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Abundance and Run Timing of Adult Pacific Salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2012

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Soldotna, Alaska
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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 *Oncorhynchus* spp. returning to the Tuluksak River, a tributary to the lower Kuskokwim River. From June 27 to September 9, 2012, a resistance board weir and an underwater video system were used to collect abundance, run timing, age, sex, and length data from returning adult salmon. These data support in-season and post-season management of commercial and subsistence fisheries that occur on the Yukon Delta National Wildlife Refuge and the Kuskokwim River. Estimated escapements of 16,981 chum salmon *O. keta*, 555 Chinook salmon *O. tshawytscha*, 189 sockeye salmon *O. nerka*, 140 pink salmon *O. gorbuscha* and 4,407 coho salmon *O. kisutch* passed through the Tuluksak River weir during 2012. Peak weekly passage occurred July 15–21 for Chinook, July 22–28 for chum and sockeye, July 29 to August 4 for pink, and August 19–25 for coho salmon. Age, sex, and length data were collected for chum and coho salmon, but only sex data were collected for Chinook and sockeye salmon. Dominant ages were 0.3 (60%) for chum and 2.1 (89%) for coho salmon. Overall percentages for female salmon were chum 51%, Chinook 33%, sockeye 64%, and coho salmon 54%. Mean lengths varied between male and female salmon for each species sampled. The estimated Chinook salmon escapement during 2012 was the fifth lowest on record and below the escapement goal range of 1,000−2,100 for the sixth successive year. Special management actions were taken for Chinook salmon during 2012 directly related to low return concerns in the Kuskokwim River drainage.

Introduction

The Tuluksak River is located approximately 192 river kilometers (rkm) upstream from the mouth of the Kuskokwim River in western Alaska (Whitmore et al. 2005). It flows through the Yukon Delta National Wildlife Refuge (Refuge) and supports spawning populations of chum salmon *Oncorhynchus keta*, Chinook salmon *O. tshawytscha*, sockeye salmon *O. nerka*, pink salmon *O. gorbuscha*, and coho salmon *O. kisutch*. These salmon 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 nutrients provided by salmon eggs and carcasses (U.S. Fish and Wildlife Service 1992).

Under guidelines established in the Sustainable Salmon Fisheries Policy, 5 AAC 39.222, the Alaska Board of Fisheries designated Kuskokwim River chum and Chinook salmon as stocks of

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yield concern in September 2000 based upon the inability, despite specific management measures, to maintain expected yields or to have a stable surplus above the stock's escapement needs. Beginning in January 2001, the salmon fishery in the Kuskokwim River drainage was managed under the Kuskokwim River Salmon Rebuilding Management Plan (Rebuilding Plan) (5 AAC 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 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 purpose to: "conserve fish and wildlife populations and habitats in their natural diversity" (ANILCA § 303 (7) (B) (i)). Despite the conservation measures taken under the Rebuilding Plan and by area managers, Chinook salmon returns to the Tuluksak River remain below the established escapement goal range.

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 (Molyneaux et al. 2010).

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

In previous years, salmon escapements were monitored using aerial surveys as indices of relative abundance in the Tuluksak River (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 1991−1994 and from 2001−2012. 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. An underwater video system was incorporated with the weir during 2010 and used to present. The objectives of the project for 2012 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. Also during 2012, otoliths were collected from Chinook salmon carcasses for a Chinook salmon population study. These data support the in-season and post season management of the Kuskokwim River subsistence and commercial fisheries. This information also assists managers in establishing escapement goals to maintain the long-term sustainability of salmon stocks returning to the Tuluksak River.

Study Area

The Tuluksak River is one of several lower Kuskokwim River tributaries and flows into the lower Kuskokwim River at River Kilometer 192. It is approximately 66 river kilometers (rkm) east-northeast of Bethel, Alaska (Whitmore et al. 2005). The Tuluksak River is approximately 137 rkm in length and its watershed encompasses approximately 2,098 km^2 (Figure 1). It originates in the Kilbuck Mountains and flows to the northwest. The Fog River drains into the lower portion of the Tuluksak River and is the only major tributary. The Tuluksak River is a medium gradient river for the majority of its length and is characterized by dense overhanging vegetation and cut banks. The lower river is characterized by low gradient, silt substrate, and turbid water. The river at the weir site is approximately 49 rkm from its confluence with the Kuskokwim River, is 42 m wide, shallowest in mid-river, and deepest near the banks. The substrate contains primarily sand mixed with fine gravel. Water clarity is moderately clear, but becomes turbid during rainy periods and when boat traffic is present. Dredging has taken place in approximately 40 kilometers of the upper Tuluksak River and Bear Creek drainages above the Refuge boundary (Figure 1).

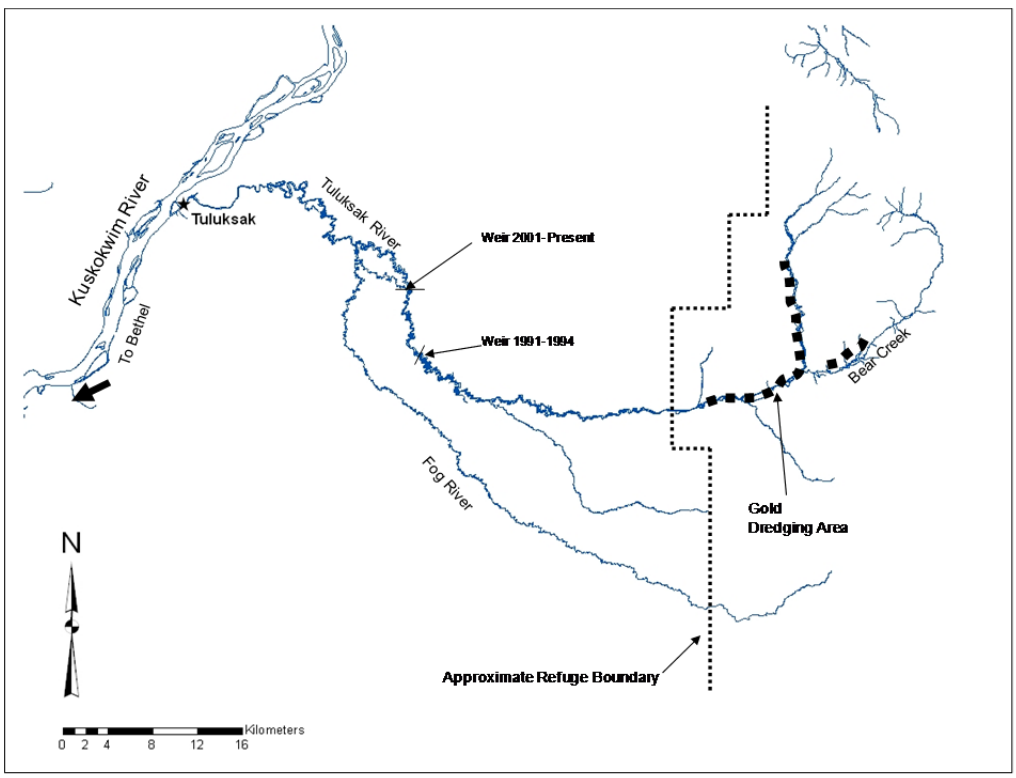

FIGURE 1.—Tuluksak River weir location, Yukon Delta National Wildlife Refuge, 1991–1994, and 2001–2012. The weir is located 49 rkm upstream from the confluence with the Kuskokwim River.

Dredge equipment operating in the floodplain of the Tuluksak River has altered the stream channel, and water in some areas flows through dredge tailings, tailing ponds, or both (Figure 1).

The mining and dredging activities, which began in 1908 and continued through most of the 20th Century, removed approximately 500,000 ounces of gold (Strachan 2005). Mining companies continue to explore for gold in the drainage and have conducted an extensive drilling program to define the lode bearing ore bodies. They have also expressed an interest in reworking the old dredge tailings.

Methods

Weir and Video Operations

A resistance board weir (Tobin 1994) affixed with an underwater video system (Gates et al. 2010; Miller and Harper 2011, 2012) was installed during 2012 in the Tuluksak River at river kilometer 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).

During 2012, one passage panel and live trap was installed and affixed with an underwater video system. The video system facilitated fish sampling during various river stage heights and allowed for salmon passage and enumeration 24 hours each day. The video system and weir were operated in unison during 2012. Visual counts, when required for a comparison, or if video footage counts experienced problems, started at approximately 0600 hours and continued until fading-daylight reduced visibility (~2300 hours). Video counts were recorded 24 hours a day, seven days each week when operable. Sex composition was determined from two independent observations using video footage similar to 2011 (Miller and Harper 2012). An object was passed in front of the video camera periodically to confirm the video system's motion detection was operating correctly. Migrating and resident fish were identified to species and recorded.

A staff gauge was installed approximately 10 m downstream of the weir to measure daily water levels from June 24 to September 25. Measurements represent the average water depth across the river channel at the upstream edge of the weir. Water and ambient temperatures were collected daily using a handheld thermometer from June 24 to September 21. Ambient temperature, water temperature, and fish passage counts were relayed daily by cell phone or email to Service staff in Bethel who in turned updated the Department via email daily. 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

Weekly strata started on a Sunday and continued through the following Saturday (Harper 1997). Biological sampling occurred between Sunday and Thursday of each stratum in order to obtain a collection that represented the age, sex, and length (ASL) characteristics of the return for each stratum (Geiger et al. 1990; Linderman et al. 2002). Target sample sizes consisted of 170 chum salmon, 210 Chinook salmon, and 170 coho salmon each week. The target sample size for sockeye salmon was 75 fish for the season. 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. Post-season analysis may include the combination of weekly strata to ensure an 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.

Age, sex, and length data 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 live 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 coho, 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 by observing external characteristics during video review and stratified ASL sampling. Females were identified as having blunt-shaped heads, presence of an ovipositor (ASL sampling only), and a round-shaped belly, whereas males generally exhibit a prolonged head accompanied with a kype, a gradual dorsal hump, and a thinner belly. Length was measured to the nearest 5 mm from the mid-eye to the fork of the caudal fin for chum, Chinook, sockeye, and coho salmon. Sex data analyzed from video footage was compared to ASL data for the same time periods and across stratum. Once ASL data were collected, each fish was released and passed unharmed upstream of the live trap. Data were recorded and later transferred to digital spreadsheets. The Department staff aged the scales and processed the forms in Anchorage under OSM-FRMP project 10-303.

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 are both six-year old fish from the same brood year (1.4 = 1 + 4 + 1 = 6, and 2.3 = 2 +3 + 1 = 6). The brood year is determined by subtracting fish age from the current year.

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

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

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

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

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

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

with estimated variance

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

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

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

with estimated variance

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

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

$$\hat{N}_{ijk} = \sum_{m}\hat{N}_{ijkm}$$

with estimated variance

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

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

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

with corresponding variance estimator

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

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

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

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

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

Estimates were calculated for dates with partial and zero counts due to flooding or holes in the weir. Estimates were based on the average daily proportion of passage from previous years. An average of the daily proportions for previous years was calculated because daily escapement can vary between years. The sum of the averaged daily proportions, calculated for days with partial or zero counts, is the estimated total proportion of the missed escapement. The total escapement is the sum of the observed counts divided by one minus the proportion missed. Averages in the historical escapement figure were generated using prior years with escapement estimates (Gates and Harper 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011, 2012).

Results

Weir and Video Operations

The crew traveled to the weir site by boat on June 22, 2012. Installation of the weir was completed on June 26, the video system on June 27, and both were operational through September 9. Visual counts were obtained June 24 to July 2 and video methods were used June 27 to September 10 to enumerate fish, identify species, and determine sex. Visual counts were made from 0800 to 2159 hours and video from 0000 to 2400 hours.

In-season counts and archived video footage counts collected were compared. A total of 1,680 hours of archived video footage collected between July 1 and September 7 for Chinook salmon were compared to the same times these fish were counted passing through the weir in real time on the computer monitor. During these paired counts, 541 Chinook salmon were counted during the season and 536 were counted from archived video files post season, a difference of five fish (Table 1). Only Chinook salmon counts were compared. The video file was used to verify species and sex ratios for chum, Chinook, sockeye, and coho salmon.

A wet year with high water affected weir operations most of the field season (Appendix 1) and low numbers of fish were sampled from the trap for ASL data during 2012; however, species and sex data were collected from video footage for the entire season. Starting June 26 and continuing through takeout during September, river stage heights often exceeded operational levels (stage height >90 cm) for technicians to safely collect scale samples from fish in the live trap (Appendix 1). The weir panels were kept operational and video files allowed for identification and enumeration of migrating fish and sex identification of each salmon species. Escapements were estimated for July 11 for chum, Chinook, and sockeye salmon. Water levels remained high until late September and the last weir components were removed on September 28. Minor repairs to damaged weir components were made on site during the field season.

Average water depth at the leading edge of the weir during 2012 was 117 cm. The recorded maximum water depth (197 cm) occurred on September 8 and the minimum water depth (53 cm) occurred on August 18 and 19 (Appendix 1). Water temperatures (daily average) ranged from a low of 5.5°C on September 8 and to a high of 11.4°C on August 13. Ambient temperatures ranged from a low of -0.3°C on September 13 to a high of 14°C on August 13(Appendix 1).

Biological Data

Chum Salmon —A total of 16,682 chum salmon was counted through the weir from June 30 to September 7 (Figure 2; Appendix 2). An additional 299 chum salmon were estimated to have passed July 11 for a total estimated escapement of 16,981 chum salmon. The peak weekly

passage of 5,256 chum salmon occurred July 22–28 (Figure 2) and median cumulative passage occurred on July 23 (Figure 3; Appendix 2).

Three ages (0.3, 0.4, and 0.5) of chum salmon were identified from scale samples. The predominant age was 0.3 for both male (52%) and female (70%) chum salmon (Appendix 3). Ages 0.3 and 0.4 comprised 99% of the total chum salmon estimated escapement. Males dominated the early portion of the run and comprised 70% of the ASL sample (n = 135) and 55% of the video sample (n = 6,228) for strata 1−4 (June 24 to July 21), and 50% (ASL) and 45% (video) for strata 5−10 (July 22 to September 8) (Figure 3). Females comprised 42% of the ASL collection and 51% of the video sample of the total estimated escapement (Appendix 3). Mean length of males was larger for ages 0.3, 0.4, and 0.5 than that of female chum salmon of the same age (Appendix 4).

Chinook Salmon —A total of 541 Chinook salmon was counted through the weir from July 1 to August 17 (Figure 2; Appendix 2). An additional 14 Chinook salmon were estimated to have passed on July 11 for a total estimated escapement of 555 Chinook salmon. The peak weekly passage of 166 Chinook salmon occurred July 15–21 (Figure 2) and the median cumulative passage occurred on July 16 (Appendix 2).

The sample size (n = 8) was considered inadequate to characterize the age structure and length-at-age of Chinook salmon; however, video footage collected from July 1 to August 18 confirmed that 33% of the 536 Chinook salmon counted were females (Appendix 5). Male Chinook salmon were dominant in every portion of the return with the exception of 48% for stratum 5 (Figure 3; Appendix 5).

Sockeye Salmon —A total of 183 sockeye salmon was counted through the weir July 4 to August 10 (Figure 2; Appendix 2). An additional 6 sockeye salmon were estimated to have passed on July 11 for a total estimated escapement of 189 sockeye salmon. The peak weekly passage of 74 sockeye salmon occurred July 22–28 (Figure 2), and the median cumulative passage occurred on July 23 (Appendix 2).

The sample size (n = 2) was too small to characterize the age structure and mean lengths of sockeye salmon; however, video footage collected from July 1 to August 18 confirmed that 64% of 103 sockeye salmon identified were female (Appendix 6). Male sockeye salmon predominated in the early portion of the return (Figure 3).

Pink Salmon —A total of 140 pink salmon was counted through the weir July 6 to August 29 (Figure 2; Appendix 2). The peak weekly passage of 36 pink salmon occurred July 29 to August 4 (Figure 2) and the median cumulative passage occurred on July 29 (Appendix 2).

Coho Salmon —A total of 4,407 coho salmon was counted through the weir July 20 to September 7 (Figure 2; Appendix 2). The peak weekly passage of 2,654 coho salmon occurred August 19–25 (Figure 2), and the median cumulative passage occurred on August 23 (Appendix 2).

Four ages (1.1, 2.1, 3.1 and 4.1) of coho salmon were identified from scale samples (Appendix 7). Age 2.1 was the predominant age for both males (92%) and females (86 %). Females comprised 53% of the ASL sample (n = 112) and 54% of a random sample (n = 797) of coho salmon collected from video footage between July 20 and September 7. Females were dominant in all strata (Figure 3; Appendix 7). Mean lengths were smaller for male than female coho salmon for ages 1.1 and 2.1 (Appendix 8).

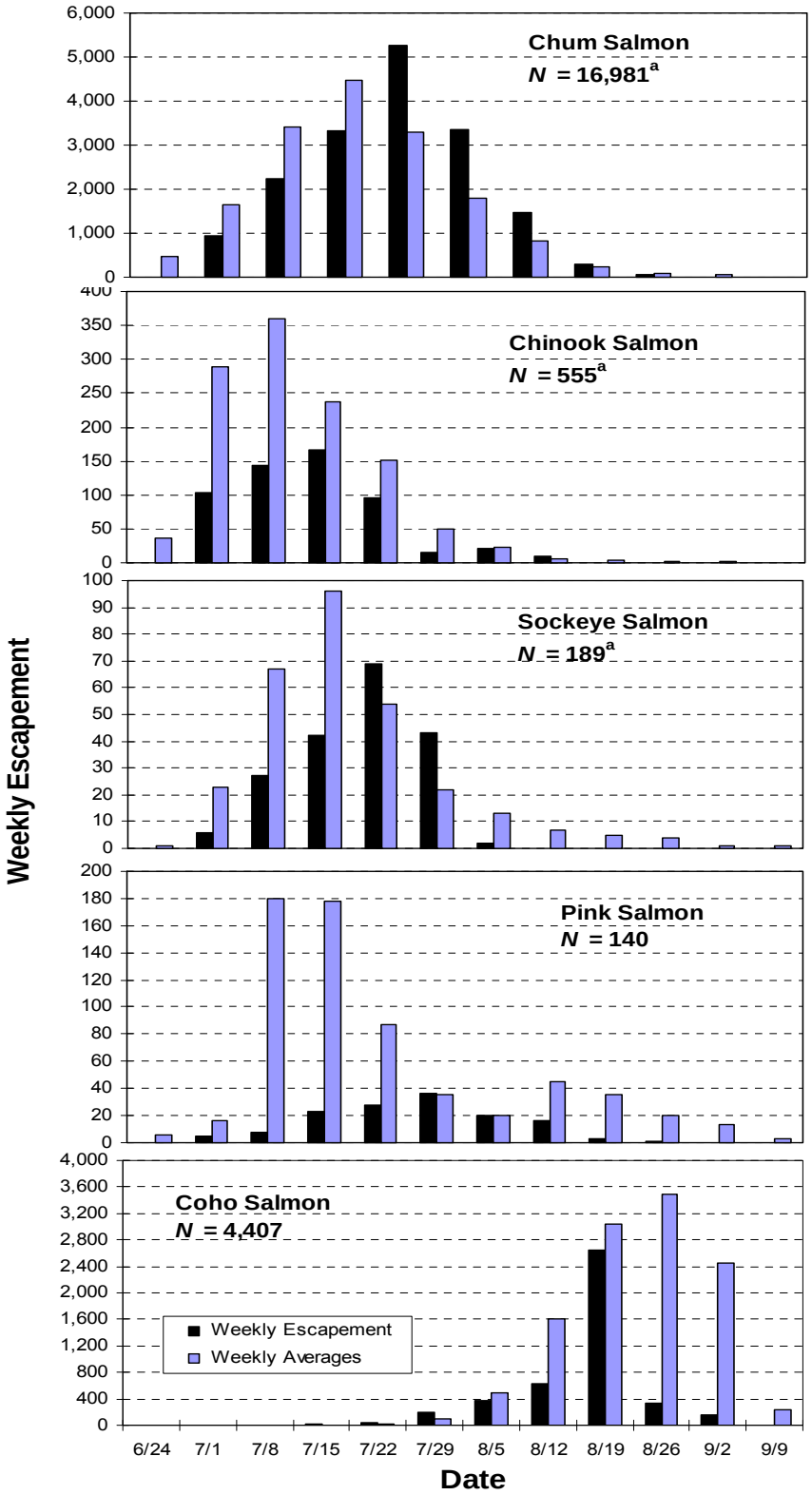

FIGURE 2.—Weekly escapement of chum, Chinook, sockeye, pink and coho salmon passing through the Tuluksak River weir, 2012. Average weekly totals for chum, Chinook, sockeye, and coho salmon are for years 1991−1994, 2001−2011 and for pink salmon even years 2002−2010. Totals with a superscript ([a]) indicate estimates are included for chum, Chinook, and sockeye salmon.

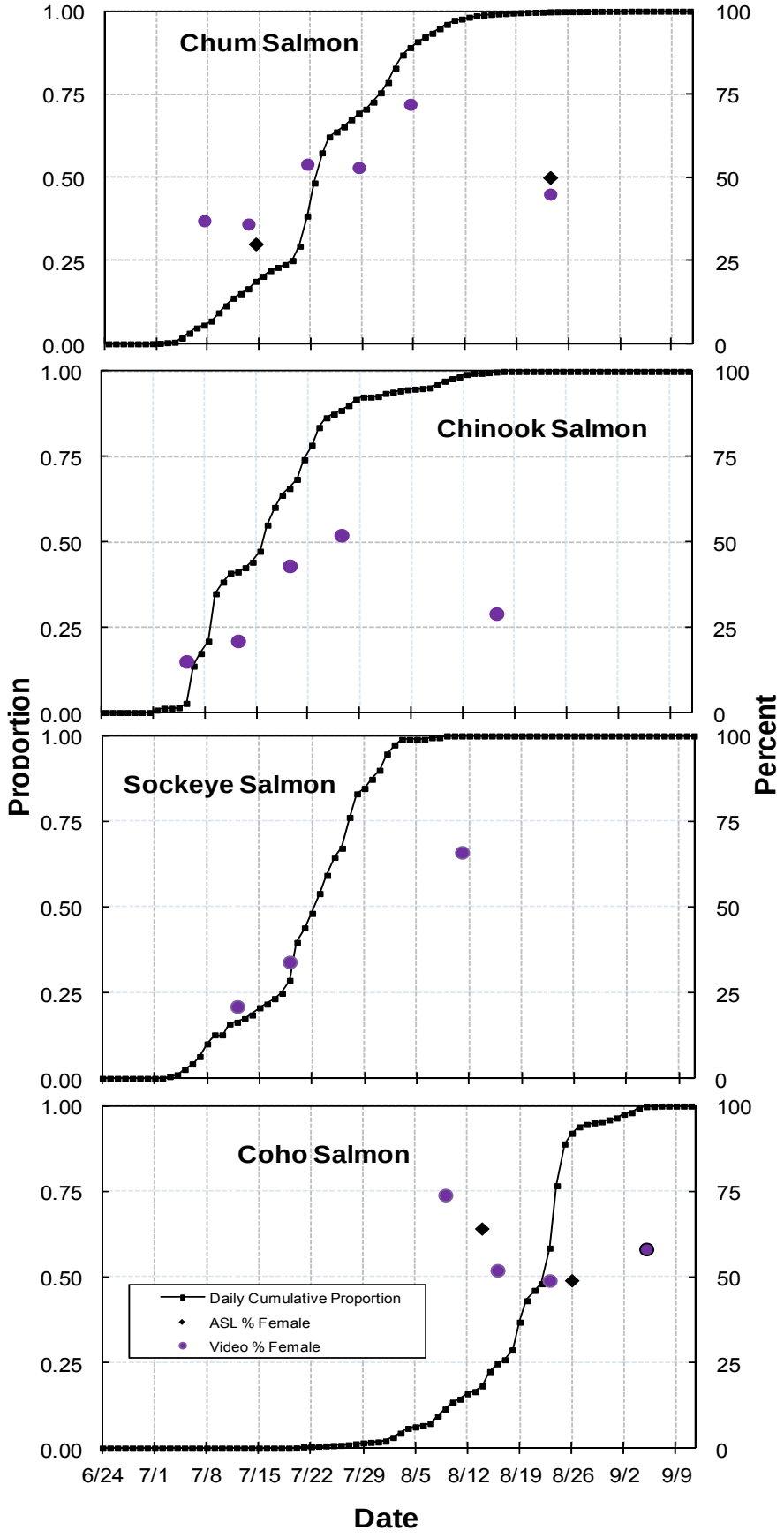

FIGURE 3.—Cumulative proportion and percent females from weekly ASL samples and video footage of chum, Chinook, sockeye, and coho salmon passed through the Tuluksak River weir, 2012.

Other —Resident and other migrant species counted through the weir in 2012 consisted of 1 Dolly Varden *Salvelinus malma*, 6 northern pike *Esox lucius*, 13 Arctic grayling *Thymallus arcticus,* 33 humpback whitefish *Coregonus pidschian*, and 20 round whitefish *Prosopium cylindraceum*. Small fish (≤40 cm) were able to pass freely through the pickets, but only fish counted through the passage chute were recorded. Otolith samples were collected at the Tuluksak River weir location from 27 Chinook salmon carcasses during 2012.

Discussion

Weir and Video Operations

The weir is typically installed the third week of June and operational through September 10 (Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011, 2012). During 2012, high water hampered weir operations and ASL collections from June through September. A large tree sank several weir panels during the early morning hours of July 11 and fish passage estimates were generated for that day (Appendix 2). High water also limited sample collections because of safety concerns (Appendix 1). Removal of debris, continual picket repair, broken bolts on resistance boards and general maintenance became more problematic due to high water.

The addition of the underwater video system proved effective in the enumeration of chum, Chinook, sockeye, and coho salmon during high water events. Data collected from video footage was very useful for counts, speciation, sex composition, and comparing sex composition across strata with the small ASL sample sizes (Figure 3; Appendices 3, 5, 6 and 7). The video system proved very useful for identification and counts of other species passing the weir. Between 2001 and 2009, coregonids were enumerated and classified as 'whitefish' and counts ranged from 3−94 fish (Gates et al 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010). Since 2010, the addition of video has allowed staff to better enumerate and identify whitefish as three distinct species and counts have ranged from 53−138 (Miller and Harper 2011, 2012).

Video counts and archived video footage were collected through September 9. The crew began to remove weir and video equipment from the river on September 10 due to rising water. The video box, live trap, passage chute and some weir panels were removed from the river by September 12. The crew returned to Bethel on September 14 and the camp was monitored daily until water levels dropped enough to complete dismantling the weir and camp. The final set of weir panels and bulkhead were removed on September 28. The substrate rail and cable remained in place to expedite the 2013 weir install.

Biological Data

Chum Salmon —The 2012 chum salmon estimated escapement of 16,981 was within the historic range of 7,675–35,696 fish (Figure 4). The 2012 estimated escapement was above a 15-year average of 15,648 chum salmon (1991–1994 and 2001–2010) (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011, 2012). The 2012 escapement was 48% of the record high 2005 chum salmon escapement of 35,696. The median passage date for chum salmon occurred on July 23. This passage date was similar to 2001 and 2009 and six days later than the earliest recorded during 2002 (Figure 5, Appendix 9). Since 2001, the average cumulative passage of 99% for chum salmon has occurred on August 17 (Gates and Harper 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller

and Harper 2009, 2010, 2011, 2012). The estimated cumulative passage during 2012 of 99% for chum salmon occurred on August 15 (Appendix 2).

Females comprised 51% of the total chum salmon escapement and the highest recorded since 2001 (Appendix 9). The difference in sex composition between the ASL sample and the video footage sample during 2012 may be the result of using a larger data set from video footage over all strata compared to the smaller ASL sample. Video and ASL data confirmed that males were predominant during the early portion of the run and the proportion of females increased during the mid to later portions of the return (Figure 3; Appendix 3). During the previous 3 years (2009−2011), male chum salmon were dominant in all strata by 11% or higher (Miller and Harper 2010, 2011, 2012).

The dominant ages during 2012 for chum salmon were split between ages 0.3 and 0.4 (Appendix 3). Age-0.3 increased from the 49% during 2011 to 59% during 2012 and age-0.4 chum salmon decreased from the 50% during 2011 to 40% during 2012 (Appendix 3) (Miller and Harper 2012). The ASL sample collection (n = 135) may be too small to characterize the age and length-at-age composition of the 2012 chum salmon return since we did not achieve the sample size goal of 170 fish per stratum.

Chinook Salmon —The estimated Chinook salmon escapement of 555 during 2012 was the fifth lowest on record and well below the 15-year average of 1,161 Chinook salmon (1991–1994 and 2001–2011; Figure 4). This was the sixth 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). This year's escapement was 94% higher than 2011, which was the second lowest on record (Figure 4).

Median passage dates for Chinook salmon have fluctuated from July 5−22 during previous years (Figure 5). The median passage date for 2012 was July 16 and the earliest observed since 2004 (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, 2011, 2012) (Figure 5, Appendix 9). Reasons for these shifts in run timing are not well understood, but possible factors may include changes in climate and oceanographic conditions, change in management strategies that perhaps directed harvest pressures on different portions of the run, prevailing winds and river flows at the time of the return, and breached tailing ponds altering habitat and river channel dynamics. Greater than 99% of the average cumulative passage for Chinook salmon from 1991−1994 and 2001−2011 occurred by August 11, one day earlier than during 2012 (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, 2011, 2012).

During 2012, female Chinook salmon comprised 33% of the estimated escapement. Video footage between July 1 and August 17 identified 180 females of the 536 Chinook salmon examined. The sex composition for 2012 was within 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, 2011, 2012). Although this is the third year since 2007 that females comprised less than 41% of the Chinook salmon sampled, it is an increase over the 26% observed during 2010 and 2011 (Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011, 2012) (Appendix 9). Given the trend of low escapement for Chinook salmon and the low number of females estimated during 2012, it is unknown how this brood year will contribute to

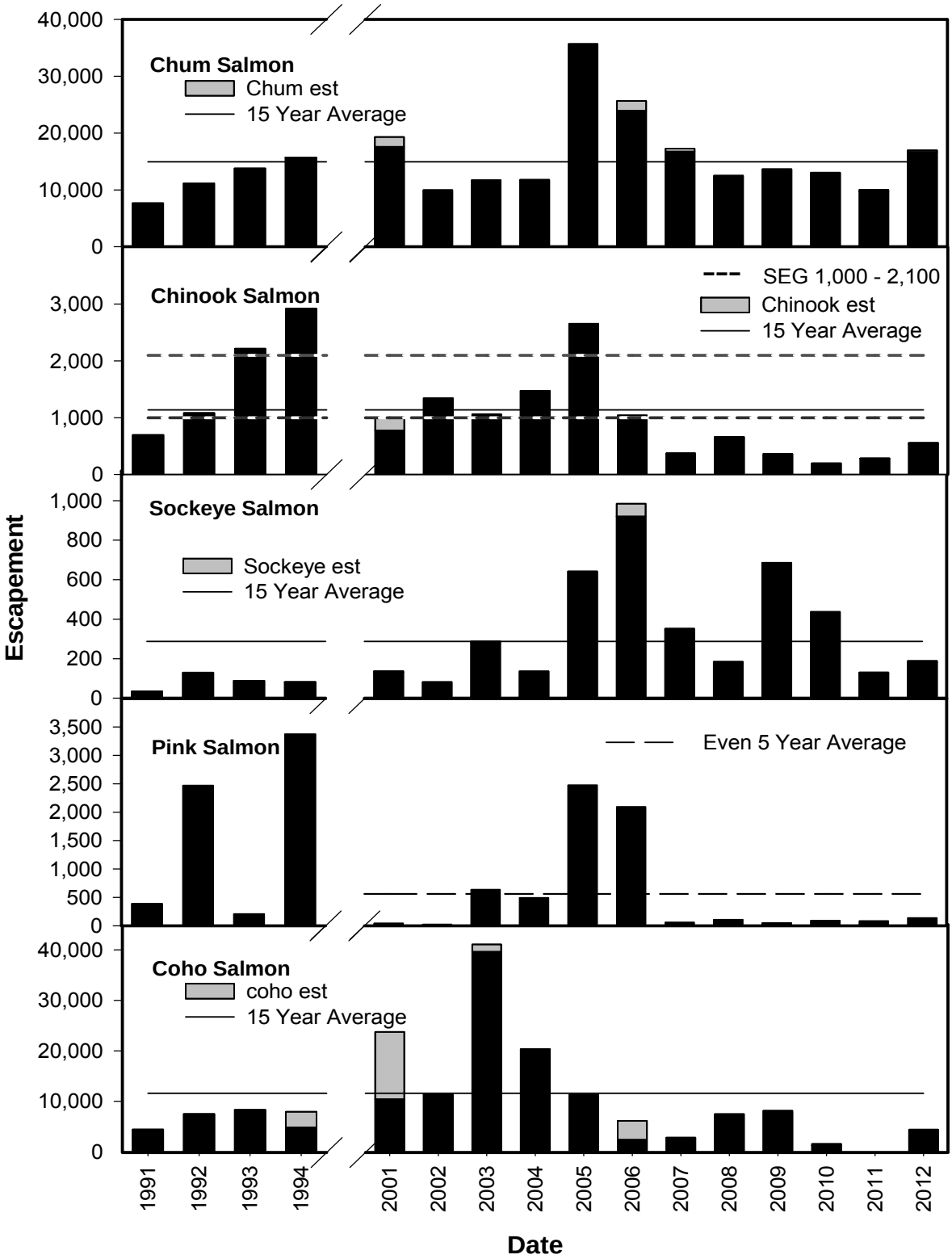

FIGURE 4.—Salmon escapement estimates through the Tuluksak River weir, 1991–1994 and 2001–2011. Averages include estimates for days missed. Pink salmon averages are for years after 2000 when wider picket spacing was used on weir panels. Total escapements for coho salmon were not estimated during 2010 and 2011 (Miller and Harper 2012) due to incomplete counts. Note: Y-axes ranges are different for all species.

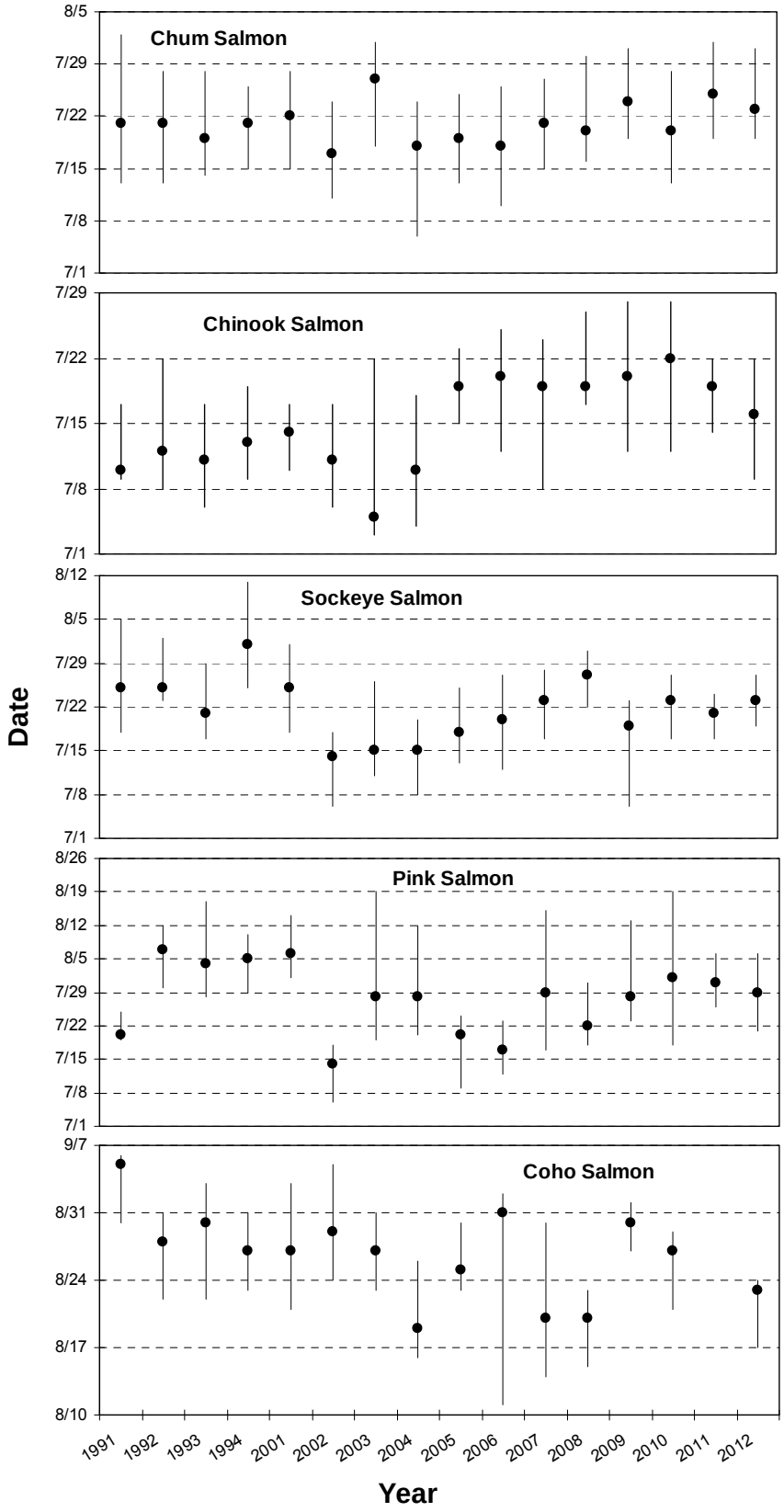

FIGURE 5.—Median cumulative passage for chum, Chinook, sockeye, pink, and coho salmon at the Tuluksak River weir, 1991–1994 and 2001–2012. A median date was not estimated for coho salmon during 2011. The filled circles represent the median (50%) passage date and the vertical line below and above the circle represent the second and third quartiles, respectively.

future returns of Chinook salmon to the Tuluksak River. The poor returns since 2007 indicate the Chinook salmon population in the Tuluksak River may still be depressed.

The 2012 ASL collection (n = 8) was too small and considered inadequate to characterize age and length-at-age of the Chinook salmon escapement. During previous years fish less than 700 mm were counted as males (Miller and Harper, 2009, 2010, 2011, 2012). During 2012 Chinook salmon were sexed visually from video footage regardless of length.

The difference between the sample size of Chinook salmon recorded on video during the field season (n = 541) and identified post season (n = 536) may be the result of errors that occurred during transcription from hard to electronic data copies, or fish sampled for ASL that subsequently were not passed through the video passage chute and captured on video footage. Age, sex and length data were recorded daily on the hard and electronic data sheets and entered into the data set.

Chinook salmon management actions taken by the Department during 2012 were based on a low projected return and low in-season escapement data (Table 2). The management strategy to conserve Chinook salmon in the Kuskokwim River drainage and meet escapements in upper and lower Kuskokwim River tributaries used 'Rolling Closures' and mesh size restrictions (www.adfg.alaska.gov/index.cfm?adfg=commercialbyareakuskokwim.main). The Kuskokwim River was divided into five sections based on run timing and demographics, and closures and openings were initiated as fish migrated (Figure 6). It is currently unknown what effect the actions taken during 2012 had on increasing the Tuluksak River Chinook salmon escapement.

Harvest data collected during 2012 (Elison et al. 2012) showed 20,000 Chinook salmon to have been harvested from the subsistence fishery and considerably less than the 10-year average of 81,786 (2002-2011; Hamazaki 2011). Restrictions and low returns in 2010 and 2011 were likely causes for the drop in the Chinook salmon subsistence harvests to approximately 66,000 and 58,836, respectively. If the subsistence harvest had not been reduced the number of Chinook salmon returning to the Tulusak River may have been smaller.

Sockeye Salmon —The estimated escapement of 189 sockeye salmon during 2012 was the seventh highest on record, yet well below the 15-year average of 294 sockeye salmon (Figure 4). Estimated escapements for sockeye salmon have ranged from 34 fish during 1991 to 985 fish during 2006. Median passage dates for sockeye salmon have fluctuated between July 14 and August 1 since 1991, a difference of 19 days (Figure 5; Appendix 9). The median passage date during 2012 was July 23, similar to 2007 and 2010 (Appendix 9). The average cumulative passage of 99% for sockeye salmon since 2001 occurs on September 2 (Gates and Harper 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011, 2012), 25 days later than the estimated passage of 99% on August 8, 2012 (Appendix 2). Although substantially earlier than average, the passage of 99% for sockeye salmon during 2009 also occurred on August 8 (Miller and Harper 2010).

During 2012, female sockeye salmon comprised 64% of the estimated escapement. From the video footage collected between July 1 and August 18 seventy females were identified out of 103 sockeye salmon viewed. The sex composition for 2012 was within the sample range (40–83%) observed during previous years and the third highest of the years recorded (Appendix 9). The ASL sample size (n = 2) was too small to characterize the age and length-at-age compositions during 2012.

TABLE 2.— Emergency orders and News Releases taken by the Department (ADF&G) during 2012.

Effective Date	Emergency Order / News Release
6/1 - 7/25	ADFG Emergency Order 3-KS-01-12, specific area/tributarie closures of sport fishing for Chinook salmon
6/13 - 7/25	ADFG Emergency Order 3-KS-03-12, closed all waters of the mainstem Kuskokwim River to sport fishing for Chinook salmon
6/22 - 7/25	ADFG Emergency Order 3-KS-04-12, order supersedes # 3-KS-01-12 and 3-KS-03-12 closing sport fishing for Chinook salmon
6/1 - 7/25	ADFG Emergency Order 1, closed subsistence fishing to hook and line and restricted mesh to 4 inch or less and gill net length to 60 feet or less in specific areas and tribs
6/10 - 6/16	ADFG Emergency Order 2, closed subsistence fishing to hook and line and restricted mesh size to 4 inch or less and length of gill net to 60 feet or less, Lower Subdistrict 1-B (RCS 1)
6/13 - 6/19	ADFG Emergency Order 3, closed subsistence fishing to hook and line and restricted mesh size to 4 inch or less and length of gill net to 60 feet or less, Upper Subdistrict 1-B (RCS 2)
6/17 - 6/23	ADFG Emergency Order 4, closed subsistence fishing to hook and line and restricted mesh size to 4 inch or less and length of gill net to 60 feet or less, Tuluksak to Chuathbaluk (RCS 3)
6/17 - 6/21	ADFG Emergency Order 5, closed subsistence fishing to hook and line and restricted mesh size to 4 inch or less and length of gill net to 60 feet or less, Lower Subdistrict 1-B (RCS 1)
6/20 - 6/24	ADFG Emergency Order 6, closed subsistence fishing to hook and line and restricted mesh size to 4 inch or less and length of gill net to 60 feet or less, Upper Subdistrict 1-B to Tuluksak (RCS 2)
6/22 - 6/24	ADFG Emergency Order 7, opened the use of gillnets with 6-inch or less, Lower Section Subdistrict 1-B (RCS 1)
6/24 - 6/27	ADFG News Release #9, extention of opening for Lower Section Subdistrict 1-B (RCS 1)
6/28 - 7/14	ADFG News Release # 10, closed subsistence fishing, based on rolling closures and districts
6/30 - season end	ADFG News Release # 11, opened the subistence fishery to the use of 6 inch mesh or less as dictated by rolling closure and districts (RCS 1-3)
7/7 - season end	ADFG News Release # 12, opened the subsistence fishery to use of 6 inch mesh or less as dictated by rolling closures and districts (RCS 1-5)
7/15 - season end	ADFG News Release # 14, opened the subsistence fishery to unrestricted mesh size as dictated by rolling closures and districts (RCS 1-5)
7/23 - season end	ADFG News Release # 17, opened the subsistence fishery to unrestricted mesh size as dictated by rolling closures and districts (RCS 4-5)
7/23 - season end	ADFG News Release # 18, opened the subsistence fishery to the use of hook and line gear

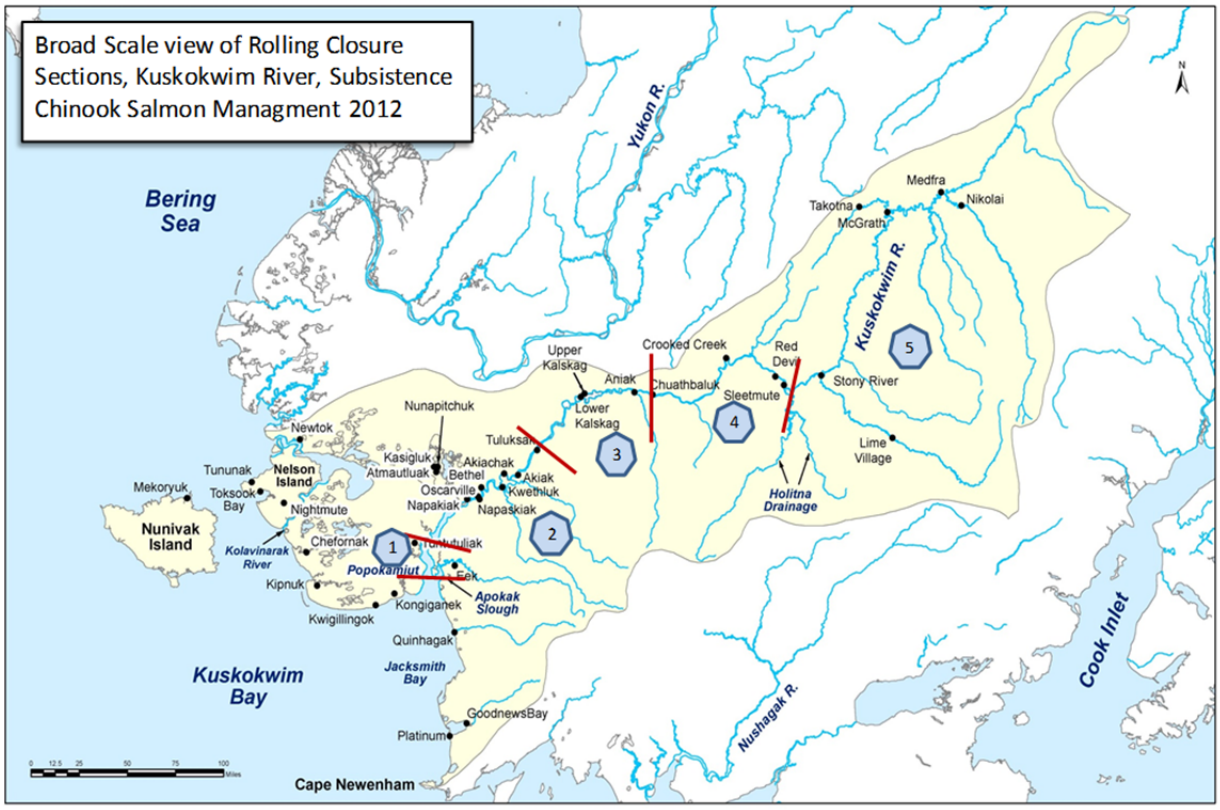

FIGURE 6.—Rolling closure boundaries starting with section one at the river mouth and moving upriver to section five which includes the drainage headwaters, 2012 (Working Group 2012).

Pink Salmon —The 140 pink salmon observed passing through the weir during 2012 was higher than even-years 2002, 2008 and 2010 but low compared to even-years 2004 and 2006 (Figure 4). The median cumulative passage date, based on the pink salmon count, was July 29; similar to 2003, 2004, 2007 and 2009 (Figure 5; Appendix 9). Age, sex, and length data were not collected for pink salmon

Coho Salmon —The estimated 2012 coho salmon escapement of 4,407 fish was within the historic range of 1,216–41,071 coho salmon, yet well below the estimated 14-year average of 11,609 (Figure 4). Coho salmon have been below the average for 8 of the past 12 years and similar to Chinook salmon being below their average for the past seven consecutive years (Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011, 2012). Both coho and Chinook salmon spend at least one year rearing in fresh water and various fresh water conditions may be factors affecting juvenile survival for both species. Groot and Margolis (1991) report that most coho juvenile mortality occurs during the rearing stage in fresh water. Mining activities in the Tuluksak River and habitat degradation may have reduced or altered flows, increased winter and spring freshets, water temperatures, flow and river channel morphology, or rearing space affecting salmon production and juvenile coho salmon survival.

The median passage date for coho salmon occurred on August 23, the fourth earliest recorded (Figure 5; Appendix 9). The 2012 estimate of 99% passage on September 4 was six days earlier than the average cumulative passage date (1991–1994 and 2001–2010) of September 10. Female coho salmon comprised 54% of the observed escapement which was the third highest recorded and within the range of 31% (2009) to 58% (2002) (Appendix 9). The sex composition of coho salmon comparison between the ASL sample (n =112) and video footage sample (n = 797) differed by only 0.5 % despite the large difference in sample size (Appendix 7). The historical coho salmon escapement has varied in number, timing, and percent females since the project began in 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, 2011, 2012).

Other —A study addressing the population structure of Chinook salmon in the Kuskokwim River was started during 2011 using microchemistry analysis. As part of the baseline collection for the microchemistry analysis technicians collected otolith (bone structure in inner ear) samples from Chinook salmon carcasses (n = 27) during August 4−27 at the Tuluksak River weir. Rivers have an elemental and isotopic composition (i.e., strontium isotopes) similar to the surrounding watershed. As otoliths form and grow they permanently absorb these elements in close ratio to that of the immediate environment. Differences in isotopic composition of tributaries can be detected using multi-collector inductively coupled mass spectrometer (MC-ICP-MS) analysis (Barnette-Johnson et al. 2005). These differences may help managers identify streams of natal origin, a certain stock in a mix stock fishery at a specific time, and run timing of specific stocks, in the Kuskokwim Chinook salmon return.

Recommendations

The Tuluksak River weir is an important project to monitor Kuskokwim River salmon stocks that originate on the Refuge. The continual low return of the Chinook salmon to the Tuluksak River should be monitored also. This weir and other escapement projects spread throughout the Kuskokwim River drainage provide important information used by Service and Department fishery managers. Annual weir operation should continue well into the future to gather a long-term data set to monitor trends and population health of salmon. All employees should be

continually trained in electrical safety precautions. A laser measurement system incorporated with the video system should be considered to enhance ASL data samples during high water. Newer methodologies may also be developed to aid in the enumeration of migrating fish during high water events. Collaboration with the Refuge and the Tuluksak Native Community should also continue to address direct and indirect effects of land management activities on this system.

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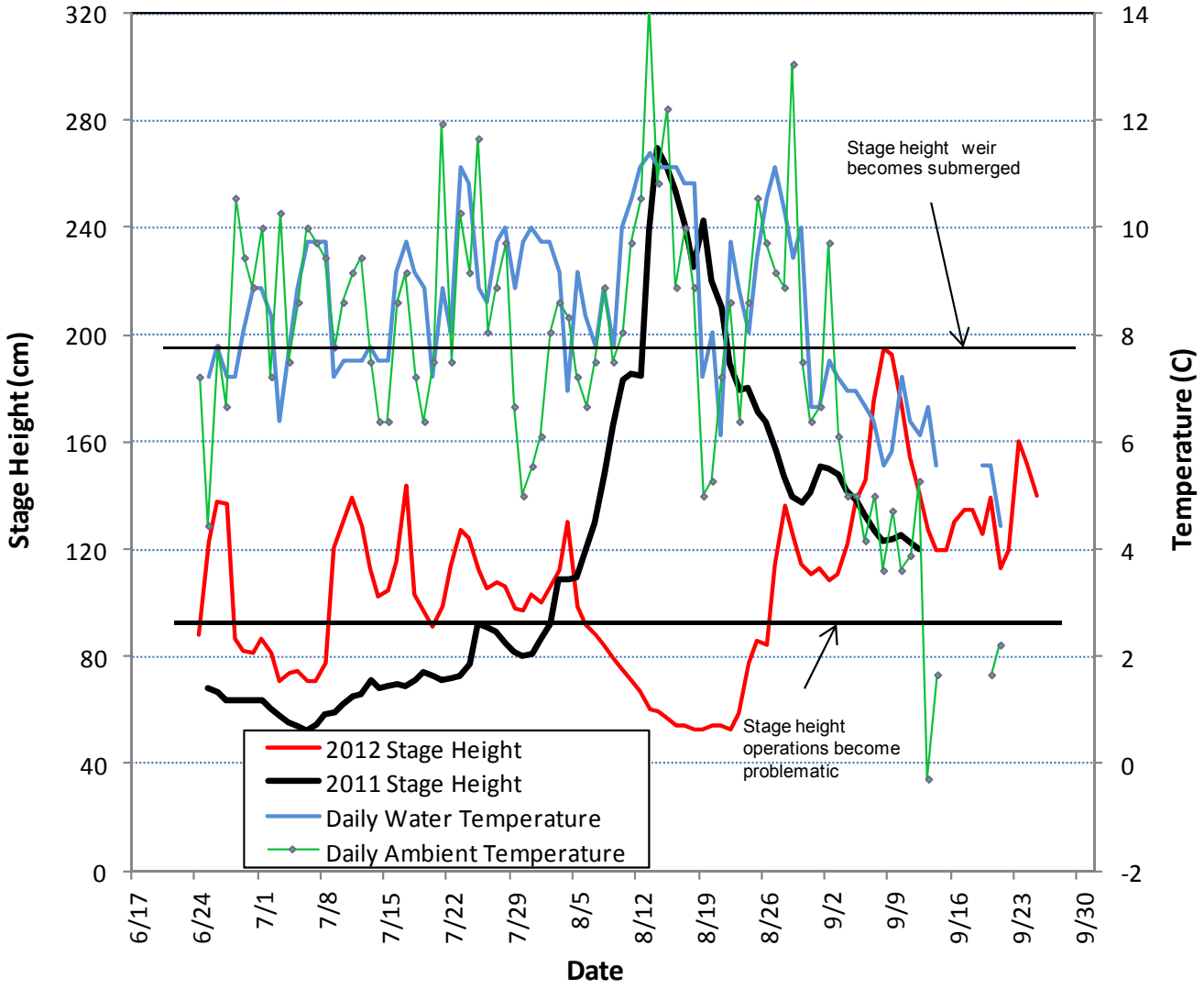

APPENDIX 1.—River stage heights and daily water temperatures at the Tuluksak River weir, 2012. The solid line at 190 cm represents a stage height at which time the entire weir becomes submerged. The solid line at 90 cm represents the stage height when sampling fish is a safety concern for staff and installation of the weir becomes problematic.

APPENDIX 2.—Daily, cumulative, and cumulative proportion of chum, Chinook, sockeye, pink, and coho salmon passing through the Tuluksak River weir, Alaska, 2012. Boxed areas represent the second and third-quartile and median passage dates. The shaded area represents a high water event when partial or no counts were recorded and escapement totals were estimated for chum, Chinook, and sockeye 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
06/29	2	2	0.000	0	0	0.000	0	0	0.000	0	0	0.000			
06/30	10	10	0.001	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
07/01	14	24	0.001	4	4	0.007	0	0	0.000	0	0	0.000	0	0	0.000
07/02	35	59	0.003	3	7	0.013	0	0	0.000	0	0	0.000	0	0	0.000
07/03	20	79	0.005	0	7	0.013	1	1	0.005	0	0	0.000	0	0	0.000
07/04	217	296	0.017	1	8	0.014	1	2	0.011	0	0	0.000	0	0	0.000
07/05	243	539	0.032	7	15	0.027	3	5	0.026	0	0	0.000	0	0	0.000
07/06	273	812	0.048	60	75	0.135	3	8	0.042	1	1	0.007	0	0	0.000
07/07	142	954	0.056	29	104	0.187	4	12	0.063	4	5	0.036	0	0	0.000
07/08	209	1,163	0.068	22	126	0.227	7	19	0.101	4	9	0.064	0	0	0.000
07/09	418	1,581	0.093	72	198	0.356	5	24	0.127	0	9	0.064	0	0	0.000
07/10	356	1,937	0.114	19	217	0.391	0	24	0.127	0	9	0.064	0	0	0.000
07/11	390	2,327	0.137	14	231	0.417	6	30	0.159	2	11	0.079	0	0	0.000
07/12	230	2,557	0.151	2	233	0.420	1	31	0.164	0	11	0.079	0	0	0.000
07/13	253	2,810	0.165	6	239	0.431	2	33	0.175	2	13	0.093	0	0	0.000
07/14	381	3,191	0.188	9	248	0.447	2	35	0.185	0	13	0.093	0	0	0.000
07/15	258	3,449	0.203	19	267	0.482	4	39	0.206	0	13	0.093	0	0	0.000
07/16	285	3,734	0.220	46	313	0.564	2	41	0.217	1	14	0.100	0	0	0.000
07/17	167	3,901	0.230	30	343	0.618	3	44	0.233	2	16	0.114	0	0	0.000
07/18	143	4,044	0.238	20	363	0.654	3	47	0.249	3	19	0.136	0	0	0.000
07/19	207	4,251	0.250	9	372	0.671	7	54	0.286	3	22	0.157	0	0	0.000
07/20	734	4,985	0.294	15	387	0.698	21	75	0.397	3	25	0.179	2	2	0.000
07/21	1,532	6,517	0.384	27	414	0.746	8	83	0.439	11	36	0.257	14	16	0.004
07/22	1,690	8,207	0.483	20	434	0.782	8	91	0.481	4	40	0.286	4	20	0.005
07/23	1,539	9,746	0.574	28	462	0.833	11	102	0.540	3	43	0.307	4	24	0.005
07/24	808	10,554	0.622	15	477	0.860	10	112	0.593	4	47	0.336	4	28	0.006
07/25	260	10,814	0.637	6	483	0.870	10	122	0.646	0	47	0.336	5	33	0.007
07/26	265	11,079	0.652	6	489	0.881	5	127	0.672	2	49	0.350	3	36	0.008
07/27	354	11,433	0.673	8	497	0.896	17	144	0.762	5	54	0.386	7	43	0.010
07/28	340	11,773	0.693	12	509	0.917	13	157	0.831	10	64	0.457	13	56	0.013
07/29	202	11,975	0.705	4	513	0.924	3	160	0.847	11	75	0.536	11	67	0.015
07/30	359	12,334	0.726	0	513	0.924	5	165	0.873	4	79	0.564	7	74	0.017
07/31	480	12,814	0.755	1	514	0.926	5	170	0.899	1	80	0.571	5	79	0.018
08/01	525	13,339	0.786	5	519	0.935	9	179	0.947	7	87	0.621	12	91	0.021
08/02	730	14,069	0.829	2	521	0.939	5	184	0.974	5	92	0.657	47	138	0.031

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	Chum Salmon			Chinook			Sockeye Salmon			Pink Salmon			Coho Salmon		
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
8/3	671	14,740	0.868	2	523	0.942	3	187	0.989	5	97	0.693	54	192	0.044
8/4	378	15,118	0.890	2	525	0.946	0	187	0.989	3	100	0.714	62	254	0.058
8/5	305	15,423	0.908	1	526	0.948	0	187	0.989	2	102	0.729	19	273	0.062
8/6	234	15,657	0.922	1	527	0.950	0	187	0.989	3	105	0.750	17	290	0.066
8/7	193	15,850	0.933	1	528	0.951	1	188	0.995	4	109	0.779	28	318	0.072
8/8	235	16,085	0.947	5	533	0.960	0	188	0.995	5	114	0.814	94	412	0.093
8/9	215	16,300	0.960	6	539	0.971	1	189	1.000	3	117	0.836	91	503	0.114
8/10	210	16,510	0.972	4	543	0.978	0	189	1.000	1	118	0.843	90	593	0.135
8/11	68	16,578	0.976	3	546	0.984	0	189	1.000	2	120	0.857	38	631	0.143
8/12	93	16,671	0.982	4	550	0.991	0	189	1.000	4	124	0.886	70	701	0.159
8/13	72	16,743	0.986	2	552	0.995	0	189	1.000	5	129	0.921	27	728	0.165
8/14	40	16,783	0.988	0	552	0.995	0	189	1.000	1	130	0.929	74	802	0.182
8/15	29	16,812	0.990	1	553	0.996	0	189	1.000	1	131	0.936	184	986	0.224
8/16	31	16,843	0.992	1	554	0.998	0	189	1.000	1	132	0.943	100	1,086	0.246
8/17	16	16,859	0.993	1	555	1.000	0	189	1.000	3	135	0.964	52	1,138	0.258
8/18	24	16,883	0.994	0	555	1.000	0	189	1.000	1	136	0.971	127	1,265	0.287
8/19	17	16,900	0.995	0	555	1.000	0	189	1.000	2	138	0.986	358	1,623	0.368
8/20	14	16,914	0.996	0	555	1.000	0	189	1.000	0	138	0.986	277	1,900	0.431
8/21	9	16,923	0.997	0	555	1.000	0	189	1.000	0	138	0.986	133	2,033	0.461
8/22	6	16,929	0.997	0	555	1.000	0	189	1.000	0	138	0.986	86	2,119	0.481
8/23	17	16,946	0.998	0	555	1.000	0	189	1.000	0	138	0.986	458	2,577	0.585
8/24	8	16,954	0.998	0	555	1.000	0	189	1.000	0	138	0.986	804	3,381	0.767
8/25	2	16,956	0.999	0	555	1.000	0	189	1.000	1	139	0.993	538	3,919	0.889
8/26	3	16,959	0.999	0	555	1.000	0	189	1.000	0	139	0.993	137	4,056	0.920
8/27	2	16,961	0.999	0	555	1.000	0	189	1.000	0	139	0.993	84	4,140	0.939
8/28	4	16,965	0.999	0	555	1.000	0	189	1.000	0	139	0.993	31	4,171	0.946
8/29	3	16,968	0.999	0	555	1.000	0	189	1.000	1	140	1.000	21	4,192	0.951
8/30	1	16,969	0.999	0	555	1.000	0	189	1.000	0	140	1.000	14	4,206	0.954
8/31	0	16,969	0.999	0	555	1.000	0	189	1.000	0	140	1.000	23	4,229	0.960
9/1	1	16,970	0.999	0	555	1.000	0	189	1.000	0	140	1.000	25	4,254	0.965
9/2	4	16,974	1.000	0	555	1.000	0	189	1.000	0	140	1.000	49	4,303	0.976
9/3	4	16,978	1.000	0	555	1.000	0	189	1.000	0	140	1.000	20	4,323	0.981
9/4	0	16,978	1.000	0	555	1.000	0	189	1.000	0	140	1.000	53	4,376	0.993
9/5	0	16,978	1.000	0	555	1.000	0	189	1.000	0	140	1.000	24	4,400	0.998
9/6	2	16,980	1.000	0	555	1.000	0	189	1.000	0	140	1.000	3	4,403	0.999
9/7	1	16,981	1.000	0	555	1.000	0	189	1.000	0	140	1.000	4	4,407	1.000

APPENDIX 3.—Age and sex composition of the weekly chum salmon estimated escapement through the Tuluksak River weir, 2012. Weekly strata were combined and age, sex, and length (ASL) samples compared to the video footage sample for sex composition.

		ASL Samples						Video
		Brood Year and Age Group						
		2009	2008	2007	2006	2005		Sex Comp.
		0.2	0.3	0.4	0.5	0.6	Total	Total
Strata 1 – 4:	06/24 – 07/21							
Sampling Dates:	ASL, 07/02, 07/04, 07/08, 07/09							
	Video, 07/01 − 07/21							
Male:	Number in Sample:	0	34	43	1	0	78	2,173
	Estimated % of Escapement:	0.0	30.6	38.7	0.9	0.0	**70.3**	**55.3**
	Estimated Escapement:	0	1,996	2,525	59	0	4,580	3,601
	Standard Error:	0.0	284.0	300.1	58.2	0.0		32.5
Female:	Number in Sample:	0	11	20	2	0	33	1,760
	Estimated % of Escapement:	0.0	9.9	18.0	1.8	0.0	**29.7**	**44.7**
	Estimated Escapement:	0	646	1,174	117	0	1,937	2,916
	Standard Error:	0.0	184.1	236.8	81.9	0.0		32.5
Total:	Number in Sample:	0	45	63	3	0	111	3,933
	Estimated % of Escapement:	0.0	40.5	56.8	2.7	0.0	**100.0**	**100.0**
	Estimated Escapement:	0	2,642	3,699	176	0	6,517 [a]	6,517 [a]
	Standard Error:	0.0	302.5	305.2	99.9	0.0		
Strata 5 – 10:	07/22 – 09/03							
Sampling Dates:	ASL, 07/22, 08/01, 08/14, 08/15, 08/17 – 08/19, 08/22, 08/23							
	Video, 07/22 − 08/18							
Male:	Number in Sample:	0	7	5	0	0	12	1,042
	Estimated % of Escapement:	0.0	29.2	20.8	0.0	0.0	**50.0**	**45.4**
	Estimated Escapement:	0	3,052	2,180	0	0	5,232	4,751
	Standard Error:	0.0	990.6	885.1	0.0	0.0		96.1
Female:	Number in Sample:	0	10	2	0	0	12	1,253
	Estimated % of Escapement:	0.0	41.7	8.3	0.0	0.0	**50.0**	**54.6**
	Estimated Escapement:	0	4,360	872	0	0	5,232	5,713
	Standard Error:	0.0	1074.5	602.4	0.0	0.0		96.1
Total:	Number in Sample:	0	17	7	0	0	24	2,295
	Estimated % of Escapement:	0.0	70.8	29.2	0.0	0.0	**100.0**	**100.0**
	Estimated Escapement:	0	7,412	3,052	0	0	10,464	10,464
	Standard Error:	0.0	990.6	990.6	0.0	0.0		
Strata 1 – 10:	06/24 – 09/03							
Sampling Dates:	ASL, 07/02 – 08/23							
	Video, 07/01 − 08/18							
Male:	Number in Sample:	0	41	48	1	0	90	3,215
	% Males in Age Group:	0.0	51.5	47.9	0.6	0.0	100.0	100.0
	Estimated % of Escapement:	0.0	29.7	27.7	0.3	0.0	**58**	**49**
	Estimated Escapement:	0	5,048	4,705	59	0	9,812	8,352
	Standard Error:	0.0	1030.5	934.6	58.2	0.0		102
Female:	Number in Sample:	0	21	22	2	0	45	3,013
	% Females in Age Group:	0.0	69.8	28.5	1.6	0.0	100.0	100.0
	Estimated % of Escapement:	0.0	29.5	12.1	0.7	0.0	**42**	**51**
	Estimated Escapement:	0	5,006	2,046	117	0	7,169	8,629
	Standard Error:	0.0	1090.1	647.2	81.9	0.0		
Total:	Number in Sample:	0	62	70	3	0	135	6,228
	Estimated % of Escapement:	0.0	59.2	39.8	1.0	0.0	**100.0**	**100.0**
	Estimated Escapement:	0	10,054	6,751	176	0	16,981 [a]	16,981 [a]
	Standard Error:	0.0	1035.7	1036.5	99.9	0.0		

[a] Estimates included in total.

APPENDIX 4.—Mean length (mm) from the mid-eye to fork in the caudal fin and age composition of the chum salmon estimated escapement through the Tuluksak River weir, 2012. Weekly strata were combined.

		Brood Year and Age Group				
		2009	2008	2007	2006	2005
		0.2	0.3	0.4	0.5	0.6
Strata 1 – 4:	06/24 – 07/21					
Sampling Dates:	07/02, 07/04, 07/08, 07/09					
Male:	Mean Length		568	585	614	
	Std. Error		5	6		
	Range		518 – 624	501 – 680	–	
	Sample Size	0	34	43	1	0
Female:	Mean Length		522	547	556	
	Std. Error		10	8	44	
	Range		460 – 556	460 – 584	512 – 600	
	Sample Size	0	11	20	2	0
Strata 5 – 10:	07/22 – 09/03					
Sampling Dates:	07/22, 08/01, 08/14, 08/15					
	08/17 – 08/19, 08/22, 08/23					
Male:	Mean Length		502	520		
	Std. Error		22	8		
	Range		430 – 596	498 – 545		
	Sample Size	0	7	5	0	0
Female:	Mean Length		479	484		
	Std. Error		14	24		
	Range		410 – 538	460 – 507		
	Sample Size	0	10	2	0	0
Strata 1 – 10:	06/24 – 09/03					
Sampling Dates:	07/02 – 08/23					
Male:	Mean Length		557	578	614	
	Std. Error		7	7		
	Range		430 – 624	498 – 680	–	
	Sample Size	0	41	48	1	0
Female:	Mean Length		501	541	556	
	Std. Error		10	9	44	
	Range		410 – 556	460 – 584	512 – 600	
	Sample Size	0	21	22	2	0

APPENDIX 5.—Sex composition of the weekly Chinook salmon estimated escapement through the Tuluksak River weir, 2012. Observed counts and sex composition from the video footage sample.

		Video Sex Composition Total
Stratum 2:	07/01 – 07/07	
Sampling Dates:	07/01 – 07/07	
Male:	Number in Sample:	88
	Estimated % of Escapement:	**84.6**
	Estimated Escapement:	88
	Standard Error:	0.0
Female	Number in Sample:	16
	Estimated % of Escapement:	**15.4**
	Estimated Escapement:	16
	Standard Error:	0.0
Total:	Number in Sample:	104
	Estimated % of Escapement:	**100.0**
	Estimated Escapement:	104
	Standard Error:	0.0
Stratum 3:	07/08 – 07/14	
Sampling Dates:	07/08 – 07/14	
Male:	Number in Sample:	103
	Estimated % of Escapement:	**79.2**
	Estimated Escapement:	114
	Standard Error:	1.6
Female	Number in Sample:	27
	Estimated % of Escapement:	**20.8**
	Estimated Escapement:	30
	Standard Error:	1.6
Total:	Number in Sample:	130
	Estimated % of Escapement:	**100.0**
	Estimated Escapement:	144 [a]
	Standard Error:	0.0
Stratum 4:	07/15 – 07/21	
Sampling Dates:	07/15 – 07/21	
Male:	Number in Sample:	94
	Estimated % of Escapement:	**56.6**
	Estimated Escapement:	94
	Standard Error:	0.0
Female	Number in Sample:	72
	Estimated % of Escapement:	**43.4**
	Estimated Escapement:	72
	Standard Error:	0.0
Total:	Number in Sample:	166
	Estimated % of Escapement:	**100.0**
	Estimated Escapement:	166
	Standard Error:	0.0

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		Video Sex Composition Total
Stratum 5:	07/22 – 07/28	
Sampling Dates:	07/22 – 07/28	
Male:	Number in Sample:	46
	Estimated % of Escapement:	**48.4**
	Estimated Escapement:	46
	Standard Error:	0.0
Female	Number in Sample:	49
	Estimated % of Escapement:	**51.6**
	Estimated Escapement:	49
	Standard Error:	0.0
Total:	Number in Sample:	95
	Estimated % of Escapement:	**100.0**
	Estimated Escapement:	95
	Standard Error:	0.0
Strata 6 − 11:	07/29 – 09/08	
Sampling Dates:	07/29 – 08/17	
Male:	Number in Sample:	29
	Estimated % of Escapement:	**70.7**
	Estimated Escapement:	33
	Standard Error:	1.1
Female	Number in Sample:	12
	Estimated % of Escapement:	**29.3**
	Estimated Escapement:	13
	Standard Error:	1.1
Total:	Number in Sample:	41
	Estimated % of Escapement:	**100.0**
	Estimated Escapement:	46
	Standard Error:	0.0
Strata 2 – 11:	07/01 – 09/07	
Sampling Dates:	07/01 – 08/17	
Male:	Number in Sample:	360
	% Males in Age Group:	100.0
	Estimated % of Escapement:	**67.5**
	Estimated Escapement:	375
	Standard Error:	1.9
Female	Number in Sample:	176
	% Females in Age Group:	100.0
	Estimated % of Escapement:	**32.5**
	Estimated Escapement:	180
	Standard Error:	1.9
Total:	Number in Sample:	536
	Estimated % of Escapement:	**100.0**
	Estimated Escapement:	555 [a]
	Standard Error:	0.0

[a] Estimates included in total.

APPENDIX 6.—Sex composition of the weekly sockeye salmon estimated escapement through the Tuluksak River weir, 2012. Observed counts and sex composition from the video footage sample.

		Video Sex Composition Total
Strata 2 – 3:	07/01 – 07/14	
Sampling Dates:	07/01 – 07/10, 07/12 – 07/14	
Male:	Number in Sample:	7
	Estimated % of Escapement:	**36.8**
	Estimated Escapement:	12
	Standard Error:	2.4
Female:	Number in Sample:	12
	Estimated % of Escapement:	**63.2**
	Estimated Escapement:	21
	Standard Error:	2.4
Total:	Number in Sample:	19
	Estimated % of Escapement:	**100.0**
	Estimated Escapement:	33 [a]
	Standard Error:	0.0
Stratum 4:	07/15 – 07/21	
Sampling Dates:	07/15 – 07/21	
Male:	Number in Sample:	7
	Estimated % of Escapement:	**17.9**
	Estimated Escapement:	8
	Standard Error:	0.7
Female:	Number in Sample:	32
	Estimated % of Escapement:	**82.1**
	Estimated Escapement:	34
	Standard Error:	0.7
Total:	Number in Sample:	39
	Estimated % of Escapement:	**100.0**
	Estimated Escapement:	42
	Standard Error:	0.0
Strata 5 – 8:	07/22 – 08/18	
Sampling Dates:	07/22 – 07/29, 07/31 – 08/18	
Male:	Number in Sample:	19
	Estimated % of Escapement:	**42.2**
	Estimated Escapement:	48
	Standard Error:	6.6
Female:	Number in Sample:	26
	Estimated % of Escapement:	**57.8**
	Estimated Escapement:	66
	Standard Error:	6.6
Total:	Number in Sample:	45
	Estimated % of Escapement:	**100.0**
	Estimated Escapement:	114
	Standard Error:	0.0

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		Video Sex Composition Total
Strata 2 – 8:	07/01 – 08/18	
Sampling Dates:	07/01 – 08/18	
Male:	Number in Sample:	33
	% Males in Age Group:	100.0
	Estimated % of Escapement:	**35.9**
	Estimated Escapement:	68
	Standard Error:	7.1
Female:	Number in Sample:	70
	% Females in Age Group:	100.0
	Estimated % of Escapement:	**64.1**
	Estimated Escapement:	121
	Standard Error:	7.1
Total:	Number in Sample:	103
	Estimated % of Escapement:	**100.0**
	Estimated Escapement:	189 [a]
	Standard Error:	0.0

[a] **Estimates included in total.**

APPENDIX 7.—Age and sex composition of the weekly coho salmon escapement through the Tuluksak River weir, 2012. Weekly strata were combined and the age, sex, and length sample compared to the video sample for sex composition.

		ASL Samples					Video
		Brood Year and Age Group					
		2009	2008	2007	2006		Sex Comp.
		1.1	2.1	3.1	4.1	Total	Total
Strata 4 – 8:	07/15 − 08/18						
Sampling Dates	ASL, 08/14, 08/15, 08/17, 08/18						
	Video, 07/20 – 8/18						
Male:	Number in Sample:	4	13	0	0	17	93
	Estimated % of Escapement:	8.5	27.7	0.0	0.0	**36.2**	**42.9**
	Estimated Escapement:	108	349	0	0	457	542
	Standard Error:	51.0	81.8	0.0	0		38.7
Female	Number in Sample:	5	23	1	1	30	124
	Estimated % of Escapement:	10.6	48.9	2.1	2.1	**63.8**	**57.1**
	Estimated Escapement:	134	619	27	27	807	722
	Standard Error:	56.4	91.4	26.4	26.4		38.7
Total:	Number in Sample:	9	36	1	1	47	217
	Estimated % of Escapement:	19.1	76.6	2.1	2.1	**100.0**	**100.0**
	Estimated Escapement:	242	968	27	27	1,264	1,264
	Standard Error:	72.0	77.4	26.4	26.4		
Strata 9 – 11:	08/19 − 09/08						
Sampling Dates	ASL, 08/19, 08/21 − 08/23						
	Video, 08/19 − 09/07						
Male:	Number in Sample:	0	32	1	0	33	275
	Estimated % of Escapement:	0.0	49.2	1.5	0.0	50.8	**47.4**
	Estimated Escapement:	0	1,548	48	0	1,596	1,490
	Standard Error:	0.0	194.4	47.9	0		58.9
Female	Number in Sample:	1	29	2	0	32	305
	Estimated % of Escapement:	1.5	44.6	3.1	0.0	49.2	**52.6**
	Estimated Escapement:	48	1,402	97	0	1,547	1,653
	Standard Error:	47.9	193.3	67.1	0.0		58.9
Total:	Number in Sample:	1	61	3	0	65	580
	Estimated % of Escapement:	1.5	93.8	4.6	0.0	100.0	**100.0**
	Estimated Escapement:	48	2,950	145	0	3,143	3,143
	Standard Error:	47.9	93.4	81.6	0.0		
Strata 4 – 11:	07/15 − 09/08						
Sampling Dates	ASL, 08/14, 08/15, 08/17 − 08/19, 08/21 − 08/23						
	Video, 07/20 − 09/07						
Male:	Number in Sample:	4	45	1	0	50	368
	% Male in Age Group:	5.2	92.4	2.4	0.0	100.0	100.0
	Estimated % of Escapement:	2.4	43.0	1.1	0.0	46.6	**46.1**
	Estimated Escapement:	108	1,897	48	0	2,053	2,032
	Standard Error:	51.0	210.9	47.9	0		70.5
Female	Number in Sample:	6	52	3	1	62	429
	% Females in Age Group:	7.8	85.8	5.3	1.1	100.0	100.0
	Estimated % of Escapement:	4.1	45.9	2.8	0.6	53.4	**53.9**
	Estimated Escapement:	182	2,021	124	27	2,354	2,375
	Standard Error:	74.0	213.8	72.1	26.4		70.5
Total:	Number in Sample:	10	97	4	1	112	797
	Estimated % of Escapement:	6.6	88.9	3.9	0.6	100.0	**100.0**
	Estimated Escapement:	290	3,918	172	27	4,407	4,407
	Standard Error:	86.4	121.3	85.7	26.4		

APPENDIX 8.—Mean length (mm) from the mid-eye to fork in the caudal fin and age composition of the coho salmon escapement through the Tuluksak River weir, 2012. Weekly strata were combined.

		Brood Year and Age Group			
		2009	2008	2007	2006
		1.1	2.1	3.1	4.1
Strata 4 – 8:	07/15 − 08/18				
Sampling Dates:	08/14, 08/15, 08/17, 08/18				
Male:	Mean Length	494	497		
	Std. Error	9	10		
	Range	470 – 510	420 – 562		
	Sample Size	4	13	0	0
Female	Mean Length	504	498	510	410
	Std. Error	28	9		
	Range	406 – 560	420 – 581	–	–
	Sample Size	5	23	1	1
Strata 9 – 11:	08/19 − 09/08				
Sampling Dates:	08/19, 08/21 − 08/23				
Male:	Mean Length		484	557	
	Std. Error		7		
	Range		410 – 547	–	
	Sample Size	0	32	1	0
Female	Mean Length	557	494	484	
	Std. Error		6	4	
	Range	–	430 – 547	480 – 487	
	Sample Size	1	29	2	0
Strata 4 – 11:	07/15 − 09/08				
Sampling Dates:	08/14, 08/15, 08/17 − 08/19, 08/21 − 08/23				
Male:	Mean Length	494	488	557	
	Std. Error	9	6		
	Range	470 – 510	410 – 562	–	
	Sample Size	4	45	1	0
Female	Mean Length	513	496	492	410
	Std. Error	25	5	9	
	Range	406 – 560	420 – 581	480 – 510	–
	Sample Size	6	52	3	1

APPENDIX 9.—Median cumulative passage dates and percent female for chum, Chinook, sockeye, pink and coho salmon at the Tuluksak River weir during 1991–1994 and 2001−2012 (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, 2012). Percent female for chum, Chinook, sockeye, and coho salmon during 2012 was based on video footage due to the small age, sex, and length sample sizes.

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

[a] Median cumulative passage dates were calculated using estimates for days missed.
[b] Percent female was based on video footage.