U.S. Fish and Wildlife Service

Abundance and Run Timing of Adult Pacific Salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2011

Alaska Fisheries Data Series Number 2012-3

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

Abstract

The Kenai Fish and Wildlife Field Office, assisted by the Organized Village of Kwethluk, monitored the escapement of five species of Pacific salmon *Oncorhynchus* spp. returning to the Kwethluk River. From July 3 to September 10, 2011, a resistance board weir was utilized to collect abundance, run-timing, age, sex, and length data from returning adult salmon. These data support in-season and post-season management of the commercial and subsistence fisheries that occur on the Yukon Delta National Wildlife Refuge and the Kuskokwim River drainage. The estimated escapement was 18,329 chum salmon *O. keta*, 4,079 Chinook salmon *O. tshawytscha*, 2,031 sockeye salmon *O. nerka*, 242 pink salmon *O. gorbuscha*, and a partial count of 4,482 coho salmon *O. kisutch*. Peak weekly passage occurred July 17–23 for chum, July 10–16 for Chinook, July 3–9 for sockeye, and July 24–30 for pink salmon. Age, sex, and length data were collected for each species except pink salmon. Dominant ages were 0.4 for chum, 1.2 for male and 1.4 for female Chinook, 1.3 for sockeye, and 2.1 for coho salmon. Overall percentages for female salmon were chum 36%, Chinook 32%, sockeye 57%, and coho 48%. Mean lengths varied between male and female salmon for each species.

Introduction

The Kwethluk River, a lower Kuskokwim River tributary located on the Yukon Delta National Wildlife Refuge (Refuge), provides important spawning and rearing habitat for chum salmon *Oncorhynchus keta*, Chinook salmon *O. tshawytscha*, sockeye salmon *O. nerka*, pink salmon *O. gorbuscha*, and coho salmon *O. kisutch* (Alt 1977; U.S. Fish and Wildlife Service 1992). Adult salmon returning to the Kwethluk River migrate 130 river kilometers (rkm) through the lower Kuskokwim River and up to an additional 160 rkm in the Kwethluk River before reaching spawning grounds. These salmon pass through one of Alaska's most intensive subsistence fisheries, which is located in the lower Kuskokwim River (U.S. Fish and Wildlife Service 1988; Burkey et al. 2001). In general, half of the total Chinook salmon statewide subsistence harvest occurs in the Kuskokwim drainage (Alaska Department of Fish and Game 2001, 2002, 2003a, 2003b).

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 and managed the fishery under those guidelines through 2006 (Bergstrom and Whitmore 2004; Linderman and Bue 2006). This designation was based upon the inability, despite specific management measures, to maintain expected yields or to have a stable surplus above the stock's escapement needs. Beginning in January 2001, the salmon fishery in the Kuskokwim River drainage was managed under the Kuskokwim River Salmon Rebuilding Management Plan (Rebuilding Plan) (5AAC 07.365; Ward et al. 2003; Bergstrom and Whitmore 2004). The stocks of concern designation 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

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(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, the 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*)). Despite conservation measures taken under the Rebuilding Plan and by area managers, Chinook salmon returns to the Kwethluk River have been below the lower bound of the Sustainable Escapement Goal (SEG) since the stocks of concern designation was removed (Miller et al. 2009, Miller and Harper 2010, 2011).

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, Department, 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.

A resistance board weir has been used to monitor salmon escapements on the Kwethluk River from mid to late June through early September during 1992, 2000–2004 and 2006–2011. After the 1992 season, the Organized Village of Kwethluk (OVK) opposed the weir, and it was not operated from 1993−1999. Since 2000, OVK and the Service have jointly cooperated in staffing and operating the weir, which remains a high priority for the Department, OVK, and Service. Objectives of the project during 2011 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 also assists managers in establishing escapement goals to maintain the sustainability of salmon stocks returning to the Kwethluk River.

The Kwethluk River weir also plays an important role as a platform to collect additional information and data for other research projects. Examples include: (1) genetic baseline collections; (2) monitoring for tagged fish in mark-recapture projects; (3) a long term data set for evaluation of management projects (e.g., Bethel test fishery) and climate change; and (4) the Salmonid Rivers Observatory Network (SaRON), a multiyear project focused on pristine Pacific salmon rivers measuring processes and changes to the shifting habitat mosaic of ecosystems (Available: http://www.umt.edu/flbs/Research/SaRON.htm).

Study Area

The Kwethluk River is in the lower Kuskokwim River drainage (Figure 1). The region has a sub-arctic climate characterized by extremes in temperature. Temperatures range from summer highs near 15˚C to average winter lows near -12˚C (Alt 1977). Average yearly precipitation is approximately 50 cm, with the majority falling between June and October. The rivers in this area generally become ice-free in the slow current sections by early May and freeze up during late November. Break up on the Kwethluk River can occur from early April to late May. The Kwethluk River originates in the Kilbuck Mountains, flows northwest approximately 222 km, and drains an area of about 3,367 km^2. The weir is located in the middle section of the river characterized by braiding and gravel substrates. Below the middle section, the lower 47 km consists of a deeper, muddy-bottomed channel that averages 53 m in width (Alt 1977). Turbid water conditions, the result of active stream cutting on tundra banks, are also characteristic of the lower section and are incompatible with weir operations.

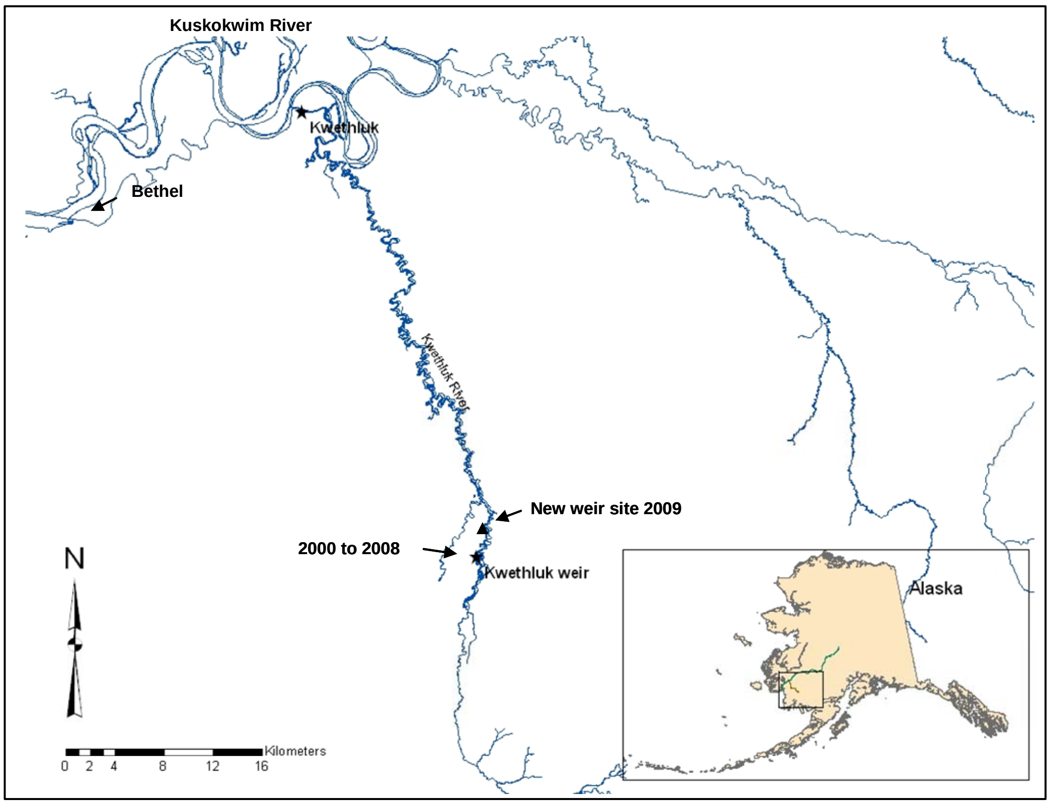

FIGURE 1.—Location of the Kwethluk River weir 2000–2008 and new weir site 2009–2011.

Methods

Weir Operations

A resistance board weir (Tobin 1994; Stewart 2002; Harper et al. 2007) spanning 56 m was installed in the Kwethluk River (N 60.51828, W 161.09245, NAD 83) approximately 84 rkm upstream from the Kuskokwim River and 42 km south of Kwethluk, Alaska (Figure 1). This location is approximately 4.1 rkm downstream from the 2008 weir site described by Miller et al. (2009). The weir was relocated during 2009 due to channel morphology changes and operated 2009–2011 (Figure 1). A staff gauge was installed upstream of the weir site to measure daily water levels and measurements were correlated to correspond with the average water depth across the river channel at the upstream edge of the weir. Hobo® recording thermometers were installed at the weir to collect water and ambient temperature data for this project (Appendix 1) and yearly water and ambient temperature data for Office Subsistence Management-Fisheries Resource Monitoring Program (OSM-FRMP) project 08-701 addressing climate change. Temperatures and fish passage counts were relayed daily by radio to the Department in Bethel.

One live trap and a counting passage-chute were installed to facilitate sampling and fish passage during varying river stage heights. Counts began at approximately 0600 hours each day and continued through 2300 hours as daylight permitted. Count periods varied with fish passage intensity and were recorded to the nearest 0.25 hours. All fish were enumerated to species as they migrated through the live trap or passage-chute.

The weir was inspected for holes and cleaned daily except on days with flooding and safety concerns. An observer outfitted with a mask and snorkel checked weir integrity and substrate conditions. Debris was removed from the upstream surface of the weir by raking, or walking across each panel until partially submerged, which allowed the current to wash accumulated debris downstream.

Biological Data

Statistical weeks started on a Sunday and continued through the following Saturday. Target sample sizes were 170 chum, 210 Chinook, 200 sockeye, and 200 coho salmon each week. Biological sampling occurred between Sunday and Thursday of each statistical week in order to obtain a snapshot sample (Geiger et al. 1990). Once the weekly sample was met for a species, then sampling would stop for that species. Sampling would not typically extend past Thursday of each week. Post-season analysis included the combination of weekly strata to ensure adequate sample sizes were obtained.

Age, sex, and length data (ASL) were collected from each salmon sampled. Salmon were caught using the live trap attached to the passage-chute. A fyke-gate installed on the entrance of the trap allowed fish to enter and, at the same time, minimized the number of fish exiting the trap downstream. Sampling typically started when approximately 40 fish were in the trap. To avoid potential bias caused by selection or capture of individual fish, all target species in the trap were included in the sample. Four scales were extracted from Chinook and coho, three from sockeye, and one from chum salmon for age analysis. All scales were taken from the preferred area using methods described by Koo (1962) and Mosher (1968). Sex was determined from external characteristics or visible sex products and length measured to the nearest 5 mm from the mid-eye to the fork of the caudal fin. Data were recorded and transferred later to the Department's mark sense forms. Department staff aged the scales and processed the forms in Anchorage. All sampled fish were released upstream of the weir.

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 are 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 sample 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 during stratum *m*, and a subscript of "+" represents summation overall possible values of the corresponding variable, e.g., n_{j++m} denotes the total number of fish of species *i* sampled in stratum *m*. The variance was estimated as

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

where N_{i++m} denotes the total number of species *i* fish passing the weir in stratum *m*. The estimated number of fish 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 during the entire period of operation was estimated as

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

with estimated variance

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

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

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

with corresponding variance estimator

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

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

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

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

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

Estimates of fish passage are calculated when flooding or holes in the weir result in days with partial or zero counts. During years when this occurs, estimates are based on the average daily proportion of passage. An average of the daily proportions for previous years is calculated since daily escapement can vary between years. The sum of the averaged daily proportions, calculated for days with partial or zero counts, is the estimated total proportion of the missed escapement. The total escapement is the sum of the observed counts divided by one minus the proportion missed.

Results

Weir Operations

Water and ice conditions of the Kwethluk River were monitored by biologists and Refuge pilots beginning April 11. River ice covered 100% of the channel at the weir site on April 25 but disappeared with high flows and warming temperatures by May 5. A helicopter was used to transport gear and 5 crew members to the weir site on May 6. The crew set-up a partial camp but were unable to install the weir at that time due to high water. They returned by helicopter to Bethel May 9. Water conditions were monitored through May and June. Personnel returned to the weir site on June 29 by boat to complete installation of the weir. The trap was installed on July 3 and the weir was operational from July 3 to September 10. Due to high water at the end of the normal escapement monitoring period which normally ends on September 10, a portion of the weir had to be left in the river. Between September 11 and September 27, crew members monitored water conditions and cleaned debris off the weir panels as needed. On September 27 the level of water had receded enough to start pulling the remaining weir panels. Weir removal was completed on September 29 and crew returned to Bethel on September 30.

Average water depth at the leading edge of the weir during 2011 was 115 cm. During August 1 to September 25, periods of high water completely submerged $\geq$ 45% of the weir. The maximum water depth of 173 cm occurred on August 15 and the minimum water depth of 94 cm occurred on July 6 (Appendix 1). Water temperatures ranged from a high of 13°C on July 29 to a low of 7°C on September 20 (Appendix 1).

Biological Data

Chum Salmon —A total of 16,854 chum salmon was counted passing through the weir from July 3 to September 10. An additional 1,475 chum salmon were estimated to have passed during high water for a total estimated escapement of 18,329 between June 20 and September 6 (Appendix 2). Peak weekly passage (N = 4,446) occurred July 17–23 (Figure 2). Median cumulative passage occurred on July 20 for adults passing upstream (Appendix 2).

Four ages (0.2, 0.3, 0.4, and 0.5) were identified from chum salmon scale samples. The predominant age was 0.4 for both male (61%) and female (58%) chum salmon (Appendix 3). Females comprised 36% of the chum salmon escapement and were more predominant as the run progressed (Figure 3; Appendix 3). Mean length of males was larger than females for all ages (Appendix 4).

Chinook Salmon —A total of 3,779 Chinook salmon was counted passing through the weir from July 3 to August 29. An additional 300 Chinook salmon were estimated to have passed during high water for a total estimated escapement of 4,079 between June 23 and August 29 (Appendix 2). Peak weekly passage (N = 1,233) occurred July 10–16 (Figure 2). Median cumulative passage occurred on July 14 for adults passing upstream (Appendix 2).

Six ages (1.2, 1.3, 2.2, 1.4, 2.3, and 1.5) were identified from Chinook salmon scale samples. The predominant age was 1.2 for males (41%) and 1.4 for females (85%; Appendix 5). Age-1.6 was not present during 2011 but present in previous years. Ages 1.2 and 1.3 accounted for 76% of the male and ages 1.3 and 1.4 for 94% of the female Chinook salmon escapement. Females comprised 32% of the Chinook salmon escapement. Sex ratios favored the male component through the entire run (Figure 3; Appendix 5). Mean length of females was greater than males for all ages except age-1.5 (Appendix 6).

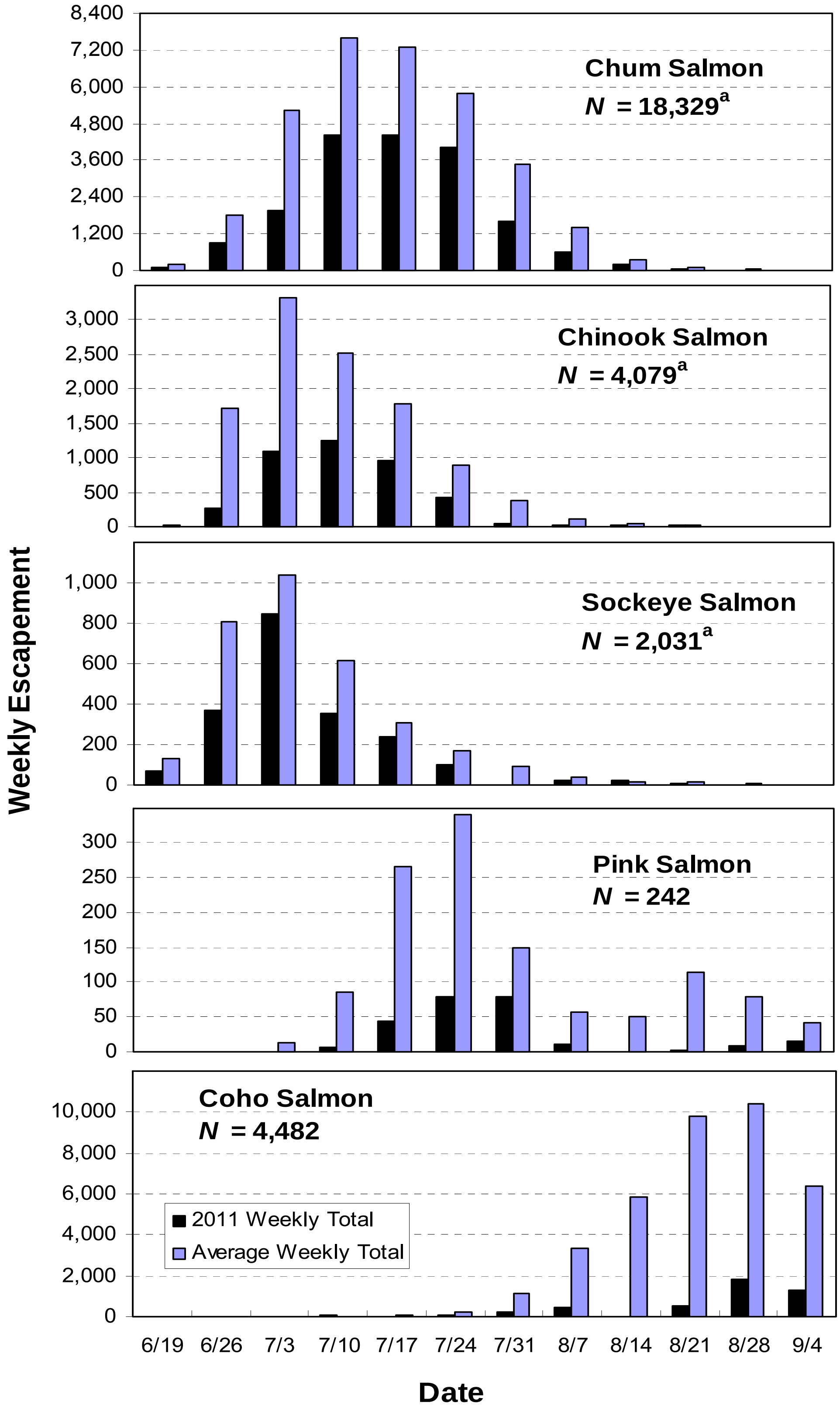

FIGURE 2.—Weekly escapements of chum, Chinook, sockeye, pink and coho salmon passing through the Kwethluk River weir, 2011. No estimate was generated for coho salmon due to high water and incomplete counts during the majority of the escapement. Average weekly totals for chum, Chinook and sockeye salmon are for years 1992, 2000, 2002−2004, 2006−2010; pink salmon odd years 2003, 2007, 2009; and coho salmon years 1992, 2000−2004, 2006−2009. Totals with a superscript ([a]) indicate estimates for chum, Chinook and sockeye salmon.

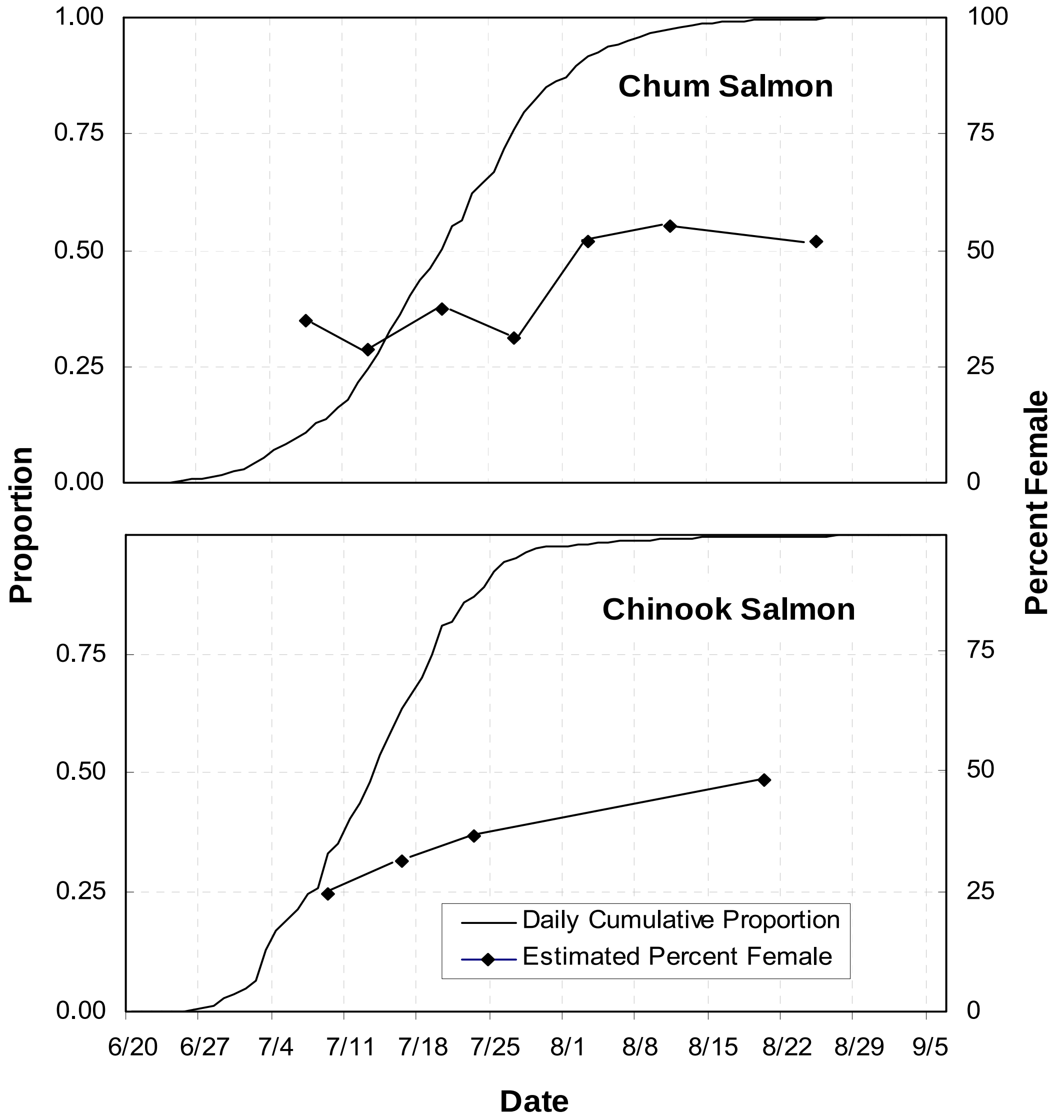

FIGURE 3.—Cumulative proportion and estimated percent female for chum and Chinook salmon returning to the Kwethluk River during 2011. Percentage of females in returns for each species was estimated by weekly stratum.

Sockeye Salmon —A total of 1,541 sockeye salmon was counted passing through the weir from July 3 to August 8. An additional 490 sockeye salmon were estimated to have passed during high water for a total estimated escapement of 2,031 between June 22 and August 26 (Figure 2; Appendix 2). Peak weekly passage ($N = 844$) occurred July 3–9 (Figure 2). Median cumulative passage occurred on July 7 for adults passing upstream of the weir (Appendix 2).

Eight ages (0.3, 1.2, 0.4, 1.3, 2.2, 1.4, 2.3, and 2.4) were identified from sockeye salmon scale samples. The predominant age was 1.3 for both males and females and comprised 59% of the estimated sockeye salmon escapement (Appendix 7). Ages 0.2 and 2.5 sockeye were not present during 2011 but present in previous years. Females comprised 57% of the total sockeye salmon escapement. The mean length of males was greater than that of females for all ages except age-1.2 (Appendix 8).

Pink Salmon —A total of 242 pink salmon was counted passing through the weir from July 13 to September 10 (Figure 2; Appendix 2). Peak weekly passage of pink salmon ($N = 78$) occurred July

24–30 (Figure 2). Median cumulative passage occurred on July 30 for adults passing upstream (Appendix 2).

Coho Salmon —A total of 4,482 coho salmon was counted passing through the weir from July 13 to September 10 (Figure 2; Appendix 2). High water conditions prevented or hampered counts of coho salmon during 22 days of the season, therefore the estimated escapement total, peak weekly passage, and median cumulative passage dates were not calculated for 2011.

Three ages (1.1, 2.1 and 3.1) were identified from scales of coho salmon (Appendix 9). Age-2.1 was the predominant age for both males (78%) and females (73%). Females comprised 48% of the escapement counted (Appendix 9) and the mean length of males was larger or equal to that of females (Appendix 10).

Resident Species

Resident species counted through the weir included five Dolly Varden *Salvelinus malma*, 28 whitefish *Coregoninae* spp., one Arctic grayling *Thymallus arcticus* and four rainbow trout *O. mykiss*. Although smaller sized resident species were able to pass freely through the pickets, passage through the passage chute was recorded the entire season.

Discussion

Weir Operations

Aerial surveys of the Kwethluk River are typically flown each season from late March through April to determine if conditions are suitable for weir installation (Roettiger et al. 2004, 2005; Miller et al. 2007, 2008, 2009; Miller and Harper 2010, 2011). The river channel at the site must be ice free and water levels low enough for installation of the weir. Weir installation during April usually avoids the annual high water event which normally begins in May and often continues until August. This strategy of installing the weir prior to these high water events, controlled by air temperature, snow pack, and rainfall, has proven successful over time (Roettiger et al. 2004, 2005; Miller et al. 2007, 2008, 2009; Miller and Harper 2010). However, for the past two years late ice free and high water conditions during May and June have delayed weir installation (Miller and Harper 2011). During 2011, the weir was operational from July 3 to September 10, however above average rainfall late in the summer resulted in high water conditions that exceeded the design capacity of the weir panels on several occasions (Appendix 1). High water conditions resulted in incomplete or no counts for 35 days between June 20 and September 10 which required estimation of passage for chum, Chinook, and sockeye salmon. The high water events experienced during 2011 dislodged debris included trees and large pieces of tundra resulting in extra weir maintenance.

High water prevented removal of the weir during the normal removal period of September 11–14. From September 11 through September 26 crew members traveled from the village of Kwethluk to the weir site monitoring water conditions and to clean debris off the weir. The weir and camp were dismantled by September 30.

Biological Data

Chum Salmon —The estimated 2011 escapement of 18,329 chum salmon to the Kwethluk River was within the range of escapements (11,691–54,913) observed during previous years (Figure 4), but lower than the 10-year average of $N = 32{,}288$ (Harper 1998; Harper and Watry 2001; Roettiger et al. 2002, 2003, 2004, 2005; Miller et al. 2007, 2008, 2009; Miller and Harper 2010, 2011). The estimate generated for incomplete counts was approximately 8% of the total chum salmon escapement. Although the 2011 return fell within the historic range of escapements, it represents the third lowest on record. The mean-passage date of July 20 was one day later than 2010 and within the mid range of median dates (Appendices 2 and 11). Females comprised 36% of the return which was the lowest on record (Appendices 3 and 11).

The dominant age for chum salmon during 2011 was age-0.4. This age represented 60% of the escapement and a significant increase from the 35% age-0.4 chum salmon observed during 2010. Age-0.3 fish represented 61% of the return during 2010 (Miller and Harper 2011).

Chinook Salmon —The estimated escapement of Chinook salmon in the Kwethluk River during 2011 (N = 4,079) was the third lowest on record, and below the SEG range (N = 6,000–11,000) set by the Department (Molyneaux and Brannian 2006; Volk et al. 2009). This was the fourth year in a row the estimated escapement of Chinook salmon at the Kwethluk River weir was below the SEG (Estensen et al. 2009; Miller et al. 2008, 2009; Miller and Harper 2011). The estimate generated for incomplete counts was approximately 7% of the total Chinook salmon escapement. The 2011 escapement represents approximately 40% of the 10-year average (N = 10,272; Figure 4). Preliminary data shows low returns of Chinook salmon were also observed at other Kuskokwim escapement projects during 2011. The median cumulative passage date for Chinook salmon was July 14, one day later than during 2000 and 2007, and 6 days later than the earliest median passage date of July 8 observed in 2004 (Appendices 2 and 11).

The dominant ages of Chinook salmon in 2011 were 1.2, 1.3, and 1.4 representing 28, 27, and 43% of the return, respectively (Appendix 5). This age composition was different from 2010, when these ages represented 18, 44, and 34% of the return (Miller and Harper 2011). The strong showing of age-1.4 during 2011 may be a result of the predominant age-1.3 fish in 2010, which indicates brood year 2005 produced a strong cohort (Van Alen 1999; Miller et al. 2008, 2009; Miller and Harper 2011). The percentage of age-1.2 fish observed at the weir increased and age-1.3 fish decreased during 2011, which may forecast a stronger return of age-1.3 fish and a weaker return of age-1.4 fish during 2012. Variation in freshwater, estuarine, and marine survival can all influence numbers of adults returning to the Kwethluk River. 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. Petrosky and Schaller (2010) indicate river velocity during smolt migration as a factor associated with Chinook salmon smolt survival as well.

Female Chinook salmon comprised 32% of the escapement during 2011, which is similar to the overall project average (Appendix 11). The decrease in the percentage of females from that of 2008–2010 may be attributed to changes in harvest and/or management strategies. Observations by Harris and Harper (2010) on the Chinook salmon subsistence harvest in the Native Community of Tuluksak indicate that some subsistence fishers from the area have changed to smaller ≤20.5-cm mesh nets that selectively harvest a higher percentage of smaller fish, which includes the more prevalent males. Bromaghin (2005) showed a correlation of catch efficiency to mesh size and fish length. The commercial fishery is restricted to the use of smaller mesh nets (≤20.5-cm stretch). There has been no directed Chinook salmon commercial fishery in recent years and the incidental harvest of Chinook salmon during 2008 (N = 8,797), 2009 (N = 6,664), and 2010 (N = 2,731) (Estensen et al. 2009; Brazil et al. 2010) was predominately male (90%, 80%, and 75%, respectively; D. Molyneaux, Department, personal communication).

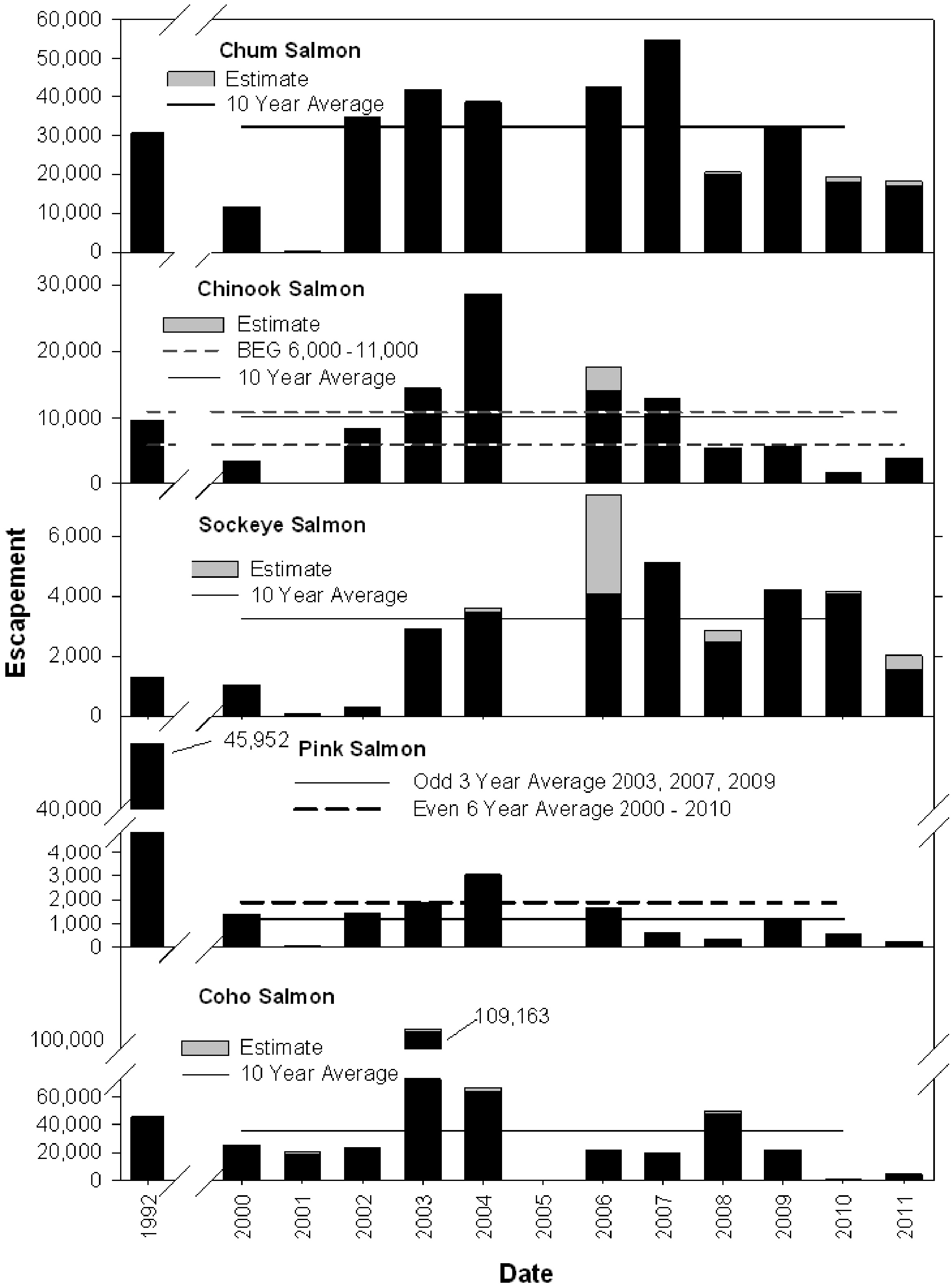

Figure 4.—Estimated salmon escapements through the Kwethluk River weir, 1992, 2000–2004, 2006–2011. Averages include estimates generated for prior years (Miller and Harper 2011). Weir operations during 2001 commenced on August 12, and high water in 2010 and 2011 hindered coho salmon counts and estimates. Ten-year averages are reported for Chinook, chum and sockeye salmon and a ten-year average for coho salmon. Pink salmon averages are based on odd (2003, 2007, 2009) and even (2000–2010) years after 2000 when wider picket spacing was used on weir panels. Averages for all species do not include the current year. An escapement goal range has only been established for Chinook salmon.

Chinook salmon management actions were taken by both State and Federal managers during 2011 (Table 1) based on a low projected return and inseason escapement data. It is currently unknown what effects these actions had on increasing the Kwethluk River escapement, or in the overall conservation of the Kuskokwim River Chinook salmon population during 2011.

TABLE 1.—Emergency orders and Special Actions taken by the Department (ADFG) and the Federal Subsistence Board and the Yukon Delta National Wildlife Refuge (FBS&YDNWR) during 2011.

Effective Dates	Emergency Order / Special Action
06/01 – 07/31	ADFG Emergency Order 3-KS-01-11, area closure of sport fishing
06/01 – 07/25	ADFG Emergency Order # 1, area closure for subsistence salmon fishing
06/16 – 06/19	ADFG Emergency Order # 2, subsistence salmon fishing closure
06/23 – 06/27	ADFG Emergency Order # 3, subsistence salmon fishing closure
06/30 – 07/02	FSB&YDNWR Special Action # 3-KS-01-11, subsistence salmon fishing closure to non-federally qualified users
06/30 – 07/02	FSB&YDNWR Special Action # 3-KS-02-11, subsistence salmon fishing closure to federally qualified users
06/29 – 07/06	ADFG Emergency Order # 4, gillnet restriction to 6 inch or less stretched mesh
07/05 – 08/23	ADFG Emergency Orders closing subsistence fishing 6 hrs prior to, during, and 3 hrs after commercial openings

Sockeye Salmon —The estimated escapement of 2,031 sockeye salmon was within the range observed during past years (272–6,732) (Figure 4). The estimate generated for incomplete counts was approximately 25% of the total sockeye salmon escapement. The escapement for 2011 was similar to that seen in 2008, but well below the 10 year average of $N = 3{,}253$. The median cumulative passage date of July 7 was similar to those of 1992 and 2003 and within the historical range of July 1–11 (Appendix 11). Female sockeye salmon comprised 57% of the return during 2011, higher than 2010 and between the 43–65% observed in previous years (Harper 1998; Harper and Watry 2001; Roettiger et al. 2002, 2003, 2004, 2005; Miller et al. 2007, 2008, 2009; Miller and Harper 2010, 2011).

The dominant age of sockeye salmon in 2011 was age-1.3 from brood year 2006 which represented 59% of the return and the lowest on record (Appendix 7). The lower return of sockeye during 2011 may be the result of a weak brood year in 2006 (Van Alen 1999). Age-1.3 fish have dominated the age structure ranging from a low of 60% during 2009 to a high of 93% during 2000 (Harper 1998; Harper and Watry 2001; Roettiger et al. 2002, 2003, 2004, 2005; Miller et al. 2007, 2008, 2009; Miller and Harper 2010). A below average estimated escapement during 2011 and a weaker showing in age-1.3 fish may also be the result of smaller sized sockeye smolt entering the ocean or differences in ocean temperatures while at sea. Groot and Margolis (1991) stated in general that an increase in fresh water growth and smolt of a larger size have a higher marine survival. McPhee et al. (2009) reported both riverine and lake-type sockeye salmon in the Kwethluk River. Lake-type sockeye salmon spend 1−3 years rearing in fresh water lakes before undergoing smoltification, whereas the riverine-type spend 1−2 years in fresh water or emigrate the first year of life to sea. These different life history strategies may influence returns as well. However, sockeye salmon ASL data collected from this project shows the majority of Kwethluk River sockeye salmon to spend one year in fresh water.

Pink Salmon —The number of pink salmon observed during 2011 ($N = 242$) was well below the odd-year ($N = 1{,}210$) and even-year ($N = 1{,}410$) average counts since year 2000 when wider picket spacing was implemented on the Kwethluk River weir (Figure 4). The actual count provides only an index of abundance since most pink salmon are small enough to pass between pickets of the weir panels. Also during 2011, high water conditions may have allowed for a higher number of pink salmon to pass the weir undetected as well. The median cumulative passage date was July 30, similar to that observed during previous odd-years (Appendices 2 and 11). Pink salmon return to spawning grounds in predictable and segregated even and odd-numbered years (Scott and Crossman 1973). Age, sex, and length data were not collected for pink salmon.

Coho Salmon —An estimated escapement of coho salmon was not generated during 2011 because of high water conditions which rendered the weir inoperable for long periods of time starting August 9 until take out during late September (Figure 4). However the collection of 574 samples from early, mid and late portions of the run provided valuable age, sex and length data. Female coho salmon comprised 48% of the fish sampled (Appendix 9). This is within the composition range observed in years prior (29–57%) although this sex ratio data may not represent the actual (Harper 1998; Harper and Watry 2001; Roettiger et al. 2002, 2003, 2004, 2005; Miller et al. 2007, 2008, 2009; Miller and Harper 2010, 2011) (Appendices 9 and 11).

The dominant age of coho salmon sampled in 2011 was age-2.1 and represented 75% of the return sampled (Appendix 9). This was the lowest representation of this age group to-date. Age-2.1 fish have dominated the age structure across strata and have ranged from 82–95% of the total escapement in previous years (Harper 1998; Harper and Watry 2001; Roettiger et al. 2002, 2003, 2004, 2005; Miller et al. 2007, 2008, 2009; Miller and Harper 2010, 2011). Coho salmon in Alaska typically spend two years in fresh water and spend one year in the marine environment (Groot and Margolis 1991).

Recommendations

The Kwethluk River weir continues to be an important project to monitor Kuskokwim River salmon stocks that originate on the Refuge. This weir and other escapement projects spread throughout the Kuskokwim River drainage provide important information used by Federal and State fishery managers. Annual operation of the weir should continue well into the future to gather a long-term data set and weir operations should continue into September to monitor coho salmon escapements. Early weir installation by mid April is essential, though more costly due to ice and debris damage to panels and increased cost for personnel and helicopter use. We have been able to operate a weir during the majority of salmon escapement for 11 of the last 12 years (2000–2011) even with high spring flows, channel changes, damage to weir components, scouring, and variable break up periods. We believe that the river channel is more stable at the new site selected in 2009 and do not anticipate having to move to another site in the years to come.

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partner, OVK hired local residents to staff the weir, provided administrative support, purchased supplies, and performed equipment maintenance.

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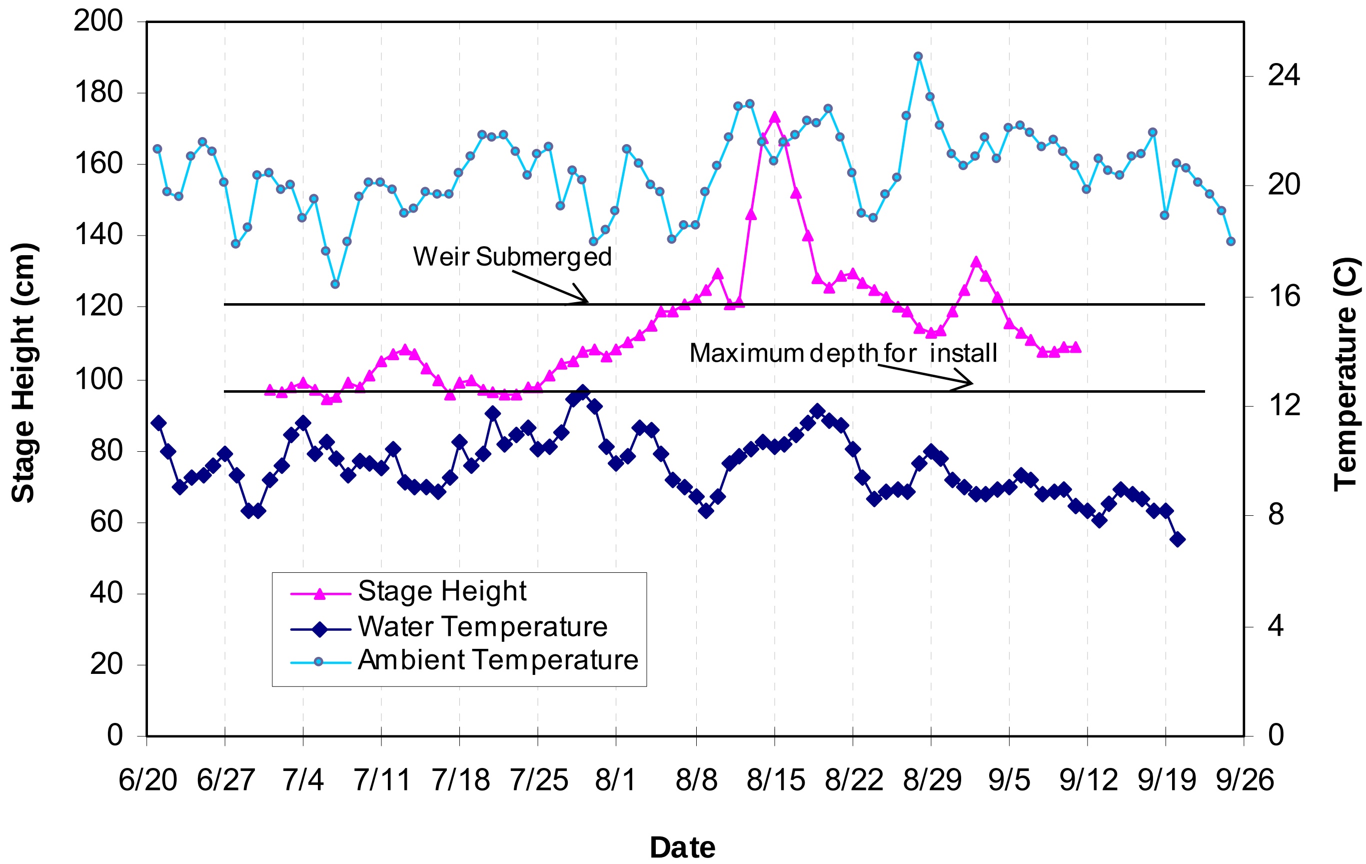

APPENDIX 1.—Water stage heights and daily ambient and water temperatures taken at the Kwethluk River weir, Alaska, 2011.

APPENDIX 2.—Daily counts, cumulative counts, and cumulative proportions of chum, Chinook, sockeye, pink, and coho salmon passing through the Kwethluk River weir, Alaska, 2011. Shaded areas represent high water events when partial or no counts were recorded and passage estimates were generated for chum, Chinook and sockeye salmon. No estimates were generated for pink or coho salmon.

	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
Date	Daily Count	Cumulative Count	Cumulative Proportion	Daily Count	Cumulative Count	Cumulative Proportion	Daily Count	Cumulative Count	Cumulative Proportion	Daily Count	Cumulative Count	Cumulative Proportion	Daily Count	Cumulative Count	Cumulative Proportion
06/20	3	3	0.000	0	0	0.000	0		0.000	0	0	0.000	0	0	0.000
06/21	4	7	0.000	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
06/22	13	20	0.000	0	0	0.000	5	5	0.003	0	0	0.000	0	0	0.000
06/23	18	38	0.001	1	1	0.000	10	15	0.008	0	0	0.000	0	0	0.000
06/24	30	68	0.002	2	3	0.001	17	32	0.016	0	0	0.000	0	0	0.000
06/25	49	117	0.004	4	7	0.002	35	67	0.033	0	0	0.000	0	0	0.000
06/26	56	173	0.006	8	15	0.004	41	108	0.053	0	0	0.000	0	0	0.000
06/27	63	236	0.009	11	26	0.006	59	167	0.083	0	0	0.000	0	0	0.000
06/28	99	335	0.013	30	56	0.014	43	210	0.104	0	0	0.000	0	0	0.000
06/29	86	421	0.018	64	120	0.029	49	259	0.128	0	0	0.000	0	0	0.000
06/30	116	537	0.023	32	152	0.037	51	310	0.152	0	0	0.000	0	0	0.000
07/01	192	729	0.029	42	194	0.048	53	363	0.179	0	0	0.000	0	0	0.000
07/02	269	998	0.040	73	267	0.065	74	437	0.215	0	0	0.000	0	0	0.000
07/03	282	1,280	0.054	256	523	0.128	229	666	0.328	0	0	0.000	0	0	0.000
07/04	213	1,493	0.070	176	699	0.171	181	847	0.417	0	0	0.000	0	0	0.000
07/05	256	1,749	0.081	69	768	0.188	60	907	0.447	0	0	0.000	0	0	0.000
07/06	248	1,997	0.095	106	874	0.214	101	1,008	0.496	0	0	0.000	0	0	0.000
07/07	331	2,328	0.109	140	1,014	0.249	92	1,100	0.542	0	0	0.000	0	0	0.000
07/08	204	2,532	0.127	47	1,061	0.260	77	1,177	0.580	0	0	0.000	0	0	0.000
07/09	424	2,956	0.138	290	1,351	0.331	104	1,281	0.631	0	0	0.000	0	0	0.000
07/10	331	3,287	0.161	85	1,436	0.352	33	1,314	0.647	0	0	0.000	0	0	0.000
07/11	687	3,974	0.179	216	1,652	0.405	58	1,372	0.676	0	0	0.000	0	0	0.000
07/12	531	4,505	0.217	131	1,783	0.437	73	1,445	0.712	0	0	0.000	0	0	0.000
07/13	557	5,062	0.246	182	1,965	0.482	54	1,499	0.738	3	3	0.012	4	4	0.001
07/14	910	5,972	0.276	227	2,192	0.537	42	1,541	0.759	2	5	0.021	7	11	0.002
07/15	622	6,594	0.326	180	2,372	0.581	41	1,582	0.779	0	5	0.021	6	17	0.004
07/16	767	7,361	0.360	212	2,584	0.633	51	1,633	0.804	1	6	0.025	30	47	0.010
07/17	652	8,013	0.402	141	2,725	0.668	8	1,641	0.808	0	6	0.025	0	47	0.010
07/18	421	8,434	0.437	132	2,857	0.700	21	1,662	0.818	4	10	0.041	3	50	0.011
07/19	745	9,179	0.460	202	3,059	0.750	51	1,713	0.843	1	11	0.045	1	51	0.011
07/20	925	10,104	0.501	233	3,292	0.807	83	1,796	0.884	4	15	0.062	0	51	0.011
07/21	249	10,353	0.551	42	3,334	0.817	18	1,814	0.893	3	18	0.074	0	51	0.011
07/22	1,046	11,399	0.565	161	3,495	0.857	29	1,843	0.907	16	34	0.140	0	51	0.011
07/23	408	11,807	0.622	54	3,549	0.870	30	1,873	0.922	15	49	0.202	0	51	0.011
07/24	461	12,268	0.644	75	3,624	0.888	17	1,890	0.931	1	50	0.207	3	54	0.012
07/25	890	13,158	0.669	144	3,768	0.924	29	1,919	0.945	17	67	0.277	4	58	0.013
07/26	766	13,924	0.718	79	3,847	0.943	17	1,936	0.953	7	74	0.306	1	59	0.013
07/27	677	14,601	0.760	30	3,877	0.950	19	1,955	0.963	21	95	0.393	8	67	0.015
07/28	557	15,158	0.797	45	3,922	0.961	8	1,963	0.967	9	104	0.430	8	75	0.017
07/29	397	15,555	0.827	34	3,956	0.970	6	1,969	0.970	12	116	0.479	16	91	0.020

APPENDIX 2. —(Page 2 of 2)

	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
Date	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
07/30	289	15,844	0.849	12	3,968	0.973	4	1,973	0.971	11	127	0.525	5	96	0.021
07/31	165	16,009	0.864	3	3,971	0.973	0	1,973	0.971	0	127	0.525	6	102	0.023
08/01	414	16,423	0.873	11	3,982	0.976	1	1,974	0.972	17	144	0.595	19	121	0.027
08/02	411	16,834	0.896	10	3,992	0.979	0	1,974	0.972	28	172	0.711	52	173	0.039
08/03	131	16,965	0.918	8	4,000	0.981	0	1,974	0.972	7	179	0.740	20	193	0.043
08/04	237	17,202	0.926	4	4,004	0.982	0	1,974	0.972	12	191	0.789	63	256	0.057
08/05	96	17,298	0.938	5	4,009	0.983	0	1,974	0.972	6	197	0.814	40	296	0.066
08/06	154	17,452	0.944	9	4,018	0.985	2	1,976	0.973	8	205	0.847	64	360	0.080
08/07	129	17,581	0.952	3	4,021	0.986	0	1,976	0.973	0	205	0.847	41	401	0.089
08/08	125	17,706	0.959	3	4,024	0.986	2	1,978	0.974	1	206	0.851	50	451	0.101
08/09	113	17,819	0.966	6	4,030	0.988	4	1,982	0.976	0	206	0.851	0	451	0.101
08/10	85	17,904	0.972	5	4,035	0.989	3	1,985	0.977	0	206	0.851	0	451	0.101
08/11	73	17,977	0.977	3	4,038	0.990	0	1,985	0.977	9	215	0.888	203	654	0.146
08/12	52	18,029	0.981	3	4,041	0.991	0	1,985	0.977	1	216	0.893	136	790	0.176
08/13	47	18,076	0.984	6	4,047	0.992	11	1,996	0.983	0	216	0.893	0	790	0.176
08/14	49	18,125	0.986	3	4,050	0.993	11	2,007	0.988	0	216	0.893	0	790	0.176
08/15	30	18,155	0.989	2	4,052	0.993	3	2,010	0.990	0	216	0.893	0	790	0.176
08/16	23	18,178	0.991	2	4,054	0.994	3	2,013	0.991	0	216	0.893	0	790	0.176
08/17	25	18,203	0.992	2	4,056	0.994	1	2,014	0.992	0	216	0.893	0	790	0.176
08/18	21	18,224	0.993	2	4,058	0.995	3	2,017	0.993	0	216	0.893	0	790	0.176
08/19	16	18,240	0.994	2	4,060	0.995	1	2,018	0.994	0	216	0.893	0	790	0.176
08/20	14	18,254	0.995	0	4,060	0.995	3	2,021	0.995	0	216	0.893	0	790	0.176
08/21	11	18,265	0.996	1	4,061	0.996	1	2,022	0.996	0	216	0.893	0	790	0.176
08/22	10	18,275	0.997	1	4,062	0.996	1	2,023	0.996	0	216	0.893	0	790	0.176
08/23	8	18,283	0.997	0	4,062	0.996	1	2,024	0.997	0	216	0.893	0	790	0.176
08/24	5	18,288	0.997	0	4,062	0.996	4	2,028	0.999	0	216	0.893	0	790	0.176
08/25	6	18,294	0.998	1	4,063	0.996	1	2,029	0.999	0	216	0.893	0	790	0.176
08/26	6	18,300	0.998	0	4,063	0.996	2	2,031	1.000	0	216	0.893	0	790	0.176
08/27	2	18,302	0.998	13	4,076	0.999	0	2,031	1.000	2	218	0.901	548	1,338	0.299
08/28	9	18,311	0.999	2	4,078	1.000	0	2,031	1.000	5	223	0.921	630	1,968	0.439
08/29	1	18,312	0.999	1	4,079	1.000	0	2,031	1.000	0	223	0.921	217	2,185	0.488
08/30	0	18,312	0.999	0	4,079	1.000	0	2,031	1.000	1	224	0.926	397	2,582	0.576
08/31	3	18,315	0.999	0	4,079	1.000	0	2,031	1.000	0	224	0.926	366	2,948	0.658
09/01	2	18,317	0.999	0	4,079	1.000	0	2,031	1.000	0	224	0.926	66	3,014	0.672
09/02	1	18,318	0.999	0	4,079	1.000	0	2,031	1.000	0	224	0.926	0	3,014	0.672
09/03	1	18,319	0.999	0	4,079	1.000	0	2,031	1.000	2	226	0.934	167	3,181	0.710
09/04	1	18,320	0.999	0	4,079	1.000	0	2,031	1.000	0	226	0.934	167	3,348	0.747
09/05	2	18,322	0.999	0	4,079	1.000	0	2,031	1.000	1	227	0.938	246	3,594	0.802
09/06	1	18,323	1.000	0	4,079	1.000	0	2,031	1.000	3	230	0.950	46	3,640	0.812
09/07	2	18,325	1.000	0	4,079	1.000	0	2,031	1.000	6	236	0.975	142	3,782	0.844
09/08	2	18,327	1.000	0	4,079	1.000	0	2,031	1.000	0	236	0.975	167	3,949	0.881
09/09	1	18,328	1.000	0	4,079	1.000	0	2,031	1.000	4	240	0.992	326	4,275	0.954
09/10	1	18,329	1.000	0	4,079	1.000	0	2,031	1.000	2	242	1.000	207	4,482	1.000

APPENDIX 3.—Estimated age and sex composition of weekly chum salmon escapements through the Kwethluk River weir, Alaska, 2011, and estimated design effects of the stratified sampling design.

		Brood Year and Age Group				
		2008	2007	2006	2005	
		0.2	0.3	0.4	0.5	Total
Strata 1 – 3:	06/19 – 07/09					
Sampling Dates:	07/05					
Male:	Number in Sample:	0	21	77	3	101
	Estimated % of Escapement:	0.0	13.5	49.4	1.9	64.7
	Estimated Escapement:	0	398	1,459	57	1,914[a]
	Standard Error:	0.0	78.9	115.5	31.7	
Female:	Number in Sample:	0	11	44	0	55
	Estimated % of Escapement:	0.0	7.1	28.2	0.0	35.3
	Estimated Escapement:	0	208	834	0	1,042[a]
	Standard Error:	0.0	59.2	104.0	0.0	
Total:	Number in Sample:	0	32	121	3	156
	Estimated % of Escapement:	0.0	20.5	77.6	1.9	100.0
	Estimated Escapement:	0	606	2,293	57	2,956[a]
	Standard Error:	0.0	93.3	96.4	31.7	
Stratum 4:	07/10 – 07/16					
Sampling Date:	07/10					
Male:	Number in Sample:	0	22	83	3	108
	Estimated % of Escapement:	0.0	14.6	55.0	2.0	71.5
	Estimated Escapement:	0	642	2,421	88	3,151
	Standard Error:	0.0	124.7	175.9	49.3	
Female:	Number in Sample:	0	14	28	1	43
	Estimated % of Escapement:	0.0	9.3	18.5	0.7	28.5
	Estimated Escapement:	0	408	817	29	1,254
	Standard Error:	0.0	102.5	137.4	28.7	
Total:	Number in Sample:	0	36	111	4	151
	Estimated % of Escapement:	0.0	23.8	73.5	2.6	100.0
	Estimated Escapement:	0	1,050	3,238	117	4,405
	Standard Error:	0.0	150.6	156.0	56.8	
Stratum 5:	07/17 – 07/23					
Sampling Dates:	07/17					
Male:	Number in Sample:	0	39	52	1	92
	Estimated % of Escapement:	0.0	26.5	35.4	0.7	62.6
	Estimated Escapement:	0	1,180	1,573	30	2,783
	Standard Error:	0.0	159.7	173.0	29.7	
Female:	Number in Sample:	0	20	34	1	55
	Estimated % of Escapement:	0.0	13.6	23.1	0.7	37.4
	Estimated Escapement:	0	605	1,028	30	1,663
	Standard Error:	0.0	124.0	152.6	29.7	
Total:	Number in Sample:	0	59	86	2	147
	Estimated % of Escapement:	0.0	40.1	58.5	1.4	100.0
	Estimated Escapement:	0	1,784	2,601	60	4,446
	Standard Error:	0.0	177.4	178.3	41.9	

APPENDIX 3.—(Page 2 of 3)

		Brood Year and Age Group				
		2008	2007	2006	2005	
		0.2	0.3	0.4	0.5	Total
Stratum 6:	07/24 – 07/30					
Sampling Dates:	07/24					
Male:	Number in Sample:	0	49	50	3	102
	Estimated % of Escapement:	0.0	33.1	33.8	2.0	68.9
	Estimated Escapement:	0	1,337	1,364	82	2,782
	Standard Error:	0.0	153.8	154.6	46.1	
Female:	Number in Sample:	0	23	22	1	46
	Estimated % of Escapement:	0.0	15.5	14.9	0.7	31.1
	Estimated Escapement:	0	627	600	27	1,255
	Standard Error:	0.0	118.4	116.3	26.8	
Total:	Number in Sample:	0	72	72	4	148
	Estimated % of Escapement:	0.0	48.6	48.6	2.7	100.0
	Estimated Escapement:	0	1,964	1,964	109	4,037
	Standard Error:	0.0	163.3	163.3	53.0	
Stratum 7:	07/31 – 08/06					
Sampling Dates:	07/31, 08/01					
Male:	Number in Sample:	1	43	31	2	77
	Estimated % of Escapement:	0.6	26.7	19.3	1.2	47.8
	Estimated Escapement:	10	429	310	20	769
	Standard Error:	9.5	53.4	47.5	13.4	
Female:	Number in Sample:	2	46	34	2	84
	Estimated % of Escapement:	1.2	28.6	21.1	1.2	52.2
	Estimated Escapement:	20	459	340	20	839
	Standard Error:	13.4	54.5	49.2	13.4	
Total:	Number in Sample:	3	89	65	4	161
	Estimated % of Escapement:	1.9	55.3	40.4	2.5	100.0
	Estimated Escapement:	30	889	649	40	1,608
	Standard Error:	16.3	60.0	59.2	18.8	
Strata 8 – 12:	08/07 – 09/10					
Sampling Dates:	08/07, 08/08					
Male:	Number in Sample:	1	46	18	1	66
	Estimated % of Escapement:	0.7	31.3	12.2	0.7	44.9
	Estimated Escapement:	6	274	107	6	394[a]
	Standard Error:	5.4	30.7	21.7	5.4	
Female:	Number in Sample:	0	58	23	0	81
	Estimated % of Escapement:	0.0	39.5	15.6	0.0	55.1
	Estimated Escapement:	0	346	137	0	483[a]
	Standard Error:	0.0	32.4	24.1	0.0	
Total:	Number in Sample:	1	104	41	1	147
	Estimated % of Escapement:	0.7	70.7	27.9	0.7	100.0
	Estimated Escapement:	6	620	245	6	877[a]
	Standard Error:	5.4	30.1	29.7	5.4	

APPENDIX 3.—(Page 3 of 3)

		Brood Year and Age Group				
		2008	2007	2006	2005	
		0.2	0.3	0.4	0.5	Total
Strata 1 – 12:	06/19 – 09/10					
Sampling Dates:	07/05 – 08/08					
Male:	Number in Sample:	2	220	311	13	546
	% Males in Age Group:	0.1	36.1	61.3	2.4	100.0
	Estimated % of Escapement:	0.1	23.2	39.5	1.5	64.3
	Estimated Escapement:	16	4,260	7,234	282	11,792[a]
	Standard Error:	10.9	273.4	317.5	81.6	
	Estimated Design Effects:	0.421	1.182	1.189	1.237	1.179
Female:	Number in Sample:	2	172	185	5	364
	% Females in Age Group:	0.3	40.6	57.5	1.6	100.0
	Estimated % of Escapement:	0.1	14.5	20.5	0.6	35.7
	Estimated Escapement:	20	2,655	3,756	107	6,537[a]
	Standard Error:	13.4	217.8	263.6	51.0	
	Estimated Design Effects:	0.493	1.084	1.203	1.266	1.179
Total:	Number in Sample:	4	392	496	18	910
	Estimated % of Escapement:	0.2	37.7	60.0	2.1	100.0
	Estimated Escapement:	36	6,914	10,990	389	18,329[a]
	Standard Error:	17.2	306.6	310.6	95.8	
	Estimated Design Effects:	0.458	1.129	1.133	1.245	

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

APPENDIX 4.—Estimated length (mm) at age composition of weekly chum salmon escapements through the Kwethluk River weir, Alaska, 2011.

		Brood Year and Age Group			
		2008	2007	2006	2005
		0.2	0.3	0.4	0.5
Strata 1 – 3:	06/19 – 07/09				
Sampling Dates:	07/05				
Male:	Mean Length		593	596	595
	Std. Error		5	3	16
	Range		550 – 630	540 – 665	565 – 620
	Sample Size	0	21	77	3
Female:	Mean Length		571	574	
	Std. Error		8	4	
	Range		505 – 615	525 – 635	
	Sample Size	0	11	44	0
Stratum 4:	07/10 – 07/16				
Sampling Date:	07/10				
Male:	Mean Length		586	592	603
	Std. Error		5	3	22
	Range		535 – 635	540 – 6660	565 – 640
	Sample Size	0	22	83	3
Female:	Mean Length		558	565	570
	Std. Error		7	4	
	Range		500 – 590	530 – 605	–
	Sample Size	0	14	28	1
Stratum 5:	07/17 – 07/23				
Sampling Dates:	07/17				
Male:	Mean Length		569	580	570
	Std. Error		5	4	
	Range		510 – 630	520 – 640	–
	Sample Size	0	39	52	1
Female:	Mean Length		551	553	525
	Std. Error		5	4	
	Range		500 – 585	505 – 60034	–
	Sample Size	0	20	46	1
Stratum 6:	07/24 – 07/30				
Sampling Dates:	07/24				
Male:	Mean Length		559	566	577
	Std. Error		4	4	12
	Range		495 – 610	520 – 625	565 – 600
	Sample Size	0	49	50	3
Female:	Mean Length		547	539	525
	Std. Error		5	4	
	Range		490 – 600	500 – 575	–
	Sample Size	0	23	22	1

APPENDIX 4.—(Page 2 of 2)

		Brood Year and Age Group			
		2008	2007	2006	2005
		0.2	0.3	0.4	0.5
Stratum 7:	07/31 – 08/06				
Sampling Dates:	07/31, 08/01				
Male:	Mean Length	530	558	563	568
	Std. Error		3	4	13
	Range	–	510 – 610	520 – 610	555 – 580
	Sample Size	1	43	31	2
Female:	Mean Length	533	541	533	535
	Std. Error	3	4	4	10
	Range	530 – 535	490 – 615	480 – 570	525 – 535
	Sample Size	2	46	34	2
Strata 8 – 12:	08/07 – 09/10				
Sampling Dates:	08/07, 08/08				
Male:	Mean Length	570	557	542	505
	Std. Error		5	6	
	Range	–	500 – 620	485 – 580	–
	Sample Size	1	46	18	1
Female:	Mean Length		531	517	
	Std. Error		3	4	
	Range		485 – 595	465 – 555	
	Sample Size	0	58	23	0
Strata 1 – 12:	06/19 – 09/10				
Sampling Dates:	07/05 – 08/08				
Male:	Mean Length	550	566	581	580
	Std. Error	20	2	2	9
	Range	530 – 570	495 – 635	485 – 665	505 – 640
	Sample Size	2	220	311	13
Female:	Mean Length	533	543	550	538
	Std. Error	3	2	2	9
	Range	530 – 535	485 – 615	465 – 635	525 – 570
	Sample Size	2	172	185	5

APPENDIX 5.—Estimated age and sex composition of weekly Chinook salmon escapements through the Kwethluk River weir, Alaska, 2011, and estimated design effects of the stratified sampling design.

		Brood Year and Age Group							
		2007	2006		2005		2004	2003	
		1.2	1.3	2.2	1.4	2.3	1.5	1.6	Total
Strata 1 – 3:	06/19 – 07/09								
Sampling Dates:	07/05, 07/06, 07/09								
Male:	Number in Sample:	43	50	0	21	0	0	0	114
	Estimated % of Escapement:	28.5	33.1	0.0	13.9	0.0	0.0	0.0	75.5
	Estimated Escapement:	385	447	0	188	0	0	0	1,020[a]
	Standard Error:	46.9	48.9	0.0	36.0	0.0	0.0	0.0	
Female:	Number in Sample:	0	6	0	30	0	1	0	37
	Estimated % of Escapement:	0.0	4.0	0.0	19.9	0.0	0.7	0.0	24.5
	Estimated Escapement:	0	54	0	268	0	9	0	331[a]
	Standard Error:	0.0	20.3	0.0	41.5	0.0	8.4	0.0	
Total:	Number in Sample:	43	56	0	51	0	1	0	151
	Estimated % of Escapement:	28.5	37.1	0.0	33.8	0.0	0.7	0.0	100.0
	Estimated Escapement:	385	501	0	456	0	9	0	1,351[a]
	Standard Error:	46.9	50.2	0.0	49.2	0.0	8.4	0.0	
Stratum 4:	07/10 – 07/16								
Sampling Dates:	07/10, 07/11								
Male:	Number in Sample:	29	35	1	30	0	0	0	95
	Estimated % of Escapement:	21.0	25.4	0.7	21.7	0.0	0.0	0.0	68.8
	Estimated Escapement:	259	313	9	268	0	0	0	849
	Standard Error:	40.4	43.2	8.4	40.9	0.0	0.0	0.0	
Female:	Number in Sample:	0	3	0	39	0	1	0	43
	Estimated % of Escapement:	0.0	2.2	0.0	28.3	0.0	0.7	0.0	31.2
	Estimated Escapement:	0	27	0	348	0	9	0	384
	Standard Error:	0.0	14.5	0.0	44.7	0.0	8.4	0.0	
Total:	Number in Sample:	29	38	1	69	0	1	0	138
	Estimated % of Escapement:	21.0	27.5	0.7	50.0	0.0	0.7	0.0	100.0
	Estimated Escapement:	259	340	9	617	0	9	0	1,233
	Standard Error:	40.4	44.3	8.4	49.6	0.0	8.4	0.0	

APPENDIX 5.—(Page 2 of 3)

		Brood Year and Age Group							
		2007	2006		2005		2004	2003	
		1.2	1.3	2.2	1.4	2.3	1.5	1.6	Total
Stratum 5:	07/17 – 07/23								
Sampling Dates:	07/17, 07/18								
Male:	Number in Sample:	54	25	0	21	1	0	0	101
	Estimated % of Escapement:	34.0	15.7	0.0	13.2	0.6	0.0	0.0	63.5
	Estimated Escapement:	328	152	0	127	6	0	0	613
	Standard Error:	33.2	25.5	0.0	23.8	5.5	0.0	0.0	
Female:	Number in Sample:	0	6	0	46	0	6	0	58
	Estimated % of Escapement:	0.0	3.8	0.0	28.9	0.0	3.8	0.0	36.5
	Estimated Escapement:	0	36	0	279	0	36	0	352
	Standard Error:	0.0	13.4	0.0	31.8	0.0	13.4	0.0	
Total:	Number in Sample:	54	31	0	67	1	6	0	159
	Estimated % of Escapement:	34.0	19.5	0.0	42.1	0.6	3.8	0.0	100.0
	Estimated Escapement:	328	188	0	407	6	36	0	965
	Standard Error:	33.2	27.8	0.0	34.6	5.5	13.4	0.0	
Strata 6 – 11:	07/24 – 09/03								
Sampling Dates:	07/24 – 07/28, 07/31, 08/07								
Male:	Number in Sample:	37	19	0	12	0	1	0	69
	Estimated % of Escapement:	27.8	14.3	0.0	9.0	0.0	0.8	0.0	51.9
	Estimated Escapement:	147	76	0	48	0	4	0	275[a]
	Standard Error:	17.9	14.0	0.0	11.4	0.0	3.4	0.0	
Female:	Number in Sample:	2	3	0	56	1	2	0	64
	Estimated % of Escapement:	1.5	2.3	0.0	42.1	0.8	1.5	0.0	48.1
	Estimated Escapement:	8	12	0	223	4	8	0	255[a]
	Standard Error:	4.9	5.9	0.0	19.7	3.4	4.9	0.0	
Total:	Number in Sample:	39	22	0	68	1	3	0	133
	Estimated % of Escapement:	29.3	16.5	0.0	51.1	0.8	2.3	0.0	100.0
	Estimated Escapement:	155	88	0	271	4	12	0	530[a]
	Standard Error:	18.2	14.8	0.0	20.0	3.4	5.9	0.0	

APPENDIX 5.—(Page 3 of 3)

		Brood Year and Age Group							
		2007	2006		2005		2004	2003	
		1.2	1.3	2.2	1.4	2.3	1.5	1.6	Total
Strata 1 – 11:	06/19 – 09/03								
Sampling Dates:	07/05 – 08/07								
Male:	Number in Sample:	163	129	1	84	1	1	0	379
	% Males in Age Group:	40.6	35.8	0.3	22.9	0.2	0.1	0.0	100.0
	Estimated % of Escapement:	27.4	24.2	0.2	15.5	0.1	0.1	0.0	67.6
	Estimated Escapement:	1,119	988	9	631	6	4	0	2,757[a]
	Standard Error:	72.5	71.5	8.4	60.5	5.5	3.4	0.0	
	Estimated Design Effects:	1.063	1.109	1.273	1.118	0.864	0.567	0.000	1.039
Female:	Number in Sample:	2	18	0	171	1	10	0	202
	% Females in Age Group:	0.6	9.7	0.0	84.6	0.3	4.7	0.0	100.0
	Estimated % of Escapement:	0.2	3.2	0.0	27.4	0.1	1.5	0.0	32.4
	Estimated Escapement:	8	129	0	1,119	4	62	0	1,322[a]
	Standard Error:	4.9	28.9	0.0	71.6	3.4	18.6	0.0	
	Estimated Design Effects:	0.563	1.095	0.000	1.036	0.567	0.940	0.000	1.039
Total:	Number in Sample:	165	147	1	255	2	11	0	581
	Estimated % of Escapement:	27.6	27.4	0.2	42.9	0.2	1.6	0.0	100.0
	Estimated Escapement:	1,127	1,116	9	1,750	10	66	0	4,079[a]
	Standard Error:	72.6	74.0	8.4	80.5	6.5	18.9	0.0	
	Estimated Design Effects:	1.061	1.100	1.273	1.062	0.747	0.918	0.000	

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

APPENDIX 6.—Estimated length (mm) at age composition of weekly Chinook salmon escapements through the Kwethluk River weir, Alaska, 2011.

		Brood Year and Age Group						
		2007	2006		2005		2004	2003
		1.2	1.3	2.2	1.4	2.3	1.5	1.6
Strata 1 – 3:	06/19 – 07/09							
Sampling Dates:	07/05, 07/06, 07/09							
Male:	Mean Length	567	686		834			
	Std. Error	7	10		21			
	Range	460 – 640	530 – 860		715 – 945			
	Sample Size	43	50	0	18	0	0	0
Female:	Mean Length		784		858		900	
	Std. Error		17		9			
	Range		740 – 840		740 – 955		–	
	Sample Size	0	6	0	30	0	1	0
Stratum 4:	07/10 – 07/16							
Sampling Dates:	07/10, 07/11							
Male:	Mean Length	581	696	530	832			
	Std. Error	8	13		21			
	Range	450 – 665	540 – 890	–	560 – 1005			
	Sample Size	29	35	1	30	0	0	0
Female:	Mean Length		775		882		910	
	Std. Error		20		10			
	Range		740 – 810		750 – 980		–	
	Sample Size	0	3	0	39	0	1	0
Stratum 5:	07/17 – 07/23							
Sampling Dates:	07/17, 07/18							
Male:	Mean Length	580	690		798	735		
	Std. Error	7	12		20			
	Range	465 – 745	575 – 850		640 – 980	–		
	Sample Size	54	25	0	21	1	0	0
Female:	Mean Length		806		875		909	
	Std. Error		15		8		12	
	Range		740 – 840		755 – 975		875 – 945	
	Sample Size	0	6	0	46	0	6	0

APPENDIX 6.—(Page 2 of 2)

		Brood Year and Age Group						
		2007	2006		2005		2004	2003
		1.2	1.3	2.2	1.4	2.3	1.5	1.6
Strata 6 – 11:	07/24 – 09/03							
Sampling Dates:	07/24 – 07/28, 07/31, 08/07							
Male:	Mean Length	571	679		785		995	
	Std. Error	9	16		29			
	Range	400 – 650	585 – 830		560 – 950		–	
	Sample Size	37	19	0	12	0	1	0
Female:	Mean Length	650	815		875	820	828	
	Std. Error	35	22		7		3	
	Range	615 – 685	775 – 850		775 – 980	–	825 – 830	
	Sample Size	2	3	0	56	1	2	0
Strata 1 – 11:	06/19 – 09/03							
Sampling Dates:	07/05 – 08/07							
Male:	Mean Length	575	688	530	817	735	995	
	Std. Error	4	6		11			
	Range	400 – 745	530 – 890	–	560 – 1005	–	–	
	Sample Size	163	129	1	84	1	1	0
Female:	Mean Length	650	795		874	820	892	
	Std. Error	35	9		4		13	
	Range	615 – 685	740 – 850		740 – 980	–	825 – 945	
	Sample Size	2	18	0	171	1	10	0

APPENDIX 7.—Estimated age and sex composition of sockeye salmon escapement through the Kwethluk River weir, Alaska, 2011, and estimated design effects of the stratified sampling design.

		Brood Year and Age Group									
		2008	2007		2006			2005		2004	
		0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3	2.4	Total
Strata 1 – 10:	06/19 – 08/27										
Sampling Dates:	07/05, 07/10, 07/17 – 07/19, 07/24 – 07/28										
Male:	Number in Sample:	0	5	3	3	24	0	5	3	0	43
	% Males in Age Group	0.0	11.6	7.0	7.0	55.8	0.0	11.6	7.0	0.0	100.0
	Estimated % of Escapement:	0.0	5.0	3.0	3.0	24.0	0.0	5.0	3.0	0.0	43.0
	Estimated Escapement:	0	102	61	61	487	0	102	61	0	873[a]
	Standard Error:	0.0	43.4	34.0	34.0	85.0	0.0	43.4	34.0	0.0	
	Estimated Design Effects:	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.000	1.000
Female	Number in Sample:	0	7	1	2	35	1	4	6	1	57
	% Female in Age Group	0.0	12.3	1.8	3.5	61.4	1.8	7.0	10.5	1.8	100.0
	Estimated % of Escapement:	0.0	7.0	1.0	2.0	35.0	1.0	4.0	6.0	1.0	57.0
	Estimated Escapement:	0	142	20	41	711	20	81	122	20	1,158[a]
	Standard Error:	0.0	50.8	19.8	27.9	94.9	19.8	39.0	47.3	19.8	
Total:	Number in Sample:	0	12	4	5	59	1	9	9	1	100
	Estimated % of Escapement:	0.0	12.0	4.0	5.0	59.0	1.0	9.0	9.0	1.0	100.0
	Estimated Escapement:	0	244	81	102	1,198	20	183	183	20	2,031[a]
	Standard Error:	0.0	64.7	39.0	43.4	97.9	19.8	57.0	57.0	19.8	
	Estimated Design Effects:	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	

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

APPENDIX 8.—Estimated length (mm) at age composition of sockeye salmon escapement through the Kwethluk River weir, Alaska, 2011.

		Brood Year and Age Group								
		2008	2007		2006			2005		2004
		0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3	2.4
Strata 1 – 10:	06/19 – 08/27									
Sampling Dates:	07/05, 07/10, 07/17 – 07/19, 07/24 – 07/28									
Male:	Mean Length		584	537	605	574		593	560	
	Std. Error		8	12	5	6		8	20	
	Range		565 – 610	515 – 555	600 – 615	530 – 650		565 – 615	520 – 590	
	Sample Size	0	5	3	3	24	0	5	3	0
Female:	Mean Length		542	565	555	546	495	576	553	565
	Std. Error		7		5	3		5	8	
	Range		510 – 575	–	550 – 560	510 – 580	–	565 – 590	530 – 575	–
	Sample Size	0	7	1	2	35	1	4	7	1

APPENDIX 9.—Estimated age and sex composition of weekly coho salmon escapements through the Kwethluk River weir, Alaska, 2011, and estimated design effects of the stratified sampling design.

		Brood Year and Age Group			
		2008	2007	2006	
		1.1	2.1	3.1	Total
Strata 4 – 8:	07/10 – 08/13				
Sampling Dates:	07/24 – 07/28, 07/31, 08/07, 08/08, 08/12				
Male:	Number in Sample:	22	80	4	106
	Estimated % of Escapement:	10.9	39.8	2.0	52.7
	Estimated Escapement:	86	314	16	417
	Standard Error:	15.1	23.6	6.7	
Female:	Number in Sample:	25	68	2	95
	Estimated % of Escapement:	12.4	33.8	1.0	47.3
	Estimated Escapement:	98	267	8	373
	Standard Error:	15.9	22.8	4.8	
Total:	Number in Sample:	47	148	6	201
	Estimated % of Escapement:	23.4	73.6	3.0	100.0
	Estimated Escapement:	185	582	24	790
	Standard Error:	20.4	21.3	8.2	
Strata 9 – 11:	08/14 – 09/03				
Sampling Dates:	08/29				
Female:	Number in Sample:	15	78	1	94
	Estimated % of Escapement:	7.9	40.8	0.5	49.2
	Estimated Escapement:	188	976	13	1,177
	Standard Error:	44.8	81.8	12.0	
Male:	Number in Sample:	24	69	4	97
	Estimated % of Escapement:	12.6	36.1	2.1	50.8
	Estimated Escapement:	300	864	50	1,214
	Standard Error:	55.2	79.9	23.8	
Total:	Number in Sample:	39	147	5	191
	Estimated % of Escapement:	20.4	77.0	2.6	100.0
	Estimated Escapement:	488	1,840	63	2,391
	Standard Error:	67.1	70.1	26.6	
Stratum 12:	09/04 – 09/10				
Sampling Dates:	09/08, 09/09				
Male:	Number in Sample:	28	72	2	102
	Estimated % of Escapement:	15.4	39.6	1.1	56.0
	Estimated Escapement:	200	515	14	729
	Standard Error:	32.4	43.9	9.3	
Female:	Number in Sample:	15	61	4	80
	Estimated % of Escapement:	8.2	33.5	2.2	44.0
	Estimated Escapement:	107	436	29	572
	Standard Error:	24.7	42.3	13.1	
Total:	Number in Sample:	43	133	6	182
	Estimated % of Escapement:	23.6	73.1	3.3	100.0
	Estimated Escapement:	307	951	43	1,301
	Standard Error:	38.1	39.8	16.0	

APPENDIX 9.—(Page 2 of 2)

		Brood Year and Age Group			
		2008	2007	2006	
		1.1	2.1	3.1	Total
Strata 4 – 12:	07/19 – 09/12				
Sampling Dates:	07/26 – 09/09				
Male:	Number in Sample:	65	230	7	302
	% Males in Age Group:	20.4	77.7	1.8	100.0
	Estimated % of Escapement:	10.6	40.3	0.9	51.8
	Estimated Escapement:	474	1,806	43	2,322
	Standard Error:	57.2	95.8	16.6	
	Estimated Design Effects:	1.115	1.216	0.969	1.211
Female:	Number in Sample:	64	198	10	272
	% Females in Age Group:	23.4	72.6	4.0	100.0
	Estimated % of Escapement:	11.3	35.0	1.9	48.2
	Estimated Escapement:	506	1,567	87	2,160
	Standard Error:	62.5	93.3	27.6	
	Estimated Design Effects:	1.240	1.220	1.279	1.211
Total:	Number in Sample:	129	428	17	574
	Estimated % of Escapement:	21.9	75.2	2.9	100.0
	Estimated Escapement:	980	3,373	129	4,482
	Standard Error:	79.8	83.3	32.1	
	Estimated Design Effects:	1.191	1.192	1.179	

APPENDIX 10.—Estimated length (mm) at age composition of weekly coho salmon escapements through the Kwethluk River weir, Alaska, 2011.

		Brood Year and Age Group		
		2008	2007	2006
		1.1	2.1	3.1
Strata 4 – 8:	07/10 – 08/13			
Sampling Dates:	07/24 – 07/28, 07/31, 08/07, 08/08, 08/12			
Male:	Mean Length	537	562	570
	Std. Error	7	4	6
	Range	480 – 590	435 – 615	560 – 580
	Sample Size	22	80	4
Female:	Mean Length	545	559	518
	Std. Error	6	4	3
	Range	465 – 605	435 – 615	515 – 520
	Sample Size	25	68	2
Strata 9 – 11:	08/14 – 09/03			
Sampling Dates:	08/29			
Male:	Mean Length	581	588	620
	Std. Error	8	4	
	Range	520 – 615	510 – 665	–
	Sample Size	15	78	1
Female:	Mean Length	575	583	579
	Std. Error	5	3	12
	Range	520 – 610	515 – 640	555 – 610
	Sample Size	24	69	4
Stratum 12:	09/04 – 09/10			
Sampling Dates:	09/08, 09/09			
Male:	Mean Length	569	600	593
	Std. Error	5	4	8
	Range	515 – 625	490 – 645	585 – 600
	Sample Size	28	72	2
Female:	Mean Length	563	581	583
	Std. Error	6	4	12
	Range	515 – 610	460 – 630	560 – 610
	Sample Size	15	61	4
Strata 4 – 12:	7/10 – 09/10			
Sampling Dates:	7/24 – 09/09			
Male:	Mean Length	561	583	584
	Std. Error	4	2	8
	Range	480 – 625	435 – 665	560 – 620
	Sample Size	65	230	7
Female:	Mean Length	561	574	568
	Std. Error	4	2	10
	Range	465 – 661	435 – 640	515 – 610
	Sample Size	64	198	10

APPENDIX 11.—Median cumulative passage dates and percent female for chum, Chinook, sockeye, pink and coho salmon at the Kwethluk River weir during 1992, 2000–2004, 2006–2011 (Harper 1998; Harper and Watry 2001; Roettiger et al. 2002, 2003, 2004, 2005; Miller et al. 2007, 2008, 2009; Miller and Harper 2010, 2011).

	Chum		Chinook		Sockeye		Pink		Coho	
Year	Date	Percent Female	Date	Percent Female	Date	Percent Female	Date	Percent Female	Date	Percent Female
1992	07/18[a]	54	07/09[a]	25	07/05	60	08/13	–	08/26	43
2000	07/16[a]	50	07/13[a]	21	07/01[a]	49	08/04	–	08/21[a]	45
2001	–	–	–	–	–	–	–	–	08/25	51
2002	07/17[a]	47	07/10[a]	22	07/11[a]	60	07/25	–	08/28	45
2003	07/22	44	07/11	19	07/07	55	08/01	–	08/29	51
2004	07/14[a]	43	07/08[a]	17	07/01[a]	48	08/06	–	08/29	43
2006	07/15	41	07/12	40	07/10	43	07/22	–	08/19[a]	37
2007	07/21	45	07/13	26	07/09	49	07/26	–	08/21	38
2008	07/22[a]	42	07/17[a]	39	07/09[a]	65	08/04	–	08/24	57
2009	07/22	48	07/12	51	07/10	65	07/27	–	08/29	51
2010	07/19[a]	41	07/17[a]	44	07/10[a]	49	07/23	–	–	29[b]
2011	07/20[a]	36	07/14[a]	32	07/07[a]	57	07/30	–	–	48

[a] Median cumulative passage dates were calculated using estimates for days missed.
[b] Percent calculated on early portion of the escapement and partial count.