U.S. Fish and Wildlife Service

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

Alaska Fisheries Data Series Number 2009-10

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

Abstract

The Kenai Fish and Wildlife Field Office, assisted by the Organized Village of Kwethluk, operated a resistance board weir on the Kwethluk River, a tributary to the lower Kuskokwim River, between July 4 and September 10, 2008. Data collected were used for in-season management of the commercial and subsistence fisheries in the Kuskokwim drainage. The estimated escapement was 20,030 chum *Oncorhynchus keta*, 5,275 Chinook *O. tshawytscha*, 2,451 sockeye *O. nerka*, 335 pink *O. gorbuscha*, and 48,049 coho *O. kisutch* salmon. Peak weekly passage occurred July 13–19 for chum, July 6–12 for Chinook and sockeye, August 3–9 for pink, and August 17–22 for coho salmon. Age, sex, and length data were collected for each species except pink salmon. Dominant age classes were 0.4 for chum, 1.4 for female and 1.3 for male Chinook, 1.3 for sockeye, and 2.1 for coho salmon. Over all percentages for female salmon were chum 42%, Chinook 39%, sockeye 65%, and coho 57%.

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 *Oncorhynchus keta*, Chinook *O. tshawytscha*, sockeye *O. nerka*, pink *O. gorbuscha*, and coho *O. kisutch* salmon (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 (Burkey et al. 2001; U.S. Fish and Wildlife Service 1988). In general, half of the total Chinook salmon statewide subsistence harvest occurs in the Kuskokwim drainage (Alaska Department 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). During 2007, the designation as stocks of concern was discontinued after chum and Chinook salmon escapements returned to levels above the historical average (Linderman and Rearden 2007).

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The Alaska Department of Fish and Game (Department), the U.S. Fish and Wildlife Service (Service), and the Kuskokwim River Salmon Management Working Group (Working Group) work together to achieve the goals of both the Kuskokwim River Salmon Management Plan (5 AAC 07.365) and the Federal Subsistence Fishery Management program. In addition to the goals set by the Department, the Service, and the Working Group, the Alaska National Interest Lands Conservation Act (ANILCA) mandates that salmon populations and their habitats be conserved in their natural diversity within the Refuge.

The broad geographic distribution of escapement monitoring projects in the Kuskokwim area provides insight for sustainable salmon management. Recent tagging studies conducted on chum, Chinook, sockeye, and coho salmon have all demonstrated differential stock-specific run timing with the general pattern of salmon stocks from upper river tributaries entering the Kuskokwim River earliest, while stocks from lower river tributaries enter progressively later (Kerkvliet and Hamazaki 2003; Kerkvliet et al. 2003, 2004; Stuby 2004, 2005, 2006). The temporal stock-specific run timings overlap and the difference between the mid-point of one stock and another of the same species can be several weeks. Concurrent with this phenomenon is the extensive subsistence fishery that harvests more heavily from early arriving salmon, and commercial fisheries that have historically focused on early, middle or late segments of the overall salmon run (Doug Molyneaux, Alaska Department of Fish and Game, personal communication).

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

A resistance board weir has been used to monitor salmon escapements on the Kwethluk River during 1992 and 2000–2004 and 2006–2008. 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 Office of Subsistence Management (OSM), Department and Service. Objectives of the project during 2008 were to: (1) enumerate adult salmon; (2) describe the run timing for chum, Chinook, sockeye, pink, and coho salmon returns; (3) estimate the age, sex, and length composition of adult chum, Chinook, sockeye, and coho salmon populations; and (4) identify and count other fish species passing through the weir. These data support the in-season and post season management of the Kuskokwim River subsistence and commercial fisheries. This information will also assist managers in establishing escapement goals to maintain the sustainability of salmon stocks returning to the Kwethluk River.

The Kwethluk River weir also plays an important role as a platform to collect additional information and data for other research projects. These include: (1) genetic samples for other funded projects; (2) monitoring for other species tagged in Kuskokwim River mark-recapture projects; (3) the Salmonid Rivers Observatory Network (SaRON), a 10 year project focused on pristine salmon rivers in the Bering Sea drainage measuring processes and changes to the shifting habitat mosaic of ecosystems (http://www.umt.edu/flbs/Research/SaRON.htm); and (4) a chum salmon juvenile emigration study (http://www.aykssi.org/Research/index.html) funded by the Arctic Yukon Kuskokwim Sustainable Salmon Initiative program.

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.

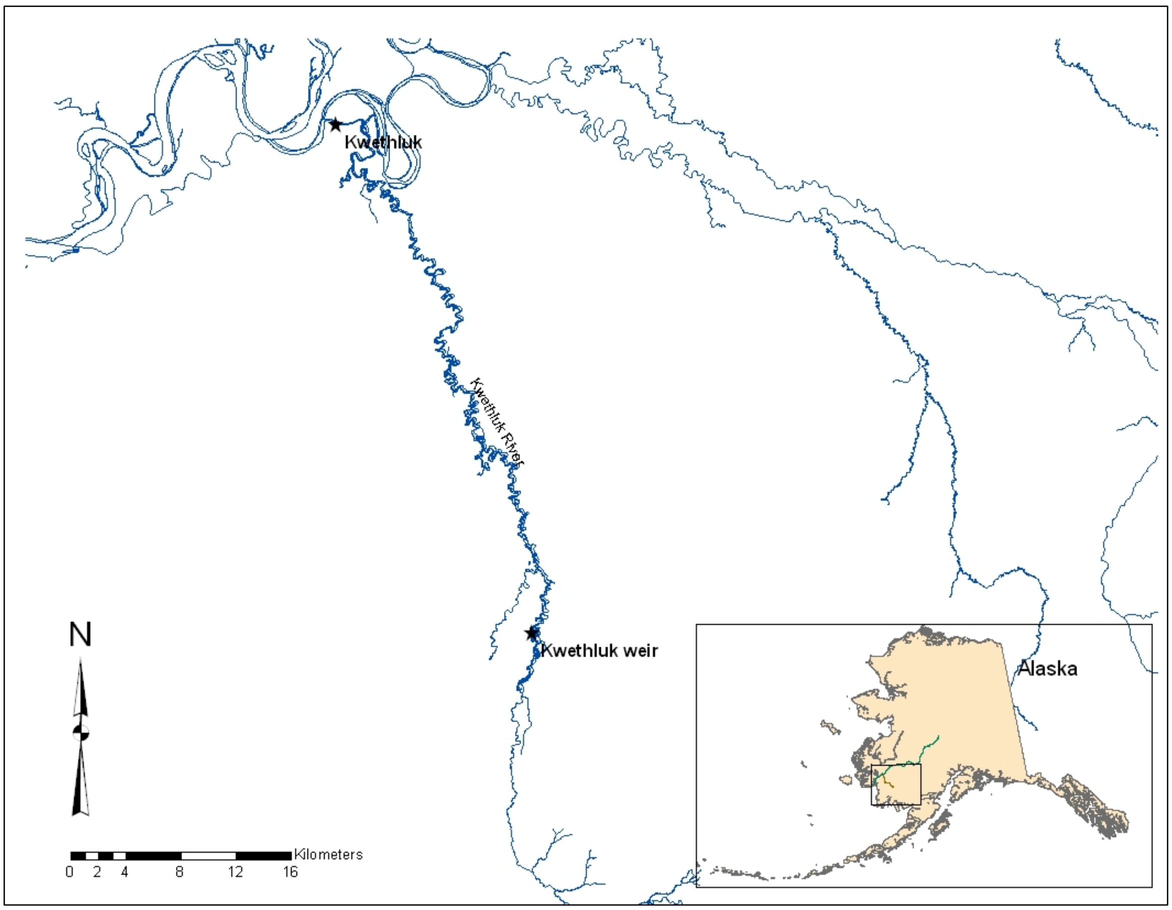

FIGURE 1.—Location of the Kwethluk River weir, 2008.

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° 29'44.68", W 161° 05'54.79", NAD 83) approximately 88 rkm upstream from the Kuskokwim River and 43 air-km east of Kwethluk, Alaska (Figure 1). This location is approximately 2.4 rkm downstream from the 1992 weir site described by Harper (1998). The weir was relocated during 2000 due to channel morphology changes. A staff gauge was installed upstream of the weir 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. Water temperatures were collected daily using a handheld thermometer between July 1 and August 6 and with a Hobo® recording thermometer from August 7 through September 10.

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. 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

A sample week (strata) began on Sunday and continued through the following Saturday. Target sample sizes were 200 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 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 (1.4=1+4+1=6 and 2.3=2+3+1=6) are both six-year-old fish from the same year class). The year class is determined by subtracting fish age from the current year.

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

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

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

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

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

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

with estimated variance

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

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

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

with estimated variance

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

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

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

with estimated variance

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

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

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

with corresponding variance estimator

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

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

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

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

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

Days with partial or zero counts were considered incomplete and estimates were calculated for these dates. Estimates were based on the average daily proportion of passage during years with similar run timing, specifically; 2003 and 2007 for chum salmon, 2000 and 2007 for Chinook salmon, and 2002 and 2007 for sockeye salmon. An average of the daily proportions for previous years was calculated since daily escapement can vary between years. The sum of the averaged daily proportions, calculated for days with partial or zero counts, is the estimated total proportion of the missed escapement. The total escapement is the sum of the observed 2008 counts divided by one minus the proportion missed during 2008.

Post-spawn Counts

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

Genetics

The Kwethluk River weir was used as a platform to collect genetic tissue samples from pink salmon. These samples were forwarded to the Department in Anchorage for processing.

Mark-Recapture Tag Recovery

The Kwethluk River weir was used as a platform to monitor for coho salmon that were tagged as part of a mark-recapture study conducted by the Department in the Kuskokwim River near Kalskag. All coho salmon that passed through the weir and those handled for ASL were visually inspected for external tags and associated data forwarded to the Department.

Results

Weir Operations

Water and ice conditions of the Kwethluk River were monitored by Refuge pilots during March and April. Supplies and equipment were transported by snow machines to the weir site on April 16. A helicopter was used to transport crew members and more supplies on April 24 to complete weir panel installation. Shore-fast ice was chipped from both river right and river left banks to expose the rail and install panels. Weir personnel returned to the weir site on June 20 to remove debris and mud from the rail and panels and set resistance boards. High water delayed trap installation until July 4 and the weir was fully operational from July 5 through September 10.

Average water depth at the leading edge of the weir during 2008 was 64 cm. The maximum water depth of 90 cm occurred on June 23 and the minimum water depth of 44 cm occurred on September 1 (Appendix 1). Water temperatures ranged from a high of 14°C on July 8 to a low of 8°C on several different days during July, August, and September (Appendix 1).

Biological Data

Chum Salmon —A total of 20,030 chum salmon was estimated to have passed through the weir between June 29–September 10 (Figure 2, Appendix 2). This total included an actual count of 19,555 plus an estimated passage of 475 chum salmon June 29–July 4. Peak weekly passage (N=4,702) occurred July 13–19 (Figure 2). Median cumulative passage occurred on July 22 for adults passing upstream (Appendix 2) and August 6 for chum salmon carcasses, a span of 15 days. The first chum salmon carcass passed downstream over the weir on July 1 (Figure 3). Gillnet marks were observed on 2% of the ASL sampled chum salmon (N=1,145).

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 (79%) and female (75%) chum salmon (Appendix 3). Females comprised 42% of the chum salmon escapement (Figure 4; Appendix 3). Mean length of males was larger than females in all ages except age 0.2 (Appendix 4).

Chinook Salmon —A total of 5,275 Chinook salmon was estimated passing through the weir June 29–August 31 (Figure 2; Appendix 2). This total included an actual count of 5,066 plus an estimated passage of 209 Chinook salmon June 29–July 4. Peak weekly passage (N=1,507) occurred July 6–12 (Figure 2). Median cumulative passage occurred on July 17 for adults passing upstream (Appendix 2) and August 16 for Chinook salmon carcasses, a span of 30 days (Figure 3). Gillnet marks were observed on 4% of the ASL sampled Chinook salmon (N=667).

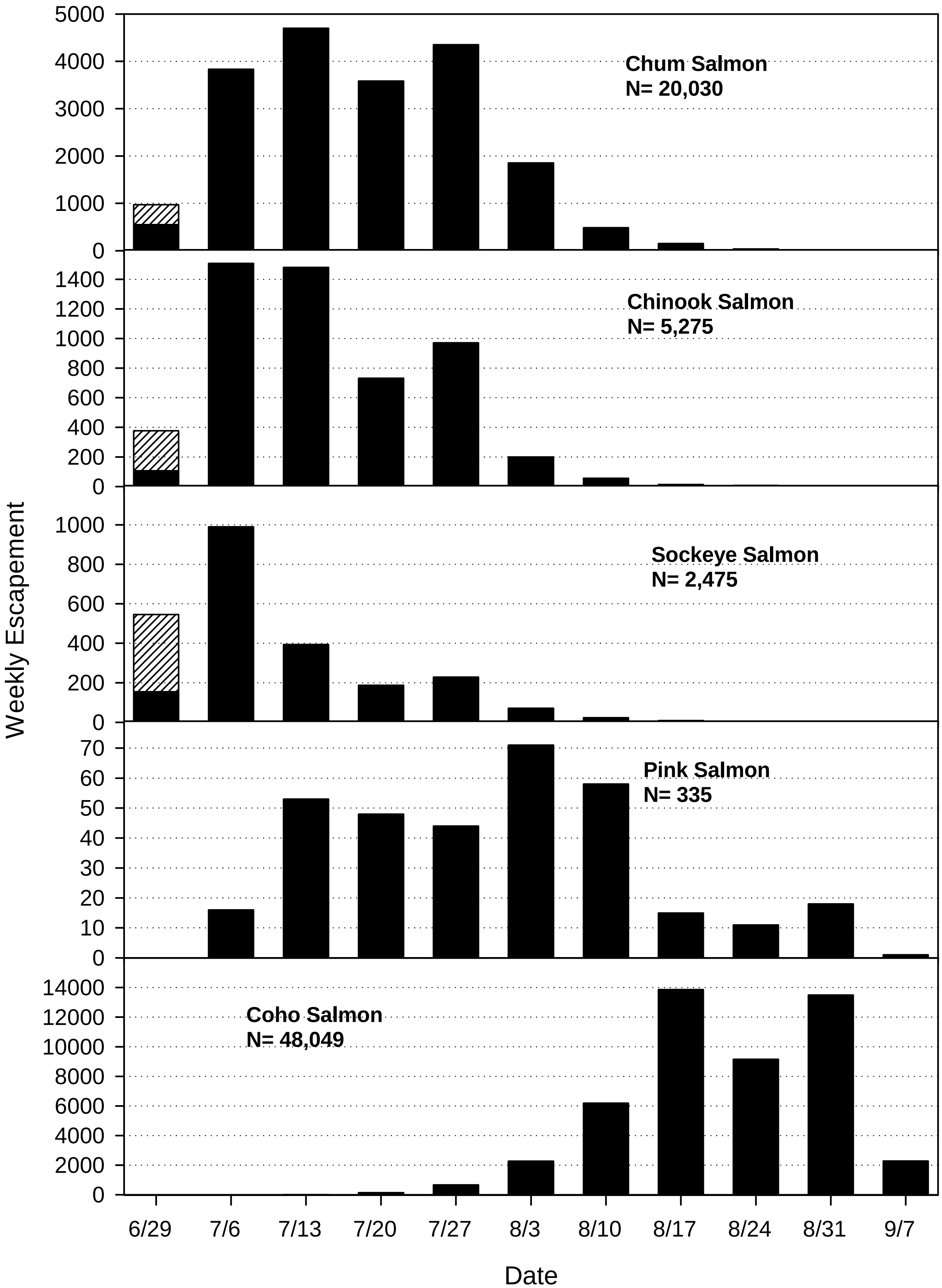

FIGURE 2.—Weekly escapement of chum, Chinook, sockeye, pink, and coho salmon at the Kwethluk River weir, 2008. Hash-marked shaded portions of bars represent portions of each week's return that were estimated. The week of September 7 represents only four days of counts (September 7—10).

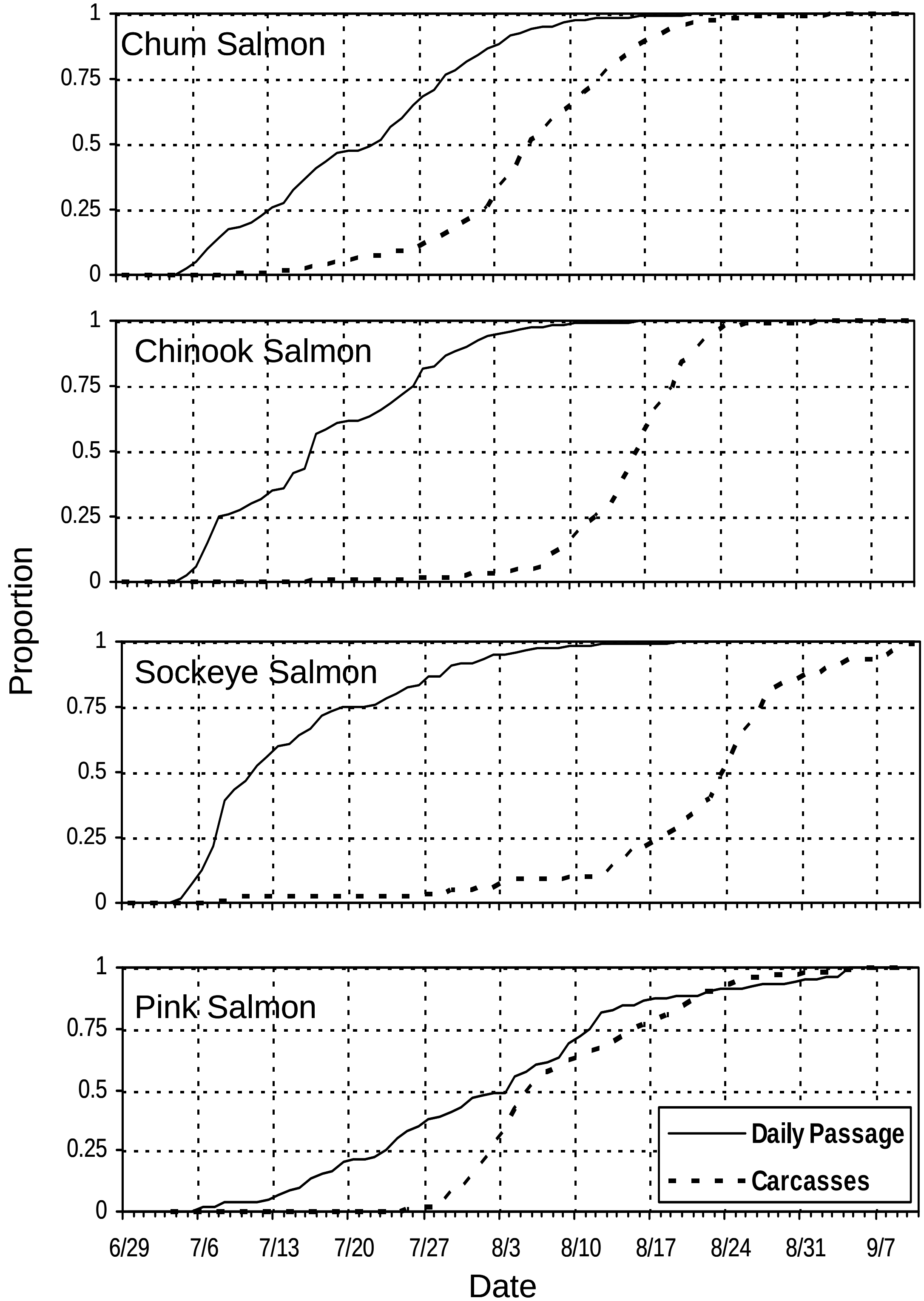

Figure 3. —Cumulative proportion of chum, Chinook, sockeye and pink salmon passage and post-spawn salmon or carcasses washing onto the upstream side of the Kwethluk River weir, 2008.

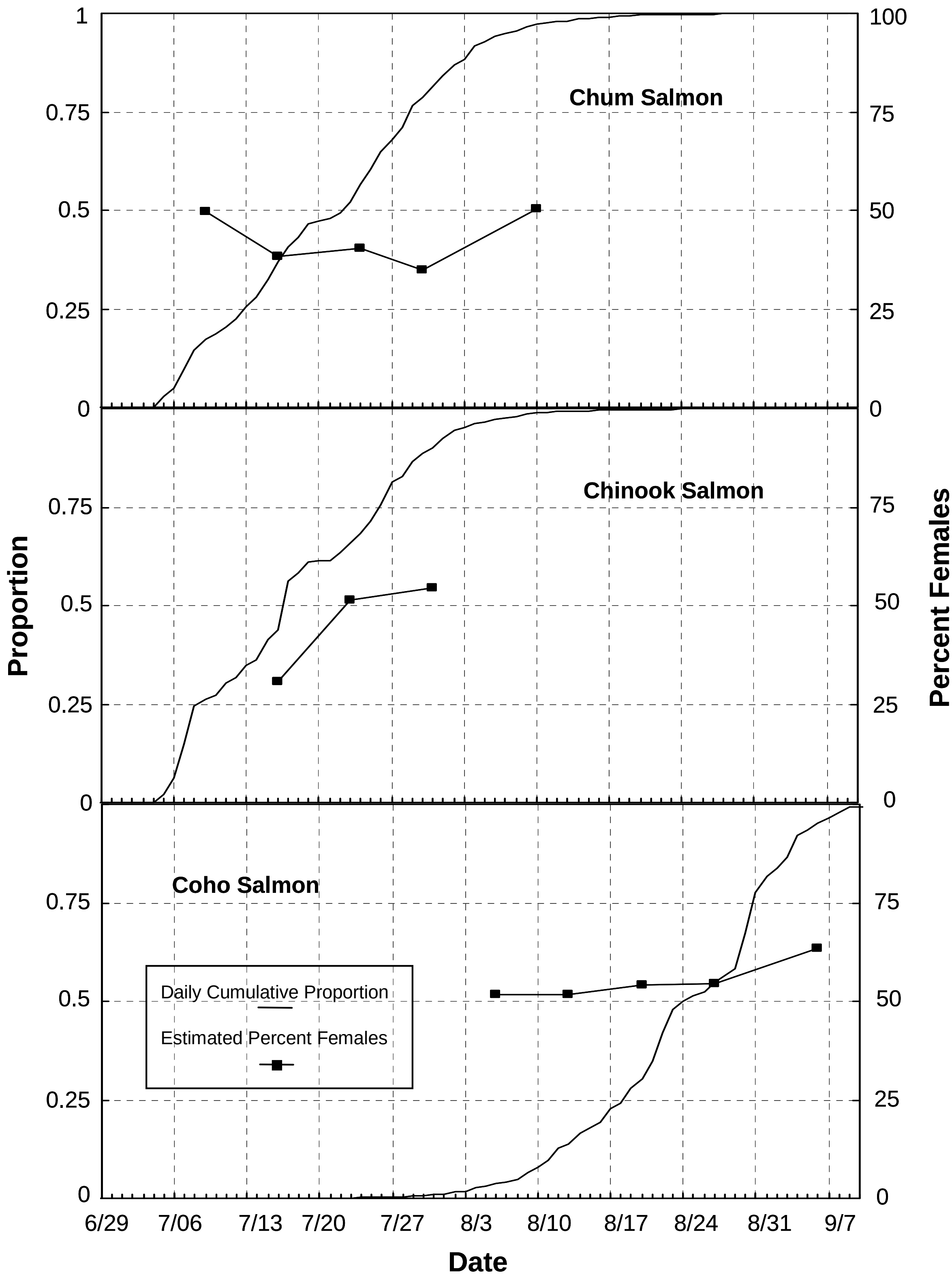

FIGURE 4.—Cumulative proportion and percent females for chum, Chinook, and coho salmon returning to the Kwethluk River during 2008. Percentage of females in returns for each species was estimated by weekly stratum.

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 1.3 for males (54%) and 1.4 (70%) for females (Appendix 5). Ages 1.2 and 1.3 accounted for 78% of the male Chinook salmon escapement. Females comprised 39% of the Chinook salmon escapement. Sex ratios favored males through mid-July, but then shifted to a dominant female component (Figure 4; Appendix 5). Mean length of females was greater than males in age groups 1.3, 1.4, and 1.5 (Appendix 6).

Sockeye Salmon —A total of 2,451 sockeye salmon was estimated passing through the weir between June 29 and August 31 (Figure 2; Appendix 2). This total included an actual count of 2,030 plus an estimated passage of 421 sockeye salmon June 29–July 4. Peak weekly passage (N=990) occurred July 6–12 (Figure 2). Median cumulative passage occurred on July 9 for adults passing upstream (Appendix 2) and August 24 for sockeye salmon carcasses, a span of 46 days (Figure 3). The first sockeye salmon carcass passed downstream over the weir July 8. Gillnet marks were observed on 4% of the ASL sampled sockeye salmon (N=98).

Four ages (0.3, 1.2, 1.3, and 2.3) were identified from sockeye salmon scale samples. The predominant age was 1.3 for both males and females and comprised 77% of the estimated sockeye salmon escapement (Appendix 7). Females comprised 65% of the total sockeye salmon escapement. The mean length of males was greater than females for ages 1.2 and 1.3 (Appendix 8).

Pink Salmon —A total of 335 pink salmon was counted through the weir between July 6–September 8 (Figure 2, Appendix 2). Peak weekly passage of pink salmon (N=71) occurred August 3–9 (Figure 2). Median cumulative passage occurred on August 4 for adults passing upstream (Appendix 2) and August 6 for pink salmon carcasses, a span of 2 days (Figure 3). A total of 298 pink salmon carcasses passed downstream over the weir between July 21–September 10. Gillnet marks were observed on 1% of the pink salmon escapement.

Genetic tissue samples were collected from live migrating pink salmon (N=70). All tissue was stored as a bulk sample according to Department protocols and forwarded to their lab in Anchorage.

Coho Salmon —A total of 48,049 coho salmon were counted through the weir during 2008 (Figure 2, Appendix 2). The first coho salmon migrated through the weir on July 13 and 392 fish were counted during the last day of operation on September 10. Peak weekly passage of coho salmon (N=13,866) occurred August 17–23 (Figure 2). Median cumulative passage occurred on August 24 for adults passing upstream (Appendix 2). The first coho salmon carcass to pass downstream over the weir was recorded on July 29. Gillnet marks were observed on 1% of the ASL sampled coho salmon (N=1,016).

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 (88%) and females (89%). Females comprised 57% of the total escapement and were more prevalent as the coho salmon migration progressed (Figure 4; Appendix 9). The average length of females was slightly larger than males in age 1.1, and males were slightly larger than females for ages 2.1 and 3.1 (Appendix 10).

Resident Species

Resident species counted through the weir included 25 Dolly Varden *Salvelinus malma*, 44 whitefish *Coregoninae* spp., 5 Arctic grayling *Thymallus arcticus* and 37 rainbow trout *O. mykiss.* Although smaller sized resident species were able to pass freely through the pickets, passage through the passage chute was recorded throughout the entire season.

Mark-Recapture Tag Recovery

None of the coho salmon that were tagged by the Department in the mainstem Kuskokwim River were observed migrating through the Kwethluk River weir July 4–September 10, 2008.

Discussion

Weir Operations

Aerial surveys of the Kwethluk River were flown from late March through April to determine when the weir site was clear of ice and water levels low enough for installation of the weir. Weir installation during April typically avoids the annual high water event, which normally begins in May and often continues until August. High water events are controlled by air temperature, snow pack, and rainfall. Weir panels were installed during late April and the weir was operational from July 4 through September 10, 2008. High water conditions that occurred during late June delayed the final stages of weir installation about 10 days from the normal start-up date of June 25.

Picket spacing on the Kwethluk River weir allows smaller pink salmon and resident species to pass uncounted between pickets while other salmon species are effectively monitored. Thus, counts of pink salmon and resident species are not representative of actual passage.

Biological Data

Chum Salmon —The estimated 2008 escapement of 20,030 chum salmon to the Kwethluk River was within the range of escapements (11,691–54,913) observed during past years (Figure 5), but substantially lower than the 7-year average of approximately 35,000 fish (Harper 1998; Harper and Watry 2001; Roettiger et al. 2002, 2003, 2004, 2005; Miller et al. 2007, 2008). Although the 2008 return fell within the historic range of escapements, it represents the second lowest on record. This below average escapement arrived late with a median passage date of July 22, which is the latest on record and about 10 days later than the earliest recorded on July 14, 2004 (Appendix 11). Females comprised 42% of the return which is at the lower end of the range (41–54%) observed during previous years (Appendices 3 and 11).

The dominant age during 2008 was 0.4 for chum salmon. This age group represented 77% of the escapement in 2008, which was a substantial increase from the 25% observed in 2007. The strong showing of age 0.4 fish in 2008 was likely due to the predominance of age 0.3 chum salmon observed during 2007 (Miller et al. 2008). Age 0.3 chum salmon decreased from 71% in 2007 to only 20% of the return in 2008 (Appendix 3). The return of age 0.4 chum salmon in 2009 will probably be weak based upon the poor showing of age 0.3 fish in 2008. The same trend in age class strength was also observed for chum salmon returning to the Tuluksak River during 2008 (Miller and Harper 2009).

Chinook Salmon —The estimated escapement of Chinook salmon in the Kwethluk River during 2008 (N=5,275) was the second lowest on record, and below the escapement goal range (N=6,000–11,000) set by the Department. This weak return was substantially lower than the record escapement (N=28,604) observed during 2004 and represented only 39% of the 7-year average (N=13,612) (Figure 5). Low returns of Chinook salmon were also observed at other Kuskokwim escapement projects during 2008. Chinook salmon returns to the Tuluksak (Miller and Harper 2009) and George rivers (Doug Molyneaux, Alaska Department of Fish and Game, personnel communication) also fell short of meeting the lower end of the escapement goal set for these rivers. The Chinook salmon

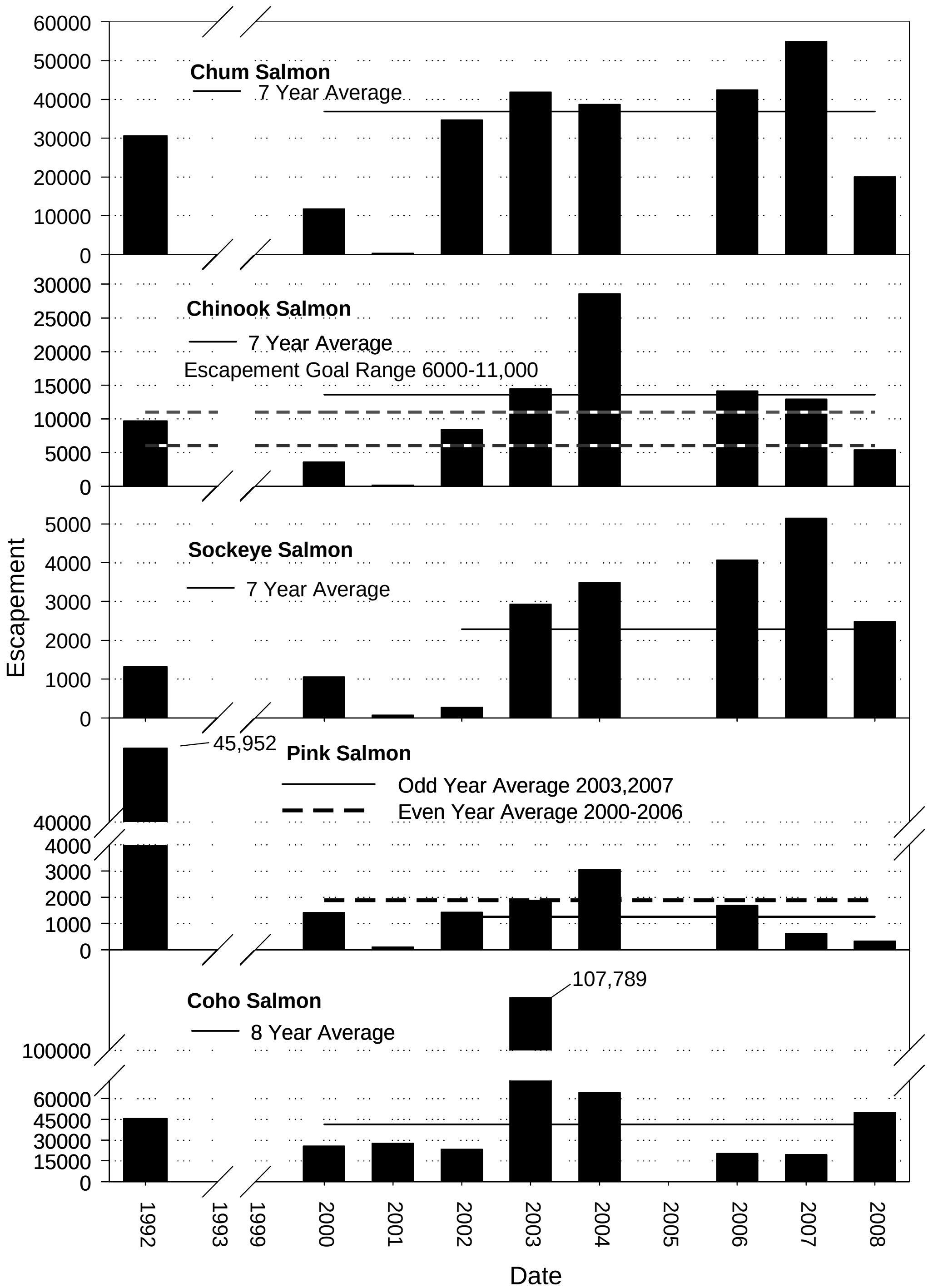

Figure 5.—Estimates of salmon escapement through the Kwethluk River weir, 1992, 2000–2004, 2006–2008. Weir operations during 2001 commenced on August 12 and only provided an estimate for coho salmon which provides a 8-year average for this species. Seven year averages are reported for Chinook, chum and sockeye salmon. Pink salmon averages are based on odd and even year averages 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.

return to the Tatlawiksuk River was one of the lowest recorded (Doug Molyneau, Alaska Department of Fish and Game, personnel communication).

The median cumulative passage date for Chinook salmon was July 17, the latest ever observed and nine days later than the earliest median passage date of July 8 observed in 2004 (Roettiger et al. 2005) (Appendices 2 and 11). Other monitoring projects further up the Kuskokwim River and subsistence fishers interviewed near Bethel also reported late run timing for Chinook salmon during 2008 (Doug Molyneaux, Alaska Department of Fish Game personal communication).

The dominant age groups of Chinook salmon in 2008 were 1.2, 1.3, and 1.4 representing 15%, 43%, and 39% of the return, respectively (Appendix 5). This age composition was different from 2007, when these ages represented 38, 29, and 32% of the return (Miller et al. 2008). The strong return of age 1.3 Chinook salmon in 2008 may result in a robust return of age 1.4 fish in 2009. Conversely, the poor showing of age 1.2 fish in 2008 may translate into weaker returns of age 1.3 fish during 2009.

Female Chinook salmon comprised 39% of the escapement during 2008, which is near the high end of the range (17-40%) observed during previous years (Appendix 11). Similarly, female Chinook salmon comprised 41% of the escapement on the Tuluksak River (Miller and Harper 2009). The higher incidence of females in the return may be attributed to changes in harvest strategies. Observations from a concurrent investigation (FIS-08-351) indicate that some subsistence fishers from Tuluksak have changed to smaller mesh nets (20.5 cm stretch mesh), which selectively harvest a higher percentage of males. Smaller mesh nets (< 20.5cm stretch) were also used in the 2008 commercial fishery that resulted in a harvest of 8,797 Chinook salmon comprised of 90% males (Doug Molyneaux, Alaska Department of Fish and Game personal communications).

Sockeye Salmon —The estimated escapement of 2,451 sockeye salmon fell within the range observed during past years (272–7,372) but was below the 7-year average (Figure 5). The estimate for 2008 was a decline of approximately 60% from the strongest returns, which occurred during 2006 and 2007. The median cumulative passage date of July 9 was fell within the previous range of July 1–11 and was similar to median dates observed during 2002, 2006 and 2007 (Appendix 11). Female sockeye salmon comprised 65% of the return during 2008, which was higher than that observed during previous years (43–60%) (Harper 1998; Harper and Watry 2001; Roettiger et al. 2002, 2003, 2004, 2005; Miller et al. 2008).

Pink Salmon —The number of pink salmon observed during 2008 (N=335) was the lowest even-year count observed since 2000 when wider picket spacing was implemented on the Kwethluk River weir (Figure 5). The actual count provides only an index of abundance since most pink salmon are small enough to pass between pickets of the weir panels. The median cumulative passage date was August 4, similar to that observed during 2000, 2003, and 2004 (Appendices 2 and 11). Age, sex, and length data were not collected for pink salmon.

Coho Salmon —The coho salmon count (N=48,049) during 2008 was more than double the escapements observed during 2006 and 2007 (Figure 5). The 2008 coho salmon escapement was higher than the 8-year average of 41,733 (including years with estimates) but lower than the record escapements observed during 2003 and 2004. The median cumulative passage date of August 24 fell in the middle of the range (August 19–29) observed during previous years (Appendix 11). Female coho salmon comprised 57% of the return during 2008 which was higher than the 38–51% previously observed (Appendices 9 and 11).

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 only been able to operate the weir during the entire season for 7 of the last 9 years (2000–2008) due to high spring flows, channel changes, damage to weir components, scouring and variable break up periods. Because of changes to the channel at the existing weir site, we anticipate having to relocate the weir to a better site downstream within the next year or two.

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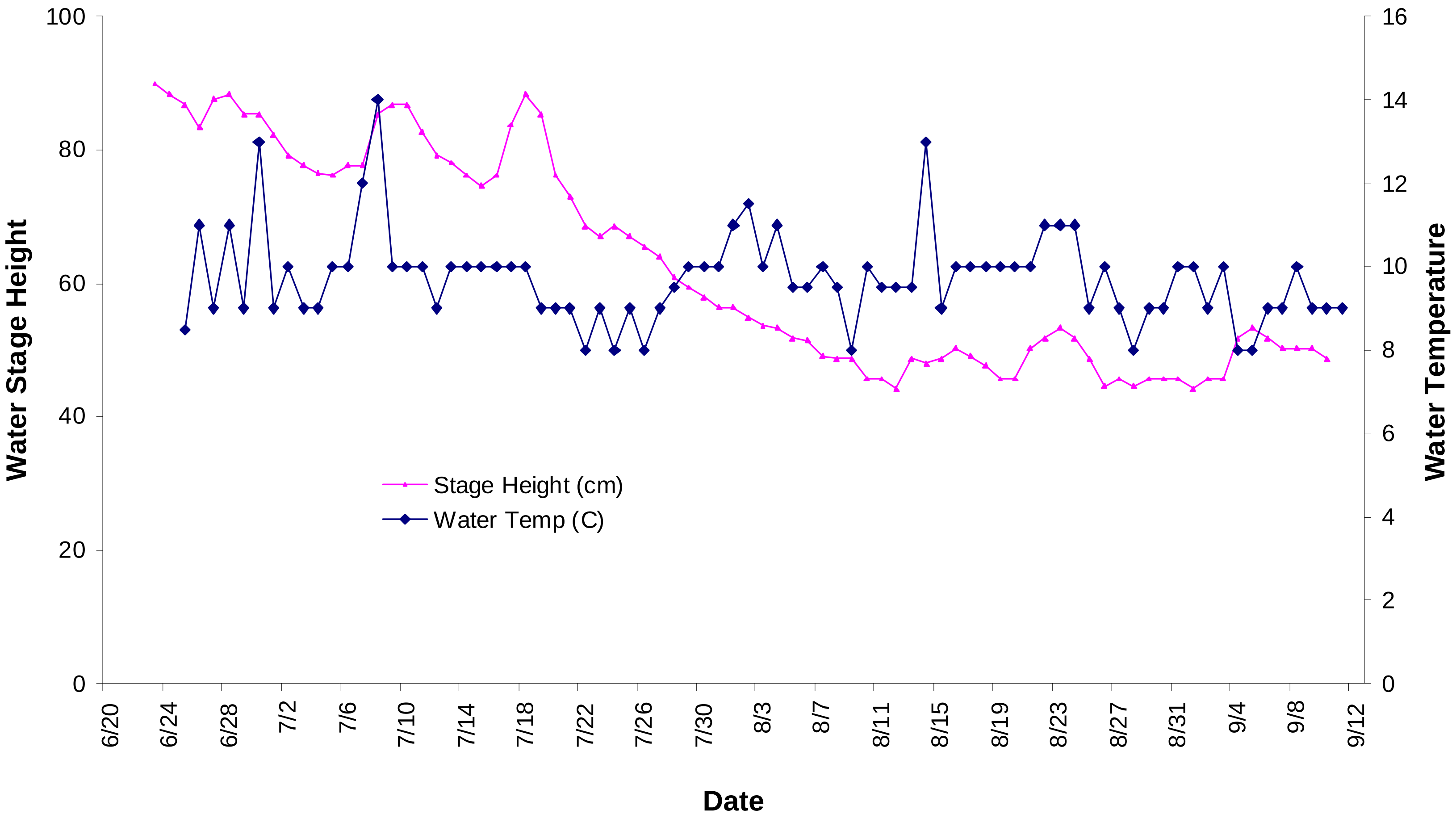

APPENDIX 1.—Water stage heights and water temperatures taken at the Kwethluk River weir, Alaska, 2008.

APPENDIX 2.—Daily counts, cumulative counts, and cumulative proportions of chum, Chinook, sockeye, pink, and coho salmon passing through the Kwethluk River weir, Alaska, 2008. Boxed areas represent the second and third quartile and median passage dates. Passage for chum, Chinook and sockeye salmon was estimated from June 29 through July 4, before the weir was fully operational (shaded area).

	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
6/29	44	44	0.002	8	8	0.001	41	41	0.017	0	0	0.000	0	0	0.000
6/30	32	76	0.004	12	20	0.004	30	71	0.029	0	0	0.000	0	0	0.000
7/1	46	122	0.006	39	59	0.011	62	134	0.055	0	0	0.000	0	0	0.000
7/2	78	200	0.010	32	91	0.017	98	231	0.094	0	0	0.000	0	0	0.000
7/3	133	333	0.017	53	144	0.027	107	338	0.138	0	0	0.000	0	0	0.000
7/4	142	475	0.024	65	209	0.040	83	421	0.172	0	0	0.000	0	0	0.000
7/5	539	1,014	0.051	101	310	0.059	124	545	0.222	0	0	0.000	0	0	0.000
7/6	405	1,419	0.071	206	516	0.098	102	647	0.264	7	7	0.021	0	0	0.000
7/7	932	2,351	0.117	451	967	0.183	197	844	0.344	0	7	0.021	0	0	0.000
7/8	910	3,261	0.163	484	1,451	0.275	347	1,191	0.486	5	12	0.036	0	0	0.000
7/9	556	3,817	0.191	80	1,531	0.290	96	1,287	0.525	0	12	0.036	0	0	0.000
7/10	245	4,062	0.203	62	1,593	0.302	58	1,345	0.549	0	12	0.036	0	0	0.000
7/11	379	4,441	0.222	143	1,736	0.329	119	1,464	0.597	2	14	0.042	0	0	0.000
7/12	406	4,847	0.242	81	1,817	0.344	71	1,535	0.626	2	16	0.048	0	0	0.000
7/13	610	5,457	0.272	162	1,979	0.375	97	1,632	0.666	7	23	0.069	6	6	0.000
7/14	449	5,906	0.295	58	2,037	0.386	19	1,651	0.674	6	29	0.087	0	6	0.000
7/15	885	6,791	0.339	272	2,309	0.438	67	1,718	0.701	5	34	0.101	0	6	0.000
7/16	856	7,647	0.382	113	2,422	0.459	40	1,758	0.717	12	46	0.137	0	6	0.000
7/17	779	8,426	0.421	638	3,060	0.580	106	1,864	0.761	6	52	0.155	0	6	0.000
7/18	449	8,875	0.443	95	3,155	0.598	32	1,896	0.774	2	54	0.161	0	6	0.000
7/19	674	9,549	0.477	142	3,297	0.625	33	1,929	0.787	15	69	0.206	0	6	0.000
7/20	141	9,690	0.484	18	3,315	0.628	6	1,935	0.789	1	70	0.209	0	6	0.000
7/21	130	9,820	0.490	5	3,320	0.629	5	1,940	0.792	0	70	0.209	0	6	0.000
7/22	285	10,105	0.504	99	3,419	0.648	21	1,961	0.800	5	75	0.224	12	18	0.000
7/23	528	10,633	0.531	120	3,539	0.671	45	2,006	0.818	8	83	0.248	26	44	0.001
7/24	852	11,485	0.573	133	3,672	0.696	35	2,041	0.833	19	102	0.304	35	79	0.002
7/25	799	12,284	0.613	150	3,822	0.725	42	2,083	0.850	8	110	0.328	27	106	0.002
7/26	850	13,134	0.656	206	4,028	0.764	33	2,116	0.863	7	117	0.349	39	145	0.003
7/27	649	13,783	0.688	311	4,339	0.823	54	2,170	0.885	11	128	0.382	46	191	0.004
7/28	609	14,392	0.719	61	4,400	0.834	11	2,181	0.890	2	130	0.388	8	199	0.004
7/29	1,028	15,420	0.770	198	4,598	0.872	79	2,260	0.922	8	138	0.412	123	322	0.007
7/30	391	15,811	0.789	106	4,704	0.892	15	2,275	0.928	4	142	0.424	59	381	0.008
7/31	559	16,370	0.817	71	4,775	0.905	7	2,282	0.931	15	157	0.469	78	459	0.010
8/1	545	16,915	0.844	120	4,895	0.928	31	2,313	0.944	2	159	0.475	86	545	0.011
8/2	568	17,483	0.873	103	4,998	0.947	32	2,345	0.957	2	161	0.481	264	809	0.017
8/3	247	17,730	0.885	28	5,026	0.953	6	2,351	0.959	2	163	0.487	50	859	0.018
8/4	685	18,415	0.919	57	5,083	0.964	17	2,368	0.966	23	186	0.555	400	1259	0.026
8/5	173	18,588	0.928	15	5,098	0.966	8	2,376	0.969	5	191	0.570	168	1427	0.030

APPENDIX 2.—(Page 2 of 2)

Date	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
	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
8/6	301	18,889	0.943	39	5,137	0.974	16	2,392	0.976	10	201	0.600	458	1,885	0.039
8/7	104	18,993	0.948	23	5,160	0.978	4	2,396	0.978	5	206	0.615	169	2,054	0.043
8/8	131	19,124	0.955	18	5,178	0.982	11	2,407	0.982	5	211	0.630	282	2,336	0.049
8/9	214	19,338	0.965	20	5,198	0.985	9	2,416	0.986	21	232	0.693	745	3,081	0.064
8/10	129	19,467	0.972	15	5,213	0.988	6	2,422	0.988	9	241	0.719	804	3,885	0.081
8/11	99	19,566	0.977	16	5,229	0.991	2	2,424	0.989	9	250	0.746	793	4,678	0.097
8/12	63	19,629	0.980	12	5,241	0.994	4	2,428	0.991	22	272	0.812	1,537	6,215	0.129
8/13	31	19,660	0.982	0	5,241	0.994	4	2,432	0.992	4	276	0.824	352	6,567	0.137
8/14	97	19,757	0.986	4	5,245	0.994	2	2,434	0.993	6	282	0.842	1,335	7,902	0.164
8/15	25	19,782	0.988	2	5,247	0.995	4	2,438	0.995	1	283	0.845	777	8,679	0.181
8/16	42	19,824	0.990	6	5,253	0.996	1	2,439	0.995	7	290	0.866	587	9,266	0.193
8/17	35	19,859	0.991	2	5,255	0.996	1	2,440	0.996	3	293	0.875	1,737	11,003	0.229
8/18	22	19,881	0.993	2	5,257	0.997	1	2,441	0.996	0	293	0.875	541	11,544	0.240
8/19	40	19,921	0.995	1	5,258	0.997	1	2,442	0.996	2	295	0.881	1,896	13,440	0.280
8/20	13	19,934	0.995	0	5,258	0.997	1	2,443	0.997	0	295	0.881	1,217	14,657	0.305
8/21	14	19,948	0.996	1	5,259	0.997	1	2,444	0.997	1	296	0.884	2,070	16,727	0.348
8/22	20	19,968	0.997	6	5,265	0.998	1	2,445	0.998	6	302	0.901	3,446	20,173	0.420
8/23	7	19,975	0.997	1	5,266	0.998	2	2,447	0.998	3	305	0.910	2,959	23,132	0.481
8/24	4	19,979	0.997	2	5,268	0.999	0	2,447	0.998	2	307	0.916	943	24,075	0.501
8/25	5	19,984	0.998	2	5,270	0.999	0	2,447	0.998	0	307	0.916	660	24,735	0.515
8/26	2	19,986	0.998	2	5,272	0.999	0	2,447	0.998	1	308	0.919	498	25,233	0.525
8/27	8	19,994	0.998	0	5,272	0.999	0	2,447	0.998	3	311	0.928	1,175	26,408	0.550
8/28	11	20,005	0.999	0	5,272	0.999	3	2,450	1.000	2	313	0.934	783	27,191	0.566
8/29	4	20,009	0.999	0	5,272	0.999	0	2,450	1.000	0	313	0.934	769	27,960	0.582
8/30	5	20,014	0.999	1	5,273	1.000	0	2,450	1.000	3	316	0.943	4,321	32,281	0.672
8/31	2	20,016	0.999	2	5,275	1.000	1	2,451	1.000	3	319	0.952	5,045	37,326	0.777
9/1	3	20,019	0.999	0	5,275	1.000	0	2,451	1.000	0	319	0.952	1,992	39,318	0.818
9/2	0	20,019	0.999	0	5,275	1.000	0	2,451	1.000	2	321	0.958	1,000	40,318	0.839
9/3	1	20,020	1.000	0	5,275	1.000	0	2,451	1.000	1	322	0.961	1,198	41,516	0.864
9/4	0	20,020	1.000	0	5,275	1.000	0	2,451	1.000	12	334	0.997	2,639	44,155	0.919
9/5	3	20,023	1.000	0	5,275	1.000	0	2,451	1.000	0	334	0.997	778	44,933	0.935
9/6	1	20,024	1.000	0	5,275	1.000	0	2,451	1.000	0	334	0.997	842	45,775	0.953
9/7	2	20,026	1.000	0	5,275	1.000	0	2,451	1.000	0	334	0.997	608	46,383	0.965
9/8	2	20,028	1.000	0	5,275	1.000	0	2,451	1.000	1	335	1.000	652	47,035	0.979
9/9	0	20,028	1.000	0	5,275	1.000	0	2,451	1.000	0	335	1.000	622	47,657	0.992
9/10	2	20,030	1.000	0	5,275	1.000	0	2,451	1.000	0	335	1.000	392	48,049	1.000

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

		Year Class and Age Group				
		2005	2004	2003	2002	
		0.2	0.3	0.4	0.5	Total
Strata 1 - 2:	06/29 - 07/12					
Sampling Dates:	07/06 - 07/09					
Male:	Number in Sample:	0	11	71	0	82
	Estimated % of Escapement:	0.0	6.7	43.6	0.0	50.3
	Estimated Escapement:	0	327	2,111	0	2,438
	Standard Error:	0.0	85.1	168.1	0.0	
Female:	Number in Sample:	0	18	59	4	81
	Estimated % of Escapement:	0.0	11.0	36.2	2.5	49.7
	Estimated Escapement:	0	535	1,754	119	2,409
	Standard Error:	0.0	106.3	162.9	52.5	
Total:	Number in Sample:	0	29	130	4	163
	Estimated % of Escapement:	0.0	17.8	79.8	2.5	100.0
	Estimated Escapement:	0	782	3,508	108	4,847
	Standard Error:	0.0	143.2	150.4	58.0	
Stratum 3:	07/13 - 0719					
Sampling Dates:	07/13 - 07/14					
Male:	Number in Sample:	0	16	98	0	114
	Estimated % of Escapement:	0.0	8.6	53.0	0.0	61.6
	Estimated Escapement:	0	407	2,491	0	2,897
	Standard Error:	0.0	95.5	169.6	0.0	
Female:	Number in Sample:	1	7	61	2	71
	Estimated % of Escapement:	0.5	3.8	33.0	1.1	38.4
	Estimated Escapement:	25	178	1,550	51	1,805
	Standard Error:	24.9	64.8	159.7	35.1	
Total:	Number in Sample:	1	23	159	2	185
	Estimated % of Escapement:	0.5	12.4	85.9	1.1	100.0
	Estimated Escapement:	25	585	4,041	51	4,702
	Standard Error:	24.9	112.1	118.1	35.1	
Stratum 4:	07/20 - 07/26					
Sampling Dates:	07/20, 07/22 - 07/25					
Male:	Number in Sample:	2	20	87	6	115
	Estimated % of Escapement:	1.0	10.4	45.1	3.1	59.6
	Estimated Escapement:	37	372	1,616	111	2,136
	Standard Error:	25.5	76.7	125.2	43.7	
Female:	Number in Sample:	1	18	57	2	78
	Estimated % of Escapement:	0.5	9.3	29.5	1.0	40.4
	Estimated Escapement:	19	334	1,059	37	1,449
	Standard Error:	18.1	73.2	114.8	25.5	
Total:	Number in Sample:	3	38	144	8	193
	Estimated % of Escapement:	1.6	19.7	74.6	4.1	100.0
	Estimated Escapement:	56	706	2,675	149	3,585
	Standard Error:	31.1	100.1	109.5	50.2	

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		Year Class and Age Group				
		2005	2004	2003	2002	
		0.2	0.3	0.4	0.5	Total
Stratum 5:	07/27 - 08/02					
Sampling Dates:	07/27 - 07/28					
Male:	Number in Sample:	0	25	103	1	129
	Estimated % of Escapement:	0.0	12.6	52.0	0.5	65.2
	Estimated Escapement:	0	549	2,262	22	2,833
	Standard Error:	0.0	100.5	151.2	21.5	
Female:	Number in Sample:	1	10	55	3	69
	Estimated % of Escapement:	0.5	5.1	27.8	1.5	34.8
	Estimated Escapement:	22	220	1,208	66	1,516
	Standard Error:	21.5	66.3	135.6	37.0	
Total:	Number in Sample:	1	35	158	4	198
	Estimated % of Escapement:	0.5	17.7	79.8	2.0	100.0
	Estimated Escapement:	22	769	3,470	88	4,349
	Standard Error:	21.5	115.5	121.5	42.6	
Strata 6 - 11:	08/3 - 09/10					
Sampling Dates:	08/03, 08/10 - 08/11					
Male:	Number in Sample:	3	49	67	2	121
	Estimated % of Escapement:	1.2	20.1	27.5	0.8	49.6
	Estimated Escapement:	31	511	699	21	1,263
	Standard Error:	17.1	62.2	69.3	14.0	
Female:	Number in Sample:	3	48	72	0	123
	Estimated % of Escapement:	1.2	19.7	29.5	0.0	50.4
	Estimated Escapement:	31	501	752	0	1,284
	Standard Error:	17.1	61.8	70.9	0.0	
Total:	Number in Sample:	6	97	139	2	244
	Estimated % of Escapement:	2.5	39.8	57.0	0.8	100.0
	Estimated Escapement:	63	1,013	1,451	21	2,547
	Standard Error:	24.1	76.0	76.9	14.0	
Strata 1 - 11:	06/29 - 9/10					
Sampling Dates:	07/06 - 08/11					
Male:	Number in Sample:	5	121	426	9	561
	% Males in Age Group:	0.6	18.8	79.2	1.4	100.0
	Estimated % of Escapement:	0.3	10.9	45.9	0.8	57.9
	Estimated Escapement:	68	2,136	8,984	154	11,568
	Standard Error:	30.7	190.3	316.8	50.6	
	Estimated Design Effects:	0.726	1.008	1.099	0.870	1.096
Female:	Number in Sample:	6	101	304	11	422
	% Females in Age Group:	1.2	20.9	74.8	3.2	100.0
	Estimated % of Escapement:	0.5	8.8	31.5	1.3	42.1
	Estimated Escapement:	97	1,768	6,323	273	8,462
	Standard Error:	41.2	177.6	307.4	81.3	
	Estimated Design Effects:	0.911	1.007	1.119	1.253	1.096
Total:	Number in Sample:	11	222	730	20	983
	Estimated % of Escapement:	0.8	19.6	77.4	2.1	100.0
	Estimated Escapement:	166	3,934	15,503	427	20,030
	Standard Error:	51.3	249.4	263.2	95.5	
	Estimated Design Effects:	0.833	1.012	1.016	1.118	

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

		Year Class and Age Group			
		2005	2004	2003	2002
		0.2	0.3	0.4	0.5
Strata 1 - 2:	06/29 - 07/12				
Sampling Dates:	07/06 - 07/09				
Male:	Mean Length		630	620	
	Std. Error		11	5	
	Range		560 - 700	520 - 690	
	Sample Size	0	11	71	0
Female:	Mean Length		568	577	573
	Std. Error		8	5	19
	Range		520 - 630	450 - 660	550 - 630
	Sample Size	0	18	59	4
Stratum 3:	07/13 - 07/19				
Sampling Dates:	07/13 - 07/14				
Male:	Mean Length		598	610	
	Std. Error		7	3	
	Range		535 - 632	545 - 675	
	Sample Size	0	16	98	0
Female:	Mean Length	535	570	573	568
	Std. Error		7	3	8
	Range	-	542 - 595	524 - 625	560 - 575
	Sample Size	1	7	61	2
Stratum 4:	07/20 - 07/26				
Sampling Dates:	07/20, 07/22 - 07/25				
Male:	Mean Length	565	593	602	603
	Std. Error	40	6	3	10
	Range	525 - 605	540 - 630	530 - 665	575 - 635
	Sample Size	2	20	87	6
Female:	Mean Length	500	564	564	585
	Std. Error	.	10	4	30
	Range	-	455 - 635	505 - 625	555 - 615
	Sample Size	1	18	57	2
Stratum 5:	07/27 - 08/02				
Sampling Dates:	07/27 - 07/28				
Male:	Mean Length		585	599	635
	Std. Error		6	3	
	Range		535 - 645	505 - 685	-
	Sample Size	0	25	103	1
Female:	Mean Length	555	562	578	538
	Std. Error		11	4	22
	Range	-	515 - 605	525 - 620	495 - 565
	Sample Size	1	10	55	3

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		Year Class and Age Group			
		2005	2004	2003	2002
		0.2	0.3	0.4	0.5
Strata 6 - 11:	08/03 - 09/10				
Sampling Dates:	08/03, 08/10 - 08/11				
Male:	Mean Length	517	562	570	588
	Std. Error	15	5	4	13
	Range	490 - 540	495 - 670	455 - 650	575 - 600
	Sample Size	3	49	67	2
Female:	Mean Length	520	540	545	
	Std. Error	19	5	3	
	Range	490 - 555	480 - 615	490 - 610	
	Sample Size	3	48	72	0
Strata: 1 - 11:	06/29 - 09/10				
Sampling Dates:	07/06 - 08/11				
Male:	Mean Length	520	589	605	611
	Std. Error	14	3	2	10
	Range	490 - 605	495 - 700	455 - 690	575 - 635
	Sample Size	5	121	426	9
Female:	Mean Length	534	557	571	562
	Std. Error	19	4	2	11
	Range	490 - 555	455 - 635	450 - 660	495 - 630
	Sample Size	6	101	304	11

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

		Year Class and Age Group						
		2004	2003		2002		2001	
		1.2	1.3	2.2	1.4	2.3	1.5	Total
Strata 1- 3:	06/29 - 07/19							
Sampling Dates:	07/05 - 07/09, 0713 - 07-15, 07/17, 07/19							
Male:	Number in Sample:	39	74	0	27	1	4	145
	Estimated % of Escapement:	18.7	35.4	0.0	12.9	0.5	1.9	69.4
	Estimated Escapement:	615	1,167	0	426	16	63	2,287
	Standard Error:	86.2	105.8	0.0	74.2	15.3	30.3	
Female	Number in Sample:	0	14	0	47	0	3	64
	Estimated % of Escapement:	0.0	6.7	0.0	22.5	0.0	1.4	30.6
	Estimated Escapement:	0	221	0	741	0	47	1,010
	Standard Error:	0.0	55.3	0.0	92.4	0.0	26.3	
Total:	Number in Sample:	39	88	0	74	1	7	209
	Estimated % of Escapement:	18.7	42.1	0.0	35.4	0.5	3.3	100.0
	Estimated Escapement:	615	1,388	0	1,167	16	110	3,297
	Standard Error:	86.2	109.2	0.0	105.8	15.3	39.8	
Stratum 4:	07/20 - 07/26							
Sampling Dates:	07/21 - 07/26							
Male:	Number in Sample:	11	45	0	12	0	0	68
	Estimated % of Escapement:	7.9	32.1	0.0	8.6	0.0	0.0	48.6
	Estimated Escapement:	57	235	0	63	0	0	355
	Standard Error:	15.0	26.0	0.0	15.6	0.0	0.0	
Female	Number in Sample:	1	15	0	52	0	4	72
	Estimated % of Escapement:	0.7	10.7	0.0	37.1	0.0	2.9	51.4
	Estimated Escapement:	5	78	0	272	0	21	376
	Standard Error:	4.7	17.2	0.0	26.9	0.0	9.3	
Total:	Number in Sample:	12	60	0	64	0	4	140
	Estimated % of Escapement:	8.6	42.9	0.0	45.7	0.0	2.9	100.0
	Estimated Escapement:	63	313	0	334	0	21	731
	Standard Error:	15.6	27.6	0.0	27.8	0.0	9.3	

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		Year Class and Age Group						
		2004	2003		2002		2001	
		1.2	1.3	2.2	1.4	2.3	1.5	Total
Strata 5 - 10:	07/27 - 09/06							
Sampling Dates:	07/27, 07/29 - 07/31, 08/02, 08/05, 08/07, 08/08							
Male:	Number in Sample:	20	58	1	16	1	3	99
	Estimated % of Escapement:	9.2	26.6	0.5	7.3	0.5	1.4	45.4
	Estimated Escapement:	114	332	6	92	6	17	566
	Standard Error:	22.2	34.0	5.2	20.1	5.2	9.0	
Female	Number in Sample:	0	37	0	77	0	5	119
	Estimated % of Escapement:	0.0	17.0	0.0	35.3	0.0	2.3	54.6
	Estimated Escapement:	0	212	0	440	0	29	681
	Standard Error:	0.0	28.9	0.0	36.8	0.0	11.5	
Total:	Number in Sample:	20	95	1	93	1	8	218
	Estimated % of Escapement:	9.2	43.6	0.5	42.7	0.5	3.7	100.0
	Estimated Escapement:	114	543	6	532	6	46	1,247
	Standard Error:	22.2	38.1	5.2	38.0	5.2	14.5	
Strata 1 - 10:	06/29 - 09/06							
Sampling Dates:	07/05 - 08/08							
Male:	Number in Sample:	70	177	1	55	2	7	312
	% Males in Age Group:	24.4	54.0	0.2	18.1	0.7	2.5	100.0
	Estimated % of Escapement:	14.8	32.9	0.1	10.9	0.4	1.5	60.5
	Estimated Escapement:	749	1,734	6	580	21	80	3,209
	Standard Error:	90.3	114.1	5.2	78.4	16.1	31.6	
	Estimated Design Effects:	1.411	1.308	0.614	1.386	1.411	1.464	1.181
Female:	Number in Sample:	0	66	0	176	0	12	254
	% Females in Age Group:	0.0	24.7	0.0	70.3	0.0	4.7	100.0
	Estimated % of Escapement:	0.0	9.7	0.0	27.6	0.0	1.8	39.2
	Estimated Escapement:	0	511	0	1,453	0	97	2,066
	Standard Error:	0.0	64.7	0.0	103.0	0.0	30.2	
	Estimated Design Effects:	0.000	1.080	0.000	1.187	0.000	1.137	1.181
Total:	Number in Sample:	71	243	1	231	2	19	566
	Estimated % of Escapement:	14.8	42.6	0.1	38.7	0.4	3.4	100.0
	Estimated Escapement:	792	2,245	6	2,034	21	177	5,275
	Standard Error:	90.4	118.9	5.2	115.8	16.1	43.4	
	Estimated Design Effects:	1.407	1.285	0.614	1.259	1.411	1.286	

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

		Year Class and Age Group					
		2004	2003		2002		2001
		1.2	1.3	2.2	1.4	2.3	1.5
Strata 1 - 3:	06/29 - 07/19						
Sampling Dates:	07/05 - 07/09, 0713 - 07/15, 07/17, 07/19						
Male:	Mean Length	551	686		853	640	808
	Std. Error	10	7		16		62
	Range	350 - 660	495 - 850		680 - 955	-	700 - 955
	Sample Size	39	74	0	27	1	4
Female:	Mean Length		788		886		825
	Std. Error		12		8		72
	Range		695- 855		755-1000		700- 950
	Sample Size	0	14	0	47	0	3
Stratum 4:	07/20 - 07/26						
Sampling Dates:	07/20, 07/22 - 07/26						
Male:	Mean Length	573	710		863		
	Std. Error	21	9		23		
	Range	480 - 760	575 - 805		720 -1000		
	Sample Size	11	45	0	12	0	0
Female:	Mean Length		830		869		856
	Std. Error	.	14		9		43
	Range		710 - 965		690 -1000		775 - 930
	Sample Size	0	15	0	52	0	4

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		Brood Year and Age Group					
		2004	2003	2003	2002	2002	2001
		1.2	1.3	2.2	1.4	2.3	1.5
Strata 5 - 10:	07/27 - 09/06						
Sampling Dates:	07/27, 07/29 - 07/31, 08/02, 08/05, 08/07, 08/08						
Male:	Mean Length	542	722	445	761	755	797
	Std. Error	13	8		16		66
	Range	435 - 645	615 - 875	-	670 - 895	-	695 - 920
	Sample Size	20	58	1	16	1	3
Female:	Mean Length		789		854		863
	Std. Error		6		6		23
	Range		705 - 885		690 - 995		775 - 900
	Sample Size	0	37	0	77	0	5
Strata 1 - 10:	06/29 - 09/06						
Sampling Dates:	07/06 - 08/08						
Male:	Mean Length	550	695	445	837	653	805
	Std. Error	8	6		13		50
	Range	350 - 760	495 - 875	-	670 -1000	640 - 755	695 - 955
	Sample Size	70	177	1	55	2	7
Female:	Mean Length		790		873		841
	Std. Error		6		5		42
	Range		695 - 965		690 -1000		700 - 950
	Sample Size	0	66	0	176	0	12

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

		Year Class and Age Group				
		2004		2003	2002	
		0.3	1.2	1.3	2.3	Total
Strata 1 - 10:	06/29 - 09/06					
Sampling Dates:	07/06 - 08/16					
Male:	Number in Sample:	0	4	23	0	27
	% Males in Age Group:	0	14.8	85.2	0	100
	Estimated % of Escapement:	0	5.1	29.5	0	34.6
	Estimated Escapement:	0	125.7	722.7	0	848
	Standard Error:	0	60.6	125.3	0	
	Estimated Design Effects:	0.00	1.00	1.00	0.00	1.00
Female:	Number in Sample:	1	12	37	1	51
	% Females in Age Group:	2.0	23.5	72.5	2.0	100
	Estimated % of Escapement:	1.3	15.4	47.4	1.3	65.4
	Estimated Escapement:	31	377	1163	31	1603
	Standard Error:	30.9	99.2	137.2	30.9	
	Estimated Design Effects:	1.00	1.00	1.00	1.00	1.00
Total:	Number in Sample:	1	16	60	1	78
	Estimated % of Escapement:	1.3	20.5	76.9	1.3	100
	Estimated Escapement:	31	503	1885	31	2451
	Standard Error:	30.9	111.0	115.8	30.9	
	Estimated Design Effects:	1.00	1.00	1.00	1.00	

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

		Year Class and Age Group			
		2004		2003	2002
		1.2	0.3	1.3	2.3
Strata 1 - 10:	06/29 - 09/06				
Sampling Dates:	07/06 - 08/16				
Male:	Mean Length	529		585	
	Std. Error	7		7	
	Range	520 - 550		480 - 630	
	Sample Size	4	0	23	0
Female:	Mean Length	518	515	533	530
	Std. Error	6		4	
	Range	480 - 550	-	490 - 600	-
	Sample Size	12	1	37	1

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

		Brood Year and Age Group			
		2005	2004	2003	
		1.1	2.1	3.1	Total
Strata 3 - 6:	07/13 - 08/09				
Sampling Dates:	07/30 - 08/01, 08/03, 08/06, 08/08 - 08/09				
Male:	Number in Sample:	3	83	6	92
	Estimated % of Escapement:	1.6	43.7	3.2	48.4
	Estimated Escapement:	49	1,346	97	1,492
	Standard Error:	27.1	107.7	38.0	
Female:	Number in Sample:	6	88	4	98
	Estimated % of Escapement:	3.2	46.3	2.1	51.6
	Estimated Escapement:	97	1,427	65	1,589
	Standard Error:	38.0	108.2	31.2	
Total:	Number in Sample:	9	171	10	190
	Estimated % of Escapement:	4.7	90.0	5.3	100.0
	Estimated Escapement:	146	2,773	162	3,081
	Standard Error:	46.1	65.1	48.5	
Stratum 7:	08/10 - 08/16				
Sampling Dates:	08/10 - 08/11				
Male:	Number in Sample:	7	75	2	84
	Estimated % of Escapement:	4.0	43.1	1.1	48.3
	Estimated Escapement:	249	2,666	71	2,986
	Standard Error:	91.1	229.6	49.4	
Female:	Number in Sample:	3	84	3	90
	Estimated % of Escapement:	1.7	48.3	1.7	51.7
	Estimated Escapement:	107	2,986	107	3,199
	Standard Error:	60.3	231.6	60.3	
Total:	Number in Sample:	10	159	5	174
	Estimated % of Escapement:	5.7	91.4	2.9	100.0
	Estimated Escapement:	355	5,652	178	6,185
	Standard Error:	107.9	130.1	77.4	
Stratum 8:	08/17 - 08/23				
Sampling Dates:	08/20 - 08/21				
Male:	Number in Sample:	5	64	1	70
	Estimated % of Escapement:	3.3	41.8	0.7	45.8
	Estimated Escapement:	453	5,800	91	6,344
	Standard Error:	198.9	551.7	90.1	
Female:	Number in Sample:	5	71	7	83
	Estimated % of Escapement:	3.3	46.4	4.6	54.2
	Estimated Escapement:	453	6,435	634	7,522
	Standard Error:	198.9	557.8	233.7	
Total:	Number in Sample:	10	135	8	153
	Estimated % of Escapement:	6.5	88.2	5.2	100.0
	Estimated Escapement:	906	12,235	725	13,866
	Standard Error:	276.4	360.4	249.0	

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		Brood Year and Age Group			
		2005	2004	2003	
		1.1	2.1	3.1	Total
Stratum 9:	08/23 - 08/30				
Sampling Dates:	08/24				
Male:	Number in Sample:	6	61	7	74
	Estimated % of Escapement:	3.7	37.4	4.3	45.4
	Estimated Escapement:	337	3,424	393	4,154
	Standard Error:	134.1	344.7	144.4	
Female:	Number in Sample:	4	79	6	89
	Estimated % of Escapement:	2.5	48.5	3.7	54.6
	Estimated Escapement:	225	4,434	337	4,995
	Standard Error:	110.2	356.0	134.1	
Total:	Number in Sample:	10	140	13	163
	Estimated % of Escapement:	6.1	85.9	8.0	100.0
	Estimated Escapement:	561	7,858	730	9,149
	Standard Error:	171.0	248.0	193.0	
Stratum 10 - 11:	08/31 - 09/10				
Sampling Dates:	09/03 - 09/06				
Male:	Number in Sample:	3	47	4	54
	Estimated % of Escapement:	2.0	31.8	2.7	36.5
	Estimated Escapement:	320	5,007	426	5,753
	Standard Error:	182.4	602.6	209.9	
Female:	Number in Sample:	5	85	4	94
	Estimated % of Escapement:	3.4	57.4	2.7	63.5
	Estimated Escapement:	533	9,056	426	10,015
	Standard Error:	233.9	640.0	209.9	
Total:	Number in Sample:	8	132	8	148
	Estimated % of Escapement:	5.4	89.2	5.4	100.0
	Estimated Escapement:	852	14,063	852	15,768
	Standard Error:	292.7	401.9	292.7	
Strata 1 - 11:	06/29 - 09/10				
Sampling Dates:	07/30 - 09/06				
Male:	Number in Sample:	24	330	20	374
	% Males in Age Group:	6.8	88.0	5.2	100.0
	Estimated % of Escapement:	2.9	38.0	2.2	43.1
	Estimated Escapement:	1,407	18,243	1,078	20,728
	Standard Error:	316.0	922.3	277.4	
	Estimated Design Effects:	1.275	1.311	1.273	1.317
Female:	Number in Sample:	23	407	24	454
	% Females in Age Group:	5.2	89.1	5.7	100.0
	Estimated % of Escapement:	2.9	50.7	3.3	56.9
	Estimated Escapement:	1,414	24,338	1,569	27,321
	Standard Error:	333.9	955.4	348.3	
	Estimated Design Effects:	1.415	1.325	1.393	1.317
Total:	Number in Sample:	47	737	44	828
	Estimated % of Escapement:	5.9	88.6	5.5	100.0
	Estimated Escapement:	2,821	42,581	2,647	48,049
	Standard Error:	452.9	611.6	439.6	
	Estimated Design Effects:	1.346	1.346	1.347	

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

		Year Class and Age Group		
		2005	2004	2003
		1.1	2.1	3.1
Strata 3 - 6:	07/13 - 08/09			
Sampling Dates:	07/30 - 08/01, 08/03, 08/06, 08/08 - 08/09			
Male:	Mean Length	507	557	543
	Std. Error	33	4	14
	Range	445 - 560	455 - 635	500 - 575
	Sample Size	3	83	6
Female:	Mean Length	544	549	535
	Std. Error	10	3	14
	Range	525 - 590	490 - 615	510 - 570
	Sample Size	6	88	4
Stratum 7:	08/10 - 08/16			
Sampling Dates:	08/10 - 08/11			
Male:	Mean Length	525	558	543
	Std. Error	14	4	3
	Range	480 - 575	455 - 625	540 - 545
	Sample Size	7	75	2
Female:	Mean Length	517	551	558
	Std. Error	13	3	16
	Range	495 - 540	455 - 600	530 - 585
	Sample Size	3	84	3
Stratum 8:	08/17 - 08/23			
Sampling Dates:	08/20 - 08/21			
Male:	Mean Length	530	560	565
	Std. Error	19	4	
	Range	485 - 585	475 - 645	-
	Sample Size	5	64	1
Female:	Mean Length	546	562	564
	Std. Error	16	4	10
	Range	505 - 590	475 - 665	535 - 600
	Sample Size	5	71	7
Stratum 9:	08/24 - 08/30			
Sampling Date:	08/24			
Male:	Mean Length	549	569	574
	Std. Error	6	5	10
	Range	530 - 565	460 - 660	540 - 625
	Sample Size	6	61	7
Female:	Mean Length	530	563	554
	Std. Error	6	3	12
	Range	515 - 540	480 - 615	530 - 600
	Sample Size	4	79	6

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		Brood Year and Age Group		
		2004	2003	2002
		1.1	2.1	3.1
Strata 10 - 11:	08/31 - 09/10			
Sampling Dates:	09/03 - 09/06			
Male:	Mean Length	525	578	586
	Std. Error	55	5	3
	Range	444 - 630	485 - 680	580 - 595
	Sample Size	3	47	4
Female:	Mean Length	548	565	593
	Std. Error	19	3	13
	Range	485 - 590	480 - 620	565 - 615
	Sample Size	5	85	4
Strata 1 - 11:	06/29 - 09/10			
Sampling Dates:	07/30 - 09/06			
Male:	Mean Length	532	566	573
	Std. Error	14	2	5
	Range	444 - 630	455 - 680	500 - 625
	Sample Size	24	330	20
Female:	Mean Length	542	561	568
	Std. Error	9	2	6
	Range	485 - 590	455 - 665	510 - 615
	Sample Size	23	407	24

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, 2006–2008 (Harper 1998; Harper and Watry 20001; Roettiger et al. 2002, 2003, 2004, 2005; Miller et al. 2007, 2008).

	Chum		Chinook		Sockeye		Pink		Coho	
Year	Date	Percent Female	Date	Percent Female	Date	Percent Female	Date	Percent Female	Date	Percent Female
1992	07/18[1]	54	07/09[1]	25	07/05	60	08/13	-	08/26	43
2000	07/16[1]	50	07/13[1]	21	07/01[1]	49	08/04	-	08/21[1]	45
2001	-	-	-	-	-	-	-	-	08/25	51
2002	07/17[1]	47	07/10[1]	22	07/11[1]	60	07/25	-	08/28	45
2003	07/22	44	07/11	19	07/07	55	08/01	-	08/29	51
2004	07/14[1]	43	07/08[1]	17	07/01[1]	48	08/06	-	08/29	43
2006	07/15	41	07/12	40	07/10	43	07/22	-	08/19[1]	37
2007	07/21	45	07/13	26	07/09	49	07/26	-	08/21	38
2008	07/22[1]	42	07/17[1]	39	07/09[1]	65	08/04		08/24	57

[1]**Median cumulative passage dates were calculated using estimates for days missed.**