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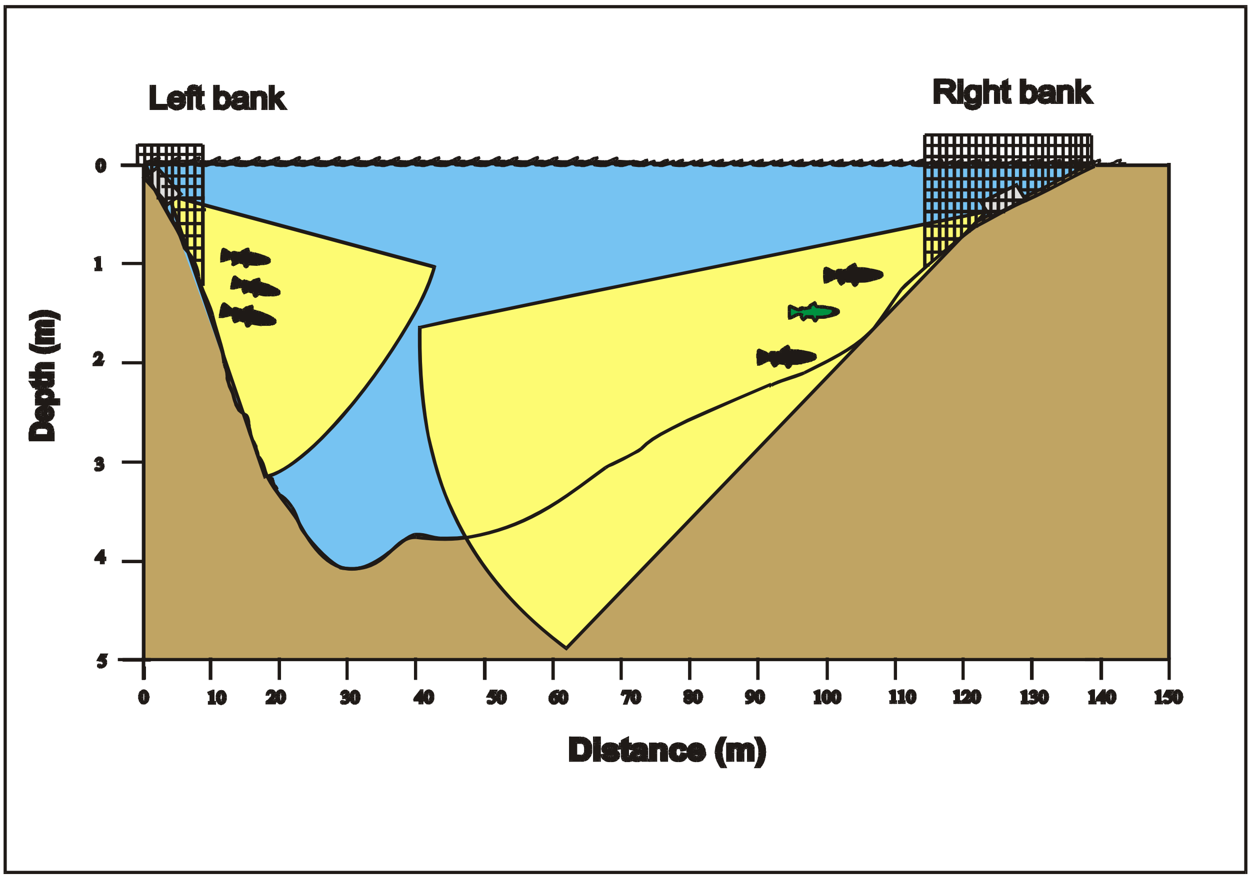

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Jeffery L. Melegari and Bruce M. Osborne

Abstract

A fixed-location split-beam hydroacoustic study was initiated in 1994 to assess the population abundance of adult fall chum salmon *Oncorhynchus keta* in the Chandalar River, a tributary of the Yukon River. Annual passage estimates have been made since 1995 and daily in-season counts have been provided since 1996. This report presents the results for the 2002 - 2006 seasons and describes the annual variability in run size and timing. Sonar operations began on August 8 and continued through September 26 for all years except 2004 when the sonar was shutdown 4 days early due to low water conditions. With the exception of 2002 and 2004, all years experienced periods of high water that interrupted data collection. Fall chum salmon passage estimates at the sonar site for 2002 - 2006 were: 89,580, 214,416, 136,703, 496,484, 245,090 respectively. These counts represent conservative estimates of total passage because they only include fish that passed during the dates of sonar operation. The passage rates on the first day of counting for all years were less than 0.8% of the total estimated count for that season. The passage rates on the final day of counting were less than 1.7% of the total estimated count for each year for all years except 2004 (4.6%). Median passage dates for 2002 - 2006 were: Sept. 12, Sept. 3, Sept. 7, Sept. 6, Sept. 6 respectively. Positional data suggested that most fish were detected by the sonar with few targets observed near the vertical or outer range limits of acoustic detection. Migrating chum salmon were shore-oriented and traveled close to the river bottom.

Introduction

Accurate salmon escapement counts on Yukon River tributaries are important for assessing annual harvest management guidelines, predicting run strength based on brood year returns, and monitoring long-term population trends. Weirs, counting towers, mark-recapture programs, ground surveys, and hydroacoustics are methods used to obtain escapement estimates of specific Yukon River salmon stocks (Bergstrom et al. 2001).

The Yukon River drainage encompasses 854,700 km^2 and is among the largest producers of wild Chinook salmon *Oncorhynchus tschawytscha* and chum salmon *O. keta* in North America (Daum and Osborne 1995). The salmon resources of this unique river support important subsistence and commercial fisheries throughout the drainage. The U.S. Fish and Wildlife Service (USFWS), through Section 302 of the Alaska National Interest Lands Conservation Act, has a responsibility to ensure that salmon populations within federal conservation units, including national wildlife refuge lands, are conserved in their natural diversity, international treaty obligations are met, and subsistence opportunities are maintained. An important

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component of these mandates is to provide accurate spawning escapement estimates for the major salmon stocks in the drainage.

The use of fixed-location hydroacoustics to count migrating salmon in Alaska began during the early 1960s. Their use provided counts in rivers where limited visibility or sample volume precluded other sampling techniques (Gaudet 1990). These early "Bendix salmon counters" were not acoustically calibrated, used factory-set echo-counting criteria to determine fish counts, had limited acoustic range (< 33 m), and could not determine direction of target travel (upriver or downriver). In 1992, the first riverine application of split-beam sonar technology was used to monitor upriver migrations of mainstream Yukon River salmon (Johnston et al. 1993). This sonar system was acoustically calibrated, had user-defined echo-tracking techniques to count fish, and had extended acoustic range (>100 m). The split-beam sonar also provided three-dimensional positioning for each returning echo, allowing the determination of direction of travel and swimming behavior for each passing target (Daum and Osborne 1998).

From 1986 to 1990, the USFWS used fixed-location, Bendix salmon counters to enumerate adult fall chum salmon in the Chandalar River, located on the Yukon Flats National Wildlife Refuge (Daum et al. 1992). The results of this study revealed that the Chandalar River fall chum salmon stock was one of the largest populations of fall chum salmon in the entire Yukon River drainage. Annual sonar counts of fall chum salmon during this period averaged 58,628, ranging from 33,619 to 78,631 fish.

Because Chandalar River fall chum salmon are important as a wildlife and subsistence resource, a study was initiated in 1994 to reassess the population status using newly developed, split-beam hydroacoustics. Overall study objectives were to: 1) Provide daily in-season counts of Chandalar River fall chum salmon to fishery managers; 2) Estimate annual passage of fall chum salmon; and 3) Describe annual variability in run size and timing. The study objectives have been retained since 1994.

The initial year, 1994, although prematurely ended due to flooding, was used to develop site-specific operational methods, evaluate site characteristics, and describe possible data collection biases (Daum and Osborne 1995). During 1995, daily and seasonal estimates of fall chum salmon passage were calculated post season and in situ target strength evaluations were collected (Daum and Osborne 1996). Since 1996 the project has provided daily in-season counts to managers, and a total estimate of passage post season.

Inherent to any sonar project where multiple species are present is the issue of distinguishing between species. Consequently, in most sonar projects a second method of capture and/or identification of the species being detected with the sonar is necessary. Ideally, different species would be isolated either spatially or temporally. When this is not the case, distinguishing between the different species with the sonar becomes increasingly difficult or impossible as the differences in size, shape, and/or behavior between the species decrease.

Based on five previous seasons of set gill net catches that consisted of more than 99% chum salmon on the Chandalar River (Daum and Osborne 1996), all upriver-swimming fish were assumed to be chum salmon. However, during 2000 while investigating the appearance of atypical sonar traces, schools of least cisco *Coregonus sardinella* were detected with an underwater video camera. Approximately 60 hours of video were recorded during 2000. During post-season analysis, the fish in these video images were compared to the corresponding sonar traces. This allowed identification of sonar trace patterns that were indicative of schools of least cisco. These sonar trace patterns were used to re-track and remove least cisco from the 2000 data set post season. A random review of a small sample of echograms from previous years indicated a few occurrences of least cisco trace patterns. This and data from later seasons leads us to believe that least cisco abundance was higher than normal during 2000, and that least cisco were a minor component of counts from previous years. During 2001 an additional 406 hours of video were recorded and compared to sonar traces. This analysis showed that least cisco could be effectively omitted from the sonar counts using the trace patterns (Osborne and Melegari 2006).

Study Area

The Chandalar River is a fifth-order tributary of the Yukon River, draining from the southern slopes of the Brooks Range. It consists of three major branches: East, Middle, and North Forks (Figure 1). Principal water sources include rainfall, snowmelt, and to a lesser extent, melt water from small glaciers, and perennial springs (Craig and Wells 1975). Summer water turbidity is highly variable, depending on rainfall. The region has a continental subarctic climate characterized by the most extreme temperatures in the state -41.7° to 37.8° C (U.S. Department of the Interior 1964). Precipitation ranges from 15 to 33 cm annually with the greater amount falling between May and September. The river is typically ice-free by early June and freeze-up occurs in late September to early October.

The lower 19 km of the Chandalar River is influenced by a series of slough systems connected to the Yukon River. River banks are typically steep and covered with overhanging vegetation and downed trees caused by active bank erosion. Gravel bars are absent in this area and the bottom substrate is primarily sand and silt. Water velocities are generally less than 0.75 m/s. Twenty-one to 22.5 km upriver from its confluence with the Yukon River, the Chandalar River is confined to a single channel with steep cut-banks alternating with large gravel bars. Upriver from this area, the river becomes braided with many islands and multiple channels. The sonar study area located at river km 21.5, was previously described by Daum et al. (1992; Figure 2). Conditions at the sonar deployment sites were fairly constant with only minor, small scale changes throughout the years of this report. The left bank site, looking downriver, has a steeper bottom gradient and higher water velocity than the right bank. River bottom slopes are approximately 7.6° on the left bank and 2.4° on the right bank. River substrate consists of small rounded cobble/gravel on the left bank and sand/silt on the right bank.

Methods

Site Selection and Sonar Deployment

A transducer deployment site for each bank was selected from cross-sectional river profiles of the area (Figure 3), which were developed from a chart recording depth sounder with an 8° transducer mounted below a boat's hull. Requirements for site selection included: 1) single channel; 2) uniform non-turbulent flow; 3) gradually sloping bottom gradient; 4) absence of highly reflective river substrate; 5) location downriver from known salmon spawning areas; and 6) active fish migration past the site (no milling behavior). Conditions at transducer deployment sites on both banks were similar over all years of the study.

Two Hydroacoustic Technology, Inc. (HTI) split-beam systems were installed on opposite river banks to optimize sonar beam coverage of the river's cross-sectional area. Each system consisted of a 200-kHz split-beam echo sounder, digital echo processor, elliptical-beam transducer, 150 m transducer cable, chart recorder, oscilloscope, and data analysis computer.

Specific component descriptions and operations are detailed in HTI manuals (HTI 1994a, 1994b). Transducers were attached to Remote Ocean Systems underwater rotators to facilitate remote aiming. Precise aiming was critical because most fish traveled close to the bottom. During aiming, a target was used to align the lower edge of the beam with the river bottom. Chart recordings, oscilloscope readings, and real-time positional displays of passing fish from the digital echo processor were used to monitor transducer aiming. For each bank, sonar equipment was housed in a portable shelter. Frequency modulation hardware (FM slide) was installed in the right bank echo sounder to reduce background noise levels (Ehrenberg 1995).

Echo sounder settings differed between banks but not among years. Left bank settings were: 10 dBW transmit power; -3 dBV total receiver gain; 40log10(R) time-varied gain function, where R = target range (m); 0.2 ms pulse width; and 10 pings/s. Right bank settings, using FM slide, were: 25 dBW transmit power; -18 dBV total receiver gain; 40log10(*R*) time-varied gain function; 0.18 ms pulse width (compressed); and 6.25 pings/s. Echo sounder settings were influenced by background noise levels and signal cross-talk between banks.

To insure that acoustic data were not biased and that passing fish were not being missed because of acoustic size or off-axis position, the voltage threshold was set at -40 dB for normal operations, which was substantially lower (10 dB) than predicted target strength values for fish of chum salmon length (Love 1977). During high-noise events (primarily caused by increased debris load on the right bank during higher flows), the voltage threshold on the right bank was increased to -34 dB at selected ranges, usually 30 - 40 m and beyond. Theoretically this could cause biased target strength values and undercounting of fish at these ranges; however, most upriver fish have historically had target strengths substantially above the elevated threshold setting and the majority of fish have been close to shore where thresholds remained unchanged.

Elliptical-beam transducers (one per bank) were used. Elliptical beams maximize sampling volume for targets moving horizontally in the water column (migrating fish) while maintaining a smaller vertical angle fitted to shallow water conditions (as in rivers). The half-power beam widths (measured at -3 dB down the acoustic axis) were 4.8° by 10.8° on the left bank and 2.1° by 9.7° on the right bank. The transducers and remote-controlled rotators were mounted on frames and deployed at depths of 0.6 - 1.5 m (see Daum and Osborne 1999 for specific description of frame assembly). Transducers were oriented perpendicular to river flow and positioned as close to the river bottom as substrate and contour allowed, usually within 5 cm of the bottom. Before deployment, the transducer face was washed with a soap solution to remove foreign matter and air bubbles that could affect performance. The transducer assembly was moved inshore or offshore during the season as water level changed. A wire fence weir (5 x 10 cm mesh) was installed 1 m downriver of each transducer and extended past calculated near-field values (MacLennan and Simmonds 1992), 1.3 m on the left bank and 7.2 m on the right bank. Fish moving upriver and close to shore would encounter the weir, be forced offshore, and then pass through the sonar beam.

Abundance Estimate and Run Timing

Data Collection − Sonar data files were created hourly, and included only returning echoes that met user-controlled pulse width, angle off-axis (vertical and horizontal), signal strength threshold, and range criteria. A detailed description of file contents can be found in Johnston et al. (1993) and HTI (1994b). On both banks, the vertical angle off-axis criteria were increased beyond the half-power beam widths so echoes from fish traveling very close to the river bottom were accepted into the echo processor data file. The maximum acquisition range (distance from the transducer) varied slightly throughout the seasons, due to transducer redeployment as water levels varied. The left bank coverage varied from 15 - 20 m, with approximately 10 m of the final distance to the thalweg not ensonified due to a change in slope of the river bottom. Right bank beam coverage was generally 70 - 80 m, with approximately 15 - 20 m of the final distance to the thalweg not ensonified due to reverberation from the irregular bottom. Changes to processor settings were recorded in hourly files and log books. Networking between the echo sounder, and computers allowed daily file backup and data analysis without interrupting real-time data collection.

Prior to acoustic data analyses, all hourly files from the digital echo processor were examined for completeness and data integrity. Subsequently, data files were processed through target-tracking software (HTI Trakman software). Echoes from boat motors, acoustic noise, and rocks were excluded from the database. Boat motor and acoustic noise echoes were visually identified by the random nature they displayed on software-produced echograms. Returning echoes from rocks exhibited a stationary bottom position in the beam with no movement in the upriver or downriver direction. Suspected fish targets, represented by a series of contiguous echoes, were examined for upriver or downriver directional progression and written to hourly files. A description of tracked fish files (*.ech and *.fsh files) can be found in Johnston et al. (1993) and HTI (1994b). All upriver targets in these tracked fish files were classified as fish. If the total distance traveled in the upriver direction was < 0.1 m, that target was deleted from the data set.

Data Processing and Analysis – Daily and seasonal estimates of upriver fish passage were calculated from the hourly tracked fish files. Time lapses in data acquisition required adjusting tracked fish counts before the daily and seasonal totals were calculated. Count adjustments were made for partial hours, missing hours, and missing days. Partial hourly counts (>15 and < 60 min) were standardized to 1 h, using

$$E_h = (60 / T_h) \bullet C_h \, , \qquad (1)$$

where E_h = estimated hourly upriver count for hour h, T_h = number of minutes sampled in hour h, and C_h = tracked upriver count during the sampled time in hour h. Counts from hours with sample times < 15 minutes were discarded and treated as missing hours.

Fish counts from missing hours were extrapolated from mean hourly passage rates for the year. Mean hourly passage rates were calculated from days with 24 h of continuous data. First, hourly passage rates (fish/h) were calculated for all hours in each day. These hourly passage rates were expressed as proportions (%) of the daily count so high-passage days did not bias results. Then mean passage rates (%) by hour were calculated for the season. Estimated fish counts for missing hours were calculated, using

$$E_d = \sum R_{di} / (100 - \sum R_{di}) \bullet T_d \, , \qquad (2)$$

where E_d = estimated upriver fish count for missing hours in day d, R_{di} = seasonal mean hourly passage rate (%) for each missing hour i in day d, and T_d = adjusted upriver fish count for non-missing hours in day d.

Daily upriver fish counts for each bank were calculated by summing all hourly counts for that day. During high-water events, missing daily counts from the right bank were estimated from left bank counts using the ratio estimator method except for 2005 where a regression estimator was deemed more appropriate (Cochran 1977). For the season, total passage was calculated by summing all estimated daily counts. Hourly fish passage rates for each bank were plotted for the season and examined for diel patterns.

Data Analysis – Fish position data allow assessment of the likelihood of failing to detect fish that pass above, below, or beyond the detection range of the sonar beam. The spatial positions of individually tracked fish were described in two dimensions, distance offshore from the transducer (range) and vertical position in the acoustic beam. Median range values and vertical position in meters were calculated for tracked fish. Median vertical positions of tracked fish were converted to angle off-axis measurements before analyses, using

$$V_a = \text{arcsine}\,(V_d / R_d)\,, \qquad (3)$$

where V_a = vertical median angle off-axis (˚), V_d = median vertical distance off-axis (m), R_d = median distance from transducer (m). For each bank, range and vertical distributions of upriver fish were plotted for the season.

Species Evaluation

Trace pattern identification was used, along with information from video monitoring and beach seining, to omit least cisco from our counts in-season. The differences in trace patterns of chum salmon and least cisco reflect the different sizes, swimming, and schooling behaviors of these species. Other species present during the fall chum salmon run were present in very low numbers relative to the fall chum salmon.

The ability to employ both video and netting to evaluate the presence of non-target species was limited by river conditions, and was variable over the years. Because of this, data from these techniques have been considered to be qualitative. These data were only used as an indicator to maintain confidence that trace pattern identification remained a reliable means to ensure that significant numbers of fish other than chum salmon were not counted.

Netting – During 2002 - 2006 a 90 m x 3.7 m, with 2.5 cm mesh, beach seine was used, as time and conditions allowed, to qualitatively evaluate presence of non-target species. A beach seine was used instead of gill nets because seining provides a less selective sampling method and does not cause mortality inherent in gillnet sampling (Hayes et al. 1996). Seining during 2001 revealed that the majority of least cisco (the most abundant non-target species), appear in significant numbers during early September (Osborne and Melegari 2006). Therefore, seining effort during the latter years was concentrated during September, with intermittent seine sets during August.

Video – During 2002 - 2006 an underwater video system was also deployed, as conditions allowed, to monitor a portion of the ensonified area (Osborne and Melegari 2006). Effectiveness of the video system varied greatly due to lighting and water clarity.

Results

Site Selection and Sonar Deployment

During all years the sonar systems were deployed at the same approximate sites as in past seasons, and only minor changes in physical conditions were observed at the sonar deployment sites. Enumeration began on August 8 and continued through September 26 during all years except for 2004 when operations were stopped on September 22 due to low water.

Abundance Estimate and Run Timing

Data Collection – With the exception of 2002 and 2004 all years experienced periods of high water, which interrupted data collection on the right bank (Table 1 and Appendices 1 - 5). During 2006 high water also interrupted data collection on the left bank.

Data Processing and Analysis – In addition to count adjustments for missing days, counts were also adjusted for missing or partial hours. For all years the right bank accounted for a higher proportion of the estimate than the left bank (Figure 4), which is consistent with previous years Fall chum salmon passage estimates at the sonar site for 2002 - 2006 were: 89,580, 214,416, 136,703, 496,484, 245,090 respectively (Table 2 and Appendices 1 - 5). These are conservative estimates of total passage because counts only include fish that passed during the dates of sonar operation. During all years the adjusted counts on the first day of sonar operation were less than 0.8% of the total seasonal estimate for that year. Adjusted counts on the final day of counting were less than 1.7% of the total seasonal estimate for all years except 2004 (4.6%) when operations were stopped early due to low water. The peak daily estimates occurred during the first week of September during all years except 2002, when the peak daily estimate occurred on September 16.

During all years, except 2006, hourly passage rates of upriver fish showed a strong diel pattern on the left bank and a less substantial diel pattern on the right bank. During 2006 a weak diel pattern was present on the left bank but no diel pattern was exhibited on the right bank (Figure 5). When present, these patterns exhibited higher passage rates during late night/early morning hours.

Upriver migrating chum salmon were shore-oriented and most fish were well within the range of acoustic detection for both banks (Figures 6 and 7). More than 90% of upriver fish were within 12 m of the left bank transducer and 38 m of the right bank transducer during all years. Vertical fish position data showed that most upriver-swimming chum salmon were bottom-oriented (Figure 8). During all years more than 91% of upriver fish passed below the acoustic axis on the left bank, and 87% on the right bank.

Species Evaluation

Netting – Beach seining was greatly affected by water conditions resulting in varied effort between and within years, and low overall catch rates (Appendix 6). High water prohibited beach seining during 2005 for most of the fall chum salmon run and for the entire fall chum salmon run during 2003 and 2006. The variable effort and the low catch rates would not support quantitative analysis of the netting data. Overall, chum salmon were the most abundant species captured. During every year, all least cisco were captured beginning the second week of September. Other species caught included northern pike *Esox lucius*, Arctic grayling *Thymallus arcticus*, longnose sucker *Catostomus catostomus*, round whitefish *Prosopium cylindraceum*, and humpback whitefish *Coregonus pidschian*.

Video – Similar to seining, video monitoring was greatly affected by water conditions and varied considerably between years. Video operations during these years have consisted of in-season monitoring of video. The results of video monitoring agree with the seining data, showing chum salmon as the most abundant species, followed by least cisco, which began appearing the second week of September. Other species seen in the video were the same as those captured in the seine, and were a small portion of the fish observed. The video images have allowed periodic corroboration of sonar trace pattern signatures with species present during operations.

Discussion

The trend of the Chandalar River having one of the highest estimates of monitored fall chum salmon spawning streams in the upper Yukon River continued during 2002 – 2006 (other 2006 data is preliminary; Table 3). During these years the Chandalar River fall chum salmon estimate ranged from 31% to 50% of the combined total of the upper Yukon River enumeration projects (i.e., Chandalar River sonar, Sheenjek River sonar, Fishing Branch River weir, and Canadian border mark-recapture estimate on the mainstem of the Yukon River) (Bue et al. 2004; JTC 2006).

Fish position data during all years were similar to previous years, and suggested that most upriver fish passing the sonar site were within the ensonified zone. Upriver fish were found close to shore and near the bottom. Few fish were found near the vertical or outer range limits of acoustic detection. This shore/bottom orientation is consistent with previous behavioral observations of upriver-migrating fall chum salmon on the Chandalar (Osborne and Melegari 2006), Sheenjek (Barton 1995) and mainstem Yukon rivers (Johnston et al. 1993).

Species identification is important to obtaining accurate counts of chum salmon. Comparison of sonar and video data indicated that we can adequately exclude least cisco from counts by trace pattern identification (Osborne and Melegari 2006). Beach seining and underwater video monitoring have been employed to evaluate the presence of other species. Both of these methods have been highly dependent on water conditions. Video can only be used when the water clarity allows. Beach seining success is affected by current velocity and water clarity. Boat control and conducting effective seine sets becomes increasingly difficult as current increases. Conversely as water levels drop and water clarity increases we believe that net avoidance behavior increases substantially. Because of this dependence on water conditions, and the low catch rates, further quantitative analysis of these data, beyond the video/split-beam comparison conducted during 2001 (Osborne and Melegari 2006), would not provide additional information. During 2001 seining and video data collection were much more extensive than the following years (Osborne and Melegari 2006). These data showed chum salmon to be the most abundant species followed by least cisco, which were caught mostly in September. Other species made up a small percentage of the catch and were the same species described in this report. This same pattern of relative abundance and timing is suggested by the 2002 - 2006 data. The netting and video data do provide practical qualitative information which helps to evaluate sonar operations, provides an indication of species presence during sonar operations, and increases confidence that the sonar is providing an accurate count of fall chum salmon.

2002

Abundance Estimate and Run Timing – The 2002 passage estimate of 89,580 fish was 61% of the average from 1995 - 2001, continuing the trend of below average returns (Figure 9). Fall chum salmon escapements to other major spawning grounds in the upper Yukon River drainage were also low during 2002 (JTC 2006).

The median passage date was September 12, 6 days later than the average for 1995 - 2001. The first quartile passage date, September 1, occurred 3 days later than the average for 1995 - 2001. However, the 1998 run was substantially later than in other years, i.e., 11 days later in both median and first quartile passage dates (Figures 10 and 11).

On the left bank, acoustic data were collected for 98% of the season and few adjustments were made to the tracked fish count, with tracked fish representing 98% of the left bank's total estimate. For the right bank, acoustic data were collected for 95% of the season, and tracked fish represented 98% of the right bank's total estimate. There were no complete days missed during 2002.

2003

Abundance Estimate and Run Timing – The 2003 passage estimate of 214,416 fish was 153% of the average from 1995 - 2002, and was the highest estimate of the previous 6 years (Figure 9). Fall chum salmon escapement estimates for other major spawning grounds in the upper Yukon River drainage also showed an increase over the previous several years (JTC 2006).

The median passage date was September 3, 4 days earlier than the average for 1995 - 2002. The first quartile passage date, August 27, occurred 4 days earlier than the average for 1995 - 2002 (Figures 10 and 11).

On the left bank, acoustic data were collected for 97% of the season and few adjustments were made to the tracked fish count, with tracked fish representing 98% of the left bank's total estimate. For the right bank, acoustic data were collected for 38% of the season, and tracked fish represented 23% of the right bank's total estimate. The largest potential source of error was in estimating daily right bank counts for the 30 missing days due to high water.

2004

Abundance Estimate and Run Timing – The 2004 passage estimate of 136,703 fish was 93% the average from 1995 - 2003. While not as high as the estimate for 2003 the 2004 estimate was higher than estimates for the 5 years prior to 2003 (Figure 9). Fall chum salmon escapements to other major spawning grounds in the upper Yukon River drainage showed a similar trend during 2004 (JTC 2006).

The median passage date was September 7, 1 day later than the average for 1995 - 2003. The first quartile passage date, September 1, occurred 3 days later than the average for 1995 - 2003 (Figures 10 and 11).

On the left bank, acoustic data were collected for 96% of the season and few adjustments were made to the tracked fish count, with tracked fish representing 94% of the left bank's total estimate. For the right bank, acoustic data were collected for 91% of the season, and tracked fish represented 97% of the right bank's total estimate. There were no complete days missed during 2004.

2005

Abundance Estimate and Run Timing – The 2005 abundance estimate of 496,484 fish was the largest estimate to date (nearly 77% greater than 1995, the next highest estimate) , and was more than 3 times greater than the 1995 - 2004 average (Figure 9). Fall chum salmon escapements to other major spawning grounds in the upper Yukon River drainage were also high during 2005 (JTC 2006).

The median passage date was September 6, 1 day earlier than the average for 1995 - 2004. The first quartile passage date, August 30, occurred 1 day later than the average for 1995 - 2004 (Figures 10 and 11).

On the left bank, acoustic data were collected for 96% of the season and few adjustments were made to the tracked fish count, with tracked fish representing 98% of the left bank's total estimate. For the right bank, acoustic data were collected for 60% of the season, and tracked fish represented 88% of the right bank's total estimate. The largest potential source of error was in estimating daily right bank counts for the 20 missing days due to high water.

2006

Abundance Estimate and Run Timing – The 2006 abundance estimate of 245,090 fish was 137% the average from 1995 - 2005, and was the third highest estimate to date (Figure 9). Preliminary data suggest that fall chum escapements to most other major spawning grounds in the upper Yukon River drainage were near or above 1995 - 2005 averages.

The median passage date was September 6, 1 day earlier than the average for 1995 - 2005. The first quartile passage date, August 31, occurred on the average for 1995 - 2005 (Figures 10 and 11).

On the left bank, acoustic data were collected for 80% of the season with tracked fish representing 84% of the left bank's total estimate. For the right bank, acoustic data were collected for 52% of the season, and tracked fish represented 54% of the right bank's total estimate. The largest potential source of error was in estimating daily counts for the 22 missing days on the right bank, and the 8 missing days on the left bank due to high water.

Recommendations

Annual sonar enumeration of fall chum salmon in the Chandalar River is important and should continue, based on its contribution to the total run of Yukon River fall chum salmon and the importance of the stock to subsistence users throughout the drainage. Daily in-season counts and post-season passage estimates provide important escapement information and should continue to be provided to managers.

Video monitoring and beach seining are both greatly impacted by water conditions. However, this additional information is beneficial to evaluating sonar performance and the presence of non-target species, with little to no additional costs, and should be continued as conditions allow.

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Table 1. – Hydroacoustic data collected at the Chandalar River from 2002 - 2006.

Year	Sample time (h)			Complete days missed			% of season monitored[b]			Fish tracked
	Left bank	Right bank	Total	Left bank	Right bank	Total bank-days	Left bank	Right bank	Total	
2002	1,176	1,140	2,316	0	0	0	98	95	97	87,664
2003	1,163	461	1,624	0	29[a]	29	97	38	68	100,684
2004[c]	1,062	1,004	2,066	0	1[d]	1	96	91	94	132,198
2005	1,154	709	1,863	0	20[a]	20	96	59	78	332,283
2006	961	625	1,586	8[a]	22[a]	30	80	52	66	151,092

[a] Sonar was shutdown due to high water.
[b] Percentage of total hours available from the first day to the last day of operations for each year.
[c] Sonar operation ended 4 days earlier than other years.
[d] Sonar was inoperable due to technical difficulties.

Table 2 – Fall chum salmon passage estimates for the Chandalar River from 2002 - 2006

Year	Passage estimates			First day estimate[a]	Last day estimate[a]	Peak daily estimate & date of occurrence	
	Left bank[a]	Right bank[a]	Total				
2002	24,188(27)	65,392(73)	89,580	216(0.2)	1,272(1.4)	4,152	Sep.16
2003	68,825(32)	145,591(68)	214,416	310(0.1)	1,801(0.8)	10,954	Sep. 4
2004	29,851(22)	106,852(78)	136,703	904(0.7)	6,403(4.6)	7,167	Sep. 4
2005	159,937(32)	336,547(68)	496,484	2,819(0.6)	7,892(1.6)	25,251	Sep. 5
2006	63,123(26)	181,967(74)	245,090	570(0.2)	2,519(1.0)	11,819	Sep. 3

[a] Values in parentheses are the percent of the total passage estimate for that season.

Table 3 – Passage/escapement estimates from major fall chum salmon spawning streams in the upper Yukon River, 1995 - 2005.

Year	Chandalar River	Sheenjek River[a]	Fishing Branch River[a]	Canadian Border Passage Estimate[a]
1995	280,999	241,855	51,971	198,203
1996	208,170	246,889	77,278	143,758
1997	199,874	80,423	26,959	94,725
1998	75,811	33,058	13,564	48,047
1999	88,662	14,229	12,904	72,188
2000	65,894	30,084	5,053	57,978
2001	110,971	53,932	21,669	38,769
2002	89,580	31,642	13,563	104,853
2003	214,416	44,047	29,519	153,656
2004	136,703	37,877	20,274	163,625
2005	496,484	438,253	121,413	451,477
2006	245,090	160,178[b]	30,233[b]	217,810[b]

[a] Data for 1995 – 2005 from JTC 2006. Data for 2006 from R. Dunbar, Alaska Department of Fish and Game, personnel communication.
[b] These data are preliminary and should not be reproduced without being verified with other sources.

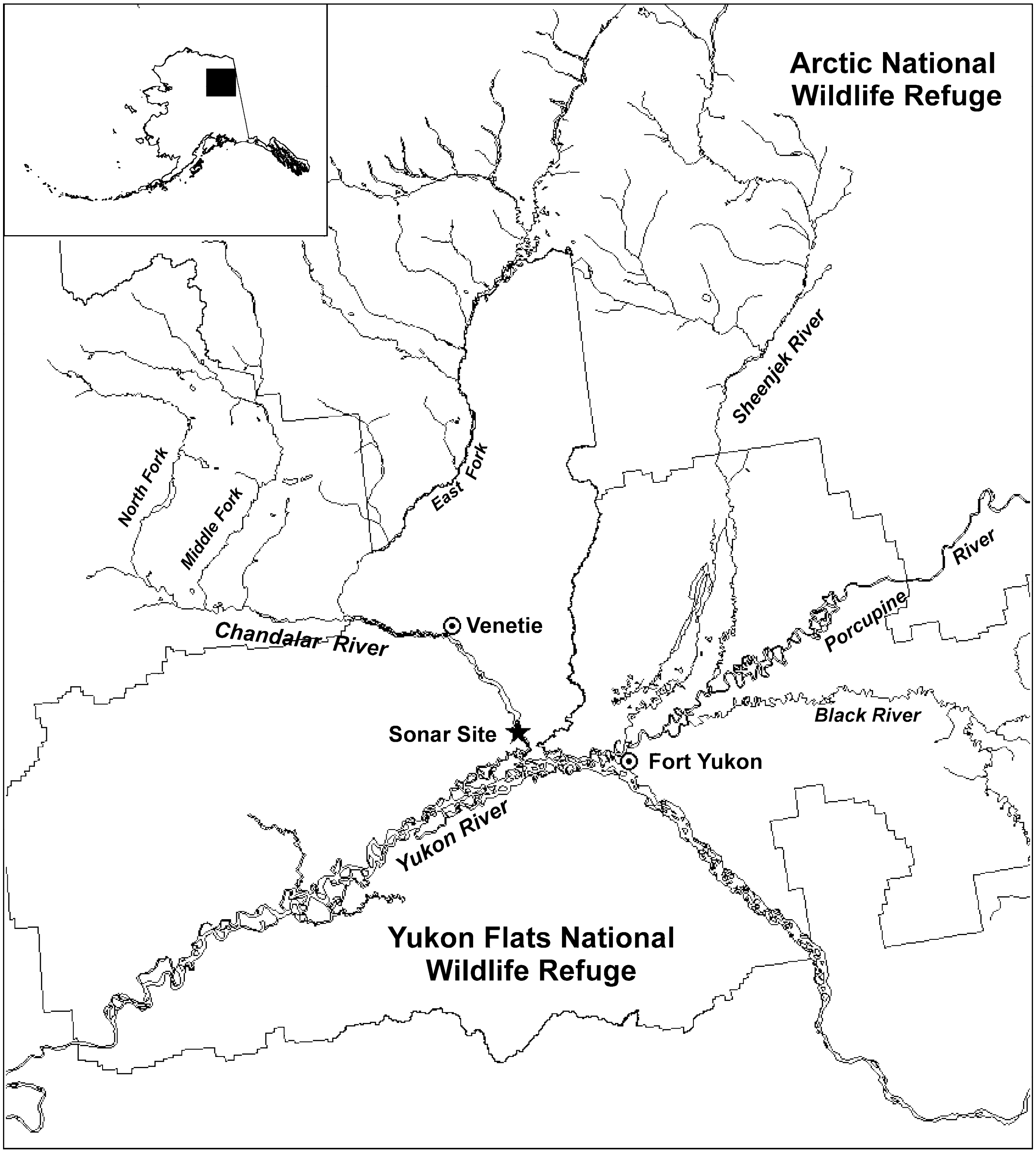

Figure 1. — Sonar site and major tributaries of the Yukon River near U.S. Canada border.

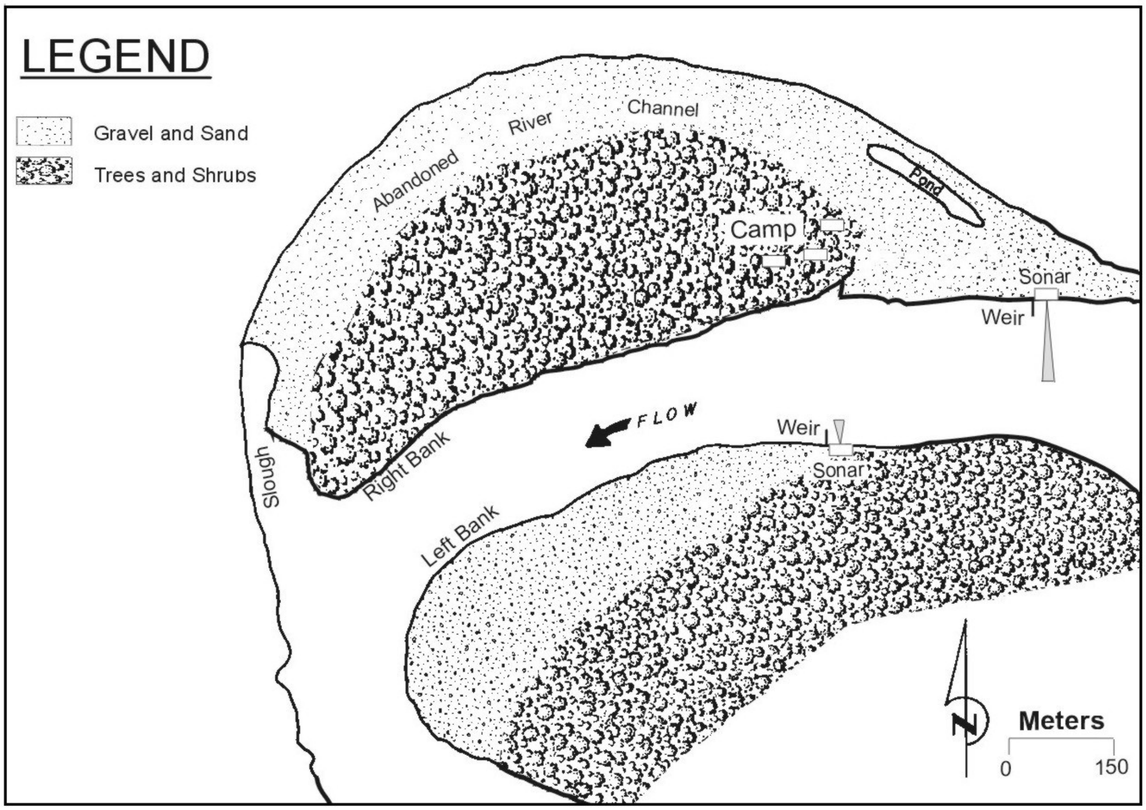

Figure 2. — Site map of Chandalar River sonar facilities.

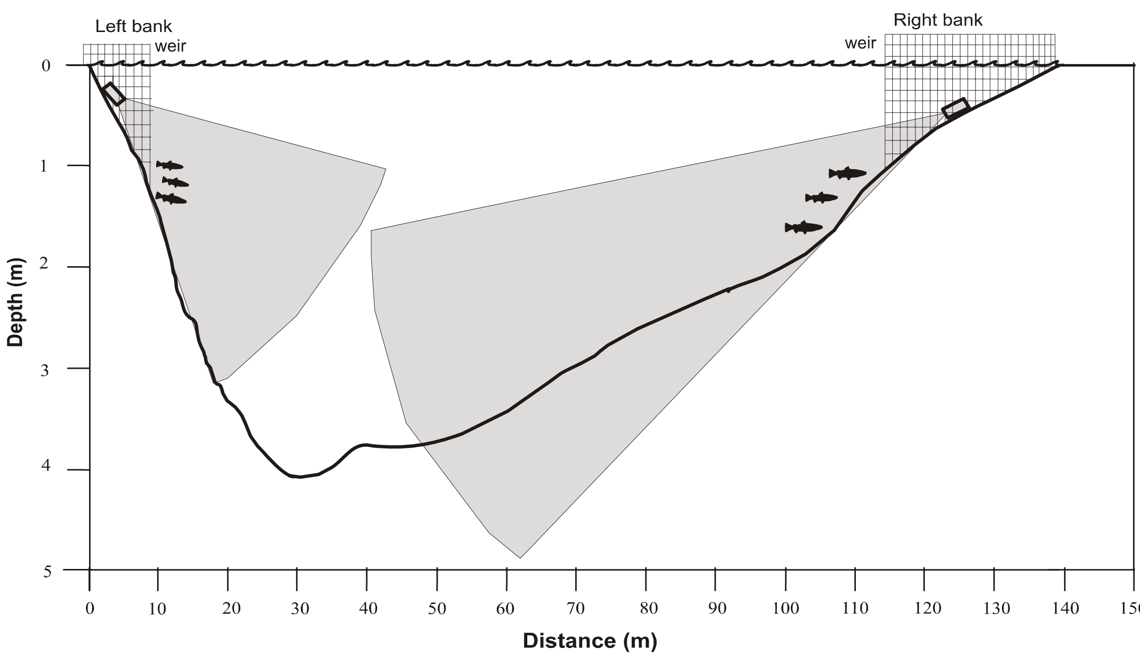

Figure 3. — River channel profile and estimated ensonified zones of the left and right banks, Chandalar River. Different axis scales are used to enhance readability.

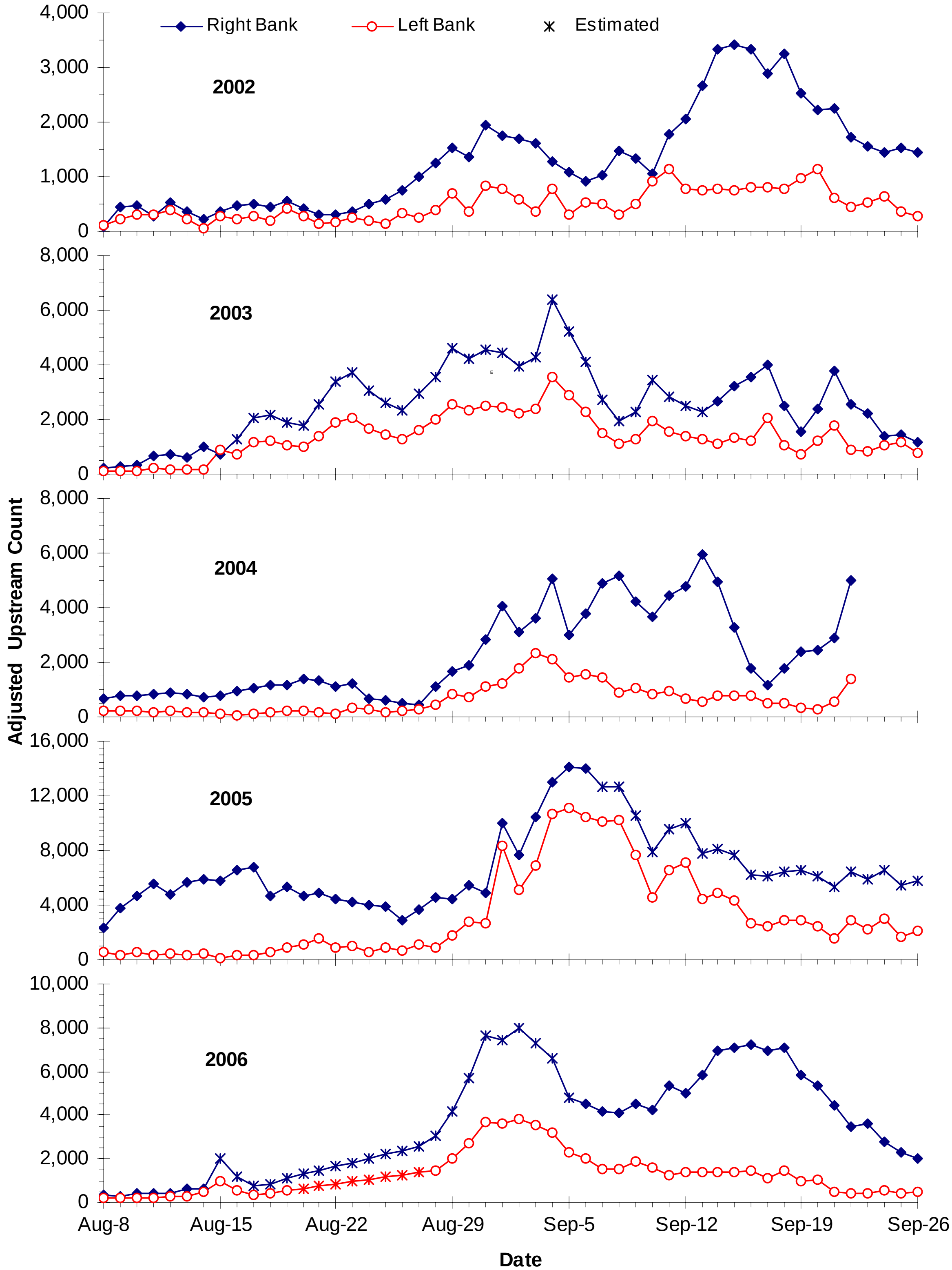

Figure 4. — Adjusted daily counts of upriver swimming fall chum salmon by bank, Chandalar River, 2002 - 2006. Note different scales on y axis

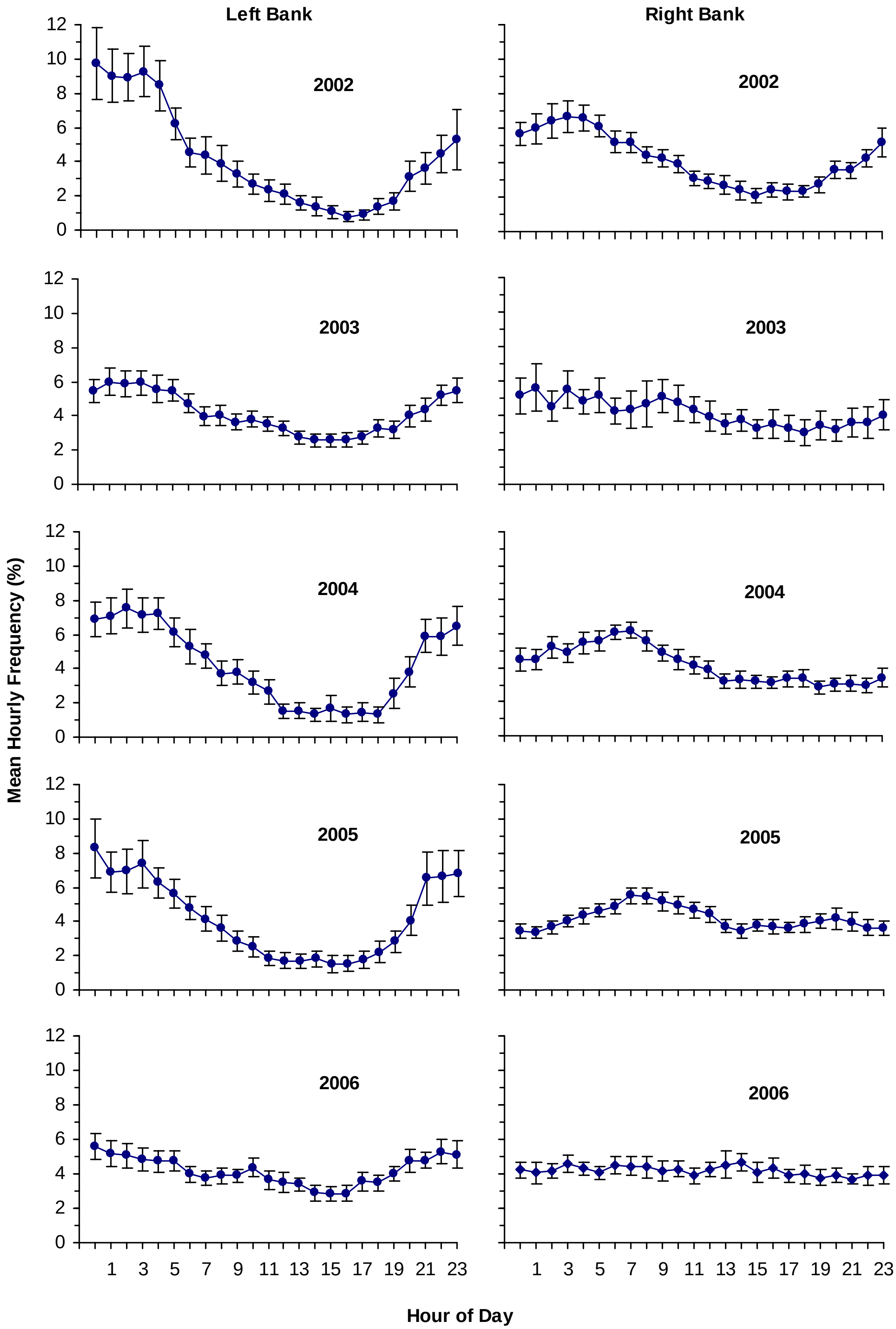

Figure 5. — Mean (± 2 SE) hourly frequencies of upriver swimming fish, Chandalar River, 2002 - 2006.

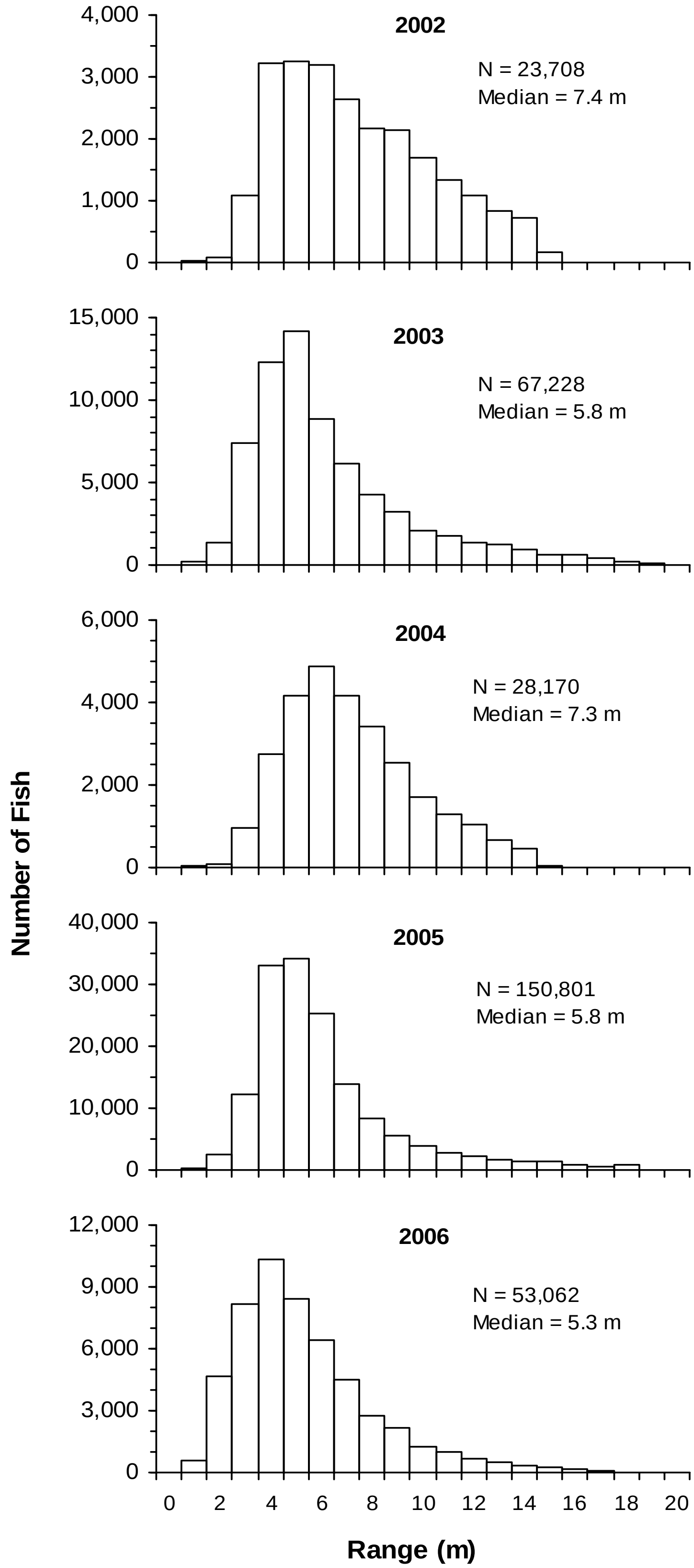

Figure 6. — Range (horizontal distance from transducer) distributions of upriver swimming fish, from hydroacoustic data collected on the left bank Chandalar River, 2002 - 2006. Note different scales on y axis.

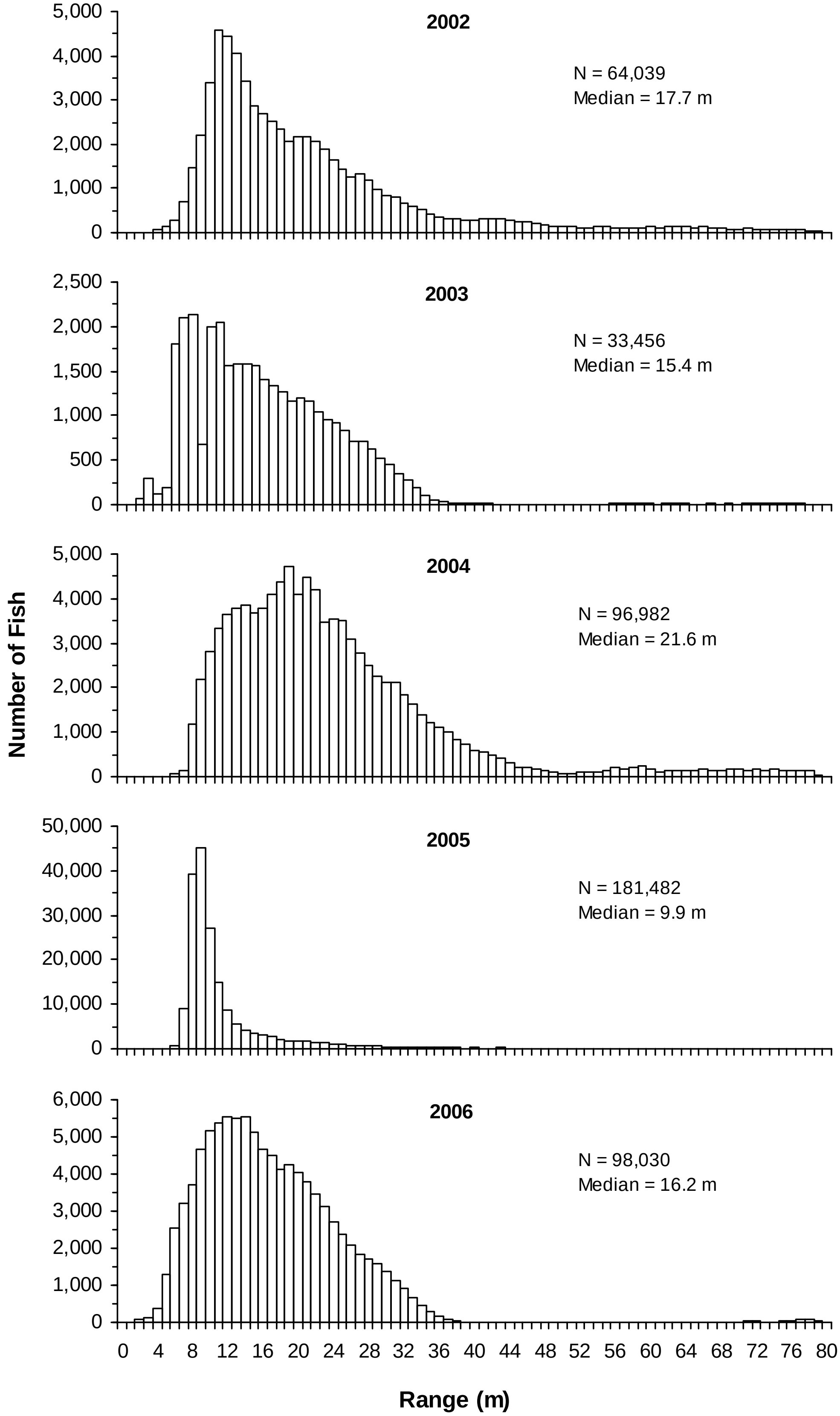

Figure 7. — Range (horizontal distance from transducer) distributions of upriver swimming fish, from hydroacoustic data collected on the right bank Chandalar River, 2002 - 2006. Note different scales on y axis. The N value for 2004 does not match the unadjusted count presented in appendix 4.A due to corruption of some data files before range analysis.

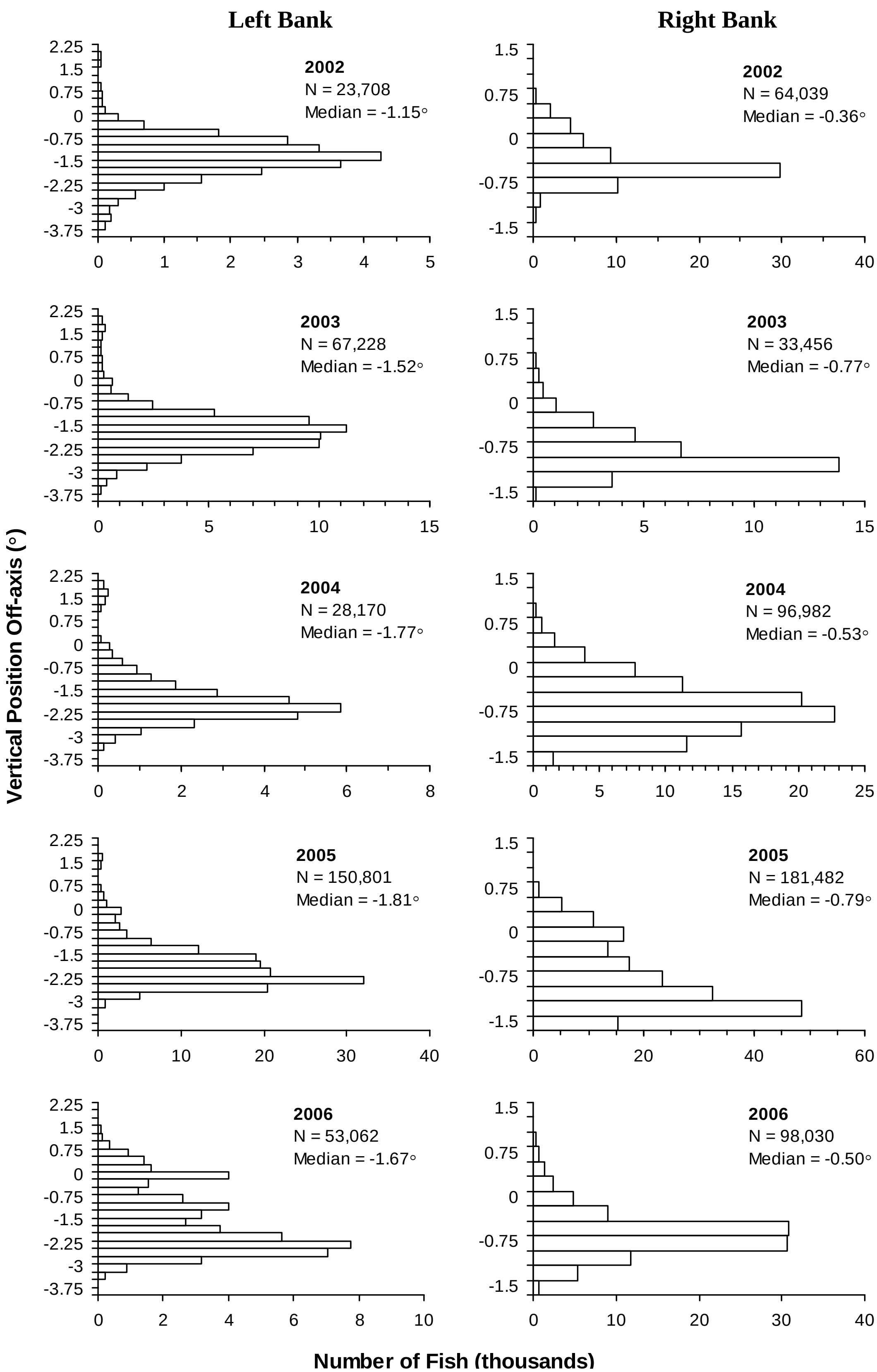

Figure 8. — Vertical distributions of upriver swimming fish, from hydroacoustic data collected on the Chandalar River, 2002 - 2006. The N value for right bank 2004 does not match the unadjusted count presented in appendix 4.A due to corruption of some data files before vertical position analysis.

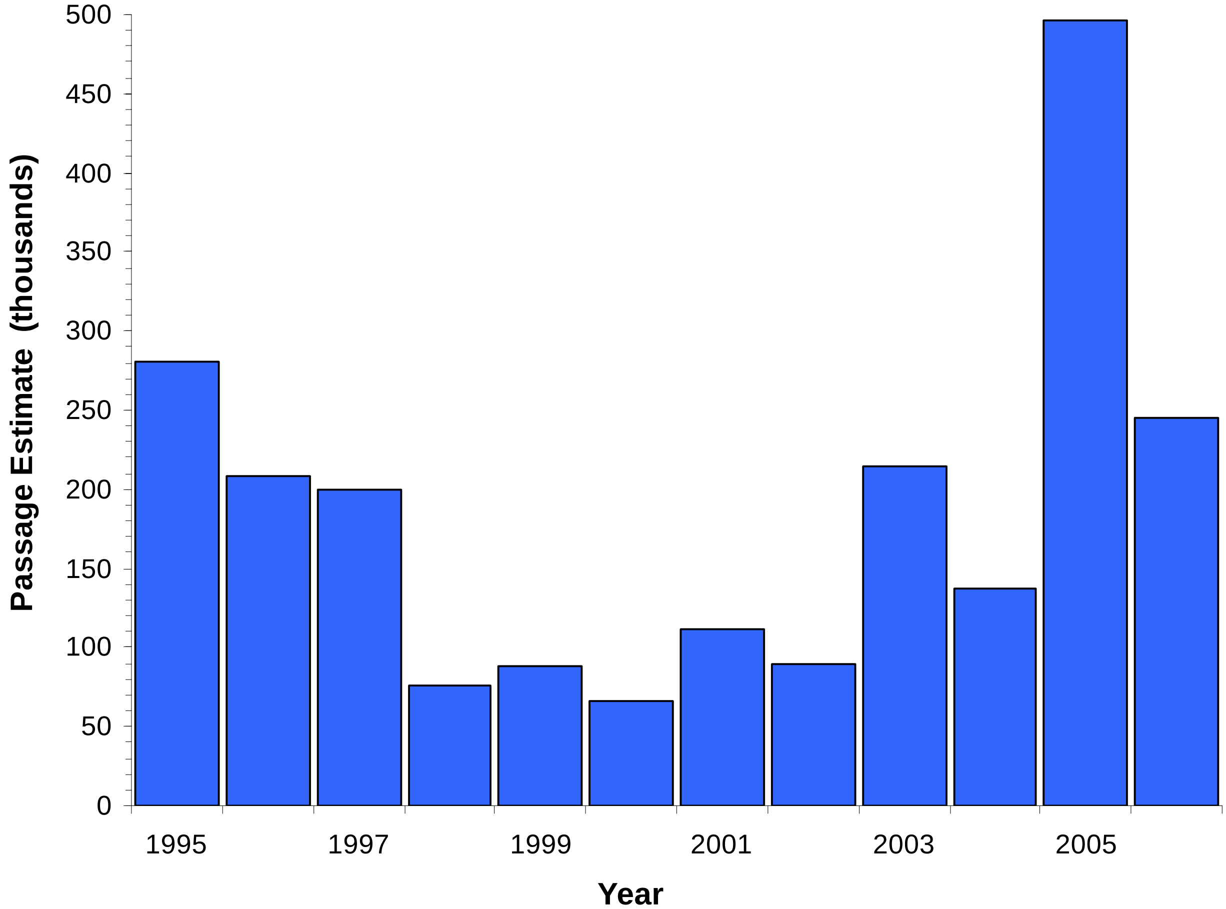

Figure 9. — Annual passage estimates of fall chum salmon from sonar counts in the Chandalar River, 1995 - 2006.

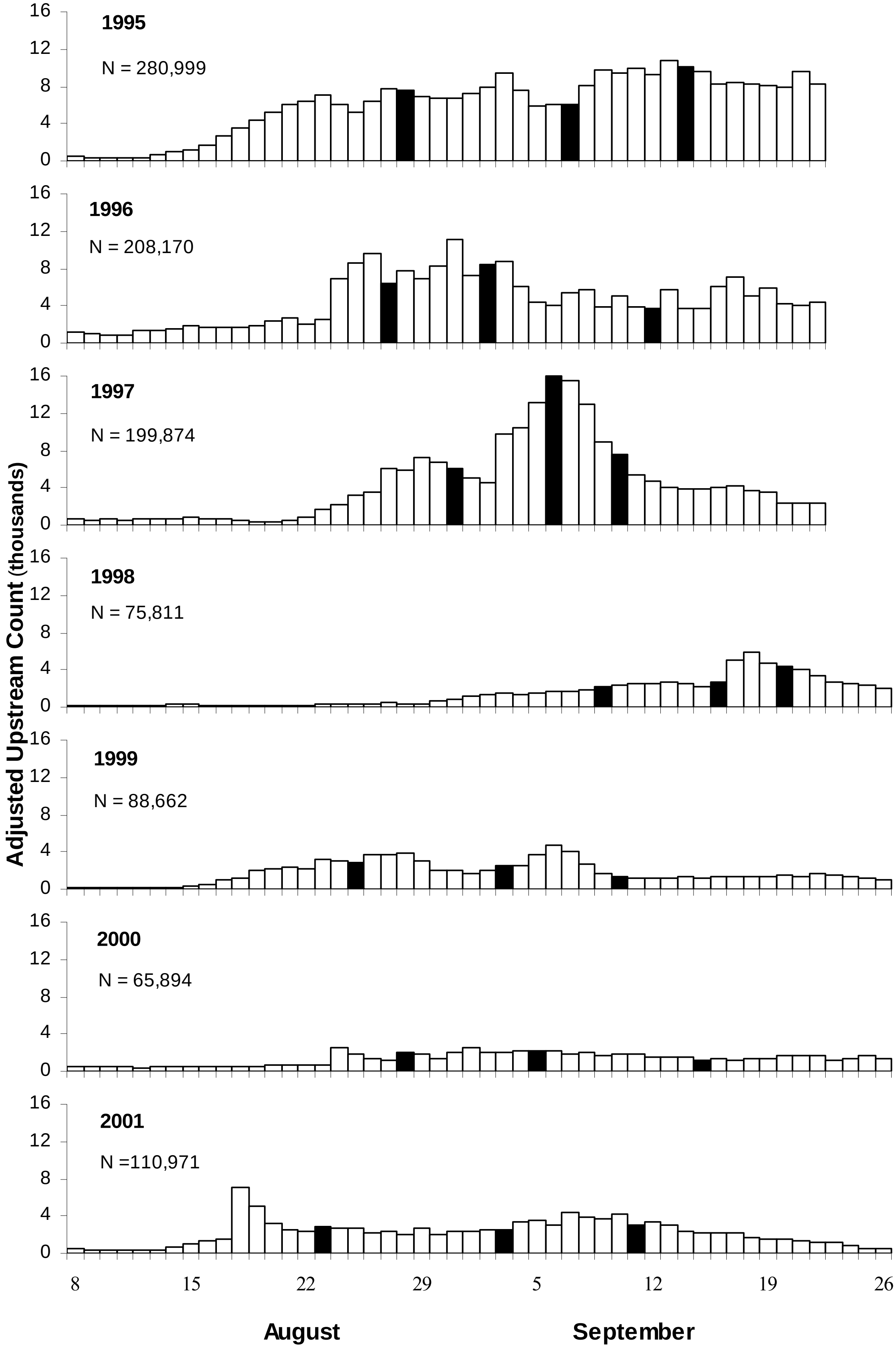

Figure 10. — Adjusted daily counts of upriver swimming fall chum salmon, Chandalar River, 1995 - 2001. Shaded bars represent quartiles.

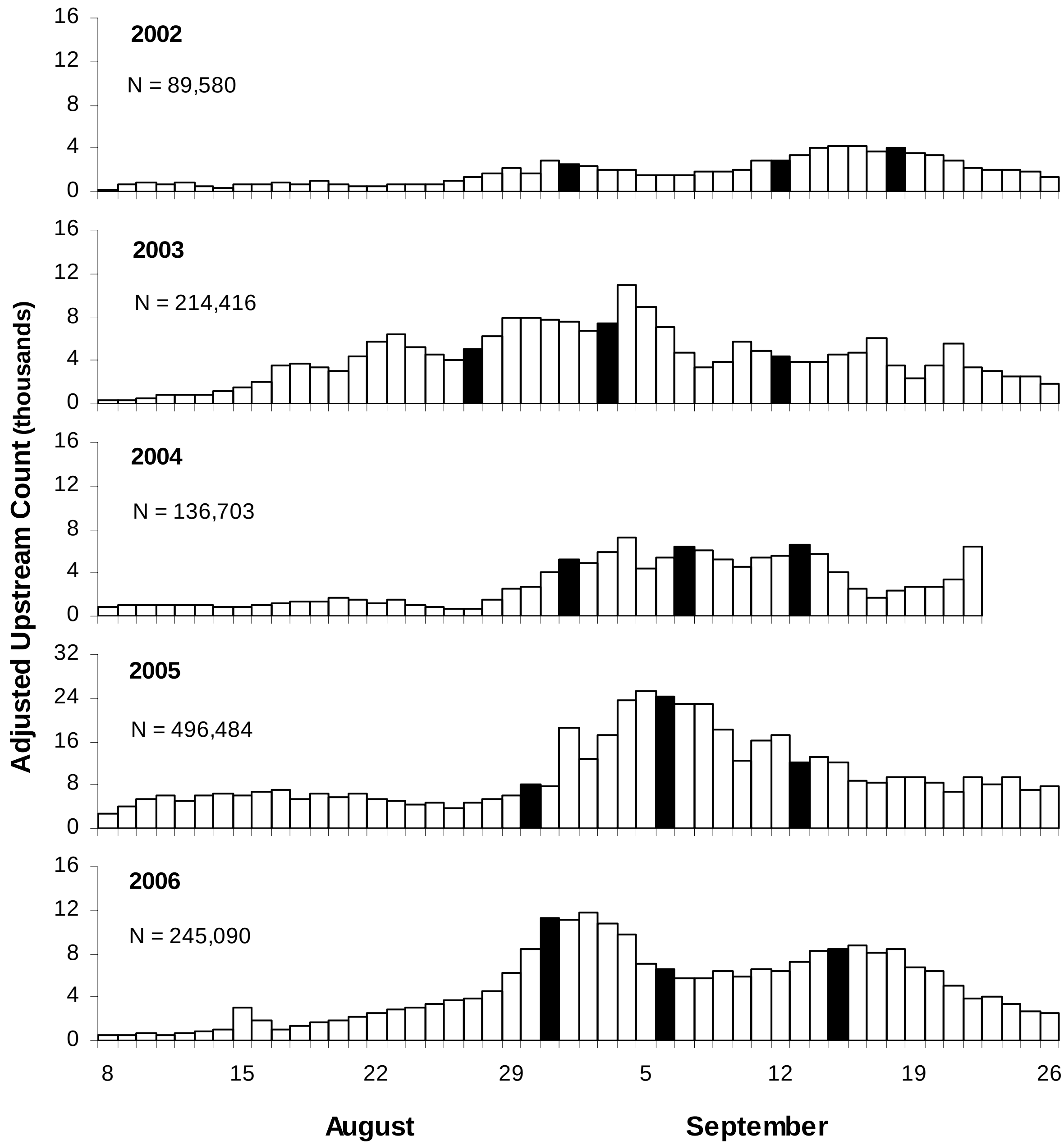

Figure 11. — Adjusted daily counts of upriver swimming fall chum salmon, Chandalar River, 2002 - 2006. Shaded bars represent quartiles.

Appendix 1.A. — Daily unadjusted upriver fish counts from hydroacoustic data collected at the Chandalar River, 2002.

	Left bank		Right bank		Total	
Date	Sample time (h)[a]	Count	Sample time (h)[a]	Count	Sample time (h)[a]	Count
Aug-08	23.91	124	8.00	86	31.91	210
Aug-09	23.94	226	23.02	417	46.96	643
Aug-10	22.98	299	24.00	463	46.98	762
Aug-11	23.98	309	23.99	292	47.97	601
Aug-12	23.94	375	23.98	527	47.92	902
Aug-13	23.22	217	23.79	344	47.01	561
Aug-14	23.92	55	23.95	214	47.87	269
Aug-15	23.88	269	17.30	252	41.18	521
Aug-16	23.94	231	23.99	460	47.93	691
Aug-17	23.96	264	20.68	438	44.64	702
Aug-18	22.23	180	14.14	249	36.37	429
Aug-19	23.99	406	24.00	553	47.99	959
Aug-20	20.60	234	24.00	416	44.60	650
Aug-21	23.96	150	23.96	318	47.92	468
Aug-22	24.00	177	21.89	285	45.89	462
Aug-23	24.00	251	23.97	353	47.97	604
Aug-24	23.98	193	24.06	507	48.04	700
Aug-25	24.00	144	23.97	577	47.97	721
Aug-26	23.96	296	23.99	740	47.95	1,036
Aug-27	24.00	121	23.79	1,002	47.79	1,123
Aug-28	23.99	385	24.00	1,257	47.99	1,642
Aug-29	23.96	703	23.99	1,527	47.95	2,230
Aug-30	23.98	362	23.98	1,359	47.96	1,721
Aug-31	24.00	845	23.97	1,941	47.97	2,786
Sep-01	24.00	783	23.09	1,695	47.09	2,478
Sep-02	23.96	596	23.99	1,683	47.95	2,279
Sep-03	23.13	319	23.99	1,624	47.12	1,943
Sep-04	24.00	768	24.00	1,270	48.00	2,038
Sep-05	23.98	308	22.92	1,040	46.90	1,348
Sep-06	23.98	537	23.92	918	47.90	1,455
Sep-07	23.81	504	19.56	872	43.37	1,376
Sep-08	24.00	304	23.24	1,424	47.24	1,728
Sep-09	23.46	486	24.00	1,346	47.46	1,832
Sep-10	24.00	930	24.00	1,051	48.00	1,981
Sep-11	23.91	1,146	24.00	1,769	47.91	2,915
Sep-12	23.95	763	23.22	1,985	47.17	2,748
Sep-13	23.69	735	24.00	2,665	47.69	3,400
Sep-14	23.53	771	24.00	3,332	47.53	4,103
Sep-15	23.00	725	23.98	3,407	46.98	4,132
Sep-16	24.00	814	24.00	3,338	48.00	4,152
Sep-17	23.98	791	24.00	2,879	47.98	3,670
Sep-18	23.60	763	24.00	3,251	47.60	4,014
Sep-19	23.94	956	23.99	2,530	47.93	3,486
Sep-20	24.00	1,130	24.00	2,226	48.00	3,356
Sep-21	23.98	604	24.01	2,242	47.99	2,846
Sep-22	24.00	440	23.97	1,732	47.97	2,172
Sep-23	23.94	528	24.00	1,549	47.94	2,077
Sep-24	23.69	641	24.00	1,452	47.69	2,093
Sep-25	23.96	370	24.00	1,533	47.96	1,903
Sep-26	12.00	180	12.00	649	24.00	829
Total	1,175.81	23,708	1,140.29	64,039	2,316.10	87,747

[a] Times are recorded to the nearest second by the computer, then converted to decimal hours.

Appendix 1.B. — Daily adjusted fall chum salmon count, Chandalar River, 2002.

Date	Left bank	Right bank	Combined	Cumulative	Cumulative (%)
Aug-08	125	91	216	216	0.24
Aug-09	227	435	662	878	0.98
Aug-10	309	463	772	1,650	1.84
Aug-11	309	291	600	2,250	2.51
Aug-12	378	527	905	3,155	3.52
Aug-13	224	348	572	3,727	4.16
Aug-14	55	215	270	3,997	4.46
Aug-15	270	386	656	4,653	5.19
Aug-16	231	460	691	5,344	5.96
Aug-17	264	513	777	6,121	6.83
Aug-18	184	532	716	6,837	7.63
Aug-19	406	553	959	7,796	8.70
Aug-20	259	416	675	8,471	9.45
Aug-21	150	319	469	8,940	9.97
Aug-22	177	301	478	9,418	10.51
Aug-23	251	353	604	10,022	11.18
Aug-24	193	507	700	10,722	11.96
Aug-25	144	577	721	11,443	12.77
Aug-26	325	741	1,066	12,509	13.96
Aug-27	340	1,003	1,343	13,852	15.46
Aug-28	385	1,259	1,644	15,496	17.29
Aug-29	703	1,527	2,230	17,726	19.78
Aug-30	362	1,359	1,721	19,447	21.70
Aug-31	845	1,945	2,790	22,237	24.82
Sep-01	783	1,746	2,529	24,766	27.64
Sep-02	596	1,685	2,281	27,047	30.19
Sep-03	345	1,624	1,969	29,016	32.39
Sep-04	768	1,270	2,038	31,054	34.66
Sep-05	308	1,161	1,469	32,523	36.30
Sep-06	537	920	1,457	33,980	37.93
Sep-07	504	987	1,491	35,471	39.59
Sep-08	304	1,476	1,780	37,251	41.58
Sep-09	511	1,346	1,857	39,108	43.65
Sep-10	930	1,051	1,981	41,089	45.86
Sep-11	1,149	1,773	2,922	44,011	49.13
Sep-12	764	2,066	2,830	46,841	52.28
Sep-13	745	2,665	3,410	50,251	56.09
Sep-14	780	3,332	4,112	54,363	60.68
Sep-15	738	3,409	4,147	58,510	65.31
Sep-16	814	3,338	4,152	62,662	69.95
Sep-17	792	2,879	3,671	66,333	74.04
Sep-18	782	3,251	4,033	70,366	78.55
Sep-19	959	2,531	3,490	73,856	82.44
Sep-20	1,130	2,226	3,356	77,212	86.19
Sep-21	604	2,242	2,846	80,058	89.37
Sep-22	439	1,735	2,174	82,232	91.79
Sep-23	528	1,549	2,077	84,309	94.11
Sep-24	643	1,452	2,095	86,404	96.45
Sep-25	371	1,533	1,904	88,308	98.58
Sep-26	248	1,024	1,272	89,580	100
Total	24,188	65,392	89,580		

Appendix 2.A. — Daily unadjusted upriver fish counts from hydroacoustic data collected at the Chandalar River, 2003.

	Left bank		Right bank		Total	
Date	Sample time (h)[a]	Count	Sample time (h)[a]	Count	Sample time (h)[a]	Count
Aug-08	23.96	110	23.96	200	47.92	310
Aug-09	23.96	129	24.00	266	47.96	395
Aug-10	23.73	98	24.00	350	47.73	448
Aug-11	24.00	203	24.00	669	48.00	872
Aug-12	24.00	177	23.50	705	47.50	882
Aug-13	24.00	182	23.97	609	47.97	791
Aug-14	12.96	104	21.08	864	34.04	968
Aug-15	23.78	849	22.72	675	46.50	1,524
Aug-16	23.18	597	0.00 [b]	-	23.18	597
Aug-17	24.00	1,146	0.00 [b]	-	24.00	1,146
Aug-18	24.00	1,209	0.00 [b]	-	24.00	1,209
Aug-19	23.78	1,057	0.00 [b]	-	23.78	1,057
Aug-20	23.84	966	0.00 [b]	-	23.84	966
Aug-21	24.00	1,408	0.00 [b]	-	24.00	1,408
Aug-22	23.52	1,839	0.00 [b]	-	23.52	1,839
Aug-23	24.00	2,074	0.00 [b]	-	24.00	2,074
Aug-24	23.96	1,687	0.00 [b]	-	23.96	1,687
Aug-25	23.98	1,462	0.00 [b]	-	23.98	1,462
Aug-26	23.90	1,285	0.00 [b]	-	23.90	1,285
Aug-27	24.00	1,637	0.00 [b]	-	24.00	1,637
Aug-28	23.94	1,986	0.00 [b]	-	23.94	1,986
Aug-29	23.70	2,528	0.00 [b]	-	23.70	2,528
Aug-30	17.91	1,752	0.00 [b]	-	17.91	1,752
Aug-31	23.90	2,518	0.00 [b]	-	23.90	2,518
Sep-01	23.98	2,462	0.00 [b]	-	23.98	2,462
Sep-02	23.99	2,196	0.00 [b]	-	23.99	2,196
Sep-03	23.96	2,370	0.00 [b]	-	23.96	2,370
Sep-04	24.00	3,535	0.00 [b]	-	24.00	3,535
Sep-05	23.98	2,895	0.00 [b]	-	23.98	2,895
Sep-06	23.98	2,274	0.00 [b]	-	23.98	2,274
Sep-07	23.98	1,505	0.00 [b]	-	23.98	1,505
Sep-08	23.95	1,091	0.00 [b]	-	23.95	1,091
Sep-09	23.83	1,253	0.00 [b]	-	23.83	1,253
Sep-10	20.98	1,683	0.00 [b]	-	20.98	1,683
Sep-11	23.93	1,562	0.00 [b]	-	23.93	1,562
Sep-12	23.98	1,396	0.00 [b]	-	23.98	1,396
Sep-13	23.87	1,272	0.00 [b]	-	23.87	1,272
Sep-14	23.91	1,101	0.00 [b]	-	23.91	1,101
Sep-15	23.98	1,305	24.00	3,214	47.98	4,519
Sep-16	23.94	1,206	23.99	3,579	47.93	4,785
Sep-17	23.75	2,033	24.00	4,003	47.75	6,036
Sep-18	24.00	1,064	23.96	2,497	47.96	3,561
Sep-19	23.96	735	24.00	1,571	47.96	2,306
Sep-20	23.96	1,229	24.00	2,362	47.96	3,591
Sep-21	23.94	1,759	24.00	3,787	47.94	5,546
Sep-22	24.00	881	23.00	2,458	47.00	3,339
Sep-23	22.98	814	23.98	2,202	46.96	3,016
Sep-24	24.00	1,071	24.00	1,395	48.00	2,466
Sep-25	24.00	1,150	23.99	1,439	47.99	2,589
Sep-26	12.00	383	10.98	611	22.98	994
Total	1,162.83	67,228	461.13	33,456	1,623.96	100,684

[a] Times are recorded to the nearest second by the computer, then converted to decimal hours.
[b] Right bank was shutdown due to high water.

Appendix 2.B. — Daily adjusted fall chum salmon count, Chandalar River, 2003.

Date	Left bank	Right bank	Combined	Cumulative	Cumulative (%)
Aug-08	110	200	310	310	0.14
Aug-09	129	266	395	705	0.33
Aug-10	99	350	449	1,154	0.54
Aug-11	203	669	872	2,026	0.94
Aug-12	177	717	894	2,920	1.36
Aug-13	182	610	792	3,712	1.73
Aug-14	229	964	1,193	4,905	2.29
Aug-15	866	732	1,598	6,503	3.03
Aug-16	639	1,341*	1,980	8,483	3.96
Aug-17	1,146	2,405*	3,551	12,034	5.61
Aug-18	1,209	2,537*	3,746	15,780	7.36
Aug-19	1,063	2,231*	3,294	19,074	8.90
Aug-20	973	2,042*	3,015	22,089	10.30
Aug-21	1,408	2,955*	4,363	26,452	12.34
Aug-22	1,868	3,920*	5,788	32,240	15.04
Aug-23	2,074	4,353*	6,427	38,667	18.03
Aug-24	1,690	3,547*	5,237	43,904	20.48
Aug-25	1,464	3,072*	4,536	48,440	22.59
Aug-26	1,288	2,703*	3,991	52,431	24.45
Aug-27	1,637	3,436*	5,073	57,504	26.82
Aug-28	1,991	4,179*	6,170	63,674	29.70
Aug-29	2,548	5,348*	7,896	71,570	33.38
Aug-30	2,575	5,404*	7,979	79,549	37.10
Aug-31	2,526	5,302*	7,828	87,377	40.75
Sep-01	2,465	5,174*	7,639	95,016	44.31
Sep-02	2,198	4,613*	6,811	101,827	47.49
Sep-03	2,374	4,983*	7,357	109,184	50.92
Sep-04	3,535	7,419*	10,954	120,138	56.03
Sep-05	2,897	6,080*	8,977	129,115	60.22
Sep-06	2,275	4,775*	7,050	136,165	63.51
Sep-07	1,506	3,161*	4,667	140,832	65.68
Sep-08	1,093	2,294*	3,387	144,219	67.26
Sep-09	1,258	2,640*	3,898	148,117	69.08
Sep-10	1,826	3,832*	5,658	153,775	71.72
Sep-11	1,567	3,289*	4,856	158,631	73.98
Sep-12	1,397	2,932*	4,329	162,960	76.00
Sep-13	1,276	2,678*	3,954	166,914	77.85
Sep-14	1,104	2,691*	3,795	170,709	79.62
Sep-15	1,306	3,214*	4,520	175,229	81.72
Sep-16	1,209	3,580*	4,789	180,018	83.96
Sep-17	2,046	4,003	6,049	186,067	86.78
Sep-18	1,064	2,501	3,565	189,632	88.44
Sep-19	736	1,571	2,307	191,939	89.52
Sep-20	1,230	2,362	3,592	195,531	91.19
Sep-21	1,763	3,788	5,551	201,082	93.78
Sep-22	881	2,549	3,430	204,512	95.38
Sep-23	843	2,204	3,047	207,559	96.80
Sep-24	1,071	1,395	2,466	210,025	97.95
Sep-25	1,150	1,440	2,590	212,615	99.16
Sep-26	661	1,140	1,801	214,416	100.00
Total	68,825	145,591	214,416		

* Daily count estimated by ratio estimator method.

Appendix 3.A. — Daily unadjusted upriver fish counts from hydroacoustic data collected at the Chandalar River, 2004.

	Left bank		Right bank		Total	
Date	Sample time (h)[a]	Count	Sample time (h)[a]	Count	Sample time (h)[a]	Count
Aug-08	12.00	73	22.97	664	34.97	737
Aug-09	24.00	204	15.94	422	39.94	626
Aug-10	23.81	197	23.99	797	47.80	994
Aug-11	23.96	164	22.66	773	46.62	937
Aug-12	23.96	213	24.00	864	47.96	1,077
Aug-13	23.96	180	23.98	851	47.94	1,031
Aug-14	24.00	172	23.96	748	47.96	920
Aug-15	23.98	129	23.98	758	47.96	887
Aug-16	24.00	61	23.98	955	47.98	1,016
Aug-17	24.00	124	23.75	1,052	47.75	1,176
Aug-18	24.00	191	23.99	1,158	47.99	1,349
Aug-19	24.00	195	22.96	1,131	46.96	1,326
Aug-20	23.98	219	23.99	1,392	47.97	1,611
Aug-21	23.96	172	23.98	1,315	47.94	1,487
Aug-22	23.85	127	24.00	1,102	47.85	1,229
Aug-23	23.88	320	23.98	1,232	47.86	1,552
Aug-24	22.94	297	23.00	651	45.94	948
Aug-25	23.91	188	23.82	594	47.73	782
Aug-26	24.00	219	23.98	480	47.98	699
Aug-27	23.91	295	24.00	442	47.91	737
Aug-28	22.76	462	23.24	1,106	46.00	1,568
Aug-29	24.00	840	24.00	1,645	24.00	2,485
Aug-30	23.70	714	24.00	1,899	23.70	2,613
Aug-31	23.98	1,132	24.00	2,851	23.98	3,983
Sep-01	24.00	1,210	24.00	4,037	48.00	5,247
Sep-02	24.00	1,781	24.00	3,129	48.00	4,910
Sep-03	24.00	2,332	24.00	3,621	48.00	5,953
Sep-04	24.00	2,130	24.00	5,037	48.00	7,167
Sep-05	23.98	1,441	24.00	2,997	47.98	4,438
Sep-06	23.98	1,565	23.99	3,791	47.97	5,356
Sep-07	23.86	1,432	24.00	4,909	47.86	6,341
Sep-08	23.84	912	24.00	5,139	47.84	6,051
Sep-09	23.24	1,052	23.00	4,088	46.24	5,140
Sep-10	23.20	768	23.99	3,656	47.19	4,424
Sep-11	23.94	960	24.00	4,453	47.94	5,413
Sep-12	23.96	690	23.98	4,797	47.94	5,487
Sep-13	23.98	568	24.00	5,957	47.98	6,525
Sep-14	23.70	763	24.03	4,968	47.73	5,731
Sep-15	24.00	802	23.96	3,243	47.96	4,045
Sep-16	23.22	735	24.00	1,762	47.22	2,497
Sep-17	23.79	495	24.00	1,172	47.79	1,667
Sep-18	23.49	467	23.98	1,800	47.47	2,267
Sep-19	24.00	338	24.00	2,393	48.00	2,731
Sep-20	23.96	295	23.94	2,463	47.90	2,758
Sep-21	24.00	537	24.00	2,864	48.00	3,401
Sep-22	1.13	9	11.00	2,870	12.13	2,879
Total	1,061.81	28,170	1,004.02	104,028	2,065.83	132,198

[a] Times are recorded to the nearest second by the computer, then converted to decimal hours.

Appendix 3.B. — Daily adjusted fall chum salmon count, Chandalar River, 2004.

Date	Left bank	Right bank	Combined	Cumulative	Cumulative (%)
Aug-08	210	694	904	904	0.66
Aug-09	204	755	959	1,863	1.36
Aug-10	198	797	995	2,858	2.09
Aug-11	164	827	991	3,849	2.82
Aug-12	213	864	1,077	4,926	3.60
Aug-13	180	851	1,031	5,957	4.36
Aug-14	172	749	921	6,878	5.03
Aug-15	129	759	888	7,766	5.68
Aug-16	61	955	1,016	8,782	6.42
Aug-17	124	1,069	1,193	9,975	7.30
Aug-18	191	1,159	1,350	11,325	8.28
Aug-19	195	1,179	1,374	12,699	9.29
Aug-20	219	1,391	1,610	14,309	10.47
Aug-21	172	1,316	1,488	15,797	11.56
Aug-22	128	1,102	1,230	17,027	12.46
Aug-23	321	1,234	1,555	18,582	13.59
Aug-24	302	672	974	19,556	14.31
Aug-25	188	599	787	20,343	14.88
Aug-26	219	480	699	21,042	15.39
Aug-27	296	442	738	21,780	15.93
Aug-28	468	1,129	1,597	23,377	17.10
Aug-29	840	1,645	2,485	25,862	18.92
Aug-30	723	1,899	2,622	28,484	20.84
Aug-31	1,134	2,851	3,985	32,469	23.75
Sep-01	1,210	4,037	5,247	37,716	27.59
Sep-02	1,781	3,129	4,910	42,626	31.18
Sep-03	2,332	3,621	5,953	48,579	35.54
Sep-04	2,130	5,037	7,167	55,746	40.78
Sep-05	1,441	2,997	4,438	60,184	44.03
Sep-06	1,565	3,792	5,357	65,541	47.94
Sep-07	1,435	4,909	6,344	71,885	52.58
Sep-08	914	5,139	6,053	77,938	57.01
Sep-09	1,082	4,219	5,301	83,239	60.89
Sep-10	815	3,658	4,473	87,712	64.16
Sep-11	962	4,453	5,415	93,127	68.12
Sep-12	692	4,799	5,491	98,618	72.14
Sep-13	568	5,957	6,525	105,143	76.91
Sep-14	774	4,967	5,741	110,884	81.11
Sep-15	802	3,253	4,055	114,939	84.08
Sep-16	753	1,762	2,515	117,454	85.92
Sep-17	497	1,172	1,669	119,123	87.14
Sep-18	479	1,801	2,280	121,403	88.81
Sep-19	338	2,393	2,731	124,134	90.81
Sep-20	295	2,470	2,765	126,899	92.83
Sep-21	537	2,864	3,401	130,300	95.32
Sep-22	1,398*	5,005	6,403	136,703	100.00
Total	29,851	106,852	136,703		

* Daily count estimated by ratio estimator method.

Appendix 4.A — Daily unadjusted upriver fish counts from hydroacoustic data collected at the Chandalar River, 2005.

	Left bank		Right bank		Total	
Date	Sample time (h)[a]	Count	Sample time (h)[a]	Count	Sample time (h)[a]	Count
Aug-08	21.83	429	23.91	2,284	45.74	2,713
Aug-09	23.57	338	23.98	3,754	47.55	4,092
Aug-10	22.98	551	23.98	4,719	46.96	5,270
Aug-11	23.88	340	24.00	5,559	47.88	5,899
Aug-12	24.00	393	24.00	4,821	48.00	5,214
Aug-13	24.00	305	24.00	5,667	48.00	5,972
Aug-14	24.00	403	24.00	5,849	48.00	6,252
Aug-15	24.00	153	23.88	5,736	47.88	5,889
Aug-16	20.48	276	24.00	6,939	44.48	7,215
Aug-17	24.00	331	24.00	6,823	48.00	7,154
Aug-18	24.00	593	22.18	4,270	46.18	4,863
Aug-19	23.00	880	24.00	5,320	47.00	6,200
Aug-20	23.98	1,150	24.00	4,668	47.98	5,818
Aug-21	24.00	1,562	24.00	4,917	48.00	6,479
Aug-22	24.00	844	24.00	4,459	48.00	5,303
Aug-23	23.98	999	24.00	4,216	47.98	5,215
Aug-24	24.00	537	23.04	3,782	47.04	4,319
Aug-25	24.00	864	23.99	3,842	47.99	4,706
Aug-26	23.99	425	18.01	2,220	42.00	2,645
Aug-27	23.90	1,129	24.00	3,675	47.90	4,804
Aug-28	23.97	922	24.00	4,588	47.97	5,510
Aug-29	24.00	1,780	24.00	4,406	48.00	6,186
Aug-30	24.00	2,734	23.37	5,336	47.37	8,070
Aug-31	23.98	2,709	23.98	4,898	47.96	7,607
Sep-01	22.65	8,205	23.96	9,979	46.61	18,184
Sep-02	23.83	5,059	24.00	7,681	47.83	12,740
Sep-03	24.00	6,857	24.00	10,433	48.00	17,290
Sep-04	24.00	10,624	23.00	12,516	47.00	23,140
Sep-05	23.98	11,087	24.00	14,153	47.98	25,240
Sep-06	24.00	10,400	24.00	13,972	48.00	24,372
Sep-07	23.45	10,032	0.00 [b]	-	23.45	10,032
Sep-08	23.82	10,118	0.00 [b]	-	23.82	10,118
Sep-09	23.93	7,695	0.00 [b]	-	23.93	7,695
Sep-10	22.92	4,463	0.00 [b]	-	22.92	4,463
Sep-11	23.00	6,364	0.00 [b]	-	23.00	6,364
Sep-12	23.93	7,039	0.00 [b]	-	23.93	7,039
Sep-13	23.61	4,395	0.00 [b]	-	23.61	4,395
Sep-14	20.48	4,066	0.00 [b]	-	20.48	4,066
Sep-15	15.67	2,102	0.00 [b]	-	15.67	2,102
Sep-16	21.87	2,518	0.00 [b]	-	21.87	2,518
Sep-17	22.90	2,354	0.00 [b]	-	22.90	2,354
Sep-18	15.96	2,115	0.00 [b]	-	15.96	2,115
Sep-19	23.94	2,926	0.00 [b]	-	23.94	2,926
Sep-20	23.96	2,412	0.00 [b]	-	23.96	2,412
Sep-21	22.70	1,485	0.00 [b]	-	22.70	1,485
Sep-22	21.96	2,561	0.00 [b]	-	21.96	2,561
Sep-23	15.76	1,051	0.00 [b]	-	15.76	1,051
Sep-24	38.43	1,364	0.00 [b]	-	38.43	1,364
Sep-25	24.00	1,658	0.00 [b]	-	24.00	1,658
Sep-26	11.33	1,204	0.00 [b]	-	11.33	1,204
Total	1,153.62	150,801	709.28	181,482	1,862.90	332,283

[a] Times are recorded to the nearest second by the computer, then converted to decimal hours.
[b] Right bank was shutdown due to high water.

Appendix 4.B. — Daily adjusted fall chum salmon count, Chandalar River, 2005.

Date	Left bank	Right bank	Combined	Cumulative	Cumulative (%)
Aug-08	528	2,291	2,819	2,819	0.57
Aug-09	360	3,757	4,117	6,936	1.40
Aug-10	513	4,722	5,235	12,171	2.45
Aug-11	340	5,559	5,899	18,070	3.64
Aug-12	393	4,821	5,214	23,284	4.69
Aug-13	305	5,667	5,972	29,256	5.89
Aug-14	403	5,849	6,252	35,508	7.15
Aug-15	153	5,770	5,923	41,431	8.34
Aug-16	308	6,585	6,893	48,324	9.73
Aug-17	331	6,823	7,154	55,478	11.17
Aug-18	593	4,652	5,245	60,723	12.23
Aug-19	913	5,320	6,233	66,956	13.49
Aug-20	1,152	4,668	5,820	72,776	14.66
Aug-21	1,562	4,917	6,479	79,255	15.96
Aug-22	844	4,459	5,303	84,558	17.03
Aug-23	1,001	4,216	5,217	89,775	18.08
Aug-24	537	3,958	4,495	94,270	18.99
Aug-25	864	3,843	4,707	98,977	19.94
Aug-26	701	2,871	3,572	102,549	20.66
Aug-27	1,130	3,668	4,798	107,347	21.62
Aug-28	922	4,588	5,510	112,857	22.73
Aug-29	1,780	4,406	6,186	119,043	23.98
Aug-30	2,734	5,428	8,162	127,205	25.62
Aug-31	2,709	4,899	7,608	134,813	27.15
Sep-01	8,385	9,987	18,372	153,185	30.85
Sep-02	5,093	7,681	12,774	165,959	33.43
Sep-03	6,857	10,433	17,290	183,249	36.91
Sep-04	10,624	13,006	23,630	206,879	41.67
Sep-05	11,098	14,153	25,251	232,130	46.75
Sep-06	10,402	13,972	24,374	256,504	51.66
Sep-07	10,166	12,622*	22,788	279,292	56.25
Sep-08	10,189	12,642*	22,831	302,123	60.85
Sep-09	7,710	10,546*	18,256	320,379	64.53
Sep-10	4,585	7,903*	12,488	332,867	67.04
Sep-11	6,507	9,528*	16,035	348,902	70.27
Sep-12	7,060	9,996*	17,056	365,958	73.71
Sep-13	4,452	7,790*	12,242	378,200	76.18
Sep-14	4,848	8,125*	12,973	391,173	78.79
Sep-15	4,302	7,664*	11,966	403,139	81.20
Sep-16	2,613	6,235*	8,848	411,987	82.98
Sep-17	2,430	6,081*	8,511	420,498	84.70
Sep-18	2,842	6,429*	9,271	429,769	86.56
Sep-19	2,931	6,504*	9,435	439,204	88.46
Sep-20	2,416	6,069*	8,485	447,689	90.17
Sep-21	1,544	5,331*	6,875	454,564	91.56
Sep-22	2,910	6,486*	9,396	463,960	93.45
Sep-23	2,171	5,862*	8,033	471,993	95.07
Sep-24	2,973	6,540*	9,513	481,506	96.98
Sep-25	1,658	5,428*	7,086	488,592	98.41
Sep-26	2,095	5,797*	7,892	496,484	100.00
Total	159,937	336,547	496,484		

* Daily count estimated by ratio estimator method.

Appendix 5.A. — Daily unadjusted upriver fish counts from hydroacoustic data collected at the Chandalar River, 2006.

	Left bank		Right bank		Total	
Date	Sample time (h)[a]	Count	Sample time (h)[a]	Count	Sample time (h)[a]	Count
Aug-08	23.98	214	23.98	355	47.96	569
Aug-09	24.00	235	23.96	291	47.96	526
Aug-10	24.00	200	23.94	424	47.94	624
Aug-11	24.00	178	24.00	411	48.00	589
Aug-12	24.00	301	24.00	450	48.00	751
Aug-13	23.98	274	23.98	596	47.96	870
Aug-14	24.00	453	22.52	584	46.52	1,037
Aug-15	23.46	940	0.00 [b]	-	23.46	938
Aug-16	23.50	574	0.00 [b]	-	23.50	574
Aug-17	24.00	351	0.00 [b]	-	24.00	351
Aug-18	23.13	397	0.00 [b]	-	23.13	397
Aug-19	12.90	312	0.00 [b]	-	12.90	312
Aug-20	0.00 [b]	-	0.00 [b]	-	0.00	-
Aug-21	0.00 [b]	-	0.00 [b]	-	0.00	-
Aug-22	0.00 [b]	-	0.00 [b]	-	0.00	-
Aug-23	0.00 [b]	-	0.00 [b]	-	0.00	-
Aug-24	0.00 [b]	-	0.00 [b]	-	0.00	-
Aug-25	0.00 [b]	-	0.00 [b]	-	0.00	-
Aug-26	0.00 [b]	-	0.00 [b]	-	0.00	-
Aug-27	0.00 [b]	-	0.00 [b]	-	0.00	-
Aug-28	7.00	421	0.00 [b]	-	7.00	421
Aug-29	23.94	1,993	0.00 [b]	-	23.94	1,993
Aug-30	24.00	2,731	0.00 [b]	-	24.00	2,731
Aug-31	19.98	3,242	0.00 [b]	-	19.98	3,242
Sep-01	22.73	3,432	0.00 [b]	-	22.73	3,432
Sep-02	24.00	3,832	0.00 [b]	-	24.00	3,832
Sep-03	24.00	3,509	0.00 [b]	-	24.00	3,509
Sep-04	24.00	3,166	0.00 [b]	-	24.00	3,166
Sep-05	24.00	2,300	0.00 [b]	-	24.00	2,300
Sep-06	23.88	2,025	5.97	925	29.85	2,950
Sep-07	24.00	1,549	23.96	4,188	47.96	5,737
Sep-08	24.00	1,550	22.16	3,807	46.16	5,357
Sep-09	23.98	1,850	23.98	4,482	47.96	6,332
Sep-10	24.00	1,618	23.98	4,264	47.98	5,882
Sep-11	24.00	1,228	23.00	5,131	47.00	6,359
Sep-12	24.00	1,379	24.04	5,045	48.04	6,424
Sep-13	24.00	1,372	23.96	5,686	47.96	7,058
Sep-14	24.00	1,395	20.21	5,584	44.21	6,979
Sep-15	24.00	1,365	23.97	7,068	47.97	8,433
Sep-16	24.00	1,470	22.02	6,865	46.02	8,335
Sep-17	23.69	1,101	21.82	6,485	45.51	7,586
Sep-18	23.98	1,443	22.99	6,793	46.97	8,236
Sep-19	24.00	988	23.99	5,817	47.99	6,805
Sep-20	23.98	1,048	23.99	5,310	47.97	6,358
Sep-21	24.00	513	24.00	4,464	48.00	4,977
Sep-22	23.98	435	24.00	3,496	47.98	3,931
Sep-23	24.00	412	23.10	3,443	47.10	3,855
Sep-24	23.98	522	23.92	2,783	47.90	3,305
Sep-25	23.98	443	23.01	2,223	46.99	2,666
Sep-26	12.87	301	10.99	1,060	23.86	1,361
Total	960.92	53,062	625.44	98,030	1,586.36	151,092

[a] Times are recorded to the nearest second by the computer, then converted to decimal hours.
[b] Sonar was shutdown due to high water.

Appendix 5.B. — Daily adjusted fall chum salmon count, Chandalar River, 2006.

Date	Left bank	Right bank	Combined	Cumulative	Cumulative (%)
Aug-08	215	355	570	570	0.23
Aug-09	235	291	526	1,096	0.45
Aug-10	200	425	625	1,721	0.70
Aug-11	178	411	589	2,310	0.94
Aug-12	301	450	751	3,061	1.25
Aug-13	274	597	871	3,932	1.60
Aug-14	453	621	1,074	5,006	2.04
Aug-15	960	2,000*	2,960	7,966	3.25
Aug-16	579	1,206*	1,785	9,751	3.98
Aug-17	351	731*	1,082	10,833	4.42
Aug-18	414	862*	1,276	12,109	4.94
Aug-19	534	1,112*	1,646	13,755	5.61
Aug-20	637**	1,294**	1,931	15,686	6.40
Aug-21	740**	1,476**	2,216	17,902	7.30
Aug-22	843**	1,658**	2,501	20,403	8.32
Aug-23	946**	1,840**	2,786	23,189	9.46
Aug-24	1,049**	2,022**	3,071	26,260	10.71
Aug-25	1,152**	2,204**	3,356	29,616	12.08
Aug-26	1,255**	2,386**	3,641	33,257	13.57
Aug-27	1,358**	2,568**	3,926	37,183	15.17
Aug-28	1,460	3,041*	4,501	41,684	17.01
Aug-29	1,998	4,162*	6,160	47,844	19.52
Aug-30	2,731	5,689*	8,420	56,264	22.96
Aug-31	3,654	7,612*	11,266	67,530	27.55
Sep-01	3,581	7,460*	11,041	78,571	32.06
Sep-02	3,832	7,983*	11,815	90,386	36.88
Sep-03	3,509	7,310*	10,819	101,205	41.29
Sep-04	3,166	6,596*	9,762	110,967	45.28
Sep-05	2,300	4,791*	7,091	118,058	48.17
Sep-06	2,035	4,487	6,522	124,580	50.83
Sep-07	1,549	4,195	5,744	130,324	53.17
Sep-08	1,551	4,124	5,675	135,999	55.49
Sep-09	1,851	4,485	6,336	142,335	58.07
Sep-10	1,618	4,268	5,886	148,221	60.48
Sep-11	1,228	5,341	6,569	154,790	63.16
Sep-12	1,379	5,033	6,412	161,202	65.77
Sep-13	1,372	5,804	7,176	168,378	68.70
Sep-14	1,395	6,929	8,324	176,702	72.10
Sep-15	1,365	7,075	8,440	185,142	75.54
Sep-16	1,470	7,251	8,721	193,863	79.10
Sep-17	1,105	6,977	8,082	201,945	82.40
Sep-18	1,444	7,055	8,499	210,444	85.86
Sep-19	988	5,817	6,805	217,249	88.64
Sep-20	1,048	5,314	6,362	223,611	91.24
Sep-21	513	4,464	4,977	228,588	93.27
Sep-22	435	3,496	3,931	232,519	94.87
Sep-23	412	3,585	3,997	236,516	96.50
Sep-24	523	2,792	3,315	239,831	97.85
Sep-25	443	2,297	2,740	242,571	98.97
Sep-26	494	2,025	2,519	245,090	100.00
Total	63,123	181,967	245,090		

* Daily count estimated by ratio estimator method.
** Daily count estimated by linear interpolation.

Appendix 6. — Seine catch data, 2002-2006.

Season	Date	Number of sets	Chum salmon	Least cisco	Northern pike	Humpback whitefish	Round whitefish	Arctic grayling
2002	9/10/2002	1	0	0	0	0	0	0
	9/12/2002	1	1	0	0	0	0	0
	9/13/2002	2	1	1	0	1	0	0
	9/14/2002	2	1	0	2	0	0	0
	9/15/2002	2	2	0	0	0	0	0
	9/17/2002	2	4	0	0	0	0	0
	9/18/2002	2	1	0	0	0	0	0
	9/19/2002	2	4	0	0	0	0	0
	9/24/2002	2	6	0	0	0	0	0
	9/25/2002	2	0	1	0	0	0	0
2003	No seining conducted							
2004	09/02/2004	2	1	0	0	0	0	0
	09/03/2004	2	0	0	0	0	0	0
	09/04/2004	2	1	0	0	0	0	0
	09/05/2004	2	4	0	0	0	0	0
	09/06/2004	2	1	0	0	0	0	0
	09/08/2004	2	2	0	0	0	0	0
	09/09/2004	2	0	0	0	0	0	0
	09/11/2004	2	3	0	0	0	0	0
	09/12/2004	2	2	0	0	0	0	1
	09/13/2004	2	5	2	0	0	0	0
	09/15/2004	2	2	0	0	0	1	0
	09/17/2004	2	6	0	0	0	1	0
	09/18/2004	2	0	0	0	0	0	0
	09/19/2004	2	3	0	0	0	0	1
2005	8/21/2005	2	1	0	0	0	0	0
	8/2-8/19/2005	10	0	0	0	0	0	0
2006	No seining conducted							