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Abundance and Run Timing of Adult Pacific Salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2010

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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 27 to September 7, 2010, a resistance board weir was utilized to collect abundance, run timing, age, sex, and length data from returning adult salmon. In conjunction with the weir, an underwater video system was affixed and utilized to collect abundance from July 19 to September 7, 2010. The addition of video methods proved successful in the enumeration and speciation of migrating fish. 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 2010, an estimated 13,042 chum salmon *Oncorhynchus keta*, 201 Chinook salmon *O. tshawytscha*, 437 sockeye salmon *O. nerka*, 95 pink salmon *O. gorbuscha,* and 1,526 coho salmon *O. kisutch* passed through the Tuluksak River weir. Peak weekly passage occurred July 11–17 for chum, July 18–24 for Chinook and sockeye salmon, July 11–17 and 25–31 for pink salmon, and August 22–28 for coho salmon. Age, sex, and length data were collected for chum, Chinook, and sockeye salmon. Dominant ages were 0.3 for chum, 1.2 for male and 1.4 for female Chinook, and 1.3 for sockeye salmon. Overall percentages for female salmon were chum 30%, Chinook 26%, sockeye 67%, and coho 56%. Video footage was used to determine sex of coho salmon. Mean lengths varied between male and female salmon for each species sampled. The estimated Chinook salmon escapement during 2010 was the lowest on record and below the escapement goal range of 1,000−2,100 for the fourth successive year. The poor returns since 2007 indicate that Chinook salmon in the Tuluksak River are still a stock of yield concern and may require specific management actions.

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 eggs and/or 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

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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 together to achieve the goals of both the Rebuilding Plan (5AAC 07.365; Ward et al. 2003; Bergstrom and Whitmore 2004) 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 and from 2001 to 2010. 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. The objectives of the project for 2010 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 east-northeast of Bethel, Alaska (Whitmore et al. 2005). The Tuluksak River is approximately 137 rkm in length and its watershed encompasses approximately 2,098 km^2 (Figure 1). It originates in the Kilbuck Mountains and flows to the northwest. The Fog River drains into the lower portion of the Tuluksak River and is the only major tributary. The Tuluksak River is a medium gradient river for the majority of its length and is characterized by dense overhanging vegetation and cut banks. The lower river is characterized by low gradient, silt substrate, and turbid water. The river 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 taken place in approximately 40-km of the upper Tuluksak River and Bear Creek drainages above the Refuge boundary.

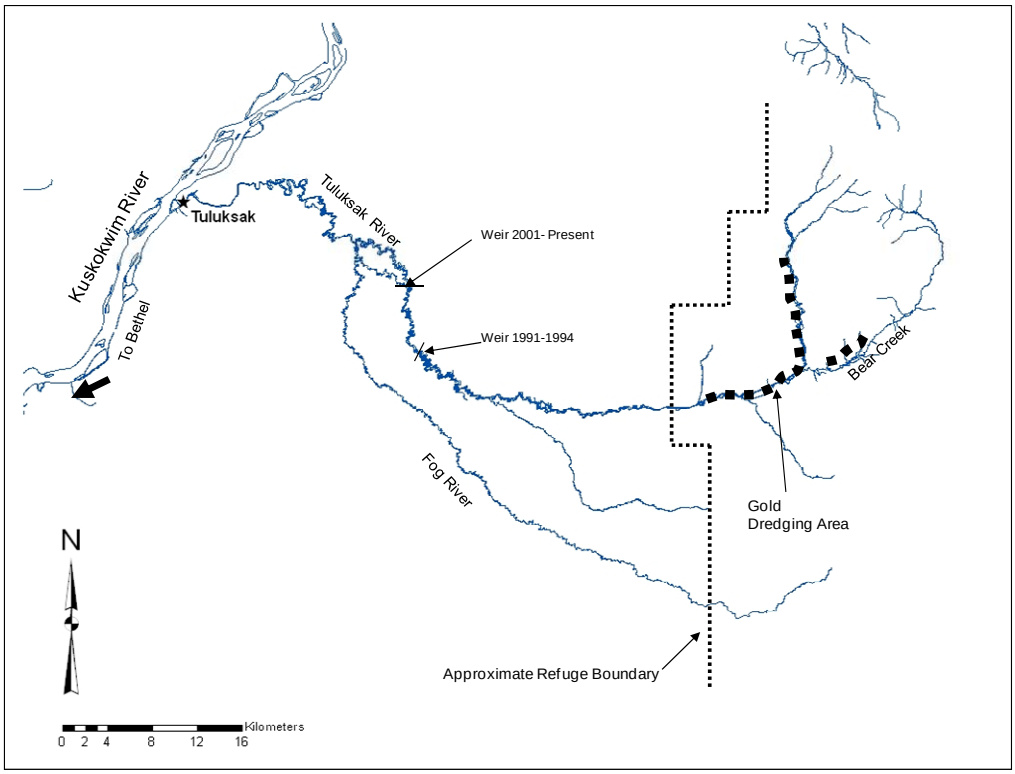

FIGURE 1. —Tuluksak River weir location, Yukon Delta National Wildlife Refuge, 1991–1994 and 2001–2010.

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 tailing 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.

Methods

Weir and Video Operations

A resistance board weir (Tobin 1994), affixed with an underwater video system (Gates et al. 2010) was installed during 2010 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).

During 2010, the weir was modified from previous designs (Tobin 1994, Gates and Harper 2002) to accommodate an underwater video system. Setup and design of the underwater video system was similar to that used by Gates et al. (2010) on the Kenai Peninsula. One passage panel and live trap was installed and affixed with an underwater video camera to facilitate fish sampling during various river stage heights and to allow for salmon passage and enumeration 24 hours each day. The video camera was fastened inside a sealed box constructed of 3.2-mm aluminum sheeting and filled with filtered water. Safety glass was installed on the front of the video box allowing for a scratch-free clear surface through which images were captured. The video passage chute frame was constructed of aluminum angle and the chute enclosed in plywood to block exterior light. The backdrop of the video passage chute was adjustable to minimize the number of fish passing through the chute at one time, and to push fish closer to the camera during turbid water conditions. Using a pair of 12-VDC underwater pond lights equipped with 10-W bulbs, artificial light was provided for the video camera, box, and passage chute. Power to the pond lights and video camera were supplied by a solar panel array and gasoline generator (alternate power), which charged four 400 Ah 6-V batteries wired in a series-parallel circuit to supply 12-VDC power to the underwater equipment. A separate solar array and generator back-up system along with a 1000-W inverter provided 110-VAC power to the computer-based digital video recorder (DVR). Video images were recorded on an external hard drive using the computer-based DVR. The DVR was equipped with motion detection to minimize the amount of blank video footage and review time. The video system and weir were operated in unison during 2010. Visual counts started at approximately 0600 hours every day and continued until fading daylight reduced visibility (~2300 hours) while video counts were collected 24 hours a day, seven days each week. Video and visual counts were compared. Migrating 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 represent 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 22 to September 11. Ambient temperature, water temperature, and fish passage counts were relayed daily by radio to the Department in Bethel. Hobo® recording thermometers were installed at the weir to collect yearly water and ambient temperature data for a separate study addressing climate change funded by the Office Subsistence Management, Fisheries Resource Monitoring Program (OSM-FRMP) project 08-701.

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, 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 sample size was 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 once approximately 20% of their weekly passage was 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. Adult salmon were captured 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 an appropriate number of 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, 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 for chum, Chinook, and sockeye salmon. Sex for coho salmon was determined from video footage. Starting at 00:01 hours, the first day of each stratum, the first 170 coho salmon viewed on video were identified as male or female. Female Chinook salmon less than 700 mm in length have been rare in samples collected from the commercial fishery (D. Molyneaux, Alaska Department of Fish and Game, personal communication). Therefore, all Chinook salmon less than 700 mm were classified as males for this study. Once ASL data were collected, each fish was released unharmed upstream of the live trap. Data were recorded and later transferred to Excel spreadsheets. The Department staff aged the scales and processed the forms in Anchorage under OSM-FRMP project10-303.

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

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

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

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

with estimated variance

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

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

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

with estimated variance

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

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

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

with corresponding variance estimator

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

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

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

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

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

Estimates were calculated for dates with partial and zero counts due to flooding or holes in the weir. Estimates were based on the average daily proportion of passage from previous years. An average of the daily proportions for previous years was calculated 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. Averages in the historical escapement figure were generated using prior years with escapement estimates (Miller and Harper 2010).

Results

Weir and Video Operations

The crew traveled to the weir site by boat on June 21. Installation of the weir was completed on June 25 and the underwater video system on July 19. The weir was operational from June 27 to September 7 and the video system was operable from July 19 to September 7, 2010. Video footage was used to enumerate and speciate fish from 24:00 to 07:59 hours during July 23–28 and August 3–7, and visual methods from 08:00 to 23:59 hours for the same dates. During July 29 to August 2 and August 8 to September 7, video footage was utilized to enumerate and speciate fish 24 hours each day.

A total of 106 hours of visual and video counts were compared. Between July 19 and August 4 visual counts were taken from on top of the trap and video counts were gathered by reviewing video files for the same periods of time. During these paired counts, 1,422 fish were counted visually and 1,417 from electronic video files, a difference of five fish (Table 1). Most fish counted using both methods were chum salmon (visual N = 1,341 and video N = 1,340). The video file was used to verify species. Visual counts of other salmon species included Chinook (N = 23), sockeye (N = 47), pink (N = 8), and coho salmon (N = 3). Three Chinook, four sockeye, and one pink salmon were mis-identified from visual counts on top of the trap, and later were correctly identified as chum salmon from video footage. One chum salmon was incorrectly identified visually as a coho salmon. Factors that may have contributed to the count and identification differences were high water levels and turbidity, and members of the crew conducting ASL sampling during the same time-periods would have released fish over the side of the trap and those fish would not have been counted on the underwater video.

TABLE 1. —Comparison of visual and underwater video counts of salmon for *N* = 106 hours of dual counts at the Tuluksak River weir, 2010.

	Count Method		
Salmon Species	Visual	Video	Difference
Chum	1,341	1,340	1
Chinook	23	20	3
Sockeye	47	43	4
Pink	8	9	1
Coho	3	5	2
Total	1,422	1,417	5

High water affected weir operations starting late July. Minor repairs to damaged weir components were made on site during the field season. ASL data were not collected from the trap for salmon after August 8. Video files allowed for the identification and enumeration of migrating fish and sex identification of coho salmon. Between August 18–23 and September 7–10, water exceeded bank-full levels submerging the weir. Coho salmon were noted passing over submerged panels on those dates as well and the efficiency of the video system during that period is unknown. Escapement estimates were generated for those dates. High water delayed removal of the weir until the last week of September. The camp and water stage height were monitored every 2–3 days by members of the TNC crew operating from the village of Tuluksak from September 10 through the last week of September.

Average water depth at the leading edge of the weir during 2010 was 114 cm. The recorded maximum water depth (266 cm) and the minimum water depth (52 cm) occurred on September 11 and July 18, respectively (Appendix 1). Water temperatures ranged from a low of 7°C on September 2 to a high of 15°C on June 25 (Appendix 1).

Biological Data

Chum Salmon —A total of 13,042 chum salmon was counted through the weir June 30 to September 7 (Figure 2; Appendix 2). The average cumulative passage since 2001 for chum salmon has been greater than 99% by August 15 and an escapement estimate generated for partial or zero counts for days missed (August 17–22 and September 7−10) was one fish less than the count used in the 2010 analysis. Peak weekly passage (*N* = 3,040) occurred July 11–17 (Figure 2). Median cumulative passage occurred on July 20 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 (66%) and female (69%) chum salmon (Appendix 3). Males dominated the run and comprised at least 62% of the run in each stratum from June 30 to September 7 (Figure 3). Females comprised 30% of the total escapement (Appendix 3). Mean length of males was greater than females for ages 0.2, 0.3, 0.4, and 0.5 (Appendix 4).

Chinook Salmon —A total of 201 Chinook salmon was counted through the weir July 3 to August 28 (Figure 2; Appendix 2). The average cumulative passage since 2001 for Chinook salmon has been greater than 99% by August 15 and there was no difference between the estimated escapement generated for partial or zero counts for days missed (August 17–22 and September 7−10) and the count used in the 2010 analysis. Peak weekly passage (*N* = 59)

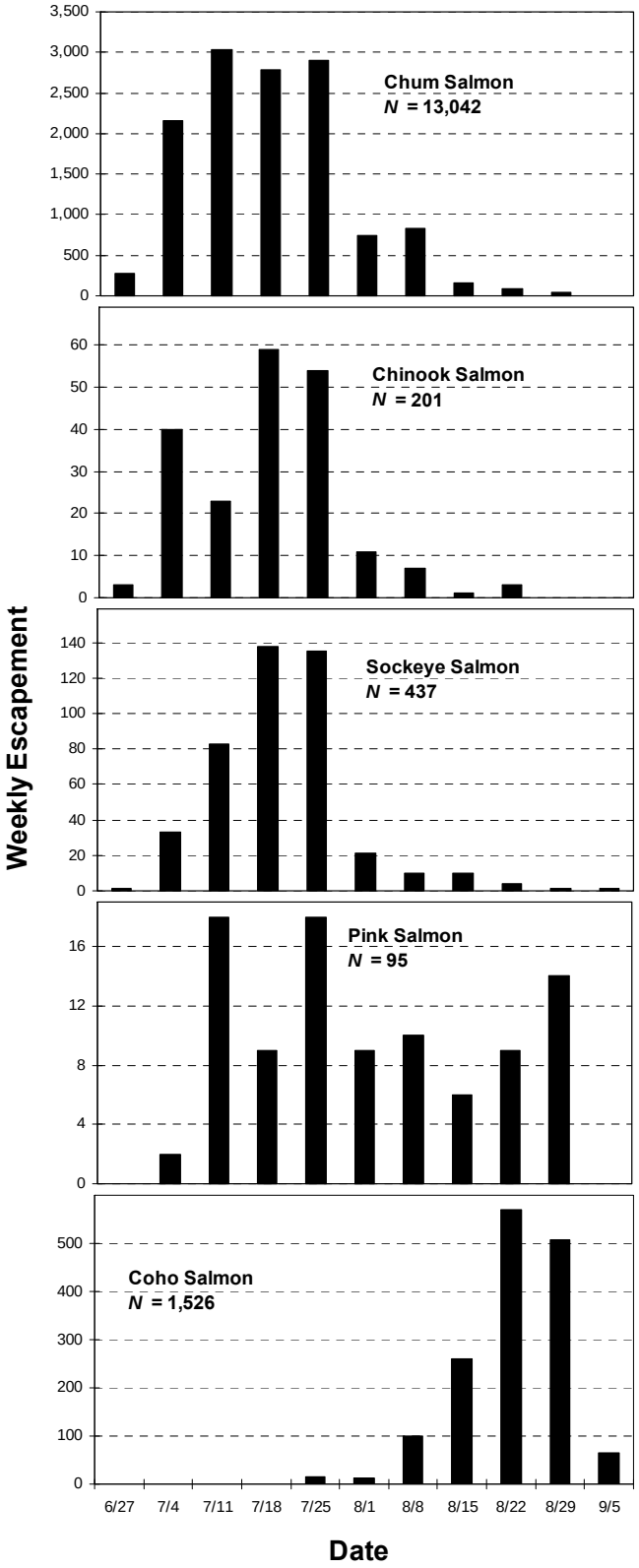

FIGURE 2. —Weekly escapement of chum, Chinook, sockeye, pink, and coho salmon through the Tuluksak River weir, 2010. The total coho salmon escapement includes estimates generated for days with partial or no counts due to high water.

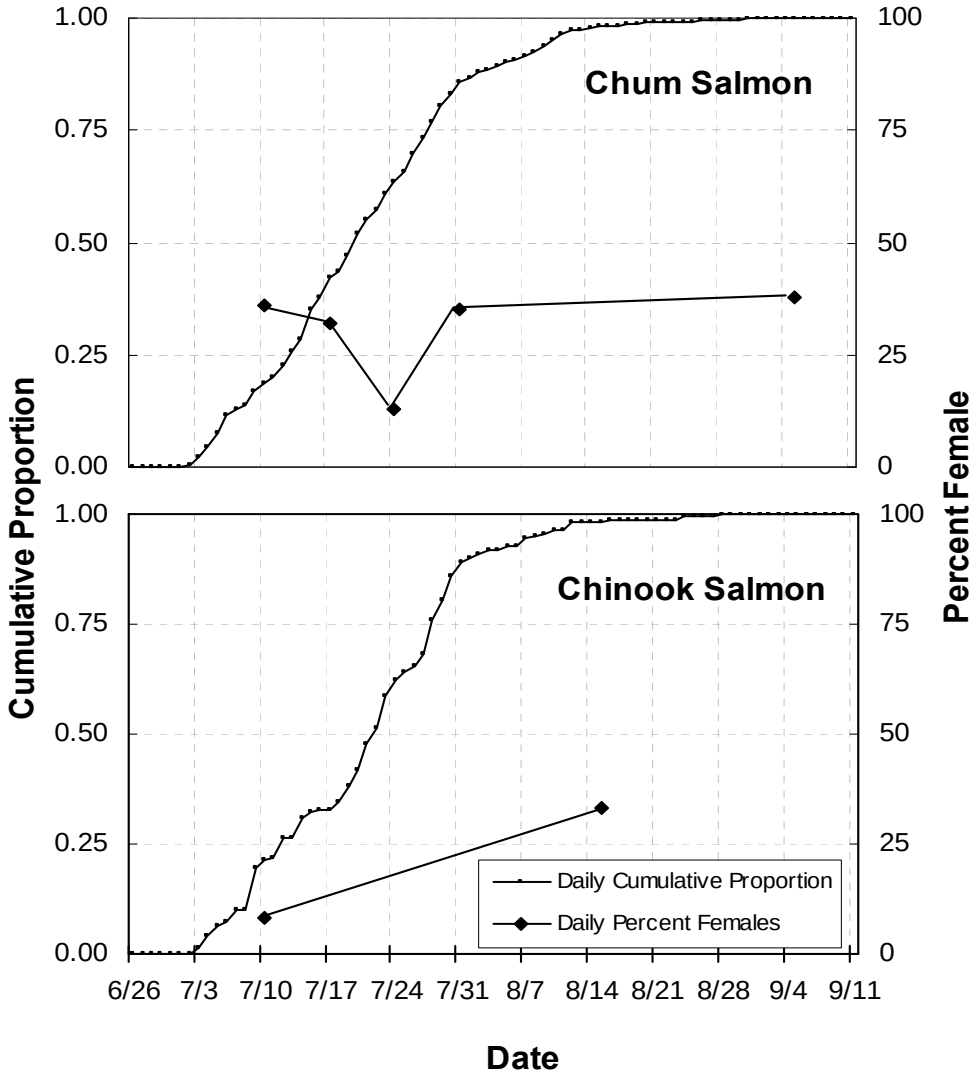

FIGURE 3. —Cumulative proportion and percent females from weekly samples of chum and Chinook salmon passed through the Tuluksak River weir, 2010.

occurred July 18–24 (Figure 2). Median cumulative passage occurred on July 22 for adults passing upstream (Figure 3; Appendix 2).

Four ages (1.2, 1.3, 1.4, and 1.5) were identified from Chinook salmon scale samples. Ages 2.2 and 2.3 present in previous years were not identified from scales during 2010. The predominant age was 1.2 for males (61%), and 1.4 (49%) for females (Appendix 5). Ages 1.3 and 1.4 accounted for 94% of the female Chinook salmon escapement. Females comprised 26% of the total Chinook salmon escapement. Sex ratios favored males through both combined strata (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 437 sockeye salmon was counted through the weir July 3 to September 5 (Figure 2; Appendix 2). The average cumulative passage since 2001 for sockeye salmon has been greater than 96% by August 15 and there was only a four fish difference between the escapement estimate generated for partial or zero counts for days missed (August 17–22 and September 7−10) and the count used in the 2010 analysis. Peak weekly passage for

sockeye salmon (*N* = 138) occurred July 18–24 (Figure 2). Median cumulative passage occurred on July 23 for adults passing upstream (Appendix 2).

Five ages (0.2, 1.2, 1.3, 1.4, and 2.3) were identified from sockeye salmon scale samples. No age 0.3 and 2.2 sockeye salmon were identified from scales during 2010. The predominant age was 1.3 for both males and females and comprised 67% of the estimated sockeye salmon escapement (Appendix 7). Females comprised 67% of the total sockeye salmon escapement but were absent from ages 0.2 and 1.2 (Appendix 7). The mean length of males was greater than females for ages 1.3, 1.4, and 2.3 (Appendix 8).

Pink Salmon —A total of 95 pink salmon was counted through the weir July 6 to September 4 (Figure 2; Appendix 2). Peak weekly passage of pink salmon (*N* = 18) occurred July 11–17 and again on July 25–31 (Figure 2). Median cumulative passage occurred on August 1 for adults passing upstream (Appendix 2).

Coho Salmon —A total of 1,526 coho salmon were estimated to have passed through the weir during 2010. The actual count observed (*N* = 1,204) passed July 28 to August 17 and August 24 to September 6. During September 7, coho salmon were visually identified passing over the submerged boat passage panels and an additional 322 coho salmon were estimated to have passed during August 18–23 (*N* = 270) and September 7–10 (*N* = 52) (Figure 2; Appendix 2). The first coho salmon migrated through the weir on July 28 and a partial count of one coho salmon was identified from video footage on September 7. Peak weekly passage of coho salmon (*N* = 569) occurred August 22–28 (Figure 2). Median cumulative passage occurred on August 27 (Appendix 2). Females comprised 56% of the estimated escapement for coho salmon. No age and length data were collected for coho salmon during 2010.

Other Species —Resident and other migrant species counted through the weir consisted of five Dolly Varden *Salvelinus malma*, seven northern pike *Esox lucius*, 10 Arctic grayling *Thymallus arcticus,* eight broad whitefish *Coregonus nasus*, 49 humpback whitefish *C. pidschian*, and 81 round whitefish *Prosopium cylindraceum*. Although smaller sized fish were able to pass freely through the pickets, escapement through the passage chute was recorded the entire season.

Discussion

Weir and Video Operations

The weir is typically installed the second to last week of June and operational through September 10 (Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010). During 2010, high water hampered operations in several ways from late July through late September. Sample collection and data associated with ASL became limited due to safety concerns. Removal of debris, continual picket repair, broken bolts on resistance boards and general maintenance became more problematic due to high water (Appendix 1). The addition of the video system proved effective in the enumeration of salmon, specifically the migration of coho salmon, which occurred later during high water events. Preliminary data suggest that visual counts were less than 1% higher on average than video counts across species and the use of video was effective in the speciation of salmon and whitefish. Since the wider picket spacing was incorporated in weir operations (2001) coregonids have been enumerated and classified as ‘whitefish’ and have ranged in count from 3 to 94 (Gates et al 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010). With the addition of video during 2010, whitefish (*N* = 138) were identified as three distinct species.

The entire weir was completely submerged starting September 7 and escapement monitoring ceased. The crew worked on building walkways and enhancing the site until water levels dropped enough to shut down the video system. Water conditions were monitored until the crew could safely remove the weir and video box from the river the last week of September. Additional costs were associated with the extended field season. The substrate rail and cable remained in place after September 25 to expedite the 2011 weir install.

Biological Data

Chum Salmon —The estimated 2010 chum salmon escapement (*N* = 13,042) was within the historic range of 7,675–35,696 fish (Figure 4). The 2010 estimated escapement was below a 13-year average (1991–1994 and 2001–2009; *N* = 15,722) (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010). The 2010 escapement was 36% of the record 2005 chum salmon escapement (*N* = 35,696). The median passage date for chum salmon occurred on July 20. This passage date was the same as 2008 and seven days earlier than the latest recorded during 2003 (Figure 5).

Females comprised 30% of the total chum salmon escapement, which was similar to that observed during 2007 (30%) and 2009 (31%), but a decrease from the 42% observed during 2008 (Plumb and Harper 2008; Miller and Harper 2009, 2010). Males were predominant during each stratum of the run (Figure 3; Appendix 3). This is the second 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 later strata (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, 2010). The dominate age during 2010 for chum salmon was age-0.3 (Appendix 3). This age represented 67% of the escapement in 2010, which was less than the 83% observed in 2009 (Miller and Harper 2010). Age-0.4 chum salmon increased from the 12% in 2009 to 30% during 2010 (Appendix 3). A strong brood year may be indicative of a strong brood year in successive years (Van Alen 1999).

Chinook Salmon —The estimated Chinook salmon escapement for 2010 (*N* = 201) was the lowest on record and well below a 13-year average (1991–1994 and 2001–2009; *N* = 1,285; Figure 4). This was the fourth consecutive year the Sustainable Escapement Goal (SEG) range of 1,000–2,100 for the Tuluksak River was not met (Molyneaux and Brannian 2006; Estensen et al. 2009; Volk et al. 2009) and this year's escapement was only 20% of that lower range (Figure 4). Chinook salmon returns were also below the lower end of the established escapement goal range for the third consecutive year on the Kwethluk River during 2010 (Miller and Harper 2011).

Median passage dates for Chinook salmon have fluctuated from July 5 to July 20 during previous years. The median passage date for 2010 was July 22 and the latest date observed (Figure 5; Appendix 2). Since 2005, the median passage date has shifted approximately seven days later than the average observed during previous 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, 2010; Figure 5). Reasons for this shift are unknown, but possible factors may include climate and oceanographic changes, harvest pressures on the early portions of the run, and prevailing winds and river flows at the time of the return.

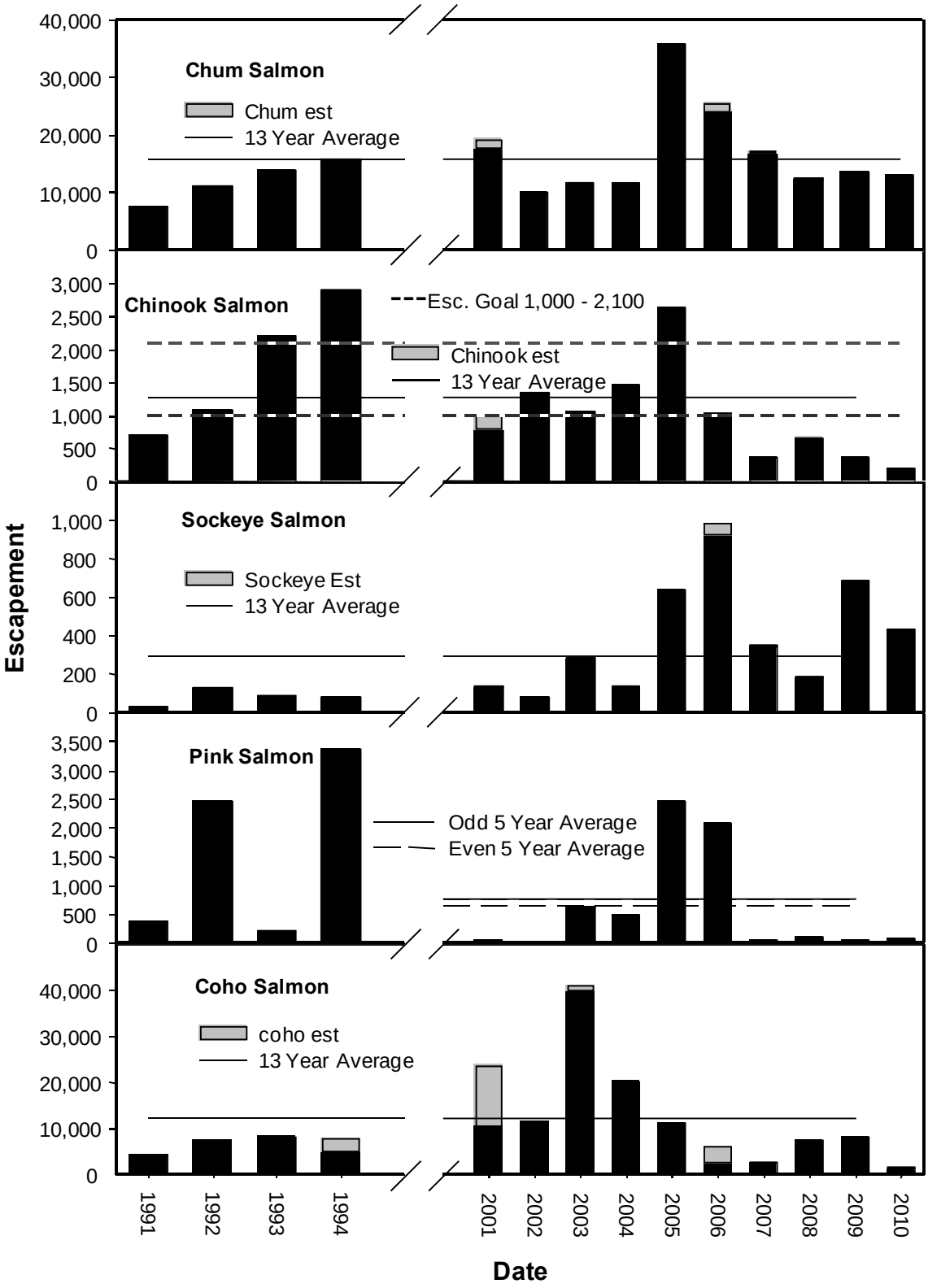

FIGURE 4. —Salmon escapement through the Tuluksak River weir; 1991–1994 and 2001–2010. Averages include estimates for days missed and do not include the current year. Pink salmon averages are for years after 2000 when wider picket spacing was used on weir panels.

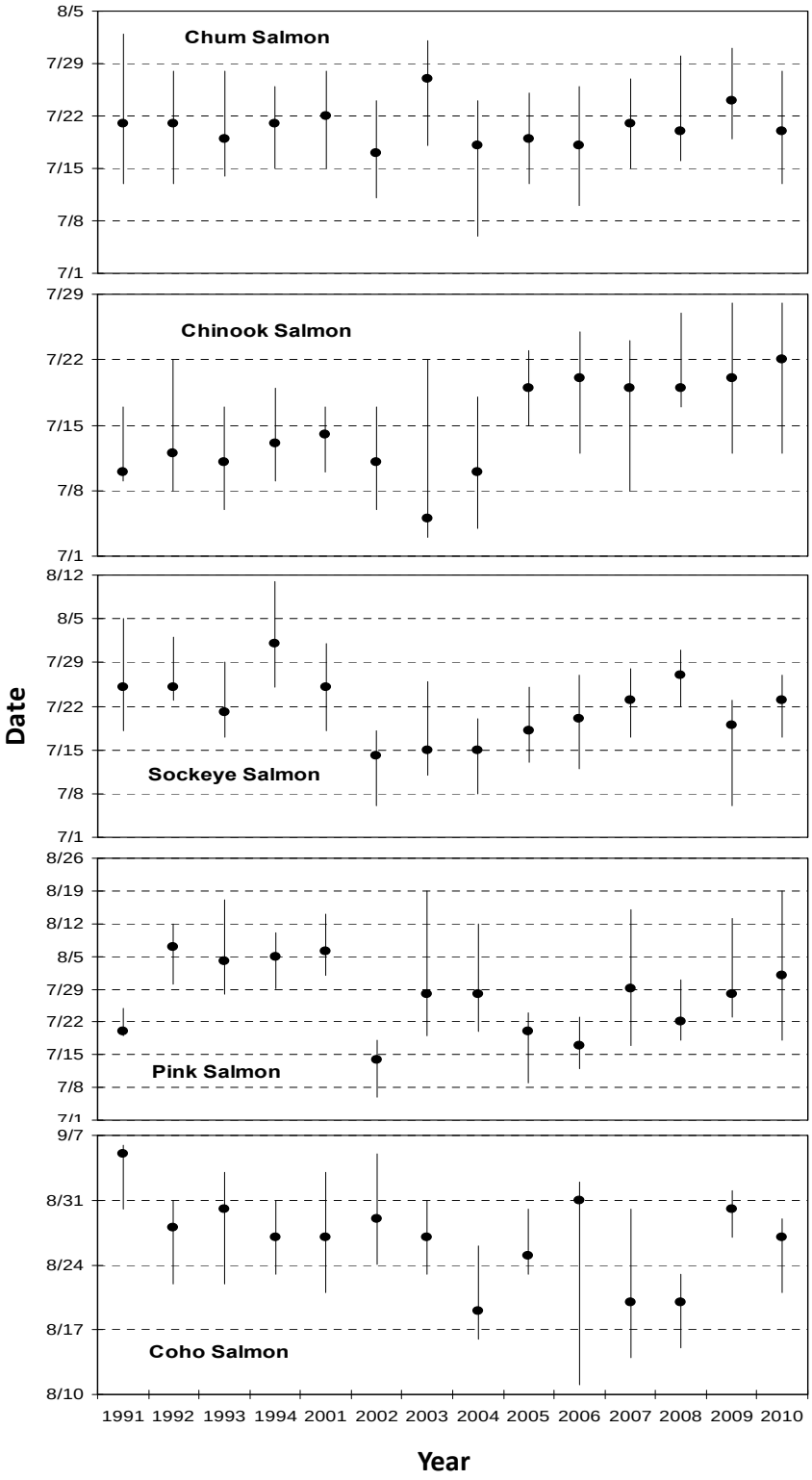

FIGURE 5. —Median cumulative passage for chum, Chinook, sockeye, pink, and coho salmon at the Tuluksak River weir, 1991–1994 and 2001–2010. The filled circles represent the median (50%) passage date and the line below and above the circle represent the second and third quartiles respectively.

During 2010, female Chinook salmon comprised 26% of the escapement. This was near the lower end of the range (14–48%) observed during previous 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, 2010). This is the first year since 2007 that females have comprised less than 40% of the Chinook salmon escapement (Plumb and Harper 2008; Miller and Harper 2009, 2010). Given the low escapement of Chinook salmon and the low number of females ($N = 53$) estimated during 2010, it is unlikely that the 2010 brood year will contribute much production to near-future adult Chinook salmon returns to the Tuluksak River. The poor returns since 2007 indicate that the Chinook salmon in the Tuluksak River are still a stock of yield concern and may require specific management actions.

The dominant ages for Chinook salmon in 2010 were 1.2, 1.3, and 1.4, representing 53, 35, and 11% of the return, respectively (Appendix 5). Age-1.2 composition was approximately three fold greater than that of 2008 (16%) and 2009 (19%), and may result in a stronger return of age-1.3 fish during 2011. The weaker return of age-1.4 Chinook salmon in 2010 may be the result of the weaker return of age-1.3 fish during 2009 (Van Alen 1999; Miller and Harper 2010). Various factors may be influencing the variation of age structure in returning adults. Hillgruber and Zimmerman (2009) state that water temperature, prey availability and abundance, and predation during the early marine life stage of Chinook salmon smolt are factors associated with survival and subsequent returns. Petrosky and Schaller (2010) indicate river velocity during smolt migration as a factor associated with Chinook salmon smolt survival as well.

Sex identification for small Chinook salmon is often difficult to ascertain. Generally, female Chinook salmon returning to the Kuskokwim River are greater 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 (D. Molyneaux, Alaska Department of Fish and Game, personal communication). Small Chinook salmon (<700 mm) were also randomly sampled at the Tuluksak weir in previous years 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 less than 700 mm were found in the total sample (J. Olsen, U. S. Fish and Wildlife Service, unpublished data). Using these length-to-sex data, Chinook salmon less than 700 mm have been classified as males unless sex products were clearly visible.

Sockeye Salmon —The estimated escapement of 437 sockeye salmon during 2010 was the fourth highest on record and above a 13-year average ($N = 287$) (Figure 4). Escapements have ranged from a low during 1991 ($N = 34$) to a high during 2006 ($N = 985$). Median passage dates for sockeye salmon have fluctuated between July 14 and August 2, a difference of 19 days (Figure 5). The median passage date in 2010 was July 23 and similar to 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; Miller and Harper 2009, 2010). There was a strong return of age-1.2 fish during 2009 (32%) which may have correlation to the strong representation of age-1.3 fish during 2010. During 2010, age-1.2 comprised less than 6% of the return, which may suggest poor ocean conditions during the first year at sea, and perhaps a weak return of age 1.3 during 2011. Reasons for these shifts are unknown but climate, water flows, oceanographic changes may be factors. Groot and Margolis (1991) suggest marine mortality estimates can be as high as 95% for different stocks, age groups, and brood years of sockeye salmon. In addition, smolts of a larger size at migration have a higher marine survival rate than smaller smolts (Groot and Margolis 1991).

Pink Salmon —The number of pink salmon observed passing through the trap during 2010 (*N* = 95) was similar to years 2002 and 2008 but low compared to even years 2004 and 2006 (Figure 4). Counts of pink salmon were below the odd 5-year 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 August 1 and the third latest recorded (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, 2010). The 2010 estimated escapement (*N* = 1,526) was the lowest observed. The estimated escapement may be conservative due to the high water; however, estimated escapements of coho salmon were well below the 10 year averages for the Kogrukluk, George, Tatlawiksuk and Tokotna rivers during 2010 (Brazil et al. 2010). The estimated escapement was only 12% of an estimated 13-year average (1991–1994 and 2001–2009; *N* = 12,343). The 2010 coho salmon escapement is also below an 11-year average (*N* = 7,095) that excludes the record years of escapement, 2003 and 2004 (Figure 4). Coho salmon similar to Chinook salmon have been below the average for the past five years. Groot and Margolis (1991) describe coho as opportunistic seeking small headwater areas of larger rivers to spawn and most coho juvenile mortality occurs during the rearing stage in fresh water. Mining activities in the Tuluksak River may have reduced or altered flows increasing winter and spring freshets, altered water temperatures, altered flow and river channel morphology, or just plain reduced rearing space for juvenile salmon due to habitat degradation.

The median cumulative passage date for coho salmon was August 27. It was within the range of dates observed during previous years (Figure 5; Appendix 2). Female coho salmon comprised 56% of the estimated escapement which was the second highest recorded and within the range of 31% (2009) to 58% (2002) (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, 2010). Age and length data were not collected for coho salmon during 2010 due to high water and safety concerns.

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 Service and Department fishery managers. Annual operation of the weir should continue well into the future to gather a long-term data set to monitor trends, population health, 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 past 10 years (2001–2010). The solar array for powering the video system needs to be upgraded to allow easier tracking of the sun. It is also suggested that the electrical system consisting of inverters, charge controller, and battery banks be reconfigured and made more user friendly. All employees should be properly trained in electrical safety precautions. A laser measurement system incorporated with the video system should be considered. We believe that the river channel is stable at the present site and do not anticipate a move of the weir to another site in the near future. Collaboration with the Refuge and the Tuluksak Native Community (TNC) should also continue into the future addressing direct and indirect effects of land management activities on this system.

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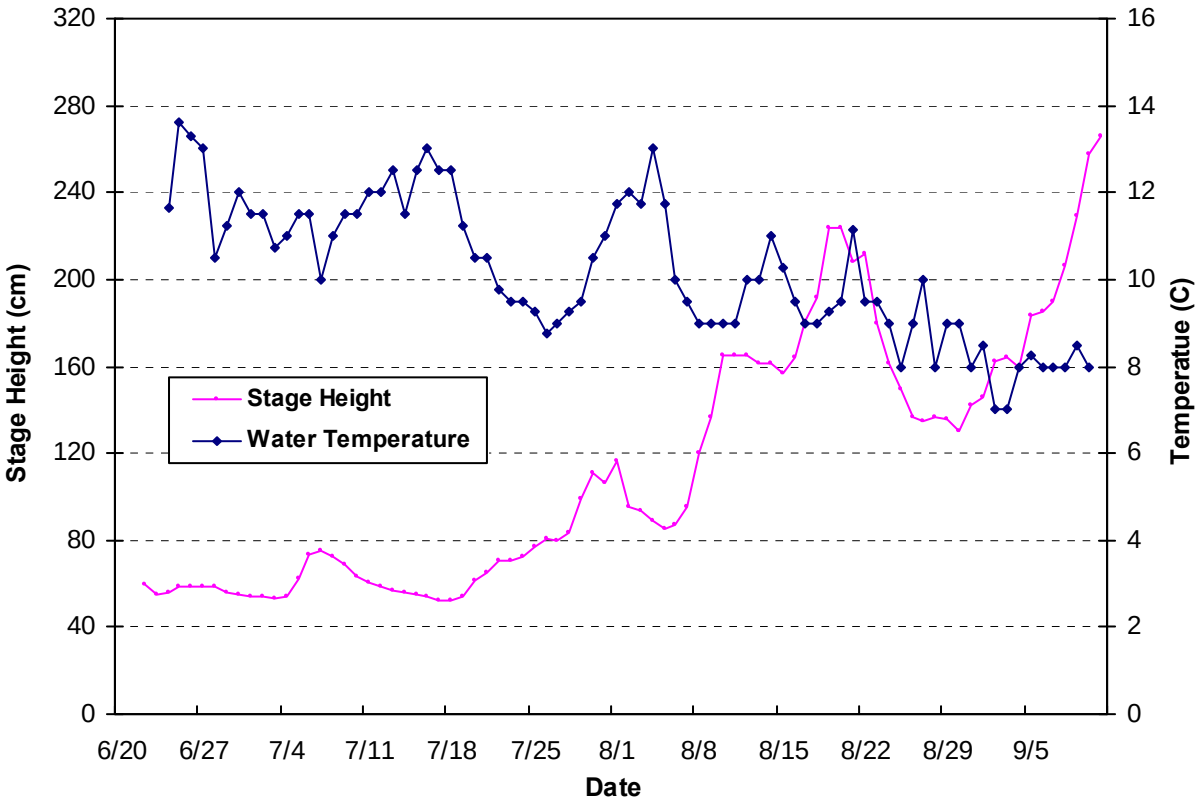
APPENDIX 1. —River stage heights and daily water temperatures at the Tuluksak River weir, 2010.



APPENDIX 2. —Daily, cumulative and cumulative proportion of chum, Chinook, sockeye, pink, and coho salmon passing through the Tuluksak River weir, Alaska, 2010. Boxed areas represent the second and third-quartile and median passage dates. Shaded areas represent high water events when partial or no counts were recorded and an estimated escapement total was generated for coho salmon.

	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
06/27	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
06/28	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
06/29	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
06/30	1	1	0.000	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
07/01	26	27	0.002	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
07/02	3	30	0.002	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
07/03	248	278	0.021	3	3	0.015	1	1	0.002	0	0	0.000	0	0	0.000
07/04	283	561	0.043	5	8	0.040	3	4	0.009	0	0	0.000	0	0	0.000
07/05	434	995	0.076	5	13	0.065	2	6	0.014	0	0	0.000	0	0	0.000
07/06	506	1,501	0.115	2	15	0.075	0	6	0.014	2	2	0.021	0	0	0.000
07/07	196	1,697	0.130	5	20	0.100	9	15	0.034	0	2	0.021	0	0	0.000
07/08	114	1,811	0.139	0	20	0.100	7	22	0.050	0	2	0.021	0	0	0.000
07/09	385	2,196	0.168	19	39	0.194	0	22	0.050	0	2	0.021	0	0	0.000
07/10	245	2,441	0.187	4	43	0.214	12	34	0.078	0	2	0.021	0	0	0.000
07/11	166	2,607	0.200	1	44	0.219	0	34	0.078	0	2	0.021	0	0	0.000
07/12	332	2,939	0.225	9	53	0.264	12	46	0.105	0	2	0.021	0	0	0.000
07/13	425	3,364	0.258	0	53	0.264	10	56	0.128	0	2	0.021	0	0	0.000
07/14	342	3,706	0.284	9	62	0.309	16	72	0.165	0	2	0.021	0	0	0.000
07/15	868	4,574	0.351	3	65	0.323	17	89	0.204	7	9	0.095	0	0	0.000
07/16	374	4,948	0.379	1	66	0.328	0	89	0.204	0	9	0.095	0	0	0.000
07/17	533	5,481	0.420	0	66	0.328	28	117	0.268	11	20	0.211	0	0	0.000
07/18	221	5,702	0.437	3	69	0.343	28	145	0.332	4	24	0.253	0	0	0.000
07/19	422	6,124	0.470	8	77	0.383	6	151	0.346	0	24	0.253	0	0	0.000
07/20	656	6,780	0.520	7	84	0.418	16	167	0.382	0	24	0.253	0	0	0.000
07/21	403	7,183	0.551	12	96	0.478	15	182	0.417	0	24	0.253	0	0	0.000
07/22	291	7,474	0.573	7	103	0.512	6	188	0.430	1	25	0.263	0	0	0.000
07/23	447	7,921	0.607	15	118	0.587	43	231	0.529	2	27	0.284	0	0	0.000
07/24	342	8,263	0.634	7	125	0.622	24	255	0.584	2	29	0.305	0	0	0.000
07/25	338	8,601	0.660	4	129	0.642	21	276	0.632	3	32	0.337	0	0	0.000
07/26	513	9,114	0.699	3	132	0.657	30	306	0.700	4	36	0.379	0	0	0.000
07/27	433	9,547	0.732	5	137	0.682	30	336	0.769	0	36	0.379	0	0	0.000
07/28	508	10,055	0.771	16	153	0.761	16	352	0.806	3	39	0.411	1	1	0.001
07/29	447	10,502	0.805	9	162	0.806	22	374	0.856	4	43	0.453	6	7	0.005
07/30	353	10,855	0.832	11	173	0.861	15	389	0.890	0	43	0.453	3	10	0.007
07/31	307	11,162	0.856	6	179	0.891	1	390	0.892	4	47	0.495	4	14	0.009
08/01	124	11,286	0.865	2	181	0.901	4	394	0.902	5	52	0.547	3	17	0.011
08/02	208	11,494	0.881	2	183	0.910	6	400	0.915	2	54	0.568	1	18	0.012

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	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
08/03	68	11,562	0.887	2	185	0.920	2	402	0.920	1	55	0.579	2	20	0.013
08/04	116	11,678	0.895	0	185	0.920	2	404	0.925	0	55	0.579	0	20	0.013
08/05	106	11,784	0.904	1	186	0.925	5	409	0.936	1	56	0.590	3	23	0.015
08/06	25	11,809	0.906	0	186	0.925	1	410	0.938	0	56	0.590	1	24	0.016
08/07	104	11,913	0.913	4	190	0.945	1	411	0.941	0	56	0.590	3	27	0.018
08/08	148	12,061	0.925	1	191	0.950	1	412	0.943	1	57	0.600	23	50	0.033
08/09	148	12,209	0.936	1	192	0.955	4	416	0.952	3	60	0.632	10	60	0.039
08/10	199	12,408	0.951	2	194	0.965	0	416	0.952	0	60	0.632	12	72	0.047
08/11	166	12,574	0.964	0	194	0.965	0	416	0.952	1	61	0.642	9	81	0.053
08/12	105	12,679	0.972	3	197	0.980	2	418	0.957	0	61	0.642	21	102	0.067
08/13	42	12,721	0.975	0	197	0.980	3	421	0.963	2	63	0.663	8	110	0.072
08/14	26	12,747	0.977	0	197	0.980	0	421	0.963	3	66	0.695	16	126	0.083
08/15	42	12,789	0.981	0	197	0.980	3	424	0.970	1	67	0.705	50	176	0.115
08/16	26	12,815	0.983	1	198	0.985	4	428	0.979	3	70	0.737	14	190	0.125
08/17	23	12,838	0.984	0	198	0.985	1	429	0.982	1	71	0.747	12	202	0.132
08/18	36	12,874	0.987	0	198	0.985	1	430	0.984	0	71	0.747	37	239	0.156
08/19	16	12,890	0.988	0	198	0.985	0	430	0.984	1	72	0.758	39	278	0.182
08/20	16	12,906	0.990	0	198	0.985	1	431	0.986	0	72	0.758	60	338	0.221
08/21	4	12,910	0.990	0	198	0.985	0	431	0.986	0	72	0.758	47	385	0.252
08/22	6	12,916	0.990	0	198	0.985	1	432	0.989	0	72	0.758	41	426	0.279
08/23	14	12,930	0.991	0	198	0.985	0	432	0.989	0	72	0.758	46	472	0.309
08/24	13	12,943	0.992	2	200	0.995	0	432	0.989	1	73	0.768	19	491	0.322
08/25	7	12,950	0.993	0	200	0.995	1	433	0.991	2	75	0.790	67	558	0.366
08/26	10	12,960	0.994	0	200	0.995	0	433	0.991	0	75	0.790	99	657	0.431
08/27	23	12,983	0.996	0	200	0.995	0	433	0.991	3	78	0.821	181	838	0.549
08/28	11	12,994	0.996	1	201	1.000	2	435	0.995	3	81	0.853	116	954	0.625
08/29	10	13,004	0.997	0	201	1.000	0	435	0.995	3	84	0.884	193	1,147	0.752
08/30	8	13,012	0.998	0	201	1.000	0	435	0.995	2	86	0.905	109	1,256	0.823
08/31	6	13,018	0.998	0	201	1.000	0	435	0.995	2	88	0.926	58	1,314	0.861
09/01	5	13,023	0.999	0	201	1.000	0	435	0.995	3	91	0.958	64	1,378	0.903
09/02	6	13,029	0.999	0	201	1.000	1	436	0.998	0	91	0.958	21	1,399	0.917
09/03	6	13,035	1.000	0	201	1.000	0	436	0.998	2	93	0.979	39	1,438	0.942
09/04	1	13,036	1.000	0	201	1.000	0	436	0.998	2	95	1.000	22	1,460	0.957
09/05	3	13,039	1.000	0	201	1.000	1	437	1.000	0	95	1.000	10	1,470	0.963
09/06	2	13,041	1.000	0	201	1.000	0	437	1.000	0	95	1.000	4	1,474	0.966
09/07	1	13,042	1.000	0	201	1.000	0	437	1.000	0	95	1.000	14	1,488	0.975
09/08	0	13,042	1.000	0	201	1.000	0	437	1.000	0	95	1.000	13	1,501	0.983
09/09	0	13,042	1.000	0	201	1.000	0	437	1.000	0	95	1.000	12	1,513	0.991
09/10	0	13,042	1.000	0	201	1.000	0	437	1.000	0	95	1.000	13	1,526	1.000

APPENDIX 3. —Estimated age and sex composition of weekly chum salmon escapement through the Tuluksak River weir, 2010.

		Brood Year and Age Group					
		2007	2006	2005	2004	2003	
		0.2	0.3	0.4	0.5	0.6	Total
Strata 1 – 2:	06/30 – 07/10						
Sampling Dates:	06/30 – 07/03						
Male:	Number in Sample:	2	63	66	1	0	132
	Estimated % of Escapement:	1.0	30.6	32.0	0.5	0.0	64.1
	Estimated Escapement:	24	747	782	12	0	1,564
	Standard Error:	16.0	75.2	76.1	11.3	0.0	
Female:	Number in Sample:	3	35	35	0	1	74
	Estimated % of Escapement:	1.5	17.0	17.0	0.0	0.5	35.9
	Estimated Escapement:	36	415	415	0	12	877
	Standard Error:	19.5	61.3	61.3	0.0	11.3	
Total:	Number in Sample:	5	98	101	1	1	206
	Estimated % of Escapement:	2.4	47.6	49.0	0.5	0.5	100.0
	Estimated Escapement:	59	1,161	1,197	12	12	2,441
	Standard Error:	25.1	81.5	81.6	11.3	11.3	
Stratum 3:	07/11 – 07/17						
Sampling Date:	07/11 – 07/12						
Male:	Number in Sample:	5	85	42	2	0	134
	Estimated % of Escapement:	2.6	43.4	21.4	1.0	0.0	68.4
	Estimated Escapement:	78	1,318	651	31	0	2,078
	Standard Error:	33.2	104.4	86.4	21.2	0.0	
Female:	Number in Sample:	2	39	21	0	0	62
	Estimated % of Escapement:	1.0	19.9	10.7	0.0	0.0	31.6
	Estimated Escapement:	31	605	326	0	0	962
	Standard Error:	21.2	84.1	65.1	0.0	0.0	
Total:	Number in Sample:	7	124	63	2	0	196
	Estimated % of Escapement:	3.6	63.3	32.1	1.0	0.0	100.0
	Estimated Escapement:	109	1,923	977	31	0	3,040
	Standard Error:	39.1	101.5	98.3	21.2	0.0	
Stratum 4:	07/18 – 07/24						
Sampling Dates:	07/18 – 07/19						
Male:	Number in Sample:	1	112	48	1	0	162
	Estimated % of Escapement:	0.5	60.2	25.8	0.5	0.0	87.1
	Estimated Escapement:	15	1,675	718	15	0	2,423
	Standard Error:	14.4	96.7	86.5	14.4	0.0	
Female:	Number in Sample:	1	16	7	0	0	24
	Estimated % of Escapement:	0.5	8.6	3.8	0.0	0.0	12.9
	Estimated Escapement:	15	239	105	0	0	359
	Standard Error:	14.4	55.4	37.6	0.0	0.0	
Total:	Number in Sample:	2	128	55	1	0	186
	Estimated % of Escapement:	1.1	68.8	29.6	0.5	0.0	100.0
	Estimated Escapement:	30	1,914	823	15	0	2,782
	Standard Error:	20.4	91.5	90.2	14.4	0.0	
Stratum 5:	07/25 – 07/31						
Sampling Dates:	07/25 – 07/26						
Male:	Number in Sample:	3	92	30	1	0	126
	Estimated % of Escapement:	1.6	47.7	15.5	0.5	0.0	65.3
	Estimated Escapement:	45	1,382	451	15	0	1,893
	Standard Error:	25.0	101.0	73.2	14.5	0.0	
Female:	Number in Sample:	0	55	12	0	0	67
	Estimated % of Escapement:	0.0	28.5	6.2	0.0	0.0	34.7
	Estimated Escapement:	0	826	180	0	0	1,006
	Standard Error:	0.0	91.2	48.8	0.0	0.0	
Total:	Number in Sample:	3	147	42	1	0	193
	Estimated % of Escapement:	1.6	76.2	21.8	0.5	0.0	100.0
	Estimated Escapement:	45	2,208	631	15	0	2,899
	Standard Error:	25.0	86.1	83.4	14.5	0.0	

APPENDIX 3. —(Page 2 of 2)

		Brood Year and Age Group					
		2007	2006	2005	2004	2003	
		0.2	0.3	0.4	0.5	0.6	Total
Strata 6 – 11:	08/01 – 09/07						
Sampling Dates:	08/03 – 08/07						
Male:	Number in Sample:	5	68	19	0	0	92
	Estimated % of Escapement:	3.4	45.6	12.8	0.0	0.0	61.7
	Estimated Escapement:	63	858	240	0	0	1,161
	Standard Error:	26.7	73.9	49.5	0.0	0.0	
Female:	Number in Sample:	1	49	7	0	0	57
	Estimated % of Escapement:	0.7	32.9	4.7	0.0	0.0	38.3
	Estimated Escapement:	13	618	88	0	0	719
	Standard Error:	12.1	69.7	31.4	0.0	0.0	
Total:	Number in Sample:	6	117	26	0	0	149
	Estimated % of Escapement:	4.0	78.5	17.4	0.0	0.0	100.0
	Estimated Escapement:	76	1,476	328	0	0	1,880
	Standard Error:	29.2	60.9	56.3	0.0	0.0	
Strata 1 – 11:	06/30 – 09/07						
Sampling Dates:	06/30 – 08/07						
Male:	Number in Sample:	16	420	205	5	0	646
	% Males in Age Group:	2.5	65.6	31.2	0.8	0.0	100.0
	Estimated % of Escapement:	1.7	45.9	21.8	0.6	0.0	69.9
	Estimated Escapement:	224	5,980	2,842	73	0	9,119
	Standard Error:	53.9	203.8	169.0	31.6	0.0	
	Estimated Design Effects:	1.010	0.983	0.985	1.051	0.000	0.966
Female:	Number in Sample:	7	194	82	0	1	284
	% Females in Age Group:	2.4	68.9	28.4	0.0	0.3	100.0
	Estimated % of Escapement:	0.7	20.7	8.5	0.0	0.1	30.1
	Estimated Escapement:	94	2,703	1,114	0	12	3,923
	Standard Error:	34.4	164.5	113.0	0.0	11.3	
	Estimated Design Effects:	0.975	0.968	0.963	0.000	0.845	0.966
Total:	Number in Sample:	23	614	287	5	1	930
	Estimated % of Escapement:	2.4	66.6	30.3	0.6	0.1	100.0
	Estimated Escapement:	318	8,683	3,956	73	12	13,042
	Standard Error:	63.6	190.9	185.9	31.6	11.3	

APPENDIX 4. —Estimated length at age composition of weekly chum salmon escapement through the Tuluksak River weir, 2010.

		Brood Year and Age Group				
		2007	2006	2005	2004	2003
		0.2	0.3	0.4	0.5	0.6
Strata 1 – 2:	06/30 – 07/10					
Sampling Dates:	06/30 – 07/03					
Male:	Mean Length	555	559	576	543	
	Std. Error	30	4	4	–	
	Range	525 – 585	455 – 460	480 – 635	543 – 543	
	Sample Size	2	63	66	1	0
Female:	Mean Length	556	540	553		520
	Std. Error	21	6	6		
	Range	515 – 581	445 – 600	575 – 598		–
	Sample Size	3	35	35	0	1
Stratum 3:	07/11 – 07/17					
Sampling Date:	07/11 – 07/12					
Male:	Mean Length	529	559	577	583	
	Std. Error	10	3	4	37	
	Range	507 – 565	498 – 645	533 – 622	546 – 619	
	Sample Size	5	85	42	2	0
Female:	Mean Length	500	540	562		
	Std. Error	11	4	5		
	Range	489 – 511	487 – 588	521 – 595		
	Sample Size	2	39	21	0	0
Stratum 4:	07/18 – 07/24					
Sampling Dates:	07/18 – 07/19					
Male:	Mean Length	576	566	582	525	
	Std. Error	–	3	5	–	
	Range	576 – 576	500 – 650	530 – 690	525 – 525	
	Sample Size	1	112	48	1	0
Female:	Mean Length	478	539	545		
	Std. Error		11	13		
	Range	–	465 – 654	500 – 586		
	Sample Size	1	16	7	0	0
Stratum 5:	07/25 – 07/31					
Sampling Dates:	07/25 – 07/26					
Male:	Mean Length	523	566	580	588	
	Std. Error	9	3	6	–	
	Range	510 – 540	492 – 664	480 – 660	588 – 588	
	Sample Size	3	92	30	1	0
Female:	Mean Length		537	542		
	Std. Error		3	6		
	Range		490 – 580	506 – 586		
	Sample Size	0	55	12	0	0
Strata 6 – 11:	08/01 – 09/07					
Sampling Dates:	08/03 – 08/07					
Male:	Mean Length	535	553	572		
	Std. Error	14	4	7		
	Range	500 – 568	450 – 620	481 – 621		
	Sample Size	5	68	19	0	0
Female:	Mean Length	490	517	525		
	Std. Error	–	4	12		
	Range	490 – 490	453 – 570	500 – 571		
	Sample Size	1	49	7	0	0

APPENDIX 4. —(Page 2 of 2)

		Brood Year and Age Group				
		2007	2006	2005	2004	2003
		0.2	0.3	0.4	0.5	0.6
Strata 1 – 11:	06/30 – 09/07					
Sampling Dates:	06/30 – 08/07					
Male:	Mean Length	536	562	578	564	
	Range	500 – 585	450 – 664	480 – 690	525 – 619	
	Sample Size	16	420	205	5	0
Female:	Mean Length	519	533	550		520
	Std. Error	15	2	3		–
	Range	478 – 581	445 – 654	457 – 598		520 – 520
	Sample Size	7	194	82	0	1

APPENDIX 5. —Estimated age and sex composition of weekly Chinook salmon escapement through the Tuluksak River weir, 2010.

		Brood Year and Age Group						
		2006	2005		2004		2003	
		1.2	1.3	2.2	1.4	2.3	1.5	Total
Strata 1 – 2:	07/03 – 07/10							
Sampling Dates:	07/05 – 07/10							
Male:	Number in Sample:	29	7	0	1	0	0	36
	Estimated % of Escapement:	74.4	17.9	0.0	1.2	0.0	0.0	92.3
	Estimated Escapement:	38	9	0	2	0	0	47
	Standard Error:	1.8	1.5	0.0	1.8	0.0	0.0	
Female:	Number in Sample:	0	3	0	8	0	0	3
	Estimated % of Escapement:	0.0	7.7	0.0	9.4	0.0	0.0	7.7
	Estimated Escapement:	0	4	0	19	0	0	4
	Standard Error:	0.0	1.1	0.0	4.9	0.0	0.0	
Total:	Number in Sample:	29	10	0	9	0	0	39
	Estimated % of Escapement:	74.4	25.6	0.0	10.6	0.0	0.0	100.0
	Estimated Escapement:	38	13	0	21	0	0	51
	Standard Error:	1.8	1.8	0.0	5.1	0.0	0.0	
Strata 3 – 9:	07/11– 08/28							
Sampling Dates:	07/11– 07/11, 07/25							
Male:	Number in Sample:	16	14	0	1	0	0	31
	Estimated % of Escapement:	34.8	30.4	0.0	2.2	0.0	0.0	67.4
	Estimated Escapement:	52	46	0	3	0	0	101
	Standard Error:	8.9	8.6	0.0	2.7	0.0	0.0	
Female:	Number in Sample:	0	6	0	8	0	1	15
	Estimated % of Escapement:	0.0	13.0	0.0	17.4	0.0	2.2	32.6
	Estimated Escapement:	0	20	0	26	0	3	49
	Standard Error:	0.0	6.3	0.0	7.1	0.0	2.7	
Total:	Number in Sample:	16	20	0	9	0	1	46
	Estimated % of Escapement:	34.8	43.5	0.0	19.6	0.0	2.2	100.0
	Estimated Escapement:	52	65	0	29	0	3	150
	Standard Error:	8.9	9.2	0.0	7.4	0.0	2.7	

APPENDIX 5. —(Page 2 of 2)

		Brood Year and Age Group						
		2006	2005		2004		2003	
		1.2	1.3	2.2	1.4	2.3	1.5	Total
Strata 1 – 9:	07/03 – 08/28							
Sampling Dates:	07/05 – 07/21, 07/25							
Male:	Number in Sample:	45	21	0	1	0	0	67
	% Males in Age Group:	60.8	37.0	0.0	2.2	0.0	0.0	100.0
	Estimated % of Escapement:	44.8	27.3	0.0	1.6	0.0	0.0	73.7
	Estimated Escapement:	90	55	0	3	0	0	148
	Standard Error:	9.0	8.7	0.0	2.7	0.0	0.0	
	Estimated Design Effects:	1.063	1.216	0.000	1.385	0.000	0.000	1.231
Female:	Number in Sample:	0	9	0	8	0	1	18
	% Females in Age Group:	0.0	44.5	0.0	49.4	0.0	6.2	100.0
	Estimated % of Escapement:	0.0	11.7	0.0	13.0	0.0	1.6	26.3
	Estimated Escapement:	0	23	0	26	0	3	53
	Standard Error:	0.0	6.4	0.0	7.1	0.0	2.7	
	Estimated Design Effects:	0.000	1.240	0.000	1.322	0.000	1.385	1.231
Total:	Number in Sample:	45	30	0	9	0	1	85
	Estimated % of Escapement:	44.8	39.0	0.0	14.6	0.0	1.6	100.0
	Estimated Escapement:	90	78	0	29	0	3	201
	Standard Error:	9.0	9.4	0.0	7.4	0.0	2.7	

APPENDIX 6. —Estimated length at age composition of weekly Chinook salmon escapement through the Tuluksak River weir, 2010.

		Brood Year and Age Group					
		2006	2005		2004		2003
		1.2	1.3	2.2	1.4	2.3	1.5
Strata 1 – 2:	07/03 – 07/10						
Sampling Dates:	07/05 – 07/10						
Male:	Mean Length	543	681				
	Std. Error	9	15				
	Range	443 – 657	571 – 900				
	Sample Size	29	21	0	0	0	0
Female:	Mean Length		701				
	Std. Error		16				
	Range		701 – 51				
	Sample Size	0	3	0	0	0	0
Strata 3 – 9:	07/11– 08/28						
Sampling Dates:	07/11– 07/21, 07/25						
Male:	Mean Length	544	700		760		
	Std. Error	14	25		–		
	Range	420 – 624	571 – 900		760 – 760		
	Sample Size	16	14	0	1	0	0
Female:	Mean Length		794		834		885
	Std. Error		22		17		–
	Range		740 – 889		781 – 920		885 – 885
	Sample Size	0	6	0	8	0	1
Strata 1 – 9:	07/03 – 08/28						
Sampling Dates:	07/05 – 07/21, 07/25						
Male:	Mean Length	543	681		760		
	Std. Error	8	18		–		
	Range	420 – 657	571 – 900		760 – 760		
	Sample Size	45	21	0	1	0	0
Female:	Mean Length		774		834		885
	Std. Error		18		17		–
	Range		701 – 889		781 – 920		885 – 885
	Sample Size	0	9	0	8	0	1

APPENDIX 7. —Estimated age and sex composition of the sockeye salmon escapement through the Tuluksak River weir, 2010.

		Brood Year and Age Group							
		2007	2006		2005		2004		
		0.2	0.3	1.2	1.3	2.2	1.4	2.3	Total
Strata 1 – 11:	07/03 – 09/05								
Sampling Dates:	07/05 – 07/13								
Male:	Number in Sample:	0	0	3	13	0	1	1	18
	Estimated % of Escapement:	0.0	0.0	5.6	24.1	0.0	1.9	1.9	33.3
	Estimated Escapement:	0	0	24	105	0	8	8	146
	Standard Error:	0.0	0.0	12.9	24.0	0.0	7.6	7.6	
Female:	Number in Sample:	1	0	0	23	0	4	8	36
	Estimated % of Escapement:	1.9	0.0	0.0	42.6	0.0	7.4	14.8	66.7
	Estimated Escapement:	8	0	0	186	0	32	65	291
	Standard Error:	7.6	0.0	0.0	27.8	0.0	14.7	20.0	
Total:	Number in Sample:	1	0	3	36	0	5	9	54
	Estimated % of Escapement:	1.9	0.0	5.6	66.7	0.0	9.3	16.7	100.0
	Estimated Escapement:	8	0	24	291	0	40	73	437
	Standard Error:	7.6	0.0	12.9	26.5	0.0	16.3	20.9	

APPENDIX 8. —Estimated length at age composition of weekly sockeye salmon escapement through the Tuluksak River weir, 2010.

		Brood Year and Age Group						
		2007	2006		2005		2004	
		0.2	0.3	1.2	1.3	2.2	1.4	2.3
Strata 1 – 11:	07/03 – 09/05							
Sampling Dates:	07/05 – 07/13							
Male:	Mean Length	531		558	573		555	567
	Std. Error	–		9	7		–	–
	Range	531 – 531		541 – 572	537 – 613		555 – 555	567 – 567
	Sample Size	1	0	3	13	0	1	1
Female:	Mean Length				515		527	530
	Std. Error				5		12	4
	Range				474 – 555		496 – 550	515 – 545
	Sample Size	0	0	0	23	0	4	8