

INFORMATIONAL LEAFLET NO. 239

YUKON RIVER FALL CHUM SALMON BIOLOGY AND STOCK STATUS

By
Lawrence S. Buklis
and
Louis H. Barton

STATE OF ALASKA
Bill Sheffield, Governor
DEPARTMENT OF FISH AND GAME
Don W. Collinsworth, Commissioner
P.O. Box 3-2000, Juneau 99802



June 1984

YUKON RIVER FALL CHUM SALMON BIOLOGY AND STOCK STATUS

by

Lawrence S. Buklis

and

Louis H. Barton

Alaska Department of Fish and Game
Division of Commercial Fisheries
Anchorage, Alaska

June 1984

TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES	i
LIST OF FIGURES	ii
LIST OF APPENDICES	iv
ABSTRACT	v
INTRODUCTION	1
LIFE HISTORY	1
Distribution and Physical Characteristics	1
Age at Maturity	3
Spawning	3
Fecundity	8
Residence Time Within Spawning Areas	9
Egg Incubation and Fry Emergence	9
Egg-to-Fry Survival	10
Fry Outmigration	10
Ocean Rearing Areas and Migration Patterns	13
YUKON RIVER FALL CHUM SALMON FISHERIES	14
Commercial Fishery	14
Subsistence Fishery	20
Current Challenges to Fisheries Management	22
STOCK COMPOSITION AND RUN TIMING	23
Tag and Recapture Study, 1976-1978	23
Run Timing and Migration Rates	29
Stock Separation Based on Migration Rate Analysis	32
ESCAPEMENT ENUMERATION	35
Assessment of Spawning Escapements	35

TABLE OF CONTENTS (Continued)

	<u>Page</u>
Escapement Trends	40
AGE AND SEX COMPOSITION	46
TOTAL RETURN ESTIMATES	50
RECOMMENDATIONS	55
ACKNOWLEDGMENTS	56
LITERATURE CITED	57
APPENDICES	63

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Age composition of Yukon River summer and fall chum salmon, District 1 commercial catch samples, 1973-1982	4
2. Chum salmon egg-to-fry survival estimated from potential egg deposition for several stocks in North America and Asia (modified from Bakkala 1970)	11
3. Yukon River commercial salmon harvest by species, 1961-1983 . . .	17
4. Number of fishing vessels participating in the Yukon River fall chum salmon commercial fishery, 1971-1983	19
5. Commercial and subsistence harvest of Yukon River fall chum salmon, 1974-1983	21
6. Number of fall chum salmon tagged at each Yukon River fishwheel site, 1976-1978	24
7. Yukon River fall chum salmon tag recoveries, 1976-1978	26
8. Migration rates of fall chum salmon in the Yukon River based on test fishing catch data, 1981 and 1982	33
9. River mileages of major Yukon River fall chum salmon spawning areas and estimated dates of peak spawning	34
10. Estimated dates of 50% run passage for major fall chum salmon stocks at the mouth of the Yukon River based on peak spawning dates and distance to spawning grounds	36
11. Fall chum salmon spawning areas in the Yukon River drainage, with the largest escapement count during the period 1959-1983 given for each area	38
12. Fall chum salmon escapement to selected index areas in the Yukon River drainage, 1973-1983	39
13. Recent fall chum salmon escapement trends in the Porcupine and Tanana River systems	43
14. A comparison of peak and non-peak years fall chum salmon escapements in the Porcupine River system	45
15. Summary of Yukon River fall chum salmon population estimates cited in literature	51
16. Total return index of Yukon River fall chum salmon, based on harvest and observed escapement, 1974-1983	52
17. Recent harvest of chum salmon in the Shumagin and south Unimak fisheries during the month of June	54

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Map of the Yukon River	2
2. Major fall chum salmon spawning areas in the Yukon River drainage	5
3. Offshore tagging locations of Yukon River fall chum salmon, 1956-1979	15
4. Map of the Alaska portion of the Yukon River, showing fishing district boundaries	16
5. Recovery of fall chum salmon in the upper Yukon River (above) and in the Tanana River (below) that were originally tagged on the north and south bank of the Yukon River in the Galena-Ruby area, 1976 and 1977	27
6. Run timing of fall chum salmon along the north and south bank of the Yukon River at Galena in 1976 and 1977 as indicated by daily tagging study fishwheel catches	28
7. Run timing of fall chum salmon in the lower, middle, and upper portion of the Yukon River drainage, 1981	30
8. Run timing of fall chum salmon in the lower, middle, and upper portion of the Yukon River drainage, 1982	31
9. Passage of fall chum salmon stocks at the south mouth of the Yukon River based on time of spawning, distance to spawning grounds, and average upstream migration rates of 15 and 20 miles/day	37
10. Fall chum salmon escapement in the Sheenjek River (open bar) and Fishing Branch River (shaded bar) based on peak aerial survey counts, 1973-1983	42
11. Fall chum salmon escapement in the upper Toklat River (open bar) and upper Tanana River (shaded bar) based on peak aerial survey counts, 1973-1983. Both upper and lower Toklat River index areas included in 1975 and 1979	44
12. Age and sex composition of fall chum salmon sampled from fishery catches at Emmonak, Nenana, and Rampart, and from escapements to the Toklat, Delta, and Sheenjek Rivers, 1973-1977	47
13. Age and sex composition of fall chum salmon sampled from fishery catches at Emmonak, Nenana, and Rampart, and from escapements to the Toklat, Delta, and Sheenjek Rivers, 1978-1982	48

LIST OF FIGURES (Continued)

<u>Figure</u>		<u>Page</u>
14.	Age and sex composition of fall chum salmon sampled in 1982 on the north bank of the Yukon River at Ruby and three upper Yukon-Porcupine River locations (above), and on the south bank of the Yukon River at Ruby and three Tanana River locations (below) . . .	49
15.	Total return indices for Yukon River fall chum salmon, 1974-1983, based on documented harvest and observed escapement indices. . . .	53

LIST OF APPENDICES

<u>Appendix Table</u>		<u>Page</u>
1.	Yukon River fall chum salmon tag recoveries from INPFC offshore tagging, 1956-1979	64
2.	Age and sex composition of Yukon River fall chum salmon sampled from selected fisheries and escapements, 1973-1982	66

ABSTRACT

Increasing exploitation by commercial and subsistence fisheries during the period 1974-1983, combined with declining escapement indices, leads the authors to recommend conservative harvest regulation of Yukon fall chum salmon (*Oncorhynchus keta*). While total return showed a moderate increase of 10% for the recent 4-year period (1980-1983) over the previous 4-year period (1976-1979), commercial harvest increased by 30%, subsistence harvest increased by 36%, while the escapement index decreased by 42% and 58% for the Porcupine and Tanana River stocks, respectively. A comprehensive review of information available on the life history, stock composition, exploitation, escapement, and stock status of Yukon River fall chum salmon is presented. Deficiencies in the present data base are discussed, and recommendations are made for future research.

KEY WORDS: chum salmon, *Oncorhynchus keta*, Yukon River, stock status, escapement, harvest, fishery summary, life history, stock composition, age composition.

INTRODUCTION

Fall chum salmon (*Oncorhynchus keta*) support a commercial fishery on the Yukon River that has developed rapidly during the past decade, and a growing subsistence fishery with a long history of traditional use. It is only since the early 1970's that the Commercial Fisheries Division has conducted test fishing, fishery catch sampling, escapement enumeration, and other research studies on these salmon stocks. The purpose of this report is to summarize current knowledge of Yukon River fall chum salmon, indicate weaknesses in the data base which future research should address, and make recommendations for management of the resource.

Much of the information collected on fall chum salmon in the Yukon River is documented in separate in-house agency reports that often neither relate results with other relevant studies nor are widely available to other agencies, libraries, and researchers. The present report provides an integrated presentation of the pertinent data which may be useful in future management, allocation, or research decisions facing the State of Alaska.

The Yukon is the largest river in Alaska, and fourth largest in North America, flowing over 2,000 mi (3,200 km) from its source in British Columbia, Canada, to the Bering Sea (Figure 1). The drainage totals approximately 330,000 square miles (854,700 km²), two-thirds of which is in Alaska. The Koyukuk, Tanana, and Porcupine Rivers are major branches, with important tributary streams for fall chum salmon production in the latter two. The Yukon River is greater than 1 mi (1.6 km) wide at many points, and is frequently braided by sand bars and large islands. Water is relatively clear in the upper reaches of the drainage, but becomes progressively more turbid with bank erosion, glacial silt, and tannic acid stain introduced from tributary streams.

LIFE HISTORY

Distribution and Physical Characteristics

Spawning distribution of chum salmon is the most extensive of any Pacific salmon. Chum salmon range south to the Sacramento River in California and to the island of Kyushu in the Sea of Japan. Chum salmon range east in the Arctic Ocean to the Mackenzie River in Canada and west to the Lena River in the Soviet Union.

Chum salmon occur in distinct summer and fall runs in the Yukon River. Fall chum salmon are larger, have a later run timing, and are less abundant than summer stocks. Fall stocks migrate farther upstream and spawn primarily in the upper Yukon River drainage in spring-fed tributaries, while summer chum salmon spawn primarily in runoff tributaries of the lower Yukon River.

Yukon River fall chum salmon characteristics appear to closely resemble those of fall chum salmon stocks of the Amur River in Siberia. Berg (1934, cited in Lovetskaya 1948) established the following differences between Amur River fall and summer chum salmon:

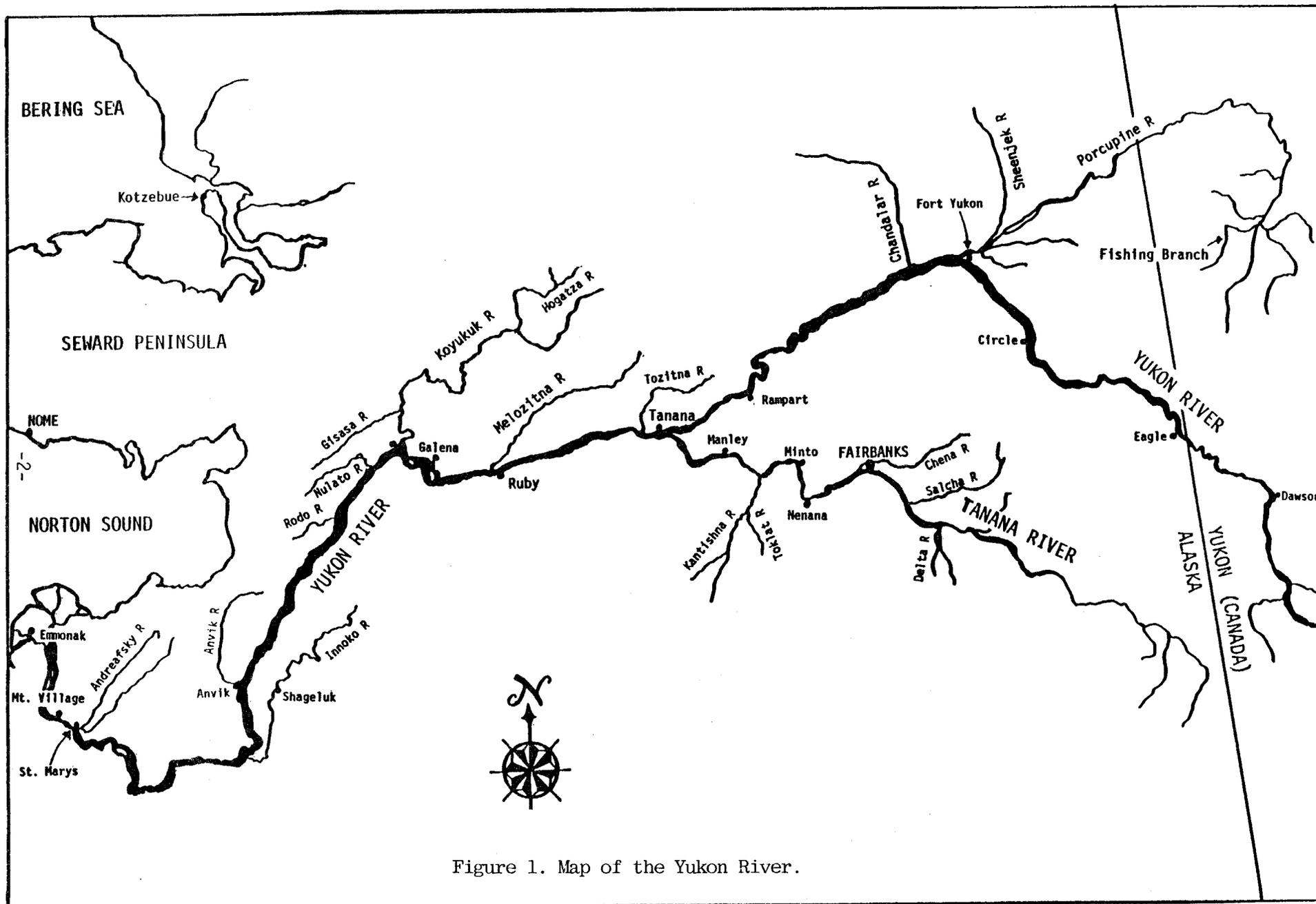


Figure 1. Map of the Yukon River.

". . . 1) the autumn chum enters the river later than the summer chum; 2) its sexual products are developed to a lesser extent when it enters the river; 3) it spawns later; 4) it migrates farther upstream; 5) it is larger and heavier than the summer chum; 6) its fecundity is higher."

Lovetskaya (1948) found that Amur River fall chum salmon mature later, the weight and size range is wider, and the absolute growth and annual increment of body length is greater than for summer chums. Grigo (1953) found a considerable difference in the number of pyloric caeca, with a higher mean count in Amur River fall chum salmon and suggested that the food composition may differ between the two runs.

Berg (1934) and later Grigo (1953) defined the summer and fall chum salmon of the Amur River as seasonal races. According to Birman (1952, cited in Grigo 1953), the fall chum salmon is a race or ecotype adapted to reproduction in predominantly groundwater-fed spawning areas and to river migrations in conditions of high water in the Amur River. The abundance of Yukon River summer chum salmon is far greater than fall chum salmon, but the opposite is the case in the Amur River (Sano 1967).

Age at Maturity

Yukon River chum salmon (both summer and fall) migrate as young-of-the-year fry to the Bering Sea soon after emergence in the spring following spawning. Adults attain sexual maturity and return to the Yukon River for spawning in the 3rd, 4th, 5th, and 6th year of life, although age 4 and 5 fish generally account for more than 90% of the returns annually. There is little difference in the age at return of Yukon River summer and fall chum salmon based on the age composition of samples collected from District 1 commercial catches. Age 4 fish are most abundant (70.5% for summer chum salmon and 72.7% for fall chum salmon), age 5 fish are next most abundant followed by age 3 and age 6 fish (Table 1). Available evidence indicates that age 4 is the predominant age of return for Yukon River summer and fall chum salmon. Fluctuations in age composition are explained by differences in abundance between year classes. Higher than average return of age 3 fish usually reflects high survivorship and abundance of that year class.

Fall chum salmon are generally more robust and "ocean bright" upon arrival at the mouth of the Yukon River. This is attributed to the fact that they migrate farther upstream to spawn than summer chum salmon. The gonads are also in a less mature state of development upon entry into the Yukon River. Whereas summer chum salmon enter the Yukon River from the end of May through mid-July, fall chum salmon entry occurs from mid-July through early September. Although there is often considerable overlap in both physical characteristics and timing of entry into the Yukon River, by 15 July the majority of chum salmon entering the Yukon River are considered to be fall chum salmon (Brady 1983).

Spawning

Fall chum salmon spawn primarily in the Porcupine, Tanana, and Canadian Yukon River drainages (Figure 2). Major known spawning areas include the Sheenjek, Fishing Branch, Chandalar, Delta, Toklat and Kluane Rivers, the Tanana River near Big Delta, and the Yukon River between Fort Selkirk and Carmacks in Canada.

Spawning takes place in channels, sloughs, springs, and heads of main tributaries where upwelling ground water prevents freezing in most years. Strict spawning

Table 1. Age composition of Yukon River summer and fall chum salmon, District 1 commercial catch samples, 1973-1982¹.

Summer Chums						Fall Chums					
Year	Percent Age				Sample Size	Year	Percent Age				Sample Size
	3	4	5	6			3	4	5	6	
1973	5.1	64.5	29.2	1.2	332	1973	6.3	73.4	19.8	0.7	611
1974	31.9	66.3	1.8	—	285	1974	43.8	53.4	2.9	—	461
1975	0.5	94.7	4.9	—	432	1975	1.4	97.7	0.5	—	646
1976	11.6	36.7	51.7	—	259	1976	11.1	36.1	52.9	—	543
1977	19.1	72.4	8.0	0.5	434	1977	9.5	85.1	5.3	0.1	923
1978	5.8	85.0	8.8	0.4	654	1978	19.9	66.0	13.9	1.0	667
1979	11.0	70.9	17.8	0.3	770	1979	7.3	87.8	5.0	—	793
1980	0.9	94.3	4.9	—	678	1980	13.7	78.2	8.2	—	820
1981	0.4	44.3	55.3	—	754	1981	1.4	87.6	11.1	—	672
1982	1.2	75.6	21.2	2.0	405	1982	6.0	62.0	31.5	0.4	1053
Average	8.8	70.5	20.4	0.4	5003		12.0	72.7	15.1	0.2	7189

¹ Captured by set and drift gill nets of 6 inch (15 cm) or smaller mesh.

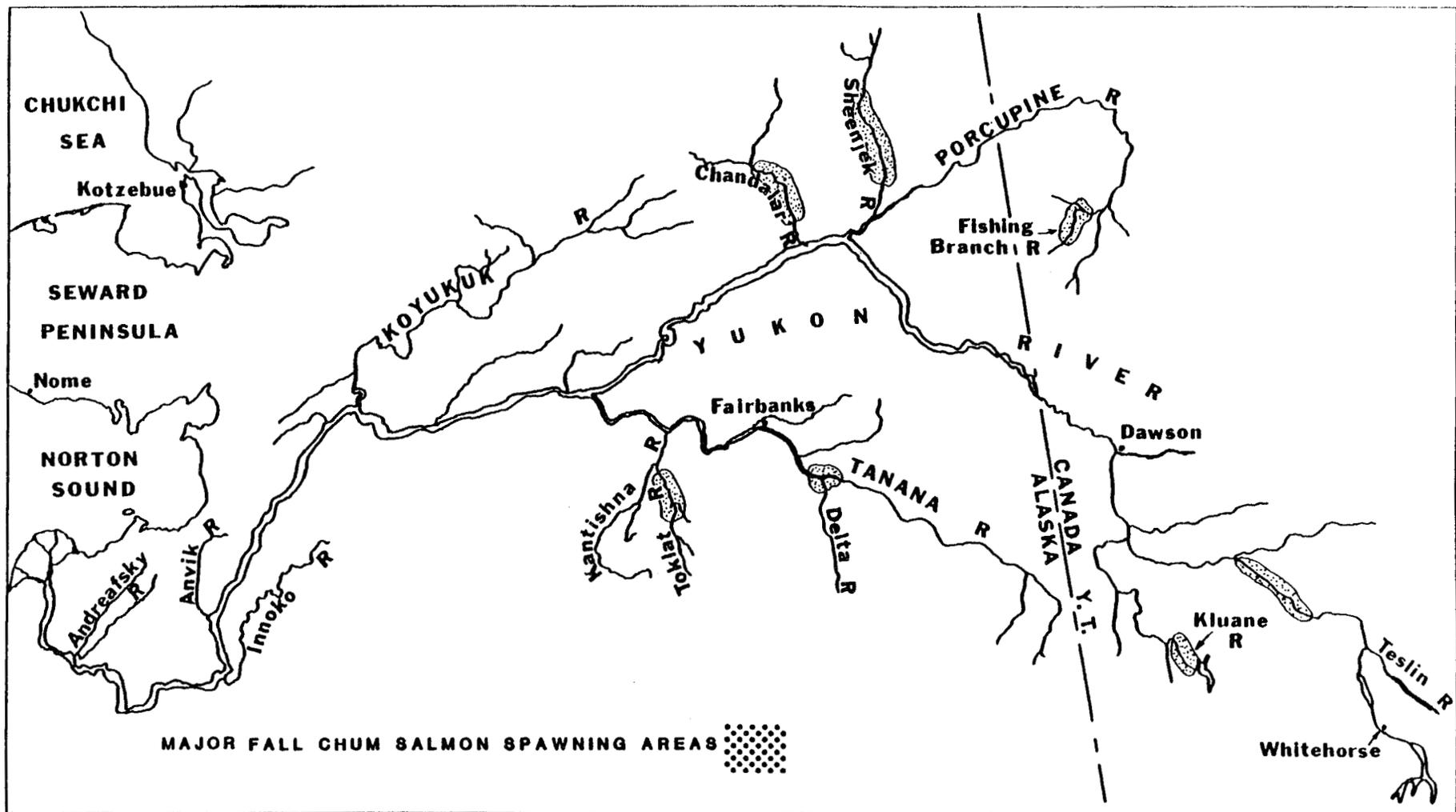


Figure 2. Major fall chum salmon spawning areas in the Yukon River drainage.

habitat requirements limit not only stock distribution but also the available spawning area within a given stream. Many of the known spawning areas are subject to periodic changes in quality and area, as they are vulnerable to mainstem channel changes by high flows during the spring and summer runoff period. Such changes have been observed in the Delta River (Francisco 1977), Sheenjek River (Barton 1982), and Toklat River (Buklis 1983a). Helle (1977) also pointed out the vulnerability of Kluane River fall chum salmon spawning areas to mainstem channel changes.

Walker (1976) observed fall chum salmon spawning areas of the mainstem Yukon River between Fort Selkirk and Carmacks and classified them into five habitat types:

1. Main river cutbank
2. Main river riffle
3. Side channel
4. Slough
5. Combination side channel and slough

Fall chum salmon spawning areas in the Kluane, Sheenjek, Chandalar, Toklat, and Delta Rivers would also fall within the classification identified by Walker, with spawning areas associated with sloughs and side channels being the most common.

The Delta River has been the most intensively studied spawning area (Francisco 1976, 1977; Francisco and Dinneford 1977). Spawning occurs in several small spring-fed channels of the lower Delta River. The channels vary in length from 2 to 730 m, while width may vary from 1 to 75 m. Maximum water depth ranges up to 1.2 m, and surface water temperatures throughout the winter months remain at 1° to 6° C. Bottom composition is mostly gravel from 1 to 13 cm in diameter, with variable amounts of fine material interspersed throughout. During the spring and summer runoff period, the stream flow is orders of magnitude higher and more turbid as a result of glacial melt in the Alaska Range. Fall and winter flows are entirely composed of clear upwelling groundwater.

Elson (1973) described the fall chum salmon spawning area in the Fishing Branch River as follows:

"Water temperatures are relatively constant throughout the year at the areas of discharge, and this section of the river remains free of ice all year. Most spawning occurs in pools above riffles where the bottom composition consists of approximately 60% coarse and 40% fine gravels. Stream discharges on 16 September and 22 September 1972, were approximately 2,000 cfs and 800 cfs, respectively. Water temperatures ranged from 5° C on 10 September to a constant minimum of 2.8° C from 1-20 October, 1972."

Water temperatures in the Sheenjek River were measured by Mauney (1977) at one major fall chum salmon spawning area on 29 and 30 October, 1975. Water temperatures in this spawning area were observed to be 2.2° C to 3.4° C warmer than surface waters of the main river.

Fall chum salmon spawn from approximately mid-September through mid-November with peak spawning varying among major spawning areas as shown below:

<u>Spawning area</u>	<u>Estimated range in peak spawning</u>
Chandalar River	4th week September through 1st week October
Porcupine River drainage	
Sheenjek River	4th week September through 1st week October
Fishing Branch River	1st through 2nd week October
Kluane River	3rd through 4th week October
Yukon River (Ft. Selkirk-Carmacks)	3rd through 4th week October
Tanana River drainage	
Toklat River	2nd through 3rd week October
Upper Tanana River	4th week October through 1st week November
Delta River	4th week October through 1st week November

It is concluded that fall chum salmon that utilize the Tanana River drainage spawn latest, while Chandalar and Porcupine River populations spawn earliest. Coho salmon utilize spawning areas similar to those of fall chum salmon, and in a few areas the spawning grounds of the two species overlap. Although coho salmon spawn slightly later than fall chum salmon, a few have been observed during peak fall chum salmon spawning in most areas. Abundance of coho salmon is small compared to fall chums, and the effect of any subsequent digging up or superimposition of redds by coho salmon is believed to be minor.

There are two opposing schools of thought on the effect of high spawner density on productivity. Kuznetsov (1928, 1937, cited in Smirnov 1947) considers a surplus of reproducing fish on the spawning grounds to be the most important factor increasing the mortality rate of fertilized fall chum salmon eggs in the Amur River. During years of large returns the usable spawning area may be insufficient for the number of females, which results in superimposition of redds, digging up eggs which have already been deposited, and considerable losses. It is believed that intensive spawning causes a deterioration of the hydrochemical regime of the spawning areas (e.g., decrease in oxygen, accumulation of carbon dioxide, and decomposition products of organic substances, resulting in increased acidity) and consequential increase in mortality of developing eggs. Smirnov (1947), on the other hand, does not associate a deterioration in the hydrochemical regime of spawning areas with large runs, but states that such changes are of a seasonal nature. He considers the "digging up" of the spawning grounds as a positive factor in the process of salmon reproduction. Consequently, the size and condition of the existing spawning areas are determined by the activity and abundance of salmon in the rivers. He believes the spawning grounds which are not dug up become unfit for salmon reproduction. It is not known which theory more closely describes the situation for Yukon River fall chum salmon.

Bakkala (1970) presented data which show that egg retention increases when chum salmon spawning density is high. Schroder (1973) not only found greater egg retention in chum salmon under conditions of increased spawning densities but also that redd superimposition increased proportionally with density of spawning fish. In his study on chum salmon spawning densities in a controlled-flow spawning channel of Big Beef Creek, Washington, Schroder found that late maturing or otherwise females retained on the average 10 times as many eggs as did earlier spawning fish. The highest density at which maximum egg deposition occurred ranged

from 1.66 m² to 2.44 m² per female. Burner (1951), in an extensive examination of redd construction of chinook, sockeye, coho, and chum salmon in selected spawning streams of the Columbia River, stated that "to arrive at a conservative figure for the number of pairs of salmon that can satisfactorily utilize a given area of gravel suitable for spawning, the area should be divided by four times the average size of the redds." This could be considered the maximum spatial requirement of a female in the absence of any competition. He found the average size of chum salmon redds to be 2.3 m², indicating 9.2 m² are needed for a pair of spawning chum salmon in the absence of competition.

Available fall chum salmon spawning area has been measured in at least one Yukon River tributary, the Delta River. Dinneford (1978) estimated 45,688 m² of spawning area was available in the Delta River in 1975 and 1977. Based on Schroder's findings, maximum densities which would still allow for maximum egg deposition range from 18,626 to 27,331 females. Findings of Burner (1951) suggest a minimum estimate of 9,890 fall chum salmon (4,945 pairs) necessary for utilization of the available spawning area.

Fecundity

The average number of eggs per female varies among species of salmon and races within a species. Stocks spawning in northerly latitudes tend to be more fecund than those at southerly latitudes (McNeil and Bailey 1975). Bakkala (1970) summarized available fecundity data for chum salmon in Asia and North America. The reported range is from about 900 to 8,000 eggs, with average fecundities between 2,000 and 4,000 eggs. Asian fall chum salmon average fecundities ranged widely (2,500 to 4,300), whereas Asian summer chum salmon fecundities were lower and less variable, ranging from 2,000 to 2,500 eggs.

Limited fecundity data on Yukon River fall chum salmon is available for the Porcupine and Tanana Rivers. Twenty-one females sampled from the Porcupine River at Old Crow in 1971 averaged 2,360 eggs and ranged from 1,658 to 3,200 (Elson 1975). In 1973, 39 females sampled from the Fishing Branch River averaged 2,513 eggs, with a 95% confidence interval of 1,672 to 3,353 (Elson 1975). Trasky (1974) reported an average of 2,634 eggs for 14 fish from the Delta River, which were 93% age 4. Trasky (1976) reports a lower average fecundity of 1,886 eggs for 18 fish sampled in 1974, which were 72% age 3. However, some of the sampled females may have been partially spent. Additional samples were collected from the Delta River in 1977 and 1978. Raymond (1981) examined 38 females in 1977 and found an average of 2,355 eggs per female. Although 92% of his sample was age 4, several of the fish were partially spent. Average fecundity was 2,762 eggs from a sample of 40 fish in 1978 as reported by Raymond (1981). In the same year, Dinneford (1978) examined nine female fall chum salmon on the Delta River spawning grounds and found an average of 2,629 eggs. Seven of the fish were age 4 and two were age 3.

Yukon River fall chum salmon fecundity appears to be similar to that of Amur River summer chum salmon, but lower than that of Amur River fall chum salmon. Available data indicate there is little difference in fecundity between Yukon River summer chum salmon (Andersen 1983a, 1983b) and fall chum salmon.

Residence Time Within Spawning Areas

Elson (1975) examined fall chum salmon stream residence time in the Fishing Branch River. Average stream life in 1972 was 30.5 days (28-32 day range), based on 39 tag recoveries, and 21 days in 1973 (14-27 day range). Trasky (1974) calculated the average stream life for Delta River fall chum salmon in 1973 to be 20.4 days (8-31 day range), similar to 1973 results in the Fishing Branch River. Trasky's results were based on 113 tag recoveries. Average stream life in 1974 was 18 days (2-33 day range) with male fish averaging 15 days and females 21 days (Trasky 1976).

Schroder's (1973) investigations of chum salmon in an artificial spawning channel at Big Beef Creek, Washington, found that no significant changes in stream life occurred seasonally or with spawning density. However, he found that males tended to live slightly longer than females. Stream life for males and females was 15.9 and 14.3 days, respectively, in 1970. In 1971, male and female stream life was 14.6 and 13.1 days, respectively.

In one coastal stream in Southeastern Alaska the average stream life for male chum salmon was 18.3 days and for females 17.6 days in 1962, and 11.6 days for males and 11.4 days for females in 1963 (Mattson et al. 1964, cited in Bakkala 1970). Bakkala (1970) indicated that these figures are probably typical for many populations that spawn within a short distance from the sea. It would appear that populations which enter relatively large rivers and migrate far upstream survive for a longer period in the natal stream. Spawning stream residence time of fall chum salmon may also be protracted by cooler water temperatures which prevail during the spawning period. Cooler temperatures slow metabolic processes, including the biochemical changes which control aging and decomposition.

Egg Incubation and Fry Emergence

Yukon River fall chum salmon deposit eggs in redds from September through November. Fall chum salmon of the Amur River deposit eggs in excavations up to 40 cm deep (Disler 1953). Similarly, Neave (1966) reported finding British Columbia chum salmon eggs at a depth of 41 cm. Francisco (1976) indicated that fall chum salmon eggs in the Delta River in spring 1975 were buried to a depth greater than 25 cm. Eggs remain in the gravel throughout the winter months until the developing embryos emerge as fry in early spring. During the period of incubation, survival of developing embryos varies greatly and is dependent upon several factors.

Smirnov (1947) stated that mortality of fall chum salmon eggs in the Amur River was most severe during the eyed stage, as opposed to summer chum and pink salmon which are subject to highest mortality in the alevin stage of their development. Smirnov (1947) further states that the most important factors which influence mortality rate of salmon eggs and fry are: drop in water level in the tributaries; freezing of the spawning grounds; flow rates; thermal and chemical characteristics of the ground water; and silting of redds. Freezing of the spawning grounds was considered one of the most important factors which adversely affect abundance of young salmon, particularly summer chum and pink salmon, where the ground may freeze to a depth of 1 m or more. Smirnov (1947) pointed out that freezing of the ground also occurred in channels and springs where fall chum salmon spawn, but a considerably smaller area was affected, most frequently only the upper layer of

redds. Disler (1953) stated the main factors affecting development of Amur River chum salmon eggs during the period from fertilization to hatching are temperature, oxygen content of the water, and light.

Francisco (1976) found similar development rates for Delta River fall chum salmon as for those of the Amur River. Total body length of alevin in the Delta River averaged 26.5 mm after incubating 141 days in temperatures of 1.1° to 4.4° C in the winter of 1974-75, while Disler (1954, cited in Francisco 1976) reported fall chum salmon in the Amur River averaged 27 mm in length after an incubation period of 140 to 144 days in temperatures of 3.3° to 5° C. Francisco (1977) estimated an incubation period of at least 110 days to hatching and 160 days to emergence for Delta River fall chum salmon in the winter of 1975-76. During the early incubation period (November), intra-redd water temperature remained a constant 6.7° C, although surface water temperatures ranged from 2.8° to 5.6° C for the same period. No intra-redd temperature readings are available for the duration of incubation in that year. Eyeing of eggs was estimated to occur after 53 days at a water temperature of 4.4° C in 1977. Hatching and emergence were estimated at 122 days and 185 days, respectively (Francisco and Dinneford 1977). Sano (1966) states that hatching of fall chum salmon eggs in the Amur River occurs at 90-100 days and up to 140-150 days in particularly cold years.

Results of 3 years of study in the Delta River from fall 1974 through spring 1977 by Francisco (1976, 1977) and Francisco and Dinneford (1977) reveal that hatching began in early February and was completed by mid-March. Emergence of fall chum salmon fry commenced about the 1st week in April, peaking in the 3rd to 4th week after 160 to 191 days from fertilization. Emergence of Amur River fall chum salmon occurs after about 188 days (Disler 1954, cited in Francisco 1976).

McLean and Raymond (1983) recovered a small sample of fall chum salmon alevins in a spring-fed slough of the Chandalar River near Venetie on 23 March 1982. The alevins had absorbed their yolk sacs, averaged 37 mm in length, and were estimated to be within 2 weeks of emergence. Intragravel water temperature in the spring was between 1.1° and 2.2° C, while water temperature elsewhere in the slough was 0° C. The alevins were recovered from a depth of about 20 cm in the gravel (J. Raymond, ADF&G-FRED, personal communication).

Egg-to-Fry Survival

Francisco (1976, 1977) estimated that between 121 and 134 females spawned in a major spring area of the Delta River in 1975. Using an average fecundity of 2,675 eggs (Trasky 1974, Dinneford 1978, Raymond 1981), potential egg deposition ranged from 323,675 to 358,450 eggs. A total of 8,438 fry was enumerated from the spawning area in the following spring, an estimated egg-to-fry survival of 2.4% to 2.6%. Survival rates of 1.5% to 27.6% for chum salmon stocks elsewhere in North America and Asia have been reported (Table 2).

Fry Outmigration

Fall chum salmon fry leave the Delta River for their downstream migration in the Tanana and Yukon Rivers during the period from mid-April to mid-May (Francisco and Dinneford 1977). Stomach contents were examined from a sample of 1,327 fry taken at the Delta River in April and May of 1976 (Francisco 1977). Approximately 94% of the fish exhibited partial yolk sacs, while the remainder had either empty

Table 2. Chum salmon egg-to-fry survival estimated from potential egg deposition for several stocks in North America and Asia (modified from Bakkala 1970).

Location	Years (number)	Method of Measuring Survival	Survival	
			range (%)	mean (%)
Big Qualicum River, Canada	4	downstream migrant fry counts	5.0-17.0	11.2
Nile Creek, Canada	4	"	0.1-7.0	1.5
Hook Nose Creek, Canada	14	"	1.0-22.0	8.5
Karymaisky Spring, Bolshaya River, U.S.S.R.	7	"	0.7-4.2	2.4
Khor River, U.S.S.R.	—	examination of redds at hatching	25.0-30.0	—
Five tributaries of the Amur River, U.S.S.R.	7	—	2.0-12.0	—
Memu River, Japan	3	downstream migrant fry counts	16.2-34.4	27.6

stomachs (4%) or contained invertebrates (2%). Francisco concluded that little feeding occurs in the Delta River prior to outmigration. Timing of fall chum salmon fry outmigration may vary significantly from one year to the next. Studies of the Delta River population in 1976 and 1977 indicate outmigration peaks which differ by nearly a month. Outmigration peaked in mid-May in 1976 but was prior to 25 April in 1977 (Francisco 1977, Francisco and Dinneford 1977). In both years, peaks in outmigration were associated with high water levels. It is likely that early emerging fry reside in their natal streams until increased water flows occur. During this period they may begin to feed on invertebrates once their yolk supply is exhausted.

Buklis (1983b) estimated that the peak in summer chum salmon outmigration from the Anvik River to the lower Yukon River occurred in early June in 1982, although fry were captured in the Anvik River as late as 21 July. The average length of fry sampled on 22 May and 21 July was 36 mm and 58 mm, respectively.

A juvenile salmon study was conducted by the U.S. Fish and Wildlife Service (USFWS) in the mainstem Yukon River near the confluence of the Hodzana River in 1965 from late April through late August with a variety of capture gear (Gissberg and Benning 1965). Juvenile chum salmon catches peaked during the first week of June when water level was highest, although the last juvenile chum salmon was captured on 28 August. Average size for duration of the study was 39 mm. The highest weekly average length was 40 mm, and the lowest was 38 mm. It is assumed because of the capture location that juvenile chum salmon captured were fall chum salmon from the Porcupine River drainage and other upper Yukon River spawning areas.

Gissberg and Benning (1965) found juvenile chum salmon dispersed across the Yukon River with results that indicated some were deep as well as near the surface. A similar finding was made by Barton (1979), who conducted juvenile salmon studies in the Yukon River near the confluence of the Anuk River from 7 June through 7 July 1977. A 7 m deep hand-operated purse seine was used to sample a cross section of the Yukon River. Juvenile chum salmon were captured in similar numbers at all stations across the river. Peak catches were made in mid-June, and size ranged from 31 to 58 mm with a mean of 41 mm. Water temperature was 9° to 11° C during the period of peak catches. Low numbers of juvenile chum salmon were captured after 24 June. Both summer and fall chum salmon could have been captured at this lower Yukon River sampling station.

Peak catches of juvenile summer chum salmon in the Chena River in 1982 occurred with peak water flow on 7 May (Jerry Stroeble, USFWS, personal communication). Summer chum salmon lengths ranged from 28 to 40 mm with a mean length of 36 mm. Method of capture in this study was the inclined plane trap, which samples the upper meter of the water column.

Results from these studies reveal that both summer and fall chum salmon outmigrations tend to be correlated with increased or peak water flows following spring breakup, resulting in similar timing among areas. Outmigration apparently varies annually, depending upon peak water flow, but generally ranges within the period of about mid-April through mid-June throughout the Yukon River drainage. Based on comparisons of similarities in timing and size of outmigrants, as well as differences in timing and habitat requirements of summer and fall chum salmon spawners, it is conjectured that embryonic development of summer chums is retarded

by colder water temperatures on their spawning grounds in comparison to faster development of fall chums in warmer, spring-fed water. However, it is probable that thermal unit requirements are similar for both races, which results in similar timing of emergence and subsequent outmigrations throughout the Yukon River drainage.

Outmigrating juvenile chum salmon may be present in the river for a prolonged period in view of the extensive size of the Yukon River drainage. Levanidov and Levanidova (1957, cited in Gissberg and Benning 1965) found minimum size chum salmon present in the Amur River throughout a 2-1/2 month downstream migration and suggested that migrating fish were continually replaced by newly hatched fish. The consistent size of juvenile chum salmon in the Yukon River during June, July, and August of 1965 led Gissberg and Benning (1965) to the same conclusion.

Dispersion and continued migration of juvenile chum salmon from the Yukon River once they reach the Bering Sea is not known. Barton (1979) during Outer Continental Shelf investigations in 1976 and 1977, found some evidence to indicate that neither juvenile pink nor chum salmon are present in the immediate nearshore coastal areas of Norton Sound by mid-July. Merritt and Raymond (1983) made similar observations in Kotzebue Sound in 1980. They stated that a failure to catch juvenile chum salmon in the nearshore waters of Kotzebue Sound after 7 July suggested that they had moved to deeper water. Sano (1966) reported that schools of chum salmon fry are found along the entire coast of northern Japan during the period of April to June. Some depart the coast in early July and most by August. Sano states that nearly all fry leave coastal waters by mid-August. Straty (1981) reported small numbers of chum salmon juveniles were captured in coastal waters of Bristol Bay as early as mid-June in 1967. However, they did not become abundant until after mid-July. They remained abundant along the southeastern coast of Bristol Bay seaward of 159°W through August and until mid-September in 1969 and 1970.

Ocean Rearing Areas and Migration Patterns

There are no data to indicate that the marine life history features of Yukon River fall chum salmon differ significantly from summer chum salmon, including ocean residence time, distribution, and migration patterns. The most recent comprehensive review of offshore chum salmon distribution is by Neave et al. (1975), in which the results of INPFC offshore tagging in the North Pacific Ocean from 1955 to 1971 are summarized.

After spending several weeks nearshore, possibly in southern Norton Sound, juvenile chum salmon from the Yukon River apparently move seaward in late summer and throughout the autumn. In winter, the juveniles along with other immature chum salmon rearing in the Bering Sea, migrate southward into the Gulf of Alaska and North Pacific Ocean. In late May or June of the following summer the pattern is reversed, with immature chum salmon moving northward to summer feeding areas in the central Bering Sea.

INPFC tagging results from 1955-1979 have been examined to identify fall chum salmon tag recoveries with reasonable certainty. Fifty-one maturing Yukon River chum salmon (recovered in the same year as tagging) were identified as fall chums by examining the location and time of recapture (Appendix Table 1). Four immature chum salmon (recovered in years subsequent to the year of tagging) were identified

as Yukon River fall chums (Appendix Table 1). The approximate location of original tagging (Figure 3) indicates that fall chum salmon are dispersed extensively in the Gulf of Alaska. The concentration of tag returns from the Unimak, Unalaska Island area is probably a function of greater tagging effort applied there, and not because of an unusual abundance of chum salmon.

The distribution of fall chum salmon of Yukon River origin is apparently extensive throughout the Gulf of Alaska, extending eastward to at least 140°W and south to 44°N. One maturing fall chum salmon was tagged in the Bering Sea in July at 60°N, 174°E, well west of the International Date Line at 180°. A recent recovery has extended the known range of chum salmon by several hundred miles to the southwest. The fish was released on 11 May 1982 by a Japanese longline research vessel at 45° 26'N, 178° 30'W, in the area of the Japanese landbased driftnet salmon fishery as it existed before 1978 (Harris 1982). The fish was recovered 1 October 1982 at Ruby, mile 580 (km 933) of the Yukon River.

YUKON RIVER FALL CHUM SALMON FISHERIES

Commercial Fishery

Commercial salmon fishing in Alaska is allowed along 1,200 mi (1,930 km) of the mainstem Yukon River and the lower 200 mi (320 km) of the Tanana River. An active but much smaller fall chum salmon fishery also exists in the Yukon Territory, Canada. The present district boundaries for Alaska were established in 1961 and redefined in 1962, 1974, and 1978. The commercial fishing area is divided into six districts for management and regulatory purposes. The Lower Yukon area (lower 3 districts) includes the coastal waters of the area and the river proper from the mouth to Old Paradise Village, river mile 301 (km 484). The Upper Yukon area (upper 3 districts) is defined as the drainage upstream of Old Paradise Village to the U.S./Canada Border including the Tanana River. The districts are further subdivided into 10 subdistricts (Figure 4) and 25 statistical areas for regulatory purposes, and to facilitate accurate harvest reporting.

Commercial catches of fall chum salmon in the Yukon area have been accurately documented since 1961, when 42,461 fish were harvested in District 1 (Table 3). Commercial fishing for fall chum salmon during the early 1960's was confined to District 1. In the early years methods of harvest were relatively unsophisticated, and the pace of the fishery was slow. Fishing was allowed on a 4 day per week basis, and the majority of fishermen used set gillnet gear which was operated from outboard powered skiffs. Net reels or rollers were not used. Only 71 fishermen participated in the fall chum salmon fishery in 1961, and the estimated value of the harvest that year was \$15,000. Fewer than one-third of those who participated in the chinook salmon fishery also fished for fall chum salmon.

Commercial harvest for the period 1961-68 average 41,400 fall chum salmon annually, excluding 1963, when no harvest was taken. Since 1969, however, the Yukon River fall chum salmon fishery has experienced rapid growth in terms of catch, numbers of fishermen, processing and tendering capability, and overall demand on the resource. Commercial harvest in the Alaska portion of the drainage averaged 337,450 fall chum salmon for the recent 5-year (1979-1983) period (Table 3). Ex-vessel value of the catch to fishermen was \$719,800 in 1983. Commercial fishing

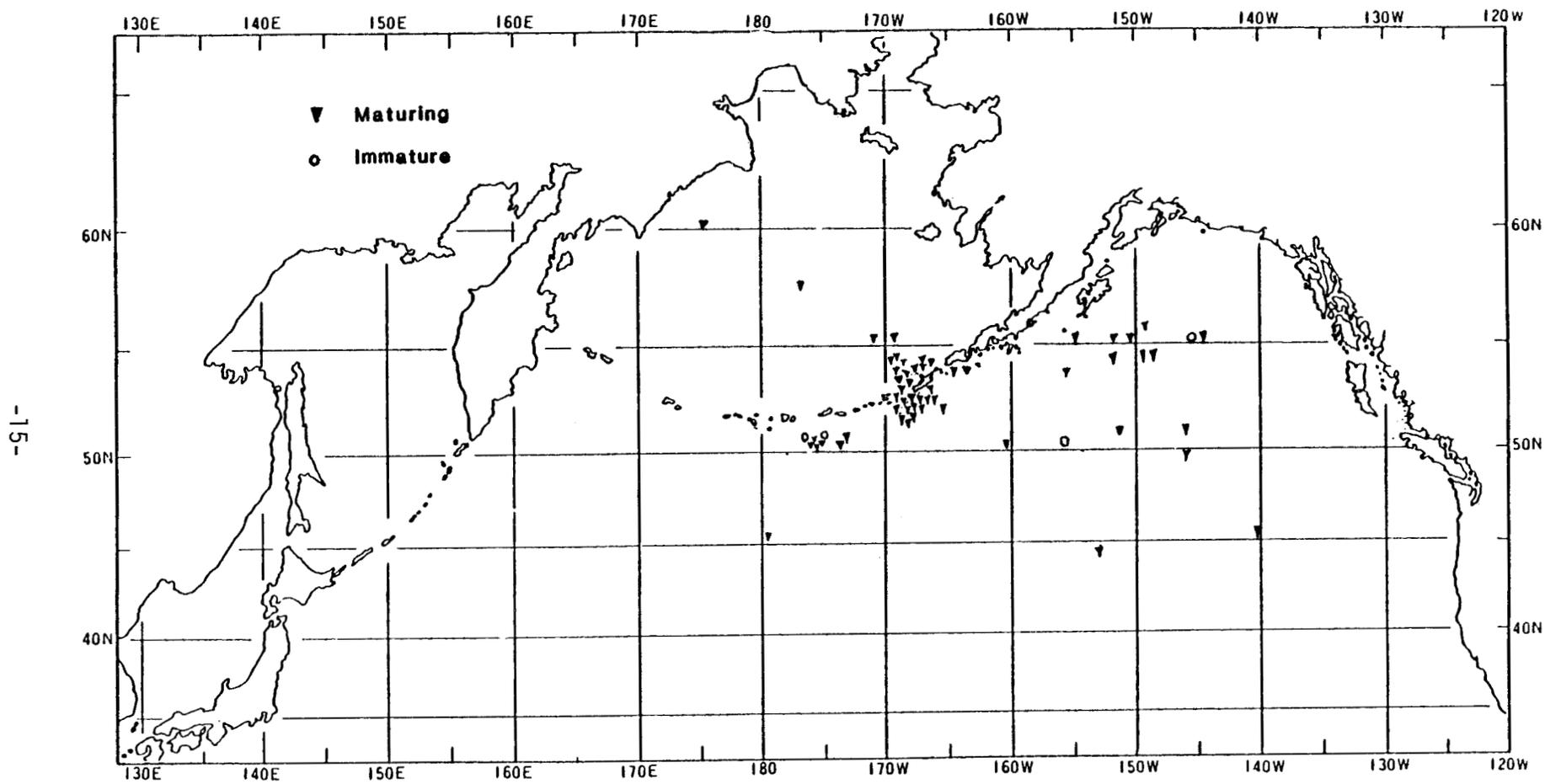


Figure 3. Offshore tagging locations of Yukon River fall chum salmon, 1956-1979.

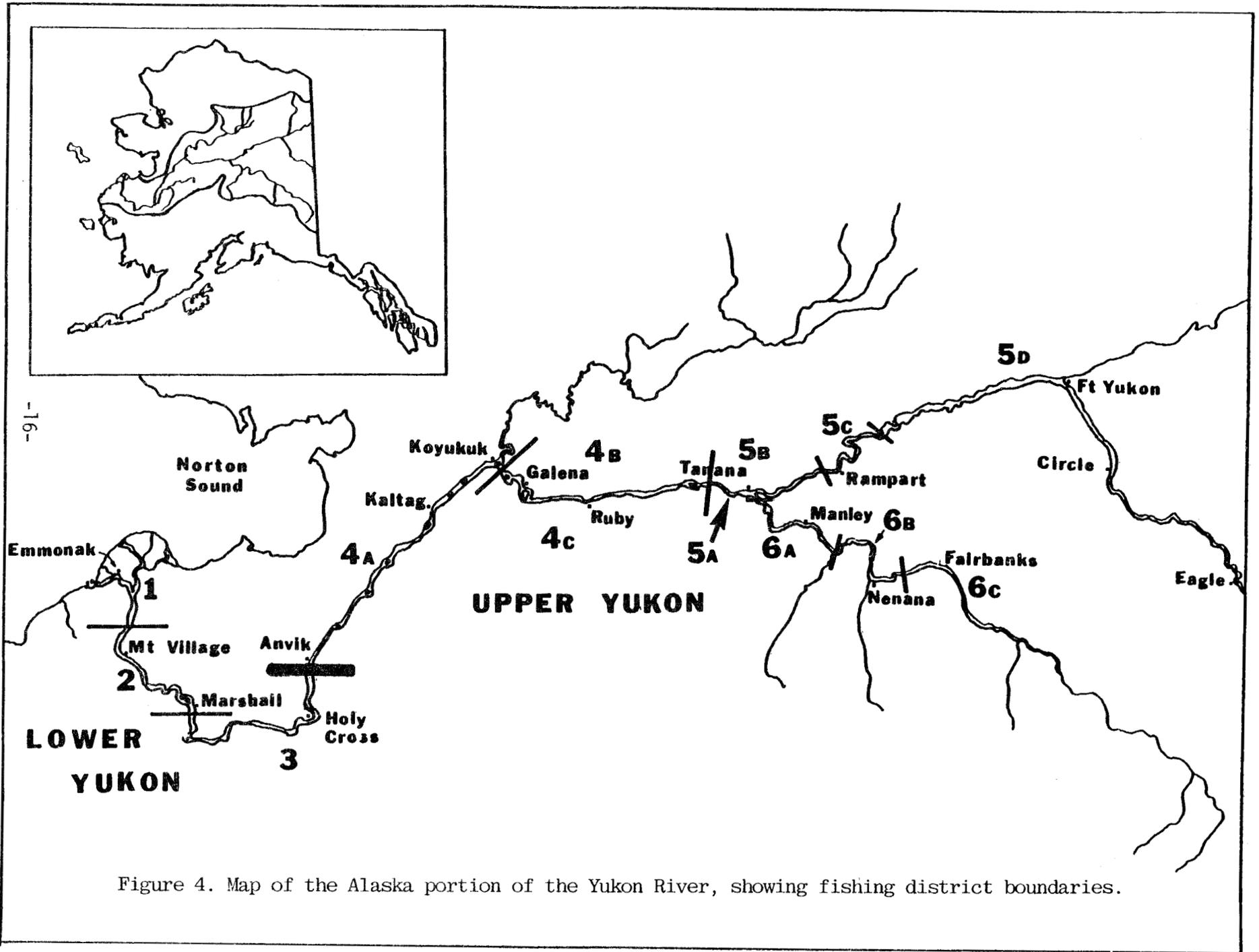


Figure 4. Map of the Alaska portion of the Yukon River, showing fishing district boundaries.

Table 3. Yukon River commercial salmon harvest by species, 1961-1983 ¹.

Year	Chinook	Summer Chum ²	Fall Chum ²	Coho	Other ³	Total
1961	119,664	-	42,461	2,855	116	165,096
1962	94,734	-	53,116	22,926	44	170,820
1963	117,048	-	-	5,572	3	122,620
1964	93,587	-	8,347	2,446	-	104,380
1965	118,098	-	23,317	350	-	141,765
1966	93,315	-	71,045	19,254	-	183,614
1967	129,656	10,935	38,274	11,047	203	190,115
1968	106,526	14,450	52,925	13,303	-	187,204
1969	91,027	61,966	131,310	15,093	-	299,396
1970	79,145	137,006	209,595	13,188	255	439,189
1971	110,507	100,090	189,594	12,203	1	412,395
1972	92,840	135,668	152,176	22,233	-	402,917
1973	75,353	285,509	232,090	36,641	101	629,694
1974	98,089	589,892	289,776	16,777	-	994,534
1975	63,838	710,295	275,009	2,546	108	1,051,796
1976	87,776	600,894	156,390	5,184	41	850,285
1977	96,757	534,875	257,986	38,863	-	928,481
1978	99,168	1,079,709	245,290	26,152	1	1,450,320
1979	127,673	819,533	378,412	17,165	7	1,342,790
1980	153,985	1,067,715	298,450	8,745	-	1,528,895
1981	158,018	1,196,006	477,736	23,680	-	1,855,440
1982	123,644	614,262	224,992	37,176	-	1,000,074
1983 ⁴	147,910	924,878	307,662	13,320	-	1,393,770
5-Year Average (1979- 1983)	142,246	924,479	337,450	20,017	2	1,424,194

¹ Alaska only, does not include Canadian harvest.

² Includes "equivalent salmon" converted from roe sales for the years 1978-1983. Conversion factor of one pound roe equal to one chum salmon was used.

³ Pink and sockeye salmon.

⁴ Preliminary data.

for fall chum salmon in the Canadian portion of the drainage occurs primarily near Dawson. The recent 5-year (1979-1983) average commercial harvest is 14,100 fall chum salmon. A record Canadian commercial harvest of 26,000 fall chum salmon was taken in 1983.

Quotas or harvest limits had not been established for fall chum salmon prior to the 1973 fishing season. The Alaska Department of Fish and Game (ADF&G) established a maximum "harvest goal" of 250,000 fish in 1973 in recognition of the development of the fall chum salmon fishery, and to establish a fixed upper harvest limit until more information could be obtained concerning stock productivity and sustained yield potential. At the same time, fishing effort in the upper river increased, due to the increasing price of salmon and the development of markets outside of Alaska. Acknowledging development of the upriver commercial fishery and the desire of fishermen in the upper portion of the drainage for increased commercial fishing opportunities, the Board of Fish and Game adopted several major regulation changes prior to the 1974 fishing season. The size of District 4 was reduced to that portion of the drainage from the mouth of the Bonasila River upstream to the mouth of Illinois Creek at Kallands. Districts 5 and 6 were created, and salmon catch quotas were established which resulted in an allocation of 200,000 fall chum salmon to Districts 1, 2, and 3, and the remaining 50,000 to Districts 4, 5, and 6. Sound biological information regarding stock status and distribution of spawning populations was not available at that time, and, as a result, the 250,000 fall chum salmon quota was based more on historical harvest than on biological considerations. Allocations were made on the basis of the amount and geographic distribution of fishing effort rather than on size and distribution of spawning stocks.

The largest commercial harvests still occur in the lower 150 mi (240 km) of the river, with diminished fishing effort dispersed in the mainstem upper Yukon and lower Tanana Rivers. In 1983 for instance, 554 vessels participated in the fishery in Districts 1, 2, and 3, and 66 vessels participated in the fishery in Districts 4, 5, and 6 (Table 4). Set and drift gillnet gear is used in the lower river, while in the upper river districts fishwheels and set gillnets are used to take salmon. The Commercial Fisheries Entry Program was implemented in 1976 to stabilize the amount of fishing gear. Presently about 700 gillnet permits are issued yearly for the Lower Yukon area. In the Upper Yukon area, about 75 gillnet and 170 fishwheel permits are issued each year. Fishermen may use up to 50 fathoms (91 m) of drift gillnet or a maximum of 150 fathoms (274 m) (aggregate length) of set gillnet in the lower river districts, Upper Yukon fishermen are allotted a maximum of 150 fathoms (274 m) (aggregate length) of set gillnet or one fishwheel. Most fishermen use 6 in (15.2 cm) mesh stretch measure or smaller gillnets for fall chum salmon.

Regulations adopted at the December 1978 Board of Fisheries meeting replaced the quota system with flexible guideline harvest ranges, and reallocated 30,000 fall chum salmon from the lower river to Subdistrict 4B of District 4. The 200,000 fish quota which had been in effect for Districts 1, 2, and 3 was replaced by a guideline harvest range of 120-220,000 fish. Guideline harvest ranges for upper river fall chum and coho salmon combined are presently: District 4, 10-40,000; District 5, 10-40,000; and District 6, 5,500-20,500. When the fall chum salmon is of average magnitude, the Yukon area commercial harvest should approximate 233,000 fish, the mid-point of the guideline harvest range for the entire river. If the run is substantially below or above average, the commercial catch should be near the lower (145,500) or upper (320,500) end of the range.

Table 4. Number of fishing vessels participating in the Yukon River fall chum salmon commercial fishery, 1971-1983¹.

Year	Lower Yukon Area				Upper Yukon Area			
	District			Total	District			Total
	1	2	3		4	5	6	
1971	352	-	-	352	-	-	-	-
1972	353	75	3	431	-	-	-	-
1973	445	183	-	628	-	-	-	-
1974	322	121	6	449	17	23	22	62
1975	428	185	12	625	44	33	33	110
1976	422	194	28	644	18	36	44	98
1977	337	172	37	546	28	34	32	94
1978	429	204	28	661	24	43	30	127
1979	458	220	32	710	31	44	37	112
1980	395	232	23	650	33	43	26	102
1981	462	240	21	723	30	50	30	100
1982	401	195	15	611	15	24	25	64
1983	312	224	18	554	13	30	23	66

¹ Actual number of fishing vessels refers to those boats which made at least one delivery. Data presented show the number of vessels that operated in each district. Some individual fishing vessels may have operated in more than one district during the year.

Scheduled fishing periods, which are subject to emergency order changes during the season, are utilized to regulate commercial harvest in all districts and sub-districts. Allowable fishing time ranges from two 12-hour periods per week in portions of District 1 and in all of District 2 to 7 days per week in Subdistrict 5D of District 5. Total fishing time allowed during the fall chum salmon season in District 1 has decreased from an average of 22 days annually for the period 1969-1973 to only 7 days annually for the period 1979-1983. Additional regulations and strategies necessary for conservation of fall chum salmon stocks have been imposed. Split fishing periods each week (as opposed to a single continuous period) distribute harvest effort over a greater portion of the run and afford additional protection for smaller stocks. Delayed season openings in the Lower Yukon area and in some portions of the Upper Yukon area reduces the impact of the commercial fishery on early run stocks. Based on results from a tagging study conducted from 1976 to 1978 (discussed in a later section of this report) Subdistrict 4B and 5A boundaries were redefined in 1980 to allow for harvest regulation on a more stock specific basis. These refinements in harvest control have been necessitated by the growth and development of the commercial fishery.

Subsistence Fishery

A comprehensive household survey is made annually by the Division of Commercial Fisheries of ADF&G to document subsistence harvest. One or more members of 1,071 fishing families operated approximately 1,200 gill net and 170 fishwheel units for subsistence fishing purposes in 1982. Often, the same fishermen take salmon for both commercial and subsistence purposes while using the same unit of gear. Chinook and chum salmon are the most important species taken for subsistence purposes. Only small numbers of pink and coho salmon are taken. Chinook salmon are utilized almost exclusively for human consumption, while chum salmon are primarily fed to sled dogs.

In recent years, subsistence fall chum salmon harvest has increased due to increased fishing effort as a result of development of the upper Yukon River commercial fishery and the increasing numbers of recreational sled-dog teams. Approximately two-thirds of the total Yukon River subsistence chum salmon harvest is composed of summer chums. Fall chum salmon are of greater importance than summer chum salmon for subsistence use upstream of the Koyukuk River, where they compose an estimated 60-75% of the total subsistence salmon harvest.

Fall chum salmon subsistence harvest in Alaska during the period 1961-1963 ranged from 36,000 to 233,000 fish annually. The recent 10-year (1974-1983) average fall chum salmon subsistence harvest in the Alaska portion of the drainage is 135,266 fish (Table 5). Fluctuations in annual harvest usually are attributed to variable run magnitude. However, between 1979 and 1983 harvest has increased dramatically in the Upper Yukon area, especially in District 5.

The subsistence fishery in the Canadian portion of the drainage occurs primarily in the mainstem Yukon River from Dawson to Carmacks. Fishing also occurs in the Pelly, Stewart, and Porcupine (Old Crow) River drainages. Fishing gear consists primarily of gill nets and a few fishwheels. Annual Canadian subsistence harvest has ranged from 3,100 to 13,500 fall chum salmon for the period 1974-1983, with a 10-year average (1974-1983) of 8,525 fish (Table 5). The Canadian subsistence harvest is difficult to adequately monitor and may be substantially greater than reported.

Table 5. Commercial and subsistence harvest of Yukon River fall chum salmon, 1974-1983 ¹.

Year	Commercial Harvest			Subsistence Harvest			Total Harvest		
	Alaska	Canada	Total	Alaska	Canada	Total	Alaska	Canada	Total
1974	289,776	3,010	292,786	95,287 ²	8,636	103,923 ²	385,063	11,646	396,709
1975	275,009	2,500	277,509	84,402 ²	13,500	97,902 ²	359,411	16,000	375,411
1976	156,390	1,000	157,390	75,573 ²	3,425	78,998 ²	231,963	4,425	236,388
1977	257,986	3,990	261,976	82,171	9,089	91,260	340,157	13,079	353,236
1978	245,290	3,356	248,646	94,867	11,210	106,077	340,157	14,566	354,723
1979	378,412	9,084	387,496	233,347	13,000	246,347	611,759	22,084	633,843
1980	298,450	9,000	307,450	172,657	13,000	185,657	471,107	22,000	493,107
1981	477,736	15,260	492,996	188,525	6,829	195,354	666,261	22,089	688,350
1982	224,992	11,158	236,150	132,897	3,459	136,356	357,889	14,617	372,506
1983 ³	307,662	25,990	333,652	192,930	3,100	196,030	500,592	29,090	529,682
10-Year Average (1974 - 1983)	291,170	8,435	299,605	135,266	8,525	143,791	426,436	16,960	443,396

¹ Includes "equivalent salmon" converted from roe sales for the years 1978-1983. Conversion factor of one pound roe equal to one chum salmon was used.

² Subsistence harvest of chum salmon was not distinguished between summer and fall runs for period 1974-1976. Chum salmon subsistence harvest was 36.4% fall chums in 1977 and 35.0% in 1978. The average for these two years (35.7%) was applied to total chum salmon subsistence harvest for each year, 1974-1976, to estimate fall chum salmon subsistence harvest. Documented Canadian harvest was subtracted from estimated total harvest to determine the Alaska fall chum salmon subsistence harvest.

³ Preliminary data.

Subsistence has been designated by the Legislature (State Law 151) as the highest priority among uses of fish and game resources in the State of Alaska. The commercial fishery is regulated on the assumption that a harvestable surplus exists after providing for spawning ground and subsistence utilization requirements. Except in areas where intensive commercial fisheries occur, the subsistence fishery is subject to few restrictions in order to give preference to subsistence users. The majority of Yukon River fishermen usually take salmon for both commercial and subsistence purposes in major commercial fishing areas. Therefore, to enforce commercial fishing regulations, it is necessary to place some restrictions on the subsistence fishery. During the commercial salmon fishing season in most areas, subsistence fishing is allowed only during the open commercial fishing periods. During the course of the year, however, substantially more subsistence fishing time is allowed than commercial fishing time.

Current Challenges to Fisheries Management

Geiger and Andersen (1983) provide a summary of recent management strategies for the Yukon River fall chum salmon fishery. Attainment of the optimum sustained yield management goal is made difficult by a number of factors. Because the fall chum salmon commercial fishery has only recently developed and escapements have been documented on a comprehensive basis only since 1973, there is a lack of adequate data on which to evaluate effects of the fishery. As with the chinook and summer chum salmon fisheries, managers have relied primarily on in-season analysis of comparative commercial catch statistics to determine relative run strength and appropriate management strategies for a given season. Since 1977, test fishing data from the lower Yukon River have been used to enhance this information.

Problems inherent in the use of comparative commercial catch data have become particularly apparent in recent years and serve to limit their value and applicability. Large single period or cumulative catches and high catch-per-unit-effort (CPUE) values do not necessarily indicate a correspondingly large run because of the "pulse" type entry pattern of fall chum salmon into the lower river. Fall chum salmon typically enter the mouth of the Yukon River in erratic and unpredictable surges which may last for 1 to 3 days, followed by periods of up to several days when virtually no fish enter the river. If, for example, fishery openings coincide with two or three surges of fish passing through the lower river, analysis of CPUE data could indicate a much stronger run than actually exists. Conversely, CPUE data would indicate a smaller run than was actually in progress if fishing periods occurred between peaks in fish passage.

A second and equally serious problem with use of comparative commercial catch and CPUE data has to do with recent changes in commercial fishing effort and efficiency of the fleet. Fishing effort for fall chum salmon has increased in recent years, especially in Districts 2 and 3 where the number of fishermen and the commercial harvest has doubled since the early 1970's. In addition, the number of major processors who remain in operation for the fall chum salmon fishery in the lower river has increased from three to six since 1972. Tendering capabilities during the same period show a corresponding increase (approximately 50 tenderboats compared to the previous 25), allowing fishermen to deliver their catch quickly and resume fishing. Competition among buyers has increased both the price and the incentive for fishermen to participate in the fishery.

Although difficult to quantify, it is apparent that individual fishermen efficiency has also rapidly increased in recent years. Use of CB and VHF radios has allowed

fishermen to learn the best fishing locations, which change throughout the season. Perhaps the single most important factor in the growing efficiency of the fleet has been the recent and rapid shift by fishermen from the use of set gillnets to drift gillnets, the result of which has been a dramatic increase in proficiency and mobility. This shift has complicated management of the fishery because the comparative catch data upon which many management decisions were made were based on the historic performance of a set gillnet fishery. Catch data generated now by a fleet using large amounts of drift gillnet gear are not directly comparable because of the greater efficiency of that gear type.

Test fishing with set gillnets appears to be a better indicator of run magnitude than comparative commercial catch statistics (Brady 1984). Test gillnetting has been carried out since 1977 in the south mouth near Emmonak and in the middle and north mouth areas since 1980. Annual variations in test fishing sites caused by bank erosion, changing water levels, and presence or absence of driftwood, however, may affect fishing success and the comparability of test fishing indices. Similar problems may occur in the upper Yukon River where test fishing has been conducted for only 3 years using fishwheels.

Fishery managers must take into account the fact that intensive fishing effort occurs throughout 1,400 mi (2,250 km) in the main Yukon and lower Tanana Rivers. Stocks are subject to capture gear for considerably greater amounts of time than in most other salmon fisheries in the State of Alaska. Fall chum salmon migrating to spawning areas in the Porcupine River drainage may be exposed to as much as 22 days of commercial fishing effort and 28 days of subsistence fishing effort.

STOCK COMPOSITION AND RUN TIMING

Tag and Recapture Study, 1976-1978

Tagging was conducted near the villages of Galena, Ruby, and Tanana between 1976 and 1978 to determine whether upper Yukon, Porcupine, and Tanana River fall chum salmon stocks could be distinguished by bank orientation or run timing in the middle Yukon River area (Buklis 1981). Fishwheels were operated throughout the fall chum salmon run each year. One fishwheel was located on the north bank and one on the south bank of the Yukon River at Galena in 1976. In addition, a third fishwheel was operated on the south bank at Ruby in 1977. Tagging effort was shifted upriver in 1978, with four fishwheels operated in the following locations: south bank at Ruby, north bank at Tanana, and one each on the north and south bank of the Yukon River 48 km above Tanana. Each fishwheel was equipped with a livebox to hold the fish until they could be tagged and released. Captured fall chum salmon in good condition were tagged with an individually numbered Petersen disc tag. A \$2.00 reward was paid for each tag returned by fishermen with date, location, and method of recovery information. In addition, Department biologists conducted spawning ground surveys in October and November of each year to recover tagged fish that had escaped the fishery.

A total of 1,217 fall chum salmon were tagged in 1976, 5,359 in 1977, and 9,668 in 1978 (Table 6). Tag recoveries totaled 608 (50%) in 1976, 1,951 (36%) in 1977, and 4,682 (48%) in 1978. The majority of the fish recovered each year were taken by fishwheels. Tag returns by commercial fishermen ranged from 30% to 62% of all recoveries, while subsistence fishermen contributed between 30% and 56% of all

Table 6. Number of fall chum salmon tagged at each Yukon River fishwheel site, 1976-1978.

Year	River Bank	Location	Number Tagged
1976	North	Galena	545
	South	Galena	<u>672</u>
		Subtotal	1,217
1977	North	Galena	1,842
	South	Galena	1,210
	South	Ruby	<u>2,307</u>
	Subtotal	5,359	
1978	North	Tanana Village	2,945
	North	30 mi above Tanana	2,039
	South	29 mi above Tanana	1,956
	South	Ruby	<u>2,728</u>
	Subtotal	9,668	

returns for each year (Table 7). Only 4 tags were returned by sport fishermen in the course of the 3-year study. Spawning ground surveys conducted by Department biologists on the Sheenjek and Fishing Branch Rivers, tributaries of the Porcupine, produced only 2 tag recoveries in 1976, 4 in 1977, and 13 in 1978. An average of 1 tagged fish was recovered for every 2,600 fall chum salmon examined. More time was spent surveying the Tanana River spawning grounds and more tags were recovered than from the Porcupine River drainage. The Toklat and Delta Rivers, tributaries of the Tanana, produced 28 tag recoveries in 1976, 102 in 1977, and 86 in 1978. An average of 1 tagged fish was recovered for every 250 fall chum salmon examined during the 3-year study.

Three hundred forty-five (57%) of the tag returns in 1976 and 610 (31%) of the tag returns in 1977 were recovered below the Yukon-Tanana confluence. These returns cannot be identified by stock. However, the distribution of the remainder of the recoveries indicates a significant difference in bank orientation. Seventy-nine percent of the fall chum salmon recovered in the upper Yukon and Porcupine Rivers in 1976 had been tagged on the north bank, 21% on the south bank. Conversely, 86% of the fall chum salmon recovered in the Tanana River had been tagged on the south bank of the Yukon River, only 14% on the north bank (Figure 5). Similar results were obtained in 1977. Eighty-eight percent of the fall chum salmon recovered in the upper Yukon and Porcupine Rivers in 1977 had been tagged on the north bank, 12% on the south bank. Conversely, 96% of the fall chum salmon recovered in the Tanana River had been tagged on the south bank of the Yukon River, only 4% on the north bank (Figure 5). These results indicate that upper Yukon and Porcupine River fall chum salmon migrate mostly along the north bank, and Tanana River fall chum salmon migrate mostly along the south bank of the Yukon River in the Galena-Ruby area.

Daily fall chum salmon catches by the fishwheels located at Galena in 1976 and 1977 indicated a difference in run timing between the north bank and south bank stocks. Run timing is described by the mean date of passage for purposes of comparison, following the method of Mundy (1982). Mean date of passage for the two stocks was separated by 5 days in 1976, occurring on the north bank on 27 August and on the south bank on 1 September, while it was separated by 10 days in 1977, occurring on the north bank on 24 August and on the south bank on 3 September (Figure 6). These tagging studies indicated that upper Yukon and Porcupine River fall chum salmon stocks migrate through the Galena area earlier than Tanana River stocks.

Objectives of the study were expanded in 1978 to determine whether upper Yukon and Porcupine River fall chum salmon stocks could be distinguished. Three fishwheels were operated at or above Tanana Village. Approximately 95% of the tag returns from these 3 tagging sites were recovered on the Yukon River below the Porcupine confluence. Too few fish were recovered above the Yukon-Porcupine confluence. Too few fish were recovered above the Yukon-Porcupine confluence to allow for any meaningful stock separation analysis, and this portion of the 1978 study proved unsuccessful.

Tag returns from a fourth fishwheel operated in 1978 and located on the south bank of the Yukon River at Ruby confirmed the results of the 1976 and 1977 tagging studies. Twenty-nine percent of the fall chum salmon tag returns from the Ruby tagging site were recovered below the Yukon-Tanana confluence 66% within the Tanana River drainage, and only 5% within the upper Yukon and Porcupine River

Table 7. Yukon River fall chum salmon tag recoveries, 1976-1978.

	1976		1977		1978	
	N	%	N	%	N	%
Commercial Fishery	376	62	594	30	2,229	48
Subsistence Fishery	185	30	1,100	56	1,704	36
Sport Fishery	0	0	3	-	1	-
Spawning Ground Survey	31	5	108	6	97	2
Unknown Source	16	3	146	7	651	14
Total	608	100	1,951	100	4,682	100

Figure 5 . Recovery of fall chum salmon in the upper Yukon River (above) and in the Tanana River (below) that were originally tagged on the north and south bank of the Yukon River in the Galena-Ruby area, 1976 and 1977.

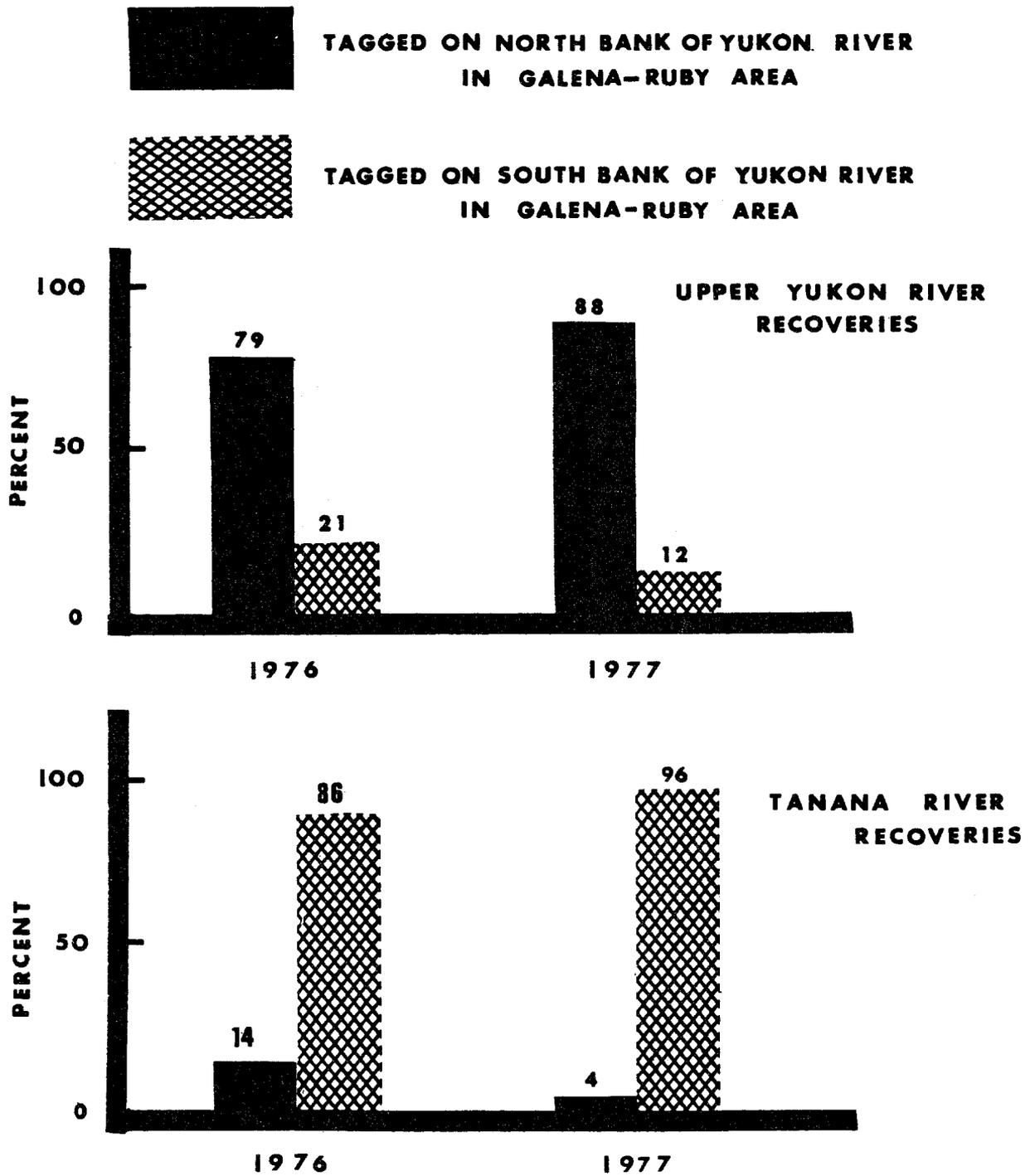
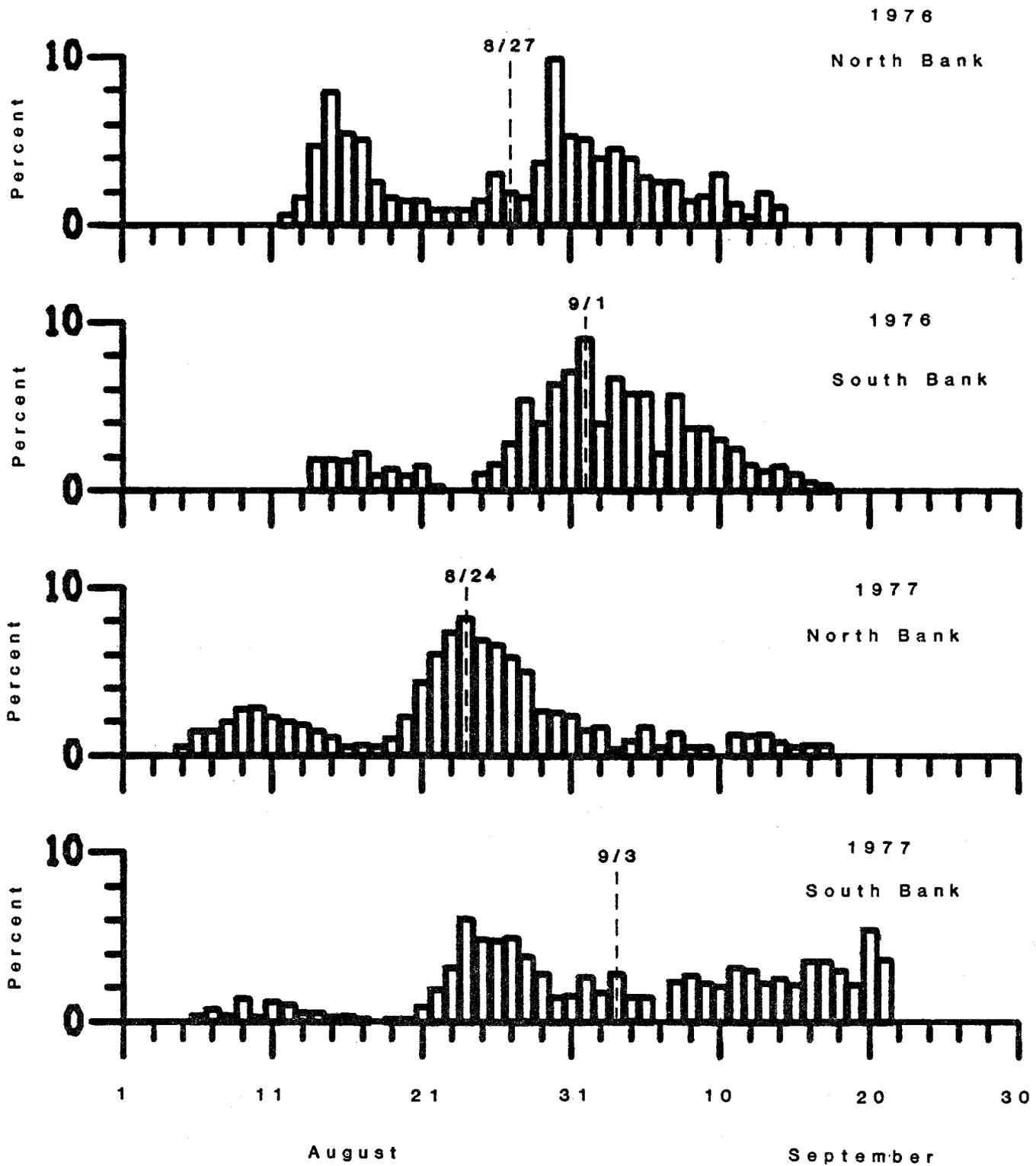


Figure 6. Run timing of fall chum salmon along the north and south bank of the Yukon River at Galena in 1976 and 1977 as indicated by daily tagging study fishwheel catches. Dashed line indicates the mean date of passage for each year and site.



drainages. This indicates once again the south bank orientation of Tanana River stocks in the Ruby area.

Regulations were adopted by the Board of Fisheries in 1980 based on the results of the tagging study. Subdistrict 4B boundaries were redefined such that Subdistrict 4B encompassed only the north bank of the Yukon River between Cone Point and Illinois Creek (Galena-Ruby area), while the new Subdistrict 4C encompassed the south bank (Figure 4). Previously both banks of the river had been in Subdistrict 4B. Similarly, the lower section of District 5 was redefined such that Subdistrict 5A encompassed the south bank and Subdistrict 5B the north bank. The new boundaries allow harvest regulation on the north and south bank of the Yukon River proportional to run magnitude and spawning requirements for each major stock grouping.

Run Timing and Migration Rates

Run timing and migration rate of fall chum salmon in the Yukon River can be estimated using catch and sonar count data from the lower, middle, and upper portions of the drainage in 1981 and 1982. Timing of fall chum salmon entering the Yukon River is assessed by set gillnet test fishing catches at the Big Eddy and Middle Mouth sites (Brady 1982). Fishwheel test fishing catches on the north bank at river mile 601 (967 km) and south bank at river mile 605 (974 km) near Ruby, index run timing of fall chum salmon for the middle portion of the Yukon River (Andersen 1983a, 1983b). In the upper portion of the drainage, escapement sonar counts are available for the Sheenjek River in both years (Barton 1982, 1983), while an index for the Tanana River is available from two sources: an experimental sonar study in 1981 (Buklis 1982), and subsistence fishery catches reported to a check station in 1982.

The shape of the frequency distribution changes from an erratic pattern in the lower river to a more uniform pattern upriver (Figures 7 and 8). Several factors may account for this:

- (1) Weather and environmental conditions trigger schools of fall chum salmon to enter the Yukon River delta, but may be of lesser influence on migration timing further upriver.
- (2) The intensive commercial fishery in the lower river removes large numbers of fish, reducing some of the peaks in abundance that are seen in test fishing catches in the lower river but are not found in upriver catches or escapement counts.
- (3) Schools of fall chum salmon are probably composed of fast, normal, and slow swimmers. Fish entering the mouth of the Yukon River at the same time would thus become more broadly distributed as they progressed upriver. Consequently, discrete schools that were temporally separated at the mouth probably demonstrate less distinct run timing patterns further upriver.

It is tempting to correlate peak values in catch and CPUE from lower river test fishing to upriver test fishing and escapement enumeration data to estimate average migration rate. Examination of data obtained in 1981 and 1982 (Figures 7 and 8) illustrate that it is not readily apparent how this can be done. Multiple surges of abundance are evident in lower river test net catches, but corresponding

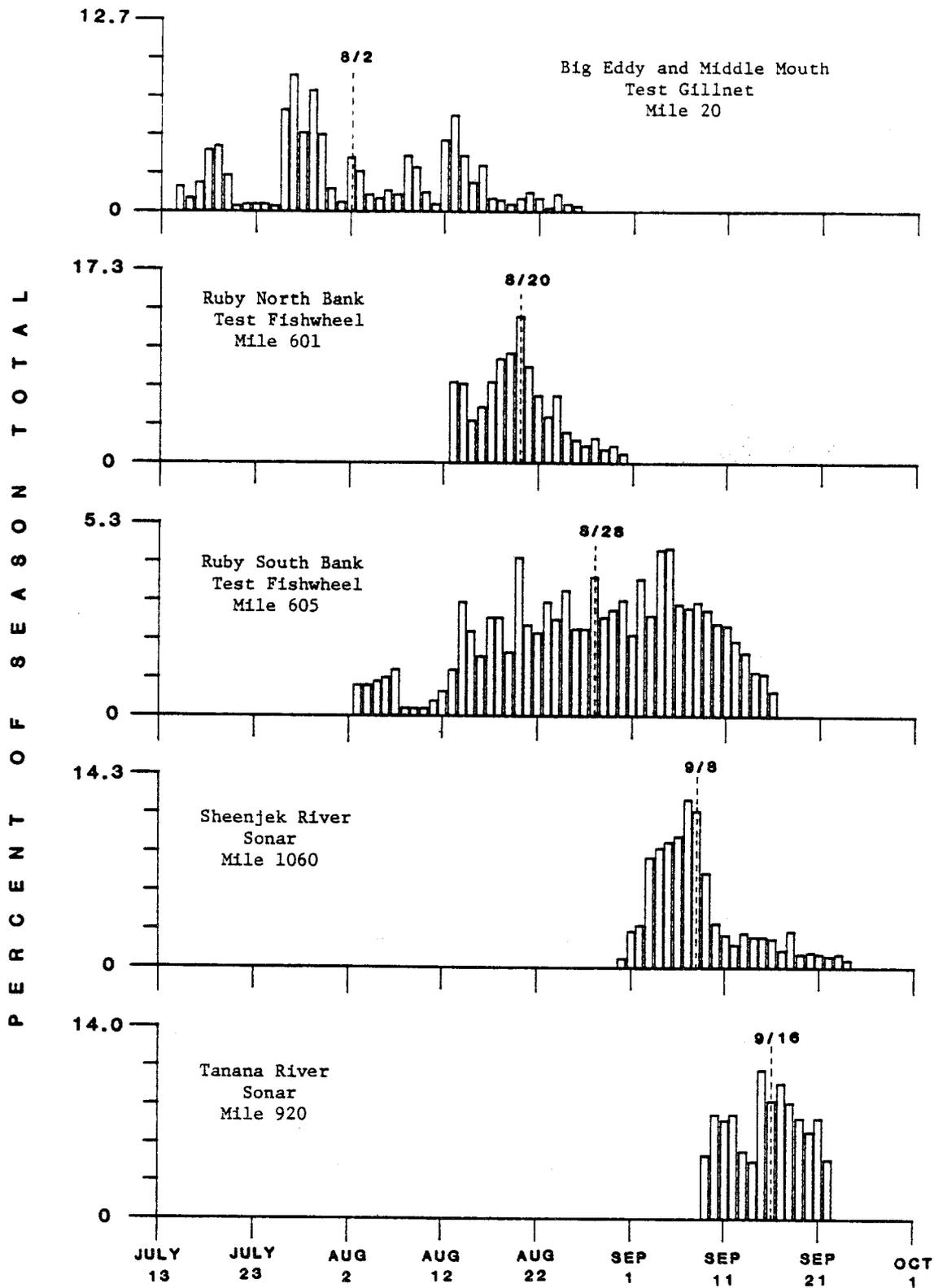


Figure 7. Run timing of fall chum salmon in the lower, middle, and upper portion of the Yukon River drainage, 1981. (Mileages are river miles from the mouth of the Yukon River. Dashed line indicates mean date of passage for each site.)

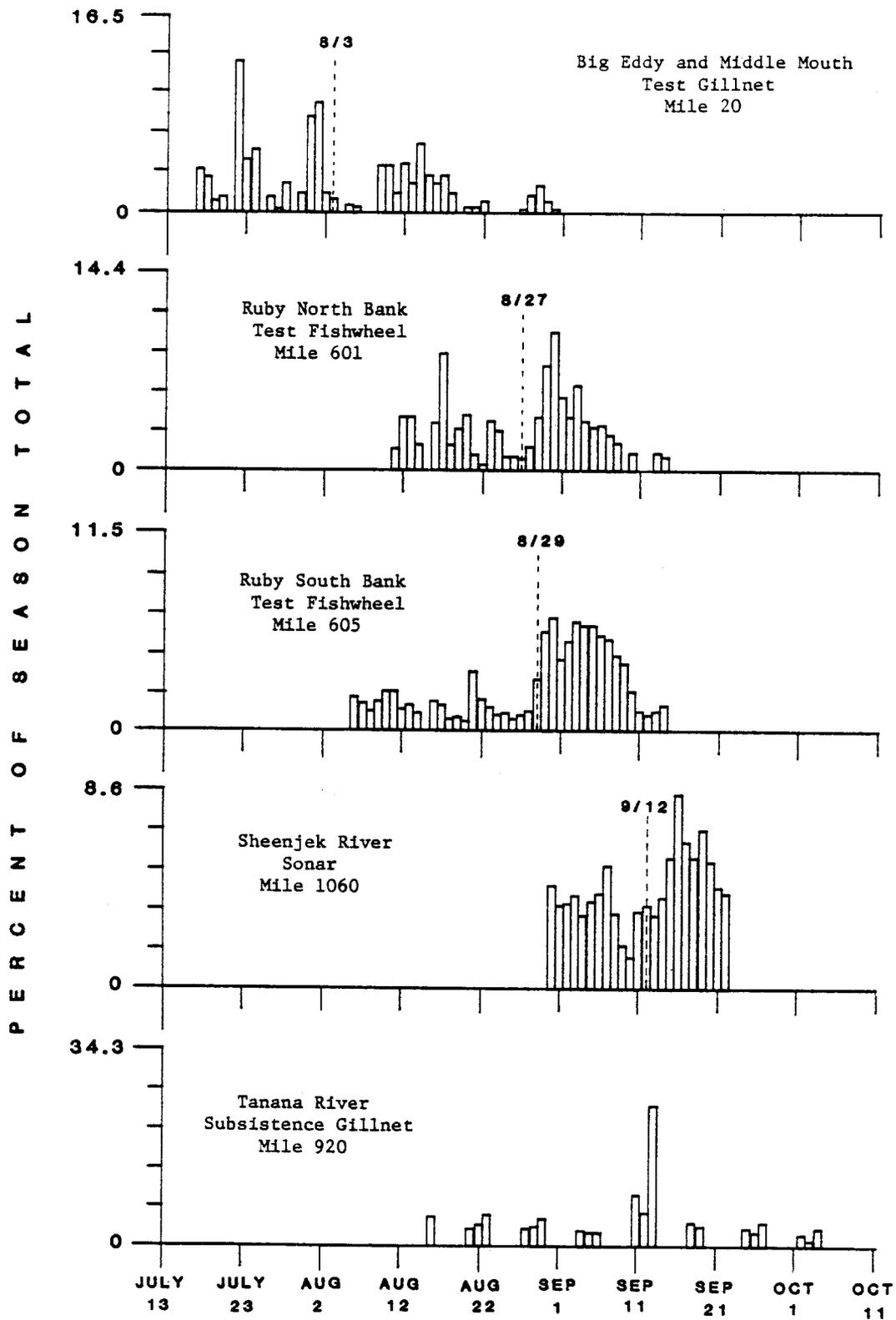


Figure 8. Run timing of fall chum salmon in the lower, middle, and upper portion of the Yukon River drainage, 1982. (Mileages are river miles from the mouth of the Yukon River. Dashed line indicates mean date of passage for each site.)

peaks in upriver catches or counts cannot be identified with assurance. Perhaps the only valid comparison that can be made is between mean date of catch in lower river test gillnets and the upper river test fishwheels, located approximately 585 mi (940 km) upstream near Ruby. Both projects operated throughout the fall chum salmon migration (except for the Ruby north bank fishwheel in 1981) and essentially all spawning stocks migrate through the areas of test fishing.

The difference in mean date of passage was 26 days between lower river test fishing sites and the Ruby south bank site in 1981, indicating a migration rate of 22.5 mi (36.2 km) per day (Table 8). An identical value of 22.5 mi (36.2 km) per day results from the 1982 catch data. An estimate of 24.2 mi (38.9 km) per day is calculated from the difference in mean dates between the lower river test fishing site and the Ruby north bank site in 1982. The migration rate averaged 23 mi (37 km) per day for these three comparisons of mean catch dates (Table 8).

Stock Separation Based on Migration Rate Analysis

Estimated dates of peak spawning for fall chum salmon at seven major spawning locations throughout the Yukon River drainage range from 30 September to 20 October and are summarized in Table 9, along with the approximate distance in river miles to each respective spawning area from the south mouth of the Yukon River at Flat Island. Estimates of average upstream migration rates of fall chum salmon based on several tagging studies are as follows: (1) 21.1 mi (34 km) per day between Ohogamiut and Rampart (Trasky 1983); (2) 21.6 mi (35 km) between Galena and Ruby (Mauney and Geiger 1977); (3) 20 to 24 mi (32 to 39 km) per day between Rampart and Fishing Branch River (Elson 1975); and (4) 17.6 mi (28 km) per day upstream of Dawson (Brock 1976).

These estimates are based on tag and recapture studies conducted in the mainstem Yukon and Porcupine River of traveling fish which have not yet arrived at their respective spawning grounds. Stream residence is not considered to have been a bias affecting these estimates. To illustrate, Mauney and Geiger (1977) reported migration rates of 13.7 to 16.2 mpd (22 to 26 km pd) for fall chum tagged in the mainstem Yukon River, with subsequent tag recoveries from the spawning grounds, often from carcasses or moribund fish. It is likely that the actual upstream migration rate of fish enroute to the spawning areas was greater than indicated because recovered tagged fish had spent an unknown amount of time in the stream. It is assumed, for purposes of the following discussion, that average migration rate is similar for all stocks while enroute to their respective spawning areas. It is also recognized that swimming rate values obtained from tagged salmon must be viewed with caution because of the unknown, but perhaps significant, behavioral changes that may be induced by capture and tag deployment. Migratory rates from the tagging studies are generally in conformance with the rate estimated from test fishing catches discussed in the preceding section of this report. Therefore, for the purposes of this discussion, the value of 23 mi (37 km) per day is assumed to be the best estimate of average fall chum salmon migratory rate in the main Yukon River.

Although peak spawning dates may vary annually (Table 9), a point estimate is given for each area based on a subjective evaluation of all available escapement data, largely provided from aerial survey observations since the early 1970's. For this discussion, peak spawning is considered to be when not less than 50% of

Table 8. Migration rate of fall chum salmon in the Yukon River based on test fishing catch data, 1981 and 1982.

Year	From	To	Distance (Miles)	Timing Difference ¹ (Days)	Migration Rate (Miles/Day)
1981	Big Eddy and Middle Mouth (River Mile 20) ²	Ruby South Bank ³ (River Mile 605)	585	26	22.5
1982	Big Eddy and Middle Mouth (River Mile 20)	Ruby North Bank ³ (River Mile 601)	581	24	24.2
1982	Big Eddy and Middle Mouth (River Mile 20)	Ruby South Bank (River Mile 605)	585	26	22.5
Average			584	25.3	23.1

¹ Difference between mean date of passage at each location.

² Set gillnet test fishing sites located in the Yukon River delta. Daily fall chum salmon catch from both sites pooled, and mean date calculated from the pooled data.

³ Fishwheel test fishing site.

Table 9. River mileages of major Yukon River fall chum salmon spawning areas and estimated dates of peak spawning.

Spawning area	Mileage from Flat Island ¹	Estimated range in dates of peak spawning	Point estimate of peak spawning
Chandalar River (near Venetie)	1,025	4th week Sep through 1st week Oct	Sep 30
<u>Porcupine River drainage:</u>			
Sheenjek River (vicinity of Russell's cabin-Haystack Mt.)	1,125	4th week Sep through 1st week Oct	Sep 30
Fishing Branch River (Bearcave Mt.)	1,600	1st through 2nd week Oct	Oct 10
<u>Tanana River drainage:</u>			
Toklat River (vicinity Sushana R.)	850	2nd through 3rd week Oct	Oct 10
Mainstem Tanana (vicinity Delta R.)	1,035	4th week Oct through 1st week Nov	Oct 30
Kluane River (vicinity Quill Cr.)	1,575	3rd-4th week Oct	Oct 20
Mainstem Upper Yukon River (vicinity Ingersol Islands)	1,490	3rd-4th week Oct	Oct 20

¹* Flat Island is located at the entrance of the south mouth of the Yukon River.

the total stream population of spawners would be observed. Although the concept of a "peak" spawning period may be an artificial one from some standpoints, it is nonetheless useful for exercises of this kind when it is clear that a difference in time of spawning does occur between stocks.

To examine timing of arrival of various fall chum salmon stocks at the mouth of the Yukon River, a migration rate of less than 23 mpd (37 km pd) should be used since timing is lagged back from estimated dates of peak spawning, which no doubt includes an unknown degree of stream residence bias. Estimated dates of 50% run passage for major fall chum salmon stocks at the mouth of the Yukon River based on average upstream migration rates of 15 and 20 mpd (24 and 32 km pd) were calculated. Based on 15 mi (24 km) per day, date of 50% passage at Flat Island near the south mouth of the Yukon River varied from 22 July to 9 August (Table 10). A multimodal entry pattern of fall chum salmon stocks into the Yukon River is hypothesized (Figure 9), with Fishing Branch River stocks arriving first and upper Tanana River stocks last. Actual passage date in the lower river varies, depending on spawning dates and the migration rate applied. In spite of the drawbacks in the analysis, stock timing differences which has significant management implications are indicated. It appears that the first fall chum salmon stocks available for commercial exploitation in the lower Yukon River are those bound for the Fishing Branch River, followed by passage of a cluster of upper Yukon River stocks (including the Sheenjek River), grouped rather closely together. Tanana River stocks appear to enter the Yukon River even later, possibly by as much as 2 weeks, showing a more distinct timing difference than earlier stocks. The present strategy of delayed season openings in the lower river districts takes this analysis into account, and affords some protection for early run stocks.

ESCAPEMENT ENUMERATION

Assessment of Spawning Escapements

Comprehensive fall chum salmon escapement studies in the Yukon River drainage have been limited to only three streams. Intensive foot surveys were conducted on the Delta River from 1973 through 1978 in conjunction with impact assessments of construction of the Trans-Alaska Oil Pipeline (Trasky 1974, 1976; Francisco 1976, 1977; Francisco and Dinneford 1977; Dinneford 1978). A weir was operated on the Fishing Branch River from 1972 through 1975 (Elson 1975, 1976). Side-scanning sonar has been employed since 1981 on the Sheenjek River (Barton 1982, 1983, 1984). Low-level aerial surveys from single-engine, fixed-wing aircraft have been the primary means of obtaining fall chum salmon escapement information due to the size of the Yukon River drainage and logistical and budget constraints. Spawning populations have been documented in 32 Alaskan and 7 Canadian streams or sloughs and the largest documented escapement has ranged from as low as 1 spawner to as many as 353,282 fish (Table 11). The Porcupine and Tanana Rivers are the two most important systems for fall chum salmon production. The most complete escapement data base, collected only since 1973, is available for eight streams or index areas in the Porcupine and Tanana River systems and the Tanana index in 1979 of 203,474 was the highest observed between 1973 and 1983 (Table 12).

Aerial survey accuracy is dependent upon a number of factors such as weather and water conditions, timing of surveys with respect to peak spawning, type of aircraft, survey altitude, experience of both pilot and observer, and species of

Table 10. Estimated dates of 50% run passage for major fall chum salmon stocks at the mouth of the Yukon River based on peak spawning dates and distance to spawning grounds.

Spawning stock (area)	Distance from Flat Island ¹ (miles)	Point estimate peak spawning (+ range)	Days required to reach spawning grounds from Flat Island ¹		Date of 50% run passage at Flat Island ¹	
			@ 15 mpd	@ 20 mpd	@ 15 mpd	@ 20 mpd
Toklat River	850	10/10 + 5 days	56	42	8/15	8/29
Chandalar River	1,025	9/30 + 7 days	68	51	7/24	8/10
Tanana-Delta River	1,035	10/30 + 7 days	69	51	8/22	9/9
Sheenjek River	1,125	9/30 + 7 days	75	56	7/17	8/5
Upper Yukon River	1,490	10/20 + 5 days	99	74	7/13	8/7
Kluane River	1,575	10/20 + 5 days	105	78	7/7	8/3
Fishing Branch River	1,600	10/10 + 5 days	106	80	6/26	7/22

¹ Flat Island is located at the entrance of the south mouth of the Yukon River.

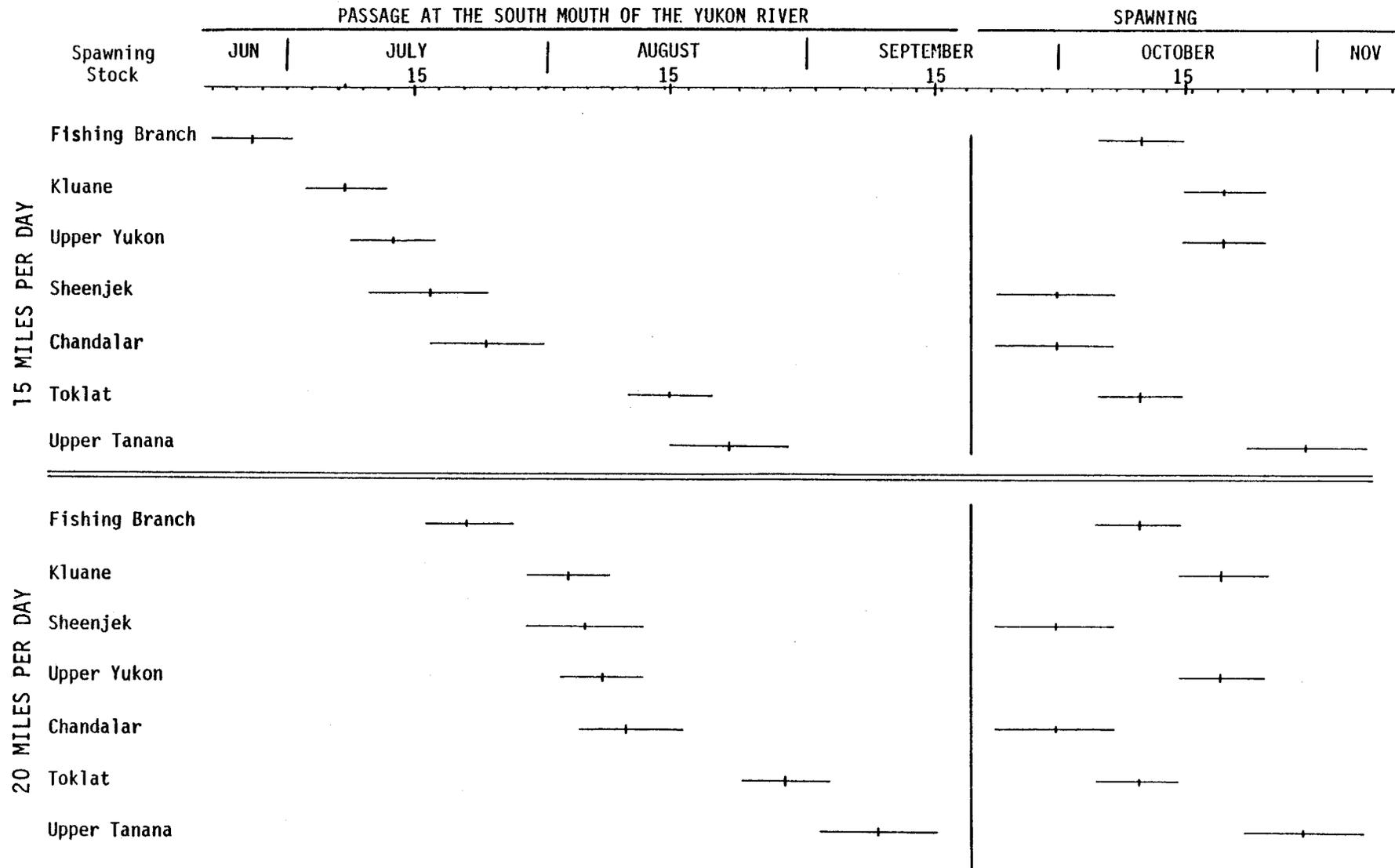


Figure 9. Passage of fall chum salmon stocks at the south mouth of the Yukon River based on time of spawning, distance to spawning grounds, and average upstream migration rates of 15 and 20 miles/day.

Table 11. Fall chum salmon spawning areas in the Yukon River drainage, with the largest escapement count during the period 1959-1983 given for each area.

Spawning Area	Largest Documented Escapement	Survey		
		Date	Method	Rating
TANANA RIVER DRAINAGE				
Kantishna River				
Toklat River	161,090	10/4/79	Aerial	Fair
Bearpaw River	2,996	10/20/74	Aerial	Fair
Moose Creek	218	10/17/83	Aerial	Poor
Birch Creek	1	10/20/74	Aerial	Fair
McKinley River	405	10/20/74	Aerial	Fair
Nenana River	23	10/10/74	Aerial	-
Seventeenmile Slough	2,169	10/17/83	Aerial	Good
Lost Slough	69	10/17/83	Aerial	Good
Glacier Creek	150	11/28/72	Aerial	Poor
Wood Creek	327	9/12-10/30/83	Weir	Good
Upper Tanana River				
Banner Creek	4	10/14/75	Foot	Poor
Richardson-Clearwater Slough	270	10/11/74	Aerial	-
Benchmark Slough	5,255	10/31/72	Aerial	Fair
Andersen Slough	1,355	11/2/81	Aerial	Fair
Delta River	22,375	11/3/81	Foot	Good
South Bank Tanana River ¹	20,820	11/8/79	Aerial	Fair
Blue Creek	15	10/29/74	Aerial	Poor
Bluff Cabin Slough	12,715	11/1/83	Foot	Fair
Clearwater Lake Outlet Slough	2,380	10/27/83	Aerial	Poor
Onemile Slough	3,850	11/18/79	Aerial	Poor
Delta Clearwater River	1,500	9/29/64	Aerial	-
Billy Creek Slough	13	11/10/80	Aerial	Fair
Sheep Creek-Chisana River	29	10/27/75	Aerial	Poor
Unnamed Slough near Eilson AFB	313	10/27/83	Aerial	Fair
PORCUPINE RIVER DRAINAGE				
Black River	50	10/8/75	Aerial	Poor
Salmon Fork River	1,510	10/8/75	Aerial	Poor
Kevinjek River	1,625	10/13/74	Aerial	Fair
Fishhole Creek	200	10/3/77	Aerial	Fair
Sheenjek River	78,060	10/8/75	Aerial	Fair
Salmon Trout River	350	9/27/75	Aerial	Poor
Fishing Branch River (YT)	353,282	9/3-10/9/75	Weir	Good
Miner River (YT)	2	10/6/81	Aerial	-
UPPER YUKON DRAINAGE				
Tozitna River	9	9/20/83	Boat	-
Chandalar River	17,455	9/18/74	Aerial	Fair
Kluane River (YT)	8,578	10/21/83	Foot	-
Duke River (YT)	1	10/25/76	Aerial	-
Koidern River (YT)	27	10/25/80	Aerial	Fair
Yukon River ² (YT)	7,671	10/23/75	Aerial	-
Little Salmon River (YT)	21	9/28/73	Foot	-

¹ Richardson Highway bridge to Blue Creek.

² Carmacks to Fork Selkirk.

Table 12. Fall chum salmon escapement to selected index areas in the Yukon River drainage, 1973-1983^a.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
<u>TANANA RIVER DRAINAGE</u>											
Upper Toklat River ^b	6957	34310	42418 ^c	35190	21800 ^c	35000	96550 ^d	23054	13907	3309 ^e	15105 ^e
Lower Toklat River	--	--	35867 ^c	(2000 ^d)	--	--	64540	(2140)	--	--	--
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	22375 ^{e,p}	3433 ^e	7230 ^e
South Bank Tanana River ^g	5635	4567 ^f	--	4979	3797	5700	20820	3444	7063	--	1350 ^c
Bluff Cabin Slough	3450	4840 ^f	5000 ^{c,d}	3197	6491	5340	6875	3190	6120	1156 ^e	12715 ^e
Onemile Slough	1720	1235	745 ^d	1552	1900	475	3850 ^c	885 ^c	632	--	1115 ^c
Subtotal	18903	16102	8834 ^r	15562	31383	23271	42384	14056	36358	4589 ^r	22410 ^r
TOTAL TANANA INDICES	25860	50412	87119 ^r	50752	53183	58271	203474	37110	50265	7898 ^r	37515 ^r
<u>PORCUPINE RIVER DRAINAGE</u>											
Sheenjek River	1175 ^{f,s}	40507	78060	11866	20506	14610 ^c	41140	13027	12625 ^{c,h}	717 ^{c,i,s}	22230 ^t
Fishing Branch River (YT)	15987 ^j	32525 ^j	78615 ^k	13450	32500	15000	44080	20319 ^c	10549 ^{c,r}	5846	10000
Total Porcupine Indices	17162 ^l	73032 ^l	156675	25316	53006	29610	85220	33346	23174 ^{c,r}	6563 ^r	32230
<u>UPPER YUKON TRIBUTARIES</u>											
Chandalar River	--	17455	6345 ^{c,r}	58 ^{c,r}	4183	--	--	2607	4906 ^{m,r}	1145 ^m	--
Kluane River (YT)	2500	350 ^r	362 ^{e,f}	20 ^f	3555	0 ^f	4640 ^e	3150	25806	5378 ^e	8578 ^{e,r}
Yukon River (YT)											
Ft. Selkirk-Carmacks	--	--	7671	--	--	--	--	--	250 ^r	1020	7560

a Peak aerial survey counts, rated fair-good unless indicated otherwise.

b Includes following areas: Toklat River in vicinity of roadhouse; Sushana River; Geiger Creek. Lower Toklat River counts included in Total Tanana Index for peak years of 1975 and 1979.

c Poor survey.

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 Peak aerial count was 10,664.

r Incomplete survey--partial survey of index areas--more chums present.

s Surveyed before peak spawning--too early.

t Sonar-estimated escapement was 45,733.

salmon being enumerated (Cousens et al. 1982). It is generally recognized that aerial survey estimates are lower than actual abundance due to these factors. The late seasonal timing and northern distribution of fall chum salmon in the upper Yukon River drainage result in poor quality of illumination when surveys are conducted due to shortness of daylight and low sun angles. Surveys made at low sun angles requires continual transition between sunshine and deep shade and have been shown to result in poor estimates (Eicher 1953, cited in Cousens et al. 1982).

An aerial survey of the Sheenjek River in 1981, while salmon were still traveling to spawning areas, accounted for only 17% of the sonar-estimated escapement through the date of the survey (Barton 1982). Approximately 61% of the sonar escapement estimate was observed on an aerial survey flown under good conditions in 1983 (Barton 1984). Elson (1976) reported only 50% aerial survey accuracy for fall chum salmon in the Fishing Branch River in 1975. It is apparent that aerial survey estimates are not only lower than actual salmon abundance but demonstrate a wide range in the proportion enumerated.

Fall chum salmon spawning in the mainstem Tanana, Delta, Fishing Branch, and Toklat Rivers is generally limited to a few discrete instream areas, where large concentrations of spawners can be easily observed. These areas are limited to about 8 km in the upper Tanana and Delta Rivers and a 13 km stretch in the Fishing Branch River. Major spawning concentrations in the Toklat River are confined to about three areas within a 3 km radius. Concentration of spawning makes it easier to schedule surveys for the peak of spawning. In contrast, spring-fed spawning areas in the Chandalar and Sheenjek Rivers are more numerous and smaller in size. The numerous spawning areas occur discontinuously throughout nearly 160 km in each river. This results in less accurate aerial escapement estimates since spawners do not all arrive at the various spawning sites at the same time. At any given time during the spawning period there is probably a substantial number of salmon migrating in the mainstem river which are obscured to the observer. If the survey is late, then an accurate carcass count of salmon is generally hindered by snow cover and river ice floes. Best results are obtained by scheduling fall chum aerial surveys after they have reached the spring-fed spawning areas. It is in these areas that water visibility is good and salmon are concentrated.

Peak spawning abundance is significantly lower than total season abundance due to the die-off of early spawners and the arrival of late fish (Gangmark and Fulton 1952, Bevan 1961, Neilson and Geen 1981). Francisco (1976) and Francisco and Dinneford (1977) expanded instantaneous fall chum salmon counts to obtain total season escapement estimates for the Delta River. They estimated total population based on a spawner residence time curve generated from average stream life data and weekly aerial and ground survey salmon counts. Peak aerial survey estimates represented approximately 86% and 83% of the total population estimates for 1975 and 1976, respectively.

Escapement Trends

Aerial survey escapement estimates are made of as many fall chum salmon spawning streams as possible within the confines of weather, personnel, and fiscal constraints. In addition, an effort is made to insure that representative spawning areas are surveyed annually to provide an index of escapement abundance. Escapements to the Sheenjek and Fishing Branch Rivers reflect trends to the Porcupine

River drainage, while escapements to the upper Toklat River and to five areas in the upper Tanana River (Benchmark Slough, Delta River, south bank Tanana River, Bluff Cabin Slough, and Onemile Slough) reflect trends to the Tanana River drainage.

It is apparent that fall chum salmon escapement trends in the Sheenjek and Fishing Branch Rivers have been similar and generally declining during the period 1973-1983 (Figure 10). Average aerial survey escapement indices have decreased 28% and 54% in the Sheenjek and Fishing Branch Rivers, respectively, resulting in an overall decrease of 42% (Table 13) in the Porcupine River index from the preceding 4-year period (1976-79) to the most recent 4-year period (1980-83).

Escapement indices for the Tanana River drainage also declined during the period 1973-1983, although the decline was much more pronounced for the upper Toklat River than for the upper Tanana River index areas (Figure 11). The average escapement index decreased 78% and 14% in the upper Toklat and upper Tanana Rivers, respectively, resulting in an overall decrease of 58% (Table 13) in the Tanana River index from the preceding 4-year period (1976-79) to the most recent 4-year period (1980-83).

A 4-year cycle in the abundance of fall chum salmon populations in the Sheenjek, Fishing Branch, and Toklat Rivers is suggested by the data, with peaks occurring in 1975 and 1979 (Figures 10 and 11). A cyclical pattern of abundance is not evident in the existing data for upper Tanana River escapements. Walker (1976) suggested that a 4-year cycle of fall chum salmon abundance exists in the upper Yukon River drainage, based on similarities in size of fish sampled at Dawson City and the Fishing Branch River, with 1971 and 1975 being the high return years. However, Fernet (1982) stated that no such pattern was apparent for the Kluane River population.

The Fishing Branch River escapement index averaged 61,347 fall chum salmon for the peak years 1975 and 1979, and only 17,423 for non-peak years. Escapement levels in the peak cycle year averaged 59,600 for the Sheenjek River, and only 18,856 for non-peak years. Escapement to the Porcupine River system in low abundance years was only 30% (peak years at 120,947 compared to non-peak years at 36,279) of peak year escapement levels (Table 14).

An apparent peak escapement year also occurred in 1971 in the Porcupine River system, based on Fishing Branch River escapement data (Elson 1973). Non-peak years were only 10% of the peak level for the 1971-1974 cycle.

Data suggest a 4-year cycle for the Toklat River, but not for the upper Tanana. Upper Toklat River escapements averaged 69,484 fall chum salmon for the peak years 1975 and 1979, but only 21,690 for the non-peak years (31% of peak year abundance). Distribution of spawners in the Toklat River appears to be a function of run size, with greater utilization of the lower Toklat River in years of high escapements (Table 12). In 1975 and 1979, 46% and 40% of the fall chum salmon observed were in the lower river, while only 5% and 8% were observed in the lower Toklat River in the low abundance years of 1976 and 1980.

The 1983 season was expected to be another peak year for Toklat, Sheenjek, and Fishing Branch River returns. However, the large escapements never materialized,

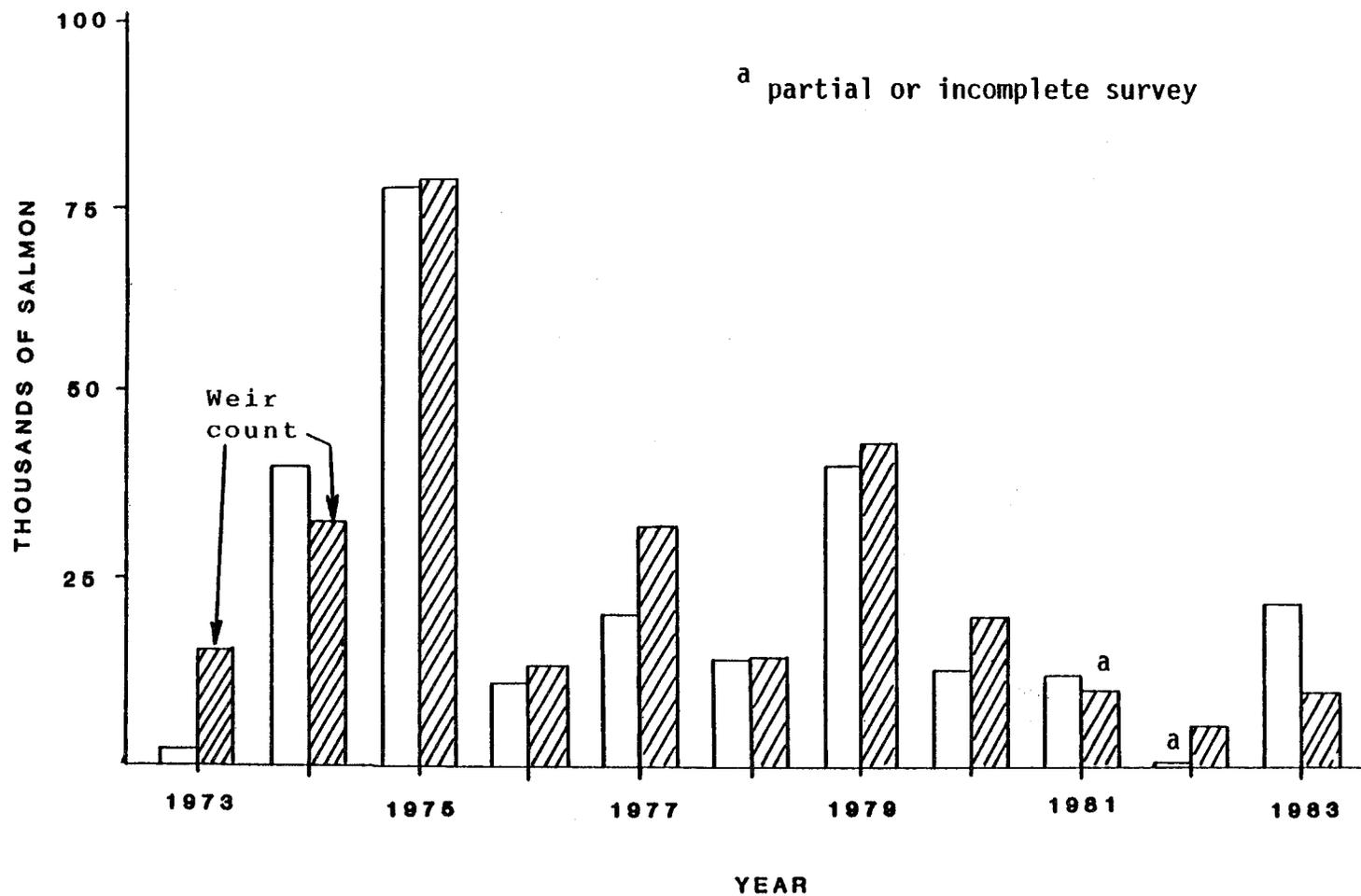


Figure 10. Fall chum salmon escapement in the Sheenjek River (open bar) and Fishing Branch River (shaded bar) based on peak aerial survey counts, 1973-1983.

Table 13. Recent fall chum salmon escapement trends in the Porcupine and Tanana River systems.

River	Average Observed Escapement			
	1976-79	1980-83	% Decrease	1976-1983
Sheenjek River	22,030	15,960 ¹	28	19,429 ¹
Fishing Branch River	26,257	12,055 ²	54	20,170 ²
Total Porcupine River	48,287	28,015	42	39,599
Upper Toklat River ³	63,270	13,843	78	38,556
Upper Tanana River	28,150	24,274 ⁴	14	26,489 ⁴
Total Tanana River	91,420	38,117	58	65,045

¹ Excludes 1982 data - surveyed too early.

² Excludes 1981 data - incomplete survey.

³ Data from both the upper and lower Toklat River were used in high abundance - cycle years (1979 and 1983), whereas only the upper Toklat River index area counts were used in other years.

⁴ Excludes 1982 data - only 2 of 5 index areas surveyed.

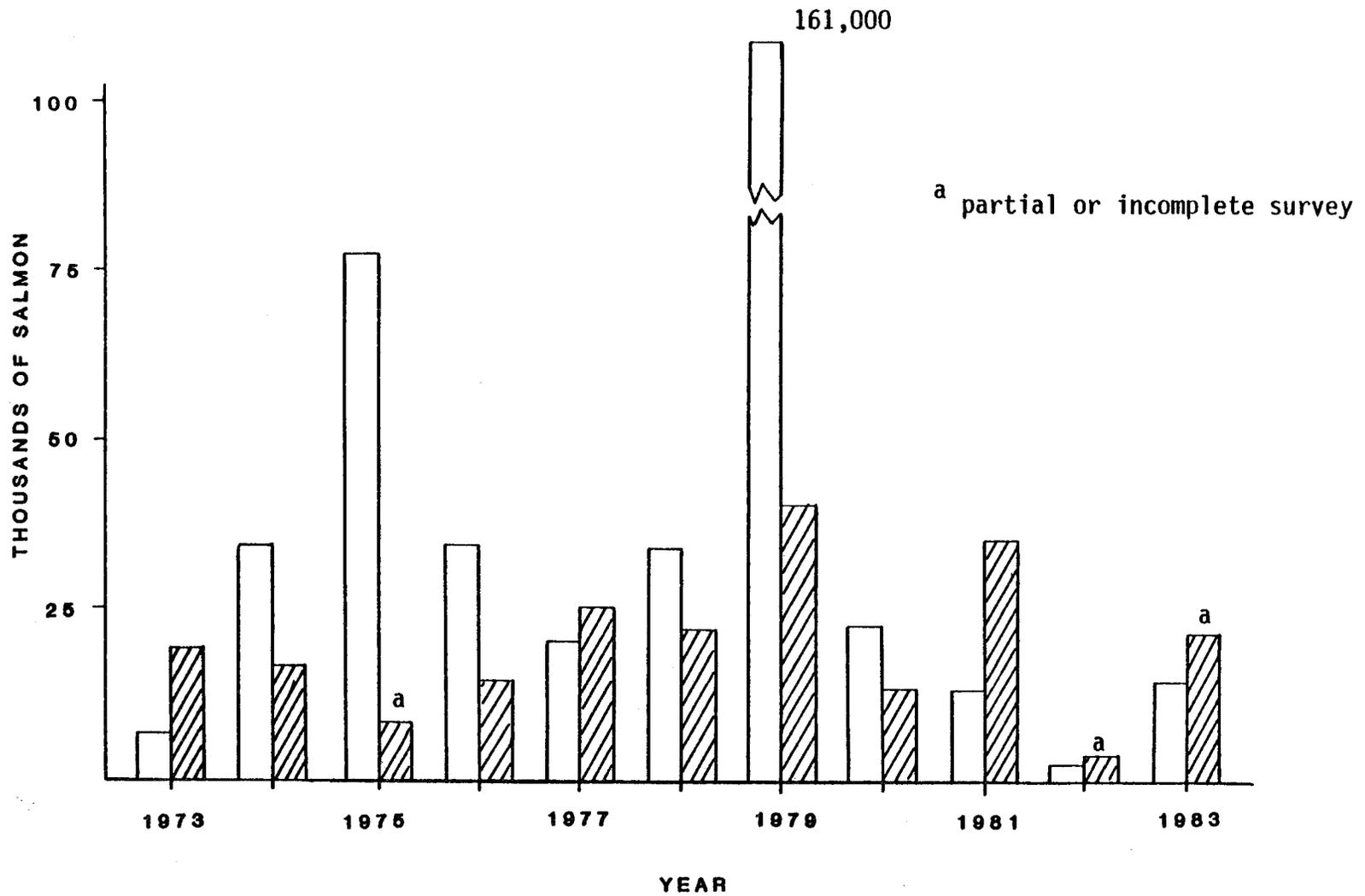


Figure 11. Fall chum salmon escapement in the upper Toklat River (open bar) and upper Tanana River (shaded bar) based on peak aerial survey counts, 1973-1983. Both upper and lower Toklat River index areas included in 1975 and 1979.

Table 14. A comparison of peak and non-peak years fall chum salmon escapement in the Porcupine River system.

River	Average Observed Escapement	
	Peak Years ¹	Non-Peak Years ²
Sheenjek River	59,600	18,856 ³
Fishing Branch River	<u>61,347</u>	<u>17,423⁴</u>
Total Porcupine River	120,947	36,279

¹ Peak years 1975 and 1979.

² Non-peak years, excluding 1975 and 1979.

³ Data from 1974 through 1981, excluding 1982 - surveyed too early.

⁴ Data from 1976 through 1982, excluding 1981 - incomplete survey.

following a continued trend of declining escapements in recent years. Although escapements to these rivers were higher than in 1982, they were well below the peak year (1975 and 1979) average. The escapement index for the Toklat River in 1983 was only 22% of the peak year average, while it was 37% and 16% for the Sheenjek and Fishing Branch Rivers, respectively.

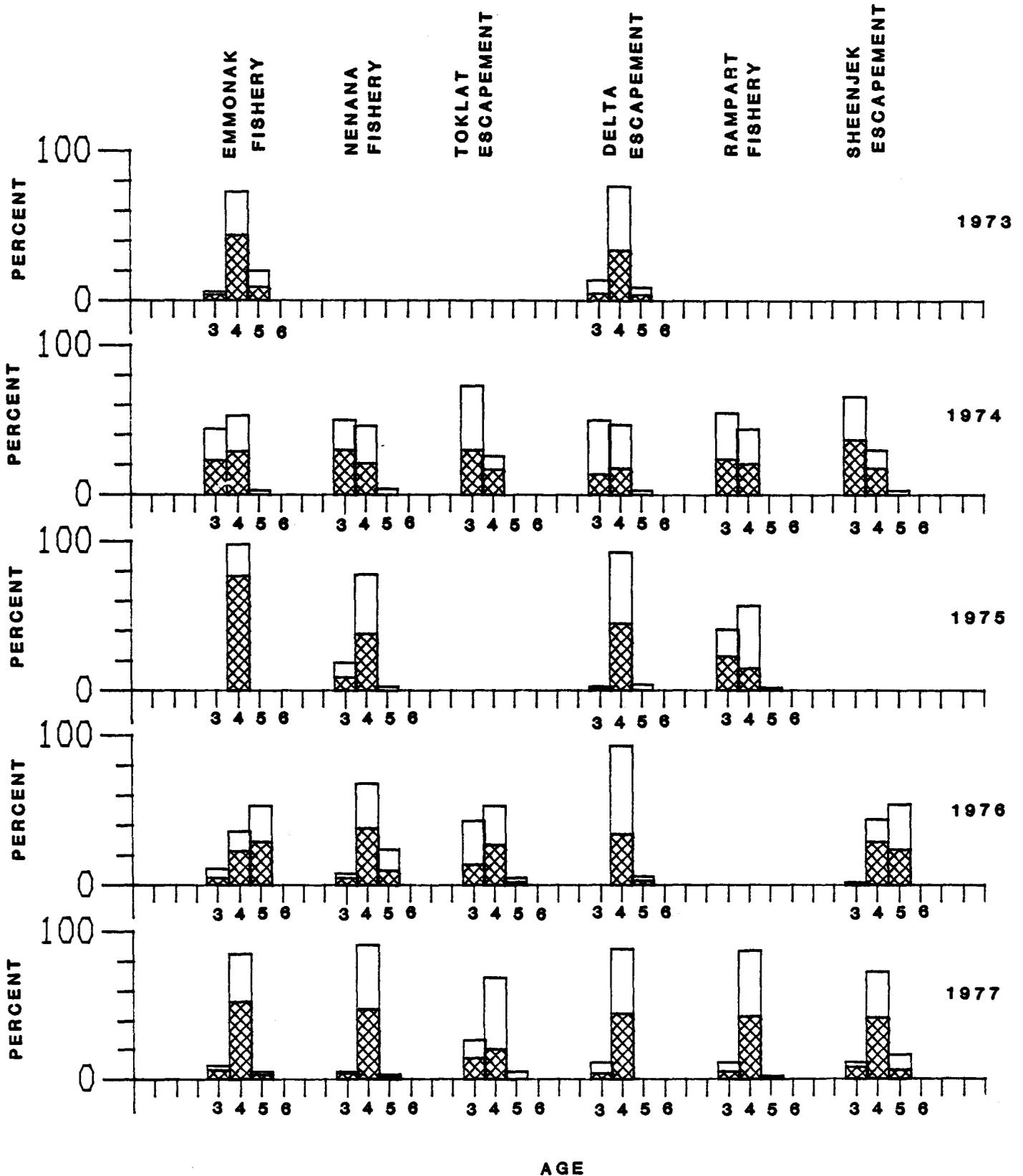
AGE AND SEX COMPOSITION

Fall chum salmon have been sampled for age and sex data from catches and escapements in the Yukon area only within the last 10 years. Even during this recent period, the Emmonak commercial gillnet fishery has been the only consistently sampled fishery in the area. Scales from upriver fisheries and from carcasses on the spawning grounds are often reabsorbed and eroded to such an extent that aging becomes difficult and of questionable accuracy. Scale samples from the Emmonak fishery each year indicate that some fish have several circuli of plus growth beyond the last annulus, while others have an annulus on the outer edge of the scale. Reabsorbed scales are missing the outer edge to varying degrees, and it becomes an educated guess as to whether the remaining circuli are plus growth from the preceding annulus, or whether the scale margin would have ended with an annulus had it not been lost. The possibility of aging fall chum salmon using otoliths or vertebrae is presently being investigated. All age data presented here, however, are based on scale patterns, and the preceding discussion should be kept in mind when reviewing the results.

Six sampling locations in the Yukon area have been selected to examine trends in fall chum salmon age and sex composition. They are the commercial fisheries at Emmonak in the Yukon delta, Rampart in the upper Yukon, and Nenana on the Tanana River, and escapements to the Toklat, Delta, and Sheenjek Rivers. Age 4 accounts for the majority of the fish for most sampling locations and years, followed by ages 5 and 3, while only a few age 6 fish are found (Figures 12 and 13, Appendix Table 2). A slightly higher percentage of females was found in the Emmonak catch sample than in other catch and escapement samples for most years, but no trends are apparent in sex composition over the 10-year period, 1973-1982. Percentage females in catch samples ranged from a low of 38% for Rampart fishwheels in 1975 to a high of 78% for Emmonak gillnets in 1975, while in escapement samples it ranged from a low of 31% for the Delta River in 1980 to a high of 62% for the Sheenjek River in 1982. Strength of the 1971 brood year can be seen both in the high percentage of age 3 fish for all locations in 1974, and in the large return of age 4 fish in 1975 and age 5 fish in 1976 for the Emmonak commercial catch sample (Figure 12).

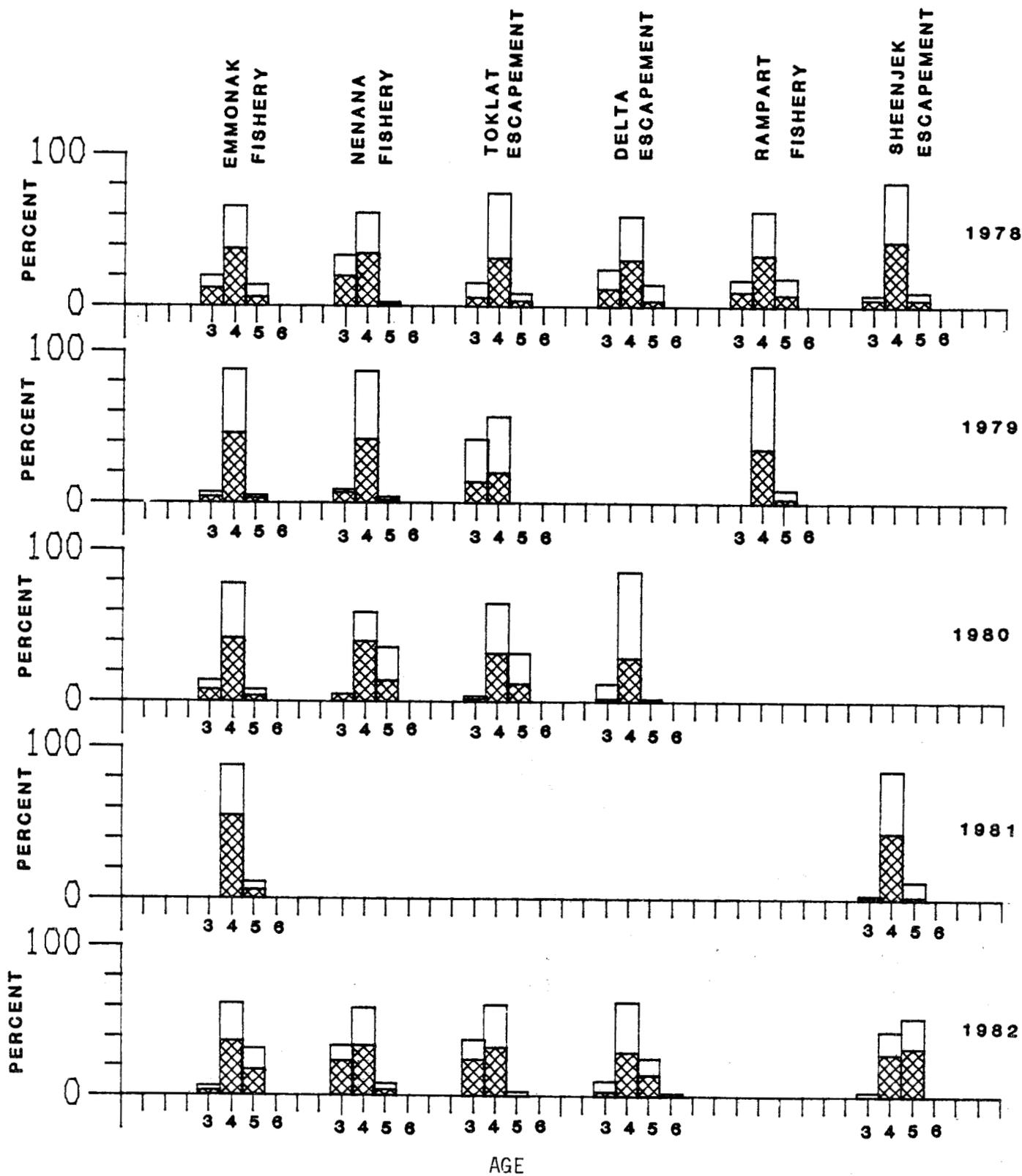
Age composition of samples collected in 1982 from a recently initiated test fishing project on the north and south bank of the Yukon River at Ruby support results of the tagging study discussed earlier in this report. The Ruby north bank sample was composed of nearly equal percentages of ages 4 and 5, and a low percentage of age 3 fish, while the Ruby south bank sample included fewer age 5 and more age 3 fish (Figure 14). These differences in age composition for the north and south bank stocks can be seen in upriver samples as well. Fishwheel catch samples from the Yukon River just upstream from the U.S.-Canadian border, gillnet samples from the Dawson commercial fishery and escapement samples from the Sheenjek River are all similar to the Ruby north bank age composition, while fishwheel catch samples

Figure 12. Age and sex composition of fall chum salmon sampled from fishery catches at Emmonak, Nenana, and Rampart, and from escapements to the Toklat, Delta, and Sheenjek Rivers, 1973-1977¹.



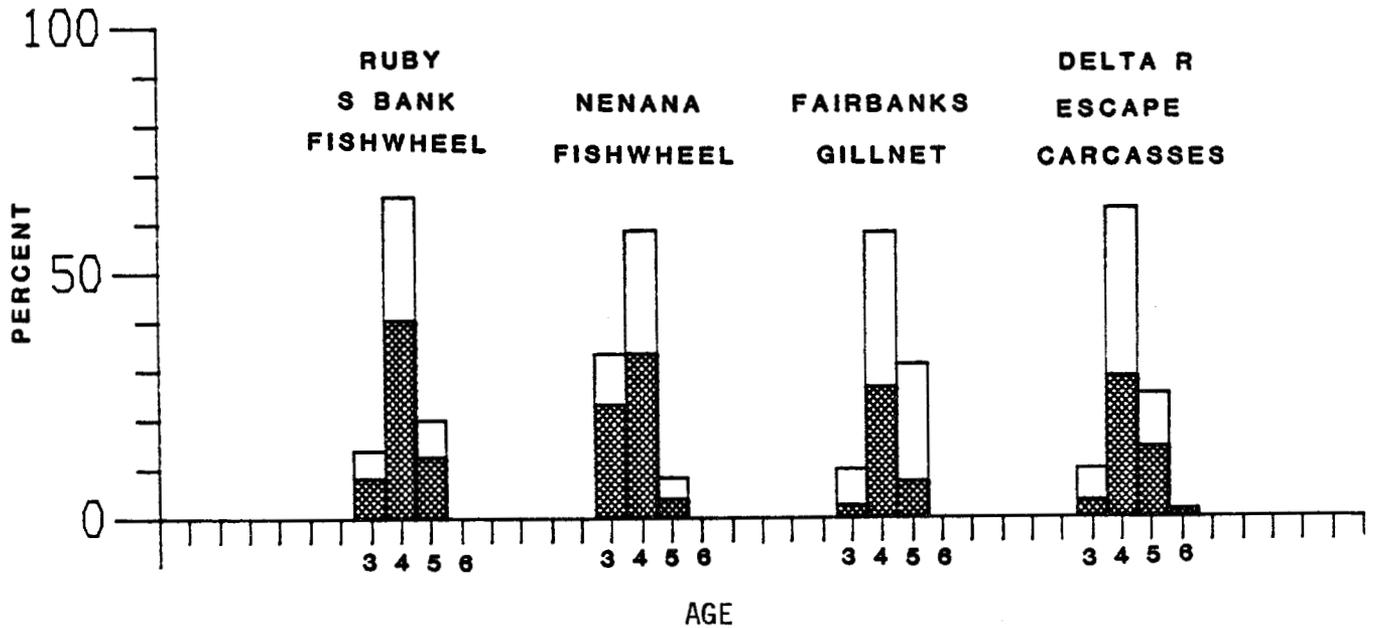
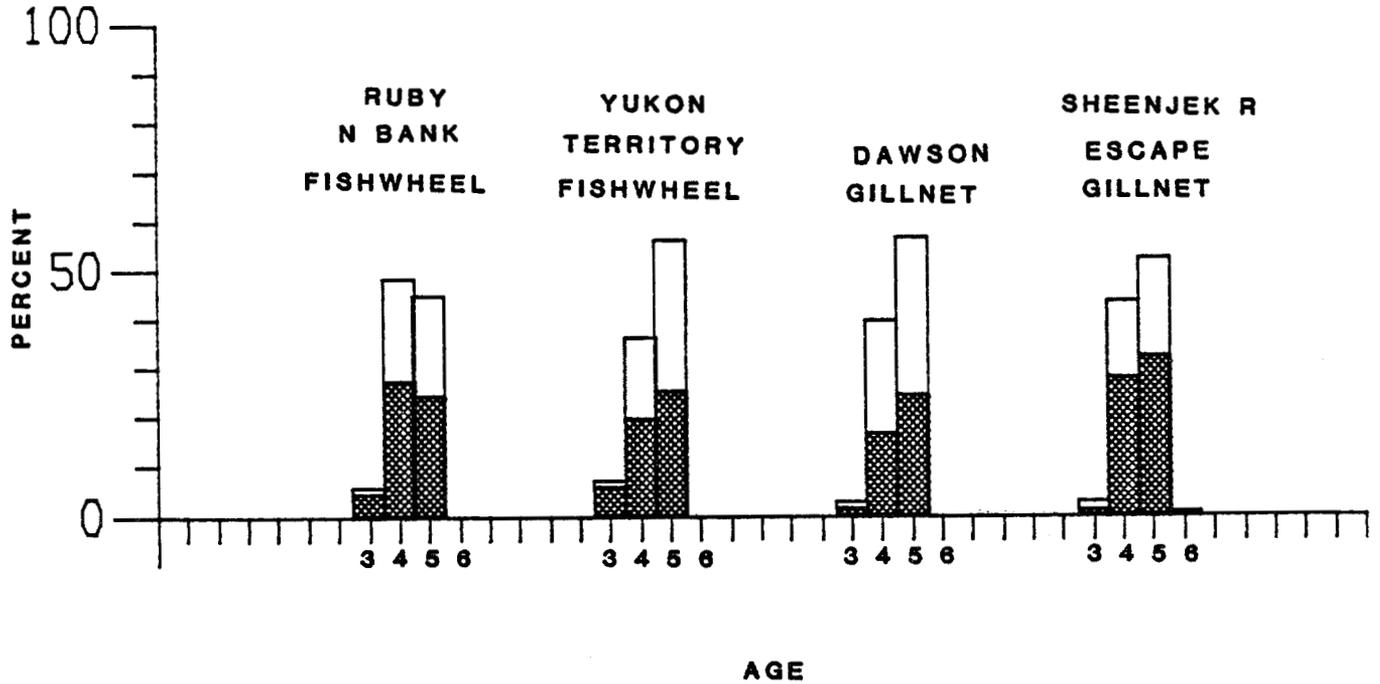
¹ Shaded bar for females, open bar for males. See Appendix Table 2 for sample sizes, gear types, and dates.

Figure 13. Age and sex composition of fall chum salmon sampled from fishery catches at Emmonak, Nenana, and Rampart, and from escapements to the Toklat, Delta, and Sheenjek Rivers, 1978-1982¹.



¹ Shaded bar for females, open bar for males. See Appendix Table 2 for sample sizes, gear types, and dates.

Figure 14. Age and sex composition of fall chum salmon sampled in 1982 on the north bank of the Yukon River at Ruby and three upper Yukon-Porcupine River locations (above), and on the south bank of the Yukon River at Ruby and three Tanana River locations (below)¹.



¹ Shaded bar for females, open bar for males. See Appendix Table 2 for sample sizes and dates.

from the Tanana River at Nenana, gillnet samples from the Fairbanks subsistence fishery and escapement samples from the Delta River are all similar to the Ruby south bank age composition (Figure 14).

TOTAL RETURN ESTIMATES

Total abundance estimates for fall chum salmon returns to the Yukon River are lacking. At best, abundance of only various segments of annual returns has been estimated in some years since 1961 from tag and recapture studies. In 1961 for instance, 131,000 fall chum salmon were estimated to have migrated upstream of Rampart (Table 15). Accuracy of tag recovery estimates is often questionable due to the following biases: (1) tag loss, (2) post-tagging mortality, (3) unreported tag recoveries, (4) fishing gear selectivity on tag types and fish age, sex, and size, and (5) disproportionate tag and recovery effort on various stocks or run segments.

The best indicator of total run strength is the sum of documented harvested and observed escapement. However, these are minimum estimates, since many spawning streams cannot be surveyed in any given year, and aerial surveys do not enumerate total season escapement. They are only indices of abundance, with actual escapements for some streams possibly twice the peak aerial survey count. Minimum estimates of total return for the 10-year period, 1974-1983 range from 312,476 fall chum salmon in 1976 to 927,177 in 1979 (Table 16). Although total return indices fluctuate greatly within this range, a trend of increasing harvest and decreasing escapement is apparent (Figure 15). Comparison of the recent 4-year average (1980-1983) with the preceding 4-year average (1976-1979) indicates the following in terms of fall chum salmon utilization and run strength:

Commercial harvest increased 30%

Subsistence harvest increased 36%

Total harvest increased 32%

Porcupine River escapement index decreased 42%

Tanana River escapement index decreased 58%

Total return index increased 10%

While total return showed a moderate increase of 10% for the recent 4-year period, inshore commercial and subsistence fishery harvests each increased by 30% or more. There has also been a marked increase in harvest of chum salmon in the Shumagin Islands and South Unimak domestic commercial fisheries since 1975. The June harvest has increased from 101,000 chum salmon in 1975 to 1,015,000 chum salmon in 1982 (Table 17). An unknown percentage of these chum salmon is known to be destined for the Yukon River, based on various tagging studies conducted from 1956-1966 (Brannian 1983).

The increased catch of fall chum salmon in both the interception and inshore fisheries has no doubt contributed to the recent decline in observed escapements to major spawning areas in the Yukon River drainage.

Table 15. Summary of Yukon River fall chum salmon population estimates cited in literature.

Portion of river	Year	Location of tagging site (river mile)	Method ¹	Fall chum salmon population estimate	Source
Upstream of Rampart	1961	763	1	131,000	USFWS 1964
Upstream of Rampart	1962	763	1	114,000	USFWS 1964
Upstream of Dawson (YT)	1973	1289	2	39,669	Sweitzer 1974
Upstream of Dawson (YT)	1974	1289	2	15,846-31,352	Brock 1976
Upstream of Tanana, including Tanana River	1976	540-555	2	197,017 ²	Buklis 1981
Upstream of Tanana, including Tanana River	1977	540-601	2	412,285 ²	Buklis 1981
Upstream of Tanana, Yukon River only	1978	601-725	2	165,390 ²	Buklis 1981
Tanana River only	1979	725-757	2	676,241	Buklis 1981
Tanana River only	1980	757-761	2	383,770	Buklis 1981
Upstream of Dawson (YT)	1982	-	-	47,000-50,000 ³	Johnston In Prep
Upstream of Dawson (YT)	1983	-	-	96,000-118,000 ³	Johnston In Prep

¹ Method: 1 - tagging estimate with only recoveries at agency fishing sites; 2 - tagging estimate with recoveries from commercial and subsistence fisheries.

² These estimates supersede population estimates presented in Mauney (1979, 1980).

³ These data are preliminary.

Table 16. Total return index of Yukon River fall chum salmon, based on harvest and observed escapement, 1974-1983.

Year	Harvest ¹			Observed Escapement Index				Index of Total Return
	Commercial	Subsistence	Total	Porcupine ²	Tanana ³	Upper Yukon ⁴	Total	
1974	292,786	103,923	396,709	73,032 ⁵	50,412	350 ⁶	123,794	520,503
1975	277,509	97,902	375,411	156,675	87,119 ⁶	362 ⁶	244,156	619,567
1976	157,390	78,998	236,388	25,316	50,752	20 ⁶	76,088	312,476
1977	261,976	91,260	353,236	53,006	53,183	3,555	109,744	462,980
1978	248,646	106,077	354,723	29,610	58,271	0 ⁶	87,881	442,604
1979	387,496	246,347	633,843	85,220	203,474	4,640	293,334	927,177
Average 1976-79	263,877	130,670	394,547	48,288	91,420	2,054	141,762	536,309
1980	307,450	185,657	493,107	33,346	37,110	3,150	73,606	566,713
1981	492,996	195,354	688,350	23,174 ⁶	50,265	25,806	99,245	787,595
1982	236,150	136,356	372,506	6,563 ⁶	7,898 ⁶	5,378	19,839	392,345
1983	333,652	196,030	529,682	32,230	37,515 ⁶	8,578 ⁶	78,323	608,005
Average 1980-83	342,562	178,349	520,911	23,828	33,197	10,728	67,753	588,664

¹ Harvest is for Alaska and Canada combined. Includes "equivalent salmon", and estimated subsistence harvests for 1974-76 (see Table 5). Harvest data is preliminary for 1983.

² Peak aerial survey counts for Sheenjek and Fishing Branch Rivers.

³ Peak aerial or foot survey counts for five index areas in the upper Tanana River near Big Delta, and the Toklat River. Both upper and lower Toklat River are included for 1975 and 1979, only the upper Toklat River for the other years.

⁴ Kluane River peak aerial or foot survey count.

⁵ Includes weir count for the Fishing Branch River.

⁶ Poor or incomplete survey - minimal escapement index.

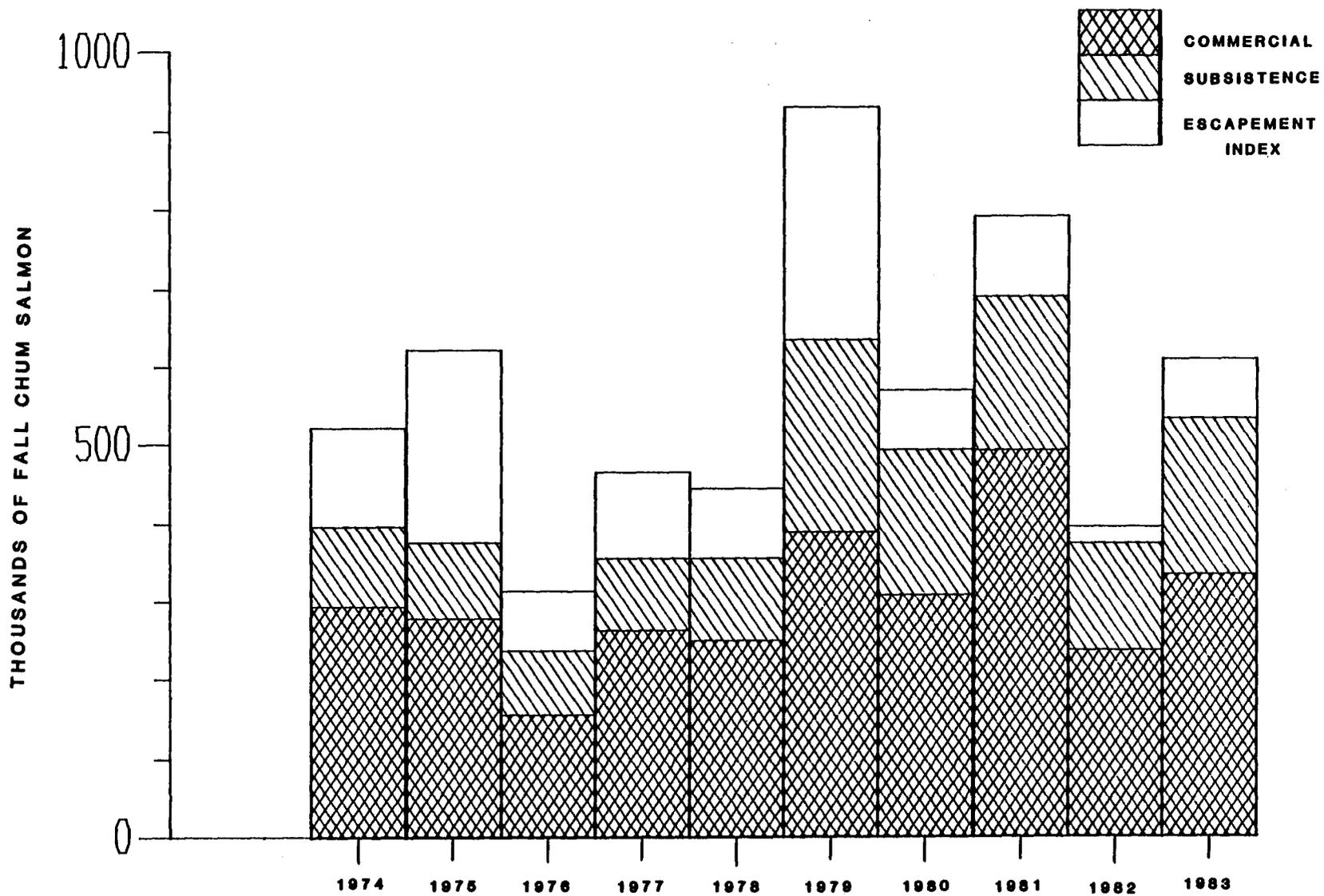


Figure 15. Total return indices for Yukon River fall chum salmon, 1974-1983, based on documented harvest and observed escapement indices. (Harvest is for Alaska and Canada combined.)

Table 17. Recent harvest of chum salmon in the Shumagin and south Unimak fisheries during the month of June.

Year	Shumagin Islands	South Unimak	Total
1975	36	65	101
1976	74	327	401
1977	22	93	115
1978	18	105	123
1979	41	64	105
1980	71	457	528
1981	54	521	575
1982	140	875	1,015
1983 ¹	166	590	756

¹ 1983 data are preliminary.

RECOMMENDATIONS

It is clear that commercial and subsistence harvests of Yukon River fall chum salmon have been increasing during the recent 4-year period from returns that show wide fluctuations in abundance. Escapement indices have shown a corresponding decline. Given the inability to accurately forecast returns, or often to even accurately assess run strength in-season, there is a very real possibility for overharvest. We recommend conservative harvest regulation to allow for greater escapements, and to reduce the risk of overharvesting anticipated weaker returns. Commercial harvests should be held to the lower half of the guideline harvest range unless a large return is apparent, and a harvestable surplus of fish is known to exist.

Exploitation of fall chum salmon in the lower river commercial fishery must be regulated to allow for spawning escapement, and upriver subsistence and commercial fisheries. Lack of information concerning total abundance, timing, and stock composition of the run into the lower river often prohibits managers from making timely in-season adjustments to the harvest. The highest research priority is in-season estimation of total run abundance. The feasibility of direct enumeration of fall chum salmon by sonar in the main Yukon River is being investigated at Pilot Station, just upstream from the intensive lower river fishery. Preliminary analysis indicates that migrating salmon can be detected by the hydroacoustic equipment, and that the migration route is limited to a relatively small portion of the river at the counting site. Given that the technology exists, it still remains to develop a sampling design to address time and water depth strata, counting schedules, expansion factors, and species identification. Several other methods might provide estimates of total abundance, including tagging studies in the Yukon River delta, modeling of run timing patterns, and analysis of trends in test fishing and commercial fishing catch and effort statistics.

The entry pattern of fall chum salmon into the Yukon River is highly variable. The migration is prolonged (mid-July through August) and often multi-modal. Factors responsible for the "pulse" entry pattern are not known, and should be investigated. Even if management of the fishery becomes more restrictive and harvest goals are lowered, it will be necessary to spread effort over the duration of the run to protect against overharvest of any one segment. To accomplish this objective the migratory timing pattern and its variability should be defined. This approach was applied by Mundy (1982) to Yukon River chinook salmon commercial and test fishery catch data with some success. Of particular interest would be the development of accurate predictors of run strength and timing based on test fishing data.

Accurate enumeration of major fall chum salmon spawning populations has been hindered by weather, logistics, and budget constraints. In addition, there are probably many smaller spawning populations that are as yet undocumented. Exploration of potential spawning areas and a more complete and accurate estimate of spawning escapement for the various known stocks is essential. It may be possible to develop a model for expanding multiple aerial survey counts for a given spawning area to a total season escapement estimate using stream residence time data from the literature. Escapement goals for the various spawning stocks should be developed based on the limited spawner-return data available.

Coupled with improved escapement enumeration is the need for a more comprehensive and consistent sampling program for age, sex, and size information. As discussed in an earlier section of this report, scales sampled from the spawning grounds are often reabsorbed and regenerated to such an extent that age cannot be determined. Alternate aging methods have been investigated on a limited basis. A more rigorous study of this problem could result in a more accurate method of determining age of fall chum salmon, a key component in the development of brood year tables and spawner-return models.

Exploitation rate of the individual stocks by the various fisheries is not known. Scale pattern analysis has been successfully applied to Yukon River chinook salmon (McBride and Marshall 1983) to identify groupings of stocks from large geographical areas. This approach may be applicable to fall chum salmon, and would allow for apportionment of catch to stock of origin. Optimum harvest in the mixed stock fishery, and protection of the less abundant stocks, is dependent on this information.

In addition to these fundamental information needs, managers of Yukon River fall chum salmon in Alaska must increasingly address the need for cooperative management and data exchange with Canadian biologists in the Yukon Territory.

ACKNOWLEDGMENTS

The authors would like to thank the following contributors for helping with various sections of this report: Fred Andersen and Mike Geiger for the description of the commercial and subsistence fisheries and management strategies, Bill Arvey for the Bering Sea migration patterns of maturing chum salmon, and James Brady for analysis of migration rates based on test fishing catch data. Critical review of the manuscript was provided by Fred Andersen, Bill Arvey, Linda Brannian, Mike Geiger, Doug McBride, and Ron Regnart.

LITERATURE CITED

- Andersen, F.M. 1983a. Upper Yukon test fishing studies, 1981. Alaska Department of Fish and Game, Commercial Fisheries Division, Fairbanks. Alaska, 20 pp.
- _____. 1983b. Upper Yukon River test fishing studies, 1982. Alaska Department of Fish and Game, Commercial Fisheries Division, Fairbanks, Alaska. 24 pp.
- Bakkala, R.G. 1970. Synopsis of biological data on the chum salmon, *Oncorhynchus keta* (Walbaum) 1792. US Department of the Interior, Food and Agriculture Organization Species Synopsis No. 41, Circ. 315. 89 pp.
- Barton, L.H. 1979. Alaska marine environmental assessment project. Finfish resource surveys in Norton Sound and Kotzebue Sound. In Environmental Assessment of the Alaskan Continental Shelf. US Department of Commerce, NOAA/OCSEAP, Final Report 4:75-313, Washington, D.C.
- _____. 1982. Enumeration of fall chum salmon by side-scanning sonar in the Sheenjek River in 1981. Yukon Salmon Escapement Report No. 13, Alaska Department of Fish and Game, Commercial Fisheries Division, Fairbanks, Alaska. 22 pp.
- _____. 1983. Enumeration of fall chum salmon by side-scanning sonar in the Sheenjek River in 1982. Yukon Salmon Escapement Report No. 19, Alaska Department of Fish and Game, Commercial Fisheries Division, Fairbanks, Alaska. 29 pp.
- _____. 1984. Enumeration of fall chum salmon by side-scanning sonar in the Sheenjek River in 1983. Yukon Salmon Escapement Report No. 22, Alaska Department of Fish and Game, Commercial Fisheries Division, Fairbanks, Alaska. 23 pp.
- Bevan, D.E. 1961. Variability in aerial counts of spawning salmon. Journal Fisheries Research Board of Canada. 18:337-348.
- Brady, J.A. 1982. Special investigation of current data bases relative to fall chum migratory timing. Memorandum dated 9 November. Alaska Department of Fish and Game, Commercial Fisheries Division, St. Mary's, Alaska. 25 pp.
- _____. 1983. Lower Yukon River salmon test and commercial fisheries, 1981. Alaska Department of Fish and Game, Technical Data Report No. 89, Juneau, Alaska. 91 pp.
- _____. 1984. Lower Yukon River salmon test fishing report, 1982-1983. AYK Region, Yukon Test Fishing Report No. 19. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage, Alaska. 73 pp.
- Brannian, L.K. 1983. Recovery distribution of chum salmon tagged offshore in the North Pacific in the vicinity of the Alaska Peninsula and eastern Aleutian Islands. Report to the Alaska Board of Fisheries, Alaska Department of Fish and Game, Commercial Fisheries Division, Anchorage, Alaska. 29 pp.

LITERATURE CITED (Continued)

- Brock, D.N. 1976. Distribution and abundance of chinook (*Oncorhynchus tshawytscha*) and chum (*O. keta*) salmon in the upper Yukon River system in 1974, as determined by a tagging program. Northern Operations Branch, Fisheries and Marine Service, Environmental Canada, PAC/T-76-3, New Westminster, Canada. 56 pp.
- Buklis, L.S. 1981. Yukon and Tanana River fall chum salmon tagging studies, 1976-1980. Informational Leaflet No. 194, Alaska Department of Fish and Game, Juneau, Alaska. 40 pp.
- _____. 1982. Anvik, Andreafsky, and Tanana River salmon escapement studies. 1981. Yukon Salmon Escapement Report No. 15. Alaska Department of Fish and Game, Commercial Fisheries Division, Anchorage, Alaska. 40 pp.
- _____. 1983a. 1983 Toklat River fall chum salmon survey. Memorandum dated 26 October. Alaska Department of Fish and Game, Commercial Fisheries Division, Anchorage, Alaska. 6 pp.
- _____. 1983b. Anvik and Andreafsky River salmon studies, 1982. Yukon Salmon Escapement Report No. 20, Alaska Department of Fish and Game, Commercial Fisheries Division, Anchorage, Alaska. 52 pp.
- Burner, C.J. 1951. Characteristics of spawning nests of Columbia River salmon. Fish Bulletin. 61(52):97-110.
- Cousens, N.B.F., G.A. Thomas, C.G. Swann, and M.C. Healey. 1982. A review of salmon escapement estimation techniques. Canadian Technical Report Fisheries Aquatic Science No. 1108. Department Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C., Canada. 121 pp.
- Dinneford, W.B. 1978. Final report of the commercial fish-technical evaluation study: Tanana and Delta Rivers. Special Report No. 20, Joint State/Federal Fish and Wildlife Advisory Team. Alaska Department of Fish and Game, Anchorage, Alaska. 52 pp.
- Disler, N.N. 1953. Ekologo-morfologicheskie osobennosti razvitiya ossennei kety - *Oncorhynchus keta* (Walbaum) r. Amura [Ecological and morphological characteristics of the development of the Amur autumn chum salmon - *Oncorhynchus keta* (Walbaum)]. Akad. Nauk SSSR, Ikhtiologicheskaya Komissiya, Trudy Soveshchaniy, No. 1:354-362 (Transl. pp. 33-41 in "Pacific salmon: selected articles from Soviet periodicals," Clearinghouse Federal Scientific Technical Informational Service, Springfield, Virginia.
- Elson, M.S. 1973. Enumeration of spawning chum salmon in the Fishing Branch River in 1971 and 1972. Technical Report 1973 - 5, Canada, Department of the Environment, Fisheries and Marine Service, Pacific Region. Vancouver, B.C., Canada. 20 pp.

LITERATURE CITED (Continued)

- Elson, M.S. 1975. Enumeration of spawning chum salmon (*Oncorhynchus keta*) in the Fishing Branch River in 1971, 1972, 1973, and 1974. In Steigenberger, L.W., M.S. Elson, and R.T. Delury, eds. Northern Yukon fisheries studies, 1971-1974. Vol. 1, Chapter II. Northern Operations Branch, Fisheries and Marine Service, Department of the Environment, PAC/T-75-19. New Westminster, British Columbia, Canada. 45 pp.
- _____. 1976. Enumeration of the 1975 chum salmon population in the Fishing Branch River. Northern Natural Resources Services, Ltd. Northern Operations Branch, Fisheries and Marine Services, Environment Canada, PAC/T-76-1. New Westminster, British Columbia, Canada. 29 pp.
- Fernet, D.A. 1982. Enumeration of spawning chum salmon in aquatic streams along the Alaska Highway gas pipeline in southern Yukon Territory, 1981. Rep. by Environmental Management Associates prepared for Foothills Pipe Lines (South Yukon) Ltd., Calgary, Alberta, Canada. 46 pp.
- Francisco, K. 1976. First interim report of the commercial fish technical evaluation study. Special Report No. 4, Joint State/Federal Fish and Wildlife Advisory Team, Alaska Department of Fish and Game, Anchorage, Alaska. 85 pp.
- _____. 1977. Second interim report of the commercial fish technical evaluation study. Special Report No. 9, Joint State/Federal Fish and Wildlife Advisory Team, Alaska Department of Fish and Game, Anchorage, Alaska. 46 pp.
- Francisco, K. and W.B. Dinneford. 1977. Fourth interim report of the commercial fish-technical evaluation study: Tanana and Delta Rivers. Special Report No. 19, Joint State/Federal Fish and Wildlife Advisory Team. Alaska Department of Fish and Game, Anchorage, Alaska. 50 pp.
- Gangmark, H.A. and L.A. Fulton. 1952. Status of Columbia River blueback salmon run, 1951. US Fish and Wildlife Service Special Scientific Report Fisheries. Washington, D.C. 74 pp.
- Geiger, M. and F. Andersen. 1983. Status of Yukon River fall chum salmon stocks and fisheries. Report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Commercial Fisheries Division, Anchorage, Alaska. 26 pp.
- Gissberg, J.G. and D.S. Benning. 1965. Yukon foundation studies summary report, 1965. US Department of Interior, Fish and Wildlife Service, Anchorage, Alaska. 68 pp.
- Grigo, L.D. 1953. O morfologicheskikh otlichiyakh letnei i osennei kety *Oncorhynchus keta* (Walbaum), *O. keta* (Walbaum) infraspecies *autumnalis* Berg (Morphological differences between the summer and autumn chum salmon *Oncorhynchus keta* (Walbaum), *O. keta* (Walbaum) infraspecies *autumnalis* Berg]. Dokl. Akad. Nauk SSSR 92, No. 6:1225-1228. (Translations pp. 13-17 in "Pacific salmon: selected articles from Soviet periodicals." Clearinghouse Federal Scientific Technical Informational Services, Springfield, Virginia.

LITERATURE CITED (Continued)

- Harris, C. 1982. Letter dated 20 October 1982, Harris to Yrjana. Alaska Department of Fish and Game, Commercial Fisheries Division letter files, W.D. Arvey, Anchorage, Alaska.
- Helle, J.H. 1977. U.S. Department of Commerce memorandum to Dr. Peter Craig, L.G.L. Biological Consultants. NOAA, Auke Bay Laboratory, Alaska, September 13. 2 pp.
- Johnston, S. In prep. Yukon Territory chinook and chum salmon tagging study, 1982 and 1983. Department of Fisheries and Oceans. Whitehorse, Yukon Territory, Canada.
- Lovetskaya, E.A. 1948. Materialy po biologii amurskoi ketz [Data on the biology of the Amur chum salmon]. Izvestiya TINRO [Bull. of TINRO], No. 27:115-137. Trans. pp. 101-126 in "Pacific salmon: selected articles from Soviet periodicals", Clearinghouse Federal Science, Technical Information Center, Springfield, VA.
- Mattson, C.R., R.G. Rowland, and R.A. Hobart. 1964. Chum salmon studies in Southeastern Alaska, 1963. Ms. Rep. 64-8, Bureau of Commercial Fisheries Biological Laboratory, Auke Bay, Alaska. 22 pp.
- Mauney, J.L. 1977. Yukon River king and chum salmon escapement studies. Anadromous Fish Conservation Act, Technical Report for period July 1, 1975 to June 30, 1976. Alaska Department of Fish and Game, Commercial Fisheries Division, Juneau, Alaska. 83 pp.
- _____. 1979. Yukon River salmon studies. Anadromous Fish Conservation Act, Technical Report for period July 1, 1977 to June 30, 1978. Alaska Department of Fish and Game, Juneau, Alaska. 74 pp.
- _____. 1980. Yukon River salmon studies. Anadromous Fish Conservation Act, Technical Report for period July 1, 1978 to June 30, 1979. Alaska Department of Fish and Game, Juneau, Alaska. 78 pp.
- Mauney, J.L. and M.F. Geiger. 1977. Yukon River anadromous fish investigations. Anadromous Fish Conservation Act, Completion Report for period July 1, 1974 to June 30, 1977. Alaska Department of Fish and Game, Commercial Fisheries Division, Juneau, Alaska. 118 pp.
- McBride, D.N. and S.L. Marshall. 1983. Feasibility of scale pattern analysis to identify the origins of chinook salmon *Oncorhynchus tshawytscha* (Walbaum) in the lower Yukon River commercial gillnet fishery, 1980-1981. Informational Leaflet No. 208, Alaska Department of Fish and Game, Commercial Fisheries Division, Juneau, Alaska. 64 pp.
- McLean, R.F. and J.A. Raymond. 1983. Chandalar-Christian Rivers area fisheries rehabilitation and enhancement study. Fisheries Rehabilitation, Enhancement, and Development Division Report No. 13, Alaska Department of Fish and Game, Juneau, Alaska. 52 pp.

LITERATURE CITED (Continued)

- McNeil, W.J. and J.E. Bailey. 1975. Salmon rancher's manual. Processed report, Auke Bay Fisheries Laboratory, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Seattle, Washington. 95 pp.
- Merritt, M.F. and J.A. Raymond. 1983. Early life history of chum salmon in the Noatak River and Kotzebue Sound. Fisheries Rehabilitation, Enhancement, and Development Division, Report No. 1, Alaska Department of Fish and Game, Juneau, Alaska. 56 pp.
- Mundy, P.R. 1982. Computation of migratory timing statistics for adult chinook salmon in the Yukon River, Alaska, and their relevance to fisheries management. *North American Journal of Fisheries Management*, 4:359-370.
- Neave, F. 1966. Salmon of the North Pacific Ocean - Part III. A review of the life history of North Pacific salmon. 6. Chum salmon in British Columbia. *International North Pacific Fisheries Commission Bulletin*. 18:81-86.
- Neave, F., Yonemori, T. and Bakkala, R.G. 1975. Distribution and origin of chum salmon in offshore waters of the North Pacific Ocean. *International North Pacific Fisheries Commission Bulletin*, No. 35. 66 pp.
- Neilson, J.D. and G.H. Geen. 1981. Enumeration of spawning salmon from spawner residence time and aerial counts. *Transactions American Fisheries Society*. 110:554-556.
- Raymond, J.A. 1981. Incubation of fall chum salmon (*Oncorhynchus keta*) at Clear Air Force Station, Alaska. Informational Leaflet No. 189, Alaska Department of Fish and Game, Juneau, Alaska. 26 pp.
- Sano, S. 1966. Salmon of the North Pacific Ocean - Part III. A review of the life history of North Pacific salmon. 3. Chum salmon in the Far East. *International North Pacific Fisheries Commission Bulletin* 18:41-57.
- _____. 1967. Salmon of the North Pacific Ocean - Part IV. Spawning populations of North Pacific salmon. 3. Chum salmon in the Far East. *International North Pacific Fisheries Commission Bulletin* 23:23-41.
- Schroder, S.L. 1973. Effects of density on the spawning success of chum salmon (*Oncorhynchus keta*) in an artificial spawning channel. M.S. Thesis, University of Washington, Seattle, Washington. 78 pp.
- Smirnov, A.G. 1947. Sostoyanie zapasov amurskikh lososei i princhiny ikh chislennykh kolebannii [Condition of stocks of the Amur salmon and causes of the fluctuations in their abundance]. *Izvestiya TINRO* 25:35-51. (Transl. pp. 66-85 in "Pacific salmon: selected articles from Soviet periodicals", Clearinghouse Federal Scientific Technical Informational Service, Springfield, VA).
- Straty, R.R. 1981. Trans-shelf movements of Pacific salmon. In D.W. Hood and J.A. Calder (eds.). *The Eastern Bering Sea Shelf: Oceanography and Resources*, Vol. 1. Offshore Marine Pollution Assessment, US Department of Commerce, National Oceanic and Atmospheric Administration, Boulder, CO.

LITERATURE CITED (Continued)

- Sweitzer, Obert. 1974. Distribution and abundance of chinook (*Oncorhynchus tshawytscha*) and chum (*Oncorhynchus keta*) salmon in the upper Yukon River system in 1973, as determined by a tagging program. Environment Canada Fisheries and Marine Service. Northern Operations Branch, Pacific Region. PAC/T-74-20, New Westminster, British Columbia, Canada. 24 pp.
- Trasky, L.T. 1973. Yukon River anadromous fish investigations. Anadromous Fish Conservation Act, Completion Report for period July 1, 1970 to June 30, 1972. Alaska Department of Fish and Game, Commercial Fisheries Division, Juneau, Alaska. 59 pp.
- _____. 1974. Yukon River anadromous fish investigations. Anadromous Fish Conservation Act, Completion Report for period July 1, 1973 to June 30, 1974. Alaska Department of Fish and Game, Commercial Fisheries Division, Juneau, Alaska. 111 pp.
- _____. 1976. Yukon River king and chum salmon escapement studies. Anadromous Fish Conservation Act, Technical Report for period July 1, 1974 to June 30, 1975. Alaska Department of Fish and Game, Commercial Fisheries Division, Juneau, Alaska. 78 pp.
- U.S. Fish and Wildlife Service. 1964. A report on fish and wildlife resources affected by Rampart Canyon dam and reservoir project, Yukon River. US Department of Interior, Juneau, Alaska. 122 pp.
- Walker, C.E. 1976. Studies on the freshwater and anadromous fishes of the Yukon River within Canada. Fisheries and Marine Service, Department of the Environment, PAC T/76-7, Vancouver, British Columbia, Canada. 99 pp.

APPENDICES

Appendix Table 1. Yukon River fall chum salmon tag recoveries from INPFC offshore tagging, 1956-1979.

Maturing Fish ¹						
Tagging Data			Recovery Data			
Date	Latitude	Longitude	Date	Latitude	Longitude	
07/30/65	60 09N	174 30E	09/18	64 40N	15 53W	
06/27/56	51 54N	175 14W	09/11	65 30N	151 15W	
06/29/56	51 45N	176 06W	09/28	65 00N	157 31W	
07/01/56	51 44N	176 06W	09/12	65 10N	152 00W	
06/23/57	57 08N	171 07W	08/31	64 30N	149 05W	
06/26/58	56 40N	169 40W	08/00 ²	62 —N ³	163 —W ³	
06/29/60	54 38N	168 49W	09/08	65 00N	157 31W	
06/20/60	53 25N	168 51W	09/22	66 35N	144 15W	
06/19/56	53 22N	167 02W	07/15	62 40N	164 40W	
06/14/56	53 22N	167 02W	07/23	62 50N	163 50W	
06/21/61	53 19N	167 10W	08/03	62 32N	164 55W	
07/03/61	53 18N	167 11W	08/07	62 32N	164 55W	
06/29/61	53 12N	167 21W	08/22	65 00N	157 31W	
06/29/61	53 18N	167 21W	07/24	62 40N	164 40W	
06/18/62 ⁴	53 01N	167 51W	08/00 ²	65 15N	152 00W	
06/10/60	52 55N	168 14W	09/09	64 50N	149 15W	
06/17/60	52 55N	168 18W	07/15	62 44N	164 28W	
06/17/60 ⁴	52 55N	168 18W	08/02	64 45N	158 00W	
06/11/60	52 55N	168 19W	09/05	65 00N	157 31W	
06/16/60	52 54N	168 21W	09/29	66 35N	144 15W	
06/16/60	52 54N	168 21W	09/29	64 30N	149 05W	
06/16/60	52 54N	168 21W	08/23	64 45N	155 30W	
06/15/62	52 25N	168 23W	08/04	62 35N	164 50W	
06/28/60	52 50N	168 24W	08/10	62 10N	159 45W	
06/28/60	52 50N	168 24W	09/12	62 40N	164 40W	
06/29/60	52 51N	168 29W	09/20	62 40N	164 40W	
06/29/60	52 51N	168 29W	10/01	64 45N	157 00W	
06/14/61	52 47N	168 38W	07/24	62 40N	164 40W	
06/15/61	52 47N	168 38W	08/24	62 42N	164 32W	
05/31/62	52 44N	168 48W	07/25	62 12N	163 52W	
06/07/65	53 23N	166 32W	09/24	62 12N	163 52W	
07/01/56	54 32N	168 —W	08/25	62 40N	164 40W	
06/21/56	54 23N	164 11W	07/25	61 50N	162 00W	
04/18/63	53 26N	155 56W	09/00 ²	62 35N	164 52W	
04/29/63	50 47N	160 00W	09/02	64 40N	155 30W	
05/28/65	54 59N	152 15W	08/28	65 00N	157 30W	
06/03/64 ⁴	55 52N	153 05W	07/16	62 —N ³	163 —W ²	
05/19/64	55 35N	154 05W	08/13	64 25N	158 30W	
05/14/64	52 40N	152 00W	08/00 ²	62 10N	159 40W	
05/09/66	53 05N	152 20W	09/00 ²	62 35N	164 —W ³	

-Continued-

Appendix Table 1. Yukon River fall chum salmon tag recoveries from INPFC offshore tagging, 1956-1979 (continued).

<u>Maturing Fish¹</u>					
<u>Tagging Data</u>			<u>Recovery Data</u>		
Date	Latitude	Longitude	Date	Latitude	Longitude
04/23/63	44 47N	153 10W	09/15	64 40N	155 30W
04/23/65	57 10N	149 50W	08/00 ²	64 45N	158 00W
05/17/67	54 36N	147 00W	09/21	64 40N	155 30W
04/26/65	52 04N	147 42W	08/07	61 55N	162 56W
04/14/62	49 20N	147 35W	09/16	64 33N	149 01W
04/10/63	55 30N	144 20W	07/21	62 35N	164 50W
05/01/66	47 00N	140 00W	07/21	62 46N	164 06W
06/26/74	57 30N	177 30W	08/06	61 58N	160 14W
07/09/71	51 05N	176 25W	08/00 ²	62 40N	164 36W
06/29/71	56 54N	173 05W	07/25	63 02N	163 34W
06/29/71	56 54N	173 05W	08/08	62 53N	164 07W
<u>Immature Fish⁵</u>					
08/14/58	51 34N	176 17W	08/17/59	61 45N	161 30W
08/16/58	51 35N	176 19W	07/25/59	62 12N	163 52W
08/19/58	51 57N	155 45W	09/24/59	65 00N	149 15W
07/08/66	56 30N	145 00W	08/30/68	61 56N	162 52W

¹ Recovered in year of tagging.
² Day of month unknown.
³ Missing latitude or longitude data.
⁴ Fall chum designation questionable.
⁵ Recovered in year(s) subsequent to tagging.

Appendix Table 2. Age and sex composition of Yukon River fall chum salmon sampled from selected fisheries and escapements, 1973-1982¹.

Year	Location	Fishery	Gear Type	Sampling Period	N	Age 31			Age 41			Age 51			Age 61			Combined Ages	
						M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F
1973	Etmonak	Commercial	6"GN	7/16-8/22	611	2.5	3.8	6.3	29.5	43.9	73.4	11.1	8.7	19.8	0.5	0.2	0.7	44	56
	Delta R.	Escapement	Carcass	10/20-11/12	453	9.1	4.9	14.0	43.3	33.8	77.1	4.4	4.4	8.8	0.0	0.2	0.2	57	43
1974	Etmonak	Commercial	6"GN	7/15-8/7	461	20.8	23.0	43.8	24.3	29.1	53.4	2.0	0.9	2.9				47	53
	Nenana	Commercial	FW	8/26-9/29	272	19.5	30.1	49.6	25.4	21.0	46.4	3.3	0.7	4.0				48	52
	Toklat R.	Escapement	Carcass	10/2-10/4	191	43.0	30.0	73.0	9.0	17.0	26.0	0.0	0.5	0.5				52	48
	Delta R.	Escapement	Carcass	10/13-11/17	438	36.0	14.0	50.0	29.0	18.0	47.0	2.0	1.0	3.0				67	33
	Rampart	Commercial	6"GN	9/11-9/29	86	30.2	24.4	54.6	23.3	21.0	44.3	1.1	0.0	1.1				55	45
	Sheenjek R.	Escapement	Carcass	10/12-10/13	137	29.0	37.0	66.0	12.0	18.0	30.0	2.0	1.0	3.0	0.0	1.0	1.0	43	57
1975	Etmonak	Commercial	6"GN	7/18-8/8	646	0.3	1.1	1.4	20.8	76.9	97.7	0.5	0.0	0.5				22	78
	Nenana	Commercial	FW	9/1-9/15	886	9.7	9.0	18.7	40.2	38.0	78.2	2.0	1.0	3.0				52	48
	Delta R.	Escapement	Carcass	10/22-11/24	271	0.7	2.2	2.9	48.7	44.7	93.4	2.6	1.1	3.7				52	48
	Rampart	Commercial	FW	8/24-8/29	104	18.3	23.1	41.4	41.3	15.4	56.7	1.9	0.0	1.9				62	38
1976	Etmonak	Commercial	6"GN	7/17-8/7	543	6.1	5.0	11.1	13.4	22.7	36.1	23.6	29.3	52.9				43	57
	Nenana	Commercial	FW	8/17-9/25	214	3.3	5.1	8.4	29.9	37.9	67.8	14.0	9.8	23.8				47	53
	Toklat R.	Escapement	Carcass	10/14-10/20	172	28.5	14.0	42.5	26.2	26.7	52.9	2.9	1.7	4.6				58	42
	Delta R.	Escapement	Carcass	10/22-11/16	351	1.1	0.3	1.4	58.2	34.4	92.6	3.1	2.6	5.7	0.0	0.3	0.3	62	38
	Sheenjek R.	Escapement	Carcass	9/25-10/19	118	0.0	1.7	1.7	15.3	28.8	44.1	30.5	23.7	54.2				46	54
1977	Etmonak	Commercial	6"GN	7/19-8/23	923	3.7	5.8	9.5	32.2	52.9	85.1	2.6	2.7	5.3	0.1	0.0	0.1	39	61
	Nenana	Commercial	FW	8/15-9/17	455	1.1	4.4	5.5	43.5	47.7	91.2	1.5	1.8	3.3				46	54
	Toklat R.	Escapement	Carcass	10/26-11/4	197	12.7	13.7	26.4	48.7	19.8	68.5	5.1	0.0	5.1				66	34
	Delta R.	Escapement	Carcass	10/6-11/16	445	6.8	4.0	10.8	44.0	44.0	88.0	0.5	0.7	1.2				51	49
	Rampart	Commercial	FW	8/23-9/11	241	6.3	5.0	11.3	44.0	42.7	86.7	0.8	1.2	2.0				51	49
	Sheenjek R.	Escapement	Carcass	10/3-10/27	178	3.3	7.9	11.2	30.9	41.6	72.5	10.7	5.6	16.3				45	55
1978	Etmonak	Commercial	6"GN	7/21-8/25	667	8.4	11.5	19.9	27.9	38.1	66.0	7.5	6.4	13.9	0.1	0.0	0.1	44	56
	Nenana	Commercial	FW	8/14-9/21	418	14.6	19.8	34.4	27.5	34.7	62.2	1.7	1.7	3.4				44	56
	Toklat R.	Escapement	Carcass	9/23-10/23	203	9.9	5.9	15.8	43.3	31.5	74.8	5.4	4.0	9.4				59	41
	Delta R.	Escapement	Carcass	11/2-11/16	182	12.6	12.1	24.7	28.6	31.3	59.9	11.0	4.4	15.4				52	48
	Rampart ²	Commercial	FW	8/15-9/24	370	8.1	9.7	17.8	29.2	34.1	63.3	10.8	8.1	18.9				48	52
	Sheenjek R.	Escapement	Carcass	10/10-10/16	190	3.2	4.7	7.9	39.5	42.6	82.1	5.3	4.7	10.0				48	52

-Continued-

Appendix Table 2. Age and sex composition of Yukon River fall chum salmon sampled from selected fisheries and escapements, 1973-1982¹ (continued).

Year	Location	Fishery	Gear Type	Sampling Period	N	Age 31			Age 41			Age 51			Age 61			Combined Ages	
						M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F
1979	Eimonak	Commercial	6 ^o GN	7/20-8/14	793	3.3	4.0	7.3	41.9	45.9	87.8	2.3	2.7	5.0				47	53
	Nenana	Com & Subs	FW	8/18-9/12	316	2.5	6.7	9.2	44.9	41.8	86.7	2.5	1.6	4.1				50	50
	Toklat R.	Escapement	Carcass	10/11-10/12	185	28.7	13.5	42.2	36.7	20.0	56.7	1.1	0.0	1.1				66	34
	Rampart ²	Commercial	FW	8/15-9/1	352	0.3	0.3	0.6	54.8	36.1	90.9	5.4	3.1	8.5				60	40
1980	Eimonak	Commercial	6 ^o GN	7/25-8/18	820	5.3	8.4	13.7	36.5	41.7	78.2	4.5	3.7	8.2				46	54
	Nenana	Com & Subs	FW	8/15-9/18	266	0.8	4.5	5.3	19.2	39.8	59.0	21.8	13.9	35.7				42	58
	Toklat R.	Escapement	Carcass	11/1	57	1.8	1.8	3.6	33.2	31.6	64.8	19.4	12.2	31.6				54	46
	Delta R.	Escapement	Carcass	10/25	49	10.2	2.0	12.2	57.1	28.7	85.8	2.0	0.0	2.0				69	31
1981	Eimonak	Commercial	6 ^o GN	7/17-8/18	672	0.9	0.5	1.4	33.0	54.6	87.6	4.8	6.3	11.1				39	61
	Sheenjek R.	Escapement	5-7/8 ^o GN	9/2-9/23	340	0.6	2.3	2.9	40.9	44.1	85.0	9.4	2.3	11.7	0.3	0.0	0.3	51	49
1982	Eimonak	Commercial	6 ^o GN	7/16-8/13	1,053	3.2	2.8	6.0	25.6	36.4	62.0	13.9	17.6	31.5	0.2	0.2	0.4	43	57
	Nenana	Commercial	FW	9/18-9/19	48	10.4	22.9	33.3	25.1	33.4	58.5	4.1	4.1	8.2				40	60
	Toklat R.	Escapement	Carcass	10/22	73	12.3	24.7	37.0	27.4	32.8	60.2	1.4	1.4	2.8				41	59
	Delta R.	Escapement	Carcass	10/28-11/10	208	6.7	3.4	10.1	34.1	28.9	63.0	10.6	14.4	25.0	0.5	1.4	1.9	52	48
	Sheenjek R.	Escapement	5-7/8 ^o GN	9/1-9/19	139	1.4	1.4	2.8	15.8	28.1	43.9	20.1	32.4	52.5	0.7	0.0	0.7	38	62
	Ruby N Bank	Test Fish	FW	8/11-9/7	488	1.4	4.7	6.1	21.0	27.5	48.5	20.7	24.5	45.2	0.2	0.0	0.2	43	57
	Ruby S Bank	Test Fish	FW	8/6-9/11	776	5.8	8.2	14.0	25.1	40.5	65.6	7.7	12.5	20.2	0.0	0.1	0.1	39	61
	Yukon Ter ³	Test Fish	FW	8/8-10/4	301	1.3	5.9	7.2	16.6	19.9	36.5	30.6	25.7	56.3				48	52
	Dawson	Commercial	GN	7/30-10/2	385	1.3	1.6	2.9	22.8	16.9	39.7	32.2	24.7	56.9	0.2	0.3	0.5	56	44
	Fairbanks	Subsistence	GN	8/16-9/27	216	7.4	2.7	10.1	31.9	26.5	58.4	24.1	7.4	31.5				63	37

¹ Age and sex composition listed as percent of total sample.

² Includes some samples from commercial fishwheels near Tanana Village.

³ Fishwheel located on Yukon River just upstream from the U.S.-Canadian Border, and operated by DFO for tagging study.

The Alaska Department of Fish and Game administers all programs and activities free from discrimination based on race, color, national origin, age, sex, religion, marital status, pregnancy, parenthood, or disability. The department administers all programs and activities in compliance with Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972.

If you believe you have been discriminated against in any program, activity, or facility, or if you desire further information please write to ADF&G, P.O. Box 25526, Juneau, AK 99802-5526; U.S. Fish and Wildlife Service, 4040 N. Fairfax Drive, Suite 300 Webb, Arlington, VA 22203 or O.E.O., U.S. Department of the Interior, Washington DC 20240.

For information on alternative formats for this and other department publications, please contact the department ADA Coordinator at (voice) 907-465-6077, (TDD) 907-465-3646, or (FAX) 907-465-6078.