REGIONAL INFORMATION REPORT 3A00-27

Alaska Department of Fish and Game
Division of Commercial Fisheries
333 Raspberry Road
Anchorage, Alaska 99518

June 2000

Sonar Estimation of Fall Chum Salmon Abundance In the Sheenjek River, 1999

by

Louis H. Barton

State of Alaska Tony Knowles, Governor

SONAR ESTIMATION OF FALL CHUM SALMON ABUNDANCE IN THE SHEENJEK RIVER, 1999

By

Louis H. Barton

Regional Information Report[1] No. 3A00-27

Alaska Department of Fish and Game
Division of Commercial Fisheries
Arctic-Yukon-Kuskokwim Region
333 Raspberry Road
Anchorage, Alaska 99518

June 2000

[1]The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or the Division of Commercial Fisheries.

AUTHOR

Louis H. Barton is the fall chum and coho salmon Yukon Area Research Biologist for the Alaska Department of Fish and Game, Division of Commercial Fisheries, 1300 College Road, Fairbanks, AK 99701.

ACKNOWLEDGMENTS

Appreciation is extended L. McKinley who supervised establishing the remote camp, and to J. Harbin and M. Weaver who participated in the hydroacoustic operations of this study. G. Sandone provided constructive comments and review of this report.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Appendix	Page

ABSTRACT

User non-configurable, side-looking sonar was used to estimate chum salmon *Oncorhynchus keta* escapement in the Sheenjek River during the period from 10 August through 23 September 1999. The sonar-estimated escapement was only 14,229 chum salmon, the lowest on record, and 78% below the minimum escapement goal of 64,000 fish. The chum salmon entry pattern was weakly bimodal with the central half of the run recorded from 27 August through 14 September. The median day of passage was observed on 8 September. Daily upstream migration was primarily confined to periods of darkness or suppressed light with greatest movement (66%) occurring between 2100 and 0700 hours.

Range of ensonification was considered adequate for detection of the majority of fish passing the sonar site and most fish passing through the acoustic beam were nearshore oriented. However, the passage estimate should be considered conservative since it does not include fish passing beyond the counting range (including along the unensonified far bank), fish present before sonar equipment was in operation, or fish passing upstream after counting ceased. Variations in Sheenjek River water levels and velocities, together with migration behavior of upstream migrant chum salmon, can affect the ability of hydroacoustic equipment to enumerate salmon passage. However, these deviations were accounted for by regularly comparing sonar counter output to visual observations on an oscilloscope.

No age composition data are available from 1999 due to the inability to capture chum salmon by beach seine as a function of the extremely weak chum salmon run.

KEY WORDS: Chum salmon, *Oncorhynchus keta,* sonar, hydroacoustics, escapement, enumeration, Yukon River, Porcupine River, Sheenjek River

INTRODUCTION

Although five species of anadromous Pacific salmon *Oncorhynchus* are found in the Yukon River drainage, chum salmon *O. keta* are the most abundant and occur in genetically distinct summer and fall runs (Wilmot et al. 1992; Seeb et al. 1995). Fall chum salmon are larger, spawn later, and are less abundant than summer chum salmon. They primarily spawn in the upper portion of the drainage in streams that are spring fed, usually remaining ice-free during the winter (Buklis and Barton 1984). Major fall chum salmon spawning areas occur within the Tanana, Chandalar, and Porcupine River systems, as well as portions of the upper Yukon River in Canada (Figure 1).

In-river Fisheries

Fall chum salmon are in great demand commercially with harvest permitted along the entire mainstem river in Alaska as well as in the lower portion of the Tanana River. No commercial harvest is permitted in any other tributaries of the drainage including the Koyukuk and Porcupine River systems. Although commercial harvest also occurs in the Canadian portion of the Yukon River near Dawson, the majority of fish taken commercially occurs in the lower river, downstream of the village of Anvik. Fall chum salmon use as a subsistence item is greatest throughout the upper river drainage, upstream of the village of Koyukuk.

Although the Alaskan commercial fishery for Yukon River fall chum salmon developed in the early 1960's, annual harvests remained relatively low through the early to mid-1970s. Estimated total in-river utilization (U.S. and Canada commercial and subsistence) of Yukon River fall chum salmon was below 300,000 fish per year prior to the mid-1970s (Table 1). However, in-river commercial fisheries became more fully developed during the late 1970's and early 1980's, with total utilization averaging 536,000 fish from 1979-1983. Harvest peaked in 1979 at 615,000 and in 1981 at 677,000 fish. Since the mid-1980's management strategies have been implemented to reduce commercial exploitation on fall chum stocks in order to improve upon low escapements observed throughout the drainage during the early 1980's. In 1987 a complete closure of the commercial fall chum fishery occurred in the Alaskan portion of the drainage, while in 1992 commercial fishing in Alaska was restricted to only a portion of the Tanana River during the fall season. In addition to a commercial fishery closure in 1993, that year marked the first in State history that a total river closure to subsistence fishing occurred in the Yukon River during the latter portion of the fall season in response to the extremely weak fall chum salmon run in that year.

Yukon River fall chum salmon runs improved somewhat from 1994 through 1996. While limited commercial fishing was permitted in 1994 in the Alaskan portion of the upper Yukon River, as well as in the Tanana River, commercial fishing was permitted in all districts throughout the Alaska portion of the drainage in 1995. In 1996, however, limited commercial fishing was only permitted in selected districts of the mainstem Yukon River, with no commercial fishing permitted in the Tanana River. Poor salmon runs to Western Alaska in 1997 and 1998 again resulted in partial or total closures to commercial fishing in the Alaskan portion of drainage; commercial fishing was only permitted in the Tanana River in 1997, and a total commercial fishery closure was required in 1998.

Escapement Assessment

During the period 1960 through 1980, only various segments of annual runs of Yukon River fall chum salmon were occasionally estimated from mark-and-recapture (M-R) studies (Buklis and Barton 1984). Excluding these tagging studies and apart from aerial assessment of selected tributaries since the early 1970's, comprehensive escapement estimation studies were sporadic and limited to only two streams, the Delta River (Tanana River drainage) and the Fishing Branch River (Porcupine River drainage). However, comprehensive escapement assessment studies intensified on major spawning tributaries throughout the drainage subsequent to the early 1980s.

In the Canadian portion of the drainage, the Canadian Department of Fisheries and Oceans (DFO) has estimated abundance of fall chum salmon crossing the US/Canada border of the mainstem river into Yukon Territory annually since 1982, excluding 1984, using M-R techniques (Milligan et al. 1984, JTC 1999). In addition, DFO reinstalled a weir in the Fishing Branch River in 1985 that was previously operated from 1971 through 1975, and has monitored chum salmon escapements to this stream annually since then, excluding 1990.

In the Alaskan portion of the drainage, the United States Fish and Wildlife Service (USFWS) estimated annual fall chum salmon escapement to the Chandalar River from 1986 through 1990 using fixed-location, single-beam hydroacoustic techniques (Daum et al. 1992). Results of that work revealed that fall chum salmon production there was similar to that of the nearby Sheenjek River. Subsequently, in 1994, the USFWS initiated a five-year study to reassess the population status of fall chum salmon with a newly developed split-beam hydroacoustic system. The initial year, 1994, was used to develop site-specific operational methods, evaluate site characteristics, and describe possible data collection biases (Daum and Osborne 1995). The project was fully operational from 1995 through 1998 with annual escapement estimates ranging from a low of 75,811 in 1998 to a high of 280,999 in 1995 (Daum and Osborne 1996, Osborne and Daum 1997, Daum and Osborne 1998, Daum and Osborne 1999).

The Alaska Department of Fish and Game (ADF&G) initiated an experimental main river sonar project near Pilot Station (rivermile 123) in 1978, for the purpose of estimating salmon passage by species. During the developmental years of 1978 through 1985, data acquisition and sampling designs were investigated using various models of scientific fisheries hydroacoustic systems. The project has operated annually since 1986, except for 1992 when it was operated for experimental purposes with upgraded sonar equipment and 1996 when it was operated for training purposes only. However, because of recent improvements in methodologies, historic data are not comparable to improved assessments available for 1995, 1997 and 1998 (JTC 1999). In addition to the Pilot Station sonar project operated by ADF&G, the USFWS has conducted a M-R project annually since 1996 at an area known locally as "The Rapids", a narrow canyon near Rampart, 1,176 kilometers from the mouth of the Yukon River. The purpose of this project is to provide abundance estimates of adult fall chum salmon bound for the upper Yukon River (Gordon et al. 1998, Underwood et al. 2000).

ADF&G conducted annual M-R studies in the Tanana River since 1995 to estimate the abundance of fall chum salmon bound for the upper river, upstream of the Kantishna River (Cappiello and Bromaghin 1997, Cappiello and Bruden 1997, Hebert and Bruden 1998, Cleary and Bruden 2000). ADF&G also conducts replicate ground surveys of the major fall chum spawning area in the Delta River of the upper Tanana River, allowing for estimates of total spawning abundance to be made annually. Intensive ground surveys are also made annually of the major spawning area in the upper Toklat River, from which total abundance estimates are derived using spawner residence time data collected from the Delta River (Barton 1997). Hydroacoustic assessment of fall chum salmon escapement in the Toklat River was investigated in 1994, 1995, and 1996 (Barton 1997, Barton 1998).

One of the most intensely monitored spawning streams during this period has been the Sheenjek River. Although escapement observations date back to 1960 when the USFWS reported chum salmon spawning in September, the best database consists of the 25-year period 1974-1998. Prior to 1981 escapement observations in the Sheenjek River were limited to aerial surveys flown in late September and early October (Barton 1984a). Subsequent to 1980, escapements were monitored annually using fixed-location, single-beam sonar systems (Barton 1982, 1983, 1984b, 1985, 1986, 1987, 1988, 1994, 1995, 1999). However, an early segment of the fall chum salmon run was not included by sonar counting operations from 1981 through 1990 due to late project startups centered around 25 August. By comparison, average startup during the period 1991 through 1998 was 8 August, more than two weeks earlier than in previous years. However, sonar-estimated escapements for the years 1986 through 1990 were subsequently expanded to include fish passing prior to sonar operations (Barton 1995). Termination of sonar counting was more consistent during the period 1981 through 1998, averaging 25 September. This report presents results of studies conducted in 1999.

Study Area

The Sheenjek River is one of the most important producers of fall chum salmon in the Yukon River. Lying above the Arctic Circle, it heads in the glacial ice fields of the Romanzof Mountains, a northern extension of the Brooks Range, and flows southward approximately 400 km to its terminus on the Porcupine River (Figure 2). Although created by glaciers, the river has numerous clearwater tributaries. Water clarity in the lower river is somewhat unpredictable, but is generally clearest during periods of low water; water level normally begins to drop in late August and September. Upwelling ground water composes a significant proportion of the river flow volume, especially in winter, and it is in these spring areas that fall chum salmon spawn, particularly within the lower 160 km. The sonar project site is located approximately 10 km upstream from the mouth of the river. Annual escapement estimates averaged 83,000 spawners for the period 1986-1993 and approximately 151,000 spawners for the most recent 5-year period of 1994-1998. At present, there is a minimum biological escapement goal (BEG) of 64,000 fall chum salmon established for this river, based upon hydroacoustic assessment of the run during the period approximating 25 August through 25 September (Buklis 1993).

Objectives

Overall objectives for the 1999 Sheenjek River fall chum salmon study were to determine the timing and magnitude of adult salmon escapement and to collect age and sex information on sampled portions of the run. To accomplish these, the following specific objectives were identified:

- Document timing and magnitude of chum salmon escapement using fixed-location, single-beam hydroacoustic techniques,

- Estimate age and sex composition of the spawning population from sampled portions of the escapement using a beach seine as the capture technique, and

- Monitor selected climatological and hydrological parameters daily at the project site for use as baseline data.

METHODS

Hydroacoustic Equipment

A fixed-location, side-looking fisheries hydroacoustic system developed by the Hydrodynamics Division of Bendix Corporation[2] was used to estimate chum salmon abundance in the Sheenjek River in 1999. Fish passage was monitored with a 1985-model transceiver and transducer deployed from a right-bank point bar at the historic sonar site (Figures 3 and 4).

Bendix side-looking transducers have co-axial, circular cross-section narrow (2°) and wide (4°) beam dimensions. Sampling ranges for the narrow and wide beams are each variable to 30 m but designed for optimum performance at 18.3 m and 9.1 m, respectively. The transceiver can be operated on either the narrow or wide beam independently, or by alternating acoustic pulse transmissions between the two beams. In the latter mode (that used on the Sheenjek River) the narrow and wide beams monitor fish passage in the outer and inner halves of the sampling range, respectively.

The transceiver maintains a record of the spatial distribution of fish estimates based upon distance of the acoustic target from the transducer. Fish estimates were tallied and stored into dynamic memory by 16 equal range intervals or sectors. A tape printout showing the number of tallies (counts) by sector was printed each hour. The transceiver was designed such that 24 counts in any one electronic sector in a 35-second period are not necessarily fish. Under such conditions, the system operator is alerted by the presence of a "debris" code appearing on the

[2] Reference to trade names does not imply endorsement by the Alaska Department of Fish and Game.

printout tape next to the suspect counts for the sector and hour in which they occurred. Examples of factors that can result in "debris counts" appearing on printout tapes include passage of debris through the ensonified water column, driving rain, snowfall, misaimed beam toward river bottom or water surface, high density of fish passage, and holding or spawning fish. In addition, a "rock inhibit" feature was designed into this counter to facilitate the system operator in maintaining aim of the acoustic beam as close to the natural bottom substrate as possible.

While other operational characteristics of Bendix hydroacoustic systems and procedures can be found in Bendix Corporation (1978) and Ehrenberg (undated), it should be noted that the 1985-model transceiver used in 1999 was modified after production to allow the system operator to lower the pulse repetition rate to a level that would not have previously been possible. This alteration was to better accommodate relatively slow chum salmon swimming speeds (A. Menin, Hydroacoustic Consulting, Sylmar, California, personal communication). The modification increased the system operator's ability to reduce the degree of positive bias associated with over-counting.

Site Selection and Transducer Deployment

The modular aluminum substrate designed for use with Bendix sonar systems has not been used on the Sheenjek River since 1984, due to the salmon avoidance problems observed in previous years when the substrate was used (Barton 1985). The relatively gentle-sloping river bottom at the historic counting location has accommodated this. A detailed bottom profile was obtained after initial transducer placement at the counting location by stretching a rope across the river and measuring water depth with a pole every 3-m. The transducer was mounted on a pod made of galvanized steel water pipe (Barton 1997) and deployed from the right-bank point bar. The pod was secured in place with sandbags and designed to permit raising and lowering the acoustic beam by using the two riser pipes that extended above the water. Fine adjustments were made with the knurled knobs that attached the transducer plate to the pod. The transducer was deployed in water ranging from approximately 0.5 to 1.0 m in depth. and aimed perpendicular to the current along the natural gravel substrate. An attempt was made to ensure the transducer was deployed at locations where minimum surface water velocities did not fall below approximately 30-45 cm/s.

The system operator used an artificial acoustic target during deployment to ensure transducer aim was low enough to prevent salmon from passing undetected beneath the acoustic beam. The target, an airtight 250 ml weighted plastic bottle, was allowed to drift downstream along the river bottom and through the acoustic beam. Several drifts were made with the target in an attempt to pass it through each electronic sector of the counting range. When the transducer was properly aimed, the target appeared as a vertical deflection (spike) on an oscilloscope screen as it transected the acoustic beam at any given distance. The target may or may not have simultaneously registered a count (or multiple counts) on the sonar counter, depending upon the length of time it remained in the acoustic beam as it drifted downstream along the river bottom.

As in previous years, a fish lead was constructed shoreward from the transducer to prevent upstream salmon passage inshore of the transducer. Fish leads were constructed using 5 cm x 5 cm by 1.2-m high Tuflink-brand fencing and 2.5 m metal "T" stakes. Leads were constructed so as to include the nearfield "dead range" of the sonar transducer. Whenever a transducer was relocated because of rising or falling water level, the inshore lead was shortened or lengthened as appropriate, and the artificial target used to ensure proper re-aiming. A 5-m aluminum counting tower was also deployed near the transducer to facilitate visual and electronic calibrations when water conditions permitted.

Sonar Calibrations and Count Adjustments

Daily comparisons (termed calibrations) were made between oscilloscope observations and automated counter output to determine if the number of fish registered by the sonar counter equaled the number of fish observed passing through the acoustic beam. A minimum of six, 15- to 30-minute calibrations were initially targeted each day within the following time periods: 0001-0100 hours; 0300-0400 hours; 0600-0700 hours; 1100-1200 hours; 1600-1700 hours; and 2100-2200 hours. Duration of calibrations was based upon the following criteria: 1) stop calibration at 15 minutes if less than 10 fish are observed; and, 2) extend 15-minute calibration to 30 minutes if 10 or more fish are observed in the first 15 minutes.

Calibration results were used to adjust automated passage estimates on a daily basis for positive or negative bias. Adjustment periods were defined by the time between individual calibrations. An associated adjustment factor (A), specific to each adjustment period (i) was calculated as follows:

$$A_i = \frac{OC}{SC} \quad (1)$$

where:

OC = oscilloscope count; and,
SC = sonar count.

Unadjusted hourly sonar passage estimates were multiplied by adjustment factors for each hour within the associated adjustment period. The resulting corrected hourly sonar estimates were summed, yielding the estimated daily passage ($\hat{D}$) of fall chum salmon, and is calculated as

$$\hat{D} = \sum \left(A_i SC_i \right) \quad (2)$$

Sonar counts caused by fish other than salmon were assumed to be insignificant based upon historic test fishing records collected at the site. Counts identified as "debris" on printout tapes were deleted and replaced by linearly interpolated values prior to making adjustments. Linear interpolation was also used to estimate missing sector counts as a result of occasional printer malfunctions. Interpolated values for a given electronic sector were based upon registered counts for that sector in the preceding and following hour. Missing hourly blocks for a given day, resulting from powering down the sonar counter to relocate the transducer or operations-tent as a result of changes in water level, were estimated by extrapolation using seasonal average hourly passage rates from days when sonar functioned 24 hours.

Adjustments to the pulse repetition rate (PRR) or ping rate of the sonar counter were made to minimize over-counting (positive bias) or under-counting (negative bias). Over- or under-counting primarily results from changes in salmon swimming speeds that may be related to fluctuations in water level and velocity, photoperiod, or fish densities (Barton 1985, 1986, 1987, 1995). Although a few occasions arose when the ping rate was subjectively changed based upon a qualitative evaluation of fish passage rates, the ping rate was generally changed at the end of any calibration when the oscilloscope count exceeded 59 per hour and differed by more than 15% from the sonar count. The new ping rate was calculated as the sonar count divided by oscilloscope count, times the current PRR setting. If passage rates during calibrations on any given day never exceeded 59 fish per hour, the ping rate was changed at 2400 hours of that particular day. However, this change was made only if the sum of sonar counts during all of the day's calibrations differed from the sum of oscilloscope counts from all calibrations by more than 15%. Otherwise, the dial setting was left unchanged.

Test Fishing and Salmon Sampling

Region-wide standards have been set for the sample size needed to describe the age composition of a salmon population. These apply to the time period or stratum in which the sample is collected. Sample size goals are based on a one-in-ten chance (precision) of not having the true age proportion (pi) within the interval pi ± 0.05 for all i ages (accuracy).

Based upon age determination from scales, it has been established that a sample size of 160 fish per stratum is needed for chum salmon assuming two major age classes with minor ages pooled, and no unreadable scales. Since the preferred method of aging Yukon River fall chum salmon when in close proximity to their natal streams is from vertebrae collections, and allowing for 20% unreadable vertebrae, the Sheenjek River sample size goal was to sample approximately 30-35 chum salmon per week up to a maximum of 200.

An adult salmon beach seine was periodically fished at different locations between the sonar site and approximately 10-12 km upstream to collect adult salmon for age and sex composition. The beach seine (3-inch stretch measure) was 30 m in length by 55 meshes deep (~3 m). The seine was dyed green, constructed of #18 twine, possessed 3x5-inch high-density, non-grommet oval poly floats spaced approximately 45 cm apart, had a 115-120 lb lead line and 1/2 in (1.3 cm) float line.

Climatological and Hydrological Observations

A water level gauge was installed at the sonar site and monitored daily with readings made to the nearest centimeter. Instantaneous surface water temperature was measured daily with a pocket thermometer. Minimum and maximum air temperatures, maximum wind chill factor, and wind velocity and direction were measured daily with a Weather Wizard III weather station. Other daily observations included recording the occurrence of precipitation and estimating percent cloud cover. Climatological observations were recorded at approximately 1800 hours daily.

RESULTS

River and Sonar Counting Conditions

Location of transducer deployment in 1999 approximated the same place on the point bar used in most previous years. River bottom at the counting location sloped gently from the convex bank (right-bank, point bar) at a rate of approximately 4.3 cm/m (bottom slope ≈ 4%) to the shelf-break that lay approximately two-thirds of the way across the channel on 12 August (Figure 5). River width measured 84 m and much of the nearshore zone along the concave, left cutbank was cluttered with fallen trees and other woody vegetation.

With respect to when the water gauge was first installed on 10 August, water level remained fairly high at the project site in 1999, with the highest level recorded on 26 August (Figure 6 and Appendix A). Although four rises and declines in water level were observed at the site through mid-September, it was not until 19 September that water had fallen to a level equal to that observed on 10 August. Overall, between 10 August and 23 September minimum and maximum water level differed by 121 cm.

Fluctuations in water level affected placement of the transducer with respect to shore, and in turn the proportion of the river ensonified. While no attempt was made to estimate fish passage beyond the counting range, an expansion of sonar counts by extrapolation was made to estimate fish passage for hours when raw data were missing as a result of powering down the sonar counter to facilitate repositioning the transducer in response to changes in water level. The average unensonified river zone in 1999 measured from the cutbank approximated 36 m, ranging from a maximum of 52 m on 26 August to a minimum of 15 m when sonar operations ended on 23 September.

Water temperature at the project site ranged from 7 to 12°C based upon instantaneous surface measurements, and averaged 8.5°C subsequent to mid-August 1999 (see Appendices A).

Abundance Estimation

The 1999 sonar-estimated escapement was 14,229 chum salmon for the 44-d period 10 August through 23 September (Table 2 and Appendix B). During the period of operation, sonar counts were adjusted daily for positive or negative bias based upon oscilloscope calibrations. A total of 206 calibrations averaging 20 minutes in duration were made (Appendix C). This approximated 68 hours or approximately 6% of the total number of hours the sonar counter was functional. Calibrations were weighted to periods of the day when upstream migration was heaviest (Figure 7). For example, an average of 35% of the calibrations were made between 0001 and 0600 hours, corresponding to an average daily fish passage estimate of 40% for the same block of time. Similarly, an average of 14% of the calibrations were made between 1200 and 1800 hours, corresponding to an average daily fish passage estimate of 12% for that period of time.

Temporal and Spatial Distribution

Very few chum salmon were present in the river when sonar counting was initiated on 10 August, as evidenced by only 32 fish estimated passing. Although passage estimates of chum salmon remained low throughout the entire season in 1999, never reaching 800 fish per day, the entry pattern appeared to be weakly bimodal in nature (Figure 8). Passage remained below 100 fish per day through 17 August, and less than 300 fish per day through 24 August. The first mode in passage was observed from 25 to 29 August when 20% of the run was estimated passing the project site (averaging 570 fish per day). Passage dropped to near 200 fish per day during the following week. A second mode was observed from 6 through 13 September when 30% of the run passed. The average passage rate during this period approximated 530 fish per day, falling to less than 390 fish per day for remainder of the season. The central half of the run was observed from 27 August through 14 September, with the median day of passage occurring on 8 September. An estimated 436 chum salmon passed the project site on 23 September, the final day of sonar sampling. Factors affecting termination of sonar counting in 1999 included low fish passage rates, logistics associated with closing down camp, and budgetary constraints.

The diel pattern in migration of Sheenjek River chum salmon typically observed in most years was again manifest in 1999 (Figure 9 and see Appendix B). Upstream migration was heaviest in periods of darkness or suppressed light, with fish moving in greater numbers close to shore. On average, the period of greatest upstream migration occurred between 2100 hours and 0700 hours the following day (66%). With ensuing hours of daylight, upstream migration lessened and fish moved farther from shore. The period of least movement in 1999 occurred between approximately 1100 and 2100 hours (<20%).

For the most part, migrating chum salmon were shore-oriented, passing through the nearshore sectors of the acoustic beam. Although a bimodal pattern was manifest in the spatial distribution of sonar counts, approximately 91% of the fish counted were estimated passing through the first 11 electronic sectors, or within ~20 m of the transducer (Figure 10). Less than 1% was observed in the outer-most sector. Approximately 37% of the counts occurred in the first 3 sectors and 42% in the middle sectors (7 through 11). The bimodal nature in spatial distribution of fish across the acoustic sampling range can be partially explained by a shift in fish movement away from shore during daylight hours. This is illustrated in Figure 11 that shows the hourly movement of fish past the sonar site on the peak passage day of 8 September. In addition, increased movement of fish through the middle and outer sectors of the acoustic sampling range is often seen during periods of higher water when less of the river is ensonified.

Age and Sex Composition

Estimation of salmon abundance received the highest priority at the Sheenjek River project site. Although an attempt was made to collect age and sex composition in 1999, no salmon samples were obtained from beach seining due to the extremely weak chum salmon run.

DISCUSSION

The 1999 sonar-estimated escapement of chum salmon in the Sheenjek River is considered conservative because it does not include fish that passed the site before or after sonar sampling, nor does it include fish that passed beyond the range of the acoustic beam, including along the unensonified far bank. Drift gillnetting results during the period 1981-1983 at the historic sonar sampling site demonstrated that distribution of upstream migrant chum salmon was primarily confined to the right side of the river, with only a small (but unknown) proportion passing beyond the sonar counting range (Barton 1982, 1983, 1984b). Barton (1985) further concluded from investigations in 1984 that although dispersed throughout the river well below the sonar site, upstream-migrant chum salmon orient toward the right bank before reaching the sonar sampling location due to physical and hydrologic conditions of the river. While no attempt was made to estimate fish passage in the unensonified river zone in 1999, it is believed to have been comparatively small based upon a review of the spatial distribution of fish by electronic sector.

Although sonar has been used to monitor chum salmon escapements in the Sheenjek River since 1981, only since 1991 have estimates been obtained for comparable time periods i.e., for the period approximating 8 August through 25 September (Barton 1999). However, Barton (1995) used run timing data collected from the nearby Chandalar River to expand Sheenjek River run size estimates for the years 1986-1988 and 1990 to a comparable time period, while the 1989 estimate was expanded based upon aerial survey observations made prior to sonar operations in that year (Appendix D). Based upon average run timing data for 1986-1998, approximately 85% of the Sheenjek River fall chum salmon run (through the end of September) materializes subsequent to 24 August, with the central half of the run passing from 31 August through 17 September (Appendix E). The historical median day of passage is 8 September. Thus, timing of the 1999 run was judged to be average, with the median day of passage in 1999 corresponding to that of the historical average.

While it is believed to be small, an unknown portion of the Sheenjek River fall chum salmon run in 1999 passed the sonar site subsequent to sonar counting. Historical run timing data for 1986-1998 suggests that approximately 5% of the run (through the end of September) passes subsequent to 23 September.

Barton (1995) pointed out that sonar-estimated escapements in the Sheenjek River should be viewed in context with dates of project operation (Table 3), and that the current BEG be considered a minimum-desired number of chum salmon passing the sonar site subsequent to 25 August. The escapement estimate in 1999 approximated only 14,200 chum salmon for the 44-d period 10 August through 23 September, 78% below the minimum escapement goal of 64,000 chum salmon. The estimated escapement subsequent to 25 August was approximately 11,700 chum salmon or 83% of the total. This is the lowest escapement observed to this river since inception of sonar counting operations in 1981 (Figure 12), and considered a total run failure given the major parent year escapement levels of 150,600 in 1994 (returning age-5 fish) and 241,900 in 1995 (returning age-4 fish) (Figure 13).

The poor 1999 Sheenjek River escapement estimate was consistent with escapement trends for other upper Yukon River areas. Escapement in the Chandalar River was estimated at 88,700 chum salmon for the 50-d period of 8 August through 26 September, with run timing characteristics similar to those observed in the Sheenjek River (D. Daum, USFWS, Fairbanks, personal communication). The run was bimodal with the median day of passage recorded on 3 September, five days earlier than the Sheenjek River. The central half of the run was observed between 25 August and 10 September. While the estimated escapement in 1999 (using split beam sonar) was 17% higher than the 1998 estimate (75,800 fish), it is 67% below the 1995-1997 average of 229,700 chum salmon; the only other years when split beam sonar was used. No fall chum salmon escapement goal has been established for the Chandalar River.

Low numbers of returning fish were also reported in the Canadian portion of the Yukon River drainage in 1999. In the Fishing Branch River only 12,900 chum salmon passed the DFO weir during the 41-day period of 1 September through 11 October (JTC 1999). Similar to the Sheenjek River, this was the lowest escapement on record and 74% below the minimum escapement goal of 50,000 fish. The 1999 estimate of spawning escapement for Canadian upper Yukon River fall chum salmon was 65,900 fish, 18% below the minimum escapement goal of 80,000 chum salmon.

Nineteen ninety-nine marked the third consecutive year characterized by very low salmon runs to some western Alaska river systems. While exact reasons for the region-wide failure are unknown, it has been speculated that it is likely an artifact of poor marine survival resulting from or accentuated by localized weather conditions in the Bering Sea (Kruse 1998). The weak salmon runs to Western Alaska have been attributed to reduced productivity (i.e., returns per spawner), and not the result of low levels of parental escapement. Like 1998, this was again exemplified in the 1999 run of Yukon River fall chum salmon. The magnitude and distribution of escapements in 1995, the major parent year contributing to the 1999 run, was among the best on record. However, total run size in 1999 was estimated to have materialized at less than half (only 44%) of what was expected given normal productivity (Bergstrom et al. *In Print*).

Timely reporting of daily passage estimates at the Sheenjek River project site corroborated other in-season indicators that the 1999 fall chum salmon run was weak. Only one fall chum salmon

BEG was achieved throughout the drainage in 1999 (Delta River in the upper Tanana River), while escapements in the Sheenjek, Toklat and Fishing Branch Rivers were among the poorest on record.

LITERATURE CITED

Barton, L.H. 1982. Enumeration of fall chum salmon by side-scanning sonar in the Sheenjek River in 1981. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Yukon Salmon Escapement Report No. 13, Fairbanks.

Barton, L.H. 1983. Enumeration of fall chum salmon by side-scanning sonar in the Sheenjek River in 1982. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Yukon Salmon Escapement Report No. 19, Fairbanks.

Barton, L.H. 1984a. A catalog of Yukon River salmon spawning escapement surveys. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report No. 121, Juneau.

Barton, L.H. 1984b. Enumeration of fall chum salmon by side-scanning sonar in the Sheenjek River in 1983. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Yukon Salmon Escapement Report No. 22, Fairbanks.

Barton, L.H. 1985. Enumeration of fall chum salmon by side-scanning sonar in the Sheenjek River in 1984. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Yukon Salmon Escapement Report No. 25, Fairbanks.

Barton, L.H. 1986. Enumeration of fall chum salmon by side-scanning sonar in the Sheenjek River in 1985. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Yukon Salmon Escapement Report No. 28, Fairbanks.

Barton, L.H. 1987. Sheenjek River salmon escapement enumeration, 1986. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Yukon Salmon Escapement Report No. 33, Fairbanks.

Barton, L.H. 1988. Sheenjek River salmon escapement enumeration in 1987. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Informational Report No. 3F88-15, Fairbanks.

Barton, L.H. 1994. Sonar enumeration of fall chum salmon on the Sheenjek River, 1993. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, AYK Region, Regional Information Report No. 4A94-24, Anchorage.

Barton, L.H. 1995. Sonar enumeration of fall chum salmon on the Sheenjek River, 1988-1992. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Technical Fishery Report 95-06, Juneau.

Barton, L.H. 1997. Sonar escapement assessment in the Toklat River, 1994. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, AYK Region, Regional Information Report No. 3A97-35, Anchorage.

Barton, L.H. 1998. Sonar escapement assessment in the Toklat River, 1995 and 1996. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, AYK Region, Regional Information Report No. 3A98-22, Anchorage.

Barton, L.H. 1999. Sonar estimation of fall chum salmon abundance in the Sheenjek River, 1994-1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A99-28, Anchorage.

Bendix Corporation. 1978. Installation and operation manual, side-scan salmon counter (1978 model). Electrodynamics Division, Report No. SP-78-017, North Hollywood, California. Prepared for the State of Alaska, Department of Fish and Game, Anchorage.

Bergstrom, D.J. and ten co-authors. *In Print*. Annual management report Yukon Area, 1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Information Report No. 3A99-26, Anchorage.

Buklis, L.S, 1993. Documentation of Arctic-Yukon-Kuskokwim region salmon escapement goals in effect as of the 1992 fishing season. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A93-03, Anchorage.

Buklis, L.S. and Barton, L.H. 1984. Yukon River fall chum salmon biology and stock status. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet No. 239, Juneau.

Cappiello, T.A. and J.F. Bromaghin. 1997. Mark-recapture abundance estimate of fall-run chum salmon in the upper Tanana River, Alaska, 1995. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Alaska Fishery Research Bulletin, 4(1):12-35.

Cappiello, T.A. and D.L. Bruden. 1997. Mark-recapture abundance estimate of fall-run chum salmon in the upper Tanana River, Alaska, 1996. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, AYK Region, Regional Information Report No. 3A97-37, Anchorage.

Cleary, P.M. and D.L. Bruden. 2000. Estimation of fall chum salmon abundance on the upper Tanana River using mark recapture techniques, 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Information Report No. 3A00-03, Anchorage.

Daum, D.W., R.C. Simmons, and K.D. Troyer. 1992. Sonar enumeration of fall chum salmon on the Chandalar River, 1986-1990. U.S. Fish and Wildlife Service, Fishery Resource Office, Alaska Fisheries Technical Report No.16, Fairbanks.

Daum, D.W. and B.M. Osborne. 1995. Enumeration of Chandalar River fall chum salmon using split-beam sonar, 1994. U.S. Fish and Wildlife Service, Fishery Resource Office, Alaska Fisheries Progress Report No. 95-4, Fairbanks.

Daum, D.W. and B.M. Osborne. 1996. Enumeration of Chandalar River fall chum salmon using split-beam sonar, 1995. U.S. Fish and Wildlife Service, Fishery Resource Office, Alaska Fisheries Progress Report No. 96-2, Fairbanks.

Daum, D.W. and B.M. Osborne. 1998 Enumeration of Chandalar River fall chum salmon using split-beam sonar, 1997. U.S. Fish and Wildlife Service, Fishery Resource Office, Alaska Fisheries Technical Report No. 47, Fairbanks.

Daum, D.W. and B.M. Osborne. 1999. Enumeration of Chandalar River fall chum salmon using split-beam sonar, 1998. U.S. Fish and Wildlife Service, Fishery Resource Office, Fairbanks.

Ehrenberg, J.E., Ph.D. *Undated*. An evaluation of the acoustic enumeration of upstream salmon in Cook Inlet Rivers in 1989. Prepared for the Trans-Alaska Pipeline Liability Fund.

Gordon, J.A. and three co-authors. 1998. Estimated abundance of adult fall chum salmon in the upper Yukon River, Alaska, 1996. U.S. Fish and Wildlife Service, Fishery Resource Office, Alaska Fisheries Technical Report No. 45, Fairbanks.

Hebert, P.H. and D.L. Bruden. 1998. Mark-recapture population size estimate of fall chum salmon in the upper Tanana River, 1997. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, AYK Region, Regional Information Report No. 3A98-21, Anchorage.

JTC (The Joint United States/Canada Yukon River Technical Committee). 1999. Yukon River salmon review for 1999 and technical committee report. Whitehorse, YT, Canada, 27-29 October.

Kruse, G.H. 1998. Salmon run failures in 1997-1998: A link to anomalous ocean conditions? Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Alaska Fishery Research Bulletin 5(1): 55-63.

Milligan, P.A. and three co-authors. 1984. The distribution and abundance of chum salmon *Oncorhynchus keta* in the upper Yukon River basin as determined by a radio-tagging and spaghetti tagging program: 1982-1983. Department of Fisheries and Oceans, Yukon River Basin Study, Technical Report No. 35, Whitehorse, Yukon.

Osborne, B.M. and D.W. Daum. 1997. Enumeration of Chandalar River fall chum salmon using split-beam sonar, 1996. U.S. Fish and Wildlife Service, Fishery Resource Office, Alaska Fisheries Technical Report No.42, Fairbanks.

Seeb, L.W., P.A. Crane, and R.B. Gates. 1995. Progress report of genetic studies of Pacific Rim chum salmon and preliminary analysis of the 1993 and 1994 South Unimak June fisheries. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report No. 5J95-07, Juneau.

Underwood, T.J. and four co-authors. 2000. Estimated abundance of adult fall chum salmon in the upper Yukon River, Alaska, 1997. U.S. Fish and Wildlife Service, Fishery Resource Office, Alaska Fisheries Technical Report No. 56, Fairbanks.

Wilmot, R.L. and three co-authors. 1992. Genetic stock identification of Yukon River chum and chinook salmon 1987 to 1990. Progress Report, U.S. Fish and Wildlife Service, Anchorage.

Table 1. Alaskan and Canadian total utilization of Yukon River fall chum salmon, 1961–1999 (taken from JTC 1999).

Year	Canada [a]	Alaska [b,c]	Total
1961	9,076	144,233	153,309
1962	9,436	140,401	149,837
1963	27,696	99,031 [d]	126,727
1964	12,187	128,707	140,894
1965	11,789	135,600	147,389
1966	13,192	122,548	135,740
1967	16,961	107,018	123,979
1968	11,633	97,552	109,185
1969	7,776	183,373	191,149
1970	3,711	265,096	268,807
1971	16,911	246,756	263,667
1972	7,532	188,178	195,710
1973	10,135	285,760	295,895
1974	11,646	383,552	395,198
1975	20,600	361,600	382,200
1976	5,200	228,717	233,917
1977	12,479	340,757	353,236
1978	9,566	331,250	340,816
1979	22,084	593,293	615,377
1980	22,218	466,087	488,305
1981	22,281	654,976	677,257
1982	16,091	357,084	373,175
1983	29,490	495,526	525,016
1984	29,267	383,055	412,322
1985	41,265	474,216	515,481
1986	14,543	303,485	318,028
1987	44,480	361,663 [d]	406,143
1988	33,565	319,677	353,242
1989	23,020	518,157	541,177
1990	33,622	316,478	350,100
1991	35,418	403,678	439,096
1992	20,815	128,031 [f]	148,846
1993	14,090	76,925 [d]	91,015
1994	38,008	131,217	169,225
1995	45,600	415,547	461,147
1996	24,354	238,686	263,040
1997	15,580	153,612 [f]	169,192
1998	7,901	62,869 [d]	70,770
1999 [g]	19,574	111,540	131,114 [g]
Average			
1961–89	17,787	300,598	318,385
1990–99	25,496	203,858	229,355
1995–99	22,602	196,451	219,053

[a] Catch in number of salmon. Includes commercial, Aboriginal, domestic and sport catches combined.

[b] Catch in number of salmon. Includes estimated number of salmon harvested for commercial production of salmon roe.

[c] Commercial, subsistence, personal–use and ADF&G test fish catches combined.

[d] Commercial fishery did not operate in Alaskan portion of drainage.

[f] Commercial fishery operated only in District 6 (Tanana River).

[g] Preliminary, (from Bergstrom et al. *In Print*)

Table 2. Sonar-estimated passage of fall chum salmon in the Sheenjek River, 1999.

Date	Number of Salmon		Proportion	
	daily	cum	daily	cum
10-Aug	32	32	0.00	0.00
11-Aug	60	92	0.00	0.01
12-Aug	37	129	0.00	0.01
13-Aug	76	205	0.01	0.01
14-Aug	41	246	0.00	0.02
15-Aug	43	289	0.00	0.02
16-Aug	70	359	0.00	0.03
17-Aug	86	445	0.01	0.03
18-Aug	101	546	0.01	0.04
19-Aug	290	836	0.02	0.06
20-Aug	217	1,053	0.02	0.07
21-Aug	224	1,277	0.02	0.09
22-Aug	59	1,336	0.00	0.09
23-Aug	138	1,474	0.01	0.10
24-Aug	279	1,753	0.02	0.12
25-Aug	730	2,483	0.05	0.17
26-Aug	395	2,878	0.03	0.20
27-Aug	645	3,523	0.05	0.25 [a]
28-Aug	676	4,199	0.05	0.30
29-Aug	410	4,609	0.03	0.32
30-Aug	247	4,856	0.02	0.34
31-Aug	207	5,063	0.01	0.36
01-Sep	115	5,178	0.01	0.36
02-Sep	164	5,342	0.01	0.38
03-Sep	203	5,545	0.01	0.39
04-Sep	327	5,872	0.02	0.41
05-Sep	186	6,058	0.01	0.43
06-Sep	422	6,480	0.03	0.46
07-Sep	416	6,896	0.03	0.48
08-Sep	742	7,638	0.05	0.54 [b]
09-Sep	555	8,193	0.04	0.58
10-Sep	594	8,787	0.04	0.62
11-Sep	514	9,301	0.04	0.65
12-Sep	470	9,771	0.03	0.69
13-Sep	589	10,360	0.04	0.73
14-Sep	343	10,703	0.02	0.75
15-Sep	309	11,012	0.02	0.77
16-Sep	303	11,315	0.02	0.80
17-Sep	430	11,745	0.03	0.83
18-Sep	542	12,287	0.04	0.86
19-Sep	294	12,581	0.02	0.88
20-Sep	290	12,871	0.02	0.90
21-Sep	389	13,260	0.03	0.93
22-Sep	533	13,793	0.04	0.97
23-Sep	436	14,229	0.03	1.00
Total	14,229		1.00	

[a] Single boxed area identifies central half of the run.
[b] Bold box indentifies median day of passage.

Table 3. Operational dates of sonar sampling in the Sheenjek River for the period 1981–1999.

Year	Starting Date	Ending Date	Project Duration	Sonar Estimate	Expanded Estimate
1981	31–Aug	24–Sep	24	74,560	
1982	31–Aug	22–Sep	22	31,421	
1983	29–Aug	24–Sep	26	49,392	
1984	30–Aug	25–Sep	26	27,130	
1985	02–Sep	29–Sep	27	152,768	
1986	17–Aug	24–Sep	38	83,197 [a]	84,207
1987	25–Aug	24–Sep	30	140,086	153,267
1988	21–Aug	27–Sep	37	40,866	45,206
1989	24–Aug	25–Sep	32	79,116	99,116
1990	22–Aug	28–Sep	37	62,200	77,750
1991	09–Aug	24–Sep	46	86,496	
1992	09–Aug	20–Sep	42	78,808	
1993	08–Aug	28–Sep	51	42,922	
1994	07–Aug	28–Sep	52	150,565	
1995	10–Aug	25–Sep	46	241,855	
1996	30–Jul	24–Sep	56	246,889	
1997	09–Aug	23–Sep	45	80,423	
1998	17–Aug	30–Sep	44	33,058	
1999	10–Aug	23–Sep	44	14,229	
Averages:					
1981–85	30–Aug	24–Sep	25	67,054	
1986–90	21–Aug	25–Sep	35	81,093	91,909
1991–99	08–Aug	25–Sep	47	108,361	

[a] The sonar-estimated escapement in these years was subsequently expanded to include fish passing prior to sonar operations (Barton 1995). Expansions for 1986–1988 and 1990 were based upon run timing data collected in the nearby Chandalar River. The 1989 estimate was expanded based upon aerial survey observations made in the Sheenjek River prior to sonar operations in that year.

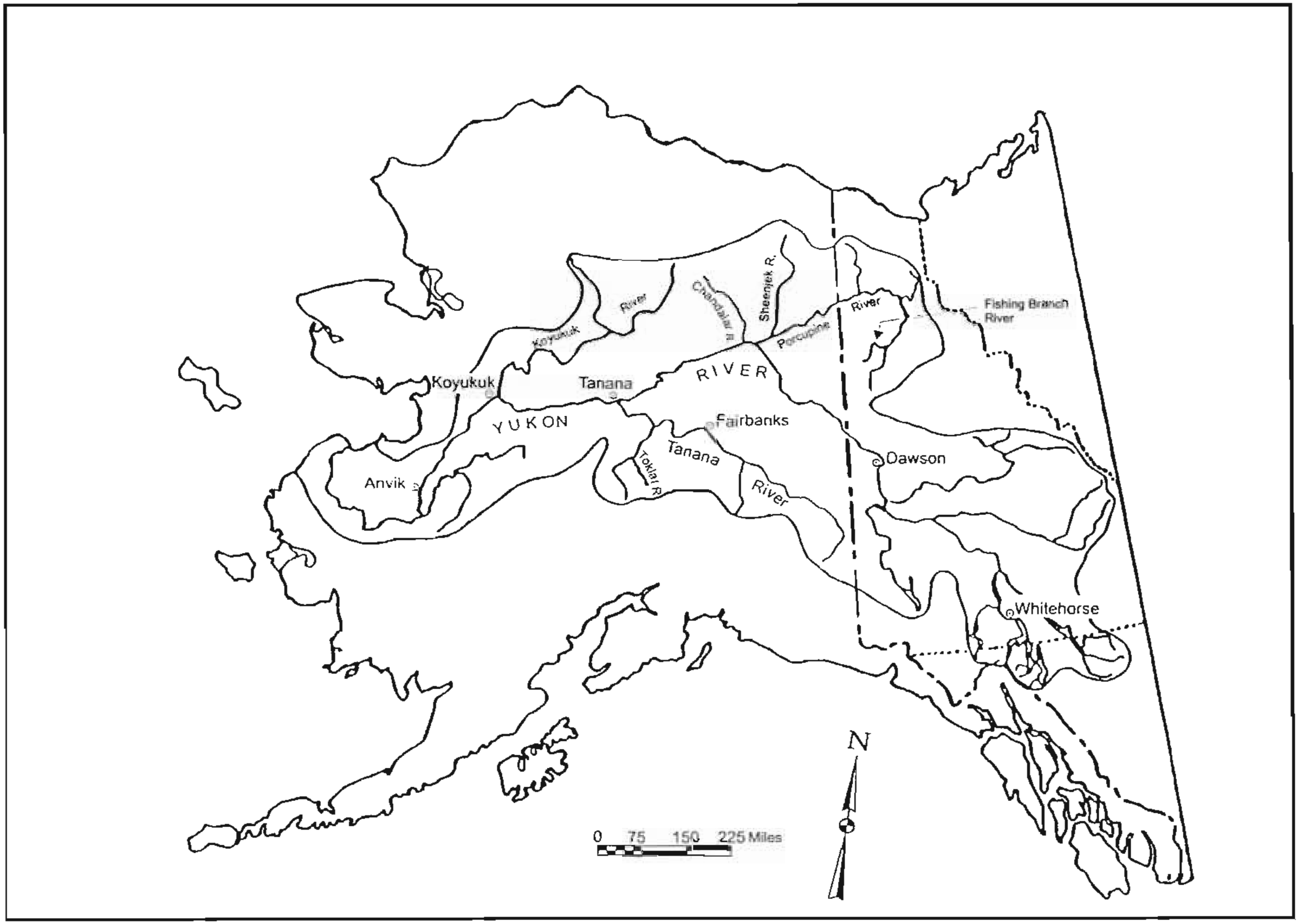


Figure 1. The Yukon River drainage showing selected locations.

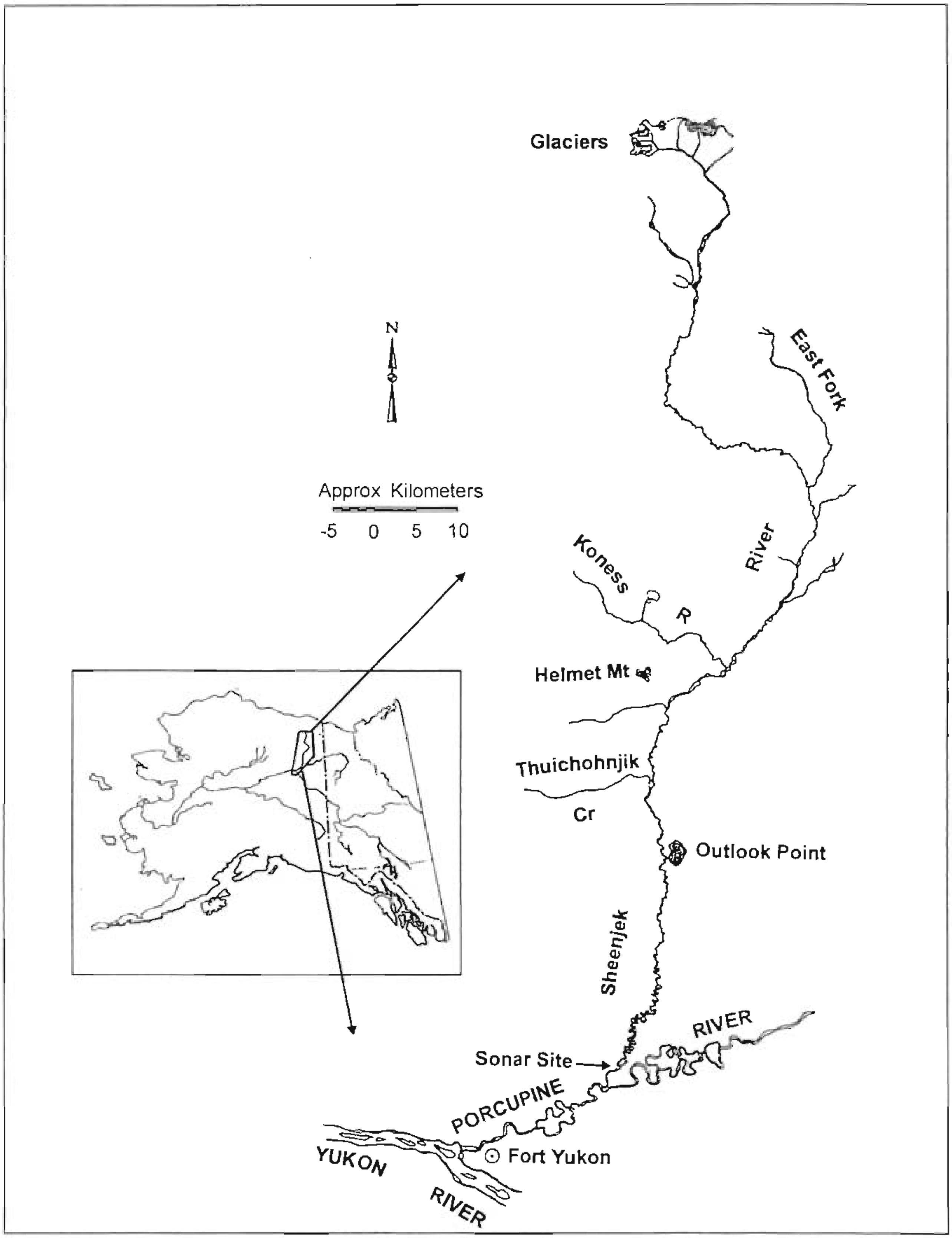


Figure 2. The Sheenjek River drainage.

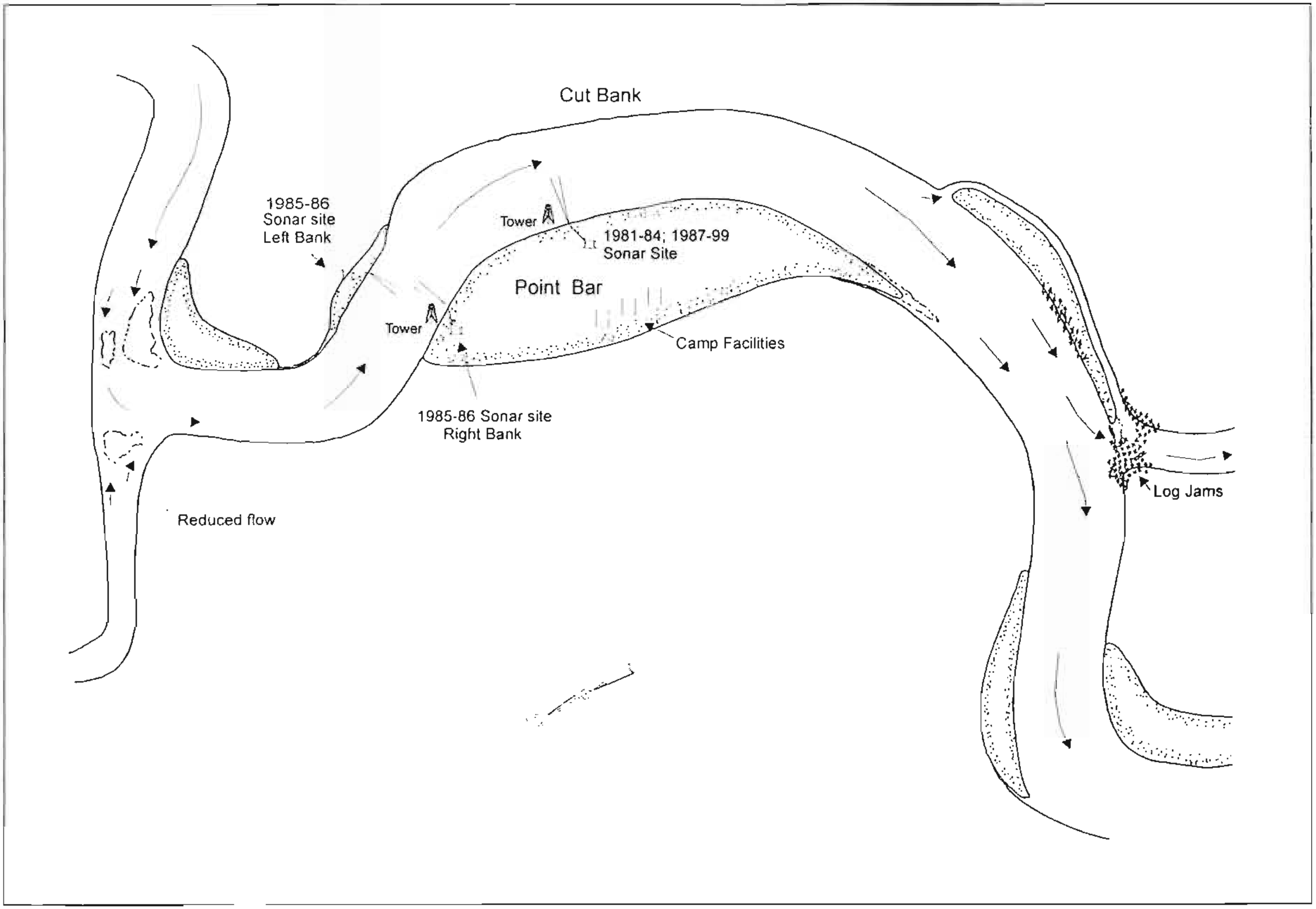
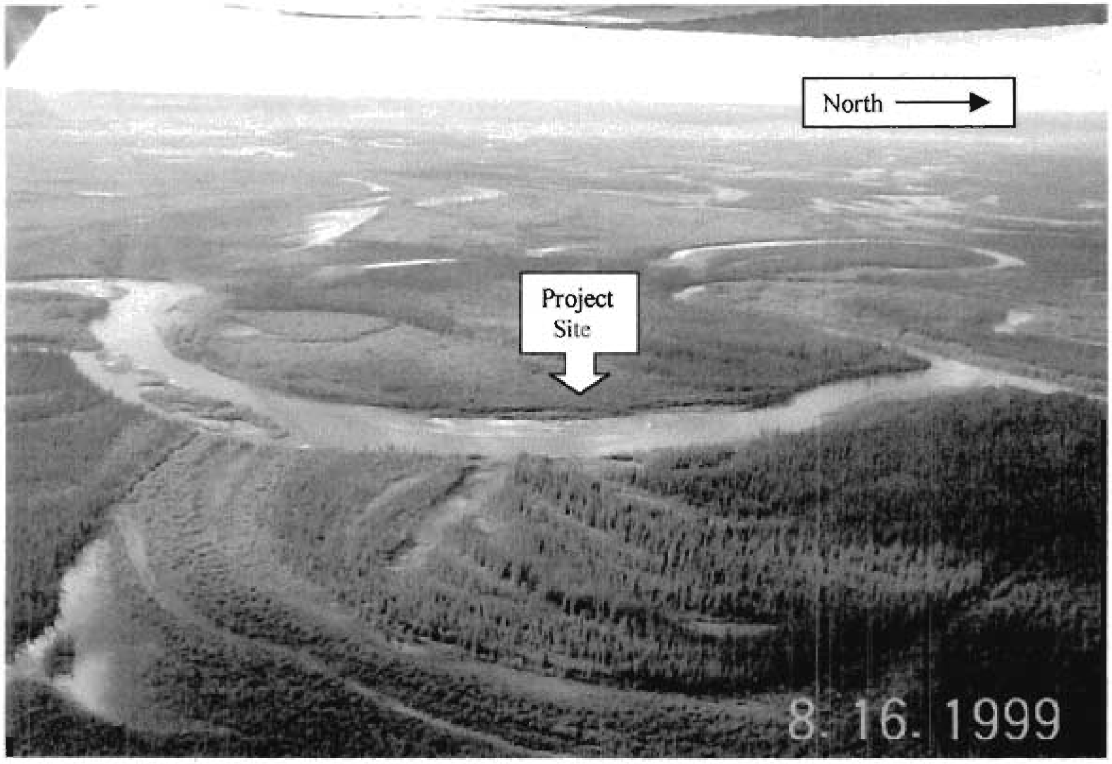


Figure 3. The Sheenjek River sonar project site.



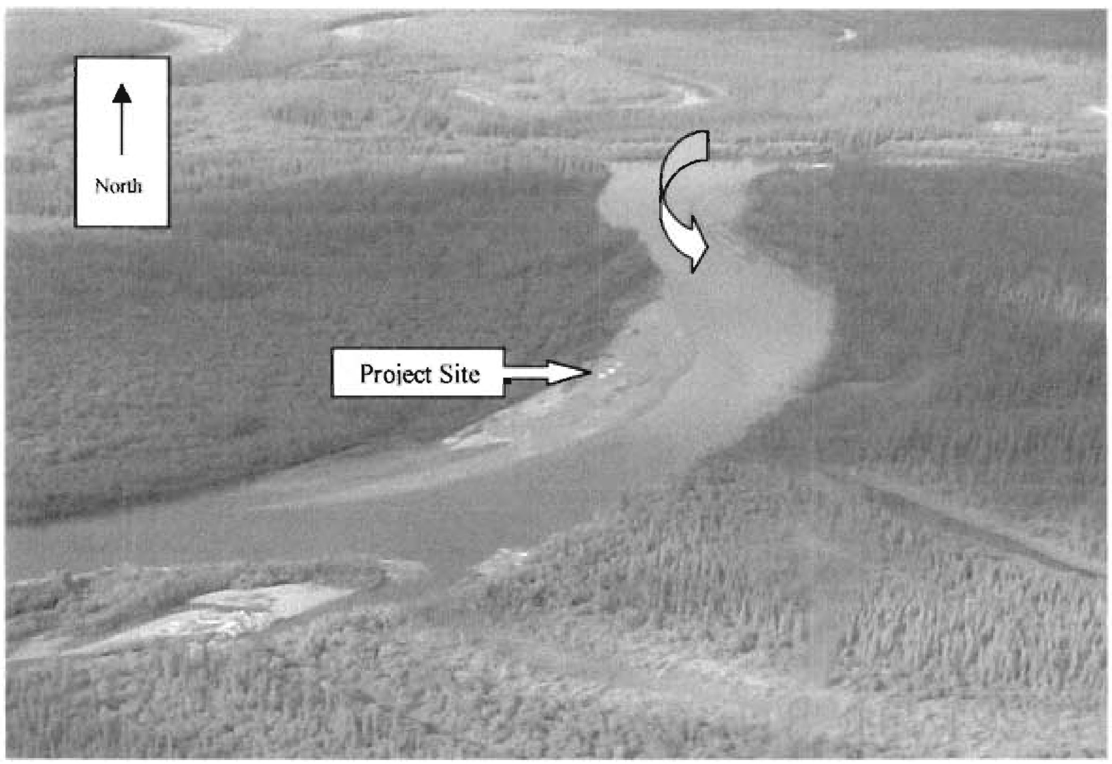


Figure 4. Aerial photographs of the Sheenjek River sonar project site taken 16 August 1999.

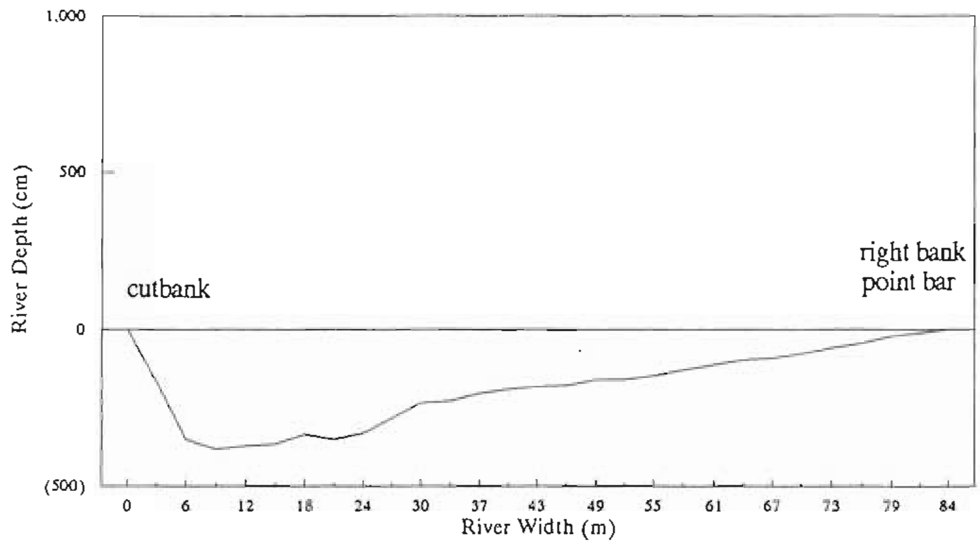


Figure 5. Depth profile (downstream view) made 12 August 1999 at the Sheenjek River sonar project site.

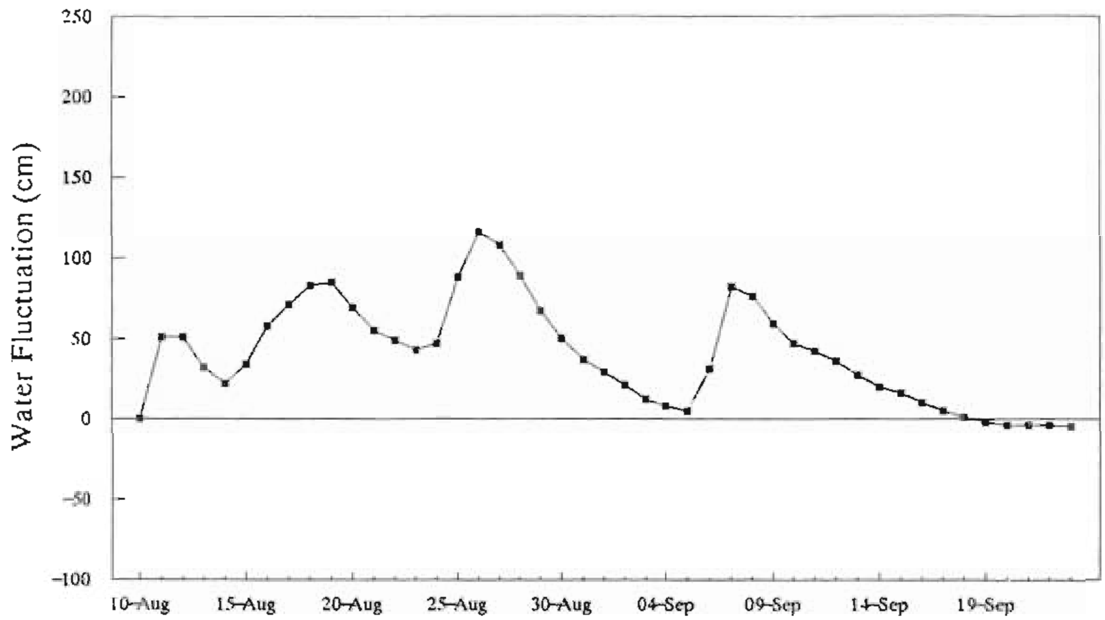


Figure 6. Changes in daily water elevation relative to 10 August measured at the Sheenjek River sonar project site, 1999.

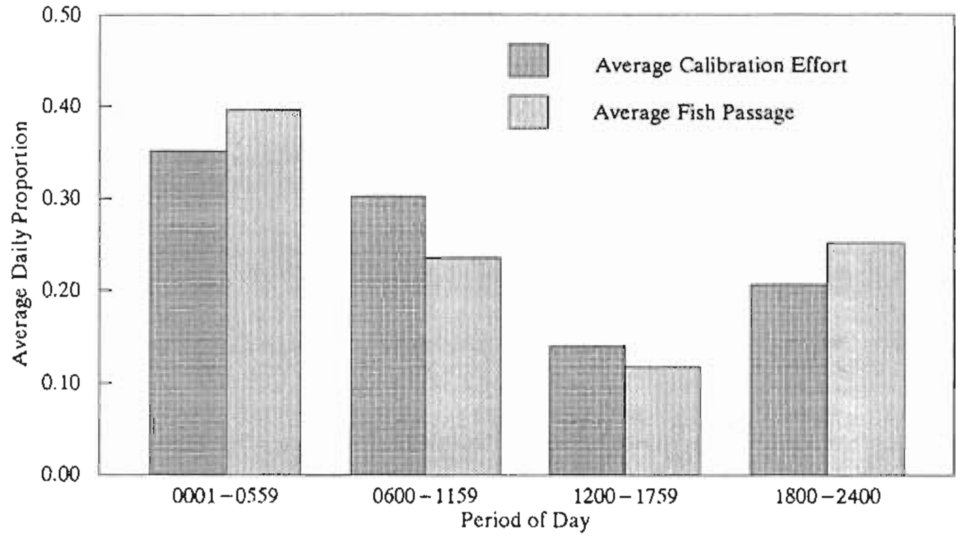


Figure 7. Comparative average sonar calibration effort versus average fish passage in the Sheenjek River, 1999.

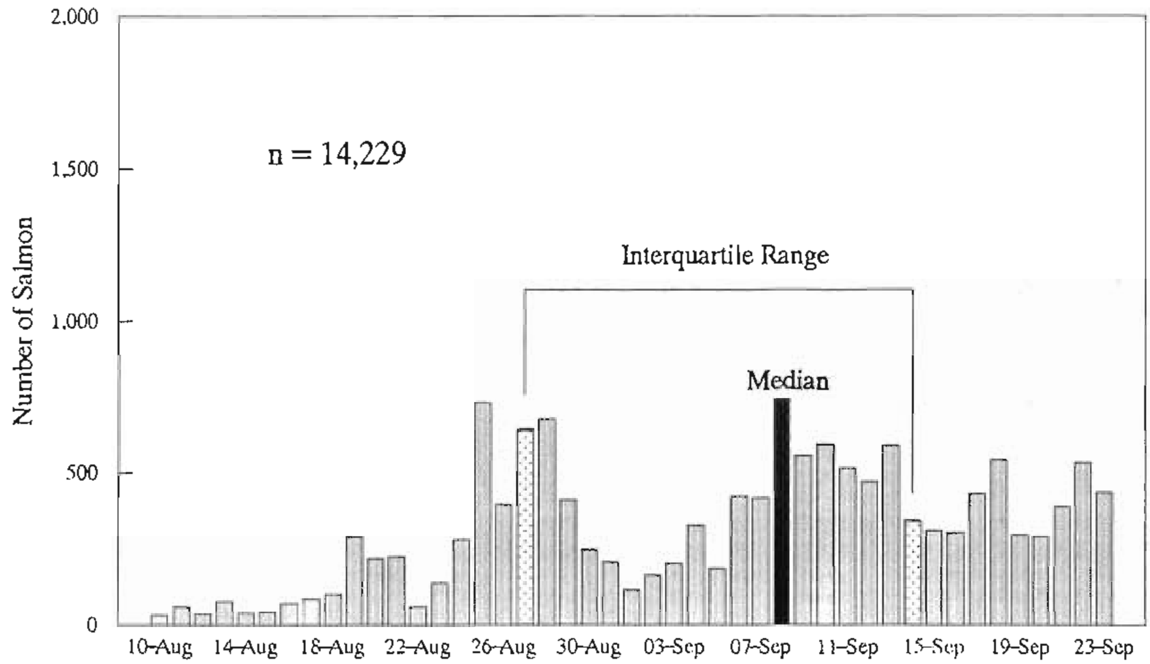


Figure 8. Adjusted sonar counts attributed to fall chum salmon by date, Sheenjek River, 1999.

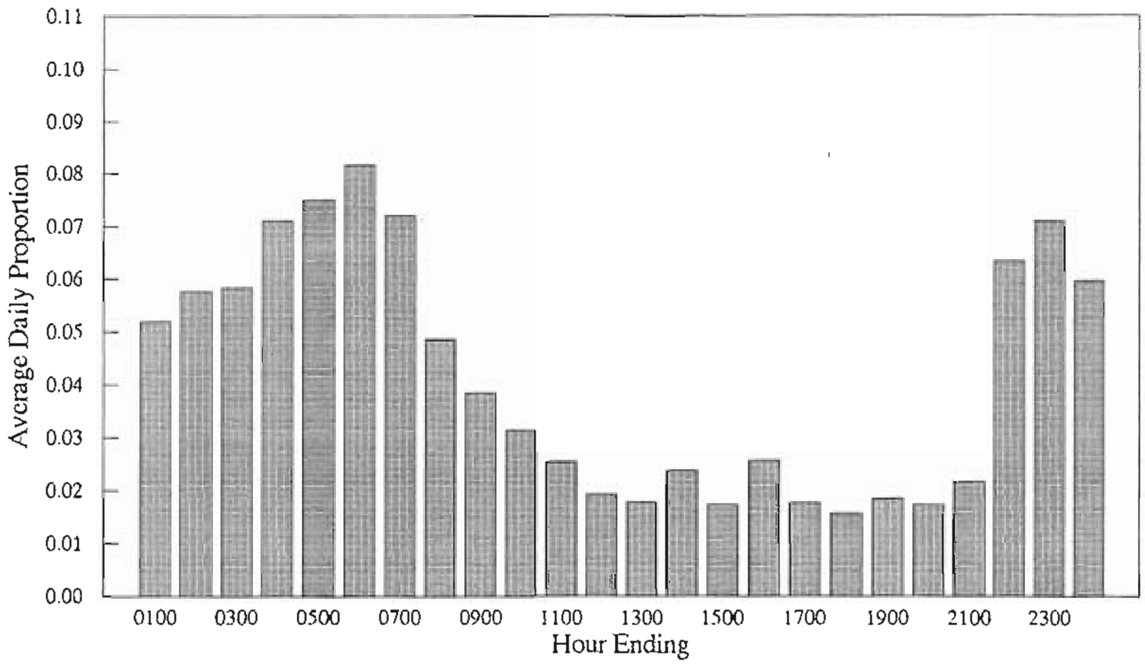


Figure 9. Temporal migration pattern of fall chum salmon observed in the Sheenjek River, 10 August through 23 September 1999.

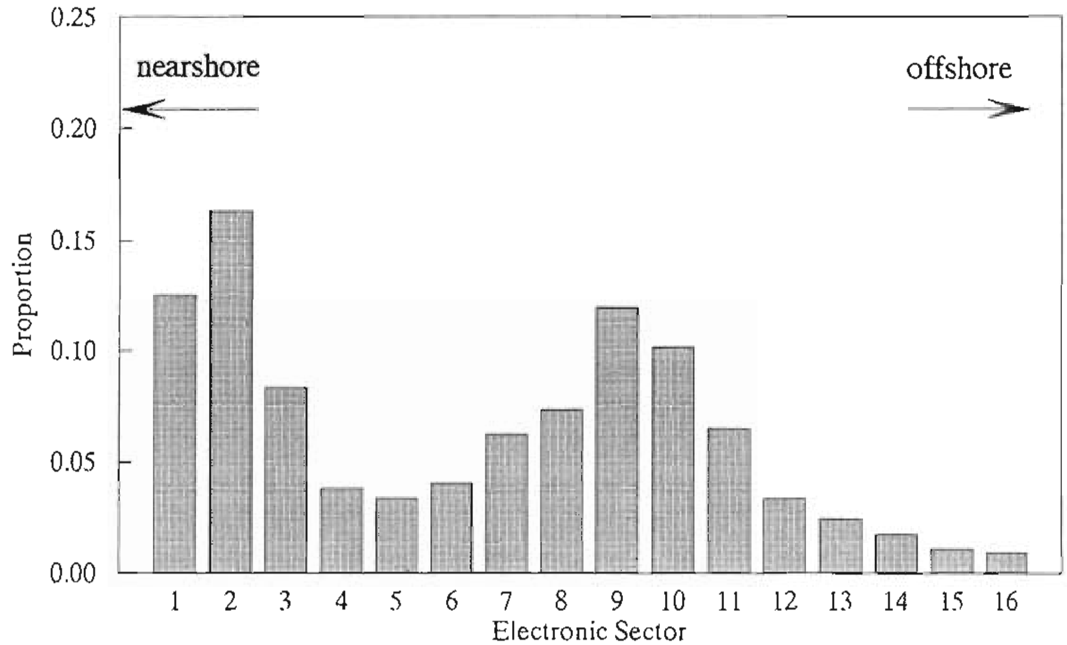


Figure 10. Average distribution of sonar counts by electronic sector attributed to fall chum salmon in the Sheenjek River, 1999.

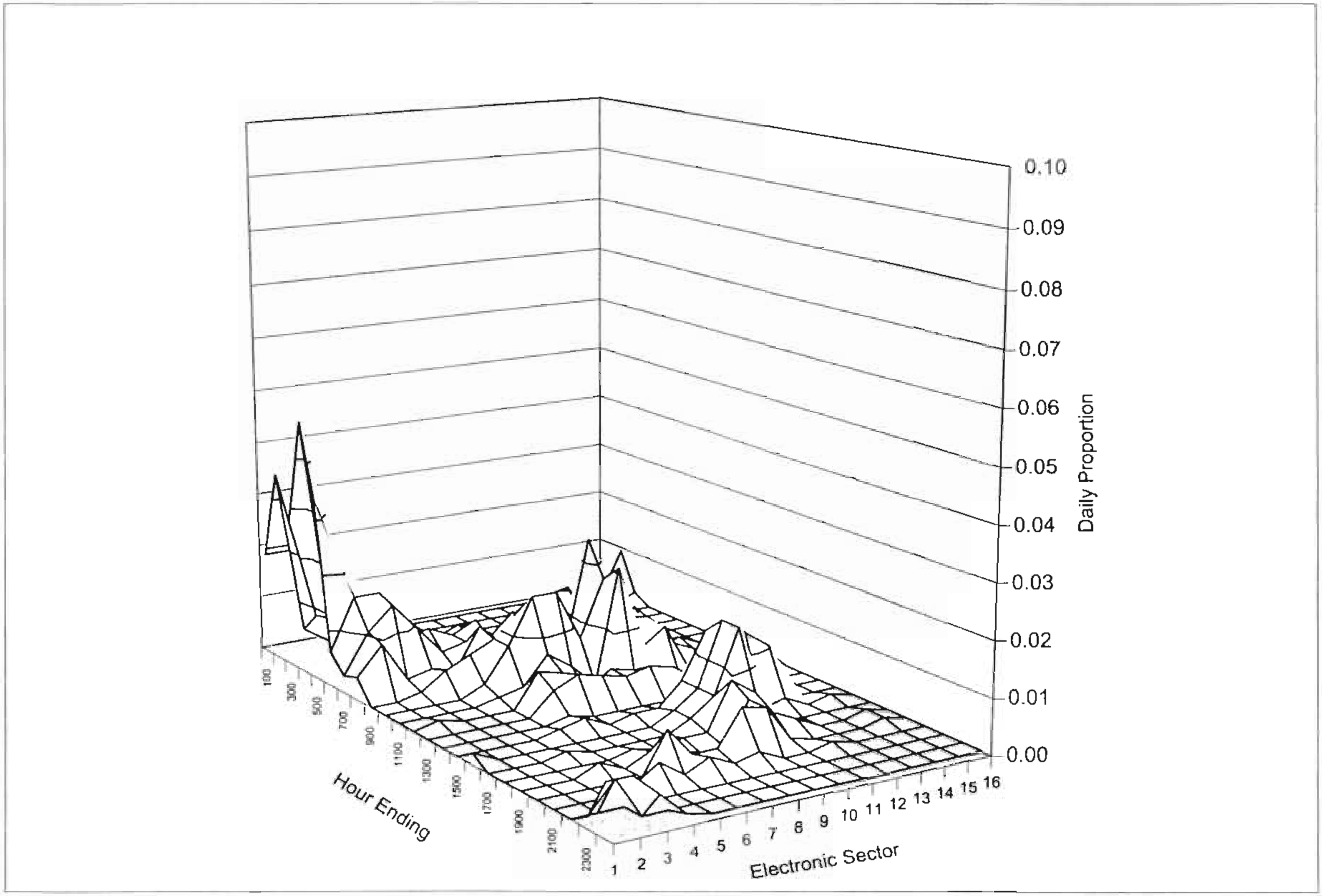


Figure 11. Spatial and temporal distribution of sonar counts attributed to fall chum salmon on 8 September 1999, Sheenjek River.

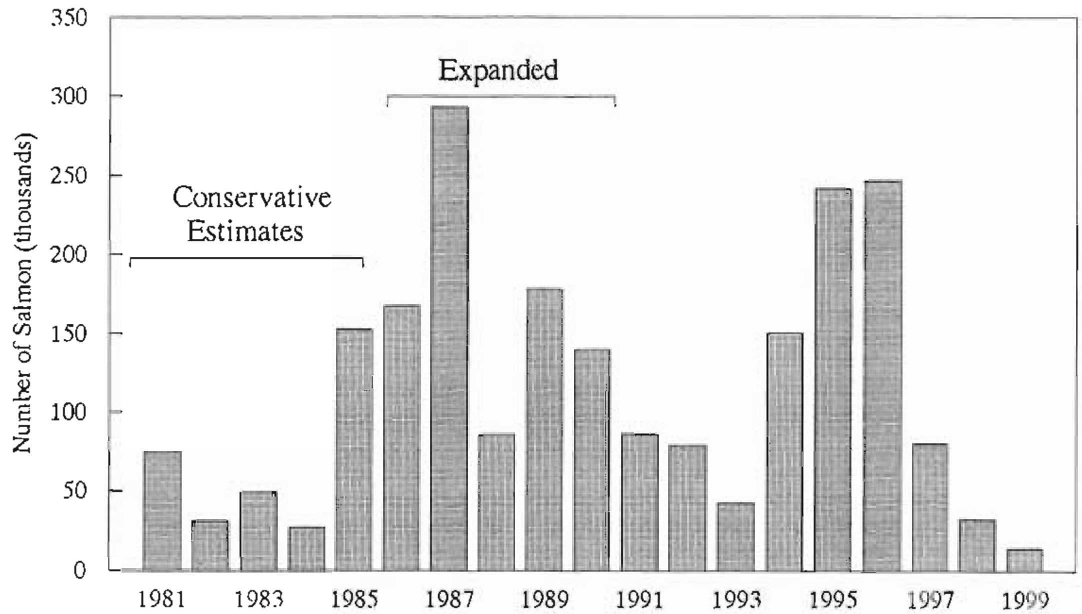
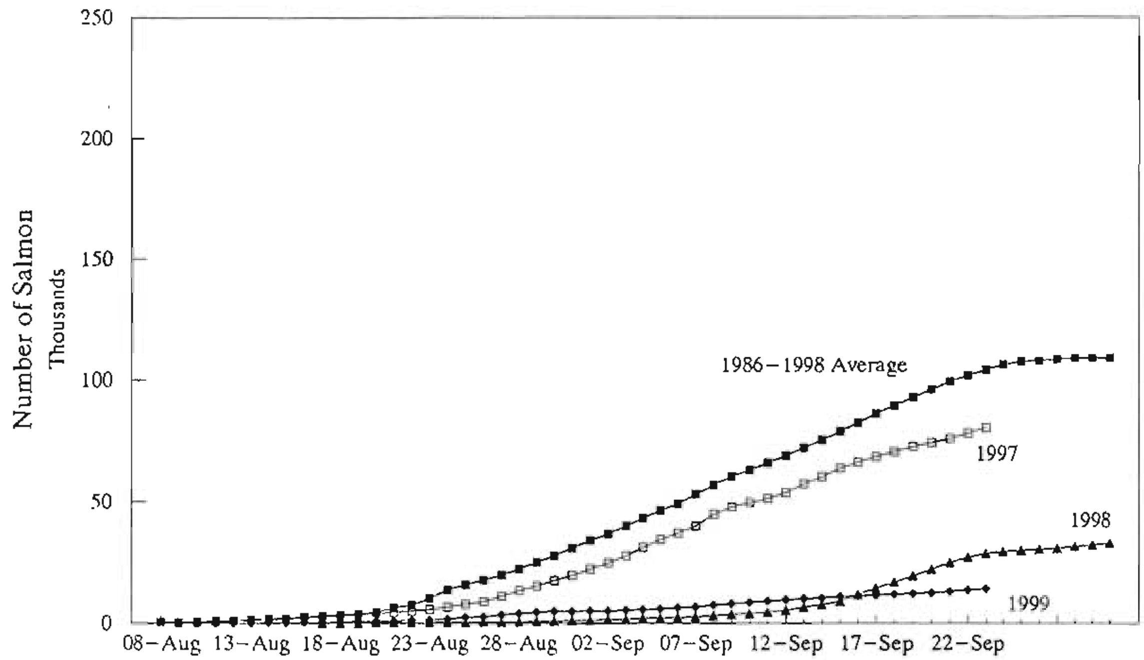


Figure 12. Sonar-estimated escapement of fall chum salmon in the Sheenjek River, 1981–1999.



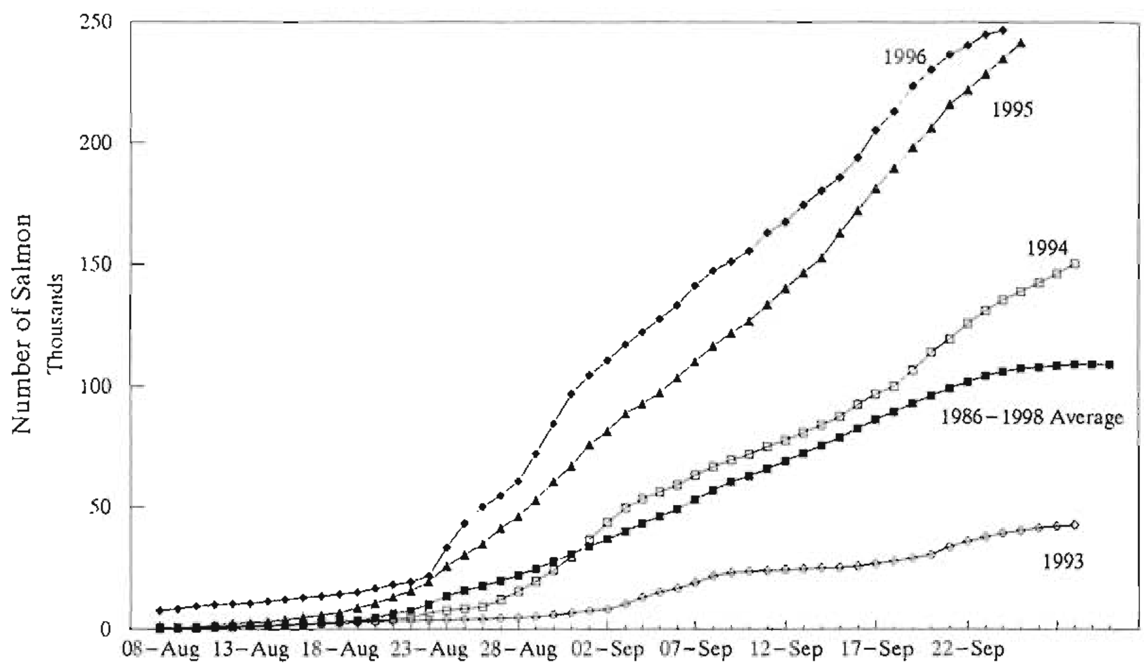


Figure 13. Fall chum salmon cumulative estimated escapement from sonar counts, Sheenjek River, 1997–1999 (top) and 1993–1996 (bottom).

Appendix A. Climatological and hydrological observations and miscellaneous comments made at the Sheenjek River project site, 1999.

Date	Observation Time	Precipitation (code) *	Cloud Cover (code) *	Wind: Current Azimuth and speed (mph)	Wind: Maximum (mph)	Wind: Maximum time	Temperature (C°): Water Surface	Temperature (C°): Air Minimum	Temperature (C°): Air Maximum	Water Level (cm): ± 24 h Change	Water Level (cm): relative to zero datum	Water Color (code) *	Remarks
08–Aug													Water rising; no signs of fish.
09–Aug												B	Removed beaver cuttings from upriver; installed 1985 ctr; few fish – 25 counts 1600–2400 hrs.
10–Aug	1600	A	S	calm	2			13	27	zero datum	0.0	A	Hook up 1985 counter; install fish lead, water gauge and weather station; water rising.
11–Aug	2130	A	S	180°–2	10	1427		12	24	51.0	51.0	B	Very few fish; water crested at midnight.
12–Aug	1900	B–C	O	270°–2	10	1554		13	22	0.0	51.0	C	Made river profile; no fish passing.
13–Aug	2400	B	O	222°–6	14	1440		9	13	–19.0	32.0	C–G	Moved xducer out ~ 6 m; little evidence of salmon passing; light rain last night/off and on today.
14–Aug	1600	A	S	120°–5	14	1110		8	23	–10.0	22.0	B	No signs of fish.
15–Aug	2000	A	S	calm	9	1234		14	27	12.0	34.0	B	Walked gravel bar saw no fish; drove boat up/downstream of camp – not sign of fish.
16–Aug	2230	A	S							24.0	58.0	B	Moved xducer in abot 6 m.
17–Aug	1848	A	S	210°–3	10	1212		7	25	13.0	71.0	B	Water 3–4 m from sonar tent; logs drifting by; still no fish passing.
18–Aug	2305	A	O	calm	13	1417		7	26	12.0	83.0	B	Moved sonar tent back about 12 m; moved xducer in about 4 m; very few fish passing.
19–Aug	1845	B	O	calm	15	1454		17	28	2.0	85.0	B	Had to build fire in woodstove to prevent printer malfunction.
20–Aug	1800	B	O	40°–2	8	1353		8	23	–16.0	69.0	A	Electrical storm in area this evening 2200–2300 hours.
21–Aug	2020	B	B	10°–3	15	1557	12	11	22	–14.0	55.0	A	Moved xducer out 6 m; beached–seined upriver caught no fish; little evidence of salmon in river.
22–Aug	2009	A	S	calm	13	1542	12	6	26	–6.0	49.0	A	Moved xducer out ~ 3 m; walked bar but saw no fish; started on calibration schedule today.
23–Aug	1800	B	S	50°–2	11	1740	12	9	23	–6.0	43.0	A	Place tower in river to look for salmon – no luck; low passage.
24–Aug	1818	B	S	40°–9	28	1713	11	7	14	4.0	47.0	B	Found one dead chum salmon on fish lead; cold and windy day.
25–Aug	1800	A	S	10°–12	21	1329	10	6	18	41.0	88.0	C	Moved xducer in ~ 7 m; windy, drift is being blown toward shore.
26–Aug	2216	A	S		18	1825				28.0	116.0	C	Moved sonar tent back ~ 11–12 m, moved xducer in ~ 10 m, heavy debris load passing.
27–Aug	1956	A	S	calm			9	1	22	–8.0	108.0	B	
28–Aug	1840	B	S	10°–12	24	1145	9	3		–19.0	89.0	B	Moved xducer out about 12 m.
29–Aug	2008	B	S	0°–5	17	1843	8	–5	12	–22.0	67.0	B	
30–Aug	1851	A	S	230°–1	8	2333	8	1	10	–17.0	50.0	A	
31–Aug	2119	A	S	calm	7	1537	8	–1	19	–13.0	37.0	A	Moved xducer out 20 m.
01–Sep	1900	A	S	calm	7	1320	9	–1	23	–8.0	29.0	A	Collected firewood today.
02–Sep	1840	A	S	20°–2	9	1029	9	3	23	–8.0	21.0	A	
03–Sep	1825	B	O	183°–2	15	1727	9	11	15	–9.0	12.0	A	
04–Sep	1808	B	O	221°–4	22	921	9	8	10	–4.0	8.0	A	
05–Sep	2134	A	S	calm	15	1629	9	8	10	–3.0	5.0	A	
06–Sep	1852	A	S	175°–3	10	1350	9	0	20	26.0	31.0	B	Ground riverboat on a gravelbar up river.
07–Sep	1846	A	S	calm	9	809	8	0	15	51.0	82.0	C	Moved xducer in 7 m; reset water gauge.
08–Sep	1732	A	S	1°–6	11	1554	8	–2	18	–6.0	76.0	C	
09–Sep	2400									–17.0	59.0	B	Moved xducer out 11 m.
10–Sep	2400	A	S							–12.0	47.0	B	
11–Sep	1919	A	S	calm	10	1533	7	–1	17	–5.0	42.0	A	Moved water gauge.
12–Sep	1800	A	S	224°–4	16	1533	8	0	21	–6.0	36.0	A	
13–Sep	1819	A	O	17°–12	20	1518	8	1		–9.0	27.0	A	Moved xducer out about 6–7 m.
14–Sep	1938	B	S	21°–2	18	1650	7	4		–7.0	20.0	A	
15–Sep	1727	A	S	25°–6	18	930	7	2	12	–4.0	16.0	A	Bear alarm went off @ 0342 h – saw no intruders (wind?).
16–Sep	1853	A	O	8°–8	13	1734	7	1		–5.0	10.0	A	
17–Sep	2030	B	O	76°–1	15	1233	7	3	18	–5.0	5.0	A	
18–Sep	2050	A	S	calm	17	1226	7	4	22	–4.0	1.0	A	
19–Sep	2045	A	S	calm	8	?	7	–1	18	–3.0	–2.0	A	
20–Sep	1942	A	C	calm	9	1312	7	1	20	–2.0	–4.0	A	
21–Sep	1847	A	S	66°–1	10	1617	7	1	17	0.0	–4.0	A	
22–Sep	1828	B	O	11°–10	23	1243	7	2	1	0.0	–4.0	A	
23–Sep	1452	A	O	211°–2	13	1928	7	5	8	–1.0	–5.0	A	
Average							8.5	5	19				

* Precipitation code for the preceding 24–hr period: A = None; B = Intermittent rain; C = Continuous rain; D = snow and rain mixed; E = light snowfall; F = Continuous snowfall; G = Thunderstorm w/ or w/o precipitation.

* Instanteous cloudcover code: C = Clear and visibility unlimited (CAVU); S = Scattered (<60%); B = Broken (60–90%); O = Overcast (100%); F = Fog or thick haze or smoke.

* Instanteous water color code: A = Clear; B = Slightly murky or glacial; C = Moderately murky or glacial; D = Heavily murky or glacial; E = Brown, tanic acid stain.

Appendix B. Temporal distribution of daily sonar counts attributed to fall chum salmon in Sheenjek River, 1999.

Hour	10-Aug	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug
0100	0	4	2	0	4	2	2	0	3	3	15	6	4	4	16	7	14
0200	0	1	6	0	0	4	5	2	4	6	3	6	8	5	18	13	22
0300	1	11	7	0	0	1	3	4	2	8	4	3	5	5	10	1	22
0400	0	2	0	2	3	3	2	2	2	16	26	8	7	14	20	4	29
0500	1	7	0	0	0	1	2	1	8	15	15	16	2	16	17	9	27
0600	0	[b]	0	7	6	0	2	3	4	23	24	36	5	18	7	[b]	18
0700	0		0	4	0	0	3	4	2	5	3	26	6	7	31	79.7%	17
0800	0		1	0	0	2	4	2	9	15	1	23	2	18	36	148	5
0900	0		1	7	7	5	13	2	7	1	5	35	1	16	25	91	6
1000	0	59.8%	1	2	1	0	3	3	1	14	6	5	1	2	20	26	15
1100	5	24	1	[b]	2	2	0	1	0	24	11	7	2	10	1	77	17
1200	0		1		1	0	0	11	0	4	14	6	0	0	5	58	8
1300	2		0	89.0%	1	0	2	2	1	4	10	3	0	0	10	49	10
1400	0		1	8	3	2	2	3	5	23	16	5	0	5	25	48	11
1500	0		7		4	0	1	1	2	8	2	2	0	0	3	31	14
1600	1		1	0	0	0	15	2	3	5	11	3	0	0	2	26	14
1700	0	2	1	8	6	0	1	8	0	16	6	1	0	1	0	35	14
1800	0	9	0	9	0	0	3	1	5	11	2	19	1	0	0	21	8
1900	0	0	0	4	0	0	0	3	2	30	2	0	0	0	2	27	17
2000	10	0	0	12	0	0	3	6	1	5	13	0	0	9	0	19	13
2100	2	0	2	0	0	0	0	1	4	4	1	0	0	0	0	1	10
2200	4	0	1	10	0	8	0	21	0	13	13	6	1	1	4	2	14
2300	3	0	0	2	0	10	3	1	29	17	9	8	10	2	4	21	17
2400	3	0	4	1	3	3	1	2	7	20	5	0	4	5	21	16	52
	32	60	37	76	41	43	70	86	101	290	217	224	59	138	279	730	395
	0.2%	0.4%	0.3%	0.5%	0.3%	0.3%	0.5%	0.6%	0.7%	2.0%	1.5%	1.6%	0.4%	1.0%	2.0%	5.1%	2.8%

- continued -

[a] Totals include only days with 24 hours counts.
[b] Boxed areas indicate times when passage was estimated by extrapolation, based upon average hourly distribution for days when sonar operated 24 hours.
[c] Total estimated passage, including days with expanded counts.

Appendix B. (p 2 of 3)

Hour	27-Aug	28-Aug	29-Aug	30-Aug	31-Aug	01-Sep	02-Sep	03-Sep	04-Sep	05-Sep	06-Sep	07-Sep	08-Sep	09-Sep	10-Sep	11-Sep	12-Sep
0100	23	23	10	20	7	9	8	8	8	10	26	9	32	19	29	43	19
0200	44	18	19	14	23	1	4	11	16	4	15	7	38	19	34	64	39
0300	44	19	22	6	23	3	2	9	14	16	31	7	48	32	37	37	30
0400	35	20	21	16	15	10	6	10	38	0	27	10	46	42	49	38	24
0500	31	11	22	8	12	9	24	17	18	0	75	18	51	49	50	37	34
0600	58	13	13	9	42	8	30	22	28	12	53	42	69	32	51	37	22
0700	22	21	17	12	25	13	15	19	26	3	26	12	55	50	44	58	67
0800	21	23	17	36	7	2	2	5	39	0	27	18	37	68	45	13	41
0900	14	23	17	2	5	0	4	2	21	0	42	13	48	31	38	14	32
1000	28	38	13	9	9	0	3	9	11	0	3	5	65	11	15	8	7
1100	38	61	5	4	3	4	0	7	11	0	1	13	37	24	9	0	1
1200	39	44	8	0	16	16	0	11	1	0	1	5	16	29	[b]	4	0
1300	25	53	17	0	0	9	0	0	15	1	1	95.8% [b]	25	12	89.6%	4	2
1400	28	36	24	37	0	3	1	17	1	0	1	17	5	4	62	4	0
1500	19	16	33	0	0	8	0	12	6	0	1	44	24	4		2	8
1600	25	22	46	12	3	2	0	0	0	13	1	26	37	14		11	0
1700	10	44	9	21	0	0	1	3	13	5	5	31	22	4	14	2	5
1800	25	45	2	1	3	0	4	3	0	21	1	18	14	18	5	5	5
1900	29	30	8	0	0	0	4	1	1	35	8	20	15	0	6	0	7
2000	10	32	7	6	0	4	2	6	5	8	2	33	22	4	7	0	9
2100	22	91.4% [b]	3	0	0	1	4	2	0	23	17	30	10	3	17	13	7
2200	17	58	58	8	0	6	9	0	0	19	45	19	0	25	20	24	37
2300	18	5	4	21	12	5	23	15	20	8	7	9	7	43	24	42	13
2400	20	21	15	5	2	2	18	14	35	8	4	12	19	18	38	54	41
	645	676	410	247	207	115	164	203	327	166	422	418	742	555	594	514	470
	4.5%	4.8%	2.9%	1.7%	1.5%	0.8%	1 2%	1.4%	2.3%	1.3%	3.0%	2.9%	5.2%	3.9%	4.2%	3.6%	3.3%

– continued –

[a] Totals include only days with 24 hours counts.

[b] Boxed areas indicate times when passage was estimated by extrapolation, based upon average hourly distribution for days when sonar operated 24 hours.

[c] Total estimated passage, including days with expanded counts.

Appendix B. (p 3 of 3)

Hour	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep	21-Sep	22-Sep	23-Sep	Total [a]	Percent
0100	45	26	15	15	34	32	33	28	28	30	39	549	0.052
0200	42	18	14	16	22	35	28	23	23	34	22	609	0.058
0300	30	29	23	12	22	38	17	18	56	53	22	616	0.058
0400	55	19	40	28	22	61	17	22	49	48	22	750	0.071
0500	25	21	12	36	39	54	33	16	16	64	39	792	0.075
0600	54	18	14	22	29	64	43	6	13	38	41	863	0.082
0700	30	37	38	15	18	46	25	27	15	20	27	761	0.072
0800	7	13	14	7	9	2	16	22	4	10	11	514	0.049
0900	10	10	5	0	0	12	1	19	1	13	11	407	0.039
1000	19	1	11	8	0	34	5	0	0	7	16	333	0.032
1100	6	19	7	6	3	5	3	7	0	2	10	269	0.025
1200	0	3	2	0	1	4	2	2	0	0	15	203	0.019
1300	14	1	2	3	0	11	1	0	1	0		188	0.018
1400	6	7	3	0	0	4	3	0		1		250	0.024
1500	4	4	0	0	0	6	3	0	91.5% [b]	5		183	0.017
1600	33	3	0	0	3	1	2	1	33	8		271	0.026
1700	8	13	1	0	3	4	1	0		2		186	0.018
1800	0	3	0	3	0	4	3	0	1	0	63.1% [b]	165	0.016
1900	3	14	1	2	1	5	1	94.2% [b]	0	4	161	195	0.018
2000	6	0	0	6	12	6	2	17	0	5		182	0.017
2100	4	3	4	4	14	7	3		3	61		229	0.022
2200	61	24	35	63	69	17	29	17	40	37		669	0.063
2300	84	41	50	28	70	56	16	34	65	53		749	0.071
2400	43	16	18	29	59	34	7	31	41	38		629	0.060
												10,562 [a]	
	589	343	309	303	430	542	294	290	389	533	436	14,229 [c]	
	4.1%	2.4%	2.2%	2.1%	3.0%	3.8%	2.1%	2.0%	2.7%	3 7%	3.1%		100%

[a] Totals include only days with 24 hours counts.
[b] Boxed areas indicate times when passage was estimated by extrapolation, based upon average hourly distribution for days when sonar operated 24 hours.
[c] Total estimated passage, including days with expanded counts.

Appendix C. Field calibrations for 1985–model Bendix sonar salmon counter, Sheenjek River 1999.

Date	Time Start	Duration	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Ctng Range	Total Range	Passage Rate (fish/hour)
15–Aug	22	33	0	0	--	0.400	2.0	90	92.0	0
16–Aug	15	40	2	3	0.667	0.400	2.0	90	92.0	3
	2325	30	1	1	1.000	0.400	2.0	98	100.0	2
17–Aug	821	16	2	37	0.054	0.400	2.0	98	100.0	8
18–Aug	11	30	1	0	--	0.400	2.0	98	100.0	2
19–Aug	18	30	2	2	1.000	0.400	2.0	98	100.0	4
	2344	15	1	40	0.025	0.400	2.0	98	100.0	4
20–Aug	944	15	0	5	--	0.400	2.0	98	100.0	0
21–Aug	2110	30	3	83	0.036	0.500	2.0	98	100.0	6
	2301	15	2	2	1.000	0.500	2.0	98	100.0	8
22–Aug	123	15	3	6	0.500	0.500	2.0	98	100.0	12
	420	17	0	0	--	0.500	2.0	98	100.0	0
	1640	15	0	0	--	0.500	2.0	98	100.0	0
	2129	15	3	2	1.500	0.500	2.0	98	100.0	12
23–Aug	2	15	0	0	--	0.500	2.0	98	100.0	0
	342	15	7	19	0.368	0.500	2.0	98	100.0	28
	602	30	7	5	1.400	0.500	2.0	98	100.0	14
	1110	30	0	0	--	0.500	2.0	98	100.0	0
	1621	30	1	2	0.500	0.500	2.0	98	100.0	2
	2103	30	2	2	1.000	0.500	2.0	98	100.0	4
24–Aug	15	30	5	3	1.667	0.803	2.0	98	100.0	10
	341	18	4	6	0.667	0.803	2.0	98	100.0	13
	601	30	5	7	0.714	0.803	2.0	98	100.0	10
	1101	30	4	3	1.333	0.803	2.0	98	100.0	8
	1601	30	1	0	--	0.803	2.0	98	100.0	2
	2101	30	7	2	3.500	0.803	2.0	98	100.0	14
25–Aug	30	15	2	3	0.667	0.729	2.0	98	100.0	8
	301	30	5	3	1.667	0.729	2.0	98	100.0	10
	1129	30	19	25	0.760	0.729	2.0	98	100.0	38
	1625	30	23	13	1.769	0.729	2.0	98	100.0	46
	2101	30	1	0	--	0.729	2.0	98	100.0	2
	2215	15	5	5	1.000	0.729	2.0	98	100.0	20
26–Aug	30	15	4	3	1.333	0.729	2.0	98	100.0	16
	312	30	16	13	1.231	0.729	2.0	98	100.0	32
	601	15	8	6	1.333	0.729	2.0	98	100.0	32
	1101	30	3	1	3.000	0.729	2.0	98	100.0	6
	1606	30	4	4	1.000	0.729	2.0	98	100.0	8
	2110	15	2	2	1.000	0.729	2.0	98	100.0	8
27–Aug	8	30	6	8	0.750	0.564	2.0	98	100.0	12
	307	30	8	20	0.400	0.564	2.0	98	100.0	16
	601	30	11	13	0.846	0.564	2.0	98	100.0	22
	1105	30	21	22	0.955	0.564	2.0	98	100.0	42
	1613	30	10	6	1.667	0.564	2.0	98	100.0	20
	2102	30	15	13	1.154	0.564	2.0	98	100.0	30
28–Aug	14	30	10	14	0.714	0.705	2.0	98	100.0	20
	301	30	9	1	9.000	0.705	2.0	98	100.0	18
	614	30	13	9	1.444	0.705	2.0	98	100.0	26
	1103	30	7	5	1.400	0.705	2.0	98	100.0	14
	1620	30	14	25	0.560	0.705	2.0	98	100.0	28
	2307	15	7	10	0.700	0.705	2.0	98	100.0	28
29–Aug	21	15	1	2	0.500	0.853	2.0	98	100.0	4
	303	15	4	4	1.000	0.853	2.0	98	100.0	16
	630	16	7	7	1.000	0.853	2.0	98	100.0	26
	1114	15	1	5	0.200	0.853	2.0	98	100.0	4
	1635	15	4	5	0.800	0.853	2.0	98	100.0	16
	2105	30	2	2	1.000	0.853	2.0	98	100.0	4
	2329	30	9	6	1.500	0.999	2.0	98	100.0	18

– continued –

Date	Time Start	Duration	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Ctng Range	Total Range	Passage Rate (fish/hour)
30-Aug	304	30	7	3	2.333	0.999	2.0	98	100.0	14
	601	30	8	9	0.889	0.999	2.0	98	100.0	16
	1103	30	0	0	--	0.999	2.0	98	100.0	0
	1604	30	0	0	--	0.999	2.0	98	100.0	0
	2115	30	3	5	0.600	0.999	2.0	98	100.0	6
31-Aug	17	30	1	1	1.000	0.999	2.0	98	100.0	2
	303	15	1	1	1.000	0.999	2.0	98	100.0	4
	601	30	2	3	0.667	0.999	2.0	98	100.0	4
	907	10	1	1	1.000	0.999	2.0	98	100.0	6
	1115	30	1	2	0.500	0.999	2.0	98	100.0	2
	1615	15	0	0	--	0.999	2.0	98	100.0	0
	2115	15	3	0	--	0.999	2.0	98	100.0	12
01-Sep	14	15	0	0	--	0.999	1.5	90	91.5	0
	301	15	3	0	--	0.999	1.5	90	91.5	12
	629	15	1	0	--	0.999	1.5	90	91.5	4
	1110	15	0	0	--	0.999	1.5	90	91.5	0
	1615	15	0	0	--	0.999	1.5	90	91.5	0
	2101	15	0	0	--	0.999	1.5	90	91.5	0
02-Sep	212	15	1	0	--	0.999	1.5	90	91.5	4
	308	15	1	0	--	0.999	1.5	90	91.5	4
	603	15	1	2	0.500	0.999	1.5	90	91.5	4
	1110	15	0	0	--	0.999	1.5	90	91.5	0
	1608	15	0	0	--	0.999	1.5	90	91.5	0
	2131	15	1	3	0.333	0.999	1.5	90	91.5	4
03-Sep	3	15	2	3	0.667	0.999	1.5	90	91.5	8
	301	15	6	6	1.000	0.999	1.5	90	91.5	24
	643	15	1	1	1.000	0.999	1.5	90	91.5	4
	1101	15	4	9	0.444	0.999	1.5	90	91.5	16
	1630	15	1	2	0.500	0.999	1.5	90	91.5	4
	2117	15	0	0	--	0.999	1.5	90	91.5	0
04-Sep	20	15	2	2	1.000	0.999	1.5	90	91.5	8
	314	30	26	14	1.857	0.999	1.5	90	91.5	52
	702	15	7	15	0.467	0.999	1.5	90	91.5	28
	1116	15	0	0	--	0.999	1.5	90	91.5	0
	1630	15	0	0	--	0.999	1.5	90	91.5	0
	2130	15	4	0	--	0.999	1.5	90	91.5	16
05-Sep	14	15	4	0	--	0.999	1.5	90	91.5	16
	311	15	1	1	1.000	0.999	1.5	90	91.5	4
	601	15	2	3	0.667	0.999	1.5	90	91.5	8
	1101	15	0	0	--	0.999	1.5	90	91.5	0
	1630	15	0	0	--	0.999	1.5	98	99.5	0
	2120	15	8	22	0.364	0.999	1.5	98	99.5	32
06-Sep	9	15	6	9	0.667	0.999	1.5	98	99.5	24
	429	30	30	10	3.000	0.999	1.5	98	99.5	60
	601	15	2	13	0.154	0.330	1.5	98	99.5	8
	1104	15	1	1	1.000	0.330	1.5	98	99.5	4
	1819	15	5	13	0.385	0.330	1.5	98	99.5	20
	2104	30	19	29	0.655	0.330	1.5	98	99.5	38
07-Sep	15	15	3	8	0.375	0.683	1.5	98	99.5	12
	105	15	3	5	0.600	0.683	1.5	98	99.5	12
	315	15	3	4	0.750	0.683	1.5	98	99.5	12
	603	15	4	5	0.800	0.683	1.5	98	99.5	16
	1101	15	2	1	2.000	0.683	1.5	98	99.5	8
	1604	30	17	33	0.515	0.683	1.5	98	99.5	34
	2129	30	17	16	1.063	0.683	1.5	98	99.5	34
08-Sep	26	15	8	8	1.000	0.999	1.5	98	99.5	32
	325	30	33	26	1.269	0.999	1.5	98	99.5	66
	603	30	26	35	0.743	0.789	1.5	98	99.5	52
	1124	15	1	1	1.000	0.789	1.5	98	99.5	4
	1636	15	2	3	0.667	0.789	1.5	98	99.5	8
	2106	15	3	2	1.500	0.789	1.5	98	99.5	12

– continued –

Appendix C. (page 3 of 4)

Date	Time Start	Duration	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Ctng Range	Total Range	Passage Rate (fish/hour)
09-Sep	2	15	3	5	0.600	0.999	1.5	98	99.5	12
	302	30	34	33	1.030	0.999	1.5	98	99.5	68
	602	15	8	13	0.615	0.999	1.5	98	99.5	32
	1105	15	2	2	1.000	0.999	1.5	98	99.5	8
	1643	15	1	2	0.500	0.999	1.5	98	99.5	4
	2103	15	3	3	1.000	0.999	1.5	98	99.5	12
10-Sep	31	15	4	5	0.800	0.999	1.5	98	99.5	16
	310	15	8	7	1.143	0.999	1.5	98	99.5	32
	602	15	8	9	0.889	0.999	1.5	98	99.5	32
	1127	15	0	0	--	0.999	1.5	98	99.5	0
	1609	15	1	0	--	0.999	1.5	98	99.5	4
	2102	15	8	4	2.000	0.999	1.5	98	99.5	32
11-Sep	2	15	5	7	0.714	0.999	1.5	98	99.5	20
	305	15	9	6	1.500	0.999	1.5	98	99.5	36
	604	30	22	28	0.786	0.999	1.5	98	99.5	44
	1115	15	0	0	--	0.999	1.5	98	99.5	0
	1643	15	4	1	4.000	0.999	1.5	98	99.5	16
	2108	30	21	9	2.333	0.999	1.5	98	99.5	42
12-Sep	10	15	9	6	1.500	0.999	1.5	98	99.5	36
	312	15	6	6	1.000	0.839	1.5	98	99.5	24
	640	15	1	2	0.500	0.839	1.5	98	99.5	4
	1109	15	2	0	--	0.839	1.5	98	99.5	8
	1617	15	0	0	--	0.839	1.5	98	99.5	0
	2120	30	22	20	1.100	0.839	1.5	98	99.5	44
13-Sep	27	30	25	21	1.190	0.839	1.5	98	99.5	50
	307	30	43	36	1.194	0.705	1.5	98	99.5	86
	618	15	4	1	4.000	0.705	1.5	98	99.5	16
	1109	15	0	0	--	0.705	1.5	98	99.5	0
	1625	15	2	3	0.667	0.705	1.5	98	99.5	8
	2112	15	5	4	1.250	0.705	1.5	98	99.5	20
14-Sep	31	15	7	8	0.875	0.515	1.5	98	99.5	28
	301	15	10	8	1.250	0.515	1.5	98	99.5	40
	644	15	9	9	1.000	0.515	1.5	98	99.5	36
	1113	15	0	1	--	0.515	1.5	98	99.5	0
	1635	15	3	12	0.250	0.515	1.5	98	99.5	12
	2135	15	8	12	0.667	0.515	1.5	98	99.5	32
15-Sep	201	15	8	4	2.000	0.695	1.5	98	99.5	32
	326	15	8	10	0.800	0.695	1.5	98	98.5	32
	630	15	8	12	0.667	0.695	1.5	98	99.5	32
	1130	15	0	0	--	0.695	1.5	98	99.5	0
	1628	15	0	0	--	0.695	1.5	98	99.5	0
	2115	15	4	3	1.333	0.695	1.5	98	99.5	16
16-Sep	19	15	7	2	3.500	0.695	1.5	98	99.5	28
	301	15	6	8	0.750	0.695	1.5	98	99.5	24
	609	15	2	2	1.000	0.695	1.5	98	99.5	8
	1122	15	0	0	--	0.695	1.5	98	99.5	0
	1615	15	0	0	--	0.695	1.5	98	99.5	0
	2129	30	22	21	1.048	0.695	1.5	98	99.5	44
17-Sep	3	15	7	5	1.400	0.695	1.5	98	99.5	28
	311	15	7	4	1.750	0.695	1.5	98	99.5	28
	611	15	7	9	0.778	0.695	1.5	98	99.5	28
	1107	15	1	1	1.000	0.695	1.5	98	99.5	4
	1605	15	0	0	--	0.695	1.5	98	99.5	0
	2108	15	6	6	1.000	0.695	1.5	98	99.5	24
18-Sep	26	30	24	11	2.182	0.535	1.5	98	99.5	48
	310	30	28	27	1.037	0.535	1.5	98	99.5	56
	601	15	7	7	1.000	0.535	1.5	98	99.5	28
	1105	15	0	1	--	0.535	1.5	98	99.5	0
	1635	15	0	1	--	0.535	1.5	98	99.5	0
	2115	15	6	6	1.000	0.535	1.5	98	99.5	24

– continued –

Appendix C. (page 4 of 4)

Date	Time Start	Duration	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Ctng Range	Total Range	Passage Rate (fish/hour)
19–Sep	10	30	22	26	0.846	0.439	1.5	98	99.5	44
	301	15	8	8	1.000	0.439	1.5	98	99.5	32
	614	15	4	23	0.174	0.439	1.5	98	99.5	16
	1128	15	1	2	0.500	0.439	1.5	98	99.5	4
	1622	14	0	1	– –	0.439	1.5	98	99.5	0
	2110	30	7	18	0.389	0.439	1.5	98	99.5	14
20–Sep	44	15	5	19	0.263	0.817	1.5	98	99.5	20
	332	30	15	10	1.500	0.817	1.5	98	99.5	30
	635	15	1	5	0.200	0.817	1.5	98	99.5	4
	1112	15	2	1	2.000	0.817	1.5	98	99.5	8
	1644	15	0	0	– –	0.817	1.5	98	99.5	0
	2202	30	21	16	1.313	0.817	1.5	98	99.5	42
21–Sep	5	15	9	3	3.000	0.947	1.0	98	99.0	36
	311	15	5	1	5.000	0.947	1.0	98	99.0	20
	610	15	6	10	0.600	0.947	1.0	98	99.0	24
	1128	15	1	0	– –	0.947	1.0	98	99.0	4
	1829	15	0	0	– –	0.947	1.0	98	99.0	0
	2111	30	36	18	2.000	0.947	1.0	98	99.0	72
22–Sep	101	30	17	17	1.000	0.530	1.5	98	99.5	34
	301	15	9	10	0.900	0.530	1.5	98	99.5	36
	613	15	6	6	1.000	0.530	1.5	98	99.5	24
	1130	15	1	0	– –	0.530	1.5	98	99.5	4
	1701	15	7	14	0.500	0.530	1.5	98	99.5	28
	2201	30	31	39	0.795	0.530	1.5	98	99.5	62
23–Sep	35	15	7	3	2.333	0.668	1.5	98	99.5	28
	305	15	5	3	1.667	0.668	1.5	98	99.5	20
	725	15	5	1	5.000	0.668	1.5	98	99.5	20
	1121	15	0	0	– –	0.668	1.5	98	99.5	0
Total	206	4,094	1,288	1,492	0.863					

Appendix D. Sonar-estimated escapement of fall chum salmon in the Sheenjek River, 1986-1999.

Date	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Date
30-Jul											670				30-Jul
31-Jul											706				31-Jul
01-Aug											541				01-Aug
02-Aug											793				02-Aug
03-Aug											685				03-Aug
04-Aug											577				04-Aug
05-Aug											469				05-Aug
06-Aug											724				06-Aug
07-Aug									146		918				07-Aug
08-Aug								45	75		1,554				08-Aug
09-Aug						255	136	95	112		930	114			09-Aug
10-Aug	||	||	||	||	||	301	172	256	38	964	963	248		32	10-Aug
11-Aug	||	||	||	||	||	179	102	143	214	882	479	332		60	11-Aug
12-Aug	||	||	||	||	||	173	272	217	243	468	315	306		37	12-Aug
13-Aug	||	||	||	||	||	178	216	227	328	344	315	421		76	13-Aug
14-Aug	||	||	||	||	||	282	337	175	215	359	903	473		41	14-Aug
15-Aug	||	||	||	||	||	551	670	291	261	1,045	762	420		43	15-Aug
16-Aug	1,010	||	||	||	||	521	571	346	333	863	753	534		70	16-Aug
17-Aug	68	||	||	||	||	418	1,100	367	378	891	602	341	56	86	17-Aug
18-Aug	345	||	||	||	||	591	1,570	245	524	1,172	724	307	98	101	18-Aug
19-Aug	769	||	||	||	||	668	1,003	316	497	1,656	753	430	63	290	19-Aug
20-Aug	1,576	||	4,340	||	||	446	2,347	466	257	2,105	1,662	354	35	217	20-Aug
21-Aug	1,178	||	981	||	15,550	1,012	1,767	117	594	2,632	1,594	291	23	224	21-Aug
22-Aug	3,023	||	1,027	||	1,718	1,990	1,353	124	642	2,677	1,178	506	27	59	22-Aug
23-Aug	1,177	||	884	20,000	1,825	1,754	1,189	157	1,673	3,525	2,472	688	58	138	23-Aug
24-Aug	1,733	13,181	744	2,685	1,940	889	1,390	177	1,035	6,301	11,459	996	43	279	24-Aug
25-Aug	5,374	168	810	2,321	1,620	1,591	1,147	156	848	4,745	9,966	1,059	95	730	25-Aug
26-Aug	4,875	314	1,528	1,392	1,047	1,684	893	248	791	4,445	7,034	1,179	93	395	26-Aug
27-Aug	3,712	795	1,203	1,129	1,055	1,846	1,032	208	2,934	6,358	4,545	2,329	59	645	27-Aug
28-Aug	4,633	951	1,087	1,009	1,337	1,508	778	296	3,677	4,839	5,778	2,320	114	676	28-Aug
29-Aug	5,150	993	756	733	1,605	1,196	463	369	4,082	6,842	11,457	1,884	47	410	29-Aug
30-Aug	4,336	1,400	914	1,265	881	905	943	647	4,487	7,436	12,249	2,067	143	247	30-Aug
31-Aug	3,889	1,839	1,512	933	1,609	1,676	840	999	5,472	6,517	12,522	2,250	274	207	31-Aug
01-Sep	2,101	3,937	1,548	1,598	1,570	2,164	835	1,045	6,912	8,782	7,597	2,433	248	115	01-Sep
02-Sep	2,230	3,295	1,492	1,759	1,095	1,749	830	632	7,196	5,856	6,326	2,616	234	164	02-Sep
03-Sep	1,819	7,585	2,203	1,739	1,002	1,808	1,217	2,092	5,918	7,049	6,457	2,799	117	203	03-Sep
04-Sep	2,406	11,386	1,991	2,819	1,159	2,026	2,023	2,557	3,666	4,185	5,113	3,404	301	327	04-Sep
05-Sep	1,645	10,962	1,309	2,571	955	2,476	2,093	2,097	2,832	4,525	5,214	3,352	118	186	05-Sep
06-Sep	2,265	5,439	1,286	2,936	1,339	1,241	3,154	1,673	2,952	6,084	5,763	2,761	277	422	06-Sep
07-Sep	2,849	10,182	1,542	4,210	1,259	3,490	4,200	2,414	3,928	6,852	7,871	2,904	254	416	07-Sep
08-Sep	2,760	11,122	1,297	3,581	1,071	2,680	3,092	2,720	3,587	6,318	6,333	4,842	590	742	08-Sep
09-Sep	2,469	8,487	1,443	4,858	1,411	4,201	4,274	1,300	2,598	5,403	3,718	2,849	412	555	09-Sep
10-Sep	1,131	5,561	1,073	4,051	854	3,541	3,209	580	2,341	4,957	4,364	1,995	416	594	10-Sep
11-Sep	1,461	4,882	696	3,551	1,746	2,236	3,815	401	3,382	6,758	7,409	1,971	594	514	11-Sep
12-Sep	2,500	6,294	340	3,414	1,726	3,136	3,816	465	2,796	6,597	4,735	2,323	722	470	12-Sep
13-Sep	1,751	5,831	673	3,227	1,803	3,139	4,047	373	3,066	6,561	6,974	3,602	1,348	589	13-Sep
14-Sep	2,866	4,485	703	2,797	2,196	3,145	6,347	351	3,294	6,184	5,944	2,983	1,120	343	14-Sep
15-Sep	2,290	3,963	1,037	2,027	2,065	4,823	4,289	197	3,522	10,161	5,406	3,294	1,201	309	15-Sep
16-Sep	1,099	4,118	1,275	2,498	2,175	4,240	3,232	407	4,764	9,026	7,871	2,376	2,850	303	16-Sep
17-Sep	1,488	4,763	1,943	3,035	2,867	2,729	2,473	1,176	4,413	9,097	11,181	2,379	2,492	430	17-Sep
18-Sep	1,481	4,326	1,637	2,090	1,909	2,734	2,158	1,053	3,249	8,525	7,850	2,101	2,607	542	18-Sep
19-Sep	1,546	2,635	1,209	1,839	2,020	3,119	2,406	1,359	6,500	8,468	10,474	2,096	2,526	294	19-Sep
20-Sep	679	3,160	1,151	2,321	2,372	3,319	1,007	1,192	7,583	8,065	6,755	1,613	2,692	290	20-Sep
21-Sep	704	3,223	716	1,273	2,444	2,461	early	3,382	5,287	9,590	6,170	1,612	2,756	389	21-Sep
22-Sep	577	1,988	743	1,384	2,667	1,924	freezeup	2,005	6,520	5,943	3,924	2,249	2,120	533	22-Sep
23-Sep	587	2,878	583	2,434	1,848	2,071		1,803	5,153	6,518	4,486	2,629	1,594	436	23-Sep
24-Sep	653	3,324	522	2,965	1,819	1,430		1,655	4,523	6,432	1,902		811		24-Sep
25-Sep			365	2,672	1,923			1,083	3,607	6,853			529		25-Sep
26-Sep			344		1,392			1,158	3,458				430		26-Sep
27-Sep			319		1,478			568	3,600				487		27-Sep
28-Sep					798			497	4,062				736		28-Sep
29-Sep													587		29-Sep
30-Sep													661		30-Sep
Total	84,207	153,267	45,206	99,116	77,750	86,496	78,808	42,922	150,565	241,855	246,889	80,423	33,058	14,229	

[a] Early portion of chum salmon run estimated from run timing and entry pattern observed in the Chandalar River (Barton 1995).
[b] Early portion of chum salmon run estimated from aerial survey (Barton 1995).

Appendix E. Cumulative proportion of Sheenjek River sonar counts, 1986–1999.

Date	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Date	1986–98 average
30–Jul											0.00				30–Jul	
31–Jul											0.01				31–Jul	
01–Aug											0.01				01–Aug	
02–Aug											0.01				02–Aug	
03–Aug											0.01				03–Aug	
04–Aug											0.02				04–Aug	
05–Aug											0.02				05–Aug	
06–Aug											0.02				06–Aug	
07–Aug									0.00		0.02				07–Aug	
08–Aug								0.00	0.00	0.00	0.03	0.00	0.00		08–Aug	
09–Aug						0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00		09–Aug	
10–Aug						0.00	0.00	0.01	0.00	0.00	0.04	0.00	0.00	0.00	10–Aug	
11–Aug						0.01	0.01	0.01	0.00	0.01	0.04	0.01	0.00	0.01	11–Aug	
12–Aug						0.01	0.01	0.02	0.01	0.01	0.04	0.01	0.00	0.01	12–Aug	
13–Aug						0.01	0.01	0.02	0.01	0.01	0.04	0.02	0.00	0.01	13–Aug	
14–Aug						0.01	0.02	0.03	0.01	0.01	0.05	0.02	0.00	0.02	14–Aug	
15–Aug						0.02	0.02	0.03	0.01	0.02	0.05	0.03	0.00	0.02	15–Aug	
16–Aug	0.01 [a]					0.03	0.03	0.04	0.01	0.02	0.05	0.04	0.00	0.03	16–Aug	
17–Aug	0.01					0.03	0.05	0.05	0.02	0.02	0.06	0.04	0.00	0.03	17–Aug	
18–Aug	0.02					0.04	0.07	0.06	0.02	0.03	0.06	0.04	0.00	0.04	18–Aug	
19–Aug	0.03					0.04	0.08	0.06	0.02	0.04	0.06	0.05	0.01	0.06	19–Aug	
20–Aug	0.04		0.10 [a]			0.05	0.11	0.07	0.02	0.04	0.07	0.05	0.01	0.07	20–Aug	
21–Aug	0.06		0.12		0.20 [a]	0.06	0.13	0.08	0.03	0.06	0.07	0.06	0.01	0.09	21–Aug	
22–Aug	0.09		0.14		0.22	0.08	0.15	0.08	0.03	0.07	0.08	0.06	0.01	0.09	22–Aug	
23–Aug	0.11		0.16	0.20 [b]	0.25	0.10	0.16	0.08	0.04	0.08	0.09	0.07	0.01	0.10	23–Aug	
24–Aug	0.13	0.09 [a]	0.18	0.23	0.27	0.12	0.18	0.09	0.05	0.11	0.14	0.08	0.01	0.12	24–Aug	0.12
25–Aug	0.19	0.09	0.19	0.25	0.29	0.13	0.19	0.09	0.06	0.13	0.18	0.10	0.02	0.17	25–Aug	0.15
26–Aug	0.25 [c]	0.09	0.23	0.27	0.30	0.15	0.21	0.10	0.06	0.15	0.20	0.11	0.02	0.20	26–Aug	0.15
27–Aug	0.29	0.09	0.25	0.28	0.32	0.17	0.22	0.10	0.08	0.17	0.22	0.14	0.02	0.25	27–Aug	0.18
28–Aug	0.35	0.10	0.28	0.29	0.34	0.19	0.23	0.11	0.11	0.19	0.25	0.17	0.02	0.30	28–Aug	0.20
29–Aug	0.41	0.11	0.30	0.30	0.36	0.21	0.23	0.12	0.13	0.22	0.29	0.19	0.02	0.32	29–Aug	0.22
30–Aug	0.46	0.12	0.32	0.31	0.37	0.22	0.25	0.13	0.16	0.25	0.34	0.22	0.03	0.34	30–Aug	0.24
31–Aug	0.51 [d]	0.13	0.35	0.32	0.39	0.24	0.26	0.16	0.20	0.28	0.39	0.25	0.04	0.36	31–Aug	0.25
01–Sep	0.53	0.15	0.38	0.33	0.41	0.26	0.27	0.18	0.24	0.31	0.42	0.28	0.04	0.36	01–Sep	0.29
02–Sep	0.56	0.17	0.42	0.35	0.43	0.28	0.28	0.19	0.29	0.34	0.45	0.31	0.05	0.38	02–Sep	0.32
03–Sep	0.58	0.22	0.46	0.37	0.44	0.30	0.29	0.24	0.33	0.37	0.48	0.34	0.06	0.39	03–Sep	0.35
04–Sep	0.61	0.30	0.51	0.40	0.46	0.32	0.32	0.30	0.36	0.38	0.50	0.39	0.06	0.41	04–Sep	0.38
05–Sep	0.63	0.37	0.54	0.42	0.47	0.35	0.35	0.35	0.37	0.40	0.52	0.43	0.07	0.43	05–Sep	0.41
06–Sep	0.66	0.40	0.57	0.45	0.49	0.37	0.39	0.39	0.39	0.43	0.54	0.46	0.08	0.46	06–Sep	0.43
07–Sep	0.69	0.47	0.60	0.50	0.50	0.41	0.44	0.45	0.42	0.46	0.57	0.50	0.08	0.48	07–Sep	0.47
08–Sep	0.72	0.54	0.63	0.53	0.52	0.44	0.48	0.51	0.44	0.48	0.60	0.56	0.10	0.54	08–Sep	0.50
09–Sep	0.75	0.60	0.66	0.58	0.54	0.49	0.53	0.54	0.46	0.50	0.61	0.59	0.11	0.58	09–Sep	0.54
10–Sep	0.77	0.64	0.68	0.62	0.55	0.53	0.57	0.55	0.48	0.53	0.63	0.62	0.13	0.62	10–Sep	0.56
11–Sep	0.78	0.67	0.70	0.66	0.57	0.55	0.62	0.56	0.50	0.55	0.66	0.64	0.14	0.65	11–Sep	0.59
12–Sep	0.81	0.71	0.71	0.69	0.59	0.59	0.67	0.57	0.52	0.58	0.68	0.67	0.17	0.69	12–Sep	0.61
13–Sep	0.83	0.75	0.72	0.72	0.61	0.63	0.72	0.58	0.54	0.61	0.71	0.72	0.21	0.73	13–Sep	0.64
14–Sep	0.87	0.78	0.74	0.75	0.64	0.66	0.80	0.59	0.56	0.63	0.73	0.75	0.24	0.75	14–Sep	0.67
15–Sep	0.90	0.80	0.76	0.77	0.67	0.72	0.86	0.60	0.58	0.68	0.75	0.80	0.28	0.77	15–Sep	0.70
16–Sep	0.91	0.83	0.79	0.80	0.70	0.77	0.90	0.61	0.62	0.71	0.79	0.83	0.36	0.80	16–Sep	0.74
17–Sep	0.93	0.86	0.83	0.83	0.73	0.80	0.93	0.63	0.64	0.75	0.83	0.85	0.44	0.83	17–Sep	0.77
18–Sep	0.94	0.89	0.87	0.85	0.76	0.83	0.96	0.66	0.67	0.79	0.86	0.88	0.52	0.86	18–Sep	0.81
19–Sep	0.96	0.90	0.90	0.87	0.78	0.87	0.99	0.69	0.71	0.82	0.91	0.91	0.59	0.88	19–Sep	0.84
20–Sep	0.97	0.93	0.92	0.89	0.82	0.91	1.00	0.72	0.76	0.85	0.93	0.93	0.68	0.90	20–Sep	0.87
21–Sep	0.98	0.95	0.94	0.90	0.85	0.93		0.80	0.79	0.89	0.96	0.95	0.76	0.93	21–Sep	0.89
22–Sep	0.99	0.96	0.95	0.92	0.88	0.96		0.84	0.84	0.92	0.97	0.97	0.82	0.97	22–Sep	0.92
23–Sep	0.99	0.98	0.97	0.94	0.90	0.98		0.88	0.87	0.95	0.99	1.00	0.87	1.00	23–Sep	0.94
24–Sep	1.00	1.00	0.98	0.97	0.93	1.00		0.92	0.90	0.97	1.00		0.90		24–Sep	0.96
25–Sep			0.99	1.00	0.95			0.95	0.93	1.00			0.91		25–Sep	
26–Sep			0.99		0.97			0.98	0.95				0.93		26–Sep	
27–Sep			1.00		0.99			0.99	0.97				0.94		27–Sep	
28–Sep					1.00			1.00	1.00				0.96		28–Sep	
29–Sep													0.98		29–Sep	
30–Sep													1.00		30–Sep	

[a] Early portion of Sheenjek River fall chum salmon run estimated from run timing and entry pattern observed in the Chandalar River (Barton 1995).
[b] Early portion of Sheenjek River fall chum salmon run estimated from aerial survey (Barton 1995).
[c] Interquartile range and median day of passage ([d]) are shown for each year.