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

Alaska Fisheries Data Series Number 2012–2

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 Tuluksak Native Community, monitored the escapement of the five species of Pacific salmon *Oncorhynchus* spp. returning to the Tuluksak River, a tributary to the lower Kuskokwim River. From June 24 to September 10, 2011, a resistance board weir was utilized to collect abundance, run timing, age, sex, and length data from returning adult salmon. In conjunction with the weir, an underwater video system was affixed and utilized to collect abundance from July 11 to September 10, 2011. 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. Estimated escapements of 10,011 chum salmon *O. keta*, 288 Chinook salmon *O. tshawytscha*, 130 sockeye salmon *O. nerka*, and partial counts of 85 pink salmon *O. gorbuscha* and 92 coho salmon *O. kisutch* passed through the Tuluksak River weir during 2011. Peak weekly passage occurred July 17–23 for chum, Chinook, and sockeye salmon, and July 31 to August 6 for pink salmon. Age, sex, and length data were collected for chum, Chinook, and sockeye salmon. Dominant ages were 0.3 (49%) and 0.4 (49%) for chum, 1.3 for male and 1.4 for female Chinook, and 1.3 for sockeye salmon. Overall percentages for female salmon were chum 34%, Chinook 26%, and sockeye salmon 56%. Mean lengths varied between male and female salmon for each species sampled. The estimated Chinook salmon escapement during 2011 was the second lowest on record and below the escapement goal range of 1,000−2,100 for the fifth successive year. Special management actions were taken for Chinook salmon during 2011 directly related to low return concerns in the Kuskokwim River drainage.

Introduction

The Tuluksak River is located approximately 222 river kilometers (rkm) upstream from the mouth of the Kuskokwim River in western Alaska (Whitmore et al. 2005). It flows through the Yukon Delta National Wildlife Refuge (Refuge) and supports spawning populations of chum salmon *Oncorhynchus keta*, Chinook salmon *O. tshawytscha*, sockeye salmon *O. nerka*, pink salmon *O. gorbuscha*, and coho salmon *O. kisutch*. These salmon contribute to large subsistence and commercial fisheries in the lower Kuskokwim River drainage. In addition to human consumption, salmon provide food for brown bears and other carnivores, raptors and scavengers. These salmon also sustain resident fish species and salmon fry that rely heavily on the nutrient base provided by salmon eggs and/or carcasses (U.S. Fish and Wildlife Service 1992).

Under guidelines established in the Sustainable Salmon Fisheries Policy 5AAC.39.222, the Alaska Board of Fisheries designated Kuskokwim River chum and Chinook salmon as stocks of yield concern in September 2000 based upon the inability, despite specific management measures, to maintain expected yields or to have a stable surplus above the stock's escapement needs. Beginning in January 2001, the salmon fishery in the Kuskokwim River drainage was

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managed under the Kuskokwim River Salmon Rebuilding Management Plan (Rebuilding Plan) (5AAC 07.365; Ward et al. 2003; Bergstrom and Whitmore 2004). The designation as stocks of concern was discontinued in 2007 after chum and Chinook salmon escapements returned to levels above the historical average (Linderman and Rearden 2007).

The Alaska Department of Fish and Game (Department), the U.S. Fish and Wildlife Service (Service), and the Kuskokwim River Salmon Management Working Group (Working Group) work together to achieve the goals of both the Rebuilding Plan (5AAC 07.365; Ward et al. 2003; Bergstrom and Whitmore 2004) and the Federal Subsistence Fishery Management program. In addition to the goals set by the Department, Service, and the Working Group; the Alaska National Interest Lands Conservation Act (ANILCA) established the Yukon Delta National Wildlife Refuge in Alaska for the general purposes to: "conserve fish and wildlife populations and habitats in their natural diversity" (ANILCA § 303 (7) (B) (i)). Despite the conservation measures taken under the Rebuilding Plan and by area managers, Chinook salmon returns to the Tuluksak River remain below the established escapement goal range.

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

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

In previous years, salmon escapements were monitored using aerial surveys as indices of relative abundance in the Tuluksak River (Tobin 1994). Aerial surveys started in 1965 and occurred sporadically until 2003 (Harper 1997; Ward et al. 2003; Whitmore et al. 2005). These surveys were used infrequently for in-season management of the Kuskokwim River fisheries because the surveys often occurred after the commercial and subsistence harvests.

A resistance board weir has been utilized to monitor salmon escapements on the Tuluksak River from 1991−1994 and from 2001−2011. After the 1994 season, the Tuluksak Native Community (TNC) opposed the weir and it was not operated from 1995−2000. Since 2001, TNC and the Service have jointly cooperated in staffing and operating the weir. The objectives of the project for 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 long-term sustainability of salmon stocks returning to the Tuluksak River.

Study Area

The Tuluksak River is one of several tributaries flowing into the lower Kuskokwim River and is located approximately 116 rkm east-northeast of Bethel, Alaska (Whitmore et al. 2005). The Tuluksak River is approximately 137 rkm in length and its watershed encompasses approximately 2,098 km^2 (Figure 1). It originates in the Kilbuck Mountains and flows to the northwest. The Fog River drains into the lower portion of the Tuluksak River and is the only major tributary. The Tuluksak River is a medium gradient river for the majority of its length and is characterized by dense overhanging vegetation and cut banks. The lower river is characterized by low gradient, silt substrate, and turbid water. The river section at the weir site, approximately 49 rkm from the mouth, is 42 m wide, shallowest in mid-river, and deepest near the banks. The substrate contains primarily sand mixed with fine gravel. Water clarity is moderately clear, but becomes turbid during rainy periods and when boat traffic is present. Dredging has taken place in approximately 40 kilometers of the upper Tuluksak River and Bear Creek drainages above the Refuge boundary.

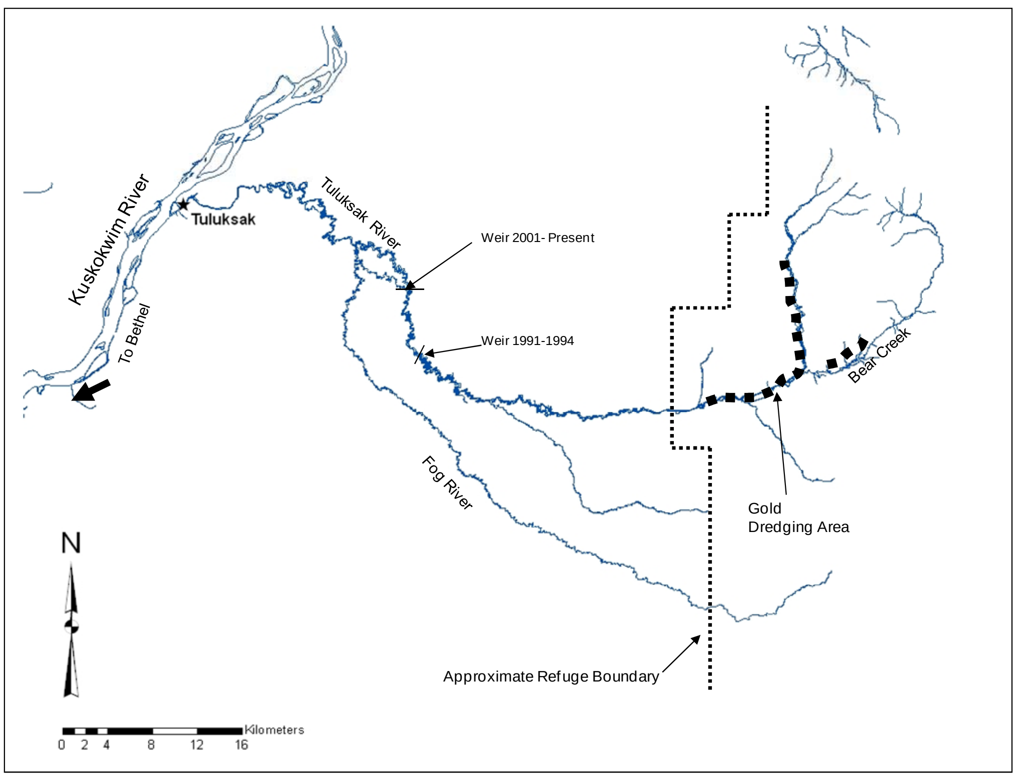

FIGURE 1.—Tuluksak River weir location, Yukon Delta National Wildlife Refuge, 1991–1994 and 2001–2011.

Dredge equipment operating in the floodplain of the Tuluksak River has altered the stream channel, and water in some areas flows through dredge tailings and/or tailing ponds (Figure 1). The mining activity and dredging, which began in 1908, continued through most of the 20th Century, and removed approximately 500,000 ounces of gold (Strachan 2005). Mining companies have continued to explore for gold in the drainage and have conducted an extensive drilling program to define the lode bearing ore bodies. They have also expressed an interest in reworking the old dredge tailings.

Methods

Weir and Video Operations

A resistance board weir (Tobin 1994) affixed with an underwater video system (Gates et al. 2010; Miller and Harper 2011a) was installed during 2011 in the Tuluksak River at rkm 49 (N 61°02.641', W160°35.049'). This location is approximately 16 rkm downstream from the weir site used by the Service from 1991−1994 (Harper 1995a, 1995b, 1995c, 1997). The lower site provides easier boat access during low water conditions and is downstream of known salmon spawning (Figure 1).

During 2011, two passage panels and live traps were installed and one was affixed with an underwater video camera. The video facilitated fish sampling during various river stage heights and allowed for salmon passage and enumeration 24 hours each day. The video system and weir were operated in unison during 2011. Visual counts started at approximately 0600 hours every day and continued until fading-daylight reduced visibility (~23:00 hours) while video counts were collected 24 hours a day, seven days each week. One four-day period was selected to evaluate day and night paired counts. To collect visual counts at night, lights were used to illuminate the trap area. An object was passed in front of the video camera periodically to confirm the video camera was operating correctly. Migrating and resident fish were identified to species and recorded.

A staff gauge was installed approximately ten meters downstream of the weir to measure daily water levels. Measurements represent the average water depth across the river channel at the upstream edge of the weir. Water temperatures were collected daily using a handheld thermometer from June 22 to September 12. Ambient temperature, water temperature, and fish passage counts were relayed daily by radio to the Department in Bethel or by cell phone to Service staff in Bethel. Hobo® recording thermometers were installed at the weir to collect yearly water and ambient temperature data for a separate study addressing climate change funded by the Office Subsistence Management, Fisheries Resource Monitoring Program (OSM-FRMP project 08-701).

Biological Data

Statistical weeks started on a Sunday and continued through the following Saturday (Harper 1997). Target sample sizes consisted of 170 chum salmon, 210 Chinook salmon, and 170 coho salmon each week. Sampling for sockeye salmon was opportunistic, with a target sample of 75 fish for the season. Biological sampling occurred between Sunday and Thursday of each statistical week in order to obtain a snapshot sample (Geiger et al. 1990). Once the weekly sample was met for a species, sampling would stop for that species. Sampling would not typically extend past Thursday of each week. Low daily numbers of Chinook salmon relative to other species required active sampling (closure of the fish trap upon Chinook salmon entry) throughout the season to meet the weekly sample quota (Linderman et al. 2002). Post-season analysis included the combination of weekly strata to ensure an adequate sample size was obtained.

During weeks with low fish numbers, the target sample size required sampling a high percentage of the weekly passage. In those situations, sampling was suspended for those species once approximately 20% of their weekly passage was sampled. This strategy reduced handling fish in the trap and holding fish downstream of the weir, and was sufficient to describe the weekly age, sex, and length compositions of the fish sampled.

Age, sex, and length data (ASL) were collected from each salmon sampled. Adult salmon were captured using the live trap attached to the passage chute. A fyke gate, installed on the entrance of the trap, allowed fish to enter and, at the same time, minimized the number of fish exiting the trap downstream. Sampling started when an appropriate number of fish were in the trap. To avoid potential bias caused by the selection or capture of individual fish, all target species within the trap were included in the sample. Four scales from Chinook, three from sockeye, and one from chum salmon were extracted for age analysis. Scales taken were from the preferred area using methods described by Koo (1962) and Mosher (1968). Sex was determined from external characteristics or visible sex products and length measured to the nearest 5 mm from the mid-eye to the fork of the caudal fin for chum, Chinook, and sockeye salmon. Sex was also determined from video footage for Chinook salmon not handled for ASL. Female Chinook salmon less than 700 mm in length have been rare in samples collected from the commercial fishery (D. Molyneaux, Alaska Department of Fish and Game, personal communication). Therefore, all Chinook salmon less than 700 mm were classified as males for this study. Once ASL data were collected, each fish was released through the video box and passed unharmed upstream of the live trap. Data were recorded and later transferred to Excel spreadsheets. The Department staff aged the scales and processed the forms in Anchorage under OSM-FRMP project10-303.

Salmon ages were reported according to the European Method (Koo 1962), where numerals preceding the decimal denote freshwater annuli and numerals following the decimal denote marine annuli. Total years of life at maturity is determined by adding one year to the sum of the two digits on either side of the decimal; i.e., age 1.4 and 2.3 are both six-year old fish from the same brood year (1.4 = 1 + 4 + 1 = 6, and 2.3 = 2 +3 + 1 = 6). The brood year is determined by subtracting fish age from the current year.

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

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

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

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

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

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

with estimated variance

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

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

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

with estimated variance

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

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

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

with estimated variance

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

If the length of the 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).

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

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

Results

Weir and Video Operations

The crew traveled to the weir site by boat on June 21. Installation of the weir was completed on June 24 and the underwater video system on July 10. The weir was operational from June 24 to September 10 and the video system was operable from July 11 to September 10, 2011. Visual methods were used June 24 to July 22 and video methods used from July 11 to September 10 to enumerate and speciate fish. Visual counts were from 08:00 to 23:59 hours and video from 00:00 to 24:00 hours.

Between July 19 and July 22, twenty hours of paired video footage and visual counts were compared. Members of the crew randomly went out during daylight hours (08:00−19:00) and scheduled hours at night (00:00−06:00) for visual counts to compare with video footage taken twenty-four hours each day. Visual counts were taken from on top of the trap and video counts were gathered by reviewing video files from the same timeframes. During these paired counts, 506 fish were counted visually and 511 from electronic video files, a difference of five fish (Table 1). Most fish counted using both methods were chum salmon (visual $N = 454$ and video $N = 458$). The video file was used to verify species. Visual counts of other salmon species included Chinook ($N = 45$) and sockeye ($N = 7$). One fish was incorrectly identified from visual counts on top of the trap as a Chinook, and later correctly identified as a coho salmon from video footage. Four chum salmon and one pink salmon were missed during visual counts when compared to video totals.

TABLE 1.—Comparison of visual and underwater video counts of salmon for $N = 20$ hours of dual counts at the Tuluksak River weir, 2011.

	Count Method		
Salmon Species	Visual	Video	Difference
Chum	454	458	4
Chinook	45	44	1
Sockeye	7	7	0
Pink	0	1	1
Coho	0	1	1
Total	506	511	7

During 2011, comparison counts were done later in the evening under low light or artificial light. These factors as well as high water levels and turbidity may have contributed to the count and identification differences.

High water affected weir operations starting early August (Appendix 1) and ASL data were not collected from the trap for salmon after August 1. Starting August 8 and continuing through takeout in early September, water exceeded operational levels (stage height >140 cm), submerging the weir and flooding the campsite August 13−27 (stage height >160 cm) (Appendix 1). Coho salmon were noted passing over submerged panels during that time. Video files allowed for the identification and enumeration of migrating fish and sex identification of salmon, but the efficiency of the video system during that period is unknown. Escapements were estimated for those dates for chum, Chinook, and sockeye salmon. High waters receded enough by September 10 to allow for the removal of the weir. Minor repairs to damaged weir components were made on site during the field season.

Average water depth at the leading edge of the weir during 2011 was 120 cm. The recorded maximum water depth (271 cm) and the minimum water depth (53 cm) occurred on August 14 and July 6, respectively (Appendix 1). Water temperatures ranged from a low of 7.5°C on August 9 to a high of 12°C on July 1 (Appendix 1).

Biological Data

Chum Salmon —A total of 9,737 chum salmon was counted through the weir June 29 to September 10 (Figure 2; Appendix 2). An additional 274 chum salmon were estimated to have passed August 10 to September 10 for a total estimated escapement of 10,011 chum salmon. Peak weekly passage (N = 2,832) occurred July 17–23 (Figure 2). Median cumulative passage occurred on July 25 for adults passing upstream (Figure 3; 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 male (51%) and 0.3 for female (52%) chum salmon (Appendix 3). Ages 0.3 and 0.4 comprised 99% of the total chum salmon escapement. Males dominated the run and comprised at least 56% of the run in each stratum from June 29 to September 10. Females comprised 34% of the total escapement (Appendix 3). Mean length of males was larger for ages 0.3, 0.4, and 0.5 than that of female chum salmon of the same age (Appendix 4).

Chinook Salmon —A total of 282 Chinook salmon was counted through the weir July 1 to September 1 (Figure 2; Appendix 2). An additional six Chinook salmon were estimated to have passed August 10 to September 1 for a total estimated escapement of 288 Chinook salmon. Peak weekly passage (N = 147) occurred July 17–23 (Figure 2). Median cumulative passage occurred on July 19 for adults passing upstream (Appendix 2).

Three ages (1.2, 1.3, and 1.4) were identified from Chinook salmon scale samples. Ages 1.5, 2.2, and 2.3 were present in previous years but were not identified from scale samples collected during 2011. However, only 19 Chinook salmon scales were readable from the total ASL collection (N = 31). This small sample size may be inadequate to describe the 2011 Chinook salmon return. The predominant age was 1.3 for males (43%), and 1.4 (80%) for females (Appendix 5). Ages 1.3 and 1.4 accounted for 100% of the female Chinook salmon escapement.

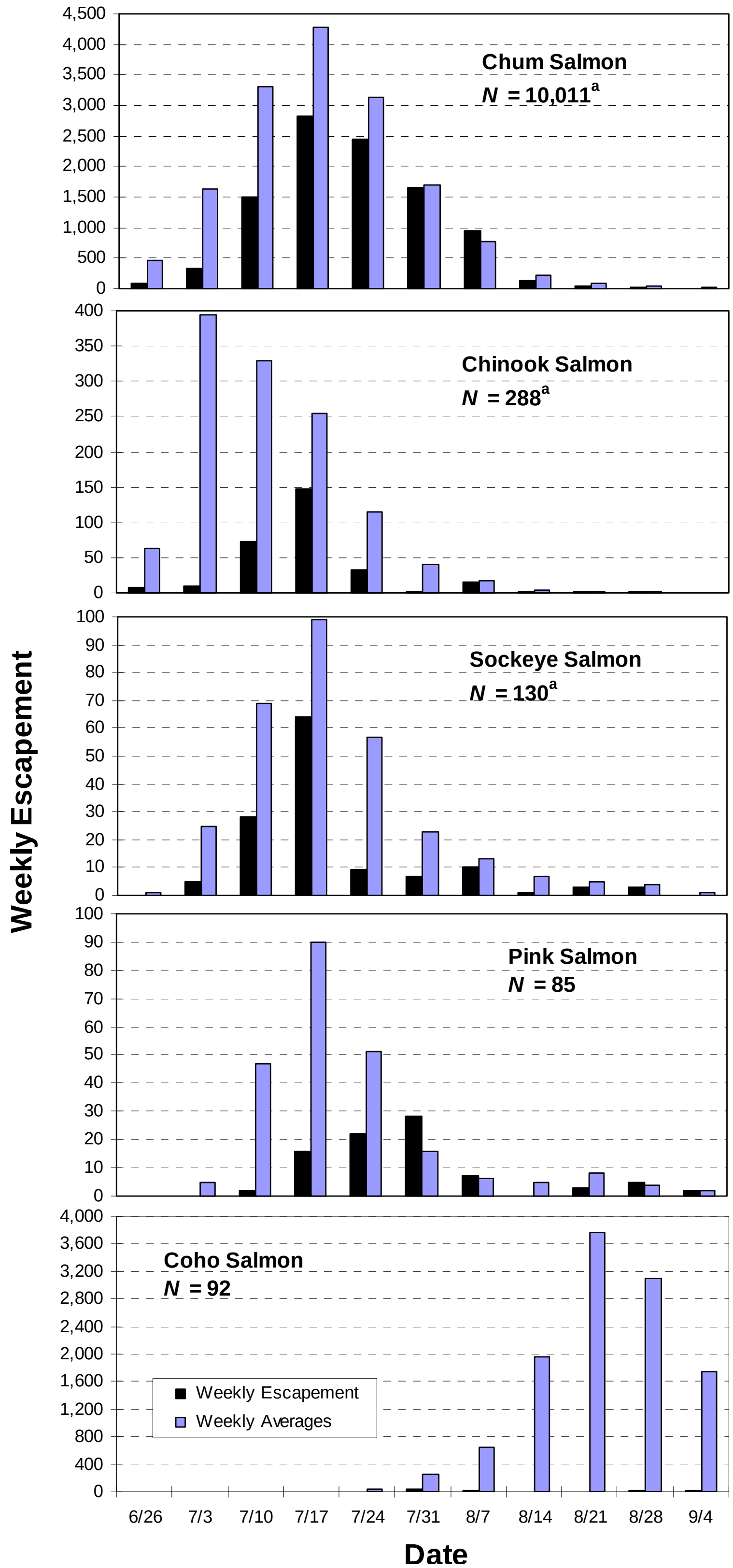

FIGURE 2.—Weekly escapements of chum, Chinook, sockeye, pink and coho salmon passing through the Tuluksak River weir, 2011. Weekly escapements were not estimated for coho salmon due to high water and incomplete counts. Average weekly totals for chum, Chinook, sockeye, and coho salmon are for years 1991−1994, 2001−2010 and for pink salmon odd years 2001−2009. Totals with a superscript ([a]) indicate estimates for chum, Chinook and sockeye salmon.

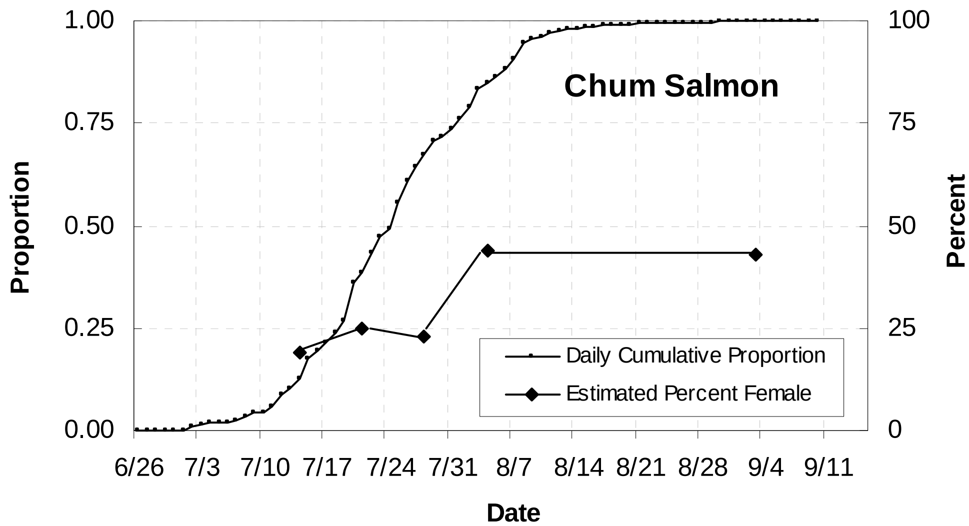

FIGURE 3.—Cumulative proportion and percent females from weekly samples of chum salmon passed through the Tuluksak River weir, 2011.

Based on ASL data ($N = 19$), females comprised 26% of that sample during 2011, and sex ratios favored males through the combined strata (Appendix 5). However, video footage collected from July 11 to September 10 confirmed that of 278 Chinook salmon counted, 50 were females (18%). Mean length of females was greater than males for ages 1.3 and 1.4 although sample sizes were small (Appendix 6).

Sockeye Salmon —A total of 124 sockeye salmon was counted through the weir July 3 to September 2 (Figure 2; Appendix 2). An additional six sockeye salmon were estimated to have passed August 10 to September 2 for a total estimated escapement of 130 sockeye salmon. Peak weekly passage for sockeye salmon ($N = 64$) occurred July 17–23 (Figure 2), and median cumulative passage occurred on July 20 for adults passing upstream (Appendices 2).

Six ages (0.2, 0.3, 1.2, 0.4, 1.3, and 2.2) were identified from sockeye salmon scale samples. No age-1.4, -2.3, -2.4 and -2.5 sockeye salmon were identified from scales during 2011. The predominant age was 1.3 for both males and females, which comprised 56% of the sample, and females comprised 56% of the total sockeye salmon sample in 2011 (Appendix 7). The mean length of males was greater than females for age-1.3 fish (Appendix 8). However, the sockeye salmon ASL collection was small ($N = 16$) and may not be representative of the actual escapement.

Pink Salmon —A total of 85 pink salmon was counted through the weir July 15 to September 5 (Figure 2; Appendix 2). Peak weekly passage of pink salmon ($N = 28$) occurred July 31 to August 6 (Figure 2). Median cumulative passage occurred on August 1 for adults passing upstream of the Tuluksak River weir (Appendix 2).

Coho Salmon —A total of 92 coho salmon was counted through the weir July 19 to September 9 (Figure 2, Appendix 2). Total escapement was not estimated for coho salmon during 2011 because high water limited our ability to count fish. Coho salmon counts continued during high water utilizing the underwater video system but our counts are considered incomplete. Once the weir became submerged on August 8, coho salmon were observed going over the boat passage and weir panels. The first coho salmon migrated through the weir on July 19 and the last fish was counted September 9 with video footage (Appendix 2). No age, sex, and length data were collected for coho salmon during 2011.

Other Species —Resident and other migrant species counted through the weir in 2011 consisted of one Dolly Varden *Salvelinus malma*, three northern pike *Esox lucius*, 13 Arctic grayling *Thymallus arcticus,* 10 humpback whitefish *Coregonus pidschian*, and 49 round whitefish *Prosopium cylindraceum*. Although smaller sized fish were able to pass freely through the pickets, escapement through the passage chute was recorded the entire season.

Discussion

Weir and Video Operations

The weir is typically installed the third week of June and operational through September 10 (Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a). During 2011, high water hampered operations in several ways from early August through early September. Sample collection and data associated with ASL became limited due to safety concerns. Removal of debris, continual picket repair, broken bolts on resistance boards and general maintenance became more problematic due to high water (Appendix 1). The addition of the video system proved effective in the enumeration of salmon, specifically the migration of chum, Chinook, and sockeye, which occurred during higher than normal water events prior to total submergence of the weir. Preliminary data suggest that visual counts were less than 1% lower on average than video counts across species (Table 1), and the use of video was effective in the speciation of salmon and whitefish. Since the wider picket spacing was incorporated in weir operations (2001) coregonids have been enumerated and classified as 'whitefish' and counts have ranged from 3−94 (Gates et al 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010). Since 2010, the addition of video has allowed us to identify and better enumerate whitefish as three distinct species (Miller and Harper 2011a).

Visual counts were not conducted after August 8 because the weir was partially or completely submerged because of high water (Appendix 1). Video counts continued through September 10 when the crew began to remove the weir and video equipment from the river. The video box, trap, passage chute and weir panels were removed from the river by September 12, camp was dismantled, and the crew returned to Bethel on September 13. The substrate rail and cable remained in place after September 13 to expedite the 2012 weir install.

Biological Data

Chum Salmon —The estimated 2011 chum salmon escapement (N = 10,011) was within the historic range of 7,675–35,696 fish (Figure 4). The 2011 estimated escapement was below a 14-year average of N = 15,322 (1991–1994 and 2001–2010) (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a). The 2011 escapement was 28% of the record 2005 chum salmon escapement of N = 35,696. The median passage date for chum salmon occurred on July 25. This passage date was the similar to 2009 and two days earlier than the latest recorded during 2003 (Figure 5, Appendix 9). The average cumulative passage since 2001 for chum salmon has been greater than 99% by August 15 (Gates and Harper 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a), which was similar to our 2011 estimate of 99% passage on August 18 (Appendix 2).

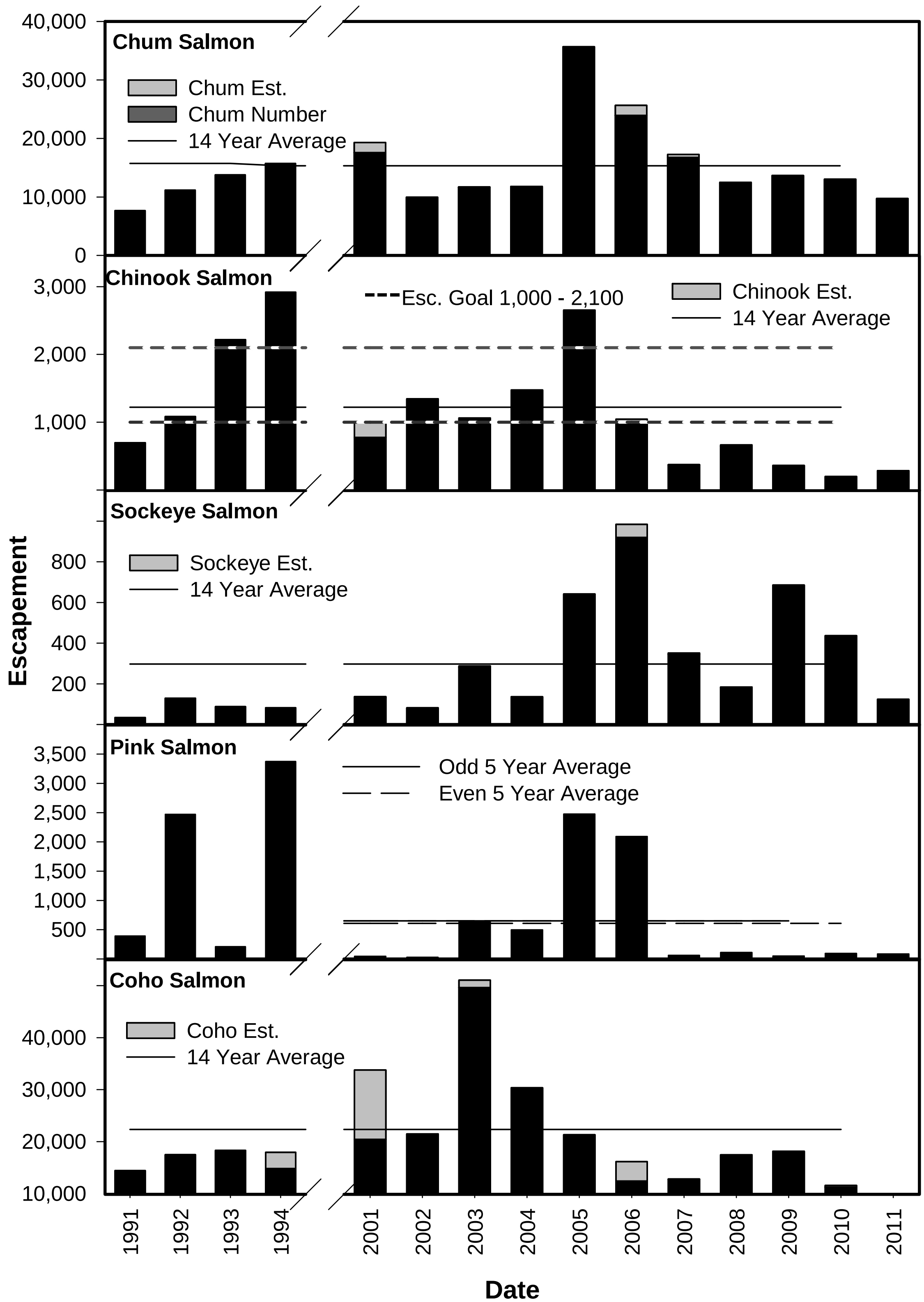

FIGURE 4.—Salmon escapement through the Tuluksak River weir; 1991–1994 and 2001–2011. Averages include estimates for days missed and do not include the current year. Pink salmon averages are for years after 2000 when wider picket spacing was used on weir panels. Total escapements for coho salmon were not estimated during 2010 (Miller and Harper 2011a) and 2011 due to the large percentage of days with incomplete counts.

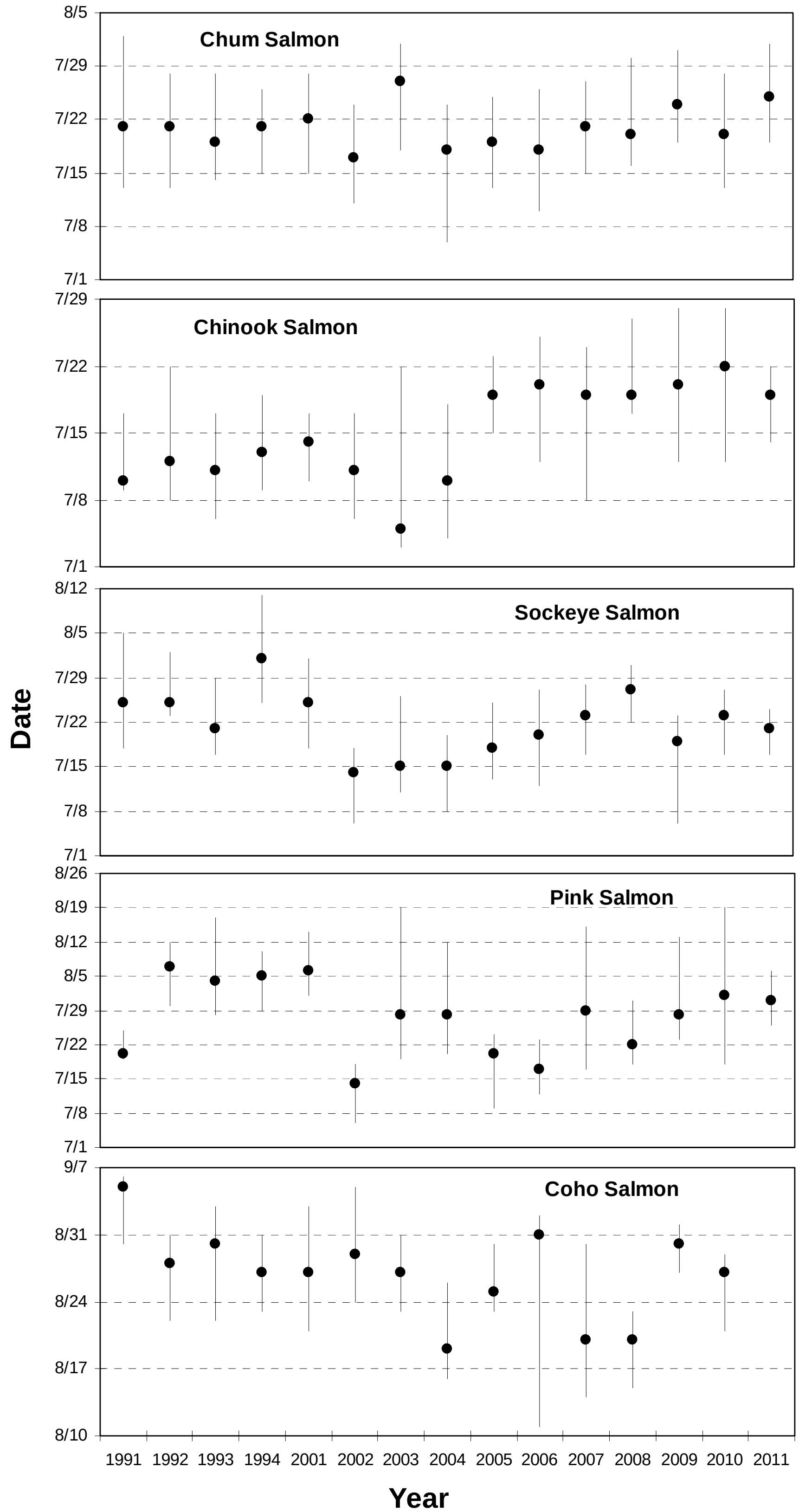

FIGURE 5.—Median cumulative passage for chum, Chinook, sockeye, and pink salmon at the Tuluksak River weir, 1991–1994 and 2001–2011. A median date was not estimated for coho salmon during 2011. The filled circles represent the median (50%) passage date and the vertical line below and above the circle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

Females comprised 34% of the total chum salmon escapement, which was similar to that observed during 2003 (Appendix 9), and males were predominant during each stratum of the run (Figure 3; Appendix 3). This is the third year male dominance has occurred in all strata. The dominance of males during the first part of the run has been predictable and females more dominant in later strata (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a). The dominant ages during 2011 for chum salmon were split between ages 0.3 and 0.4 (Appendix 3). Age-0.3 decreased from the 67% documented in 2010 to 49% during 2011 and age-0.4 chum salmon increased from the 12% in 2009 and 30% in 2010 to 50% during 2011 (Appendix 3) (Miller and Harper 2010, 2011a).

Chinook Salmon —The estimated Chinook salmon escapement for 2011 ($N = 288$) was the second lowest on record and well below a 14-year average of $N = 1{,}224$ (1991–1994 and 2001–2010; Figure 4). This was the fifth consecutive year the Sustainable Escapement Goal (SEG) range of 1,000–2,100 for the Tuluksak River was not met (Molyneaux and Brannian 2006; Estensen et al. 2009; Volk et al. 2009). This year's escapement was a 44% increase over 2010, which was the lowest on record (Figure 4). During 2011, Chinook salmon returns were also below the lower end of the established escapement goal range (6,000−11,000) for the fourth consecutive year on the Kwethluk River (Miller and Harper 2011b; S. Miller, U. S. Fish and Wildlife Service, unpublished data).

Median passage dates for Chinook salmon have fluctuated from July 5−22 during previous years. The median passage date for 2011 was July 19 and similar to median passage dates observed 2005, 2006, and 2008 (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a) (Figure 5, Appendix 9). Since 2005, the median passage date has become later by 5 to 15 days (Figure 5). Reasons for this shift are unknown, but possible factors may include climate and oceanographic changes, directed harvest pressures on different portions of the run, prevailing winds and river flows at the time of the return, and breached tailing pond altering habitats and river channel dynamics. The average cumulative passage since 2001 for Chinook salmon has been greater than 99% by August 15 (Gates and Harper 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a), which was also earlier than our 2011 estimate of 99% passage on August 24 (Appendix 2).

During 2011, female Chinook salmon comprised 26% of the ASL sample and we are hesitant to make inferences to the entire escapement because of our low sample size ($N = 19$). However, video footage collected between July 11 and September 10 confirmed that 50 of 278 Chinook salmon viewed on filed video tapes were considered females (18%), based on observations by two independent observers (S. Miller, U. S. Fish and Wildlife Service, unpublished data). Regardless of the method used to identify sexes, both were near the lower end of the sample range (14–48%) observed during previous years (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a). This is the second year since 2007 that females have comprised less than 41% of the Chinook salmon sample (Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a). Given the trend of low escapement for Chinook salmon and the low number of females ($N = 76$) estimated during 2011, it is unknown how the 2011 brood year will contribute to future returns of Chinook salmon to the Tuluksak River. The poor returns since 2007 indicate that the Chinook salmon population in the Tuluksak River is still depressed.

Chinook salmon management actions were taken by both State and Federal managers during 2011 (Table 2) based on a low projected return and inseason escapement data. It is currently unknown what effects these actions had on increasing the Tuluksak River escapement, or in the overall conservation of the Kuskokwim River Chinook salmon population during 2011.

TABLE 2.—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

Various factors may have influenced the age structure observed for Chinook salmon during 2011. The 2011 ASL Chinook salmon sample was small and may be inadequate in accurately describing the age structure of thereturn. Ages 1.2, 1.3, and 1.4 represented 21, 37, and 42% of the return, respectively (Appendix 5). The strong showing of age-1.4 fish, a four-fold increase over 2010, may be the result of the stronger 2005 brood year as well (Van Alen 1999; Miller and Harper 2010). Zabkar (2006) reported that 2005 had the strongest year to date return of age-1.4 Chinook salmon on record. Harvest methods may play a role in selecting against or for a specific size at age (Bromaghin 2005). Hillgruber and Zimmerman (2009) state that water temperature, prey availability and abundance, and predation during the early marine life stage of Chinook salmon smolt are factors associated with survival and subsequent returns. Petrosky and Schaller (2010) indicate river velocity during smolt migration as a factor associated with Chinook salmon smolt survival as well.

Sex identification for small Chinook salmon is often difficult to ascertain. Generally, female Chinook salmon returning to the Kuskokwim River are greater than 700 mm. The Department has explored this issue and sampled extensively in the commercial fishery in Bethel, where very few female Chinook salmon less than 700 mm were found (D. Molyneaux, Alaska Department of Fish and Game, personal communication). Small Chinook salmon (<700 mm) were also randomly sampled at the Tuluksak weir in previous years that had the outward appearance of females, but were identified as males after examination of their gonads. This classification was further supported during 2008 when carcasses from 262 Chinook salmon were examined as part of a genetics heritability study and only five (<2%) female Chinook salmon less than 700 mm were found in the total sample (J. Olsen, U. S. Fish and Wildlife Service, unpublished data). Using these length-to-sex data, Chinook salmon less than 700 mm have been classified as males unless sex products were clearly visible during sampling for this project.

Sockeye Salmon —The estimated escapement of 130 sockeye salmon during 2011 was the fifth lowest on record and well below a 14-year average (N = 305) (Figure 4). Escapements have ranged from a low during 1991 (N = 34) to a high during 2006 (N = 985). Median passage dates for sockeye salmon have fluctuated between July 14 and August 2, a difference of 19 days (Figure 5, Appendix 9). The median passage date in 2011 was July 20 and similar to 2006 (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a) (Appendix 9). The average cumulative passage since 2001 for sockeye salmon has been greater than 96% by August 15 (Gates and Harper 2002; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a), which was earlier than our 2011 estimate of 96% passage on August 22 (Appendix 2).

During 2011 and 2010 (Miller and Harper 2011a), age-1.2 fish comprised less than 6% of the return, which may suggest poor ocean conditions during the first year at sea. However, sample sizes in 2011 were small ($N = 16$) and may not be representative of the entire escapement. Age-2.3 fish comprised 17% of the sockeye salmon return during 2010 but no age-2.4 fish were present in the 2011 ASL collection. Reasons for these shifts are unknown but climate, water flows, and oceanographic changes may be factors. Groot and Margolis (1991) suggest marine mortality estimates can be as high as 95% for different stocks, age groups, and brood years of sockeye salmon. In addition, smolts of a larger size at migration can have a higher marine survival rate than smaller smolts (Groot and Margolis 1991). Kruse (1998) suggests that changes in ocean condition (Pacific Decadal Oscillations) have significant effects on the marine ecosystem.

Pink Salmon —The number of pink salmon observed passing through the trap during 2011 ($N = 85$) was higher than odd years 2001, 2007, and 2009 but low compared to odd years 2003 and 2005 (Figure 4). Counts of pink salmon were below the odd 5-year ($N = 654$) and even 5-year ($N = 564$) averages (Figure 4). Pink salmon return to spawning grounds in predictable and segregated even and odd-numbered years (Scott and Crossman 1973). The median cumulative passage date, based on fish counted, was July 31 and similar to odd years 2007 and 2009 (Figure 5). Age, sex, and length data were not collected for pink salmon.

Coho Salmon —The 2011 count ($N = 92$) was incomplete and ASL data were not collected for coho salmon during 2011. High water events beginning in early August and continuing through September completely submerged the weir at times and less than 6% of the cumulative proportion of coho salmon passes the weir by August 7. The historical coho salmon escapement has varied in number, timing, and percent females since 1991 (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a).

Recommendations

The Tuluksak River weir continues to be an important project to monitor Kuskokwim River salmon stocks that originate on the Refuge. This weir and other escapement projects spread throughout the Kuskokwim River drainage provide important information used by Service and Department fishery managers. Annual operation of the weir should continue well into the future to gather a long-term data set to monitor trends and population health, and weir operations should continue into September to monitor coho salmon escapements. Installation by late June has proven successful over time and we have been able to operate a weir during the entire season for ten of the past 11 years (2001–2011). We believe that the river channel is stable at the present site and do not anticipate moving the weir to another site in the near future. It is suggested that the electrical system consisting of inverters, charge controller, and battery banks be reconfigured to increase efficiency, address safety concerns, and easier for crews to setup and dismantle each year. All employees should be properly trained in electrical safety precautions. A laser measurement system incorporated with the video system should be considered. Newer methodologies may also be developed to aid in the enumeration of migrating fish during high water events. Collaboration with the Refuge and the Tuluksak Native Community (TNC) should also continue into the future addressing direct and indirect effects of land management activities on this system.

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References

ANILCA (Alaska National Interest Lands Conservation Act). 1980. 94 STAT. Public Law 96-487 96th Congress, Section 303 (7) (B) (*i*).

Bergstrom, D. J., and C. Whitmore. 2004. Kuskokwim River Chinook and chum salmon stock status and action plan, a report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report 3A04-02, Anchorage.

Bromaghin, J. F. 2005. A versatile net selectivity model, with application to Pacific salmon and freshwater species of the Yukon River, Alaska. Fisheries Research. 74 (1-3):157-168.

Cochran, W. G. 1977. Sampling techniques, 3rd edition. John Wiley and Sons, New York.

Estensen, J. L., D. B. Molyneaux, and D. J. Bergstrom. 2009. Kuskokwim River Salmon Status and Kuskokwim Area Fisheries, 2009; a Report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Sport Fish and Commercial Fisheries, Special Publication 09-21, Anchorage. Available: http:www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm.

Gates, K. S., and K. C. Harper. 2002. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2001. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2002-6, Kenai, Alaska. Available: http://alaska.fws.gov/fisheries/fish/DataSeries/d20026.pdf

Gates, K. S., and K. C. Harper. 2003. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2002. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2003-1, Kenai, Alaska. Available: http://alaska.fws.gov/fisheries/fish/DataSeries/d20095.pdf

Gates, K. S., J. K. Boersma, D. E. Palmer, and J. F. Bromaghin. 2010. Run timing, abundance, and distribution of adult coho salmon in the Kasilof River watershed, Alaska, 2007- 2009. U. S Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2010-3, Soldotna, Alaska. Available http://alaska.fws.gov/fisheries/fish/DataSeries/d201003.pdf

Geiger, J. H., J. E. Clark, B. Cross, and S. McPherson. 1990. Report from the work group on sampling. Pages 3-12 *in* H.J. Geiger, and R.L. Wilbur, editors. Proceedings of the 1990 Alaska stock separation workshop. Alaska Department of Fish and Game, Division of Commercial Fisheries, Special Fisheries Report Number 2, Juneau, Alaska.

Groot, C., and L. Margolis, editors. 1991. Pacific Salmon Life Histories. UBC Press, Vancouver, BC.

Harper, K. C. 1995a. Run timing and abundance of adult salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1991. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Progress Report, 95-1, Kenai, Alaska.

Harper, K. C. 1995b. Run timing and abundance of adult salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1992. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Progress Report, 95-3, Kenai, Alaska.

Harper, K. C. 1995c. Run timing and abundance of adult salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1993. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Progress Report, 95-2, Kenai, Alaska.

Harper, K. C. 1997. Run timing and abundance of adult salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1994. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report 41, Kenai, Alaska.

Hillgruber, N., and C. E. Zimmerman. 2009. Estuarine ecology of juvenile salmon in Western Alaska: a review. Pages 183-199 *in* Krueger, C. C., and C. E. Zimmerman, editors. Pacific Salmon Ecology and Management of Western Alaska's Populations, American Fisheries Society Symposium 70.

Kerkvliet, C. M., and T. Hamazaki. 2003. A mark-recapture experiment to estimate the total population of Kuskokwim River coho salmon (*Oncorhynchus kisutch*), 2001. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report Number 3A02-15, Anchorage.

Kerkvliet, C. M., T. Hamazaki, K. E. Hyer, and D. Cannon. 2003. A mark–recapture experiment to estimate the abundance of Kuskokwim River chum, sockeye, and coho salmon, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report Number 3A03-25, Anchorage.

Kerkvliet, C. M., J. Pawluk, T. Hamazaki, K. E. Hyer, and D. Cannon. 2004. A mark–recapture experiment to estimate the abundance of Kuskokwim River chum, sockeye and coho salmon, 2003. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report Number 3A04-14, Anchorage.

Koo, T. S. Y. 1962. Age determination in salmon. Pages 37-48 *in* T.S.Y. Koo, editor. Studies of Alaskan red salmon. University of Washington Press, Seattle, Washington.

Kruse, G. H. 1998. Salmon run failures in 1997−1998: A link to anomalous ocean conditions? Alaska Department Fish and Game, Division of Commercial Fisheries, Alaska Fisheries Research Bulletin 5(1):55-63.

Linderman, J. C., D. B. Molyneaux, L. Dubois, and W. Morgan. 2002. Tatlawiksuk River salmon studies, 1998-2001. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Information Report Number 3A02-11, Anchorage.

Linderman, J. C., and M. Rearden. 2007. Kuskokwim Bay Salmon Fishery News Release #1, 2007 Kuskokwim Area regulatory changes, salmon outlook, and management strategies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Area Office, Bethel, Alaska. Available:http://csfish.adfg.state.ak.us/region3/finfish/salmon/forecast/07kskmp.pdf.=29 (February 2009).

Miller, S. J., and K. C. Harper. 2009. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2008. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2009-5, Kenai, Alaska. Available: http://alaska.fws.gov/fisheries/fish/Data_Series/d_2009_5.pdf

Miller, S. J., and K. C. Harper. 2010. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2009. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2010-2, Soldotna, Alaska. Available: http://alaska.fws.gov/fisheries/fish/Data_Series/d_2010_2.pdf

Miller, S. J., and K. C. Harper. 2011a. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2010. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2011-4, Soldotna, Alaska. Available: http://alaska.fws.gov/fisheries/fish/Data_Series/d_2011_4.pdf

Miller, S. J., and K. C. Harper. 2011b. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2010. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2011-3, Soldotna, Alaska. Available: http://alaska.fws.gov/fisheries/fish/Data_Series/d_2011_3.pdf

Molyneaux, D. M., and L. K. Brannian. 2006. Review of escapement and abundance information for Kuskokwim area salmon stocks. Alaska Department of Fish and Game, Fishery manuscript No. 06-08, Anchorage. Available: http:www.sf.adfg.state.ak.us/FedAidpdfs/fms06-08.pdf

Mosher, K. H. 1968. Photographic atlas of sockeye salmon scales. U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Fishery Bulletin Number 2: 243-274.

Petrosky, C. E., and H. A. Schaller. 2010. Influence of river conditions during seaward migration and ocean conditions on survival rates of Snake River Chinook salmon and steelhead. Ecology of Freshwater Fish 19:520-536.

Plumb, M. P., K. C. Harper, and D. G. Spencer. 2007. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2006. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2007-4, Kenai, Alaska. Available: http://alaska.fws.gov/fisheries/fish/Data_Series/d_2007_4.pdf

Plumb, M. P., and K. C. Harper. 2008. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2007. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2008-4, Kenai, Alaska. Available: http://alaska.fws.gov/fisheries/fish/Data_Series/d_2001_4.pdf

Scott, W. B., and E. J. Crossman. 1973. Freshwater Fishes of Canada. Bulletins of Fisheries Research Board of Canada, Bulletin 184, Ottawa, Canada.

Seber, G. A .F. 1982. The estimation of animal abundance and related parameters, 2nd edition. Maxmillan, New York.

Strachan, D. G. 2005. 2005 soil geochemistry with recommendations for 2006 NYAC Gold District, Tintina Gold Province, Southwest Alaska. Available: http://www.tonogold.com (March 2009).

Stuby, L. 2004. Inriver abundance of Chinook salmon in the Kuskokwim River, 2003. Alaska Department of Fish and Game, Fishery Data Series Number 04-30, Anchorage.

Stuby, L. 2005. Inriver abundance of Chinook salmon in the Kuskokwim River, 2002-2004. Alaska Department of Fish and Game, Fishery Data Series Number 05-39, Anchorage.

Stuby, L. 2006. Inriver abundance of Chinook salmon in the Kuskokwim River, 2005. Alaska Department of Fish and Game, Fishery Data Series Number 05-302, Anchorage.

Tobin, J. H. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office. Alaska Fisheries Technical Report Number 22. Kenai, Alaska.

U.S. Fish and Wildlife Service. 1992. Fishery management plan for the Yukon Delta National Wildlife Refuge. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Van Alen, B. V. 1999. Status and stewardship of salmon stocks in southeast Alaska. Pages 161-194 *in* E.E. Knudsen, C.R. Steward, D. D. MacDonald, J. E Williams, and D.W. Reiser, editors. Sustainable fisheries management: Pacific salmon. Lewis Publishers, Boca Raton, Florida.

Volk, E. C, M. J. Evenson, and R. A. Clark. 2009. Escapement goal recommendations for select Arctic-Yukon-Kuskokwim Region salmon stocks, 2010. Alaska Department Fish and Game, Fishery Manuscript No. 09-07, Anchorage. Available: http://www.sf.adfg.state.ak.us/FedAidpdfs/fms06-08.pdf

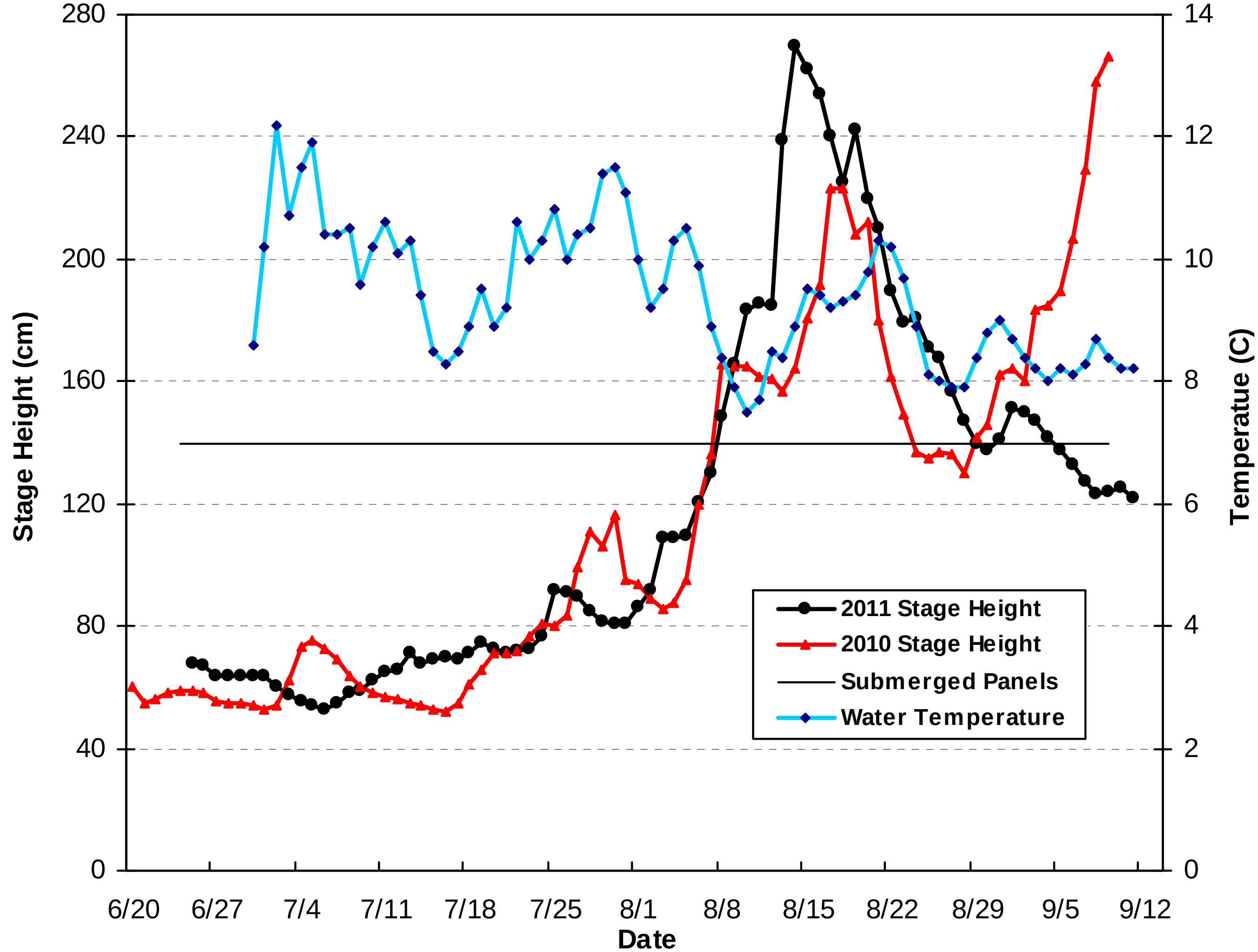
Ward, T. C., M. Coffing, J. Estenson, R. Fisher, and D. Molyneaux. 2003. Annual management report for the subsistence and commercial fisheries of the Kuskokwim Area, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A03-27, Anchorage, Alaska.

Whitmore, C., M. Martz, D. G. Bue, J. C. Linderman, and R. Fisher. 2005. Annual fishery management report for the subsistence and commercial fisheries of the Kuskokwim area 2003. Alaska Department of Fish and Game, Fisheries Management Report Number 05-72, Anchorage.

Zabkar, L. M., and K. C. Harper. 2004. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2003. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2004-6, Kenai, Alaska.

Zabkar, L. M., and K. C. Harper. 2005. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2004. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2006-8, Kenai, Alaska.

Zabkar, L. M., F. Harris, and K. C. Harper. 2006. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2005. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2006-8, Kenai, Alaska.



APPENDIX 1.—River stage heights and daily water temperatures at the Tuluksak River weir, 2011. The solid line at 140 cm represents a stage height at which time weir panels become submerged.

APPENDIX 2.—Daily, cumulative, and cumulative proportion of chum, Chinook, sockeye, pink, and coho salmon passing through the Tuluksak River weir, Alaska, 2011. Boxed areas represent the second and third-quartile and median passage dates. Shaded areas represent high water events when partial or no counts were recorded and escapement totals were estimated for chum, Chinook, and sockeye salmon.

	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
06/29	2	2	0.000	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
06/30	4	6	0.001	0	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000
07/01	6	12	0.001	1	1	0.003	0	0	0.000	0	0	0.000	0	0	0.000
07/02	82	94	0.009	7	8	0.028	0	0	0.000	0	0	0.000	0	0	0.000
07/03	58	152	0.015	1	9	0.031	1	1	0.008	0	0	0.000	0	0	0.000
07/04	36	188	0.019	3	12	0.042	0	1	0.008	0	0	0.000	0	0	0.000
07/05	0	188	0.019	0	12	0.042	0	1	0.008	0	0	0.000	0	0	0.000
07/06	0	188	0.019	0	12	0.042	0	1	0.008	0	0	0.000	0	0	0.000
07/07	58	246	0.025	0	12	0.042	0	1	0.008	0	0	0.000	0	0	0.000
07/08	84	330	0.033	4	16	0.056	0	1	0.008	0	0	0.000	0	0	0.000
07/09	91	421	0.042	1	17	0.059	4	5	0.038	0	0	0.000	0	0	0.000
07/10	26	447	0.045	0	17	0.059	0	5	0.038	0	0	0.000	0	0	0.000
07/11	147	594	0.059	0	17	0.059	1	6	0.046	0	0	0.000	0	0	0.000
07/12	263	857	0.086	18	35	0.122	3	9	0.069	0	0	0.000	0	0	0.000
07/13	156	1,013	0.101	12	47	0.163	2	11	0.084	0	0	0.000	0	0	0.000
07/14	243	1,256	0.125	34	81	0.281	0	11	0.084	0	0	0.000	0	0	0.000
07/15	506	1,762	0.176	8	89	0.309	14	25	0.192	2	2	0.024	0	0	0.000
07/16	167	1,929	0.193	0	89	0.309	8	33	0.253	0	2	0.024	0	0	0.000
07/17	243	2,172	0.217	35	124	0.431	2	35	0.268	1	3	0.035	0	0	0.000
07/18	241	2,413	0.241	9	133	0.462	4	39	0.299	0	3	0.035	0	0	0.000
07/19	278	2,691	0.269	25	158	0.549	9	48	0.368	3	6	0.071	1	1	0.000
07/20	937	3,628	0.362	24	182	0.632	19	67	0.514	2	8	0.094	7	8	0.000
07/21	220	3,848	0.384	9	191	0.663	4	71	0.545	6	14	0.165	0	8	0.000
07/22	481	4,329	0.432	29	220	0.764	21	92	0.706	2	16	0.188	0	8	0.000
07/23	432	4,761	0.476	16	236	0.819	5	97	0.744	2	18	0.212	0	8	0.000
07/24	165	4,926	0.492	6	242	0.840	0	97	0.744	0	18	0.212	1	9	0.000
07/25	633	5,559	0.555	10	252	0.875	4	101	0.775	1	19	0.224	0	9	0.000
07/26	545	6,104	0.610	8	260	0.903	1	102	0.782	5	24	0.282	1	10	0.000
07/27	351	6,455	0.645	2	262	0.910	3	105	0.805	5	29	0.341	2	12	0.000
07/28	289	6,744	0.674	3	265	0.920	1	106	0.813	7	36	0.424	0	12	0.001
07/29	341	7,085	0.708	3	268	0.931	0	106	0.813	2	38	0.447	1	13	0.006
07/30	115	7,200	0.719	0	268	0.931	0	106	0.813	2	40	0.471	0	13	0.008
07/31	175	7,375	0.737	0	268	0.931	0	106	0.813	2	42	0.494	0	13	0.012
08/01	260	7,635	0.763	1	269	0.934	1	107	0.821	5	47	0.553	2	15	0.014
08/02	282	7,917	0.791	0	269	0.934	1	108	0.828	4	51	0.600	9	24	0.015
08/03	422	8,339	0.833	0	269	0.934	0	108	0.828	3	54	0.635	9	33	0.016
08/04	171	8,510	0.850	0	269	0.934	0	108	0.828	2	56	0.659	12	45	0.016

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	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
08/05	137	8,647	0.864	0	269	0.934	5	113	0.867	2	58	0.682	7	52	0.019
08/06	212	8,859	0.885	0	269	0.934	0	113	0.867	10	68	0.800	5	57	0.020
08/07	204	9,063	0.905	6	275	0.955	5	118	0.905	3	71	0.835	5	62	0.022
08/08	389	9,452	0.944	2	277	0.962	2	120	0.921	2	73	0.859	5	67	0.041
08/09	101	9,553	0.954	1	278	0.965	1	121	0.928	0	73	0.859	0	67	0.049
08/10	86	9,639	0.963	2	280	0.973	1	122	0.938	1	74	0.871	0	67	0.059
08/11	78	9,717	0.971	1	281	0.975	1	123	0.943	1	75	0.882	0	67	0.067
08/12	62	9,779	0.977	2	283	0.983	0	123	0.945	0	75	0.882	0	67	0.084
08/13	27	9,806	0.980	1	284	0.984	0	123	0.947	0	75	0.882	0	67	0.090
08/14	23	9,829	0.982	0	284	0.985	0	123	0.947	0	75	0.882	0	67	0.104
08/15	29	9,858	0.985	0	284	0.987	1	124	0.951	0	75	0.882	0	67	0.145
08/16	19	9,877	0.987	0	284	0.986	0	124	0.951	0	75	0.882	0	67	0.156
08/17	21	9,898	0.989	0	284	0.986	0	124	0.952	0	75	0.882	0	67	0.166
08/18	13	9,911	0.990	0	284	0.986	0	124	0.954	0	75	0.882	0	67	0.167
08/19	8	9,919	0.991	0	284	0.987	0	124	0.954	0	75	0.882	0	67	0.167
08/20	11	9,930	0.992	0	284	0.987	0	124	0.954	0	75	0.882	0	67	0.167
08/21	9	9,939	0.993	0	284	0.987	0	124	0.954	0	75	0.882	0	67	0.167
08/22	6	9,945	0.993	1	285	0.989	1	125	0.962	0	75	0.882	0	67	0.167
08/23	6	9,951	0.994	0	285	0.989	1	126	0.969	0	75	0.882	0	67	0.175
08/24	9	9,960	0.995	1	286	0.993	0	126	0.969	1	76	0.894	0	67	0.191
08/25	3	9,963	0.995	0	286	0.993	0	126	0.969	0	76	0.894	0	67	0.246
08/26	5	9,968	0.996	0	286	0.993	1	127	0.977	1	77	0.906	0	67	0.327
08/27	5	9,973	0.996	0	286	0.993	0	127	0.977	1	78	0.918	1	68	0.476
08/28	4	9,977	0.997	0	286	0.993	0	127	0.977	0	78	0.918	0	68	0.572
08/29	5	9,982	0.997	0	286	0.993	0	127	0.977	0	78	0.918	0	68	0.730
08/30	5	9,987	0.998	0	286	0.993	0	127	0.977	1	79	0.929	5	73	0.820
08/31	4	9,991	0.998	1	287	0.997	2	129	0.992	1	80	0.941	4	77	0.868
09/01	2	9,993	0.998	1	288	1.000	0	129	0.992	0	80	0.941	1	78	0.920
09/02	5	9,998	0.999	0	288	1.000	1	130	1.000	1	81	0.953	0	78	0.938
09/03	3	10,001	0.999	0	288	1.000	0	130	1.000	2	83	0.976	1	79	0.970
09/04	2	10,003	0.999	0	288	1.000	0	130	1.000	1	84	0.988	1	80	0.988
09/05	1	10,004	0.999	0	288	1.000	0	130	1.000	1	85	1.000	3	83	0.996
09/06	3	10,007	1.000	0	288	1.000	0	130	1.000	0	85	1.000	1	84	0.999
09/07	2	10,009	1.000	0	288	1.000	0	130	1.000	0	85	1.000	6	90	1.000
09/08	0	10,009	1.000	0	288	1.000	0	130	1.000	0	85	1.000	1	91	1.000
09/09	0	10,009	1.000	0	288	1.000	0	130	1.000	0	85	1.000	1	92	1.000
09/10	2	10,011	1.000	0	288	1.000	0	130	1.000	0	85	1.000	0	92	1.000

APPENDIX 3.—Estimated age and sex composition of weekly chum salmon escapement through the Tuluksak River weir, 2011.

		Brood Year and Age Group					
		2008	2007	2006	2005	2004	
		0.2	0.3	0.4	0.5	0.6	Total
Strata 2 – 3:	06/26 – 07/09						
Sampling Dates:	07/03, 07/04						
Male:	Number in Sample:	0	17	39	3	0	59
	Estimated % of Escapement:	0.0	23.3	53.4	4.1	0.0	80.8
	Estimated Escapement:	0	98	225	17	0	340
	Standard Error:	0.0	19.1	22.5	9.0	0.0	
Female:	Number in Sample:	0	9	5	0	0	14
	Estimated % of Escapement:	0.0	12.3	6.8	0.0	0.0	19.2
	Estimated Escapement:	0	52	29	0	0	81
	Standard Error:	0.0	14.8	11.4	0.0	0.0	
Total:	Number in Sample:	0	26	44	3	0	73
	Estimated % of Escapement:	0.0	35.6	60.3	4.1	0.0	100.0
	Estimated Escapement:	0	150	254	17	0	421
	Standard Error:	0.0	21.6	22.1	9.0	0.0	
Stratum 4:	07/10 – 07/16						
Sampling Date:	07/10, 07/11						
Male:	Number in Sample:	0	26	63	0	0	89
	Estimated % of Escapement:	0.0	22.0	53.4	0.0	0.0	75.4
	Estimated Escapement:	0	332	805	0	0	1,137
	Standard Error:	0.0	55.5	66.8	0.0	0.0	
Female:	Number in Sample:	0	8	21	0	0	29
	Estimated % of Escapement:	0.0	6.8	17.8	0.0	0.0	24.6
	Estimated Escapement:	0	102	268	0	0	371
	Standard Error:	0.0	33.6	51.2	0.0	0.0	
Total:	Number in Sample:	0	34	84	0	0	118
	Estimated % of Escapement:	0.0	28.8	71.2	0.0	0.0	100.0
	Estimated Escapement:	0	435	1,073	0	0	1,508
	Standard Error:	0.0	60.6	60.6	0.0	0.0	
Stratum 5:	07/17 – 07/23						
Sampling Dates:	07/17 – 07/20						
Male:	Number in Sample:	0	57	63	1	0	121
	Estimated % of Escapement:	0.0	36.3	40.1	0.6	0.0	77.1
	Estimated Escapement:	0	1,028	1,136	18	0	2,183
	Standard Error:	0.0	106.0	108.0	17.5	0.0	
Female:	Number in Sample:	0	17	19	0	0	36
	Estimated % of Escapement:	0.0	10.8	12.1	0.0	0.0	22.9
	Estimated Escapement:	0	307	343	0	0	649
	Standard Error:	0.0	68.5	71.9	0.0	0.0	
Total:	Number in Sample:	0	74	82	1	0	157
	Estimated % of Escapement:	0.0	47.1	52.2	0.6	0.0	100.0
	Estimated Escapement:	0	1,335	1,479	18	0	2,832
	Standard Error:	0.0	110.0	110.1	17.5	0.0	
Stratum 6:	07/24 – 07/30						
Sampling Dates:	07/24, 07/25						
Male:	Number in Sample:	0	53	35	1	0	89
	Estimated % of Escapement:	0.0	33.1	21.9	0.6	0.0	55.6
	Estimated Escapement:	0	808	534	15	0	1,357
	Standard Error:	0.0	88.0	77.3	14.7	0.0	
Female:	Number in Sample:	0	41	30	0	0	71
	Estimated % of Escapement:	0.0	25.6	18.8	0.0	0.0	44.4
	Estimated Escapement:	0	625	457	0	0	1,082
	Standard Error:	0.0	81.6	73.0	0.0	0.0	
Total:	Number in Sample:	0	94	65	1	0	160
	Estimated % of Escapement:	0.0	58.8	40.6	0.6	0.0	100.0
	Estimated Escapement:	0	1,433	991	15	0	2,439
	Standard Error:	0.0	92.0	91.8	14.7	0.0	

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		Brood Year and Age Group					
		2008	2007	2006	2005	2004	
		0.2	0.3	0.4	0.5	0.6	Total
Strata 7 – 12:	07/31 – 09/10						
Sampling Dates:	07/31, 08/01						
Male:	Number in Sample:	1	52	41	0	0	94
	Estimated % of Escapement:	0.6	31.7	25.0	0.0	0.0	57.3
	Estimated Escapement:	17	891	703	0	0	1,611[a]
	Standard Error:	16.6	99.4	92.5	0.0	0.0	
Female:	Number in Sample:	1	40	27	2	0	70
	Estimated % of Escapement:	0.6	24.4	16.5	1.2	0.0	42.7
	Estimated Escapement:	17	686	463	34	0	1,200[a]
	Standard Error:	16.6	91.8	79.2	23.4	0.0	
Total:	Number in Sample:	2	92	68	2	0	164
	Estimated % of Escapement:	1.2	56.1	41.5	1.2	0.0	100.0
	Estimated Escapement:	34	1,577	1,166	34	0	2,811[a]
	Standard Error:	23.4	106.0	105.3	23.4	0.0	
Strata 2 – 12:	06/26 – 09/10						
Sampling Dates:	07/03 – 08/01						
Male:	Number in Sample:	1	205	241	5	0	452
	% Males in Age Group:	0.3	47.6	51.3	0.8	0.0	100.0
	Estimated % of Escapement:	0.2	31.5	34.0	0.5	0.0	66.2
	Estimated Escapement:	17	3,158	3,403	51	0	6,628[a]
	Standard Error:	16.6	179.7	176.5	24.6	0.0	
Female:	Number in Sample:	1	115	102	2	0	220
	% Females in Age Group:	0.5	52.4	46.1	1.0	0.0	100.0
	Estimated % of Escapement:	0.2	17.7	15.6	0.3	0.0	33.8
	Estimated Escapement:	17	1,771	1,560	34	0	3,383[a]
	Standard Error:	16.6	145.3	139.7	23.4	0.0	
Total:	Number in Sample:	2	320	343	7	0	672
	Estimated % of Escapement:	0.3	49.2	49.6	0.8	0.0	100.0
	Estimated Escapement:	34	4,929	4,963	85	0	10,011[a]
	Standard Error:	23.4	189.6	189.2	34.0	0.0	

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

APPENDIX 4.—Estimated length at age composition of weekly chum salmon escapement through the Tuluksak River weir, 2011.

		Brood Year and Age Group				
		2008	2007	2006	2005	2006
		0.2	0.3	0.4	0.5	0.6
Strata 2 – 3:	06/26 – 07/09					
Sampling Dates:	07/03, 07/04					
Male:	Mean Length		564	574	601	
	Std. Error		6	5	20	
	Range		500 – 602	510 – 650	562 – 630	
	Sample Size	0	17	39	1	0
Female:	Mean Length		549	536		
	Std. Error		10	10		
	Range		500 – 585	500 – 560		
	Sample Size	0	9	5	0	0
Stratum 4:	07/10 – 07/16					
Sampling Date:	07/10, 07/11					
Male:	Mean Length		572	571		
	Std. Error		7	3		
	Range		506 – 683	500 – 643		
	Sample Size	0	26	63	0	0
Female:	Mean Length		537	544		
	Std. Error		3	4		
	Range		520 – 550	503 – 593		
	Sample Size	0	8	21	0	0
Stratum 5:	07/17 – 07/23					
Sampling Dates:	07/17 – 07/20					
Male:	Mean Length		566	573	615	
	Std. Error		5	4		
	Range		495 – 717	510 – 633	–	
	Sample Size	0	57	63	1	0
Female:	Mean Length		542	543		
	Std. Error		8	8		
	Range		485 – 590	505 – 620		
	Sample Size	0	17	19	0	0
Stratum 6:	07/24 – 07/30					
Sampling Dates:	07/24, 07/25					
Male:	Mean Length		551	555	550	
	Std. Error		4	6		
	Range		480 – 610	456 – 605	–	
	Sample Size	0	53	35	1	0
Female:	Mean Length		528	525		
	Std. Error		5	4		
	Range		461 – 590	565 – 570		
	Sample Size	0	41	30	0	0

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		Brood Year and Age Group				
		2008	2007	2006	2005	2004
		0.2	0.3	0.4	0.5	0.6
Strata 7 – 12:	07/31 – 09/10					
Sampling Dates:	07/31, 08/01					
Male:	Mean Length	520	533	536		
	Std. Error		4	7		
	Range	–	460 – 620	446 – 620		
	Sample Size	1	52	41	0	0
Female:	Mean Length	570	508	513	543	
	Std. Error		5	5	13	
	Range	–	412 – 580	478 – 594	530 – 555	
	Sample Size	1	40	27	2	0
Strata 2 – 12:	06/26 – 09/10					
Sampling Dates:	07/03 – 08/01					
Male:	Mean Length	520	554	564	593	
	Std. Error		2	2	16	
	Range	–	460 – 717	446 – 650	550 – 630	
	Sample Size	1	205	241	5	0
Female:	Mean Length	570	525	530	543	
	Std. Error		3	3	13	
	Range	–	412 – 590	465 – 620	530 – 555	
	Sample Size	1	115	102	2	0

APPENDIX 5.—Estimated age and sex composition of Chinook salmon sampled at the Tuluksak River weir, 2011. Weekly stratum were combined and the ASL sample (*N* = 19) may be inadequate to characterize the 2011 Chinook salmon escapement.

		Brood Year and Age Group						
		2007	2006		2005		2004	
		1.2	1.3	2.2	1.4	2.3	1.5	Total
Strata 2 – 11:	06/26 – 09/03							
Sampling Dates:	07/03, 07/04, 07/14, 07/15, 07/17 – 07/19, 07/24, 08/01							
Male:	Number in Sample:	4	6	0	4	0	0	14
	% Males in Age Group:	28.6	42.9	0.0	28.6	0.0	0.0	100.0
	Estimated % of Escapement:	21.1	31.6	0.0	21.1	0.0	0.0	73.7
	Estimated Escapement:	61	91	0	61	0	0	212[a]
	Standard Error:	26.7	30.5	0.0	26.7	0.0	0.0	
Female:	Number in Sample:	0	1	0	4	0	0	5
	% Females in Age Group:	0.0	20.0	0.0	80.0	0.0	0.0	100.0
	Estimated % of Escapement:	0.0	5.3	0.0	21.1	0.0	0.0	26.3
	Estimated Escapement:	0	15	0	61	0	0	76[a]
	Standard Error:	0.0	14.6	0.0	26.7	0.0	0.0	
Total:	Number in Sample:	4	7	0	8	0	0	19
	Estimated % of Escapement:	21.1	36.8	0.0	42.1	0.0	0.0	100.0
	Estimated Escapement:	61	106	0	121	0	0	288[a]
	Standard Error:	26.7	31.6	0.0	32.4	0.0	0.0	

[a] Estimates included in total.

APPENDIX 6.—Estimated length at age composition of Chinook salmon sampled at the Tuluksak River weir. Weekly stratum were combined and the ASL sample size (*N* = 19) inadequate to characterize the 2011 Chinook salmon escapement.

		Brood Year and Age Group					
		2007	2006		2005		2004
		1.2	1.3	2.2	1.4	2.3	1.5
Strata 2 – 11:	06/26 – 09/03						
Sampling Dates:	07/03, 07/04, 07/14, 07/15 07/17 – 07/19, 07/24, 08/ 28						
Male:	Mean Length	535	711		838		
	Std. Error	22	44		60		
	Range	476 – 576	622 – 910		700 – 990		
	Sample Size	4	6	0	4	0	0
Female:	Mean Length		770		888		
	Std. Error				45		
	Range		–		780 – 994		
	Sample Size	0	1	0	4	0	0

APPENDIX 7. —Estimated age and sex composition of the sockeye salmon sampled at the Tuluksak River weir, 2011. Weekly stratum were combined and the ASL sample (*N* = 16) to small to adequately characterize the 2011 sockeye salmon escapement.

		Brood Year and Age Group										
		2008	2007		2006			2005		2004	2003	
		0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3	2.4	2.5	Total
Strata 3 – 11:	06/27 – 09/11											
Sampling Dates:	07/09, 07/15, 07/19, 08/01											
Male:	Number in Sample:	0	0	1	1	4	1	0	0	0	0	7
	% Males in Age Group:	0.0	0.0	14.3	14.3	57.1	14.3	0.0	0.0	0.0	0.0	100
	Estimated % of Escapement:	0.0	0.0	6.25	6.25	25.00	6.25	0.00	0.00	0.00	0.00	44
	Estimated Escapement:	0	0	8	8	33	8	0	0	0	0	57[a]
	Standard Error:	0.0	0.0	7.6	7.6	13.6	7.6	0.0	0.0	0.0	0.0	
Female	Number in Sample:	1	2	1	0	5	0	0	0	0	0	9
	% Females in Age Group:	11.1	22.2	11.1	0.0	55.6	0.0	0.0	0.0	0.0	0.0	100
	Estimated % of Escapement:	6.25	12.50	6.25	0.00	31.25	0.00	0.00	0.00	0.00	0.00	56
	Estimated Escapement:	8	16	8	0	41	0	0	0	0	0	73[a]
	Standard Error:	7.6	10.4	7.6	0.0	14.6	0.0	0.0	0.0	0.0	0.0	
Total:	Number in Sample:	1	2	2	1	9	1	0	0	0	0	16
	Estimated % of Escapement:	6.25	12.50	12.50	6.25	56.25	6.25	0.00	0.00	0.00	0.00	100
	Estimated Escapement:	8	16	16	8	73	8	0	0	0	0	130[a]
	Standard Error:	7.6	10.4	10.4	7.6	15.6	7.6	0.0	0.0	0.0	0.0	

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

APPENDIX 8. —Estimated length at age composition of sockeye salmon sampled at the Tuluksak River weir, 2011. Weekly stratum were combined and the ASL sample (*N* = 16) to small to adequately characterize the 2011 sockeye salmon escapement.

		Brood Year and Age Group									
		2008	2007		2006			2005		2004	2003
		0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3	2.4	2.5
Strata 3 – 11:	06/27 – 09/11										
Sampling Dates:	07/09, 07/15, 07/19, 08/01										
Male:	Mean Length	611		573		563	600				
	Std. Error					8					
	Range	–		–		542 – 581	–				
	Sample Size	1	0	1	0	4	1	0	0	0	0
Female:	Mean Length		541	520	565	533					
	Std. Error		19			7					
	Range		522 – 559	–	–	507 – 553					
	Sample Size	0	2	1	1	5	0	0	0	0	0

APPENDIX 9.—Median cumulative passage dates and percent female for chum, Chinook, sockeye, pink and coho salmon at the Tuluksak River weir during 1991–1994 and 2001−2011 (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004, 2005; Zabkar et al. 2006; Plumb et al. 2007; Plumb and Harper 2008; Miller and Harper 2009, 2010, 2011a). Percent female (26%) for Chinook salmon during 2011 was based on an ASL sample size of 19 fish.

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

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