FRED Reports

SOCKEYE SALMON SMOLT STUDIES
KASILOF RIVER, ALASKA 1981
BY
Loren B. Flagg
Number 11

Alaska Department of Fish & Game
Division of Fisheries Rehabilitation,
Enhancement and Development

Technical Data Report

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ABSTRACT

The estimated number of sockeye salmon (Oncorhynchus nerka) smolts emigrating from Tustumena Lake in 1981 was 2.26 million. Of these, 1.86 million (82%) were age 1.0 and .4 million (18%) age 2.0. The estimated sockeye salmon smolt biomass produced from the lake was 7.3 x 10^3 kg.

The weighted mean lengths, weights, and ages of migrating sockeye salmon smolts were determined from randomly selected samples. The mean length of age 1.0 smolts was 69.9 mm and the mean weight was 2.8 g. Age 2.0 smolts averaged 86.7 mm in length and 5.1 g in weight.

Sockeye salmon smolts captured in the Kasilof River were examined for missing ventral fins that represented hatchery-released fish. During the migration, 43.8% of the 155,596 smolts caught were examined and 109 marked fish were recovered. The estimated survival rate of marked hatchery fry to age 1.0 smolt was 5.5%. The estimated hatchery contribution to the total smolt outmigration was 298,600 or 13.1%.

Key words: sockeye salmon smolt, (Oncorhynchus nerka), Tustumena Lake, Kasilof River, fan traps, migration estimate, mark and recapture, fin clipped fish, survival rate, and hatchery contribution.

INTRODUCTION

Studies were initiated on the Kasilof River in 1980 to obtain information on the sockeye salmon (Oncorhynchus nerka) smolt emigration from Tustumena Lake and to assess the survival and contribution of hatchery stocked sockeye salmon fry to the total outmigration (Todd et. al. 1981). Hatchery raised sockeye salmon fry have been released into Tustumena Lake every year since 1976 except for 1977 (Appendix Table 1). The stocking was performed by the Division of Fisheries Rehabilitation, Enhancement, and Development (FRED) of the Alaska Department of Fish and Game (ADF&G) in an attempt to enhance sockeye salmon production in the system. This report presents the results of the 1981 smolt project on the Kasilof River including evaluation of the survival of sockeye salmon fry released into Tustumena Lake in 1980 to age 1.0 smolt.

The smolt study site is located on the Kasilof River approximately 7 km upstream from Cook Inlet and 10 m upstream from the confluence of Crooked Creek with the Kasilof River (Figure 1). The Kasilof River drains Tustumena Lake, which is turbid with glacial flour. It is an important sockeye salmon nursery lake with a surface area of 29,100 ha. The average estimated adult sockeye salmon return per year (catch plus escapement) attributed to Tustumena Lake wild stocks was 481,000 from 1975-1981. Average escapement to the lake during this period was 147,000 (Tarbox et. al. 1982).

The objectives of this project were:

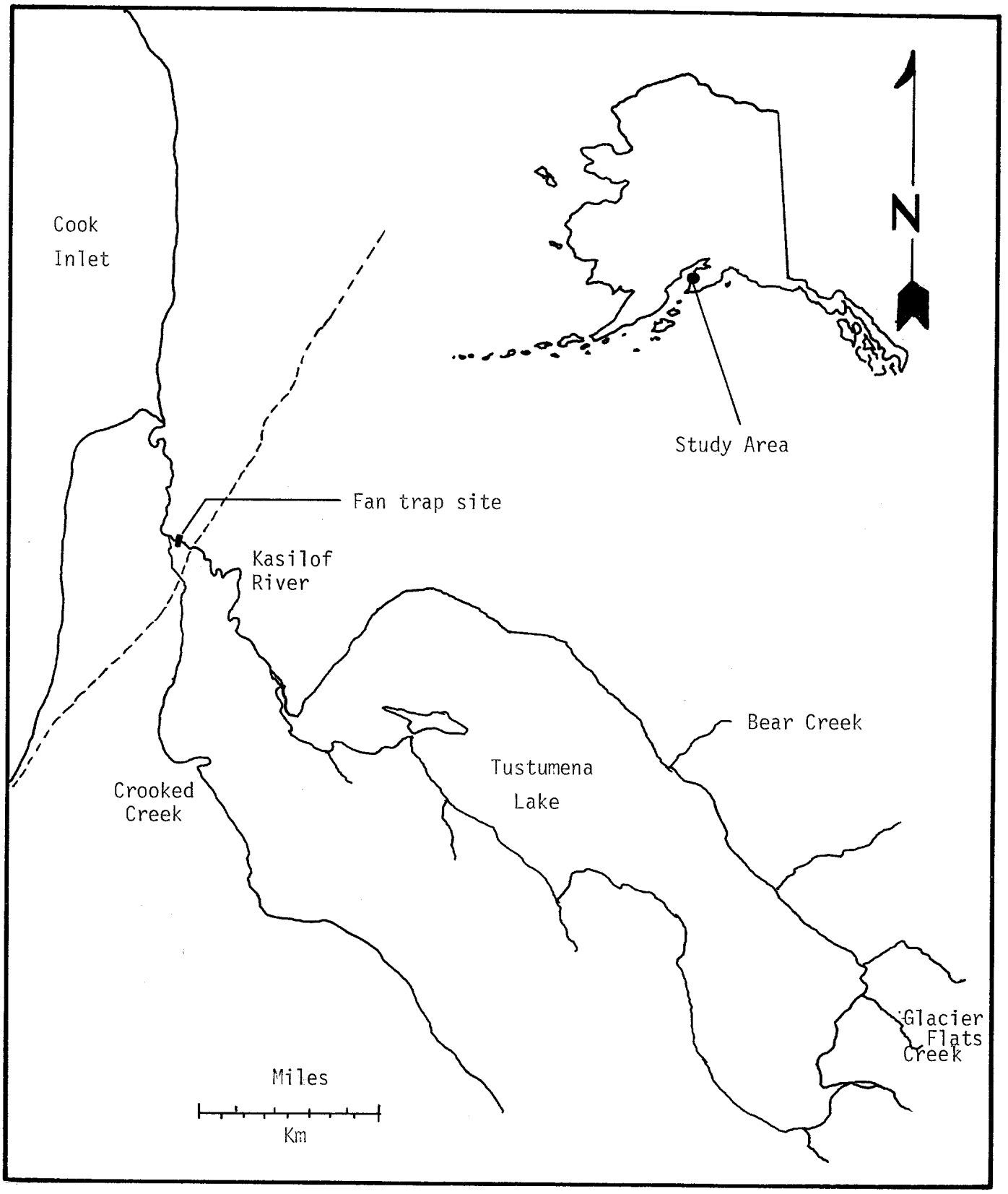

Figure 1. Map showing the relative location of Tustumena Lake, Kasilof River and Crooked Creek.

1. to determine the timing and magnitude of the sockeye salmon outmigration;

2. to assess the survival rate of hatchery-reared sockeye salmon fry and their contribution to the total smolt migration;

3. to determine the age structure and the average weight and length of the migrating smolts.

MATERIALS AND METHODS

Fan-Trap and Live-Box Design

Canadian fan-traps were used to capture smolts and to monitor their migration. The fan-traps were constructed of angle aluminum so they would be light enough to transport yet strong enough to withstand the current and the impact from large debris. The traps are 1.5 m square at the upstream opening, and they are 3 m in length. From the mouth, they taper to a 0.3 m square opening (Figure 2).

The traps were attached to a cable that was secured to large boulders in the river. The traps were further anchored by 20-mm steel reinforcing rods driven into the riverbed through eyelets on the bottom front edge of the traps. Aluminum tripods equipped with a pulley system were used to adjust the height of the downstream end of the traps. Elevation adjustments were made to accommodate different water levels and to prevent the downstream trap end from becoming submerged.

Holding boxes were connected to the downstream trap end by a camlock fitting. The live-boxes were rectangular with dimensions of 1.5 x 0.9 x 0.6 m. The front, back, and bottom were constructed of .75 inch plywood and the remaining two sides of perforated aluminum plate. These boxes were floated by attaching styrofoam panels to both sides. The bottom was vented to provide continual water circulation (Figure 3).

Smolt Sampling and Enumeration

Five fan-traps were placed in the river on 6 May (Figure 4). A sixth older model trap with a 1 m square upstream opening was placed in the river on 17 May. All six traps were fished until 1 July for a total time of 56 days.

All fish captured by the fan-traps were enumerated by species and released daily. Weights (g), fork lengths (mm), and scale samples ("AWL data") were collected daily from 20 randomly selected sockeye salmon smolts. In addition, the lengths of 30 more sockeye salmon smolts were measured daily. An anesthetic, Tricaine methanesulfonate (MS-222), was administered to sample smolts for ease in AWL data gathering.

Each year, prior to release, a portion of the Crooked Creek Hatchery reared sockeye salmon fry are marked for identification by clipping either the right or left ventral fin. Therefore, each day the ventral fins of a minimum of two thousand sockeye salmon smolts were examined. The numbers

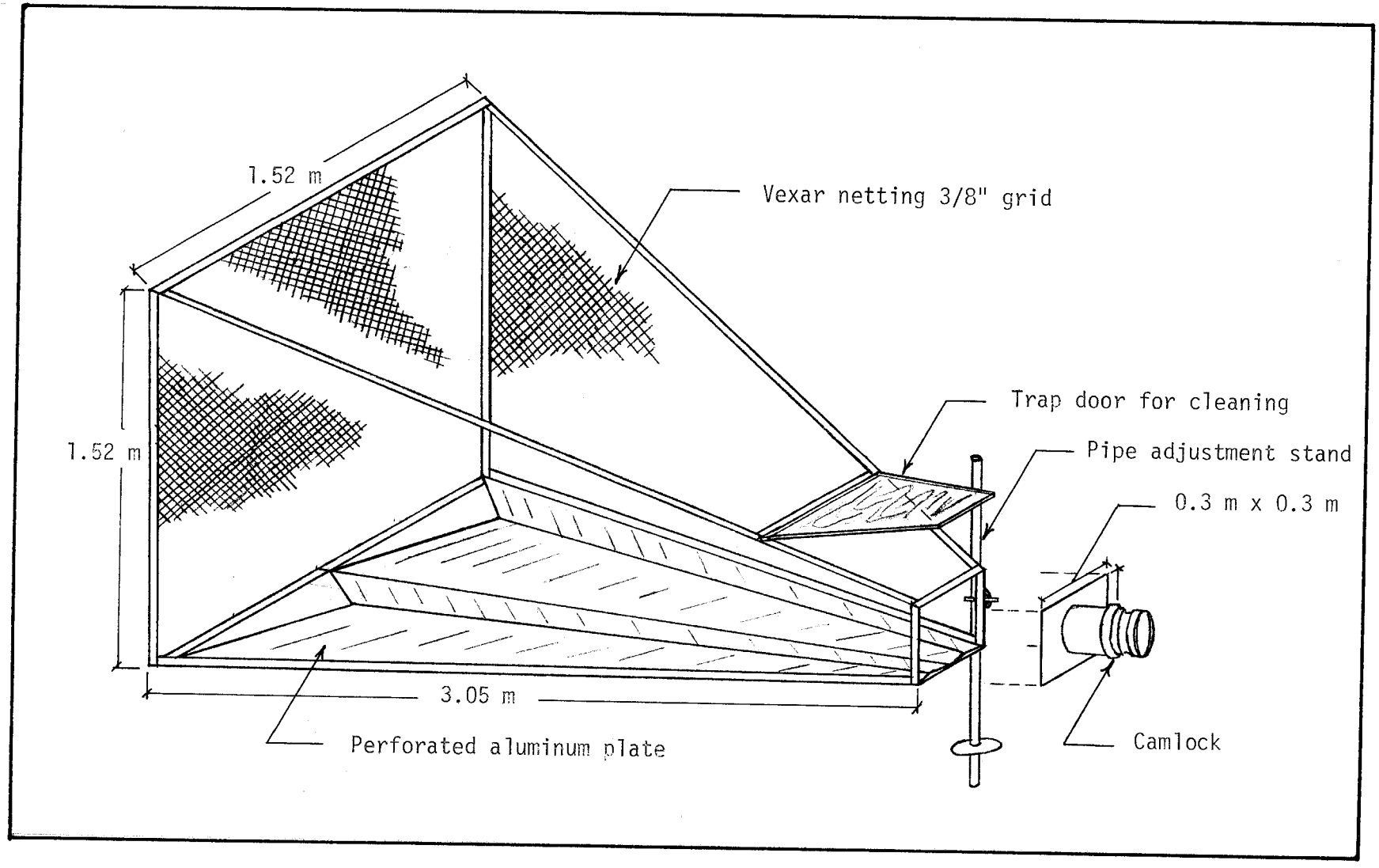

Figure 2. Schematic diagram of the Kasilof River smolt fan-trap.

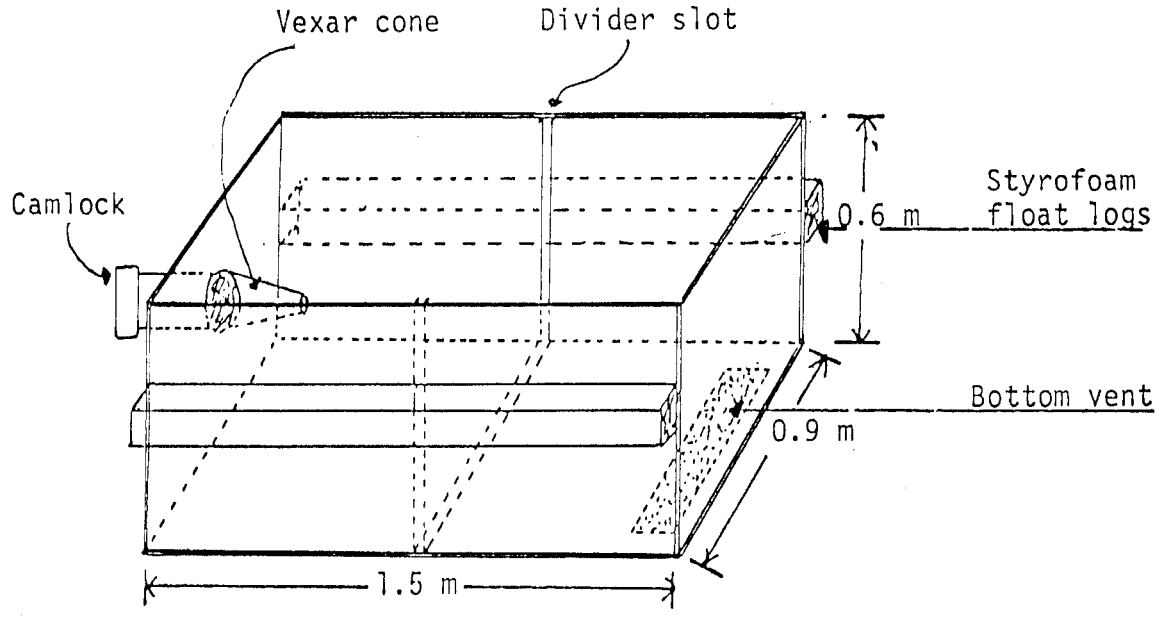

Figure 3. Schematic diagram of the live-box used to capture migrating smolts.

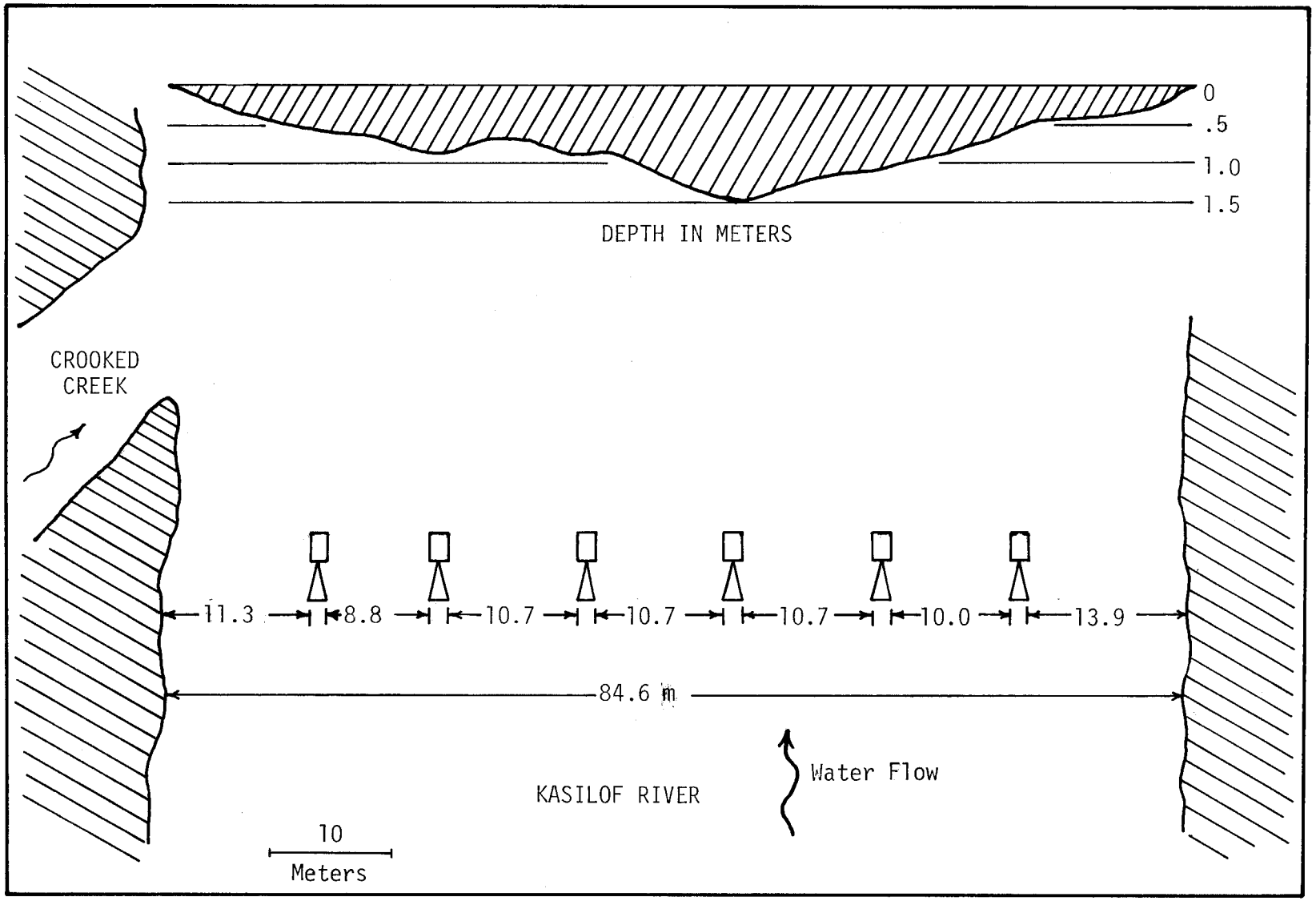

Figure 4. Sampling location of fan traps in the Kasilof River and water depths along the sampling transect, 9 June, 1981.

of marked fish provided information to determine the hatchery-fry survival rate and contribution to the total outmigration.

On 6 June, the traps were checked every 3 h for 24 h to determine diel changes in the rate of smolt migration.

Smolt Population Estimate

The trap efficiency (interception rate) was estimated four times during the migration period by a simple mark and recapture procedure. This involved placing several hundred smolts into a holding tank containing a Bismark Brown Y dye solution (1 g dye per 30 L H_2O) for 30 minutes. The smolts became gold tinted and were easily distinguished from undyed smolts. The holding tank was equipped with an aeration system that provided a continuous flow of bottled oxygen. The tank was transported approximately 1.6 km upstream by riverboat, and the smolts were distributed evenly across the river. The numbers of dyed smolts recovered in the traps were used to estimate the proportion of smolts that were intercepted by the fan traps and to provide a measure of "trap efficiency". The trap efficiency, expressed as a percentage, was applied to the total smolt catch to estimate the total outmigration.

Rawson (1982) discusses the estimation of migrating smolt populations from dye marking data. The population estimate he recommends is calculated according to the formula:

$$\hat{N} = \frac{nD}{d} \; 1 + \frac{D-d}{Dd} \qquad [1]$$

Where: $\hat{N}$ = estimated total population
D = number of fish dyed

d = number of dyed fish recaptured
n = number of unmarked smolt caught in traps

The estimated variance of $\hat{N}$ may be calculated from the formula [see Rawson (1982)]:

$$\text{Var}(\hat{N}) = n(n + d)\, D(D - d)/d^3. \qquad [1]$$

Using this quantity, a 95% confidence interval for $\hat{N}$ may be determined under the assumption of a normal distribution for N.

The percent composition of age 1.0 and 2.0 smolts was estimated for each weekly period from the daily sampling results. This percentage was then applied to the weekly total trap catch and expanded, based on dye test results, to represent the total outmigration for each week by age class.

Table 1. Daily catches of sockeye salmon smolts by trap, Kasilof River, 1981.

Date	Daily 1	2	3	4	5	6	Total
May							
7	0	0	0	18	7	0	25
8	0	0	2	19	14	0	35
9	0	0	3	43	13	0	59
10	0	0	5	105	40	0	150
11	0	1	10	135	41	1	188
12	0	5	17	284	78	2	386
13	0	10	33	943	150	3	1,139
14	0	26	90	1,707	316	12	2,151
15	0	17	46	1,331	218	8	1,620
16	0	19	64	989	210	11	1,293
17	0	34	125	1,267	237	19	1,682
18	1	46	107	1,097	155	5	1,411
19	0	18	63	718	170	8	977
20	1	29	49	583	135	10	807
21	1	64	225	2,328	788	58	3,464
22	4	297	712	5,857	1,032	110	8,012
23	10	235	684	4,950	1,162	128	7,169
24	8	213	617	4,142	1,176	63	6,219
25	6	134	376	1,679	423	30	2,648
26	10	165	592	2,796	822	53	4,438
27	5	124	650	2,584	887	55	4,305
28	3	99	450	2,130	831	37	3,550
29	3	159	539	3,247	700	104	4,752
30	1	428	2,397	6,786	2,244	219	12,075
31	9	343	1,338	4,510	1,013	120	7,333
Jun							
1	4	174	836	2,368	598	89	4,069
2	12	391	1,650	7,082	947	231	10,313
3	12	263	2,181	5,236	1,914	137	9,743
4	12	364	3,503	4,059	1,572	301	9,811
5	3	423	1,197	2,160	985	193	4,961
6	7	242	567	2,087	546	112	3,561
7	5	204	744	1,010	463	85	2,511
8	6	448	3,390	2,605	1,492	575	8,516
9	3	223	1,242	1,233	304	162	3,167
10	1	211	238	1,149	480	295	2,374
11	8	392	2,221	985	364	253	4,223
12	4	121	1,058	700	233	165	2,281
13	4	144	1,015	709	222	150	2,244
14	1	138	783	651	160	128	1,861
15	8	91	603	440	103	137	1,382
16	5	188	589	468	140	61	1,451
17	0	89	625	335	70	62	1,181
18	0	71	644	274	58	47	1,094
19	1	82	391	137	29	38	678

Table 1. (continued)

20	5	26	293	207	55	51	637
21	0	117	214	215	33	19	598
22	0	32	634	162	27	34	889
23	0	13	129	88	13	15	258
24	0	62	266	78	15	31	452
25	0	130	207	143	18	43	541
26	0	14	102	69	12	9	206
27	0	23	88	17	5	8	141
28	0	42	89	0	10	5	146
29	0	38	172	5	6	33	254
30	0	24	65	4	3	6	102
Jul 1	0	6	23	0	0	14	43
Totals	163	7,252	34,984	84,923	23,729	4,545	155,596
% of Total	0.1%	4.7%	22.5%	54.6%	15.2%	2.9%	

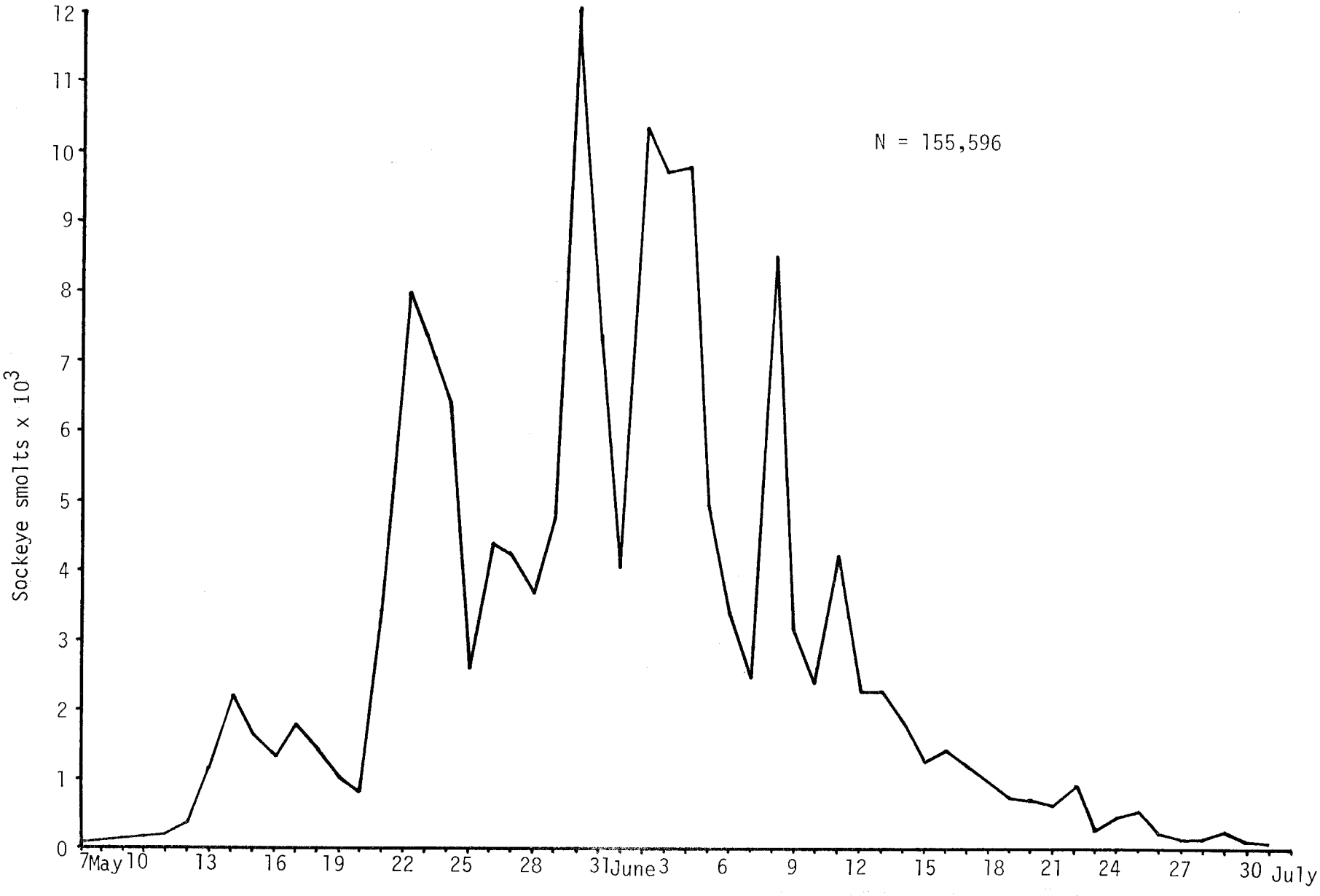

Figure 5. Daily catches of sockeye salmon smolts in fan traps, Kasilof River, 7 May-1 July 1981.

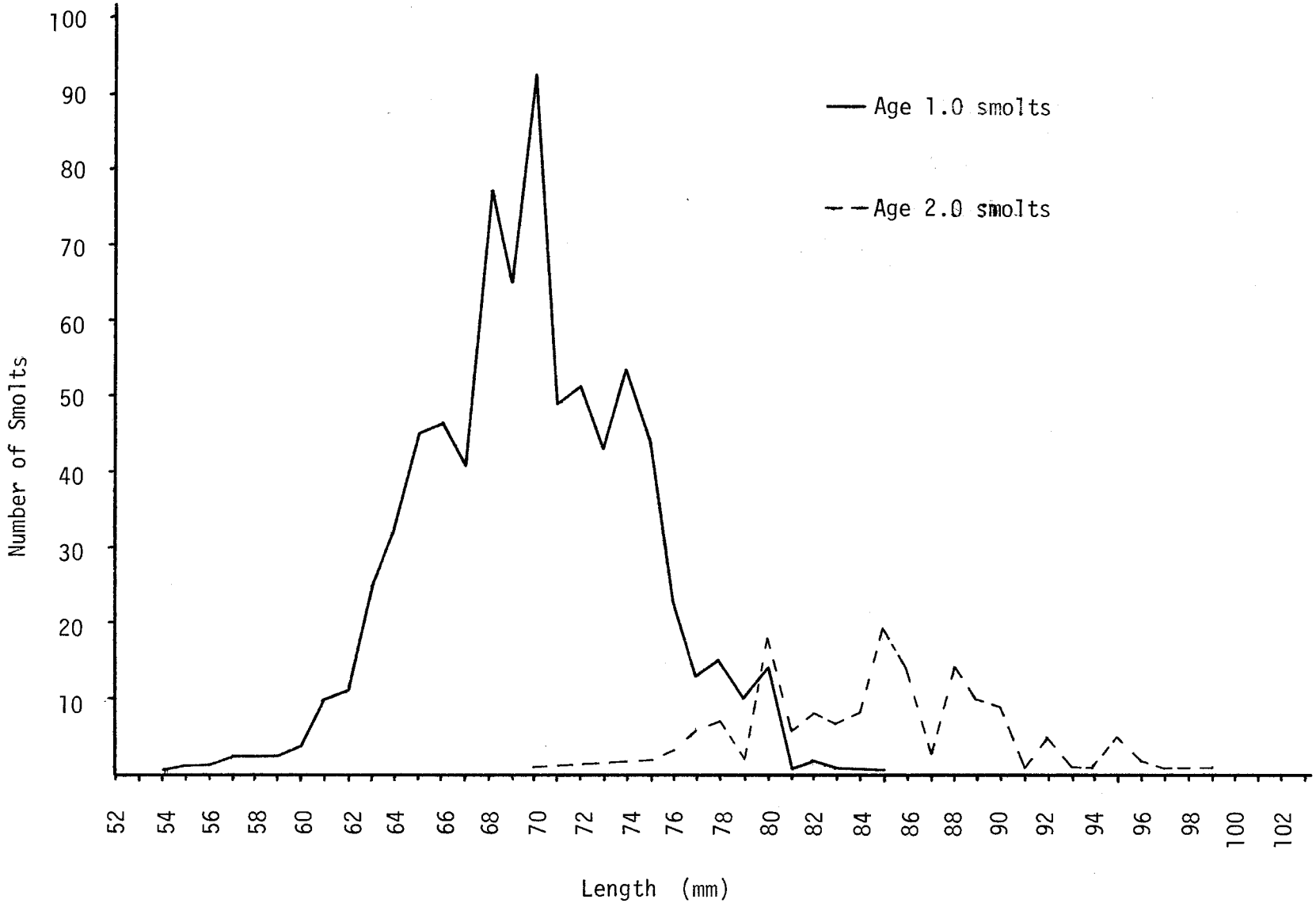

Figure 6. Length frequency of age 1.0 and age 2.0 sockeye salmon smolts, Kasilof River 1981.

Table 2. Mean lengths and weights of sockeye salmon smolts, Kasilof River, 1981.

Sample period	Dates	Mean length (mm)	S.D.	Mean weight (g)	S.D.	Sample size
Age 2.0						
1	5/07-5/13	81.4	4.6	4.8	.7	45
2	5/14-5/20	84.3	5.4	4.8	.9	22
3	5/21-5/27	86.8	3.9	5.2	1.0	21
4	5/28-6/03	86.7	4.9	5.2	.8	27
5	6/04-6/10	88.0	3.8	5.1	.8	20
6	6/11-6/17	86.8	4.0	4.9	.7	9
7	6/18-6/22	83.0	5.7	4.8	.8	8
8	6/23-7/01	93.0	--	6.6	--	1
	Season	87.7[1]	4.6	5.1[1]	.8	153
Age 1.0						
1	5/07-5/13	66.2	4.8	2.7	.5	73
2	5/14-5/20	67.4	4.3	2.5	.5	98
3	5/21-5/27	69.9	5.2	2.8	.6	104
4	5/28-6/03	69.9	3.9	2.8	.5	112
5	6/04-6/10	70.4	4.5	2.8	.5	82
6	6/11-6/17	70.5	4.2	2.9	.5	111
7	6/18-6/22	71.0	4.6	3.2	.6	92
8	6/23-7/01	72.4	4.1	3.5	.6	119
	Season	69.9[1]	4.4	2.8[1]	.5	791

[1] Weighted by weekly estimated total migration in this age class.

Hatchery Contribution and Survival Rate

In June 1979, 7.76 million sockeye fry from the Kasilof Hatchery were released into Bear Creek and Glacier Flats Creek, tributaries of Tustumena Lake. Of these, 66,597 or .86% were marked by ventral fin clips (Bear Creek-LV; Glacier Flats Creek-RV). Age 1.0 sockeye salmon smolts from the 1979 fry release migrated from Tustumena Lake during 1980 and age 2.0 smolts from the same release migrated during 1981.

In June 1980, 5.20 million hatchery-reared sockeye salmon fry were released from the Kasilof Hatchery into Bear Creek and Glacier Flats Creek. A total of 65,427 or 1.26% of those fry were fin clipped. The survivors of these fry migrated out of the lake as age 1.0 smolts in 1981.

During 1981 the sockeye salmon smolts caught in the fan traps were inspected for clipped ventral fins. The number of marked fish recovered was then used to estimate the hatchery fry survival and contribution to the total smolt migration. The formula used for calculating the variance of this estimate was developed by Dan Reed, and it is available in an HP-97 program from the FRED Biometrics section in Anchorage (Howe 1981).

Physical Parameters

Discharge in cubic feet per second was measured with a Teledyne Gurley meter. Velocity measurements were taken 2 m in front of each trap to avoid any turbulence created by the traps. To correlate with trends in the smolt migration, discharge measurements were made on five separate days: 18 May, 21 May, 31 May, 9 June, and 25 June.

Total discharge was also measured periodically throughout the study using a U. S. Geological Survey water gauge located at the Kasilof River - Sterling Highway bridge.

Water temperatures (¼C) were recorded daily at the trap site to assess any relationship between smolt migration and water temperature.

RESULTS

Smolt Enumeration and Sampling

Between 7 May and 1 July, 155,596 sockeye salmon smolts were captured in the six fan traps (Table 1). The peak of the migration occurred between 22 May and 7 June when 94,446 smolts (60.7% of the total catch) were caught (Figure 5). The highest daily catch occurred on 30 May when 12,075 smolts were captured.

Scales were collected and the weights and lengths of 944 sockeye salmon smolts were measured. The mean lengths of age 1.0 and age 2.0 smolts were 69.9 mm and 86.7 mm, respectively, but some of the age 1.0 smolts were longer than some of the age 2.0 smolts (Figure 6, Table 2). The mean weights of age 1.0 and age 2.0 smolts were 2.8 g and 5.1 g, respectively (Table 2).

During 1981, 82% of the smolts were age 1.0 and 18% were age 2.0. Although the peak migration of age 1.0 and 2.0 smolts occurred during the same week (28 May - 3 June), age 2.0 smolts made up a larger proportion of the catch during the first week of the migration (38%) and then declined rapidly, especially after the peak week (Table 3).

In addition to sockeye salmon, nine other fish species, including three other Pacific salmon species, were captured and enumerated in the Kasilof River fan traps (Table 4). Of these, pink salmon (Oncorhynchus gorbuscha) were the most abundant; 19,508 were caught. Most pink salmon fry were caught during the week of 14 May - 20 May when 11,785 (60.4%) were enumerated. The pink salmon migration, which was well under way when sampling began on 7 May, was essentially completed by 1 June.

Smolt Population Estimate

Four trap efficiency tests were conducted during the migration. The trap efficiency (percentage of dyed smolts recaptured) was highest on the first trial on May 19 (8.35%) and then decreased with each succeeding trial to 5.69% on June 24. A total of 2,560 dyed smolts were released, and 176 were recaptured during the four tests. The overall estimated trap efficiency was 6.87%.

	Number of dyed smolts		Trap efficiency		
				95% confidence interval	
Date	Released	Recovered	Estimate	Lower	Upper
19 May	539	45	8.35	6.22	11.09
27 May	1,012	70	6.91	5.47	8.70
6 June	500	32	6.40	4.49	9.01
24 June	509	29	5.69	3.91	8.18
Total	2,560	176	6.87	5.94	7.94

Table 3. Age composition of sockeye salmon smolts, Kasilof River, 1981.

Sample Period	Smolt Age Percent 1.0	Smolt Age Percent 2.0	Sample Size	Total Trap Catch	Catch Composition 1.0	Catch Composition 2.0	Estimated[1] Total Outmigration 1.0	Estimated[1] Total Outmigration 2.0
5/07-5/13	62	38	118	1,982	1,229	753	17,894	10,964
5/14-5/20	82	18	121	9,941	8,152	1,789	118,679	26,047
5/21-5/27	83	17	122	36,255	30,092	6,163	438,139	89,733
5/28-6/03	80	20	140	51,835	41,468	10,367	603,774	150,943
6/04-6/10	80	20	100	34,901	27,921	6,980	406,529	101,628
6/11-6/17	93	7	120	14,623	13,599	1,024	198,001	14,909
6/18-6/22	92	8	100	4,606	4,238	368	61,705	5,358
6/23-7/01	99	1	119	1,433	1,419	34	20,660	495
Totals	82	18	940	155,596	128,478	27,478	1,865,378	

[1] Catch x 14.56 (since traps caught 6.87% of migration).

Table 4. List of species captured by fan-traps in the Kasilof River, 1980 and 1981.

Common Name	Scientific Name	Catch 1980	Catch 1981
Sockeye salmon	*Oncorhynchus nerka* (Walbaum)	64,535	155.596
Chinook salmon	*Oncorhynchus tshawytscha* (Walbaum)	335[1] 2,933[2]	1,413[1] 8,367[2]
Coho salmon	*Oncorhynchus kisutch* (Walbaum)	45	19,508
Pink salmon	*Oncorhynchus gorbuscha* (Walbaum)	436	107
Dolly Varden	*Salveninus malma* (Walbaum)	90	132
Rainbow trout	*Salmo gairdneri* (Richardson)	1	-
Round whitefish	*Prosopium cylindraceum* (Phallas)	3	-
Eulachon	*Thaleichthys pacificus* (Richardson)	-	9
Slimy sculpin	*Cottus cognatus* (Richardson)	681	4,929
Threespine stickleback	*Gasterosteus aculeatus* (Linnaeus)	181	2,994

[1] Smolt
[2] Fry

Since the results from the four dye tests were not significantly different ($x^2 = 3.12$, d.f. = 3), they were combined to make the population estimate (Figure 7).

The estimated 1981 Kasilof River sockeye salmon smolt migration, based on equation [1] was 2.276×10^6 smolts.

Then, using the variance formula in equation [2], and, assuming that $\hat{N}$ follows a normal distribution, the 95% confidence interval was:

$$95\% \text{ C.I.} = 1.953 \times 10^6 \text{ to } 2.599 \times 10^6$$

Of the estimated total smolt migration, 1.86 million were age 1.0 and 0.4 million were age 2.0 (Table 3). The peak of the migration for age 1.0 and age 2.0 smolts occurred during the week of 28 May - 3 June with an estimated 604,000 and 151,000, respectively.

The estimated biomass of sockeye salmon smolts migrating from Tustumena Lake was 7.3×10^3 kg (Table 5).

Hatchery Contribution and Survival Rate

A total of 68,053 sockeye salmon smolts or 43.8% of the smolts captured in the fan-traps were examined for clipped ventral fins. Of these, 109 smolts were missing fins: 45 from Bear Creek and 64 from Glacier Flats Creek. Only three of these or 2.75%, were age 2.0 smolts.

Survival to age 1.0 of the marked hatchery sockeye salmon fry released into Tustumena Lake in 1980 was estimated at 5.4%. The total survival rate will be greater, since the age 2.0 smolts from the 1980 release will not migrate until 1982. Survival of 1979-released fry to age 2.0 was estimated at 0.15%. Total estimated survival rate of the 1979 hatchery-released fry was 0.46% (.31% to age 1.0; .15% to age 2.0).

The estimated contribution of hatchery-produced fish to the 1981 Kasilof River sockeye salmon smolt migration was:

Brood year	Smolt age	Survival of marked fish ±95% CI		Total release	Hatchery contribution
1978	2.0	0.0015 ±0.0017	x	7.76×10^6	11,600 ±13,200
1979	1.0	0.0542 ±0.0103	x	5.20×10^6	282,000 ±53,600

The estimated total number of hatchery sockeye smolts in the 1981 migration was 293,600 fish and the estimated hatchery contribution was 13.1% of the total.

Table 5. Estimated sockeye salmon smolt biomass migrating from Tustumena Lake, 1981.

Sample Period	Mean Weight (g)		Estimated No. Migrants		Estimated Biomass (kg)	
	1.0	2.0	1.0	2.0	1.0	2.0
5/07-5/13	2.7	4.8	17,894	10,974	48.3	52.6
5/14-5/20	2.5	4.8	118,679	26,047	296.7	125.0
5/21-5/27	2.8	5.2	138,139	89,733	1,226.8	466.6
5/28-6/03	2.8	5.2	603,774	150,943	1,690.6	784.9
6/11-6/17	2.9	4.9	198,001	14,909	574.2	73.0
6/18-6/22	3.2	4.8	61,705	5,358	197.4	17.1
6/23-7/01	3.5	6.6	20,660	495	72.3	1.7
Season	2.8	5.1	1,865,378	400,077	5,244.6	2,039.2

Total Estimated Biomass = 7,283.8 kg (7.3×10^3 kg)
7.3×10^3 kg ÷ 29,107 ha = .25 kg/ha (250 g/ha)

Physical Parameters

Kasilof River Discharge:

During 1981, the discharge in the Kasilof River was higher than normal. Because of warm weather, a large volume of glacial water entered Tustumena Lake and, eventually, the Kasilof River. The discharge during May (18 May - 1,042, 21 May - 1,079 CFS, and 31 May -1,289) was nearly twice the 20 year average May discharge of 664 (Scully et. al. 1978). During June, the discharge was also above the average of 1,369 (9 June - 1,707 CFS, 25 June - 2,281). Typically, the discharge of the Kasilof River does not exceed 2,000 until 30 June.

Discharge readings at the U.S.G.S. gauge on the Kasilof River at the Sterling Highway bridge were taken periodically to check the accuracy of our discharge measurements at the smolt trapping site. The first two gauge readings taken in May (18 May - 1,060 CFS, 21 May - 1,170 CFS) compared favorably with the above Gurley meter measurements, however the 31 May (1,590 CFS), 9 June (1,940 CFS), and 25 June (2,560 CFS) gauge readings ranged from 12% to 23% higher. I believe this was due to the difficulty in operating the Gurley meter during high water conditions at the smolt trapping site.

The percentage of the total discharge passing through the individual traps and through all six traps was similar during each of the five days that discharge measurements were made. There was a direct correlation between the distribution of the discharge within the river and the percentage of smolts caught in each of the traps (Figure 8). The highest smolt catches were consistently made in the center of the river where the greatest discharge occurred.

Water Temperature:

The lowest water temperature recorded during the smolt migration was 6.7°C (44°F) on 26 May. The highest temperature was 14.4°C (58°F) recorded on 23 June. The mean high temperatures for May and June were 10.0°C (49.9°F) and 11.4°C (52.4°F), respectively.

During the early part of the migration there was a direct relationship between rising water temperatures and numbers of sockeye smolts. However, after 11 June the numbers of smolts caught declined while the water temperature continued to increase (Figure 9).

Diel Distribution:

Between 1200 h on 6 June and 1200 h on 7 June, 3,139 smolts were captured; most were caught between 0300 and 0900 (Figure 10). The fewest were captured between 0900 and 1200 h. Except for 1200 h on 7 June, it appears that more smolts migrate during the day (0600-1800 h) than at night.

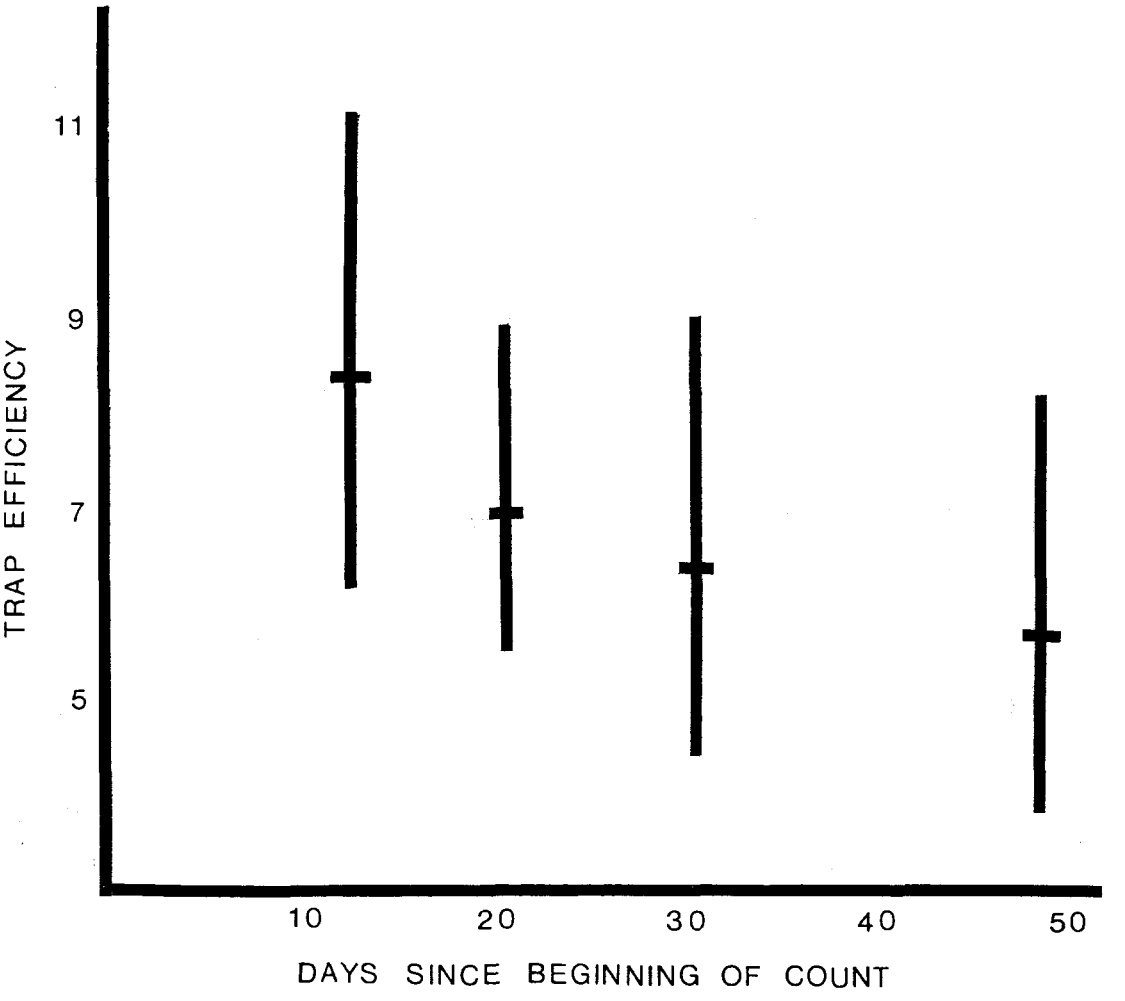

Figure 7. Trap efficiency (percentage of dyed fish recaptured) and 95% confidence intervals (vertical bars) for each of the Kasilof River dye tests in 1981.

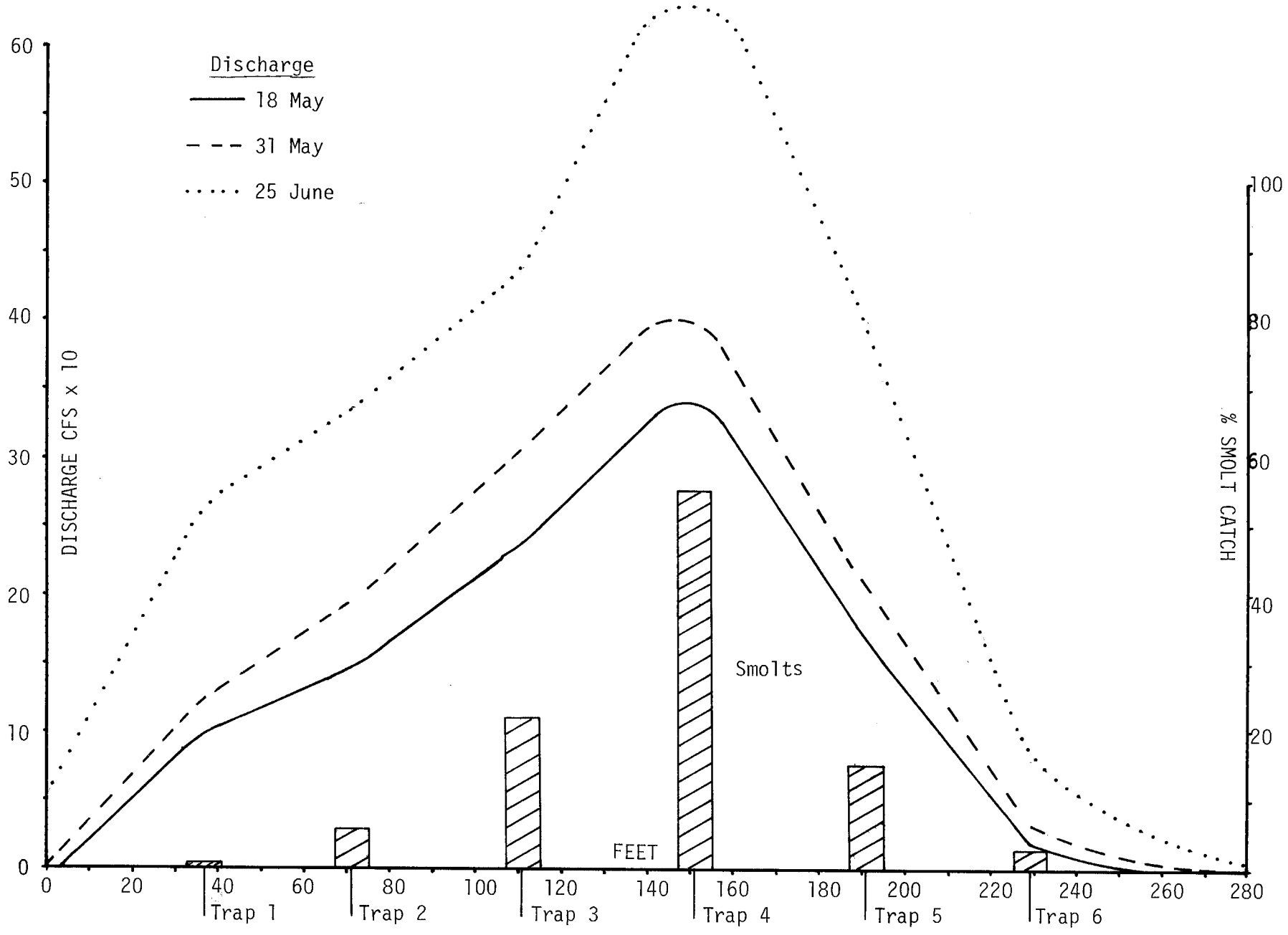

Figure 8. The distribution of discharge and percentage distribution of smolts trapped in the Kasilof River, 1981.

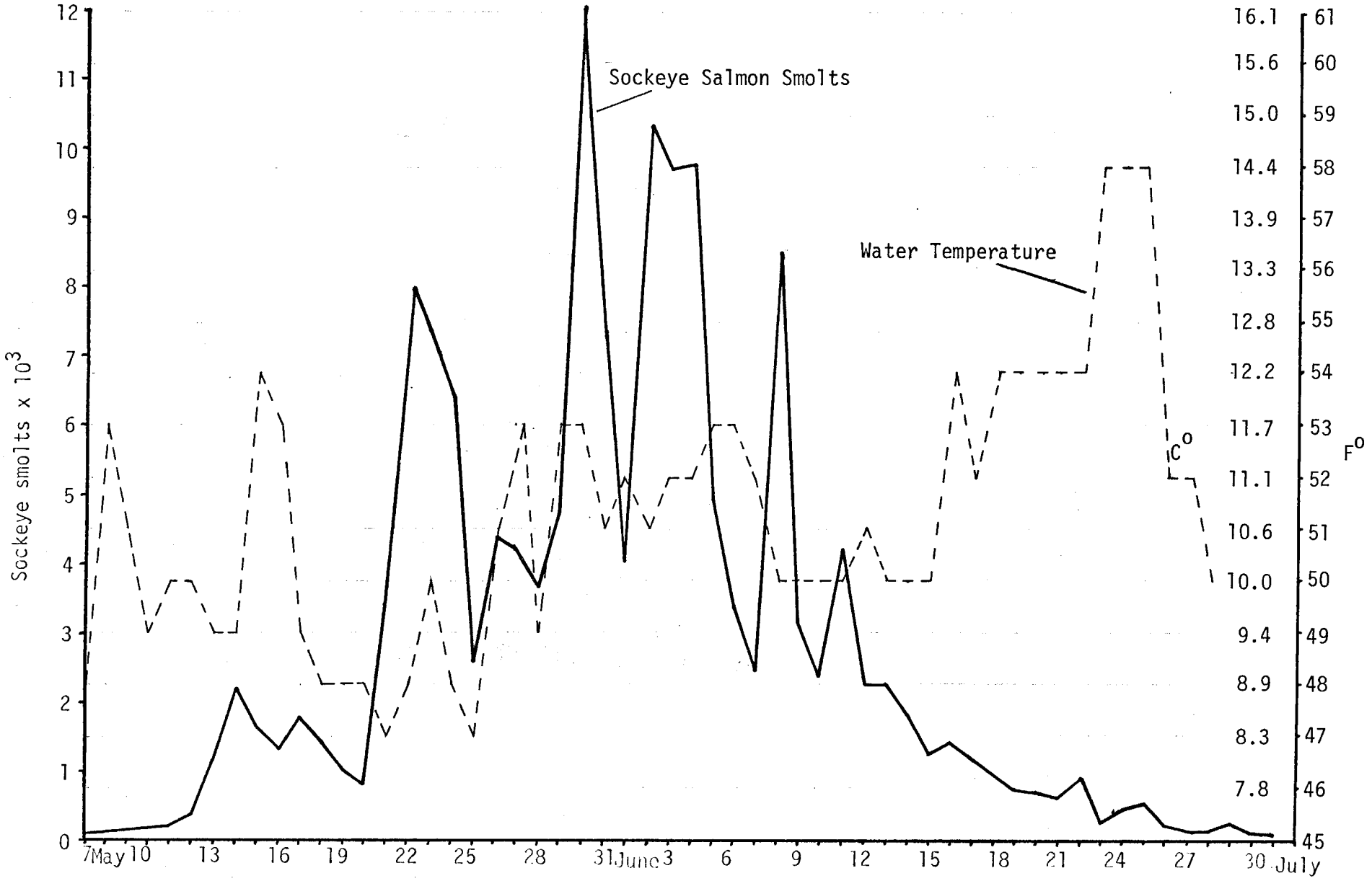

Figure 9. Number of sockeye salmon smolts caught daily and daily maximum water temperature in the Kasilof River, 1981.

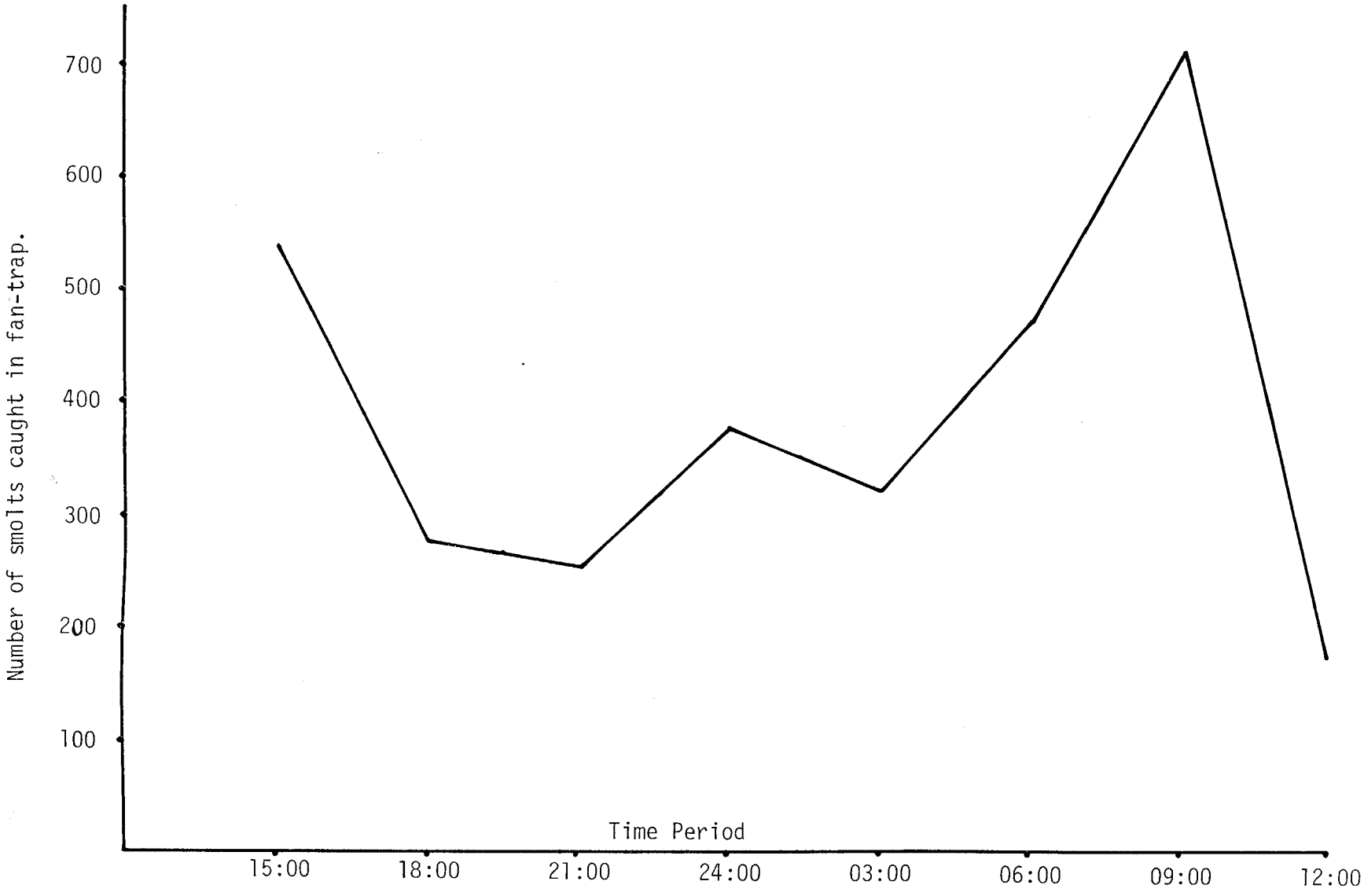

Figure 10. Diel migration pattern of Sockeye salmon smolts in the Kasilof River during 24 hour period, 6-7 June 1981.

DISCUSSION

The smolt monitoring project conducted in the Kasilof River during 1981 ran more smoothly than during 1980 because of experience gained during the first year and design modifications made in the fan traps. The addition of a tripod stand with a pulley system to adjust the elevation of the downstream end of the traps resulted in an easier and more efficient operation. An improved camlock plate connection resulted in better water flow through the traps; however, some smolts (approximately 15%) were killed when the discharge approached 2,000. During 1982 we may modify the downstream end of one of the center traps to allow more water flow to the live-box. We may also construct an inclined plane trap for use in the middle of the river where the flow is greatest to test its suitability for operation in the Kasilof.

The dye mark and recovery method, which estimates the efficiency of the fan traps, has several advantages: (1) An estimate of the trap efficiency with confidence intervals is obtained; (2) any trap avoidance by the smolts is incorporated in the trap efficiency; (3) it is easily and rapidly performed in the field with no expensive equipment required; (4) smolt handling is reduced to a minimum; (5) since this is a simple procedure, it can be readily repeated; and (6) results from each calibration are readily calculated.

Though the trap efficiency did not change significantly during this study, the proportion of recaptured dyed fish declined as the river discharge increased. Consequently, I will determine the trap efficiency each week during 1982. Ordinarily, this is frequent enough unless the discharge of the river changes rapidly. During 1982, I will also release some dyed fish closer to the trap to minimize possible differential predation by birds on dyed smolts. We will attempt to measure differences in recapture rates between this release site (approximately .4 km upstream) and the original release site (1.4 km upstream).

The 1981 sockeye salmon smolt migration consisted of an estimated 82% age 1.0 and 18% age 2.0. During 1980, an estimated 91% were age 1.0 and 9% were age 2.0. By comparing this with sockeye salmon smolt age composition data from other glacial and semi-glacial systems in Cook Inlet it appears that the age structure of Kasilof River sockeye salmon smolts in 1981 was not unusual. For example, the Commercial Fisheries Division reported that in 1969, the age composition of smolts in the Kasilof River was 72% age 1.0, 28% age 2.0; and, studies on the lower Kenai River in 1969 and 1970, which would have included fish from both glacial and clear water rearing systems, showed an average age composition of 71% age 1.0 and 29% age 2.0 for both years (ADF&G 1969-1970). More recently, studies at the outlet of glacial Kenai Lake in 1981 showed an age composition of 51% age 1.0, 49% age 2.0 (Litchfield 1982). In the semi-glacial Crescent Lake system on the west side of Cook Inlet, sockeye salmon smolts were 72% age 1.0 and 28% age 2.0 (Kyle and Koenings 1982). I will continue to collect and analyze scales from Kasilof River smolts to determine if changes occur in the age composition with increased fry stocking in Tustumena Lake.

The size of sockeye salmon smolts migrating from Tustumena Lake in 1980 and 1981, as measured by mean lengths and weights, was similar to that of smolts from two other glacial systems in Cook Inlet:

Year	Location	Mean Length (mm)		Mean Weight (g)	
		Age 1.0	Age 2.0	Age 1.0	Age 2.0
1980	Kasilof River	68	86	2.7	4.7
1981	Kasilof River	70	87	2.8	5.1
1981	Kenai River	62	72	2.1	3.1
1981	Crescent Lake	68	76	2.8	3.8

Sockeye salmon smolts from clear water systems in Cook Inlet and other areas of Alaska, however, have substantially better growth as juveniles. Kyle's (1982) summary of data for different clear water lakes in Alaska showed an average length and weight of age 1.0 smolts of 95 mm and 9.8 g, respectively. Age 2.0 smolts averaged 118 mm in length and 20.8 g in weight. He postulated that the smaller-sized smolts from glacial or semi-glacial lakes are a reflection of fry rearing conditions since both the quality and the quantity of zooplankton in these types of lakes are much lower than that found in clear water systems. Further evidence of this comes from the 1980 stocking of Tustumena Lake sockeye fry into Leisure Lake, which is a clear water system with high zooplankton density on the lower Kenai Peninsula. These fry, which were from the same lot of fish stocked into Tustumena Lake in 1980, averaged 97 mm in length as age 1.0 smolts, or 27 mm longer than their counterparts smolted in the Kasilof River (Dudiak 1982).

The 1981 Kasilof River sockeye salmon smolt outmigration estimate of 2.26 million was about three times greater than the estimate of 722,000 for 1980. Rearing conditions were obviously better during 1980 than the previous year and the survival rate of marked fry to age 1.0 smolts was better during 1981 (5.52%) than 1980 (.31%).

There is some evidence that the survival rate of fin-clipped fish is less than that of nonclipped fish. Nicola and Cordone (1973) observed a 60 to 70% long-term reduction in survival in rainbow trout after the removal of a ventral fin. Weber and Wahle (1969) estimated that a 39% differential mortality rate in sockeye salmon resulted from the removal of the adipose fin and part of the left maxillary. Foerster (1968) reported that marking experiments on sockeye salmon at Cultus Lake suggest a 62% differential mortality due to marking and/or absence of excised fins. There is some indication that fin regeneration may cause a substantial loss of marks. Hauser (1982) estimated a 47% mark loss rate due to fin regeneration in sockeye salmon fry only 8 months after removal of a ventral fin.

If the survival rate of the ventral fin-clipped sockeye salmon fry released in 1980 is actually less than the survival rate of the unmarked fry, then the hatchery contribution to the total smolt outmigration would be greater

than we have reported. If we assumed an average mark loss rate of 50% (which may be reasonable), then hatchery contribution to the 1981 Kasilof River sockeye salmon smolt outmigration would be estimated at 26%.

Litchfield (1981) estimated that there were 3.1 x 10^6 ($\pm$332,000) age 0 sockeye salmon fry in Tustumena Lake in September 1980. These fry migrated out of Tustumena Lake as age 1.0 smolts during the spring of 1981. The estimated survival rate of these fish from fall fry to age 1.0 smolt, therefore is 60%. Foerster (1968) also estimated that the survival rate of fall fry to yearling sockeye salmon migrants of the 1933 year class in Cultus Lake was approximately 60%, however we were unable to find any other estimate in the literature for this measurement. This estimated survival rate for fall fry to smolt does not imply a 40% mortality rate however since some of these fry may migrate as age 2.0 smolts. For example, during 1980 and 1981, an estimated 9% and 18%, respectively, of migrating smolts were age 2.0.

The 1981 estimated smolt migration is more typical of the expected annual migration from Tustumena Lake than the 1980 estimate. [Tarbox (1982) estimated the average total Tustumena Lake adult sockeye salmon production to be 426,000 for brood years 1971-1975.] If 10% of the estimated number of smolts return as adults (FRED Division 1979), a total return of approximately 226,000 adult sockeye salmon is forecasted from the 1981 smolt migration. Although this estimate is well below the 1971-1975 average, it is above the estimated average production from the 1968-1970 brood years of 184,000 (Tarbox 1982).

Considering our sockeye salmon smolt outmigration estimate of 2.26 million and an estimated adult production of approximately 226,000 from these smolts, it appears that 1981 production is similar to the 1968-1970 period, when the system was believed to be operating at less than rearing capacity. It was this rationale, in fact, that led to the sockeye salmon fry stocking program initiated in 1976. The question that confronts us now is whether the 1979 and 1980 fry stocking in Tustumena Lake made any appreciable addition to expected natural smolt production from the system. From our studies to date, we cannot determine whether the estimated hatchery contribution of 13% of the smolts in the 1981 Kasilof River smolt emigration represented an actual increase in the population or simply resulted in a replacing of wild stock. In addition, we recognize that highly variable environmental factors have a great influence over the annual production cycle in Tustumena Lake as in other sockeye salmon nursery areas. We are attempting to answer these questions through a comprehensive program which includes continued smolt monitoring, hydroacoustic surveys, tow net surveys, and limnological research in Tustumena Lake.

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APPENDIX A

Appendix A. Tustumena Lake sockeye salmon fry stocking and marking history, 1976-1981.

Release year	Glacier Flats Creek			Bear Creek			Total		
	Number fry stocked	Number marked RV	Percent	Number fry stocked	Number marked LV	Percent	Number fry stocked	Number marked	Percent
1976	1,137,784	--	--	--	--	--	1,137,784	--	--
1977	--	--	--	--	--	--	--	--	--
1978	400,000	--	--	--	--	--	400,000	--	--
1979	4,864,193	30,502	.62	2,899,785	36,095	1.24	7,763,978	66,597	.86
1980	2,706,610	32,669	1.20	2,499,232	32,758	1.31	5,205,842	65,427	1.26
1981	4,967,526	198,409	3.99	3,809,045	253,947	6.67	8,776,571	452,356	5.15