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Abundance and Run Timing of Adult Pacific Salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2008

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Steve J. Miller and Ken C. Harper

Abstract

The Kenai Fish and Wildlife Field Office operated a weir on the Tuluksak River, a tributary to the lower Kuskokwim River in the Yukon Delta National Wildlife Refuge, between June 29 and September 10, 2008. A resistance board weir was used to collect abundance, run timing, and biological data from returning adult salmon. These data support in-season and post-season management of the commercial and subsistence fisheries in the Kuskokwim area. In 2008, an estimated 12,550 chum *Oncorhynchus keta*, 701 Chinook *O. tshawytscha*, 188 sockeye *O. nerka*, 111 pink *O. gorbuscha* and 7,457 coho salmon *O. kisutch* passed through the Tuluksak River weir. Peak weekly passage occurred July 13–19 for chum, Chinook and pink salmon, July 27–August 2 for sockeye salmon, and August 17–23 for coho salmon. Age, sex, and length data were collected for each species except pink salmon. Dominant age classes were 0.4 for chum, 1.4 for female and 1.3 for male Chinook, 1.3 for sockeye, and 2.1 for coho salmon. Over all percentages for female salmon were chum 42%, Chinook 41%, sockeye 54%, and coho 39%.

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 *Oncorhynchus keta*, Chinook *O. tshawytscha*, sockeye *O. nerka*, pink *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. This 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 (Rebuilding Plan) (5AAC 07.365; Ward et al. 2003; Bergstrom and Whitmore 2004). During 2007, the designation as stocks of concern was discontinued 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 together to achieve the goals of both the Kuskokwim River Salmon Management Plan (5 AAC 07.365) and the Federal Subsistence Fishery Management program. In addition to the goals set by

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the Department, the Service, and the Working Group, the Alaska National Interest Lands Conservation Act (ANILCA) mandates that salmon populations and their habitats be conserved in their natural diversity within the Refuge.

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 (Doug 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 infrequently used 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 used to monitor salmon escapements on the Tuluksak River from 1991–1994. After the 1994 season, the Tuluksak Native Community (TNC) opposed the weir and it was not operated from 1995–2000. Since 2001, TNC and the Service have jointly cooperated in staffing and operating the weir. Objectives of the project during 2008 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.

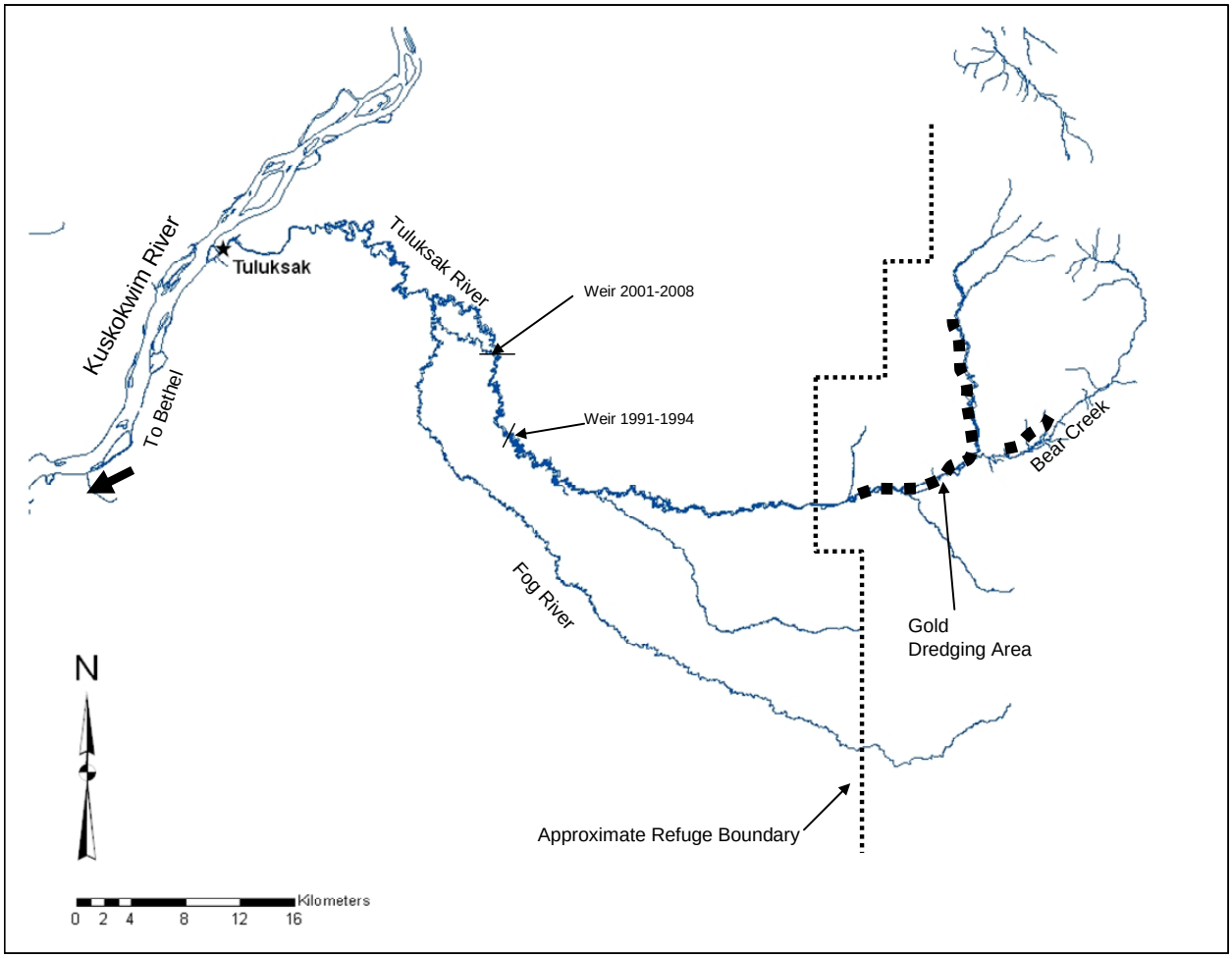

FIGURE 1.—Tuluksak River weir location, Yukon Delta National Wildlife Refuge, 1991–1994 and 2001–2008.

Methods

Weir Operations

A resistance board weir (Tobin 1994) was installed during 2008 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 1991–1994 (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 between 1991 and 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 2008. 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 using a Hobo® recording thermometer.

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 were extracted from Chinook and coho, three from sockeye, and one from chum salmon for age analysis. All scales were taken 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. 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 parent year). The parent 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* ($\mu_{ijk)}$ 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).

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

Days with partial or zero counts were considered incomplete and estimates were calculated for these dates. Estimates were based on the average daily proportion of passage from data collected between 1991–1993 and 2002–2007. An average of the daily proportions for previous years was 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 2008 counts divided by one minus the proportion missed in 2008. Prior years with estimates (1994 and 2001) were not used to calculate the current year estimates.

Genetics

Genetic tissue samples were collected from adult Chinook and pink salmon. Chinook salmon tissue 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 (Olsen et al. 2004; Crane et al. 2007; Liller et al. 2008).

Post-spawn counts

Technicians counted post-spawn salmon and carcasses of dead salmon that washed up on the weir. Counts were to species and the salmon passed downstream. Counts were conducted at the start of the first shift, each subsequent crew change, and the end of the last member's shift resulting in counts at least every four hours or as daylight permitted.

Results

Weir Operations

The crew traveled to the weir site on June 16, but high water conditions delayed installation for several days. The weir was installed by June 29 and operated through September 10. The weir ran smoothly during the entire operational period except for one high water event that flooded the weir and traps on July 9 and 10. Minor repairs were made to damaged weir components during the field season and the weir was removed from the river by September 12, 2008.

Average water depth at the leading edge of the weir during 2008 was 101 cm. The maximum water depth of 201 cm occurred on July 10 and the minimum water depth of 59 cm occurred on September 2 (Appendix 1). Water temperatures ranged from a high of 14°C on July 8 to the low of 8°C on August 8 and 29 (Appendix 1).

Biological Data

Chum Salmon —A total of 12,550 chum salmon was estimated to have passed through the weir between June 29–September 2 (Figure 2, Appendix 2). This total included an actual count of 12,110 plus and estimated passage of 440 chum salmon on July 9 and 10, when high water prevented direct counts. Peak weekly passage (N=3,693) occurred July 13–19 (Figure 2). Median cumulative passage occurred on July 20 for adults passing upstream (Appendix 2) and August 10 for chum salmon carcasses, a span of 21 days. The first chum salmon carcass passed downstream over the weir on July 4 (Figure 3). Gillnet marks were observed on 1% of the ASL sampled chum salmon (N=1,468).

Four age groups (0.2, 0.3, 0.4, and 0.5) were identified from chum salmon scale samples. The predominant age group was 0.4 for both male (82%) and female (77%) chum salmon (Appendix 3). Males comprised over 60% of the run in each strata from June 29–July 26. Females dominated the return after July 26, but comprised only 42% of the total escapement (Figure 4, Appendix 3). Mean length of males was larger in all age groups than that of female chum salmon (Appendix 4).

Chinook Salmon —A total of 701 Chinook salmon was estimated to have passed through the weir between July 1–August 19 (Figure 2, Appendix 2). This total included an actual count of 642 plus an estimated passage of 59 Chinook salmon on July 9 and 10, when high water prevented direct counts. Peak weekly passage (N=286) occurred July 13–19 (Figure 2). Median cumulative passage occurred on July 18 for adults passing upstream (Appendix 2) and August 16 for Chinook salmon carcasses passing downstream, a span of 29 days. The first Chinook salmon carcass passed downstream over the weir on July 7 (Figure 3). Gillnet marks were observed on 7% of ASL sampled Chinook salmon (N=290).

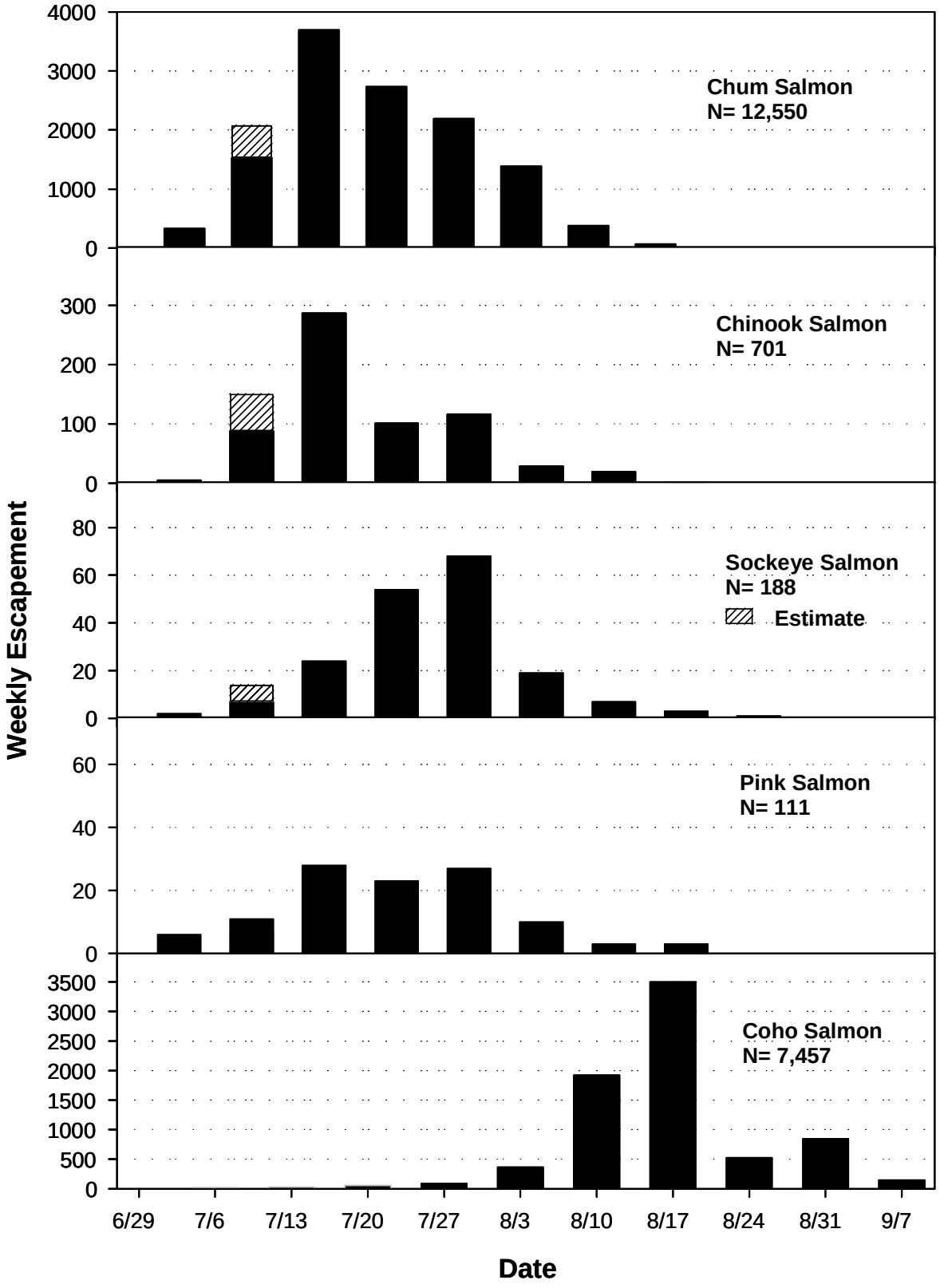

FIGURE 2. —Weekly chum, Chinook, sockeye, pink, and coho salmon escapements through the Tuluksak River weir, 2008. Hash-marked shaded portions of bars represent portions of each week's return that were estimated.

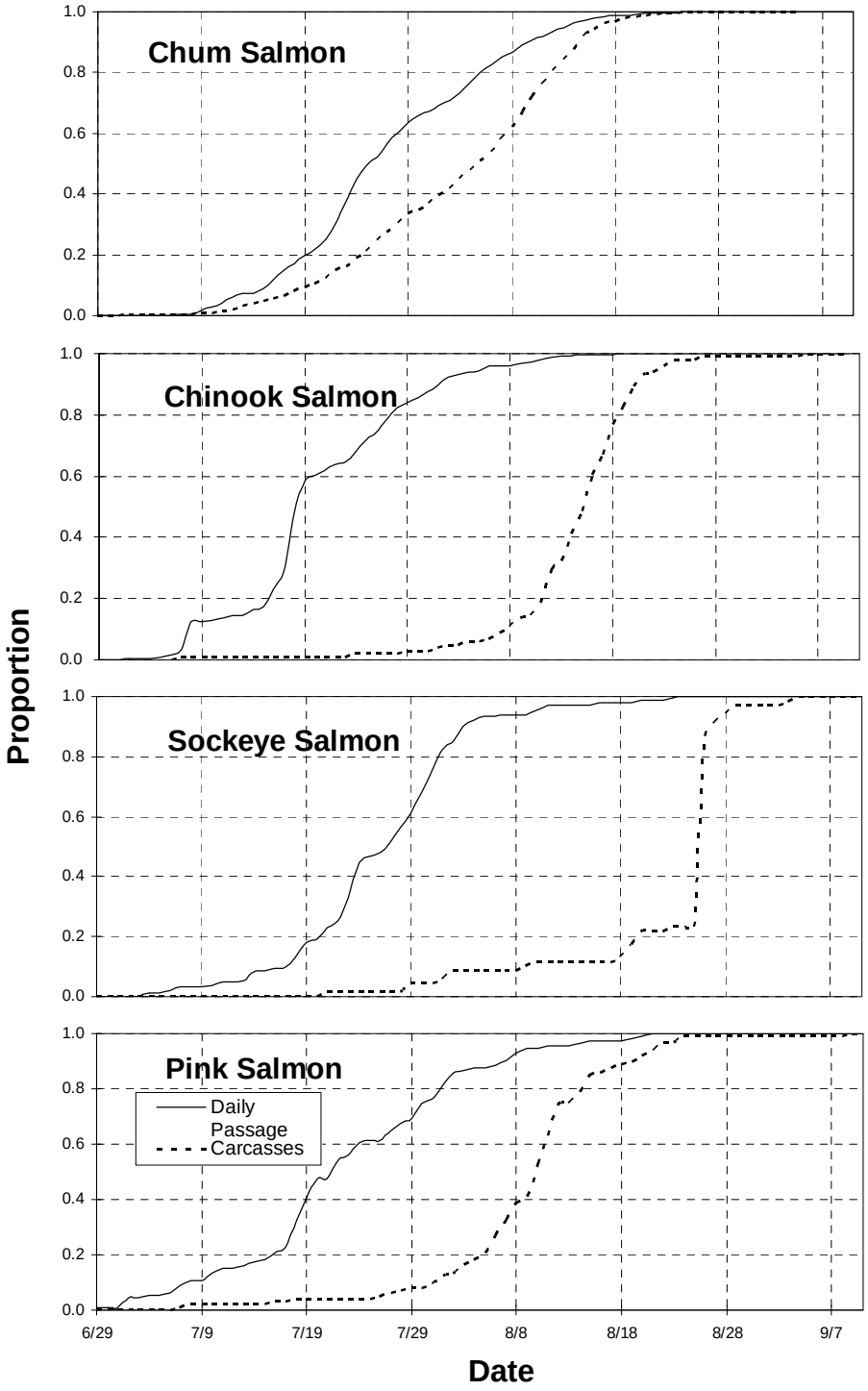

FIGURE 3. —Cumulative proportion of chum, Chinook, sockeye and pink salmon passage and post-spawn salmon or carcasses washing onto the upstream side of the Tuluksak River weir, 2008.

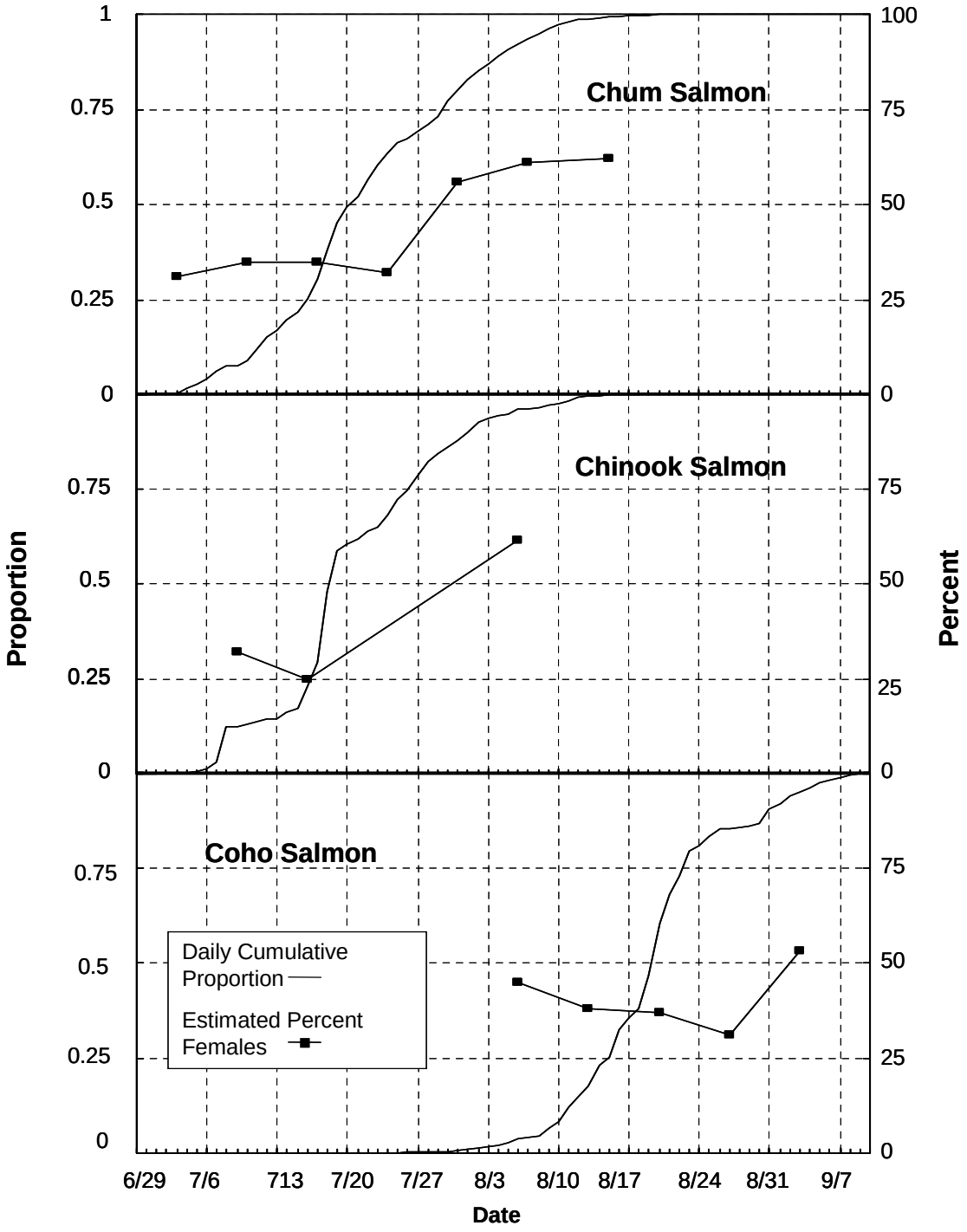

FIGURE 4. —Cumulative proportion and percent females from weekly samples of chum, Chinook, and coho salmon passed through the Tuluksak River weir, 2008.

Six age groups (1.2, 1.3, 2.2, 1.4, 2.3, and 1.5) were identified from Chinook salmon scale samples. The predominant age group was 1.3 for males (67%) and 1.4 (68%) for females (Appendix 5). Age groups 1.2 and 1.3 accounted for 94% of the male Chinook salmon escapement. Females comprised 41% of the Chinook salmon escapement. Sex ratios favored males through mid-July, but then shifted to a dominant female component (Figure 4, Appendix 5). Mean length of females was greater than males in age groups 1.3, 1.4, and 1.5 (Appendix 6).

Sockeye Salmon —A total of 188 sockeye salmon was estimated to have passed through the weir between July 4–August 24 (Figure 2, Appendix 2). This total included an actual count of 181 plus an estimated passage of seven sockeye salmon on July 9 and 10, when high water prevented direct counts. Peak weekly passage for sockeye salmon (N=68) occurred July 27–August 2 (Figure 2). Median cumulative passage occurred on July 27 for adults passing upstream (Appendix 2) and August 26 for sockeye salmon carcasses, a span of 30 days. The first sockeye salmon carcass passed downstream over the weir July 21 (Figure 3). Gillnet marks were observed on 1% of the ASL sampled sockeye salmon (N=149).

Five age groups (1.2, 1.3, 2.2, 1.4, and 2.3) were identified from sockeye salmon scale samples. The predominant age group was 1.3 for both males and females and comprised 69% of the sockeye salmon sample (Appendix 7). Females comprised just over half (54%) of the total sockeye salmon escapement. The mean length of males was greater than females for age groups 1.2, 1.3, and 1.4 (Appendix 8).

Pink Salmon —A total of 111 pink salmon was counted through the weir between June 29–August 21 (Figure 2, Appendix 2). Passage was not estimated for pink salmon during the high water period experienced on July 9 and 10. Peak weekly passage of pink salmon (N=28) occurred July 13–19 (Figure 2). Median cumulative passage occurred on July 22 for adults passing upstream (Appendix 2) and August 10 for pink salmon carcasses, a span of 19 days (Figure 4). A total of 98 pink salmon carcasses passed downstream over the weir between July 7–September 9. No gillnet marks were observed in the pink salmon counted past the weir.

Coho Salmon —A total of 7,457 coho salmon were counted through the weir during 2008 (Figure 2, Appendix 2). The first coho salmon migrated through the weir on July 17 and 26 fish were counted during the last day of operation on September 10. Peak weekly passage of coho salmon (N=3,503) occurred August 17–23 (Figure 2). Median cumulative passage occurred on August 20 (Appendix 2). The first coho salmon carcass to pass downstream over the weir was recorded on August 3. Gillnet marks were observed on 1% of the ASL sampled coho salmon (N=1,087).

Three age groups (1.1, 2.1, and 3.1) were identified from scales of coho salmon (Appendix 9). Age 2.1 was the predominant group for both males (94%) and females (93%). Females comprised 39% of the total escapement and were more prevalent than males in the last strata sampled (Figure 4, Appendix 9). Mean lengths were similar for both male and female coho salmon in each age group (Appendix 10).

Genetics collections

Genetic tissue samples (fin-clips) were collected from live migrating pink salmon (N=56), stored as a bulk sample, and then forwarded to the Department in Bethel. Samples were collected from live migrating Chinook salmon (N=290) and from carcasses (N=208) for a trait heritability study on Tuluksak River Chinook salmon. This collection was shipped to the Conservation Genetics Laboratory in Anchorage.

Resident Species —Resident species counted through the weir consisted of five Dolly Varden *Salvelinus malma*, three whitefish *Coregoninae* spp. and 13 Arctic grayling *Thymallus arcticus*. Although smaller sized resident species were able to pass freely through the pickets, passage through the passage chute was recorded throughout the entire season.

Discussion

Weir Operations

The weir was operated from June 29 through September 10, 2008. High water conditions delayed installation until the last week in June. High water conditions persisted into early July and no fish counts were recorded during a flood event that occurred on July 9 and for a half day on July 10. The substrate rail and cable were left in place after September 10 to expedite the 2009 weir install.

Biological Data

Chum Salmon —The estimated 2008 chum salmon escapement (*N*=12,550) was within the historic range of 7,675 to 35,696 fish (Figure 5), but below an eleven year average (1991–1994 and 2001–2007; *N*=15,965) (Harper 1995a, b, c, Harper 1997; Gates et al 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008). The 2008 escapement was 35% of the record 2005 chum salmon escapement (*N*=35,696). Below average escapement of chum salmon was also recorded at the Kwethluk river weir, another project that monitors escapements into a lower Kuskokwim River tributary. The median passage date for chum salmon occurred on July 20. This passage date was similar to all previous years with the exception of 2003 (Figure 6).

Females comprised 42% of the total chum salmon escapement, which is an increase from that observed (31%) during 2007 (Plumb and Harper 2008). Males predominated during the first four stratum of the run (Figure 4). The dominance of males during the first part of the run is predictable and has occurred every year the weir was operated (Harper 1995a, b, c, Harper 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).

The dominate age during 2008 was 0.4 for chum salmon. This age group represented 80% of the escapement in 2008, which was a substantial increase from the 22% observed in 2007. The strong showing of age 0.4 fish in 2008 was likely due to the predominance of age 0.3 chum salmon observed during 2007 (Plumb and Harper 2008). Age 0.3 chum salmon decreased from 73% in 2007 to only 19% of the return in 2008 (Appendix 3). The return of age 0.4 chum salmon in 2009 will probably be weak based upon the poor showing of age 0.3 fish in 2008. Strong year classes often drive runs in successive years (Van Alen 1999).

Gill net marks (N=64) were observed on <0.5% of the chum salmon passing the weir. This incidence of gill net marks was similar to that observed from 2003–2007 (Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper. 2008) and much lower than the 4% observed in 1992 (Harper 1995c).

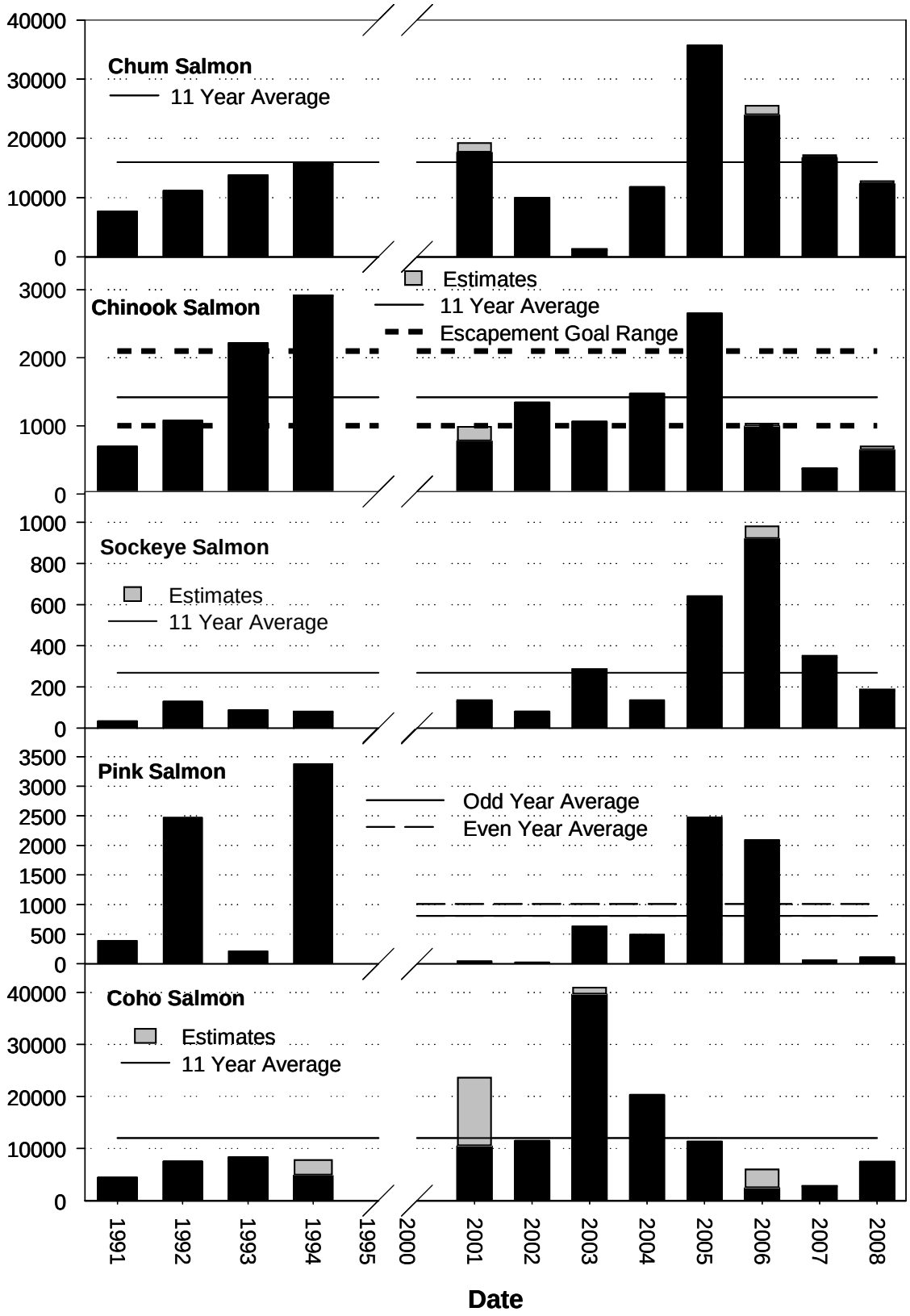

FIGURE 5. —Salmon escapements through the Tuluksak River weir, 1991–1994, and 2001–2008. Averages do not include 2008 and for pink salmon are for years after 2000 when wider picket spacing was used on weir panels.

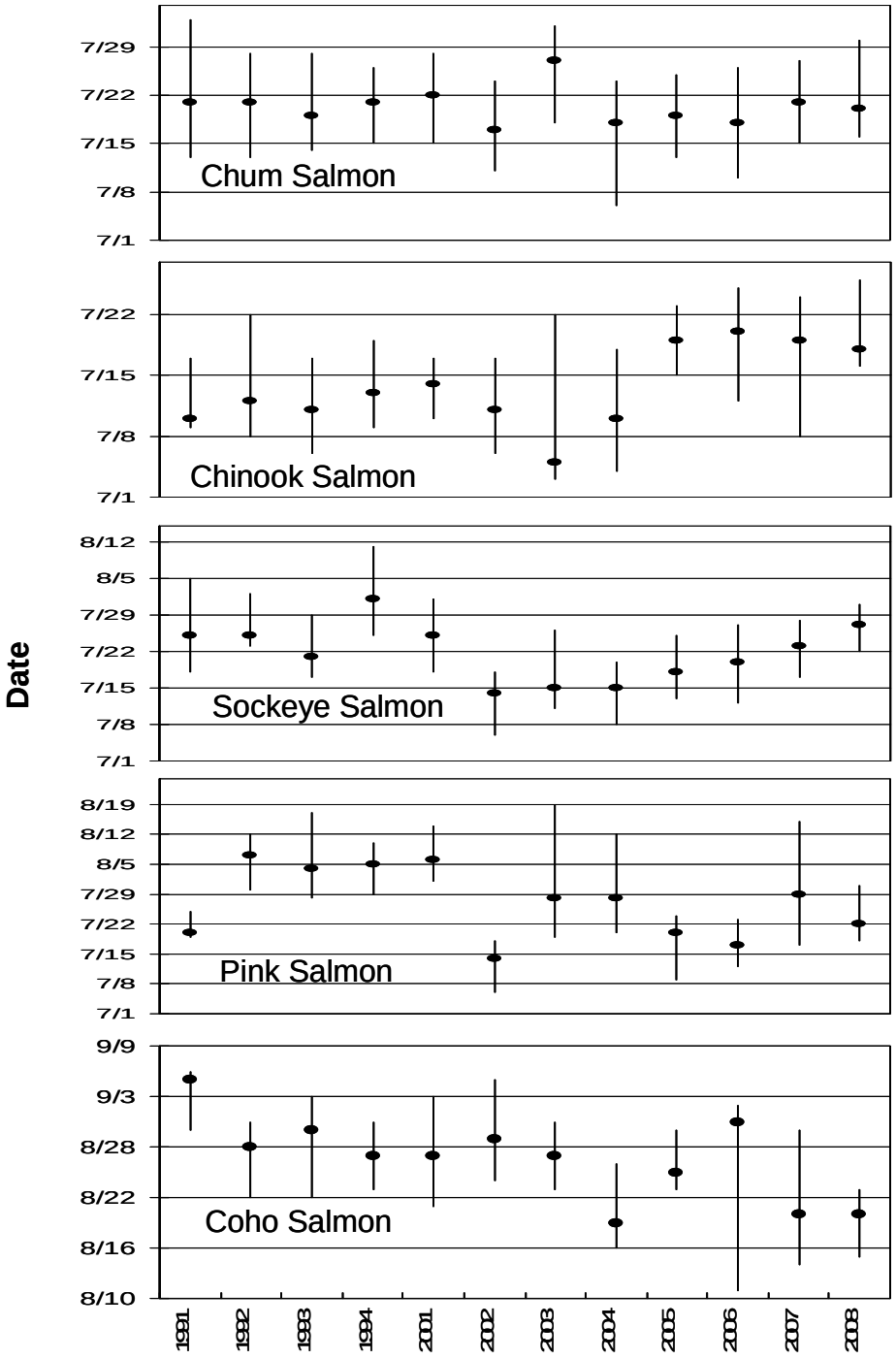

FIGURE 6. —Median cumulative passage for chum, Chinook, sockeye, pink and coho salmon at the Tuluksak River weir, 1991–1994, and 2001–2008. The filled circles represent the median (50%) passage date and the line below and above the circle represent the second and third quartiles respectively.

Chinook Salmon —The estimated Chinook salmon escapement for 2008 (N=701) was the third lowest on record, well below an 11-year average (1991–1994 and 2001– 2007; N=1,401) (Figure 5). The escapement goal range for the Tuluksak River is between 1,000 and 2,100 Chinook salmon and this year's low escapement achieved only 70% of the lower goal. Low returns of Chinook salmon were also observed at other Kuskokwim River escapement projects. Chinook salmon returns to the Kwethluk and George rivers also fell short of meeting the lower end of the escapement goal set for these rivers. The Chinook salmon return to the Tatlawiksuk River was one of the lowest recorded (Doug Molyneaux, Alaska Department of Fish and Game personal communication).

Median passage dates for Chinook salmon have fluctuated from as early as July 5 to as late as July 20. The median passage date for 2008 was July 18, similar to dates observed during 2005–2007 (Figure 6; 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). Reasons for this shift are unknown, but climate and oceanographic changes may be factors.

During 2008, female Chinook salmon comprised 41% of the escapement, near the high end of the range (14–48%) observed during previous years, 1991–1994 and 2001–2007 (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). This is the second consecutive year that females have comprised over 40% of the escapement. The higher incidence of females in the return during the past two years may be attributed to changes in harvest strategies. Observations from a concurrent investigation (FIS-08-351) indicate that some subsistence fishers from Tuluksak have changed to smaller mesh nets (20.5 cm stretch mesh), which selectively harvest a higher percentage of males. Smaller mesh nets (< 20.5cm stretch) were also used in the 2008 commercial fishery that resulted in a harvest of 8,797 Chinook salmon comprised of 90% males (Doug Molyneaux, Alaska Department of Fish and Game personal communications).

The dominant age groups of Chinook salmon in 2008 were 1.2, 1.3, and 1.4, representing 16%, 50%, and 31% of the return, respectively (Appendix 5). This age composition was different from 2007, when these ages represented 13, 26, and 56% of the return. The strong return of age 1.3 Chinook salmon in 2008 may result in a robust return of age 1.4 fish in 2009. Strong year classes often drive runs in successive years (Van Alen 1999).

Sex identification for small Chinook salmon is often difficult to ascertain. Generally, female Chinook salmon returning to the Kuskokwim River are larger than 700 mm. The Department has explored this issue and sampled extensively in the commercial fishery in Bethel, where very few female Chinook salmon less than 700 mm were found (Doug Molyneaux, Alaska Department of Fish 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. Using this data, these small Chinook salmon (<700 mm) in ASL samples have thus been classified as males unless sex products were visible. This classification was further supported during 2008 when 208 carcasses were examined as part of a genetics heritability study. Only five (<2%) female Chinook salmon smaller than 700 mm were found in this sample.

Sockeye Salmon —The estimated escapement of 188 sockeye salmon during 2008 was slightly below the average (N=260) but comparable to returns observed prior to 2003 (Figure 5).

Escapements have ranged from a low of 34 in 1991 to a high of 985 in 2006 (Figure 5). The highest returns occurred in 2005–2006 but have since declined to levels observed prior to those record years.

Median passage dates for sockeye salmon have fluctuated from as early as July 14 to as late as July 30. The median passage date in 2008 was July 27, similar to dates observed during 1991–1992, and 2001 (Figure 6). The earliest median passage date occurred in 2002 and has gradually shifted to a later date each successive year (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). Reasons for this shift are unknown but climate and oceanographic changes may be factors.

Pink Salmon —The number of pink salmon observed during 2008 (N=111) was low compared to 2004 and 2006 (Figure 5). Counts of pink salmon were below the odd and even year averages. The median cumulative passage date, based on fish counted, was July 22, similar to 1991 and 2004. 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. For example, 2008 escapement (N=7,457) was an increase over 2006 and 2007 (Figure 5). Although the 2008 escapement was higher than 2006–2007, it was well below that observed in 2001–2005 and lower than an 11-year average (1991–1994 and 2001–2007; N=11,980). The medium cumulative passage date of August 20 was early, but within the range of dates (August 19–September 5) observed during previous years (Figure 6, Appendix 2). Female coho salmon comprised 39% of the return during 2008, which was within the range (32–58%) observed for females from 1991–2007 (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).

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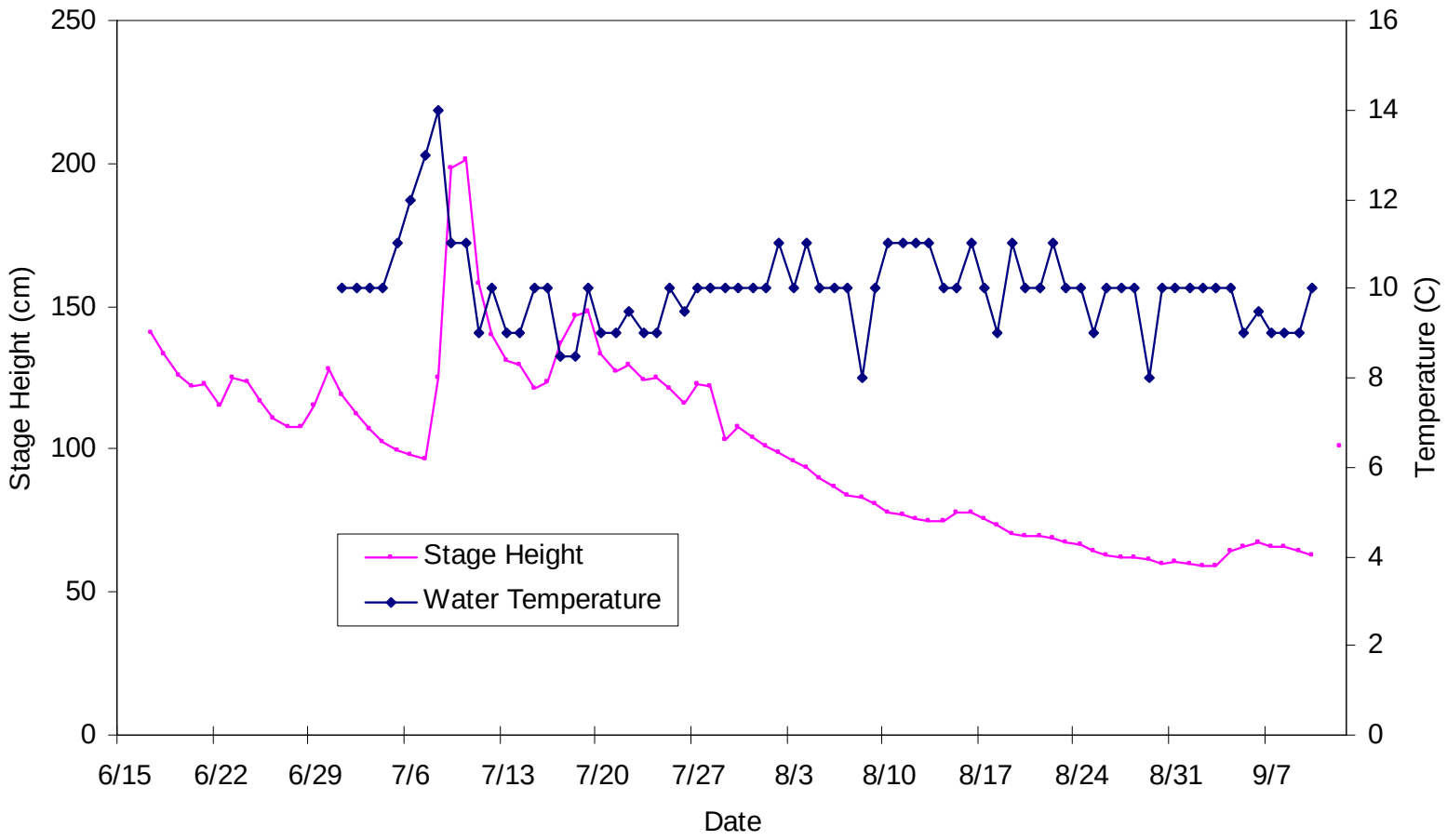

APPENDIX 1. —River stage heights and water temperatures at the Tuluksak River weir, 2008.

APPENDIX 2. —Daily, cumulative, and cumulative proportion of chum, Chinook, sockeye, pink, and coho salmon passing through the Tuluksak River weir, Alaska, 2008. Boxed areas represent the second and third quartile and median passage dates. Passage for chum, Chinook, and sockeye salmon was estimated during high water for July 9 and 10 (shaded area).

	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
06/29	7	7	0.0006	0	0	0.0000	0	0	0.0000	1	1	0.0090	0	0	0.0000
06/30	6	13	0.0010	0	0	0.0000	0	0	0.0000	0	1	0.0090	0	0	0.0000
07/01	11	24	0.0019	1	1	0.0014	0	0	0.0000	0	1	0.0090	0	0	0.0000
07/02	25	49	0.0039	1	2	0.0029	0	0	0.0000	4	5	0.0450	0	0	0.0000
07/03	9	58	0.0046	0	2	0.0029	0	0	0.0000	0	5	0.0450	0	0	0.0000
07/04	136	194	0.0155	1	3	0.0043	2	2	0.0106	1	6	0.0541	0	0	0.0000
07/05	134	328	0.0261	2	5	0.0071	0	2	0.0106	0	6	0.0541	0	0	0.0000
07/06	168	496	0.0395	5	10	0.0143	2	4	0.0213	1	7	0.0631	0	0	0.0000
07/07	258	754	0.0601	11	21	0.0299	2	6	0.0319	3	10	0.0901	0	0	0.0000
07/08	159	913	0.0728	60	81	0.1155	0	6	0.0319	2	12	0.1081	0	0	0.0000
07/09	174	1,087	0.0866	18	99	0.1415	3	9	0.0492	0	12	0.1081	0	0	0.0000
07/10	266	1,353	0.1078	41	140	0.2000	4	13	0.0690	3	15	0.1351	0	0	0.0000
07/11	357	1,710	0.1362	4	144	0.2057	2	15	0.0797	2	17	0.1532	0	0	0.0000
07/12	387	2,097	0.1671	5	149	0.2128	0	15	0.0797	0	17	0.1532	0	0	0.0000
07/13	237	2,334	0.1859	0	149	0.2128	1	16	0.0850	1	18	0.1622	0	0	0.0000
07/14	344	2,678	0.2134	12	161	0.2299	5	21	0.1116	1	19	0.1712	0	0	0.0000
07/15	233	2,911	0.2319	6	167	0.2385	1	22	0.1169	1	20	0.1802	0	0	0.0000
07/16	422	3,333	0.2656	37	204	0.2913	1	23	0.1222	3	23	0.2072	0	0	0.0000
07/17	651	3,984	0.3174	41	245	0.3497	1	24	0.1276	2	25	0.2252	1	1	0.0001
07/18	937	4,921	0.3921	120	365	0.5208	6	30	0.1595	11	36	0.3243	0	1	0.0001
07/19	869	5,790	0.4613	70	435	0.6207	9	39	0.2074	9	45	0.4054	0	1	0.0001
07/20	539	6,329	0.5043	10	445	0.6349	2	41	0.2180	8	53	0.4775	0	1	0.0001
07/21	318	6,647	0.5296	10	455	0.6492	7	48	0.2552	0	53	0.4775	2	3	0.0004
07/22	552	7,199	0.5736	12	467	0.6663	4	52	0.2765	7	60	0.5405	2	5	0.0007
07/23	451	7,650	0.6095	7	474	0.6763	14	66	0.3510	2	62	0.5586	1	6	0.0008
07/24	404	8,054	0.6417	20	494	0.7048	21	87	0.4627	5	67	0.6036	3	9	0.0012
07/25	321	8,375	0.6673	26	520	0.7419	4	91	0.4840	1	68	0.6126	3	12	0.0016
07/26	150	8,525	0.6793	16	536	0.7647	2	93	0.4946	0	68	0.6126	2	14	0.0019
07/27	246	8,771	0.6989	27	563	0.8032	6	99	0.5265	4	72	0.6486	3	17	0.0023
07/28	202	8,973	0.7150	23	586	0.8360	10	109	0.5797	3	75	0.6757	5	22	0.0030
07/29	287	9,260	0.7378	12	598	0.8531	8	117	0.6223	2	77	0.6937	0	22	0.0030
07/30	468	9,728	0.7751	11	609	0.8688	13	130	0.6915	6	83	0.7477	11	33	0.0044
07/31	372	10,100	0.8048	11	620	0.8845	14	144	0.7659	2	85	0.7658	12	45	0.0060
08/01	329	10,429	0.8310	14	634	0.9045	12	156	0.8298	6	91	0.8198	27	72	0.0097
08/02	287	10,716	0.8539	18	652	0.9301	5	161	0.8564	4	95	0.8559	26	98	0.0131

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
08/03	210	10,926	0.8706	6	658	0.9387	9	170	0.9042	1	96	0.8649	28	126	0.0169
08/04	281	11,207	0.8930	5	663	0.9458	4	174	0.9255	1	97	0.8739	29	155	0.0208
08/05	186	11,393	0.9078	3	666	0.9501	2	176	0.9362	0	97	0.8739	38	193	0.0259
08/06	183	11,576	0.9224	8	674	0.9615	0	176	0.9362	1	98	0.8829	78	271	0.0363
08/07	185	11,761	0.9371	1	675	0.9629	1	177	0.9415	2	100	0.9009	44	315	0.0422
08/08	136	11,897	0.9480	1	676	0.9643	0	177	0.9415	3	103	0.9279	31	346	0.0464
08/09	205	12,102	0.9643	4	680	0.9701	0	177	0.9415	2	105	0.9459	145	491	0.0658
08/10	124	12,226	0.9742	4	684	0.9758	3	180	0.9574	0	105	0.9459	114	605	0.0811
08/11	90	12,316	0.9814	3	687	0.9800	3	183	0.9734	1	106	0.9550	306	911	0.1222
08/12	55	12,371	0.9857	7	694	0.9900	0	183	0.9734	0	106	0.9550	192	1,103	0.1479
08/13	29	12,400	0.9880	2	696	0.9929	0	183	0.9734	0	106	0.9550	202	1,305	0.1750
08/14	25	12,425	0.9900	1	697	0.9943	0	183	0.9734	1	107	0.9640	423	1,728	0.2317
08/15	28	12,453	0.9923	2	699	0.9971	0	183	0.9734	1	108	0.9730	151	1,879	0.2520
08/16	24	12,477	0.9942	0	699	0.9971	1	184	0.9787	0	108	0.9730	539	2,418	0.3243
08/17	15	12,492	0.9954	0	699	0.9971	0	184	0.9787	0	108	0.9730	235	2,653	0.3558
08/18	12	12,504	0.9963	0	699	0.9971	0	184	0.9787	0	108	0.9730	181	2,834	0.3800
08/19	18	12,522	0.9978	2	701	1.0000	0	184	0.9787	1	109	0.9820	632	3,466	0.4648
08/20	7	12,529	0.9983	0	701	1.0000	2	186	0.9894	1	110	0.9910	1,044	4,510	0.6048
08/21	12	12,541	0.9993	0	701	1.0000	0	186	0.9894	1	111	1.0000	548	5,058	0.6783
08/22	6	12,547	0.9998	0	701	1.0000	0	186	0.9894	0	111	1.0000	355	5,413	0.7259
08/23	0	12,547	0.9998	0	701	1.0000	1	187	0.9947	0	111	1.0000	508	5,921	0.7940
08/24	0	12,547	0.9998	0	701	1.0000	1	188	1.0000	0	111	1.0000	100	6,021	0.8074
08/25	1	12,548	0.9998	0	701	1.0000	0	188	1.0000	0	111	1.0000	184	6,205	0.8321
08/26	0	12,548	0.9998	0	701	1.0000	0	188	1.0000	0	111	1.0000	140	6,345	0.8509
08/27	0	12,548	0.9998	0	701	1.0000	0	188	1.0000	0	111	1.0000	17	6,362	0.8532
08/28	0	12,548	0.9998	0	701	1.0000	0	188	1.0000	0	111	1.0000	23	6,385	0.8562
08/29	1	12,549	0.9999	0	701	1.0000	0	188	1.0000	0	111	1.0000	19	6,404	0.8588
08/30	0	12,549	0.9999	0	701	1.0000	0	188	1.0000	0	111	1.0000	59	6,463	0.8667
08/31	0	12,549	0.9999	0	701	1.0000	0	188	1.0000	0	111	1.0000	272	6,735	0.9032
09/01	0	12,549	0.9999	0	701	1.0000	0	188	1.0000	0	111	1.0000	112	6,847	0.9182
09/02	1	12,550	1.0000	0	701	1.0000	0	188	1.0000	0	111	1.0000	145	6,992	0.9376
09/03	0	12,550	1.0000	0	701	1.0000	0	188	1.0000	0	111	1.0000	74	7,066	0.9476
09/04	0	12,550	1.0000	0	701	1.0000	0	188	1.0000	0	111	1.0000	80	7,146	0.9583
09/05	0	12,550	1.0000	0	701	1.0000	0	188	1.0000	0	111	1.0000	102	7,248	0.9720
09/06	0	12,550	1.0000	0	701	1.0000	0	188	1.0000	0	111	1.0000	63	7,311	0.9804
09/07	0	12,550	1.0000	0	701	1.0000	0	188	1.0000	0	111	1.0000	43	7,354	0.9862
09/08	0	12,550	1.0000	0	701	1.0000	0	188	1.0000	0	111	1.0000	43	7,397	0.9920
09/09	0	12,550	1.0000	0	701	1.0000	0	188	1.0000	0	111	1.0000	34	7,431	0.9965
09/10	0	12,550	1.0000	0	701	1.0000	0	188	1.0000	0	111	1.0000	26	7,457	1.0000

APPENDIX 3. —Estimated age and sex composition of weekly chum salmon escapements through the Tuluksak River weir, Alaska, 2008, and estimated design effects of the stratified sampling design.

		Brood Year and Age Group				
		2005	2004	2003	2002	
		0.2	0.3	0.4	0.5	Total
Stratum 1:	06/29 - 07/05					
Sampling Dates:	06/30 - 07/05					
Male:	Number in Sample:	0	1	119	8	128
	Estimated % of Escapement:	0.0	0.5	64.3	4.3	69.2
	Estimated Escapement:	0	2	211	14	227
	Standard Error:	0.0	1.2	7.6	3.2	
Female:	Number in Sample:	0	3	49	5	57
	Estimated % of Escapement:	0.0	1.6	26.5	2.7	30.8
	Estimated Escapement:	0	5	87	9	101
	Standard Error:	0.0	2.0	7.0	2.6	
Total:	Number in Sample:	0	4	168	13	185
	Estimated % of Escapement:	0.0	2.2	90.8	7.0	100.0
	Estimated Escapement:	0	7	298	23	328
	Standard Error:	0.0	2.3	4.6	4.1	
Stratum 2:	07/06 - 07/12					
Sampling Dates:	07/06 - 07/07					
Male:	Number in Sample:	1	1	105	4	111
	Estimated % of Escapement:	0.6	0.6	61.8	2.4	65.3
	Estimated Escapement:	9	9	941	36	995
	Standard Error:	8.4	8.4	53.7	16.7	
Female:	Number in Sample:	0	2	53	4	59
	Estimated % of Escapement:	0.0	1.2	31.2	2.4	34.7
	Estimated Escapement:	0	18	475	36	529
	Standard Error:	0.0	11.9	51.2	16.7	
Total:	Number in Sample:	1	3	158	8	170
	Estimated % of Escapement:	0.6	1.8	92.9	4.7	100.0
	Estimated Escapement:	9	27	1,416	72	1,524
	Standard Error:	8.4	14.5	28.3	23.4	
Stratum 3:	07/13 - 07/19					
Sampling Dates:	07/13 - 07/14					
Male:	Number in Sample:	1	10	102	5	118
	Estimated % of Escapement:	0.6	5.5	56.4	2.8	65.2
	Estimated Escapement:	20	204	2,081	102	2,408
	Standard Error:	19.9	61.3	133.1	44.0	
Female:	Number in Sample:	0	6	54	3	63
	Estimated % of Escapement:	0.0	3.3	29.8	1.7	34.8
	Estimated Escapement:	0	122	1,102	61	1,285
	Standard Error:	0.0	48.1	122.8	34.3	
Total:	Number in Sample:	1	16	156	8	181
	Estimated % of Escapement:	0.6	8.8	86.2	4.4	100.0
	Estimated Escapement:	20	326	3,183	163	3,693
	Standard Error:	19.9	76.2	92.6	55.2	

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		Brood Year and Age Group				
		2005	2004	2003	2002	
		0.2	0.3	0.4	0.5	Total
Stratum 4:	07/20 - 07/26					
Sampling Date:	07/21					
Male:	Number in Sample:	1	19	101	8	129
	Estimated % of Escapement:	0.5	10.0	53.2	4.2	67.9
	Estimated Escapement:	14	274	1,454	115	1,857
	Standard Error:	13.9	57.6	95.8	38.5	
Female:	Number in Sample:	0	13	45	3	61
	Estimated % of Escapement:	0.0	6.8	23.7	1.6	32.1
	Estimated Escapement:	0	187	648	43	878
	Standard Error:	0.0	48.5	81.6	23.9	
Total:	Number in Sample:	1	32	146	11	190
	Estimated % of Escapement:	0.5	16.8	76.8	5.8	100.0
	Estimated Escapement:	14	461	2,102	158	2,735
	Standard Error:	13.9	71.8	81.0	44.8	
Stratum 5:	07/27 - 08/02					
Sampling Date:	07/27					
Male:	Number in Sample:	1	20	53	2	76
	Estimated % of Escapement:	0.6	11.6	30.6	1.2	43.9
	Estimated Escapement:	13	253	671	25	963
	Standard Error:	12.2	51.3	73.9	17.1	
Female:	Number in Sample:	2	24	68	3	97
	Estimated % of Escapement:	1.2	13.9	39.3	1.7	56.1
	Estimated Escapement:	25	304	861	38	1,228
	Standard Error:	17.1	55.4	78.3	20.9	
Total:	Number in Sample:	3	44	121	5	173
	Estimated % of Escapement:	1.7	25.4	69.9	2.9	100.0
	Estimated Escapement:	38	557	1,532	63	2,191
	Standard Error:	20.9	69.8	73.5	26.9	
Stratum 6:	08/03 - 08/09					
Sampling Dates:	08/03 - 08/04					
Male:	Number in Sample:	1	17	52	1	71
	Estimated % of Escapement:	0.5	9.3	28.4	0.5	38.8
	Estimated Escapement:	8	129	394	8	538
	Standard Error:	7.1	27.8	43.2	7.1	
Female:	Number in Sample:	0	31	79	2	112
	Estimated % of Escapement:	0.0	16.9	43.2	1.1	61.2
	Estimated Escapement:	0	235	598	15	848
	Standard Error:	0.0	35.9	47.4	10.0	
Total:	Number in Sample:	1	48	131	3	183
	Estimated % of Escapement:	0.5	26.2	71.6	1.6	100.0
	Estimated Escapement:	8	364	992	23	1,386
	Standard Error:	7.1	42.1	43.2	12.2	

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		Brood Year and Age Group				
		2005	2004	2003	2002	
		0.2	0.3	0.4	0.5	Total
Strata 7 - 10:	08/10 - 09/06					
Sampling Dates:	08/10 - 08/17					
Male:	Number in Sample:	0	26	48	7	81
	Estimated % of Escapement:	0.0	12.1	22.4	3.3	37.9
	Estimated Escapement:	0	54	100	15	170
	Standard Error:	0.0	7.2	9.3	3.9	
Female:	Number in Sample:	1	46	83	3	133
	Estimated % of Escapement:	0.5	21.5	38.8	1.4	62.1
	Estimated Escapement:	2	96	174	6	278
	Standard Error:	1.5	9.1	10.8	2.6	
Total:	Number in Sample:	1	72	131	10	214
	Estimated % of Escapement:	0.5	33.6	61.2	4.7	100.0
	Estimated Escapement:	2	151	274	21	448
	Standard Error:	1.5	10.5	10.8	4.7	
Strata 1 - 10:	06/29 - 09/06					
Sampling Dates:	06/30 - 08/17					
Male:	Number in Sample:	5	94	580	35	714
	% Males in Age Group:	0.9	12.9	81.8	4.4	100.0
	Estimated % of Escapement:	0.5	7.5	47.6	2.6	58.2
	Estimated Escapement:	64	925	5,853	315	7,156
	Standard Error:	29.3	103.0	193.0	63.8	
	Estimated Design Effects:	1.523	1.408	1.376	1.502	1.359
Female:	Number in Sample:	3	125	431	23	582
	% Females in Age Group:	0.5	18.8	76.6	4.1	100.0
	Estimated % of Escapement:	0.2	7.9	32.1	1.7	41.8
	Estimated Escapement:	27	968	3,945	209	5,149
	Standard Error:	17.2	96.2	181.4	50.8	
	Estimated Design Effects:	1.244	1.192	1.396	1.429	1.359
Total:	Number in Sample:	8	219	1,011	58	1,296
	Estimated % of Escapement:	0.7	15.4	79.6	4.3	100
	Estimated Escapement:	91	1,893	9,798	523	12,305
	Standard Error:	33.9	133.9	152.8	80.7	
	Estimated Design Effects:	1.439	1.278	1.331	1.472	

APPENDIX 4. —Estimated length at age composition of weekly chum salmon escapements through the Tuluksak River weir, Alaska, 2008.

		Brood Year and Age Group			
		2005	2004	2003	2002
		0.2	0.3	0.4	0.5
Stratum 1:	06/29 - 07/05				
Sampling Dates:	06/30 - 07/05				
Male:	Mean Length		565	586	593
	Std. Error			2	9
	Range		-	520 - 670	560 - 640
	Sample Size	0	1	119	8
Female:	Mean Length		545	561	556
	Std. Error		23	3	13
	Range		515 - 590	490 - 595	520 - 585
	Sample Size	0	3	49	5
Stratum 2:	07/06 - 07/12				
Sampling Dates:	07/06 - 07/07				
Male:	Mean Length	565	590	590	584
	Std. Error			2	13
	Range	-	-	530 - 650	555 - 610
	Sample Size	1	1	105	4
Female:	Mean Length		558	564	568
	Std. Error		38	3	9
	Range		520 - 595	520 - 620	550 - 590
	Sample Size	0	2	53	4
Stratum 3:	07/13 - 07/19				
Sampling Dates:	07/13 - 07/14				
Male:	Mean Length	530	573	582	609
	Std. Error		8	3	21
	Range	-	540 - 625	525 - 660	555 - 660
	Sample Size	1	10	102	5
Female:	Mean Length		550	563	578
	Std. Error		10	3	7
	Range		515 - 590	505 - 605	565 - 590
	Sample Size	0	6	54	3
Stratum 4:	07/20 - 07/26				
Sampling Date:	07/21				
Male:	Mean Length	565	559	582	590
	Std. Error		6	3	12
	Range	-	510 - 610	525 - 670	540 - 650
	Sample Size	1	19	101	8
Female:	Mean Length		546	561	560
	Std. Error		6	3	13
	Range		500 - 585	500 - 605	535 - 580
	Sample Size	0	13	45	3

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		Brood Year and Age Group			
		2005	2004	2003	2002
		0.2	0.3	0.4	0.5
Stratum 5:	07/27 - 08/02				
Sampling Date:	07/27				
Male:	Mean Length	555	553	589	570
	Std. Error		7	5	20
	Range	-	505 - 640	540 - 685	550 - 590
	Sample Size	1	20	53	2
Female:	Mean Length	500	538	556	543
	Std. Error		6	3	19
	Range	-	490 - 600	515 - 610	510 - 575
	Sample Size	2	24	68	3
Stratum 6:	08/03 - 08/09				
Sampling Dates:	08/03 - 08/04				
Male:	Mean Length	515	552	560	560
	Std. Error		6	4	
	Range	-	505 - 590	485 - 615	-
	Sample Size	1	17	52	1
Female:	Mean Length		528	535	525
	Std. Error		4	3	5
	Range		490 - 565	490 - 595	520 - 530
	Sample Size	0	31	79	2
Strata 7 - 10:	08/10 - 09/06				
Sampling Dates:	08/10 - 08/17				
Male:	Mean Length		548	551	556
	Std. Error		5	6	13
	Range		470 - 590	465 - 635	520 - 610
	Sample Size	0	26	48	7
Female:	Mean Length	520	523	526	535
	Std. Error		3	3	5
	Range	-	480 - 580	455 - 595	525 - 540
	Sample Size	1	46	83	3
Strata 1 - 10:	06/29 - 09/06				
Sampling Dates:	06/30 - 08/17				
Male:	Mean Length	546	559	582	592
	Std. Error		3	1	9
	Range	515 - 565	470 - 640	465 - 685	520 - 660
	Sample Size	5	94	580	35
Female:	Mean Length	502	537	555	560
	Std. Error		3	1	5
	Range	500 - 520	480 - 600	455 - 620	510 - 590
	Sample Size	3	125	431	23

APPENDIX 5. —Estimated age and sex composition of weekly Chinook salmon escapements through the Tuluksak River weir, Alaska, 2008, and estimated design effects of the stratified sampling design.

		Brood Year and Age Group						
		2004	2003		2002		2001	
		1.2	1.3	2.2	1.4	2.3	1.5	Total
Strata 1 - 2:	06/29 - 07/12							
Sampling Dates:	07/01, 07/02, 07/04, 07/06 - 07/08							
Male:	Number in Sample:	3	10	0	2	0	0	15
	Estimated % of Escapement:	13.6	45.5	0.0	9.1	0.0	0.0	68.2
	Estimated Escapement:	13	42	0	8	0	0	63
	Standard Error:	6.1	8.8	0.0	5.1	0.0	0.0	
Female:	Number in Sample:	0	1	0	5	0	1	7
	Estimated % of Escapement:	0.0	4.5	0.0	22.7	0.0	4.5	31.8
	Estimated Escapement:	0	4	0	21	0	4	30
	Standard Error:	0.0	3.7	0.0	7.4	0.0	3.7	
Total:	Number in Sample:	3	11	0	7	0	1	22
	Estimated % of Escapement:	13.6	50.0	0.0	31.8	0.0	4.5	100.0
	Estimated Escapement:	13	47	0	30	0	4	93
	Standard Error:	6.1	8.9	0.0	8.3	0.0	3.7	
Stratum 3:	07/13 - 07/19							
Sampling Dates:	07/14 - 07/17							
Male:	Number in Sample:							
	Estimated % of Escapement:	6	12	0	0	0	0	18
	Estimated Escapement:	25.0	50.0	0.0	0.0	0.0	0.0	75.0
	Standard Error:	72	143	0	0	0	0	215
		24.7	28.5	0.0	0.0	0.0	0.0	
Female:	Number in Sample:							
	Estimated % of Escapement:	0	1	0	5	0	0	6
	Estimated Escapement:	0.0	4.2	0.0	20.8	0.0	0.0	25.0
	Standard Error:	0	12	0	60	0	0	72
		0.0	11.4	0.0	23.2	0.0	0.0	
Total:	Number in Sample:							
	Estimated % of Escapement:	6	13	0	5	0	0	24
	Estimated Escapement:	25.0	54.2	0.0	20.8	0.0	0.0	100.0
	Standard Error:	72	155	0	60	0	0	286
		24.7	28.4	0.0	23.2	0.0	0.0	

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		Brood Year and Age Group						
		2004	2003		2002		2001	
		1.2	1.3	2.2	1.4	2.3	1.5	Total
Strata 4 - 8:	07/20 - 08/23							
Sampling Dates:	07/21 - 08/08, 08/10 - 08/15, 08/19							
Male:	Number in Sample:	14	54	1	10	0	1	80
	Estimated % of Escapement:	6.8	26.1	0.5	4.8	0.0	0.5	38.6
	Estimated Escapement:	18	69	1	13	0	1	103
	Standard Error:	2.2	3.8	0.6	1.9	0.0	0.6	
Female:	Number in Sample:	0	41	0	77	0	9	127
	Estimated % of Escapement:	0.0	19.8	0.0	37.2	0.0	4.3	61.4
	Estimated Escapement:	0	53	0	99	0	12	163
	Standard Error:	0.0	3.5	0.0	4.2	0.0	1.8	
Total:	Number in Sample:	14	95	1	87	0	10	207
	Estimated % of Escapement:	6.8	45.9	0.5	42.0	0.0	4.8	100.0
	Estimated Escapement:	18	122	1	112	0	13	266
	Standard Error:	2.2	4.3	0.6	4.3	0.0	1.9	
Strata 1 - 8:	06/29 - 08/23							
Sampling Dates:	07/01 - 08/19							
Male:	Number in Sample:	23	76	1	12	0	1	113
	% Males in Age Group:	26.8	66.9	0.3	5.6	0.0	0.3	100.0
	Estimated % of Escapement:	15.8	39.5	0.2	3.3	0.0	0.2	59.0
	Estimated Escapement:	102	255	1	21	0	1	381
	Standard Error:	25.5	30.1	0.6	5.4	0.0	0.6	
	Estimated Design Effects:	3.349	2.681	0.503	0.945	0.000	0.503	2.098
Female:	Number in Sample:	0	43	0	87	0	10	140
	% Females in Age Group:	0.0	26.0	0.0	68.0	0.0	6.0	100.0
	Estimated % of Escapement:	0.0	10.7	0.0	27.9	0.0	2.4	41.0
	Estimated Escapement:	0	69	0	180	0	16	264
	Standard Error:	0.0	12.5	0.0	24.7	0.0	4.1	
	Estimated Design Effects:	0.000	1.363	0.000	2.228	0.000	0.815	2.098
Total:	Number in Sample:	23	119	1	99	0	11	253
	Estimated % of Escapement:	15.8	50.2	0.2	31.2	0.0	2.6	100.0
	Estimated Escapement:	102.2	323.5	1.3	201.0	0.0	17.1	645.0
	Standard Error:	26	30	1	25	0	4	
	Estimated Design Effects:	3.3	2.6	0.5	2.1	0.0	0.8	

APPENDIX 6. —Estimated length at age composition of weekly Chinook salmon escapements through the Tuluksak River weir, Alaska, 2008.

		Brood Year and Age Group					
		2004	2003		2002		2001
		1.2	1.3	2.2	1.4	2.3	1.5
Strata 1 - 2:	06/29 - 07/12						
Sampling Dates:	07/01, 07/02, 07/04, 07/06 - 07/08						
Male:	Mean Length	508	659		843		
	Std. Error	29	31		48		
	Range	470 - 565	470 - 750		795 - 890		
	Sample Size	3	10	0	2	0	0
Female:	Mean Length		705		825		885
	Std. Error				24		
	Range		-		750 - 880		-
	Sample Size	0	1	0	5	0	1
Stratum 3:	07/13 - 07/19						
Sampling Dates:	07/14 - 07/17						
Male:	Mean Length	540	715				
	Std. Error	17	22				
	Range	480 - 590	625 - 890				
	Sample Size	6	12	0	0	0	0
Female:	Mean Length		730		839	620	
	Std. Error				21		
	Range		-		805 - 905	-	
	Sample Size	0	1	0	5	1	0

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		Brood Year and Age Group					
		2004	2003		2002		2001
		1.2	1.3	2.2	1.4	2.3	1.5
Strata 4 - 8:	07/20-08/23						
Sampling Dates:	07/21 - 08/08, 08/10 - 08/15, 08/19						
Male:	Mean Length	509	727	600	761		755
	Std. Error	15	10		25		
	Range	420 - 580	515 - 905	-	630 - 920		-
	Sample Size	14	54	1	10	0	1
Female:	Mean Length		790		860	745	896
	Std. Error		8		6		15
	Range		690- 890		750- 970	-	810- 950
	Sample Size	0	41	0	77	1	9
Strata 1 - 8:	06/29 - 08/23						
Sampling Dates:	07/01 - 08/19						
Male:	Mean Length	531	709	600	793		755
	Std. Error	12	14		24		
	Range	420 - 590	470 - 905	-	630 - 920	0	-
	Sample Size	23	76	1	12		1
Female:	Mean Length		774		849	631	893
	Std. Error		8		8		15
	Range		690 - 890		750 - 970	620 - 745	810 - 950
	Sample Size	0	43	0	87	2	10

APPENDIX 7. —Estimated age and sex composition of sockeye salmon escapements through the Tuluksak River weir, Alaska, 2008, and estimated design effects of the stratified sampling design.

		Brood Year and Age Group					
		2004	2003		2002		
		1.2	1.3	2.2	1.4	2.3	Total
Strata 1 - 9:	06/29 - 08/30						
Sampling Dates:	07/03 - 08/24						
Male:	Number in Sample:	15	61	2	8	0	86
	Estimated % of Escapement:	8.1	33.0	1.1	4.3	0.0	46.5
	Estimated Escapement:	15	60	2	8	0	85
Female:	Number in Sample:	14	66	0	15	4	99
	Estimated % of Escapement:	7.6	35.7	0.0	8.1	2.2	53.5
	Estimated Escapement:	14	65	0	15	4	97
Total:	Number in Sample:	29	127	2	23	4	185
	Estimated % of Escapement:	15.7	68.6	1.1	12.4	2.2	100.0
	Estimated Escapement:	29	125	2	23	4	182

APPENDIX 8. —Estimated length at age composition of weekly sockeye salmon escapements through the Tuluksak River weir, Alaska, 2008.

		Brood Year and Age Group				
		2004	2003		2002	
		1.2	1.3	2.2	1.4	2.3
Strata 1 - 9:	06/29 - 08/30					
Sampling Dates:	07/03 - 08/24					
Male:	Mean Length	525	577	580	589	
	Std. Error	17	5		7	
	Range	460 - 600	520 - 620	-	570 - 600	
	Sample Size	7	30	1	4	0
Female:	Mean Length	511	543		546	553
	Std. Error	11	4		11	7
	Range	450 - 530	490 - 595		510 - 600	545 - 560
	Sample Size	7	32	0	7	2

APPENDIX 9. —Estimated age and sex composition of weekly coho salmon escapements through the Tuluksak River weir, Alaska, 2008, and estimated design effects of the stratified sampling design.

		Brood Year and Age Group			
		2005	2004	2003	
		1.1	2.1	3.1	Total
Strata 3 - 6:	07/13 - 08/09				
Sampling Dates:	07/17, 07/21, 07/28 - 07/31, 08/07				
Male:	Number in Sample:	2	116	5	123
	Estimated % of Escapement:	0.9	52.0	2.2	55.2
	Estimated Escapement:	4	255	11	271
	Standard Error:	2.3	12.2	3.6	
Female:	Number in Sample:	0	99	1	100
	Estimated % of Escapement:	0.0	44.4	0.4	44.8
	Estimated Escapement:	0	218	2	220
	Standard Error:	0.0	12.1	1.6	
Total:	Number in Sample:	2	215	6	223
	Estimated % of Escapement:	0.9	96.4	2.7	100.0
	Estimated Escapement:	4	473	13	491
	Standard Error:	2.3	4.5	3.9	
Stratum 7:	08/10 - 08/16				
Sampling Dates:	08/10 - 8/11				
Male:	Number in Sample:	1	90	7	98
	Estimated % of Escapement:	0.6	57.0	4.4	62.0
	Estimated Escapement:	12	1,098	85	1,195
	Standard Error:	11.7	73.0	30.3	
Female:	Number in Sample:	0	56	4	60
	Estimated % of Escapement:	0.0	35.4	2.5	38.0
	Estimated Escapement:	0	683	49	732
	Standard Error:	0.0	70.5	23.1	
Total:	Number in Sample:	1	146	11	158
	Estimated % of Escapement:	0.6	92.4	7.0	100.0
	Estimated Escapement:	12	1,781	134	1,927
	Standard Error:	11.7	39.0	37.5	
Stratum 8:	08/17 - 08/23				
Sample Date:	08/17				
Male:	Number in Sample:	0	100	5	105
	Estimated % of Escapement:	0.0	60.2	3.0	63.3
	Estimated Escapement:	0	2,110	106	2,216
	Standard Error:	0.0	130.3	45.5	
Female:	Number in Sample:	0	57	4	61
	Estimated % of Escapement:	0.0	34.3	2.4	36.7
	Estimated Escapement:	0	1,203	84	1,287
	Standard Error:	0.0	126.4	40.8	
Total:	Number in Sample:	0	157	9	166
	Estimated % of Escapement:	0.0	94.6	5.4	100.0
	Estimated Escapement:	0	3,313	190	3,503
	Standard Error:	0.0	60.3	60.3	

APPENDIX 9. —(Page 2 of 2)

		Brood Year and Age Group			
		2005	2004	2003	
		1.1	2.1	3.1	Total
Stratum 9:	08/24 - 08/30				
Sampling Dates:	08/24 - 08/25				
Male:	Number in Sample:	3	104	7	114
	Estimated % of Escapement:	1.8	62.7	4.2	68.7
	Estimated Escapement:	10	340	23	372
	Standard Error:	4.7	17.0	7.1	
Female:	Number in Sample:	0	48	4	52
	Estimated % of Escapement:	0.0	28.9	2.4	31.3
	Estimated Escapement:	0	157	13	170
	Standard Error:	0.0	15.9	5.4	
Total:	Number in Sample:	3	152	11	166
	Estimated % of Escapement:	1.8	91.6	6.6	100.0
	Estimated Escapement:	10	496	36	542
	Standard Error:	4.7	9.8	8.7	
Strata 10 - 11:	08/31 - 09/10				
Sample Date:	08/31				
Male:	Number in Sample:	2	71	5	78
	Estimated % of Escapement:	1.2	43.0	3.0	47.3
	Estimated Escapement:	12	428	30	470
	Standard Error:	7.8	35.1	12.2	
Female:	Number in Sample:	0	77	10	87
	Estimated % of Escapement:	0.0	46.7	6.1	52.7
	Estimated Escapement:	0	464	60	524
	Standard Error:	0.0	35.4	16.9	
Total:	Number in Sample:	2	148	15	165
	Estimated % of Escapement:	1.2	89.7	9.1	100.0
	Estimated Escapement:	12	892	90	994
	Standard Error:	7.8	21.5	20.4	
Strata 3 - 11:	07/13 - 09/10				
Sampling Dates:	07/17 - 08/31				
Male:	Number in Sample:	8	481	29	518
	% Males in Age Group:	0.8	93.5	5.6	100.0
	Estimated % of Escapement:	0.5	56.7	3.4	60.7
	Estimated Escapement:	38	4,231	255	4,524
	Standard Error:	15.0	154.8	56.6	
	Estimated Design Effects:	0.806	1.656	1.647	1.653
Female:	Number in Sample:	0	337	23	360
	% Females in Age Group:	0.0	92.9	7.1	100.0
	Estimated % of Escapement:	0.0	36.5	2.8	39.3
	Estimated Escapement:	0	2,724	209	2,933
	Standard Error:	0.0	150.3	50.2	
	Estimated Design Effects:	0.000	1.654	1.578	1.653
Total:	Number in Sample:	8	818	52	878
	Estimated % of Escapement:	0.5	93.3	6.2	100.0
	Estimated Escapement:	38	6,955	464	7,457
	Standard Error:	15.0	75.7	74.5	
	Estimated Design Effects:	0.806	1.559	1.618	

APPENDIX 10. —Estimated length at age composition of weekly coho salmon escapements through the Tuluksak River weir, Alaska, 2008.

		Brood Year and Age Group		
		2005	2004	2003
		1.1	2.1	3.1
Strata 3 - 6:	07/13 - 08/09			
Sampling Dates:	07/17, 07/21 - 07/28, 07/31 - 08/07			
Male:	Mean Length	513	537	538
	Std. Error	3	3	16
	Range	510 - 515	405 - 620	480 - 570
	Sample Size	2	116	5
Female:	Mean Length		534	550
	Std. Error		3	
	Range		395 - 590	-
	Sample Size	0	99	1
Stratum 7:	08/10 - 08/16			
Sampling Dates:	08/10 - 08/11			
Male:	Mean Length	510	531	531
	Std. Error		4	13
	Range	-	430 - 620	485 - 580
	Sample Size	1	90	7
Female:	Mean Length		544	529
	Std. Error		3	12
	Range		500 - 590	495 - 550
	Sample Size	0	56	4
Stratum 8:	08/17 - 08/23			
Sample Date:	08/17			
Male:	Mean Length		547	562
	Std. Error		4	22
	Range		440 - 620	500 - 615
	Sample Size	0	100	5
Female:	Mean Length		546	556
	Std. Error		3	7
	Range		445 - 595	540 - 575
	Sample Size	0	57	4

APPENDIX 10. —(Page 2 of 2)

		Brood Year and Age Group		
		2005	2004	2003
		1.1	2.1	3.1
Stratum 9:	08/24 - 08/30			
Sampling Dates:	08/24 - 08/25			
Male:	Mean Length	538	554	561
	Std. Error	14	4	15
	Range	510 - 555	400 - 630	500 - 620
	Sample Size	3	104	7
Female:	Mean Length		550	543
	Std. Error		4	19
	Range		480 - 610	490 - 580
	Sample Size	0	48	4
Strata 10 - 11:	08/31 - 09/10			
Sample Date:	08/31			
Male:	Mean Length	570	557	562
	Std. Error	30	4	11
	Range	540 - 600	470 - 640	530 - 590
	Sample Size	2	71	5
Female:	Mean Length		558	551
	Std. Error		3	11
	Range		490 - 610	515 - 630
	Sample Size	0	77	10
Strata 3 - 11:	07/13 - 09/10			
Sampling Dates:	07/17 - 08/31			
Male:	Mean Length	536	544	550
	Std. Error	15	2	10
	Range	510 - 600	400 - 640	480 - 620
	Sample Size	8	481	29
Female:	Mean Length		547	547
	Std. Error		2	5
	Range		395 - 610	490 - 630
	Sample Size	0	337	23