lake.

METHODS AND MATERIALS

Smolt Capture

A Canadian fan trap with wings was placed approximately 150 meters downstream from the lake outlet. The trap and wings extended from the east bank of the

river and covered approximately 40 percent of the river width (figure 2). The trap was fished 24 hours per day (0900 hours one day to 0900 hours the next day) from May 14 through June 16, 1983. All smolts captured were tallied each morning and released. A random sample of approximately 10 percent of the total catch for each morning was sampled for age, weight, and length data.

Mark-Recapture

The basic study plan had been designed to utilize the Schaefer method for stratified populations as outlined by Ricker (1975) with the use of aluminum staple tags for marking as outlined by Jordan and Smith (1968). The methodology was proposed so that those smolts schooling in the vicinity of the lake outlet could be captured with purse seine gear and the smolts marked with color coded (day of marking) staples. Unfortunately the purse seine gear did not arrive in time for use during the 1983 migration. In addition, although the aluminum staples were color coded and attached to the dorsal surface with little damage, the type of alloy in the newer staples precluded the tagger from applying more than a few hundred staples before their fingers became badly bruised and cut. To circumvent these problems a interim mark-recapture method was devised whereby a percentage of smolts captured during the night were marked using a caudal clip and released at the lake outlet the same night. Those fish recaptured the same night and the subsequent night were utilized as a mark sample.

Marking was accomplished by clipping the upper or lower 2 mm of the caudal fin allowing for easy recognition of marked fish caught in the trap. In addition groups of marked fish released indicated most marked fish, if released by 0300 hours, migrated the same night and the remainder completed migration the next

night. Therefore by alternating the upper and lower caudal clip on marking days tracking of marks for each days marking could be accomplished.

A minimum of approximately 100 smolts captured by 2300 hours each night was used as a basis to determine whether or not to tag on a specific night. The number of smolts tagged and released on marking nights ranged from approximately 100 - 500 depending on numbers captured as the night progressed.

RESULTS

Populations Estimates

From May 14 through June 16 a total of 17,726 smolts were captured. Catch during all mark-recovery days (table 1) indicated trap efficiency varied through the migration period. Chi square tests showed a significant difference between all mark-recovery days at the 90 percent level, however no significant difference was found on days within period 1, 2, or 3 (table 2). Since the results of all mark-recapture days could not be lumped, data within periods 1, 2, and 3 were combined and treated spearately.

The total point estimate for the 1983 migration was 941,550 smolts with a 90 percent confidence interval of [0.638×10^6, 1.24×10^6]. This total estimate and the daily estimates depicted in figure 3 and given in table 3 were obtained by utilizing formulas outlined in table 4. The 90 percent confidence interval for total daily estimates was utilized to be consistent with the chi square tests.

Age, Weight and Length

A total of 1186 smolts were sampled for age, weight and length data from May 14 to June 16. The 1^+, 2^+, and 3^+ smolt comprised 1.4, 86.0 and 12.6 percent of the migration respectively (table 5). Daily age composition of migrants (figure 4) indicate the 2^+ smolts dominated the entire migration period with 3^+ smolts present

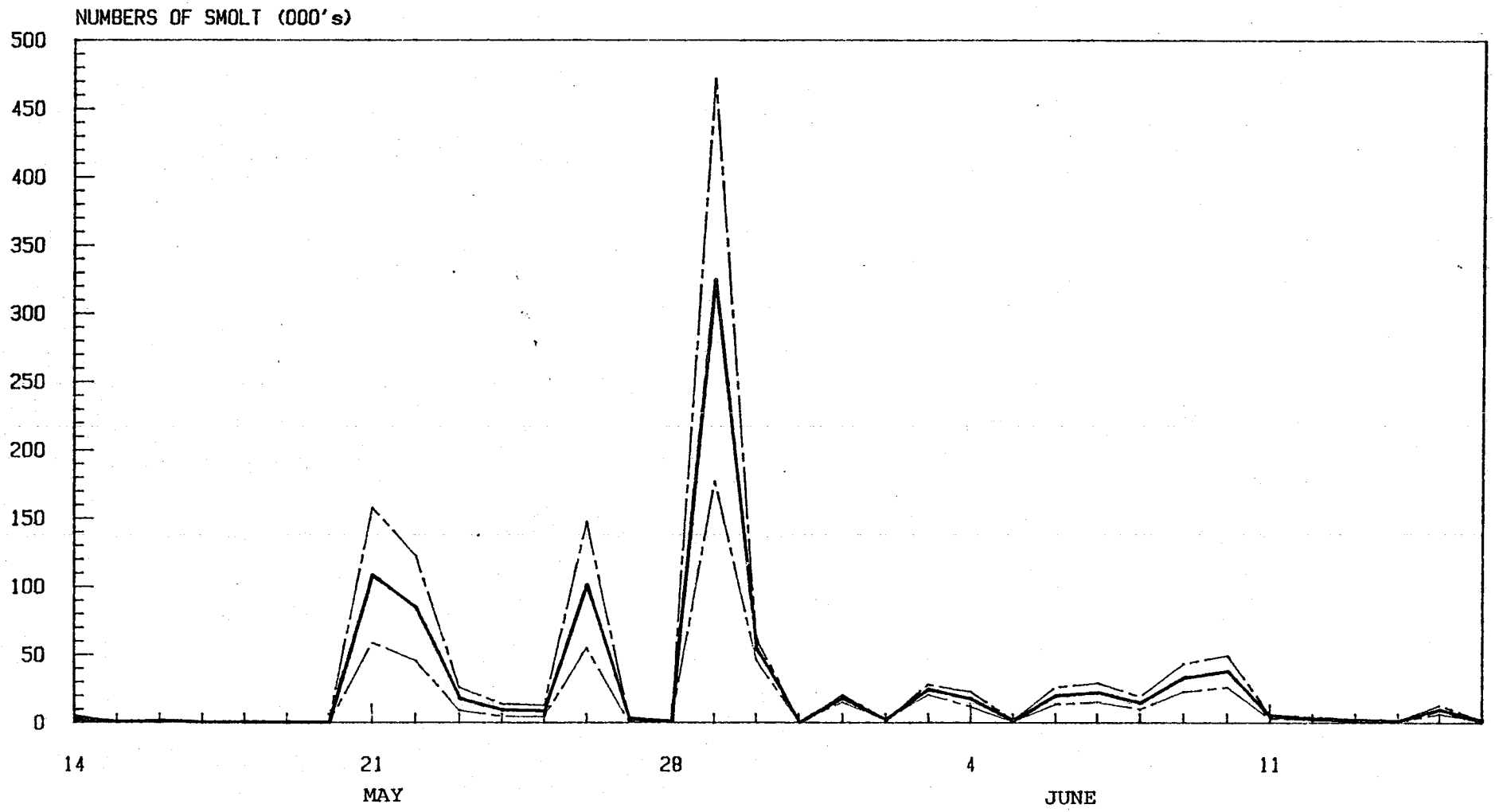

Figure 3. Estimated daily smolt migration (solid line) with 90% confidence intervals (dash lines), Karluk river 1983.

Table 1. Karluk river sockeye smolt mark/recapture data, May 14 - June 16, 1983.

Date	Number Marked (D)	Mark[1] Type	No. Recovered Same Night (-)	No. Recovered Next Night (-)	Total Recovered (d)	Total[2] Catch (ni)	Estimated Trap Efficiency (d/D)
May 14	7	S	0	0	0	34	-
21	142	S	0	0	0	958	-
22	185	S	0	1	1	745	0.0054
23	86	UC	1	0	1	158	0.0116
26	117	LC	3	0	3	896	0.0256
29	557	UC	4	2	6	2870	0.0108
30	507	LC	37	0	37	3764	0.0730
June 1	456	UC	29	2	31	1263	0.0680
2	77	LC	5	5	10	173	0.1299
3	260	UC	19	1	20	1700	0.0769
6	290	LC	5	4	9	573	0.0310
7	332	UC	6	1	7	640	0.0211
8	301	LC	7	4	11	421	0.0365
11	10	UC	1	0	1	1080	0.1000

1 Staple tag(s), upper caudal clip (UC), lower caudal clip (LC).

2 Does not include marked fish released.

Table 2. Karluk river sockeye smolt, Chi Square Analysis mark/recapture data, 1983.

Period No.	Dates	X^2	Degrees Freedom
All	May 14 - June 16	68.46	11
1	May 14 - May 29	1.66	2
2	May 30 - June 3	3.68	3
3	June 4 - June 16	1.36	2

Table 3. Daily sockeye smolt counts at the Karluk River smolt trap and estimated daily smolt migration, Karluk River 1983.

Date	Smolts Captured	Estimate of Total Run	90% Confidence Interval Lower	Upper
May 14	34	3850	1840	5850
15	8	900	270	1540
16	15	1700	690	2710
17	4	450	60	850
18	4	450	60	850
19	3	340	10	670
20	5	570	110	1020
21	958	108410	59040	157780
22	745	84310	45850	122760
23	158	17880	9510	26250
24	84	9510	4930	14080
25	78	8830	4560	13100
26	896	101390	55200	147590
27	26	2940	1350	4530
28	10	1130	390	1870
29	2870	324770	177420	472130
30	3764	54640	46560	62720
31	27	390	270	520
June 1	1263	18330	15560	21110
2	173	2510	2050	2970
3	1700	24680	20970	28380
4	500*	17710	12230	23180
5	56	1980	1260	2710
6	573	20290	14040	26550
7	640	22670	15700	29630
8	421	14910	10280	19540
9	941	33330	23150	43500
10	1080	38250	26590	49910
11	137	4850	3250	6450
12	98	3470	2290	4650
13	64	2270	1450	3080
14	47	1660	1040	2290
15	288	10200	6990	13410
16	56	1983	1260	2710
Total	17726	941550	638670	1244430

*Estimated.

Table 4. Formulas for population estimates, Karluk smolt, 1983 (Adapted from Rawson 1982)

Notation: D = No. smolts marked.] for each period
d = No. smolts recovered
ni = No. smolts captured/period
Ni = No. smolts migrating/period

A. Period Estimates

$$Ni = \frac{ni\ D}{d} \left(1 + \frac{D-d}{Dd}\right)$$

$$Var[Ni] = ni\ (ni+d)D(D-d)/d^3$$

$$S = \sqrt{Var\ (Ni)}$$

$$90\%\ C.I\ (Ni) = [Ni-1.645(S),\ Ni+1.645(S)]$$

B. Daily Estimates

Substitute ni with nj No. smolts captured/night
Substitute Ni with Nj No. smolts migration/night
Use total (D), (d) for corresponding period
Use 90% CI(Nj)=[Nj-1.645(S), Nj+1.645(S)]

C. Overall Estimate

$$\hat{N} = Ni\ Period\ 1 + Ni\ Period\ 2 + Ni\ Period\ 3$$

$$Var\ [\hat{N}] = Var\ P_1+P_2+P_3$$

$$S\ [\hat{N}] = \sqrt{Var[\hat{N}]}$$

$$90\%\ C.I.\ [\hat{N}] = [\hat{N} - 1.645(S),\ \hat{N} + 1.645(S)]$$

only in abundance up to the last week in May. The 1^+ smolt were virtually absent and only observed in small numbers during the 2nd week of May and again near the end of the migration period.

Cumulative mean length and condition factors for 1^+, 2^+, and 3^+ smolt are shown in table 6. Although mean lengths except for 1^+ smolt were comparable to the 1982 migration the (K) value is lower in 1983 than smolt in 1982.

Daily mean length of 2^+ and 3^+ smolts decreased somewhat during the latter part of the migration (figure 5). The daily mean length of 1^+ smolts, although more variable than 2^+ or 3^+ fish, also decreased during the end of the migration.

Daily mean condition (K) of 1^+, 2^+, and 3^+ smolts was generally equal throughout the migration, and as observed by previous investigators (Gard and Drucker 1961-68, White 1979-82) increased as the migration progressed (figure 6).

Timing

Although smolt were captured from May 14 through June 16, few smolt were estimated to have moved downstream prior to May 20. From May 20 - 31 approximately 77.5 percent of the migration moved downstream past the trapping site. Daily estimates indicate major peaks of movement occurred on May 21, 26, and 29 when 11.5, 10.8, and 34.4 percent respectively migrated (figure 3). Movement of smolt from June 1 to 16 consisted of several smaller peaks making up the remaining 22.5 percent of the total migration.

DISCUSSION

Overall the 1983 smolt trapping was successful with more smolt being captured than had been anticiapted. Smolt movement as reported by Gard and Drucker (1961-68) and

White (1979-82) followed the same pattern in 1983. Major peaks or spikes of movement occurring in approximately a 10 day period.

The use of a upper or lower caudal clip for marking gave a easily recognizable mark when examining the 24 hour total catch but the caudal clip may cause differential behavior in movement between marked and unmarked fish. Although the caudal clip may eventually cause some differential mortality, the numbers marked compared to the total smolt migration is small and was not considered to be a source of significant impact. Mortality due to trapping and or fish being impinged on the wings or handling was minimal. It would be desirable to utilize either the correct staples for tagging or a freeze brand which would have been less possible impact on smolt behavior.

The mark-recapture procedure analysis generated in 1983 worked reasonably well and the total point estimate of 941.5 thousand fish is considered to be compatable with recent 1980-82 estimates (table 7).

Comparison of age structure and length of migrating smolts overall (tables 5, 6, and 7) and daily (figures 4, 5, and 6) with previous years data from both Gard and Drucker and White indicate the smolt trap was not selective for any one age or size of migrating smolt.

Although the cumulative mean condition (K) of 1^+, 2^+, and 3^+ smolt indicate a lower mean (K) value for 1983 than previous years (table 8), examination of figure 6 indicates that after May 20th the daily mean (K) value for all age smolt was greater than or equal to 0.8500. Considering that only approximately 0.9 percent of the smolt migrated prior to May 20th it is felt that the condition of the

Table 5. Karluk lake sockeye smolt migration by year class and age, May - June 1983.

Year Class	Age	Estimated Smolts (-000)	Percent of Total Migration
1979	3^+	118.6	12.6
1980	2^+	809.7	86.0
1981	1^+	13.2	1.4
Total		941.5	100.0

Table 6. Cumulative mean length and condition (k) factors by year class of Karluk lake sockeye smolt, May - June 1983.

Year Class	Age	Mean Length (mm)	Mean Condition (k)[1]
1979	3^+	132	0.8085
1980	2^+	116.7	0.7651
1981	1^+	89.6	0.7158

[1] $k = \frac{w}{L^3} \times 10^5$

Table 7. Karluk lake sockeye salmon smolt numbers (-000) by year of migration and age, May - June 1980 - 1983.

Age	1980[1]	1981[1]	1982[1]	1983[2]
3^+	131.2	260.9	108.4	118.6
2^+	1061.0	1561.0	698.8	809.7
1^+	495.0	220.0	14.0	13.2
Total	1687.2	2041.9	821.2	941.5

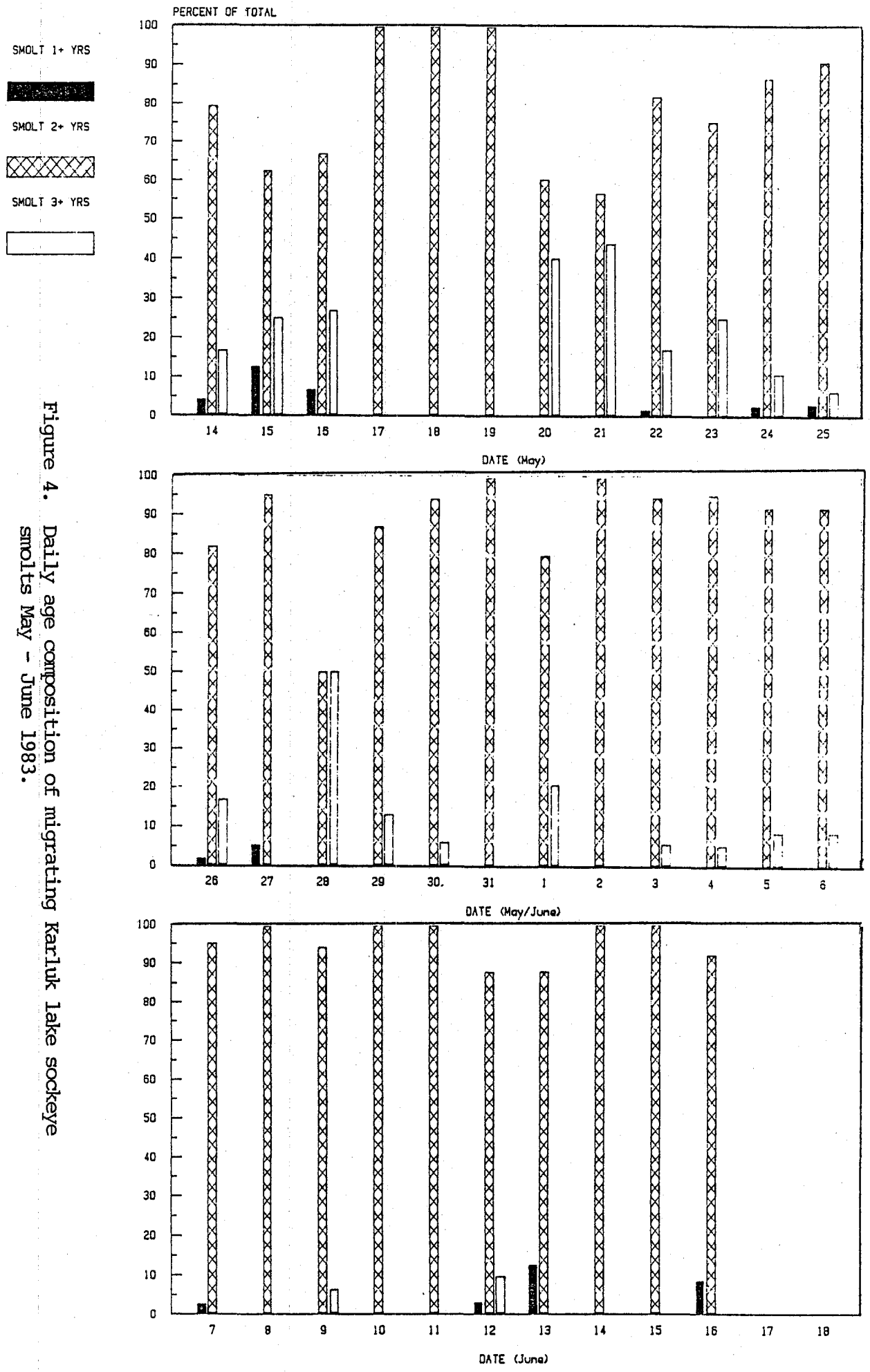

Figure 4. Daily age composition of migrating Karluk lake sockeye smolts May - June 1983.

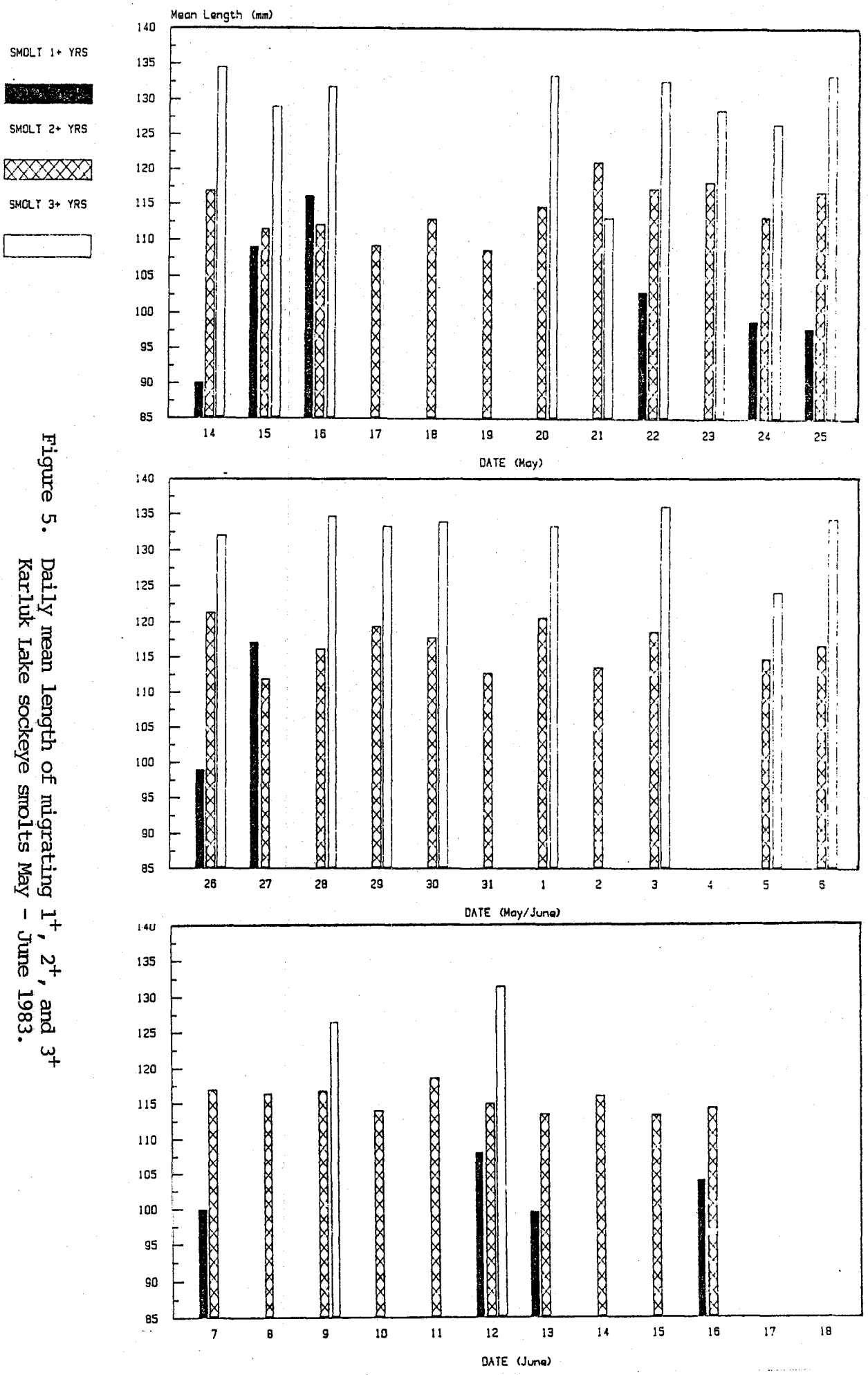

Figure 5. Daily mean length of migrating 1^+, 2^+, and 3^+ Karluk Lake sockeye smolts May - June 1983.

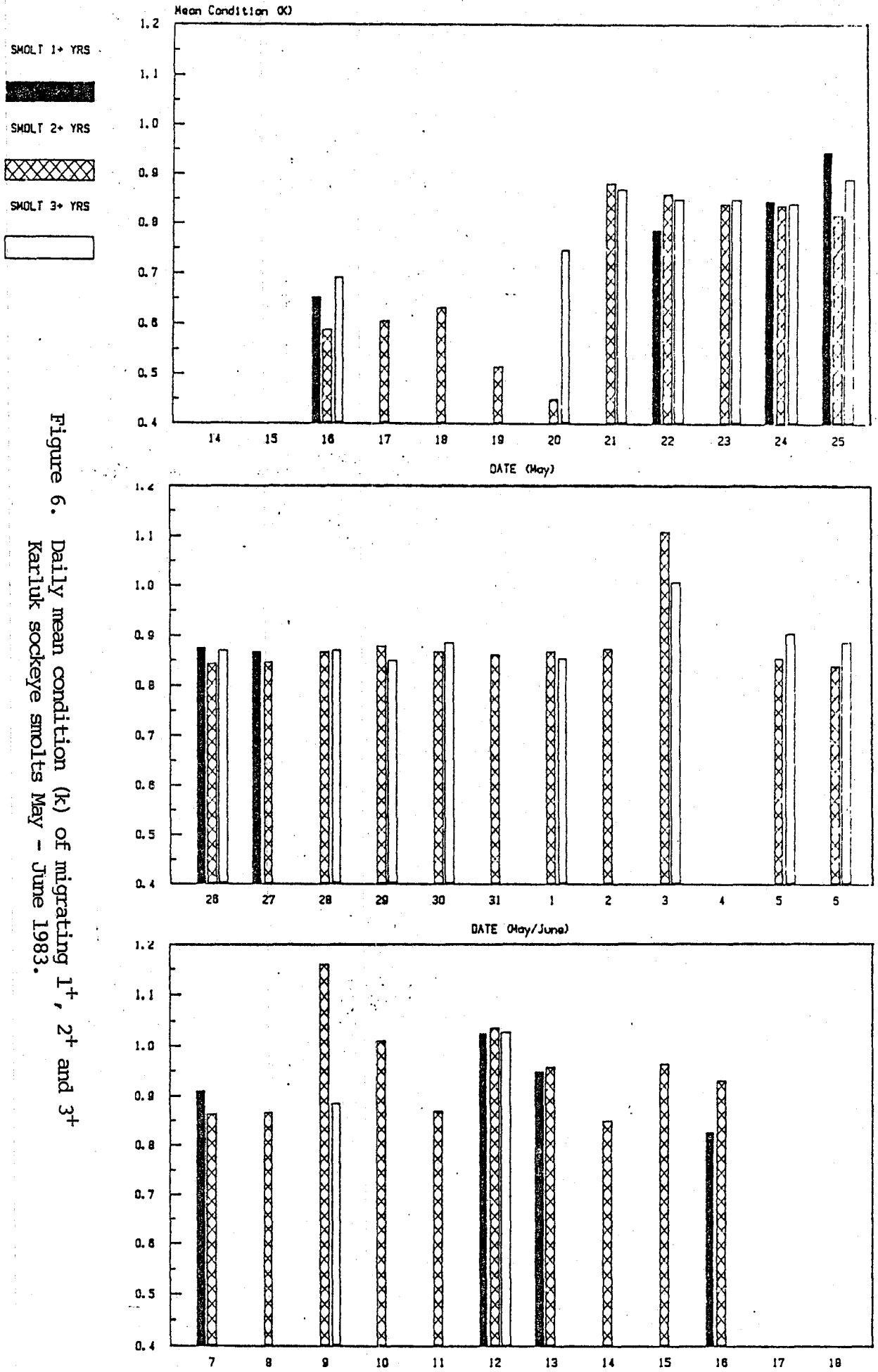

Figure 6. Daily mean condition (K) of migrating 1^+, 2^+ and 3^+ Karluk sockeye smolts May - June 1983.

Table 8. Mean length and condition (k) factors of 2^+ and 3^+ Karluk lake sockeye salmon smolts 1961 - 68[1], 1980 - 82[2], 1983.

Year of Migration	Length (mm)		Condition Factor (k)	
	2^+	3^+	2^+	3^+
1961	114.8	123.5	0.9068	0.8786
1962	112.5	123.1	0.8609	0.8202
1963	118.7	128.6	0.8730	0.8697
1964	127.7	135.7	1.0084	0.9644
1965	126.6	142.4	0.9413	0.9247
1966	115.4	130.9	0.8589	0.8426
1967	112.8	133.1	0.9615	0.9797
1968	113.0	123.5	0.8594	0.8123
1980	102.8	112.5	0.8653	0.8007
1981	111.4	119.7	0.9693	1.0493
1982	119.0	132.0	0.8961	0.8783
1983	116.7	132.0	0.7651	0.8085

1 = Adapted from Gard and Drucker (1961 - 68).
2 = Adapted from White (1980 - 82).

migrants is better represented by examining the daily mean condition factor than a cumulative (K) factor as used by previous investigators.

The 1979-81 parent year escapement of approximately 513, 147 and 221 thousand fish respectively which would produce the corresponding 3^+, 2^+, and 1^+ smolt in 1983 indicate the 2^+ smolt had extremely good survival compared to those 2^+ fish in 1982 (table 7) produced from the 1979 brood year.

Data from Gard and Drucker (1961-68) and White (1979-80) indicate that 2^+ smolt in most years dominate the Karluk smolt population. Linear regression analysis of 2^+ smolt on the total estimated migrant populations for the years 1980-83 indicate a significant correlation ($r \neq 0.95$, $P = <.05$) and for the years 1961-68, 1980-83 combined ($r = 0.84$ $P = <.05$). Recent data (table 7) indicate that 2^+ smolt comprise approximately 65-85 percent and 3^+ smolt approximately 7-14 percent of the total outmigration. Therefore the relative abundance or percent of 2^+ smolt comprising the annual migration should provide a method of monitoring major changes in the age structure of migrating smolt thus a indirect mean of indexing smolt productivity.

CONCLUSION AND RECOMMENDATIONS FOR 1984

Overall the 1983 study appears to have produced an estimate of the Karluk smolt migration that required less logistical support and technical difficulties than that encountered by ADF&G utilizing sonar gear at a more inaccessible site.

Although the 1983 estimate indicated a increase of approximately 13 percent in smolt abundance over 1982 the age structure of migrating smolt remained the same.

The use of a overall or cumulative mean condition (K) factor to adequately describe the fitness of migrating smolt instead of examining daily mean values may lead to erroneous conclusions on overall condition.

Although the determination of total numbers of smolt leaving Karluk lake is desirable for predictive capabilities on adult returns, it does not appear to be necessary in the case of the Karluk smolt studies.

Since the current ADF&G management strategy for Karluk sockeye does not rely on total smolt numbers for predictive purposes and the major thrust of other components of the Karluk lake sockeye studies are to measure relative changes in predation, competition and basic productivity. It would seem more productive in both dollars and effort to utilize a single trap as in 1983 to collect age, weight and length data for 1^+, 2^+, and 3^+ smolt thus indirectly monitor changes in smolt productivity as described earlier.

Several recommendations for 1984 are listed below:

1. Study emphasis be changed from one of determining total numbers of smolt to sampling for age, weight and length as an index for smolt productivity.
2. The Canadian fan trap be modified at the terminal end to alleviate backwater conditions. This would increase sample size approximately 30-40 percent.
3. The study be conducted through the end of June 1984 since some smolt were still being caught by mid-June 1983.

Although the USFWS-KNWR had the lead role during the 1983 smolt work the invaluable assistance was provided in the field by the USFWS-SNFRC-Anchorage Project Leader Dick Wilmot and his Karluk field project personnel contributed to the relative success of the study. In addition most of the trapping and wier material was provided by ADF&G-FRED Division-Kodiak. Also Kit Rawson ADF&G-FRED Division-Anchorage visited the project and provided assistance in statistical analysis of the population estimates

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