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YUKON SALMON ESCAPEMENT
REPORT #19

ENUMERATION OF FALL CHUM SALMON BY SIDE-SCANNING SONAR IN THE SHEENJEK RIVER IN 1982

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ABSTRACT

A total of 29,093 fall chum salmon were enumerated in the Sheenjek River by side-scanning sonar from August 31 through September 22, 1982. The run peaked on September 16 when 8.5% of the total sonar-estimated escapement was counted. Differences were observed in daily chum salmon migration patterns, with greatest movement occurring during hours of darkness or suppressed light. River water surface temperatures and velocities were monitored daily.

Gillnet samples revealed age 5_1 (49%) and age 4_1 (47%) fish predominated the 1982 Sheenjek River fall chum salmon spawning escapement. The male-to-female ratio was 1.00:1.37. Mean size at age data are presented for Sheenjek and Fishing Branch River fall chum salmon, and escapement trends to the Porcupine River drainage are discussed.

SHEENJEK RIVER SONAR

Introduction

Summer and fall chum salmon represent two major stock groupings in the Yukon River. Differences between the two are based on morphological characteristics and run timing. Fall chum salmon are larger, spawn later (early September through November), and are less abundant than summer chum salmon. They primarily spawn in the upper Yukon River drainage (upstream of the village of Tanana) in spring-fed tributaries which usually remain ice free during the winter. In contrast, summer chum salmon spawn in run-off tributaries of the Tanana, Koyukuk, and lower Yukon rivers. Fall chum salmon have composed an increasingly important part of the total Yukon River commercial salmon harvest in recent years.

Fall chum salmon are in great demand commercially and are harvested in all Yukon River fishing districts. (No commercial fishing is permitted in the Porcupine River drainage). The majority of commercial catches are presently made in the lower three districts (downstream of the village of Anvik). They are of lesser importance for subsistence than summer chum salmon in that part of the Yukon River drainage downstream from the village of Koyukuk. On the other hand, fall chum salmon composed approximately 65% of the total chum salmon subsistence harvest in 1981 in the upper Yukon River drainage (upstream of the village of Koyukuk).

Prior to 1981, comprehensive enumeration studies on fall chum salmon in the Yukon River drainage, apart from aerial assessment of selected tributaries since the early 1970's, were limited to only two streams. Abundance, timing, and distribution information on spawning populations in the Delta River (Tanana River drainage) was collected from 1973 through 1978 as a result of construction of the Trans-Alaska Pipeline (Dinneford 1978). The Canadian Fisheries Service operated a weir in the Fishing Branch River (Porcupine River drainage) from 1972 through 1975 to enumerate fall chum salmon spawning populations (Elson 1976).

Because of a need for more finite data on fall chum salmon stocks, the Sheenjek River was identified in 1975 as a potential river for installation of a counting tower to enumerate fall chum salmon escapement and collect age-sex-size data. Specific spawning areas were located, and, due to its accessibility by aircraft or boat, this stream is considered one from which detailed stream life data on fall chum salmon can be obtained. The Sheenjek River heads in the Davidson Mountains of the eastern Brooks Range and flows approximately 250 miles to its confluence with the Porcupine River near the village of Fort Yukon.

Funding was made available in 1980 to erect a counting tower and partial weir on the Sheenjek River, approximately 6 river miles upstream from its confluence with the Porcupine River, to monitor fall chum salmon escapement. The operation was unsuccessful due to abnormally high and

turbid water conditions in that year. Abundance and timing data on Sheenjek River fall chum salmon escapements were collected in 1981 and 1982 by side-scanning sonar.

This report presents results of the 1982 studies. Results from the 1981 studies can be found in Barton (1982).

Objectives

Overall objectives of the 1982 Sheenjek River fall chum salmon study were to determine timing and magnitude of adult salmon escapements in this stream and to collect salmon age-sex-size information. The following specific objectives were identified in order to meet overall project objectives:

1. Install a single side-scanning sonar unit and partial adult salmon weir to count upstream migrants;

2. Operate a counting tower to visually count adult salmon passing the sonar substrate, as water conditions permit, to determine sonar accuracy;

3. Test fish with gillnets to examine species composition and age-sex-size characteristics of adult salmon escapement; and

4. Monitor selected climatological and hydrological parameters at the sonar site.

Methods

Salmon escapement was enumerated with a single side-scanning sonar counter (1981 model) developed by the Hydrodynamics Division of Bendix Corporation. A single 60-ft aluminum substrate was assembled and deployed on August 31 from the west bank of the Sheenjek River (Figures 1 and 2). The substrate was deployed so that the top of the inshore transducer housing rested approximately 6-8 inches below the water surface. The offshore end was approximately 5 ft below the water surface.

Surface water velocity was measured daily with a digital flow meter in the main river channel near the target end of the substrate. A depth profile of the river was made at the sonar counting site on September 9.

A salmon weir, constructed from the west bank to the inshore end of the sonar substrate (about 70 ft), helped direct upstream migrant salmon over the sonar substrate. The weir was constructed of metal "T" stakes and 1-inch by 2-inch cattle fencing. Additional weir sections were added or removed and the sonar substrate moved as necessary to compensate for fluctuations in river water level.

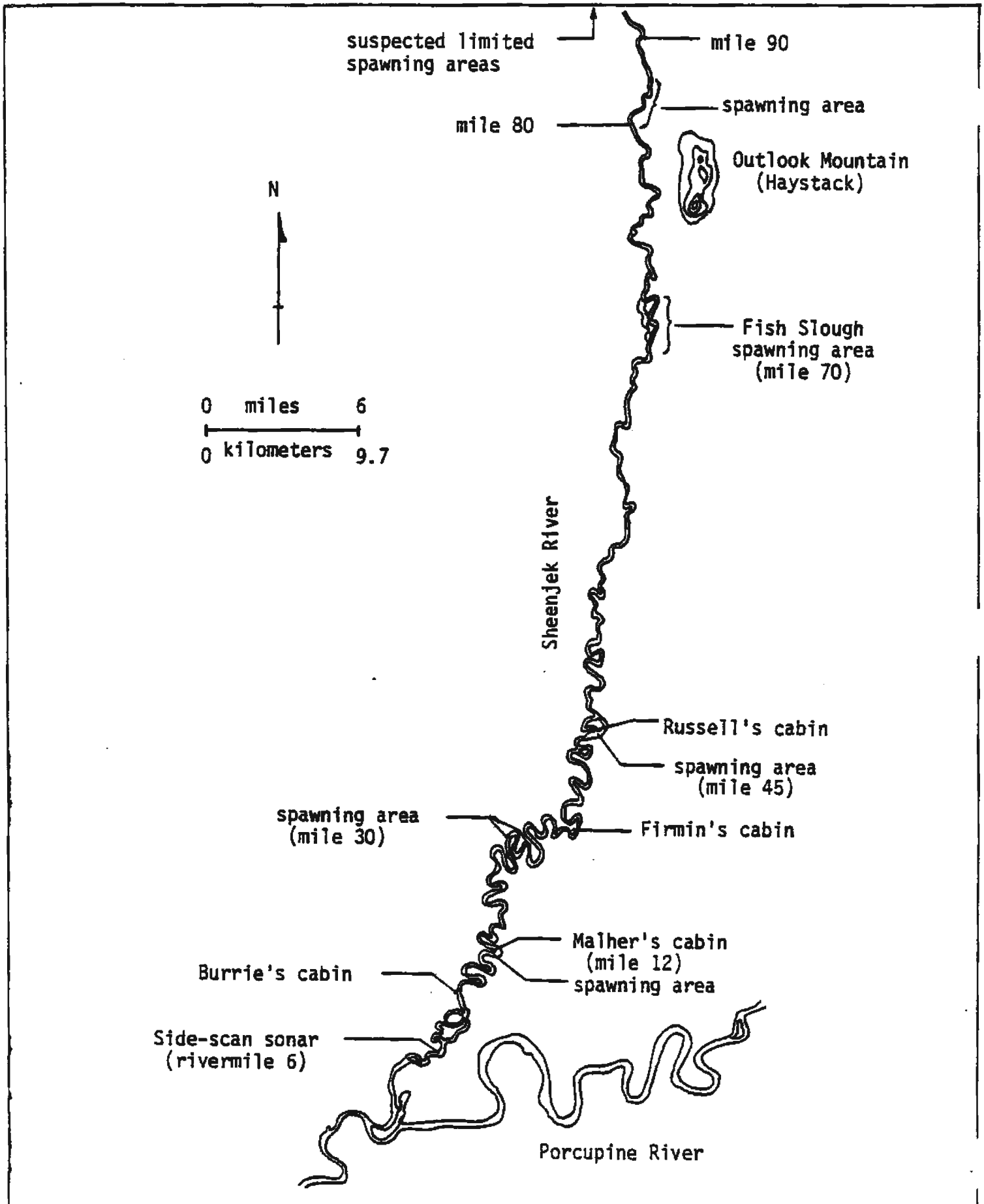

Figure 1. Major fall chum salmon spawning areas in the Sheenjek River.

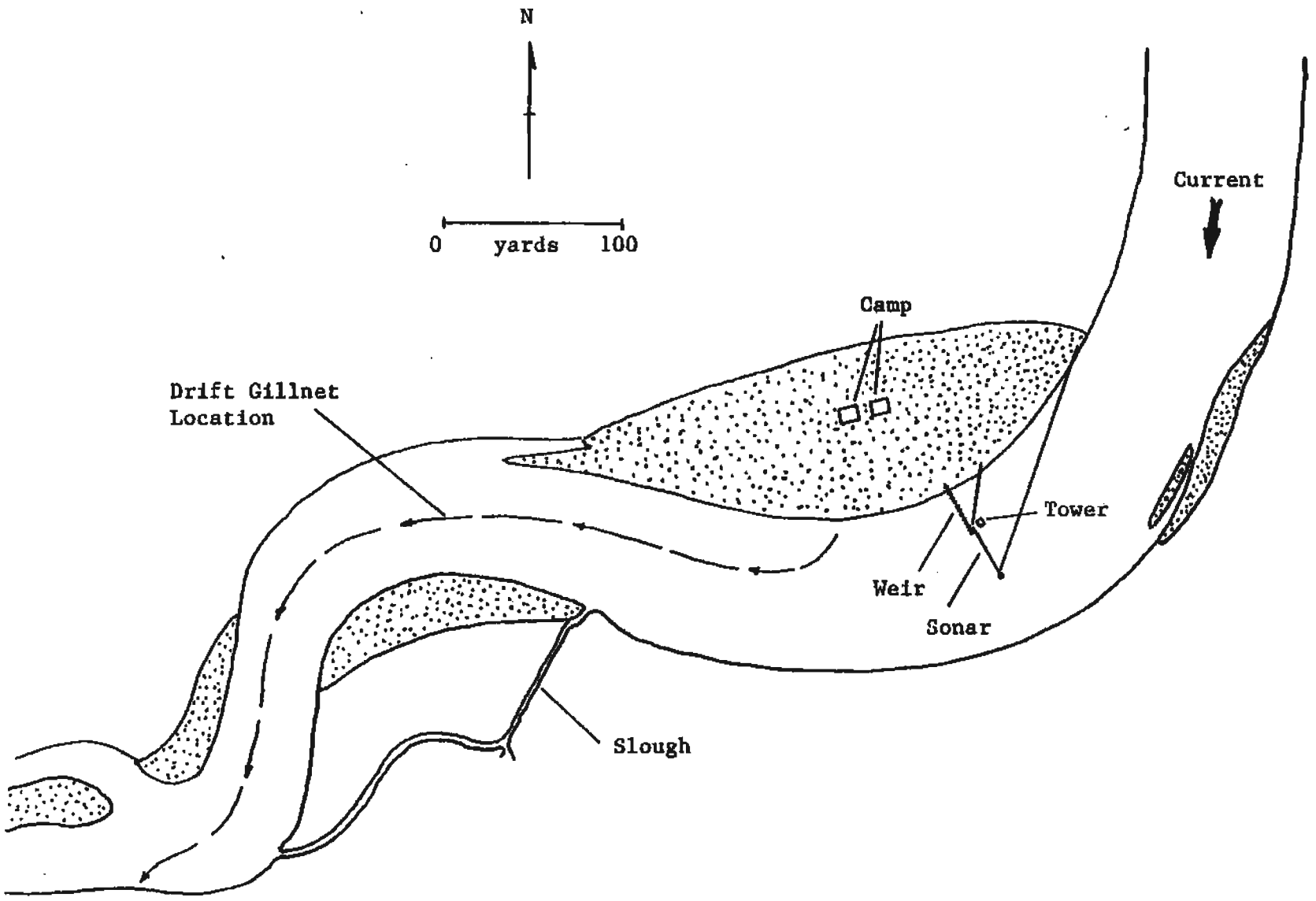

Figure 2. Sheenjek River field study site approximately 6 river miles upstream from its confluence with the Porcupine River, September 1982.

A 20-ft prefabricated aluminum tower was erected upstream of the weir and positioned in the river near the inshore end of the sonar substrate. Three 150-watt lights were secured to the counting tower and directed over the sonar substrate to permit visual counting during hours of darkness.

Assembly and installation of the sonar substrate and counting tower and weir construction were completed on August 31, and sonar enumeration commenced at 1500 hours. The sonar counter tabulated hourly counts separately into 16 sectors, each sector representing approximately 3.75 ft of the counting range. Counts were hand tabulated by sector for each 24-hour period from 0001-2400 hours. Missing sector counts (illegible, printer malfunction, or debris) were interpolated by averaging the sector counts from the hour before and after the missing hour(s).

Adult salmon swimming speed may vary within a given day or throughout the duration of the salmon run as a function of changes in water level and velocity, intensity of light penetration into the water (i.e., darkness versus light), or possibly upstream salmon migration densities. Consequently, the pulse repetition rate of the sonar counter was checked daily and adjusted as necessary to prevent overcounting or undercounting of salmon.

Salmon passing through the insonified water column produce a distinct pattern on an oscilloscope screen which can be distinguished from patterns caused by debris or smaller fish species. Consequently, oscilloscope calibration data were collected daily and used to adjust the pulse repetition rate of the counter and sonar counts as necessary.

Initially, the sonar counter was calibrated daily for a minimum of four 20- to 30-minute periods within the following hourly blocks:

0830-0930 hours
1600-1700 hours
2000-2100 hours
2230-2330 hours

Once the daily salmon migration pattern was identified, 30-minute calibration periods were scheduled to insure adequate (increased) coverage was made during hours of peak migration. Less calibration effort was placed on periods of the day or night when salmon passage rates were the lowest. Whenever a difference of 16% or more occurred between oscilloscope counts and sonar counts, the pulse repetition rate was adjusted, provided that fish were passing at a rate of 100/hour or more during that particular calibration period. After any adjustment to the pulse repetition rate, an additional 10- to 15-minute calibration was made. If salmon passage rates were less than 100/hour during any calibration period, no adjustment was made to the pulse repetition rate, regardless of the percent agreement. If fish passage rates for any given day never exceeded 100/hour, the pulse repetition rate was only changed at 2400 hours of that day, but

only if the average deviation for all calibration periods for that day was 16% or greater.

Oscilloscope calibration data were also used to adjust daily sonar counts. Adjustments to sonar counts were made in a similar fashion as adjustments to the pulse repetition rate (i.e., based upon the 100 fish/hour passage rate), except that count adjustments were always made (when necessary) following the final daily tape printout at 2400 hours. This permitted having all calibration data for the 2400-hour period available to help make proper count adjustments. However, more than one adjustment to the day's count was made when necessary, based upon calibration results and fish passage rates.

A single 5-7/8"-mesh gillnet, 50 ft long by 10 ft deep, was fished by drifting in the vicinity of the sonar site to capture adult salmon for age-sex-size sampling. The same section of the river was fished in 1982 as in 1981.

A maximum of 25 adult chum salmon was sampled daily for age-sex-size data. Each fish was sexed by external examination, measured to the nearest 5 mm from mid-eye to fork-of-tail, scale sampled for subsequent age analysis, and the adipose fin clipped to prevent resampling. Duration of each gillnet drift, resulting catch, and age-sex-size data were recorded.

A river water-level gauge (meter stick) was installed at the sonar site on September 1. Daily changes in water level and surface water temperature were monitored at noon. Other daily observations included recording the occurrence of precipitation and percent cloud cover.

An aerial survey of the Sheenjek River was flown on September 14 to enumerate chum salmon escapement and examine fish distribution within the river.

Results and Discussion

Timing: A total of 493 chum salmon was counted from 1500 hours through midnight on August 31, indicating that salmon were already present in the Sheenjek River prior to sonar operations (Table 1). This number was subsequently expanded to 1,297 chum salmon, based on average percent passage over the next 3 days from 0001 to 1500 hours (62%). A Fish and Wildlife Protection officer working in the area reported that chum salmon had been present at least in the lower part of the river for nearly 2 weeks prior to sonar installation.

Chum salmon continued to pass the sonar site at a rate of approximately 1,000-1,500 per day through September 14, with the exception of September 9 and 10, when only 400 to 500 were counted (Figure 3). Daily passage then increased to a peak on September 16, when 2,460 salmon were enumerated, representing 8.5% of the total sonar-estimated escapement. Approximately 53% of the total sonar-estimated escapement was accounted for by this

Table 1. Sheenjek River daily and cumulative sonar counts from August 31 through September 22, 1982.

	Sonar count			
Date	Daily	Percent	Cumulative	Percent
8/31	1,297[a]	4.5	1,297	4.5
9/1	1,050	3.6	2,347	8.1
9/2	1,076	3.7	3,423	11.8
9/3	1,186	4.1	4,609	15.8
9/4	926	3.2	5,535	19.0
9/5	1,089	3.7	6,624	22.8
9/6	1,189	4.1	7,813	26.9
9/7	1,551	5.3	9,364	32.2
9/8	962	3.3	10,326	35.5
9/9	560	1.9	10,886	37.4
9/10	406	1.4	11,292	38.8
9/11	975	3.4	12,267	42.2
9/12	1,045	3.6	13,312	45.8
9/13	923	3.2	14,235	48.9
9/14	1,161	4.0	15,396	52.9
9/15	1,654	5.7	17,050	58.6
9/16	2,460	8.5	19,510	67.1
9/17	1,861	6.4	21,371	73.5
9/18	1,655	5.7	23,026	79.1
9/19	2,002	6.9	25,028	86.0
9/20	1,596	5.5	26,624	91.5
9/21	1,269	4.4	27,893	95.9
9/22	1,200[b]	4.1	29,093	100.0

[a] Actual count was 493 from 1501-2400 hours. Count was expanded to 1,297 based on average percentage of salmon counted on 9/1, 9/2, and 9/3 from 0001-1500 hours.

[b] Actual count was 780 from 0001-1730 hours. Count was expanded to 1,200 based on average percentage of salmon counted on 9/19, 9/20, and 9/21 from 1800-2400 hours.

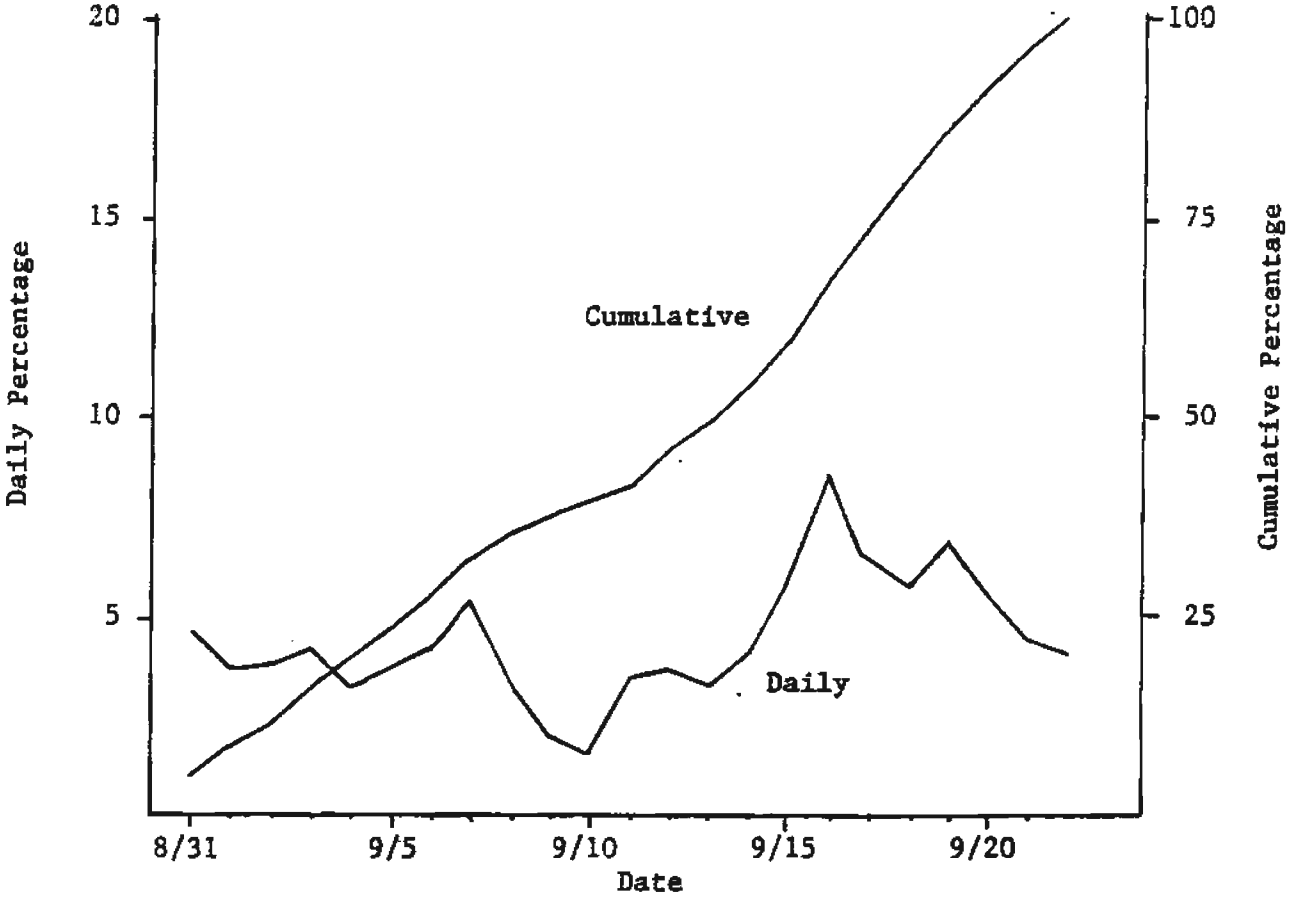

Figure 3. Relative timing of Sheenjek River fall chum salmon escapement based on side-scan sonar data, 1982.

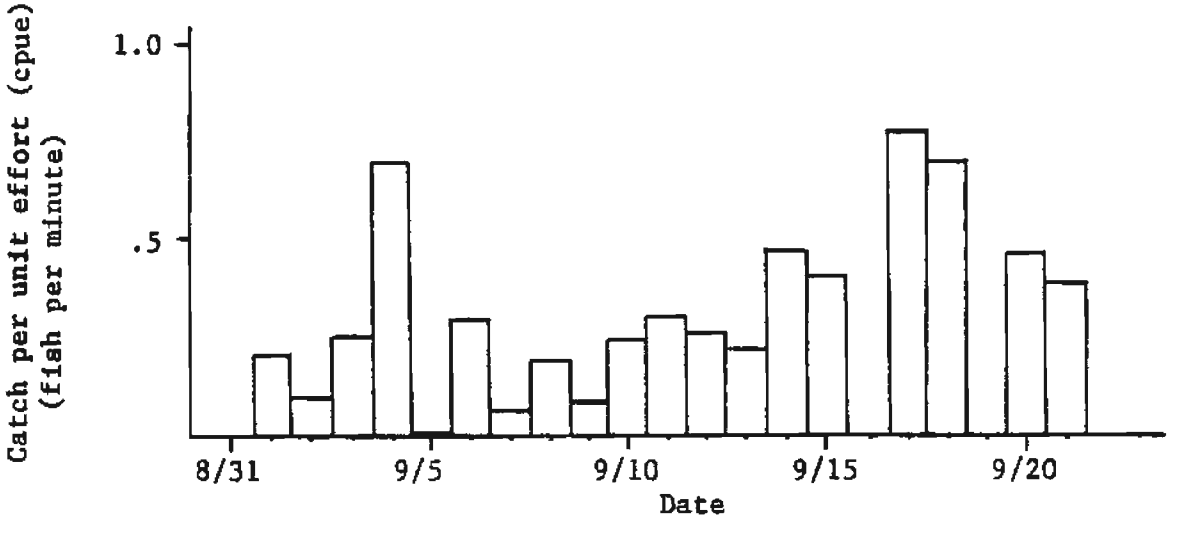

Figure 4. Drift gillnet catch per unit effort in the Sheenjek River at the 1982 sonar site.

date. By comparison, the highest CPUE from gillnet test fishing occurred on September 17 (Figure 4).

A moderate decline in daily counts was observed from September 17 through September 22, when river flood conditions necessitated project termination. An estimated 1,200 salmon passed the sonar site on the last day of operation, indicating that the project terminated prior to the end of the fall chum salmon run.

Results indicate that the 1982 migration was relatively long in duration, with the peak occurring in mid-September. This was about a week later than the peak observed in 1981, which occurred on September 7. By that date 55% of the Sheenjek River sonar-estimated escapement had been passed in 1981 (Barton 1982).

Surface water temperature at the sonar site ranged from 46.4°F on September 1 to 41.0°F on September 21, averaging 43.8°F for duration of the project (Figure 5). The average temperature was 1.9°F warmer than that in 1981. In 1982, surface water temperature averaged 43.6°F from September 13 through the 18th, the period of peak salmon passage.

In general, chum salmon were observed holding or resting in shallow water along gravel bars and slough areas during daylight hours. Upstream migration commenced with the onset of darkness and continued through hours of suppressed light, decreasing rapidly in the early morning hours (Figure 6). This was particularly the case when sonar operations first began. As the counting period progressed into late September, daily upstream movement began progressively earlier and continued progressively later. This behavior may have been a result of decreasing daylight throughout the month of September.

Aerial survey observations from 1975 through 1980 indicate that peak spawning in the Sheenjek River generally occurs sometime between the last week of September and first week of October (Barton 1982). Based on similarity in timing of chum salmon to their respective spawning areas on the Sheenjek and Fishing Branch rivers, it is probable that early Porcupine River fall chum salmon are destined largely for the Fishing Branch River, while the later portion of the run is bound for the Sheenjek River and possibly the Black River system.

Only a single aerial survey of the Sheenjek River was flown in 1982. The survey was flown under poor conditions on September 14, and only a few chum salmon were observed at known major spawning areas.

Distribution: The Sheenjek River was approximately 165 ft wide at the sonar site when a depth profile was made on September 9 (Figure 7). Approximately 64% of the river's width was covered by the inshore weir and sonar substrate.

Distribution of upstream migrants past the 1982 sonar site was primarily confined to the west side of the river, although a few fish

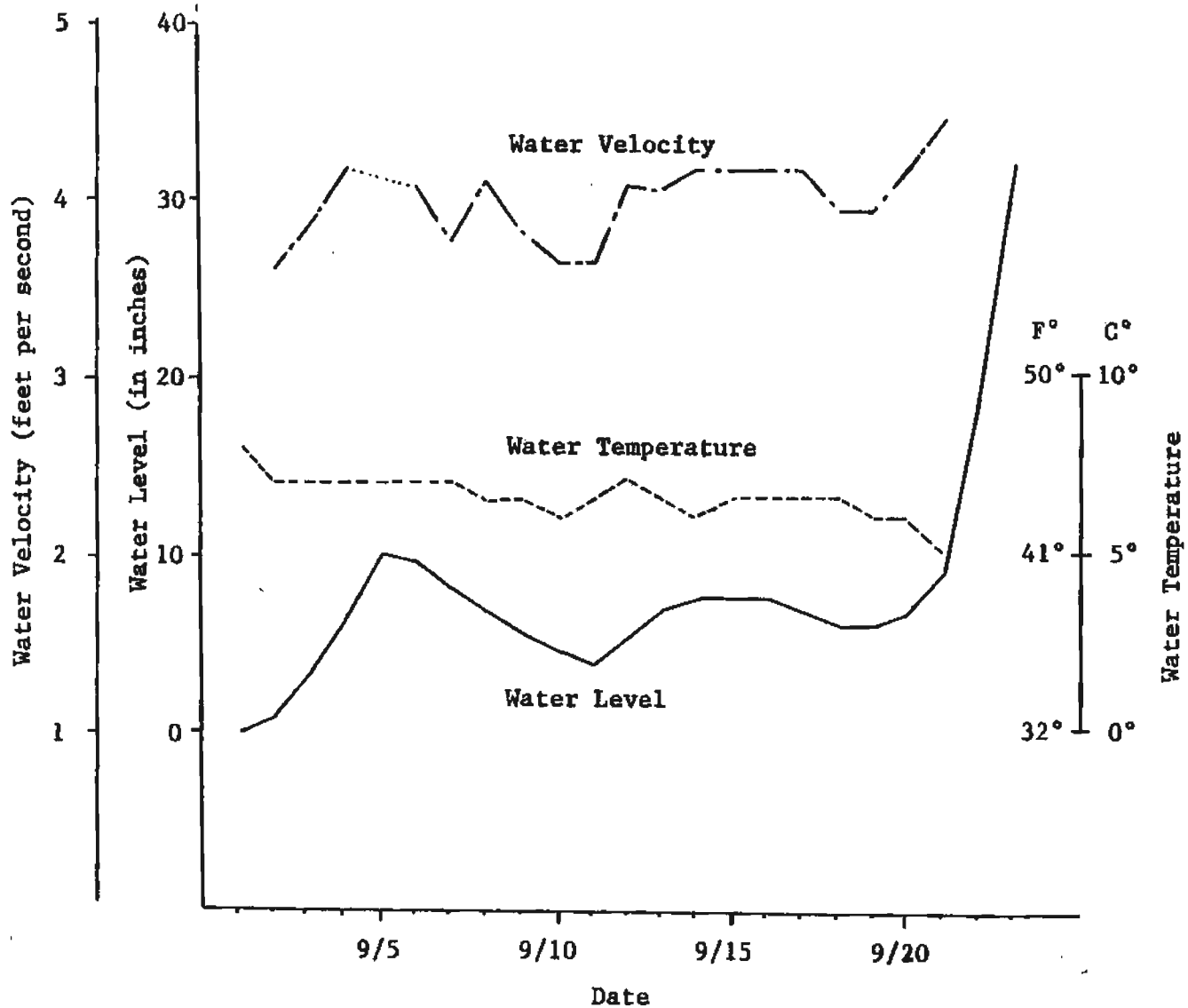

Figure 5. Daily changes in water level, surface water temperature, and surface water velocity at the Sheenjek River sonar site, September 1982.

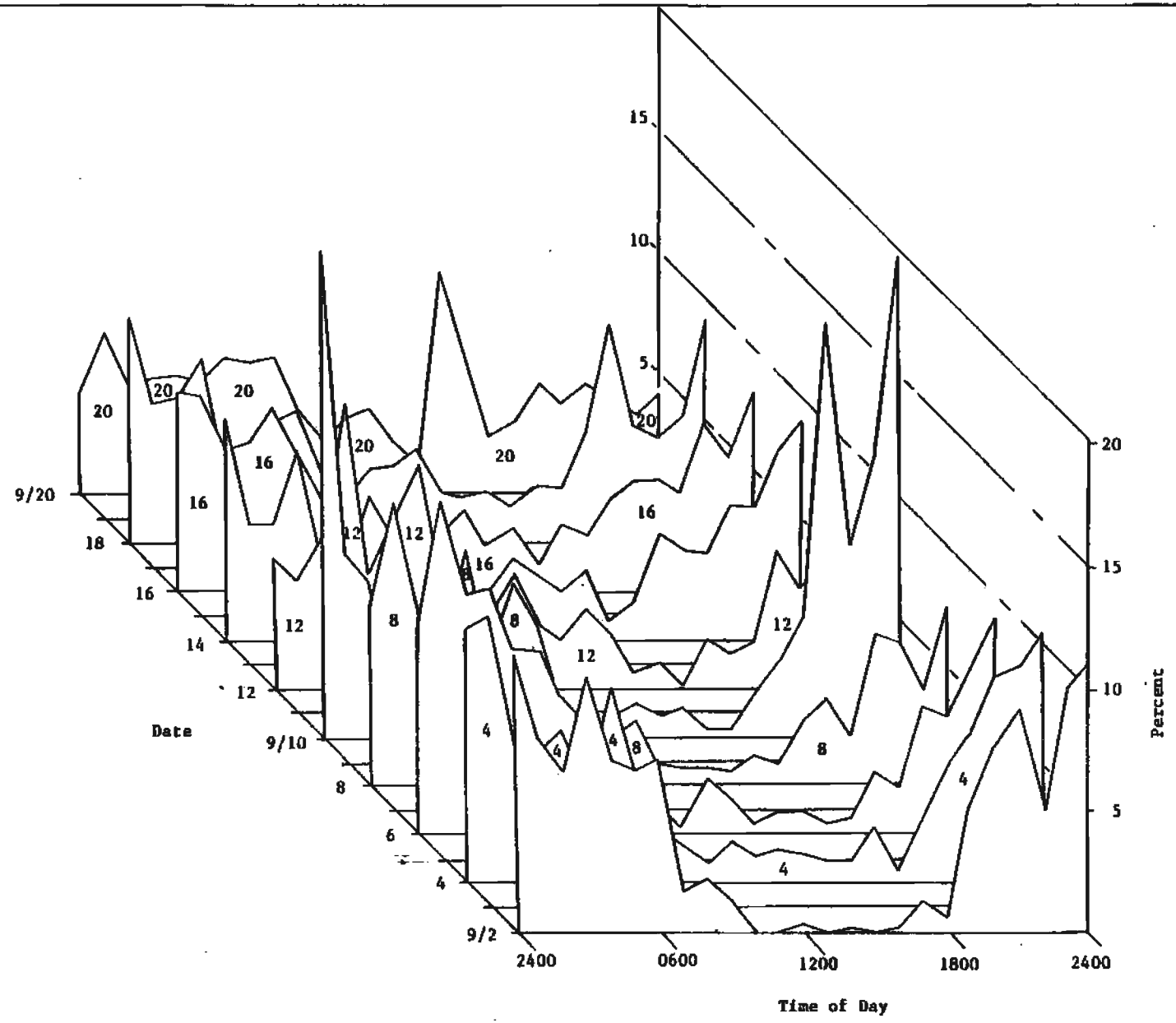

Figure 6. Daily upstream migration behavior of fall chum salmon in the Sheenjek River, September 2 through September 20, 1982.

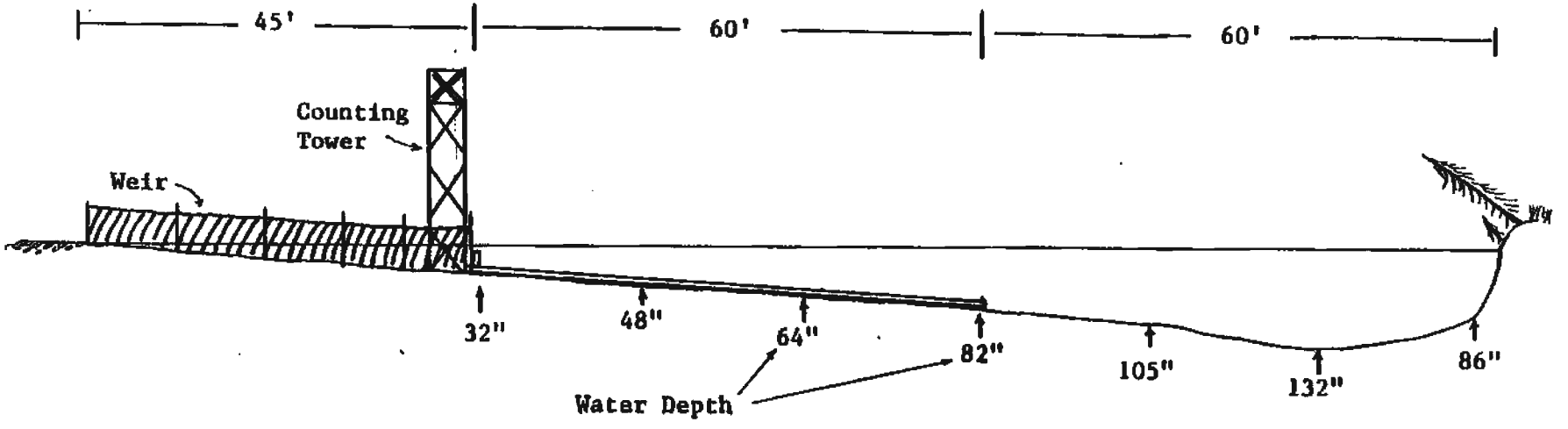

Figure 7. Depth profile of the Sheenjek River made on September 9 at the side-scan sonar site in 1982.

were observed skirting around the sonar substrate. Approximately 55% of the sonar counts were made through the outer 30 ft of the counting range (Figure 8). Although some salmon passed beyond the counting range, the percentage is believed to have been small since only 2.5% of the total sonar count occurred in the outer 3.75 ft of the counting range (sector 16).

The occurrence of sweepers and other underwater snags determined the actual location where gillnet drifts could be made. Consequently, it was difficult to drift with equal effort to precisely compare riverbank distribution of migrating salmon. It was concluded, however, that few adult chum salmon migrated along the east side of the river at the sonar site. Average water velocity for the duration of the counting period was 4.0 ft/sec at the target end of the substrate, in the main river channel (Figure 5).

Although past aerial observations have shown that most fall chum salmon spawn within the lower 100 river miles in several spring-fed side channels and back sloughs, more effort is needed to accurately document spawning habitats and distribution (Figure 1). The extent of mainstem spawning is not known.

Abundance: The total sonar-estimated escapement from August 31 through September 22 was 29,093 chum salmon (Table 1). The estimate was based on daily oscilloscope calibrations since water visibility was such that tower observations could not be used to accurately adjust counts. A total of 148 oscilloscope calibration periods, averaging 28 minutes each, occurred over a 23-day period from August 31 through September 22. This represents in excess of 68 hours of oscilloscope calibration or approximately 13% of the total number of hours the sonar unit was functional. Approximately 36% of the calibration effort was made between 0800 and 1900 hours, with 64% of the effort between 1901 and 0200 hours of the following day (i.e., most effort occurred in late evening through midnight hours). No calibrations were made during the early morning hours (i.e., from about 0200 through 0800 hours).

Tower observations at night could not be reliably used to calibrate the sonar counter as the flood lamps used for illumination adversely affected fish movement over the substrate.

The 1982 sonar-estimated escapement can be considered conservative since it is known that chum salmon were present in the Sheenjek River up to at least 2 weeks prior to sonar installation. Further, it is reasonable to assume that more salmon passed the sonar site after September 22, when river flood conditions necessitated project termination, since approximately 1,200 were counted on the last day of operation. In any event, the 1982 sonar estimate of 29,093 fall chum salmon from August 31 through September 22 represents only 42% of the 1981 sonar-estimated escapement (69,043) for approximately the same time period (August 31-September 24).

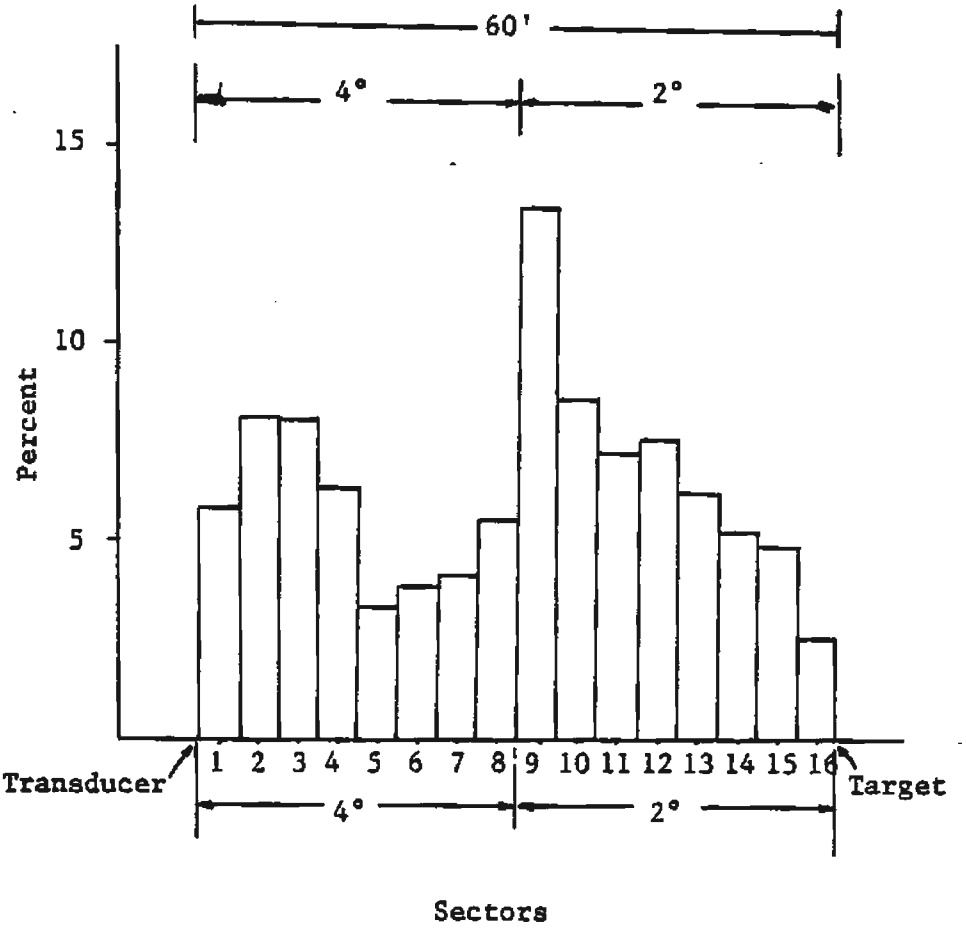

Figure 8. Distribution of salmon counts by sonar sector in the Sheenjek River, August 31 through September 22, 1982.

Age, Sex, and Size: A total of 166 chum salmon, 1 sheefish, and 1 whitefish (not identified) was gillnetted from September 1 through 21. The chum salmon male-to-female ratio was 1.00:1.37 or 42% males and 58% females. One hundred fifty-seven of the chum salmon were examined for age and size composition by sex. Preliminary results from 109 readable scales (69%) reveal age 5_1 and 4_1 fish predominated, representing 49% and 47%, respectively. Age 3_1 fish accounted for approximately 3%, while less than 1% were age 6_1. Overall, males averaged 27 mm larger than females.

The only comparative size-at-age data available from the Sheenjek River are from carcasses collected from two spawning areas in 1975 (at Russell's cabin and Fish Slough) and escapement samples collected with gillnets in 1981 and 1982 at the sonar site (Table 2). The average mean size at age was larger (in the dominant age groups) for the 1981 and 1982 samples. However, this could be a function of sampling bias, with gillnets tending to select larger and older fish from the population.

Limited data on mean size at age of fall chum salmon from the Fishing Branch River are available from 1972 (Elson 1973). Original lengths of these samples collected by the Canadian Fisheries Service were measured from tip-of-snout to fork-of-tail. Mid-eye to fork-of-tail estimates for these samples (Table 2) were derived from conversion factors obtained on fall chum salmon during 1977 tagging studies at Galena and Ruby (Buklis 1981). Mean size at age for the dominant age group in that year (age 4_1 fish) more closely resembles the 1981 and 1982 Sheenjek River samples for each sex.

Remaining data on fall chum salmon size in the Porcupine River drainage consist of tip-of-snout to fork-of-tail measurements taken by the Canadian Fisheries Service from the subsistence catch at Old Crow in 1971 and spawning runs into the Fishing Branch from 1972 through 1975 (Table 3). Statistical summaries of these measurements are presented in Elson (1976). Only mean sizes were given for all ages combined for each sex. The estimated mid-eye to fork-of-tail lengths in Table 3 are also based on conversion factors presented by Buklis (1981).

Elson (1976) indicated there was a significant difference in the mean fork lengths of fish of each sex for different years and hypothesized that sampling procedures in some years may have accounted for some of the differences. The 1971 samples were collected with gillnets at Old Crow and may have been affected by gillnet size selectivity (mesh size of net not given). Elson also suggested that the 1974 small sample size could have resulted in the smaller mean fork lengths for that year.

Available age composition data from fall chum salmon escapements to the Sheenjek River are shown in Table 4. It can be seen that age 3_1 fish predominated the 1974 population (66%), reflecting a very large year class that returned predominantly in 1975. Trasky (1976) sampled fall chum salmon escapements to selected spawning areas in the Tanana River drainage in 1974, and, like the Sheenjek River samples, age 3_1

Table 2. Comparative age, sex, and size composition of fall chum salmon sampled at various sites in the Porcupine River drainage, 1972, 1975, 1981, and 1982.[a]

	Age 3_1				Age 4_1				Age 5_1				Age 6_1				Total			
	n	(%)	$\bar{x}$	SD	n	(%)	$\bar{x}$	SD	n	(%)	$\bar{x}$	SD	n	(%)	$\bar{x}$	SD	n	(%)	$\bar{x}$	SD
Sheenjek River[b]																				
1982 male	1	(1.0)	570	-	15	(14.0)	615	22.9	22	(20.0)	651	-	1	(1.0)	640	-	39	(35.8)	635	33.7
1982 female	2	(2.0)	525	-	36	(33.0)	601	22.9	32	(29.0)	621		-	-	-	-	70	(64.2)	608	28.5
total	3	(3.0)	540	-	51	(47.0)	605	24.4	54	(49.0)	633	29.8	1	(1.0)	640	-	109	(100.0)	617	33.0
Sheenjek River[b]																				
1981 male	2	(0.6)	547	-	139	(40.9)	620	-	32	(9.4)	637	-	1	(0.3)	620	-	174	(51.2)	622	-
1981 female	8	(2.3)	574	17.2	150	(44.1)	596	-	8	(2.3)	613	-	-	-	-	-	166	(48.8)	596	-
total	10	(2.9)	569	25.9	289	(85.0)	608	-	40	(11.8)	632	-	1	(0.3)	620	-	340	(100.0)	610	-
Sheenjek River[c]																				
1975 male	2	(1.0)	599	-	79	(40.1)	599	34.2	2	(1.0)	654	-	-	-	-	-	83	(42.1)	601	34.7
1975 female	5	(2.5)	544	23.0	108	(54.8)	582	27.8	1	(0.5)	520	-	-	-	-	-	114	(57.9)	581	28.7
total	7	(3.5)	559	35.7	187	(94.9)	589	31.7	3	(1.5)	642	-	-	-	-	-	197	(100.0)	589	32.8
Fishing Branch River[d]																				
1972 male	1	(1.7)	610	-	20	(34.5)	621	31.9	1	(1.7)	649	-	-	-	-	-	22	(37.9)	621	31.0
1972 female	4	(6.9)	561	-	29	(50.0)	598	23.2	3	(5.2)	614	-	-	-	-	-	36	(62.1)	596	26.0
total	5	(8.6)	571	29.3	49	(84.5)	607	29.0	4	(6.9)	623	-	-	-	-	-	58	(100.0)	605	30.5

[a] Age designated by Gilbert-Rich formula: total years of life in superscript; years of freshwater life in subscript. All lengths are mid-eye to fork-of-tail measurements in millimeters.

[b] Samples collected with 5-7/8 inch gillnets at sonar site. (The 1982 data are preliminary.)

[c] Carcass samples at Russell's cabin and Fish Slough areas.

[d] Samples collected by Canadians at counting fence. Data modified from Elson (1973). Fish were initially measured from tip of snout to fork of tail; lengths shown here were converted to mid-eye to fork-of-tail estimates based upon fall chum salmon conversions derived from tagging studies in 1977 at Galena and Ruby (Buklis 1981).

Table 3. Comparative size composition of fall chum salmon from the Sheenjek and Fishing Branch rivers.

Year	Male (all ages) sample size	mean fork length (mm)	SD	estimated mid-eye fork tail length (mm)	Female (all ages) sample size	mean fork length (mm)	SD	estimated mid-eye fork tail length (mm)
Fishing Branch River[a]								
1971	275	639.0	31.8	574	48	609.6	34.5	561
1972	226	691.3	33.5	621	435	643.3	28.2	592
1973	272	685.3	37.5	616	345	638.9	31.8	588
1974	62	634.6	53.8	571	57	598.9	46.3	551
1975	151	680.5	36.5	612	151	634.3	25.6	584
Sheenjek River[b]								
1974[c]	59	--	--	578	78	--	--	553
1975[c]	83	--	34.7	601	114	--	28.7	581
1981[d]	174	--	32.5	622	166	--	25.7	596
1982[d]	39	--	33.7	635	70	--	28.5	608

[a] Data modified from Elson (1976). Initial measurements were from tip-of-snout to fork-of-tail; estimated mid-eye to fork-of-tail lengths are based upon fall chum salmon conversions derived from 1977 tagging studies at Galena and Ruby (Buklis 1981). The 1971 sample was taken with gillnets at Old Crow. Remaining samples were collected from spawning grounds.

[b] All samples measured from mid-eye to fork-of-tail.

[c] Data from carcass samples collected from Russell's cabin area and Fish Slough.

[d] Data from samples collected with 5-7/8 inch gillnets at sonar site.

Table 4. Comparative age composition (in percent) of Sheenjek River fall chum salmon spawning escapements, 1974-1982.[a]

Year	Age 3_1	Age 4_1	Age 5_1	Age 6_1	Sample size
1974	66	30	3	0	137
1975	3	95	2	1	197
1976	2	44	54	0	118
1977	11	73	16	0	178
1978	8	82	10	0	190
1979	-	-	-	-	-
1980	-	-	-	-	-
1981[b]	3	85	12	trace	340
1982[b]	3	47	50	trace	109

[a] All samples from carcasses on spawning grounds unless indicated otherwise.

[b] Escapement samples taken with 5-7/8-inch mesh gillnets in lower river.

fish predominated, ranging from 73% in the Toklat River to approximately 50% in the Delta River. Evidently a very large proportion of the 1974 fall chum salmon run to the Tanana and Porcupine River systems was age 3_1 fish. In other years (from which data exist), age 4_1 and 5_1 fish predominated. Consequently, it is probable that smaller mean fork lengths reported in 1974 by Elson (1976) were a result of a high proportion of the sample being age 3_1 fish. The 1974 return was composed primarily of progeny from the 1971 brood year.

Similarly, the larger overall mean size (shown in Table 2) by sex for combined ages in the Sheenjek River in 1982 is probably a result of the high proportion of age 5_1 fish in the population.

Escapement Trends: Very little information regarding abundance and distribution of fall chum salmon throughout the Yukon River drainage was available prior to 1972. Since that time, primarily from expanded aerial escapement surveys, the Porcupine and Tanana River systems have been identified as two of the most important in terms of fall chum salmon production, although spawning has been documented in approximately 30 Alaskan and 10 Canadian streams (Table 5).

Major spawning areas in the Porcupine River drainage include the Sheenjek River in Alaska and the Fishing Branch River in Canada. Important areas in the Tanana River drainage are the Toklat River, Delta River, and mainstem Tanana River upstream from Fairbanks (Figure 9). Other spawning areas include the Chandalar River in Alaska and the Kluane River in Canada. Spawning has also been noted or suspected in a few other upper Yukon River tributaries in Canada; e.g., the Koidern River, Klondike River, and Teslin River, as well as the mainstem Yukon River in the vicinity of Fort Selkirk to Carmacks. The most complete data base (dating back to 1973) exists for only nine of these streams (or index areas) (Table 6).

The proportion of the Porcupine River drainage fall chum salmon escapement attributable to the Sheenjek River has ranged from about 39% in 1977 to 50% in 1975, based on aerial surveys from 1975 through 1980. The average has been about 47%. Further, average escapement to the Sheenjek River has represented about 23% of the observed average fall chum salmon escapement to both the Tanana and Porcupine River systems from 1975 through 1980, based on aerial surveys of selected tributaries.

The following table indicates the high, low, and average escapement to the Tanana and Porcupine River systems (since 1973) based on aerial surveys. The average is the arithmetic mean of all years in Table 6 from which data were used.

estimates, 1973 through 1982.[a]

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
TANANA RIVER DRAINAGE										
Kantishna River										
Birch Creek		1	—	—	—	—	—	—	—	—
McKinley River		405	—	—	—	—	—	—	—	—
Bearpaw River	1530		1657	—	—	—	—	—	—	—
Moose Creek		2996								
Toklat River drainage										
* Upper Toklat[b]	6957	34310	42418[c]	35190	21800[c]	35000	96550[d]	23054	13907	3309[e]
Lower Toklat	—	—	35867[c]	2000[d]	—	—	64540	2140	—	—
Subtotal Toklat R. drainage	—	—	78285	37190	—	—	161090	25194	—	—
Nenana River										
Lost Slough	115	—	—	—	—	—	—	—	—	—
Seventeenmile Slough	—	1571	—	—	—	—	—	—	—	—
Upper Tanana River drainage										
Banner Creek	—	—	4[d]	—	—	—	—	—	—	—
Richardson Clearwater	4	270	0	228	0	—	100	0	0	—
* Benchmark 735	127	1450[c]	—	336	1270	1705[c]	2714	1900[e]	168[c]	—
Andersen Slough	—	—	—	—	—	—	—	125	1355	—
* Delta River	7971[f]	4010	3089[e]	5498	17925	10051	8125	4637	10664[m]	3433[e]
* South Bank Tanana[g]	5635	4567[f]	—	4979	3797	5700	20820	3444	7063	—
Blue Creek	—	15	—	—	—	—	—	—	—	—
* Bluff Cabin Slough	3450	4840[f]	5000[c,d]	3197	6491	5340	6875	3190	6120	1156[e]
Clearwater Lake outlet slough	—	496	—	225	—	—	—	66	1780	—
Clearwater Lake and outlet	12	10	many	many	—	—	—	—	—	—
* Onemile Slough	1720	1235	745[d]	1552	1900	475	3850[c]	885[c]	632	—
Delta Clearwater River	40	95	—	671	—	—	—	355	—	—
Pearse Slough	—	—	100	—	—	—	—	—	—	—
Billy Creek Slough	—	—	—	—	—	—	—	13	—	—
Sheep Creek-Chisana River	—	—	29	—	—	—	—	—	—	—
PORCUPINE RIVER DRAINAGE										
Black River			50[c]							
Salmon Fork River	—	444	1517[c]	0[c]	—	—	—	—	—	—
Kevinjek River	—	1625	582[c]	7[c]	—	—	—	—	—	—
Fishhole Creek	—	—	—	—	200[c]	—	—	31[c]	—	—
*Sheenjek River	1175[f],[p]	40507	78060	11866	20506	14610[c]	41140	13027	12625[c,h]	717[c,i,p]
Salmon-Trout River	—	6	350[c]	20	—	—	—	—	—	—
*Fishing Branch River (YT)	15987[j]	32525[j]	78615[k]	13450	32500	15000	44080	20319[c]	10549[c,r]	5846
Miner River (YT)	—	—	—	—	—	—	—	—	2	—
UPPER YUKON TRIBUTARIES										
*Chandalar River										
Mouth to Venetie	—	5157	—	58[c]	3318	—	—	2477	167[l]	1067[l]
Venetie to East Fork	—	12298	6345[c]	—	865	—	—	130	4739[l]	78[l]
Total		17455	6345[c]	58[c]	4183			2607	4906	1145
Kluane River drainage (YT)[n] (areas surveyed not given)	2500	350	362	20	736	0	4640	2750		5378

a All surveys rated fair-good unless indicated otherwise. Peak estimates are listed. 1982 figures are preliminary.
b Includes following areas: Toklat River vicinity of roadhouse; Sushana River; Geiger Creek.
c Poor survey rating.
d Combined aerial and ground survey estimates.
e Foot survey.
f Survey rating not given.
g Richardson Highway bridge to Blue Creek.
h Sonar-estimated escapement was 69,043.
i Sonar-estimated escapement was 29,093.
j Weir count
k Total escapement through weir was 353,282.
l Fair to poor survey rating.
m Foot survey was 22,375.
n Fall chum salmon have been documented using other Canadian streams, but escapement numbers are lacking. Such streams include the Koidern, Klondike, Teslin, and Little Salmon rivers.
p Surveyed well before peak spawning—too early.
r Incomplete survey—partial survey of index area(s).
* Annual index streams.

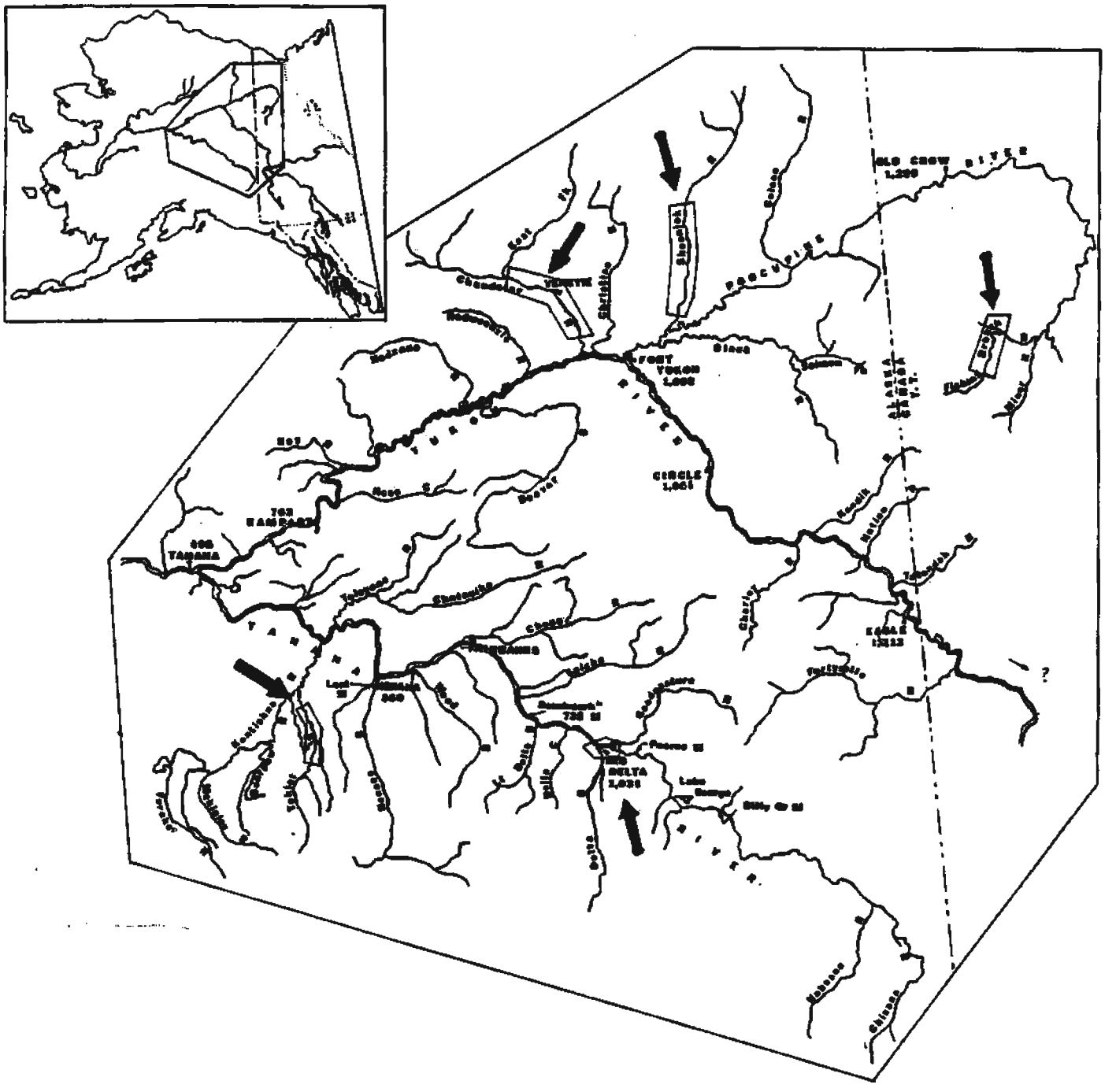

Figure 9. Major fall chum salmon spawning areas in the Tanana and Porcupine river drainages and the Chandalar River. Numbers represent river miles from selected villages to the mouth of the Yukon River at Flat Island.

Table 6. Yukon River drainage fall chum salmon aerial survey spawning escapement estimates for selected index streams, 1973 through 1982.[a]

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
TANANA RIVER DRAINAGE										
Toklat River[b]	6957	34310	42418[c]	35190	21800[c]	35000	96550[d]	23054	13907	3309[e]
Upper Tanana River										
Benchmark #735 Slough	127	1450[c]	--	336	1270	1705[c]	2714	1900[e]	168[c]	--
Delta River	7971[f]	4010	3089[e]	5498	17925	10051	8125	4637	10664[p]	3433[e]
South Bank Tanana River[g]	5635	4567[f]	--	4979	3797	5700	20820	3444	7063	--
Bluff Cabin Slough	3450	4840[f]	5000[c,d]	3197	6491	5340	6875	3190	6120	1156[e]
Onemile Slough	1720	1235	745[d]	1552	1900	475	3850[c]	885[c]	632	--
Subtotal	18903	16102	8834[t]	15562	31383	23271	42384	14056	36358	4589
TOTAL TANANA INDICES	25860	50412	51252[t]	50752	53183	58271	138934	37110	50265	7898[t]
PORCUPINE RIVER DRAINAGE										
Sheenjek River	1175[f,s]	40507	78060	11866	20506	14610[c]	41140	13027	12625[c,h]	717[c,i,s]
Fishing Branch River (YT)	15987[j]	325251[j]	78615[k]	13450	32500	15000	44080	20319[c]	10549[c,r,t]	5846
Total Porcupine Indices	17162[l]	73032[l]	156675	25316	53006	29610	85220	33346	23174[c]	6563
UPPER YUKON TRIBUTARIES										
Chandalar River	--	17455	6345[c,t]	58[c,t]	4183	--	--	2607	4906[m]	1145[m]
TOTAL PORCUPINE AND UPPER YUKON TRIBUTARY INDICES	17162[c,l]	90484[l]	163020	25374	57189	29610[c]	85220[c]	35953	28080	7708[m]

[a] All surveys rated fair-good unless indicated otherwise. Only peak estimates are listed.
[b] Includes following areas: Toklat River in vicinity of roadhouse; Sushana River; Geiger Creek.
[c] Poor survey rating.
[d] Combined aerial and ground surveys.
[e] Foot survey.
[f] Survey rating not given.
[g] Richardson Highway bridge to Blue Creek.
[h] Sonar-estimated escapement was 69,043.
[i] Sonar-estimated escapement was 29,093.
[j] Weir count.
[k] Total escapement through weir was 353,282.
[l] Figure includes a weir count--not comparable.
[m] Fair to poor survey
[p] Ground count was 22,375.
[r] Surveyed only half of index area--many more chum salmon present.
[s] Surveyed well before peak spawning--too early.
[t] Incomplete survey--partial survey of index area(s).

Index area(s)	Observed escapement low	average	high	Years of data used
Upper Toklat River	3,309	31,249	96,550	1973-82
Upper Tanana River[a]	14,506	26,216	48,069	1973-74; 1976-81[b]
(total average)		57,465		
Sheenjek River	11,866	29,042	78,060	1974-81[c]
Fishing Branch River	5,846	29,972	78,615	1975-82[d]
(total average)		59,014		

[a] Includes 5 index areas near Delta River.
[b] The 1975 data were excluded because only 3 of 5 index areas were surveyed. The 1982 data were excluded since only 2 of 5 index areas were surveyed.
[c] The 1973 and 1982 data were excluded because surveys were flown well before peak spawning.
[d] The 1973 and 1974 data were excluded because they were total estimated escapement. The 1981 data were from a partial survey and thus excluded.

It can be seen that the average observed escapement to selected spawning streams in the Tanana and Porcupine rivers was approximately 57,500 and 59,000, respectively, from 1973 through 1982.

Accuracy of aerial survey data can be highly variable and is dependent upon a number of factors such as weather and water conditions, timing of surveys with respect to peak spawning, type of aircraft, experience of both pilot and observer, streambed coloration, and species of salmon being enumerated. Consequently, the surveyor attempts to subjectively evaluate each survey by rating it as poor, fair, or good, based upon the factors he feels influence survey results. It is known that aerial escapement estimates are lower than actual salmon escapement, even when survey conditions are optimal. This phenomenon is probably even more pronounced when surveying fall chum salmon spawning populations in the Yukon River drainage.

The unique timing and distribution of fall chum salmon compared to their counterparts (summer chum salmon) in the Yukon River drainage results in extreme difficulty in collecting accurate aerial escapement information from year to year. Fall chum salmon primarily spawn from September through November in areas that are spring fed, and, except for the Delta River area near Fairbanks, major spawning grounds are very remote.

There is little daylight available during the fall chum salmon spawning season in which to reach and survey most major spawning areas.

Further, unfavorable weather and water conditions tend to generate the largest problem for obtaining accurate escapement estimates. Frequent snowfalls not only limit available days for surveying but also cover salmon carcasses on river bars. Generally, rivers are running ice, which precludes making salmon counts in the mainstem river. Even in years when river ice may not be a substantial problem, most fall chum salmon spawning streams are silty in nature or dark stained from tundra runoff. This, together with poor visibility, renders only the very shallow areas along sand or gravel bars visible to the observer.

A further reason fall chum salmon escapement estimates are lower than actual escapement is because spawner residence time for any given stream has not been considered to attempt to estimate actual spawning escapements. Gangmark and Fulton (1952), Bevan (1961), and Neilson and Geen (1981) have shown that usually peak spawning abundance, measured by aerial survey methods, is significantly lower than the actual seasonal stream population of spawners.

Aerial estimates provide an "index of abundance" for examining trends in relative escapement. With that in mind, it is apparent that fall chum salmon escapement trends in the Sheenjek and Fishing Branch rivers were very similar during the past 8 years (1975-1982) (Figure 10). (Escapement figures for the Fishing Branch River for 1973 and 1974 are the total estimated escapements made by ECFS through a salmon weir and are not comparable to aerial survey estimates). Results also show a trend of declining escapements in the last 4 years to each of these rivers (see below):

	Average observed escapements		
	1975-1978	1979-1982	1975-1982
Sheenjek River	31,260	22,264[a]	27,404[a]
Fishing Branch River	34,891	23,415[b]	29,972[b]
Total Porcupine River	66,151	45,679	57,376

[a] Excluding 1982 data--surveyed too early.
[b] Excluding 1981 data--incomplete survey.

Available data show Porcupine River system returning fall chum salmon to be predominantly 4-year-old fish in most years. Figure 10 indicates an apparent peak-abundance, 4-year cycle occurring in 1975 and 1979 in Porcupine River populations. Average observed escapement to each river during high abundance years and low abundance years based on aerial surveys is listed below:

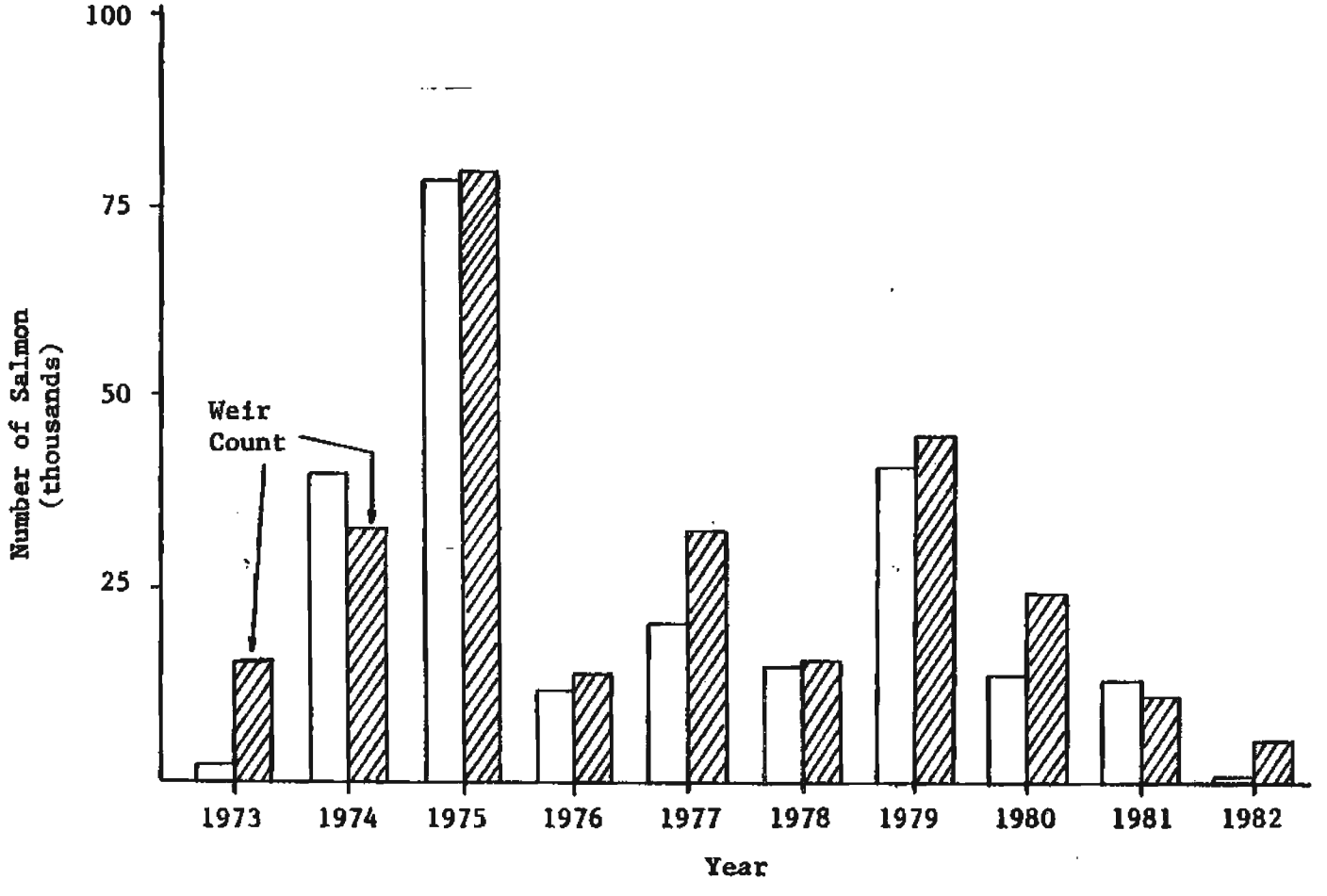

Figure 10. Fall chum salmon observed escapements in the Sheenjek River (open bars) and Fishing Branch River (hashed bars) based on aerial and ground surveys, 1973 through 1982.

	Average observed escapement	
	peak years[a]	non-peak years[b]
Sheenjek River	59,600	18,856[c]
Fishing Branch River	61,347	17,423[d]
Total Porcupine River	120,947	36,279

[a] Peak years 1975 and 1979.
[b] Non-peak years exclude 1975 and 1979.
[c] Data from 1974 through 1981, excludes 1982--surveyed too early.
[d] Data from 1976 through 1982, excluding 1981--incomplete survey.

Average escapement to the Porcupine River system in non-peak years was only about 30% of the average which occurred in high abundance-cycle years based on aerial surveys since 1975.

That a peak-abundance, 4-year cycle may exist throughout the Porcupine River drainage is further illustrated by total estimated chum salmon escapements to the Fishing Branch River from 1971 through 1975. Estimates were based upon a combination of weir and aerial counts:

1971 - 115,000
1972 - 35,325
1973 - 15,989
1974 - 31,525
1975 - 353,282

The 1971 escapement estimate of 115,000 chum salmon in the Fishing Branch River was a result of aerial surveys by the same observer who conducted aerial surveys in 1975 with only 50% accuracy (Elson 1976). Elson expanded the 1971 estimate to 250,000 to 300,000 based upon a comparison of aerial versus weir counts in 1975. He concluded that the 1971 aerial estimate of the chum salmon population in the Fishing Branch River accounted for less than 50% of the actual number of fish. Elson further hypothesized that the 1975 chum salmon population was composed of progeny from the 1971 population and that most of the 1975 fish were 4 years old.

These results reveal the average fall chum salmon escapement to the Fishing Branch River from 1972 through 1974 (non-peak years) was approximately 27,600. The average in 1971 and 1975 (peak years) was approximately 300,000+. Thus, non-peak year escapements to the Fishing Branch River averaged only about 10% of peak-abundance, cycle years from 1971 through 1975.

Available data for the Porcupine River system show that peak escapement levels of fall chum salmon occurred in 1971, 1975, and 1979. Escapement

in 1983 would mark the next year in this 4-year cycle of peak returns. However, existing data are insufficient to conclusively state that high returns will in fact be experienced, particularly in view of the low percentage of age 3_1 fish observed in the 1982 Sheenjek River escapement and the apparent recent trend (since 1979) of declining Porcupine River escapements. Reasons for this apparent decline are not understood but may be a function of increased commercial and subsistence harvests as well as high seas interceptions.

Project Application to Fishery Management

Fall chum salmon began appearing in the middle Yukon River (the area of Kaltag to Galena) in early August in 1982. However, commercial and subsistence catch results and reconnaissance surveys of the various fisheries through late August indicated a very poor run of upper Yukon River populations. Consequently, commercial fishing time in various districts was reduced or entirely closed, and subsistence fishing was also curtailed. Only in mid-September did the late portion of the upper Yukon River fall chum salmon run appear to show in enough strength to relax subsistence fishery restrictions and permit two 24-hour commercial openings.

The Sheenjek River sonar project proved extremely valuable to fishery managers in 1982. Sonar-estimated fall chum salmon escapement was relayed daily to the Area management office, and results, although not used to directly manage the various fisheries, did in fact verify the suspected poor run strength of upper Yukon River fall chum salmon stocks.

Summary

1. A sonar estimate of 29,093 fall chum salmon was obtained in the Sheenjek River from August 31 through September 22, 1982. Peak passage occurred on September 16, when 8.5% of the sonar-estimated escapement was observed.

2. Approximately 55% of the sonar counts were registered within the outer half of the sonar counting range. Although only the west side of the river was sampled by the sonar counter, test fishing results indicated the majority of chum salmon migrated up the west side.

3. In general, daily upstream migration of chum salmon commenced with the onset of darkness and continued through hours of suppressed light, decreasing rapidly in the early morning hours.

4. The male-to-female chum salmon ratio was 1.00:1.37 (42% males, 58% females) based on gillnet samples collected from September 1-21.

5. Gillnet sampling revealed the Sheenjek River chum salmon escapement to be predominated by age 5_1 (49%) followed by age 4_1 (47%) fish.

6. River surface water temperature at the sonar site ranged from 46.4°F to 41.0°F, with an average of 43.8°F for the duration of the project. This average temperature was 1.9°F warmer than in 1981.

7. Only a single aerial survey of the Sheenjek River could be flown in 1982 (September 14) due to unfavorable weather.

Conclusions

The sonar-estimated escapement to the Sheenjek River in 1982 (29,093) can be considered a minimal count since it is known that chum salmon were present in the river prior and subsequent to sonar operations. However, it is probable that the greatest proportion of the run was enumerated.

It is further concluded from available data that the 1982 escapement of fall chum salmon to the Porcupine River drainage was the lowest observed during the past 10 years.

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