U.S. Fish & Wildlife Service

Abundance and Run Timing of Adult Pacific Salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2009

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Kenai Fish and Wildlife Field Office
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Steve J. Miller and Ken C. Harper

Abstract

The Kenai Fish and Wildlife Field Office, assisted by the Tuluksak Native Community, monitored the escapement of the five species of Pacific salmon returning to the Tuluksak River, a tributary to the lower Kuskokwim River. From June 25 to September 10, 2009, a resistance board weir was utilized to collect abundance, run timing, age, sex, and length data from returning adult salmon. These data support in-season and post-season management of the commercial and subsistence fisheries that occur on the Yukon Delta National Wildlife Refuge and the Kuskokwim River. In 2009, an estimated 13,671 chum salmon *Oncorhynchus keta*, 362 Chinook salmon *O. tshawytscha*, 686 sockeye salmon *O. nerka*, 51 pink salmon *O. gorbuscha* and 8,137 coho salmon *O. kisutch* passed through the Tuluksak River weir. Peak weekly passage occurred July 19–25 for chum, Chinook and pink salmon, July 12–18 for sockeye salmon, and August 30 to September 5 for coho salmon. Age, sex, and length data were collected for each species, except pink salmon. Dominant ages were 0.3 for chum, 1.3 for male and 1.4 for female Chinook, 1.3 for sockeye, and 2.1 for coho salmon. Over all percentages for female salmon were chum 30%, Chinook 44%, sockeye 49%, and coho 31%.

Introduction

The Tuluksak River is located approximately 222 river kilometers (rkm) upstream from the mouth of the Kuskokwim River, 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 contribute 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 nutrient base provided by salmon carcasses (U.S. Fish and Wildlife Service 1992).

Under guidelines established in the Sustainable Salmon Fisheries Policy 5AAC.39.222, the Alaska Board of Fisheries designated Kuskokwim River chum and Chinook salmon as stocks of yield concern in September 2000, 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 (Rebuilding Plan) (5AAC 07.365; Ward et al. 2003; Bergstrom and Whitmore 2004). The designation as stocks of concern was discontinued in 2007, after chum and Chinook salmon escapements returned to levels above the historical average (Linderman and Rearden 2007).

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

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together to achieve the goals of both the Rebuilding Plan (5 AAC 07.365) and the Federal Subsistence Fishery Management program. 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 for the general purposes to: "conserve fish and wildlife populations and habitats in their natural diversity," (ANILCA § 303 (7) (B) (*i*)).

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 the general pattern of salmon stocks from upper river tributaries entering the Kuskokwim River earliest, while stocks from lower river tributaries enter progressively later (Kerkvliet and Hamazaki 2003; Kerkvliet et al. 2003, 2004; Stuby 2004, 2005, 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 several weeks. Concurrent with this phenomenon is the extensive subsistence fishery that harvests more heavily from early arriving salmon, and commercial fisheries that have historically focused on early, middle or late segments of the overall salmon run (D. Molyneaux, Alaska Department of Fish and Game, personal communication).

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 (Tobin 1994). 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 to1994. After the 1994 season, the Tuluksak Native Community (TNC) opposed the weir and it was not operated from 1995 to 2000. Since 2001, TNC and the Service have jointly cooperated in staffing and operating the weir. Objectives of the project during 2009 were to: (1) enumerate adult salmon; (2) describe the run timing for chum, Chinook, sockeye, pink, and coho salmon returns; (3) estimate the age, sex, and length composition of adult chum, Chinook, sockeye, and coho salmon populations; and (4) identify and count other fish species passing through the weir. These data support the in-season and post season management of the Kuskokwim River subsistence and commercial fisheries. This information will also assist managers in establishing escapement goals to maintain the sustainability of salmon stocks returning to the Tuluksak River.

Study Area

The Tuluksak River is one of several tributaries flowing into the lower Kuskokwim River and is located approximately 116 rkm 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 section at the weir site, approximately 49 rkm from the mouth, 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 when boat traffic is present.

Dredging has altered approximately 40-km of the upper Tuluksak River and Bear Creek drainages above the refuge boundary. Dredge equipment operating in the floodplain of the Tuluksak River has altered the stream channel and water in some areas flows through dredge tailings and or tailings ponds (Figure 1). The mining activity and dredging, which began in 1908 and continued through most of the 20th century, removed approximately 500,000 ounces of gold (Strachan 2005). Mining companies have continued 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.

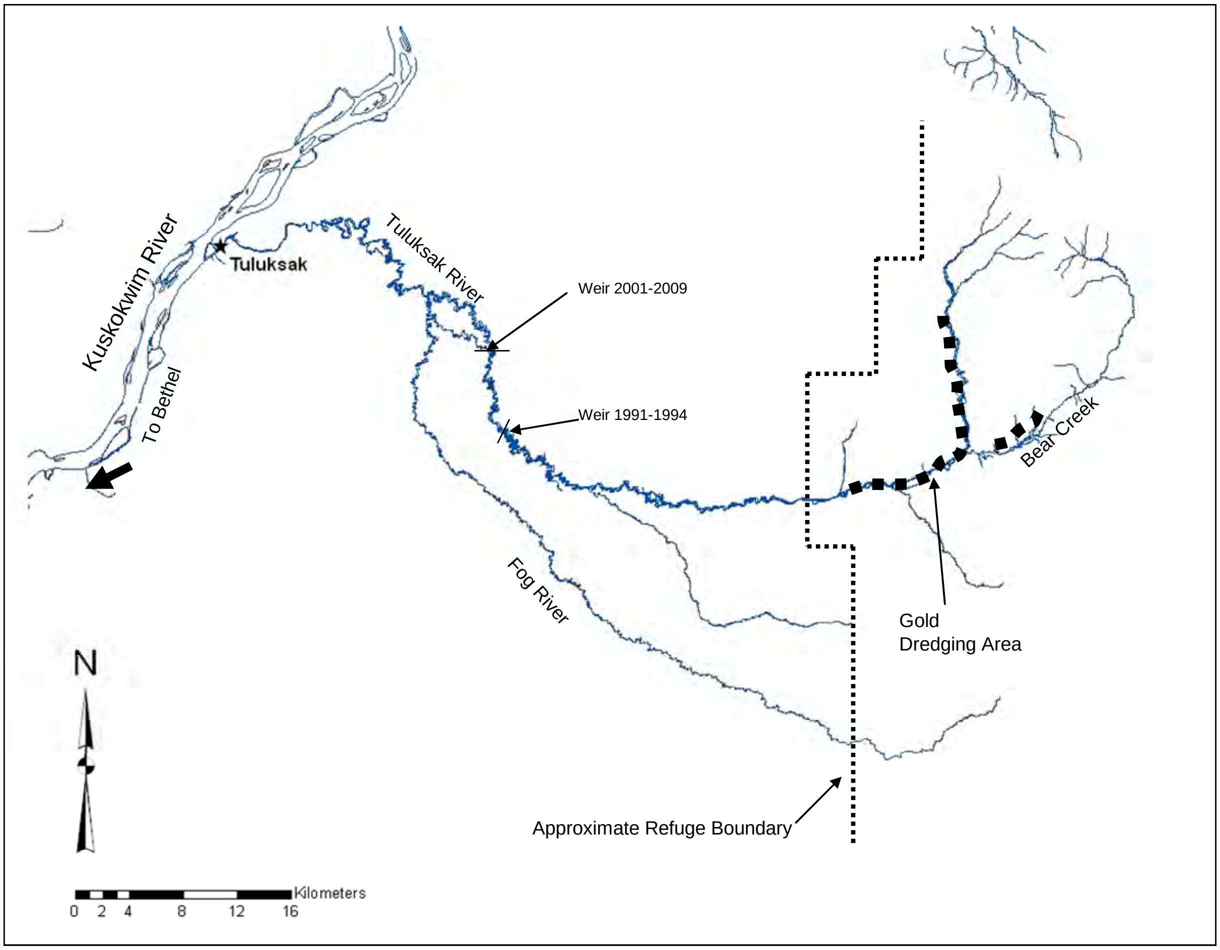

FIGURE 1.—Tuluksak River weir location, Yukon Delta National Wildlife Refuge, 1991–1994 and 2001–2009.

Methods

Weir Operations

A resistance board weir (Tobin 1994) was installed during 2009 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).

The weir was modified from the previous design (Tobin 1994) used from 1991 to 1994. Several modifications have taken place since 2001 to increase installation, operations, and takeout efficiencies (Gates and Harper 2002). Two passage panels and live traps were installed to facilitate fish sampling during various river stage heights during 2009. Counts started at approximately 0800 hours every day and continued until fading-daylight reduced visibility (~2300 hours). All passing salmon and resident fish were identified to species and recorded.

A staff gauge was installed approximately 10 m downstream of the weir to measure daily water levels. Measurements were correlated to correspond with the average water depth across the river channel at the upstream edge of the weir. Water temperatures were collected daily using a handheld thermometer from June 30 to September 10. Ambient temperature, water temperature, and fish passage counts were relayed daily by radio to the Department in Bethel. Hobo® recording thermometers were also installed at the weir to collect yearly water and ambient temperature data for an Office of Subsistence Management study addressing climate change.

Biological Data

Statistical weeks started on a Sunday and continued through the following Saturday (Harper 1997). Target sample size consisted of 200 chum salmon, 210 Chinook salmon, and 170 coho salmon each week. Sampling for sockeye salmon was opportunistic, with a target sample of 75 fish for the season. Biological sampling occurred between Sunday and Thursday of each statistical week in order to obtain a snapshot sample (Geiger et al. 1990). Once the weekly sample was met for a species, then sampling would stop for that species. Sampling would not typically extend past Thursday of each week. Low daily numbers of Chinook salmon relative to other species required active sampling (closure of the fish trap upon Chinook salmon entry) throughout the season to meet the weekly sample quota (Linderman et al. 2002). Post-season analysis included the combination of weekly strata to ensure adequate samples sizes were obtained.

During weeks with low fish numbers, the target sample size required sampling a high percentage of the weekly passage. In those situations, sampling was suspended for those species that had approximately 20% of their weekly passage sampled. This strategy reduced handling fish in the trap and holding fish downstream of the weir, and was sufficient to describe the weekly age, sex, and length compositions of the fish sampled.

Age, sex, and length data (ASL) were collected from each salmon sampled. Salmon were caught using the live trap attached to the passage chute. A fyke gate, installed on the entrance of the trap, allowed fish to enter and, at the same time, minimized the number of fish exiting the trap downstream. Sampling started when approximately 40 fish were in the trap. To avoid potential bias caused by the selection or capture of individual fish, all target species within the trap were included in the sample. Four scales from Chinook and coho, three from sockeye, and one from chum salmon were extracted for age analysis. Scales taken were from the preferred area using methods described by Koo (1962) and Mosher (1968). Sex was determined from external characteristics or visible sex products and length measured to the nearest 5 mm from the mid-eye to the fork of the caudal fin. All Chinook salmon <700 mm in length were classified as males. Data were recorded and transferred later to mark-sense forms. The Department staff aged the scales and processed the forms 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 (1.4 = 1 + 4 + 1 = 6, and 2.3 = 2 +3 + 1 = 6) are both six-year old fish from the same brood year. 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 r^{th} 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 of fish passage are calculated when flooding or holes in the weir result in days with partial or zero counts. During years when this occurs, estimates are based on the average daily proportion of passage from previous years. An average of the daily proportions for previous years is calculated since 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.

Collections for Concurrent Projects

Genetic tissue samples were collected from adult Chinook and pink salmon. Otoliths were collected from Chinook salmon carcasses. Chinook salmon samples were forwarded to the Conservation Genetics Laboratory (CGL) in Anchorage and pink salmon samples were provided to the Department. All tissue samples were collected according to project specific protocols (Secor et al. 1992; Olsen et al. 2004; D. Molyneaux, Alaska Department of Fish and Game, personal communication).

Results

Weir Operations

The crew traveled to the weir site by boat on June 21. Installation of the weir was completed on June 24, and the weir operated from June 25 to September 10. Water levels remained low the entire season and the weir ran smoothly during the operational period with no partial or zero count days. To facilitate fish passage during periods of low and clear water conditions, the trap was left open during nights (2300 to 0400 hours) and fish counted under artificial light. Minor repairs to damaged weir components were made during the field season. The weir was removed from the river by September 12, 2009.

Average water depth at the leading edge of the weir during 2009 was 54 cm. The maximum water depth of 77 cm occurred on June 21 (first day at site) and the minimum water depth of 43 cm occurred on July 30 (Appendix 1). Water temperatures ranged from a low of 8.8°C on August 26 to a high of 16.5°C on July 12 (Appendix 1).

Biological Data

Chum Salmon —A total of 13,671 chum salmon was counted through the weir from June 26 to September 9 (Figure 2; Appendix 2). Peak weekly passage (N = 4,089) occurred July 19–25 (Figure 2). Median cumulative passage occurred on July 24 for adults passing upstream (Figure 3; Appendix 2).

Five ages (0.2, 0.3, 0.4, 0.5, and 0.6) were identified from chum salmon scale samples. The predominant age was 0.3 for both male (83%) and female (82%) chum salmon (Appendix 3). Males dominated the run and comprised over 55% of the run in each stratum from June 25 to September 10 (Figure 3). Females comprised only 30% of the total escapement (Appendix 3). Mean length of males was larger for all ages than that of female chum salmon (Appendix 4).

Chinook Salmon —A total of 362 Chinook salmon was counted through the weir from June 30 to August 22 (Figure 2; Appendix 2). Peak weekly passage (N = 105) occurred July 19–25 (Figure 2). Median cumulative passage occurred on July 20 for adults passing upstream (Figure 3; Appendix 2).

Five ages (1.2, 1.3, 2.2, 1.4, and 1.5) were identified from Chinook salmon scale samples. The predominant age was 1.3 for males (45%) and 1.4 (74%) for females (Appendix 5). Age-1.2 and age-1.3 accounted for 78% of the male Chinook salmon escapement. Females comprised 44% of the Chinook salmon escapement. Sex ratios favored males through late July, but then shifted to a dominant female component (Figure 3; Appendix 5). Mean length of females was greater than males in ages 1.3 and 1.4 (Appendix 6).

Sockeye Salmon —A total of 686 sockeye salmon was counted through the weir from July 6 to August 27 (Figure 2; Appendix 2). Peak weekly passage for sockeye salmon (N = 290) occurred

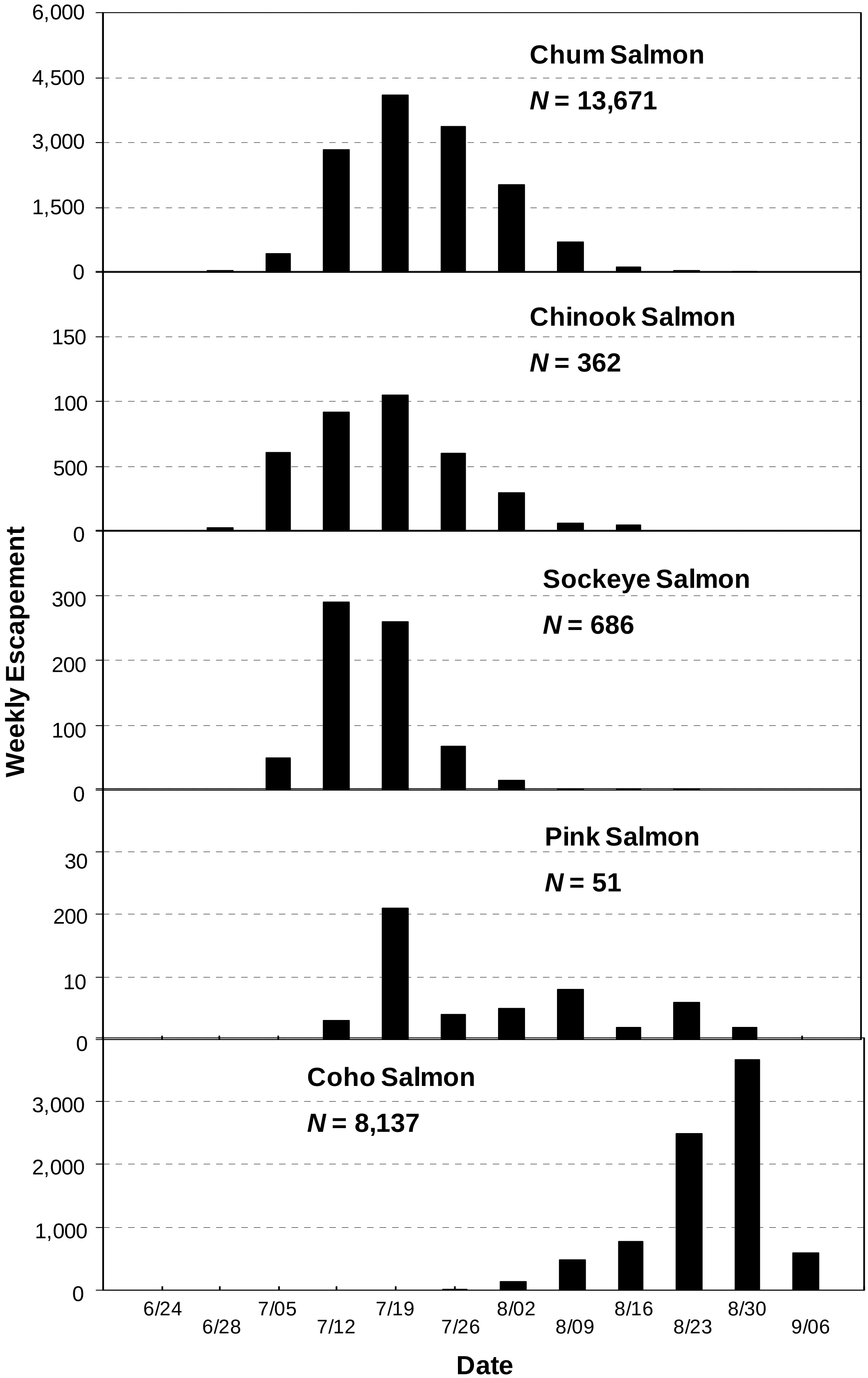

FIGURE 2. —Weekly escapement of chum, Chinook, sockeye, pink, and coho salmon through the Tuluksak River weir, 2009.

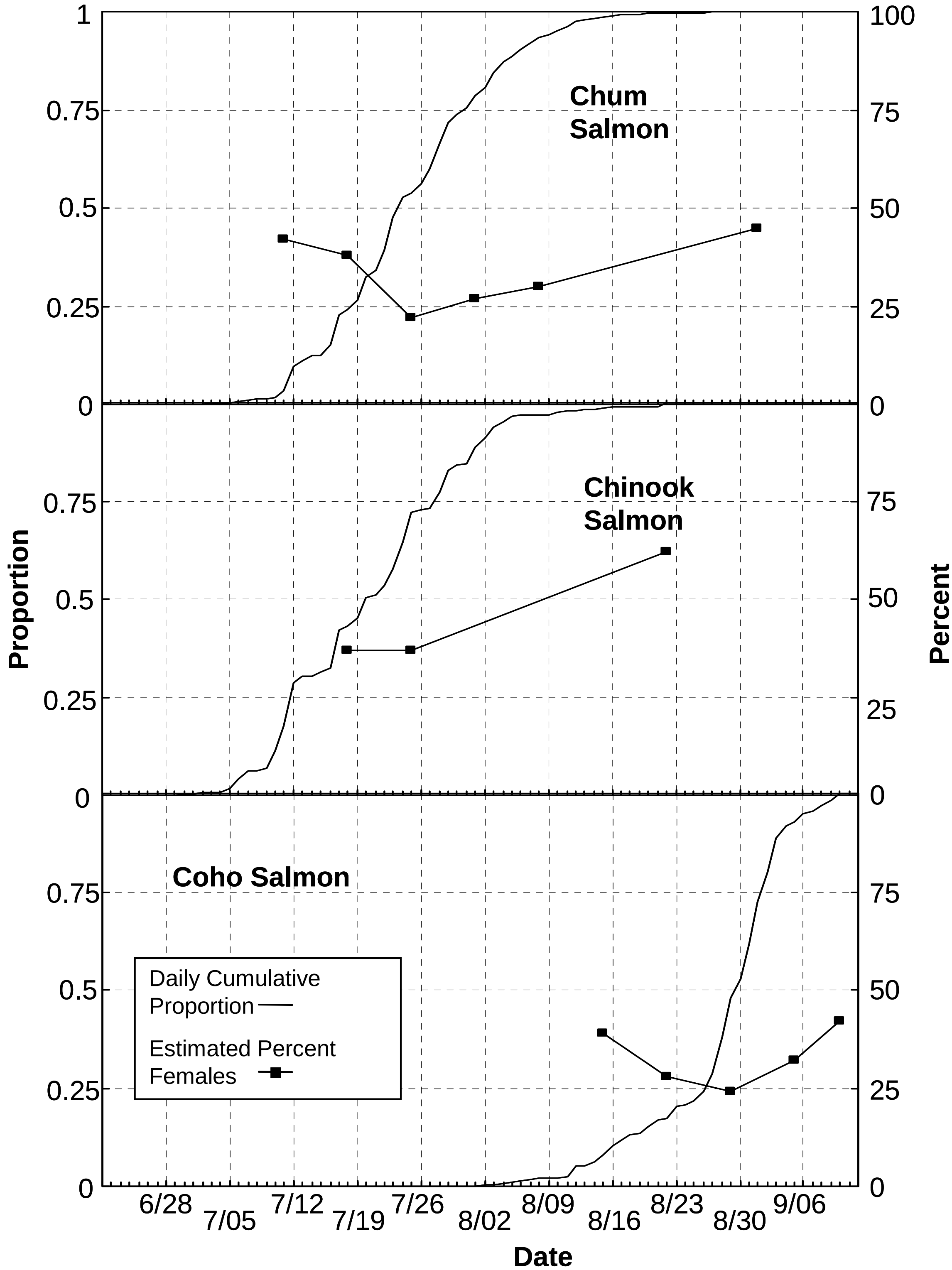

FIGURE 3. —Cumulative proportion and percent females from weekly samples of chum, Chinook and coho salmon passed through the Tuluksak River weir, 2009.

July 12–18 (Figure 2). Median cumulative passage occurred on July 19 for adults passing upstream (Appendix 2).

Five ages (0.3, 1.2, 1.3, 2.2, and 1.4) were identified from sockeye salmon scale samples. The predominant age was 1.3 for both males and females and comprised 63% of the sockeye salmon sample (Appendix 7). Females comprised 49% of the total sockeye salmon escapement (Appendix 7). The mean length of males was greater than females for ages 1.2 and 1.3 (Appendix 8).

Pink Salmon —A total of 51 pink salmon was counted through the weir from July 17 to August 31 (Figure 2; Appendix 2). Peak weekly passage of pink salmon (*N* = 21) occurred July 19–25 (Figure 2). Median cumulative passage occurred on July 28 for adults passing upstream (Appendix 2).

Coho Salmon —A total of 8,137 coho salmon was counted through the weir during 2009 (Figure 2; Appendix 2). The first coho salmon migrated through the weir on July 22 and 149 fish were counted during the last day of operation on September 10. Peak weekly passage of coho salmon (*N* = 3,656) occurred August 30–September 5 (Figure 2). Median cumulative passage occurred on August 30 (Figure 3; Appendix 2).

Three ages (1.1, 2.1, and 3.1) were identified from coho salmon scale samples (Appendix 9). Age-2.1 was the predominant age for both males (93%) and females (88%). Females comprised 31% of the total escapement and males were more prevalent than females in all stratum sampled (Appendix 9). Mean lengths were similar for both male and female coho salmon for all ages (Appendix 10).

Resident Species —Resident species counted through the weir consisted of one Dolly Varden *Salvelinus malma*, 24 whitefish *Coregoninae* spp., one northern pike *Esox lucius* and five Arctic grayling *Thymallus arcticus*. Although smaller sized resident species were able to pass freely through the pickets, passage through the passage chute was recorded the entire season.

Collections for Concurrent Projects

Genetic tissue samples (fin-clips) were collected from live migrating pink salmon (*N* = 20), stored as a bulk sample, and then forwarded to the Department in Bethel. Samples were collected from live migrating Chinook salmon (*N* = 253) and from carcasses (*N* = 54) for a trait heritability study on Tuluksak River Chinook salmon. Otoliths from Chinook salmon carcasses (*N* = 92) were also taken for age determination of fish being analyzed for heritability traits. Chinook salmon collections were stored in individual vials and shipped to the Conservation Genetics Laboratory in Anchorage.

Discussion

Weir Operations

The weir was operated from June 25 through September 10, 2009. Low water conditions persisted from the time of weir installation during late June into early September (Appendix 1). The substrate rail and cable remained in place after September 10 to expedite the 2010 weir install.

Biological Data

Chum Salmon —The estimated 2009 chum salmon escapement (*N* = 13,671) was within the historic range of 7,675–35,696 fish (Figure 4). The 2009 estimated escapement was below a 12-year average (1991–1994 and 2001–2008; *N* = 16,028) (Harper 1995a, 1995b, 1995c, 1997; Gates et al 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009). The 2009 escapement was 38% of the record 2005 chum salmon escapement (*N* = 35,696). The median

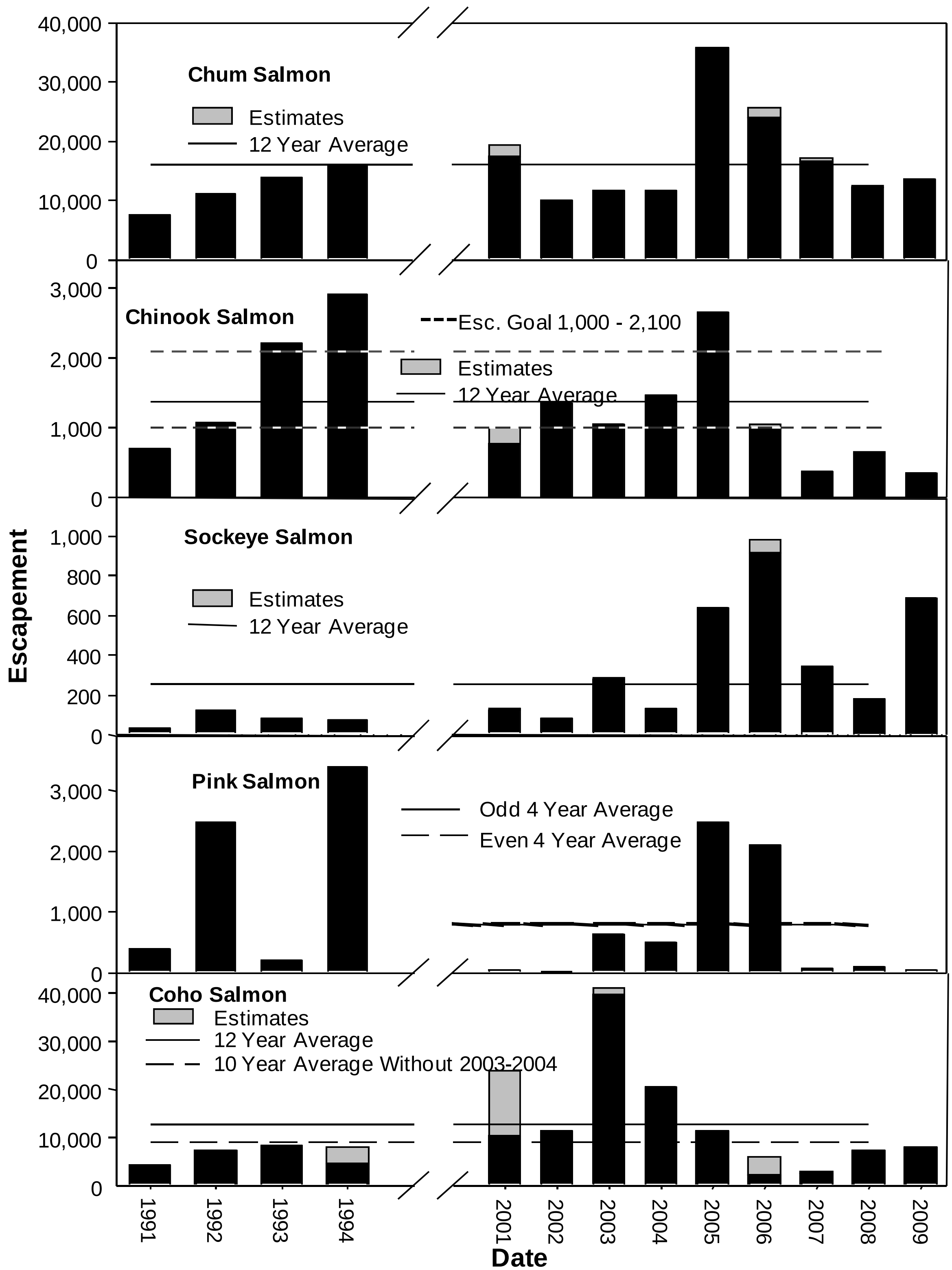

FIGURE 4. —Salmon escapement through the Tuluksak River weir; 1991–1994 and 2001–2009. Averages include estimates for days missed, do not include the current year, and for pink salmon averages are for years after 2000 when wider picket spacing was used on weir panels.

passage date for chum salmon occurred on July 24. This passage date was later than previous years with the exception of 2003 (Figure 5).

Females comprised 30% of the total chum salmon escapement, which was a decrease from that observed (42%) in 2008 and similar to that observed (31%) during 2007 (Plumb and Harper 2008; Miller and Harper 2009). Males predominated during all stratum of the run (Figure 3; Appendix 3). This is the first year male dominance has occurred in all strata. The dominance of males during the first part of the run has been predictable and females more dominant in latter stratum (Harper 1995a, 1995b, 1995c, 1997; Gates et al 2002; Gates and Harper 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009).

The dominate age during 2009 for chum salmon was age 0.3 (Appendix 3). This age represented 83% of the escapement in 2009, which was a substantial increase from the 16% observed in 2008 (Miller and Harper 2009). Age-0.4 chum salmon decreased from 80% in 2008 to only 12% of the return in 2009 (Appendix 3). The strong showing of age-0.3 fish may result in a strong showing of age-0.4 fish in 2010 (Plumb and Harper 2008; Miller and Harper 2009; Van Alen 1999).

Chinook Salmon —The estimated Chinook salmon escapement for 2009 (N = 362) was the second lowest on record and well below a 12-year average (1991–1994 and 2001–2008; N = 1,378; Figure 4). The Sustainable Escapement Goal (SEG) range for the Tuluksak River is between 1,000 and 2,100 Chinook salmon (Molyneaux and Brannian 2006; Volk et al. 2009) and this year's low escapement achieved only 36% of the lower range. Chinook salmon escapements have fallen below the SEG for three consecutive years 2007-2009 (Plumb and Harper 2008; Miller and Harper 2009; Figure 4). During 2009 Chinook salmon returns were also below or near the lower end of established or suggested SEGs for the George and Tuluksak, river weirs, and for three tributaries monitored by aerial surveys (Estensen et al. 2009; Miller and Harper 2010). Several factors, any one or a combination of climate, water temperature, river discharge, habitat, egg to smolt survival, ocean survival or exploitation, could have influenced the Chinook salmon abundance during 2009.

Median passage dates for Chinook salmon have fluctuated from July 5 to July 20. The median passage date for 2009 was July 20 and similar to dates observed during 2005–2008 (Figure 5; Appendix 2). Since 2005, the median passage date has shifted approximately seven days later than the average observed in prior years (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009; Figure 5). Reasons for this shift are unknown, but possible factors may include climate and oceanographic changes, and harvest pressures on the early portions of the run.

During 2009, female Chinook salmon comprised 44% of the escapement and near the high end of the range (14–48%) observed during previous years 1991–1994 and 2001–2008 (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009). This is the third consecutive year that females have comprised >40% of the escapement (Plumb and Harper 2008; Miller and Harper 2009).

The higher incidence of females in the return during the past three years may be to the result of changes in harvest strategies. Observations from a concurrent investigation (FIS 08-351) indicate that some subsistence fishers from TNC have changed to smaller 20.5-cm mesh nets, which selectively harvest a higher percentage of smaller and the more prevalent males.

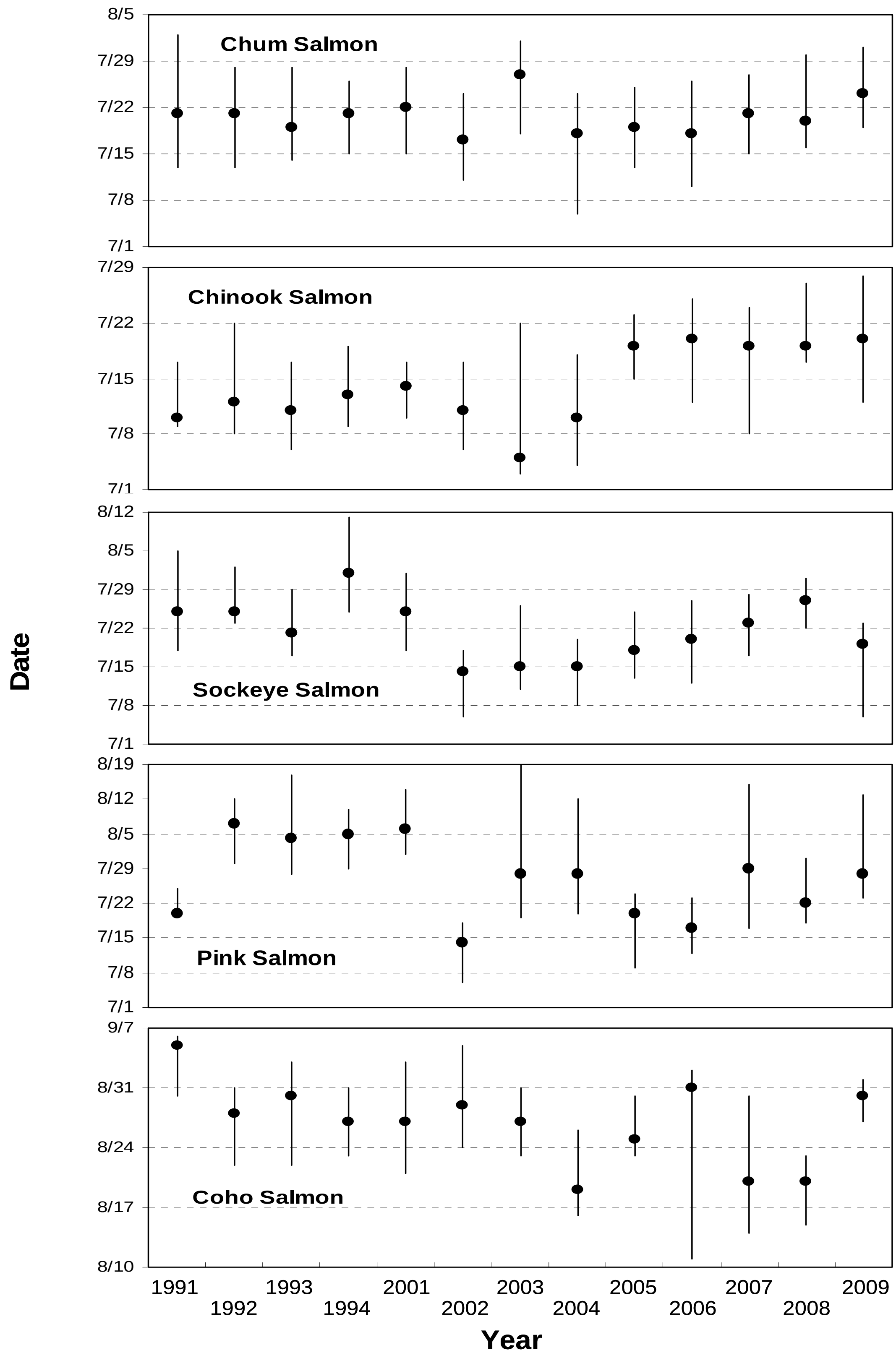

FIGURE 5. —Median cumulative passage for chum, Chinook, sockeye, pink, and coho salmon at the Tuluksak River weir (1991–1994 and 2001–2009). The filled circles represent the median (50%) passage date and the line below and above the circle represent the second and third quartiles respectively.

Bromaghin (2005) showed a correlation of catch efficiency to mesh size and fish length. Smaller mesh nets (< 20.5-cm stretch) were also used in the commercial harvest of Chinook salmon during the 2008 (*N* = 8,797) and 2009 (*N* = 6,664) seasons (Estensen et al. 2009). Male Chinook salmon comprised 90% and 80% of those harvests, respectively (D. Molyneaux, Alaska Department of Fish and Game, personal communication).

The dominant ages for Chinook salmon in 2009 were 1.2, 1.3, and 1.4, representing 19, 35, and 45% of the return, respectively (Appendix 5). This age composition was different from 2008, when these ages represented 16, 50, and 31% of the return (Miller and Harper 2009). The strong return of age-1.4 Chinook salmon in 2009 may be the result of a strong return of age-1.3 fish in 2008 (Van Alen 1999; Miller and Harper 2009).

Sex identification for small Chinook salmon is often difficult to ascertain. Generally, female Chinook salmon returning to the Kuskokwim River are ≥700 mm. The Department has explored this issue and sampled extensively in the commercial fishery in Bethel, where very few female Chinook salmon <700 mm were found (D. Molyneaux, Alaska Department of Fish and Game, personal communication). Small Chinook salmon (<700 mm) were also randomly sampled at the Tuluksak weir that had the outward appearance of females, but were determined to be males after examination of their gonads. This classification was further supported during 2008 when carcasses from 262 Chinook salmon were examined as part of a genetics heritability study and only five (<2%) female Chinook salmon <700 mm were found in the total sample (J. Olsen, U.S. Fish and Wildlife Service, personal communication). Using these length-to-sex data, Chinook salmon <700 mm have thus been classified as males unless sex products were visible.

Sockeye Salmon **—**The estimated escapement of 686 sockeye salmon during 2009 was the second highest on record, above a 12-year average (*N* = 262) and comparable to the return observed in 2005 (Figure 4). Escapements have ranged from a low of 34 in 1991 to a high of 985 recorded in 2006. Median passage dates for sockeye salmon have fluctuated from July 14 to August 2, a difference of 19 days (Figure 5). The median passage date in 2009 was July 19 and similar to dates observed during 2005 and 2006 (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009). Reasons for these shifts are unknown but climate, water flows, and oceanographic changes may be factors.

Pink Salmon **—**The number of pink salmon observed passing through the trap during 2009 (*N* = 51) was similar to odd years 2001 and 2007, and low compared to 2005 (Figure 4). Counts of pink salmon were below the odd and even 4-year averages (Figure 4). Pink salmon return to spawning grounds in predictable and segregated even and odd-numbered years (Scott and Crossman 1973). The median cumulative passage date, based on fish counted, was July 28, similar to 2003, 2004, and 2007 (Figure 5). Age, sex, and length data were not collected for pink salmon.

Coho Salmon **—**The coho salmon escapement has varied in number, timing, and percent females since 1991 (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009). The 2009 escapement (*N* = 8,137) was comparable to 1993; higher than 2006–2008; below that observed 2001–2005; and lower than a 12-year average (1991–1994 and 2001–2008; *N* = 12,717). The 2009 coho salmon escapement is also slightly below a 10-year average (*N* = 9,120) that excludes the record years of escapement, 2003 and 2004 (Figure 4).

The medium cumulative passage date of August 30 was later than 2007 and 2008, but within the range of dates (August 19–September 5) observed during previous years (Figure 5; Appendix 2). Male coho salmon dominated each stratum and females only comprised 31% of the total return during 2009. This percentage was lower than any previously recorded (32–58%) for females from 1991–1994 and 2001–2008 (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009).

Recommendations

The Tuluksak River weir continues to be an important project to monitor Kuskokwim River salmon stocks that originate on the Refuge. This weir and other escapement projects spread throughout the Kuskokwim River drainage provide important information used by Federal and State fishery managers. Annual operation of the weir should continue in future years to gather a long-term data set and weir operations should continue into September to monitor coho salmon escapements. Installation by late June has proven successful over time and we have been able to operate a weir during the entire season for the last 9 years (2001–2009). We believe that the river channel is stable at the current site and do not anticipate having to move to another site in the immediate future.

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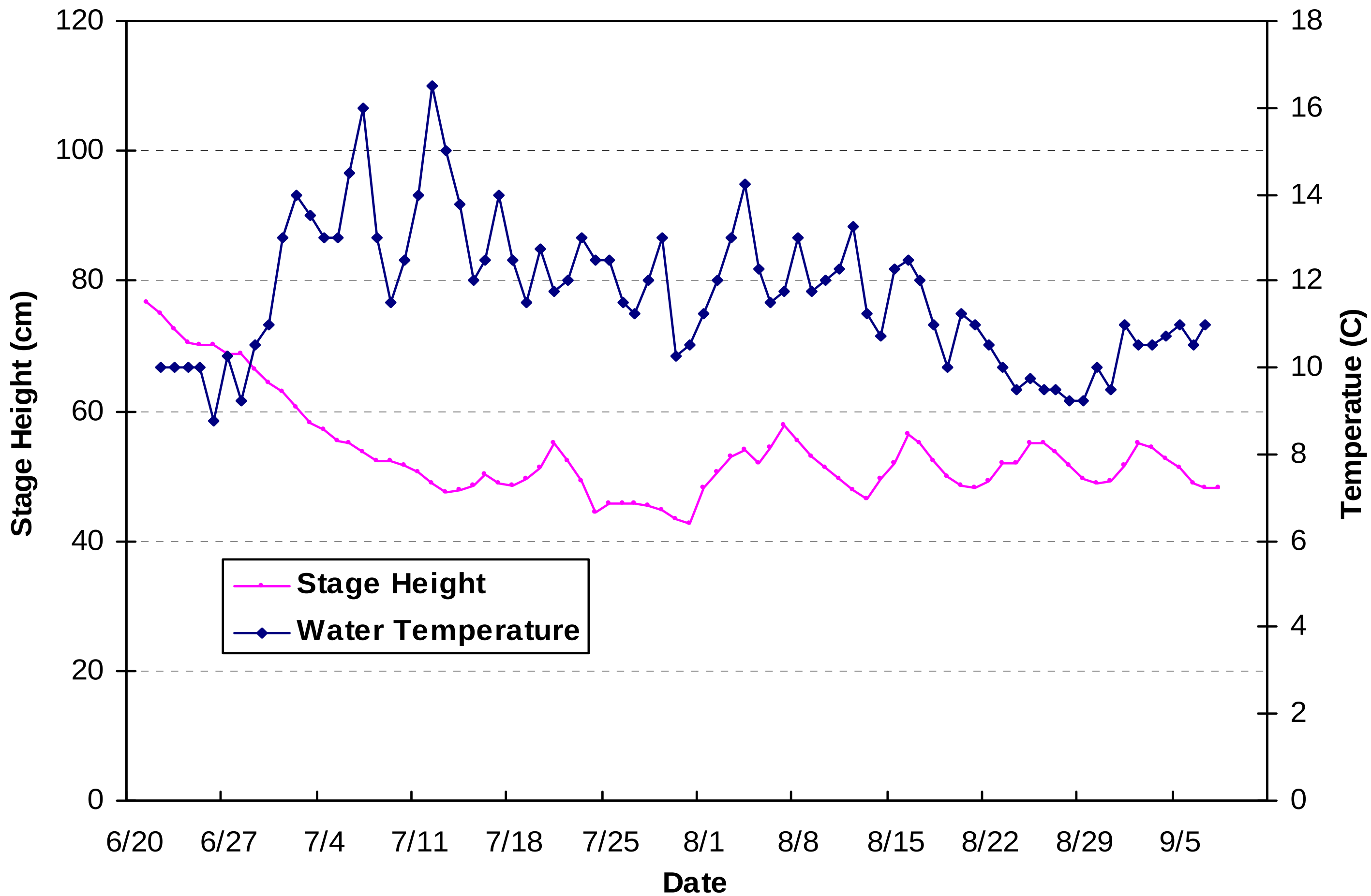

APPENDIX 1. —River stage heights and daily water temperatures at the Tuluksak River weir, 2009.

APPENDIX 2. —Daily, cumulative and cumulative proportion of chum, Chinook, sockeye, pink, and coho salmon passing through the Tuluksak River weir, Alaska, 2009. Boxed areas represent the second and third-quartile and median passage dates.

	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coh
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily
Date	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count
06/25	0	0	0.0000	0	0	0.0000	0	0	0.0000	0	0	0.0000	0
06/26	3	3	0.0002	0	0	0.0000	0	0	0.0000	0	0	0.0000	0
06/27	0	3	0.0002	0	0	0.0000	0	0	0.0000	0	0	0.0000	0
06/28	0	3	0.0002	0	0	0.0000	0	0	0.0000	0	0	0.0000	0
06/29	0	3	0.0002	0	0	0.0000	0	0	0.0000	0	0	0.0000	0
06/30	4	7	0.0005	1	1	0.0028	0	0	0.0000	0	0	0.0000	0
07/01	2	9	0.0007	0	1	0.0028	0	0	0.0000	0	0	0.0000	0
07/02	9	18	0.0013	1	2	0.0055	0	0	0.0000	0	0	0.0000	0
07/03	14	32	0.0023	0	2	0.0055	0	0	0.0000	0	0	0.0000	0
07/04	3	35	0.0026	1	3	0.0083	0	0	0.0000	0	0	0.0000	0
07/05	9	44	0.0032	3	6	0.0166	0	0	0.0000	0	0	0.0000	0
07/06	57	101	0.0074	9	15	0.0414	4	4	0.0058	0	0	0.0000	0
07/07	59	160	0.0117	8	23	0.0635	4	8	0.0117	0	0	0.0000	0
07/08	9	169	0.0124	0	23	0.0635	0	8	0.0117	0	0	0.0000	0
07/09	7	176	0.0129	2	25	0.0691	1	9	0.0131	0	0	0.0000	0
07/10	73	249	0.0182	16	41	0.1133	6	15	0.0219	0	0	0.0000	0
07/11	211	460	0.0336	23	64	0.1768	35	50	0.0729	0	0	0.0000	0
07/12	883	1,343	0.0982	40	104	0.2873	108	158	0.2303	0	0	0.0000	0
07/13	181	1,524	0.1115	6	110	0.3039	3	161	0.2347	0	0	0.0000	0
07/14	153	1,677	0.1227	0	110	0.3039	7	168	0.2449	0	0	0.0000	0
07/15	39	1,716	0.1255	3	113	0.3122	2	170	0.2478	0	0	0.0000	0
07/16	378	2,094	0.1532	4	117	0.3232	55	225	0.3280	0	0	0.0000	0
07/17	1,033	3,127	0.2287	35	152	0.4199	97	322	0.4694	3	3	0.0588	0
07/18	160	3,287	0.2404	4	156	0.4309	18	340	0.4956	0	3	0.0588	0
07/19	324	3,611	0.2641	8	164	0.4530	34	374	0.5452	0	3	0.0588	0
07/20	829	4,440	0.3248	18	182	0.5028	72	446	0.6501	0	3	0.0588	0
07/21	205	4,645	0.3398	3	185	0.5110	24	470	0.6851	5	8	0.1569	0
07/22	752	5,397	0.3948	8	193	0.5331	26	496	0.7230	5	13	0.2549	1
07/23	1,105	6,502	0.4756	16	209	0.5773	48	544	0.7930	6	19	0.3725	1
07/24	726	7,228	0.5287	25	234	0.6464	31	575	0.8382	5	24	0.4706	0
07/25	148	7,376	0.5395	27	261	0.7210	24	599	0.8732	0	24	0.4706	0
07/26	327	7,703	0.5635	2	263	0.7265	9	608	0.8863	0	24	0.4706	0
07/27	512	8,215	0.6009	2	265	0.7320	11	619	0.9023	1	25	0.4902	0
07/28	883	9,098	0.6655	15	280	0.7735	17	636	0.9271	2	27	0.5294	0
07/29	686	9,784	0.7157	19	299	0.8260	10	646	0.9417	0	27	0.5294	5
07/30	298	10,082	0.7375	5	304	0.8398	7	653	0.9519	0	27	0.5294	0
07/31	237	10,319	0.7548	2	306	0.8453	4	657	0.9577	0	27	0.5294	4

APPENDIX 2. —(Page 2 of 2)

	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
08/01	437	10,756	0.7868	15	321	0.8867	10	667	0.9723	1	28	0.5490	3	14	0.0017
08/02	298	11,054	0.8086	8	329	0.9088	2	669	0.9752	1	29	0.5686	2	16	0.0020
08/03	485	11,539	0.8440	11	340	0.9392	6	675	0.9840	2	31	0.6078	10	26	0.0032
08/04	380	11,919	0.8718	4	344	0.9503	3	678	0.9883	0	31	0.6078	42	68	0.0084
08/05	214	12,133	0.8875	6	350	0.9669	1	679	0.9898	0	31	0.6078	26	94	0.0116
08/06	206	12,339	0.9026	1	351	0.9696	0	679	0.9898	0	31	0.6078	16	110	0.0135
08/07	238	12,577	0.9200	0	351	0.9696	1	680	0.9913	2	33	0.6471	21	131	0.0161
08/08	211	12,788	0.9354	0	351	0.9696	2	682	0.9942	0	33	0.6471	24	155	0.0190
08/09	100	12,888	0.9427	0	351	0.9696	0	682	0.9942	0	33	0.6471	10	165	0.0203
08/10	134	13,022	0.9525	2	353	0.9751	1	683	0.9956	0	33	0.6471	17	182	0.0224
08/11	117	13,139	0.9611	1	354	0.9779	0	683	0.9956	2	35	0.6863	15	197	0.0242
08/12	190	13,329	0.9750	0	354	0.9779	0	683	0.9956	4	39	0.7647	213	410	0.0504
08/13	45	13,374	0.9783	2	356	0.9834	1	684	0.9971	0	39	0.7647	12	422	0.0519
08/14	65	13,439	0.9830	0	356	0.9834	0	684	0.9971	0	39	0.7647	90	512	0.0629
08/15	60	13,499	0.9874	1	357	0.9862	0	684	0.9971	2	41	0.8039	126	638	0.0784
08/16	37	13,536	0.9901	1	358	0.9890	1	685	0.9985	0	41	0.8039	191	829	0.1019
08/17	26	13,562	0.9920	0	358	0.9890	0	685	0.9985	1	42	0.8235	121	950	0.1168
08/18	16	13,578	0.9932	0	358	0.9890	0	685	0.9985	0	42	0.8235	106	1,056	0.1298
08/19	6	13,584	0.9936	0	358	0.9890	0	685	0.9985	0	42	0.8235	30	1,086	0.1335
08/20	17	13,601	0.9949	0	358	0.9890	0	685	0.9985	0	42	0.8235	146	1,232	0.1514
08/21	10	13,611	0.9956	0	358	0.9890	0	685	0.9985	1	43	0.8431	137	1,369	0.1682
08/22	4	13,615	0.9959	4	362	1.0000	0	685	0.9985	0	43	0.8431	46	1,415	0.1739
08/23	13	13,628	0.9969	0	362	1.0000	0	685	0.9985	0	43	0.8431	232	1,647	0.2024
08/24	5	13,633	0.9972	0	362	1.0000	0	685	0.9985	0	43	0.8431	48	1,695	0.2083
08/25	7	13,640	0.9977	0	362	1.0000	0	685	0.9985	0	43	0.8431	72	1,767	0.2172
08/26	7	13,647	0.9982	0	362	1.0000	0	685	0.9985	2	45	0.8824	210	1,977	0.2430
08/27	5	13,652	0.9986	0	362	1.0000	1	686	1.0000	2	47	0.9216	365	2,342	0.2878
08/28	2	13,654	0.9988	0	362	1.0000	0	686	1.0000	0	47	0.9216	734	3,076	0.3780
08/29	1	13,655	0.9988	0	362	1.0000	0	686	1.0000	2	49	0.9608	818	3,894	0.4786
08/30	1	13,656	0.9989	0	362	1.0000	0	686	1.0000	1	50	0.9804	390	4,284	0.5265
08/31	3	13,659	0.9991	0	362	1.0000	0	686	1.0000	1	51	1.0000	748	5,032	0.6184
09/01	3	13,662	0.9993	0	362	1.0000	0	686	1.0000	0	51	1.0000	871	5,903	0.7255
09/02	3	13,665	0.9996	0	362	1.0000	0	686	1.0000	0	51	1.0000	597	6,500	0.7988
09/03	1	13,666	0.9996	0	362	1.0000	0	686	1.0000	0	51	1.0000	722	7,222	0.8876
09/04	1	13,667	0.9997	0	362	1.0000	0	686	1.0000	0	51	1.0000	233	7,455	0.9162
09/05	0	13,667	0.9997	0	362	1.0000	0	686	1.0000	0	51	1.0000	95	7,550	0.9279
09/06	0	13,667	0.9997	0	362	1.0000	0	686	1.0000	0	51	1.0000	157	7,707	0.9472
09/07	2	13,669	0.9999	0	362	1.0000	0	686	1.0000	0	51	1.0000	74	7,781	0.9562
09/08	1	13,670	0.9999	0	362	1.0000	0	686	1.0000	0	51	1.0000	104	7,885	0.9690
09/09	1	13,671	1.0000	0	362	1.0000	0	686	1.0000	0	51	1.0000	103	7,988	0.9817
09/10	0	13,671	1.0000	0	362	1.0000	0	686	1.0000	0	51	1.0000	149	8,137	1.0000

APPENDIX 3. —Estimated age and sex composition of weekly chum salmon escapement through the Tuluksak River weir, Alaska, 2009 and estimated design effects of the stratified sampling design.

		Brood Year and Age					
		2006	2005	2004	2003	2002	
		0.2	0.3	0.4	0.5	0.6	Total
Strata 1 – 3:	06/21 – 07/11						
Sampling Dates:	06/30, 07/01 – 07/04, 07/09, 07/11						
Male:	Number in Sample:	1	47	13	10	0	71
	Estimated % of Escapement:	0.8	38.5	10.7	8.2	0.0	58.2
	Estimated Escapement:	4	177	49	38	0	268
	Standard Error:	3.2	17.4	11.1	9.8	0.0	
Female:	Number in Sample:	0	46	3	2	0	51
	Estimated % of Escapement:	0.0	37.7	2.5	1.6	0.0	41.8
	Estimated Escapement:	0	173	11	8	0	192
	Standard Error:	0.0	17.4	5.6	4.6	0.0	
Total:	Number in Sample:	1	93	16	12	0	122
	Estimated % of Escapement:	0.8	76.2	13.1	9.8	0.0	100.0
	Estimated Escapement:	4	351	60	45	0	460
	Standard Error:	3.2	15.3	12.1	10.7	0.0	
Stratum 4:	07/12 – 07/18						
Sampling Date:	07/12						
Male:	Number in Sample:	7	126	22	6	2	163
	Estimated % of Escapement:	2.7	47.7	8.3	2.3	0.8	61.7
	Estimated Escapement:	75	1,349	236	64	21	1,745
	Standard Error:	26.7	82.9	45.9	24.7	14.4	
Female:	Number in Sample:	9	74	16	2	0	101
	Estimated % of Escapement:	3.4	28.0	6.1	0.8	0.0	38.3
	Estimated Escapement:	96	792	171	21	0	1,082
	Standard Error:	30.1	74.6	39.6	14.4	0.0	
Total:	Number in Sample:	16	200	38	8	2	264
	Estimated % of Escapement:	6.1	75.8	14.4	3.0	0.8	100.0
	Estimated Escapement:	171	2,142	407	86	21	2,827
	Standard Error:	39.6	71.1	58.3	28.5	14.4	
Stratum 5:	07/19 – 07/25						
Sampling Dates:	07/19, 07/20						
Male:	Number in Sample:	4	95	12	0	0	111
	Estimated % of Escapement:	2.8	66.4	8.4	0.0	0.0	77.6
	Estimated Escapement:	114	2,716	343	0	0	3,174
	Standard Error:	55.6	159.2	93.5	0.0	0.0	
Female:	Number in Sample:	2	27	2	1	0	32
	Estimated % of Escapement:	1.4	18.9	1.4	0.7	0.0	22.4
	Estimated Escapement:	57	772	57	29	0	915
	Standard Error:	39.6	131.9	39.6	28.1	0.0	
Total:	Number in Sample:	6	122	14	1	0	143
	Estimated % of Escapement:	4.2	85.3	9.8	0.7	0.0	100.0
	Estimated Escapement:	172	3,489	400	29	0	4,089
	Standard Error:	67.6	119.3	100.2	28.1	0.0	

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		Brood Year and Age					
		2006	2005	2004	2003	2002	
		0.2	0.3	0.4	0.5	0.6	Total
Stratum 6:	07/26 – 08/01						
Sampling Dates:	07/26, 07/27						
Male:	Number in Sample:	5	107	17	0	0	129
	Estimated % of Escapement:	2.8	60.5	9.6	0.0	0.0	72.9
	Estimated Escapement:	95	2,043	325	0	0	2,463
	Standard Error:	41.1	121.3	73.1	0.0	0.0	
Female:	Number in Sample:	3	40	5	0	0	48
	Estimated % of Escapement:	1.7	22.6	2.8	0.0	0.0	27.1
	Estimated Escapement:	57	764	95	0	0	917
	Standard Error:	32.0	103.7	41.1	0.0	0.0	
Total:	Number in Sample:	8	147	22	0	0	177
	Estimated % of Escapement:	4.5	83.1	12.4	0.0	0.0	100.0
	Estimated Escapement:	153	2,807	420	0	0	3,380
	Standard Error:	51.5	93.1	81.8	0.0	0.0	
Stratum 7:	08/02 – 08/08						
Sampling Dates:	08/02, 08/03						
Male:	Number in Sample:	3	116	13	4	0	136
	Estimated % of Escapement:	1.5	59.8	6.7	2.1	0.0	70.1
	Estimated Escapement:	31	1,215	136	42	0	1,424
	Standard Error:	17.2	68.2	34.8	19.8	0.0	
Female:	Number in Sample:	1	50	7	0	0	58
	Estimated % of Escapement:	0.5	25.8	3.6	0.0	0.0	29.9
	Estimated Escapement:	10	524	73	0	0	608
	Standard Error:	10.0	60.8	25.9	0.0	0.0	
Total:	Number in Sample:	4	166	20	4	0	194
	Estimated % of Escapement:	2.1	85.6	10.3	2.1	0.0	100.0
	Estimated Escapement:	42	1,739	209	42	0	2,032
	Standard Error:	19.8	48.9	42.3	19.8	0.0	
Strata 8 – 12:	08/09 – 09/12						
Sampling Dates:	08/09, 08/10, 08/16, 08/17						
Male:	Number in Sample:	1	107	14	1	0	123
	Estimated % of Escapement:	0.4	47.8	6.3	0.4	0.0	54.9
	Estimated Escapement:	4	422	55	4	0	485
	Standard Error:	3.4	25.5	12.4	3.4	0.0	
Female:	Number in Sample:	3	83	11	4	0	101
	Estimated % of Escapement:	1.3	37.1	4.9	1.8	0.0	45.1
	Estimated Escapement:	12	327	43	16	0	398
	Standard Error:	5.9	24.7	11.0	6.8	0.0	
Total:	Number in Sample:	4	190	25	5	0	224
	Estimated % of Escapement:	1.8	84.8	11.2	2.2	0.0	100.0
	Estimated Escapement:	16	749	99	20	0	883
	Standard Error:	6.8	18.3	16.1	7.5	0.0	

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		Brood Year and Age					
		2006	2005	2004	2003	2002	
		0.2	0.3	0.4	0.5	0.6	Total
Strata 1 – 12:	06/21 – 09/12						
Sampling Dates:	06/30 – 08/17						
Male:	Number in Sample:	21	598	91	21	2	733
	% Males in Age Group:	3.4	82.9	12.0	1.5	0.2	100
	Estimated % of Escapement:	2.4	58.0	8.4	1.1	0.2	69.9
	Estimated Escapement:	324	7,923	1,144	148	21	9,560
	Standard Error:	76.2	229.2	132.9	33.3	14.4	
	Estimated Design Effects:	1.590	1.376	1.467	0.705	0.878	1.321
Female:	Number in Sample:	18	320	44	9	0	391
	% Females in Age Group:	5.7	81.6	11.0	1.8	0.0	100.0
	Estimated % of Escapement:	1.7	24.5	3.3	0.5	0.0	30.1
	Estimated Escapement:	233	3,353	452	73	0	4,111
	Standard Error:	60.3	195.8	75.2	32.6	0.0	
	Estimated Design Effects:	1.384	1.326	1.144	1.279	0.000	1.321
Total:	Number in Sample:	39	918	135	30	2	1,124
	Estimated % of Escapement:	4.1	82.5	11.7	1.6	0.2	100.0
	Estimated Escapement:	557	11,276	1,596	221	21	13,671
	Standard Error:	96.1	175.8	149.4	46.5	14.4	
	Estimated Design Effects:	1.502	1.367	1.383	0.896	0.878	

APPENDIX 4. —Estimated length at age composition of weekly chum salmon escapement through the Tuluksak River weir, Alaska, 2009.

		Brood Year and Age				
		2006	2005	2004	2003	2002
		0.2	0.3	0.4	0.5	0.6
Strata 1 – 3:	06/21 – 07/11					
Sampling Dates:	06/30, 07/01 – 07/04, 07/09, 07/11					
Male:	Mean Length	515	574	598	595	
	Std. Error		5	15	7	
	Range	–	505 – 635	503 – 676	560 – 630	
	Sample Size	1	47	13	10	0
Female:	Mean Length		544	559	573	
	Std. Error		5	24	33	
	Range		500 – 630	512 – 591	540 – 605	
	Sample Size	0	46	3	2	0
Stratum 4:	07/12 – 07/18					
Sampling Date:	07/12					
Male:	Mean Length	558	566	575	587	550
	Std. Error	11	3	8	14	25
	Range	512 – 590	468 – 662	512 – 627	530 – 618	525 – 574
	Sample Size	7	126	22	6	2
Female:	Mean Length	528	535	551	552	
	Std. Error	10	3	7	24	
	Range	480 – 570	470 – 621	503 – 614	528 – 575	
	Sample Size	9	74	16	2	0
Stratum 5:	07/19 – 07/25					
Sampling Dates:	07/19, 07/20					
Male:	Mean Length	555	567	577		
	Std. Error	10	3	11		
	Range	536 – 581	500 – 637	523 – 670		
	Sample Size	4	95	12	0	0
Female:	Mean Length	528	535	551	543	
	Std. Error	14	5	18		
	Range	530 – 557	496 – 590	531 – 566	–	
	Sample Size	2	27	2	1	0
Stratum 6:	07/26 – 08/01					
Sampling Dates:	07/26, 07/27					
Male:	Mean Length	502	560	553		
	Std. Error	26	3	11		
	Range	407 – 556	482 – 623	495 – 660		
	Sample Size	5	107	17	0	0
Female:	Mean Length	505	525	529		
	Std. Error	10	6	13		
	Range	490 – 525	408 – 580	502 – 572		
	Sample Size	3	40	5	0	0

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		Brood Year and Age				
		2006	2005	2004	2003	2002
		0.2	0.3	0.4	0.5	0.6
Stratum 7:	08/02 – 08/08					
Sampling Dates:	08/02, 08/03					
Male:	Mean Length	548	555	558	570	
	Std. Error	22	3	11	15	
	Range	518 – 590	472 – 624	502 – 623	540 – 602	
	Sample Size	3	116	13	4	0
Female:	Mean Length	455	535	551		
	Std. Error		5	14		
	Range	–	430 – 606	480 – 582		
	Sample Size	1	50	7	0	0
Strata 8 – 12:	08/09 – 09/12					
Sampling Dates:	08/09, 08/10, 08/16, 08/17					
Male:	Mean Length	556	547	543	530	
	Std. Error		3	7		
	Range	–	465 – 620	490 – 600	–	
	Sample Size	1	107	14	1	0
Female:	Mean Length	470	509	505	562	
	Std. Error	10	3	4	17	
	Range	460 – 490	410 – 575	485 – 521	534 – 600	
	Sample Size	3	83	11	4	0
Strata 1 – 12:	06/21 – 09/12					
Sampling Dates:	06/30 – 08/17					
Male:	Mean Length	541	560	567	585	550
	Std. Error	9	1	4	6	25
	Range	407 – 590	465 – 662	495 – 676	530 – 630	525 – 574
	Sample Size	21	598	91	21	2
Female:	Mean Length	512	528	535	560	
	Std. Error	8	2	5	10	
	Range	455 – 570	408 – 630	480 – 614	528 – 605	
	Sample Size	18	320	44	9	0

APPENDIX 5. —Estimated age and sex composition of weekly Chinook salmon escapement through the Tuluksak River weir, Alaska, 2009 and estimated design effects of the stratified sampling design.

		Brood Year and Age					
		2005	2004		2003	2002	
		1.2	1.3	2.2	1.4	1.5	Total
Strata 2 – 4:	06/28 – 07/18						
Sampling Dates:	06/30, 07/03 – 07/07, 07/10 – 07/13, 07/15 – 07/18						
Male:	Number in Sample:	22	18	1	13	0	54
	Estimated % of Escapement:	25.9	21.2	1.2	15.3	0.0	63.5
	Estimated Escapement:	40	33	2	24	0	99
	Standard Error:	5.0	4.7	1.2	4.1	0.0	
Female:	Number in Sample:	0	3	0	26	2	31
	Estimated % of Escapement:	0.0	3.5	0.0	30.6	2.4	36.5
	Estimated Escapement:	0	6	0	48	4	57
	Standard Error:	0.0	2.1	0.0	5.3	1.7	
Total:	Number in Sample:	22	21	1	39	2	85
	Estimated % of Escapement:	25.9	24.7	1.2	45.9	2.4	100.0
	Estimated Escapement:	40	39	2	72	4	156
	Standard Error:	5.0	5.0	1.2	5.7	1.7	
Stratum 5:	07/19 – 07/25						
Sampling Dates:	07/19 – 07/25						
Male:	Number in Sample:	12	23	0	5	0	40
	Estimated % of Escapement:	19.0	36.5	0.0	7.9	0.0	63.5
	Estimated Escapement:	20	38	0	8	0	67
	Standard Error:	3.3	4.1	0.0	2.3	0.0	
Female:	Number in Sample:	0	6	0	17	0	23
	Estimated % of Escapement:	0.0	9.5	0.0	27.0	0.0	36.5
	Estimated Escapement:	0	10	0	28	0	38
	Standard Error:	0.0	2.5	0.0	3.7	0.0	
Total:	Number in Sample:	12	29	0	22	0	63
	Estimated % of Escapement:	19.0	46.0	0.0	34.9	0.0	100.0
	Estimated Escapement:	20	48	0	37	0	105
	Standard Error:	3.3	4.2	0.0	4.0	0.0	

APPENDIX 5. —(Page 2 of 2)

		Brood Year and Age					
		2005	2004		2003	2002	
		1.2	1.3	2.2	1.4	1.5	Total
Strata 6 – 9:	07/26 – 08/22						
Sampling Dates:	07/26 – 08/06						
Male:	Number in Sample:	5	14	0	8	0	27
	Estimated % of Escapement:	7.0	19.7	0.0	11.3	0.0	38.0
	Estimated Escapement:	7	20	0	11	0	38
	Standard Error:	1.7	2.6	0.0	2.1	0.0	
Female:	Number in Sample:	0	15	0	29	0	44
	Estimated % of Escapement:	0.0	21.1	0.0	40.8	0.0	62.0
	Estimated Escapement:	0	21	0	41	0	63
	Standard Error:	0.0	2.7	0.0	3.2	0.0	
Total:	Number in Sample:	5	29	0	37	0	71
	Estimated % of Escapement:	7.0	40.8	0.0	52.1	0.0	100.0
	Estimated Escapement:	7	41	0	53	0	101
	Standard Error:	1.7	3.2	0.0	3.3	0.0	
Strata 2 – 9:	06/28 – 08/22						
Sampling Dates:	06/30 – 08/06						
Male:	Number in Sample:	39	55	1	26	0	121
	% Males in Age Group:	33.1	44.7	0.9	21.3	0.0	100.0
	Estimated % of Escapement:	18.6	25.2	0.5	12.0	0.0	56.4
	Estimated Escapement:	67	91	2	44	0	204
	Standard Error:	6.3	6.7	1.2	5.2	0.0	
	Estimated Design Effects:	1.015	0.994	1.111	1.023	0.000	0.965
Female:	Number in Sample:	0	24	0	72	2	98
	% Females in Age Group:	0.0	23.3	0.0	74.3	2.3	100.0
	Estimated % of Escapement:	0.0	10.2	0.0	32.4	1.0	43.6
	Estimated Escapement:	0	37	0	117	4	158
	Standard Error:	0.0	4.2	0.0	7.2	1.7	
	Estimated Design Effects:	0.000	0.900	0.000	1.001	1.103	0.965
Total:	Number in Sample:	39	79	1	98	2	219
	Estimated % of Escapement:	18.6	35.4	0.5	44.4	1.0	100.0
	Estimated Escapement:	67	128	2	161	4	362
	Standard Error:	6.3	7.3	1.2	7.7	1.7	
	Estimated Design Effects:	1.015	0.970	1.111	1.002	1.103	

APPENDIX 6. —Estimated length at age composition of weekly Chinook salmon escapement through the Tuluksak River weir, Alaska, 2009.

		Brood Year and Age				
		2005	2004		2003	2002
		1.2	1.3	2.2	1.4	1.5
Strata 2 – 4:	06/28 – 07/18					
Sampling Dates:	06/30, 07/03 – 07/07, 07/10 – 07/13, 07/15 – 07/18					
Male:	Mean Length	567	655	497	774	
	Std. Error	10	11		29	
	Range	460 – 625	587 – 749	–	550 – 955	
	Sample Size	22	18	1	13	0
Female:	Mean Length		782		863	826
	Std. Error		35		11	72
	Range		715 – 833		720 – 1010	754 – 897
	Sample Size	0	3	0	26	2
Stratum 5:	07/19 – 07/25					
Sampling Dates:	07/09 – 07/25					
Male:	Mean Length	591	640		766	
	Std. Error	16	13		11	
	Range	504 – 700	501 – 743		708 – 825	
	Sample Size	12	23	0	5	0
Female:	Mean Length		822		872	
	Std. Error		15		8	
	Range		790 – 876		810 – 920	
	Sample Size	0	6	0	17	0
Strata 6 – 9:	07/26 – 09/12					
Sampling Dates:	07/26 – 08/06					
Male:	Mean Length	628	723		762	
	Std. Error	26	11		28	
	Range	580 – 700	657 – 780		623 – 863	
	Sample Size	5	14	0	8	0
Female:	Mean Length		778		845	
	Std. Error		12		10	
	Range		658 – 852		720 – 970	
	Sample Size	0	15	0	29	0

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		Brood Year and Age				
		2005	2004		2003	2002
		1.2	1.3	2.2	1.4	1.5
Strata 2 – 9:	06/28 – 09/12					
Sampling Dates:	06/30 – 08/06					
Male:	Mean Length	582	666	497	769	
	Std. Error	8	8		17	
	Range	460 – 700	501 – 780	–	550 – 955	
	Sample Size	39	55	1	26	0
Female:	Mean Length		790		858	826
	Std. Error		10		6	72
	Range		658 – 876		720 – 1010	754 – 897
	Sample Size	0	24	0	72	2

APPENDIX 7. —Estimated age and sex composition of the sockeye salmon escapement through the Tuluksak River weir, Alaska, 2009 and estimated design effects of the stratified sampling design.

		Brood Year and Age					
		2005		2004		2003	
		0.3	1.2	1.3	2.2	1.4	Total
Strata 3 – 10:	07/05 – 08/29						
Sampling Dates:	07/11, 07/12, 07/17, 07/27 – 08/02, 08/04, 08/05						
Male	Number in Sample:	0	14	17	1	1	33
	Estimated % of Escapement:	0.0	21.5	26.2	1.5	1.5	50.8
	Estimated Escapement:	0	148	179	11	11	348
	Standard Error:	0.0	33.5	35.9	10.0	10.0	
Female:	Number in Sample:	1	7	24	0	0	32
	Estimated % of Escapement:	1.5	10.8	36.9	0.0	0.0	49.2
	Estimated Escapement:	11	74	253	0	0	338
	Standard Error:	10.0	25.3	39.4	0.0	0.0	
Total:	Number in Sample:	1	21	41	1	1	65
	Estimated % of Escapement:	1.5	32.3	63.1	1.5	1.5	100.0
	Estimated Escapement:	11	222	433	11	11	686
	Standard Error:	10.0	38.2	39.4	10.0	10.0	

APPENDIX 8. —Estimated length at age composition of weekly sockeye salmon escapement through the Tuluksak River weir, Alaska, 2009.

		Brood Year and Age				
		2005		2004		2003
		0.3	1.2	1.3	2.2	1.4
Strata 3 – 10:	07/05 – 08/29					
Sampling Dates:	07/11, 07/12, 07/17, 07/27 – 08/02, 08/04, 08/05					
Male:	Mean Length		580	566	570	590
	Std. Error		7	8		
	Range		507 – 609	460 – 600	–	–
	Sample Size	0	14	17	1	1
Female:	Mean Length	554	526	535		
	Std. Error		8	5		
	Range	–	500 – 557	480 – 580		
	Sample Size	1	7	24	0	0

APPENDIX 9. —Estimated age and sex composition of the weekly coho salmon escapement through the Tuluksak River weir, Alaska, 2009 and estimated design effect of the stratified sampling design.

		Brood Year and Age			
		2006	2005	2004	
		1.1	2.1	3.1	Total
Strata 5 – 8:	07/19 – 08/15				
Sampling Dates:	08/03 – 08/06, 08/09, 08/10				
Male:	Number in Sample:	0	50	8	58
	Estimated % of Escapement:	0.0	52.6	8.4	61.1
	Estimated Escapement:	0	336	54	390
	Standard Error:	0.0	30.3	16.9	
Female:	Number in Sample:	0	30	7	37
	Estimated % of Escapement:	0.0	31.6	7.4	38.9
	Estimated Escapement:	0	201	47	248
	Standard Error:	0.0	28.2	15.9	
Total:	Number in Sample:	0	80	15	95
	Estimated % of Escapement:	0.0	84.2	15.8	100.0
	Estimated Escapement:	0	537	101	638
	Standard Error:	0.0	22.1	22.1	
Stratum 9:	08/16 – 08/22				
Sampling Dates:	08/16				
Male:	Number in Sample:	2	92	5	99
	Estimated % of Escapement:	1.4	66.7	3.6	71.7
	Estimated Escapement:	11	518	28	557
	Standard Error:	7.2	28.4	11.2	
Female:	Number in Sample:	0	33	6	39
	Estimated % of Escapement:	0.0	23.9	4.3	28.3
	Estimated Escapement:	0	186	34	220
	Standard Error:	0.0	25.7	12.3	
Total:	Number in Sample:	2	125	11	138
	Estimated % of Escapement:	1.4	90.6	8.0	100.0
	Estimated Escapement:	11	704	62	777
	Standard Error:	7.2	17.6	16.3	
Stratum 10:	08/23 – 08/29				
Sampling Dates:	08/24 – 08/26				
Male:	Number in Sample:	0	107	5	112
	Estimated % of Escapement:	0.0	72.3	3.4	75.7
	Estimated Escapement:	0	1,792	84	1,876
	Standard Error:	0.0	88.7	35.8	
Female:	Number in Sample:	1	30	5	36
	Estimated % of Escapement:	0.7	20.3	3.4	24.3
	Estimated Escapement:	17	503	84	603
	Standard Error:	16.2	79.7	35.8	
Total:	Number in Sample:	1	137	10	148
	Estimated % of Escapement:	0.7	92.6	6.8	100.0
	Estimated Escapement:	17	2,295	168	2,479
	Standard Error:	16.2	52.0	49.8	

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		Brood Year and Age			
		2006	2005	2004	
		1.1	2.1	3.1	Total
Stratum 11:	08/30 – 09/05				
Sampling Dates:	08/30				
Male:	Number in Sample:	1	85	6	92
	Estimated % of Escapement:	0.7	62.5	4.4	67.6
	Estimated Escapement:	27	2,285	161	2,473
	Standard Error:	26.4	149.5	63.4	
Female:	Number in Sample:	0	41	3	44
	Estimated % of Escapement:	0.0	30.1	2.2	32.4
	Estimated Escapement:	0	1,102	81	1,183
	Standard Error:	0.0	141.7	45.3	
Total:	Number in Sample:	1	126	9	136
	Estimated % of Escapement:	0.7	92.6	6.6	100.0
	Estimated Escapement:	27	3,387	242	3,656
	Standard Error:	26.4	80.6	76.8	
Stratum 12:	09/06 – 09/12				
Sampling Dates:	09/06, 09/07				
Male:	Number in Sample:	2	77	8	87
	Estimated % of Escapement:	1.3	51.7	5.4	58.4
	Estimated Escapement:	8	303	32	343
	Standard Error:	4.8	20.8	9.4	
Female:	Number in Sample:	2	54	6	62
	Estimated % of Escapement:	1.3	36.2	4.0	41.6
	Estimated Escapement:	8	213	24	244
	Standard Error:	4.8	20.0	8.2	
Total:	Number in Sample:	4	131	14	149
	Estimated % of Escapement:	2.7	87.9	9.4	100.0
	Estimated Escapement:	16	516	55	587
	Standard Error:	6.7	13.6	12.2	
Strata 5 – 12:	07/19 – 09/12				
Sampling Dates:	08/03 – 09/07				
Male:	Number in Sample:	5	411	32	448
	% Males in Age Group:	0.8	92.8	6.4	100.0
	Estimated % of Escapement:	0.6	64.3	4.4	69.3
	Estimated Escapement:	46	5,234	358	5,639
	Standard Error:	27.8	179.9	76.2	
	Estimated Design Effects:	1.458	1.498	1.466	1.504
Female:	Number in Sample:	3	188	27	218
	% Females in Age Group:	1.0	88.3	10.8	100.0
	Estimated % of Escapement:	0.3	27.1	3.3	30.7
	Estimated Escapement:	25	2,205	269	2,498
	Standard Error:	16.9	168.2	61.7	
	Estimated Design Effects:	1.036	1.519	1.279	1.504
Total:	Number in Sample:	8	599	59	666
	Estimated % of Escapement:	0.9	91.4	7.7	100.0
	Estimated Escapement:	71	7,439	627	8,137
	Standard Error:	32.5	100.9	96.3	
	Estimated Design Effects:	1.315	1.386	1.390	

APPENDIX 10. —Estimated length at age composition of weekly coho salmon escapement through the Tuluksak River weir, Alaska, 2009.

		Brood Year and Age		
		2006	2005	2004
		1.1	2.1	3.1
Strata 5 – 8:	07/19 – 08/15			
Sampling Dates:	08/03 – 08/06, 08/09, 08/10			
Male:	Mean Length		543	553
	Std. Error		6	19
	Range		450 – 640	473 – 615
	Sample Size	0	50	8
Female:	Mean Length		540	557
	Std. Error		5	9
	Range		472 – 615	532 – 590
	Sample Size	0	30	7
Stratum 9:	08/16 – 08/22			
Sampling Dates:	08/16			
Male:	Mean Length	542	559	568
	Std. Error		4	17
	Range	542 – 542	460 – 625	515 – 620
	Sample Size	2	92	5
Female:	Mean Length		565	579
	Std. Error		6	7
	Range		465 – 609	559 – 600
	Sample Size	0	33	6
Stratum 10:	08/23 – 08/29			
Sampling Dates:	08/24 – 08/26			
Male:	Mean Length		543	546
	Std. Error		5	30
	Range		440 – 859	447 – 597
	Sample Size	0	107	5
Female:	Mean Length	547	536	524
	Std. Error		9	22
	Range	–	400 – 594	444 – 576
	Sample Size	1	30	5
Stratum 11:	08/30 – 09/05			
Sampling Dates:	08/30			
Male:	Mean Length	539	550	588
	Std. Error		4	12
	Range	–	460 – 640	540 – 630
	Sample Size	1	85	6
Female:	Mean Length		555	537
	Std. Error		5	10
	Range		485 – 618	524 – 556
	Sample Size	0	41	3

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		Brood Year and Age		
		2006	2005	2004
		1.1	2.1	3.1
Stratum 12:	09/06 – 09/12			
Sampling Dates:	09/06, 09/07			
Male:	Mean Length	579	563	570
	Std. Error	24	5	15
	Range	555 – 603	470 – 634	533 – 614
	Sample Size	2	77	8
Female:	Mean Length	538	562	585
	Std. Error	18	5	8
	Range	520 – 556	485 – 665	553 – 613
	Sample Size	2	54	6
Strata 5 – 12:	07/19 – 09/12			
Sampling Dates:	08/03 – 09/07			
Male:	Mean Length	556	552	565
	Std. Error	12	2	8
	Range	539 – 603	440 – 859	447 – 630
	Sample Size	5	411	32
Female:	Mean Length	541	554	560
	Std. Error	11	3	7
	Range	520 – 556	400 – 665	444 – 613
	Sample Size	3	188	27