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Abundance and Run Timing of Adult Pacific Salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2015

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Abstract

The Kenai Fish and Wildlife Conservation Office, assisted by the Organized Village of Kwethluk, monitored the escapement of five species of Pacific salmon *Oncorhynchus* spp. returning to the Kwethluk River. From May 18 to September 10, 2015, a resistance board weir and underwater video system were used to collect abundance, run-timing, age, sex, and length data from returning adult salmon. These data support in-season and post-season management of commercial and subsistence fisheries that occur on the Yukon Delta National Wildlife Refuge and the Kuskokwim River drainage. A total of 23,071 Chum Salmon *O. keta*, 8,163 Chinook Salmon *O. tshawytscha*, 8,998 Sockeye Salmon *O. nerka*, 551 Pink Salmon *O. gorbuscha* and 24,367 Coho Salmon *O. kisutch* passed through the Kwethluk River weir during 2015. The first passage date was June 10 for Chum Salmon, June 17 for Chinook Salmon, June 12 for Sockeye Salmon, July 6 for Pink Salmon, and July 21 for Coho Salmon. Peak weekly passage occurred July 12–18 for Chum, Chinook, and Sockeye salmon, July 19–25 for Pink Salmon, and August 30–September 5 for Coho Salmon. Age, sex, and length (ASL) data were collected for each species except Pink Salmon. Dominant ages were 0.3 for Chum Salmon, 1.2 for male and 1.3 for female Chinook Salmon, 1.2 for male and 1.3 for female Sockeye Salmon, and 2.1 for Coho Salmon. Overall percentages of female salmon in the ASL sample were: Chum 33%, Chinook 21%, Sockeye 44%, and Coho salmon 43%. Mean lengths differed between male and female salmon for each species. The Chinook Salmon escapement during 2015 met the Sustainable Escapement Goal of 4,100−7,500 for the first time since 2009. Special management actions were taken to restrict harvests during 2015 to conserve Chinook Salmon throughout the Kuskokwim River system, including the Kwethluk River drainage. These actions likely contributed to the relatively large escapement observed at the weir in 2015.

Introduction

The Kwethluk River, a lower Kuskokwim River tributary located on the Yukon Delta National Wildlife Refuge (Refuge), provides important spawning and rearing habitat for Chum Salmon *Oncorhynchus keta*, Chinook Salmon *O. tshawytscha*, Sockeye Salmon *O. nerka*, Pink Salmon *O. gorbuscha*, and Coho Salmon *O. kisutch* (Alt 1977; U.S. Fish and Wildlife Service 1992). Adult salmon returning to the Kwethluk River migrate 130 river kilometers (rkm) through the lower Kuskokwim River and another 90 to 160 rkm in the Kwethluk River before reaching their natal spawning grounds. These salmon pass through one of Alaska's most intensive subsistence fisheries located on the lower Kuskokwim River (U.S. Fish and Wildlife Service 1988; Burkey et al. 2001). Half of the total statewide Chinook Salmon subsistence harvest occurs in the

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Kuskokwim drainage (Fall et al. 2013).

A resistance board weir was used to monitor salmon escapement on the Kwethluk River from mid-to-late June through early September during 1992, 2000–2004, and 2006–2015 (Harper 1998; Harper and Watry 2001; Roettiger et al. 2002, 2003, 2004, 2005; Miller et al. 2007, 2008, 2009; Miller and Harper 2010, 2011a, 2012a, 2013a, 2014; Miller et al. 2015). After 1992, budget constraints and the lack of support from the Organized Village of Kwethluk (OVK) prevented operation of the weir from 1993–1999. Under the Alaska National Interest Lands Conservation Act (ANILCA), the Federal Subsistence Management Program expanded to include fisheries on Federal Conservation System Units in October 1999. The U.S. Fish and Wildlife Service (Service) was designated as the lead federal agency for managing subsistence fisheries on federal lands within the Kuskokwim River drainage and the Kwethluk River weir project was re-established to monitor escapements. Between 2000 and 2013, OVK and the Service cooperated in staffing and operating the weir, except in 2005 when the weir was not operated due to high water. During 2014, however, the monitoring projects were opposed by the villages of Akiachak, Akiak, Kwethluk, and Tuluksak because of subsistence fishing restrictions implemented by federal and state managers to conserve Chinook Salmon. Because escapement monitoring in the Kwethluk River is critical to managing Chinook Salmon in the Kuskokwim River, the Service operated the Kwethluk River weir without support from the villages in 2014. The Service and OVK cooperated in staffing and operating the weir again in 2015.

Under guidelines established in the Sustainable Salmon Fisheries Policy, 5 AAC 39.222, the Alaska Board of Fisheries designated Kuskokwim River Chum and Chinook salmon as stocks of yield concern in September 2000 and managed the fishery under those guidelines through 2006 (Bergstrom and Whitmore 2004; Linderman and Bue 2006). This designation was based upon the inability to maintain expected yields or to have a stable surplus above the stock's escapement needs despite specific management measures. Beginning in January 2001, the salmon fishery in the Kuskokwim River drainage was managed under the Kuskokwim River Salmon Rebuilding Management Plan (Rebuilding Plan; Ward et al. 2003; Bergstrom and Whitmore 2004). The yield concern designation was discontinued in 2007 after Chum Salmon and Chinook Salmon escapements returned to levels above the historical average (Linderman and Rearden 2007). The Alaska Board of Fisheries adopted a new Kuskokwim River Salmon Management Plan in January 2013. This plan established a new drainage-wide Sustainable Escapement Goal (SEG) of 65,000−120,000 Chinook Salmon and reduced the SEG from 6,000−11,000 to 4,100−7,500 Chinook Salmon for the Kwethluk River (5 AAC 07.365; Conitz et al. 2012).

The Alaska Department of Fish and Game (Department), the Service , and the Kuskokwim River Salmon Management Working Group (Working Group) work together to achieve the goals of the Kuskokwim River Salmon Management Plan and the Federal Subsistence Fishery Management program. In addition to the goals set by the Department, the Service, and the Working Group, ANILCA established the Yukon Delta National Wildlife Refuge in Alaska to: "conserve fish and wildlife populations and habitats in their natural diversity" (ANILCA 1980). Despite conservation measures taken under the Rebuilding Plan and by area managers, Chinook Salmon returns to the Kwethluk River were at or below the lower threshold of the current SEG for five consecutive years until 2015.

The broad geographic distribution of escapement monitoring projects in the Kuskokwim area provides insight for sustainable salmon management. Recent tagging studies conducted on Chum, Chinook, Sockeye, and Coho salmon have all demonstrated differential stock-specific run timing with a general pattern of salmon stocks from upper river tributaries entering the

Kuskokwim River earlier than stocks from lower river tributaries (Kerkvliet and Hamazaki 2003; Kerkvliet et al. 2003, 2004; Stuby 2004, 2005, 2006). The observed differential stock-specific run timing combined with an extensive subsistence fishery that harvests more heavily from early arriving salmon (Molyneaux and Brannian 2006; Molyneaux et al. 2010a) results in the selective harvest of early returning stocks. The Kuskokwim River mixed stock fishery requires that managers develop and maintain a rigorous monitoring program capable of assessing escapement trends to manage for continued sustained yields and salmon population diversity.

Maintaining and developing rigorous monitoring programs requires the continuous development of new tools and procedures to increase the quality and efficiency of operations. The progression at the Kwethluk River weir has included the installation of a video system to monitor salmon escapement during high water events and test the use of video images to collect gender and length data similar to the Tuluksak River drainage (Miller and Harper 2011b, 2012b, 2013b).

In addition to run timing and abundance data, the Kwethluk River weir has been an important platform for collecting data for other research projects such as: (1) genetic baseline collections; (2) the collection of otoliths for microchemistry analysis used to determine the origin of stocks in a mixed-stock fishery; (3) monitoring tagged fish in mark-recapture projects; (4) monitoring the production of juvenile salmon in alluvial river floodplains (Refuge); (5) a long-term data set for evaluation of management projects (e.g., Bethel test fishery); (6) climate change (Office of Subsistence Management-Fisheries Resource Monitoring Program (OSM-FRMP) project 08-701); and (7) the Salmonid River Observatory Network (SaRON), a multiyear project focused on the pristine Pacific Salmon rivers measuring processes and changes to the shifting habitat mosaic of ecosystems.

Study Area

The Kwethluk River is in the lower Kuskokwim River drainage (Figure 1). The region has a sub-arctic climate characterized by extremes in temperature ranging from summer highs near 15˚C to average winter lows near -12˚C (Alt 1977). Average yearly precipitation is approximately 50 cm, with the majority falling between June and October. The rivers in this area are generally ice-free in the slow current sections by early May and freeze up during late October. Break up on the Kwethluk River can occur from early April to late May. The Kwethluk River originates in the Kilbuck Mountains, flows northwest for approximately 222 rkm, and drains an area of about 3,367 km^2. The weir is located in the middle section of the Kwethluk River, which is characterized by braiding and gravel substrates. The lower 47 rkm of the Kwethluk River consists of a deeper, muddy-bottom channel that averages 53 m in width (Alt 1977). Turbid water conditions, the result of active stream cutting on tundra banks, are also characteristic of the lower section and are incompatible with weir operations.

Project Objectives

Project objectives for 2015 were to: (1) Enumerate daily fish passage and characterize the run timing of Chinook, Chum, Coho, Sockeye, and Pink salmon and resident fish species through the weir; (2) estimate the weekly sex and age composition of Chinook, Chum, and Coho salmon such that the simultaneous 95% confidence intervals have a maximum width of 0.20; (3) estimate the mean length of Chinook, Chum and Coho salmon by sex and age; and (4) identify and count other fish species passing through the weir and enumerate salmon carcasses passing back over the weir. These data support the in-season and post-season management of the Kuskokwim River subsistence and commercial fisheries. This information also assists managers

in establishing and evaluating escapement goals to maintain the sustainability of salmon stocks returning to the Kwethluk River.

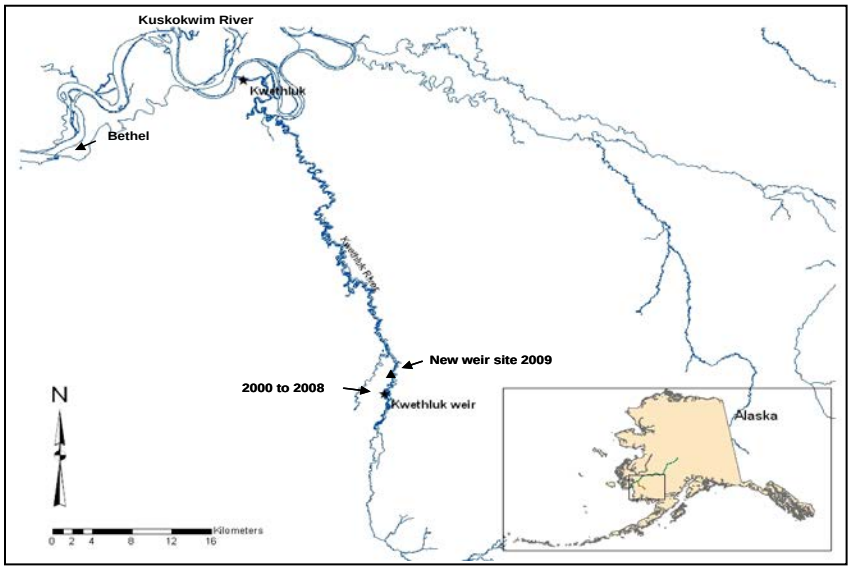

FIGURE 1.—Location of the Kwethluk River weir 2000–2008 and new weir site 2009–2015.

Methods

Weir Operations

A resistance board weir (Tobin 1994; Stewart 2002; Harper et al. 2007) affixed with an underwater video system (Gates et al. 2010; Miller and Harper 2014) was installed during 2015 in the Kwethluk River (N 60.51828, W 161.09245, NAD 83) approximately 84 rkm upstream of the Kuskokwim River and 42 km south of Kwethluk, Alaska (Figure 1). The current weir location is approximately 4.1 rkm downstream of the 2008 weir site described by Miller et al. (2009).

Setup and design of the video system was similar to that used by Miller and Harper (2014). One underwater video camera was located inside a sealed video box attached to the fish passage chute. The video box was constructed of 3.2-mm aluminum sheeting and was filled with filtered water. Safety glass was installed on the front of the video box for a scratch-free, clear surface through which images were captured. The passage chute was constructed from aluminum angle and was enclosed in plywood isolating it from exterior light. The backdrop of the passage chute from which video images were captured could be adjusted laterally to minimize the number of fish passing through the chute at any one time. The backdrop could also be easily removed from the video chute when dirty and replaced with a new one. All video images were recorded on a removable 1,000 gigabyte hard drive at 30 frames per second using a computer-based digital video recorder (DVR). Stored video files were reviewed daily. The video box and fish passage chute were artificially lit using a pair of 12-V DC underwater pond lights. Pond lights were equipped with 10-W bulbs which provided quality images. The lights provided a consistent source of light during day and night hours. The DVR was equipped with motion detection to minimize the amount of blank video footage and review time. The underwater cameras, lights, DVR and monitor were powered by 110-V AC inverted from 12-V DC. Power was supplied using eight 120-W solar panels wired in parallel, one 12-V DC wind generator, and one 5000-W

gasoline generator. Power storage consisted of four 400-ampere hour 6-V DC batteries wired in a series–parallel circuit to produce 12-V DC.

The video system and weir were operated in unison during 2015 and the video system allowed for enumeration of fish passage 24 hours each day. Visual counts from live video or counts from motion detection data files were recorded during each shift. Video footage collected between 0000 hours and 0700 hours was reviewed and counts added to hourly passage for that day. Paired counts using continuous video feed and motion detection footage were performed daily for one hour to validate counts. If problems with the video equipment occurred, live counts through the passage chute were taken until issues could be resolved. Gender composition was determined using sex composition from age, sex and length data (ASL) and from observations using video footage similar to 2011−2013 (Miller and Harper 2014). Migrating and resident fish were identified to species and recorded.

The daily average depth of the river at the weir site was estimated using fixed staff-gauge measurements from April 29 to September 27. Staff-gauge measurements were converted to average depth of the river at the weir site for comparison between and among years. The average depth of the river at the weir site (stage) was defined as:

$$average\ water\ depth = \frac{S_t}{\left({S_y}/{\mu_y}\right)}$$

Where: S_t is the observed staff gauge height at time *t*, $S_y$is the observed staff gauge height while measuring the benchmark mean depth during year *y*, μ_y is the mean depth during year *y*. The benchmark mean depth (stage) at the weir for each year was calculated from 80 measurements made every 2 feet spanning the river. Ambient and water temperatures were collected daily using a handheld thermometer May 6 to September 27. Hobo® recording thermometers were installed at the weir to collect water and ambient temperature data for a separate study addressing climate change funded by OSM-FRMP project 08-701. Temperature data and daily fish escapement counts were relayed via electronic mail to Service staff in Bethel and from there to the Department in Anchorage.

The weir was inspected for holes every morning and evening and cleaned daily. An observer outfitted with a mask and snorkel checked weir integrity and substrate conditions. Debris was removed from the upstream surface of the weir by raking, or walking across each panel until partially submerged, which allowed the current to wash accumulated debris downstream.

Biological Data

Biological ASL data on fish were collected using a temporally stratified sampling design (Cochran 1977), with statistical weeks defining strata. Adult salmon were captured using the live trap attached to the passage chute and sampled for ASL information. Sampling started when approximately 40 fish were in the trap. To the extent logistically feasible, a sample was collected over the shortest possible period and on days when sampling occurred, samples were taken periodically throughout the day. To avoid potential bias caused by the selection or capture of individual fish, all fish within the trap were included in the sample, even if the target number of fish was exceeded. If the sample goal for a given species was attained, the trap was closed to sample other species and those fish were netted and released upstream of the weir and the desired species sampled.

Sample size goals for Chum, Chinook and Coho salmon for each stratum (Table 1) were adopted from Bromaghin (1993) using simultaneous 95% confidence intervals with $\alpha = 0.05$ and $d = 0.10$, and an expected unreadable rate of 20%. Sampling for Sockeye Salmon was opportunistic, with a target sample size of 75 fish for the season. If too few fish passed the weir during a stratum to meet the sample goal, as many fish as possible were sampled each day of that stratum.

Sampling (ASL) consisted of measuring length from mid-eye to fork in the caudal fin (MEF) to the nearest mm, determining gender, collecting scales, examining fish for gill-net marks, and then releasing the fish upstream of the weir. Gender was determined by observing external sex characteristics including the presence or advanced development of an ovipositor.

TABLE 1.— Stratum sample size goals.

Salmon Species	Age Classes	Sample size
Chum	0.3, 0.4	188
Chinook	1.2, 1.3, 1.4, 1.5	225
Coho	2.1, other	188

Scales were removed from the preferred area for age determination (Koo 1962; Mosher 1968). Scales were collected and checked visually to the best extent possible to make sure they were not damaged, regenerated, or from the lateral line. One scale was collected from each Chum Salmon, three from each Sockeye and Coho salmon, and four from each Chinook Salmon. If the preferred scale was missing or damaged, a scale from the preferred area on the opposite side of the fish was removed. If scales were absent in the preferred area on either side of the fish, a scale as close to the preferred area as possible was removed and a note “non-preferred scale” was entered on the ASL field form. Once ASL data were collected, each fish was released unharmed upstream of the live trap. Data were recorded and later transferred to digital spreadsheets.

Gender composition of Chinook Salmon passage was also determined from qualitative sexual dimorphism differences in general body shape derived from archived video footage (Merz and Merz 2004; Miller and Harper 2014). Females are identified as having blunt-shaped heads, and a round-shaped abdomen, whereas males generally exhibit a prolonged head accompanied with a kype, a gradual dorsal hump, and a thinner abdomen. The observations used to estimate the sexual composition of Chinook Salmon from the video were made within individual strata during times of the day when high volumes of fish were expected to pass (e.g., 1800 to 0300 hours). Once the strata ASL sample sizes were met for a species, sampling stopped for that species. Although biological sampling was stratified into statistical weeks a priori, strata for the analysis of Pacific salmon biological data at the Kwethluk River weir were modified following the field season to represent actual weir passage and ASL sample sizes.

Salmon ages were reported according to the European method (Koo 1962) where numerals preceding the decimal denote freshwater annuli and numerals following the decimal denote marine annuli. Total years of life at maturity are determined by adding one year to the sum of the two digits on either side of the decimal; i.e., age-1.4 and 2.3 are both 6-year-old fish from the same brood year ($1.4 = 1 + 4 + 1 = 6$, and $2.3 = 2 + 3 + 1 = 6$). The brood year is determined by subtracting fish-age from the current year.

Characteristics of fish passing through the weir were estimated using standard stratified random sample estimators (Cochran 1977). Within a given stratum *m*, the proportion of species *i* passing the weir that are of sex *j* and age *k* (p_{ijkm}) was estimated as:

$$\hat{P}_{ijkm} = \frac{n_{ijkm}}{n_{i++m}}$$

where n_{ijkm} denotes the number of fish of species *i*, sex *j*, and age *k* sampled during stratum *m*, and a subscript of "+" represents summation over all possible values of the corresponding variable, e.g., n_{j++m} denotes the total number of fish of species *i* sampled in stratum *m*. The variance was estimated as:

$$\hat{v}(\hat{p}_{ijkm}) = \left(1 - \frac{n_{i++m}}{N_{i++m}}\right)\frac{\hat{p}_{ijkm}\left(1 - \hat{p}_{ijkm}\right)}{n_{i++m} - 1}$$

where N_{i++m} denotes the total number of species *i* fish passing the weir in stratum *m*. The estimated number of fish species *i*, sex *j*, age *k* passing the weir in stratum *m* (N_{ijkm}) is

$$\hat{N}_{ijkm} = N_{i++m}\hat{P}_{ijkm}$$

with estimated variance

$$\hat{v}\left(\hat{N}_{ijkm}\right) = N^2_{i++m}\hat{v}\left(\hat{p}_{ijkm}\right)$$

Estimates of proportions for the entire period of weir operation were computed as weighted sums of the stratum estimates, i.e.,

$$\hat{p}_{ijk} = \sum_m \left(\frac{N_{i++m}}{N_{i+++}}\right)\hat{p}_{ijkm}$$

with estimated variance

$$\hat{v}\left(\hat{p}_{ijk}\right) = \sum_m \left(\frac{n_{i++m}}{N_{i+++}}\right)^2 \hat{v}\left(\hat{p}_{ijkm}\right)$$

The total number of fish in a species, sex, and age category passing the weir during the entire period of operation was estimated as:

$$\hat{N}_{ijk} = \sum_m \hat{N}_{ijkm}$$

with estimated variance

$$\hat{v}\left(\hat{N}_{ijk}\right) = \sum_{m} \hat{v}\left(\hat{N}_{ijkm}\right)$$

If the length of the rth fish of species i, sex j, and age k sampled in stratum m is denoted x_{ijkmr}, then the mean length of all such fish (μ_{ijkm}) was estimated as:

$$\hat{\mu}_{ijkm} = \left(\frac{1}{n_{ijkm}}\right)\sum_{r} x_{ijkmr}$$

with corresponding variance estimator

$$\hat{v}\left(\hat{\mu}_{ijkm}\right) = \left(1 - \frac{n_{ijkm}}{\hat{N}_{ijkm}}\right)\frac{\sum_{r}\left(x_{ijkmr} - \hat{\mu}_{ijkm}\right)^2}{n_{ijkm}\left(n_{ijkm} - 1\right)}$$

The mean length of all fish of species i, sex j, and age k ($\hat{\mu}_{ijk}$) was estimated as a weighted sum of the stratum means, i.e.,

$$\hat{v}\left(\hat{\mu}_{ijk}\right) = \sum_{m}\left\{\hat{v}\left(\hat{N}_{ijkm}\right)\left[\frac{\hat{\mu}_{ijkm}}{\sum_{x}\hat{N}_{ijkx}} - \sum_{y}\frac{\hat{N}_{ijky}\,\hat{\mu}_{ijky}}{\left(\sum_{x}\hat{N}_{ijkx}\right)^2}\right]^2 + \left(\frac{\hat{N}_{ijkm}}{\sum_{x}\hat{N}_{ijkx}}\right)^2 \hat{v}\left(\hat{\mu}_{ijkm}\right)\right\}$$

$$\hat{\mu}_{ikk} = \sum_{m}\left(\frac{\hat{N}_{ijkm}}{\hat{N}_{ijk}}\right)\hat{\mu}_{ijkm}$$

An approximate estimator of the variance of $\hat{\mu}_{ijk}$ was obtained using the delta method (Seber 1982). Prior to 2014 estimates of escapement were calculated for dates when flooding or holes in the weir resulted in days with partial or zero counts. In years when this occurred, estimates were based on the average daily proportion of passage. An average of the daily proportions for previous years was calculated because daily escapement can vary between years. The sum of the averaged daily proportions, calculated for days with partial or zero counts, was the estimated total proportion of the missed escapement. The total escapement was estimated as the sum of the observed counts divided by one minus the proportion missed. Averages in the historical escapement figure were generated using escapement estimates from prior years (Miller et al. 2015).

All fish sampled for ASL were also examined for gill-net marks. Because the average age of female Chinook Salmon is older than males, and more males return to the spawning grounds than females we wanted to test if net marks were found equally on both sexes. A Chi-square test of

homogeneity was used to test the hypothesis Ho: Gill-net marks in Chinook Salmon are independent of sex. Gill-net marks were only noted for other salmon species.

Results

Weir Operations

Water and ice conditions of the Kwethluk River were monitored beginning April 2015. Water conditions at the weir site on April 26 were too high to install the weir. However, a smolt screw trap was set up and operated. The weir and video were set up and working by May 18 and remained operational through September 10. Although weir operations ceased on September 10, removal of the weir from the river was not completed until October 21 because of high water.

The maximum average water depth during weir operation of 106 cm occurred on June 4 and the minimum water depth of 46 cm occurred on August 7. Water temperatures ranged from 5.8°C on September 23 to 19.7°C on August 3. Average ambient temperature ranged from -2.2°C on September 23 to 18.9°C on June 25 (Appendix 1).

Biological Data

Chum Salmon —A total of 23,071 Chum Salmon were counted passing through the weir; the first arrived June 10 and 8 passed the last day of operations on September 10 (Table 2: Figure 2; Appendix 2). The peak weekly passage of 7,423 Chum Salmon occurred July 12 to July 18 (Figure 2) and the median cumulative passage occurred on July 21 (Figure 3; Appendix 2).

Four age classes (0.2, 0.3, 0.4, 0.5) were identified from Chum Salmon ASL samples (*n* = 1,088). The predominant age was 0.3 for male (54%) and female (57%) Chum Salmon (Appendix 3). Females comprised 33% of the estimated escapement and were less than 50% of the escapement during the entire run (Figure 3). The mean MEF length of males was larger than females for all ages (Appendix 4). Gill-net marks (GNM) were noted on 4 % of the ASL sampled male and 1% of the female Chum Salmon.

Table 2.— Escapement and sample size summary for scales and archived video footage.

		Age, Sex and Length Collections		
		Scales		Video
Salmon Species	Escapement Total	Sample Total	Readable Total	Viewed Total
Chum	23,071	1,188	1,088	0
Chinook	8,163	1,003	895	8,163
Sockeye	8,998	856	827	0
Pink	551	0	0	0
Coho	24,367*	959	825	0

***Coho Salmon run was late and partial days were not estimated. Numbers after the weir was closed and total escapement including the tail of the escapement after the weir was removed was not estimated. Sex ID was completed only for Chinook Salmon.**

Chinook Salmon —A total of 8,163 Chinook Salmon were counted passing through the weir; the first arrived June 17 and the last was observed on September 8 (Table 2; Figure 2; Appendix 2). The peak weekly passage of 2,461 Chinook Salmon occurred July 12 to July 18 (Figure 2) and the median cumulative passage occurred on July 15 (Figure 3; Appendix 2).

Age, sex, and length data were collected from 895 Chinook Salmon. Seven age classes (1.1, 1.2, 1.3, 1.4, 2.1, 2.2 and 2.3) were identified from scale samples (Appendix 5). Age-1.5 fish were absent from the ASL samples in 2015. The predominant age was 1.2 for males (64%) and 1.3 for females (82%; Appendix 5). Females comprised 21% of the estimated escapement and 19% were visually classified as females from a total of 8,163 Chinook Salmon examined from video footage. Females were below 25% for each of the sample stratum for both ASL samples and video examination (Figure 3). The mean MEF length for females was larger than males for all ages where both species were represented in the sample (Appendix 6).

Gill-net marks were noted on 3% of the ASL sampled Chinook Salmon in 2015: 4.8% for females and 2.1% for males. Gill-net marks were significantly higher for females than males (X^2=4.14 df=1, p=0.036).

Sockeye Salmon —A total of 8,998 Sockeye Salmon were counted passing through the weir: the first arrived June 12 and 5 passed the last day of operations on September 10 (Table 2; Figure 2; Appendix 2). The peak weekly passage of 2,979 Sockeye Salmon occurred July 12 to July 18 (Figure 2), and the median cumulative passage occurred on July 15 (Figure 3; Appendix 2).

Age, sex and length data were collected from 827 Sockeye Salmon. There were eight age classes (0.2, 0.3, 0.4, 1.2, 1.3, 1.4, 2.2, and 2.3) identified from scale samples (Appendix 8). The predominant age was 1.2 for males (44%) and 1.3 for females (38%; Appendix 7). Females comprised 44% of the ASL collection. Females predominated early in the escapement but comprised a smaller percentage as the season progressed (Figure 3). The mean MEF length of males was larger than females for all ages except 0.2 (Appendix 8). Gill-net marks were noted on 2 % of the ASL sampled Sockeye Salmon for both males and females.

Pink Salmon —A total of 551 Pink Salmon were observed passing through the weir: the first arrived July 6 and 5 were observed the last day of operations on September 10 (Figure 2; Appendix 2). The peak weekly passage of 138 Pink Salmon occurred July 19 to July 25 (Figure 2) and the median cumulative passage occurred on July 28 (Appendix 2). Age, sex, and length data were not collected for Pink Salmon.

Coho Salmon —A total of 24,367 Coho Salmon were counted passing through the weir: the first arrived July 21 and 618 passed on the last day of operations on September 10 (Figure 2; Appendix 2). The peak weekly passage of 11,596 Coho Salmon occurred August 30 to September 5 (Figure 2), and the median cumulative passage occurred on September 3 (Figure 3; Appendix 2).

ASL data were collected from 959 Coho Salmon of which 825 had readable scales (Table 2). Females comprised 43% of the ASL collection. Three age classes (1.1, 2.1 and 3.1) were identified from the ASL collection (Appendix 9). Age-2.1 was the predominant age for both males and females and represented 80% of the escapement. The mean MEF length of females was larger than that of males for all ages (Appendix 10). Gill-net marks were noted on <1% of the ASL sampled Coho Salmon males and 1% of the females.

Other —Resident and other migrant species counted through the weir during 2015 consisted of 199 Dolly Varden *Salvelinus malma*, 12 Arctic Grayling *Thymallus arcticus*, 2 Northern Pike *Esox lucius*, 58 Rainbow Trout *O. mykiss*, 35 Broad Whitefish *Coregoninae nasus*, and one unidentified whitefish *Coregoninae* spp. Although smaller fish (≤40 cm) likely passed through the pickets, only escapement through the passage chute was recorded the entire season with video footage.

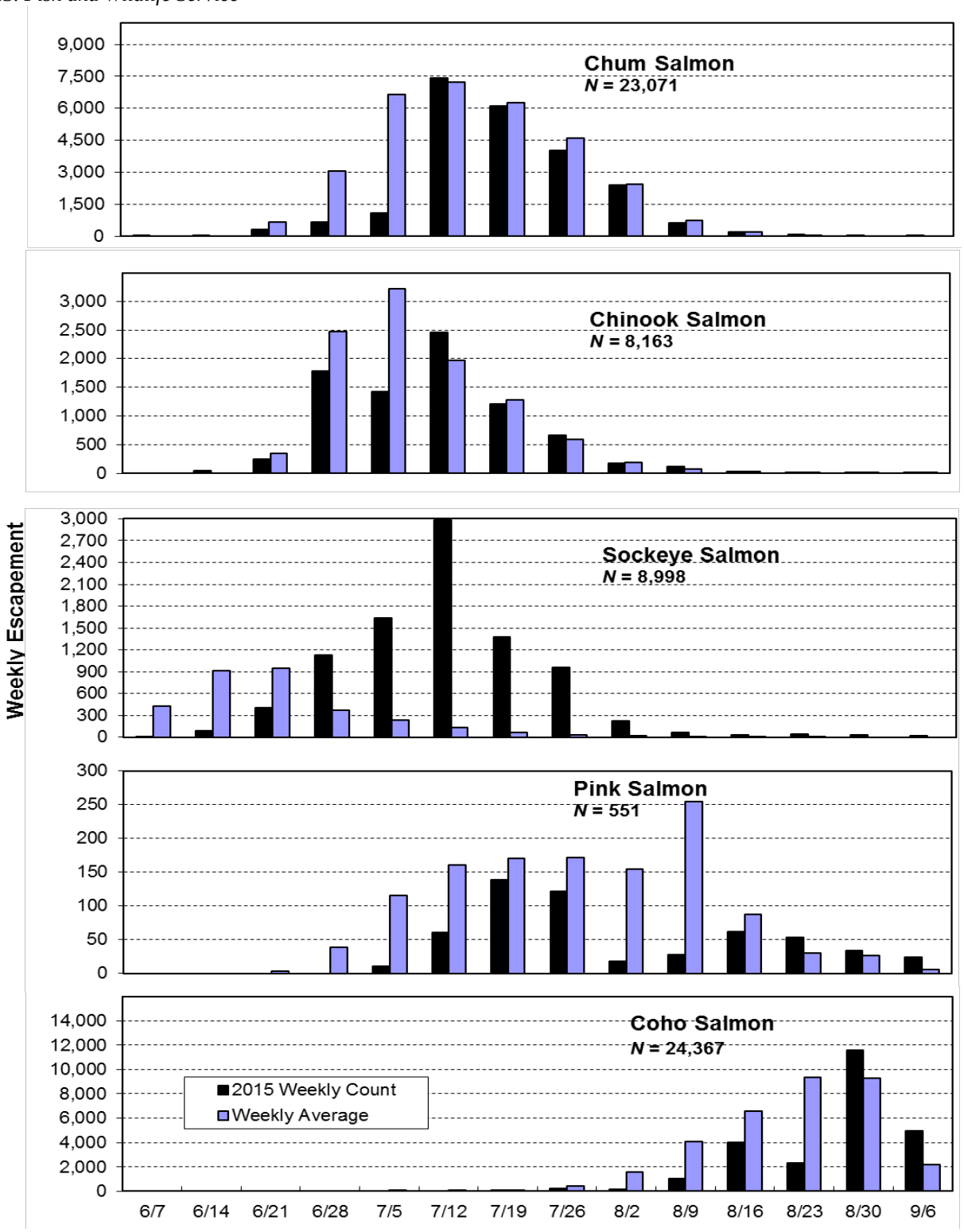

FIGURE 2.—Observed weekly escapement of Chum, Chinook, Sockeye, Pink and Coho salmon passing through the Kwethluk River weir June 7 to September 10, 2015. Average weekly totals for Chum, Chinook and Sockeye salmon are for years 1992, 2000, 2002−2004, 2006−2014; and for Pink Salmon in even years 2000−2014; and for Coho Salmon in years 1992, 2000−2004, 2006−2009, 2012, and 2014. Counts from September 4 to September 10 were incomplete due to high water. Note: Y-axis ranges are different for each species.

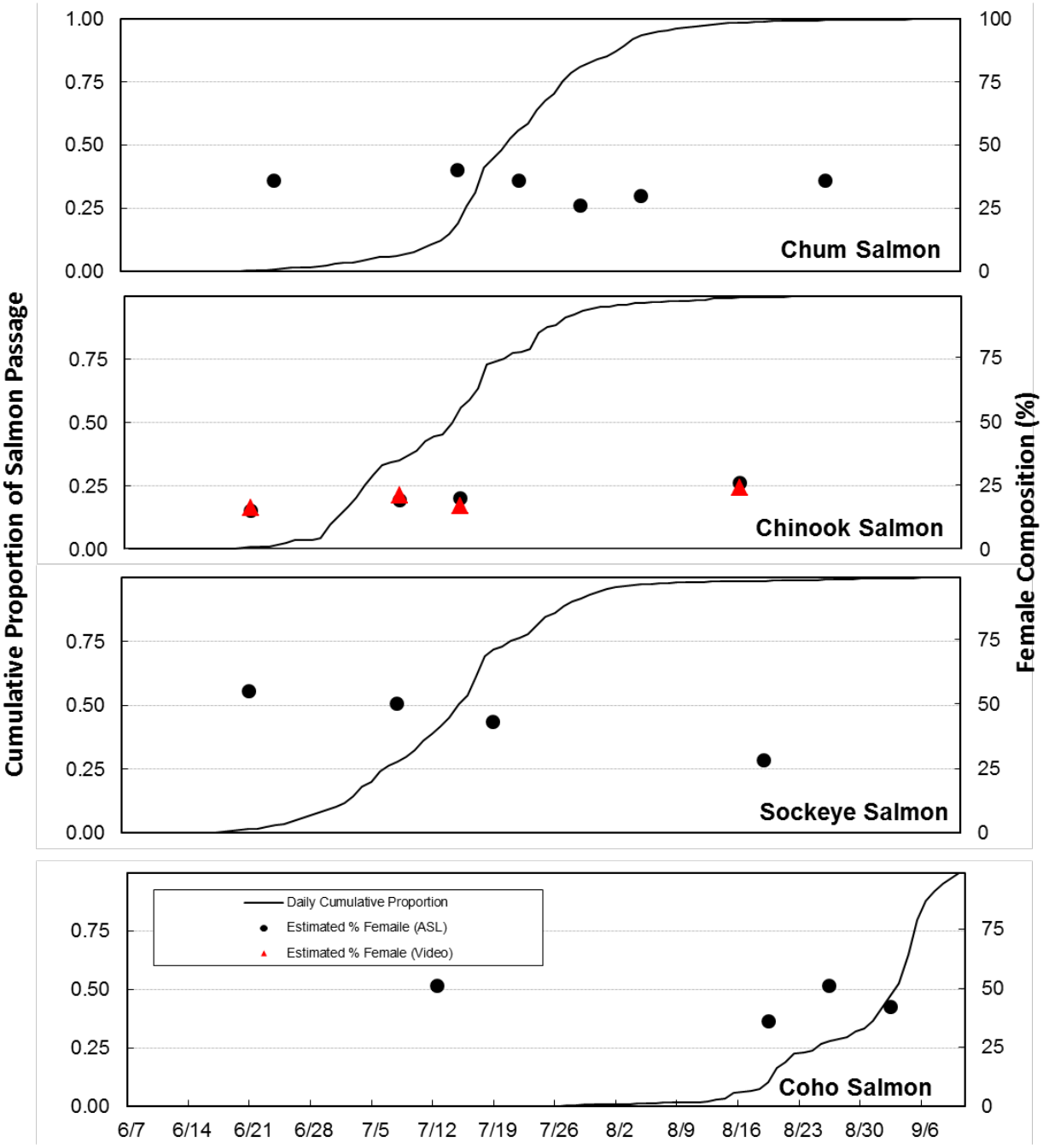

FIGURE 3.—Cumulative proportion of passage, and estimated percent of females from age, sex, and length (ASL) samples and video for Chum, Chinook, Sockeye and Coho salmon returning to the Kwethluk River June 7 to September 10, 2015. Estimates of percent female passage are represented by symbols at the midpoint of each categorical stratum. Strata with low ASL sample sizes were combined. Counts from September 4 to September 10 were incomplete due to high water.

Discussion

Weir Operations

The observed passage of Pacific salmon during 2015 through the Kwethluk River video weir characterized the strength and timing of Chum, Chinook, Sockeye, Pink, and Coho salmon runs. The weir was fully operational prior to salmon arriving in June (Appendix 2). However, due to high water from September 4 to September 10, only partial counts of Coho Salmon were recorded. During the last 3 days of partial counts over 7% of the observed return occurred indicating a substantial number returned after weir operations ceased. The proportion of passage missed for Chum, Chinook, Sockeye and Pink salmon was likely small based on passage of only single digit daily passage during the last 5 days and examination of both the in-season and historical run timings of these species (Miller et al. 2015).

During the winter of 2013 the Alaska Board of Fisheries established a drainage-wide Chinook Salmon SEG of 65,000−120,000 fish (Conitz et al. 2012). The 2015 Kuskokwim River Chinook Salmon pre-season forecast estimate was 96,000−117,000 fish (ADF&G 2015). Based on this forecast, the SEG of 65,000−120,000 fish, and an average subsistence harvest of 84,000 fish, managers decided to restrict fishing for Chinook Salmon at the start of the season and use abundance indices at the Bethel Test Fishery to inform management decisions. Restrictions on gill-net mesh size and closures in various locations along the Kuskokwim River and its tributaries were implemented by state and federal managers during 2015 to conserve the Kuskokwim River Chinook Salmon population (Table 3). These harvest restrictions led to some local opposition to the weirs on the Kwethluk and Tuluksak rivers in 2015. Once Chum and Sockeye abundance exceeded Chinook Salmon abundance, restrictions on subsistence opportunity for Chinook Salmon were relaxed. Community harvest permits were allocated to 32 villages for up to 7,000 Chinook Salmon in 2015.

TABLE 3.— Special actions[1] and emergency orders[2] enacted during 2015 in the Kuskokwim River drainage.

Release Date	Special Action/Emergency Order / News Release
4/17	Federal Subsistence Board (FSB) Limits 2015 Chinook Salmon fisheries to Federally qualified subsistence users.
5/18	FSB 3KS-01-15 Special Action limits who can participate in the Chinook Salmon fishery on the Kuskokwim River.
5/18	FSB 3KS-02-15 closes the Chinook Salmon fishery on the federal public waters in the lower portion of the Kuskokwim River drainage downstream of Tuluksak to all user groups.
5/21	Gear and time restrictions set in Refuge boundary waters: allows nets set from 6 am to 6 am thurs-sun for 5 weeks beginning 5/21 for 4 in. mesh or less and no more than 60 ft. long and no more than 45 meshes deep
5/24	FSB 3KS-03-15 Chinook Salmon fishing on all of the Kuskokwim River and its salmon tributaries within the Refuge will be closed to all user groups from May 28-July 20, 2015
6/1	FSB 3KS-04-15 Use of gillnets on Kwethluk, Kasigluk, Kisaralik , Tuluksak, and Aniak rivers and their salmon tributaries within the boundaries of the Yukon Delta National Wildlife Refuge is prohibited.
6/5	FSB 3KS-05-15 Chinook Salmon fishing closed to all non-federally qualified users in the Kuskokwim River from the mouth to Aniak and the Eek River and all of its salmon tributaries.
6/6	FSB 3KS-06-15 opens a limited harvest of Chinook Salmon with a community harvest permit to federally qualified residents in 32 villages for up to 7,000 Chinook Salmon.
6/16	FSB 3KS-07-15 this special action closed a scheduled four-inch set gill net opportunity downstream of Tuluksak on the Kuskokwim River and all its salmon tributaries.
6/21	FSB 3KS-09-15 opened a four hour gillnet opportunity with nets with 6 in. or less mesh not exceeding 300 ft. in length and 45 meshes in depth from Johnson River to lower Refuge boundary on 6/22 from 4-8 pm for federally qualified users.
6/25	FSB 3KS-010-15 opened 2 sections of the Kuskokwim River for gillnet opportunities for federally qualified users.
8/4	ADFG News Release: the following restrictions to the Kuskokwim River subsistence salmon fishery are rescinded: gillnet use in the Kwethluk, Kasigluk, Kisaralik, Tuluksak, and Aniak rivers; 6-in or less mesh requirements for subsistence gillnets; the closed waters at the mouth of the Aniak, and restrictions to hook and line bag and possession limits for Chinook Salmon
8/19	ADFG News Release: two commercial salmon fishing openings: Upper Section of Subdistrict 1-B opened for 6 hours from 12 pm - 6 pm August 20, 2015; Lower Section of Subdistrict 1-B opened for 8 hours from 10 am - 6 pm August 20, 2015.

[1]https://www.doi.gov/subsistence/news/fishing
[2]https//www.adfg.alaska.gov/index.cfm?adfg=cfnews.main

Biological Data

Chum Salmon —The total count of 23,071 Chum Salmon is below the 13-year average (1992, 2000, 2002−2004, 2006−2011, 2013−2014) escapement estimate, which has not been exceeded since 2009 (Figure 4). The 2015 escapement was 42% of the record high 2007 Chum Salmon escapement of 54,913 fish. The median passage date for Chum Salmon occurred on July 21, the same as 2014 (Figure 5; Appendix 11). The ASL sample size (n = 1,088) was adequate to accurately characterize the overall age, length-at-age, and sex of the Chum Salmon escapement during 2015, but our weekly sample size goal (n = 188) was only achieved for 3 weeks in 2015 (Appendix 2). Therefore, we likely did not achieve the accuracy and precision for the estimates as outlined in Objective 2 for most weeks.

Chinook Salmon —The total count of Chinook Salmon in the Kwethluk River during 2015 (n = 8,163) met the escapement goal for the first year since 2007, but was still below the 13-year average (Figure 4). The estimated escapement was substantially lower than the record high escapement (n = 28,604) observed during 2004 (Figure 4). The median passage date for Chinook Salmon occurred on July 15, which is the third latest in 14 years (Figure 5; Appendix 11).

The ASL sample size (n = 895) collected during 2015 represented 11% of the escapement and was considered adequate to characterize the overall Chinook Salmon escapement. However, our weekly sample size goal (n = 225) was not achieved for any week in 2015 and we likely did not achieve the accuracy and precision for the estimates as outlined in Objective 2. Age-1.2 represented 51% of the Chinook Salmon escapement and age-1.3 40% (Appendix 5).

Female Chinook Salmon composition was similar between the two methods used to identify gender in 2015. Female composition from ASL samples was 21%, whereas video classification indicated 19%. The female composition is on the lower end, but within the historical range of 17−51%. The difference in results between methods used and sample size has been much greater in previous years. Until these issues are resolved, ASL percentages for female salmon will be used unless the ASL sample size is considered inadequate as in 2013 (Miller and Harper 2014).

The escapement goal for Chinook Salmon was met during 2015, however the quality of the escapement was poor with only 21% returning as females. Female Chinook Salmon returning as ≥6 year olds (age 1.4 or 2.3) comprised less than 4% of the escapement. Between 1992 and 2009 these age classes averaged approximately 20% (range 13-35%; Molyneaux et al. 2010b). The poor quality of the escapement may be evident in future returns due to reduced smolt production.

Observed differences in gender composition between years (Appendix 11) may partially be the result of changes in subsistence harvest methods and management strategies. Observations by Harris and Harper (2010) on the Chinook Salmon subsistence harvest in the Native Community of Tuluksak indicate that some subsistence fishers from the area have changed to smaller mesh nets (≤15.2-cm stretch; 6 inches) that selectively harvest a higher percentage of smaller fish which normally include more males. The commercial fishery is restricted to smaller mesh nets (≤15.2-cm stretch). There has been no directed Chinook Salmon commercial fishery since 1986 and the incidental harvest of Chinook Salmon during commercial openers for Chum Salmon in 2008 (n = 8,797), 2009 (n = 6,664), and 2010 (n = 2,731) was predominately male (90%, 80%, and 75%, respectively)(Estensen et al. 2009; Brazil et al. 2010; Molyneaux et al. 2010a). There were fewer harvest restrictions on Chinook Salmon during 2013 than during 2012 (Miller and

Harper 2013a) and an increase in restrictions during 2014 and 2015 over prior years. Restrictions during 2014 and 2015 included limiting gill-net mesh size to ≤15.2-cm or less.

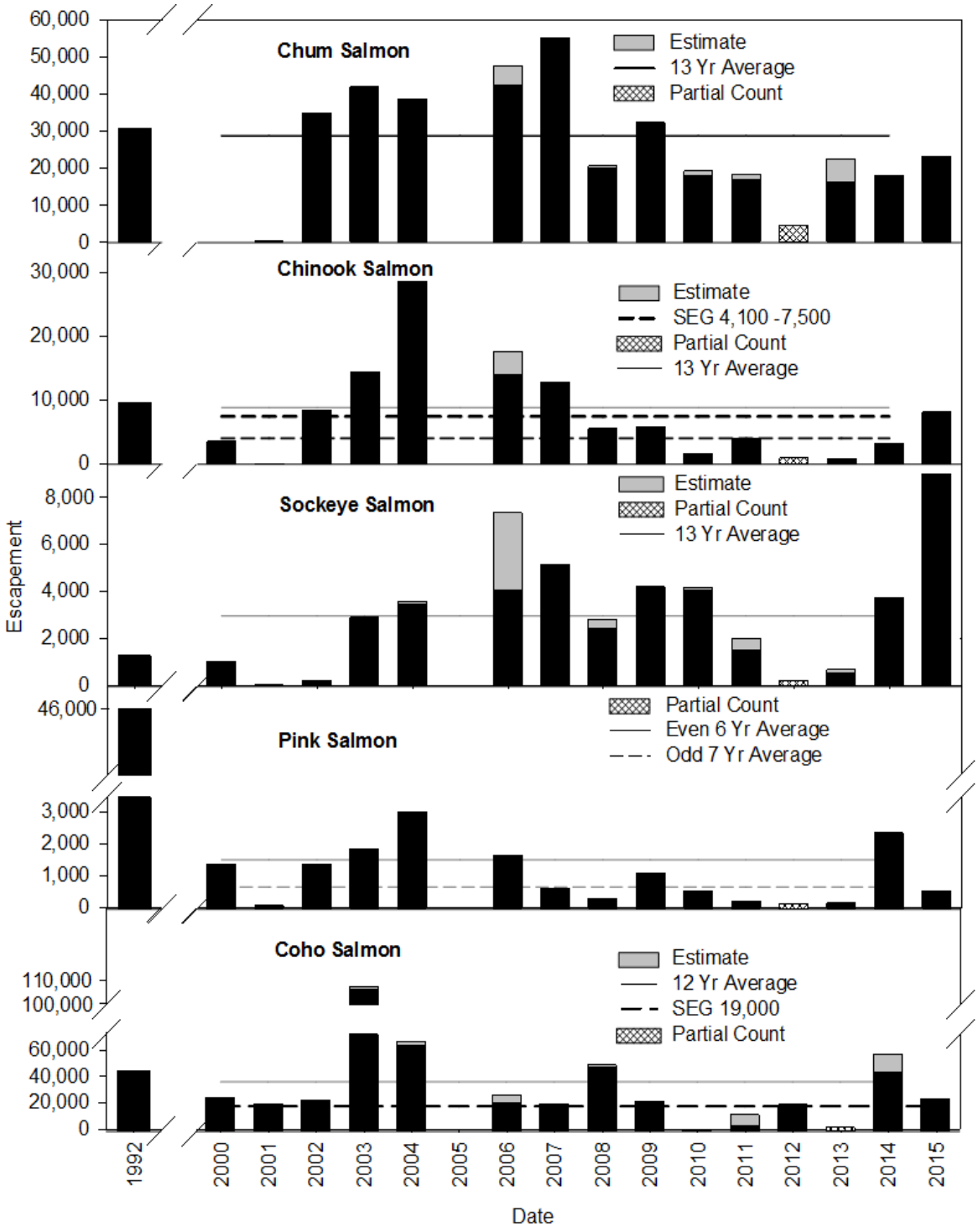

FIGURE 4.—Estimated salmon escapements through the Kwethluk River weir, 1992, 2000–2004, 2006–2015. Averages include only years with an estimated escapement and do not include the current year. Note: Y-axis ranges are different for each species. Run timing for Coho Salmon was 5 days later than any year on record; therefore, estimates for 2015 were not made for partial days from September 4 to 10.

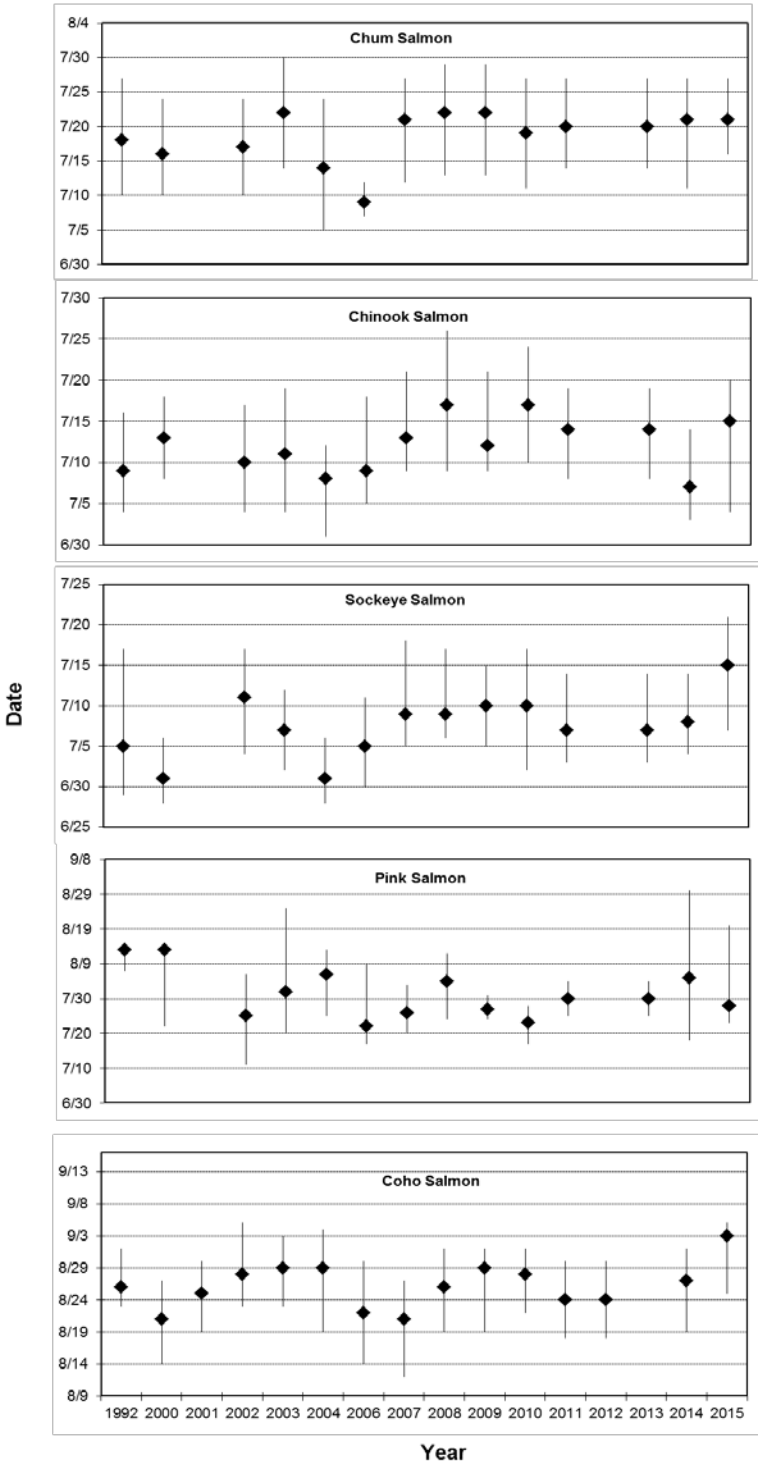

FIGURE 5.—The median cumulative passage date for Chum, Chinook, Sockeye and Coho salmon at the Kwethluk River weir, 1992, 2000–2004, and 2006–2014. The filled diamonds represent the median (50%) passage date and the vertical line below and above the circle represent the first (25%) and third quartiles (75%), respectively. Median dates were not estimated during 2012 for Chum, Chinook, Sockeye, and Pink salmon or during 2013 for Coho Salmon. The median cumulative passage date for Coho Salmon during 2016 is based upon weir passage without estimates to account for the weir not being fish tight due to high water September 4-10, or fish passing the weir site after it was removed. Note that Y-axis scales are different for each species.

Conservation measures have been implemented during recent years of reduced runs to meet escapements and improve quality of escapements for Chinook Salmon. These have included time, area and gear restrictions, with the latter restricting the allowable mesh size to ≤15.2-cm stretch to reduce harvests of larger more productive salmon. Data from 2010 to 2015 indicates gill-net marks were higher in female Chinook Salmon than males (Table 4). The GNM percentage in 2015 was 4.8% for females and 2.1% for males (X^2=4.41 df=1, p=0.036), the lowest since 2011. The higher percentage of females with gill net-marks may have to do with morphological differences and the ability of larger females to escape smaller ≤15.2-cm mesh gill nets used to target smaller salmon and mesh sizes ≤10.2 cm used to target whitefish. During 2015, conservation measures were put in place to provide limited harvest opportunities for Chinook Salmon and provide opportunities for species other than salmon. To accomplish this small (<10.2 cm) mesh nets were allowed for 3 days a week for 5 weeks beginning May 25 to target whitefish, and Northern Pike. The directed harvest of Chinook Salmon with mesh sizes ≤15.2cm was also restricted to a community harvest quota starting on June 6 and general subsistence fishery openers late in the run on June 22 and 25. Even with the net restrictions and conservation closures effective during 2015 (Table 3; Table 4), gill-net marked fish still appeared at approximately half the rate as during 2011 when the Chinook Salmon run sustained a 45% harvest rate (Poetter 2015). Net-marked fish observed at the weir indicate survival of an unknown proportion of fish escaping nets in the lower river. Other concerns with the disproportionate number of females with gill-net marks include possible lower survival of net-marked fish and possible loss of fish to dropout mortality (i.e., dead fish falling out of gill nets or fish escaping from gill nets, but unable to reach spawning grounds).

Table 4.—Number and percentage of gill-net marks (GNM) on male (M) and female (F) Chinook Salmon sampled for age, sex, and length (ASL) at the Kwethluk River weir 2010−2015.

	Sample			GNM		%GNM		X^2 Probability
Year	ASL	M	F	M	F	M	F	
2010	428	231	197	23	26	9.9	13.2	0.351
2011	795	527	268	39	24	7.0	9.0	0.479
2012	134	70	64	2	17	2.8	23.0	0.001
2013	71	42	29	1	3	2.4	10.0	0.306
2014	513	273	240	36	34	13.0	14.0	0.777
2015	1,003	794	209	17	10	2.1	4.8	0.042
2010-2015	2,944	1,937	1,007	118	114	6.1	11.3	0.000

Ricker (1980) analyzed Chinook Salmon stocks from the early 1900s through the 1970s and found a shift in age at maturation. His analysis suggested that the shift to earlier maturing fish was the result of harvest pressure removing a disproportionate number of larger older fish. In the Kwethluk River three small age-1.2 Chinook Salmon were classified as females using external characteristics, representing 0.3% of the escapement. The long-term average proportion of age-1.2 Chinook Salmon in the commercial fishery is 0.9% (1964-2010; Molyneaux et al. 2010b) and in the Kuskokwim River subsistence fishery the range is 0.4-0.9% of the harvest from 2008 to 2011 (Liller et al. 2013). Monitoring for potential shifts in age at maturation should continue as a check on management practices. Additional work should be conducted at the Kwethluk River weir to verify sex of small (<650 mm MEF) age-1.2 and -1.3 fish. This may include the use of

additional morphometric characteristics (Merz and Merz 2004; Clary 2006, 2007; Miller and Harper 2014), the use of genetic markers, or ultrasound.

Sockeye Salmon —The total count of Sockeye Salmon (*n* = 8,998) was the highest ever recorded at the Kwethluk River weir (Figure 4). The median cumulative passage date of July 15 was the latest ever recorded; the next closest was July 11 in 2002 (Appendix 10).

The ASL sample size (*n* = 827) was adequate to characterize the age, length-at-age, and sex composition of the Sockeye Salmon escapement during 2015. Females comprised 44% of the ASL collection, which is within the 13-year observed range (36−65%; Appendix 11).

Pink Salmon —The number of Pink Salmon counted passing through the weir during 2015 (*n* = 551) was below the odd-year (*n* = 692) and even-year (*n* = 1,410) average counts since 2000, when wider picket spacing was implemented on the Kwethluk River weir (Figure 4). The actual count provides only an index of abundance because most Pink Salmon may be small enough to pass between pickets of the weir panels. Pink Salmon return to spawning grounds in predictable and segregated even and odd numbered years (Scott and Crossman 1973).

Coho Salmon —The observed escapement of 24,367 for was within the historical range (19,473−109,173) and above the 12-year average and the established threshold of 19,000 (Volk et al. 2009; Figure 4). The median cumulative passage date was September 3, which is later than the historical range of August 21−29 (Figures 5 and 6; Appendix 11). However, on September 3, the last day of complete counts, a total of 1,271 Coho Salmon passed the weir. During the next 4 days, which were considered incomplete counts when the weir was partially or fully submerged, 9,645 (40%) of the counted fish passed. Thus, with 40% of the cumulative passage occurring between September 4 and 7, and 618 more fish on September 10 (the last day of operations), the observed Coho Salmon escapement is incomplete for 2015.

Female Coho Salmon comprised 43% of the ASL sample (*n* = 959); within the historical escapement percentage range of 29-57% (Appendix 11). The predominant age of Coho Salmon sampled during 2015 was age-2.1, which represented 80% of the Coho Salmon counted (Appendix 9). Age-2.1 fish dominate the age structure across strata and range from 75% to 95% of the total escapement during previous years (Miller et al. 2015). Coho Salmon in Alaska typically spend 2 years in fresh water and 1 year in the marine environment (Groot and Margolis 1991).

Recommendations

The Kwethluk River weir and other escapement projects throughout the Kuskokwim River drainage provide invaluable information for Service and Department fishery managers. Because this project monitors an important Refuge resource and contributes a substantial number of fish to the subsistence fishery, it is recommended that the operation of the Kwethluk River weir continue during 2016 and beyond. Specific objectives and a study design should be developed to test the hypothesis that length measurements and morphological features derived from video images can successfully describe the length and sex composition of returning adult salmon. Age-1.5 Chinook Salmon were absent from samples this year, placing emphasis on continued monitoring of age-at-maturity of female Chinook Salmon to detect shifts in maturation.

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References

Alaska Department of Fish and Game. 2015. 2014 Kuskokwim River Chinook Salmon run reconstructions and 2015 outlook; upcoming public outreach February 24, 2015: Division of Commercial Fisheries.

Alt, K. 1977. Inventory and cataloging in Western Alaska waters. Alaska Department of Fish and Game, Federal Aid in Fish Restoration Completion Report, Study G-I-P, Volume 18, Juneau, Alaska.

ANILCA (Alaska National Interest Lands Conservation Act). 1980. 94 STAT. Public Law 96-487 96th Congress, Section 303 (7) (B) (*i*).

Bergstrom, D. J., and C. Whitmore. 2004. Kuskokwim River Chinook and Chum salmon stock status and action plan, a report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report 3A04-02, Anchorage, Alaska.

Brazil, C., H. Carroll, and T. Elison. 2010. 2010 Kuskokwim area salmon fishery news release, 2010 Kuskokwim area salmon fishery summary. Alaska Department of Fish and Game, Division of Commercial Fisheries, News Release, Anchorage.

Bromaghin, J. F. 1993. Sample size determination for interval estimation of multinomial probabilities. The American Statistician 47:203-206.

Burkey, C., M. Coffing, J. Menard, D. Molyneaux, P. Salomone, and C. Utermohle. 2001. Annual management report for the subsistence and commercial fisheries of the Kuskokwim area, 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Information Report Number 3A01-34, Anchorage, Alaska.

Clary, S. L. 2006. A device for determining the sex (gender) of fish by morphological characteristics, utility patent app. Nr. US11/580,254, USPTO, Washington, DC.

Clary, S. L. 2007. The determination of gender in Pacific and Atlantic salmon for improved management of threatened and endangered stocks, 58th ISEF Abstracts, Science Service, Washington, DC.

Cochran, W. G. 1977. Sampling techniques, 3rd edition. John Wiley and Sons, New York.

Conitz, J. M., K. G. Howard, and M. J. Evenson. 2012. Escapement goal recommendations for select Arctic-Yukon-Kuskokwim Region salmon stocks, 2013. Alaska Department of Fish and Game, Fishery manuscript No. 12-07, Anchorage.

Estensen, J. L., D. B. Molyneaux, and D. J. Bergstrom. 2009. Kuskokwim River salmon status and Kuskokwim area fisheries, 2009; a report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Sport Fish and Commercial Fisheries, Special Publication 09-21, Anchorage.

Fall, J. A., A. R. Brenner, S. S. Evans, D. Holen, L Hutchinson-Scarborough, B. Jones, R. La Vine, T. Lemons, M. A. Marchioni, E. Mikow, J. T. Ream, L. A. Sill, and A. Trainor. 2013. Alaska subsistence and personal use salmon fisheries 2011 annual report. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 387, Anchorage, Alaska.

Gates, K. S., J. K. Boersma, D. E. Palmer, and J. F. Bromaghin. 2010. Run timing, abundance, and distribution of adult Coho Salmon in the Kasilof River watershed, Alaska, 2007-2009. U. S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2010-3, Soldotna, Alaska.

Groot, C., and L. Margolis, editors. 1991. Pacific salmon life histories. UBC Press, Vancouver, BC.

Harper, K. C. 1998. Run timing and abundance of adult salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 1992. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report Number 44, Kenai, Alaska.

Harper, K. C., F. Harris, and S. J. Miller. 2007. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2005: Weir Rebuild. U.S. Fish and Wildlife Service, Office of Subsistence Management Annual Report 04-301.

Harper, K. C., and C. B. Watry. 2001. Abundance and run timing of adult salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2000. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Data Series Report 2001-4, Kenai, Alaska.

Harris, F., and K. C. Harper. 2010. Characterization of Tuluksak Chinook Salmon Subsistence Harvests, 2008 and 2009. U.S. Fish and Wildlife Service, Kenai Fish & Wildlife Field Office, Alaska Fisheries Data Series Report 2010-7, Soldotna, Alaska.

Kerkvliet, C. M., and T. Hamazaki. 2003. A mark-recapture experiment to estimate the total population of Kuskokwim River Coho Salmon (*Oncorhynchus kisutch*), 2001. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report Number 3A02-15, Anchorage.

Kerkvliet, C. M., T. Hamazaki, K. E. Hyer, and D. Cannon. 2003. A mark–recapture experiment to estimate the abundance of Kuskokwim River Chum, Sockeye, and Coho salmon, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report Number 3A03-25, Anchorage.

Kerkvliet, C. M., J. Pawluk, T. Hamazaki, K. E. Hyer, and D. Cannon. 2004. A mark–recapture experiment to estimate the abundance of Kuskokwim River Chum, Sockeye and Coho salmon, 2003. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report Number 3A04-14, Anchorage.

Koo, T. S. Y. 1962. Age determination in salmon. Pages 37-48 *in* T.S.Y. Koo, editor. Studies of Alaskan red salmon. University of Washington Press, Seattle, Washington.

Liller, Z. W., A. R. Brodersen, T. R. Hansen, D. B. Molyneaux, and E. Patton. 2013. Age, sex, and length composition of Chinook salmon harvested in the 2008–2011 Lower Kuskokwim River subsistence fishery. Alaska Department of Fish and Game, Fishery Data Series No. 13-10, Anchorage.

Linderman, J. C., and B. Bue. 2006. Kuskokwim Bay Salmon Fishery News Release #29, Preliminary 2006 Kuskokwim Area Salmon Fishery Summary. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Area Office, Bethel, Alaska.

Linderman, J. C., and M. Rearden. 2007. Kuskokwim Bay salmon fishery news release #1, 2007 Kuskokwim Area regulatory changes, salmon outlook, and management strategies.

Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Area Office, Bethel, Alaska.

Merz, J. E., and W. R. Merz. 2004. Morphological features used to identify Chinook Salmon sex during fish passage. The Southwestern Naturalist 49 (2): 197-202.

Miller, S. J., and K. C. Harper. 2010. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2009. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2010-1, Soldotna, Alaska.

Miller, S. J., and K. C. Harper. 2011a. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2010. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2011-3, Soldotna, Alaska.

Miller, S. J., and K. C. Harper. 2011b. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2010. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2011-4, Soldotna, Alaska.

Miller, S. J., and K. C. Harper. 2012a. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2011. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2012-3, Soldotna, Alaska.

Miller, S. J., and K. C. Harper. 2012b. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2011. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2012-3, Soldotna, Alaska.

Miller, S. J., and K. C. Harper. 2013a. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2012. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2013-7, Soldotna, Alaska.

Miller, S. J., and K. C. Harper. 2013b. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2012. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2013-6, Soldotna, Alaska.

Miller, S. J., and K. C. Harper. 2014. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2013. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2014-9, Soldotna, Alaska.

Miller, S. J., K. C. Harper, and D. G. Spencer. 2007. Abundance and run timing of adult salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2006. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Report 2007-9, Soldotna, Alaska.

Miller, S. J., K. C. Harper, and C. Whaley. 2008. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2007. U.S.

Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2008-18, Soldotna, Alaska.

Miller, S. J., K. C. Harper, and S. Sanders. 2009. Abundance and run timing of adult salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2008. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Report 2009-10, Soldotna, Alaska.

Miller, S. J., K. C. Harper, and J. K. Boersma. 2015. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2014. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2015-6, Soldotna, Alaska.

Molyneaux, D. M., and L. K. Brannian. 2006. Review of escapement and abundance information for Kuskokwim area salmon stocks. Alaska Department of Fish and Game, Fishery manuscript No. 06-08, Anchorage.

Molyneaux, D. M., A. R. Brodersen, D. L. Folletti, Z. W. Liller, and G. Roczicka. 2010a. Age, sex and length composition of Chinook Salmon in the 2005−2007 Kuskokwim River subsistence fishery. Alaska Department of Fish and Game. Fishery Data Series No. 10-39, Anchorage.

Molyneaux, D. M., A. R. Brodersen, and C. A. Shelden. 2010b. Salmon age, sex, and length catalog for the Kukskowim area, 2009. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A10-05, Anchorage.

Mosher, K. H. 1968. Photographic atlas of Sockeye Salmon scales. U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Fishery Bulletin Number 2: 243-274.

Poetter, A. D. 2015. Kuskokwim River salmon stock status and Kuskokwim area fisheries, 2015; a report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Special Publication No.15-21, Anchorage.

Ricker, W.E. 1980. Causes of the Decrease in age and size of Chinook Salmon Onchorhynchus Tshawytscha. Canadian Technical Report of Fisheries and Aquatic Sciences No 944. Department of Fisheries and Oceans. Nanaimo, British Columbia

Roettiger, T. G., K. C. Harper, and A. Chikowsky. 2002. Abundance and run timing of adult salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2001. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Report 2002-8, Kenai, Alaska.

Roettiger, T. G., K. C. Harper, and D. Nolfi. 2003. Abundance and run timing of adult salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2002. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Report 2003-6, Kenai, Alaska.

Roettiger, T. G., F. Harris, and K. C. Harper. 2004. Abundance and run timing of adult salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2003. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Report 2004-8, Kenai, Alaska.

Roettiger, T. G., F. Harris, and K. C. Harper. 2005. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2004. U.S.

Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Report 2005-7, Kenai, Alaska.

Scott, W. B., and E. J. Crossman. 1973. Freshwater Fishes of Canada. Bulletins of Fisheries Research Board of Canada, Bulletin 184, Ottawa, Canada.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters, 2nd edition. Maxmillan, New York.

Stewart, R. 2002. Resistance board weir panel construction manual, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A02-21, Anchorage, Alaska.

Stuby, L. 2004. Inriver abundance of Chinook Salmon in the Kuskokwim River, 2003. Alaska Department of Fish and Game, Fishery Data Series Number 04-30, Anchorage.

Stuby, L. 2005. Inriver abundance of Chinook Salmon in the Kuskokwim River, 2002-2004. Alaska Department of Fish and Game, Fishery Data Series Number 05-39, Anchorage.

Stuby, L. 2006. Inriver abundance of Chinook Salmon in the Kuskokwim River, 2005. Alaska Department of Fish and Game, Fishery Data Series Number 05-302, Anchorage.

Tobin, J. H. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report Number 22, Kenai, Alaska.

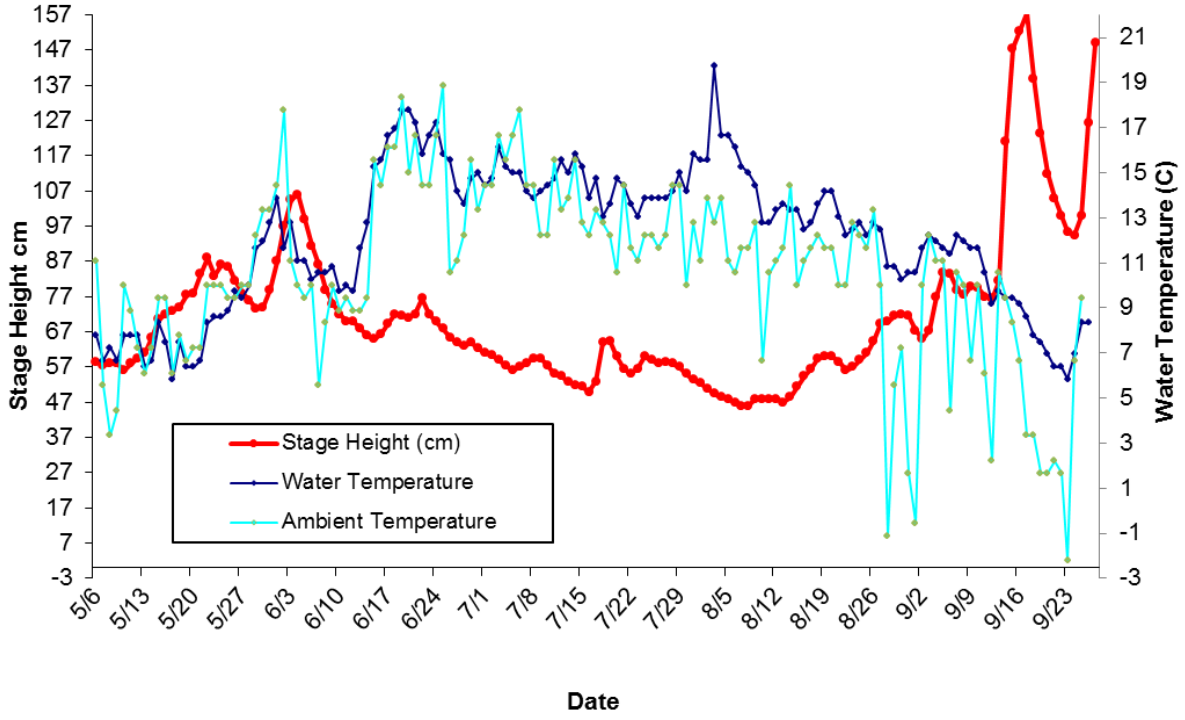
U.S. Fish and Wildlife Service. 1988. Yukon Delta National Wildlife Refuge comprehensive conservation plan, environmental impact statement, wilderness review, and wild river plan. U.S. Department of Interior, Fish and Wildlife Service, Anchorage, Alaska.

U.S. Fish and Wildlife Service. 1992. Fishery Management Plan for the Yukon Delta National Wildlife Refuge. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Volk, E. C, M. J. Evenson, and R. A. Clark. 2009. Escapement goal recommendations for select Arctic-Yukon-Kuskokwim Region salmon stocks, 2010. Alaska Department Fish and Game, Fishery Manuscript No. 09-07, Anchorage. Available: http://www.sf.adfg.state.ak.us/FedAidpdfs/fms06-08.pdf

Ward, T. C., M. Coffing, J. Estenson, R. Fisher, and D. Molyneaux. 2003. Annual management report for the subsistence and commercial fisheries of the Kuskokwim Area, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A03-27, Anchorage, Alaska.

APPENDIX 1.—Water stage heights, ambient temperatures, and water temperatures taken at the Kwethluk River weir during 2015.



Appendix 2.—Observed escapements, cumulative counts, and cumulative proportions of Chum, Chinook, Sockeye, Pink and Coho salmon that passed through the Kwethluk River weir, Alaska, 2015.

	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
06/10	1	1	0.000	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
06/11	0	1	0.000	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
06/12	1	2	0.000	0	0	0.000	1	1	0.000	0	0	0.000	0	0	0.000
06/13	0	2	0.000	0	0	0.000	4	5	0.001	0	0	0.000	0	0	0.000
06/14	0	2	0.000	0	0	0.000	2	7	0.001	0	0	0.000	0	0	0.000
06/15	1	3	0.000	0	0	0.000	3	10	0.001	0	0	0.000	0	0	0.000
06/16	4	7	0.000	0	0	0.000	3	13	0.001	0	0	0.000	0	0	0.000
06/17	2	9	0.000	4	4	0.000	8	21	0.002	0	0	0.000	0	0	0.000
06/18	3	12	0.001	7	11	0.001	15	36	0.004	0	0	0.000	0	0	0.000
06/19	15	27	0.001	12	23	0.003	25	61	0.007	0	0	0.000	0	0	0.000
06/20	22	49	0.002	21	44	0.005	34	95	0.011	0	0	0.000	0	0	0.000
06/21	28	77	0.003	28	72	0.009	47	142	0.016	0	0	0.000	0	0	0.000
06/22	21	98	0.004	6	78	0.010	11	153	0.017	0	0	0.000	0	0	0.000
06/23	26	124	0.005	15	93	0.011	52	205	0.023	0	0	0.000	0	0	0.000
06/24	58	182	0.008	39	132	0.016	65	270	0.030	0	0	0.000	0	0	0.000
06/25	96	278	0.012	56	188	0.023	53	323	0.036	0	0	0.000	0	0	0.000
06/26	63	341	0.015	92	280	0.034	91	414	0.046	0	0	0.000	0	0	0.000
06/27	23	364	0.016	4	284	0.035	90	504	0.056	0	0	0.000	0	0	0.000
06/28	11	375	0.016	16	300	0.037	97	601	0.067	0	0	0.000	0	0	0.000
06/29	71	446	0.019	65	365	0.045	111	712	0.079	0	0	0.000	0	0	0.000
06/30	127	573	0.025	408	773	0.095	117	829	0.092	0	0	0.000	0	0	0.000
07/01	117	690	0.030	300	1,073	0.131	90	919	0.102	0	0	0.000	0	0	0.000
07/02	68	758	0.033	275	1,348	0.165	124	1,043	0.116	0	0	0.000	0	0	0.000
07/03	70	828	0.036	306	1,654	0.203	233	1,276	0.142	0	0	0.000	0	0	0.000
07/04	184	1,012	0.044	414	2,068	0.253	353	1,629	0.181	0	0	0.000	0	0	0.000
07/05	89	1,101	0.048	328	2,396	0.294	158	1,787	0.199	0	0	0.000	0	0	0.000
07/06	199	1,300	0.056	314	2,710	0.332	394	2,181	0.242	1	1	0.002	0	0	0.000
07/07	67	1,367	0.059	87	2,797	0.343	197	2,378	0.264	0	1	0.002	0	0	0.000
07/08	47	1,414	0.061	67	2,864	0.351	141	2,519	0.280	0	1	0.002	0	0	0.000
07/09	138	1,552	0.067	154	3,018	0.370	155	2,674	0.297	2	3	0.005	0	0	0.000
07/10	175	1,727	0.075	150	3,168	0.388	224	2,898	0.322	4	7	0.013	0	0	0.000
07/11	350	2,077	0.090	321	3,489	0.427	363	3,261	0.362	4	11	0.020	0	0	0.000
07/12	365	2,442	0.106	138	3,627	0.444	208	3,469	0.386	2	13	0.024	0	0	0.000
07/13	327	2,769	0.120	81	3,708	0.454	274	3,743	0.416	1	14	0.025	0	0	0.000
07/14	616	3,385	0.147	362	4,070	0.499	316	4,059	0.451	5	19	0.034	0	0	0.000
07/15	1,001	4,386	0.190	510	4,580	0.561	498	4,557	0.506	6	25	0.045	0	0	0.000
07/16	1,551	5,937	0.257	229	4,809	0.589	275	4,832	0.537	6	31	0.056	0	0	0.000
07/17	1,295	7,232	0.313	388	5,197	0.637	685	5,517	0.613	4	35	0.064	0	0	0.000

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	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
07/18	2,268	9,500	0.412	753	5,950	0.729	723	6,240	0.693	37	72	0.131	0	0	0.000
07/19	773	10,273	0.445	92	6,042	0.740	224	6,464	0.718	15	87	0.158	0	0	0.000
07/20	741	11,014	0.477	99	6,141	0.752	110	6,574	0.731	9	96	0.174	0	0	0.000
07/21	1,066	12,080	0.524	193	6,334	0.776	214	6,788	0.754	32	128	0.232	6	6	0.000
07/22	787	12,867	0.558	38	6,372	0.781	82	6,870	0.764	3	131	0.238	3	9	0.000
07/23	622	13,489	0.585	66	6,438	0.789	124	6,994	0.777	16	147	0.267	2	11	0.000
07/24	1,245	14,734	0.639	535	6,973	0.854	324	7,318	0.813	35	182	0.330	5	16	0.001
07/25	889	15,623	0.677	191	7,164	0.878	303	7,621	0.847	28	210	0.381	16	32	0.001
07/26	546	16,169	0.701	65	7,229	0.886	128	7,749	0.861	23	233	0.423	10	42	0.002
07/27	1,170	17,339	0.752	245	7,474	0.916	254	8,003	0.889	39	272	0.494	49	91	0.004
07/28	820	18,159	0.787	94	7,568	0.927	139	8,142	0.905	28	300	0.544	31	122	0.005
07/29	503	18,662	0.809	130	7,698	0.943	123	8,265	0.919	11	311	0.564	41	163	0.007
07/30	378	19,040	0.825	54	7,752	0.950	137	8,402	0.934	10	321	0.583	30	193	0.008
07/31	362	19,402	0.841	55	7,807	0.956	94	8,496	0.944	5	326	0.592	32	225	0.009
08/1	249	19,651	0.852	17	7,824	0.958	84	8,580	0.954	6	332	0.603	7	232	0.010
08/2	448	20,099	0.871	42	7,866	0.964	73	8,653	0.962	6	338	0.613	10	242	0.010
08/3	503	20,602	0.893	21	7,887	0.966	39	8,692	0.966	4	342	0.621	9	251	0.010
08/4	654	21,256	0.921	44	7,931	0.972	44	8,736	0.971	2	344	0.624	70	321	0.013
08/5	310	21,566	0.935	21	7,952	0.974	18	8,754	0.973	2	346	0.628	8	329	0.014
08/6	160	21,726	0.942	18	7,970	0.976	25	8,779	0.976	0	346	0.628	22	351	0.014
08/7	194	21,920	0.950	17	7,987	0.978	12	8,791	0.977	3	349	0.633	11	362	0.015
08/8	120	22,040	0.955	6	7,993	0.979	11	8,802	0.978	1	350	0.635	2	364	0.015
08/9	157	22,197	0.962	20	8,013	0.982	16	8,818	0.980	3	353	0.641	76	440	0.018
08/10	94	22,291	0.966	4	8,017	0.982	7	8,825	0.981	3	356	0.646	4	444	0.018
08/11	60	22,351	0.969	9	8,026	0.983	5	8,830	0.981	0	356	0.646	0	444	0.018
08/12	57	22,408	0.971	12	8,038	0.985	13	8,843	0.983	0	356	0.646	15	459	0.019
08/13	137	22,545	0.977	50	8,088	0.991	18	8,861	0.985	5	361	0.655	238	697	0.029
08/14	65	22,610	0.980	10	8,098	0.992	7	8,868	0.986	6	367	0.666	126	823	0.034
08/15	61	22,671	0.983	10	8,108	0.993	4	8,872	0.986	11	378	0.686	602	1,425	0.058
08/16	14	22,685	0.983	3	8,111	0.994	2	8,874	0.986	2	380	0.690	82	1,507	0.062
08/17	27	22,712	0.984	2	8,113	0.994	1	8,875	0.986	2	382	0.693	97	1,604	0.066
08/18	42	22,754	0.986	3	8,116	0.994	3	8,878	0.987	8	390	0.708	250	1,854	0.076
08/19	43	22,797	0.988	13	8,129	0.996	3	8,881	0.987	7	397	0.721	629	2,483	0.102
08/20	32	22,829	0.990	7	8,136	0.997	10	8,891	0.988	20	417	0.757	1,548	4,031	0.165
08/21	20	22,849	0.990	3	8,139	0.997	5	8,896	0.989	6	423	0.768	583	4,614	0.189
08/22	25	22,874	0.991	5	8,144	0.998	4	8,900	0.989	17	440	0.799	853	5,467	0.224
08/23	13	22,887	0.992	1	8,145	0.998	6	8,906	0.990	7	447	0.811	103	5,570	0.229

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	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
08/24	11	22,898	0.993	3	8,148	0.998	6	8,912	0.990	9	456	0.828	212	5,782	0.237
08/25	13	22,911	0.993	2	8,150	0.998	7	8,919	0.991	11	467	0.848	680	6,462	0.265
08/26	18	22,929	0.994	4	8,154	0.999	5	8,924	0.992	6	473	0.858	335	6,797	0.279
08/27	15	22,944	0.994	0	8,154	0.999	10	8,934	0.993	5	478	0.868	220	7,017	0.288
08/28	8	22,952	0.995	1	8,155	0.999	4	8,938	0.993	8	486	0.882	219	7,236	0.297
08/29	10	22,962	0.995	1	8,156	0.999	9	8,947	0.994	7	493	0.895	570	7,806	0.320
08/30	13	22,975	0.996	3	8,159	1.000	7	8,954	0.995	4	497	0.902	299	8,105	0.333
08/31	10	22,985	0.996	1	8,160	1.000	6	8,960	0.996	5	502	0.911	844	8,949	0.367
09/01	7	22,992	0.997	1	8,161	1.000	3	8,963	0.996	8	510	0.926	1,226	10,175	0.418
09/02	9	23,001	0.997	0	8,161	1.000	2	8,965	0.996	0	510	0.926	1,352	11,527	0.473
09/03	3	23,004	0.997	1	8,162	1.000	4	8,969	0.997	4	514	0.933	1,271	12,798	0.525
09/04	7	23,011	0.997	0	8,162	1.000	5	8,974	0.997	8	522	0.947	2,971	15,769	0.647
09/05	8	23,019	0.998	0	8,162	1.000	5	8,979	0.998	5	527	0.956	3,633	19,402	0.796
09/06	13	23,032	0.998	0	8,162	1.000	8	8,987	0.999	5	532	0.966	1,956	21,358	0.877
09/07	14	23,046	0.999	0	8,162	1.000	3	8,990	0.999	6	538	0.976	1,085	22,443	0.921
09/08	4	23,050	0.999	1	8,163	1.000	2	8,992	0.999	3	541	0.982	785	23,228	0.953
09/09	13	23,063	1.000	0	8,163	1.000	1	8,993	0.999	5	546	0.991	521	23,749	0.975
09/10	8	23,071	1.000	0	8,163	1.000	5	8,998	1.000	5	551	1.000	618	24,367	1.000

Shaded areas depict counts during days when the weir was partially or totally submerged.

Appendix 3.—Age and sex composition of the weekly Chum Salmon estimated escapement through the Kwethluk River weir, Alaska, 2015. Rounding errors affect totals.

		Brood Year and Age Group				
		2012	2011	2010	2009	
		0.2	0.3	0.4	0.5	Total
Strata 1 – 5:	06/07 – 07/11					
Sampling Dates:	06/22 – 07/02, 07/05 – 07/11					
Male:	Number in Sample:	0	30	75	11	116
	Estimated % of Escapement:	0.0	16.6	41.4	6.1	**64.1**
	Estimated Escapement:	0	344	861	126	1,331
	Standard Error:	0.0	55.0	72.9	35.3	
Female:	Number in Sample:	1	18	42	4	65
	Estimated % of Escapement:	0.6	9.9	23.2	2.2	**35.9**
	Estimated Escapement:	11	207	482	46	746
	Standard Error:	11.0	44.3	62.4	21.7	
Total:	Number in Sample:	1	48	117	15	181
	Estimated % of Escapement:	0.6	26.5	64.6	8.3	**100.0**
	Estimated Escapement:	11	551	1,343	172	2,077
	Standard Error:	11.0	65.3	70.7	40.8	
Stratum 6:	07/12 – 07/18					
Sampling Dates:	07/12 – 07/15					
Male:	Number in Sample:	0	36	33	0	69
	Estimated % of Escapement:	0.0	31.6	28.9	0.0	**60.5**
	Estimated Escapement:	0	2,344	2,149	0	4,493
	Standard Error:	0.0	322.1	314.2	0.0	
Female:	Number in Sample:	0	27	18	0	45
	Estimated % of Escapement:	0.0	23.7	15.8	0.0	**39.5**
	Estimated Escapement:	0	1,758	1,172	0	2,930
	Standard Error:	0.0	294.6	252.7	0.0	
Total:	Number in Sample:	0	63	51	0	114
	Estimated % of Escapement:	0.0	55.3	44.7	0.0	**100.0**
	Estimated Escapement:	0	4,102	3,321	0	7,423
	Standard Error:	0.0	344.5	344.5	0.0	
Stratum 7:	07/19 – 07/25					
Sampling Dates:	07/19 – 07/21					
Male:	Number in Sample:	4	84	30	0	118
	Estimated % of Escapement:	2.2	45.7	16.3	0.0	**64.1**
	Estimated Escapement:	133	2,795	998	0	3,927
	Standard Error:	65.0	222.0	164.7	0.0	
Female:	Number in Sample:	2	47	17	0	66
	Estimated % of Escapement:	1.1	25.5	9.2	0.0	**35.9**
	Estimated Escapement:	67	1,564	566	0	2,196
	Standard Error:	46.2	194.4	129.1	0.0	
Total:	Number in Sample:	6	131	47	0	184
	Estimated % of Escapement:	3.3	71.2	25.5	0.0	**100.0**
	Estimated Escapement:	200	4,359	1,564	0	6,123
	Standard Error:	79.2	201.9	194.4	0.0	
Stratum 8:	07/26 – 08/01					
Sampling Dates:	07/26, 07/28 – 07/30					
Male:	Number in Sample:	5	108	69	1	183
	Estimated % of Escapement:	2.0	43.9	28.0	0.4	**74.4**
	Estimated Escapement:	82	1,768	1,130	16	2,996
	Standard Error:	35.2	123.7	112.0	15.9	
Female:	Number in Sample:	1	40	22	0	63
	Estimated % of Escapement:	0.4	16.3	8.9	0.0	**25.6**
	Estimated Escapement:	16	655	360	0	1,032
	Standard Error:	15.9	92.0	71.2	0.0	
Total:	Number in Sample:	6	148	91	1	246
	Estimated % of Escapement:	2.4	60.2	37.0	0.4	**100.0**
	Estimated Escapement:	98	2,423	1,490	16	4,028
	Standard Error:	38.5	122.1	120.4	15.9	

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		Brood Year and Age Group				
		2012	2011	2010	2009	
		0.2	0.3	0.4	0.5	Total
Stratum 9:	08/02 – 08/08					
Sampling Dates:	08/02 – 08/04					
Male:	Number in Sample:	11	63	50	3	127
	Estimated % of Escapement:	6.0	34.6	27.5	1.6	**69.8**
	Estimated Escapement:	144	827	656	39	1,667
	Standard Error:	40.7	81.2	76.2	21.7	
Female:	Number in Sample:	3	38	14	0	55
	Estimated % of Escapement:	1.6	20.9	7.7	0.0	**30.2**
	Estimated Escapement:	39	499	184	0	722
	Standard Error:	21.7	69.4	45.5	0.0	
Total:	Number in Sample:	14	101	64	3	182
	Estimated % of Escapement:	7.7	55.5	35.2	1.6	**100.0**
	Estimated Escapement:	184	1,326	840	39	2,389
	Standard Error:	45.5	84.8	81.5	21.7	
Strata 10 – 14:	08/09 – 09/12					
Sampling Dates:	08/09 – 08/12, 08/16 – 08/18, 08/23 – 08/27, 08/30 – 08/31, 09/06					
Male:	Number in Sample:	3	70	42	1	116
	Estimated % of Escapement:	1.7	38.7	23.2	0.6	**64.1**
	Estimated Escapement:	17	399	239	6	661
	Standard Error:	8.9	34.0	29.5	5.2	
Female:	Number in Sample:	3	35	26	1	65
	Estimated % of Escapement:	1.7	19.3	14.4	0.6	**35.9**
	Estimated Escapement:	17	199	148	6	370
	Standard Error:	8.9	27.6	24.5	5.2	
Total:	Number in Sample:	6	105	68	2	181
	Estimated % of Escapement:	3.3	58.0	37.6	1.1	**100.0**
	Estimated Escapement:	34	598	387	11	1,031
	Standard Error:	12.5	34.4	33.8	7.3	
Strata 1 – 14:	06/07 – 09/12					
Male:	Number in Sample:	23	391	299	16	729
	Estimated % of Escapement:	2.1	35.9	27.5	1.5	**67.0**
	Estimated Escapement:	488	8,291	6,340	339	15,458
	Standard Error:	98.3	327.7	304.9	82.2	
Female:	Number in Sample:	10	205	139	5	359
	Estimated % of Escapement:	0.9	18.8	12.8	0.5	**33.0**
	Estimated Escapement:	212	4,347	2,947	106	7,613
	Standard Error:	65.2	267.1	228.0	46.2	
Total:	Number in Sample:	33	596	438	21	1,088
	Estimated % of Escapement:	3.0	54.8	40.3	1.9	**100.0**
	Estimated Escapement:	700	12,638	9,288	445	23,071
	Standard Error:	117.1	340.0	335.0	94.0	

Appendix 4.—Mean length (mm) from the mid-eye to fork in the caudal fin and age composition of the Chum Salmon estimated escapement through the Kwethluk River weir, Alaska, 2015.

		Brood Year and Age Group			
		2012	2011	2010	2009
		0.2	0.3	0.4	0.5
Strata 1 – 5:	06/07 – 07/11				
Sampling Dates:	06/22 – 07/02, 07/05 – 07/11				
Male:	Mean Length		577	592	598
	Std. Error		4	4	9
	Range		540 – 615	535 – 675	535 – 645
	Sample Size		30	75	11
Female:	Mean Length	495	547	563	566
	Std. Error		7	4	13
	Range		495 – 605	515 – 610	530 – 595
	Sample Size	1	18	42	4
Stratum 6:	07/12 – 07/18				
Sampling Dates:	07/12 – 07/15				
Male:	Mean Length		564	592	
	Std. Error		6	11	
	Range		500 – 695	510 – 850	
	Sample Size		36	33	
Female:	Mean Length		547	559	
	Std. Error		4	7	
	Range		500 – 590	510 – 595	
	Sample Size		27	18	
Stratum 7:	07/19 – 07/25				
Sampling Dates:	07/19 – 07/21				
Male:	Mean Length	506	559	574	
	Std. Error	13	4	6	
	Range	490 – 545	480 – 640	510 – 650	
	Sample Size	4	84	30	
Female:	Mean Length	493	527	549	
	Std. Error	33	4	7	
	Range	460 – 525	450 – 590	510 – 610	
	Sample Size	2	47	17	
Stratum 8:	07/26 – 08/01				
Sampling Dates:	07/26, 07/28 – 07/30				
Male:	Mean Length	505	552	567	575
	Std. Error	12	3	4	
	Range	485 – 550	460 – 665	505 – 635	
	Sample Size	5	108	69	1
Female:	Mean Length	500	531	531	
	Std. Error		6	6	
	Range		400 – 595	480 – 575	
	Sample Size	1	40	22	
Stratum 9:	08/02 – 08/08				
Sampling Dates:	08/02 – 08/04				
Male:	Mean Length	521	558	561	560
	Std. Error	9	4	5	12
	Range	450 – 555	495 – 630	475 – 655	540 – 580
	Sample Size	11	63	50	3
Female:	Mean Length	520	541	547	
	Std. Error	5	5	5	
	Range	510 – 525	480 – 625	510 – 570	
	Sample Size	3	38	14	

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		Brood Year and Age Group			
		2012	2011	2010	2009
		0.2	0.3	0.4	0.5
Strata 10 – 14:	08/09 – 09/12				
Sampling Dates:	08/09 – 08/12, 08/16 – 08/18, 08/23 – 08/27, 08/30 – 08/31, 09/06				
Male:	Mean Length	493	542	559	510
	Std. Error	11	5	5	
	Range	480 – 515	460 – 650	460 – 625	
	Sample Size	3	70	42	1
Female:	Mean Length	495	514	524	510
	Std. Error	8	7	5	
	Range	485 – 510	405 – 590	465 – 565	
	Sample Size	3	35	26	1
Strata 1 – 14:	06/07 – 09/12				
Male:	Mean Length	511	556	575	584
	Std. Error	6	2	2	9
	Range	450 – 555	460 – 695	460 – 850	510 – 645
	Sample Size	23	391	299	16
Female:	Mean Length	503	533	547	555
	Std. Error	7	2	2	15
	Range	460 – 525	400 – 625	465 – 610	510 – 595
	Sample Size	10	205	139	5

Appendix 5.—Age and sex composition of the weekly Chinook Salmon estimated escapement through the Kwethluk River weir, Alaska, 2015. Small female Chinook Salmon age-1.2 were not verified via visual examination of gonads and may be small males. No age-1.5 fish were sampled during 2015.

		Brood Year and Age Group							
		2012	2011		2010		2009		
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	Total
Strata 1 – 4:	06/07 – 07/04								
Sampling Dates:	06/22 − 06/26, 06/28 − 07/02								
Male:	Number in Sample:	1	115	0	50	6	7	0	179
	Estimated % of Escapement:	0.5	55.0	0.0	23.9	2.9	3.3	0.0	**85.6**
	Estimated Escapement:	10	1,138	0	495	59	69	0	1,771
	Standard Error:	9.4	67.6	0.0	58.0	22.7	24.5	0.0	
Female:	Number in Sample:	0	0	0	24	0	6	0	30
	Estimated % of Escapement:	0.0	0.0	0.0	11.5	0.0	2.9	0.0	**14.4**
	Estimated Escapement:	0	0	0	237	0	59	0	297
	Standard Error:	0.0	0.0	0.0	43.3	0.0	22.7	0.0	
Total:	Number in Sample:	1	115	0	74	6	13	0	209
	Estimated % of Escapement:	0.5	55.0	0.0	35.4	2.9	6.2	0.0	**100.0**
	Estimated Escapement:	10	1,138	0	732	59	129	0	2,068
	Standard Error:	9.4	67.6	0.0	65.0	22.7	32.8	0.0	
Stratum 5:	07/05 – 07/11								
Sampling Dates:	07/05 − 07/10								
Male:	Number in Sample:	3	80	1	56	5	4	2	151
	Estimated % of Escapement:	1.6	43.0	0.5	30.1	2.7	2.2	1.1	**81.2**
	Estimated Escapement:	23	611	8	428	38	31	15	1,154
	Standard Error:	12.3	48.2	7.1	44.7	15.8	14.1	10.0	
Female:	Number in Sample:	0	0	0	26	0	9	0	35
	Estimated % of Escapement:	0.0	0.0	0.0	14.0	0.0	4.8	0.0	**18.8**
	Estimated Escapement:	0	0	0	199	0	69	0	267
	Standard Error:	0.0	0.0	0.0	33.8	0.0	20.9	0.0	
Total:	Number in Sample:	3	80	1	82	5	13	2	186
	Estimated % of Escapement:	1.6	43.0	0.5	44.1	2.7	7.0	1.1	**100.0**
	Estimated Escapement:	23	611	8	626	38	99	15	1,421
	Standard Error:	12.3	48.2	7.1	48.4	15.8	24.8	10.0	
Stratum 6:	07/12 – 07/18								
Sampling Dates:	07/12 − 07/15								
Male:	Number in Sample:	3	89	0	37	1	2	0	132
	Estimated % of Escapement:	1.8	54.6	0.0	22.7	0.6	1.2	0.0	**81.0**
	Estimated Escapement:	45	1,344	0	559	15	30	0	1,993
	Standard Error:	25.1	93.0	0.0	78.3	14.6	20.6	0.0	
Female:	Number in Sample:	0	0	0	28	0	3	0	31
	Estimated % of Escapement:	0.0	0.0	0.0	17.2	0.0	1.8	0.0	**19.0**
	Estimated Escapement:	0	0	0	423	0	45	0	468
	Standard Error:	0.0	0.0	0.0	70.5	0.0	25.1	0.0	
Total:	Number in Sample:	3	89	0	65	1	5	0	163
	Estimated % of Escapement:	1.8	54.6	0.0	39.9	0.6	3.1	0.0	**100.0**
	Estimated Escapement:	45	1,344	0	981	15	75	0	2,461
	Standard Error:	25.1	93.0	0.0	91.5	14.6	32.2	0.0	

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		Brood Year and Age Group							
		2012	2011		2010		2009		
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	Total
Strata 7 – 14:	07/19 – 09/12								
Sampling Dates:	07/19 − 07/24, 07/26, 07/28 − 08/12, 08/16 − 08/18, 08/23 − 08/25, 08/30, 09/03								
Male:	Number in Sample:	3	172	1	63	10	0	1	250
	Estimated % of Escapement:	0.9	51.0	0.3	18.7	3.0	0.0	0.3	**74.2**
	Estimated Escapement:	20	1,129	7	414	66	0	7	1,642
	Standard Error:	10.4	55.6	6.0	43.3	18.9	0.0	6.0	
Female:	Number in Sample:	0	0	0	72	0	14	1	87
	Estimated % of Escapement:	0.0	0.0	0.0	21.4	0.0	4.2	0.3	**25.8**
	Estimated Escapement:	0	0	0	473	0	92	7	571
	Standard Error:	0.0	0.0	0.0	45.6	0.0	22.2	6.0	
Total:	Number in Sample:	3	172	1	135	10	14	2	337
	Estimated % of Escapement:	0.9	51.0	0.3	40.1	3.0	4.2	0.6	**100.0**
	Estimated Escapement:	20	1,129	7	887	66	92	13	2,213
	Standard Error:	10.4	55.6	6.0	54.5	18.9	22.2	8.5	
Strata 1 – 14:	06/07 – 09/12								
Male:	Number in Sample:	10	456	2	206	22	13	3	712
	Estimated % of Escapement:	1.1	50.9	0.2	23.0	2.5	1.5	0.3	**79.6**
	Estimated Escapement:	91	4,159	18	1,879	201	119	27	6,494
	Standard Error:	27.1	128.8	12.2	108.4	39.9	30.8	14.9	
Female:	Number in Sample:	0	0	0	150	0	32	1	183
	Estimated % of Escapement:	0.0	0.0	0.0	16.8	0.0	3.6	0.1	**20.4**
	Estimated Escapement:	0	0	0	1,368	0	292	9	1,669
	Standard Error:	0.0	0.0	0.0	96.2	0.0	47.8	8.6	
Total:	Number in Sample:	10	456	2	356	22	45	4	895
	Estimated % of Escapement:	1.1	50.9	0.2	39.8	2.5	5.0	0.4	**100.0**
	Estimated Escapement:	91	4,159	18	3,247	201	410	36	8,163
	Standard Error:	27.1	128.8	12.2	126.1	39.9	56.3	17.2	

Appendix 6.—Mean length (mm) from the mid-eye to fork in the caudal fin and age composition of the Chinook Salmon estimated escapement through the Kwethluk River weir, Alaska, 2015. Sex of small female Chinook salmon were not verified via examination of gonads. No age-1.5 fish were sampled during 2015.

		Brood Year and Age Group						
		2012	2011		2010		2009	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3
Strata 1 – 4:	06/07 – 07/04							
Sampling Dates:	06/22 − 06/26, 06/28 − 07/02							
Male:	Mean Length	500	582		711	594	774	
	Std. Error		5		14	44	28	
	Range		480 – 800		515 – 925	505 – 790	690 – 885	
	Sample Size	1	115		50	6	7	
Female:	Mean Length				828		923	
	Std. Error				10		22	
	Range				700 – 895		855 – 1005	
	Sample Size				24		6	
Stratum 5:	07/05 – 07/11							
Sampling Dates:	07/05 − 07/10							
Male:	Mean Length	419	591	465	731	592	808	733
	Std. Error	43	8		12	47	32	33
	Range	333 – 470	455 – 795		510 – 960	485 – 745	735 – 870	700 – 765
	Sample Size	3	80	1	56	5	4	2
Female:	Mean Length				854		911	
	Std. Error				11		19	
	Range				585 – 990		810 – 985	
	Sample Size				26		9	
Stratum 6:	07/12 – 07/18							
Sampling Dates:	07/12 − 07/15							
Male:	Mean Length	463	578		731	505	825	
	Std. Error	21	7		14		105	
	Range	540 – 505	450 – 755		520 – 900		720 – 930	
	Sample Size	3	89		37	1	2	
Female:	Mean Length				822		917	
	Std. Error				10		10	
	Range				700 – 900		900 – 935	
	Sample Size				28		3	
Strata 7 – 14:	07/19 – 09/12							
Sampling Dates:	07/19 − 07/24, 07/26, 07/28 − 08/12, 08/16 − 08/18, 08/23 − 08/25, 08/30, 09/03							
Male:	Mean Length	463	586	565	722	568		795
	Std. Error	12	4		11	18		
	Range	445 – 485	490 – 775		550 – 900	490 – 675		
	Sample Size	3	172	1	63	10		1
Female:	Mean Length				828		868	885
	Std. Error				6		17	
	Range				725 – 940		775 – 960	
	Sample Size				72		14	1
Strata 1 – 14:	06/07 – 09/12							
Male:	Mean Length	453	584	515	723	578	792	753
	Std. Error	15	3	50	6	17	21	28
	Range	333 – 505	450 – 800	465 – 565	510 – 960	485 – 790	690 – 930	700 – 795
	Sample Size	10	456	2	206	22	13	3
Female:	Mean Length				832		895	885
	Std. Error				4		11	
	Range				700 – 990		775 – 1005	
	Sample Size				150		32	1

Appendix 7.—Age and sex composition of the estimated Sockeye Salmon escapement through the Kwethluk River weir, Alaska, 2015.

		Brood Year and Age Group								
		2012	2011		2010			2009		
		0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3	Total
Strata 1 - 4:	06/07 - 07/04									
Sampling Dates:	06/22 - 07/02									
Male:	Number in Sample:	0	0	28	0	23	20	2	8	81
	Estimated % of Escapement:	0.0	0.0	15.5	0.0	12.7	11.0	1.1	4.4	**44.8**
	Estimated Escapement:	0	0	252	0	207	180	18	72	729
	Standard Error:	0.0	0.0	41.4	0.0	38.1	35.9	12.0	23.5	0
Female	Number in Sample:	0	1	22	0	41	14	4	18	100
	Estimated % of Escapement:	0.0	0.6	12.2	0.0	22.7	7.7	2.2	9.9	**55.2**
	Estimated Escapement:	0	9	198	0	369	126	36	162	900
	Standard Error:	0.0	8.5	37.4	0.0	47.9	30.6	16.8	34.3	0
Total:	Number in Sample:	0	1	50	0	64	34	6	26	181
	Estimated % of Escapement:	0.0	0.6	27.6	0.0	35.4	18.8	3.3	14.4	**100.0**
	Estimated Escapement:	0	9	450	0	576	306	54	234	1,629
	Standard Error:	0.0	8.5	51.2	0.0	54.7	44.7	20.5	40.1	0
Stratum 5:	07/05 - 07/11									
Sampling Dates:	07/05 - 07/11									
Male:	Number in Sample:	1	1	33	1	29	21	0	13	99
	Estimated % of Escapement:	0.5	0.5	16.7	0.5	14.6	10.6	0.0	6.6	**50.0**
	Estimated Escapement:	8	8	272	8	239	173	0	107	816
	Standard Error:	7.7	7.7	40.6	7.7	38.5	33.6	0.0	27.0	
		0	0	0	0	0	0	0		
Female	Number in Sample:	2	1	22	0	37	11	1	25	99
	Estimated % of Escapement:	1.0	0.5	11.1	0.0	18.7	5.6	0.5	12.6	**50.0**
	Estimated Escapement:	16	8	181	0	305	91	8	206	816
	Standard Error:	10.9	7.7	34.3	0.0	42.5	25.0	7.7	36.2	
		0	0	0	0	0	0	0		
Total:	Number in Sample:	3	2	55	1	66	32	1	38	198
	Estimated % of Escapement:	1.5	1.0	27.8	0.5	33.3	16.2	0.5	19.2	**100.0**
	Estimated Escapement:	25	16	453	8	544	264	8	313	1,632
	Standard Error:	13.3	10.9	48.8	7.7	51.4	40.1	7.7	42.9	
Strata 6 - 7:	07/12 - 07/25									
Sampling Dates:	07/12 - 07/15, 07/19 - 07/25									
Male:	Number in Sample:	3	9	76	2	43	10	9	3	155
	Estimated % of Escapement:	1.1	3.3	27.7	0.7	15.7	3.6	3.3	1.1	**56.6**
	Estimated Escapement:	48	143	1,209	32	684	159	143	48	2,466
	Standard Error:	26.6	45.5	114.4	21.7	92.9	47.9	45.5	26.6	
Female	Number in Sample:	1	0	39	0	45	8	14	12	119
	Estimated % of Escapement:	0.4	0.0	14.2	0.0	16.4	2.9	5.1	4.4	**43.4**
	Estimated Escapement:	16	0	621	0	716	127	223	191	1,894
	Standard Error:	15.4	0.0	89.3	0.0	94.6	43.0	56.2	52.3	
Total:	Number in Sample:	4	9	115	2	88	18	23	15	274
	Estimated % of Escapement:	1.5	3.3	42.0	0.7	32.1	6.6	8.4	5.5	**100.0**
	Estimated Escapement:	64	143	1,830	32	1,400	286	366	239	4,360
	Standard Error:	30.6	45.5	126.1	21.7	119.3	63.3	70.8	58.1	

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		Brood Year and Age Group								
		2012	2011		2010			2009		
		0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3	Total
Strata 8 - 14:	07/26 - 09/12									
Sampling Dates:	07/26, 07/28 - 08/12, 08/18, 08/23 -									
Male:	Number in Sample:	6	13	67	2	22	11	1	2	124
	Estimated % of Escapement:	3.5	7.5	38.7	1.2	12.7	6.4	0.6	1.2	**71.7**
	Estimated Escapement:	48	103	533	16	175	88	8	16	987
	Standard Error:	18.0	25.9	47.8	10.5	32.7	24.0	7.4	10.5	
Female	Number in Sample:	0	3	19	3	16	2	2	4	49
	Estimated % of Escapement:	0.0	1.7	11.0	1.7	9.2	1.2	1.2	2.3	**28.3**
	Estimated Escapement:	0	24	151	24	127	16	16	32	390
	Standard Error:	0.0	12.8	30.7	12.8	28.4	10.5	10.5	14.8	
Total:	Number in Sample:	6	16	86	5	38	13	3	6	173
	Estimated % of Escapement:	3.5	9.2	49.7	2.9	22.0	7.5	1.7	3.5	**100.0**
	Estimated Escapement:	48	127	685	40	302	103	24	48	1,377
	Standard Error:	18.0	28.4	49.1	16.4	40.6	25.9	12.8	18.0	
Strata 1 - 14:	06/07 - 09/12									
Male:	Number in Sample:	10	23	204	5	117	62	12	27	460
	Estimated % of Escapement:	1.2	2.8	24.7	0.6	14.1	7.5	1.5	3.3	**55.6**
	Estimated Escapement:	109	250	2,220	54	1,273	675	131	294	5,005
	Standard Error:	32.6	49.1	128.6	23.1	104.0	78.6	35.7	53.0	
Female	Number in Sample:	3	5	102	3	139	35	21	59	367
	Estimated % of Escapement:	0.4	0.6	12.3	0.4	16.8	4.2	2.5	7.1	**44.4**
	Estimated Escapement:	33	54	1,110	33	1,512	381	228	642	3,993
	Standard Error:	17.9	23.1	98.1	17.9	111.6	60.1	46.9	76.8	
Total:	Number in Sample:	13	28	306	8	256	97	33	86	827
	Estimated % of Escapement:	1.6	3.4	37.0	1.0	31.0	11.7	4.0	10.4	**100.0**
	Estimated Escapement:	141	305	3,329	87	2,785	1,055	359	936	8,998
	Standard Error:	37.1	54.0	144.0	29.2	137.9	96.0	58.4	91.1	

Appendix 8.—Mean length (mm) from the mid-eye to fork in the caudal fin and age composition of weekly Sockeye Salmon estimated escapements through the Kwethluk River weir, Alaska, 2015

		Brood Year and Age Group							
		2012	2011		2010			2009	
		0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3
Strata 1 - 4:	06/07 - 07/04								
Sampling Dates:	06/22 - 07/02								
Male:	Mean Length			567		561	557	530	554
	Std. Error			1		5	5	60	11
	Range			505 – 640		505 – 595	520 – 605	470 – 590	525 – 620
	Sample Size			28		23	20	2	8
Female:	Mean Length		575	529		525	523	540	535
	Std. Error			6		5	5	20	4
	Range			470 – 575		435 – 560	480 – 545	505 – 595	510 – 570
	Sample Size		1	22		41	14	4	18
Stratum 5:	07/05 - 07/11								
Sampling Dates:	07/05 - 07/11								
Male:	Mean Length	535	560	559	575	565	565		562
	Std. Error			6		5	6		7
	Range			495 – 630		475 – 615	510 – 610		525 – 610
	Sample Size	1	1	33	1	29	21		13
Female:	Mean Length	528	520	529		532	533	540	531
	Std. Error	3		4		3	4		4
	Range	525 – 530		490 – 570		470 – 570	510 – 555		485 – 570
	Sample Size	2	1	22		37	11	1	25
Strata 6 - 7:	07/12 - 07/25								
Sampling Dates:	07/12 - 07/15, 07/19 - 07/25								
Male:	Mean Length	527	539	558	533	551	556	549	555
	Std. Error	27	9	3	13	4	8	14	15
	Range	495 – 580	500 – 575	480 – 600	520 – 545	485 – 595	490 – 585	460 – 595	525 – 575
	Sample Size	3	9	76	2	43	10	9	3
Female:	Mean Length	545		523		519	521	532	535
	Std. Error			3		4	7	6	7
	Range			480 – 575		410 – 570	490 – 545	495 – 560	500 – 575
	Sample Size	1		39		45	8	14	12

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		Brood Year and Age Group							
		2012	2011		2010			2009	
		0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3
Strata 8 - 14:	07/26 - 09/12								
Sampling Dates:	07/26, 07/28 - 08/12, 08/18, 08/23 - 08/27, 08/31								
Male:	Mean Length	516	527	558	560	565	551	555	548
	Std. Error	10	8	2	0	4	6	9	8
	Range	495 – 540	460 – 585	485 – 600	560 – 560	520 – 605	515 – 585		540 – 555
	Sample Size	6	13	67	2	22	11	1	2
Female:	Mean Length		503	530	520	519	533	525	510
	Std. Error		18	4	17	4	6	8	10
	Range		470 – 530	480 – 570	490 – 550	490 – 560	525 – 540	505 – 545	475 – 540
	Sample Size		3	19	3	16	2	2	4
Strata 1 - 14:	06/07 - 09/12								
Male:	Mean Length	521	534	559	552	559	558	546	558
	Std. Error	8	7	2	9	3	3	13	5
	Range	495 – 580	460 – 585	480 – 640	520 – 575	475 – 615	490 – 610	460 – 595	525 – 620
	Sample Size	10	23	204	5	117	62	12	27
Female:	Mean Length	533	521	527	520	524	526	533	531
	Std. Error	6	17	2	17	2	3	6	3
	Range	525 – 545	470 – 575	470 – 575	490 – 550	410 – 570	480 – 555	495 – 595	475 – 575
	Sample Size	3	5	102	3	139	35	21	59

Appendix 9.—Age and sex composition of the weekly Coho Salmon estimated escapement through the Kwethluk River weir, 2015. Rounding errors affect totals.

		Brood Year and Age Group			
		2012	2011	2010	
		1.1	2.1	3.1	Total
Strata 1 − 10:	06/07 − 08/15				
Sampling Dates:	07/29 − 08/01, 08/03 − 08/10, 08/12				
Male:	Number in Sample:	14	57	1	72
	Estimated % of Escapement:	9.6	39.0	0.7	**49.3**
	Estimated Escapement:	137	556	10	703
	Standard Error:	33.0	54.7	9.2	
Female	Number in Sample:	11	58	5	74
	Estimated % of Escapement:	7.5	39.7	3.4	**50.7**
	Estimated Escapement:	107	566	49	722
	Standard Error:	29.6	54.9	20.4	
Total:	Number in Sample:	25	115	6	146
	Estimated % of Escapement:	17.1	78.8	4.1	**100.0**
	Estimated Escapement:	244	1,122	59	1,425
	Standard Error:	42.2	45.8	22.3	
Stratum 11:	08/16 − 08/22				
Sampling Dates:	08/16 − 08/18				
Male:	Number in Sample:	23	97	5	125
	Estimated % of Escapement:	11.7	49.5	2.6	**63.8**
	Estimated Escapement:	474	2,000	103	2,578
	Standard Error:	90.9	141.2	44.5	
Female	Number in Sample:	10	58	3	71
	Estimated % of Escapement:	5.1	29.6	1.5	**36.2**
	Estimated Escapement:	206	1,196	62	1,464
	Standard Error:	62.1	128.9	34.7	
Total:	Number in Sample:	33	155	8	196
	Estimated % of Escapement:	16.8	79.1	4.1	**100.0**
	Estimated Escapement:	681	3,196	165	4,042
	Standard Error:	105.7	114.8	55.9	
Stratum 12:	08/23 − 08/29				
Sampling Dates:	08/23 − 08/27				
Male:	Number in Sample:	15	56	8	79
	Estimated % of Escapement:	9.3	34.6	4.9	**48.8**
	Estimated Escapement:	217	809	116	1,141
	Standard Error:	51.5	84.6	38.5	
Female	Number in Sample:	9	64	10	83
	Estimated % of Escapement:	5.6	39.5	6.2	**51.2**
	Estimated Escapement:	130	924	144	1,198
	Standard Error:	40.7	86.9	42.8	
Total:	Number in Sample:	24	120	18	162
	Estimated % of Escapement:	14.8	74.1	11.1	**100.0**
	Estimated Escapement:	347	1,733	260	2,339
	Standard Error:	63.2	77.9	55.9	
Stratum 13:	08/30 − 09/05				
Sampling Dates:	08/30 − 09/01, 09/03				
Male:	Number in Sample:	12	82	3	97
	Estimated % of Escapement:	7.1	48.8	1.8	**57.7**
	Estimated Escapement:	828	5,660	207	6,695
	Standard Error:	229.4	445.3	118.0	
Female	Number in Sample:	9	59	3	71
	Estimated % of Escapement:	5.4	35.1	1.8	**42.3**
	Estimated Escapement:	621	4,072	207	4,901
	Standard Error:	200.6	425.2	118.0	
Total:	Number in Sample:	21	141	6	168
	Estimated % of Escapement:	12.5	83.9	3.6	**100.0**
	Estimated Escapement:	1,450	9,732	414	11,596
	Standard Error:	294.6	327.2	165.3	

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		Brood Year and Age Group			
		2012	2011	2010	
		1.1	2.1	3.1	Total
Stratum 14:	09/06 − 09/12				
Sampling Dates:	09/06 − 09/08				
Male:	Number in Sample:	12	81	4	97
	Estimated % of Escapement:	7.8	52.9	2.6	**63.4**
	Estimated Escapement:	389	2,629	130	3,148
	Standard Error:	106.6	197.9	63.3	
Female	Number in Sample:	8	46	2	56
	Estimated % of Escapement:	5.2	30.1	1.3	**36.6**
	Estimated Escapement:	260	1,493	65	1,817
	Standard Error:	88.3	181.8	45.0	
Total:	Number in Sample:	20	127	6	153
	Estimated % of Escapement:	13.1	83.0	3.9	**100.0**
	Estimated Escapement:	649	4,121	195	4,965
	Standard Error:	133.6	148.9	77.0	
Strata 1 − 14:	06/07 − 09/12				
Male:	Number in Sample:	76	373	21	470
	Estimated % of Escapement:	9.2	45.2	2.5	**57.0**
	Estimated Escapement:	2,245	11,017	620	13,882
	Standard Error:	241.3	415.3	131.4	
Female	Number in Sample:	47	285	23	355
	Estimated % of Escapement:	5.7	34.5	2.8	**43.0**
	Estimated Escapement:	1,388	8,418	679	10,485
	Standard Error:	193.4	396.8	137.4	
Total:	Number in Sample:	123	658	44	825
	Estimated % of Escapement:	14.9	79.8	5.3	**100.0**
	Estimated Escapement:	3,633	19,435	1,300	24,367
	Standard Error:	297.2	335.3	187.5	

Appendix 10.—Mean length (mm) from the mid-eye to fork in the caudal fin and age composition of weekly Coho Salmon escapements through the Kwethluk River weir, Alaska, 2015.

		Brood Year and Age Group		
		2012	2011	2010
		1.1	2.1	3.1
Strata 1 − 10:	06/07 − 08/15			
Sampling Dates:	07/29 − 08/01, 08/03 − 08/10, 08/12			
Male:	Mean Length	569	546	555
	Std. Error	1	6	
	Range	495 – 635	445 – 625	
	Sample Size	14	57	1
Female:	Mean Length	561	560	564
	Std. Error	11	5	5
	Range	495 – 605	465 – 675	545 – 575
	Sample Size	11	58	5
Stratum 11:	08/16 − 08/22			
Sampling Dates:	08/16 − 08/18			
Male:	Mean Length	574	566	543
	Std. Error	8	4	27
	Range	475 – 625	455 – 665	475 – 635
	Sample Size	23	97	5
Female:	Mean Length	558	571	543
	Std. Error	11	4	9
	Range	495 – 590	410 – 620	530 – 560
	Sample Size	10	58	3
Stratum 12:	08/23 − 08/29			
Sampling Dates:	08/23 − 08/27			
Male:	Mean Length	551	567	573
	Std. Error	15	6	19
	Range	455 – 635	470 – 645	455 – 630
	Sample Size	15	56	8
Female:	Mean Length	578	574	576
	Std. Error	11	4	12
	Range	510 – 615	505 – 640	505 – 625
	Sample Size	9	64	10
Stratum 13:	08/30 − 09/05			
Sampling Dates:	08/30 − 09/01, 09/03			
Male:	Mean Length	587	586	582
	Std. Error	11	4	20
	Range	495 – 635	500 – 645	555 – 620
	Sample Size	12	82	3
Female:	Mean Length	592	592	603
	Std. Error	4	3	4
	Range	575 – 610	520 – 635	595 – 610
	Sample Size	9	59	3
Stratum 14:	09/06 − 09/12			
Sampling Dates:	09/06 − 09/08			
Male:	Mean Length	580	597	575
	Std. Error	13	4	17
	Range	510 – 655	500 – 650	540 – 620
	Sample Size	12	81	4
Female:	Mean Length	584	588	560
	Std. Error	9	4	50
	Range	540 – 610	500 – 630	510 – 610
	Sample Size	8	46	2
Strata 1 − 14:	06/07 − 09/12			
Male:	Mean Length	571	574	566
	Std. Error	2	2	10
	Range	455 – 655	445 – 665	455 – 635
	Sample Size	76	373	21
Female:	Mean Length	573	577	571
	Std. Error	5	2	7
	Range	495 – 615	410 – 675	505 – 625
	Sample Size	47	285	23

Appendix 11.—Median cumulative passage dates and percent females for Chum, Chinook, Sockeye, Pink, and Coho salmon at the Kwethluk River weir during 1992, 2000–2004, 2006–2015.

	Chum		Chinook		Sockeye		Pink		Coho	
Year	Date	Percent Female	Date	Percent Female	Date	Percent Female	Date	Percent Female	Date	Percent Female
1992	07/18[a]	54	07/09[a]	25	07/05	60	08/13	–	08/26	43
2000	07/16[a]	50	07/13[a]	21	07/01[a]	49	08/04	–	08/21[a]	45
2001	–	–	–	–	–	–	–	–	08/25	51
2002	07/17[a]	47	07/10[a]	22	07/11[a]	60	07/25	–	08/28	45
2003	07/22	44	07/11	19	07/07	55	08/01	–	08/29	51
2004	07/14[a]	43	07/08[a]	17	07/01[a]	48	08/06	–	08/29	43
2006	07/15	41	07/12	40	07/10	43	07/22	–	08/19[a]	37
2007	07/21	45	07/13	26	07/09	49	07/26	–	08/21	38
2008	07/22[a]	42	07/17[a]	39	07/09[a]	65	08/04	–	08/24	57
2009	07/22	48	07/12	51	07/10	65	07/27	–	08/29	51
2010	07/19[a]	41	07/17[a]	44	07/10[a]	49	07/23	–	–	29[b]
2011	07/20[a]	36	07/14[a]	32	07/07[a]	57	07/30	–	–	48
2012	–	34	–	42[b]	–	–	–	–	08/26[a]	52[a]
2013	07/24[a]	34	07/16[a]	38[c]	07/09[a]	36[c]	08/10	–	–	39[b]
2014	07/21	34	07/07	42	07/08	52	08/05	–	08/29[a]	44
2015	07/21	33	07/15	21	07/15	44	07/28	–	09/05[a]	43