U.S. Fish and Wildlife Service
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Abundance and Run Timing of Adult Salmon in the Tozitna River, Alaska, 2004

Annual Report for Study 04-206

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REPORT SUMMARY

Title: Abundance and Run Timing of Adult Salmon in the Tozitna River, Alaska, 2004

Study Number: 04-206

Investigator(s)/Affiliation(s): Tim Sundlov, Carl Kretsinger, and Bob Karlen, U.S. Department of Interior, Bureau of Land Management, Northern Field Office; Julie Roberts, Tanana Tribal Council.

Geographic Area: Middle Yukon River

Information Type: Stock Status and Trends

Issue(s) Addressed: Lack of escapement and run timing data in middle Yukon River Basin tributaries for Chinook *Oncorhynchus tshawytscha* and summer chum salmon *O. keta* to support Federal subsistence fishery management.

Study Cost: \$144,000 (\$66,000 contributed by the Office of Subsistence Management and \$78,000 funded by the Bureau of Land Management).

Study Duration: 1 April 2004 to 1 May 2005

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 River Basin tributary. A resistance board weir was operated from 21 June to 10 August 2004. High stream discharge from the period of 1 to 3 August prevented counting and biological sampling; counts were interpolated for this period. The escapement for Chinook salmon was 1,880. The age composition was 39 % age-4, 41 % age-5, and 20 % age-6. The sex composition from readable scales was 17.5 % female. The escapement for summer chum salmon was 25,003. The age composition was 3 % age-3, 64 % age-4, and 33 % age-5. The sex composition from readable scales was 47 % female.

Key Words: Chinook salmon, chum salmon, *Oncorhynchus tshawytscha, O. keta,* resistance board weir, sex ratio, spawning adults, stock status and trend, subsistence fishery, Tozitna River, Yukon River drainage.

Project Data: *Description* - Data for this study consist of escapement counts, age (scales), sex, and length information, and genetic samples (fin clips) for Chinook and summer chum salmon. *Format* – Escapement, age, sex, length and genetic data are stored in Microsoft Access and Excel. Scale impressions were created on cellulose acetate cards and DNA samples are stored at -20 °C. *Custodians* - Escapement, age, sex, and length data: Bureau of Land Management (BLM), Northern Field Office, 1150 University Avenue, Fairbanks, Alaska 99709 and the Alaska Department of Fish and Game, Division of Commercial Fisheries (ADF&G-DCF), 333

Raspberry Road, Anchorage, Alaska 99518. Genetic samples and data: U.S. Fish and Wildlife Service Fish Genetics Laboratory (USFWS-FGL), 1011 East Tudor Road, Anchorage, Alaska 99503. *Availability* - Access to the data is available from the custodians upon request.

Report Availability: Please contact either the author(s) or Alaska Resources Library and Information Services to obtain a copy of this report.

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TABLE OF CONTENTS

TABLES

FIGURES

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, BLM in Alaska received a Congressional appropriation for Yukon River salmon restoration. In response to this appropriation, the BLM convened interagency coordination meetings to determine the most beneficial use of the funding. Emphasis was placed on funding projects that would satisfy both the 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 as the site for an escapement study. The 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 the 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 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 salmon in the Middle Yukon River Sub-Basin, the BLM has operated a resistance board weir on the Tozitna River since 2002. The objectives of the project are:

(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 the weekly age and sex proportions of Chinook salmon so that the simultaneous estimates have a probability of 95 % of being within .05 of the population proportion; and so that estimates for chum salmon have an $\alpha = .10$ and $d = .10$.

Additional project tasks are:

(1) Measure water temperature, turbidity, precipitation, stream stage, and determine daily stream discharge;

(2) Collect Chinook salmon fin tissue samples for the USFWS effective population size study of Chinook salmon from the Tozitna River;

(3) Recover radio telemetry tags for the National Marine Fisheries Service and ADF&G Yukon River Basin Chinook radio telemetry study; and

(4) Provide ADF&G with scale samples from Chinook salmon to assist in their scale pattern analysis program.

In addition, BLM seeks to provide ADF&G with 6 to 10 years of accurate estimates of total abundance for adult Chinook and summer chum salmon in the Tozitna River so that escapement goals for this system can be addressed.

STUDY AREA

The Tozitna River is a large, clear-water, northern tributary to the middle Yukon River, with a watershed area of 4, 215 km^2, 90 % of which the 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 [(1)] with 62 % occurring between June and September. Average monthly ambient temperature ranges from -28 to 22 °C [(1)]. The 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 2001, 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 a live trap. Construction and installation of the weir were as described by Tobin (1994). The trap (fabricated by Mackey Lake Co., Soldotna, AK) was incorporated into the weir on the upstream side. The weir was 65 m in width and was operational on 21 June. The weir was cleaned and inspected on a daily basis to remove debris and ensure the only avenue for fish passage was through the trap.

Escapement

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 hours /day, 7 days / week and consisted of one observer for each 6 h period. During daily sampling efforts the trap could be closed for up to 45 minutes but on average salmon were able to pass through the trap within 15 minutes after entering. Hourly counts were summed to achieve a daily count (0000 – 2359 hours). High water resulted in missed counts from 1800 hours on 1 August to 1000 hours on 3 August. Counts for 1 and 3 August were estimated by averaging the counts for the corresponding hours from the first day before and after the missed periods and adding this number to the partial counts for each day. The missing day of 2 August was estimated by averaging the interpolated counts of 1 and 3 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.

Data Analysis

Chinook Salmon

Temporally stratified random sampling design (Cochran 1977) was used to collect and analyze ASL data, with statistical weeks defining strata. Strata began on Wednesday and ended the following Tuesday with a weekly sample size target of 112 Chinook salmon distributed uniformly throughout the week (16 fish/day). The weekly sample goal allowed up to 5 % of the scales to be illegible. An overall sample goal of 448 fish was established so that there was a probability of .95 that all of the estimates were simultaneously within .05 of the population proportions (Thompson 1987). 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.

Summer Chum Salmon

Sampling for chum salmon was done in much the same manner as Chinook. The only difference was the weekly sample goal was established using the method described by Bromaghin (1993) so that simultaneous interval estimates of sex and age proportions for each week had .90 probability of being within .10 of population proportions. Strata began on Thursday and ended the following Wednesday with a weekly sample size target of 175 chum salmon distributed uniformly throughout the week (25 fish/day). The weekly sample goal allowed up to 15 % of the scales to be illegible.

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

$$N_{ijkm} = N_{i++m} \, P_{ijkm} \, ,$$

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 is estimated as

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

with estimated variance

$$v(N_{ijk}) = \sum_{m} v(N_{ijkm})$$

Abundance Downstream of the Weir

An aerial survey was to be conducted on 29 July to estimate the relative abundance of Chinook and summer chum salmon downstream of the weir and document spawning locations. The survey was aborted because of poor viewing conditions downstream of Dagislakhna Creek. A localized storm in the Dagislakhna Creek watershed in combination with the recently burned watershed caused both Dagislakhna Creek and Tozitna River below Dagislakhna Creek to run extremely turbid. Approximately 90 % of the Dagislakhna Creek watershed burned in 2004 during the North Dag Fire (BLM 2004).

Age-Sex-Length

The live trap was used to capture salmon sampled for age, sex, and length. 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 ADF&G-DCF in Anchorage for aging. Aging was conducted by creating impressions on cellulose acetate cards with a heated hydraulic press (Clutter and Whitsel 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 hours. The holding pen allowed sampled fish to recover in an area out of the main current.

Genetic Samples

Throughout the run, dorsal fins were clipped from 250 Chinook salmon to provide tissue samples for genetic analysis. Fin clips were placed in 2 ml sample vials filled with 95 % ethanol and sent to USFWS-CGL, Anchorage for processing.

Abiotic Measurements

Water temperature, turbidity, precipitation, and stream stage (water surface elevation) measurements were collected daily from the period 21 June to 10 August. Water temperature was monitored with an Onset® Tidbit temperature logger placed on the stream bottom in a shaded location within a deep (>1 m) meander pool upstream from the weir. Water temperature was recorded every hour. Turbidity was measured using a HACH model 2100P turbidimeter. Precipitation was measured daily for the previous 24 hours with a rain gauge. A staff gauge was used to record daily variation in stream stage.

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

RESULTS

Weir and Trap

Weather systems in the summer often bring periods of rain to the interior of Alaska and result in elevated stream discharge in the Tozitna River. During these periods of increased discharge, weir panels can be submerged and allow salmon to migrate over the weir undetected. A strong precipitation event occurred at the weir in late July and early August (Figure 2). During the period of 29 July to 1 August, 5.2 cm of rain was recorded. This event resulted in submerged weir panels from 1 to 3 August, allowing salmon to migrate over the weir undetected. The weir was back in operation on 3 August at 1000 hours. On 10 August it was assumed from previous run timing data (Kretsinger and Sundlov, in preparation), that the migration period of Chinook and summer chum 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 = 1,880) passed through the weir from 24 June to 10 August (Table 1). Daily Chinook escapement during the last week of counting was < 1 % of the cumulative escapement. The quartile days (25, 50, and 75%) of cumulative passage for Chinook salmon were 11, 16, and 18 July, respectively (Table 1; Figure 3). The date of peak passage was 17 July (n = 221), and the eight day period between 11 and 18 July accounted for 53 % of the escapement. Gillnet marks were observed on 6 % (n = 4) of the female and 1 % (n = 3) of male Chinook salmon sampled for ASL data.

Summer Chum Salmon

Summer chum salmon (N = 25,003) migrated through the weir from 22 June to 10 August (Table 1). Daily chum escapement for the last three complete days of counting was < 2 % of the cumulative escapement. The quartile days (25, 50, and 75 %) of cumulative passage for summer chum salmon were 18, 24 July, and 1 August, respectively (Table 1; Figure 4). The date of peak passage was 18 July (n = 2,015), and the two week period between 18 - 31 July accounted for 50 % of the escapement.

Age-Sex-Length

Chinook Salmon

The sex composition of Chinook salmon was 17.5 % female, ranging from 15 % (7 - 13 July) to 19 % (14 - 20 July) throughout weekly sampling stratum (Table 2). Five age groups were identified from 416 readable scale samples. Overall, Chinook salmon were predominantly age 1.3 (41 %) and 1.2 (39 %), followed by age 1.4 (20 %) (Table 3). Females were generally older (84 % age 1.4 and 11 % age 1.3) than males (47 % age 1.3 and 47 % age1.2). The age structure of the run was reflected in size, with females ranging from 740 mm to 930 mm and the males ranging from 345 mm to 905 mm (Table 4). A majority of the males (89 %) were < 740 mm. Mean length of females age 1.3 and 1.4 was greater than that of same-age males.

Summer Chum Salmon

The sex composition of summer chum salmon was 47 % female, ranging from 24 % (22 - 30 June) to 53 % (5 - 10 August) throughout weekly sampling stratum (Table 5). Four age groups were identified from 1,013 readable scale samples. Overall, chum salmon were predominantly age 0.3 (64 %) followed by age 0.4 (33 %) (Table 6). Female chum salmon ranged from 470 to 625 mm and male chum salmon ranged from 460 to 655 mm (Table 7).

Abiotic Measurements

Hourly water temperatures (°C) ranged from 9.3 -16.0, with a mean daily water temperature of 12.7. Daily variation in water temperatures ranged between 1.2 and 4.5, averaging 2.4. During a majority (59 %) of the monitoring period, water temperatures remained within those favorable for the migration, spawning, and incubation of salmon (Environmental Protection Agency 2001 and 1999, Hale 1981, Bell 1973, Combs and Burrows 1957). Water temperatures did exceed 15 °C on 12 days during the project period and reached 16 °C for two hours on 20 July. The 16 °C threshold was found by Alderdice and Velsen (1978) to be the temperature at which 50 % pre-hatch mortality occurs for Chinook salmon eggs. Water temperatures did exceed both the State standard for maximum water temperature during migration (15 °C) and the State standard for maximum water temperature during spawning and egg incubation (13 °C). In addition, water temperatures exceeded those considered to cause elevated disease rates (14 – 17 °C) and reduced gamete viability (13-16 ° C) in salmon (EPA 2001; Table 8). The maximum duration in which 13 °C was exceeded was 22 hours during any one 24-hour period; 46 hours in a 48-hour period, and 107 hours in a 120-hour (5 day) period.

Turbidity (NTU) ranged from 0.2 to 2.2 and averaged 0.6. Total precipitation for the period was 8.1 cm. Stream stage (cm) fluctuated from 13 to 91 and averaged 29. Daily discharge (m^3/s) ranged from 6 to 43 and averaged 12 (Figure 2).

Radio Tagged Fish

BLM assisted with the recovery of radio telemetry tags for the Yukon River Basin Chinook radio telemetry study. A total of six radio telemetry tags were recovered from Chinook salmon at the weir.

DISCUSSION

The preliminary post-season analysis of Yukon River summer chum salmon run in 2004 was below average, but 13 % above 2003 based on Pilot Station estimates (ADF&G 2004b). The 2004 Tozitna River summer chum escapement was 158 % of the 2001 and 2002 average (2003 was an incomplete count). Summer chum salmon age composition and proportion of females was similar to other Yukon River Basin escapement projects (unpublished data, ADF&G). Quartile dates for 2004 were similar to the 2-year average (2001-2002; 2003 was an incomplete count) differing by no more than 3 days. On average, the quartile dates of passage for chum salmon have been about 7 days later than those for Chinook salmon.

Yukon River Chinook escapement in 2004 was assessed as better than average for the third consecutive year, with several escapements near all time highs (ADF&G 2004b). The 2004 Tozitna River Chinook escapement was 10 % below the 3–year average (2001-2003). Quartile dates in 2004 were similar to the 3-year average (2001-2003) differing by no more than one day. The midpoint of the run for Chinook salmon in the lower Yukon River was three days earlier than the average date (preliminary data, ADF&G 2004b).

In the fall of 2004, in part driven by the reoccurring low female Chinook salmon returns to the Tozitna River, agency discussions took place which brought into question the accuracy of the sex data being reported for Chinook salmon. On the Tozitna River, the field identification of Chinook salmon sex is based on external characteristics. The Chinook salmon returning to the Tozitna River generally have well developed secondary sexual characteristics. Nonetheless, BLM had the opportunity to verify that the sex of Chinook salmon was being accurately determined by field crews. The USFWS Genetic Laboratory in Anchorage offered to genetically verify the sex of 110 Chinook salmon sampled at the Tozitna River weir in 2003. Genetic tissue samples were subsequently analyzed at the University of Idaho. The genetically determined sex matched with the field determinations for all 110 fish.

Correct identification of sex is of particular concern for this project because one conspicuous component of the Chinook escapement is the low number of returning females (329 fish; Table 2). The Tozitna River had the lowest proportion (17.5 %) of female Chinook salmon of the four Yukon River Basin weir projects monitoring Chinook salmon in 2004 (Figure 5 and Table 9). This compares with 14 % Chinook females returning in 2002 (first year of the project using a weir) and 18 % Chinook females returning in 2003**.** 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 - 1998, the Gisasa River averaged 20 % female, ranging from 17 – 23 %, and the East Fork of the Andreafsky River from 1994 - 1998 had female returns ranging from 25 – 42 % (Wiswar 2000, Tobin and Harper 1999). In 2004, preliminary data indicate that all of the Yukon tributary weirs monitoring Chinook salmon had sex ratios favoring males (65 – 83 %; Table 9).

There is currently no conclusive explanation for the low numbers of returning female Chinook. It is likely that there is a combination of factors influencing female returns. Given that the field identification of Chinook salmon sex appears to be accurate, we offer several other plausible explanations.

Since the Tozitna River weir has only been in operation for three years, it is possible that the low number of females recorded for the years 2002 - 2004 are statistical outliers. However, with three consecutive years of low female returns this possibility is becoming less likely.

The influence of harvest on Chinook returns is also a possible factor in the low number of females returning to spawn. Low female Chinook sex ratios reported by weir escapement projects are largely the result of the low proportion of age 1.4 fish, the predominant age class among females (Harper and Watry 2001; Table 3). In 2004, preliminary data indicate age 1.4 Chinook salmon represented 17 – 26 % of the escapement at the four weir projects monitoring Chinook salmon in the Yukon River Basin (Table 9) and 70 % in the combined commercial harvest (preliminary data, ADF&G 2004 b). In 2004, the Tozitna River had the lowest proportion of age 1.4 female Chinook salmon (14.7 %) of the four weir projects (Table 9). 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 2004, 94 % of the Alaskan commercial harvest (preliminary data, ADF&G 2004 b) occurred in the lower Yukon River. Small mesh size gear was not used in the lower Yukon River commercial fishery due to a lack of a summer chum market. Gillnets are also the gear of choice for subsistence fishing as demonstrated by the 2003 subsistence harvest in which 87 % of the Chinook salmon were taken with gillnets (preliminary data, ADF&G 2004a). There were no gillnet mesh restrictions for the subsistence fishery in 2004, although it is thought the majority of Yukon River gillnet subsistence fishers use eight inch mesh or greater.

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 select for larger Chinook salmon and harvests during unrestricted mesh-size openings generally include a much larger proportion of females than fishing periods restricted to small mesh size (ADF&G 2002). As they migrate upstream to their natal streams, salmon encounter gillnets from the Yukon River mouth up to and beyond the confluence with the Tozitna River. With the large mesh nets in use today, the largest, and generally the oldest, fish are continuously selected. This may explain why the Tozitna River escapement project has had the lowest female sex ratio and the lowest proportion of age 1.4 female Chinook salmon in the last two years (Table 9; Sundlov et al. 2003).

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). The longer duration of ocean residency may increase the mortality rate of females, however, the issue of when mortality occurs in the marine environment remains unresolved. Currently most information seems to suggest that mortality is greatest during the first summer at sea with declining rates as fish grow (Quinn 2005).

Recently, there has been speculation that the disease-induced mortality caused by the internal parasite *Icthyophonus* 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. It appears that *Icthyophonus* may play a role in selective mortality but not on a consistent basis. Because of this, *Icthyophonus* does not fully explain the low female Chinook salmon returns to the Tozitna River that we have observed from 2002 - 2004. Studies continue to investigate this disease as a potential cause of mortality.

Lastly, BLM has investigated the possibility that a number of Chinook are spawning below the weir and possibly skewing the sex ratios. In 2004, we planned to conduct an aerial survey to estimate the number of fish spawning downstream of the weir. We were unable to conduct the survey due to high stream discharge and turbid water. However, in the past, BLM has conducted two aerial surveys using a helicopter to count the number of Chinook salmon spawning below the weir. In 2001, an aerial survey was conducted on 31 July (from the mouth of the Tozitna River upstream to weir) and 10 live Chinook and 1 Chinook carcass were counted. In 2002, on 30 July, 30 live Chinook and 4 Chinook carcasses were counted in this same reach. Based on these assessments, it appears that the majority of Chinook spawning occurs upstream of the weir. In the future, BLM plans to conduct aerial spawning assessments downstream of the weir on an annual basis.

With the exception of the 2001 Chinook return and noting the incomplete count for chum salmon in 2003, the Tozitna River salmon escapement in 2004 had the largest return of both chum and Chinook since the projects inception in 2001. One issue that remains a concern to BLM is the low return of older age class female Chinook salmon. 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). Currently, it is unclear what is contributing to the low proportion of female Chinook salmon in the Tozitna River escapement. Given that long-term weir escapement data is not available on the Tozitna River and there is no conclusive data for selective harvest, disease and/or differential mortality, the low proportion of returning Chinook females warrants further evaluation and ongoing monitoring.

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FOOTNOTES

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

Table 1. Daily and cumulative counts for Chinook and summer chum salmon with the second quartile, median, and third quartile outlined; Tozitna River, Alaska, 2004.

	Chinook			Summer chum		
	Daily	Cumulative		Daily	Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion
6/21	0	0	0.00	0	0	0.00
6/22	0	0	0.00	3	3	0.00
6/23	0	0	0.00	20	23	0.00
6/24	2	2	0.00	4	27	0.00
6/25	1	3	0.00	4	31	0.00
6/26	1	4	0.00	6	37	0.00
6/27	1	5	0.00	13	50	0.00
6/28	2	7	0.00	21	71	0.00
6/29	4	11	0.01	7	78	0.00
6/30	5	16	0.01	20	98	0.00
7/1	3	19	0.01	34	132	0.01
7/2	4	23	0.01	93	225	0.01
7/3	5	28	0.01	82	307	0.01
7/4	15	43	0.02	204	511	0.02
7/5	72	115	0.06	247	758	0.03
7/6	170	285	0.15	266	1024	0.04
7/7	57	342	0.18	232	1256	0.05
7/8	20	362	0.19	143	1399	0.06
7/9	9	371	0.20	132	1531	0.06
7/10	61	432	0.23	169	1700	0.07
7/11	171	603	0.32	202	1902	0.08
7/12	75	678	0.36	319	2221	0.09
7/13	93	771	0.41	531	2752	0.11
7/14	54	825	0.44	497	3249	0.13
7/15	52	877	0.47	551	3800	0.15
7/16	217	1094	0.58	816	4616	0.18
7/17	221	1315	0.70	552	5168	0.21
7/18	109	1424	0.76	2015	7183	0.29
7/19	79	1503	0.80	1555	8738	0.35
7/20	36	1539	0.82	1148	9886	0.40
7/21	31	1570	0.84	805	10691	0.43
7/22	11	1581	0.84	743	11434	0.46

- Continued -

Table 1. (Continued)

	Chinook			Summer chum		
	Daily	Cumulative		Daily	Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion
23-Jul	43	1624	0.86	911	12345	0.49
24-Jul	46	1670	0.89	757	13102	0.52
25-Jul	14	1684	0.9	578	13680	0.55
26-Jul	21	1705	0.91	585	14265	0.57
27-Jul	10	1715	0.91	473	14738	0.59
28-Jul	10	1725	0.92	604	15342	0.61
29-Jul	20	1745	0.93	594	15936	0.64
30-Jul	12	1757	0.93	842	16778	0.67
31-Jul	12	1769	0.94	848	17626	0.7
8/1 [a]	18	1787	0.95	1331	18957	0.76
8/2 [b]	18	1805	0.96	1397	20354	0.81
8/3 [a]	18	1823	0.97	1463	21817	0.87
4-Aug	9	1832	0.97	684	22501	0.9
5-Aug	12	1844	0.98	692	23193	0.93
6-Aug	13	1857	0.99	482	23675	0.95
7-Aug	7	1864	0.99	439	24114	0.96
8-Aug	3	1867	0.99	250	24364	0.97
9-Aug	2	1869	0.99	355	24719	0.99
10-Aug	11	1880	1	284	25003	1

[a] Portion of daily count missed; partial count (0100 – 1700) on 8/1 was 8 Chinook and 908 chum salmon; the partial count (1100-2400) on 8/3 was 15 Chinook and 1,145 chum salmon.

[b] Entire daily count missed

Table 2. Female Chinook salmon composition for the Tozitna River, Alaska, 2004. SE = Standard Error.

Stratum Dates	**Sample**			**Escapement**			
	n	# Females	% Female	Weir Count	Estimated # Females	% Female	SE
6/22 - 7/6	70	12	17.1	285	49	2.6	4.54
7/7 - 7/13	123	19	15.4	486	75	4.0	3.27
7/14 - 7/20	140	26	18.6	768	143	7.6	3.30
7/21 - 8/8	83	15	18.1	341	62	3.3	4.25
All strata	416	72	-	1,880	329	17.5	1.90

Table 3. Age composition of the Tozitna River Chinook salmon escapement by stratum and sex; Alaska, 2004. Standard error in parenthesis.

				Brood Year and Age										
				2001		2000		1999		1998		1997		
				1.1		1.2		1.3		1.4		1.5		
Stratum Dates	Weir Count	Sex	# Fish Sampled	%		%		%		%		%		% Escapement
6/22 - 7/6	285	M	58	0.3		6.5		7.6		0.8		0.0		15.2
		F	12	0.0		0.0		2.5		12.6		0.0		
		Subtotal	70											
7/7 - 7/13	486	M	104	0.0		11.2		12.2		2.5		0.0		25.9
		F	19	0.0		0.0		2.7		23.1		0.0		
		Subtotal	123											
7/14 - 7/20	768	M	114	0.0		20.4		18.6		1.8		0.0		40.9
		F	26	0.0		0.0		4.7		31.4		4.7		
		Subtotal	140											
7/21 - 8/8	341	M	68	0.3		8.5		8.3		1.1		0.0		18.2
		F	15	0.0		0.0		1.2		16.9		0.0		
		Subtotal	83											100.0
Combined Strata	1551[a]	M	344	0.5	(0.9)	46.69	(5.3)	46.66	(5.3)	6.13	(2.5)	0	(0)	100.0
	329[a]	F	72	0.0	(0)	0	(0)	11.17	(7.6)	84.11	(8.4)	4.71	(4.1)	100.0
Total	1,880		416	-		-		-		-		-		-
Age Composition With Sexes Combined				0.4	(0.8)	38.5	(4.7)	40.5	(4.8)	19.7	(3.9)	0.9	(0.8)	100.0

[a] Estimated number of male and female salmon derived from strata weighted ASL data

Table 4. Chinook salmon mid-eye to fork length (mm) by age and sex; Tozitna River, Alaska, 2004. SE = Standard Error.

Age	Sex	Sample	Mean	SE	Range
1.1	Male	2	360	15	345 - 375
	Female	0	-	-	-
1.2	Male	159	590	3.0	495 - 725
	Female	0	-	-	-
1.3	Male	161	685	3.5	585 - 850
	Female	8	770	9.2	740 - 815
1.4	Male	22	799	12.7	675 - 905
	Female	61	845	5.5	760 - 930
1.5	Male	0	-	-	-
	Female	3	880	20.8	850 - 920

Table 5. Female summer chum salmon composition for the Tozitna River, Alaska, 2004. SE = Standard Error.

Stratum Dates	Sample			Escapement			
	n	# Females	% Female	Weir Count	Estimated # Females	% Female	SE
22 - 30 June	55	13	23. 6	98	23	0.1	5.8
1 - 7 July	177	54	30. 5	1,158	353	1.4	3.5
8 - 14 July	165	77	46. 7	1,993	930	3.7	3.9
15 - 21 July	183	90	49. 2	7,442	3,660	14.6	3.7
22 - 28 July	161	68	42. 2	4,651	1,964	7.9	3.9
29 Jul - 4 Aug	155	77	49. 7	7,159	3,556	14.2	4.0
5 - 10 Aug	117	62	53. 0	2,502	1,326	5.3	4.6
All Strata	1,013	441	-	25,003	11,813	47.3	1.2

Table 6. Age composition of the Tozitna River summer chum salmon escapement by stratum and sex; Alaska, 2004. Standard error in parenthesis.

				Brood Year and Age								
				2001		2000		1999		1998		
				0.2		0.3		0.4		0.5		
Stratum Dates	Weir Count	Sex	# Fish Sampled	%		%		%		%		% Escapement
6/22 - 6/30	98	M	42	0.0		0.1		0.3		0.0		0.4
		F	13	0.0		0.1		0.3		0.0		
		Subtotal	55									
7/1 - 7/07	1,158	M	123	0.0		2.0		2.6		0.0		4.6
		F	54	0.0		3.0		1.6		0.0		
		Subtotal	177									
7/8 - 7/14	1,993	M	88	0.2		4.8		3.0		0.0		8.0
		F	77	0.1		5.0		2.8		0.1		
		Subtotal	165									
7/15 - 7/21	7,442	M	93	0.3		17.3		12.2		0.0		29.8
		F	90	0.9		20.2		8.6		0.0		
		Subtotal	183									
7/22 - 7/28	4,651	M	93	0.6		10.0		8.0		0.0		18.6
		F	68	0.8		12.6		5.2		0.0		
		Subtotal	161									
7/29 - 8/4	7,159	M	78	0.4		18.0		10.3		0.0		28.6
		F	77	1.5		21.6		5.6		0.0		
		Subtotal	155									
8/5 - 8/10	2,502	M	55	0.2		6.6		3.3		0.0		10.0
		F	62	0.7		7.6		1.8		0.0		
		Subtotal	117									100.0
Combined Strata	13,177[a]	M	572	1.7	(1.5)	58.7	(5.7)	39.7	(5.7)	0.0	(0.2)	100.0
	11,826[a]	F	441	4.0	(2.5)	70.0	(5.6)	25.9	(5.3)	0.1	(0.4)	100.0
Total	25,003		1,013	-			-		-		-	-
Age Composition With Sexes Combined				2.8	(1.4)	63.9	(4.0)	33.2	(3.9)	0.1	(0.2)	100.0

[a] Estimated number of male and female salmon derived from strata weighted ASL data

Table 7. Summer chum salmon mid-eye to fork length (mm) by age and sex; Tozitna River, Alaska, 2004. SE = Standard Error.

Age	Sex	Sample	Mean	SE	Range
0.2	Male	8	520	11.3	460-555
	Female	15	516	7.3	470-565
0.3	Male	301	568	1.4	505-650
	Female	298	549	1.3	480-605
0.4	Male	262	594	1.5	525-655
	Female	127	571	2.1	520-625
0.5	Male	1	635	-	-
	Female	1	565	-	-

Table 8. Number of days, average hours per day, and percent of the monitoring period (22 June to13 August 2004) in which the water temperatures of the Tozitna River at the weir site exceeded water temperature threshold values considered to have an effect on salmon health and reproduction. The water quality standards and health and reproduction temperature threshold values are from 18 Alaska Administrative Code 70 and EPA (2001).

	State Water Qual Standard for Max Migration Temp (>15 °C)	State Water Qual Standard for Max Spawning and Egg Incubation Temp (>13 ºC)	Reduced Gamete Viability (13-16 °C)	Elevated Disease Rate (14-17 ºC)	50% Pre-Hatch Mortality (≥16 ºC)
No. days exceeding the parameter during the monitoring period	12	45	45	25	1
Avg. hours /day exceeding the parameter	4.3	10.6	10.6	7.7	2.0
% of monitoring period exceeding the parameter (hourly basis)	4.2	38.1	38.1	15.4	0.2

Table 9. Comparison of preliminary Chinook salmon age composition by sex at the East Fork Andreafsky River, Gisasa River, Henshaw Creek, and the Tozitna River, Alaska, 2004.

				Brood year and Age					
				2001	2000	1999	1998	1997	Total
		Sample		1.1	1.2	1.3	1.4	1.5	
Location	River (km) [a]	Size	Sex	%	%	%	%	%	%
EF Andreafsky			Males	0.0	29.9	33.2	1.9	0.0	65.0
Weir	167	508 [b]	Females	0.0	9.1	10.3	15.3	0.3	35.0
			Subtotal	0.0	39.0	43.5	17.2	0.3	100.0
Gisasa			Males	0.5	39.6	26.7	3.0	0.0	69.8
Weir	908	540 [b]	Females	0.0	1.6	6.2	22.2	0.2	30.2
			Subtotal	0.5	41.2	32.9	25.2	0.2	100.0
Henshaw			Males	0.1	44.2	24.9	9.4	0.0	78.6
Weir	1,539	637 [b]	Females	0.0	1.5	2.5	16.6	0.8	21.4
			Subtotal	0.1	45.7	27.4	26.0	0.8	100.0
Tozitna			Males	0.4	38.5	38.5	5.1	0.0	82.5
Weir	1,096	416	Females	0.0	0.0	2.0	14.7	0.8	17.5
			Subtotal	0.4	38.5	40.5	19.8	0.8	100.0

[a] Kilometers from the Flat Island test fishing site near the south mouth of the Yukon River to the confluence of the listed tributary.
[b] Age data (preliminary) obtained from ADF&G, 2004.

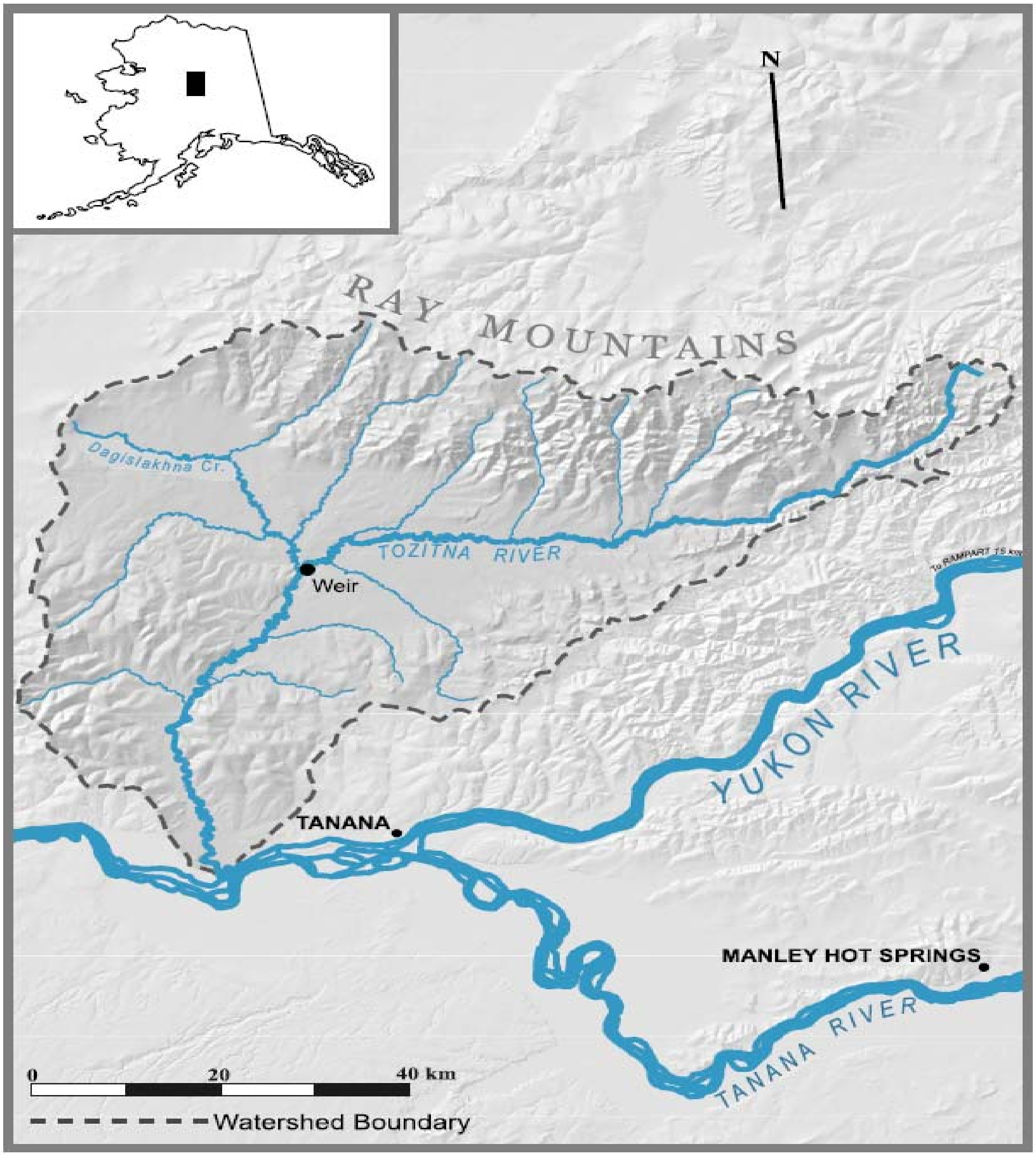

Figure 1. Location of the Tozitna River weir, Alaska 2005.

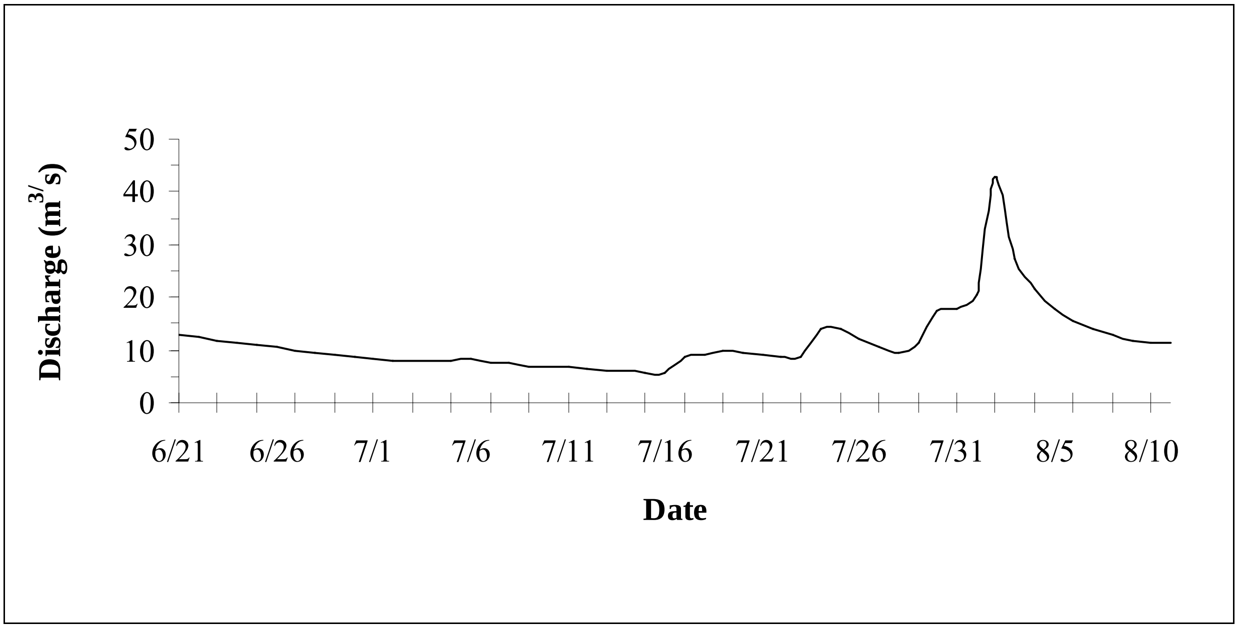

Figure 2. Daily discharge (m^3/s) for the period 21 June - 11 August 2004, Tozitna River, Alaska.

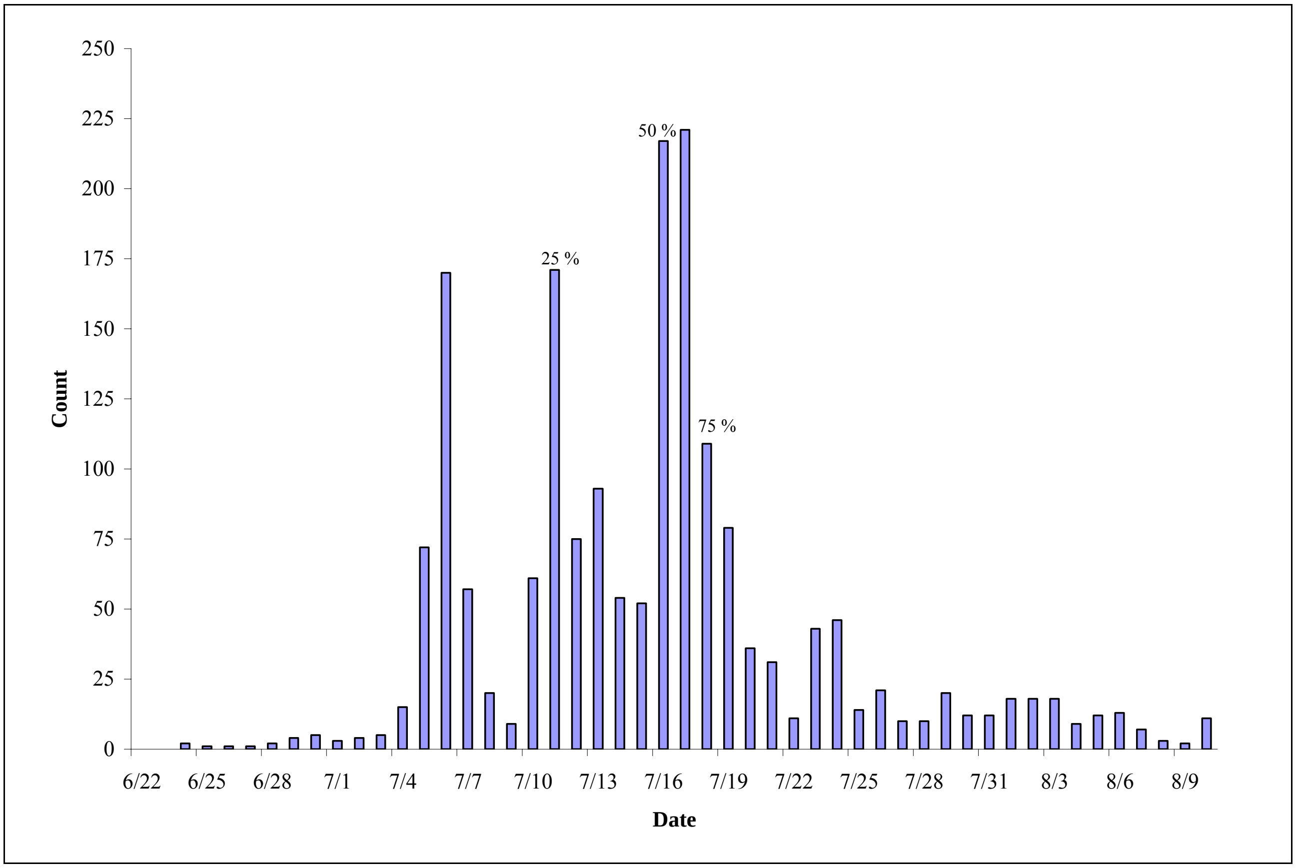

Figure 3. Chinook salmon daily counts with quartiles shown (25, 50, 75 %) of cumulative escapement for the period 22 June - 10 August, 2004, Tozitna River, Alaska.

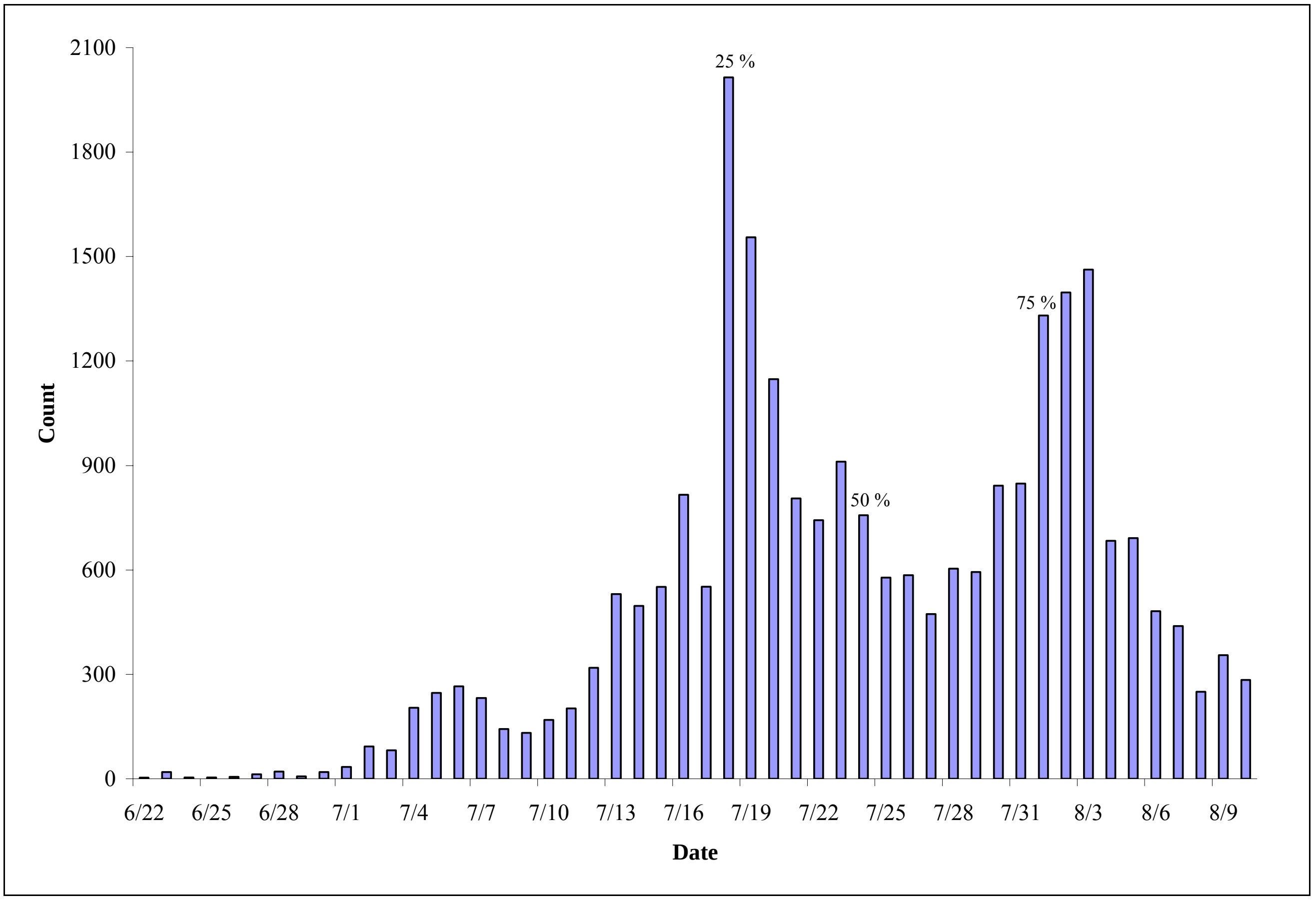

Figure 4. Summer chum salmon daily counts with quartiles shown (25, 50, 75 %) of cumulative escapement for the period 22 June - 10 August, 2004, Tozitna River, Alaska.

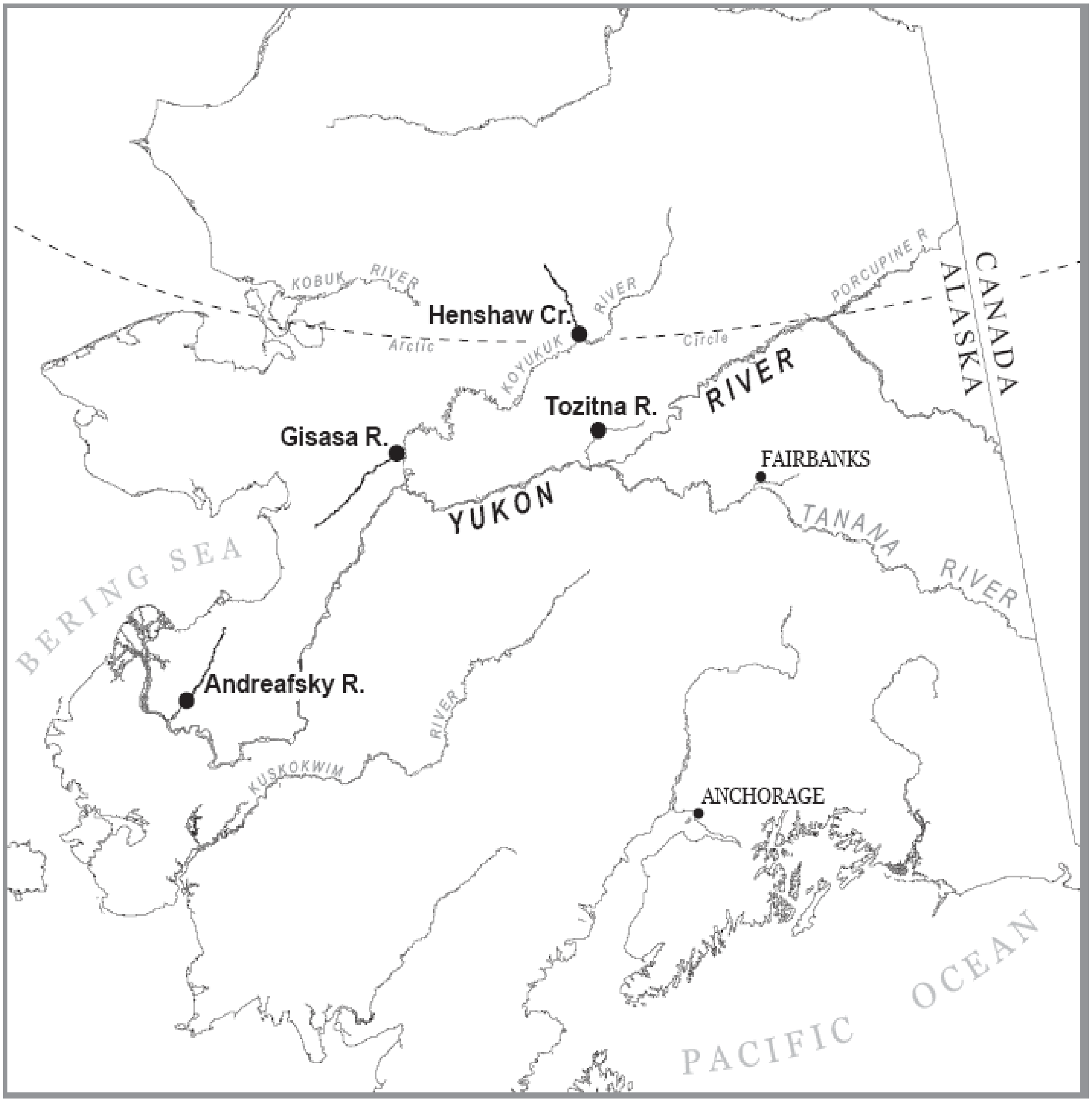

Figure 5. Location of the four weir projects monitoring Chinook salmon escapement in the Alaska portion of the Yukon River Basin in 2004. The projects were located on the East Fork Andreafsky River, Henshaw Creek, Gisasa River, and the Tozitna River.