U.S. Fish & Wildlife Service

Abundance and Run Timing of Adult Salmon in the Gisasa River, Koyukuk National Wildlife Refuge, Alaska, 2009

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Fairbanks Fish and Wildlife Field Office
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Cover Photo: Gisasa River Weir 2009, courtesy of Mike Parker, Alaska Department of Fish and Game

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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 *Oncorhynchus tshawytscha* and chum salmon *O. keta* in the Gisasa River. This was the fifteenth year of operating the weir at this location. In 2009, the weir was operated from June 23 through July 30. An estimated 1,955 Chinook salmon and 25,904 summer chum salmon passed through the weir. The most abundant other species was longnose sucker *Catostomus catostomus* (N = 61), followed by northern pike *Esox lucius* (N = 38), sockeye salmon *O. nerka* (N = 10), Arctic grayling *Thymallus arcticus* (N = 8), Dolly Varden *Salvelinus malma* (N = 5), and whitefish spp. (Coregoninae; N = 3). The estimated weekly sex composition for Chinook salmon ranged from 21% to 32% female fish. Three primary age classes were identified, 1.2, 1.3, and 1.4, for Chinook salmon, with a dominant age class of 1.2 (42%). The estimated weekly sex composition for summer chum salmon ranged from 33% to 71% female fish. There were two primary age classes identified, 0.3 and 0.4, with a dominant age class of 0.3 (61%).

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 some improvement beginning in 2001 and continuing through 2005 (JTC 2006), with some declines again occurring in 2007 and 2008 (JTC 2009). 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 counts; information provided by test

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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) has conducted these surveys on several index tributaries within the Koyukuk River drainage intermittently since 1960 (Barton 1984). Aerial surveys, however, are highly variable and provide only a point in time 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. Therefore, weirs or counting towers have been operated in five different Koyukuk River tributaries between 1994 and 2009 (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 2008 ranged from 1,427 to 4,023 fish (Figure 2). Chum salmon escapement estimates for the same period ranged from 10,155 to 261,305 fish (Figure 3). For 2009, the objectives of the Gisasa River weir were to: (1) determine daily passage, estimate seasonal escapement, and describe 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 to the northeast as it passes through the Koyukuk National Wildlife Refuge. Approximately 112 km from its source, the Gisasa river enters the Koyukuk River at roughly 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 dramatic 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 is located approximately 4 km upriver from the mouth of the Gisasa River. This section of the river is straight with generally laminar flow. The river bed slopes gradually from the stream banks to the thalweg. The river width is approximately 45 m, and depth, measured at the trap located near the thalweg, ranged from 44 to 81 cm throughout the 2009 season (Appendix 2). Predominant substrate at the weir site consisted of medium size gravel 25-50 mm diameter.

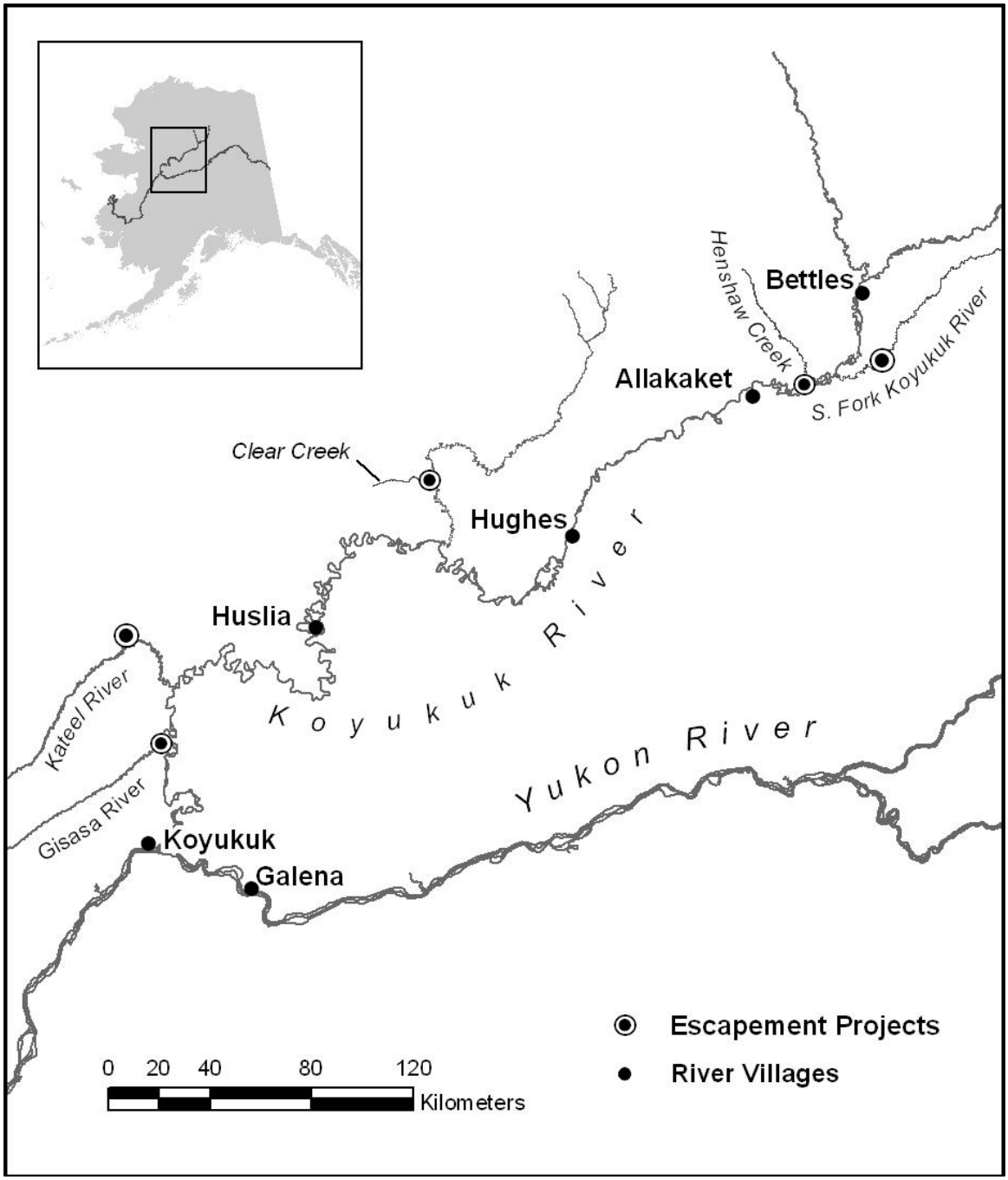

Figure 1. — Location of the Gisasa River weir and other active and historical tributary escapement project sites in the Koyukuk River drainage, Alaska.

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 Gisasa River weir has been installed at the same site since the project was initiated in 1994, following the construction and installation methods described by Tobin (1994). 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 approximately mid-channel, near the thalweg, 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.

Biological Data

The target start date of the project was based on previous years' salmon run timing data. The end date of the project is determined in-season, normally 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. Daily counts were less than 1% for the last five days of counting for chum salmon and for four of the last five days for Chinook salmon. All fish passing through the weir were identified to species and enumerated, with the exception of whitefish *Coregonus* and *Prosopium* spp. Non-salmon species were not handled, so it was difficult to identify 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 in the season, when fish passage was low, the weir was unmonitored from 0000 hours to 0800 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

Days with counts greater than 6 h but less that 24 h were 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*. Counts from days with less than 6 h of the day counted were disregarded and those days were treated as completely missed days. Completely missed days were 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. A statistical week was generally 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 salmon 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 1400 hours on June 23, with one summer chum salmon and no Chinook salmon counted on that day. Counting continued throughout the season with no substantial interruptions. The counting was discontinued at 1200 hours on July 30 and adjusted for 24 hours. The picket spacing (3.5cm space between pickets) within the trap and weir panels was narrow enough to prevent adult Chinook salmon 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 1,955 Chinook salmon and 25,904 summer chum salmon (Table 1). The most abundant other species was longnose sucker *Catostomus catostomus* (N = 61), followed by northern pike *Esox lucius* (N = 38), sockeye salmon *O. nerka* (N = 10) Arctic grayling *Thymallus arcticus* (N = 8), Dolly Varden *Salvelinus malma* (N = 5) and whitefish spp. (Coregoninae; N = 3).

Chinook Salmon

The first Chinook salmon was counted on July 1, when five were passed through the weir. During the final day of weir operation (July 30), 14 Chinook salmon (0.7% of the seasonal estimate) were estimated to have passed through the weir. Run timing was near average, with the first quartile passage date (July 13) two days later than the 1995-2008 average, the median passage date (July 16), one day later than the average, and the third quartile passage date (July 19) occurring on the 1995-2008 average (Table 1). The seasonal estimate of 1,955 Chinook salmon was 78% of the 1995-2008 average (2,499) and was the fifth lowest weir estimate to date (Figure 2, Appendix 1).

Due to low passage, minimal samples for age, sex, and length were collected during the early weeks of weir operations. Therefore, these statistical weeks were combined to make the first strata (6/23-7/11; Table 2). Samples were collected from 575 Chinook salmon during the season, with age unable to be determined for 54 (9%) of those samples. There were three primary age classes; 1.2, 1.3, and 1.4 from brood years 2005, 2004, and 2003, respectively. Age class 1.2 was predominant overall, accounting for 42% of the season total, with stratum estimates ranging from 39% to 44%. The second most abundant age class was 1.4, accounting for 32% of the season total, with stratum estimates ranging from 26% to 36%. Age class 1.3 accounted for 25% of the season total with stratum estimates ranging from 20% to 34%. The age distributions differed between males and females. Males were predominantly age 1.2 (58%) followed by age 1.3 (31%), while females were overwhelmingly dominated by age class 1.4 (89%). The estimated sex ratio for the entire run was 26% female, and estimates for each stratum ranged from 21% to 32% female fish. Female Chinook salmon ranged from 650 to 920 mm METF and males ranged from 395 to 915 mm METF (Table 3). For length-at-age measurements, mean lengths of female fish were larger than males.

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, 2009. Asterisks (*****) indicate first, median, and third quartiles of Chinook salmon and summer chum salmon passage estimates.

	Chinook salmon		Chum salmon		Longnose sucker	Northern pike	Sockeye salmon	Arctic grayling	Dolly Varden	Whitefish spp.
Date	Daily	Cum	Daily	Cum	Daily	Daily	Daily	Daily	Daily	Daily
Jun-23	0	0	2[a]	2	8	2	0	0	0	0
Jun-24	0	0	3	5	2	0	0	0	0	0
Jun-25	0	0	3	8	4	1	0	0	0	0
Jun-26	0	0	27	35	0	0	0	0	0	0
Jun-27	0	0	26	61	0	0	0	0	0	0
Jun-28	0	0	70	131	1	0	0	0	0	0
Jun-29	0	0	126	257	0	0	0	0	0	0
Jun-30	0	0	550	807	0	0	0	0	0	0
Jul-01	5	5	817	1,624	0	0	0	0	1	0
Jul-02	0	5	515	2,139	2	0	0	1	0	0
Jul-03	6	11	667	2,806	6	1	0	2	0	0
Jul-04	3	14	828	3,634	6	1	0	0	1	1
Jul-05	7	21	838	4,472	2	1	0	1	0	0
Jul-06	12	33	1,451	5,923	3	2	0	1	0	1
Jul-07	12	45	947	6,870*	4	0	0	2	0	0
Jul-08	44	89	1,197	8,067	2	0	0	0	1	0
Jul-09	36	125	1,062	9,129	2	2	0	0	0	0
Jul-10	23	148	1,002	10,131	2	2	0	0	0	0
Jul-11	254	402	1,961	12,092	3	0	0	1	0	1
Jul-12	40	442	1,578	13,670*	4	5	0	0	0	0
Jul-13	288	730*	2,060	15,730	4	2	1	0	0	0
Jul-14	40	770	1,484	17,214	1	0	0	0	0	0
Jul-15	189	959	1,180	18,394	0	3	2	0	0	0
Jul-16	201	1,160*	863	19,257	0	1	1	0	1	0
Jul-17	90	1,250	957	20,214*	2	4	1	0	0	0
Jul-18	200	1,450	736	20,950	0	0	1	0	0	0
Jul-19	20	1,470*	628	21,578	1	1	0	0	0	0
Jul-20	27	1,497	969	22,547	0	1	1	0	0	0
Jul-21	86	1,583	680	23,227	1	2	0	0	0	0
Jul-22	105	1,688	606	23,833	0	1	0	0	0	0
Jul-23	20	1,708	519	24,352	0	1	1	0	0	0
Jul-24	39	1,747	312	24,664	0	0	0	0	0	0
Jul-25	140	1,887	349	25,013	0	2	1	0	1	0
Jul-26	13	1,900	224	25,237	0	0	0	0	0	0
Jul-27	12	1,912	150	25,387	1	0	0	0	0	0
Jul-28	9	1,921	143	25,530	0	1	1	0	0	0
Jul-29	20	1,941	210	25,740	0	2	0	0	0	0
Jul-30	14[b]	1,955	164[b]	25,904	0	0	0	0	0	0
Total	1,955		25,904		61	38	10	8	5	3

[a] Counting began at 14:00 h, chum salmon passage estimates expanded to 24 hrs.
[b] Counting ceased at 12:00 h, passage estimates expanded to 24 hrs.

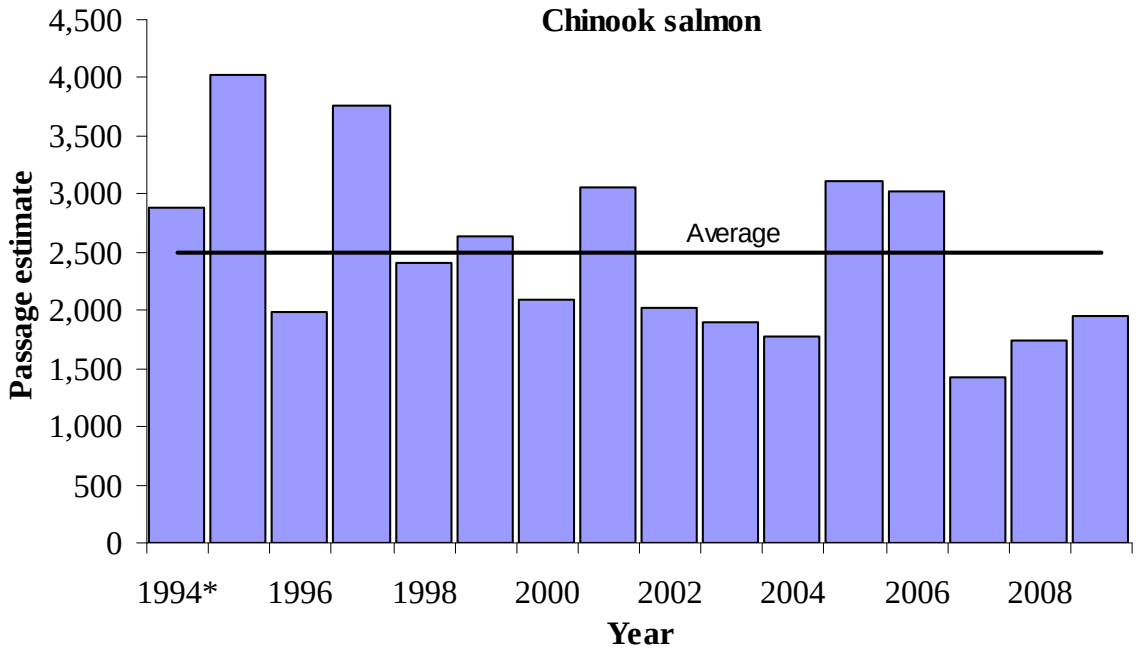

Figure 2. — Chinook salmon escapement estimates at the Gisasa River weir 1994-2009. *Data from the first year of operation (1994) is only a partial count; counting did not begin until July 10, after the run was underway and this data is not included in averages. Horizontal line represents the 1995-2008 average.

Table 2. — Age and sex ratio estimates, by stratum, of Chinook salmon at Gisasa River weir, Alaska, 2009. 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			
					2005	2004	2003	2002
Strata dates	Run size (N)	Sample size (n)	% Female	Unknown age	1.2	1.3	1.4	1.5
6/23 - 7/11	402	177	21 (3.1)	20	39% (3.9)	34% (3.8)	26% (3.5)	0% (0.0)
7/12 - 18	1,048	161	26 (3.5)	17	43% (4.1)	23% (3.5)	34% (4.0)	0% (0.0)
7/19 - 24	297	133	31 (4.0)	8	42% (4.4)	24% (3.8)	33% (4.2)	1% (0.8)
7/25 - 30	208	104	32 (4.6)	9	44% (5.1)	20% (4.1)	36% (4.9)	0% (0.0)
Total	1,955	575	26 (2.1)	54	42% (2.5)	25% (2.2)	32% (2.4)	<1% (0.1)
Female	515	153		9	0% (0.0)	10% (2.8)	89% (2.8)	<1% (0.5)
Male	1,440	422		45	58% (2.9)	31% (2.7)	11% (1.9)	0.0% (0.0)

Table 3. — Length at age of female and male Chinook salmon sampled at Gisasa River weir, Alaska, 2009.

	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	-	-	-	-	219	574	3.7	575	395 - 740
1.3	17	766	15.0	795	650 - 855	119	690	5.5	680	555 - 915
1.4	126	837	3.7	835	745 - 920	39	779	7.1	780	650 - 885
1.5	1	875	-	-	-	0	-	-	-	-
Total	144					377				

Chum Salmon

The first chum salmon was counted on June 23. During the final day of counting (July 30), 164 summer chum salmon (0.6% of the seasonal estimate) were estimated to have passed through the weir. Run timing was near average, with the first quartile passage date (July 7) one day later than the 1995-2008 average, and the median and third quartile passage dates (July 12 and 17 respectively) occurring on the 1995-2008 averages. The 1995-2008 average of the seasonal estimates for summer chum salmon is greatly influenced by the high escapements during 1995, 1996, 2005, and 2006 (Figure 3). The 2009 estimate of 25,904 summer chum salmon was only 36% of this average (71,584), and 74% of the median (35,210) for the same period (Figure 3, Appendix 1). The 2009 estimate was the 5th lowest estimate to date.

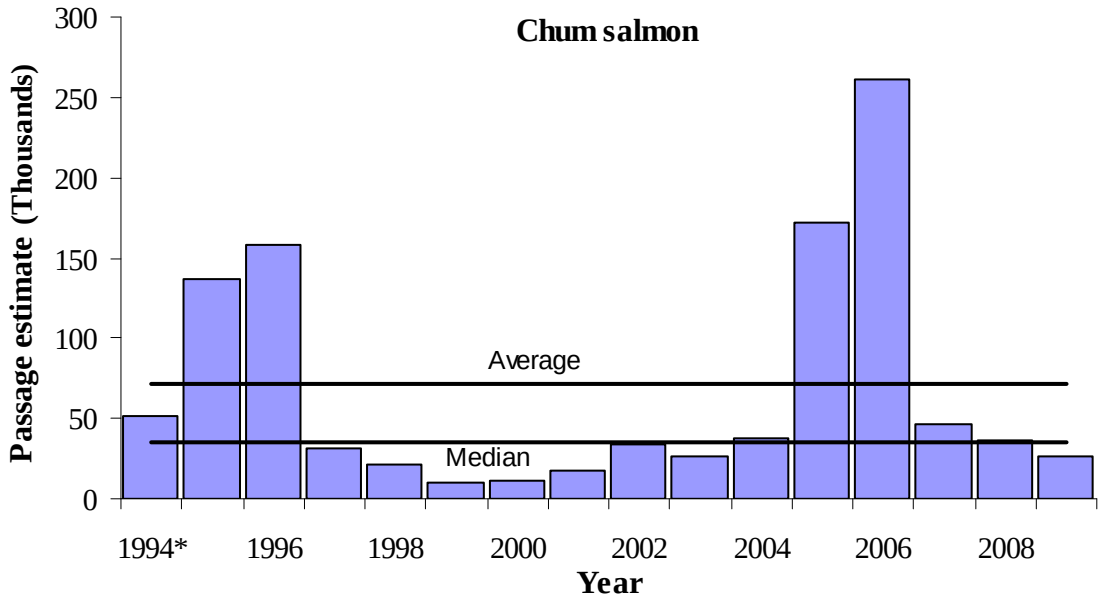

Figure 3. — Chum salmon escapement estimates at the Gisasa River weir 1994-2009. *Data from the first year of operation (1994), is only a partial count; counting did not begin until July 10, after the run was underway and this data is not included in averages. Horizontal lines represent the 1995-2008 average and median.

Due to low passage, minimal samples for age, sex, and length were collected during the first statistical week of weir operations. Because of this low sample size, the first two statistical weeks were combined to make the first strata (6/23-7/4; Table 4). Age, sex, and length samples were collected from 667 summer chum salmon, with age unable to be determined for 48 (7%) of those samples. There were two primary age classes; 0.3 and 0.4, from brood years 2005 and 2004, respectively. Age class 0.3 was predominant, accounting for 61% of the season total, with stratum estimates ranging from 51% to 70%. Age class 0.4 accounted for 34% of the season total, with stratum estimates ranging from 26% to 43%. Also included were age classes 0.2 and 0.5, accounting for 3% and 2% of the season total respectively. Age distributions were similar for both sexes. The estimated sex ratio for the entire run was 53% female, and estimates for each stratum ranged from 33% to 71% female fish. Female summer chum salmon ranged from 435 to 615 mm METF and males ranged from 485 to 660 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 at Gisasa River weir, Alaska, 2009. 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			
					2006	2005	2004	2003
Strata dates	Run size (N)	Sample size (n)	% Female	Unknown age	0.2	0.3	0.4	0.5
6/23 - 7/4	3,634	101	33 (4.7)	9	1% (1.1)	51% (5.2)	43% (5.2)	4% (2.1)
7/5 - 7/11	8,458	163	44 (3.9)	9	1% (0.6)	58% (4.0)	38% (3.9)	3% (1.3)
7/12 - 18	8,858	158	61 (3.9)	17	4% (1.7)	63% (4.1)	30% (3.9)	3% (1.4)
7/19 -24	3,714	165	71 (3.5)	12	6% (1.9)	68% (3.8)	26% (3.6)	0% (0.0)
7/25 - 30	1,240	80	63 (5.4)	1	3% (1.8)	70% (5.2)	28% (5.1)	0% (0.0)
Total	25,904	667	53 (2.0)	48	3% (0.7)	61% (2.1)	34% (2.1)	2% (0.7)
Female	13,718	368		30	4% (1.1)	63% (2.9)	31% (2.8)	1% (0.8)
Male	12,186	299		18	2% (0.6)	58% (3.1)	37% (3.0)	4% (1.2)

Table 5. — Length at age of female and male summer chum salmon sampled at Gisasa River weir, Alaska, 2009.

	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	14	540	7.0	543	500 - 590	5	546	20.2	540	485 - 610
0.3	219	542	1.8	545	435 - 600	166	574	2.1	570	500 - 640
0.4	102	554	2.7	555	460 - 615	101	590	3.1	590	515 - 660
0.5	3	573	11.7	570	555 - 595	9	595	12.6	605	540 - 650
Total	338					281				

The information collected at the Gisasa River weir is vital to the difficult task of managing the complex mixed-stock subsistence and commercial salmon fisheries in the Yukon River. In-season management and post season evaluations of management actions are greatly enhanced by the data from this and other stock assessment projects. Additionally, this project has produced 15 years of data enabling analyses of trends in population status, size, length, age, and gender composition of the run, developing future run projections, and setting and evaluating harvest and escapement goals and allocations. Furthermore, these time series data will become increasingly valuable as stressors such as climate change, disease, selective harvest, and overall demand on the resources of the dynamic Yukon River system continue to increase.

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Appendix 1. — Historical Chinook salmon and summer chum salmon escapement in the Gisasa River, 1960 - 2009 (Aerial index data from Barton 1984; Alaska Department of Fish and Game unpublished data)

	Aerial index estimates			Weir estimates	
Year	Chinook salmon	Chum salmon	Survey 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
2008	487		Fair	1,738	36,938
2009	515[b]	1060[b]	Good[b]	1,955	25,904

[a] Partial weir count.
[b] Preliminary data

Appendix 2. — Water depth, water temperature, and air temperature data collected at the Gisasa River weir, 2009. Depth is the water depth at the trap. Measurements were taken twice daily at approximately 07:00 and 19:00 hours.

	Depth (cm)		Water temperature (°C)		Air temperature (°C)	
Date	07:00	19:00	07:00	19:00	07:00	19:00
6/24/08	70	—	12	—	10.6	—
6/25/08	75	—	11	—	9.8	—
6/26/08	81	—	9	—	9.1	—
6/27/08	79	—	9	—	8.3	—
6/28/08	77	76	9	10	7.0	13.7
6/29/08	74	70	9	10	9.1	14.9
6/30/08	69	67	9	12	9.0	22.3
7/1/08	65	—	11	—	9.5	—
7/2/08	62	62	11	16	14.2	—
7/3/08	60	59	14	17	13.0	29.0
7/4/08	58	58	15	16	14.9	19.3
7/5/08	57	56	13	17	12.7	23.6
7/6/08	56	55	15	19	13.6	28.0
7/7/08	55	54	16	19	18.5	27.6
7/8/08	54	54	17	16	14.4	14.0
7/9/08	55	57	13	15	15.1	19.0
7/10/08	56	55	13	17	11.0	21.5
7/11/08	54	53	14	18	12.0	24.4
7/12/08	52	52	15	19	17.4	28.0
7/13/08	51	51	17	19	16.5	26.6
7/14/08	50	50	18	19	18.5	24.8
7/15/08	49	49	17	19	13.0	22.8
7/16/08	48	48	16	17	11.1	22.8
7/17/08	48	48	16	18	13.0	25.1
7/18/08	48	47	16	18	10.5	22.4
7/19/08	47	47	17	18	15.0	20.3
7/20/08	47	47	16	17	15.5	22.4
7/21/08	46	46	16	18	11.5	22.4
7/22/08	45	45	16	16	10.8	20.8
7/23/08	45	45	14	15	7.4	16.3
7/24/08	46	46	14	16	10.5	19.0
7/25/08	46	45	14	17	9.7	19.3
7/26/08	45	45	14	16	13.0	19.6
7/27/08	44	44	14	15	8.7	17.6
7/28/08	45	44	14	16	8.6	19.4
7/29/08	45	46	15	17	12.8	22.6
7/30/08	46	—	15	—	10.5	—