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

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P. Aaron Webber, James K. Boersma and Ken C. Harper

Abstract

The Kenai Fish and Wildlife Conservation Office, assisted by the Tuluksak Native Community, monitored the escapement of the five species of Pacific salmon *Oncorhynchus* spp. returning to the Tuluksak River, a tributary to the lower Kuskokwim River. From June 16 to September 10, 2015, a resistance board weir and an 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. Estimated escapements of 6,362 Chum Salmon *O. keta*, 711 Chinook Salmon *O. tshawytscha*, 831 Sockeye Salmon *O. nerka*, 206 Pink Salmon *O. gorbuscha* and 9,749 Coho Salmon *O. kisutch* passed through the Tuluksak River weir during 2015. Peak weekly passage occurred July 19-25 for Chum Salmon, July 12-18 for Chinook Salmon, July 19-25 for Sockeye Salmon, August 9-15 for Pink Salmon, and August 23-29 for Coho Salmon. Age, sex, and length (ASL) data were collected for Chum, Chinook, Sockeye, and Coho salmon. Dominant ages were 0.3 (58%) for Chum, 1.2 (49%) for Chinook, 1.3 (34%) for Sockeye, and 2.1 (81%) for Coho salmon. Overall percentages of female salmon from ASL collections were: Chum 33%, Chinook 25%, Sockeye 46%, and Coho salmon 42%. Mean lengths varied between male and female salmon for each species sampled. The estimated Chinook Salmon escapement of 711 during 2015 was below a 18-year average of 1,007 for the tenth successive year. Special management actions taken for Chinook Salmon during 2015 were similar to 2012−2014 and included closure of the Tuluksak River to Chinook Salmon harvest.

Introduction

The Tuluksak River is located approximately 192 river kilometers (rkm) upstream from the mouth of the Kuskokwim River in western Alaska (Whitmore et al. 2005). It flows through the Yukon Delta National Wildlife Refuge (Refuge) and supports spawning populations of Chum Salmon *Oncorhynchus keta*, Chinook Salmon *O. tshawytscha*, Sockeye Salmon *O. nerka*, Pink Salmon *O. gorbuscha*, and Coho Salmon *O. kisutch*. These salmon have historically contributed to large subsistence and commercial fisheries in the lower Kuskokwim River drainage. In addition to human consumption, salmon provide food for brown bears and other carnivores, raptors, and scavengers. These salmon also sustain resident fish species and salmon fry that rely heavily on the nutrients provided by salmon eggs and carcasses (U.S. Fish and Wildlife Service 1992).

Under guidelines established in the policy for the management of sustainable salmon fisheries, 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

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2006 (Bergstrom and Whitmore 2004; Linderman and Bue 2006). This designation was based upon the inability, despite specific management measures, to maintain expected yields or to have a stable surplus above the stock's escapement needs. Beginning in January 2001, the salmon fishery in the Kuskokwim River drainage was managed under the Kuskokwim River Salmon Rebuilding Management Plan (Ward et al. 2003; Bergstrom and Whitmore 2004). The yield concern designation was discontinued in 2007 after Chum and Chinook salmon escapements returned to levels considered sustainable (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 eliminated the SEG of 1,000−2,100 Chinook Salmon for the Tuluksak River (5 AAC 07.365; Conitz et al. 2012; Elison et al. 2012).

The Alaska Department of Fish and Game (Department), the U.S. Fish and Wildlife Service (Service), and the Kuskokwim River Salmon Management Working Group (Working Group) work together to achieve the goals of both the Kuskokwim River Salmon Management and the Federal Subsistence Fishery Management programs. In addition to the goals set by the Department, Service, and the Working Group, the Alaska National Interest Lands Conservation Act (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 the conservation measures taken by area managers, Chinook Salmon returns to the Tuluksak River have been below the average escapement total for the past 9 years.

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 earliest, whereas stocks from lower river tributaries enter progressively later (Kerkvliet and Hamazaki 2003; Kerkvliet et al. 2003, 2004; Stuby 2006). The temporal stock-specific run timings overlap and the difference between the mid-point of one stock and another of the same species can be greater than two weeks. Concurrent with this phenomenon is the extensive subsistence fishery that more heavily harvests early arriving salmon, and commercial fisheries that have historically focused on early, middle, and late segments of the overall salmon run (Molyneaux et al. 2010).

This mixture of different stock-specific run timings and uneven distribution of harvest produce the possibility of significant differential exploitation rates between stocks. This situation mandates that managers develop and maintain a rigorous monitoring program capable of assessing escapement trends within the Kuskokwim River drainage. To manage for sustained yields and conservation of individual salmon stocks, managers need data on escapement, migratory timing, and sex and age composition.

In previous years, salmon escapements were monitored using aerial surveys as indices of relative abundance in the Tuluksak River. Aerial surveys started in 1965 and occurred sporadically until 2003 (Harper 1997; Ward et al. 2003; Whitmore et al. 2005). These surveys were used infrequently for in-season management of the Kuskokwim River fisheries because the surveys often occurred after the commercial and subsistence harvests.

A resistance board weir has been utilized to monitor salmon escapements on the Tuluksak River from 1991 to 1994 and from 2001 to 2015. After the 1994 season, the Tuluksak Native Community (TNC) opposed the weir. Budget constraints and the lack of TNC support caused redirecting of funding to other projects and it was not operated from 1995 to 2000. With the designation of Chinook and Chum salmon as stocks of concern in January of 2000 and with the availability of funding since 2001,

TNC and the Service cooperated in staffing and operating the weir until 2014. During 2014 State and Federal managers had conservation concerns similar to 2000. The preseason run forecast was less than necessary for an unrestricted harvest of Chinook Salmon to meet anticipated needs of subsistence users. Restrictions implemented by managers to conserve the Kuskokwim River Chinook Salmon population were met with resistance by local communities and subsistence users and the Service operated the weir independent of TNC. The Service and TNC cooperated in staffing and operating the weir again in 2015.

Study Area

The Tuluksak River is one of several lower Kuskokwim River tributaries and flows into the lower Kuskokwim River at rkm 192. It is approximately 66 rkm east-northeast of Bethel, Alaska (Whitmore et al. 2005). The Tuluksak River is approximately 137 rkm in length and its watershed encompasses approximately 2,098 km^2 (Figure 1). It originates in the Kilbuck Mountains and flows to the northwest. The Fog River drains into the lower portion of the Tuluksak River and is the only major tributary. The Tuluksak River is a medium gradient river for the majority of its length and is characterized by dense overhanging vegetation and cut banks. The lower river is characterized by low gradient, silt substrate, and turbid water. The river at the weir site is approximately 49 rkm from its confluence with the Kuskokwim River, is 42 m wide, shallowest in mid-river, and deepest near the banks. The substrate contains primarily sand mixed with fine gravel. Water clarity is moderately clear, but becomes turbid during rainy periods and with boat traffic.

Dredging has taken place in approximately 40 km of the upper Tuluksak River and Bear Creek drainages upstream of the Refuge boundary (Figure 1). Dredge equipment operating in the floodplain of the Tuluksak River has altered the stream channel, and water in some areas flows through dredge tailings, tailing ponds, or both. The mining and dredging activities, which began in 1908 and continued through most of the 20th Century, removed approximately 500,000 ounces of gold (Strachan 2005). Mining companies continue to explore for gold in the drainage and have conducted an extensive drilling program to define the lode bearing ore bodies. They have also expressed an interest in reworking the old dredge tailings.

Project Objectives

Project objectives for 2015 were to:

1. Enumerate the daily 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.
4 Enumerate other species and the number of Chinook, chum, coho, sockeye, and pink salmon

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 Tuluksak River.

Methods

Weir and Video Operations

A resistance board weir (Tobin 1994) affixed with an underwater video system (Gates et al. 2010; Miller et al. 2015) was installed during 2015 in the Tuluksak River at rkm 49 (N 61°02.641', W160°35.049'). This location is approximately 16 rkm downstream from the weir site used by the

Service from 1991 to 1994 (Harper 1995a, 1995b, 1995c, 1997). The lower site provides easier boat access during low water conditions and is downstream of known salmon spawning (Figure 1).

Setup and design of the video system was similar to that used in previous years (Miller et al. 2015). 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 a quality image. The lights provided a consistent source of lighting during day and night hours. The DVR was equipped with motion detection to minimize the amount of blank video footage and review time.

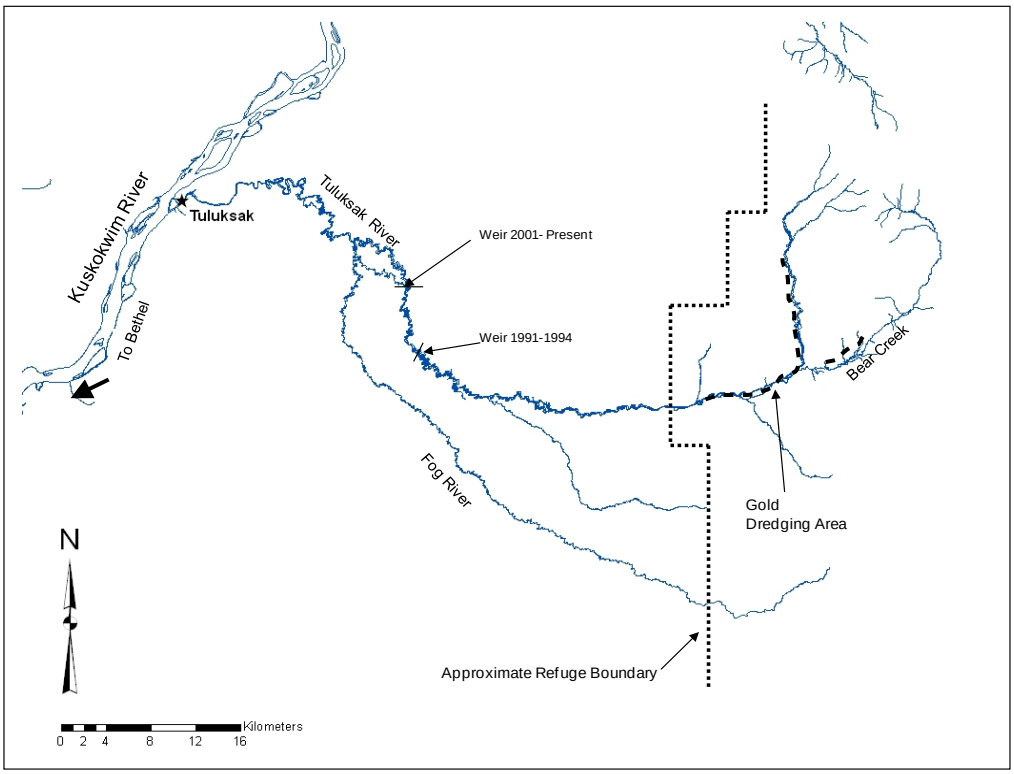

FIGURE 1.—Tuluksak River weir location, Yukon Delta National Wildlife Refuge, 1991–1994, and 2001–2015. The current weir location is 49 rkm upstream from the confluence with the Kuskokwim River. Black squares represent areas where dredge equipment operated in the floodplain of the Tuluksak River.

During 2015, one passage panel and live trap was installed and affixed with an underwater video system. The video system and weir were operated in unison and the video system recorded 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 a one hour block to validate visual counts. If problems with the video equipment occurred, live counts through the passage chute were taken until issues could be resolved. Sex composition was determined from two independent observations using video footage similar to 2011-2014 (Miller and Harper 2014). An object was passed in front of the video camera periodically to confirm the video system's motion detection was operating correctly. 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 June 25 to September 10. Staff-gauge measurements were converted to average depth of the river at the weir site for comparison between and amongst 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 measurements made every 2−3 m spanning the river. Ambient temperature, water temperature, and fish passage counts were relayed daily by cell phone or email to Service staff in Bethel who in turn updated the Department via email daily. Hobo® recording thermometers were installed at the weir to collect water and ambient temperature data for a separate study addressing climate change funded by the Office of Subsistence Management, Fisheries Resource Monitoring Program (OSM-FRMP) project 08-701.

Biological Data

Biological data on fish age, sex, and length (ASL) was collected using a temporally stratified sampling design (Cochran 1977), with statistical weeks defining strata. A sample of fish was drawn weekly for ASL information from the live trap. Adult salmon were captured using the live trap attached to the passage chute. 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 quota 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 of 75 fish for the season. However, if not enough 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 the mid-eye to fork in the caudal fin (MEF), determining gender, collecting scales, examining fish for gill-net marks, and then releasing the fish upstream of the weir. Salmon were measured from mid-eye to fork-of-caudal fin to the nearest millimeter. Gender was determined by observing external sex characteristics including the presence or advanced development of an ovipositor. Male Chinook Salmon were positively identified by the presence of milt.

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) and checked visually to ensure they were not damaged, regenerated, or from the lateral line. One scale was collected from each Chum, three from each Sockeye, and four from each Chinook and Coho salmon. If a scale from the preferred area was missing, damaged, or regenerated, a scale from the same area on the opposite side of the fish was selected. 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 selected 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.

Video footage was also used to determine the gender of passing Chinook Salmon. Females were 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 number of fish viewed from the video followed the same strategy used for that of fish collected from the live trap. Once the weekly ASL sample size was met for a species, sampling would stop for that species. Although biological sampling was stratified into statistical weeks a priori, strata for the analysis of Pacific salmon biological data at the Tuluksak River weir were modified following the field season to represent actual weir passage and ASL sample sizes.

Service staff aged the scales and processed the forms. Counts and ASL data were shared with the Department in Anchorage. 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 is 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 sampling 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 in stratum *m* and a subscript of "+" represents summation over all possible values of the corresponding variable, e.g., n_{i++m} denotes the total number of fish of species *i* sampled in stratum *m*. The variance was estimated as:

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

where N_{i++m} denotes the total number of species *i* fish passing the weir in stratum *m*. The estimated number of fish of 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

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

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 in 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}, 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* (μ_{ijk}) was estimated as a weighted sum of the stratum means, i.e.,

$$\hat{\mu}_{ijk} = \sum_m\left(\frac{\hat{N}_{ijkm}}{\hat{N}_{ijk}}\right)\hat{\mu}_{ijkm}.$$

An approximate estimator of the variance of $\hat{\mu}_{ijk}$ was obtained using the delta method (Seber 1982):

$$\hat{v}\left(\hat{\mu}_{ijk}\right) = \sum_m\left\{\hat{v}\left(\hat{N}_{ijkm}\right)\left[\frac{\hat{\mu}_{ijkm}}{\sum_x\hat{N}_{ijkx}}-\sum_y\frac{\hat{N}_{ijky}\,\hat{\mu}_{ijky}}{\left(\sum_x\hat{N}_{ijkx}\right)^2}\right]^2+\left(\frac{\hat{N}_{ijkm}}{\sum_x\hat{N}_{ijkx}}\right)^2\hat{v}\left(\hat{\mu}_{ijkm}\right)\right\}$$

Estimates were calculated for dates with partial and zero counts due to flooding or holes in the weir. Estimates were based on the average daily proportion of passage from previous years. 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, is the estimated total proportion of the missed escapement. The total escapement is the sum of the observed counts divided by one minus the proportion missed. Averages in the historical escapement were generated using prior years with escapement estimates (Gates and Harper 2002; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009-2014; Miller et al. 2015).

Results

Weir and Video Operations

The crew traveled to the weir site by boat on June 13, 2015. Installation of the weir and video system were completed on June 16, and both were operational through September 10. The water stage depth ranged from 62 to 196 cm during weir operation. The recorded minimum water stage height occurred June 25 through July 8, and the maximum stage height depth occurred on August 28 (Appendix 1). Water temperatures (daily average) ranged from 6.5°C on August 30 to 14°C on July 11. Ambient temperatures (daily average) ranged from 5°C on August 28 to 17°C on July 11 (Appendix 1).

Biological Data

Chum Salmon —A total of 6,362 Chum Salmon were counted through the weir; the first fish arrived June 19, and 6 passed the last day of operation on September 10 (Figure 2; Appendix 2). The peak weekly passage of 2,497 Chum Salmon occurred July 19–25 (Figure 2) and median cumulative passage occurred on July 24 (Figure 3; Appendix 2).

Age, sex and length were collected from 1,514 Chum Salmon scale samples of which 1,406 (93%) were readable (Table 2). Four ages (0.2, 0.3, 0.4, and 0.5) of Chum Salmon were identified from scale samples. The predominant age was 0.3 for both male (55%) and female (62%) Chum Salmon (Appendix 3). Ages 0.3 and 0.4 comprised 97% of the total Chum Salmon escapement. Females

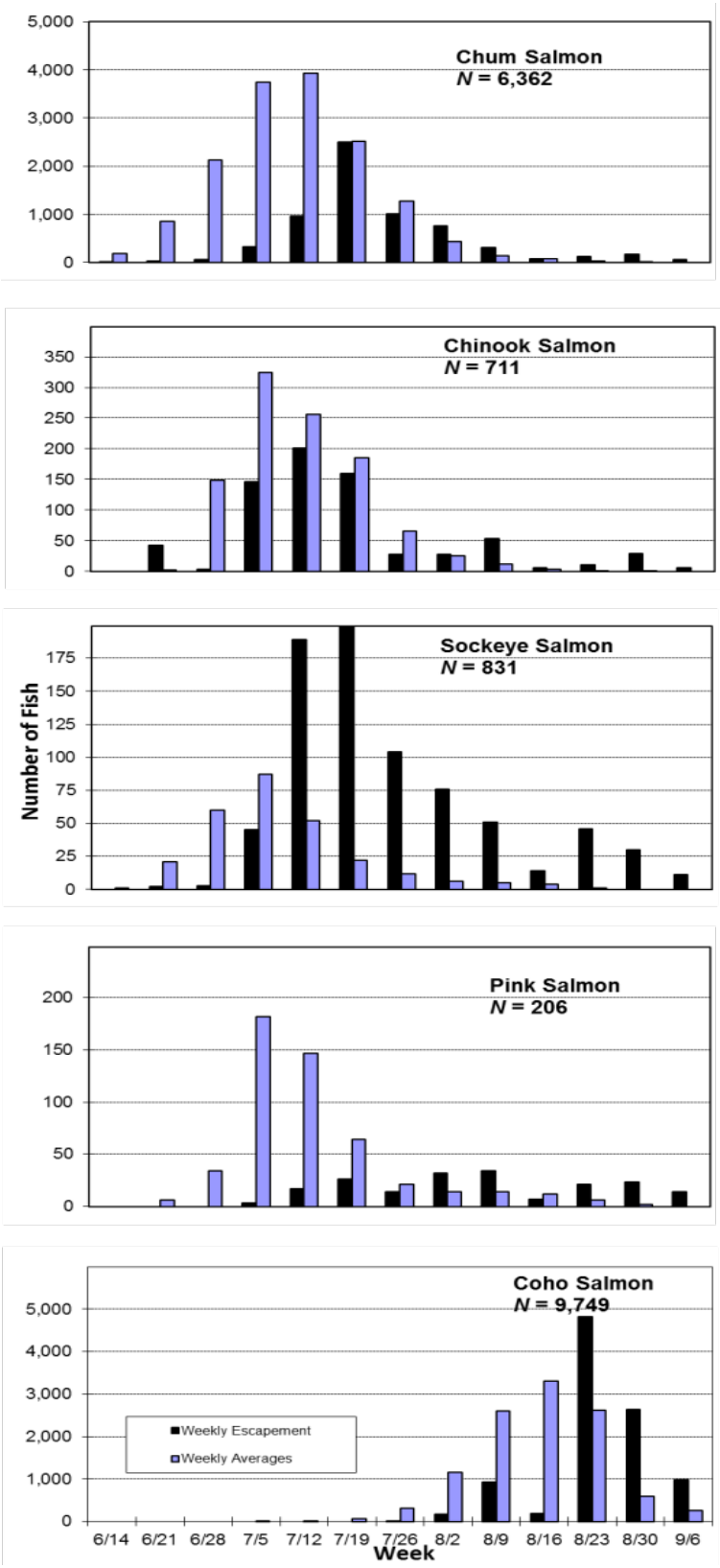

FIGURE 2.—Weekly escapement of Chum, Chinook, Sockeye, Pink and Coho salmon passing through the Tuluksak River weir, 2015. Average weekly totals for Chum, Chinook, Sockeye, and Coho salmon are for years 1991−1994, 2001−2014 and for Pink Salmon odd years 2001−2013. Note different scales on Y-axes.

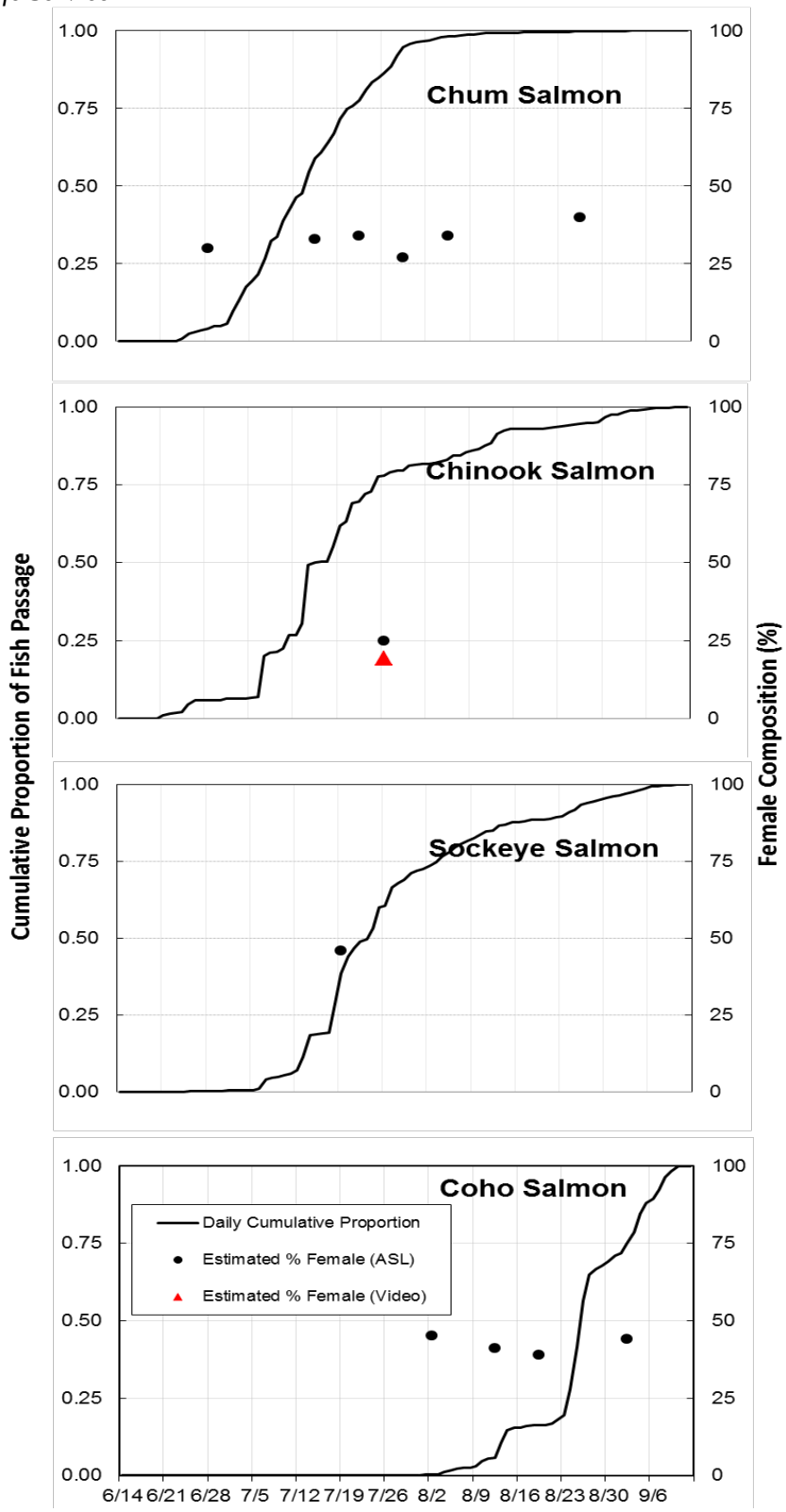

FIGURE 3.— Cumulative proportion, and estimated percent of females from age, sex, and length (ASL) samples for Chum, Chinook, Sockeye and Coho salmon that passed through the Tuluksak River weir, 2015. Estimates of female percent passage are represented by symbol at the midpoint of each categorical stratum. Strata with low ASL sample sizes were combined. Only Chinook Salmon were categorized to sex using video.

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

		Age, Sex and Length Collections		
		Scales		Video
Salmon Species	Escapement Total	Sample Total	Readable Total	Viewed Total
Chum	6,362	1,514	1,406	0
Chinook	711	196	169	482
Sockeye	831	288	267	0
Pink	206	0	0	0
Coho	7,158*	855	746	0

***Total does not include an estimated 2,591 Coho Salmon when the weir was partially or fully submerged**

comprised 33% of the estimated passage (Appendix 11). The mean MEF lengths of males for all ages was larger than for females (range 23-31 mm; Appendix 4).

Chinook Salmon —A total of 711 Chinook Salmon were counted through the weir; the first arrived June 21 and 2 fish passed the last day of operations on September 10 (Appendix 2). The peak weekly passage of 201 Chinook Salmon occurred July 12-18 (Figure 2) and the median cumulative passage occurred on July 16 (Figure 3; Appendix 2).

Age, sex, and length were collected from 196 Chinook Salmon of which 169 (86%) scale samples were readable (Table 2). The scale collection represents 28% of the total Chinook Salmon counted past the weir. Five ages (1.1, 1.2, 1.3, 1.4, 2.2) of Chinook Salmon were identified from scale samples. The predominant age was 1.2 for male (63%) and 1.3 for female (57%) Chinook Salmon (Appendix 5). Ages 1.2 and 1.3 comprised 87% of the total Chinook Salmon escapement. Females comprised 24.9% of the estimated passage (Appendix 5) and 19.2% of the observed video footage (Figure 3).

Sockeye Salmon —A total of 831 Sockeye Salmon were counted through the weir; the first arrived June 24 and 1 passed the last day of operations on September 10 (Table 2; Appendix 2). The peak weekly passage of 260 Sockeye Salmon occurred July 19-25 (Figure 2), and the median cumulative passage occurred on July 24 (Figure 3; Appendix 2).

Age, sex and length were collected from 288 Sockeye Salmon of which 267 (93%) scale samples were readable (Table 2). The scale collection represents 35% of the total Sockeye Salmon counted past the weir. Eight ages (0.2, 0.3, 0.4, 1.2, 1.3, 1.4, 2.2, and 2.3) of Sockeye Salmon were identified from scale samples. The predominant age was 1.2 for males (33%) and 1.3 for females (37%). Ages 1.2 and 1.3 comprised 63% of the total Sockeye Salmon escapement. Females comprised 46% of the estimated passage (Appendix 11). Sockeye Salmon MEF lengths ranged from 400 to 640 mm in the ASL collection and the MEF length of males was larger than females for all ages except age-0.2 (Appendix 8).

Pink Salmon —A total of 206 Pink Salmon were counted through the weir; the first arrived July 7 and the 4 were counted on September 10 (Table 2; Appendix 2). The peak weekly passage of 34 Pink Salmon occurred August 9−15 (Figure 2) and the median cumulative passage occurred on August 9 (Appendix 2). Age, sex, and length data were not collected for Pink Salmon.

Coho Salmon —There were 7,158 Coho Salmon counted through the weir and an estimated 2,591 that passed when the weir was partially or fully submerged for a total of 9,749; the first arrived July 27 and 121 were counted the last day of operation on September 10 (Table 2; Appendix 2). The peak weekly passage of 4,828 (includes estimated totals) Coho Salmon occurred August 23–29 (Figure 2),

and the median cumulative passage occurred on August 27 (Figure 3; Appendix 2). The tail of the escapement was not estimated.

Age, sex and length were collected from 855 Coho Salmon of which 746 (87%) scale samples were readable (Table 2). The scale collection represents 12% of the total Coho Salmon counted past the weir. Three ages (1.1, 2.1 and 3.1) of Coho Salmon were identified from scale samples. The predominant age was 2.1 for both male (83%) and female (78%) Coho Salmon (Appendix 9). Age-2.1 comprised 81% of the total Coho Salmon escapement. Females comprised 42% of the estimated passage (Appendix 11).

Other —Resident and other migrant species counted through the weir in 2015 consisted of 325 Dolly Varden *Salvelinus malma*, 17 Northern Pike *Esox lucius*, 38 Arctic Grayling *Thymallus arcticus*, 12 Humpback Whitefish *Coregonus pidschian*, 10 Broad Whitefish *C. nasus*, and 6 Round Whitefish *Prosopium cylindraceum*. Small fish (≤40 cm) were likely able to pass through the pickets, and only fish observed through the passage chute were recorded.

Discussion

Weir and Video Operations

The weir and video operations began June 16 and the first salmon was documented passing the weir on June 19. The average cumulative proportion of fish passage prior to June 30 for Chinook Salmon is less than 2% and for all other species less than 1% (Miller et al. 2015). Thus, it is likely the weir was operational before the first salmon arrived. High water later during the season limited sample collections because of safety concerns, and the weir was submerged or partially submerged 11 days from August 28 to September 8 (Appendix 1). Because most of the other salmon species had already passed the weir, we only estimated passage of Coho Salmon for that period. Routine maintenance became problematic late in the season due to high water with debris removal, continual picket repair, and broken bolts on resistance boards.

The underwater video system proved effective in the enumeration of Chum, Chinook, Sockeye, and Coho salmon during most flow conditions. Data collected from video footage were useful for counts, speciation, sex composition, and for comparing sex composition across strata with the Chinook Salmon ASL samples (e.g., Figure 3; Appendix 11). The video system was useful for identification and counts of other species passing the weir. Between 2001 and 2009, three species of coregonids were collectively enumerated and classified as 'whitefish' with counts ranging from 3 to 94 fish (Miller and Harper 2014). The addition of video since 2010 has allowed us to enumerate and identify the three whitefish species (Miller and Harper 2014).

To conserve Kuskokwim River Chinook Salmon stocks, fishery restrictions were implemented by managers during 2015 (Table 3). During the winter of 2013 the Alaska Board of Fisheries established a drainage-wide Chinook Salmon SEG of 65,000−163,000 fish based on ADF&G escapement goal recommendations (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, a decision was made by managers 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 (Table 3). Once Chum and Sockeye salmon abundance exceeded Chinook Salmon abundance, restrictions on subsistence opportunities for Chinook Salmon were relaxed. Community harvest permits were allocated to 32 villages for up to 7,000 Chinook Salmon. These

Table 3.—Special actions and emergency orders 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.

harvest restrictions may be the reason for the increased number of Chinook Salmon passing the Tuluksak River weir in 2015.

Biological Data

Chum Salmon —The 2015 Chum Salmon count of 6,362 was the lowest in the 19 years of operation (Figure 4) and below the 18-year average of 14,154. The 2015 Chum Salmon escapement was 18% of the 2005 record high escapement of 35,696. The median passage date for Chum Salmon occurred on July 24, which was similar to 2009, 2011, and 2012, but later than average (Figure 5). The cumulative Chum Salmon passage of 99% occurred on September 9, which is considerably later than the August 17 mean since 2001 (Appendix 2; Miller et al. 2015).

Females comprised an estimated 33% of the total Chum Salmon escapement, which is within the historical range of 24-51% (Appendix 11). The weekly composition of female Chum Salmon gradually increased from 28% at the beginning of the run to 40% as the season progressed (Figure 3; Appendix 3).

The dominant age during 2015 for Chum Salmon was 0.3 (97%; Appendix 3), which was an increase from 68% during 2014. The number of readable scales (n = 1,406) was 93% of the total sample (n = 1,514; Table 2) and greater than the average percentage (85%) of readable scales.

Chinook Salmon—The Chinook Salmon count of 711 during 2015 is the highest since 2006, but still below the 18-year average of 1,007 (Figure 4). Median passage dates for Chinook Salmon have fluctuated from July 5 to July 22 during previous years (Figure 5). The median passage date in 2015 was July 16, similar to 2012 (Figure 5, Appendix 11). Greater than 99% of the average cumulative passage for Chinook Salmon from 1991 to 1994 and 2001 to 2014 occurred by August 12, but occurred on September 5 in 2015. The anomaly was caused by 20% of the Chinook Salmon passing

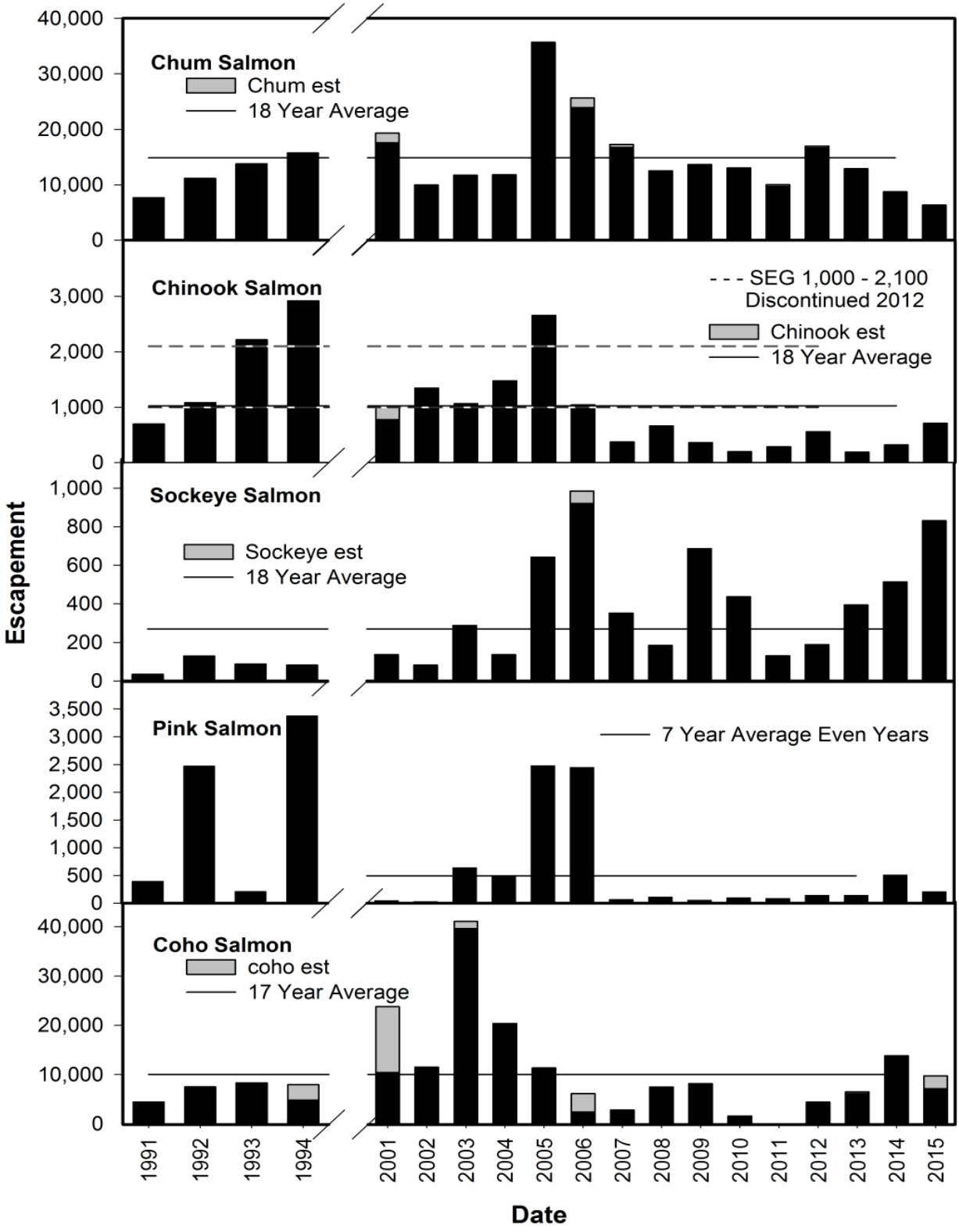

FIGURE 4.—Salmon escapement estimates through the Tuluksak River weir, 1991–1994 and 2001–2015. Averages include estimates for days missed. Pink Salmon averages are for years after 2000 when wider picket spacing was used on weir panels. Total escapements for Coho Salmon were not estimated during 2010 and 2011 (Miller and Harper 2012) due to incomplete counts. Note: Y-axis ranges are different for all species. No estimate was made for Coho Salmon escapement in 2011.

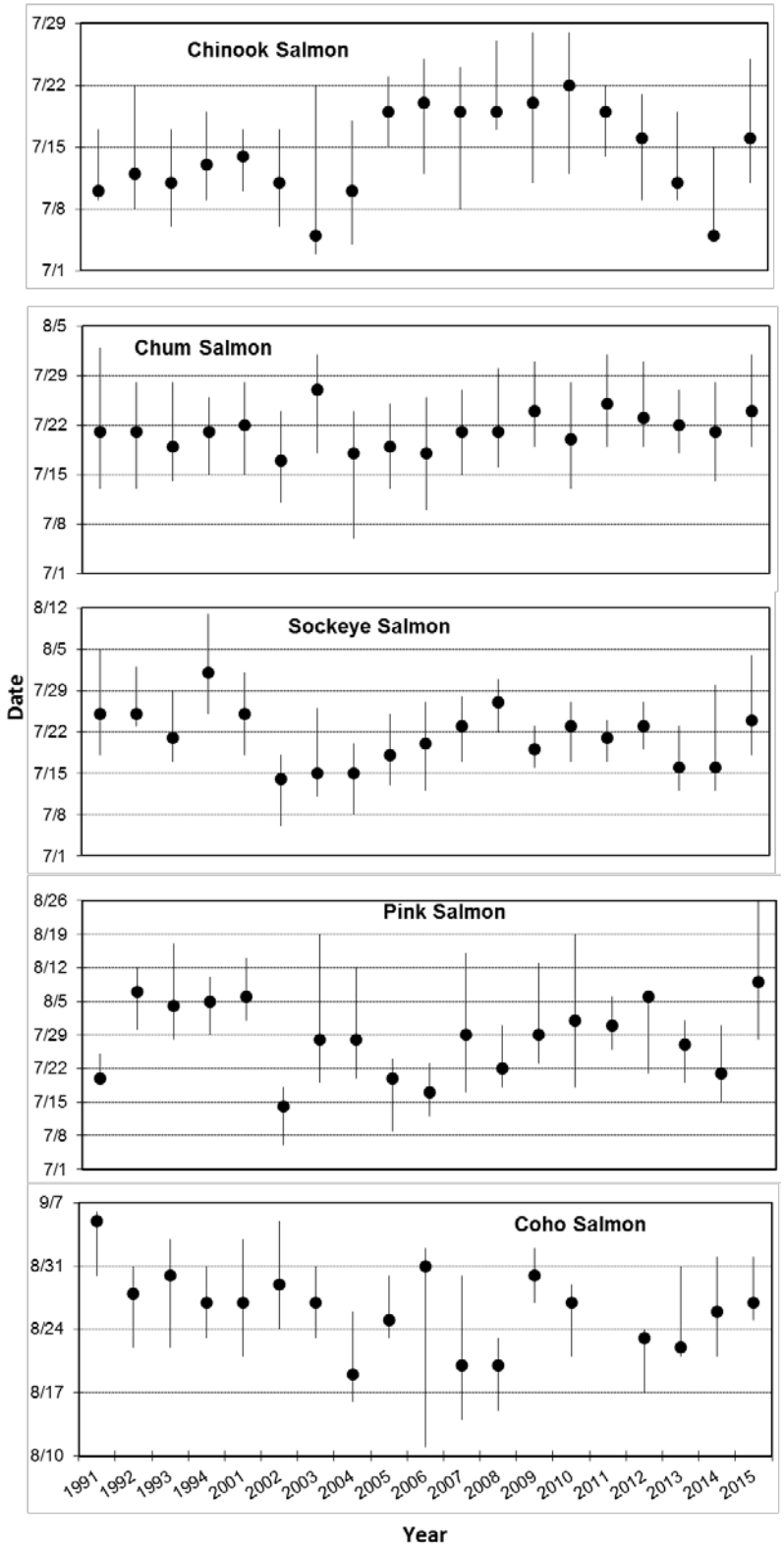

FIGURE 5.—Median cumulative passage for Chinook, Chum, Sockeye, Pink, and Coho salmon at the Tuluksak River weir, 1991–1994 and 2001–2015. A median date was not estimated for Coho Salmon during 2011. The filled circles represent the median (50%) passage date and the vertical line below and above the circle represent the first and third quartiles, respectively. Note date differences on Y-axis.

after August 1, and 18 passing in September. Reasons for shifts in run timing are not well understood, but possible factors include changes in climate and oceanographic conditions, a shift in run timing due to harvest on early arriving fish or low river flows and high temperatures at the time of the runs.

During 2015, female Chinook Salmon comprised 24.9% of the estimated passage and 19.2% of the video footage (Figure 3) and was within the 14−48% historical range of ASL samples (Appendix 11). Age, sex and length data were collected between July 7 and July 31 and sex was determined from video footage sampled between June 30 and August 12. During 2015, quality of escapement was considered poor as only 10% of the spawning females were age-1.4. Age-1.5 fish were absent from our samples. This is half of what was present during the 1990s when 24% of the escapement was age-1.4 or older. The lack of large females and their larger egg capacity will impact future returns from the 2015 brood year. The absence of the older ages also reduces the population's fitness (Walters and Martel 2004; Allendorf et al. 2008). There was also a substantial shift in age composition between 2014 and 2015. Age-1.1 males comprised 23% of the return in 2014 and only 2% in 2015. The strong age 1.1 cohort showed up in 2015 with males age-1.2 comprising 47% of the escapement. This cohort may show up again duing 2016 with increased numbers of age-1.3 fish both males and females.

Two small Chinook Salmon age-1.2 were classified as females using external characteristics, which represented 1.2% of the escapement in 2015. Normally these fish would raise a red flag and be considered misidentified. However, this age was present in samples from both the commercial fishery with a long-term average (1964-2010) of 0.9% (Molyneaux et al. 2010) and samples from the Kuskokwim River subsistence fishery, which ranged from 0.4-0.9% of the harvest 2008-2011 (Liller et al. 2013). Monitoring this composition of this age group will be important as a steady increase in females maturing at this age may be evidence of harvest pressure on larger fish causing a shift towards smaller and younger fish (Ricker 1980). Additional work needs to be conducted at the Tuluksak River weir to verify sex of fish less than 650 mm in both ages 1.2 and 1.3. This may include use of additional morphometric characteristics (Merz and Merz 2004; Clary 2006, 2007; Miller and Harper 2014) or the use of genetic markers or ultra shound (Novelo and Tiersch 2012):

Sockeye Salmon —The Sockeye Salmon count of 831 during 2015 was the second highest in 19 years of operation (Figure 4). Estimated escapements for Sockeye Salmon range from 34 fish in 1991 to 985 fish in 2006. The Kwethluk River also located in the lower Kuskokwim drainage experienced the largest return in the past 15 years (Webber et al. 2016 in review). Median passage dates for Sockeye Salmon fluctuate between July 14 and August 1 since 1991, a difference of 19 days (Figure 5; Appendix 11). The median passage date during 2015 was July 24 which falls within 1 day of the median passage date for 6 of the 19 years of record (Appendix 11). The average cumulative passage date of 99% for Sockeye Salmon since 2001 is September 2 (Miller and Harper 2014); this year it was September 6 (Appendix 2).

During 2015, female Sockeye Salmon comprised 46% of the escapement. The ASL samples represented 32% of the total Sockeye Salmon escapement and is considered adequate to accurately characterize the age, sex, and length-at-age for the Sockeye Salmon escapement.

Pink Salmon —The count of 206 Pink Salmon observed passing through the weir during 2015 was below the odd-year average (2001−2013) of 529 fish (Figure 4). The median cumulative passage date of August 9 was the latest recorded in 19 years of operation (Figure 5; Appendix 11). Age, sex, and length data were not collected for Pink Salmon.

Coho Salmon —The Coho Salmon actual count of 7,158 and the estimated total escapement of 9,749 in 2015 were both below the 17-year average of 10,839 (Figure 4). The estimate of 2,591 for 3 of the

11 days when the weir was submerged or partially submerged had fewer fish than the actual count, so we used the actual count for those days (September 3,4,5; Appendix 2). The total escapement with estimates is the second highest in the last 10 years (Figure 4).

The median passage date for Coho Salmon occurred in the last week of August, similar to the majority of other years (Figure 5; Appendix 11). Female Coho Salmon comprised 42% of the ASL collection which is within the historical range of 31% (2009) to 58% (2002; Appendix 11). The historical Coho Salmon escapement has varied in number, timing, and percent females since the project began in 1991 (Figure 4; Appendix 11; Miller et al. 2015).

Recommendations

The Tuluksak weir and other escapement projects throughout the Kuskokwim River drainage provide important information for Service and Department fishery managers. Continued monitoring of the Tuluksak River will build on an existing long-term data set for this small Chinook Salmon stock that can serve as an indicator for other small stocks in the basin which may be vulnerable to overharvest in mixed-stock fisheries. If only strong productive stocks are monitored the risk of overharvesting weak stocks increases and may be unacceptable. One of the principles of the Alaska Sustainable Salmon Fisheries Policy (5 AAC 39.222) is that "*salmon escapement should be managed in a manner to maintain genetic and phenotypic characteristics of the stock by assuring appropriate geographic and temporal distribution of spawners as well as consideration of range, sex ratio, and other population attributes.*" This principle is consistent with tenets of the Service's policy on Biological Integrity, Diversity, and Environmental Health (601 FW 3) which directs the Service to maintain biological integrity on national wildlife refuges, defined as "*Biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions…*" Managing Kuskokwim River fisheries to maintain all spawning components would address the needs of both policies and both agencies, and promotes conservation of the overall Kuskokwim River Chinook Salmon stock complex. Maintaining life history diversity and biocomplexity is not only important for the long-term sustainability of the overall stock, but also for the overall sustainability of the fisheries that exploit them (Hilborn et al. 2003). Therefore, we recommend operating the Tuluksak River weir during 2016 and into the foreseeable future and using the dataset to inform development of an escapement goal for Chinook Salmon. We also recommend modifying regulations to close the Tuluksak River drainage including its confluence with the Kuskokwim River and downstream approximately 1 mile to the harvest of Chinook Salmon to protect this stock from overharvest.

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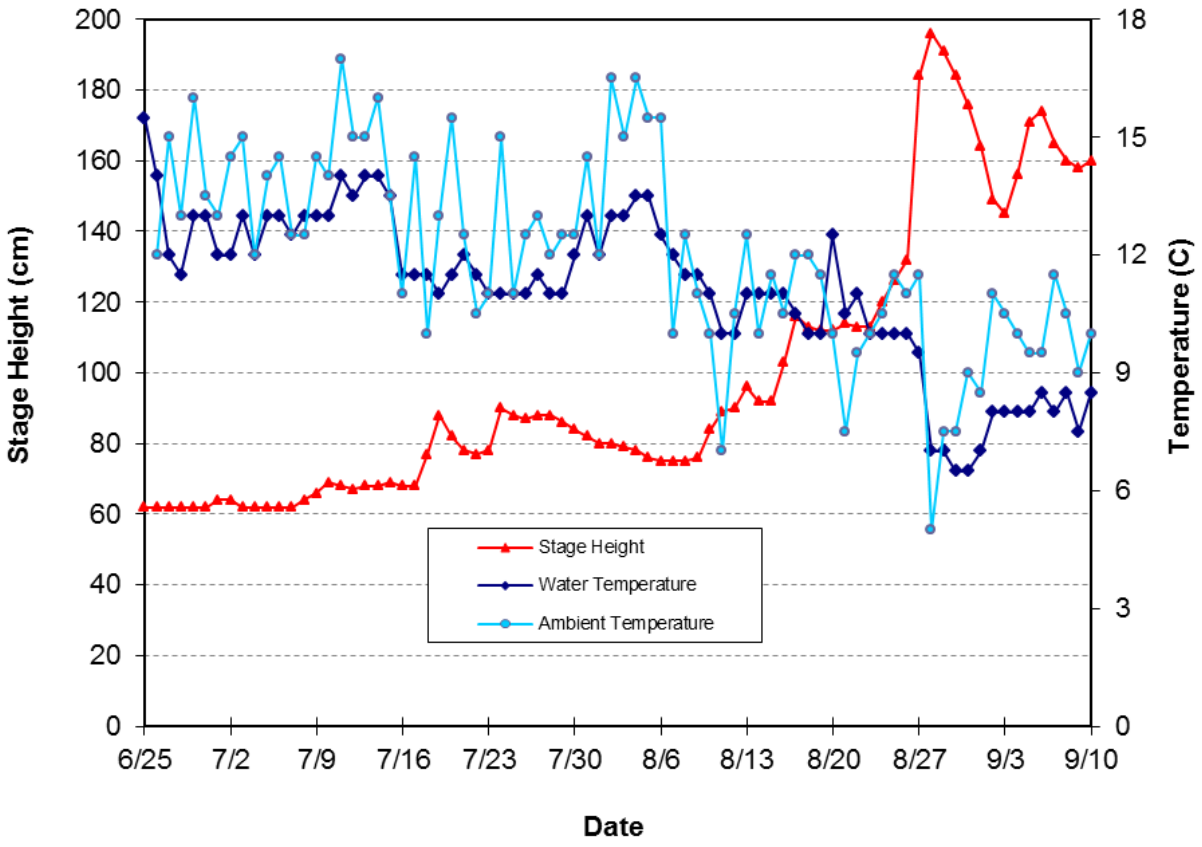
APPENDIX 1.—Water stage height and average daily ambient and water temperatures at the Tuluksak River weir, 2015.



APPENDIX 2.—Daily, cumulative, and cumulative proportion of Chum, Chinook, Sockeye, Pink, and Coho salmon passing through the Tuluksak River weir, Alaska, June 19-September 10, 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
6/19	3	3	0.000	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
6/20	1	4	0.001	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
6/21	1	5	0.001	8	8	0.011	0	0	0.000	0	0	0.000	0	0	0.000
6/22	0	5	0.001	4	12	0.017	0	0	0.000	0	0	0.000	0	0	0.000
6/23	0	5	0.001	1	13	0.018	0	0	0.000	0	0	0.000	0	0	0.000
6/24	4	9	0.001	2	15	0.021	1	1	0.001	0	0	0.000	0	0	0.000
6/25	6	15	0.002	18	33	0.046	1	2	0.002	0	0	0.000	0	0	0.000
6/26	8	23	0.004	8	41	0.058	0	2	0.002	0	0	0.000	0	0	0.000
6/27	2	25	0.004	1	42	0.059	0	2	0.002	0	0	0.000	0	0	0.000
6/28	0	25	0.004	0	42	0.059	0	2	0.002	0	0	0.000	0	0	0.000
6/29	2	27	0.004	0	42	0.059	1	3	0.004	0	0	0.000	0	0	0.000
6/30	8	35	0.006	0	42	0.059	0	3	0.004	0	0	0.000	0	0	0.000
7/1	16	51	0.008	3	45	0.063	1	4	0.005	0	0	0.000	0	0	0.000
7/2	16	67	0.011	0	45	0.063	1	5	0.006	0	0	0.000	0	0	0.000
7/3	7	74	0.012	0	45	0.063	0	5	0.006	0	0	0.000	0	0	0.000
7/4	14	88	0.014	0	45	0.063	0	5	0.006	0	0	0.000	0	0	0.000
7/5	10	98	0.015	2	47	0.066	0	5	0.006	0	0	0.000	0	0	0.000
7/6	41	139	0.022	2	49	0.069	4	9	0.011	0	0	0.000	0	0	0.000
7/7	90	229	0.036	94	143	0.201	26	35	0.042	1	1	0.005	0	0	0.000
7/8	12	241	0.038	7	150	0.211	3	38	0.046	1	2	0.010	0	0	0.000
7/9	38	279	0.044	3	153	0.215	3	41	0.049	0	2	0.010	0	0	0.000
7/10	59	338	0.053	7	160	0.225	4	45	0.054	0	2	0.010	0	0	0.000
7/11	79	417	0.066	31	191	0.269	5	50	0.060	1	3	0.015	0	0	0.000
7/12	92	509	0.080	0	191	0.269	10	60	0.072	0	3	0.015	0	0	0.000
7/13	118	627	0.099	26	217	0.305	35	95	0.114	2	5	0.024	0	0	0.000
7/14	170	797	0.125	134	351	0.494	60	155	0.187	5	10	0.049	0	0	0.000
7/15	41	838	0.132	4	355	0.499	1	156	0.188	1	11	0.053	0	0	0.000
7/16	107	945	0.149	2	357	0.502	2	158	0.190	1	12	0.058	0	0	0.000
7/17	121	1,066	0.168	1	358	0.504	2	160	0.193	0	12	0.058	0	0	0.000
7/18	313	1,379	0.217	34	392	0.551	79	239	0.288	8	20	0.097	0	0	0.000
7/19	583	1,962	0.308	47	439	0.617	82	321	0.386	3	23	0.112	0	0	0.000
7/20	324	2,286	0.359	10	449	0.632	45	366	0.440	4	27	0.131	0	0	0.000
7/21	463	2,749	0.432	42	491	0.691	23	389	0.468	8	35	0.170	0	0	0.000
7/22	91	2,840	0.446	3	494	0.695	17	406	0.489	1	36	0.175	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
7/23	239	3,079	0.484	18	512	0.720	8	414	0.498	4	40	0.194	0	0	0.000
7/24	353	3,432	0.539	5	517	0.727	29	443	0.533	0	40	0.194	0	0	0.000
7/25	444	3,876	0.609	35	552	0.776	56	499	0.600	6	46	0.223	0	0	0.000
7/26	138	4,014	0.631	1	553	0.778	5	504	0.606	2	48	0.233	0	0	0.000
7/27	223	4,237	0.666	8	561	0.789	49	553	0.665	2	50	0.243	3	3	0.000
7/28	155	4,392	0.690	4	565	0.795	11	564	0.679	2	52	0.252	1	4	0.000
7/29	110	4,502	0.708	1	566	0.796	10	574	0.691	1	53	0.257	0	4	0.000
7/30	140	4,642	0.730	11	577	0.812	17	591	0.711	6	59	0.286	7	11	0.001
7/31	124	4,766	0.749	1	578	0.813	8	599	0.721	2	61	0.296	2	13	0.001
8/1	122	4,888	0.768	2	580	0.816	4	603	0.726	3	64	0.311	3	16	0.002
8/2	110	4,998	0.786	1	581	0.817	9	612	0.736	2	66	0.320	1	17	0.002
8/3	141	5,139	0.808	1	582	0.819	10	622	0.748	1	67	0.325	13	30	0.003
8/4	150	5,289	0.831	4	586	0.824	15	637	0.767	3	70	0.340	48	78	0.008
8/5	110	5,399	0.849	4	590	0.830	11	648	0.780	2	72	0.350	36	114	0.012
8/6	75	5,474	0.860	9	599	0.842	14	662	0.797	5	77	0.374	37	151	0.016
8/7	64	5,538	0.870	1	600	0.844	8	670	0.806	7	84	0.408	19	170	0.017
8/8	101	5,639	0.886	7	607	0.854	9	679	0.817	12	96	0.466	14	184	0.019
8/9	46	5,685	0.894	4	611	0.859	7	686	0.826	8	104	0.505	35	219	0.023
8/10	51	5,736	0.902	4	615	0.865	9	695	0.836	3	107	0.519	110	329	0.034
8/11	48	5,784	0.909	7	622	0.875	10	705	0.848	6	113	0.549	62	391	0.040
8/12	21	5,805	0.912	6	628	0.883	3	708	0.852	0	113	0.549	18	409	0.042
8/13	52	5,857	0.921	22	650	0.914	13	721	0.868	5	118	0.573	351	760	0.078
8/14	50	5,907	0.928	7	657	0.924	3	724	0.871	7	125	0.607	285	1,045	0.107
8/15	35	5,942	0.934	3	660	0.928	6	730	0.878	5	130	0.631	64	1,109	0.114
8/16	4	5,946	0.935	0	660	0.928	0	730	0.878	3	133	0.646	0	1,109	0.114
8/17	23	5,969	0.938	0	660	0.928	1	731	0.880	1	134	0.650	43	1,152	0.118
8/18	14	5,983	0.940	0	660	0.928	5	736	0.886	0	134	0.650	11	1,163	0.119
8/19	3	5,986	0.941	0	660	0.928	0	736	0.886	0	134	0.650	5	1,168	0.120
8/20	13	5,999	0.943	0	660	0.928	1	737	0.887	2	136	0.660	4	1,172	0.120
8/21	7	6,006	0.944	2	662	0.931	2	739	0.889	1	137	0.665	28	1,200	0.123
8/22	15	6,021	0.946	3	665	0.935	5	744	0.895	0	137	0.665	95	1,295	0.133
8/23	11	6,032	0.948	1	666	0.937	2	746	0.898	0	137	0.665	99	1,394	0.143
8/24	17	6,049	0.951	3	669	0.941	10	756	0.910	1	138	0.670	597	1,991	0.204
8/25	27	6,076	0.955	2	671	0.944	8	764	0.919	8	146	0.709	989	2,980	0.306

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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
8/26	23	6,099	0.959	1	672	0.945	14	778	0.936	1	147	0.714	1,065	4,045	0.415
8/27	10	6,109	0.960	1	673	0.947	4	782	0.941	5	152	0.738	881	4,926	0.505
8/28	20	6,129	0.963	1	674	0.948	4	786	0.946	4	156	0.757	669	5,595	0.574
8/29	15	6,144	0.966	2	676	0.951	4	790	0.951	2	158	0.767	527	6,123	0.628
8/30	14	6,158	0.968	11	687	0.966	6	796	0.958	2	160	0.777	632	6,755	0.693
8/31	23	6,181	0.972	6	693	0.975	3	799	0.961	2	162	0.786	437	7,191	0.738
9/1	25	6,206	0.975	0	693	0.975	3	802	0.965	0	162	0.786	321	7,513	0.771
9/2	37	6,243	0.981	5	698	0.982	4	806	0.970	8	170	0.825	332	7,845	0.805
9/3	20	6,263	0.984	4	702	0.987	4	810	0.975	3	173	0.840	252	8,097	0.831
9/4	22	6,285	0.988	1	703	0.989	5	815	0.981	7	180	0.874	422	8,519	0.874
9/5	24	6,309	0.992	2	705	0.992	5	820	0.987	1	181	0.879	245	8,764	0.899
9/6	21	6,330	0.995	1	706	0.993	6	826	0.994	1	182	0.883	233	8,997	0.923
9/7	8	6,338	0.996	2	708	0.996	0	826	0.994	6	188	0.913	205	9,202	0.944
9/8	7	6,345	0.997	1	709	0.997	2	828	0.996	9	197	0.956	280	9,482	0.973
9/9	11	6,356	0.999	0	709	0.997	2	830	0.999	5	202	0.981	146	9,628	0.988
9/10	6	6,362	1.000	2	711	1.000	1	831	1.000	4	206	1.000	121	9,749	1.000

Shaded areas depict estimates for days when the weir was partially or totally submerged and estimates were generated for that species only.

APPENDIX 3.—Age and sex composition of the Chum Salmon estimated escapement from scale samples (ASL) for the same stratum and combined strata through the Tuluksak River weir, 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 - 4:	06/14 − 07/11					
Sampling Dates:	06/24 − 06/26, 06/29 − 07/06, 07/08 − 07/11					
Male:	Number in Sample:	0	68	116	6	190
	Estimated % of Escapement:	0.0	25.5	43.4	2.2	**71.2**
	Estimated Escapement:	0	106	181	9	297
	Standard Error:	0.0	6.7	7.6	2.3	
Female	Number in Sample:	0	30	46	1	77
	Estimated % of Escapement:	0.0	11.2	17.2	0.4	**28.8**
	Estimated Escapement:	0	47	72	2	120
	Standard Error:	0.0	4.8	5.8	0.9	
Total:	Number in Sample:	0	98	162	7	267
	Estimated % of Escapement:	0.0	36.7	60.7	2.6	**100.0**
	Estimated Escapement:	0	153	253	11	417
	Standard Error:	0.0	7.4	7.5	2.5	
Stratum 5:	07/12 − 07/18					
Sampling Dates:	07/12 − 07/13, 07/15 − 07/16, 07/18					
Male:	Number in Sample:	0	73	58	2	133
	Estimated % of Escapement:	0.0	39.5	31.4	1.1	**71.9**
	Estimated Escapement:	0	380	302	10	692
	Standard Error:	0.0	31.2	29.6	6.6	
Female	Number in Sample:	0	33	19	0	52
	Estimated % of Escapement:	0.0	17.8	10.3	0.0	**28.1**
	Estimated Escapement:	0	172	99	0	270
	Standard Error:	0.0	24.4	19.3	0.0	
Total:	Number in Sample:	0	106	77	2	185
	Estimated % of Escapement:	0.0	57.3	41.6	1.1	**100.0**
	Estimated Escapement:	0	551	400	10	962
	Standard Error:	0.0	31.5	31.4	6.6	
Stratum 6:	07/19 – 07/25					
Sampling Dates:	07/19 – 07/21					
Male:	Number in Sample:	0	101	36	0	137
	Estimated % of Escapement:	0.0	48.6	17.3	0.0	**65.9**
	Estimated Escapement:	0	1,212	432	0	1,645
	Standard Error:	0.0	83.0	62.9	0.0	
Female	Number in Sample:	0	52	19	0	71
	Estimated % of Escapement:	0.0	25.0	9.1	0.0	**34.1**
	Estimated Escapement:	0	624	228	0	852
	Standard Error:	0.0	72.0	47.9	0.0	
Total:	Number in Sample:	0	153	55	0	208
	Estimated % of Escapement:	0.0	73.6	26.4	0.0	**100.0**
	Estimated Escapement:	0	1,837	660	0	2,497
	Standard Error:	0.0	73.3	73.3	0.0	

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		Brood Year and Age Group				
		2012	2011	2010	2009	
		0.2	0.3	0.4	0.5	Total
Stratum 7:	07/26 – 08/01					
Sampling Dates:	07/26 – 07/27					
Male:	Number in Sample:	4	113	57	2	176
	Estimated % of Escapement:	1.7	47.3	23.8	0.8	**73.6**
	Estimated Escapement:	17	478	241	8	745
	Standard Error:	7.4	28.6	24.4	5.2	
Female	Number in Sample:	0	17	46	0	63
	Estimated % of Escapement:	0.0	7.1	19.2	0.0	**26.4**
	Estimated Escapement:	0	72	195	0	267
	Standard Error:	0.0	14.7	22.6	0.0	
Total:	Number in Sample:	4	130	103	2	239
	Estimated % of Escapement:	1.7	54.4	43.1	0.8	**100.0**
	Estimated Escapement:	17	550	436	8	1,012
	Standard Error:	7.4	28.6	28.4	5.2	
Stratum 8:	08/02 – 08/08					
Sampling Dates:	08/02 − 08/04					
Male:	Number in Sample:	6	96	70	5	177
	Estimated % of Escapement:	2.2	35.6	25.9	1.9	**65.6**
	Estimated Escapement:	17	267	195	14	492
	Standard Error:	5.4	17.5	16.1	4.9	
Female	Number in Sample:	1	70	22	0	93
	Estimated % of Escapement:	0.4	25.9	8.1	0.0	**34.4**
	Estimated Escapement:	3	195	61	0	259
	Standard Error:	2.2	16.1	10.0	0.0	
Total:	Number in Sample:	7	166	92	5	270
	Estimated % of Escapement:	2.6	61.5	34.1	1.9	**100.0**
	Estimated Escapement:	19	462	256	14	751
	Standard Error:	5.8	17.8	17.4	4.9	
Strata 9 − 13:	08/09 – 09/12					
Sampling Dates:	08/09 − 08/13, 08/16 − 08/17, 08/19, 08/21 − 08/24, 09/09					
Male:	Number in Sample:	5	72	56	0	133
	Estimated % of Escapement:	2.3	32.6	25.3	0.0	**60.2**
	Estimated Escapement:	16	236	183	0	435
	Standard Error:	6.0	19.0	17.7	0.0	
Female	Number in Sample:	2	50	34	2	88
	Estimated % of Escapement:	0.9	22.6	15.4	0.9	**39.8**
	Estimated Escapement:	7	164	111	7	288
	Standard Error:	3.8	17.0	14.7	3.8	
Total:	Number in Sample:	7	122	90	2	221
	Estimated % of Escapement:	3.2	55.2	40.7	0.9	**100.0**
	Estimated Escapement:	23	399	294	7	723
	Standard Error:	7.1	20.2	20.0	3.8	

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		Brood Year and Age Group				
		2012	2011	2010	2009	
		0.2	0.3	0.4	0.5	Total
Strata 1 − 13:	08/09 – 09/12					
Male:	Number in Sample:	15	523	393	15	946
	Estimated % of Escapement:	1.1	37.6	28.3	1.1	**68.1**
	Estimated Escapement:	69	2,394	1,799	69	4,330
	Standard Error:	15.6	73.1	68.0	15.6	
Female	Number in Sample:	3	252	186	3	444
	Estimated % of Escapement:	0.2	18.1	13.4	0.2	**31.9**
	Estimated Escapement:	14	1,153	851	14	2,032
	Standard Error:	7.0	58.1	51.4	7.0	
Total:	Number in Sample:	18	775	579	18	1,390
	Estimated % of Escapement:	1.3	55.8	41.7	1.3	**100.0**
	Estimated Escapement:	82	3,547	2,650	82	6,362
	Standard Error:	17.1	75.0	74.4	17.1	

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

		Brood Year and Age Group			
		2012	2011	2010	2009
		0.2	0.3	0.4	0.5
Strata 1 - 4:	06/14 − 07/11				
Sampling Dates:	06/24 − 06/26, 06/29 − 07/06, 07/08 − 07/11				
Male:	Mean Length		585	595	578
	Std. Error		4	3	18
	Range		500 – 665	505 – 690	515 – 625
	Sample Size	0	68	116	6
Female:	Mean Length		551	570	570
	Std. Error		5	5	
	Range		500 – 630	495 – 660	
	Sample Size	0	30	46	1
Stratum 5:	07/12 − 07/18				
Sampling Dates:	07/12 − 07/13, 07/15 − 07/16, 07/18				
Male:	Mean Length		578	601	648
	Std. Error		4	5	13
	Range		485 – 650	530 – 685	635 – 660
	Sample Size	0	73	58	2
Female:	Mean Length		560	568	
	Std. Error		5	5	
	Range		475 – 630	520 – 600	
	Sample Size	0	33	19	0
Stratum 6:	07/19 − 07/25				
Sampling Dates:	07/19 − 07/21				
Male:	Mean Length		566	577	
	Std. Error		3	4	
	Range		485 – 635	535 – 625	
	Sample Size	0	101	36	0
Female:	Mean Length		554	560	
	Std. Error		3	5	
	Range		505 – 605	530 – 600	
	Sample Size	0	52	19	0
Stratum 7:	07/26 − 08/01				
Sampling Dates:	07/26 − 07/27				
Male:	Mean Length	529	606	575	598
	Std. Error	6	3	4	28
	Range	515 – 545	470 – 655	535 – 670	570 – 625
	Sample Size	4	113	57	2
Female:	Mean Length		544	547	
	Std. Error		4	5	
	Range		490 – 595	495 – 605	
	Sample Size	0	17	46	0

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		Brood Year and Age Group			
		2012	2011	2010	2009
		0.2	0.3	0.4	0.5
Stratum 8:	08/02 − 08/08				
Sampling Dates:	08/02 − 08/04				
Male:	Mean Length	546	553	570	589
	Std. Error	18	4	4	16
	Range	505 – 620	470 – 650	500 – 655	535 – 620
	Sample Size	6	96	70	5
Female:	Mean Length	535	538	539	
	Std. Error		4	5	
	Range		455 – 625	495 – 575	
	Sample Size	1	70	22	0
Strata 9 - 13:	08/09 − 09/12				
Sampling Dates:	08/09 − 08/13, 08/16 − 08/17, 08/19, 08/21 − 08/24, 09/09				
Male:	Mean Length	555	542	569	
	Std. Error	19	5	4	
	Range	510 – 625	460 – 690	505 – 645	
	Sample Size	5	72	56	0
Female:	Mean Length	513	519	531	568
	Std. Error	3	5	5	23
	Range	510 – 515	445 – 605	485 – 605	545 – 590
	Sample Size	2	50	34	2
Strata 1 - 13:	06/14 − 09/12				
Male:	Mean Length	544	566	584	593
	Std. Error	9	2	2	11
	Range	505 – 625	460 – 690	500 – 690	515 – 660
	Sample Size	15	523	393	15
Female:	Mean Length	520	543	553	568
	Std. Error	8	2	2	13
	Range	510 – 535	445 – 630	485 – 660	545 – 590
	Sample Size	3	286	169	3

APPENDIX 5.— Age and sex composition of the Chinook Salmon estimated escapement from scale samples (ASL) for all strata combined through the Tuluksak River weir, 2015. Sex was not confirmed for age 1.2 female Chinook Salmon. Not all ages present in past years were represented during 2015. Rounding errors affect totals.

		Brood Year and Age Group					
		2012	2011	2010		2009	
		1.1	1.2	1.3	2.2	1.4	Total
Strata 1 – 13:	06/21 − 08/29						
Sampling Dates:	06/22 − 06/26, 07/01, 07/05, 07/08 − 07/11, 07/13− 07/15, 07/19, 07/21− 07/22, 07/24− 07/26, 07/28 − 07/29, 07/31, 08/01 − 08/13, 08/21 − 08/24						
Male:	Number in Sample:	2	80	41	3	1	127
	Estimated % of Escapement:	1.2	47.3	24.3	1.8	0.6	**75.1**
	Estimated Escapement:	8	337	172	13	4	534
	Standard Error:	5.2	23.9	20.5	6.3	3.7	
Female	Number in Sample:	0	2	24	0	16	42
	Estimated % of Escapement:	0.0	1.2	14.2	0.0	9.5	**24.9**
	Estimated Escapement:	0	8	101	0	67	177
	Standard Error:	0.0	5.2	16.7	0.0	14.0	
Total:	Number in Sample:	2	82	65	3	17	169
	Estimated % of Escapement:	1.2	48.5	38.5	1.8	10.1	**100.0**
	Estimated Escapement:	8	345	273	13	72	711
	Standard Error:	5.2	23.9	23.3	6.3	14.4	

APPENDIX 6.— Mean length (mm) from the mid-eye to fork in the caudal fin and age composition of Chinook Salmon through the Tuluksak River weir, 2015. Weekly strata were combined and the ASL samples represent 24% of the total Chinook Salmon escapement. Sex was not confirmed for age-1.2 or smaller <650 mm age-1.3 female Chinook Salmon.

		Brood Year and Age Group				
		2012	2011	2010		2009
		1.1	1.2	1.3	2.2	1.4
Strata 1 − 13:	06/14 − 09/12					
Sampling Dates:	06/22 − 06/26, 07/01, 07/05, 07/08 − 07/11, 07/13 − 07/15, 07/19, 07/21 − 07/22, 07/24 − 07/26, 07/28 − 07/29, 07/31, 08/01 − 08/13, 08/21 − 08/24					
Male:	Mean Length	475	570	729	673	945
	Std. Error	25	6	10	27	
	Range	450 − 500	460 − 665	565 − 885	635 − 725	
	Sample Size	2	80	41	3	1
Female:	Mean Length		573	821		898
	Std. Error		48	12		8
	Range		525 − 620	575 − 895		840 − 950
	Sample Size	0	2	24	0	16

APPENDIX 7.—Age and sex composition of the Sockeye Salmon estimated escapement from scale samples (ASL) for the combined strata through the Tuluksak River weir, 2015. Rounding errors affect totals.

		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 - 13:	06/14 − 09/12									
Sampling Dates:	06/24 − 06/25, 07/01 − 07/02, 07/06, 07/08 − 07/13, 07/16, 07/18 − 07/20, 07/24− 07/29, 07/31− 08/13, 08/17, 08/21− 08/27									
Male:	Number in Sample:	8	14	47	3	45	20	6	1	144
	Estimated % of Escapement:	3.0	5.2	17.6	1.1	16.9	7.5	2.2	0.4	**53.9**
	Estimated Escapement:	25	44	146	9	140	62	19	3	448
	Standard Error:	7.2	9.4	16.0	4.4	15.7	11.0	6.2	2.6	
Female	Number in Sample:	3	3	31	3	46	17	10	10	123
	Estimated % of Escapement:	1.1	1.1	11.6	1.1	17.2	6.4	3.7	3.7	**46.1**
	Estimated Escapement:	9	9	96	9	143	53	31	31	383
	Standard Error:	4.4	4.4	13.4	4.4	15.9	10.2	8.0	8.0	
Total:	Number in Sample:	11	17	78	6	91	37	16	11	267
	Estimated % of Escapement:	4.1	6.4	29.2	2.2	34.1	13.9	6.0	4.1	**100.0**
	Estimated Escapement:	34	52.9	242.8	18.7	283	115.2	50	34.2	831
	Standard Error:	8.3	10.2	19.1	6.2	19.9	14.5	10.0	8.3	

APPENDIX 8.— Mean length (mm) from the mid-eye to fork in the caudal fin and age composition of Sockeye Salmon sampled at the Tuluksak River weir, 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 − 13:	06/21 − 08/29								
Sampling Dates:	06/24 − 06/25, 07/01 − 07/02, 07/06, 07/08 − 07/13, 07/16, 07/18 − 07/20, 07/24 − 07/29, 07/31 − 08/13, 08/17, 08/21 − 08/27								
Male:	Mean Length	478	558	577	593	576	567	583	575
	Std. Error	24	14	5	16	5	10	14	
	Range	400 − 575	455 − 625	500 − 635	565 − 620	450 − 640	465 − 610	555 − 630	
	Sample Size	8	14	47	3	45	20	6	1
Female:	Mean Length	553	533	538	533	538	545	536	543
	Std. Error	7	3	4	18	4	6	7	4
	Range	540 − 560	530 − 540	470 − 590	500 − 560	460 − 575	475 − 565	495 − 560	530 − 565
	Sample Size	3	3	31	3	46	17	10	10

APPENDIX 9.—Age and sex composition of the Coho Salmon estimated escapement from scale samples (ASL) for the same stratum and combined strata through the Tuluksak River weir, 2015. The ASL samples represent 17% of the total Coho Salmon escapement.

		Brood Year and Age Group			
		2012	2011	2010	
		1.1	2.1	3.1	Total
Strata 1 – 8:	06/14 – 08/08				
Sampling Dates:	07/27 – 07/28, 07/31 – 08/08				
Male:	Number in Sample:	16	66	2	84
	Estimated % of Escapement:	10.7	44.0	1.3	**56.0**
	Estimated Escapement:	20	81	2	103
	Standard Error:	2.0	3.2	0.7	
Female	Number in Sample:	20	42	4	66
	Estimated % of Escapement:	13.3	28.0	2.7	**44.0**
	Estimated Escapement:	25	52	5	81
	Standard Error:	2.2	2.9	1.0	
Total:	Number in Sample:	36	108	6	150
	Estimated % of Escapement:	24.0	72.0	4.0	**100.0**
	Estimated Escapement:	44	132	7	184
	Standard Error:	2.8	2.9	1.3	
Stratum 9:	08/09 – 08/15				
Sampling Dates:	08/09 – 08/13				
Male:	Number in Sample:	23	89	6	118
	Estimated % of Escapement:	11.3	43.8	3.0	**58.1**
	Estimated Escapement:	105	406	27	538
	Standard Error:	18.2	28.5	9.7	
Female	Number in Sample:	16	67	2	85
	Estimated % of Escapement:	7.9	33.0	1.0	**41.9**
	Estimated Escapement:	73	305	9	387
	Standard Error:	15.5	27.0	5.7	
Total:	Number in Sample:	39	156	8	203
	Estimated % of Escapement:	19.2	76.8	3.9	**100.0**
	Estimated Escapement:	178	711	36	925
	Standard Error:	22.7	24.3	11.2	
Stratum 10:	08/16 – 08/22				
Sampling Dates:	08/17, 08/19, 08/21 – 08/22				
Male:	Number in Sample:	9	80	1	90
	Estimated % of Escapement:	6.3	55.6	0.7	**62.5**
	Estimated Escapement:	12	103	1	116
	Standard Error:	1.8	3.7	0.6	
Female	Number in Sample:	9	43	2	54
	Estimated % of Escapement:	6.3	29.9	1.4	**37.5**
	Estimated Escapement:	12	56	3	70
	Standard Error:	1.8	3.4	0.9	
Total:	Number in Sample:	18	123	3	144
	Estimated % of Escapement:	12.5	85.4	2.1	**100.0**
	Estimated Escapement:	23	159	4	186
	Standard Error:	2.4	2.6	1.1	

APPENDIX 9.—(Page 2 of 2)

		Brood Year and Age Group			
		2012	2011	2010	
		1.1	2.1	3.1	Total
Strata 11 − 13:	08/23 − 9/12				
Sampling Dates:	08/23 − 08/24, 09/03, 09/09 − 09/10				
Male:	Number in Sample:	58	363	15	436
	Estimated % of Escapement:	7.8	48.6	2.0	**58.4**
	Estimated Escapement:	656	4,108	170	4,934
	Standard Error:	79.1	147.7	41.5	
Female	Number in Sample:	55	241	15	311
	Estimated % of Escapement:	7.4	32.3	2.0	**41.6**
	Estimated Escapement:	622	2,727	170	3,519
	Standard Error:	77.2	138.1	41.5	
Total:	Number in Sample:	113	604	30	747
	Estimated % of Escapement:	15.1	80.9	4.0	**100.0**
	Estimated Escapement:	1,279	6,835	339	8,453
	Standard Error:	105.9	116.3	58.0	
Strata 1 − 13:	06/14 − 9/12				
Male:	Number in Sample:	106	598	24	728
	Estimated % of Escapement:	8.5	48.1	1.9	**58.5**
	Estimated Escapement:	831	4,686	188	5,705
	Standard Error:	72.1	129.0	35.5	
Female	Number in Sample:	100	393	23	516
	Estimated % of Escapement:	8.0	31.6	1.8	**41.5**
	Estimated Escapement:	784	3,080	180	4,044
	Standard Error:	70.2	120.1	34.8	
Total:	Number in Sample:	206	991	47	1,244
	Estimated % of Escapement:	16.6	79.7	3.8	**100.0**
	Estimated Escapement:	1,614	7,766	368	9,749
	Standard Error:	96.0	104.0	49.2	

APPENDIX 10.—Mean length (mm) from the mid-eye to fork in the caudal fin and age composition of the Coho Salmon estimated escapement through the Tuluksak River weir, 2015. The ASL sample size represents 10% of the total Coho Salmon escapement.

		Brood Year and Age Group		
		2012	2011	2010
		1.1	2.1	3.1
Strata 7 − 8:	07/26 − 08/08			
Sampling Dates:	07/27 − 07/28, 07/31 − 08/08			
Male:	Mean Length	561	549	525
	Std. Error	16	6	55
	Range	455 – 695	425 – 635	470 – 580
	Sample Size	16	66	2
Female:	Mean Length	569	563	561
	Std. Error	6	6	13
	Range	510 – 605	470 – 635	535 – 595
	Sample Size	20	42	4
Stratum 9:	08/09 − 08/15			
Sampling Dates:	08/09 − 08/13			
Male:	Mean Length	571	615	538
	Std. Error	8	5	27
	Range	490 – 640	440 – 590	460 – 615
	Sample Size	23	89	6
Female:	Mean Length	563	572	478
	Std. Error	10	4	18
	Range	460 – 625	475 – 625	460 – 495
	Sample Size	16	67	2
Stratum 10:	08/16 − 08/22			
Sampling Dates:	08/17, 08/19, 08/21 − 08/22			
Male:	Mean Length	563	578	560
	Std. Error	17	5	
	Range	460 − 610	435 − 640	
	Sample Size	9	80	1
Female:	Mean Length	556	572	535
	Std. Error	13	6	10
	Range	480 − 610	480 − 620	525 − 545
	Sample Size	9	43	2
Strata 11 − 13:	08/23 − 9/12			
Sampling Dates:	08/23 − 08/24, 09/03, 09/09 − 09/10			
Male:	Mean Length	585	584	571
	Std. Error	11	4	24
	Range	530 – 625	470 – 665	510 – 645
	Sample Size	10	128	6
Female:	Mean Length	568	582	591
	Std. Error	11	4	6
	Range	510 – 620	475 – 655	570 – 620
	Sample Size	10	89	7
Strata 1 − 13:	06/14 − 9/12			
Male:	Mean Length	570	569	551
	Std. Error	6	3	16
	Range	455 – 695	425 – 665	460 – 645
	Sample Size	58	363	15
Female:	Mean Length	565	574	561
	Std. Error	5	2	11
	Range	460 – 625	470 – 655	460 – 620
	Sample Size	55	241	15

APPENDIX 11.—Median cumulative passage dates and percent female for Chum, Chinook, Sockeye, Pink and Coho salmon at the Tuluksak River weir 1991–1994 and 2001−2015 (Miller et al. 2015).

	Chum		Chinook		Sockeye		Pink		Coho	
Year	Date	Percent Female	Date	Percent Female	Date	Percent Female	Date	Percent Female	Date	Percent Female
1991	07/21	48	07/10	29	07/25	–	07/20	–	09/05	53
1992	07/21	50	07/12	15	07/25	43	08/07	–	08/28	43
1993	07/19	24	07/11	14	07/21	49	08/04	–	08/30	43
1994	07/21[a]	51	07/13[a]	24	08/01[a]	83	08/05	–	08/27[a]	38
2001	07/22[a]	44	07/14[a]	–	07/25[a]	–	08/06	–	08/27[a]	46
2002	07/17	44	07/11	24	07/14	–	07/14	–	08/29	58
2003	07/27[a]	33	07/05[a]	27	07/15[a]	63	07/28	–	08/27[a]	52
2004	07/18	43	07/10	37	07/15	–	07/28	–	08/19	32
2005	07/19	39	07/19	35	07/18	–	07/20	–	08/25	51
2006	07/18[a]	48	07/20[a]	28	07/20[a]	–	07/17	–	08/31[a]	54
2007	07/21[a]	31	07/19[a]	48	07/23[a]	40	07/29	–	08/20[a]	36
2008	07/20[a]	42	07/19[a]	41	07/27[a]	54	07/22	–	08/20	41
2009	07/24	30	07/20	43	07/19	49	07/28	–	08/30	31
2010	07/20	30	07/22	26	07/23	67	08/01	–	08/27[a]	56
2011	07/25[a]	34	07/19[a]	26	07/20[a]	56	07/31	–	08/27	–
2012	07/23[a]	51[b]	07/16[a]	33[b]	07/23[a]	64[b]	07/29	–	08/23	54[b]
2013	07/22	35	07/11	39[c]	07/16	63[c]	07/27	–	08/22[a]	39
2014	07/21	47	07/05	32	07/16	48	07/21	–	08/26	37
2015	07/24	33	07/24	25	07/24	46	08/09	–	08/27[a]	42

[a] Median cumulative passage dates were calculated using estimates for days missed.
***[b]* Percent female was based on video footage.**
[c] Small ASL collection used in analysis.