U.S. Fish & Wildlife Service

# Abundance and Run Timing of Adult Salmon in the Gisasa River, Koyukuk National Wildlife Refuge, Alaska, 2007

*Alaska Fisheries Data Series Number 2008–13*

**Fairbanks Fish and Wildlife Field Office**
**Fairbanks, Alaska**
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# Abundance and Run Timing of Adult Salmon in the Gisasa River, Koyukuk National Wildlife Refuge, Alaska, 2007

**Jeffery L. Melegari**

## Abstract

A resistance board weir was operated by the U.S. Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office to collect information on abundance, run timing, and biology of returning adult Chinook salmon and chum salmon in the Gisasa River. This was the thirteenth year of operating the weir at this location. In 2007, the weir was operated from June 23 through July 28 with no lost counting time. An estimated 1,427 Chinook salmon *Oncorhynchus tshawytscha* and 46,257 summer chum salmon *O. keta* passed through the weir. The most abundant non-salmon species was northern pike *Esox lucius* (N=67), followed by whitefish spp. (Coregoninae; N=53), Arctic grayling *Thymallus arcticus* (N=19), and longnose sucker *Catostomus catostomus* (N=8). The estimated weekly sex composition for Chinook salmon ranged from 21% to 51% female fish. Three primary age classes were identified, 1.2, 1.3, and 1.4, for Chinook salmon, with a dominant age class of 1.4 (47%). The estimated weekly sex composition for summer chum salmon ranged from 51% to 68% female fish. There were two primary age classes identified, 0.3 and 0.4, with a dominant age class of 0.3 (55%).

## Introduction

The Gisasa River, located within the Koyukuk National Wildlife Refuge in north-central Interior Alaska, is a tributary of the Koyukuk River and provides spawning and rearing habitat for Chinook salmon *Oncorhynchus tshawytscha* and chum salmon *O. keta*. The U.S. Fish and Wildlife Service (USFWS), through Section 302 of the Alaska National Interest Lands Conservation Act, has a responsibility to ensure that salmon populations within federal conservation units are conserved in their natural diversity, international treaty obligations are met, and subsistence opportunities are maintained. Salmon species from the Gisasa River contribute to mixed stock subsistence and commercial fisheries in the Yukon River (USFWS 1993).

Yukon River salmon stocks began to decline in the late 1990s (Kruse 1998). These declines led to harvest restrictions, complete fishery closures, and spawning escapements below management goals (Vania et al. 2002). Returns showed improvement beginning in 2001 and continuing through 2005 (JTC 2006). Management of individual stocks does not occur and accurate escapement data are limited throughout the Yukon River drainage. In-season management of the salmon fisheries is conducted using: preseason projections based on parent stock returns; Pilot Station sonar; information provided by test fisheries; data from escapement projects; and harvest data from subsistence and commercial fisheries.

Historically, escapement information on individual salmon stocks from the Koyukuk River has been collected by aerial surveys. The Alaska Department of Fish and Game (ADF&G) conducted these surveys on several index tributaries within the Koyukuk River drainage

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intermittently since 1960 (Barton 1984). Aerial surveys are highly variable and provide only an index of relative run strength. Counts produced using weirs or counting towers provide a better estimation of escapement and provide a platform for collecting other biological data. Weirs or counting towers have been operated in five different Koyukuk River tributaries between 1994 and the present (Figure 1). The USFWS, Fairbanks Fish and Wildlife Field Office (FFWFO) has operated a resistance board weir on the Gisasa River since 1994 (Melegari and Wiswar 1995; O'Brien 2006).

Chinook salmon escapement estimates from weir counts on the Gisasa River from 1994 to 2006 ranged from 1,774 to 4,023 fish. Chum salmon escapement estimates for the same period ranged from 10,155 to 172,259 fish. For 2007, the objectives of the Gisasa River weir were to: (1) determine daily escapement and run timing of adult Chinook salmon and summer chum salmon, (2) determine sex and size composition of adult Chinook salmon and summer chum salmon, and (3) document observations of resident fish.

## Study Area

The Gisasa River headwaters originate in the Nulato Hills and the river flows northeast, passing through the Koyukuk National Wildlife Refuge. Approximately 112 km from its source, the Gisasa river enters the Koyukuk River (65° 15.206' N, 157° 42.529' W; USGS 1:63,360 series, Kateel River B-4 quadrangle) 90 km upriver from the mouth of the Koyukuk River (Figure 1). Climate of the region is continental subarctic with great seasonal temperature variations and low precipitation. Mean annual air temperature at the village of Galena, 64 km southeast of the Gisasa River, is 3.8° C with extremes ranging from 32° C during summer months to -57° C during winter months (USFWS 1993). The hydrology of this area is dynamic throughout the year, with lower flows generally occurring in summer. Peak flows usually occur during spring snow melt/breakup or occasionally during summer high precipitation events. Rivers in the area generally begin to freeze during October and breakup during May.

The weir site was located approximately 4 km upriver from the mouth of the Gisasa River. This section of the river was straight with generally laminar flow. The bottom contour sloped gradually from the stream banks, river width was 45 m, and maximum depth was approximately 0.7 m. Substrate at the weir site consisted of primarily medium size gravel 25-50 mm diameter.

## Methods

*Weir Construction and Deployment*

A resistance board weir was used to enumerate and collect biological data from adult salmon as they migrated up the Gisasa River to spawn. The construction and installation of resistance board weirs was described by Tobin (1994). The Gisasa River weir has been installed at the same site since the project was initiated. More detailed information on deployment of the Gisasa River weir can be found in Melegari and Wiswar (1995). The weir was visually inspected for integrity and cleaned of debris daily. A live trap was installed near mid-channel, allowing fish to be recorded as they passed through the weir and, when necessary, the trap could be closed to hold fish for sampling. Water depth (cm) and temperature (°C) were recorded daily at the trap.

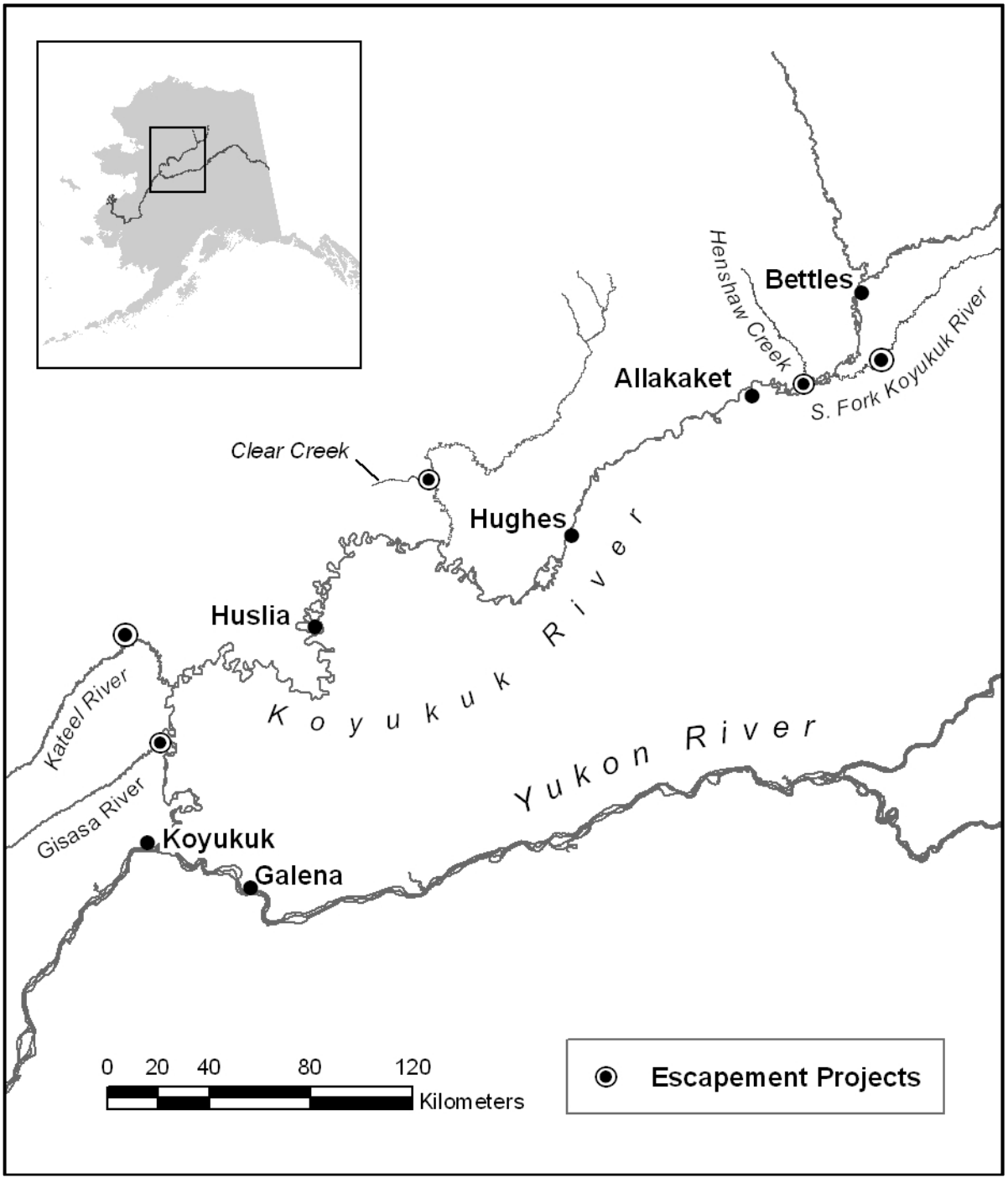


Figure 1. — Location of the Gisasa River weir and other active and historical tributary escapement project sites in the Koyukuk River drainage, Alaska.

*Biological Data*

The target start date of the project was based on previous years' salmon run timing data. The end date of the project has generally been determined in-season when the daily count of both species has dropped to less than 1% of the seasonal passage to date and continued at this level for three or more consecutive days. Due to logistic constraints operations were stopped slightly before this point was reached in 2007. All fish passing through the weir, with the exception of whitefish spp *Coregonus* and *Prosopium* spp, were identified to species and enumerated. Non-salmon species were not handled so it was difficult to identify the different whitefish species, therefore all whitefish species were grouped under the subfamily Coregoninae.

The daily counting schedule was variable, depending on the quantity of fish migrating upriver. Early and late in the season, when fish passage was lower, the weir was unmonitored from 00:00 to 08:00 hours with the trap closed to prevent upstream passage. As the fish passage increased the counting schedule increased to 24 hours per day. Counts and sex ratios from the previous day were reported daily to the FFWFO using a satellite telephone.

A stratified random sampling scheme (Cochran 1977), with weeks as the strata, was used to collect age, sex, and length data from adult Chinook salmon and summer chum salmon. Sampling started at the beginning of each week and generally was conducted over a 3-4 day period, targeting 160 salmon/species/week. Lengths were measured to the nearest 5 mm from mid-eye to fork of the caudal fin (METF) and sex was visually determined by external morphological characteristics. Scales were collected for aging with ages being reported using the European method (Foerster 1968). Three scales were collected from Chinook salmon and one scale from chum salmon. Scales were sampled from the left side of the fish, two rows above the lateral line on a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin. Scales from both adult salmon species were sent to the ADF&G for processing. Age 1.2 Chinook salmon were assumed to be males (Brady 1983; Bales 2007; Karpovich and DuBois 2007) regardless of their field determination.

*Data Analysis*

While no time was missed during 2007, methodology for estimating passage during missed times is included to maintain uniformity with other years of operation and reporting. Days with counts greater than 6 h but less that 24 h would have been adjusted for a 24 h period using:

$$E_d = (24/T_d) \bullet C_d ,$$

Where $E_d$ = estimated daily count for day $d$, $T_d$ = number of hours sampled during day $d$, and $C_d$ = number of fish counted during the time sampled in day $d$. Days with less than 6 h of the day counted would have been disregarded and treated as completely missed days. Completely missed days would have been estimated by linear interpolation from the daily counts before and after the missing period.

Calculations for age and sex information were treated as a stratified random sample (Cochran 1977) with statistical weeks as the strata. Each statistical week was defined as beginning on Sunday and ending on Saturday. Within a week, the proportion of the samples composed of a given sex or age, $\hat{p}_{ij}$ , were calculated as:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_j},$$

where $n_{ij}$ is the number of fish by sex *i* or age *i* sampled in week *j*, and $n_j$ is the total number of fish sampled in week *j*. The variance of $\hat{p}_{ij}$ was calculated as:

$$\hat{v}(\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_j - 1}.$$

Sex and age compositions for the total run of Chinook and chum salmon of a given sex or age, $\hat{p}_i$ were calculated as:

$$\hat{p}_i = \sum_{j-1} \hat{W}_j \hat{p}_{ij,}$$

where $\hat{W}_j$ = the stratum weight and was calculated as:

$$\hat{W}_j = \frac{N_j}{N},$$

and $N_j$ equals the total number of fish of a given species passing through the weir during week *j*, and *N* is the total number of fish of a given species passing through the weir during the run. Variance, $\hat{v}(\hat{p}_i)$ of sex and age compositions for the run was calculated as

$$\hat{v}(\hat{p}_i) = \sum_{j-1} \hat{W}_j^2 \hat{v}(\hat{p}_{ij}).$$

## Results and Discussion

*Weir Operation*

The weir was fully operational at 18:00 h on June 23, with no fish counted on that day. The first full day of operation was June 24 and counts continued through July 28, 2007 with no counting time missed. The picket spacing (3.5cm space between pickets) within the trap and weir panels was narrow enough to prevent adult Chinook and chum salmon from passing through the weir. However, some individuals of the smaller fish species, such as Arctic grayling and whitefish, likely passed through the weir undetected.

*Biological Data*

The seasonal estimates of fish passage at the weir were 1,427 Chinook salmon and 46,257 summer chum salmon (Table 1). The most abundant non-salmon species was northern pike *Esox lucius* (N=67) followed by whitefish spp. (Coregoninae) (N=53), Arctic grayling *Thymallus arcticus* (N=19), and longnose sucker *Catostomus catostomus* (N=8).

Table 1. — Daily and cumulative (Cum) estimates of Chinook salmon and summer chum salmon passage, and daily counts of other species, at the Gisasa River weir, Alaska, 2007. Asterisks (*****) indicate first, median, and third quartiles of Chinook salmon and summer chum salmon passage estimates.

| | Chinook salmon | | Chum salmon | | Northern pike | Whitefish spp. | Arctic grayling | Longnose sucker |
|---|---|---|---|---|---|---|---|---|
| Date | Daily | Cum | Daily | Cum | Daily | Daily | Daily | Daily |
| Jun-23[a] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-24 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| Jun-25 | 0 | 0 | 9 | 14 | 0 | 0 | 0 | 0 |
| Jun-26 | 0 | 0 | 5 | 19 | 0 | 0 | 0 | 0 |
| Jun-27 | 0 | 0 | 12 | 31 | 0 | 0 | 0 | 0 |
| Jun-28 | 0 | 0 | 31 | 62 | 0 | 0 | 0 | 0 |
| Jun-29 | 0 | 0 | 214 | 276 | 2 | 0 | 0 | 2 |
| Jun-30 | 2 | 2 | 1,513 | 1,789 | 1 | 0 | 0 | 1 |
| Jul-01 | 6 | 8 | 1,925 | 3,714 | 0 | 0 | 1 | 0 |
| Jul-02 | 10 | 18 | 2,870 | 6,584 | 0 | 4 | 1 | 1 |
| Jul-03 | 41 | 59 | 2,926 | 9,510 | 0 | 11 | 5 | 0 |
| Jul-04 | 29 | 88 | 2,666 | 12,176***** | 6 | 17 | 4 | 0 |
| Jul-05 | 19 | 107 | 2,322 | 14,498 | 3 | 4 | 2 | 0 |
| Jul-06 | 24 | 131 | 2,196 | 16,694 | 0 | 0 | 0 | 0 |
| Jul-07 | 13 | 144 | 2,028 | 18,722 | 2 | 0 | 0 | 0 |
| Jul-08 | 32 | 176 | 2,207 | 20,929 | 6 | 0 | 0 | 1 |
| Jul-09 | 31 | 207 | 1,817 | 22,746 | 13 | 2 | 1 | 1 |
| Jul-10 | 41 | 248 | 1,620 | 24,366***** | 5 | 1 | 3 | 0 |
| Jul-11 | 43 | 291 | 1,446 | 25,812 | 9 | 0 | 1 | 0 |
| Jul-12 | 56 | 347 | 1,155 | 26,967 | 3 | 1 | 0 | 0 |
| Jul-13 | 59 | 406***** | 1,000 | 27,967 | 2 | 1 | 0 | 1 |
| Jul-14 | 99 | 505 | 1,368 | 29,335 | 1 | 3 | 0 | 1 |
| Jul-15 | 64 | 569 | 1,184 | 30,519 | 2 | 4 | 0 | 0 |
| Jul-16 | 48 | 617 | 908 | 31,427 | 2 | 0 | 0 | 0 |
| Jul-17 | 47 | 664 | 1,134 | 32,561 | 0 | 0 | 0 | 0 |
| Jul-18 | 94 | 758***** | 1,152 | 33,713 | 2 | 0 | 0 | 1 |
| Jul-19 | 106 | 864 | 918 | 34,631 | 0 | 0 | 0 | 0 |
| Jul-20 | 43 | 907 | 1,177 | 35,808***** | 0 | 0 | 0 | 0 |
| Jul-21 | 30 | 937 | 909 | 36,717 | 2 | 0 | 0 | 0 |
| Jul-22 | 136 | 1,073***** | 903 | 37,620 | 1 | 0 | 0 | 0 |
| Jul-23 | 39 | 1,112 | 1,151 | 38,771 | 2 | 3 | 1 | 0 |
| Jul-24 | 44 | 1,156 | 1,257 | 40,028 | 1 | 0 | 0 | 0 |
| Jul-25 | 70 | 1,226 | 1,740 | 41,768 | 1 | 1 | 0 | 0 |
| Jul-26 | 138 | 1,364 | 1,703 | 43,471 | 0 | 1 | 0 | 0 |
| Jul-27 | 37 | 1,401 | 1,532 | 45,003 | 0 | 0 | 0 | 0 |
| Jul-28 | 26 | 1,427 | 1,254 | 46,257 | 1 | 0 | 0 | 0 |
| Total | 1,427 | | 46,257 | | 67 | 53 | 19 | 8 |

[a] Counting began at 18:00 h on the first day of operation.

### *Chinook Salmon*

The first Chinook salmon was counted on June 30, when two were passed through the weir. During the final day of weir operation, July 28, 26 Chinook salmon (1.8% of the seasonal estimate) were counted. Run timing was near average, with the first quartile passage date (July 13) two days later than the 1995-2006 average. Both the median, and third quartile passage dates (July 18 and 22, respectively) were three days later than the 1995-2006 average (Table 1). The

seasonal estimate of 1,427 Chinook salmon was 54% of the average (1995-2006) and was the lowest weir estimate to date (Figure 2, Appendix 1).

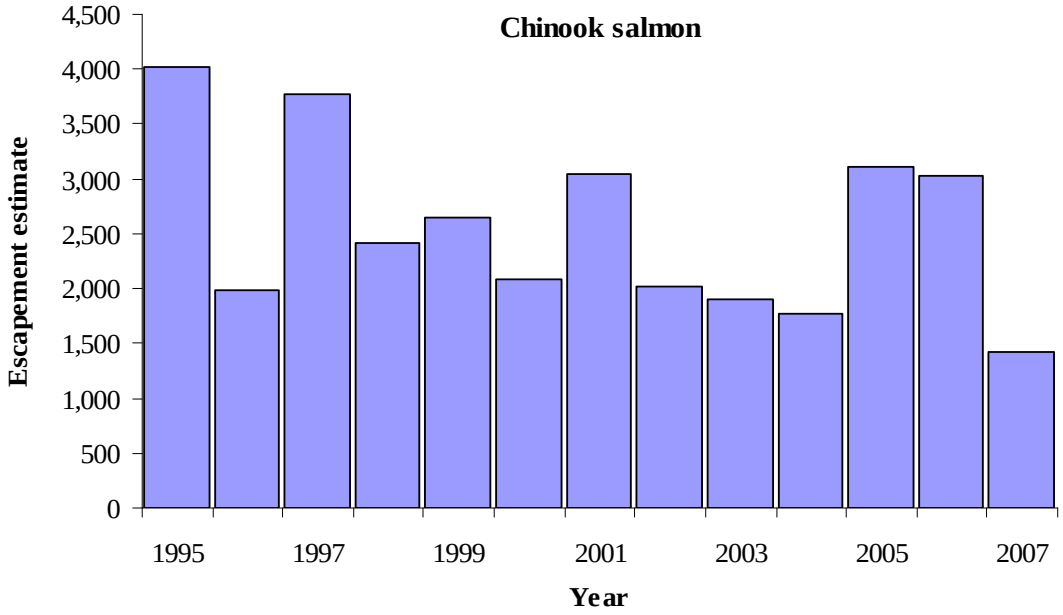


Figure 2. — Chinook salmon escapement estimates at the Gisasa River weir 1995-2007. Data from the first year of operation (1994) is not included as counting did not begin until July 10, after the run was underway.

Age, sex, and length samples were not collected during the first statistical week of weir operations; therefore, fish passing during the first week were included in the second statistical week calculations. Samples were collected from 355 Chinook salmon but age was unable to be determined for 19 (5%) of those samples. There were three primary age classes, 1.4, 1.3, and 1.2 from brood years 2001, 2002, and 2003, respectively (Table 2). Age class 1.4 was predominant, accounting for 47% of the season total, with stratum estimates ranging from 15% to 62%. The second most abundant age class was 1.2, accounting for 32% of the season total, with stratum estimates ranging from 21% to 77%. The age distributions differed between males and females. Females were predominantly age 1.4 (91%), while males were more evenly distributed across the age classes, with age 1.2 being predominant (49%). In addition to these age classes, one fish in each of the age classes 2.3 and 1.5 was present in the samples. The estimated sex ratio for the entire run was 34% female, and estimates for each stratum ranged from 0% to 50% female fish. Female Chinook salmon ranged from 660 to 930 mm METF and males ranged from 425 to 920 mm METF (Table 3). For length-at-age measurements, mean lengths of female fish were larger than males.

Table 2. — Age and sex ratio estimates, by stratum of Chinook salmon sampled at Gisasa River weir, Alaska, 2007. Standard errors are in parentheses. Season totals are calculated from weighted strata totals. Unknown age indicates numbers of fish that could not be aged from the scales sampled and were not included in age calculations.

| | | | | | Brood year and age | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Strata | Run size | Sample | | Unknown | 2003 | 2002 | 2001 | | 2000 |
| dates | (N) | size (n) | % Female | age | 1.2 | 1.3 | 1.4 | 2.3 | 1.5 |
| 6/24 - 7/7 | 144 | 14 | 0 (0.0) | 1 | 77% (12.2) | 8% (7.7) | 15% (10.4) | 0.0% (0.0) | 0.0% (0.0) |
| 7/8 - 14 | 361 | 81 | 20 (4.5) | 3 | 41% (5.6) | 26% (5.0) | 33% (5.4) | 0.0% (0.0) | 0.0% (0.0) |
| 7/15 -21 | 432 | 122 | 39 (4.4) | 8 | 21% (3.8) | 25% (4.1) | 54% (4.7) | 0.0% (0.0) | 0.0% (0.0) |
| 7/22 - 28 | 490 | 138 | 50 (4.3) | 7 | 23% (3.7) | 14% (3.0) | 62% (4.3) | 0.8% (0.8) | 0.8% (0.8) |
| Total | 1,427 | 355 | 34 (2.3) | 19 | 32% (2.5) | 20% (2.2) | 47% (2.7) | 0.3% (0.3) | 0.3% (0.3) |
| Female | 483 | 132 | | 6 | 0% (0.0) | 8% (2.5) | 91% (2.6) | 0.0% (0.0) | 0.8% (0.8) |
| Male | 944 | 223 | | 13 | 49% (3.5) | 26% (3.0) | 25% (3.1) | 0.4% (0.4) | 0.0% (0.0) |

Table 3. — Length at age of female and male Chinook salmon sampled at Gisasa River weir, Alaska, 2007.

| | Female | | | | | Male | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mid-eye to fork length (mm) | | | | | Mid-eye to fork length (mm) | | | |
| Age | N | Mean | SE | Median | Range | N | Mean | SE | Median | Range |
| 1.2 | 0 | - | - | - | - | 95 | 533 | 5.8 | 530 | 425 - 830 |
| 1.3 | 10 | 740 | 15.0 | 750 | 660 - 830 | 58 | 691 | 8.3 | 680 | 590 - 870 |
| 1.4 | 114 | 826 | 4.1 | 830 | 690 - 930 | 55 | 792 | 8.8 | 790 | 620 - 920 |
| 1.5 | 1 | 915 | - | - | - | 0 | - | - | - | - |
| 2.3 | 0 | - | - | - | - | 1 | 770 | - | - | - |
| Total | 125 | | | | | 209 | | | | |

### *Chum Salmon*

The first chum salmon were counted on June 24, when five were passed through the weir. During the final day of counting, July 28, 1,254 summer chum salmon (2.7% of the seasonal estimate) were counted. Run timing was near average, with the first quartile passage date (July 4) two days later than the 1995-2006 average, median passage date (July 10) one day later, and the third quartile passage date (July 20) six days later than the 1995-2006 average. The average (1995-2006) seasonal estimate for summer chum salmon was greatly influenced by the high escapements during 1995, 1996, 2005, and 2006 (Figure 3). Therefore, while the 2007 estimate of 46,257 summer chum salmon was only 60% of the average, it was 142% of the median for the same period and was the fifth highest estimate to date (Figure 3, Appendix 1).

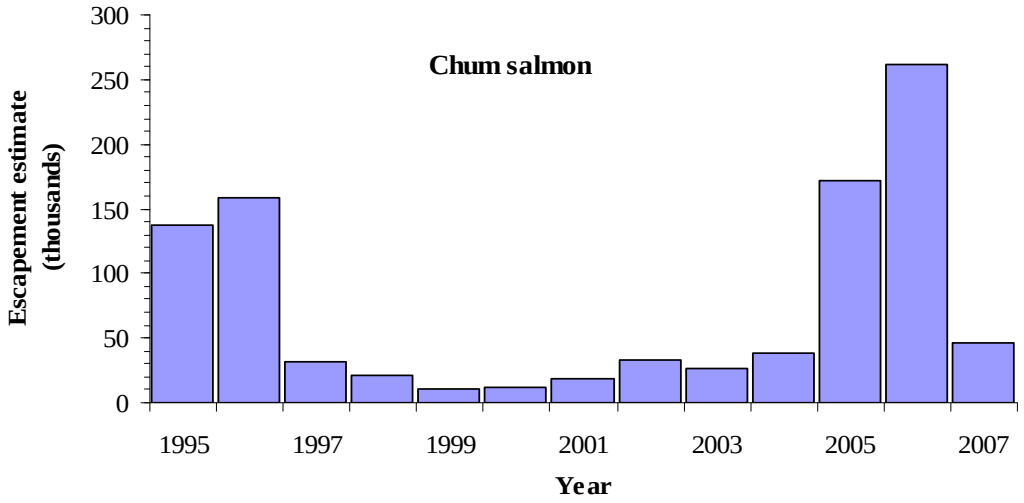


Figure 3. — Chum salmon escapement estimates at the Gisasa River weir 1995-2007. Data from the first year of operation, 1994, is not included as counting did not begin until July 10, after the run was underway.

Age, sex, and length samples were not collected during the first statistical week of weir operations; therefore, fish passing during the first week were included in the second statistical week calculations. Age, sex, and length samples were collected from 664 summer chum salmon but age was unable to be determined for 85 (13%) of those samples. There were two primary age classes, 0.4 and 0.3, from brood years 2002 and 2003, respectively (Table 4). Age class 0.3 was predominant, accounting for 55% of the season total, with stratum estimates ranging from 53% to 58%. Age class 0.4 accounted for 37% of the season total, with stratum estimates ranging from 31% to 39%. Also included were age classes 0.5 and 0.2, accounting for 6% and 2% of the season total respectively. The estimated sex ratio for the entire run was 57% female, and estimates for each stratum ranged from 51% to 68% female fish. Female summer chum salmon ranged from 400 to 650 mm METF and males ranged from 500 to 670 mm METF (Table 5). For length-at-age measurements, mean lengths of male fish were larger than females.

Table 4. — Age and sex ratio estimates, by stratum of summer chum salmon sampled at Gisasa River weir, Alaska, 2007. Standard errors are in parentheses. Season totals are calculated from weighted strata totals. Unknown age data indicate numbers of fish that could not be aged from the scales sampled and were not included in age calculations.

| | | | | | Brood year and age | | | |
|---|---|---|---|---|---|---|---|---|
| | Run size | Sample | | Unknown | 2004 | 2003 | 2002 | 2001 |
| Strata | (N) | size (n) | % Female | age | 0.2 | 0.3 | 0.4 | 0.5 |
| 6/24 – 7/7 | 18,722 | 178 | 54 (3.7) | 21 | 1% (0.9) | 56% (4.0) | 39% (3.9) | 3% (1.4) |
| 7/8 - 14 | 10,613 | 159 | 51 (4.0) | 20 | 4% (1.7) | 55% (4.2) | 33% (4.0) | 7% (2.2) |
| 7/15 -21 | 7,382 | 167 | 68 (3.6) | 23 | 3% (1.5) | 58% (4.1) | 31% (3.9) | 8% (2.3) |
| 7/22 - 28 | 9,540 | 160 | 59 (3.9) | 21 | 1% (1.0) | 53% (4.3) | 39% (4.1) | 7% (2.2) |
| Total | 46,257 | 664 | 57 (2.0) | 85 | 2% (0.6) | 55% (2.2) | 37% (2.1) | 6% (1.0) |
| Female | 26,265 | 389 | | 52 | 3% (0.9) | 55% (2.9) | 37% (2.8) | 5% (1.1) |
| Male | 19,992 | 275 | | 33 | 2% (1.7) | 56% (3.3) | 35% (3.2) | 7% (1.6) |

Table 5. — Length at age of female and male summer chum salmon sampled at Gisasa River weir, Alaska, 2007.

| | Female | | | | | Male | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mid-eye to fork length (mm) | | | | | Mid-eye to fork length (mm) | | | |
| Age | N | Mean | SE | Median | Range | N | Mean | SE | Median | Range |
| 0.2 | 9 | 532 | 17.9 | 550 | 400 - 575 | 6 | 561 | 10.4 | 555 | 540 - 610 |
| 0.3 | 183 | 540 | 2.4 | 545 | 425 - 650 | 138 | 562 | 2.6 | 560 | 500 - 670 |
| 0.4 | 125 | 554 | 2.6 | 550 | 465 - 630 | 81 | 579 | 3.9 | 580 | 500 - 660 |
| 0.5 | 20 | 552 | 8.0 | 553 | 460 - 620 | 17 | 579 | 8.0 | 575 | 535 - 660 |
| Total | 337 | | | | | 242 | | | | |

It is essential to continue collecting information from individual salmon stocks, including those in the Koyukuk River drainage because of the complexity and difficulty of managing the mixed-stock subsistence and commercial salmon fisheries in the Yukon River,. Additionally, this project has a history of 13 years of data, providing population status and trend data over a time-series, the value of which will increase as the length of time series increases. Additionally, time series data such as these will likely become increasingly important for investigating the effects of climate change.

## Acknowledgements

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Appendix 1. — Historical Chinook salmon and summer chum salmon escapement in the Gisasa River, 1960 - 2007 (Aerial index data from Barton 1984; Alaska Department of Fish and Game unpublished data)

| | Aerial index estimates | | | Weir estimates | |
|---|---|---|---|---|---|
| Year | Chinook salmon | Chum salmon | Rating | Chinook salmon | Chum salmon |
| 1960 | 300 | 400 | Good | | |
| 1961 | 266 | 0 | Good | | |
| | | | | | |
| 1974 | 161 | 22,022 | Good | | |
| 1975 | 385 | 56,904 | Good | | |
| 1976 | 332 | 21,342 | Good | | |
| 1977 | 255 | 2,204 | Good | | |
| 1978 | 45 | 9,280 | Good | | |
| 1979 | 484 | 10,962 | Good | | |
| 1980 | 951 | 10,388 | Good | | |
| | | | | | |
| 1982 | 421 | 334 | Good | | |
| 1983 | 572 | 2,356 | Good | | |
| | | | | | |
| 1985 | 735 | 13,232 | Good | | |
| 1986 | 1,346 | 12,114 | Good | | |
| 1987 | 731 | 2,123 | Good | | |
| 1988 | 797 | 9,284 | Good | | |
| | | | | | |
| 1990 | 884 | 450 | Good | | |
| 1991 | 1,690 | 7,003 | Good | | |
| 1992 | 910 | 9,300 | Good | | |
| 1993 | 1,573 | 1,581 | Good | | |
| 1994 | 2,775 | 6,827 | Good | 2,888[a] | 51,116[a] |
| 1995 | 410 | 6,458 | Good | 4,023 | 136,886 |
| 1996 | | | | 1,991 | 158,752 |
| 1997 | 144 | 686 | Good | 3,764 | 31,800 |
| 1998 | 889 | | Poor | 2,414 | 21,142 |
| 1999 | | | | 2,644 | 10,155 |
| 2000 | | | | 2,089 | 11,410 |
| 2001 | 1298 | | Good | 3,052 | 17,946 |
| 2002 | 506 | | Good | 2,025 | 33,481 |
| 2003 | | | | 1,901 | 25,999 |
| 2004 | 731 | | Good | 1,774 | 37,851 |
| 2005 | 958 | | Good | 3,111 | 172,259 |
| 2006 | 843 | 1000 | Fair | 3,030 | 261,305 |
| 2007 | 593 | | Fair | 1,427 | 46,257 |

[a] Partial weir count.

Appendix 2. — Water depth and temperature data collected at the Gisasa River weir, 2008. Depth is the water depth at the trap.

| Date | Depth (cm) | Temperature (°C) |
|---|---|---|
| 6/24/05 | 66 | - |
| 6/25/05 | 66 | - |
| 6/26/05 | 73 | 14.0 |
| 6/27/05 | 74 | 14.0 |
| 6/28/05 | 66 | 14.0 |
| 6/29/05 | 64 | 14.0 |
| 6/30/05 | 62 | 11.0 |
| 7/1/05 | 82 | 13.0 |
| 7/2/05 | 74 | 15.0 |
| 7/3/05 | 72 | 17.0 |
| 7/4/05 | 65 | 13.0 |
| 7/5/05 | 62 | 17.0 |
| 7/6/05 | 60 | 15.0 |
| 7/7/05 | 57 | 17.0 |
| 7/8/05 | 55 | 18.0 |
| 7/9/05 | 54 | 17.0 |
| 7/10/05 | 52 | 18.0 |
| 7/11/05 | 52 | 18.0 |
| 7/12/05 | 54 | 17.0 |
| 7/13/05 | 60 | 15.0 |
| 7/14/05 | 68 | 15.0 |
| 7/15/05 | 60 | 15.0 |
| 7/16/05 | 56 | 14.0 |
| 7/17/05 | 55 | 14.0 |
| 7/18/05 | 57 | 15.0 |
| 7/19/05 | 65 | 15.0 |
| 7/20/05 | 61 | 15.0 |
| 7/21/05 | 62 | 14.0 |
| 7/22/05 | 65 | 14.0 |
| 7/23/05 | 61 | 13.0 |
| 7/24/05 | 58 | 14.0 |
| 7/25/05 | 56 | 14.0 |
| 7/26/05 | 54 | 16.0 |
| 7/27/05 | 53 | 16.0 |
| 7/28/05 | 52 | 14.0 |