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Abundance and Run Timing of Adult Fall Chum Salmon in the Teedriinjik (Chandalar) River, Yukon Flats National Wildlife Refuge, Alaska, 2018 and 2019

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Cover: View from the right bank of the Teedriinjik river at the sonar site, looking upstream. Inset: fall Chum Salmon and a DIDSON unit mounted on a "pod".

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Abstract

In 2018 and 2019, Dual Frequency Identification Sonar (DIDSON) was used to assess the abundance of adult fall Chum Salmon *Oncorhynchus keta* in the Teedriinjik River (formerly known as the Chandalar River before its name was changed in 2015), a tributary of the Yukon River. In 2018, high water delayed sonar deployment by 4 days and sonar operations began on August 12 and continued through September 28. In 2019, sonar operations began on August 8 and continued through September 27. Thirty-minute fish counts from each hour were sampled and expanded to estimate hourly passage.

During 2018, a total of 1,125.8 hours of acoustic data were analyzed, resulting in 71,441 upriver swimming fish enumerated. After expanding sample counts and adjusting for missed time, the fall Chum Salmon passage estimate for 2018 was 143,220 fish, with a 95% confidence interval of 142,703–143,737 fish. This estimate is approximately 69% of the average (through 2017) of 208,213. The upriver swimming fall Chum Salmon passage estimate was 291 fish on the first day of counting and 5,614 fish on the last day of counting. The first-quarter point of the run occurred on September 12, the mid-point on September 18, and the third-quarter point on September 23. Overall, run timing was 1 to 1.5 weeks later than average.

During 2019, a total of 1,198.9 hours of acoustic data were analyzed, resulting in 51,626 upriver swimming fish enumerated. After expanding sample counts and adjusting for missed time, the fall Chum Salmon passage estimate for 2019 was 104,089 fish, with a 95% confidence interval of 103,746–104,432 fish. This estimate is approximately 51% of the average (through 2018) of 205,387 and is the 5th lowest estimate since the project began in 1987. The upriver swimming fall Chum Salmon passage estimate was 331 fish on the first day of counting and 3,430 fish on the last day of counting. The first-quarter point of the run occurred on September 8, the mid-point on September 14, and the third-quarter point on September 21. Overall, run timing was slightly later than average.

Most fish were observed near shore, and few were observed near the outer range limits of the ensonified zones suggesting that most fish were within the detection range of the DIDSON. These passage estimates are conservative because they only include fish that passed during the dates of sonar operation and within the ensonified portions of the river.

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Introduction

The Yukon River drainage encompasses 854,700 km^2 and is among the largest producers of wild Chinook Salmon *Oncorhynchus tshawytscha* 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 and the Yukon River Salmon Agreement, has a responsibility to ensure that salmon populations within federal conservation units are conserved in their natural diversity, subsistence opportunities are maintained, and international treaty obligations are met. Estimating spawning escapements for major salmon stocks in the drainage is essential for addressing these mandates. The Teedriinjik River (formerly known as the Chandalar River before its name was changed in 2015) is a tributary of the Yukon River. The fall Chum Salmon stock in the Teedriinjik River is one of the largest stocks in the Yukon River drainage (JTC 2016) and is an important resource for wildlife and subsistence users.

Accurate salmon escapement counts on Yukon River tributaries are important for informing and assessing annual harvest management decisions, 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 used to obtain escapement estimates of specific Yukon River Salmon stocks (Bergstrom et al. 2001).

The use of fixed-location hydroacoustics to count migrating salmon in Alaska began during the early 1960s and has provided counts in rivers where limited visibility or sample volume precluded other sampling techniques (Gaudet 1990). The USFWS conducted a 5-year study from 1986 to 1990 using fixed-location Bendix side scanning sonar salmon counters to enumerate adult fall Chum Salmon in the Teedriinjik River. The annual Bendix sonar counts of fall Chum Salmon during that period averaged 58,457 fish and ranged from 33,619 to 78,631 fish (Appendix A). These early Bendix sonar 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 the direction of target travel (upriver or downriver). Due to these technological limitations, it is suspected that, overall, the Bendix sonar yielded low estimates of fall Chum Salmon passage on the Teedriinjik River.

A study was initiated in 1994 to reassess the Teedriinjik River fall Chum Salmon population status using split-beam sonar technology. This sonar technology was acoustically calibrated, had user-defined echo-tracking techniques to count fish, and had an extended acoustic range (>100 m). The split-beam sonar also provided three-dimensional positioning for each returning echo, which allowed the determination of direction of travel and swimming behavior for each passing target (Daum and Osborne 1998). Operations during 1994 were used to develop site-specific procedures and methods, evaluate site characteristics, and describe possible data collection biases (Daum and Osborne 1995). In 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). Fall Chum Salmon enumeration with the split-beam sonar continued through 2006. From 1994 through 2006 fall Chum Salmon passage estimates from split-beam sonar counts averaged 184,388 and ranged from 65,894 to 489,833.

Experimentation to evaluate DIDSON (Dual Frequency Identification Sonar) technology from Sound Metrics (Lake Forest Park, Washington), for enumeration of fall Chum Salmon in the Teedriinjik River was initiated in 2004 and continued through 2006. DIDSON offers some advantages over the previous sonar technologies used on the Teedriinjik River. These include deployment over a wider range of site conditions, production of a more easily interpreted visual image, reduction of training requirements for technicians due to operation and image interpretation that is more intuitive, easier setup and deployment, and the potential for increased capacity for species determination under some conditions. The primary limitations of DIDSON, relative to split-beam sonar, include limited range capabilities, lack of vertical position data, and larger data files requiring large hard drives to store or archive data. During the evaluation period, up to three DIDSONs were set up at different locations, both adjacent to the split-beam sonar, and at independent locations. During these evaluations the DIDSON produced counts that were similar to those from the split-beam while being less complicated to deploy and operate. Additionally, since fall Chum Salmon are generally shore and bottom oriented during migration in the Teedriinjik River, the lack of vertical position data and the more limited range capabilities of the DIDSON compared to the split-beam were not a hinderance. Conclusions from these evaluations indicated that DIDSON is well suited to enumerate fall Chum Salmon on the Teedriinjik River (Melegari 2008). Therefore, DIDSON has been used on the Teedriinjik River since 2007.

Objectives of the Teedriinjik River sonar project have consistently been to: (1) provide daily in-season passage estimates of Teedriinjik 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. Since 1996, the project has provided daily in-season passage estimates to managers and an estimate of annual passage post season. Sonar passage estimates from 1995 to 2019 averaged 201,166 fall Chum Salmon and ranged from 65,894 (2000) to 496,484 (2005) fall Chum Salmon (Appendix A).

Several years of gill net and beach seine sampling and observations with underwater video cameras have shown that, during sonar operations, the number of fish of other species in the same size range as Chum Salmon is inconsequential relative to the number of Chum Salmon present (Daum and Osborne 1995, 1996, 1998; Osborne and Melegari 2006; Melegari and Osborne 2007; Melegari 2011, 2012). Therefore, all upriver swimming fish in the size range of Chum Salmon are assumed to be Chum Salmon.

Additionally, carcass sampling for age, sex, and length data has been conducted at fall Chum Salmon spawning grounds upstream of the community of Venetie on the Teedriinjik River during some years (Appendix A). However, funding has not available for this work in recent years, including 2018 and 2019.

Study Area

The Teedriinjik River is a fifth-order tributary of the Yukon River that drains part of the southern slopes of the Brooks Range. The Teedriinjik River drainage consists of three major branches (Figure 1). These branches are the Teedriinjik River, which includes the main branch from the mouth up to and including what was formerly known as the North Fork Chandalar River prior to 2015, the Ch'idriinjik River, which was formerly known as the Middle Fork Chandalar River prior to 2015, and the East Fork Chandalar River (name was not changed in 2015). The sonar site is located on the lower Teedriinjik River, below any of the other two branches or any notable tributaries (Figure 1). The Teedriinjik River enters the Yukon River approximately 32 km downriver of Fort Yukon. 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 some of the largest temperature extremes in the state, -59°C to 38°C (USFWS 1987). Precipitation ranges from 15 to 33 cm annually with the greatest amount falling between May and September. The river is typically ice-free by early June and freeze-up typically occurs in early October.

The lower 19 km of the Teedriinjik River is influenced by a series of slough systems connected to the Yukon River. Riverbanks are typically steep and covered with overhanging vegetation and downed trees caused by active bank erosion. Gravel bars are generally absent in this area and the bottom substrate is primarily sand and silt. Water velocities are generally less than 0.75 m/s. From approximately 21.0 to 22.5 km upriver from its confluence with the Yukon River, the Teedriinjik River is confined to a single channel with steep cut-banks alternating with large gravel bars. Substrate in this area is primarily small gravel to cobble with some sand/silt in slow current areas. Upriver from this area, the river becomes braided with many islands and multiple channels. The sonar study area is described in more detail by Daum et al. (1992), it is in a remote location 21.5 km upriver from the Teedriinjik River's confluence with the Yukon River (Figure 2).

The left bank (facing downriver) DIDSON site has a bottom slope of approximately 5° out to approximately 40 m where it flattens out (Figure 3). On the right bank site, the bottom slopes at approximately 7° out to approximately 27 m before it flattens out. Substrate on both banks consists mainly of large gravel. Overall river width at the site varies with water levels and typically ranges from approximately 140 m to 160 m.

Methods

Water Quality Monitoring

A staff gauge was installed upstream of the right bank sonar to measure daily water levels and was calibrated using a benchmark established on the right bank in 1989. Water temperatures were taken daily at approximately 1200 hours using a glass thermometer. Additionally, a YSI model 6920V2 sonde was deployed from August 3 through September 28, 2018 to collect temperature (°C), conductivity (µS/cm), dissolved oxygen (mg/L and % saturation), pH, and turbidity (NTU) data every 15 minutes. A sonde was not deployed in 2019.

Site Selection and Sonar Deployment

A sonar deployment site for each bank was selected from several cross-sectional river profiles of the area, developed using a Lowrance (Tulsa, Oklahoma) HDS-7 depth sounder–GPS. Requirements for site selection included: (1) single channel; (2) uniform non-turbulent flow; (3) gradually sloping bottom gradient without sudden inflections; (4) absence of structure or debris that could impede fish detection; (5) location downriver from known salmon spawning areas; and (6) active fish migration past the site (no milling behavior).

The Sound Metrics DIDSON system is a high frequency 12° X 29° multiple beam sonar (Belcher et al. 2001, 2002). Standard and long-range models are currently in use. The standard DIDSON operates at frequencies of 1.8 or 1.1 MHz and has an effective range for confidently enumerating fall Chum Salmon on the Teedriinjik River of approximately 30 m, based on detection of known targets drifted through the sonar beam, and on analysis of fish data. The long-range model operates at frequencies of 1.2 MHz or 700 KHz with an effective range of approximately 60 m. DIDSON specifications are available in the DIDSON operation manual V5.25 (Sound Metrics

Corp. 2010). The DIDSON units were deployed at fixed locations in the river and communicated with laptop computers for control and data management.

DIDSON settings were the same during both 2018 and 2019. The long-range DIDSON was deployed on the left bank and the standard DIDSON was used on the right bank. Both DIDSON models were operated in the low frequency mode (1.1 MHz for the standard range and 700 KHz for the long range). Partial weirs, constructed with T-posts and 2 in x 4 in (5.08 cm x 10.16 cm) welded wire fence, were installed approximately 1 m downriver of each DIDSON and extended a minimum of one meter farther offshore than the DIDSON's location. These weirs prevent migrating fish from passing behind or too close to the DIDSON and direct fish through the beam. The left bank DIDSON had a window start setting of 0.83 m, and a window length setting of 40.01 m (the window settings determine the range within which the DIDSON acquires data). The right bank had a window start setting of 0.83 m, and a window length setting of 20.01 m. The left bank recorded at one frame per second, and the right bank recorded at six frames per second. The recording rate on the left bank was limited by the slower wireless network used to transmit data across the river, and by the longer window setting.

The DIDSON units were mounted to aluminum frames and oriented perpendicular to river flow. The mounting brackets allow for manual adjustments to vertical and horizontal aim of the DIDSON. The aim was adjusted by verifying the detection of targets (liter plastic bottle half filled with steel shot) placed on the river bottom at varying ranges within the ensonified area and drifted through the ensonified area from a boat.

A wireless network was installed for the left bank so all DIDSON communications, data acquisition, and analysis could occur at a single data tent located on the right bank next to the camp. This remote communications network consisted of two D-Link® DWL-2100AP wireless access points, one connected to the DIDSON on the left bank, and the other, connected to the receiving computer on the right bank. A D-Link® ANT24-1800 outdoor directional panel antenna was attached to each access point using an outdoor low loss radio frequency cable.

Sonar Data Collection and Analysis

In the data tent, a wired network was set up for each DIDSON to facilitate data collection and analysis. Each DIDSON was networked with two laptop computers and a 4-terabyte network attached storage (NAS) drive. One computer was used to control and communicate with the DIDSON and save the collected data to files on the NAS. The second computer was used to analyze the data and manage data files. Additional backup copies of the count data and summary data files were saved to USB flash drives at the end of each day.

The sonar systems were operated continuously 24 hours per day, except during intermittent periods for maintenance, repairs, aim adjustments, relocating the DIDSON as water levels changed, or during periods of high water and/or heavy debris loads that would impede the safe operation of the sonar equipment. The collected data were saved to files at 30-minute intervals. Data were analyzed using the DIDSON control and display software (version 5.25.32; Sound Metrics Corp. 2010). Data files were examined in the echogram view and when a potential target was encountered it was further evaluated by reviewing that section of data in the normal image view to verify the target was a fish and to determine direction of travel. Data from counted files were then saved to ASCII text files, which were compiled and summarized using a Microsoft Excel Visual Basic for Applications macro developed by the author.

Because most fish present during sonar operations are Chum Salmon, apportioning sonar counts to Chum Salmon was based on relative target size as each fish passed through the ensonified field. All upstream swimming fish that appeared large enough to be a Chum Salmon on the DIDSON were assumed to be Chum Salmon. While actual length measurements from the DIDSON are not precise, relative fish sizes can be observed, and fish that were obviously smaller than Chum Salmon were not counted. Conversely, fish larger than typical Chum Salmon are very uncommon during sonar operations. Additionally, previous years of beach seining, gill netting, and underwater video monitoring all indicate that the majority of fish present during sonar operations that are in the same size range as Chum Salmon are Chum Salmon (Daum and Osborne 1995, 1996, 1998; Osborne and Melegari 2006; Melegari and Osborne 2007; Melegari 2011, 2012).

A sampling protocol where 30-minute fish counts from each hour were expanded to obtain hourly fish passage estimates was used to reduce crew size and save associated project costs. Prior to first initiating this sampling protocol in 2014, a comparison of full 24-hour counts and estimates from simulated 30-minute sample counts was conducted using data from 2011 to 2013 (Melegari 2015). This comparison showed that the sampling protocol produced estimates with acceptable accuracy and precision. Additionally, we compared mean hourly passage rates (the proportion of the daily passage that passed during a given hour) calculated from the 30-minute sample counts with those calculated from full 24-hour counts. In all cases, the values calculated from the samples were equivalent to those calculated from the complete counts (author's unpublished data). The first 30 minutes of each hour was used for the sample. If the first 30-minute data file of an hour was missing or incomplete, then the second 30-minute data file for that hour was used. If neither 30-minute data file in an hour contained at least 28 minutes of continuous data, that hour was treated as a missing hour.

Thirty-minute sample counts were expanded to obtain hourly passage estimates using the formula:

$$E_h = \left(60/T_h\right) \cdot C_h$$

Where E_h = estimated hourly fish passage for hour h, T_h = number of minutes sampled in hour h, and C_h = upriver count during the sampled time during hour h.

Fish counts for missing hours were estimated from seasonal mean hourly passage percent. Hourly passage percent (proportion (%) of the total daily count passing during a given hour) were determined for all hours in each day from days when all 30-minute sample periods were fully sampled. These hourly passage rates were expressed as a proportion (%) of the daily count so high-passage days did not bias results. Then, mean hourly passage percent for the season was calculated for each hour. During the season, missing hours were estimated using the averaged mean hourly passage percent from all previous seasons. During post-season analysis, missing hours were re-estimated using the seasonal mean hourly passage percent for that year. Estimated fish counts for missing hours were calculated, using:

$$E_d = \sum R_{dj} / \left(100 - \sum R_{dj}\right) \cdot T_d$$

Where E_d = estimated upriver fish count for missing hours in day d, R_{di} = mean hourly passage percent for each missing hour i in day d, and T_d = expanded upriver fish count for non-missing hours in day d.

Daily upriver fish passage estimates for each bank were calculated by summing all hourly passage estimates for that day. For the season, total fish passage was calculated by summing all daily estimates. Hourly fish passage rates for each bank were plotted for the season and examined for diel patterns. Range distributions of fish targets were evaluated to assess the likelihood of fish passing beyond the detection range of the DIDSON.

For calculating the variance of the seasonal estimate from the sampling, a sample observation consisted of the sum of counts from both banks. If either bank had a missing count during an hour then we treated that hour as a missed sample observation. Variance (*V*) of the seasonal estimates was calculated using the V5 sample variance estimator suggested by Reynolds et al. (2007):

$$\widehat{V}=(1-f)(1/n)\sum_{j=5}^{n}C_j^2/(3.5(n-4))$$

Where *f* is the proportion of possible observations that were actually observed,
$c_j=y_j/2-y_{j-1}+y_{j-2}-y_{j-3}+y_{j-4}/2$
and y_j is the *j*th observation of a systematic sample of *n* observations.

A 95% confidence interval for the total seasonal estimate was calculated using the normal interval estimator also recommended by Reynolds et al. (2007):

$$95\%\ CI=\widehat{Y}\pm 1.96\sqrt{(\widehat{V}(\widehat{Y}))}$$

Where *Y* is the seasonal passage estimate and *V* is the variance of the seasonal passage estimate.

Results

Water Quality Monitoring

2018— Calibrated daily water levels ranged from approximately 1.5 to 3.1 m (average 2.0 m) (Figure 4; Appendix C). River width at the sonar deployment site ranged from approximately 143 to >149 m. Water levels rose abruptly shortly after arriving on site, interrupting our ability to determine river width for 6 days. Daily water temperatures taken with the glass thermometer ranged from 3.0°C to 12.5°C (average 7.9°C). Water temperatures, recorded with the YSI sonde ranged from 2.7°C to 16.7°C and averaged 9.0°C. Staff gauge and Sonde water quality data are presented in Appendix C.

2019— Calibrated daily water levels ranged from approximately 1.5 to 2.7 m (average 1.9 m) during 2019 (Figure 4; Appendix C). River width at the sonar deployment site ranged from approximately 138 to 153 m. Daily water temperatures taken with the glass thermometer ranged from 3.0°C to 13.5°C (average 9.2°C). A sonde was not deployed in 2019.

Site Selection and Sonar Deployment

Several cross-sectional profiles were recorded on each bank near the previous deployment locations and the DIDSONs were deployed where the bottom profiles were considered best for counting fish with the DIDSONs. The same approximate locations on both banks that have been used since 2007 when operations switched to DIDSON, were used again in both 2018 and 2019 given that minimal changes in physical conditions have been observed at these locations between years.

Sonar Data Collection and Analysis

2018— Normal sonar deployment was delayed by 4 days due to high water in 2018. Operations began on August 12 and continued through September 28. Complete sample data were collected and analyzed for 1,111 of the projected 1,152 30-minute sample periods. A total of 1,125.8 hours of acoustic data were analyzed. The total hours analyzed includes all time counted on both banks and includes time when counts occurred on only one bank during a given hour. These hours were not considered a complete sample period because a sample period includes counts from both banks. Approximately 26 hours were missed due to repositioning the DIDSONs as water levels changed during the season or due to equipment maintenance or malfunctions. A total of 72,111 fish were counted and upriver swimming fish accounted for 99.1% (71,441) of the total (Table 1). Upriver swimming fish counts were 12,409 for the left bank and 59,032 for the right bank.

After expanding sample counts, and adjusting for missed sampling time, the estimated fall Chum Salmon passage for 2018 is 143,220 fish (Table 2; Appendix D), with a 95% confidence interval of 142,703 to 143,737 fish. The 95% confidence interval only includes the variance associated with subsampling and does not include any other sources of error. The left bank estimate was 24,929 fall Chum Salmon accounting for 17% of the total. The right bank estimate was 118,291 fall Chum Salmon accounting for 83% of the total. The adjusted count was 291 upriver swimming fall Chum Salmon on the first day of sonar operation (0.2% of the total), and 5,614 upriver swimming fall Chum Salmon on the final day of counting (3.9% of the total). Peak daily passage occurred on September 21 (Figure 5; Table 2). The first-quarter point of the run occurred on September 12, the mid-point on September 18, and the third-quarter point on September 23.

Mean hourly passage rates (number of fish estimated to have passed during each hour expressed as a proportion of the daily estimate) of upriver swimming fall Chum Salmon showed a strong diel pattern on the left bank and a weaker but clear diel pattern on the right bank (Figure 6). On the left bank, the pattern displayed higher counts during late night and early morning (approximately 2200–0800 hours). On the right bank, the higher counts occurred during early to late morning (approximately 0400–1100 hours).

Range distribution data indicates that upriver swimming fall Chum Salmon were shore-oriented, and most were within the range of acoustic detection for both banks. More than 50 % of upriver swimming fall Chum Salmon were within the first 5 m on both banks; and more than 95% were within 19 m on the left bank and 15 m on the right bank (Figure 7; Figure 8). Downriver swimming fish, while being somewhat shore-oriented, were more dispersed across the full detection range of the DIDSONs on both banks.

2019— In 2019 operations began on August 8 and continued through September 27. Complete sample data were collected and analyzed for 1,179 of the projected 1,224 30-minute sample periods. A total of 1,198.9 hours of acoustic data were analyzed. The total hours analyzed includes all time counted on both banks and would include time when counts occurred on only one bank during a given hour. These hours were not considered a complete sample period because a sample period includes counts from both banks. Approximately 25 hours were missed due to repositioning the DIDSONs as water levels changed during the season and due to equipment maintenance or malfunctions. A total of 52,519 fish were counted and upriver swimming fish accounted for 98.3% (51,626) of the total (Table 3). Upriver swimming fish counts were 10,608 for the left bank and 41,018 for the right bank.

After expanding sample counts, and adjusting for missed sampling time, the estimated fall Chum Salmon passage for 2019 was 104,089 fish (Table 4; Appendix D), with a 95% confidence interval of 103,746 to 104,432 fish. The 95% confidence interval only includes the variance associated with subsampling and does not include any other sources of error. The left bank estimate was 21,567 fall Chum Salmon accounting for 21% of the total. The right bank estimate was 82,522 fall Chum Salmon accounting for 79% of the total. The adjusted count was 331 upriver swimming fall Chum Salmon on the first day of sonar operation (0.3% of the total), and 3,430 upriver swimming fall Chum Salmon on the final day of counting (3.3% of the total). Peak daily passage occurred on September 7 (Figure 9; Table 4). The first-quarter point of the run occurred on September 8, the mid-point on September 14, and the third-quarter point on September 21.

Mean hourly passage rates (number of fish estimated to have passed during each hour expressed as a proportion of the daily estimate) of upriver swimming fall Chum Salmon showed a strong diel pattern on the left bank and a weaker but clear diel pattern on the right bank (Figure 10). On the left bank, the pattern displayed higher counts during late night and early morning (approximately 2200–0800 hours). On the right bank, the higher counts occurred during early to late morning (approximately 0400–1100 hours).

Range distribution data indicates that upriver swimming fall Chum Salmon were shore-oriented and most were within the range of acoustic detection for both banks. More than 50 % of upriver swimming fall Chum Salmon were within the first 6 m on the left bank and the first 7 m on the right bank; and more than 95% were within 10 m on the left bank and 13 m on the right bank (Figure 11; Figure 12). Downriver swimming fish, while also generally shore-oriented, were slightly more dispersed across the full detection range of the DIDSONs on both banks.

Discussion

Water Quality Monitoring

During 2018, water levels were high during the first few days of the project, but quickly dropped below average and remained that way throughout the remainder of the season (Figure 4). Water levels showed a similar pattern during 2019, and were above or near average during the first 10 days, then dropped below average and remained that way throughout the remainder of the season (Figure 4).

Water temperatures were generally near average throughout 2018 (Appendix C; Figure C.1). In 2019 water temperatures were near or below average for approximately the first two weeks and were above average for most of the rest of the season (Appendix C; Figure C.2).

Site Selection and Sonar Deployment

Similar to most years, little to no change in bottom profiles were detected at the deployment sites in 2018 or 2019, allowing deployment in the same approximate locations on both banks. The absence of substantial changes in bottom profiles since 2007 has allowed for consistent deployment, data collection, and analysis.

Data were collected at one frame per second on the left bank with the long range DIDSON and the wireless communications network. One frame per second was considered sufficient to capture fall Chum Salmon migrating upriver past the site. This is supported by the data, in which nearly all fish were captured in several frames. If substantial numbers of fish were being missed because the frame rate was too low, then we would expect more fish to be "nearly missed" or captured in only one or two frames.

Sonar Data Collection and Analysis

Run timing was markedly later than average in 2018 and slightly later in 2019. During 2018 the first-quarter point (September 12) occurred 11 days later than average (1995–2017, excluding 2009 when the project terminated early); the mid-point (September 18) occurred 9 days later than average; and the third-quarter point (September 23) occurred 7 days later than average. During 2019 the first-quarter point (September 8) occurred 7 days later than average (1995–2018, excluding 2009); and both the mid-point (September 14) and the third-quarter point (September 21) occurred 4 days later than average. This is consistent with data for overall Yukon River fall Chum Salmon run timing, where all assessment projects averaged 7 days late in 2018 (JTC 2019) and 3 days late in 2019 (JTC 2020). The estimated passage on the last day of sampling in 2018 (5,614) was 3.9% of the cumulative and in 2019 (3,430) it was 3.3% of the cumulative, indicating some fish passage continued after enumerations stopped. Thus, the actual quarter points of the runs during both years may be slightly later than calculated.

The 2018 passage estimate of 143,220 fall Chum Salmon is 69% of the historical average (1995–2017; Figure 13) and is the 8th lowest passage estimate for the project. This is consistent with the preliminary estimate of U.S.-Canada border passage during 2018, which was below the average for recent years (JTC 2019). However, other fall Chum Salmon abundance or escapement estimates in Alaska were slightly above averages (JTC 2019). The estimate exceeded the minimum escapement goal range set by Alaska Department of Fish and Game at that time (74,000–152,000). Additionally, considering the late run timing and the number of fish still passing on the last day of counts it is likely a notable number of fish passed after operations ceased.

The 2019 passage estimate of 104,089 fall Chum Salmon is 51% of the historical average (1995-2018; Figure 14) and is the 5th lowest passage estimate for the project. Preliminary abundance or escapement estimates from other Yukon River fall Chum Salmon assessment projects during 2019 indicated slightly below average runs (JTC 2020), but they were generally nearer average than the Teedriinjik River run. However, the Teedriinjik River estimate did exceed the minimum sustainable escapement goal range, revised by Alaska Department of Fish and Game in 2019 (85,000–234,000). Additionally, the 2019 estimate should be considered a conservative estimate of passage considering the number of fish still passing on the last day of counts.

The observed diel patterns in upriver fish passage on both banks during both years were similar to patterns seen during most previous years (Daum and Osborne 1998; Melegari and Osborne 2007; Figure 6; Figure 10). During most years, the left bank exhibits a strong diel pattern with higher passage during late night through early morning. Whereas the right bank generally exhibits a weaker pattern with higher passage during mid to late morning, or occasionally no diel pattern.

The right bank accounted for 83% of the total passage during 2018 and 79% in 2019. Higher passage has been observed on the right bank during all years of the project (Appendix A). During both 2018 and 2019, the proportion of passage on the right bank is above the historical average of 71% (range 55% to 86%) and both are among the higher values observed. Since switching to DIDSON, enumeration has been able to continue during higher water than was possible with the split-beam sonar. Observations during these higher water levels have shown a tendency for an increased proportion of fish passage on the left bank during higher water levels. Conversely, with lower water levels a higher proportion of passage on the right bank would be expected. Water levels during 2018 and 2019 were below average throughout most of the season.

Fish range data collected with the DIDSONs were similar to previous years and suggests that most upriver swimming fish passing the sonar site were within the ensonified zone. Upriver swimming fish were found close to shore with relatively few fish found near the range limits of acoustic detection. This shore orientation is consistent with previous behavioral observations of upriver-migrating fall Chum Salmon on the Teedriinjik (Daum and Osborne 1998; Osborne and Melegari 2006), Sheenjek (Barton 1995), and main-stem Yukon rivers (Johnston et al. 1993; Lozori and McDougall 2016).

Unlike split-beam sonar, DIDSON does not obtain vertical fish position data. However, the larger vertical angle of the DIDSON's beams (12° vs. the 2.1° and 4.8° of the split-beam previously used on the Teedriinjik River) reduces the potential of fish passing above or below the beams. This is further supported by the DIDSON data, in which surface waves were usually detected on windy days, and the river bottom was normally visible throughout the range.

Conclusions

The DIDSONs performed well overall during both years with minimal time missed due to technical issues and, except for the delayed deployment in 2018, no other interruptions to data collection were experienced due to high water. The 30-minute sampling protocol produced small variance estimates and tight confidence intervals for the estimated passage for both years. During simulations of this sampling protocol using data from the 2011 to 2013 seasons, the 95% confidence intervals for the seasonal passage estimates included the actual value from the full count for all 3 years (Melegari 2015).

The Teedriinjik River sonar passage estimate is a conservative estimate because it does not include fish that passed before or after sonar operation. Additionally, while Chum Salmon are shore and bottom oriented during migration, it is probable that some fish passed undetected outside of the ensonified zone.

Annual sonar enumeration of fall Chum Salmon in the Teedriinjik River is a vital component for effectively managing the complex mixed-stock subsistence and commercial fisheries in the Yukon River. The Teedriinjik River fall Chum Salmon stock is crucial to the total Yukon River fall Chum Salmon run and is important to users throughout the drainage. Daily in-season counts and post-season passage estimates provide important escapement information to managers and users of this resource, allowing for better-informed management decisions and evaluation of previous management actions. This project is a key component in assessing the lower river abundance estimate proportioned by mixed-stock genetic analysis. Additionally, this project has provided accurate population status and trend data for 25 years. These time series data will become more important as stressors such as climate change, disease, selective harvest, and overall demand on the fisheries and resources in the Yukon River drainage continue to increase.

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Table 1. — Hydroacoustic data collected via DIDSON at the Teedriinjik (Chandalar) River, Alaska, 2018.

Date	Left bank sample time (h)	Left bank upriver count	Left bank downriver count	Right bank sample time (h)	Right bank upriver count	Right bank downriver count	Combined sample time (h)	Combined upriver count	Combined downriver count
12-Aug	4.00	10	0	4.00	28	2	8.00	38	2
13-Aug	12.00	42	0	12.00	65	6	24.00	107	6
14-Aug	12.00	24	0	12.00	86	2	24.00	110	2
15-Aug	12.00	33	0	12.00	81	4	24.00	114	4
16-Aug	12.00	28	0	12.00	107	2	24.00	135	2
17-Aug	12.00	60	2	12.00	108	0	24.00	168	2
18-Aug	12.00	53	1	12.00	176	5	24.00	229	6
19-Aug	12.00	83	3	12.00	210	2	24.00	293	5
20-Aug	12.00	92	3	12.00	272	2	24.00	364	5
21-Aug	12.00	64	1	12.00	338	3	24.00	402	4
22-Aug	12.00	94	5	12.00	185	5	24.00	279	10
23-Aug	12.00	89	4	12.00	218	2	24.00	307	6
24-Aug	12.00	58	3	12.00	167	0	24.00	225	3
25-Aug	8.00	28	1	12.00	318	6	20.00	346	7
26-Aug	12.00	69	2	12.00	248	6	24.00	317	8
27-Aug	12.00	130	0	12.00	287	6	24.00	417	6
28-Aug	12.00	76	15	12.00	247	4	24.00	323	19
29-Aug	12.00	95	12	12.00	308	9	24.00	403	21
30-Aug	12.00	119	6	12.00	154	3	24.00	273	9
31-Aug	8.47	68	4	10.50	203	2	18.97	271	6
1-Sep	11.83	76	1	12.00	226	15	23.83	302	16
2-Sep	11.50	59	2	12.00	284	5	23.50	343	7
3-Sep	12.00	74	5	12.00	458	7	24.00	532	12
4-Sep	12.00	92	4	12.00	619	3	24.00	711	7
5-Sep	12.00	127	1	12.00	689	6	24.00	816	7
6-Sep	12.00	189	6	12.00	1,120	5	24.00	1,309	11
7-Sep	12.00	216	6	12.00	749	12	24.00	965	18
8-Sep	12.00	229	3	12.00	1,142	5	24.00	1,371	8
9-Sep	12.00	301	6	12.00	1,612	14	24.00	1,913	20
10-Sep	12.00	216	7	12.00	1,595	0	24.00	1,811	7
11-Sep	12.00	244	3	12.00	2,044	10	24.00	2,288	13
12-Sep	12.00	312	2	12.00	1,847	3	24.00	2,159	5
13-Sep	11.49	180	3	12.00	1,786	4	23.49	1,966	7
14-Sep	12.00	269	1	12.00	2,318	3	24.00	2,587	4
15-Sep	12.00	354	4	12.00	2,556	5	24.00	2,910	9
16-Sep	12.00	434	3	12.00	2,571	5	24.00	3,005	8
17-Sep	12.00	378	12	12.00	2,868	11	24.00	3,246	23
18-Sep	12.00	562	16	12.00	2,967	6	24.00	3,529	22
19-Sep	12.00	573	3	12.00	2,720	14	24.00	3,293	17
20-Sep	12.00	515	9	12.00	3,308	5	24.00	3,823	14
21-Sep	12.00	479	7	12.00	3,615	21	24.00	4,094	28
22-Sep	12.00	707	8	12.00	3,132	12	24.00	3,839	20
23-Sep	12.00	644	17	12.00	2,898	17	24.00	3,542	34
24-Sep	12.00	679	11	12.00	2,383	21	24.00	3,062	32
25-Sep	12.00	736	11	12.00	2,628	16	24.00	3,364	27
26-Sep	12.00	840	24	12.00	2,408	33	24.00	3,248	57
27-Sep	12.00	862	15	12.00	2,623	25	24.00	3,485	40
28-Sep	12.00	747	3	12.00	2,060	20	24.00	2,807	23
Totals	559.29	12,409	255	566.50	59,032	374	1,125.79	71,441	629

Table 2. — Daily fall Chum Salmon upriver passage estimates at the Teedriinjik (Chandalar) River, Alaska, 2018.

Date	Left bank	Right bank	Combined	Cumulative	Cumulative %
12-Aug	75	216	291	291	0.20
13-Aug	84	130	214	505	0.35
14-Aug	48	172	220	725	0.51
15-Aug	66	162	228	953	0.67
16-Aug	56	214	270	1,223	0.85
17-Aug	120	216	336	1,559	1.09
18-Aug	106	352	458	2,017	1.41
19-Aug	166	420	586	2,603	1.82
20-Aug	184	544	728	3,331	2.33
21-Aug	128	676	804	4,135	2.89
22-Aug	188	370	558	4,693	3.28
23-Aug	178	436	614	5,307	3.71
24-Aug	116	334	450	5,757	4.02
25-Aug	109	636	745	6,502	4.54
26-Aug	138	496	634	7,136	4.98
27-Aug	260	574	834	7,970	5.56
28-Aug	152	494	646	8,616	6.02
29-Aug	190	616	806	9,422	6.58
30-Aug	238	308	546	9,968	6.96
31-Aug	149	473	622	10,590	7.39
1-Sep	152	452	604	11,194	7.82
2-Sep	120	568	688	11,882	8.30
3-Sep	148	916	1,064	12,946	9.04
4-Sep	184	1,238	1,422	14,368	10.03
5-Sep	254	1,378	1,632	16,000	11.17
6-Sep	378	2,240	2,618	18,618	13.00
7-Sep	432	1,498	1,930	20,548	14.35
8-Sep	458	2,284	2,742	23,290	16.26
9-Sep	602	3,224	3,826	27,116	18.93
10-Sep	432	3,190	3,622	30,738	21.46
11-Sep	488	4,088	4,576	35,314	24.66
12-Sep	604	3,694	4,298	39,612	27.66
13-Sep	368	3,572	3,940	43,552	30.41
14-Sep	538	4,636	5,174	48,726	34.02
15-Sep	708	5,112	5,820	54,546	38.09
16-Sep	868	5,142	6,010	60,556	42.28
17-Sep	756	5,736	6,492	67,048	46.81
18-Sep	1,124	5,934	7,058	74,106	51.74
19-Sep	1,146	5,440	6,586	80,692	56.34
20-Sep	1,030	6,616	7,646	88,338	61.68
21-Sep	958	7,230	8,188	96,526	67.40
22-Sep	1,414	6,264	7,678	104,204	72.76
23-Sep	1,288	5,796	7,084	111,288	77.70
24-Sep	1,358	4,766	6,124	117,412	81.98
25-Sep	1,472	5,256	6,728	124,140	86.68
26-Sep	1,680	4,816	6,496	130,636	91.21
27-Sep	1,724	5,246	6,970	137,606	96.08
28-Sep	1,494	4,120	5,614	143,220	100.00
Totals	24,929	118,291	143,220		

Table 3. — Hydroacoustic data collected via DIDSON at the Teedriinjik (Chandalar) River, Alaska, 2019.

Date	Left bank sample time (h)	Left bank upriver count	Left bank downriver count	Right bank sample time (h)	Right bank upriver count	Right bank downriver count	Combined sample time (h)	Combined upriver count	Combined downriver count
8-Aug	4.50	24	1	4.50	24	0	9.00	48	1
9-Aug	16.00	78	3	12.00	63	6	28.00	141	9
10-Aug	12.00	42	5	12.00	60	5	24.00	102	10
11-Aug	12.00	34	3	10.00	53	5	22.00	87	8
12-Aug	12.00	22	6	12.00	41	4	24.00	63	10
13-Aug	12.00	15	5	12.00	28	3	24.00	43	8
14-Aug	12.00	28	6	12.00	46	2	24.00	74	8
15-Aug	12.00	33	3	12.00	37	1	24.00	70	4
16-Aug	12.00	34	3	12.00	46	2	24.00	80	5
17-Aug	12.00	33	6	12.00	48	2	24.00	81	8
18-Aug	12.00	42	5	8.00	39	2	20.00	81	7
19-Aug	12.00	63	5	12.00	61	3	24.00	124	8
20-Aug	12.00	68	6	12.00	86	3	24.00	154	9
21-Aug	12.00	52	9	12.00	89	4	24.00	141	13
22-Aug	12.00	58	4	12.00	67	3	24.00	125	7
23-Aug	10.50	69	5	12.00	162	8	22.50	231	13
24-Aug	12.00	41	4	12.00	118	3	24.00	159	7
25-Aug	12.00	46	4	12.00	153	5	24.00	199	9
26-Aug	12.00	86	0	12.00	197	3	24.00	283	3
27-Aug	12.00	85	4	12.00	274	3	24.00	359	7
28-Aug	12.00	86	4	12.00	238	8	24.00	324	12
29-Aug	12.00	76	3	12.00	194	6	24.00	270	9
30-Aug	12.00	86	0	12.00	196	3	24.00	282	3
31-Aug	12.00	60	4	12.00	194	3	24.00	254	7
1-Sep	11.94	61	3	12.00	226	7	23.94	287	10
2-Sep	11.50	94	1	12.00	362	2	23.50	456	3
3-Sep	8.50	67	6	12.00	493	3	20.50	560	9
4-Sep	12.00	163	2	12.00	916	4	24.00	1,079	6
5-Sep	12.00	273	3	12.00	1,310	3	24.00	1,583	6
6-Sep	12.00	303	5	12.00	1,794	5	24.00	2,097	10
7-Sep	12.00	355	8	12.00	1,989	8	24.00	2,344	16
8-Sep	12.00	338	15	12.00	1,685	8	24.00	2,023	23
9-Sep	12.00	312	28	12.00	1,976	8	24.00	2,288	36
10-Sep	12.00	158	9	12.50	1,920	2	24.50	2,078	11
11-Sep	12.00	264	9	12.00	1,635	4	24.00	1,899	13
12-Sep	12.00	393	5	12.00	1,342	7	24.00	1,735	12
13-Sep	12.00	250	4	12.00	1,702	3	24.00	1,952	7
14-Sep	12.00	173	14	12.00	1,546	11	24.00	1,719	25
15-Sep	12.00	218	13	12.00	1,781	2	24.00	1,999	15
16-Sep	12.00	469	18	12.00	1,641	5	24.00	2,110	23
17-Sep	12.00	546	20	12.00	1,791	12	24.00	2,337	32
18-Sep	12.00	563	25	12.00	1,413	16	24.00	1,976	41
19-Sep	12.00	533	28	12.00	1,580	7	24.00	2,113	35
20-Sep	12.00	595	13	12.00	1,433	10	24.00	2,028	23
21-Sep	12.50	580	14	12.00	1,584	13	24.50	2,164	27
22-Sep	12.00	356	19	12.00	1,522	8	24.00	1,878	27
23-Sep	12.00	336	26	12.00	1,574	11	24.00	1,910	37
24-Sep	11.99	425	46	12.00	1,422	35	23.99	1,847	81
25-Sep	12.00	667	39	12.00	1,343	26	24.00	2,010	65
26-Sep	12.00	465	45	12.00	1,462	18	24.00	1,927	63
27-Sep	10.50	390	40	10.00	1,062	12	20.50	1,452	52
Totals	601.93	10,608	556	597.00	41,018	337	1,198.93	51,626	893

Table 4. — Daily fall Chum Salmon upriver passage estimates at the Teedriinjik (Chandalar) River, Alaska, 2019.

Date	Left bank	Right bank	Combined	Cumulative	Cumulative %
8-Aug	183	148	331	331	0.32
9-Aug	105	126	231	562	0.54
10-Aug	84	120	204	766	0.74
11-Aug	68	123	191	957	0.92
12-Aug	44	82	126	1,083	1.04
13-Aug	30	56	86	1,169	1.12
14-Aug	56	92	148	1,317	1.27
15-Aug	66	74	140	1,457	1.40
16-Aug	68	92	160	1,617	1.55
17-Aug	66	96	162	1,779	1.71
18-Aug	84	110	194	1,973	1.90
19-Aug	126	122	248	2,221	2.13
20-Aug	136	172	308	2,529	2.43
21-Aug	104	178	282	2,811	2.70
22-Aug	116	134	250	3,061	2.94
23-Aug	145	324	469	3,530	3.39
24-Aug	82	236	318	3,848	3.70
25-Aug	92	306	398	4,246	4.08
26-Aug	172	394	566	4,812	4.62
27-Aug	170	548	718	5,530	5.31
28-Aug	172	476	648	6,178	5.94
29-Aug	152	388	540	6,718	6.45
30-Aug	172	392	564	7,282	7.00
31-Aug	120	388	508	7,790	7.48
1-Sep	119	452	571	8,361	8.03
2-Sep	195	724	919	9,280	8.92
3-Sep	246	986	1,232	10,512	10.10
4-Sep	326	1,832	2,158	12,670	12.17
5-Sep	546	2,620	3,166	15,836	15.21
6-Sep	606	3,588	4,194	20,030	19.24
7-Sep	710	3,978	4,688	24,718	23.75
8-Sep	676	3,370	4,046	28,764	27.63
9-Sep	624	3,952	4,576	33,340	32.03
10-Sep	316	3,800	4,116	37,456	35.98
11-Sep	528	3,270	3,798	41,254	39.63
12-Sep	786	2,684	3,470	44,724	42.97
13-Sep	500	3,404	3,904	48,628	46.72
14-Sep	346	3,092	3,438	52,066	50.02
15-Sep	436	3,562	3,998	56,064	53.86
16-Sep	938	3,282	4,220	60,284	57.92
17-Sep	1,092	3,582	4,674	64,958	62.41
18-Sep	1,126	2,826	3,952	68,910	66.20
19-Sep	1,066	3,160	4,226	73,136	70.26
20-Sep	1,190	2,866	4,056	77,192	74.16
21-Sep	1,155	3,168	4,323	81,515	78.31
22-Sep	712	3,044	3,756	85,271	81.92
23-Sep	672	3,148	3,820	89,091	85.59
24-Sep	850	2,844	3,694	92,785	89.14
25-Sep	1,334	2,686	4,020	96,805	93.00
26-Sep	930	2,924	3,854	100,659	96.70
27-Sep	929	2,501	3,430	104,089	100.00
Totals	21,567	82,522	104,089		

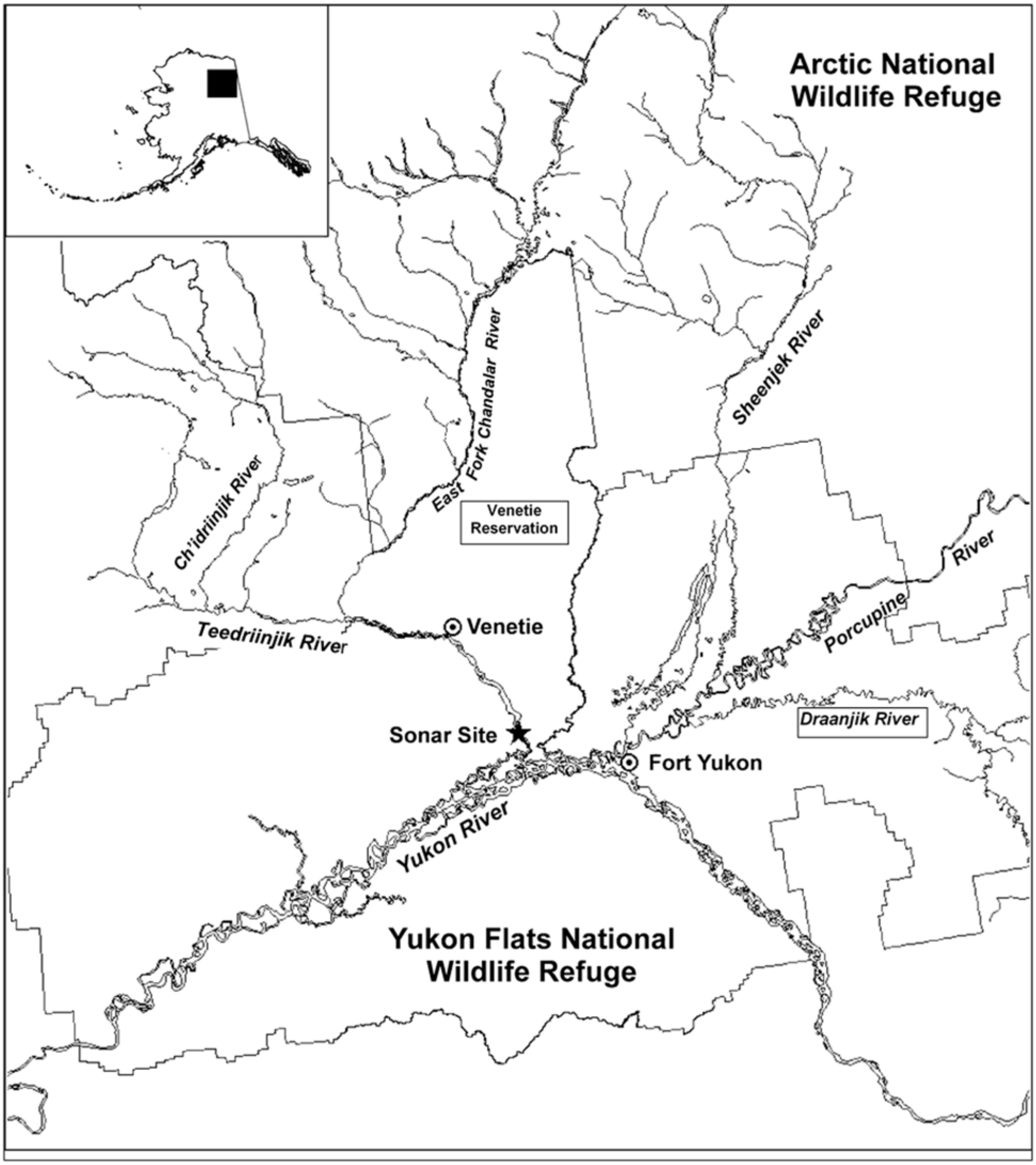


Figure 1. — Teedriinjik (Chandalar) River sonar site and major tributaries of the Yukon River near the U.S.-Canada border.

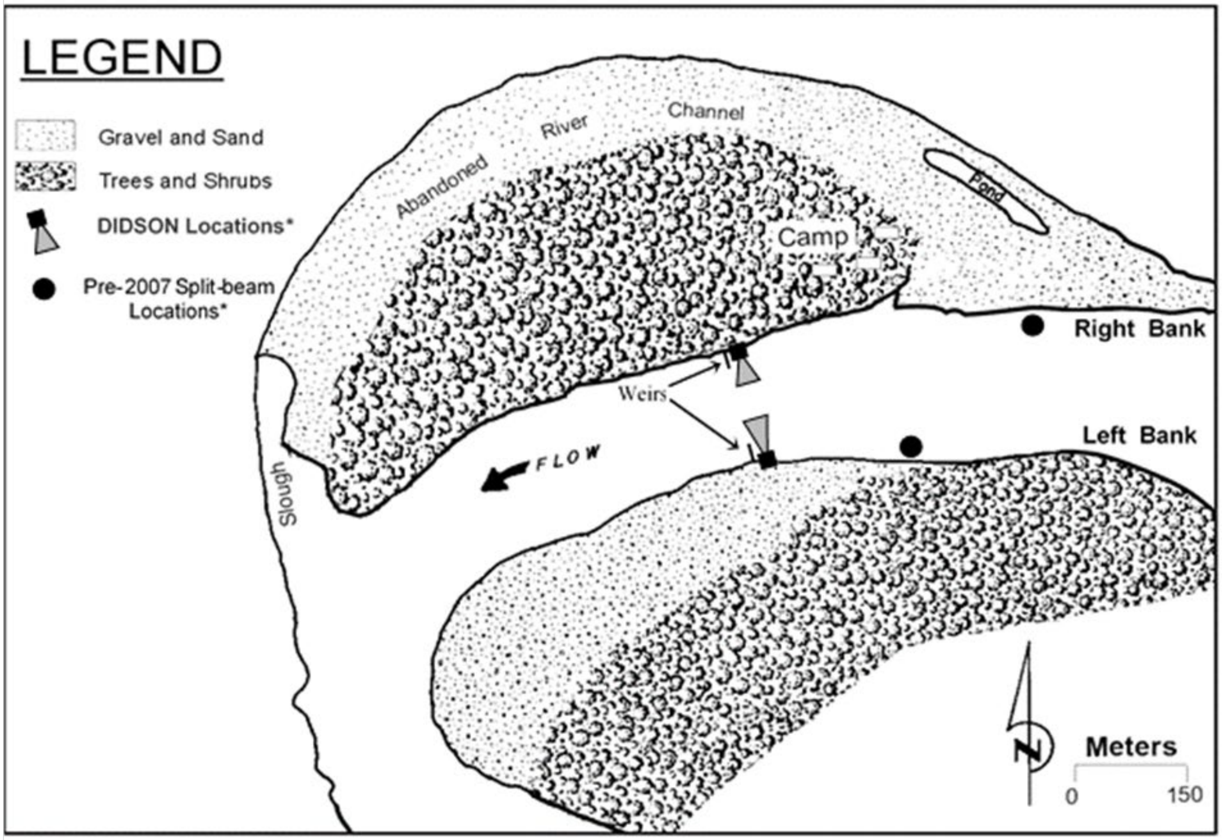


Figure 2. — Site map of Teedriinjik (Chandalar) River sonar facilities. *Sonar locations are approximate.

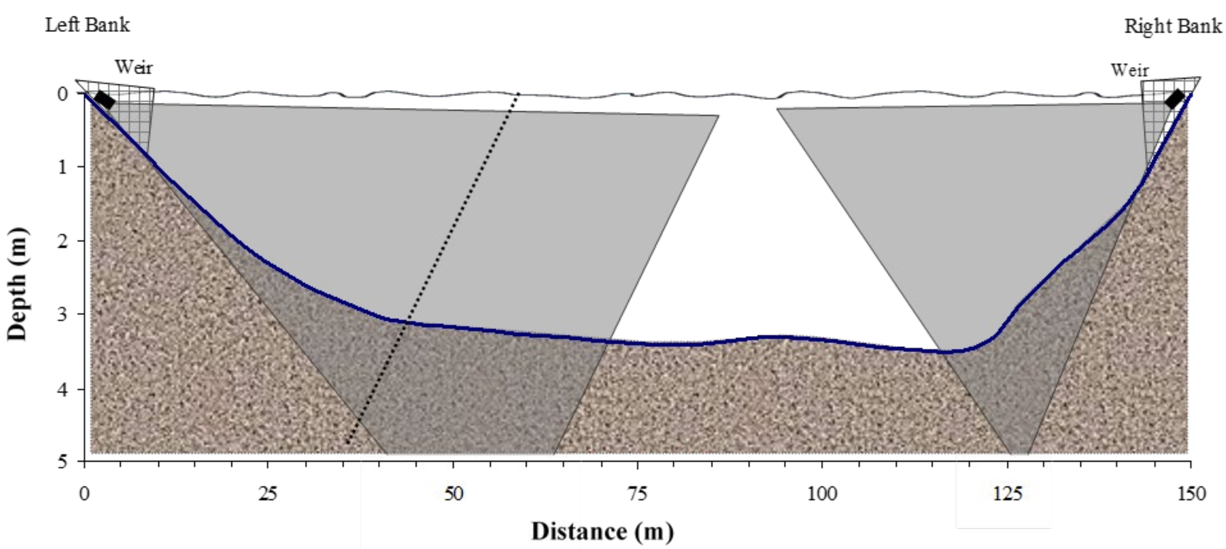
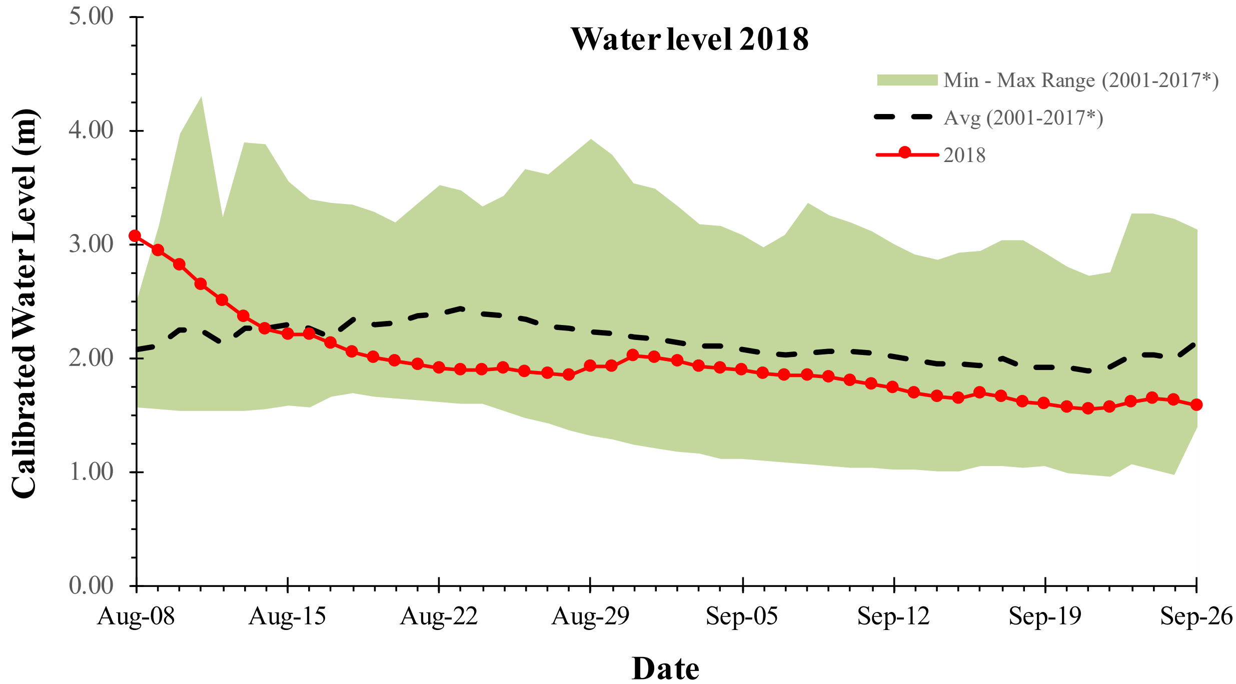


Figure 3 — River channel profile and approximated ensonified zones during 2009 for the left and right bank sonar sites, Teedriinjik (Chandalar) River. Dotted line on left bank indicates the approximate limit of the ensonified zone with the range reduced to 40 m. Little change has occurred in channel profile from 2008 through 2019. Note: different axis scales are used to enhance readability.



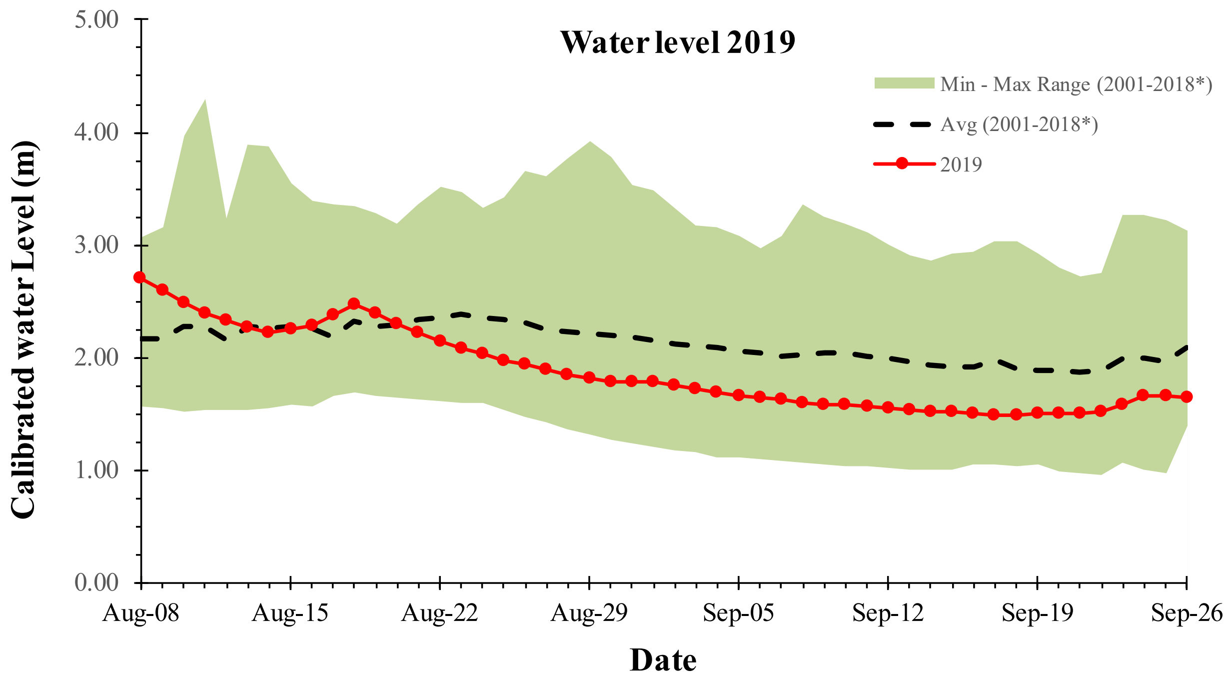


Figure 4 — Daily calibrated water levels from the Teedriinjik (Chandalar) River sonar site, 2018 and 2019. Green shaded area represents historical range of minimum and maximum water levels. *Historical min – max ranges and averages do not include data from 2003, 2005, 2006, and 2009.

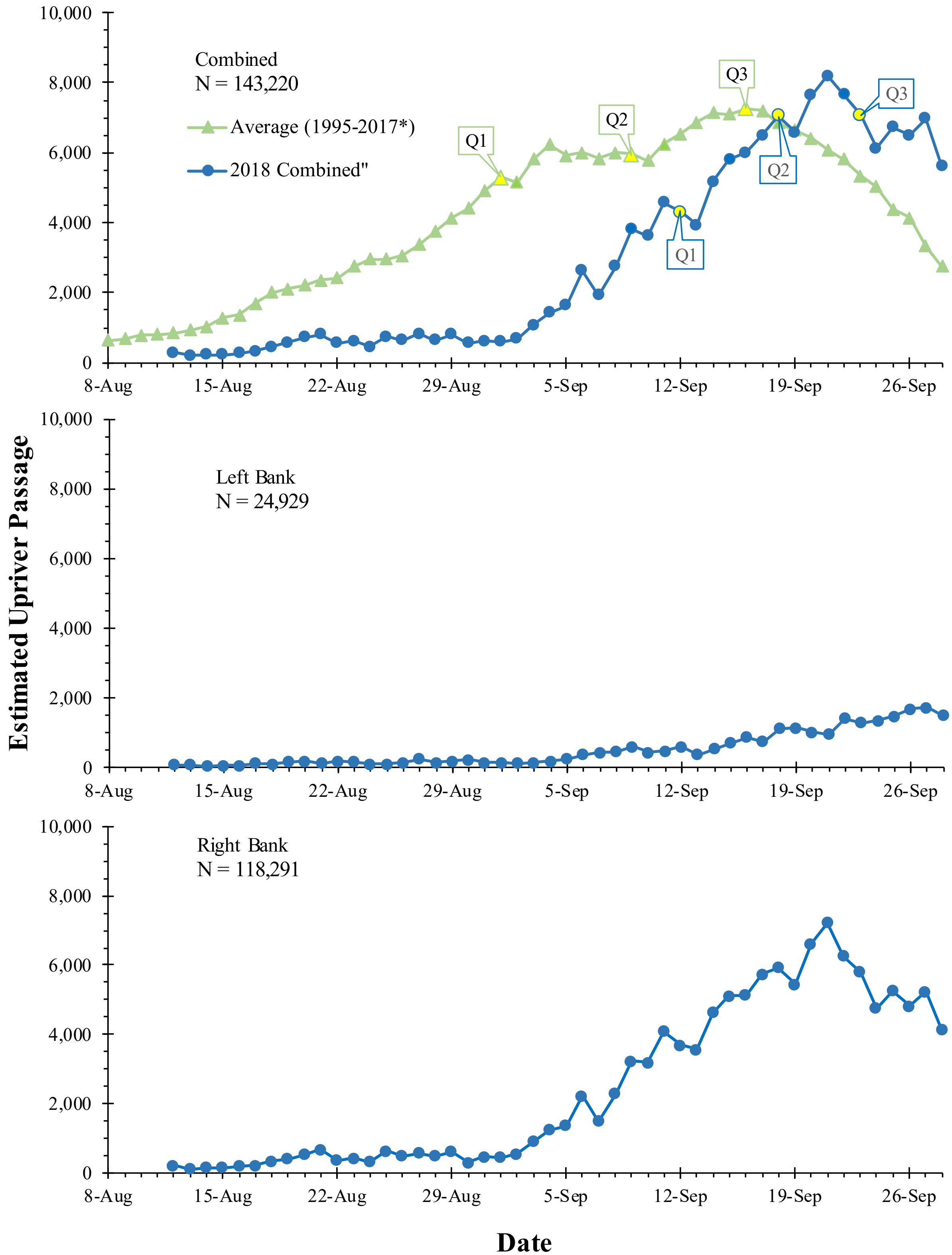


Figure 5 — Estimated passage of upriver swimming fall Chum Salmon by bank and combined, Teedriinjik (Chandalar) River, 2018. Highlighted points in the top graph indicate the 1st-quarter, mid, and 3rd-quarter points of passage. *Average does not include data from 2009 because the project ended early, before most of the run normally passes.

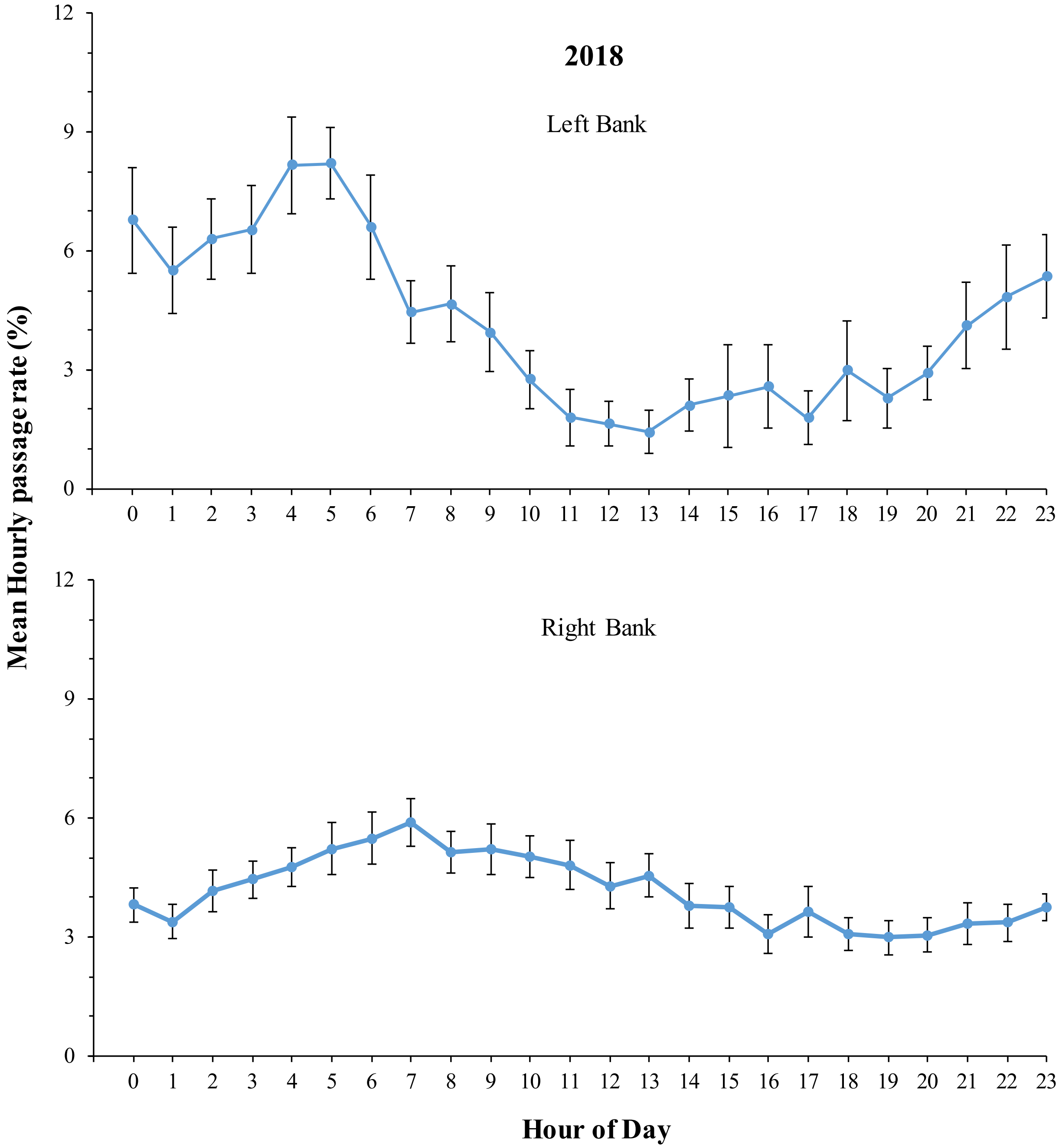


Figure 6 — Mean (±2 SE) hourly passage rate (expressed as a percent of the total daily estimate) of upriver swimming fall Chum Salmon, Teedriinjik (Chandalar) River, 2018. Results include 41 days of complete sampling (12 hours/day) on the left bank and 46 days on the right bank.

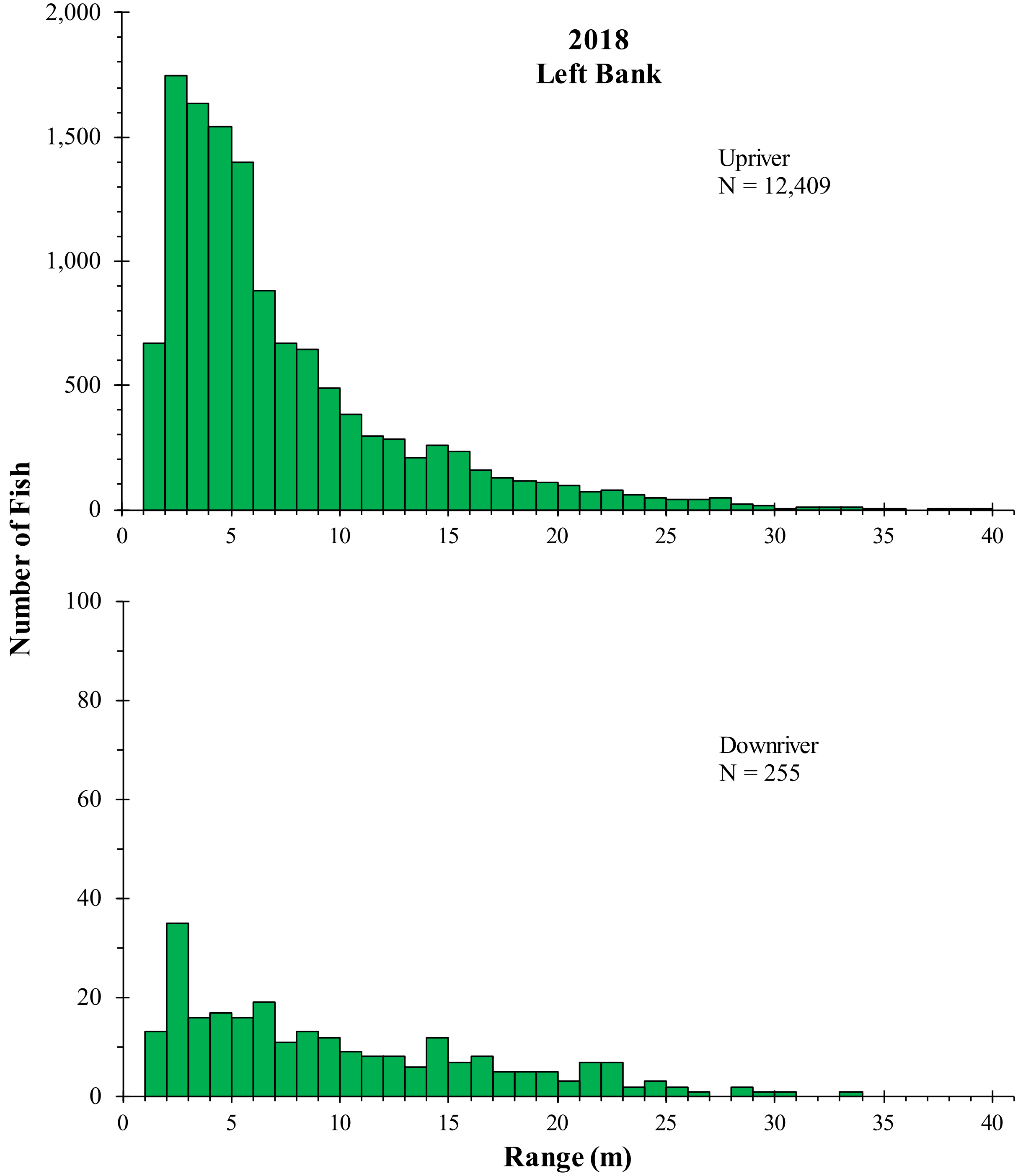


Figure 7 — Range (horizontal distance from DIDSON) distribution of upriver and downriver swimming Chum Salmon from hydroacoustic data collected on the left bank Teedriinjik (Chandalar) River, August 12 to September 28, 2018. Note different Y-axis scales.

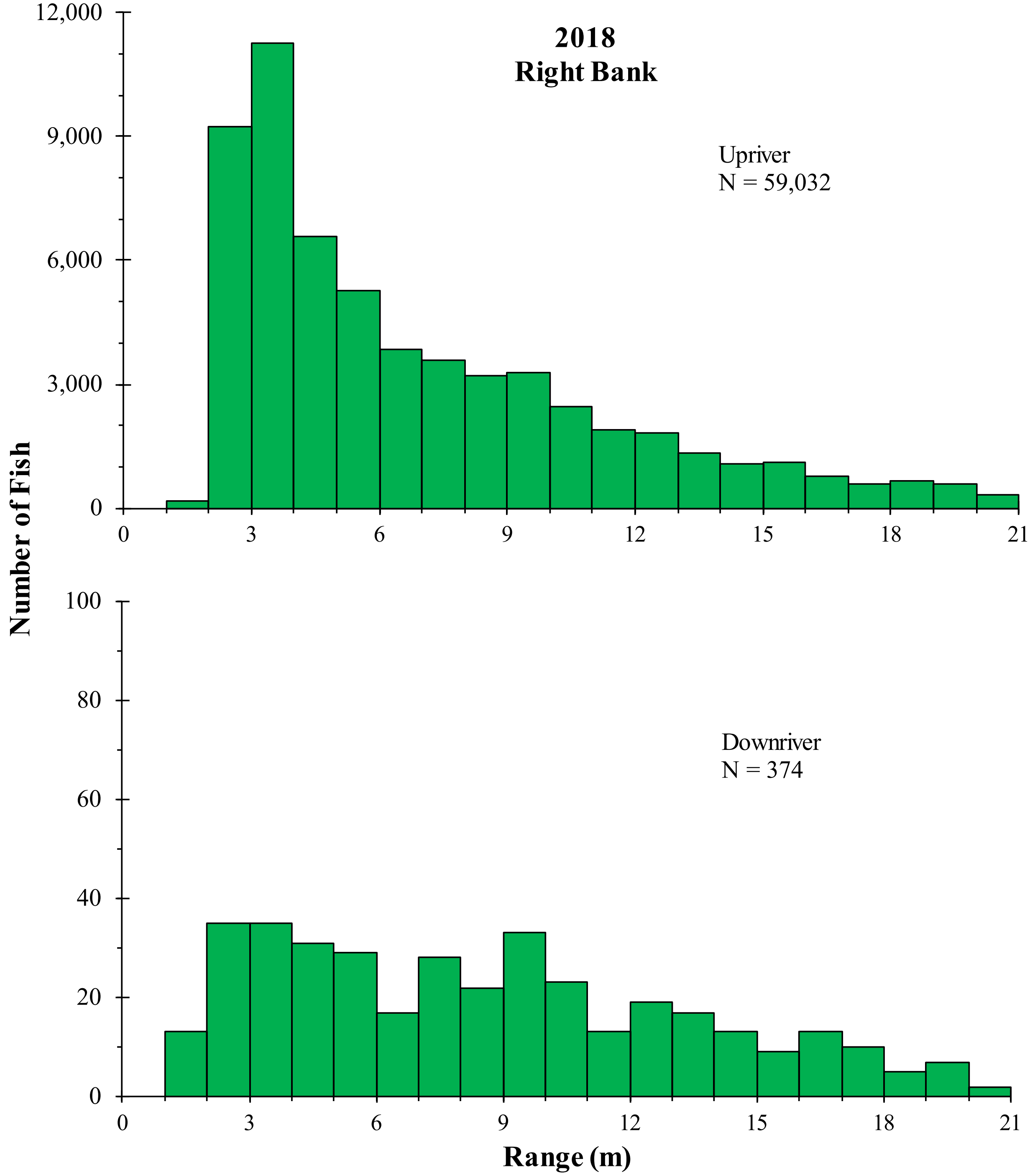


Figure 8 — Range (horizontal distance from DIDSON) distribution of upriver and downriver swimming Chum Salmon from hydroacoustic data collected on the right bank Teedriinjik (Chandalar) River, August 12 to September 28, 2018. Note different Y-axis scales.

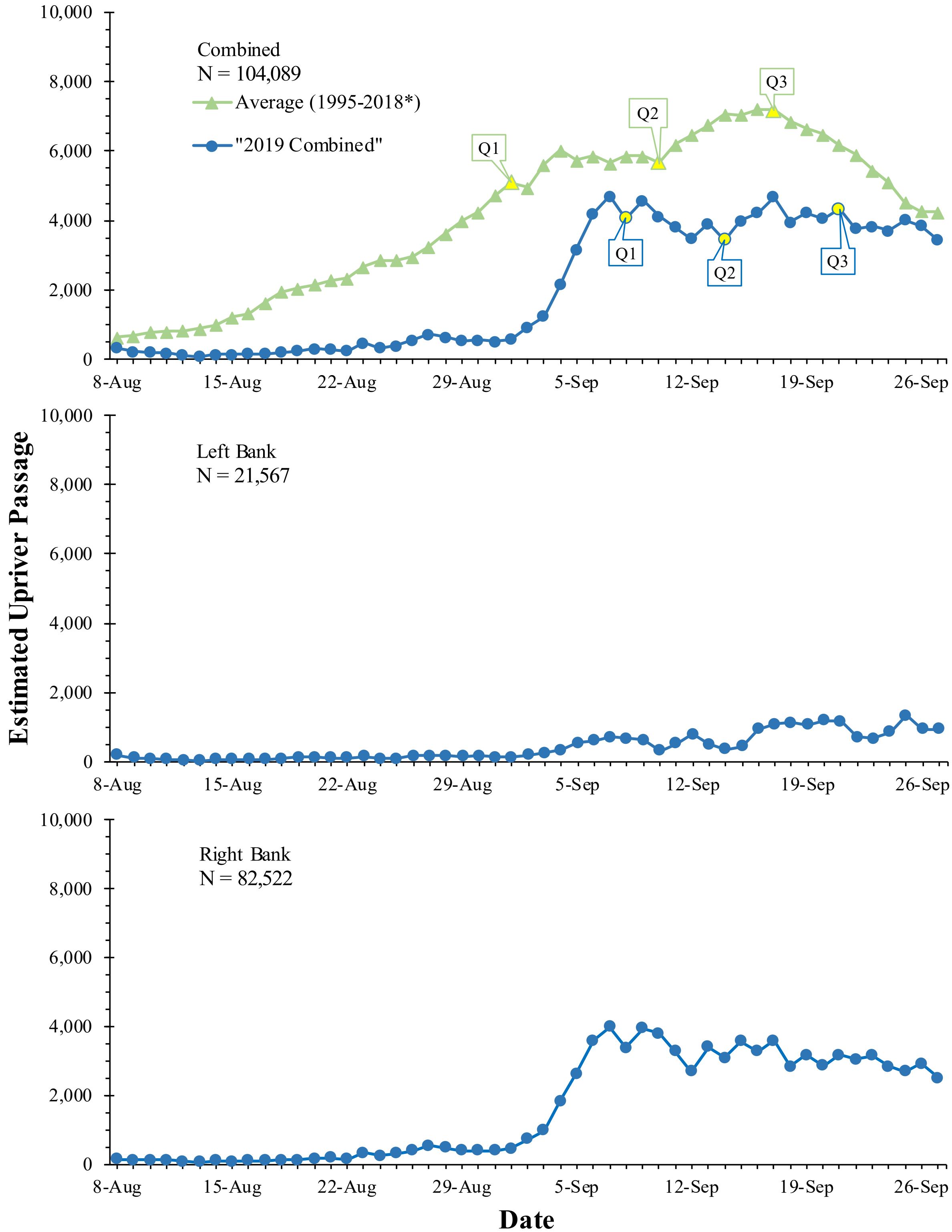


Figure 9 — Estimated passage of upriver swimming fall Chum Salmon by bank and combined, Teedriinjik (Chandalar) River, 2019. Highlighted points in the top graph indicate the 1st-quarter, mid, and 3rd-quarter points of passage. *Average does not include data from 2009 because the project ended early, before most of the run normally passes.

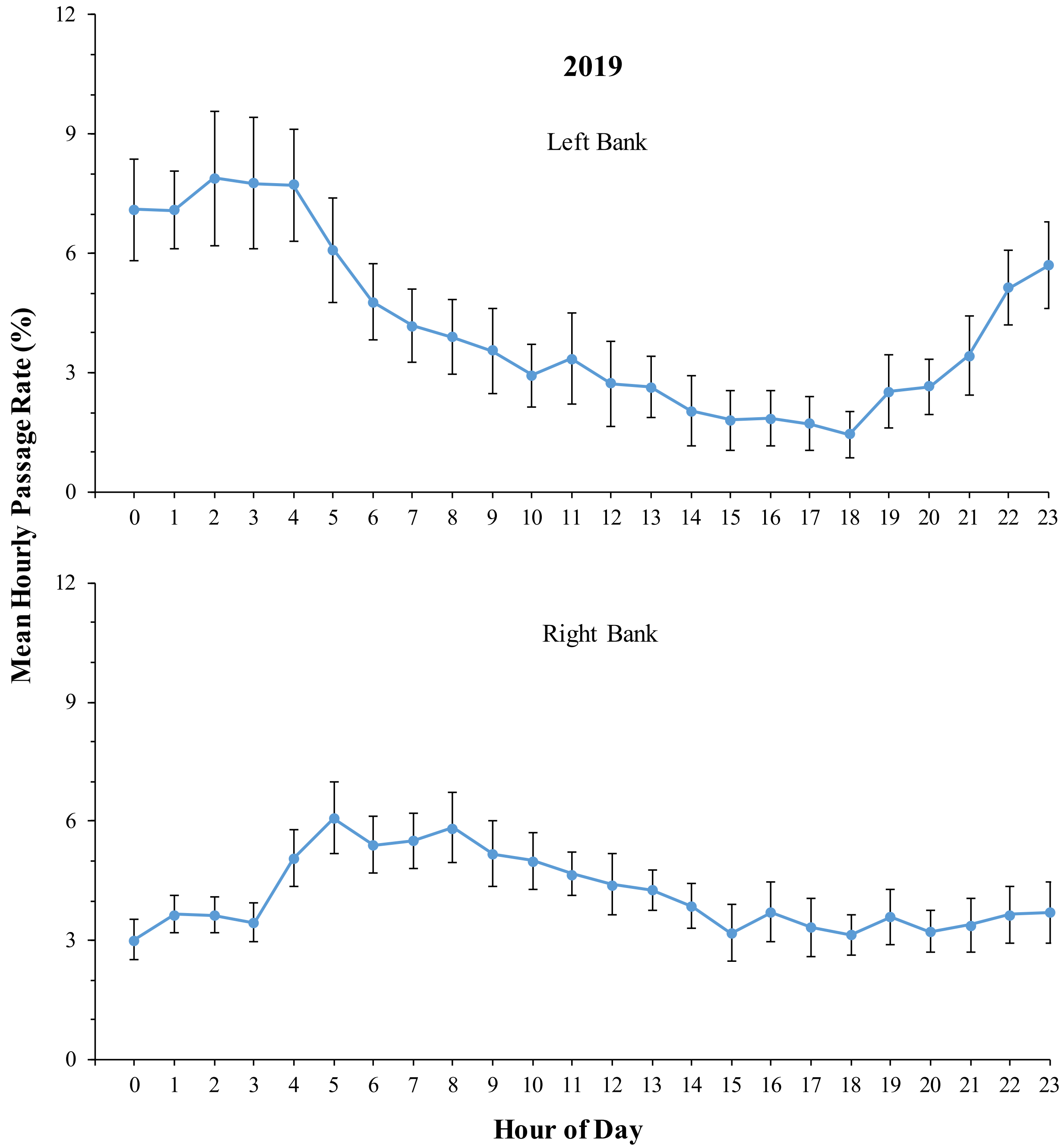


Figure 10 — Mean (±2 SE) hourly passage rate (expressed as a percent of the total daily estimate) of upriver swimming fall Chum Salmon, Teedriinjik (Chandalar) River, 2019. Results include 45 days of complete sampling (12 hours/day) on the left bank and 47 days on the right bank.

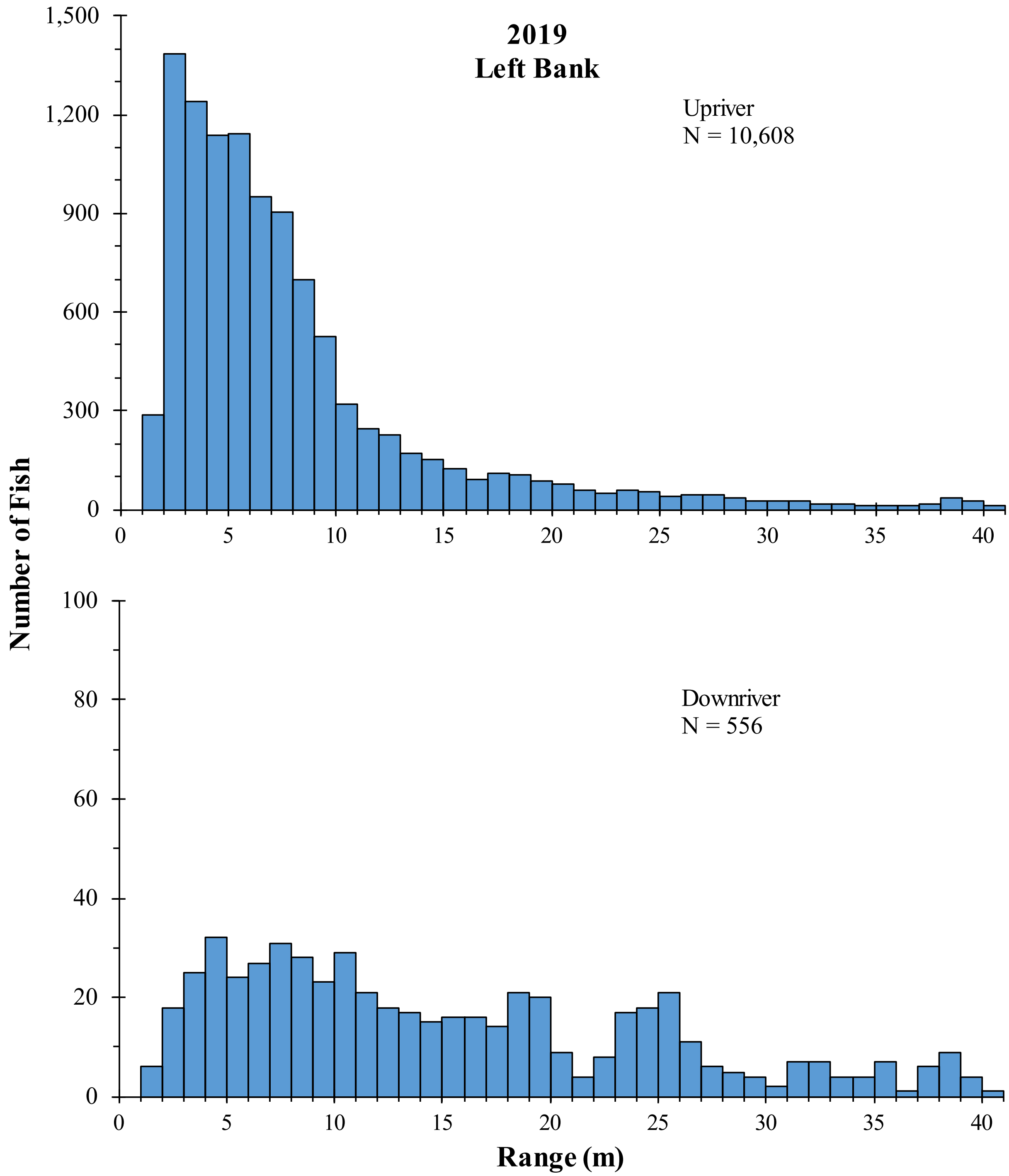


Figure 11 — Range (horizontal distance from DIDSON) distribution of upriver and downriver swimming Chum Salmon from hydroacoustic data collected on the left bank Teedriinjik (Chandalar) River, August 8 to September 27, 2019. Note different Y-axis scales.

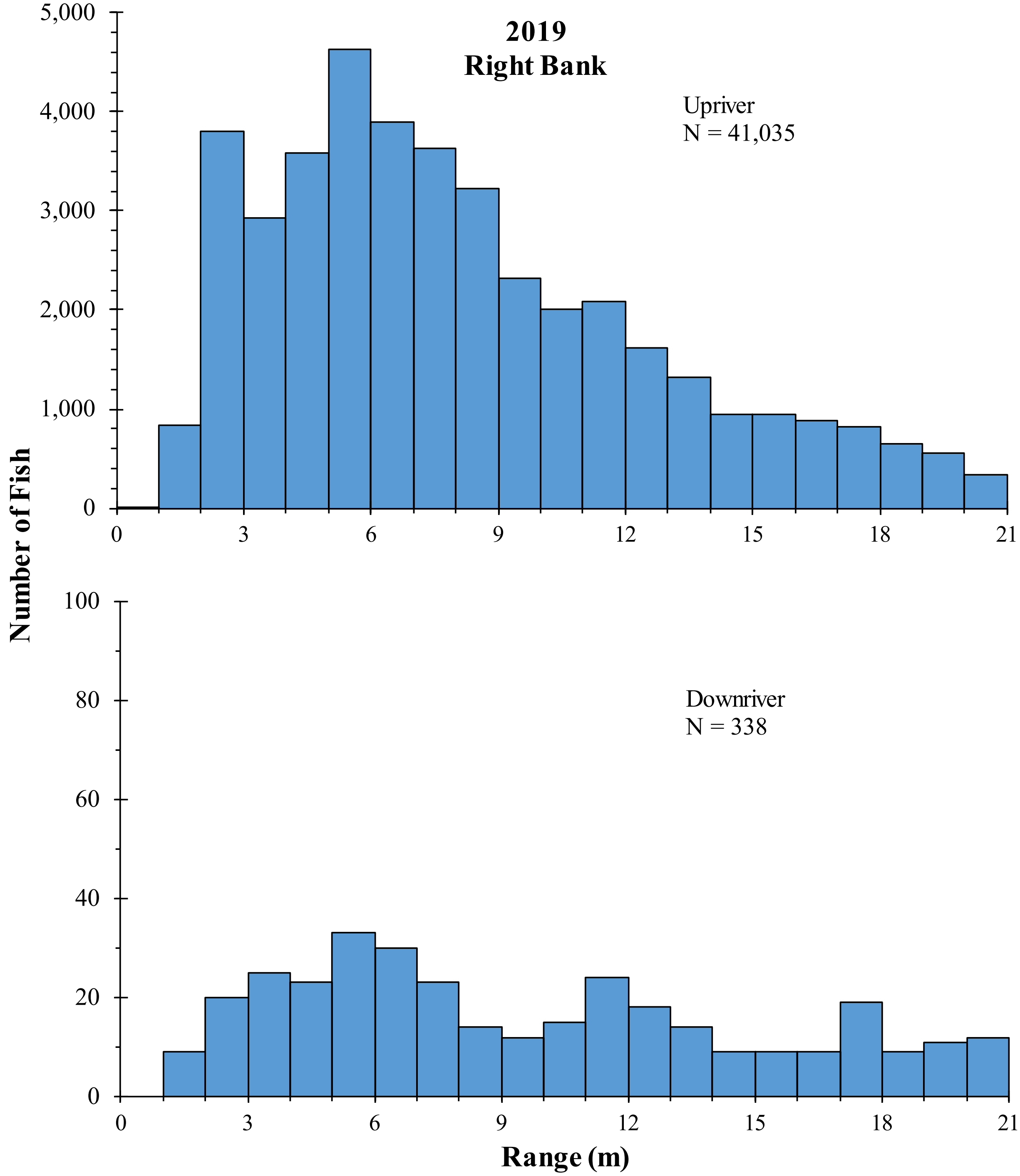


Figure 12 — Range (horizontal distance from DIDSON) distribution of upriver and downriver swimming Chum Salmon from hydroacoustic data collected on the right bank Teedriinjik (Chandalar) River, August 8 to September 27, 2019. Note different Y-axis scales.

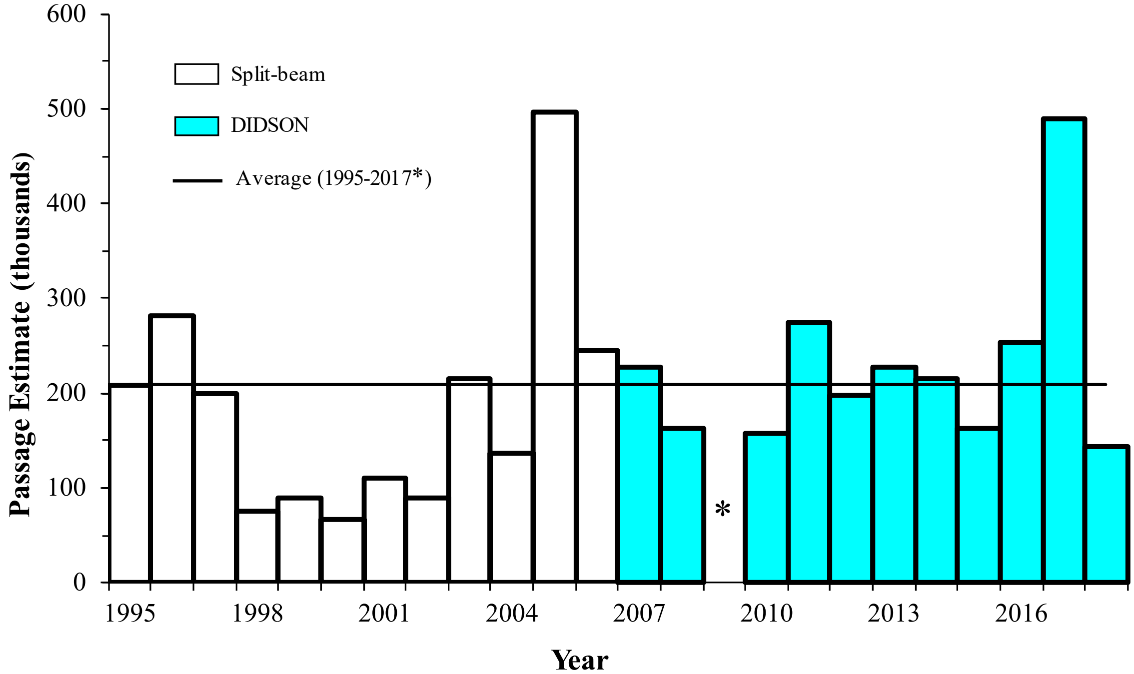


Figure 13 — **Annual passage estimates (in thousands of fish) of fall Chum Salmon from sonar counts on the Teedriinjik (Chandalar) River, 1995 to 2018. The horizontal line indicates the average of 1995 to 2017 passage estimates. *Average does not include data from 2009 because the project ended early, before most of the run normally passes.**

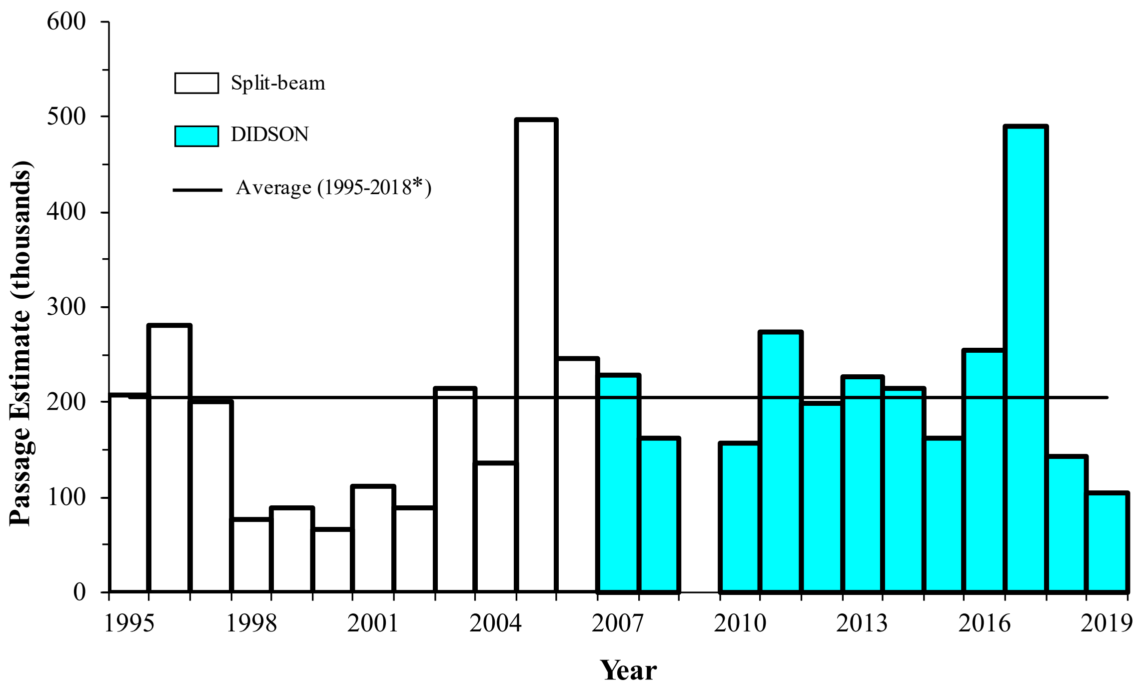


Figure 14 — Annual passage estimates (in thousands of fish) of fall Chum Salmon from sonar counts on the Teedriinjik (Chandalar) River, 1995 to 2019. The horizontal line indicates the average of 1995 to 2018 passage estimates. *Average does not include data from 2009 because the project ended early, before most of the run normally passes.

Appendix A Historical Passage

Table A.1. — Historical fall Chum Salmon passage estimates from sonar counts on the Teedriinjik (Chandalar) River, Alaska.

Year	Sonar type	Left bank passage estimate	Right bank passage estimate	Combined passage estimate
1987	Bendix	36,089	16,327	52,416
1988	Bendix	20,516	13,103	33,619
1989	Bendix	36,495	32,666	69,161
1990	Bendix	24,635	53,996	78,631
1995[a]	Split-beam	116,074	164,925	280,999
1996	Split-beam	75,630	132,540	208,170
1997	Split-beam	65,471	134,403	199,874
1998	Split-beam	31,676	44,135	75,811
1999	Split-beam	38,091	50,571	88,662
2000	Split-beam	16,420	49,474	65,894
2001	Split-beam	20,299	90,672	110,971
2002	Split-beam	24,188	65,392	89,580
2003	Split-beam	68,825	145,591	214,416
2004	Split-beam	29,851	106,852	136,703
2005	Split-beam	159,937	336,547	496,484
2006	Split-beam	63,123	181,967	245,090
2007	DIDSON	31,193	196,862	228,055
2008	DIDSON	22,261	139,763	162,024
2009[b]	DIDSON	1,314	4,861	6,175
2010	DIDSON	38,539	119,205	157,744
2011	DIDSON	76,638	197,327	273,965
2012	DIDSON	67,731	130,200	197,931
2013	DIDSON	56,073	171,072	227,145
2014	DIDSON	72,803	141,593	214,396
2015	DIDSON	50,170	112,368	162,538
2016	DIDSON	87,579	166,816	254,395
2017	DIDSON	217,079	266,754	483,833
2018	DIDSON	24,929	118,291	143,220
2019	DIDSON	21,567	82,522	104,089

[a] Estimates calculated post season.
[b] Incomplete counts, operations stopped before most of the run normally passes.

Appendix B Age, Sex, and Length Data

Table B.1. — Historical age and sex of fall Chum Salmon carcasses sampled on spawning grounds in the Teedriinjik (Chandalar) River, Alaska. Vertebrae were aged by Alaska Department of Fish and Game. Unknown age indicates the number of samples that could not be aged and were not included in age calculations.

Year	Sex	Sample size	Unknown age	Age 0.2 brood year 2003 n (%)	Age 0.3 brood year 2002 n (%)	Age 0.4 brood year 2001 n (%)	Age 0.5 brood year 2000 n (%)	Age 0.6 brood year 1999 n (%)
2006	Female	72(41.1%)	0 (0.0%)	8 (11.1%)	45 (62.5%)	16 (22.2%)	3 (4.2%)	0 (0.0%)
	Male	103(58.9%)	0 (0.0%)	6 (5.8%)	69 (67.0%)	28 (27.2%)	0 (0.0%)	0 (0.0%)
	Total	175(100.0%)	0 (0.0%)	14 (8.0%)	114 (65.1%)	44 (25.1%)	3 (1.7%)	0 (0.0%)
2008	Female	102(56.4%)	2 (2.0%)	4 (4.0%)	45 (45.0%)	41 (41.0%)	7 (7.0%)	3 (3.0%)
	Male	79(43.6%)	1 (1.3%)	2 (2.6%)	28 (35.9%)	42 (53.8%)	6 (7.7%)	0 (0.0%)
	Total	181(100.0%)	3 (1.7%)	6 (3.4%)	73 (41.0%)	83 (46.6%)	13 (7.3%)	3 (1.7%)
2009	Female	104(57.7%)	0 (0.0%)	10 (9.6%)	70 (67.3%)	23 (22.1%)	1 (0.9%)	0 (0.0%)
	Male	76(42.2%)	0 (0.0%)	6 (7.9%)	43 (56.6%)	23 (30.3%)	3 (3.9%)	1 (1.3%)
	Total	180(100.0%)	0 (0.0%)	16 (8.8%)	113 (62.8%)	46 (25.6%)	4 (2.2%)	1 (0.6%)
2010	Female	124(70.1%)	0 (0.0%)	30 (24.2%)	70 (56.5%)	19 (15.3%)	4 (3.2%)	1 (0.8%)
	Male	53(29.9%)	0 (0.0%)	7 (13.2%)	33 (62.3%)	11 (20.8%)	2 (3.8%)	0 (0.0%)
	Total	177(100.0%)	0 (0.0%)	37 (20.9%)	103 (58.2%)	30 (16.9%)	6 (3.4%)	1 (0.6%)
2011	Female	277 (51.3%)	6 (2.1%)	4 (1.5%)	161 (61.7%)	92 (35.2%)	14 (5.4%)	0 (0.0%)
	Male	263 (48.7%)	3 (1.1%)	3 (1.2%)	116 (44.6%)	126 (48.5%)	15 (5.8%)	0 (0.0%)
	Total	540 (100.0%)	9 (1.7%)	7 (1.3%)	277 (52.2%)	218 (41.1%)	29 (5.5%)	0 (0.0%)

Table B.2. — Historical length-at-age (mid-eye to fork length (mm)) of female and male fall Chum Salmon carcasses sampled on Teedriinjik (Chandalar) River spawning grounds, Alaska.

Year	Age	Female N	Female Mean	Female SE	Female Median	Female Range	Male N	Male Mean	Male SE	Male Median	Male Range
2006											
	0.2	8	542	13.2	540	480-590	6	573	15.6	585	510-620
	0.3	45	551	3.5	550	500-600	69	583	3.8	580	500-655
	0.4	16	564	5.6	560	530-600	28	604	6.1	600	550-660
	0.5	3	607	18.6	–	570-630	–	–	–	–	–
	0.6	0	–	–	–	–	–	–	–	–	–
	Total	72					103				
2008											
	0.2	4	543	19.3	545	500-580	2	540	10	540	530-550
	0.3	45	552	3.3	550	510-610	28	575	5.9	570	520-640
	0.4	41	578	4.0	580	530-630	42	608	4.3	605	560-700
	0.5	7	560	11.1	560	520-610	6	595	4.3	595	580-610
	0.6	3	593	8.8	590	580-610	0	–	–	–	–
	Total	100					78				
2009											
	0.2	10	553	8.8	555	505-590	6	575	14.1	585	510-610
	0.3	70	557	2.9	558	500-600	43	584	4.3	580	540-650
	0.4	23	565	6.6	570	470-620	23	615	4.8	620	560-660
	0.5	1	590	–	590	–	3	607	16.7	590	590-640
	0.6	0	–	–	–	–	1	660	–	660	–
	Total	104					76				
2010											
	0.2	30	545	4.6	543	490-610	7	599	6.6	600	575-630
	0.3	70	558	3.2	560	500-650	33	605	7.7	610	530-720
	0.4	19	568	8.2	570	500-630	11	586	12.1	580	540-670
	0.5	4	585	11.9	585	560-610	2	595	15.0	595	580-610
	0.6	1	630	–	630	–	0	–	–	–	–
	Total	124					53				
2011											
	0.2	4	531	11.4	530	505-560	3	558	25.9	535	530-610
	0.3	161	562	2.2	560	500-670	116	600	2.9	605	510-660
	0.4	92	582	2.7	580	505-645	126	614	2.3	615	555-695
	0.5	14	594	8.7	588	550-650	15	612	10.3	620	530-695
	0.6	0	–	–	–	–	0	–	–	–	–
	Total	271					260				

Appendix C. Water Quality, Staff Gauge, and Water Temperature Data

Table C.1. — Daily water quality data collected with a YSI sonde at the Teedriinjik (Chandalar) River sonar project, 2018. Daily average, minimum, and maximum calculated from readings taken every 15 minutes.

Date (m/d/y)		Temperature (°C)	Specific Conductance (uS/cm)	Conductivity (uS/cm)	pH	Turbidity (NTU)	DO (% saturation)	DO (mg/L)
8/3/2018	Average	15.60	410	337	8.15	5.9	96.3	9.58
	Min	14.72	408	328	8.14	4.6	95.4	9.41
	Max	16.69	414	348	8.16	8.2	97.1	9.81
8/4/2018	Average	14.42	405	323	8.15	4.3	97.4	9.93
	Min	14.09	403	321	8.14	3.3	96.2	9.79
	Max	14.73	408	328	8.15	9.1	98.7	10.01
8/5/2018	Average	13.48	405	316	8.14	8.5	97.2	10.12
	Min	12.95	403	312	8.14	3.2	96.7	9.96
	Max	14.36	409	322	8.15	30.5	97.8	10.29
8/6/2018	Average	12.59	426	325	8.12	183.3	98.1	10.41
	Min	12.32	410	316	8.10	36.0	97.2	10.26
	Max	12.94	439	334	8.14	334.0	99.0	10.50
8/7/2018	Average	12.02	414	312	8.09	325.5	98.1	10.56
	Min	11.62	409	306	8.08	276.1	96.9	10.46
	Max	12.45	422	321	8.10	359.4	99.3	10.63
8/8/2018	Average	11.93	415	311	8.09	188.1	98.2	10.59
	Min	11.50	410	306	8.08	122.4	97.1	10.48
	Max	12.30	420	316	8.10	286.8	99.4	10.66
8/9/2018	Average	11.52	424	314	8.09	87.0	98.3	10.70
	Min	11.19	420	311	8.08	61.0	97.3	10.62
	Max	11.84	426	318	8.09	123.0	99.3	10.76
8/10/2018	Average	11.25	426	314	8.10	48.0	98.2	10.76
	Min	10.84	426	311	8.09	36.3	97.1	10.67
	Max	11.80	427	319	8.11	63.5	99.5	10.83
8/11/2018	Average	11.62	428	319	8.10	31.2	98.5	10.70
	Min	10.88	426	312	8.09	24.2	97.2	10.58
	Max	12.39	430	326	8.11	43.8	99.9	10.79
8/12/2018	Average	11.97	431	324	8.09	19.9	98.0	10.55
	Min	11.53	430	320	8.09	15.9	97.2	10.44
	Max	12.27	432	327	8.10	24.7	98.7	10.62
8/13/2018	Average	11.97	430	323	8.10	13.4	96.6	10.40
	Min	11.82	429	321	8.10	10.0	96.1	10.36
	Max	12.14	432	325	8.11	18.7	97.3	10.44
8/14/2018	Average	11.28	432	319	8.12	9.0	96.6	10.57
	Min	11.00	431	316	8.10	6.4	95.4	10.36
	Max	11.89	433	324	8.13	12.9	97.9	10.72
8/15/2018	Average	10.80	429	313	8.12	6.3	97.7	10.81
	Min	10.31	424	310	8.11	5.2	96.6	10.71
	Max	11.27	432	316	8.12	7.6	99.2	10.88
8/16/2018	Average	10.63	419	304	8.11	5.3	97.8	10.86
	Min	10.29	416	301	8.10	4.6	96.5	10.76
	Max	10.98	424	310	8.12	6.5	99.1	10.94
8/17/2018	Average	10.09	418	299	8.12	4.1	97.8	11.00
	Min	9.87	417	297	8.11	3.1	96.9	10.89
	Max	10.52	419	301	8.13	5.1	98.6	11.08
8/18/2018	Average	10.28	420	302	8.12	3.0	98.8	11.07
	Min	9.82	419	298	8.10	2.4	97.7	10.98
	Max	10.96	422	308	8.12	6.7	100.4	11.13
8/19/2018	Average	11.07	422	310	8.11	2.7	99.1	10.90
	Min	10.35	421	304	8.10	1.8	97.5	10.75
	Max	11.88	423	317	8.12	4.2	100.6	10.99
8/20/2018	Average	12.11	418	315	8.10	2.1	99.1	10.64
	Min	11.54	415	311	8.09	1.3	98.1	10.50
	Max	12.84	422	319	8.10	4.2	100.4	10.75

Table C.1. — Continued.

Date (m/d/y)		Temperature (°C)	Specific Conductance (uS/cm)	Conductivity (uS/cm)	pH	Turbidity (NTU)	DO (% saturation)	DO (mg/L)
8/21/2018	Average	12.14	417	315	8.09	2.0	97.6	10.47
	Min	11.48	416	310	8.07	1.0	96.9	10.43
	Max	12.56	418	317	8.11	4.9	98.9	10.56
8/22/2018	Average	10.76	418	304	8.12	2.0	97.8	10.83
	Min	10.21	418	300	8.11	1.0	95.9	10.55
	Max	11.46	419	310	8.14	6.2	99.9	10.98
8/23/2018	Average	9.94	420	299	8.12	1.2	97.7	11.02
	Min	9.68	419	297	8.11	0.4	96.9	10.93
	Max	10.57	420	304	8.13	3.4	98.4	11.11
8/24/2018	Average	9.79	418	296	8.11	0.6	97.6	11.06
	Min	9.31	416	293	8.10	0.0	96.4	11.03
	Max	10.24	420	299	8.12	2.7	98.7	11.09
8/25/2018	Average	10.19	417	299	8.11	0.5	98.5	11.05
	Min	9.56	416	294	8.10	-0.1	96.9	10.97
	Max	11.03	417	306	8.12	1.6	100.3	11.12
8/26/2018	Average	10.22	418	300	8.10	0.6	98.3	11.03
	Min	9.68	417	296	8.10	0.1	97.0	10.97
	Max	10.59	418	303	8.12	1.7	99.6	11.08
8/27/2018	Average	10.71	419	304	8.11	0.6	98.1	10.88
	Min	10.37	418	301	8.10	0.0	97.1	10.81
	Max	11.34	419	310	8.12	2.5	99.4	10.95
8/28/2018	Average	10.90	418	305	8.12	0.3	98.4	10.86
	Min	10.33	417	301	8.11	-0.3	97.0	10.79
	Max	11.54	418	310	8.13	2.8	100.1	10.91
8/29/2018	Average	10.66	412	299	8.11	1.5	98.1	10.89
	Min	10.29	404	290	8.09	0.0	97.3	10.80
	Max	11.06	417	306	8.12	5.0	99.0	10.97
8/30/2018	Average	9.40	404	284	8.10	2.9	97.1	11.10
	Min	8.98	401	281	8.09	1.8	96.4	10.95
	Max	10.27	409	290	8.10	4.8	97.8	11.21
8/31/2018	Average	8.45	412	282	8.10	2.2	97.5	11.41
	Min	8.00	409	278	8.10	1.2	95.9	11.18
	Max	8.97	414	285	8.12	5.1	99.3	11.59
9/1/2018	Average	7.59	418	279	8.11	1.5	97.9	11.70
	Min	7.31	414	276	8.10	0.5	97.2	11.58
	Max	7.96	422	282	8.13	4.1	98.8	11.76
9/2/2018	Average	7.35	424	281	8.11	1.6	98.3	11.82
	Min	6.64	422	276	8.10	0.5	96.7	11.67
	Max	7.95	426	287	8.12	3.0	100.2	11.91
9/3/2018	Average	7.84	426	287	8.11	0.9	98.8	11.74
	Min	7.50	426	284	8.09	0.2	97.8	11.70
	Max	8.15	427	289	8.11	1.9	99.8	11.78
9/4/2018	Average	7.92	427	288	8.11	0.1	99.2	11.75
	Min	7.48	426	284	8.11	-0.5	98.0	11.70
	Max	8.31	428	291	8.12	1.2	100.3	11.81
9/5/2018	Average	8.42	428	293	8.12	-0.3	99.7	11.67
	Min	7.75	427	287	8.11	-0.8	98.2	11.52
	Max	9.03	429	298	8.13	0.5	101.2	11.73
9/6/2018	Average	8.91	427	296	8.11	-0.3	99.2	11.47
	Min	8.62	427	294	8.11	-0.7	98.2	11.44
	Max	9.22	428	298	8.13	0.9	100.0	11.53
9/7/2018	Average	8.28	427	290	8.12	1.5	99.2	11.66
	Min	7.87	426	287	8.11	0.3	97.8	11.46
	Max	8.80	427	295	8.14	4.0	100.9	11.76
9/8/2018	Average	7.55	427	285	8.12	0.1	99.4	11.89
	Min	7.02	427	280	8.10	-0.7	97.9	11.74
	Max	8.04	428	289	8.14	1.4	101.2	11.98

Table C.1. — Continued.

Date (m/d/y)		Temperature (°C)	Specific Conductance (uS/cm)	Conductivity (uS/cm)	pH	Turbidity (NTU)	DO (% saturation)	DO (mg/L)
9/9/2018	Average	7.09	427	281	8.11	-0.2	98.8	11.95
	Min	6.73	427	278	8.09	-0.7	97.8	11.90
	Max	7.45	428	284	8.12	1.7	100.1	12.01
9/10/2018	Average	7.01	427	280	8.10	0.1	98.5	11.94
	Min	6.40	426	275	8.09	-0.7	97.0	11.86
	Max	7.63	427	285	8.11	1.8	100.2	12.01
9/11/2018	Average	7.31	425	281	8.10	0.4	98.5	11.85
	Min	7.07	424	280	8.09	-0.3	97.7	11.80
	Max	7.58	426	283	8.12	1.2	99.5	11.90
9/12/2018	Average	7.30	424	280	8.10	0.1	98.1	11.81
	Min	7.00	423	278	8.09	-0.7	97.3	11.77
	Max	7.59	424	282	8.11	1.7	99.0	11.85
9/13/2018	Average	7.59	422	282	8.10	-0.3	98.8	11.81
	Min	7.02	421	278	8.09	-0.8	97.3	11.76
	Max	8.21	423	286	8.12	0.7	100.7	11.86
9/14/2018	Average	7.62	421	281	8.11	-0.1	98.9	11.81
	Min	7.22	420	278	8.10	-0.7	97.7	11.74
	Max	8.03	422	284	8.13	1.0	100.3	11.87
9/15/2018	Average	7.06	420	276	8.12	-0.2	98.0	11.87
	Min	6.67	420	273	8.10	-0.7	96.8	11.76
	Max	7.46	420	279	8.14	2.2	99.1	11.94
9/16/2018	Average	6.95	420	275	8.13	-0.4	98.3	11.93
	Min	6.63	418	272	8.12	-0.8	97.3	11.89
	Max	7.40	423	279	8.16	0.4	99.6	11.98
9/17/2018	Average	6.60	422	274	8.12	0.2	98.2	12.02
	Min	6.09	421	270	8.11	-0.5	96.7	11.92
	Max	7.07	424	277	8.14	1.8	99.8	12.10
9/18/2018	Average	6.07	422	269	8.11	-0.4	98.3	12.20
	Min	5.78	421	267	8.10	-1.0	97.0	12.05
	Max	6.51	422	273	8.13	0.6	99.7	12.31
9/19/2018	Average	5.55	421	264	8.10	-0.7	98.2	12.35
	Min	5.41	420	263	8.10	-1.0	97.5	12.26
	Max	5.81	421	267	8.11	-0.2	98.9	12.43
9/20/2018	Average	5.76	418	264	8.10	-0.9	98.4	12.31
	Min	5.40	417	262	8.10	-1.3	97.6	12.17
	Max	6.19	420	268	8.11	3.3	99.3	12.40
9/21/2018	Average	6.37	414	267	8.10	-0.6	97.8	12.05
	Min	6.05	413	265	8.09	-1.1	97.1	11.92
	Max	6.80	417	270	8.11	1.5	98.7	12.17
9/22/2018	Average	6.43	409	264	8.10	-0.9	96.7	11.90
	Min	6.30	407	262	8.09	-1.3	96.3	11.87
	Max	6.61	412	268	8.11	0.2	97.4	11.92
9/23/2018	Average	6.01	404	258	8.10	-0.8	96.7	12.02
	Min	5.45	398	250	8.09	-1.2	95.8	11.89
	Max	6.28	407	261	8.11	2.4	97.7	12.18
9/24/2018	Average	4.97	392	242	8.09	-0.6	96.8	12.36
	Min	4.59	389	238	8.08	-1.0	96.0	12.17
	Max	5.44	398	250	8.10	0.7	97.8	12.50
9/25/2018	Average	4.29	391	236	8.09	-1.0	96.9	12.59
	Min	3.97	390	235	8.08	-1.5	96.1	12.47
	Max	4.57	393	238	8.10	1.5	98.0	12.75
9/26/2018	Average	3.84	393	235	8.09	-1.2	98.3	12.93
	Min	3.60	393	233	8.08	-1.8	97.2	12.75
	Max	4.03	394	236	8.10	28.5	99.5	13.02
9/27/2018	Average	3.79	394	235	8.08	-1.8	99.0	13.04
	Min	3.62	393	233	8.08	-1.9	98.2	12.97
	Max	3.97	395	236	8.10	-1.5	99.8	13.09

Table C.1. — Continued.

Date (m/d/y)		Temperature (°C)	Specific Conductance (uS/cm)	Conductivity (uS/cm)	pH	Turbidity (NTU)	DO (% saturation)	DO (mg/L)
9/28/2018	Average	3.20	393	230	8.09	-1.7	98.7	13.20
	Min	2.67	393	226	8.08	-1.8	98.0	13.06
	Max	3.63	394	233	8.11	-1.0	99.5	13.36
	Grand Average	8.99	418	290	8.11	16.8	98.1	11.38
	Grand Min	2.67	389	226	8.07	-1.9	95.4	9.41
	Grand Max	16.69	439	348	8.16	359.4	101.2	13.36

Table C.2. — Daily staff gauge data collected at the Teedriinjik (Chandalar) River sonar project, 2018. Daily gauge readings have been calibrated to a benchmark established on the right bank in 1989.

Date	Staff gauge (m)	Date	Staff gauge (m)	Date	Staff gauge (m)
8/5/2018	2.13	8/24/2018	1.90	9/12/2018	1.74
8/6/2018	2.72	8/25/2018	1.91	9/13/2018	1.69
8/7/2018	3.06	8/26/2018	1.88	9/14/2018	1.66
8/8/2018	3.07	8/27/2018	1.87	9/15/2018	1.64
8/9/2018	2.94	8/28/2018	1.85	9/16/2018	1.69
8/10/2018	2.81	8/29/2018	1.93	9/17/2018	1.66
8/11/2018	2.64	8/30/2018	1.93	9/18/2018	1.61
8/12/2018	2.51	8/31/2018	2.02	9/19/2018	1.60
8/13/2018	2.37	9/1/2018	2.01	9/20/2018	1.57
8/14/2018	2.26	9/2/2018	1.98	9/21/2018	1.55
8/15/2018	2.21	9/3/2018	1.93	9/22/2018	1.57
8/16/2018	2.21	9/4/2018	1.91	9/23/2018	1.62
8/17/2018	2.13	9/5/2018	1.89	9/24/2018	1.64
8/18/2018	2.05	9/6/2018	1.86	9/25/2018	1.62
8/19/2018	2.01	9/7/2018	1.85	9/26/2018	1.58
8/20/2018	1.98	9/8/2018	1.85	9/27/2018	1.55
8/21/2018	1.94	9/9/2018	1.83	9/28/2018	1.51
8/22/2018	1.91	9/10/2018	1.80		
8/23/2018	1.90	9/11/2018	1.76		

Table C.3. — Daily staff gauge data collected at the Teedriinjik (Chandalar) River sonar project, 2019. Daily gauge readings have been calibrated to a benchmark established on the right bank in 1989.

Date	Staff gauge (m)	Date	Staff gauge (m)	Date	Staff gauge (m)
8/8/2018	2.70	8/25/2018	1.97	9/11/2018	1.56
8/9/2018	2.60	8/26/2018	1.94	9/12/2018	1.55
8/10/2018	2.49	8/27/2018	1.89	9/13/2018	1.54
8/11/2018	2.39	8/28/2018	1.85	9/14/2018	1.53
8/12/2018	2.33	8/29/2018	1.81	9/15/2018	1.51
8/13/2018	2.26	8/30/2018	1.78	9/16/2018	1.50
8/14/2018	2.22	8/31/2018	1.79	9/17/2018	1.49
8/15/2018	2.25	9/1/2018	1.78	9/18/2018	1.49
8/16/2018	2.28	9/2/2018	1.75	9/19/2018	1.50
8/17/2018	2.38	9/3/2018	1.72	9/20/2018	1.50
8/18/2018	2.47	9/4/2018	1.69	9/21/2018	1.50
8/19/2018	2.39	9/5/2018	1.67	9/22/2018	1.52
8/20/2018	2.30	9/6/2018	1.64	9/23/2018	1.58
8/21/2018	2.23	9/7/2018	1.62	9/24/2018	1.66
8/22/2018	2.15	9/8/2018	1.60	9/25/2018	1.67
8/23/2018	2.08	9/9/2018	1.58	9/26/2018	1.64
8/24/2018	2.03	9/10/2018	1.58	9/27/2018	1.58

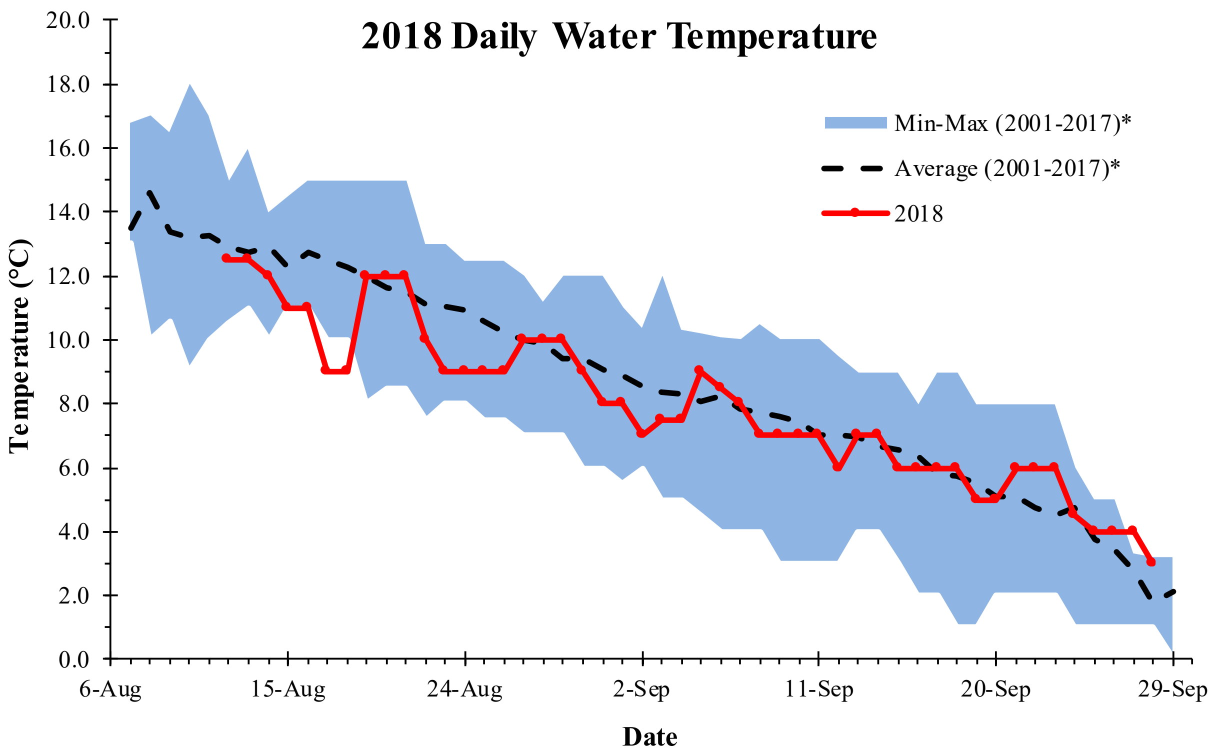


Figure C.1. — Daily water temperatures (collected with glass thermometer) from the Teedriinjik (Chandalar) River sonar site, 2018. Blue shaded area represents historical range of min-max temperatures. *Historical min-max and averages do not include data from 2003, 2005, 2007, and 2009.

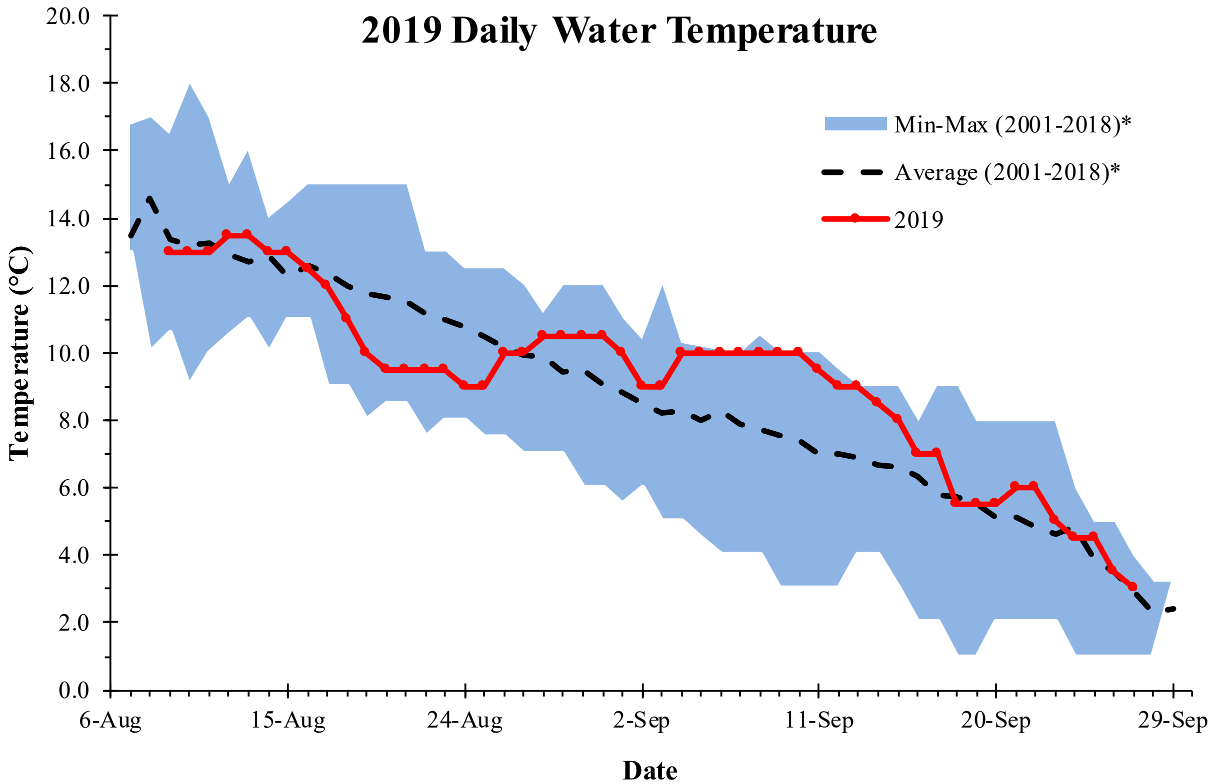


Figure C.2. — Daily water temperatures (collected with glass thermometer) from the Teedriinjik (Chandalar) River sonar site, 2019. Blue shaded area represents historical range of min-max temperatures. *Historical min-max and averages do not include data from 2003, 2005, 2007, and 2009.

Appendix D. Historical Daily and Cumulative Passage Estimates

Table D.1. — Historical daily and cumulative fall Chum Salmon passage estimates from sonar counts on the Teedriinjik (Chandalar) River. Highlighted cells indicate the mid-point of the run, and boxes indicate the quarter points.

Date	1995 Daily	1995 Cum	1996 Daily	1996 Cum	1997 Daily	1997 Cum	1998 Daily	1998 Cum	1999 Daily	1999 Cum
6-Aug										
7-Aug										
8-Aug	1,172	1,172	517	517	619	619	90	90	149	149
9-Aug	928	2,100	341	858	522	1,141	152	242	128	277
10-Aug	861	2,961	323	1,181	682	1,823	215	457	123	400
11-Aug	856	3,817	262	1,443	435	2,258	189	646	119	519
12-Aug	1,269	5,086	356	1,799	752	3,010	162	808	114	633
13-Aug	1,327	6,413	628	2,427	729	3,739	119	927	203	836
14-Aug	1,600	8,013	928	3,355	723	4,462	270	1,197	214	1,050
15-Aug	1,876	9,889	1,209	4,564	838	5,300	395	1,592	368	1,418
16-Aug	1,761	11,650	1,743	6,307	619	5,919	235	1,827	561	1,979
17-Aug	1,672	13,322	2,633	8,940	639	6,558	160	1,987	1,032	3,011
18-Aug	1,741	15,063	3,523	12,463	423	6,981	158	2,145	1,232	4,243
19-Aug	1,851	16,914	4,413	16,876	388	7,369	151	2,296	1,985	6,228
20-Aug	2,297	19,211	5,302	22,178	365	7,734	139	2,435	2,269	8,497
21-Aug	2,729	21,940	6,085	28,263	540	8,274	141	2,576	2,372	10,869
22-Aug	1,988	23,928	6,449	34,712	793	9,067	168	2,744	2,227	13,096
23-Aug	2,596	26,524	7,132	41,844	1,617	10,684	273	3,017	3,266	16,362
24-Aug	6,893	33,417	5,996	47,840	2,263	12,947	318	3,335	3,052	19,414
25-Aug	8,540	41,957	5,165	53,005	3,125	16,072	400	3,735	2,854	22,268
26-Aug	9,666	51,623	6,469	59,474	3,458	19,530	421	4,156	3,679	25,947
27-Aug	6,388	58,011	7,750	67,224	6,103	25,633	486	4,642	3,635	29,582
28-Aug	7,723	65,734	7,572	74,796	5,942	31,575	330	4,972	3,928	33,510
29-Aug	6,842	72,576	6,834	81,630	7,217	38,792	273	5,245	2,961	36,471
30-Aug	8,212	80,788	6,677	88,307	6,661	45,453	651	5,896	2,022	38,493
31-Aug	11,146	91,934	6,737	95,044	6,020	51,473	917	6,813	2,034	40,527
1-Sep	7,229	99,163	7,233	102,277	5,123	56,596	1,230	8,043	1,754	42,281
2-Sep	8,390	107,553	7,982	110,259	4,509	61,105	1,321	9,364	1,974	44,255
3-Sep	8,708	116,261	9,500	119,759	9,720	70,825	1,455	10,819	2,444	46,699
4-Sep	6,136	122,397	7,572	127,331	10,468	81,293	1,379	12,198	2,571	49,270
5-Sep	4,308	126,705	5,837	133,168	13,069	94,362	1,505	13,703	3,716	52,986
6-Sep	3,991	130,696	6,086	139,254	15,951	110,313	1,630	15,333	4,767	57,753
7-Sep	5,354	136,050	6,132	145,386	15,420	125,733	1,675	17,008	3,965	61,718
8-Sep	5,795	141,845	8,090	153,476	12,953	138,686	1,824	18,832	2,775	64,493
9-Sep	3,859	145,704	9,847	163,323	8,872	147,558	2,128	20,960	1,743	66,236
10-Sep	5,087	150,791	9,422	172,745	7,602	155,160	2,429	23,389	1,417	67,653
11-Sep	3,825	154,616	9,870	182,615	5,458	160,618	2,503	25,892	1,227	68,880
12-Sep	3,728	158,344	9,263	191,878	4,660	165,278	2,512	28,404	1,195	70,075
13-Sep	5,764	164,108	10,708	202,586	4,109	169,387	2,723	31,127	1,238	71,313
14-Sep	3,672	167,780	10,095	212,681	3,956	173,343	2,524	33,651	1,363	72,676
15-Sep	3,739	171,519	9,527	222,208	3,900	177,243	2,273	35,924	1,133	73,809
16-Sep	6,104	177,623	8,324	230,532	4,124	181,367	2,747	38,671	1,357	75,166
17-Sep	7,063	184,686	8,439	238,971	4,264	185,631	4,999	43,670	1,340	76,506
18-Sep	5,089	189,775	8,274	247,245	3,656	189,287	5,935	49,605	1,352	77,858
19-Sep	5,819	195,594	8,086	255,331	3,513	192,800	4,731	54,336	1,332	79,190
20-Sep	4,186	199,780	7,836	263,167	2,320	195,120	4,401	58,737	1,510	80,700
21-Sep	4,086	203,866	9,605	272,772	2,428	197,548	4,053	62,790	1,324	82,024
22-Sep	4,304	208,170	8,227	280,999	2,326	199,874	3,329	66,119	1,628	83,652
23-Sep							2,738	68,857	1,490	85,142
24-Sep							2,498	71,355	1,362	86,504
25-Sep							2,336	73,691	1,112	87,616
26-Sep							2,103	75,794	1,046	88,662
27-Sep										
28-Sep										
29-Sep										

Table D.1. — Continued.

Date	2000 Daily	2000 Cum	2001 Daily	2001 Cum	2002 Daily	2002 Cum	2003 Daily	2003 Cum	2004 Daily	2004 Cum
6-Aug										
7-Aug										
8-Aug	226	226	454	454	216	216	310	310	880	880
9-Aug	232	458	368	822	665	881	395	705	907	1,787
10-Aug	222	680	355	1,177	774	1,655	449	1,154	995	2,782
11-Aug	260	940	317	1,494	600	2,255	872	2,026	991	3,773
12-Aug	200	1,140	385	1,879	905	3,160	894	2,920	1,077	4,850
13-Aug	238	1,378	322	2,201	569	3,729	792	3,712	1,031	5,881
14-Aug	264	1,642	626	2,827	270	3,999	1,193	4,905	921	6,802
15-Aug	216	1,858	969	3,796	623	4,622	1,598	6,503	888	7,690
16-Aug	240	2,098	1,270	5,066	691	5,313	1,980	8,483	1,016	8,706
17-Aug	500	2,598	1,561	6,627	772	6,085	3,551	12,035	1,193	9,899
18-Aug	451	3,049	7,024	13,651	641	6,726	3,747	15,781	1,350	11,249
19-Aug	460	3,509	5,108	18,759	959	7,685	3,294	19,076	1,374	12,623
20-Aug	665	4,174	3,164	21,923	683	8,368	3,015	22,091	1,610	14,233
21-Aug	621	4,795	2,576	24,499	469	8,837	4,363	26,454	1,488	15,721
22-Aug	706	5,501	2,279	26,778	481	9,318	5,789	32,243	1,230	16,951
23-Aug	591	6,092	2,902	29,680	604	9,922	6,427	38,671	1,555	18,506
24-Aug	2,270	8,362	2,744	32,424	700	10,622	5,237	43,908	981	19,487
25-Aug	1,616	9,978	2,630	35,054	721	11,343	4,537	48,445	787	20,274
26-Aug	1,231	11,209	2,272	37,326	1,074	12,417	3,992	52,436	699	20,973
27-Aug	1,051	12,260	2,282	39,608	1,260	13,677	5,073	57,509	738	21,711
28-Aug	1,742	14,002	1,940	41,548	1,644	15,321	6,170	63,680	1,602	23,313
29-Aug	1,598	15,600	2,728	44,276	2,230	17,551	7,896	71,576	2,485	25,798
30-Aug	1,303	16,903	2,066	46,342	1,722	19,273	7,980	79,556	2,622	28,420
31-Aug	1,943	18,846	2,359	48,701	2,790	22,063	7,828	87,384	3,985	32,405
1-Sep	2,601	21,447	2,307	51,008	2,541	24,604	7,639	95,023	5,247	37,652
2-Sep	1,981	23,428	2,575	53,583	2,281	26,885	6,812	101,834	4,910	42,562
3-Sep	2,021	25,449	2,478	56,061	1,977	28,862	7,357	109,191	5,953	48,515
4-Sep	2,159	27,608	3,421	59,482	2,038	30,900	10,955	120,146	7,167	55,682
5-Sep	2,150	29,758	3,540	63,022	1,389	32,289	8,978	129,124	4,438	60,120
6-Sep	2,262	32,020	3,086	66,108	1,458	33,747	7,050	136,174	5,357	65,477
7-Sep	1,902	33,922	4,437	70,545	1,530	35,277	4,667	140,842	6,344	71,821
8-Sep	1,983	35,905	3,860	74,405	1,780	37,057	3,387	144,229	6,053	77,874
9-Sep	1,650	37,555	3,746	78,151	1,857	38,914	3,899	148,127	5,308	83,182
10-Sep	1,791	39,346	4,176	82,327	1,981	40,895	5,659	153,786	4,473	87,655
11-Sep	1,921	41,267	3,108	85,435	2,922	43,817	4,856	158,642	5,415	93,070
12-Sep	1,484	42,751	3,311	88,746	2,830	46,647	4,329	162,972	5,491	98,561
13-Sep	1,496	44,247	3,107	91,853	3,410	50,057	3,954	166,926	6,525	105,086
14-Sep	1,517	45,764	2,320	94,173	4,112	54,169	3,795	170,721	5,741	110,827
15-Sep	1,160	46,924	2,208	96,381	4,145	58,314	4,520	175,241	4,055	114,882
16-Sep	1,292	48,216	2,165	98,546	4,152	62,466	4,789	180,030	2,515	117,397
17-Sep	1,225	49,441	2,173	100,719	3,671	66,137	6,049	186,079	1,669	119,066
18-Sep	1,409	50,850	1,696	102,415	4,033	70,170	3,565	189,644	2,280	121,346
19-Sep	1,289	52,139	1,525	103,940	3,490	73,660	2,307	191,951	2,731	124,077
20-Sep	1,690	53,829	1,530	105,470	3,356	77,016	3,592	195,543	2,765	126,842
21-Sep	1,765	55,594	1,293	106,763	2,846	79,862	5,551	201,094	3,401	130,243
22-Sep	1,607	57,201	1,203	107,966	2,174	82,036	3,430	204,524	6,845	137,088
23-Sep	1,113	58,314	1,201	109,167	2,077	84,113	3,047	207,571		
24-Sep	1,280	59,594	786	109,953	2,095	86,208	2,466	210,037		
25-Sep	1,665	61,259	578	110,531	1,904	88,112	2,590	212,627		
26-Sep	1,340	62,599	440	110,971	1,735	89,847	1,801	214,428		
27-Sep										
28-Sep										
29-Sep										

Table D.1. — Continued, (no data for 2009, when the project was terminated early, before the majority of the run occurred).

Date	2005 Daily	2005 Cum	2006 Daily	2006 Cum	2007 Daily	2007 Cum	2008 Daily	2008 Cum	2010 Daily	2010 Cum
6-Aug										
7-Aug										
8-Aug	2,819	2,819	570	570	269	269	521	521	173	173
9-Aug	4,117	6,936	526	1,096	375	644	673	1,194	130	303
10-Aug	5,235	12,171	625	1,721	551	1,195	717	1,911	258	561
11-Aug	5,899	18,070	589	2,310	553	1,748	662	2,573	386	947
12-Aug	5,214	23,284	751	3,061	628	2,376	877	3,450	514	1,461
13-Aug	5,972	29,256	871	3,932	504	2,880	1,332	4,782	641	2,102
14-Aug	6,252	35,508	1,074	5,006	522	3,402	1,008	5,790	769	2,871
15-Aug	5,923	41,431	2,960	7,966	553	3,955	1,136	6,926	897	3,768
16-Aug	6,893	48,324	1,785	9,751	572	4,527	1,054	7,980	1,025	4,793
17-Aug	7,154	55,478	1,082	10,833	674	5,201	1,321	9,301	1,152	5,945
18-Aug	5,245	60,723	1,276	12,109	786	5,987	1,099	10,400	1,381	7,326
19-Aug	6,233	66,956	1,646	13,755	591	6,578	862	11,262	1,562	8,888
20-Aug	5,820	72,776	1,931	15,686	496	7,074	755	12,017	1,865	10,753
21-Aug	6,479	79,255	2,216	17,902	454	7,528	967	12,984	1,468	12,221
22-Aug	5,303	84,558	2,501	20,403	437	7,965	819	13,803	1,596	13,817
23-Aug	5,217	89,775	2,786	23,189	419	8,384	939	14,742	1,509	15,326
24-Aug	4,495	94,270	3,071	26,260	427	8,811	1,006	15,748	1,893	17,219
25-Aug	4,707	98,977	3,356	29,616	408	9,219	1,158	16,906	2,096	19,315
26-Aug	3,572	102,549	3,641	33,257	336	9,555	1,799	18,705	2,179	21,494
27-Aug	4,798	107,347	3,926	37,183	381	9,936	2,318	21,023	2,055	23,549
28-Aug	5,510	112,857	4,501	41,684	417	10,353	2,424	23,447	2,310	25,859
29-Aug	6,186	119,043	6,160	47,844	458	10,811	4,259	27,706	2,392	28,251
30-Aug	8,162	127,205	8,420	56,264	476	11,287	4,596	32,302	1,926	30,177
31-Aug	7,608	134,813	11,266	67,530	556	11,843	5,376	37,678	2,046	32,223
1-Sep	18,372	153,185	11,041	78,571	897	12,740	6,184	43,862	1,937	34,160
2-Sep	12,774	165,959	11,815	90,386	994	13,734	6,440	50,302	1,883	36,043
3-Sep	17,290	183,249	10,819	101,205	1,658	15,392	7,210	57,512	1,847	37,890
4-Sep	23,630	206,879	9,762	110,967	2,965	18,357	8,411	65,923	1,816	39,706
5-Sep	25,251	232,130	7,091	118,058	5,086	23,443	7,530	73,453	1,914	41,620
6-Sep	24,374	256,504	6,522	124,580	6,739	30,182	6,979	80,432	2,330	43,950
7-Sep	22,788	279,292	5,744	130,324	9,676	39,858	6,814	87,246	3,224	47,174
8-Sep	22,831	302,123	5,675	135,999	13,137	52,995	5,439	92,685	4,058	51,232
9-Sep	18,256	320,379	6,336	142,335	14,952	67,947	4,535	97,220	4,501	55,733
10-Sep	12,488	332,867	5,886	148,221	14,571	82,518	3,982	101,202	5,183	60,916
11-Sep	16,035	348,902	6,569	154,790	17,754	100,272	3,624	104,826	6,330	67,246
12-Sep	17,056	365,958	6,412	161,202	17,067	117,339	3,765	108,591	7,344	74,590
13-Sep	12,242	378,200	7,176	168,378	15,931	133,270	3,501	112,092	8,106	82,696
14-Sep	12,973	391,173	8,324	176,702	16,398	149,668	3,189	115,281	8,103	90,799
15-Sep	11,966	403,139	8,440	185,142	13,399	163,067	2,851	118,132	8,255	99,054
16-Sep	8,848	411,987	8,721	193,863	12,772	175,839	3,215	121,347	7,820	106,874
17-Sep	8,511	420,498	8,082	201,945	11,374	187,213	3,626	124,973	8,160	115,034
18-Sep	9,271	429,769	8,499	210,444	6,934	194,147	4,107	129,080	7,028	122,062
19-Sep	9,435	439,204	6,805	217,249	5,690	199,837	4,085	133,165	6,991	129,053
20-Sep	8,485	447,689	6,362	223,611	4,644	204,481	5,082	138,247	6,538	135,591
21-Sep	6,875	454,564	4,977	228,588	3,598	208,079	4,008	142,255	6,154	141,745
22-Sep	9,396	463,960	3,931	232,519	3,364	211,443	4,108	146,363	4,459	146,204
23-Sep	8,033	471,993	3,997	236,516	4,102	215,545	3,660	150,023	3,337	149,541
24-Sep	9,513	481,506	3,315	239,831	4,099	219,644	4,145	154,168	2,804	152,345
25-Sep	7,086	488,592	2,740	242,571	4,316	223,960	3,630	157,798	2,854	155,199
26-Sep	7,892	496,484	2,519	245,090	4,095	228,055	4,226	162,024	2,545	157,744
27-Sep										
28-Sep										
29-Sep										

Table D.1. — Continued.

Date	2011 Daily	2011 Cum	2012 Daily	2012 Cum	2013 Daily	2013 Cum	2014 Daily	2014 Cum	2015 Daily	2015 Cum
6-Aug							262	262		
7-Aug							222	484		
8-Aug			670	670	1,134	1,134	226	710	272	272
9-Aug	481	481	669	1,339	1,053	2,187	302	1,012	282	554
10-Aug	760	1,241	673	2,012	1,028	3,215	402	1,414	328	882
11-Aug	835	2,076	659	2,671	1,030	4,245	484	1,898	190	1,072
12-Aug	840	2,916	642	3,313	954	5,199	878	2,776	280	1,352
13-Aug	813	3,729	640	3,953	1,072	6,271	1,156	3,932	444	1,796
14-Aug	729	4,458	788	4,741	1,093	7,364	1,472	5,404	600	2,396
15-Aug	693	5,151	888	5,629	991	8,355	2,470	7,874	898	3,294
16-Aug	786	5,937	988	6,617	1,012	9,367	2,486	10,360	1,014	4,308
17-Aug	1,153	7,090	1,215	7,832	872	10,239	3,884	14,244	1,110	5,418
18-Aug	1,349	8,439	1,095	8,927	1,210	11,449	4,706	18,950	1,368	6,786
19-Aug	1,819	10,258	1,392	10,319	1,343	12,792	4,054	23,004	1,752	8,538
20-Aug	1,638	11,896	1,731	12,050	1,341	14,133	5,030	28,034	2,307	10,845
21-Aug	1,081	12,977	1,998	14,048	1,025	15,158	5,490	33,524	2,356	13,201
22-Aug	1,237	14,214	2,114	16,162	2,000	17,158	5,150	38,674	2,405	15,606
23-Aug	1,384	15,598	3,000	19,162	2,463	19,621	4,914	43,588	2,454	18,060
24-Aug	1,331	16,929	4,049	23,211	2,351	21,972	3,996	47,584	2,502	20,562
25-Aug	1,360	18,289	3,859	27,070	1,920	23,892	3,680	51,264	2,551	23,113
26-Aug	1,840	20,129	3,489	30,559	1,642	25,534	3,562	54,826	2,600	25,713
27-Aug	2,971	23,100	4,104	34,663	1,740	27,274	3,304	58,130	2,649	28,362
28-Aug	4,527	27,627	4,410	39,073	2,332	29,606	2,662	60,792	2,697	31,059
29-Aug	5,985	33,612	4,353	43,426	2,957	32,563	3,006	63,798	2,747	33,806
30-Aug	7,672	41,284	5,924	49,350	3,917	36,480	2,443	66,241	2,795	36,601
31-Aug	9,218	50,502	7,410	56,760	2,573	39,053	2,152	68,393	2,844	39,445
1-Sep	9,918	60,420	5,734	62,494	2,749	41,802	2,620	71,013	2,892	42,337
2-Sep	10,228	70,648	5,221	67,715	2,918	44,720	3,610	74,623	2,942	45,279
3-Sep	11,965	82,613	5,040	72,755	3,303	48,023	2,986	77,609	2,990	48,269
4-Sep	11,836	94,449	5,379	78,134	3,209	51,232	2,368	79,977	2,909	51,178
5-Sep	11,185	105,634	4,316	82,450	3,881	55,113	1,750	81,727	2,802	53,980
6-Sep	10,787	116,421	4,012	86,462	3,395	58,508	2,232	83,959	3,122	57,102
7-Sep	7,711	124,132	3,123	89,585	3,783	62,291	1,850	85,809	3,216	60,318
8-Sep	9,406	133,538	3,043	92,628	4,333	66,624	1,894	87,703	3,661	63,979
9-Sep	10,524	144,062	2,963	95,591	5,612	72,236	2,752	90,455	4,368	68,347
10-Sep	8,010	152,072	2,882	98,473	7,506	79,742	3,544	93,999	3,760	72,107
11-Sep	6,554	158,626	2,802	101,275	9,069	88,811	3,728	97,727	4,162	76,269
12-Sep	6,809	165,435	2,984	104,259	11,157	99,968	4,253	101,980	4,490	80,759
13-Sep	7,486	172,921	3,297	107,556	12,687	112,655	5,276	107,256	5,656	86,415
14-Sep	7,132	180,053	4,463	112,019	11,042	123,697	6,438	113,694	5,082	91,497
15-Sep	7,458	187,511	4,843	116,862	10,104	133,801	7,722	121,416	5,958	97,455
16-Sep	7,256	194,767	6,006	122,868	10,600	144,401	10,222	131,638	7,787	105,242
17-Sep	8,123	202,890	9,631	132,499	8,588	152,989	9,100	140,738	6,615	111,857
18-Sep	7,914	210,804	8,659	141,158	7,530	160,519	9,692	150,430	6,670	118,527
19-Sep	8,773	219,577	7,093	148,251	10,424	170,943	9,564	159,994	7,024	125,551
20-Sep	8,789	228,366	8,000	156,251	10,184	181,127	9,640	169,634	6,754	132,305
21-Sep	7,772	236,138	8,643	164,894	6,280	187,407	9,038	178,672	5,630	137,935
22-Sep	8,487	244,625	6,220	171,114	7,598	195,005	7,974	186,646	3,764	141,699
23-Sep	8,395	253,020	4,418	175,532	8,735	203,740	7,516	194,162	4,778	146,477
24-Sep	7,369	260,389	5,642	181,174	8,405	212,145	5,682	199,844	5,576	152,053
25-Sep	7,269	267,658	4,037	185,211	8,353	220,498	4,174	204,018	4,304	156,357
26-Sep	6,307	273,965	3,411	188,622	6,647	227,145	4,094	208,112	3,562	159,919
27-Sep			3,273	191,895			4,076	212,188	2,619	162,538
28-Sep			3,278	195,173			2,208	214,396		
29-Sep			2,758	197,931						

Table D.1. — Continued.

Date	2016 Daily	2016 Cum	2017 Daily	2017 Cum	2018 Daily	2018 Cum	2019 Daily	2019 Cum
6-Aug								
7-Aug								
8-Aug	443	443	1,706	1,706			331	331
9-Aug	471	914	1,356	3,062			231	562
10-Aug	538	1,452	987	4,049			204	766
11-Aug	602	2,054	692	4,741			191	957
12-Aug	481	2,535	594	5,335	291	291	126	1,083
13-Aug	427	2,962	520	5,855	214	505	86	1,169
14-Aug	649	3,611	642	6,497	220	725	148	1,317
15-Aug	609	4,220	956	7,453	228	953	140	1,457
16-Aug	832	5,052	1,485	8,938	270	1,223	160	1,617
17-Aug	1,443	6,495	2,339	11,277	336	1,559	162	1,779
18-Aug	1,776	8,271	2,462	13,739	458	2,017	194	1,973
19-Aug	2,282	10,553	2,874	16,613	586	2,603	248	2,221
20-Aug	3,147	13,700	2,942	19,555	728	3,331	308	2,529
21-Aug	4,033	17,733	2,744	22,299	804	4,135	282	2,811
22-Aug	4,608	22,341	2,920	25,219	558	4,693	250	3,061
23-Aug	4,856	27,197	3,735	28,954	614	5,307	469	3,530
24-Aug	5,839	33,036	3,866	32,820	450	5,757	318	3,848
25-Aug	5,544	38,580	4,000	36,820	745	6,502	398	4,246
26-Aug	4,752	43,332	4,821	41,641	634	7,136	566	4,812
27-Aug	5,424	48,756	5,650	47,291	834	7,970	718	5,530
28-Aug	5,293	54,049	6,738	54,029	646	8,616	648	6,178
29-Aug	5,066	59,115	6,230	60,259	806	9,422	540	6,718
30-Aug	4,824	63,939	5,998	66,257	546	9,968	564	7,282
31-Aug	4,906	68,845	6,191	72,448	622	10,590	508	7,790
1-Sep	4,973	73,818	6,384	78,831	604	11,194	571	8,361
2-Sep	5,063	78,881	6,576	85,408	688	11,882	919	9,280
3-Sep	4,526	83,407	6,769	92,177	1,064	12,946	1,232	10,512
4-Sep	4,545	87,952	6,268	98,445	1,422	14,368	2,158	12,670
5-Sep	4,740	92,692	5,764	104,209	1,632	16,000	3,166	15,836
6-Sep	4,403	97,095	5,328	109,537	2,618	18,618	4,194	20,030
7-Sep	3,258	100,353	5,592	115,129	1,930	20,548	4,688	24,718
8-Sep	2,929	103,282	7,216	122,345	2,742	23,290	4,046	28,764
9-Sep	3,045	106,327	10,330	132,675	3,826	27,116	4,576	33,340
10-Sep	3,082	109,409	12,012	144,687	3,622	30,738	4,116	37,456
11-Sep	3,167	112,576	16,642	161,329	4,576	35,314	3,798	41,254
12-Sep	3,622	116,198	20,334	181,663	4,298	39,612	3,470	44,724
13-Sep	3,247	119,445	23,388	205,051	3,940	43,552	3,904	48,628
14-Sep	3,387	122,832	31,542	236,593	5,174	48,726	3,438	52,066
15-Sep	4,198	127,030	34,214	270,807	5,820	54,546	3,998	56,064
16-Sep	5,750	132,780	33,240	304,047	6,010	60,556	4,220	60,284
17-Sep	8,299	141,079	27,584	331,631	6,492	67,048	4,674	64,958
18-Sep	11,136	152,215	25,838	357,469	7,058	74,106	3,952	68,910
19-Sep	11,528	163,743	24,064	381,533	6,586	80,692	4,226	73,136
20-Sep	12,737	176,480	20,886	402,419	7,646	88,338	4,056	77,192
21-Sep	13,311	189,791	21,042	423,461	8,188	96,526	4,323	81,515
22-Sep	14,449	204,240	18,942	442,403	7,678	104,204	3,756	85,271
23-Sep	14,106	218,346	13,469	455,872	7,084	111,288	3,820	89,091
24-Sep	12,033	230,379	11,380	467,252	6,124	117,412	3,694	92,785
25-Sep	11,413	241,792	8,421	475,673	6,728	124,140	4,020	96,805
26-Sep	12,603	254,395	8,160	483,833	6,496	130,636	3,854	100,659
27-Sep					6,970	137,606	3,430	104,089
28-Sep					5,614	143,220		
29-Sep								