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Abundance and Run Timing of Adult Salmon in the Tozitna River, Alaska, 2001-2009

Final Report for Study 07-208

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REPORT SUMMARY

Title: Abundance and Run Timing of Adult Salmon in the Tozitna River, Alaska, 2001-2009
Study Number: 07-208

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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: $939,000 from 2003 to 2009 ($561,000 contributed by the Office of Subsistence Management and $378,000 funded by the Bureau of Land Management).

Study Duration: 1 April 2001 to 12 August 2009

Abstract: The Tozitna River project was 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 counting tower and partial weir were operated in 2001 and replaced by a floating resistance board weir from 2002 to 2009. The yearly escapement for Chinook salmon ranged from 494 to 2854 with a mean of 1,449. The age composition for all Chinook samples collected was 0.4 % age-3, 33.3 % age-4, 43.5 % age-5, 22.4 % age-6, and 0.3% age-7. The mean sex composition from strata-weighted sample data ranged from 9.0 % to 30.0 % female with a mean of 18.2 %. The escapement for summer chum salmon ranged from 8,470 to 39,700 with a mean of 21,030. The age composition was 1.8 % age-3, 59.0 % age-4, 37.0 % age-5, 2.1 % age-6, and 0.1 % age-7. The sex composition from strata-weighted sample data ranged from 33.9 % to 55.9% female with a mean of 43.2%.

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 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. *Custodians* - Escapement, age, sex, and length data: Bureau of Land Management (BLM), Fairbanks District Office, 1150 University Avenue, Fairbanks, Alaska 99709 and the Alaska Department of Fish and Game (ADFG), Division of Commercial Fisheries

(ADF&G-DCF), 333 Raspberry Road, Anchorage, Alaska 99518. *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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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). Management of the Yukon River salmon escapement is mostly 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).

The Bureau of Land Management (BLM) received a Congressional appropriation for Yukon River salmon restoration in 2000. 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 the Alaska Department of Fish & 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 salmon in the Middle Yukon River Sub-Basin, the BLM initiated a salmon enumeration project on the Tozitna River, operating a counting tower in 2001 and a resistance board weir from 2002-2009.

The objectives of the project were:

(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
(4) Estimate the weekly age and sex proportions of Chinook salmon so that the simultaneous estimates have a 95% probability 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 were:

(1) Measure water temperature, turbidity, precipitation, stream stage, and determine daily stream discharge
(2) Provide ADF&G with scale samples from Chinook salmon to assist in their scale pattern analysis program

In addition, the BLM sought to provide ADF&G with 7 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 was located at lat 65º 31.0980' N, long 152º 12.8622' W, approximately 80 km upstream from the mouth of the Tozitna River and approximately 0.5 km upstream from the Tozitna River's confluence with Dagislakhna Creek. The weir was located between a downstream riffle and upstream deep meander pool. At this location the average wetted width at summer flows was 52 m with an average depth of 0.6 m. This site is downstream of most

Chinook salmon spawning (Post et al., 2007). The cross-section is gradually sloping, and the substrate consists of sand to cobble.

METHODS

Counting Tower

In 2001 the Bureau of Land Management began a cooperative project with the Tanana Tribal Council to evaluate the feasibility of enumerating adult salmon escapement within the Tozitna River drainage using a counting tower and partial weir. Salmon escapement and run timing were assessed by visually identifying and counting fish from a 7.3 m high viewing platform on the North side of the river, for at least 30 minutes of every hour, 24 hours a day and seven days a week.

Weir and Trap

Salmon escapement, run timing, and composition were assessed from 2002-2009 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 60 m wide and typically operational by the end of June. The weir was cleaned and inspected on a daily basis to remove debris and ensure that the trap provided the only avenue for fish passage.

In 2005 the weir was relocated 200 m downstream of its original (2002-2004) location due to a change in channel morphology. The Tozitna River weir remained in the same location for the duration of the project (2005-2009).

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. Counting occurred 24 hours per day, 7 days per week and consisted of four 6-hour shifts. During daily sampling efforts the trap could be closed for up to 45 minutes. 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). Run timing was calculated by the proportion of daily to cumulative passage to determine quartile (25%, 50%, and 75%) dates, peak, and median date of passage.

Data Analysis

Chinook Salmon

In 2001 carcass sampling was used to obtain age-sex-length (ASL) data, with a target sample size of 640 chum and 185 Chinook in one stratum to achieve a probability of .95 that all of the estimates were simultaneously within .05 of the population proportions (Thompson 1987). The weekly sample goal allowed up to 10% of the scales to be illegible.

From 2002 to 2009 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 to achieve 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. In some years, the first and last sampling strata were greater or less than a week because of low escapement or flooding events during those periods.

Summer Chum Salmon

From 2002 to 2009 sampling for chum salmon was done in much the same manner as the sampling for Chinook. The only difference was that the weekly sample goal for chum 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 typically began on Saturday and ended the following Friday with a weekly sample size target of 175 chum salmon distributed uniformly throughout the week (25 fish per day). In some years sampling stratum were greater or less than a week because of low escapement or flooding events during those periods. The weekly sample goal allowed up to 15% of the scales to be illegible.

Statistical Method

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

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

Age-Sex-Length

In 2001, an attempt was made to capture fish for age, sex, and length (ASL) sampling using a seine, but this proved unsuccessful due to the depth and velocity of the water as well as an abundance of woody debris. Carcasses were sampled when available, but sample goals were not reached. Salmon carcasses were identified to species and sex, and measured to the nearest 5 mm from mid-eye to fork of the caudal fin. Scale samples were taken from both chum and Chinook salmon.

From 2002-2009 a live trap was used to capture salmon for ASL 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). 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 3 scales for Chinook salmon were removed from the left side, 2 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 Whitsel 1956) and then examining the scale annuli patterns (Gilbert 1922). European notation (Koo 1962) was used to record the ages. A holding pen (6 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.

Spawning Locations

Aerial surveys were conducted by helicopter on the entire length of the Tozitna River from 2007-2009 to document the abundance and location of Chinook and summer chum spawning areas (redds). In 2005 and 2006, aerial surveys were conducted only on the portion of the river above the weir site. Observers wore polarized sunglasses to facilitate locating and counting redds, which were then recorded with GPS equipment. Some reaches of the river contained high concentrations of redds; in these areas, observers estimated the number of redds. In years when the entire river was flown, the survey was broken into 2 segments. The first segment started at the mouth of the Tozitna River and ended at the fish weir, and the second segment started at the fish weir and ended a few kilometers beyond the upper reaches of spawning.

Abiotic Measurements

Water temperature, turbidity, precipitation, and stream stage (water surface elevation) measurements were collected daily throughout the project. 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 2100P Portable Turbidimeter. Precipitation for the previous 24 hours was measured daily 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. Annual stream stage versus discharge ratings can be 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 become submerged, allowing salmon to migrate over the weir undetected. We experienced periods of increased discharge in 2002, 2003, 2004, 2006, 2007, and 2008 that affected operation of the weir, either forcing the crew to let fish pass undetected for a matter of hours or days and interpolate data later or to pull the project completely before salmon escapement had been satisfactorily enumerated. Only in 2005 and 2009 were complete counts of both summer chum and Chinook salmon achieved.

Escapement

Chinook Salmon

Between 2002 and 2009 Chinook salmon began passing through the weir on an average date of 30 June, with the first passage occurring as early as 24 June and as late as 8 July (Table 1). An average run of 1449 Chinook salmon passed through the weir during years of complete counting with commercial fishing seasons, with a low of 494 in 2007 and a high of 1880 in 2002 (Table 1). The average quartile days (25%, 50%, and 75%) of cumulative passage for Chinook salmon were 12 July, 17 July, and 20 July, respectively (Table 1). Peak passage days occurred between 9 and 24 July with an average of 16 July and 50% of the escapement typically passing between 17 and 20 July (Table 1).

Summer Chum Salmon

Between 2002 and 2009 summer chum salmon began passing through the weir on an average date of 30 June, with the first passage occurring as early as 22 June and as late as 5 July (Table 2). An average run of 21,030 summer chum salmon passed through the weir during years of complete counting, with a low of 8,470 in 2008 and a high of 39,700 in 2005 (Table 2). The average quartile days (25%, 50%, and 75%) of cumulative passage for summer chum salmon were 20 July, 25 July, and 30 July, respectively (Table 2). Peak passage days occurred between 17 July and 29 July with an average of 23 July and 50% of the escapement typically passing between 17 and 29 July (Table 2).

Age-Sex-Length

Chinook Salmon

The sex composition of Chinook salmon sampled from 2002 to 2009 ranged from 9.0% female in 2008 to 30.0% female in 2005, with an average of 18.2% (Table 3). Seven age groups were identified from a total of 2,507 readable scale samples taken. Overall, Chinook salmon were predominantly age 1.3 (46.6%) and age 1.2 (28.2%), followed by age 1.4 (24.0%), age1.1 (0.5%), age 1.5 (0.5%), age 2.3 (0.1%) and age 2.2 (less than 0.1%) (Table 4). Females were generally older (65.8% age 1.4 and 30.6% age 1.3) than males (53.8% age 1.3 and 36.1% age 1.2) (Table 4). The structure of the run was influenced by sex and age, with the mean length of females age 1.3 (767 mm) and age 1.4 (835 mm) greater than that of same-age males (686 mm and 775 mm, respectively). Females ranged from 465 mm to 995 mm, while males ranged from 305 mm to 975 mm (Table 5).

Summer Chum Salmon

The sex composition of summer chum sampled from 2002 to 2009 ranged from 33.9% female in 2003 to 55.9% female in 2006, with an average of 43.2% (Table 6). Five age groups were identified from a total of 5,835 readable scale samples taken. Overall, summer chum salmon were predominantly age 0.3 (53.1%) and age 0.4 (43.3%), followed by age 0.5 (2.3%), age 0.2 (1.6%), and age 0.6 (less than 0.1%) (Table 7). Females ranged from 360 mm to 650 mm while males ranged from 460 mm to 695 (Table 8).

Spawning Ground Survey

Aerial surveys were conducted to document spawning areas on the Tozitna River in late July of 2005 to 2009. In 2005 and 2006 the survey began at the weir site and ended a few kilometers beyond the Chinook redd observed furthest upstream. From 2007 to 2009 the survey was expanded into two sections. The first segment started at the mouth of the Tozitna River and ended at the weir (Figure 2) and the second segment began at the weir and ended a few kilometers beyond the last observed Chinook redd (Figure 3). Water conditions varied from year to year, with low water levels in the Tozitna River at the time of the survey providing the best observation conditions.

Downstream of Weir

Observers recorded 130 Chinook redds and 3399 summer chum redds downstream of the Tozitna River fish weir (Figures 4 and 5) from 2007 to 2009. These figures represent 23.2% of the total Chinook redds and 61.4% of the total summer chum redds observed in the Tozitna River from 2007 to 2009, respectively (Figures 8 and 9). Downstream of the weir, the majority of Chinook redds (58.5%), as well as 28.7% of the summer chum redds, were found between Reindeer Creek and the weir (Figures 4 and 5).

Upstream of Weir

Observers recorded 431 Chinook redds and 2136 summer chum redds upstream of the weir from 2007 to 2009 (Figures 6 and 7). These figures represent 76.8% of the total Chinook redds and 38.6% of the total summer chum redds observed in the Tozitna River from 2007 to 2009, respectively (Figures 8 and 9). The Chinook redd observed farthest upstream was approximately 39 km upstream of the weir and just above Gishna Creek (Figure 3). Upstream of the weir, over half (58.2%) of these Chinook redds and almost half (48.0%) of the summer chum redds were observed within the 24 km stretch of river between Crooked Creek and McQuesten Creek (Figures 6 and 7).

Abiotic Measurements

During monitoring periods from 2001 to 2009, hourly water temperatures ranged from 7.0 to 17.6 with a mean of 11.35 °C (Table 9). During a majority of the monitoring period, water temperatures remained within those favorable for the migration (<15 °C) and the spawning and egg incubation (<13°C) of salmon (Combs and Burrows 1957; Bell 1973; Hale 1981; McCullogh 1999, Poole et al. 2001). However, water temperatures did at times exceed the State of Alaska standard for maximum water temperature during spawning and egg incubation (13 °C), as well as temperatures considered to cause elevated disease rates (14–17 °C) and reduced gamete viability (13-16 ° C) in salmon (Poole et al. 2001; Table 10).

Turbidity (NTU) during monitoring periods from 2001 to 2009 ranged from 0.15 to 96.50 and averaged 2.97 overall (Table 11). Total precipitation during monitoring periods from 2001 to 2009 ranged from 2.05 cm to 16.33 cm with a mean of 8.67 cm (Table 12). Monthly mean discharge from 2002-2009 ranged from 22 to 2,880 cfs (Table 13).

DISCUSSION

Chinook Salmon

The 2009 Yukon River Chinook run was projected to be below average to poor, i.e. unlikely to provide for a commercial harvest, and with the need for subsistence conservation measures to meet escapement goals and provide for some shared subsistence (ADF&G 2009). Because of a below average to poor preseason outlook for Yukon River Chinook salmon stocks, conservative measures were taken to reduce impacts from commercial fishermen on salmon escapement and provide for subsistence opportunites. There was no directed commercial Chinook fishery on the Yukon River in 2009 and approximately 1075 Chinook salmon were caught incidentally in the commercial summer chum fishery (ADF&G 2009). Inseason subsistence closures were initiated to aid in escapement for the early portion of the Chinook run. Even with an overall weak Chinook run, most escapement goals were met, and the harvest sharing agreement with Canada fisheries was likely fulfilled (ADF&G 2009). The total commercial harvest of 316 was 99% below the recent 10-year (1999-2008) average of 35,027 for the Alaska portion of the Yukon River drainage (ADF&G 2009).

The 2009 Chinook salmon escapement (1,112) on the Tozitna River was the fourth highest escapement count recorded since the project's inception in 2001. The 2009 Chinook escapement was 23% below the 5-year average (2002-2005, 2007) of 1,449. Escapement counts from 2001, 2006 and 2008 were not included in the average because there was no commercial fishing on the Yukon River in 2001, 2008, and 2009, and the Tozitna counts were incomplete in 2006. Two factors suggest that the 2009 Chinook escapement counts on the Tozitna River are accurate: (1) the first Chinook passed 8 days after the weir was installed, and (2) Chinook escapement in the last 12 days of counting was < 1% of the cumulative escapement. With 23% of the Chinook escapement sampled, the sex ratio of 19.6% female should likewise be considered accurate. This sex ratio is slightly higher than the 7-year average of 19.1% female. Given an escapement of 1112 Chinook and a sex ratio of 19.6% female, an estimated 218 females returned to spawn above the Tozitna River weir in 2009.

Chinook run timing and quartile dates were later than normal in 2009. The first Chinook passed the Tozitna River weir on 8 July, 8 days later than the average of 30 June. Quartile dates were also 2 to 4 days later than the 8-year averages. The date of peak passage (166 Chinook) occurred on 24 July, which was 8 days later than average (Table 1). Delayed passage may have been influenced by unusually low water levels in the Tozitna River, which were a result of the lowest amount of precipitation since the project's inception (Table 12).

The sex ratio of Chinook salmon in the Tozitna River has been consistently lower than the average sex ratio of the other Yukon River drainage weirs, which include the East Fork Andreafsky, Gisasa, and Henshaw Rivers, in every year from 2003-2009 (Table 3, Figure 8). It is uncertain what causes the Tozitna River population to be predictably skewed in this way. However, our spawning surveys found that 23.2% of all Chinook redds occurred below the weir from 2007 to 2009 and so consequently ASL data for this notable portion of the stock remains unknown. If there truly is an abnormally skewed sex ratio on the Tozitna River the long-term genetic health and diversity of the population, and its effective population size, may be adversely impacted (Olsen et. al, 2005).

A comparative analysis of run timing was performed on 2001-2009 Tozitna River escapement data to compare run timing with subsistence and commercial fishing seasons in the Yukon River in order to determine if run-timing is influenced by open fishing seasons on the Yukon River. In every year of the project, quartile dates (25%, 50%, and 75%) were within just 6 days of the respective averages in both years with and without commercial fishing seasons (Table 1), suggesting that commercial fishing seasons do not seem to have a drastic effect on the run timing of Chinook in the Tozitna River. However, such an effect would be difficult to detect given the relatively small number of fish spawning in the Tozitna River. A radio-tagging project indicated that while the Tozitna River may be an important area for Chinook salmon spawning compared to other Middle Yukon River tributaries (i.e. the Melozitna River and the Nowitna River), it's overall contribution to Yukon River stock composition is estimated at around 1.1% (Eiler et. al, 2004).

Summer Chum Salmon

The 2009 summer chum outlook was for an average run, which would provide for escapements and support normal subsistence and commercial harvests (ADF&G 2009). Concern about incidental harvest of Chinook salmon in 2009 caused conservative measures to be taken in opening the summer chum fishery. The total commercial harvest of 170,272 summer chum salmon was 140% greater than the 1999-2008 average harvest of 63,341 for the Alaska portion of the Yukon River drainage (ADF&G 2009).

The 2009 summer chum salmon escapement count (9,133) for the Tozitna River is considered a complete count. The average daily escapement for the last 3 days of counting was less than 1.0% of the cumulative escapement. The 2009 total escapement was well below the 6-year average (2001, 2002, 2004, 2005, 2007, 2009) of 21,030 (Table 2).

The date of the first chum passing through the weir, quartile dates, and the date of peak passage in 2009 were 3 to 7 days later than the 5-year average of 30 June (2003, 2006, 2007, and 2008 were not included due to incomplete counts). The sex ratio (41.3% female) was slightly below the 8-year average (2002-2009) of 43.2% (Figure 11).

The last decade has shown that stock composition of summer chum runs is shifting geographically in the Yukon River (Bergstrom et. al, 2009). With these fluctuations, smaller streams like the Tozitna River may become more important contributors to overall stock composition.

Future Plans

As an index of Chinook and summer chum salmon abundance the Tozitna River weir counts proved useful, but given the unknown contribution of the estimated 23% of Chinook and 61% of summer chum stock spawning below the weir location, it is hard to make confident statements about the overall health and composition of the stock. Additionally, the almost yearly high water events occurring in August presented difficulties in obtaining years of complete data sets, and serious issues for the safety of the field crew as they attempted to work in high water and save equipment from large trees coming rapidly downriver. Because of these issues, and foreseeable upcoming budgetary restraints, the BLM has not sought to continue the Tozitna River project as of 2010. In order for the project to be continued safely and with effectiveness, it would be wise to move the weir to a different location where large trees coming downriver during flood events, which destroyed a $10,000 fish trap in the past, can be dealt with in a safe manner, and downstream from a larger percentage of the Chinook and summer chum spawning areas. Additionally, it may be prudent to look into different fish trap designs or the implementation of sonar technology for any weir project dealing with dangerous yearly flood events.

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FOOTNOTES

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

Table 1. Quartile dates and first, peak, and cumulative passage for Chinook salmon, Tozitna River, Alaska, 2001-2009[a].

Year	1st Pass	25% Quartile		50% Quartile		75% Quartile		Total Run		% of Avg. Esc.
		Date	Cum.	Date	Cum.	Date	Cum.	Peak	Cum.	
2001	7/6	7/15	789	7/19	1501	7/22	2181	7/20	2854	197.0
2002	6/29	7/10	400	7/14	806	7/18	1112	7/10	1441	99.4
2003	6/26	7/9	471	7/14	966	7/19	1460	7/9	1819	125.5
2004	6/24	7/11	603	7/16	1094	7/18	1424	7/17	1880	129.7
2005	7/2	7/14	744	7/15	908	7/18	1217	7/14	1611	111.2
2006	7/3	7/11	196	7/16	270	7/25	400	7/11	533	36.8
2007	7/3	7/13	149	7/20	245	7/24	397	7/23	494	34.1
2008	7/8	7/18	192	7/21	358	7/22	511	7/22	681	47.0
2009	7/8	7/15	294	7/19	578	7/24	847	7/24	1112	76.7
Avg.	6/30	7/12	426	7/17	747	7/20	1061	7/16	1449	100.0

[a] The average total run figure does not include counts for 2001, 2008, and 2009 because there were no commercial fisheries targeting Chinook salmon during those years, and 2006 because the count was considered incomplete.

Table 2. Quartile dates and first, peak, and cumulative passage for summer chum salmon, Tozitna River, Alaska, 2001-2009[a].

Year	1st Pass	25% Quartile		50% Quartile		75% Quartile		Total Run		% of Avg. Esc.
		Date	Cum.	Date	Cum.	Date	Cum.	Peak	Cum.	
2001	7/5	7/19	3393	7/23	6680	7/30	9570	7/21	12527	59.6
2002	6/26	7/16	4951	7/20	9860	7/25	14176	7/17	18789	89.3
2003	6/25	-	-	-	-	-	-	-	8487	40.4
2004	6/22	7/18	7183	7/24	13102	8/1	18957	7/18	25003	118.9
2005	6/29	7/19	11012	7/25	20706	7/31	30368	7/27	39700	188.8
2006	7/4	7/15	5749	7/25	12086	7/29	17645	7/24	22629	107.6
2007	7/3	7/25	4063	7/29	7844	8/2	11163	7/23	14147	67.3
2008	7/3	7/22	2202	7/26	4220	7/31	6621	7/25	8470	40.3
2009	7/3	7/27	2243	7/31	5150	8/4	7196	7/29	9133	43.4
Avg.		7/20	5100	7/25	9956	7/30	14462	7/23	21030	100.0

[a]The average total run figure does not include counts for 2003, 2006, 2007, and 2008 because the counts were considered incomplete.

Table 3. Percentage of male and female Chinook salmon, Tozitna River, Alaska, 2002-2009.

Year	% Male	% Female
2002	85.9	14.1
2003	81.8	18.2
2004	82.7	17.3
2005	70.0	30.0
2006	88.4	11.6
2007	74.3	25.7
2008	91.0	9.0
2009	80.4	19.6
Avg.	81.8	18.2

Table 4. Age composition of the Tozitna River Chinook salmon escapement by sex; Alaska, 2001-2009. Standard error in parenthesis.

				Brood Year and Age													
				1.1		1.2		1.3		2.2		1.4		2.3		1.5	
Year	Weir Count	Sex	# Fish Sampled	%		%	.	%		%		%		%		%	
		M	35	2.9	(2.9)	22.9	(7.2)	40.0	(8.4)	0.0	(0.0)	34.3	(8.1)	0.0	(0.0)	0.0	(0.0)
2001	2854	F	24	0.0	(0.0)	0.0	(0.0)	20.8	(8.5)	0.0	(0.0)	75.0	(9.0)	0.0	(0.0)	4.2	(4.2)
		Subtotal	59	1.7	(1.7)	13.6	(4.5)	32.2	(6.1)	0.0	(0.0)	50.8	(6.6)	0.0	(0.0)	1.7	(1.7)
		M	421	0.7	(0.4)	49.6	(2.4)	40.9	(2.4)	0.0	(0.0)	8.8	(1.4)	0.0	(0.0)	0.0	(0.0)
2002	1441	F	62	0.0	(0.0)	0.0	(0.0)	17.7	(4.9)	0.0	(0.0)	77.4	(5.4)	0.0	(0.0)	4.8	(2.8)
		Subtotal	483	0.6	(0.4)	43.3	(2.3)	37.9	(2.2)	0.0	(0.0)	17.6	(1.7)	0.0	(0.0)	0.6	(0.4)
		M	410	0.5	(0.5)	33.9	(4.9)	56.3	(5.0)	0.0	(0.0)	9.0	(3.3)	0.0	(0.0)	0.2	(0.4)
2003	1819	F	91	0.0	(0.0)	0.0	(0.0)	30.8	(8.8)	0.0	(0.0)	68.1	(8.9)	0.0	(0.0)	1.1	(1.4)
		Subtotal	501	0.4	(0.5)	27.7	(3.6)	51.7	(4.1)	0.0	(0.0)	19.8	(3.4)	0.0	(0.0)	0.4	(0.4)
		M	344	0.5	(0.9)	46.7	(5.3)	46.7	(5.3)	0.0	(0.0)	6.1	(2.5)	0.0	(0.0)	0.0	(0.0)
2004	1880	F	72	0.0	(0.0)	0.0	(0.0)	11.2	(7.6)	0.0	(0.0)	84.1	(8.4)	0.0	(0.0)	4.7	(4.1)
		Subtotal	416	0.4	(0.8)	38.5	(4.7)	40.5	(4.8)	0.0	(0.0)	19.7	(3.9)	0.0	(0.0)	0.9	(0.8)
		M	200	0.1	(0.7)	38.2	(6.3)	47.0	(6.8)	0.0	(0.0)	14.7	(4.8)	0.0	(0.0)	0.0	(0.0)
2005	1611	F	96	0.0	(0.0)	0.0	(0.0)	41.7	(10.3)	0.0	(0.0)	58.2	(10.3)	0.0	(0.0)	0.0	(0.0)
		Subtotal	296	0.1	(0.4)	20.9	(4.4)	46.4	(5.4)	0.0	(0.0)	32.6	(5.0)	0.0	(0.0)	0.0	(0.0)
		M	61	0.0	(0.0)	14.8	(4.6)	82.0	(5.0)	0.0	(0.0)	3.2	(2.3)	0.0	(0.0)	0.0	(0.0)
2006	533	F	8	0.0	(0.0)	0.0	(0.0)	87.5	(12.5)	0.0	(0.0)	12.5	(12.5)	0.0	(0.0)	0.0	(0.0)
		Subtotal	69	0.0	(0.0)	13.0	(4.1)	82.6	(4.6)	0.0	(0.0)	4.4	(2.5)	0.0	(0.0)	0.0	(0.0)
		M	165	0.0	(0.0)	39.9	(7.9)	42.5	(7.9)	0.0	(0.0)	17.5	(5.5)	0.0	(0.0)	0.0	(0.0)
2007	494	F	52	0.0	(0.0)	0.0	(0.0)	12.7	(8.4)	0.0	(0.0)	85.7	(9.1)	0.0	(0.0)	1.5	(4.3)
		Subtotal	217	0.0	(0.0)	29.3	(6.3)	34.6	(6.4)	0.0	(0.0)	35.8	(6.4)	0.0	(0.0)	0.4	(0.0)
		M	215	1.4	(0.8)	20.5	(2.8)	74.9	(0.6)	0.0	(0.0)	2.3	(0.1)	0.9	(0.1)	0.0	(0.0)
2008	681	F	24	0.0	(0.0)	4.2	(4.2)	45.8	(1.4)	0.0	(0.0)	45.8	(1.4)	0.0	(0.0)	4.2	(0.4)
		Subtotal	239	1.3	(0.7)	18.8	(2.5)	72.0	(0.5)	0.0	(0.0)	6.7	(0.2)	0.8	(0.1)	0.4	(0.0)
		M	186	0.0	(0.0)	58.1	(3.6)	24.7	(3.2)	0.5	(0.5)	16.1	(2.7)	0.5	(0.5)	0.0	(0.0)
2009	1112	F	41	0.0	(0.0)	7.3	(4.1)	7.3	(4.1)	0.0	(0.0)	85.4	(5.6)	0.0	(0.0)	0.0	(0.0)
		Subtotal	227	0.0	(0.0)	48.9	(3.3)	21.6	(2.7)	0.4	(0.4)	28.6	(3.0)	0.4	(2.7)	0.0	(0.0)
	Avg.	M		0.7		36.1		53.8		0.1		12.4		0.2		0.0	
		F		0.0		1.3		30.6		0.0		65.8		0.0		2.3	
		Total		0.5		28.2		46.6		0.0		24.0		0.1		0.5	

Table 5. Length at age of Chinook salmon, Tozitna River, Alaska, 2001-2009.

Age	Sex	Sample	Mean	SE	Range
	Male	11	364	12.5	305-460
1.1	Female	0		-	-
	Male	738	554	1.9	380-830
1.2	Female	4	546	27.2	465-580
	Male	871	686	1.8	480-850
1.3	Female	105	767	4.6	585-895
	Male	185	775	4.6	440-975
1.4	Female	326	835	2.7	660-995
	Male	1	805	-	805
1.5	Female	10	894	16.2	830-980
	Male	1	590	-	590
2.2	Female	0		-	-
	Male	3	663	15.9	635-690
2.3	Female	1	665	-	665

Table 6. Percentage of male and female summer chum salmon passing through Tozitna River weir, Alaska, 2002-2009.

Year	**% Male**	**% Female**
2002	63.8	36.2
2003	66.1	33.9
2004	52.7	47.3
2005	49.3	50.7
2006	44.1	55.9
2007	56.7	43.3
2008	62.9	37.1
2009	58.7	41.3
Avg.	56.8	43.2

Table 7. Age composition of Tozitna River summer chum salmon escapement by sex; Alaska, 2001-2009. Standard error in parenthesis.

				Age									
				0.2		0.3		0.4		0.5		0.6	
Year	Weir Count	Sex	# Fish Sampled	%		%		%		%		%	
		M	140	0.0	(0)	13.6	(2.9)	80.7	(3.3)	5.7	(2.0)	0.0	(0.0)
2001	12527	F	163	0.0	(0)	23.3	(3.3)	76.1	(3.4)	0.6	(0.6)	0.0	(0.0)
		Subtotal	303	0.0	(0)	18.8	(2.2)	78.2	(2.4)	3.0	(1.0)	0.0	(0.0)
		M	460	0.4	(0.3)	17.0	(1.8)	74.6	(2.0)	7.6	(1.2)	0.4	(0.3)
2002	18789	F	260	1.5	(0.8)	23.1	(2.6)	71.5	(2.8)	3.8	(1.2)	0.0	(0.0)
		Subtotal	720	0.8	(0.3)	19.2	(1.5)	73.5	(1.6)	6.3	(0.9)	0.3	(0.2)
		M	362	0.8	(0.5)	81.8	(2.0)	14.4	(1.8)	3.0	(0.9)	0.0	(0.0)
2003	8487	F	193	1.0	(0.7)	85.5	(2.5)	11.4	(2.3)	2.1	(1.0)	0.0	(0.0)
		Subtotal	555	0.9	(0.4)	83.1	(1.6)	13.3	(1.4)	2.7	(0.7)	0.0	(0.0)
		M	572	1.4	(0.5)	52.6	(2.1)	45.8	(2.1)	0.2	(0.2)	0.0	(0.0)
2004	25003	F	441	3.4	(0.9)	67.6	(2.2)	28.8	(2.2)	0.2	(0.2)	0.0	(0.0)
		Subtotal	1013	2.3	(0.5)	59.1	(1.5)	38.4	(1.5)	0.2	(0.1)	0.0	(0.0)
		M	419	0.0	(0)	89.5	(1.5)	10.5	(1.5)	0.0	(0.0)	0.0	(0.0)
2005	39700	F	408	0.0	(0)	97.5	(0.8)	2.5	(0.8)	0.0	(0.0)	0.0	(0.0)
		Subtotal	827	0.0	(0)	93.5	(0.9)	6.5	(0.9)	0.0	(0.0)	0.0	(0.0)
		M	285	0.7	(0.5)	16.5	(2.2)	82.8	(2.2)	0.0	(0.0)	0.0	(0.0)
2006	22629	F	258	1.2	(0.7)	35.7	(3.0)	63.2	(3.0)	0.0	(0.0)	0.0	(0.0)
		Subtotal	543	1.0	(0.4)	26.6	(1.9)	76.3	(1.8)	0.0	(0.0)	0.0	(0.0)
		M	450	2.9	(0.8)	61.1	(2.3)	33.1	(2.2)	2.9	(0.8)	0.0	(0.0)
2007	14147	F	258	3.5	(1.1)	63.6	(3.0)	30.2	(2.9)	2.7	(1.0)	0.0	(0.0)
		Subtotal	708	3.1	(0.7)	62.0	(1.8)	32.1	(1.8)	2.8	(0.6)	0.0	(0.0)
		M	378	2.4	(0.8)	45.8	(2.6)	45.8	(2.6)	6.1	(1.2)	0.0	(0.0)
2008	8470	F	246	7.3	(1.7)	49.2	(3.2)	38.2	(3.1)	5.3	(1.4)	0.0	(0.0)
		Subtotal	624	4.3	(0.8)	47.1	(2.0)	42.8	(2.0)	5.8	(0.9)	0.0	(0.0)
		M	316	2.5	(0.9)	63.6	(2.7)	33.5	(2.7)	0.3	(0.3)	0.0	(0.0)
2009	9133	F	226	2.2	(1.0)	74.8	(2.9)	22.6	(2.8)	0.4	(0.4)	0.0	(0.0)
		Subtotal	542	2.4	(0.7)	68.3	(2.0)	29.0	(2.0)	0.4	(0.3)	0.0	(0.0)
	Avg.	M	3382	1.2	(0.2)	49.0	(0.9)	46.8	(0.9)	2.9	(0.3)	0.0	(0.0)
		F	2453	2.2	(0.3)	57.8	(1.0)	38.3	(1.0)	1.7	(0.3)	0.0	(0.0)
		Total	5835	1.6	(0.2)	53.1	(0.7)	43.3	(0.6)	2.3	(0.2)	0.0	(0.0)

Table 8. Length at age of summer chum salmon, Tozitna River, Alaska, 2001-2009.

Age	Sex	Sample	Mean	SE	Range
	Male	45	542	4.6	460-605
0.2	Female	56	519	3.6	420-585
	Male	1765	569	0.7	470-675
0.3	Female	1505	545	0.7	360-635
	Male	1478	590	0.8	510-695
0.4	Female	855	561	1.0	480-650
	Male	92	603	3.6	505-680
0.5	Female	37	573	5.6	465-650
	Male	2	575	15.0	560-590
0.6	Female	0	-	-	-

Table 9. Water temperature (°C) in the Tozitna River, Alaska, 2001-2009.

Year	Min.	Max.	Avg.
2001	7.74	15.18	11.13
2002	5.96	15.57	10.87
2003	6.11	13.96	9.63
2004	9.34	15.98	12.71
2005	7.67	14.77	11.17
2006	5.97	13.06	9.91
2007	7.00	14.50	11.80
2008	6.97	16.32	11.38
2009	8.90	17.63	13.54
Avg.	7.30	15.22	11.35

Table 10. Number of days in which the water temperature of the Tozitna River exceeded water temperature threshold values considered to have an effect on salmon health and reproduction. The water quality standards and health and reproduction threshold values are from 18 Alaska Administrative Code 70 and Poole et al. (2001).

Year	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)
2001	2	17	17	8	0
2002	7	21	21	14	0
2003	0	8	8	0	0
2004	12	45	45	25	1
2005	0	42	42	13	0
2006	0	1	1	0	0
2007	0	29	29	10	0
2008	8	22	22	15	5
2009	28	38	37	33	14

Table 11. Turbidity (NTU) in the Tozitna River, Alaska, during monitoring periods from 2001-2009.

Year	**Min.**	**Max.**	**Avg.**
2001	0.40	18.60	1.58
2002	0.39	24.60	1.75
2003	0.78	55.80	5.46
2004	0.15	2.17	0.56
2005	0.46	9.42	1.36
2006	0.97	96.50	7.15
2007	0.70	56.60	4.28
2008	0.93	40.10	3.70
2009	0.16	8.22	0.88
Avg.	0.55	34.67	2.97

Table 12. Total precipitation (cm) in the Tozitna River, Alaska, during monitoring periods from 2001-2009.

Year	Total Precipitation (cm)
2001	6.46
2002	n/a
2003	10.21
2004	8.08
2005	6.46
2006	11.46
2007	16.33
2008	8.33
2009	2.05
Avg.	8.67

Table 13. Monthly mean discharge (cfs) in the Tozitna River, Alaska, 2002-2007. ND = not determined. Preliminary data, subject to review.

Month	Average	2002	2003	2004	2005	2006	2007	2008	2009
Jan	122	ND	103	81	150	179	97	99	120
Feb	81	ND	62	49	124	122	46	49	74
Mar	56	ND	42	29	103	84	22	25	46
Apr	154	ND	44	34	123	62	506	59	715
May	1397	ND	502	789	2034	2833	824	3449	5874
Jun	1197	1,126	1524	556	2185	1120	669	2172	2071
Jul	1282	978	1921	618	1181	2149	846	773	557
Aug	1490	600	2578	1084	760	1578	2341	993	292
Sep	1273	951	1219	693	2880	894	1001	706	276
Oct	652	663	402	339	949	902	657	538	202
Nov	329	300	238	223	396	458	360	329	54
Dec	197	178	141	183	267	213	197	200	26
Avg. Annual	710	685	731	390	929	883	631	783	859

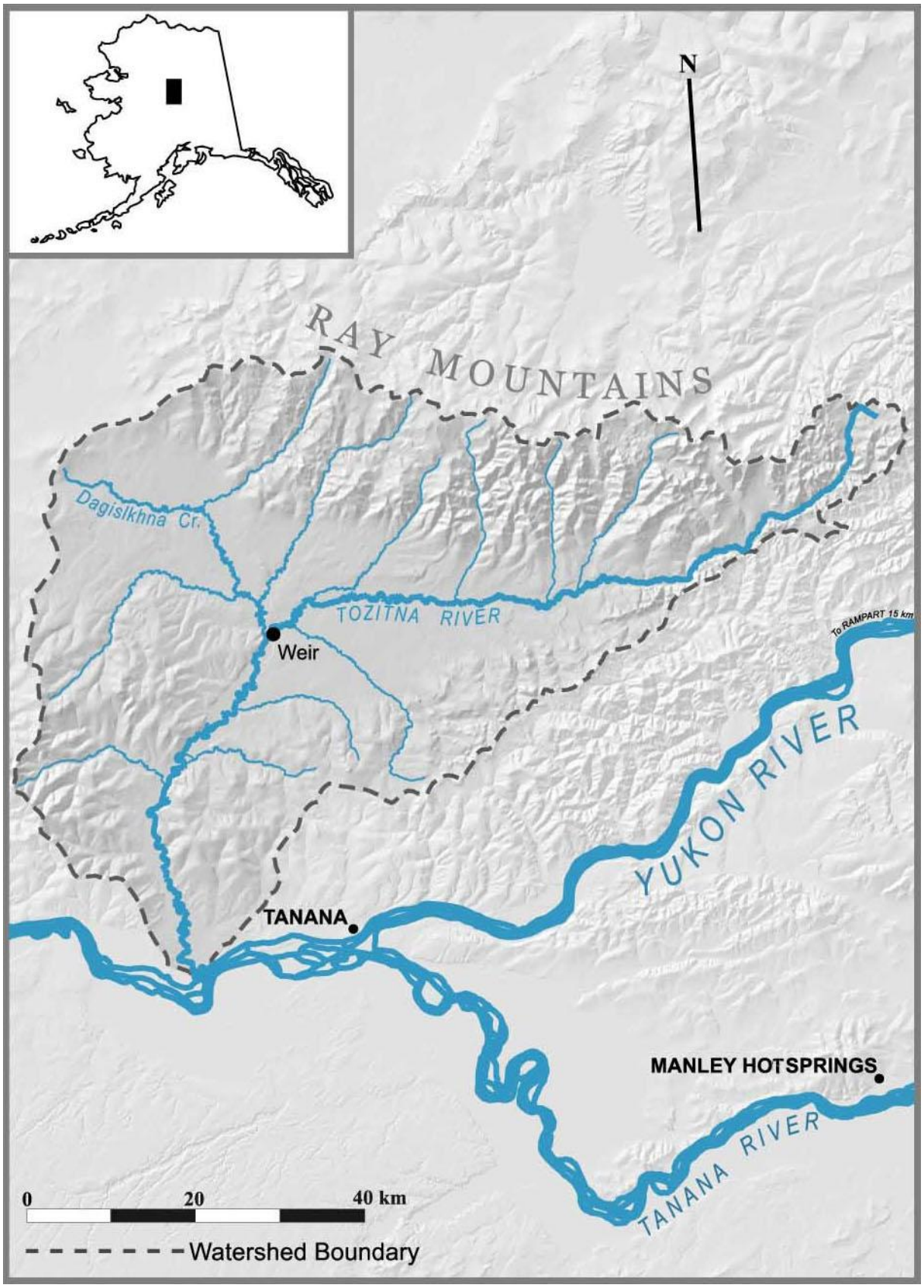

Figure 1. Location of the Tozitna River project, Alaska, 2001-2009.

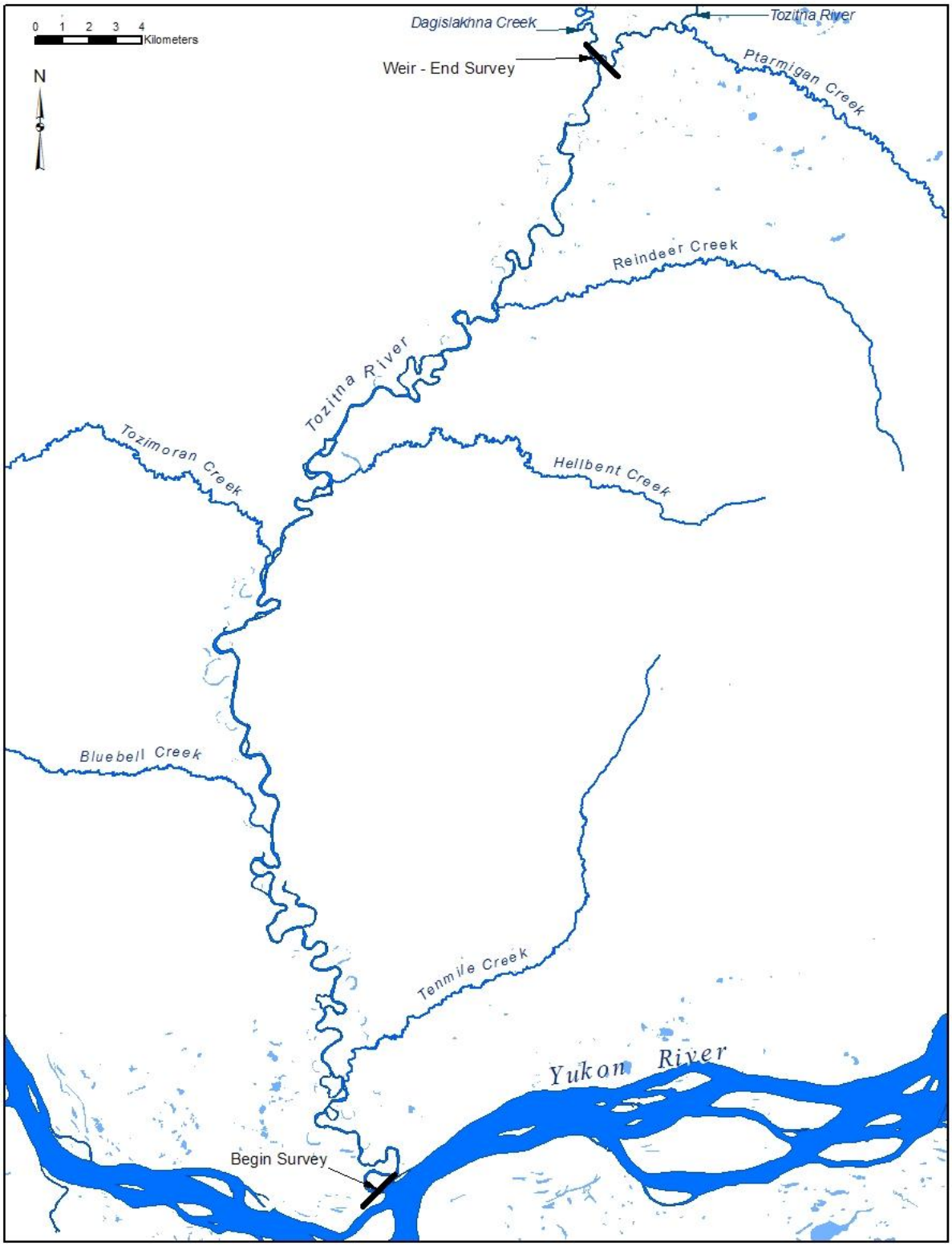

Figure 2. Downstream portion of Tozitna River spawning survey, from the mouth to the weir site.

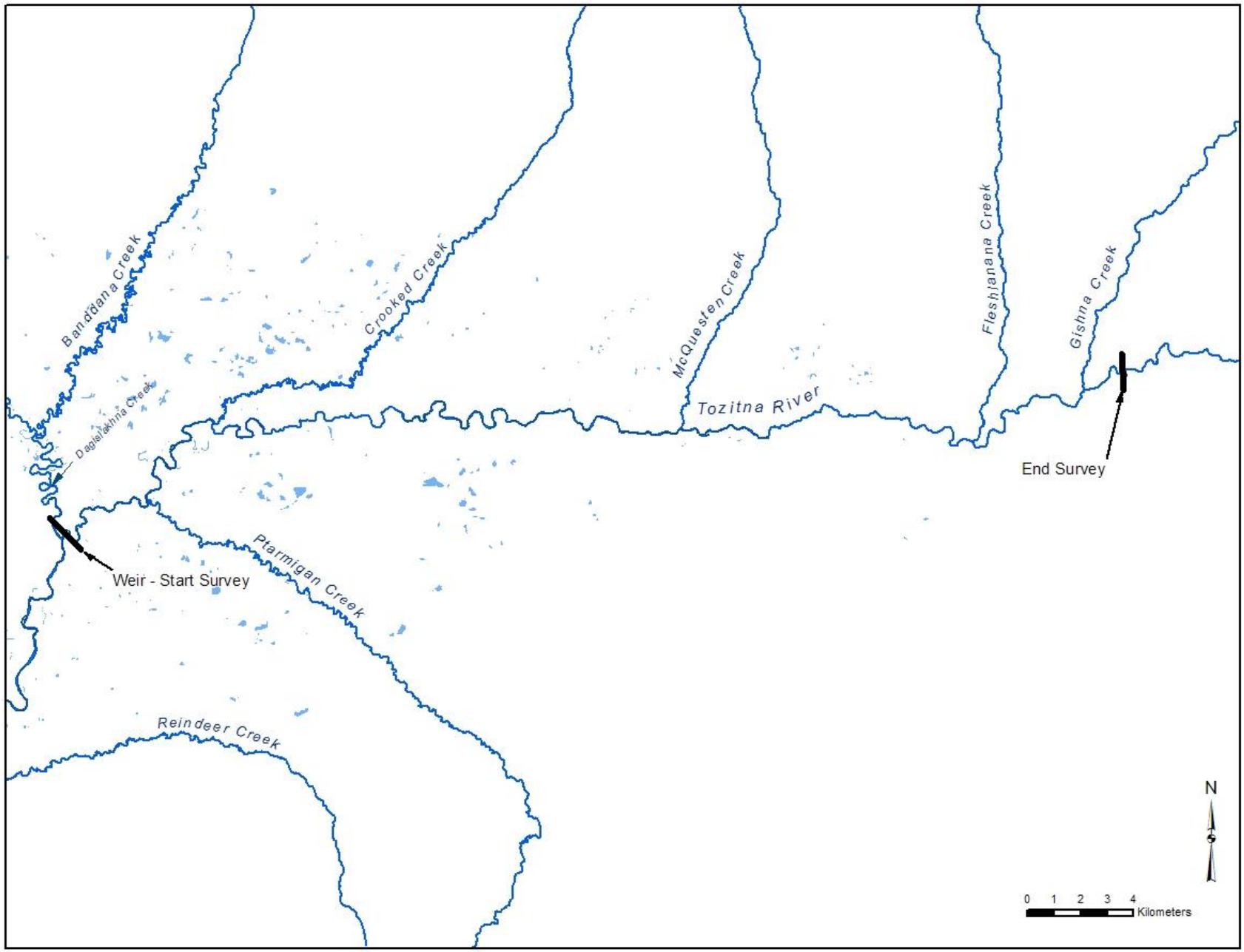

Figure 3. Upstream portion of Tozitna River spawning survey, from the weir site to Gishna Creek.

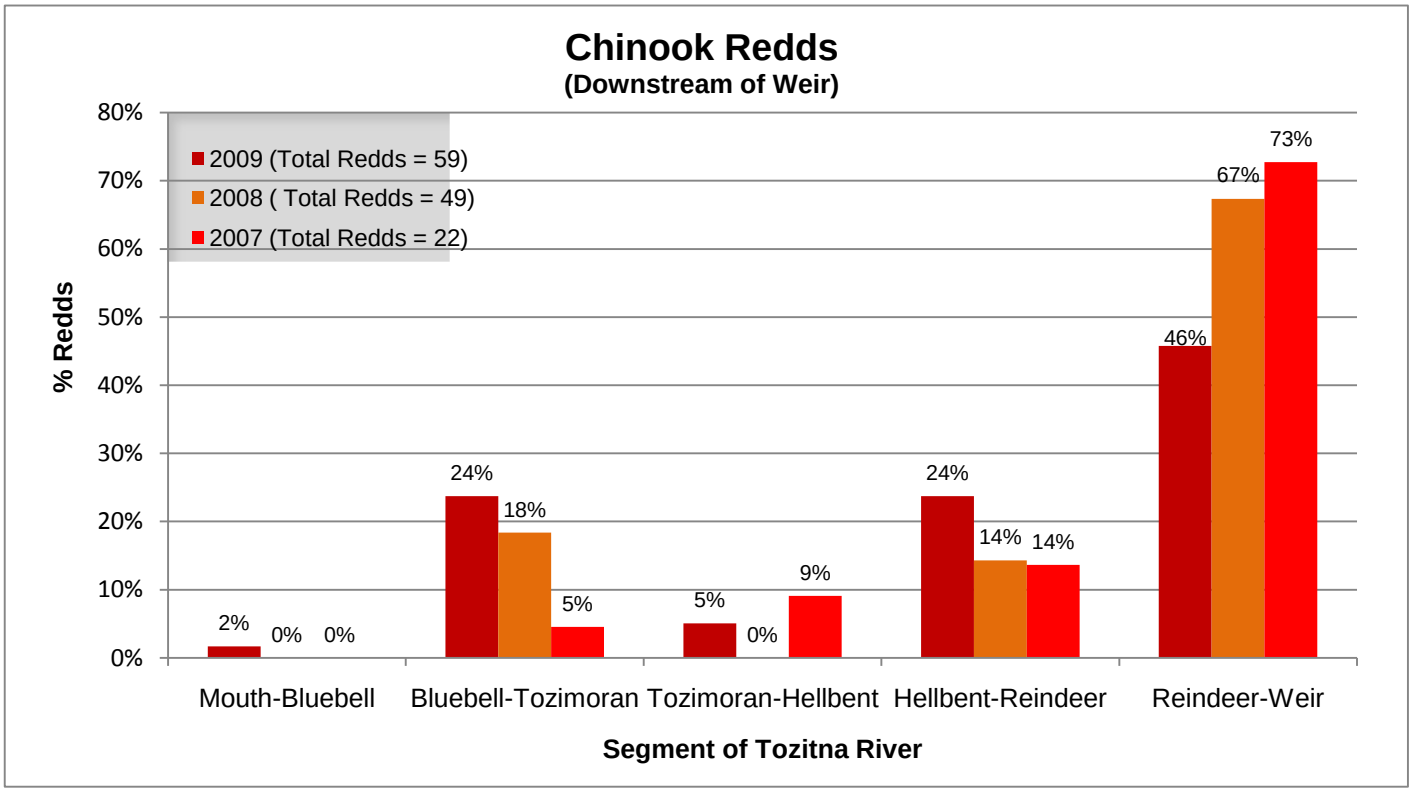

Figure 4. Distribution of Chinook redds downstream of the Tozitna River fish weir, 2007-2009.

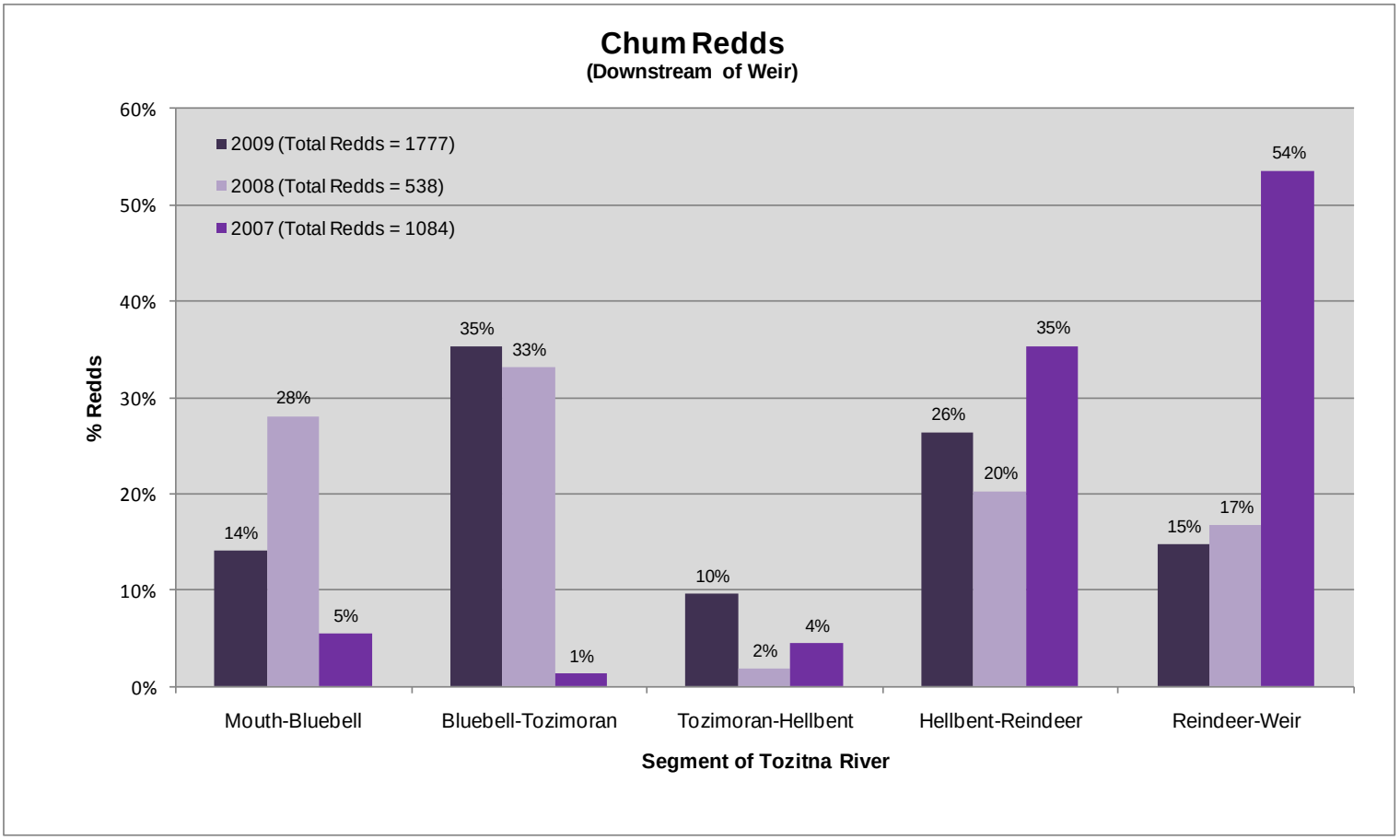

Figure 5. Distribution of summer chum redds downstream of the Tozitna River fish weir, 2007-2009.

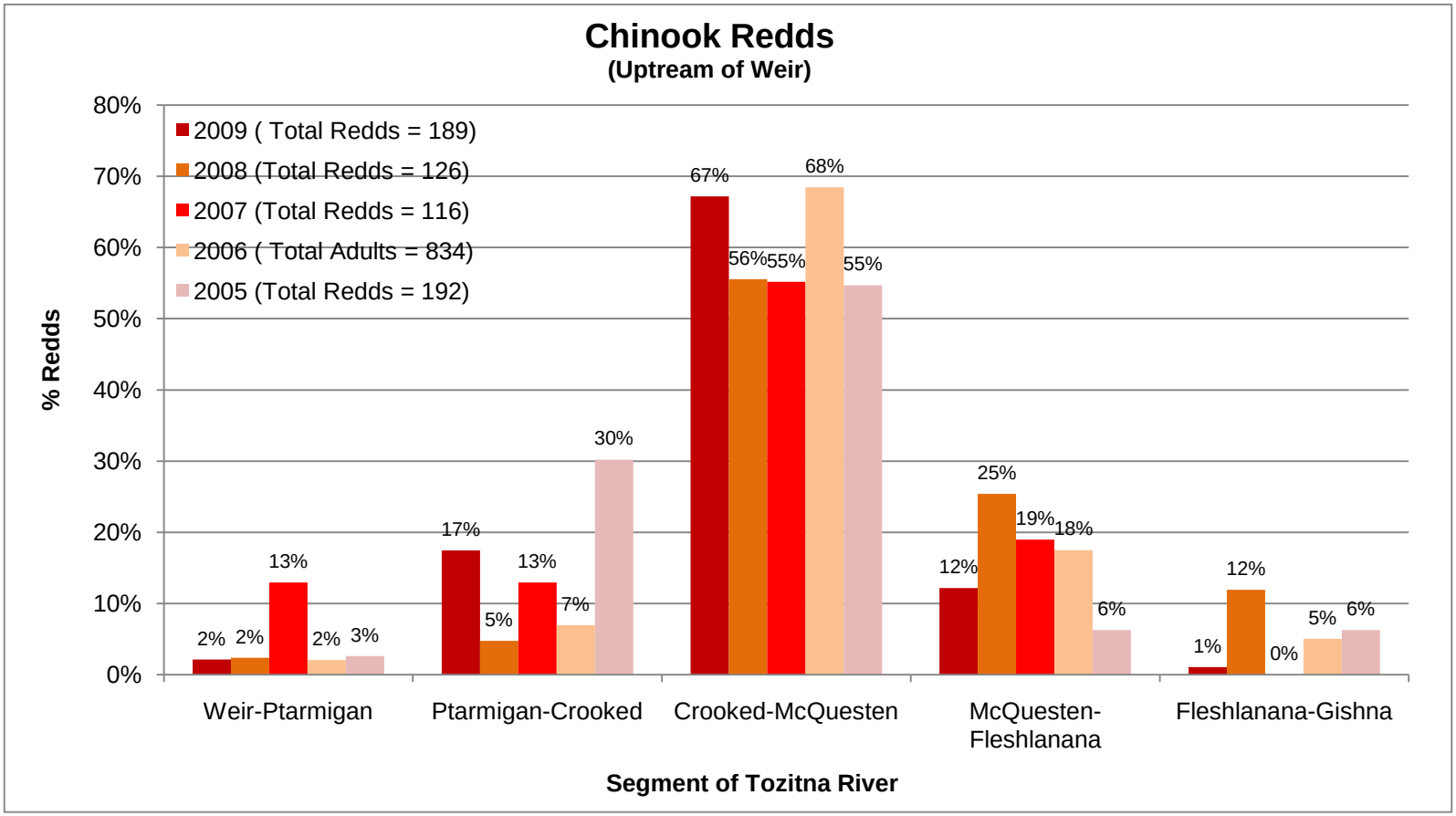

Figure 6. Distribution of Chinook redds upstream of the Tozitna River fish weir, 2005-2009.

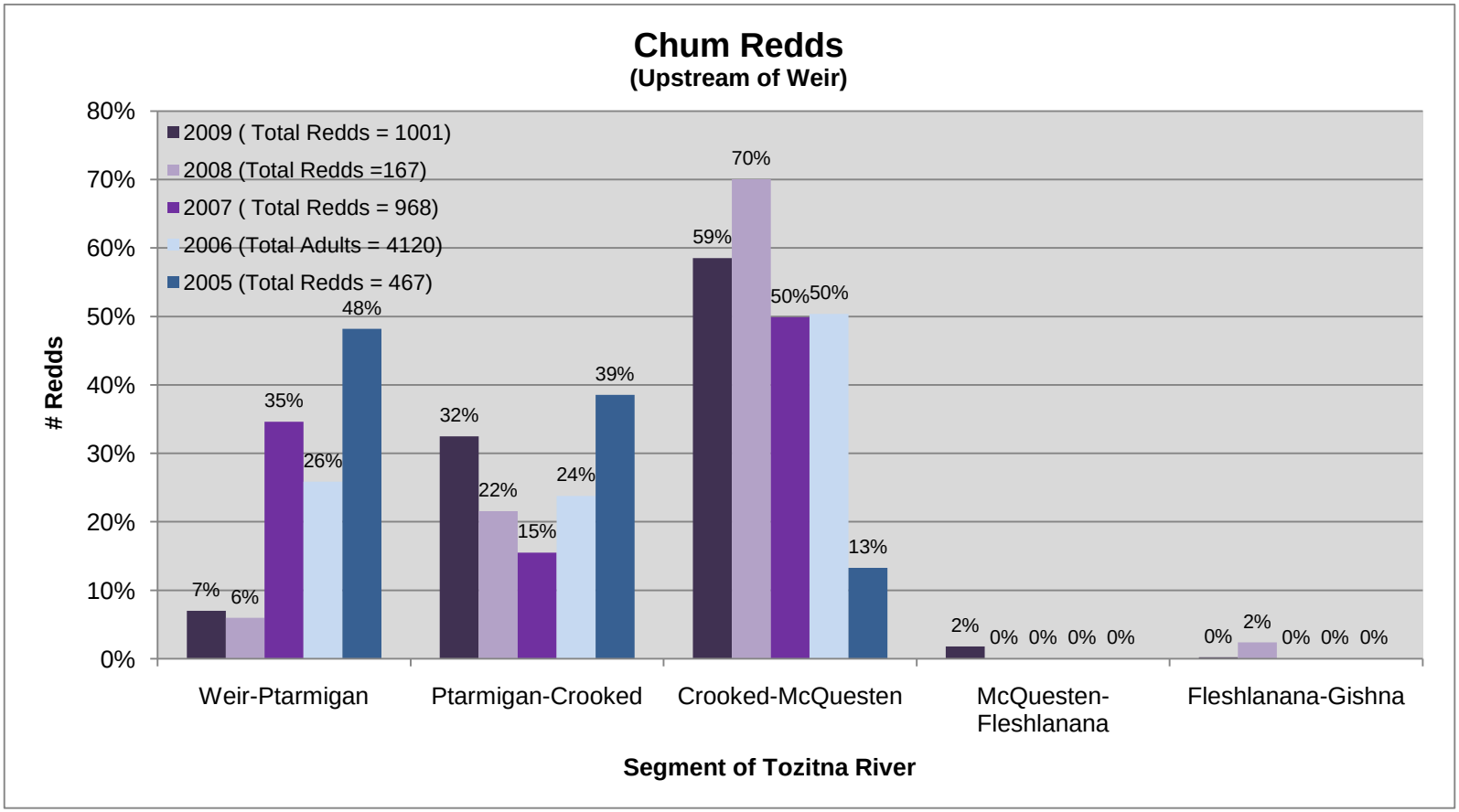

Figure 7. Distribution of summer chum redds upstream of the Tozitna River fish weir, 2005-2009.

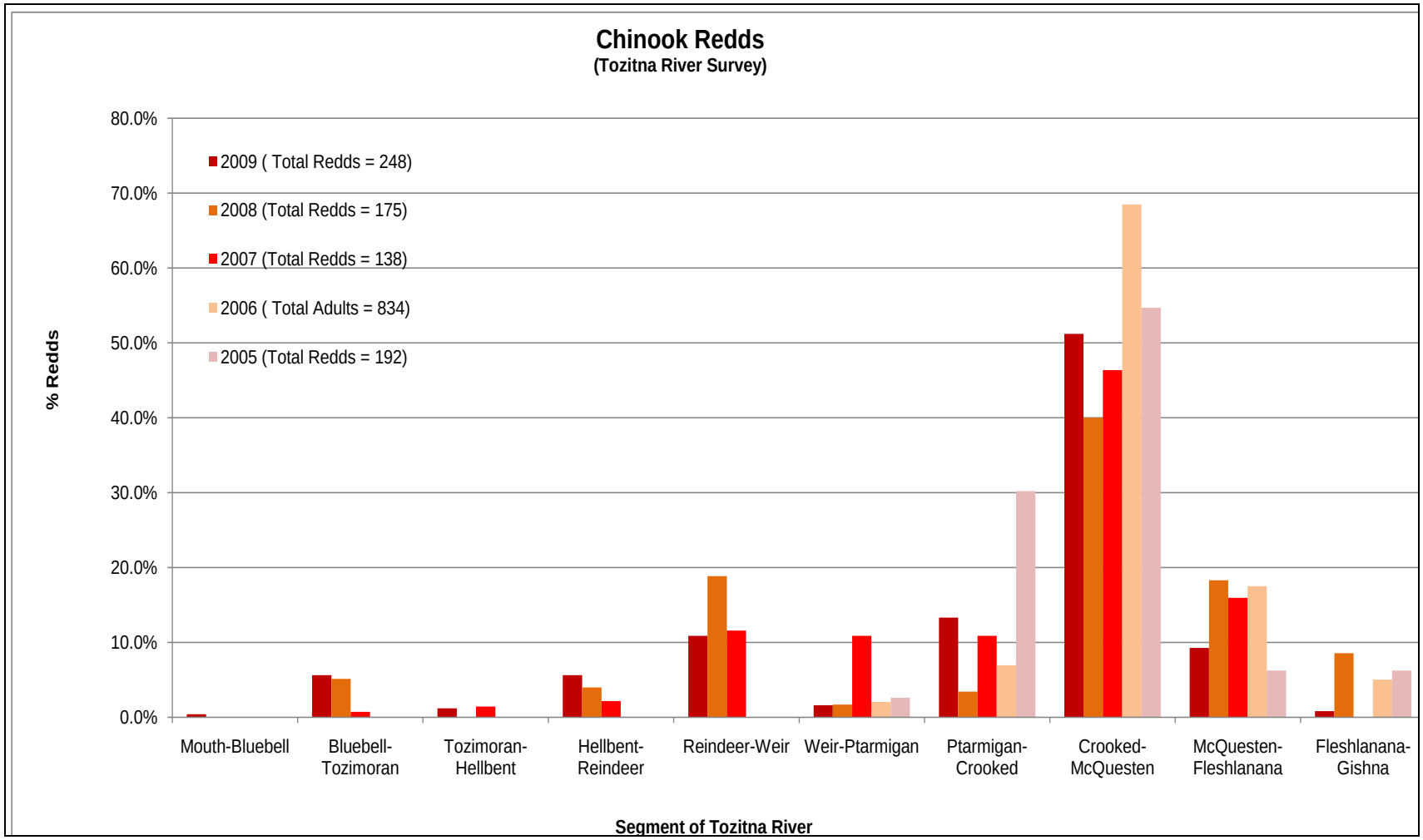

Figure 8. Chinook redd distribution in Tozitna River, Alaska, 2005-2009.

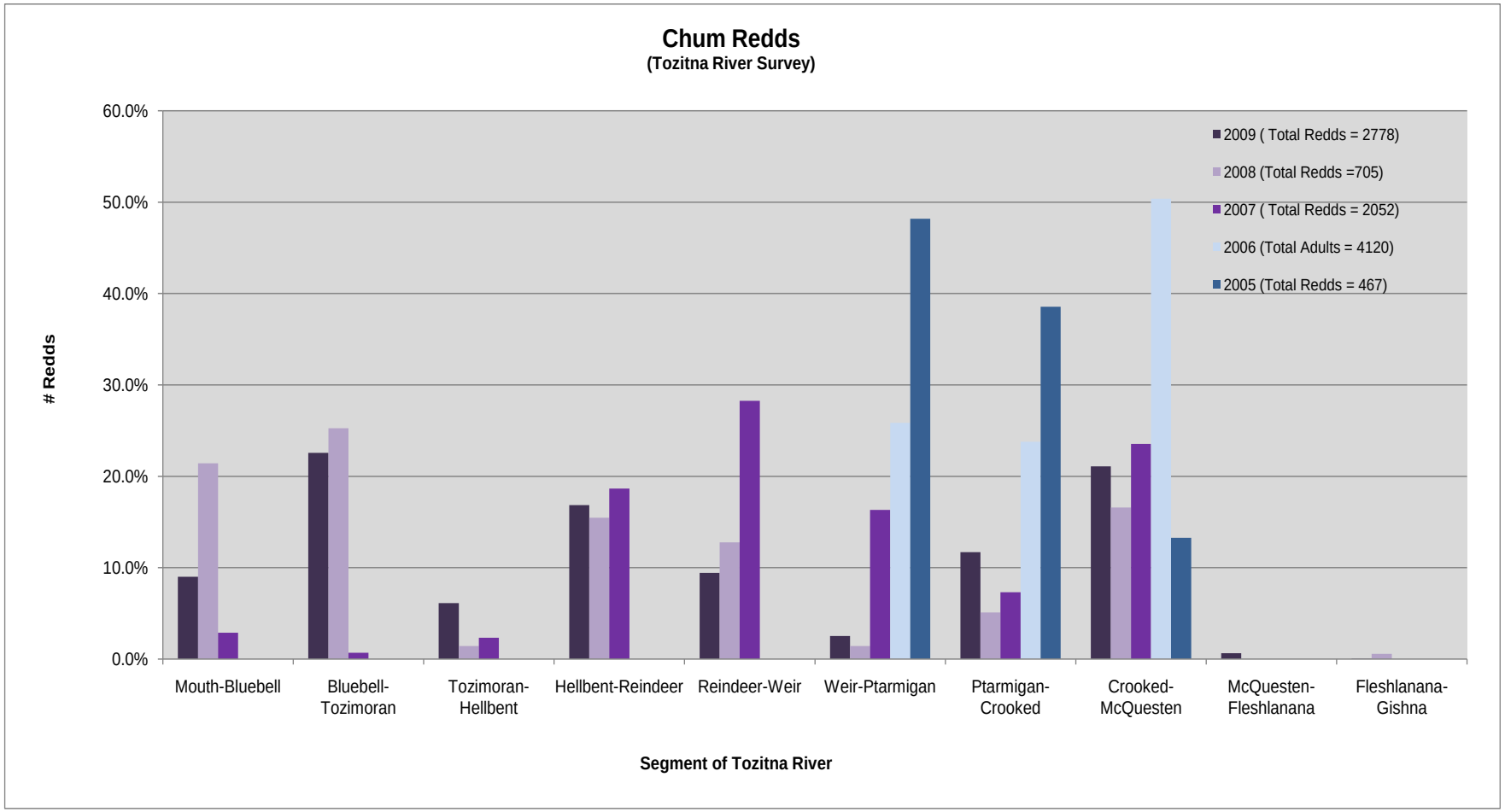

Figure 9. Summer chum redd distribution in the Tozitna River, Alaska, 2005-2009.

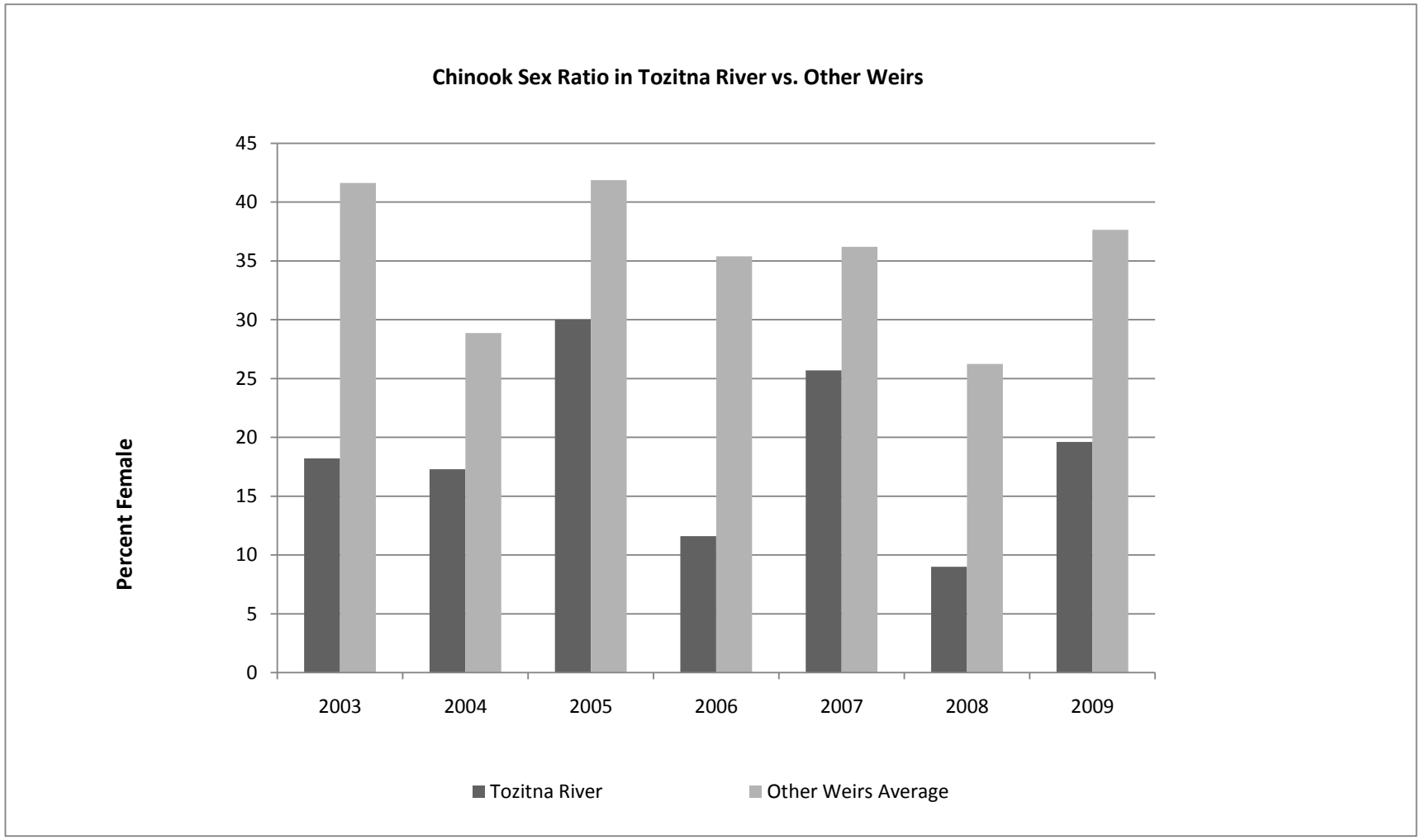

Figure 10. Sex ratio of sampled Chinook salmon in the Tozitna River, Alaska, compared to average for Andreafsky, Gisasa, and Henshaw River weirs 2003-2009.

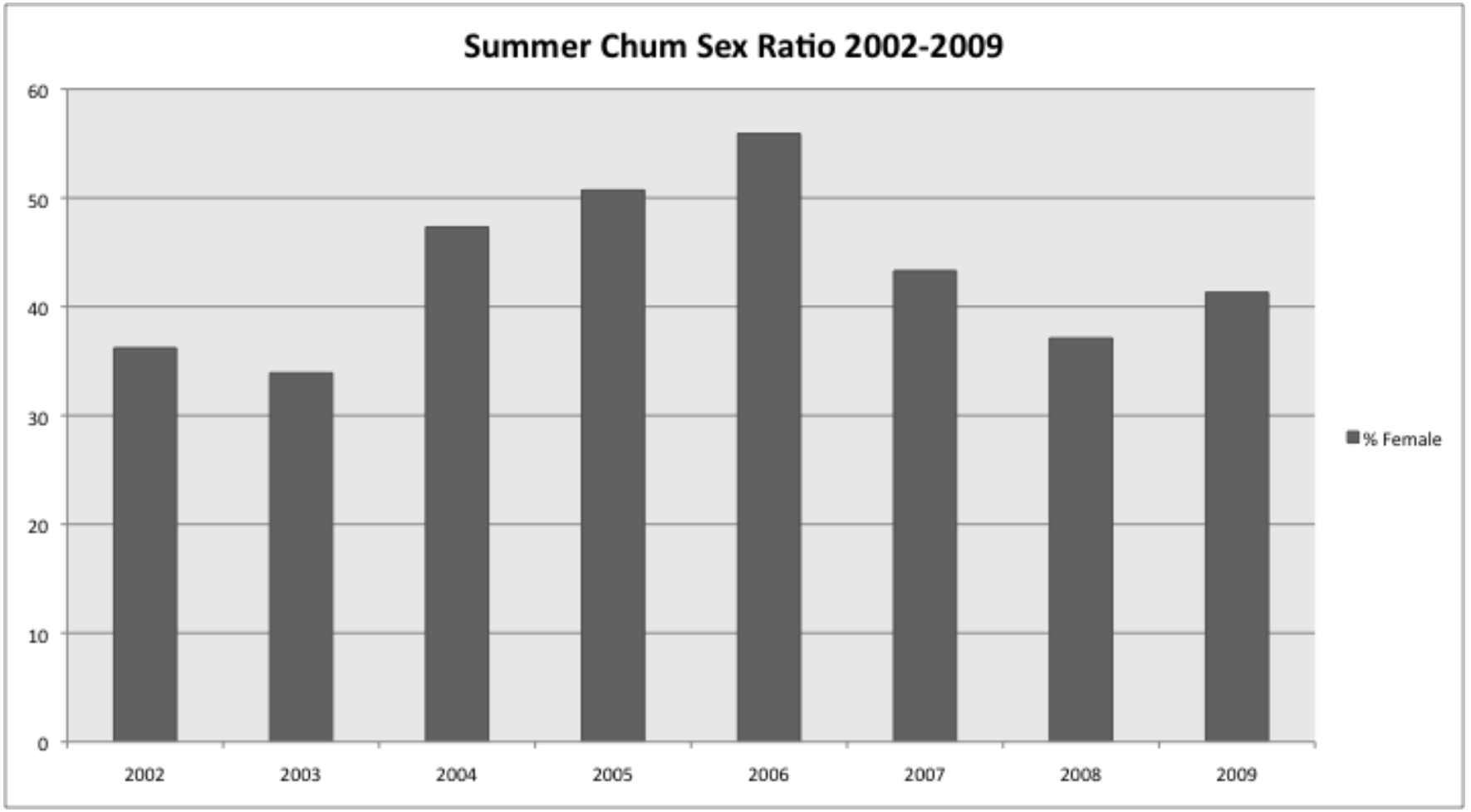

Figure 11. Sex ratio of sampled summer chum salmon in the Tozitna River, Alaska, 2002-2009.

Figure 12. Location of the four weir projects monitoring Chinook salmon escapement in the Alaska portion of the Yukon River Basin as of 2009. The projects were located on the East Fork Andreafsky River, Henshaw Creek, Gisasa River, and the Tozitna River.