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Abundance and Run Timing of Adult Salmon in the Tozitna River, Alaska, 2003

Tim Sundlov, Carl Kretsinger, and Bob Karlen

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Cover Photo

Tim Sundlov counts salmon as they exit the weir's live trap, Tozitna River. BLM photo by Craig McCaa.

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ABSTRACT

The Tozitna River project is a multi-agency study to determine escapement, run timing, and age–sex–length (ASL) composition of adult Chinook and summer chum salmon in a middle Yukon Basin tributary. A resistance board weir was operated from 23 June to 8 August 2003. High stream discharge from the periods of 2 to 6 July and 26 July to 8 August prevented counting and biological sampling; no interpolation was made for these periods. Comparison of run timing to 2002 and to other tributaries with similar run timing suggests the majority of the Chinook salmon run was counted. The escapement for Chinook salmon was 1,819. Females composed 18% of the overall escapement. Age groups 1.2 and 1.3 accounted for 28% and 52% of the escapement, respectively. The majority of the summer chum salmon escapement was not counted, and ASL composition was determined with partial escapement data. The escapement for summer chum salmon was 8,487, and 34% of the total fish sample was female. Age 0.3 comprised 83% of the chum escapement.

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INTRODUCTION

Conservation of salmon in the Yukon River drainage is complex and challenging for fisheries managers because of several biological and social factors: mixed-stocks, large geographic spawning distribution, overlapping and compressed run timing, recent declines in escapement, multiple user groups, and multi-agency management. Several plans and policies have been created to manage the Yukon River salmon escapement (see Holder and Senecal-Albrecht 1998). Mostly, the Yukon River salmon escapement is managed based on sustained yield, defined as the average annual yield resulting from an escapement level that can be maintained on a continuing basis.

In 1998, the Yukon River Comprehensive Salmon Plan for Alaska (YRCSPA) was developed to improve salmon management in the Yukon Area. On October 1, 1999, the Federal government joined the State of Alaska in managing Yukon River fisheries, assuming responsibility for subsistence fisheries management in inland navigable waters on, and adjacent to, Federal conservation lands (Buklis 2002).

In 2000, the Bureau of Land Management (BLM) in Alaska received a Congressional appropriation for Yukon River salmon restoration. In response to this appropriation, BLM convened interagency coordination meetings to determine the most beneficial use of the funding. Emphasis was placed on funding projects that would satisfy both BLM and Yukon River fisheries management. Yukon River fisheries managers placed a priority on addressing escapement and run timing data gaps in the middle Yukon River Sub-Basin for Chinook (*Oncorhynchus tshawytscha*) and summer chum (*O. keta*) salmon, as identified in the YRCSPA (Holder and Senecal-Albrecht 1998). After interagency coordination meetings, the BLM chose the Tozitna River. BLM had in 1986 designated the Tozitna River an Area of Critical Environmental Concern for the protection of salmon spawning habitat and had identified acquisition of baseline resource data as a management objective (BLM 1986; Knapman 1989). In addition to addressing data gaps identified in the YRCSPA, salmon escapement and run timing data collected on the Tozitna River would assist BLM in fulfilling its management objectives.

Accurate escapement estimates from spawning tributaries are an important fisheries management tool used to assist in the determination of production, marine survival, harvest, and spawner recruit relationships (Neilson and Geen 1981; Labelle 1994). Although aerial escapement surveys on the Tozitna River have been conducted by the Alaska Department of Fish and Game (ADF&G) since 1959, results of aerial surveys are inherently variable (Schultz et al. 1993) and should only be used to examine trends in relative escapement abundance (Barton 1984). Samples taken at weirs are considered to be the least biased and most accurate data available for assessing escapement and age composition of a mixed stock fishery (Halupka et al. 2000).

To accurately assess escapement of Chinook and summer chum in the Middle Yukon Sub-Basin, BLM has operated a resistance board weir on the Tozitna River since 2002. Objectives of the project are to:

(1) Determine escapement of Chinook and summer chum salmon;
(2) Describe the run timing of Chinook and summer chum salmon;
(3) Estimate relative abundance of Chinook and summer chum salmon downstream of the weir and document spawning locations using aerial survey techniques; and
(4) Estimate age–sex–length (ASL) composition of Chinook and summer chum salmon such that simultaneous 90% confidence intervals have maximum width of 0.20.

Additional project tasks are to:

(1) Measure water temperature, turbidity, precipitation, stream height, and determine stream discharge;
(2) Collect Chinook and summer chum salmon fin tissue samples for the USFWS genetic stock analysis; and
(3) Recover radio telemetry tags for the National Marine Fisheries Service and ADF&G Yukon Basin Chinook radio telemetry study.

STUDY AREA

The Tozitna River is a large, clear-water, northern tributary to the middle Yukon River, with a watershed area of 4, 212 km^2, 90% of which BLM manages (Figure 1). The watershed originates in the southeastern Ray Mountains at 1,676 m and flows southwesterly approximately 207 km to its confluence with the Yukon River (1,096 river km), 16 km downstream of Tanana. The average yearly precipitation is 32 cm with 62% occurring between June and September. Average monthly ambient temperature ranges from –28 to 22 °C.[1] The

[1] 1949 – 2003 average monthly temperature and precipitation data for the Tanana FAA Airport, Alaska, supplied by Western Regional Climate Center, Reno, Nevada.

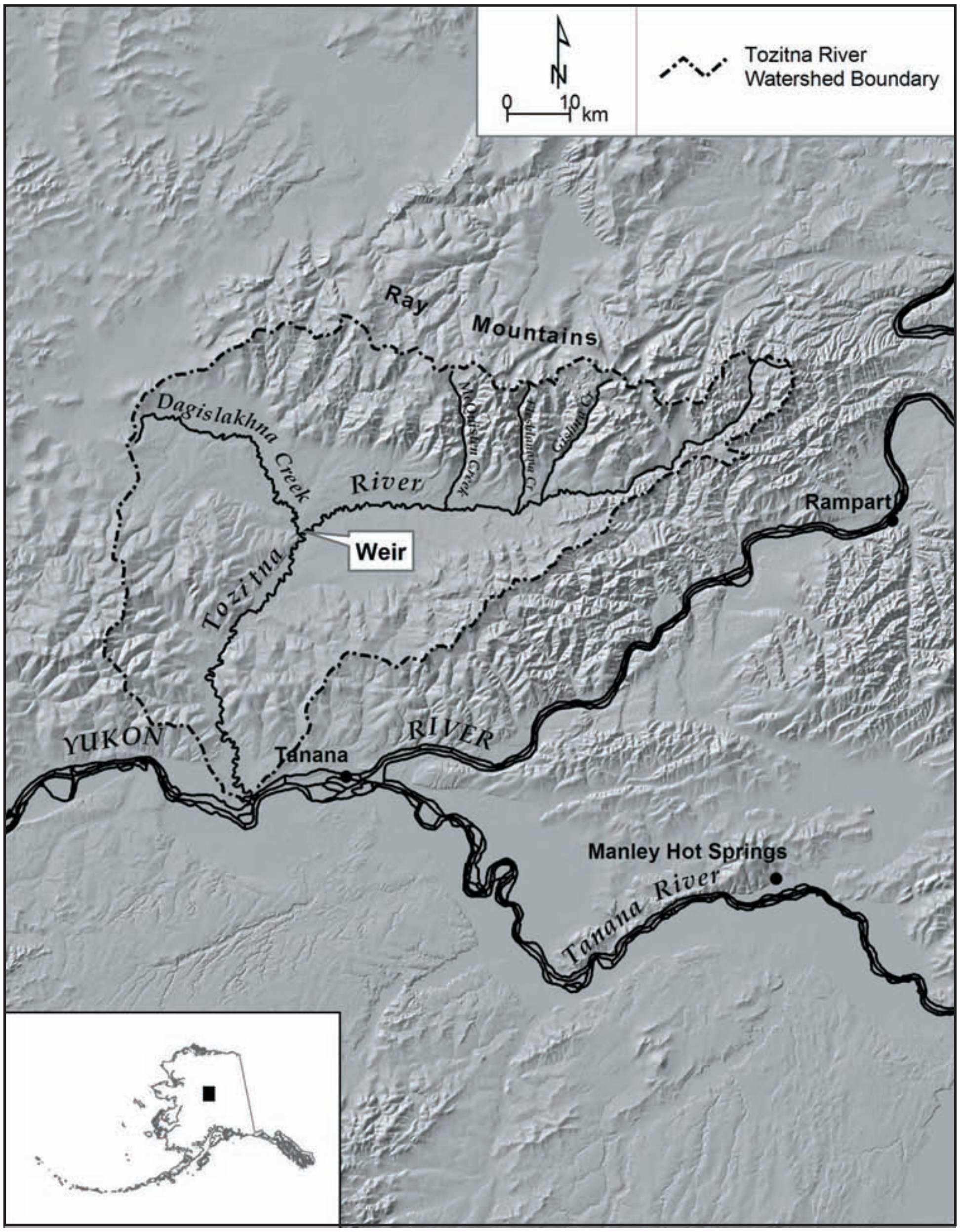


Figure 1. Location of the Tozitna River weir, Alaska, 2003. -

river is usually ice-free in May, and freeze-up commonly occurs by November (J. Blume, Tozitna River homesteader, Fairbanks, personal communication). Peak discharge is correlated with spring snowmelt or high-intensity rainstorms during the summer. Water turbidity remains low for the period from late June through early August, except for periods of high-intensity precipitation. Fish species in the Tozitna River include Chinook salmon, summer and fall chum salmon (Barton, 1984), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), Dolly Varden (*Salvelinus malma*), Arctic grayling (*Thymallus arcticus*), northern pike (*Esox lucius*), burbot (*Lota lota*), round whitefish (*Prosopium cylindraceum*), slimy sculpin (*Cottus cognatus*), and longnose sucker (*Catostomus catostomus*).

The weir site is approximately 80 km upstream from the mouth of the Tozitna River. The weir is located between a downstream riffle and upstream deep meander pool. At this location the average wetted width at summer flows is 64 m with an average depth of 0.7 m. This site is downstream of most Chinook salmon spawning (Kretsinger and Sundlov, in preparation). The cross-section is gradually sloping and the substrate consists of sand to cobble.

METHODS

Weir and Trap

Salmon escapement, run timing, and composition were assessed by counting and sampling fish as they passed through the resistance board weir fitted with an in-stream live trap. Construction and installation of the weir were as described by Tobin (1994).

The trap was preconstructed (Mackey Lake Co., Soldotna, AK) and incorporated into the weir on the upstream side. The weir was 65 m in width and was operational on 19 June.

The weir panels, base rail, and trap were visually inspected daily for possible escapement openings and for removal of accumulated debris.

Biological Data

All salmon passing through the weir and live trap were counted and identified to species.

Observers wore polarized sunglasses to facilitate in fish identification. The counting schedule was 24 h/d, 7 d/wk and consisted of one observer for each 6 h period. Except for sampling, salmon were counted without migration interruption as they proceeded through the open trap. Hourly counts were summed to achieve a daily count (0000–2359 hours). No interpolation was made for missed counting periods during high flows, which occurred from 2 to 6 July and 26 July to 8 August. Run timing was calculated by the proportion of daily to cumulative passage to determine quartile (25%, 50%, and 75%) dates and peak and median date of passage.

The live trap was used to capture salmon for biological sampling. The upstream gate of the trap was closed for periods to obtain an adequate sample size. During sampling, a dip-net was used to capture salmon in the live trap. Salmon were then placed in a partially submerged, aluminum cradle for identifying species and sex, measuring, and removing scale(s) and a fin clip. Lengths were measured to the nearest 5 mm from mid-eye to fork of the caudal fin. Morphological maturation characteristics were used to determine sex. One scale for chum and three scales for Chinook salmon were removed from the left side, two rows above the lateral line and on a diagonal line from the posterior end of the dorsal fin to the anterior end of the anal fin (Anas 1963; Mosher 1968). Scales were then placed on numbered gum cards and sent to the ADF&G, Division of Commercial Fisheries in Anchorage for aging. Aging was conducted by creating impressions on cellulose acetate cards with a heated hydraulic press (Clutter and Whitesel 1956) and then examining the scale annuli patterns (Gilbert 1922). European notation (Koo 1962) was used to record the ages. A holding pen (4 m x 2 m) was constructed adjacent to the trap, and after sampling, fish were transferred and held for 0.5 h. The holding pen provided sampling recovery with low water velocity that facilitated upstream migration.

Abundance Downstream of the Weir

An aerial survey was to be conducted late in the run to estimate relative abundance of Chinook and summer chum salmon downstream of the weir and to document spawning locations. However, high stream flows and turbidities prevented this from occurring.

Genetic Samples

Throughout the run, dorsal fins were clipped from 250 Chinook and 250 summer chum salmon to provide tissue samples for genetic analysis. Fin clips were placed in 2 ml sample vials filled with 95% ethanol and sent to the U.S. Fish and Wildlife Service Fish Genetics Laboratory, Anchorage for processing.

Abiotic Measurements

Water temperature, turbidity, precipitation, and stream height data were collected daily from the period 21 June to 11 August. Water temperature was monitored with an Onset® Tidbit temperature logger at the weir, recorded every hour, and summarized as daily mean. Turbidity was measured using a Hach 2100P Portable Turbidimeter. Precipitation was measured daily for the previous 24 h with a rain gauge. A staff gauge was surveyed to reference marks at the weir to record relative stream height.

To determine stream discharge, water velocity was measured over a range of staff gauge heights using a Price AA current meter. Stream height measurements were used as the independent variable to estimate stream discharge for days when discharge was not measured. A stream height versus discharge rating was developed by combining the direct discharge measurements and computer-simulated peak flows using log-log regression (Rantz et al. 1982).

Data Analysis

Temporally stratified random sampling design (Cochran 1977) was used to collect and analyze ASL data, with statistical weeks defining strata. Sample size goals were established so that simultaneous 90% interval estimates of sex and age composition for each week have maximum widths of 0.20 (Bromaghin 1993). Strata began on Monday and ended the following Sunday with a weekly sample size target of 154 chum and 169 Chinook salmon sampled uniformly throughout the week (25 fish/species/day). All target species within the trap at the time of sampling were sampled to avoid bias. The first and last sampling strata are greater than a week because of low escapement for those periods. Details of statistical methods are presented in Appendix A.

RESULTS

Weir and Trap Operation

Weather systems in the summer often bring periods of rain to the interior of Alaska and occasionally produce high stream discharge, which can submerge weir panels and allow salmon to migrate over the weir undetected. Two strong precipitation events occurred at the weir in early and late July (Figure 2). During the period of 2 to 3 July, 2.1 cm of rain was recorded. This event resulted in submerged weir panels from 2 to 6 July, allowing salmon to migrate over the weir undetected. Large trees were caught on the weir panels, base rail, and trap during this period. Entire trees were pulled over the weir and pushed off the trap and base rail when possible, but on occasion debris had to be separated into smaller pieces and removed. On 3 July, a large tree and its root mass, caught by the trap perpendicular to the current, generated enough force to cause the trap's earth anchors to fail; subsequently the trap was washed 300 m downstream. Several pickets in four panels broke as the trap moved downstream over the weir. The trap was then winched upstream back into position and the weir panels were repaired. The weir was back in operation on 6 July at 1830 hours. Another strong system in late July brought record rainfall to the central interior. The high stream discharge submerged the panels from 26 July to 7 August, a result of 5.8 cm of rain. The weir and trap remained in place, but several trees had damaged the trap. On 8 August it was assumed from previous run timing data (Kretsinger and Sundlov, in preparation) that the migration period of summer chum and Chinook salmon was ending, and removal of the weir and trap was initiated during an available window of reduced stream discharge. The removal was completed on 12 August.

Escapement

Chinook salmon

Chinook salmon (N = 1,819) passed through the weir from 26 June to 26 July (Table 1). Daily Chinook escapement for the last four complete days of counting was < 3% of the cumulative escapement. Gisasa River Chinook have similar run timing (Kretsinger and Sundlov, in preparation), and 2003 preliminary data indicated that the Gisasa River midpoint was 13 July, a day earlier than the Tozitna River. More than 95% of the Gisasa River Chinook salmon cumulative escapement had occurred by 25 July, suggesting that the majority of the Tozitna River Chinook run was counted. The quartile days (25%, 50%, and 75%) of cumulative passage for Chinook salmon were 9, 14, and 19 July, respectively (Table 1 and Figure 3). Interpolation of Chinook salmon escapement for the missed counting period of 2 to 6 July did not affect run timing date determination. The

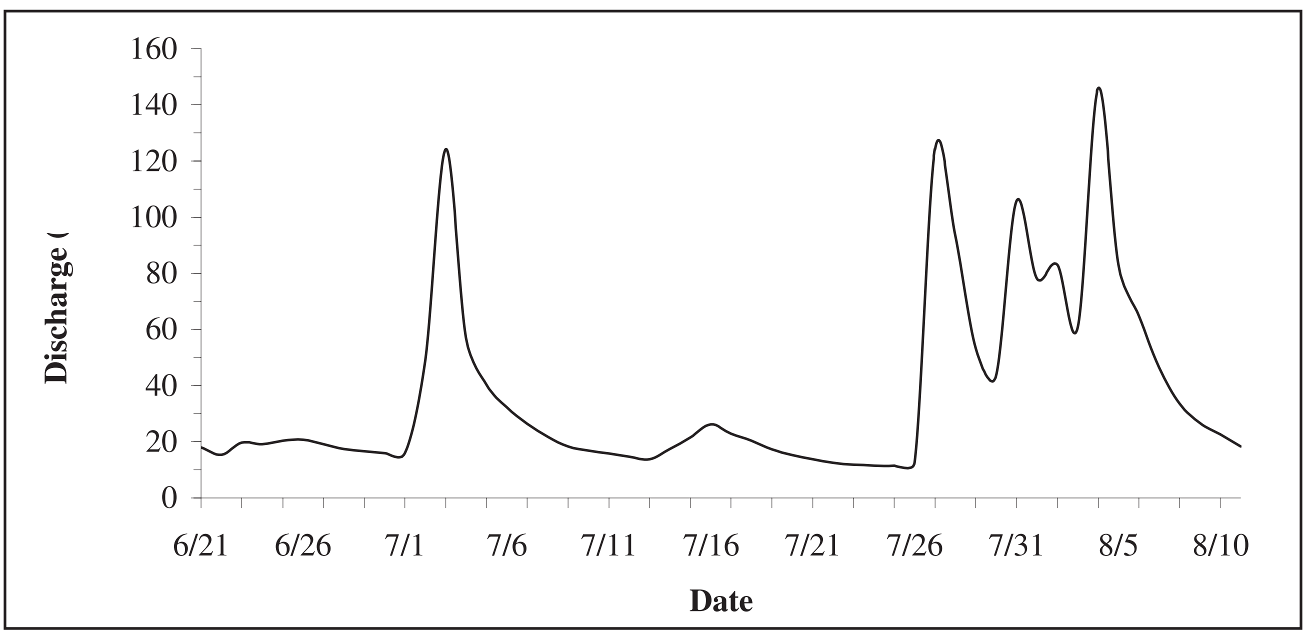


Figure 2. Daily discharge (m^3/s) for the period 21 June – 11 August 2003, Tozitna River, Alaska.

Table 1. Daily and cumulative counts for Chinook and summer chum salmon with quartiles shown (25%, 50%, and 75%) of cumulative escapement, Tozitna River, Alaska, 2003.

Date	Chinook			Summer chum	
	Daily Count	Cumulative Count	Cumulative Proportion	Daily Count	Cumulative Count
6/25	0	0	0.00	2	2
6/26	2	2	0.00	0	2
6/27	1	3	0.00	2	4
6/28	0	3	0.00	0	4
6/29	0	3	0.00	2	6
6/30	1	4	0.00	1	7
7/1	0	4	0.00	0	7
7/2[a]	4	8	0.00	1	8
7/3[b]	0	8	0.00	0	8
7/4[b]	0	8	0.00	0	8
7/5[b]	0	8	0.00	0	8
7/6[a]	25	33	0.02	3	11
7/7	21	54	0.03	3	14
7/8	52	106	0.06	13	27
7/9	365	471	0.26	92	119
7/10	140	611	0.34	146	265
7/11	50	661	0.36	106	371
7/12	90	751	0.41	138	509
7/13	153	904	0.49	72	581
7/14	62	966	0.53	155	736
7/15	98	1064	0.58	184	920
7/16	61	1125	0.61	72	992
7/17	46	1171	0.64	65	1057
7/18	166	1337	0.73	238	1295
7/19	123	1460	0.80	472	1767
7/20	92	1552	0.85	741	2508
7/21	117	1669	0.92	864	3372
7/22	25	1694	0.93	458	3830
7/23	12	1706	0.94	829	4659
7/24	54	1760	0.97	1403	6062
7/25	46	1806	0.99	1689	7751
7/26[a]	13	1819	1.00	736	8487

Boxed areas encompass second quartile, median, and third quartile.

[a] Portion of daily count missed; no interpolation made.

[b] Entire daily count missed; no interpolation made.

date of peak passage was 9 July (n = 365), and the 7 d period between 9 and 15 July accounted for 53% of the escapement. The midpoint date of passage for Chinook salmon in the lower Yukon River was six days earlier than the average date for the midpoint (preliminary data, ADF&G 2003a). The Tozitna River escapement midpoint was six days earlier than 2002.

Summer chum salmon

Summer chum salmon (N = 8,487) migrated through the weir from 25 June to 26 July (Table 1). Determinations of run timing and escapement for summer chum salmon were not possible because a significant portion of the run was missed due to high stream discharge.

Age–Sex–Length

Chinook salmon

Overall, Chinook salmon were predominantly age 1.3 (51.7%) and 1.2 (27.7%) (Table 3). Females were generally older (68% age 1.4 and only 31% age 1.3) than males (56% age 1.3 and 34% age1.2). The sex composition of Chinook salmon was 18% female, ranging from 3% to 55% throughout weekly sampling stratum (Table 2). The age structure of the run was reflected in size, with females ranging from 725 to 940 mm (97% ≥ 750 mm) and the smaller males ranging from 330 to 975 mm (18% ≥ 750 mm) (Table 4). Mean length of females age 1.3 and 1.4 was greater than that of same-age males.

Table 2. Proportion and estimated number of female Chinook salmon, Tozitna River, Alaska, 2003. Standard error in parentheses.

Strata	Run	N	Percent Female	Estimate # Females
6/26–7/7	54	38	2.6 (2.2)	1
7/8–7/14	912	208	11.5 (1.1)	105
7/15–7/21	703	213	20.2 (1.5)	142
7/22–7/28	150	42	54.8 (4.1)	82
Total	1819	501	18.2 (0.9)	330

Summer chum salmon

Overall, chum salmon were predominantly age 0.3 (83%) (Table 6). The sex composition of summer chum salmon was 34% female, ranging from 0% to 37% throughout weekly sampling stratum (Table 5). Female chum salmon ranged from 500 to 640 mm and male chum salmon ranged from 510 to 675 mm (Table 7).

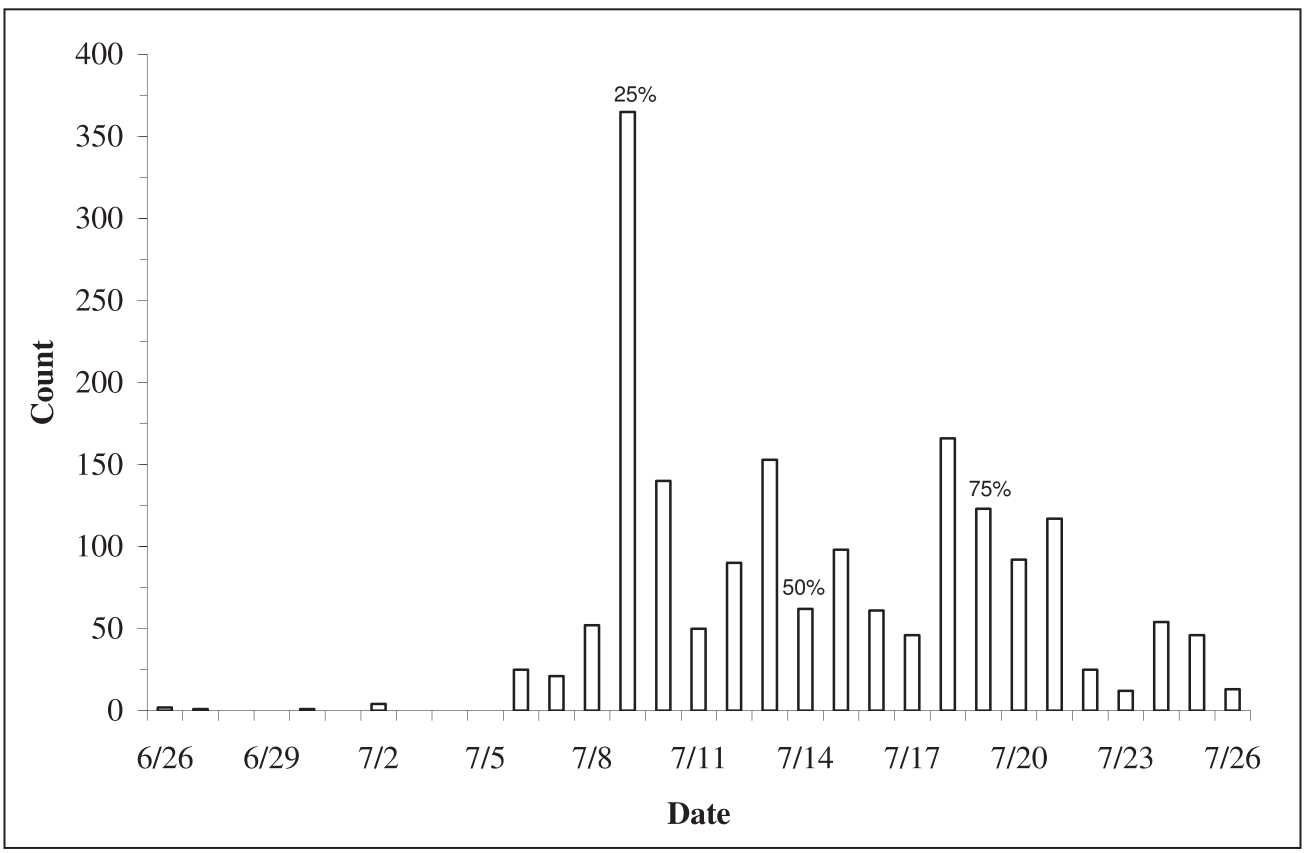


Figure 3. Chinook salmon daily counts with quartiles shown (25%, 50%, and 75%) of cumulative escapement for the period 26 June – 26 July, 2003, Tozitna River, Alaska.

Table 3. Chinook salmon escapement age composition by stratum and sex, Tozitna River, Alaska, 2003. Standard error in parentheses.

			Brood Year and Age											
			2000		1999		1998		1997		1996		Total	
			1.1		1.2		1.3		1.4		1.5			
Strata	Run	Sex	N	%	N	%	N	%	N	%	N	%	N	%
6/26–7/7	54	Males	0	0.0	9 (7.2)	23.7	22 (8.2)	57.9	6 (6.1)	15.8	0	0.0	37	97
		Females	0	0.0	0	0.0	1[a]	2.6	0	0.0	0	0.0	1	3
		Subtotal	0	0.0	9 (7)	23.7	23 (8)	60.5	6 (6)	15.8	0	0.0	38	100
7/8–7/14	912	Males	1 (.5)	0.5	61 (3.5)	29.3	109 (3.6)	52.4	13 (1.9)	6.3	0	0.0	184	89
		Females	0	0.0	0	0.0	12 (10.4)	5.8	12 (10.4)	5.8	0	0.0	24	12
		Subtotal	1 (.5)	0.5	61 (3.2)	29.3	121 (3.4)	58.2	25 (2.3)	12.1	0	0.0	208	100
7/15–7/21	703	Males	1 (.6)	0.5	61 (3.7)	28.6	92 (3.8)	43.2	15 (2.2)	7.0	1 (0.6)	0.5	170	80
		Females	0	0.0	0	0.0	11 (6.7)	5.2	31 (6.9)	14.6	1 (2.3)	0.5	43	20
		Subtotal	1 (.5)	0.5	61 (3.1)	28.6	103 (3.4)	48.4	46 (2.8)	21.6	2 (0.7)	1.0	213	100
7/22–7/28	150	Males	0	0.0	8 (11.6)	19.0	8 (11.6)	19.0	3 (8.6)	7.1	0	0.0	19	45
		Females	0	0.0	0	0.0	4 (8.1)	9.5	19 (8.1)	45.2	0	0.0	23	55
		Subtotal	0	0.0	8 (6.1)	19.0	12 (7.1)	28.5	22 (7.8)	52.3	0	0.0	42	100
Subtotal		Males	2 (.5)	0.4	139 (4.9)	27.7	231 (5.0)	46.1	37 (3.3)	7.4	1 (0.4)	0.2	410	82
		Females	0	0.0	0	0.0	28 (8.8)	5.6	62 (8.9)	12.4	1 (1.4)	0.2	91	18
Total	1819		2	0.4	139 (3.6)	27.7	259 (4.1)	51.7	99 (3.4)	19.8	2 (0.4)	0.4	501	100

[a] Standard error was not calculated because of low sample size.

Abiotic Measurements

Water temperature (°C) at the weir ranged from 6.1 to 14.0 and averaged 9.6. Turbidity (NTU) ranged from 0.8 to 56.9 and averaged 3.8. Total precipitation for the period was 10.2 cm. Stream height (cm) fluctuated from 98 to 207 and averaged 130. Daily discharge (m^3/s) ranged from 12 to 146 and averaged 37 (Figure 2).

Table 4. Chinook salmon mid-eye to fork length (mm) by age and sex, Tozitna River, Alaska, 2003.

Age	Sex	N	Mean	SE	Range
1.1	Male	2	378	48	330–425
	Female	0	–	–	–
1.2	Male	139	518	4.3	400–755
	Female	0	–	–	–
1.3	Male	231	703	3.5	500–850
	Female	28	778	7.1	725–895
1.4	Male	37	793	15	440–975
	Female	62	859	5.2	780–940
1.5	Male	1	805	–	805
	Female	1	865	–	865

Table 5. Proportion and estimated number of female summer chum salmon, Tozitna River, Alaska, 2003. Standard error in parentheses.

Strata	Run	N	Percent Female	Estimated # Females
6/26–7/7	14	10	0.0	0
7/8–7/14	722	162	36.4 (1.8)	263
7/15–7/21	2636	234	36.8 (0.9)	969
7/22–7/28	5115	149	32.2 (0.7)	1648
Total	8487	555	33.9[a] (0.5)	2880[a]

[a]Calculation were determined with partial escapement data because of high stream discharge.

Table 7. Summer chum salmon mid-eye to fork length (mm) by age and sex, Tozitna River, Alaska, 2003. SE = Standard Error

Age	Sex	N	Mean	SE	Range
0.2[a]	Male	3	560	8.7	545–575
	Female	2	530	15	515–545
0.3[a]	Male	296	575	1.6	510–655
	Female	165	550	2.1	500–620
0.4[a]	Male	52	608	4.4	525–675
	Female	22	590	5.4	540–640
0.5[a]	Male	11	626	9.6	575–675
	Female	4	605	9.6	580–620

[a]Calculation were determined with partial escapement data because of high stream discharge.

DISCUSSION

Assessment of sex and age composition of salmon stocks offers insight into the effects of fisheries management regulations and environmental influences. In 2003, there were four weirs in Alaska monitoring Chinook salmon escapement on Yukon River tributaries: East Fork of the Andreafsky River, Henshaw Creek, Gisasa River, and the Tozitna River (Figure 4). These weirs provide the most accurate method for assessing sex and age composition. This section discusses the low proportion of females in escapement data at these four weirs, following the conclusion in ADF&G (2002) and Wiswar (2000) that the proportion of females should be taken into account when assessing escapement.

The Tozitna River had the lowest proportion of female Chinook salmon of the four Yukon River tributary weirs monitoring Chinook salmon in 2002 and 2003 (Table 8), at 13% and 18%, respectively. Although the 2003 Tozitna River Chinook escapement was 21% above that of 2002, the proportion of females was only 5% higher. The low proportion of female Chinook salmon is not unique to the Tozitna River and has been documented for other Yukon River tributaries. From 1996 to 1998, the Gisasa River averaged 20% female, ranging from 17% to 23%, and the East Fork of the Andreafsky River from 1994 to 1998 averaged 35% female, ranging from 25% to 42% (Wiswar 2000, Tobin and Harper 1999, USFWS 2003). In 2003, preliminary data (ADF&G 2003b) indicated that three of the four Yukon tributary weirs had sex ratios favoring males (61% to 82%; Table 8).

Recently, there has been speculation that the disease-induced mortality caused by the internal parasite *Icthyophonus hoferi* has played a role in the selective mortality of female Chinook salmon in the Yukon River. Kocan et al. (2003) reported that significantly more Yukon River females than males were infected during 1999–2002. However, in 2003 the infection in females was not significantly different from males, indicating this may not be a plausible explanation for the low number of female Chinook salmon.

Low female Chinook sex ratios at weir escapement projects are largely the result of the low proportion of age 1.4 females, the predominate age class among females (Harper and Watry 2001). In 2003, preliminary data indicated that age 1.4 female Chinook salmon represented 12% to 29% of escapement at the four Yukon tributary weirs monitoring Chinook salmon (Table 8)

Table 6. Summer chum salmon escapement age composition by stratum and sex, Tozitna River, Alaska, 2003. Standard error in parentheses.

Strata	Run	Sex	Brood Year and Age								Total	
			2000		1999		1998		1997			
			0.2		0.3		0.4		0.5			
			N	%	N	%	N	%	N	%	N	%
6/26–7/7	14	Males	0	0.0	6 (16.3)	60.0	4(16.3)	40.0	0	0.0	10	100
		Females	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
		Subtotal	0	0.0	6 (16.3)	60.0	4 (16.3)	40.0	0	0.0	10	100
7/8–7/14	722	Males	1 (1)	0.6	83 (3.9)	51.2	15 (3.5)	9.3	4 (1.9)	2.5	103	64
		Females	0	0.0	4 9 (4.9)	30.2	7 (4.2)	4.3	3 (2.9)	1.9	59	36
		Subtotal	1 (.6)	0.6	132 (3.1)	81.4	22 (2.7)	13.6	7 (1.6)	4.4	162	100
7/15–7/21	2636	Males	1 (.7)	0.4	119 (3.3)	50.9	22 (2.9)	9.4	6 (1.6)	2.6	148	63
		Females	1 (1.2)	0.4	71 (4.1)	30.3	13 (3.9)	5.6	1 (1.2)	0.4	86	37
		Subtotal	2 (.6)	0.8	190 (2.6)	81.2	35 (2.3)	15.0	7 (1.1)	3.0	234	100
7/22–7/28	5115	Males	1 (1)	0.7	88 (3.3)	59.0	11 (3.1)	7.4	1 (1)	0.7	101	68
		Females	1 (2.1)	0.7	45 (3.5)	30.2	2 (2.9)	1.3	0	0.0	48	32
		Subtotal	2 (1)	1.4	133 (2.5)	89.2	13 (2.3)	8.7	1(.7)	0.7	149	100
Subtotal		Males	3 (1.1)	0.5	296 (3.4)	53.3	52 (3.2)	9.4	11 (1.3)	2.0	362	66
		Females	2 (1.7)	0.4	165 (3.9)	29.7	22 (3.4)	4.0	4 (1.1)	0.7	193	34
Total	8487		5 (1)	0.9	461 (2.6)	83.0	74 (2.4)	13.4	15 (1.0)	2.7	555	100

Table 8. Comparison of preliminary Chinook salmon escapement age composition by sex at the East Fork (EF) of Andreafsky River, Gisasa River, Henshaw Creek, and the Tozitna River, Alaska, 2003.

Location	Yukon River (km)	N	Sex	Brood year and Age					Total
				2000	1999	1998	1997	1996	
				1.1	1.2	1.3	1.4	1.5	
				%	%	%	%	%	%
EF Andreafsky Weir	167[a]	533[d]	Males	0.4	12.7	33.2	6.0	0.0	52.3
			Females	0.0	3.2	17.3	26.1	1.1	47.7
			Subtotal	0.4	15.9	50.5	32.1	1.1	100.0
Gisasa Weir	818[b]	472[d]	Males	0.2	5.5	51.3	4.9	0.0	61.9
			Females	0.0	0.0	18.2	18.8	1.1	38.1
			Subtotal	0.2	5.5	69.5	23.7	1.1	100.0
Henshaw Weir	818[b]	304[d]	Males	1.6	19.4	35.5	4.3	0.0	60.9
			Females	0.0	0.0	8.6	28.9	1.6	39.1
			Subtotal	1.6	19.4	44.1	33.2	1.6	100.0
Tozitna Weir	1096[c]	501[d,e]	Males	0.4	27.7	46.1	7.4	0.2	81.8
			Females	0.0	0.0	5.6	12.4	0.2	18.2
			Subtotal	0.4	27.7	51.7	19.8	0.4	100.0

[a] Kilometers from the mouth of the Andreafsky River to the mouth of the Yukon River.
[b] Kilometers from the mouth of the Koyukuk River to the mouth of the Yukon River.
[c] Kilometers from the mouth of the Tozitna River to the mouth of the Yukon River.
[d] Preliminary escapement age data from ADF&G, 2003.
[e] Preliminary escapement age data from BLM, 2003.

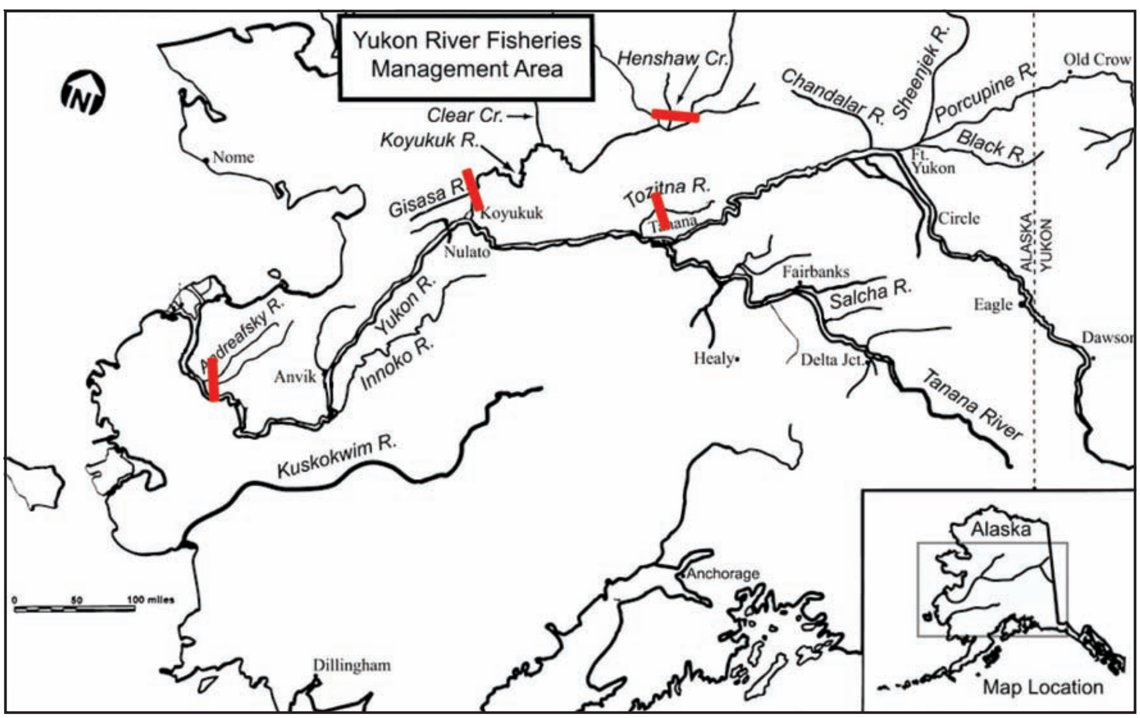
and 39% in the lower commercial harvest (ADF&G 2003b). The Tozitna River escapement in 2003 had the lowest proportion of age 1.4 female Chinook at 12%. ASL composition is not available for the subsistence harvest, although in the lower Yukon River it is assumed to be similar to the lower commercial harvest, since the same gear is used (Menard 1996).

Chinook salmon harvest in the Yukon River is comprised predominately of commercial and subsistence gillnet fisheries. In 2003, the majority of commercial harvest (91%; preliminary data, ADF&G 2003) occurred in the lower Yukon River, where gillnet mesh size (stretched) was restricted to eight inch or greater. Fully 87% of the Chinook salmon subsistence harvest in 2002 was taken with gillnets, and 44% of the harvest occurred in the lower Yukon River (Brase and Hamner 2003). There were no gillnet mesh restrictions for the subsistence fishery in 2003, although it is thought the majority of Yukon River gillnet subsistence fishers use eight inch or greater because this is a requirement needed to participate in the commercial fishery.

Yukon Chinook populations are heterogeneous in age, size, and sex, and all individuals are not equally vulnerable to harvest. For example, Tozitna River female Chinook exhibited sexual dimorphism, with females longer than males of the same age (Table 4). Large-mesh gillnets used during unrestricted mesh-size openings select older, larger Chinook salmon, which include a much larger proportion of females than the salmon caught during small mesh-size periods (ADF&G 2002). Salmon encounter gillnets from the Yukon River mouth to river km 493 with cumulative harvest effects, as the largest and oldest fish are continuously selected as they migrate upstream. The Tozitna River escapement project is the furthest upstream of the four Yukon River tributary weirs, and in 2002–2003 (Table 8) it had the lowest female sex ratio and the lowest proportion of age 1.4 female Chinook salmon.

Another possible explanation of low abundance of age 1.4 female Chinook is their possible differential exposure to ocean mortality. The average age of maturity for Yukon River Chinook is 6.12 years for females and 5.64 years for males (McBride et al. 1983). Therefore, females' longer duration of ocean residency may increase exposure to mortality.

Preliminary results indicate that the selective harvest of larger salmon in the commercial and subsistence fisheries and/or differential mortality may have contributed to the



escapement on Yukon River tributaries: East Fork of the Addreafsky River, Henshaw Creek, Gisasa River, and the Tozitna River. Map is adapted from Holder and Senecal-Albrecht (1998).

low proportion of female Chinook salmon in the Tozitna River escapement. Reduction and removal of the largest and potentially most successful spawners reduces the overall fitness of a population and reduces the ability to compensate for environmental and anthropogenic impacts (Livingston 1998). Furthermore, Ricker (1981) argues that selective harvest by fisheries changes the genetic basis for maturation and can result in a reduction in adult size. Although long-term weir escapement data is not available on the Tozitna River and there is no conclusive data for selective harvest and/or differential mortality, the low proportion of returning females warrants further evaluation and ongoing monitoring.

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APPENDIX 1. STATISTICAL METHODS

Within a given stratum m, the proportion of species i passing the weir that are of sex j and age k (P_{ijkm}) is estimated as

$$P_{ijkm} = n_{ijkm} / n_{i++m}$$

where n_{ijkm} denotes the number of fish of species i, sex j, and age k sampled during stratum m and a subscript of "+" represents summation 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 of P_{ijkm} is estimated as

$$v(P_{ijkm}) = (1 - n_{i++m} / N_{i++m}) (P_{ijkm} (1 - P_{ijkm}) / n_{i++m} - 1)$$

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

$$\mathrm{N}_{\mathrm{ijkm}} = \mathrm{N}_{\mathrm{i++m}} \mathrm{P}_{\mathrm{ijkm}}$$

with estimated variance

$$v(N_{ijkm}) = N^2_{i++m} v(P_{ijkm})$$

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

$$P_{ijk} = \sum_m (N_{i++m} / N_{i+++}) P_{ijkm}$$

and

$$v(P_{ijk}) = \sum_m (N_{i++m} / N_{i+++})^2 v(P_{ijkm})$$

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

$$N_{ijk} = \sum_m N_{ijkm}$$

with estimated variance

$$v(N_{ijk}) = \sum_m v(N_{ijkm})$$