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Fall Chum Salmon Abundance Estimation On the Tanana and Kantishna Rivers Using Mark Recapture Techniques, 2003

By

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OEO/ADA STATEMENT

TABLE OF CONTENTS

Page

LIST OF TABLES iv

LIST OF FIGURES v

LIST OF APPENDICES vi

ABSTRACT vii

INTRODUCTION 1

METHODS 3

SAMPLING 3

Tag Deployment 3

Tag Recovery 5

DATA ANALYSIS 5

Abundance Estimation 5

Migration Rate 6

Statistical Tests 6

Stock Timing 7

RESULTS 7

SAMPLING 7

Tag Deployment 7

Tag Recovery 7

DATA ANALYSIS 8

Abundance Estimation 8

Migration Rates 8

Statistical Tests 8

Stock Timing 9

DISCUSSION 9

RECOMMENDATIONS 10

LITERATURE CITED 11

TABLES 13

FIGURES 18

APPENDIX 23

LIST OF TABLES

Table		Page
1.	Tags recovered by location from fall chum salmon tagged in the Tanana and Kantishna Rivers, 2003	13
2.	Daily and cumulative catch statistics and Bailey abundance estimates of fall chum salmon in the Tanana River, 2003.	14
3.	Daily and cumulative catch statistics and Bailey abundance estimates of fall chum salmon in the Kantishna River, 2003.	15
4.	Estimated migration rates (km/day) for day and night caught fall chum salmon in the Tanana and Kantishna Rivers, 1995-2003.	16
5.	Tanana and Kantishna River fall chum salmon abundance estimates 1995-2003.	17

LIST OF FIGURES

Figure		Page
1.	Fishery management districts and subdistricts in the Yukon and Tanana River drainages	18
2.	Location of tag deployment (circles) and recovery fish wheels (squares) used in the Tanana and Kantishna River fall chum salmon mark-recapture project	19
3.	Daily fall chum salmon CPUE at the Tanana River tagging and recovery fish wheels (above), and CPUE at the Kantishna River tagging and recovery fish wheels and the recovery fish wheels on the Toklat River (below), 2003	20
4.	Abundance estimates for fall chum salmon on the Tanana and Kantishna River, 2003 (above) and abundance estimates for the Tanana River 1995-2003 and Kantishna River, 1999-2003 (below). Error bars represent standard error	21
5.	Daily water levels on the Tanana River as measured by a United States Geological Survey gauge located near Nenana, 1999-2003 (above) and mean water temperatures at selected sites, 2003 (below)	22

LIST OF APPENDICES

Appendix		Page
A.	Daily effort and catch of fall chum salmon at the Tanana River tag deployment wheel, 2003	23
B.	Daily effort and catch of fall chum salmon at the Kantishna River tag deployment wheel, 2003	24
C.	Daily effort and catch of fall chum salmon at the Tanana River recovery wheel, 2003	25
D.	Daily effort and catch of fall chum salmon at the Toklat River recovery wheels, (both combined), 2003	26
E.	Daily effort and catch of fall chum salmon at the Kantishna River recovery wheels, (both combined), 2003	27
F.	Daily effort and catch of coho salmon a the Tanana tagging project wheels, 2003	28
G.	Climatological and hydrological observations, Tanana River project and fish wheel sites, 2003.	29
H.	Climatological and hydrological observations, Toklat River project site, 2003	30

ABSTRACT

Fall chum salmon, *Oncorhynchus keta*, mark-recapture studies were conducted for the ninth consecutive year on the Tanana River and for the fifth year on the Kantishna River. In the Tanana River, chum salmon were captured and tagged using a fish wheel located on the right bank of the river, approximately 5-km upstream of the Kantishna River mouth, and recaptured in a fish wheel located approximately 76 km upriver on the right bank. In the Kantishna River, chum salmon were captured in a fish wheel on the left bank of the river, approximately 9-km upstream of its confluence with the Tanana River, and recaptured in four fish wheels. Two fish wheels were located approximately 113 km upstream in the Toklat River, and two fish wheels were located 139 km upstream on the Kantishna River. These studies were conducted during August and September 2003. The final (Bailey model) abundance estimates were 193,418 (SE = 9,976) and 87,359 (SE = 8,041) fall chum salmon for the Tanana and Kantishna Rivers respectively.

KEY WORDS: Tanana River, Kantishna River, chum salmon, *Oncorhynchus keta*, mark-recapture, fish wheel, abundance estimate.

INTRODUCTION

The Yukon River drainage is the largest in Alaska (854,700 km^2), comprising nearly one-third the area of the entire state. Five species of Pacific salmon return to the Yukon River and its tributaries and are captured in subsistence, personal use, commercial, and sport fisheries. The Tanana River is the largest tributary of the Yukon River. It flows northwest through a broad alluvial valley for approximately 700 km to the Yukon River, draining an area of 115,250 km^2. Chum salmon, *Oncorhynchus keta,* return to the Yukon River in genetically distinct summer and fall runs (Seeb et al. 1995). Summer chum salmon enter the Yukon River in early May, and fall chum salmon in mid-July. Fall chum salmon (chum) migration usually peaks mid-September in the Tanana River and continues into early October. Spawning occurs from October through November, predominantly in areas where upwelling ground water prevents freezing. Fall chum are larger on average than summer chum, have higher oil content, and important for subsistence, personal use, and commercial fisheries within the upper Yukon and Tanana Rivers.

The Tanana River drainage is a major producer of Yukon River fall chum and contributes to various fisheries in the Yukon River. The 5-year (1996-2000) average total harvest of fall chum in the Tanana River is approximately 21,000 fish, which is approximately 16% of the entire average catch of the Yukon River drainage for those years (Vania et al. 2002).

The Alaska Department of Fish and Game (ADF&G) manages fisheries in the Alaska portion of the Yukon River drainage. For management purposes, the drainage is divided into 13 districts and subdistricts. The Tanana River (District 6) is divided into Subdistricts, 6-A, 6-B, and 6-C and the area upstream of Subdistrict 6-C to the headwaters known as the upper Tanana River (Figure 1). For the purpose of the Tanana tagging project, all areas upstream of Subdistrict 6-A are considered to be upper Tanana River because the location of tagging projects with respect to the major fall chum spawning grounds. Tanana River summer and fall chum are managed as separate stocks based on average run timing and are divided into summer (before 16 August) and fall seasons (after 16 August), although some overlap in migration does occur.

Subsistence and personal use fisheries occur within District 6 and are usually open for two 42-hour periods per week, with the exception of the "Old Minto" area where subsistence fishing is allowed five days a week. Commercial fishing occurs on the Tanana River in Subdistricts 6-B and 6-C by emergency order up to 42-hours fishing per week (Subdistrict 6-A is limited to one 24 hour period per week). The Tanana River commercial guideline harvest range is 2,750 to 20,500 fall chum, but harvest level may be exceeded if assessment of run size indicates both escapement goals and subsistence needs will be met. In 2003, commercial fishing was permitted because a strong return of fall chum.

Aside from information provided by this project, management decisions for the Tanana River are partially based on catch-per-unit-effort (CPUE) data from department-contracted "test" fish wheels (wheels) and historical fishery data. Information obtained from these sources are used inseason to assess run strength. However, these data have limitations, and managers are unable to use them to assess total run strength. Although test wheels are operated at the same approximate location each year, conditions at a given location may change annually in relation to

water level, current and the channel. Consequently fish wheels are susceptible to variation in efficiency, both in season and between years. These factors are known to fluctuate widely in the Tanana River, which reduces the reliability of test wheel data for making inseason management decisions.

Fishery managers rely on aerial and ground surveys to assess the escapement into select fall chum spawning areas within the Tanana River drainage. However like test wheel CPUE data, aerial and ground survey data (aerial surveys in particular) have limited use inseason and when comparing between years. The Alaska Department of Fish and Game established biological escapement goal of 15,000 to 33,000 in the Toklat River, a tributary of the Kantishna River; 6,000 to 13,000 in the Delta River, a tributary of the Tanana River; and 61,000 to 136,000 for the entire Tanana River (Eggers 2001). Ground surveys are conducted on spawning grounds in each of these rivers to estimate salmon escapement. Because of its importance as a fall chum spawning tributary (Barton 1997), a sonar project using Bendix equipment was operated in the Toklat River from 1994 to 1996. However, prior to 1995 no project existed to estimate fall chum abundance in the mainstem Tanana River. A main river sonar project located at river mile 123 near the village of Pilot Station estimates passage of all salmon species in the lower Yukon River (McIntosh in prep). Additional projects estimate spawning escapement of fall chum in the upper Yukon River tributaries, including the Chandalar, Sheenjek, and Fishing Branch Rivers and the upper Yukon River (JTC 2004).

In 1996, the U.S. Fish and Wildlife Service (USFWS) began a mark-recapture project at Rampart Rapids on the Yukon River, 58 km upriver of the Tanana-Yukon River confluence, to estimate abundance of fall chum in the Yukon River drainage upstream of the village of Rampart (Underwood et al. 2000). Although this project provides an inseason estimate of Yukon River fall chum run strength, it may not accurately reflect the strength of the Tanana River run element because of differences in run strength and run timing between Tanana and non-Tanana stocks. Consequently, an inseason estimate of run strength for the Tanana River has proven to be useful for management.

The Kantishna River drainage contains a major fall chum stock that spawns in the Toklat River tributary. In 1999 the scope of the project was expanded through the Western Alaska Salmon Fisheries Disaster Mitigation Research Plan (WADG) to estimate the abundance of both upper Tanana and Kantishna River fall chum. In addition to one tagging and one recovery wheel operated in the mainstem Tanana River, one tagging wheel was operated in the lower Kantishna River, and two recovery wheels were operated in the Toklat River (Cleary and Bromaghin 2001). In 1999, there was a large disparity between the Kantishna River fall chum abundance estimate and the upper Toklat River expanded ground survey estimate. This disparity led to an assumption a larger proportion of chum migrated to the upper Kantishna River (i.e., upstream of the Toklat River) than was previously thought. To understand the relative abundance and timing of upper Kantishna River fall chum stocks and to satisfy the closed population premise of the study, an additional recovery wheel has operated in the upper Kantishna River since 2000 (Cleary and Hamazaki 2002).

Objectives for the 2003 season were to: Provide management staff with both inseason and postseason abundance estimates of fall chum in the Tanana (above the mouth of the Kantishna

River) and Kantishna Rivers, estimate migration rates for fall chum, count tagged and untagged fall chum using video methods at the Tanana recovery wheel, and estimate run timing of fall chum to the Delta, Toklat, and Kantishna Rivers.

METHODS

Sampling

In 2003, one tagging wheel and one recovery wheel were operated in the Tanana River. One tagging wheel was operated in the Kantishna River, two recovery wheels were operated in the Toklat River, and two recovery wheels (one new in 2003) were operated in the upper Kantishna River. The Bailey population model (Bailey 1951) was used to generate abundance estimates for the Tanana and Kantishna Rivers.

In the Tanana River, one tagging wheel was located 9 km upstream of the Kantishna River mouth, and a recovery wheel was located 76 km upstream of the tagging sites and downstream from the Nenana River (Figure 2). These two locations were selected because of the absence of main tributaries between the two sites, with the exception of the Tolovana River in the Tanana drainage. This satisfies a 'closed population' (i.e., no immigration, emigration, mortality) assumption, the key assumption of this mark-recapture study.

The Toklat River, a tributary to the Kantishna River, ends on the Kantishna River 58 km upstream of the tagging site. Because fall chum spawn in the Toklat River and in streams in the upper Kantishna River drainage, tag recovery wheels were located in both the Toklat and upper Kantishna Rivers. The Toklat River recovery site is located 113 km upstream of the Kantishna River tagging wheel where two tag recovery wheels were operated on both banks of the river. In the upper Kantishna River, two recovery wheels (one new in 2003) were operated 139 km upstream of the Kantishna River tagging wheel on both banks of the river. By operating recovery wheels in each tributary, the closed population assumption was satisfied.

Tag Deployment

The Tanana and Kantishna River tagging wheels are owned and operated by private contractors. In the Tanana River, the wheel was positioned on the right bank at approximately 8 km upstream from the mouth of the Kantishna River and within 100 meters of the 1995-2002 location (Figure 2). This site has a fairly stable river channel that provides a relatively consistent location for wheel operation. In the Kantishna River, a tag deployment wheel funded by the Bering Sea Fishermen's Association (BSFA), was positioned on the left bank at approximately 9 km above the mouth of the river. Both tagging wheels were equipped with baskets that measured 2.5-3 m in width with a dip capacity of approximately 4 m, and live boxes that measured 2.4 x 1.2 x 0.6 m (length, width, depth) and were constructed of spruce poles and one-half inch plywood and submerged on the offshore side of the wheel. Fish leads ranging from 2 to 5 meters in length

were installed shoreward as needed, depending on the distance of the wheel from the riverbank. Contractors examined their respective wheels at least once a day to determine operating efficiency, to check for damage such as holes in the baskets or live-box, and to remove any accumulated debris. To maximize operating efficiency, the wheels were adjusted by moving the wheel laterally, raising or lowering the axle to allow baskets to turn close to the bottom, lengthening or shortening onshore fish leads, and adding or removing basket paddle boards to accommodate changes in water velocity.

Unless interrupted by debris accumulation, repairs, adjustments or relocation, the two tag deployment wheels were operated 24 hours per day. However, large catches in 2003 caused reduced hours of operation for each tag deployment wheel because the crew was unable to process all the catch. Tagging wheels operated from 16 August until 27 September on the Tanana River and from 16 August to 24 September on the Kantishna River. At each location a daily 12-hour tag deployment schedule was maintained from 08:00 to 20:00. A 24-hour tagging-day was designated as 08:00 to 08:00 the following day. The sampling crew checked the live-box at each wheel in approximate 4-hour intervals (07:30, 12:00, 16:00 and 19:30) or more often depending on catch. Using a dip net, all chum in the live-box were individually transferred to a sampling tub. Fish were tagged with a 30 cm, hollow core, individually numbered spaghetti tag (Floy Tag and Manufacturing Inc., Seattle, WA)[2] inserted with a 16 cm applicator needle into the dorsal musculature behind the dorsal fin and secured with an overhand knot tied close to the body. The adipose fin was removed as a secondary mark. Data recorded were: length, measured from mid-eye to fork-of-tail to the nearest five cm; sex, determined by external physical appearance; condition, determined by external physical aberrations subjectively judged as having the potential to affect survival or migration; and exterior color, graded by light or dark and used as an indicator of maturity. Because of the possible effect on the abundance estimate, chum subjectively judged to have severe wounds (bleeding, gashes, head injuries, fungus, etc.) were not tagged. Fish caught between 08:00 and 20:00 were categorized as day-fish, while fish caught between 20:00 and 08:00, tagged in the morning and held in the live-box for up to 12 hours were categorized as night-fish. Total handling time per fish was approximately one minute, not including capture in the fish wheel and holding in the live box. All Chinook salmon, *O. tshawytsha,* and coho salmon, *O. kisutch*, were enumerated by sex and released, while other species were identified, enumerated, and released.

To monitor wheel efficiency, wheel revolutions occurring over 15-minute intervals were recorded daily. In addition, meteorological data, water and level (on the Kantishna and Tanana Rivers) were recorded once a day. Water temperatures were recorded using Tidbit (Onset Inc.) data loggers at the Tanana and Kantishna tag deployment and Toklat and Tanana recovery wheel sites. These data were downloaded in the ADF&G Fairbanks office after loggers were retrieved at the end of the field season. Tagging data were recorded in the field using an Allegro CE handheld field computer that was downloaded daily into an Access database. A data summary query for the previous 24-hour tagging day was reported daily to the ADF&G Fairbanks office via cellular or satellite telephone.

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[2] Mention of trade names does not constitute endorsement by ADF&G.

Tag Recovery

Recovery wheels in the upper Tanana and upper Kantishna Rivers were owned and operated by private contractors, while the Toklat River recovery wheels were operated by ADF&G. In the upper Tanana River, one wheel was positioned on the right bank approximately 76 km upstream from the tagging wheel. The Tanana River recovery wheel also served as an ADF&G management test wheel and was operated during both the summer and fall chum migrations. Two wheels were positioned on each bank of the Toklat River 113 km upstream, and two wheels (one new in 2003) were located on each bank of the Kantishna River 139 km upstream of the tagging site (Figure 2). Design, size and construction materials used in the recovery wheels and live-boxes were similar to those of the tag deployment wheels, except the wheels on the Toklat River had rafts made of plastic foam-filled floats.

As an additional aspect of the mark-recapture study, a video monitoring system (Fliris 2001 and Zuray 2002) was operated on the Tanana River recovery wheel to examine the feasibility of operating a video at this location. Salmon captured in the wheel were viewed on video for the presence or absence of spaghetti tags, and other species were enumerated as they pass through the view of the camera. For verification, fish were dipped from the live box (when catches were low) and compared to data generated by the video system. When catch rates were too high, a door in the live box was opened so fish could escape immediately after being counted by the video.

Like tag deployment wheels, recovery wheels were inspected daily and adjusted as necessary. All chum were enumerated by sex and released. The color and identification numbers of all recaptured tags were recorded at the Toklat and Kantishna River recovery wheels. At the Tanana recovery wheel only 9.3% of tag numbers were recorded because of video methods. All chum not bearing tags were examined for the secondary mark, an adipose fin clip. All chinook and coho salmon were enumerated by sex, while other species were enumerated daily. The ADF&G office in Fairbanks was contacted daily via satellite or cellular telephone to report summary data for the previous 24-hour catch. ADF&G personnel recovered tags on the Toklat and Delta Rivers and on Bluff Cabin Slough.

Data Analysis

Abundance Estimation

Tag deployment and tag recovery data were entered daily into an Access database and made available in an Excel spreadsheet in the Fairbanks office. Daily inseason abundance estimates were provided to management staff once the coefficient of variance was less than 0.30. Inseason estimates were considered preliminary because assumption testing occurs postseason.

Bailey's modified Peterson estimate (1) and variance (2) were employed to estimate the total fall chum run size for the Tanana and Kantishna Rivers.

Bailey's estimation equation is:

$$\hat{N} = \frac{(C+1)(M)}{R+1} \tag{1}$$

$$V[\hat{N}] \cong \frac{M^2(C+1)(C-R)}{(R+1)^2(R+2)} \tag{2}$$

Where:

$\hat{N}$ = Total run estimate.

M = The number of fish tagged and released at the tagging wheels.

C = The number of fish caught at the recovery wheels.

R = The number of tagged fish recaptured at the recovery wheels.

Migration Rate

Migration rate between the tagging and recovery fish wheels was calculated as:

$$\hat{M} = \frac{RD}{D} \tag{3}$$

Where:

RD = Distance between tagging wheel and recovery wheel (s).

D = Number of days travel time between the tag and recovery wheels.

Statistical Tests

Bailey's closed population model requires the following assumptions: no immigration, emigration or mortality between the tagging and recovery sites, all marked fish mix completely with unmarked fish; and all fish have an equal probability of recapture. While mortality induced by tagging and handling is incalculable, a mortality rate of 5% has been used in all years of this study. This number is derived from a radio-tag study (Barton 1992). However delayed mortality rate may vary depending on various factors such sex, energy reserves, handling time and water temperature.

Chi-square tests were used to explore the assumption that tagged fish are mixed with untagged fish. These tests were; equal migration rate from tag deployment to recapture sites between day fish and night fish; equal recapture rate (marked-unmarked ratio) among recovery wheels,

(between left and right bank wheels, between the Toklat and Kantishna River recovery sites) and equal recapture rate over time.

Stock Timing

ADF&G personnel conducted ground surveys of the Delta and Toklat Rivers. Escapement counts consisted of the number of live and dead chum and coho salmon. On the Delta River, nine replicate surveys were conducted from 3 October through 4 December. On the Toklat River, one survey was conducted of the fall chum spawning area on 23 and 24 October. ADF&G personnel conducted one ground survey on 15 November (just past peak spawning activity) on Bluff Cabin Slough on the Tanana River. When possible, tags were retrieved at these locations.

RESULTS

Sampling

Tag Deployment

Tagging wheels operated from 16 August until 27 September on the Tanana River and from 16 August to 24 September on the Kantishna River. At the Tanana River tagging wheel, a total of 5,377 fall chum were tagged of which 2,969 were males and 2,408 were females (Appendix A). The peak chum CPUE of 30.7 fish/hour occurred on 7 September on the Tanana River (Figure 3, above). A total of 1,055 chum were not tagged due to death in the live-box, escape during tagging procedures, released during high catch rates, or because of injuries that might affect swimming ability. At the Kantishna River tagging wheel, 3,929 chum were tagged (Appendix B) of which 2,470 were males and 1,458 were females. The peak chum catch of 20.8 fish/hour occurred on 13 September (Figure 3, below). A total of 665 fall chum were not tagged for the same reasons as above. Fishing hours were reduced on 4 through 18 September on the Tanana River and 11 through 16 September on the Kantishna River. This was due to a large volume of fall chum and coho salmon captured in each wheel, which the crew could not process in a reasonable amount of time.

Tag Recovery

On the Tanana River, the recovery wheel began operation on 16 August and continued through 30 September. On the Toklat River, recovery wheel operations began on 16 and 22 August and ended on September 30 and 29 on the left and right bank respectively. On the Upper Kantishna River, recovery wheels operated from 16 August and ended on 10 October. At the Tanana River recovery wheel, a total of 13,820 chum were captured primarily on digital video enumerated by sex, and examined for tags or a secondary mark. A total of 364 were tagged 34 of which were identified with a tag number during dip to video comparisons (Appendix C). The peak chum CPUE of 42.3 fish/hour occurred on 9 September at the Tanana River recovery site (Figure 3,

above). In the Toklat River recovery wheels, 1,899 chum were examined of which 85 were tagged (Appendix D). In the upper Kantishna River recovery wheels, 825 chum were examined of which 26 were tagged (Appendix E). The total number of tags recovered, including public tag recoveries, is listed in Table 1.

Coho salmon represented a significant portion of total catch at all fish wheels. Coho CPUE was highest at the Tanana River tag recovery wheel (88.3 fish/hour) and occurred on 16 September (Appendix F).

Data Analysis

Abundance Estimate

At each tag deployment site fish were released untagged during high catch events. Consequently, the Darroch model (Darroch 1961), which stratifies tag deployment and recovery events through time, appeared to be an appropriate model for each data set. However, on the Kantishna River a small number of tags recovered in early season strata resulted in an inaccurate (biased high) Darroch model point estimate. On the Tanana River, video methods used to view most of the recovered tags. This provided insufficient tag and recovery data (fewer tag numbers) required for the Darroch model. Therefore both inseason and postseason abundance estimates for the Tanana and Kantishna Rivers were generated using the Bailey model. The final abundance estimates of fall chum salmon were 193,418 (SE 9,976) for the Tanana River and 87,359 (SE 8,041) for the Kantishna River (Tables 2 and 3, Figure 4 above).

Migration Rate

Migration rates for fall chum tagged in the Tanana River were greater for day-tagged fish (day tagged 27 km/day n = 21, night tagged 21 km/day, n = 13). Toklat River fall chum migration rates were similar for day and night fish (day tagged 16 km/day n = 54, night tagged 15 km/day, n = 31) (Table 4).

Statistical Tests

Chi-square tests indicated no significant difference in recapture rates (tagged vs. total catch) between left and right bank wheels on the Toklat River (left = 0.05, right = 0.04, Chi-square 0.172, df 1, P = 0.70), for day and night tagged fish on the Tanana River (day = 0.005, night = 0.007, Chi-square 0.444, df =1, P = 0.505), or for day and night tagged fish on the Toklat River (day = 0.02, night = 0.02, Chi-square 0.00391, df =1, P = 0.090). In addition, no significant difference was detected in recapture rates between the Toklat and Kantishna River recapture sites (Toklat = 0.04, Kantishna = 0.03, Chi-square 2.069, df =1, P = 0.150). Recapture rates did vary over time (10-day periods) on the Toklat River, but were not significantly different (Chi-square 4.720, df =3, P = 0.194). On the other hand, recapture rates were significantly different over time on the Tanana River (Chi-square 12.161, df =3, P = 0.007).

Stock Timing

Thirty-one tags were recovered during surveys of spawning grounds in the Delta River conducted between 3 October and 17 November 2003. The median tag deployment date for these fish was 3 September and tagging dates ranged from 20 August through 22 September. Median tag deployment date for tags recovered at the Toklat River tag recovery fish wheel was 11 September, and tag deployment dates ranged from 18 August to 23 September. Median tag deployment dates for tags recovered at the Toklat Springs was 5 September and tag dates ranged from 23 August to 18 September.

DISCUSSION

The 2003 Tanana River abundance estimate of 193,1418 fall chum was the strongest run on the Tanana River since 1995. (Table 5, Figure 4 below). The Yukon River fall chum run strength was also the best since 1995 as indicated by the 2003 preliminary estimate of 930,452 fall chum at Pilot Station sonar (McIntosh In prep). Other evidence of a strong fall chum run was provided by the ADF&G test wheel located on the left bank of the Yukon River near the village of Tanana. This wheel captured 10,434 fall chum which is approximately 29% above the 1994-2002 average catch. Exceptional run strength in the Tanana River in 2003 included the Delta River escapement estimate of approximately 22,582 fall chum (calculated from area-under-the-curve replicate foot survey counts), which was well above the biological escapement goal of 6,000 to 13,000 (Borba, personal communication).

Migration rates for fish tagged in the Tanana River were greater for day-tagged fish (day tagged= 27 km/day n = 21, night tagged 22 km/day, n = 13) although this may have been due to sample size rather than a holding effect. Conversely, decreased migration rates in the Kantishna drainage compared to previous years, may have been due to holding since live box densities were greater than in all previous years. It is possible that stress from tagging caused reduced migration rates given that tagging has been documented to reduce metabolic energy (Cleary and Margraf In prep). However, water levels were higher than prior years in the Tanana River drainage, and this may have reduced migration rate in the Kantishna River. (Table 4, Figure 5, above). It is unknown why there was a significant difference in recapture rates over time on the Tanana River however this is likely due to variations in fish wheel efficiency through changes in water level.

The 2003 Kantishna River abundance estimate is the largest since this phase of the mark-recapture project began. However, the Toklat Springs escapement estimate is 21,492 fall chum as calculated from foot survey count time-density curves (Borba personal communication). Although this estimate is below the minimum escapement objective of 33,000 fish (BOF regulation 5AAC 01.248), it is within the established biological escapement goal range of 15,000 to 33,000 fall chum (Eggers 2001). Nevertheless, the Toklat Springs estimate is far less than expected given the Kantishna River abundance estimate of 87,359 fall chum. Conceivably the Kantishna River abundance estimate could be biased high because of low tag recovery rates or the difference may be due to timing of foot surveys at the Toklat Springs. For instance,

carcasses may have been washed out, fish may not have arrived on the spawning grounds or they may be holding below spawning areas due to frazil ice and/or high water. Alternatively, the abundance estimate may be affected by reduced tag recoveries rates at the Toklat wheels. This may have occurred because of recent modifications (plastic foam filled rafts), which cause the wheels to float higher in the water and reduce basket dip capacity. In addition, high water events this season may have reduced fish wheel efficiency.

RECOMMENDATIONS

Approximately 42,000 fish were counted through the Tanana tag recovery wheel during the fall season alone, 99% of which were chum and coho salmon (Appendices C and F). This is unprecedented since the inception of the project. Video methods were vital for accurate enumeration of all species this season. Had digital video counting methods not been in place, the Tanana recovery wheel would have ceased operation to avoid mortalities during both summer and fall seasons. As a consequence of the digital video equipment, there was little mortality in 2003 even with record catches of fall chum and coho salmon. To provide accurate inseason mark-recapture and CPUE data and reduce stress on fish, digital video counting is essential, and its funding should be continued.

Tanana River recapture rates were not uniform over time and tags were not deployed in proportion to run strength due to large catch. For these reasons, a model that stratifies through time (Darroch) was more suitable for this data set. However, because of the reasons stated above, the Bailey model was used post season for the Tanana River abundance estimate. In 2004, tag color will be changed every two weeks for post season stratification and will provide a more accurate abundance estimate.

This was the first year water temperatures were collected at all (except the upper Kantishna River site) tag and recovery wheel sites for the Tanana/Kantishna mark-recapture project (Figure 5 below, Appendices G and H). Given the growing concern over increased Yukon River drainage water temperatures and its possible negative effect on salmon physiology, water temperature data collection efforts should continue so ADF&G can document inseason and between year changes. This is important given increased water temperature has been documented to affect other fish species. For example, in Atlantic salmon ova quality was significantly reduced (King and Pankhurst 2000) and plasma chloride levels in smolts increased (Handeland et al. 2000) through elevated water temperature.

LITERATURE CITED

Bailey, N.J.J. 1951. On estimating the size of mobile populations from recapture data. Biometrika. 38: 293-306.

Barton, L.H. 1992. Tanana River, Alaska, fall chum salmon radio telemetry study. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fishery Research Bulletin 92-01, Juneau.

Barton, L.H. 1997. Salmon escapement assessment in the Toklat River, 1994. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 3A97-35, Anchorage.

Cleary, P.M. and J.F. Bromaghin. 2001. Estimation of fall chum salmon abundance on the upper Tanana and Kantishna Rivers using mark-recapture techniques, 1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A01-24, Anchorage.

Cleary, P.M. and T. Hamazaki. 2002. Estimation of fall chum salmon abundance on the upper Tanana and Kantishna Rivers using mark-recapture techniques, 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A02-17, Anchorage.

Cleary, P.M. and F. J. Margraf. In prep. Stress related effects of capture and tagging on fall chum salmon. North American Journal of Fisheries Management.

Darroch, J.N. 1961. The two-sample capture-recapture census when tagging and sampling are stratified. Biometrika, 48, 241-260.

Eggers, D. 2001. Biological escapement goal for Yukon River fall chum salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries. Regional Information Report No. 3A01-10, Anchorage.

Fliris, B. 2001. Modification of video storage equipment for the purposes of providing accurate catch-per-unit-effort data from the Yukon River sub-district 5-A test fish wheel project. A final report to the Yukon River Panel, Anchorage, Alaska.

Handeland, S.O., A. Berge, B.T. Bjornsson, Lie., and S.O. Stefansson. 2000. Seawater adaptation by out of season Atlantic salmon (Salmo salar L.) smolts at different temperatures. Aquaculture. 181: no. 3-4. 377-397.

Joint Technical Committee of the Yukon River US/Canada Panel. 2004 Regional Information Report No. 3A04-09. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, 333 Raspberry Road, Anchorage, Alaska 99518-5526.

LITERATURE CITED (Continued)

King, H.R. and N.W. Pankhurst. 2000. Ovulation of Tasmanian Atlantic salmon maintained at elevated temperatures: Implications of climate change for sustainable industry development. Reproductive Physiology of Fish. 396-398.

McIntosh, B. Sonar estimation of salmon passage in the Yukon River at Pilot Station, 2003 In prep. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report.

Seeb, L.W., P.A. Crane, and R.B. Gates. 1995. Progress report of genetic studies of Pacific Rim chum salmon and preliminary analysis of the 1993 and 1994 south Unimak June fisheries. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 5J95-07, Anchorage.

Underwood, T.J., S.P. Klosiewski, J.L. Melegari, and R.J. Brown. 2000. Estimated abundance of adult fall chum salmon in the Upper Yukon River, Alaska, 1998-1999. U.S. Fish and Wildlife Service. Alaska Fisheries Technical Report Number 57, Fairbanks.

Vania, T. and six co-authors. 2002 Annual management report for subsistence, personal use, and commercial fisheries of the Yukon area, 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A02-29, Anchorage.

Zuray, S. 2002. Rampart Rapids summer catch-per-unit-effort video monitoring- 2002 using a fishwheel on the Yukon River, Alaska. Federal Subsistence Fishery Monitoring Program annual Project Report FIS 01-197, U.S. Fish and Wildlife Service Office of Subsistence Management, Fishery Information Service Division, Anchorage, Alaska.

Table 1.Tags recovered by location from fall chum salmon tagged in the Tanana and Kantishna Rivers, 2003.

Recapture Location	Number of Tags
Bluff Cabin Slough [a]	14
Delta River [a]	31
Toklat Springs [a]	89
Tanana River recovery wheel [b c]	364
Toklat River recovery wheels [c]	85
Kantishna River recovery wheels [c]	26
Public tag recoveries [d]	138
Total	747

[a] Tags recovered from foot surveys.

[b] 325 of these tags were viewed on video only.

[c] Includes tags recaptured after 9/29 not used in the abundance estimate.

[d] Tags recovered from subsistence catches.

Table 2. Daily and cumulative catch statistics and Bailey abundance estimates of fall chum salmon in the Tanana River, 2003. [a]

Date	Adjusted (Releases)	Examined For Tags	Recaptures	Abundance	95% Confidence Bounds Lower	95% Confidence Bounds Upper	Standard Error	CV
8/16	45	12	0					
8/17	89	24	0					
8/18	133	61	0					
8/19	154	135	2					
8/20	181	235	5					
8/21	200	358	8					
8/22	223	483	9					
8/23	236	585	10					
8/24	323	699	11					
8/25	386	840	12					
8/26	422	957	13					
8/27	599	1,172	17					
8/28	713	1,376	23	40,908	25,012	56,804	8,110	0.20
8/29	822	1,662	25	52,576	32,900	72,252	10,039	0.19
8/30	892	1,920	29	57,118	37,169	77,067	10,178	0.18
8/31	935	2,172	33	59,758	40,116	79,400	10,022	0.17
9/1	1,072	2,392	40	62,568	43,808	81,328	9,571	0.15
9/2	1,240	2,532	42	73,045	51,646	94,444	10,918	0.15
9/3	1,566	2,630	44	91,559	65,327	117,791	13,384	0.15
9/4	1,699	2,668	44	100,770	71,896	129,644	14,732	0.15
9/5	1,947	2,811	46	116,489	83,811	149,167	16,673	0.14
9/6	2,213	3,241	58	121,602	91,114	152,090	15,555	0.13
9/7	2,426	3,919	92	102,257	81,832	122,682	10,421	0.10
9/8	2,668	4,808	117	108,732	89,437	128,027	9,844	0.09
9/9	2,860	5,822	148	111,770	94,113	129,427	9,008	0.08
9/10	3,087	6,706	170	121,079	103,216	138,942	9,114	0.08
9/11	3,261	7,426	186	129,516	111,237	147,795	9,326	0.07
9/12	3,403	8,279	208	134,817	116,814	152,820	9,185	0.07
9/13	3,544	8,923	215	146,420	127,176	165,664	9,819	0.07
9/14	3,689	9,522	218	160,413	139,461	181,365	10,690	0.07
9/15	3,836	9,985	226	168,750	147,096	190,404	11,048	0.07
9/16	3,969	10,420	232	177,515	155,026	200,004	11,474	0.06
9/17	4,048	10,733	241	179,551	157,231	201,871	11,388	0.06
9/18	4,187	11,117	255	181,840	159,865	203,815	11,212	0.06
9/19	4,328	11,469	259	190,931	168,031	213,831	11,684	0.06
9/20	4,475	11,704	267	195,447	172,359	218,535	11,779	0.06
9/21	4,596	11,904	278	196,112	173,412	218,812	11,582	0.06
9/22	4,705	12,108	291	195,112	173,042	217,182	11,260	0.06
9/23	4,783	12,451	301	197,212	175,277	219,147	11,191	0.06
9/24	4,873	12,597	311	196,763	175,236	218,290	10,983	0.06
9/25	4,970	12,831	320	198,676	177,248	220,104	10,932	0.06
9/26	5,053	13,094	329	200,512	179,184	221,840	10,881	0.05
9/27	5,108	13,416	346	197,504	177,023	217,985	10,450	0.05
9/28	5,108	13,484	352	195,131	175,071	215,191	10,234	0.05
9/29	5,108	13,677	361	193,003	173,413	212,593	9,995	0.05
9/30	5,108	13,820	364	193,418	173,866	212,970	9,976	0.05

[a] The number of tags deployed was adjusted by 5% for mortality.

Table 3. Daily and cumulative catch statistics and Bailey abundance estimates of fall chum salmon in the Kantishna River, 2003. [a]

Date	Adjusted (Releases)	Examined For Tags	Recaptures	Abundance	95% Confidence Bounds Lower	95% Confidence Bounds Upper	Standard Error	CV
8/16	4	0	0					
8/17	10	4	0					
8/18	32	0	0					
8/19	45	0	0					
8/20	54	8	0					
8/21	62	11	0					
8/22	79	17	0					
8/23	88	25	0					
8/24	112	35	0					
8/25	141	43	0					
8/26	231	51	0					
8/27	320	68	0					
8/28	450	83	0					
8/29	537	104	0					
8/30	626	130	1					
8/31	699	169	1					
9/1	795	195	1					
9/2	875	216	3					
9/3	1,004	227	3	57,228	7,507	106,949	25,368	0.44
9/4	1,085	239	3	65,100	8,515	121,685	28,870	0.44
9/5	1,205	255	3	77,120	10,052	144,188	34,219	0.44
9/6	1,333	286	4	76,514	15,826	137,202	30,963	0.40
9/7	1,504	317	6	68,325	21,502	115,148	23,889	0.35
9/8	1,778	393	7	87,567	30,941	144,193	28,891	0.33
9/9	1,891	483	11	76,270	35,326	117,214	20,890	0.27
9/10	2,186	584	20	60,896	35,910	85,882	12,748	0.21
9/11	2,309	672	22	67,563	40,998	94,128	13,554	0.20
9/12	2,473	736	24	72,904	45,360	100,448	14,053	0.19
9/13	2,612	766	24	80,136	49,839	110,433	15,458	0.19
9/14	2,759	818	28	77,918	50,534	105,302	13,972	0.18
9/15	2,904	928	33	79,348	53,546	105,150	13,164	0.17
9/16	3,028	1,103	42	77,742	55,222	100,262	11,490	0.15
9/17	3,110	1,217	46	80,595	58,239	102,951	11,406	0.14
9/18	3,232	1,301	50	82,511	60,528	104,494	11,216	0.14
9/19	3,378	1,399	53	87,578	64,883	110,273	11,579	0.13
9/20	3,495	1,488	58	88,204	66,332	110,076	11,159	0.13
9/21	3,554	1,620	61	92,920	70,418	115,422	11,481	0.12
9/22	3,598	1,745	67	92,384	71,014	113,754	10,903	0.12
9/23	3,693	1,859	75	90,381	70,610	110,152	10,087	0.11
9/24	3,733	1,943	80	89,592	70,608	108,576	9,685	0.11
9/25	3,733	2,034	84	89,372	70,882	107,862	9,434	0.11
9/26	3,733	2,109	89	87,518	69,924	105,112	8,977	0.10
9/27	3,733	2,258	94	88,767	71,387	106,147	8,867	0.10
9/28	3,733	2,389	100	88,335	71,558	105,112	8,560	0.10
9/29	3,733	2,514	108	86,133	70,389	101,877	8,033	0.09
9/30	3,733	2,584	110	86,935	71,184	102,686	8,036	0.09
10/1	3,733	2,598	111	86,626	71,002	102,250	7,972	0.09
10/2	3,733	2,620	111	87,359	71,600	103,118	8,041	0.09

a The number of tags deployed was adjusted by 5% for mortality.

Table 4. Estimated migration rates (km/day) for day and night caught fall chum salmon in the Tanana and Kantishna Rivers, 1995-2003.

Tanana River tagging fish wheel to Tanana River recovery fish wheel (76 km)

	Day		Night		Combined	
Year	km/day	n	km/day	n	km/day	Total - n
1995	-	-	-	-	26	166
1996	-	-	-	-	31	187
1997	-	-	-	-	21	104
1998	29	49	31	30	30	79
1999	29	8	16	14	23	22
2000	25	25	20	20	23	45
2001	24	10	49	7	37	17
2002	28	22	29	47	29	69
2003	27	21	21	13	24	34
1995-2002 mean	27	23	28	22	27	80

Kantishna River tagging fish wheel to Toklat River recovery fish wheels (114 km)

	Day		Night		Combined	
Year	km/day	n	km/day	n	km/day	Total - n
1999	20	26	22	28	21	54
2000	25	24	29	9	27	33
2001	25	52	28	37	27	89
2002	24	84	27	81	26	165
2003	16	54	15	31	15	85
1999-2002 mean	24	48	24	37	23	85

Kantishna River tagging fish wheel to upper Kantishna River recovery fish wheel (139 km)

	Day		Night		Combined	
Year	km/day	n	km/day	n	km/day	Total - n
2000	26	10	27	1	27	11
2001	31	2	28	3	30	5
2002	21	10	21	4	21	14
2003	16	22	15	4	16	26
2000-2002 mean	26	11	23	3	23	14

Table. 5. Tanana and Kantishna fall chum salmon abundance estimates 1995-2003.

Tanana River

Year	Point Estimate	S.E.	95% Lower Bound	95% Upper bound
1995	268,173	21,597	225,842	310,503
1996	134,563	16,945	101,351	167,775
1997	71,661	11,876	48,384	94,937
1998	62,014	6,556	49,164	74,863
1999	97,843	19,362	59,893	135,792
2000	34,844	4,970	25,104	44,584
2001	96,556	20,955	55,484	137,627
2002	109,961	12,724	85,022	134,900
2003	193,418	9,976	173,866	212,970
1995-2002 Mean	109,452			

Kantishna River

Year	Point Estimate	S.E.	95% Lower Bound	95% Upper bound
1999	27,199	3,562	20,218	34,180
2000	21,450	3,031	15,510	27,390
2001	22,992	2,172	18,734	27,250
2002	56,665	4,122	48,587	64,743
2003	87,359	8,041	71,600	103,118
1999-2002 Mean	32,077			

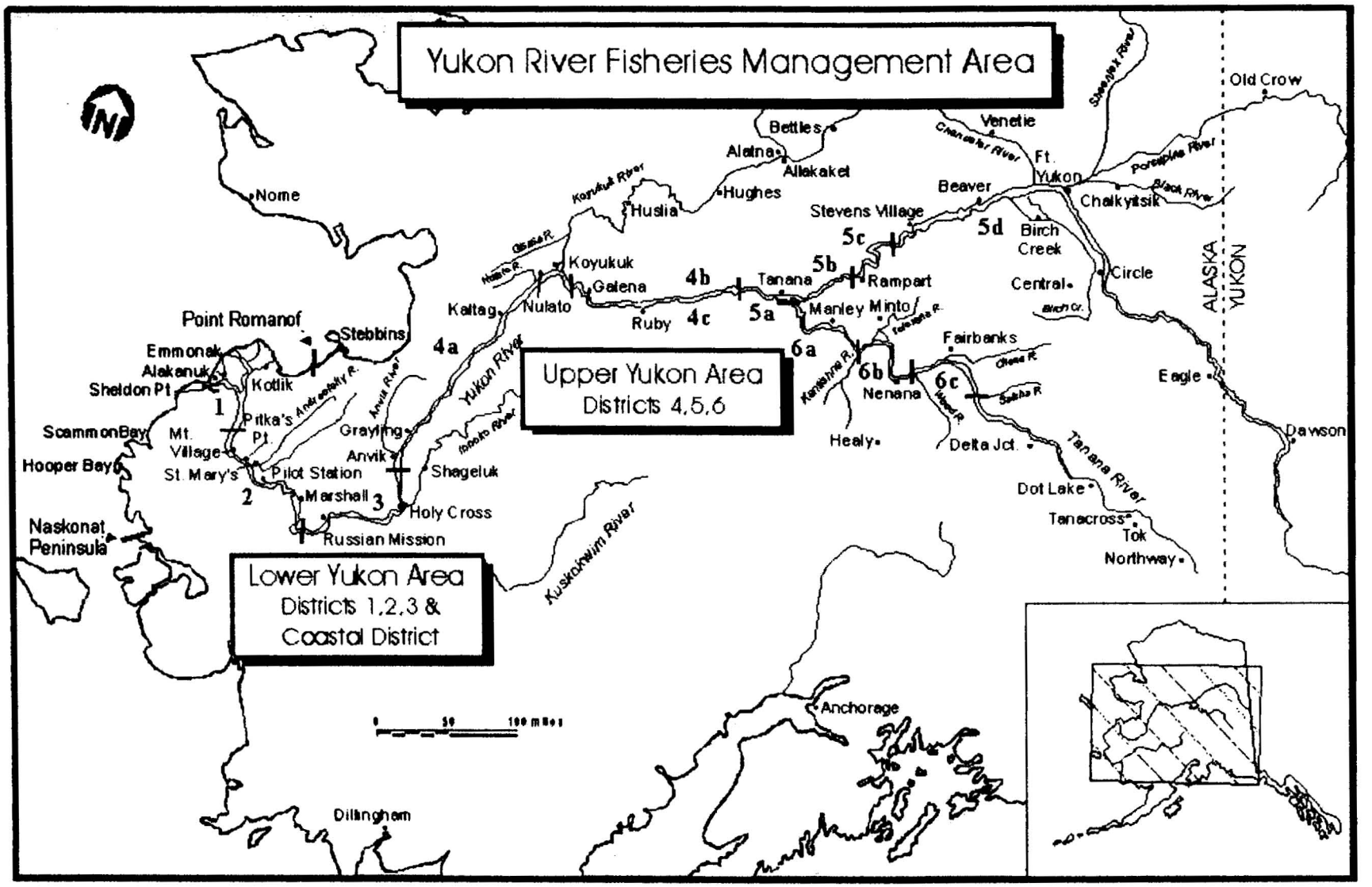


Figure 1. Fishery management districts and subdistricts on the Yukon and Tanana River drainages.

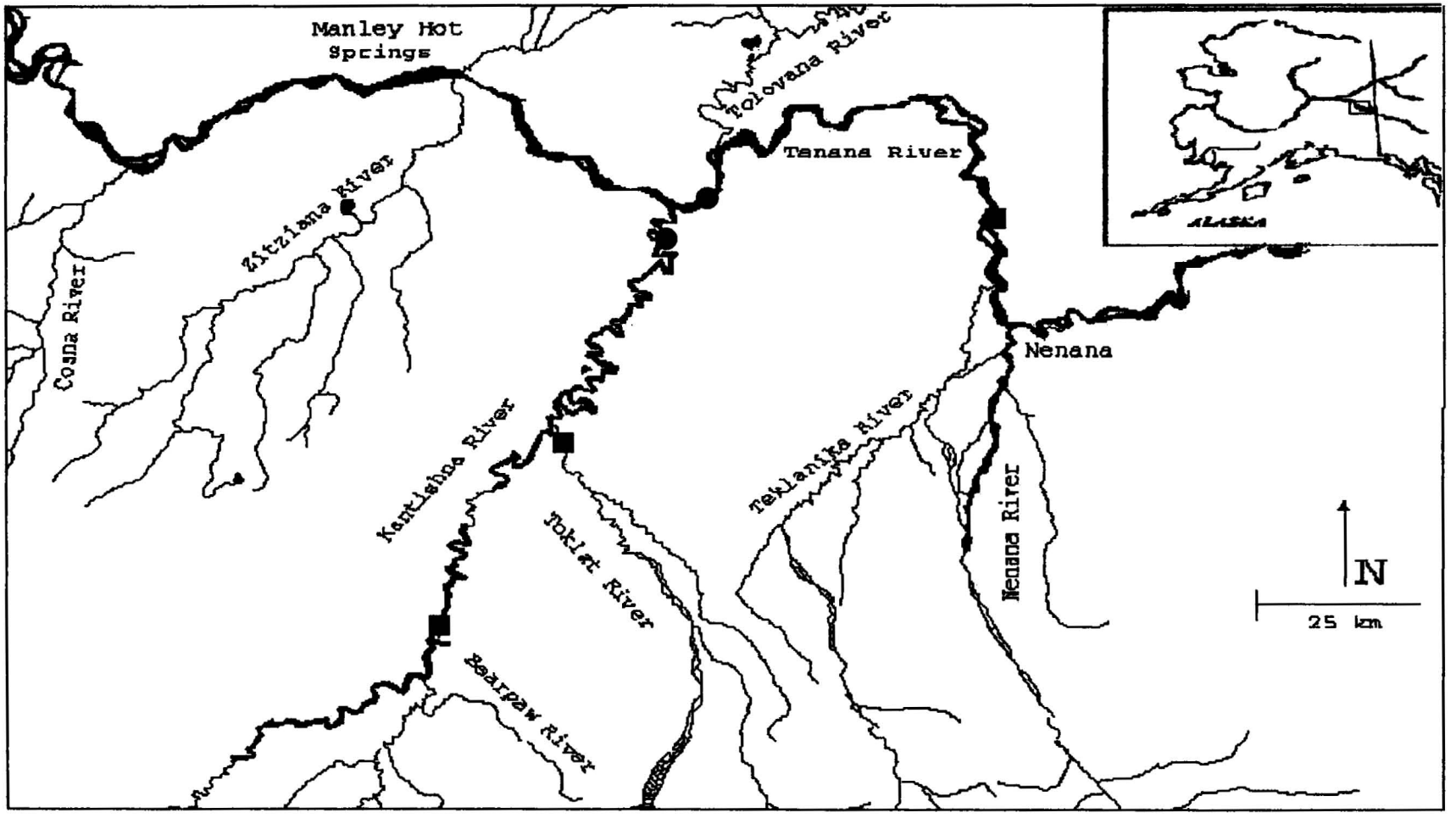


Figure 2. Location of tag deployment (circles) and recovery wheels (squares) used in the Tanana and Kantishna River fall chum salmon mark-recapture project.

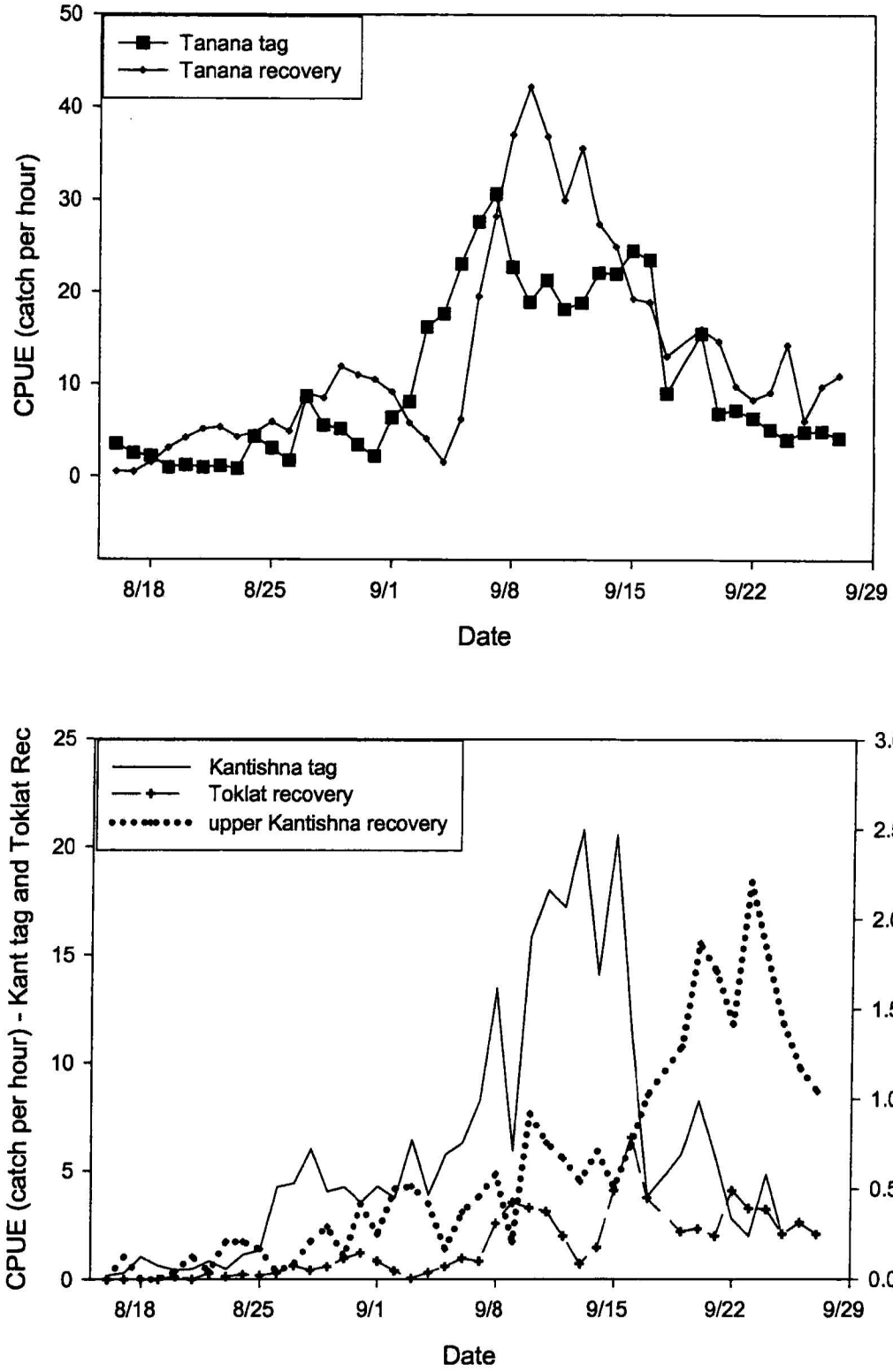


Figure 3. Daily fall chum salmon CPUE at the Tanana River tagging and recovery fish wheels (above), and CPUE at the Kantishna River tagging and recovery fish wheels and the recovery fish wheels on the Toklat River (below), 2003.

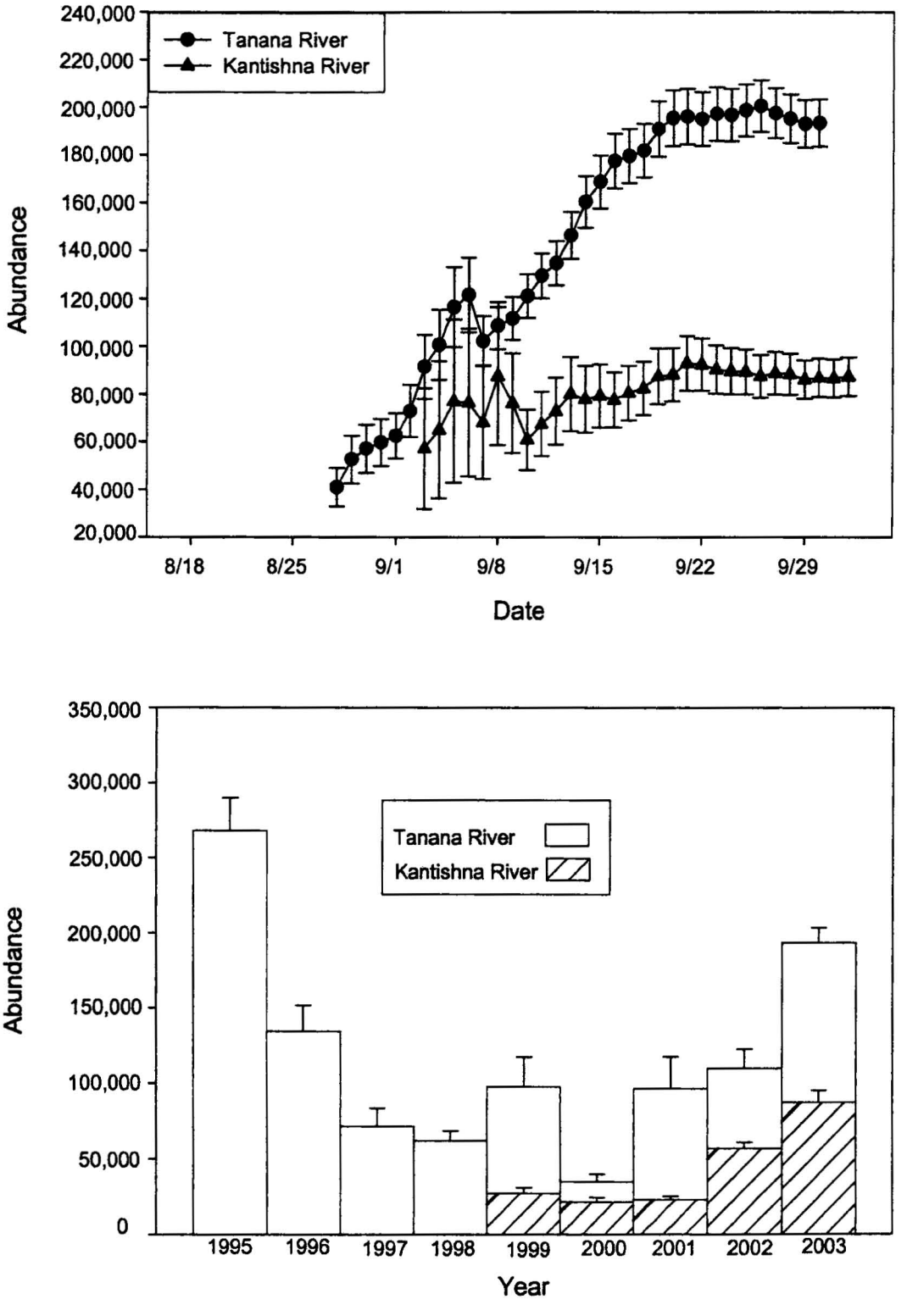
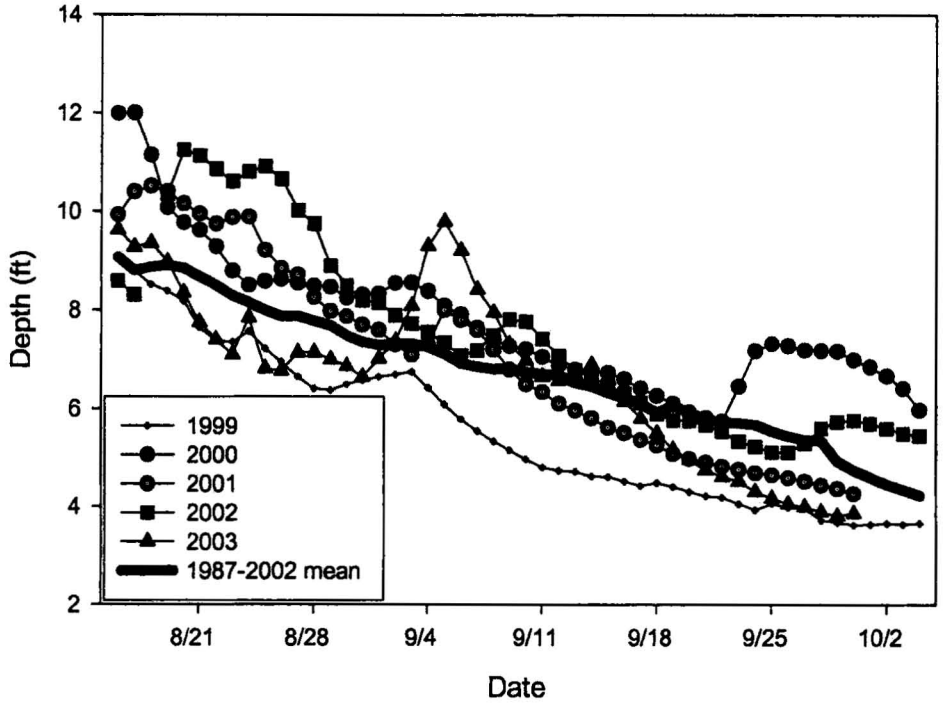


Figure 4. Abundance estimates for fall chum salmon on the Tanana and Kantishna Rivers, 2003 (above) and abundance estimates for the Tanana River 1995-2003 and Kantishna Rivers, 1999-2003 (below). Error bars represent standard error.



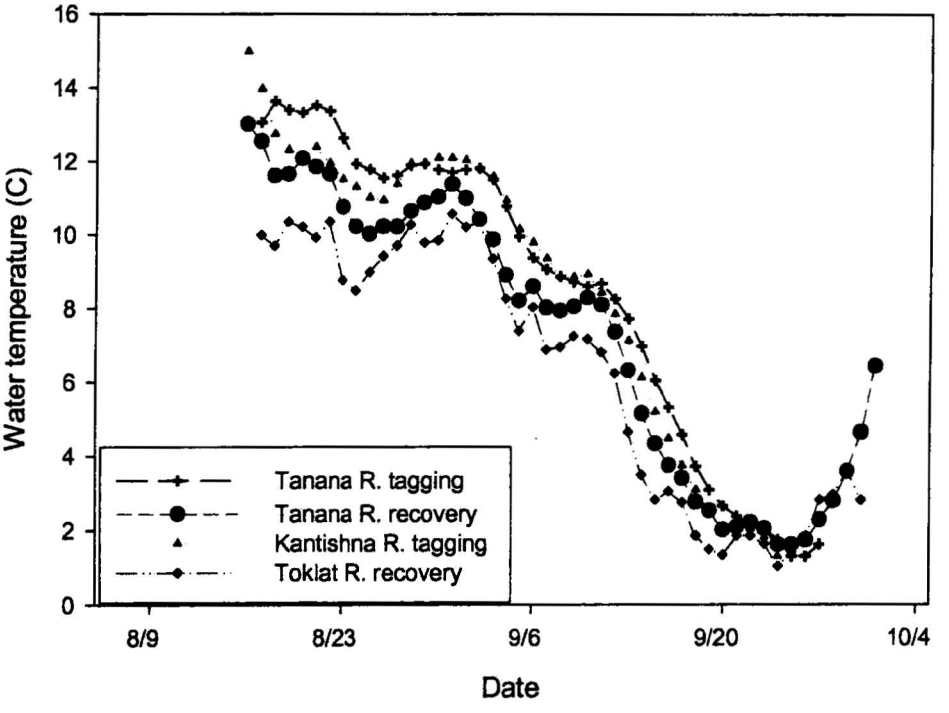


Figure 5. Daily water levels on the Tanana River as measured by a United States Geological Survey gauge located near Nenana, 1999-2003 (above) and mean water temperatures at selected sites, 2003 (below).

Appendix A. Daily effort and catch of fall chum salmon at the Tanana River tag deployment wheel, 2003[a].

		Tagged					Not tagged					Total					Total	
	Hours			Unidentifed					Unidentifed					Unidentifed			Catch	Tagging
Date	Fished	Males	Females	Sex	Total	Cumulative	Males	Females	Sex	Total	Cumulative	Males	Females	Sex	Total	Cumulative	Per hour	rate
8/16	15	25	22	0	47	47	3	3	0	6	6	28	25	0	53	53	3.5	0.00
8/17	24	27	20	0	47	94	5	8	0	13	19	32	28	0	60	113	2.5	0.00
8/18	24	25	21	0	46	140	0	7	0	7	26	25	28	0	53	166	2.2	0.00
8/19	24	11	11	0	22	162	1	0	0	1	27	12	11	0	23	189	1.0	0.00
8/20	24	14	14	0	28	190	0	1	0	1	28	14	15	0	29	218	1.2	0.83
8/21	24	10	10	0	20	210	1	2	0	3	31	11	12	0	23	241	1.0	0.00
8/22	24	18	7	0	25	235	2	0	0	2	33	20	7	0	27	268	1.1	0.93
8/23	24	8	5	0	13	248	1	6	0	7	40	9	11	0	20	288	0.8	0.65
8/24	24	61	31	0	92	340	7	4	0	11	51	68	35	0	103	391	4.3	0.89
8/25	24	47	19	0	66	406	6	1	0	7	58	53	20	0	73	464	3.0	0.90
8/26	24	28	10	0	38	444	2	1	0	3	61	30	11	0	41	505	1.7	0.93
8/27	24	123	64	0	187	631	15	6	0	21	82	138	70	0	208	713	8.7	0.90
8/28	24	83	36	0	119	750	4	10	0	14	96	87	46	0	133	846	5.5	0.89
8/29	24	79	36	0	115	865	5	4	0	9	105	84	40	0	124	970	5.2	0.93
8/30	24	48	26	0	74	939	4	4	0	8	113	52	30	0	82	1,052	3.4	0.90
8/31	24	28	17	0	45	984	4	4	0	8	121	32	21	0	53	1,105	2.2	0.85
9/1	24	87	57	0	144	1,128	8	1	0	9	130	95	58	0	153	1,258	6.4	0.94
9/2	24	106	71	0	177	1,305	7	11	0	18	148	113	82	0	195	1,453	8.1	0.91
9/3	24	201	142	0	343	1,648	18	28	0	46	194	219	170	0	389	1,842	16.2	0.88
9/4	12	68	72	0	140	1,788	25	38	0	63	257	93	110	0	203	2,045	17.7	0.69
9/5	12	135	126	0	261	2,049	6	10	0	16	273	141	136	0	277	2,322	23.1	0.94
9/6	12	139	141	0	280	2,329	30	22	0	52	325	169	163	0	332	2,654	27.7	0.84
9/7	12	126	99	0	225	2,554	72	71	0	143	468	198	170	0	368	3,022	30.7	0.61
9/8	12	141	113	0	254	2,808	9	10	0	19	487	150	123	0	273	3,295	22.8	0.93
9/9	12	118	85	0	203	3,011	12	12	0	24	511	130	97	0	227	3,522	18.9	0.89
9/10	12	144	94	0	238	3,249	8	10	0	18	529	152	104	0	256	3,778	21.3	0.93
9/11	12	110	74	0	184	3,433	21	13	0	34	563	131	87	0	218	3,996	18.2	0.84
9/12	12	92	57	0	149	3,582	40	37	0	77	640	132	94	0	226	4,222	18.8	0.66
9/13	8	87	62	0	149	3,731	16	12	0	28	668	103	74	0	177	4,399	22.1	0.84
9/14	8	97	55	0	152	3,883	15	12	0	27	695	112	67	0	179	4,578	22.0	0.85
9/15	10	84	71	0	155	4,038	41	37	0	78	773	125	108	0	233	4,811	24.5	0.67
9/16	9	86	54	0	140	4,178	29	31	0	60	833	115	85	0	200	5,011	23.5	0.70
9/17	12	42	41	0	83	4,261	7	18	0	25	858	49	59	0	108	5,119	9.0	0.77
9/18	12	64	82	0	146	4,407	12	26	2	40	898	76	108	2	186	5,305	15.5	0.78
9/19	24	76	73	0	149	4,556	8	7	0	15	913	84	80	0	164	5,469	6.8	0.91
9/20	24	84	70	0	154	4,710	10	9	0	19	932	94	79	0	173	5,642	7.2	0.89
9/21	24	56	72	0	128	4,838	8	16	0	24	956	64	88	0	152	5,794	6.3	0.84
9/22	24	41	74	0	115	4,953	3	5	0	8	964	44	79	0	123	5,917	5.1	0.93
9/23	24	30	52	0	82	5,035	10	5	0	15	979	40	57	0	97	6,014	4.0	0.85
9/24	24	36	58	0	94	5,129	10	13	0	23	1,002	46	71	0	117	6,131	4.9	0.80
9/25	24	37	66	0	103	5,232	7	8	0	15	1,017	44	74	0	118	6,249	4.9	0.87
9/26	24	31	56	0	87	5,319	6	8	0	14	1,031	37	64	0	101	6,350	4.2	0.86
9/27	24	16	42	0	58	5,377	15	9	0	24	1,055	31	51	0	82	6,432	3.4	0.71
Total		2,969	2,408	0	5,377		513	540	2	1,055		3,482	2,948	2	6,432			

[a] Does not include recaptures or other data removed before the final abundance estimate.

Appendix B. Daily effort and catch of fall chum salmon at the Kantishna River tag deployment wheel, 2003[a].

		Tagged					Not tagged					Total					Total	
Date	Hours Fished	Males	Females	Unidentifed Sex	Total	Cumulative	Males	Females	Unidentifed Sex	Total	Cumulative	Males	Females	Unidentifed Sex	Total	Cumulative	Catch Per hour	Tagging rate
8/16	24	3	1	0	4	4	0	0	0	0	0	3	1	0	4	4	0.2	1.00
8/17	24	4	2	0	6	10	1	0	0	1	1	5	2	0	7	11	0.3	0.86
8/18	24	14	10	0	24	34	1	0	0	1	2	15	10	0	25	36	1.0	0.96
8/19	24	9	4	0	13	47	1	1	0	2	4	10	5	0	15	51	0.6	0.87
8/20	24	9	1	0	10	57	0	0	0	0	4	9	1	0	10	61	0.4	1.00
8/21	24	8	0	0	8	65	2	1	0	3	7	10	1	0	11	72	0.5	0.73
8/22	24	14	4	0	18	83	2	0	0	2	9	16	4	0	20	92	0.8	0.90
8/23	24	8	2	0	10	93	0	1	0	1	10	8	3	0	11	103	0.5	0.91
8/24	24	22	3	0	25	118	2	0	0	2	12	24	3	0	27	130	1.1	0.93
8/25	24	20	10	0	30	148	2	0	0	2	14	22	10	0	32	162	1.3	0.94
8/26	24	73	22	0	95	243	5	2	0	7	21	78	24	0	102	264	4.3	0.93
8/27	24	74	20	0	94	337	6	6	0	12	33	80	26	0	106	370	4.4	0.89
8/28	24	95	42	0	137	474	6	1	0	7	40	101	43	0	144	514	6.0	0.95
8/29	24	64	27	0	91	565	4	2	0	6	46	68	29	0	97	611	4.0	0.94
8/30	24	66	28	0	94	659	7	1	0	8	54	73	29	0	102	713	4.3	0.92
8/31	24	44	33	0	77	736	7	1	0	8	62	51	34	0	85	798	3.5	0.91
9/1	24	64	37	0	101	837	1	1	0	2	64	65	38	0	103	901	4.3	0.98
9/2	24	60	24	0	84	921	4	2	0	6	70	64	26	0	90	991	3.8	0.93
9/3	24	88	48	0	136	1,057	10	8	0	18	88	98	56	0	154	1,145	6.4	0.88
9/4	24	51	34	0	85	1,142	7	1	0	8	96	58	35	0	93	1,238	3.9	0.91
9/5	24	74	52	0	126	1,268	7	5	0	12	108	81	57	0	138	1,376	5.8	0.91
9/6	24	79	56	0	135	1,403	9	7	0	16	124	88	63	0	151	1,527	6.3	0.89
9/7	24	122	58	0	180	1,583	12	6	0	18	142	134	64	0	198	1,725	8.3	0.91
9/8	24	192	97	0	289	1,872	23	11	0	34	176	215	108	0	323	2,048	13.5	0.89
9/9	24	65	53	0	118	1,990	20	4	0	24	200	85	57	0	142	2,190	5.9	0.83
9/10	24	208	103	0	311	2,301	49	20	0	69	269	257	123	0	380	2,570	15.8	0.82
9/11	14	63	66	0	129	2,430	46	77	0	123	392	109	143	0	252	2,822	18.0	0.51
9/12	12	116	57	0	173	2,603	20	14	0	34	426	136	71	0	207	3,029	17.3	0.84
9/13	10	93	53	0	146	2,749	32	30	0	62	488	125	83	0	208	3,237	20.8	0.70
9/14	12	87	68	0	155	2,904	4	3	0	7	495	91	71	0	162	3,399	14.1	0.96
9/15	11	101	52	0	153	3,057	38	25	0	63	558	139	77	0	216	3,615	20.6	0.71
9/16	12	71	59	0	130	3,187	2	5	0	7	565	73	64	0	137	3,752	11.4	0.95
9/17	24	52	35	0	87	3,274	2	2	0	4	569	54	37	0	91	3,843	3.8	0.96
9/18	24	70	58	0	128	3,402	4	5	1	10	579	74	63	2	139	3,982	5.8	0.92
9/19	24	97	56	1	154	3,556	18	26	0	44	623	115	82	0	197	4,179	8.2	0.78
9/20	24	70	53	0	123	3,679	9	3	0	12	635	79	56	0	135	4,314	5.6	0.91
9/21	24	35	27	0	62	3,741	3	2	0	5	640	38	29	0	67	4,381	2.8	0.93
9/22	24	26	20	0	46	3,787	2	0	0	2	642	28	20	0	48	4,429	2.0	0.96
9/23	24	37	63	0	100	3,887	8	8	0	16	658	45	71	0	116	4,545	4.8	0.86
9/24	24	22	20	0	42	3,929	2	5	0	7	665	24	25	0	49	4,594	2.0	0.86
Total		2,470	1,458	1	3,929		378	286	1	665		2,848	1,744	2	4,594			

[a] Does not include recaptures or other data removed before the final abundance estimate.

Appendix C. Daily effort and catch of fall chum salmon at the Tanana River recovery wheel, 2003[a].

		Tagged					Not tagged					Total					Total
	Hours			Unidentified					Unidentified					Unidentified			
Date	Fished	Males	Females	Sex	Total	Cumulative	Males	Females	Sex	Total	Cumulative	Males	Females	Sex	Total	Cumulative	Catch per hour
8/16	24	0	0	0	0	0	6	6	0	12	12	6	6	0	12	12	0.5
8/17	23	0	0	0	0	0	7	5	0	12	24	7	5	0	12	24	0.5
8/18	24	0	0	0	0	0	19	18	0	37	61	19	18	0	37	61	1.5
8/19	24	2	0	0	2	2	39	33	0	72	133	41	33	0	74	135	3.1
8/20	24	1	2	0	3	5	45	52	0	97	230	46	54	0	100	235	4.2
8/21	24	2	1	0	3	8	63	57	0	120	350	65	58	0	123	358	5.1
8/22	24	1	0	0	1	9	54	70	0	124	474	55	70	0	125	483	5.3
8/23	24	1	0	0	1	10	48	53	0	101	575	49	53	0	102	585	4.3
8/24	24	1	0	0	1	11	63	50	0	113	688	64	50	0	114	699	4.8
8/25	24	1	0	0	1	12	83	57	0	140	828	84	57	0	141	840	5.9
8/26	24	0	1	0	1	13	58	58	0	116	944	58	59	0	117	957	4.9
8/27	24	3	1	0	4	17	120	91	0	211	1,155	123	92	0	215	1,172	9.0
8/28	24	5	1	0	6	23	111	87	0	198	1,353	116	88	0	204	1,376	8.5
8/29	24	1	1	0	2	25	159	125	0	284	1,637	160	126	0	286	1,662	11.9
8/30	24	4	0	0	4	29	174	80	0	254	1,891	178	80	0	258	1,920	11.0
8/31	24	4	0	0	4	33	162	86	0	248	2,139	166	86	0	252	2,172	10.5
9/1	24	4	3	0	7	40	139	74	0	213	2,352	143	77	0	220	2,392	9.2
9/2	24	1	1	0	2	42	96	42	0	138	2,490	97	43	0	140	2,532	5.8
9/3	24	0	2	0	2	44	65	31	0	96	2,586	65	33	0	98	2,630	4.1
9/4	24	0	0	0	0	44	26	12	0	38	2,624	26	12	0	38	2,668	1.6
9/5	23	2	0	0	2	46	81	60	0	141	2,765	83	60	0	143	2,811	6.2
9/6	22	10	2	0	12	58	236	182	0	418	3,183	246	184	0	430	3,241	19.5
9/7	24	19	15	0	34	92	350	294	0	644	3,827	369	309	0	678	3,919	28.3
9/8	24	15	10	0	25	117	476	388	0	864	4,691	491	398	0	889	4,808	37.0
9/9	24	17	14	0	31	148	534	449	0	983	5,674	551	463	0	1,014	5,822	42.3
9/10	24	11	11	0	22	170	496	366	0	862	6,536	507	377	0	884	6,706	36.8
9/11	24	7	9	0	16	186	370	334	0	704	7,240	377	343	0	720	7,426	30.0
9/12	24	10	12	0	22	208	458	373	0	831	8,071	468	385	0	853	8,279	35.5
9/13	24	5	2	0	7	215	352	285	0	637	8,708	357	287	0	644	8,923	27.4
9/14	24	2	1	0	3	218	304	292	0	596	9,304	306	293	0	599	9,522	25.0
9/15	24	6	2	0	8	226	213	242	0	455	9,759	219	244	0	463	9,985	19.3
9/16	23	3	3	0	6	232	207	222	0	429	10,188	210	225	0	435	10,420	18.9
9/17	24	5	4	0	9	241	135	169	0	304	10,492	140	173	0	313	10,733	13.0
9/18	24	3	11	0	14	255	175	195	0	370	10,862	178	206	0	384	11,117	16.0
9/19	24	1	3	0	4	259	154	194	0	348	11,210	155	197	0	352	11,469	14.7
9/20	24	5	3	0	8	267	117	110	0	227	11,437	122	113	0	235	11,704	9.8
9/21	24	4	7	0	11	278	102	87	0	189	11,626	106	94	0	200	11,904	8.3
9/22	22	7	6	0	13	291	89	102	0	191	11,817	96	108	0	204	12,108	9.1
9/23	24	3	7	0	10	301	243	90	0	333	12,150	246	97	0	343	12,451	14.3
9/24	24	5	5	0	10	311	58	78	0	136	12,286	63	83	0	146	12,597	6.1
9/25	24	6	3	0	9	320	105	120	0	225	12,511	111	123	0	234	12,831	9.8
9/26	24	3	6	0	9	329	99	155	0	254	12,765	102	161	0	263	13,094	11.0
9/27	24	4	13	0	17	346	123	182	0	305	13,070	127	195	0	322	13,416	13.4
9/28	24	3	3	0	6	352	23	39	0	62	13,132	26	42	0	68	13,484	2.8
9/29	24	1	8	0	9	361	55	129	0	184	13,316	56	137	0	193	13,677	8.0
9/30	24	1	2	0	3	364	47	93	0	140	13,456	48	95	0	143	13,820	6.0
Total		189	175	0	364		7,139	6,317	0	13,456		7,328	6,492	0	13,820		

[a] Does not include recaptures, undetermined tags from video monitoring, or other data removed before the final abundance estimate.

Appendix D. Daily effort and catch of fall chum salmon at the Toklat River recovery wheels (both combined),2003[a] .

		Tagged					Not tagged					Total					Total
	Hours			Unidentifed					Unidentifed					Unidentifed			
Date	Fished	Males	Females	Sex	Total	Cumulative	Males	Females	Sex	Total	Cumulative	Males	Females	Sex	Total	Cumulative	Catch per hour
8/16	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
8/17	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
8/18	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
8/19	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
8/20	24	0	0	0	0	0	1	2	0	3	3	1	2	0	3	3	0.1
8/21	24	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0.0
8/22	18	0	0	0	0	0	2	3	0	5	8	2	3	0	5	8	0.3
8/23	24	0	0	0	0	0	1	2	0	3	11	1	2	0	3	11	0.1
8/24	24	0	0	0	0	0	1	4	0	5	16	1	4	0	5	16	0.2
8/25	24	0	0	0	0	0	1	3	0	4	20	1	3	0	4	20	0.2
8/26	24	0	0	0	0	0	3	4	0	7	27	3	4	0	7	27	0.3
8/27	24	0	0	0	0	0	4	11	0	15	42	4	11	0	15	42	0.6
8/28	24	0	0	0	0	0	4	6	0	10	52	4	6	0	10	52	0.4
8/29	24	0	0	0	0	0	6	8	0	14	66	6	8	0	14	66	0.6
8/30	24	0	1	0	1	1	13	9	0	22	88	13	10	0	23	89	1.0
8/31	24	0	0	0	0	1	18	11	0	29	117	18	11	0	29	118	1.2
9/1	24	0	0	0	0	1	13	7	0	20	137	13	7	0	20	138	0.8
9/2	24	1	0	0	1	2	8	0	0	8	145	9	0	0	9	147	0.4
9/3	24	0	0	0	0	2	1	0	0	1	146	1	0	0	1	148	0.0
9/4	24	0	0	0	0	2	2	5	0	7	153	2	5	0	7	155	0.3
9/5	24	0	0	0	0	2	8	6	0	14	167	8	6	0	14	169	0.6
9/6	24	1	0	0	1	3	9	13	0	22	189	10	13	0	23	192	1.0
9/7	24	1	1	0	2	5	6	12	0	18	207	7	13	0	20	212	0.8
9/8	24	1	0	0	1	6	26	35	0	61	268	27	35	0	62	274	2.6
9/9	24	3	1	0	4	10	41	40	0	81	349	44	41	0	85	359	3.5
9/10	24	5	3	0	8	18	40	31	0	71	420	45	34	0	79	438	3.3
9/11	24	1	1	0	2	20	39	34	0	73	493	40	35	0	75	513	3.1
9/12	24	1	1	0	2	22	18	28	0	46	539	19	29	0	48	561	2.0
9/13	24	0	0	0	0	22	13	4	0	17	556	13	4	0	17	578	0.7
9/14	24	1	1	0	2	24	22	11	0	33	589	23	12	0	35	613	1.5
9/15	24	1	3	0	4	28	56	38	0	94	683	57	41	0	98	711	4.1
9/16	24	5	3	0	8	36	85	64	0	149	832	90	67	0	157	868	6.5
9/17	24	3	1	0	4	40	51	35	0	86	918	54	36	0	90	958	3.8
9/18	24	1	0	0	1	41	35	17	0	52	970	36	17	0	53	1,011	2.2
9/19	24	1	1	0	2	43	36	18	0	54	1,024	37	19	0	56	1,067	2.3
9/20	24	2	2	0	4	47	29	15	0	44	1,068	31	17	0	48	1,115	2.0
9/21	24	1	2	0	3	50	50	45	0	95	1,163	51	47	0	98	1,213	4.1
9/22	22	2	2	0	4	54	33	35	0	68	1,231	35	37	0	72	1,285	3.3
9/23	22	5	1	0	6	60	23	42	0	65	1,296	28	43	0	71	1,356	3.2
9/24	24	2	1	0	3	63	19	28	0	47	1,343	21	29	0	50	1,406	2.1
9/25	24	1	2	0	3	66	28	32	0	60	1,403	29	34	0	63	1,469	2.6
9/26	24	3	0	0	3	69	26	21	0	47	1,450	29	21	0	50	1,519	2.1
9/27	24	1	3	0	4	73	39	75	0	114	1,564	40	78	0	118	1,637	4.9
9/28	24	4	0	0	4	77	32	72	0	104	1,668	36	72	0	108	1,745	4.5
9/29	24	2	5	0	7	84	30	62	0	92	1,760	32	67	0	99	1,844	4.1
9/30	24	0	1	0	1	85	23	31	0	54	1,814	23	32	0	55	1,899	2.3
Total		49	36	0	85		895	919	0	1,814		944	955	0	1,899		

[a] Does not include recaptures or other data removed before the final abundance estimate.

Appendix E. Daily effort and catch of fall chum salmon at the Kantishna River recovery wheels (both combined), 2003[a].

		Tagged					Not tagged					Total					Total
Date	Hours Fished	Males	Females	Unidentified Sex	Total	Cumulative	Males	Females	Unidentified Sex	Total	Cumulative	Males	Females	Unidentified Sex	Total	Cumulative	Catch per hour
8/16	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
8/17	23	0	0	0	0	0	2	1	0	3	3	2	1	0	3	3	0.1
8/18	24	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0.0
8/19	24	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0.0
8/20	24	0	0	0	0	0	0	1	0	1	4	0	1	0	1	4	0.0
8/21	24	0	0	0	0	0	1	2	0	3	7	1	2	0	3	7	0.1
8/22	24	0	0	0	0	0	1	0	0	1	8	1	0	0	1	8	0.0
8/23	24	0	0	0	0	0	2	3	0	5	13	2	3	0	5	13	0.2
8/24	24	0	0	0	0	0	3	2	0	5	18	3	2	0	5	18	0.2
8/25	24	0	0	0	0	0	2	2	0	4	22	2	2	0	4	22	0.2
8/26	24	0	0	0	0	0	0	1	0	1	23	0	1	0	1	23	0.0
8/27	24	0	0	0	0	0	1	1	0	2	25	1	1	0	2	25	0.1
8/28	24	0	0	0	0	0	4	1	0	5	30	4	1	0	5	30	0.2
8/29	24	0	0	0	0	0	4	3	0	7	37	4	3	0	7	37	0.3
8/30	24	0	0	0	0	0	1	2	0	3	40	1	2	0	3	40	0.1
8/31	24	0	0	0	0	0	7	3	0	10	50	7	3	0	10	50	0.4
9/1	24	0	0	0	0	0	3	3	0	6	56	3	3	0	6	56	0.3
9/2	24	1	0	0	1	1	9	2	0	11	67	10	2	0	12	68	0.5
9/3	20	0	0	0	0	1	6	4	0	10	77	6	4	0	10	78	0.5
9/4	12	0	0	0	0	1	4	1	0	5	82	4	1	0	5	83	0.4
9/5	12	0	0	0	0	1	1	1	0	2	84	1	1	0	2	85	0.2
9/6	22	0	0	0	0	1	5	3	0	8	92	5	3	0	8	93	0.4
9/7	24	0	0	0	0	1	9	2	0	11	103	9	2	0	11	104	0.5
9/8	24	0	0	0	0	1	12	2	0	14	117	12	2	0	14	118	0.6
9/9	24	0	0	0	0	1	2	3	0	5	122	2	3	0	5	123	0.2
9/10	24	1	0	0	1	2	12	9	0	21	143	13	9	0	22	145	0.9
9/11	17	0	0	0	0	2	6	7	0	13	156	6	7	0	13	158	0.8
9/12	24	0	0	0	0	2	6	10	0	16	172	6	10	0	16	174	0.7
9/13	24	0	0	0	0	2	5	8	0	13	185	5	8	0	13	187	0.5
9/14	24	1	1	0	2	4	11	4	0	15	200	12	5	0	17	204	0.7
9/15	24	1	0	0	1	5	7	4	0	11	211	8	4	0	12	216	0.5
9/16	24	1	0	0	1	6	12	5	0	17	228	13	5	0	18	234	0.8
9/17	24	0	0	0	0	6	11	13	0	24	252	11	13	0	24	258	1.0
9/18	24	1	2	0	3	9	18	10	0	28	280	19	12	0	31	289	1.3
9/19	23	0	1	0	1	10	23	18	0	41	321	23	19	0	42	331	1.9
9/20	24	1	0	0	1	11	20	20	0	40	361	21	20	0	41	372	1.7
9/21	24	0	0	0	0	11	18	16	0	34	395	18	16	0	34	406	1.4
9/22	24	1	1	0	2	13	24	27	0	51	446	25	28	0	53	459	2.2
9/23	24	2	0	0	2	15	19	22	0	41	487	21	22	0	43	502	1.8
9/24	24	2	0	0	2	17	14	18	0	32	519	16	18	0	34	536	1.4
9/25	24	1	0	0	1	18	11	16	0	27	546	12	16	0	28	564	1.2
9/26	24	2	0	0	2	20	12	11	0	23	569	14	11	0	25	589	1.0
9/27	24	0	1	0	1	21	12	18	0	30	599	12	19	0	31	620	1.3
9/28	24	2	0	0	2	23	7	14	0	21	620	9	14	0	23	643	1.0
9/29	24	1	0	0	1	24	10	15	0	25	645	11	15	0	26	669	1.1
9/30	24	1	0	0	1	25	7	7	0	14	659	8	7	0	15	684	0.6
10/1	24	1	0	0	1	26	8	5	0	13	672	9	5	0	14	698	0.6
10/2	24	0	0	0	0	26	9	13	0	22	694	9	13	0	22	720	0.9
10/3	24	0	0	0	0	26	2	3	0	5	699	2	3	0	5	725	0.2
10/4	24	0	0	0	0	26	9	10	0	19	718	9	10	0	19	744	0.8
10/5	24	0	0	0	0	26	8	8	0	16	734	8	8	0	16	760	0.7
10/6	24	0	0	0	0	26	2	7	0	9	743	2	7	0	9	769	0.4
10/7	24	0	0	0	0	26	5	12	0	17	760	5	12	0	17	786	0.7
10/8	24	0	0	0	0	26	2	12	0	14	774	2	12	0	14	800	0.6
10/9	24	0	0	0	0	26	7	15	0	22	796	7	15	0	22	822	0.9
10/10	24	0	0	0	0	26	0	3	0	3	799	0	3	0	3	825	0.1
Total		20	6	0	26		396	403	0	799		416	409	0	825		

* Does not include recaptures or other data removed before the final abundance estimate.

Appendix F. Daily effort and catch of coho salmon in the Tanana tagging project wheels, 2003.

	Tanana Tag Deployment			Tanana Tag Recovery			Kantishna Tag Deployment			Toklat Tag Recovery			Kantishna Tag Recovery		
Date	Catch	Cumulative	Catch Per Hour	Catch	Cumulative	Catch Per Hour	Catch	Cumulative	Catch Per Hour	Catch	Cumulative	Catch Per Hour	Catch	Cumulative	Catch Per Hour
8/16	1	1	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
8/17	0	1	0.0	1	1	0.0	1	1	0.0	0	0	0.0	0	0	0.0
8/18	2	3	0.1	0	1	0.0	1	2	0.0	0	0	0.1	0	0	0.0
8/19	0	3	0.0	6	7	0.3	1	3	0.0	0	0	0.0	0	0	0.0
8/20	0	3	0.0	6	13	0.3	0	3	0.0	0	0	0.0	0	0	0.0
8/21	0	3	0.0	19	32	0.8	1	4	0.0	0	0	0.0	0	0	0.0
8/22	0	3	0.0	13	45	0.6	0	4	0.0	0	0	0.0	0	0	0.0
8/23	0	3	0.0	10	55	0.4	1	5	0.0	0	0	0.0	0	0	0.0
8/24	2	5	0.1	15	70	0.6	0	5	0.0	0	0	0.1	0	0	0.0
8/25	2	7	0.1	27	97	1.1	1	6	0.0	2	2	0.1	0	0	0.0
8/26	1	8	0.0	25	122	1.0	7	13	0.3	1	3	0.0	0	0	0.0
8/27	7	15	0.3	63	185	2.6	1	14	0.0	2	5	0.3	1	1	0.0
8/28	5	20	0.2	83	268	3.5	5	19	0.2	6	11	0.2	0	1	0.0
8/29	6	26	0.3	76	344	3.2	2	21	0.1	2	13	0.3	1	2	0.0
8/30	3	29	0.1	138	482	5.9	1	22	0.0	1	14	0.1	1	3	0.0
8/31	2	31	0.1	291	773	12.1	1	23	0.0	0	14	0.1	2	5	0.1
9/1	11	42	0.5	204	977	8.5	1	24	0.0	0	14	0.5	4	9	0.2
9/2	18	60	0.8	188	1,165	7.8	2	26	0.1	0	14	0.8	6	15	0.3
9/3	9	69	0.4	160	1,325	6.7	4	30	0.2	0	14	0.4	3	18	0.1
9/4	20	89	0.8	42	1,367	1.8	9	39	0.4	0	14	0.8	2	20	0.1
9/5	11	100	0.5	118	1,485	5.1	0	39	0.0	0	14	0.5	9	29	0.4
9/6	18	118	0.8	209	1,694	9.5	7	46	0.3	0	14	0.8	2	31	0.1
9/7	15	133	0.6	322	2,016	13.4	5	51	0.2	1	15	0.6	14	45	0.6
9/8	24	157	1.0	512	2,528	21.3	10	61	0.4	12	27	1.0	10	55	0.4
9/9	32	189	1.3	644	3,172	26.8	6	67	0.3	9	36	1.3	28	83	1.2
9/10	25	214	1.0	506	3,678	21.1	11	78	0.5	7	43	1.0	10	93	0.4
9/11	24	238	1.0	734	4,412	30.6	15	93	1.1	9	52	1.0	14	107	0.6
9/12	24	262	1.0	901	5,313	37.5	7	100	0.6	9	61	1.0	4	111	0.2
9/13	36	298	1.5	1,287	6,600	54.8	16	116	1.6	2	63	1.5	36	147	1.8
9/14	108	406	4.5	1,565	8,165	65.2	12	128	1.0	5	68	4.5	15	162	1.3
9/15	94	500	3.9	1,700	9,865	70.8	27	155	2.6	19	87	3.9	46	208	3.8
9/16	53	553	2.3	2,030	11,895	88.3	33	188	2.8	34	121	2.3	29	237	1.3
9/17	98	651	4.1	1,904	13,799	79.3	18	206	0.8	42	163	4.1	24	261	1.0
9/18	136	787	5.7	1,787	15,586	74.5	24	230	1.0	21	184	5.7	18	279	0.8
9/19	174	961	7.3	1,725	17,311	71.9	43	273	1.8	25	209	7.3	16	295	0.7
9/20	137	1,098	5.7	1,407	18,718	58.6	21	294	0.9	21	230	5.7	21	316	0.9
9/21	117	1,215	4.9	1,276	19,994	53.2	44	338	1.8	27	257	4.9	31	347	1.8
9/22	230	1,445	10.3	1,575	21,569	70.6	4	342	0.2	47	304	10.3	30	377	1.3
9/23	169	1,614	7.0	1,598	23,167	66.6	74	416	3.1	34	338	7.0	16	393	0.7
9/24	99	1,713	4.1	495	23,662	20.6	19	435	0.8	17	355	4.1	22	415	0.9
9/25	100	1,813	4.2	772	24,434	32.2				42	397	4.2	25	440	1.1
9/26	71	1,884	3.0	1,016	25,450	42.3				99	496	3.0	21	461	0.9
9/27				959	26,409	40.0				47	543	0.0	35	496	1.5
9/28				196	26,605	8.2				46	589	0.0	19	515	0.8
9/29				595	27,200	24.8				72	661	0.0	29	544	1.3
9/30				364	27,564	15.2				22	683	0.0	16	560	0.7
10/1													45	605	1.9
10/2													12	617	0.5
10/3													23	640	1.0
10/4													10	650	0.4
10/5													1	651	0.0
10/6													16	667	0.7
10/7													7	674	0.3
10/8													7	681	0.3
10/9													6	687	0.3
10/10													7	694	0.3
Total	1,884			27,564			435			683			694		

Appendix G. Climatological and hydrological observations, Tanana River project and fish wheel sites, 2003.

Date	Time	Precipitation [a]	Cloud cover [b] (sky)	Water Temp. (C°) [c]		Water Level (cm) ± 24 h		Air Temp. (C°)	Water velocity (f/s)		Wind		Comments
				Tanana	Kantishna	Tanana	Kantishna		Tanana	Kantishna	Direction	Speed (mph)	
15-Aug	9:00	G	1			79						0	water up over night about 15 cm
16-Aug	9:00	B	4			66			10.2	10.3		0	started raining at 7:30 a.m
17-Aug	10:48	B	4		14.0	66		15.2	9.2	10.7		0	
18-Aug	10:08	G	3		12.8	69	32	16.7	11.3	11.1	NE	0.5	a.m fog patches
19-Aug	8:10	G	5	13.6	12.3	67.5	28.5	9.8	11.9	10.5		0	very heavy fog had to wait on tagging
20-Aug	9:45	G	1	13.4	12.2	80.5	32	10.0	13.0	11.0	NE	0-5	nice sunny day
21-Aug	8:59	G	2	13.3	12.4	98	52	12.5	12.6	9.8	NE	0-5	chilly fall morning
22-Aug	10:52	G	3	13.5	12.3	117	61	10.1	13.3	8.7		0	
23-Aug	9:40	B	4	13.4	11.5	47	71	14.4	12.7	8.7	C	0	moved water level stick (to 47) on Tanana
24-Aug	9:40	B	4	12.6	11.3	55	72	12.0	13.4	9.7	NE	0-5	raining and breezy
25-Aug	10:27	A	4	11.9	11.0	60	72	12.5	12.7	9.8		0	soggy and wet
26-Aug	9:37	G	4	11.8	10.9	67	74	18.0	12.3	10.7		0	
27-Aug	9:45	G	5	11.5	11.4	69	74	11.5	12.4		W	0.5	
28-Aug	11:40	G	1	11.6	12.0	61	75	9.9	12.9	9.7	NE	3.5	heavy fog
29-Aug	11:40	G	3	11.9	12.0		74	14.5	13.4	10.2	E	1.5	lost depth measure stick due to logs
30-Aug	11:50	A	4	11.9	12.1		81	14.5	9.2	9.1		0	
31-Aug	10:30	B	4	11.8	12.1		84	13.9	10.2	9.5	E	1	
01-Sep	9:53	G	4	11.7	12.0	68	85	11.5	10.5	8.9	NE	3.4	replaced tape measure for Tanana depth
02-Sep	10:51	A	4	11.8	11.8	61	84	12.4	11.2	9.5	W	0.1	
03-Sep	10:51	G	4	11.8	11.8	51	78	13.1	10.4	9.1	W	3.3	
04-Sep	14:30	A	4	11.5	10.9	21	51	9.8	12.4	10.4		0	
05-Sep	20:20	G	1	10.8	10.2		31	10.7		11.1		0	
06-Sep	9:00	G	3	10.0	9.8		24	10.4		10.7	NW	0-10	
07-Sep	21:00	G	2	9.4	9.4		30	6.0	11.8	10.4		0	
08-Sep	10:22	G	1	9.1	8.9		40	9.5	11.3	11.2	NW	2.7+	
09-Sep	9:35	G	3	8.9	8.1		51	4.5		11.2	W	3.4+	
10-Sep	10:30	G	1	8.1	8.9		58	6.0	11.0	10.8	W	2.3+	
11-Sep				8.6	8.4			5.7	10.3	9.6			
12-Sep	19:50	G	1	8.7	7.9		84	7.7	12.2	1.5		0	
13-Sep	18:51	G	1	8.3	7.1		88	8.2	10.2	9.5		0	
14-Sep	20:00	G	1	7.7	6.1		82	6.7	11.7	9.3		0	
15-Sep	9:00	G	1	7.0	5.2		67	-0.8	10.6	10.5		0	
16-Sep	9:00	G	1	6.1	4.5		74	-0.1	10.6	10.3		0	
17-Sep	9:11	G	2	5.3	3.7			-0.8		9.3	SE	aprox 17	
18-Sep				4.6	3.1					7.6			
19-Sep				3.7	2.5		124		9.7				
20-Sep		G	1	3.1	2.0		124	5.5	9.8	8.0	E	5	
21-Sep		G	1	2.6	2.1		123	5.5	11.2	8.3			
22-Sep	19:20	G	1	2.4	2.0	88	127	5.7	9.8	7.4	E	1.5	
23-Sep	16:00	G	1	2.2	1.8	89	132	6.3	10.3		E	5	
24-Sep	10:38	G	1	2.1	1.3		138	-0.3	11.3		E	6.5	
25-Sep	10:32	G	4	1.7	3.1	96	142	3.3	10.2		E	3.3	
26-Sep	11:00	G	4	1.3		99		3.9	10.7			0	
27-Sep	10:00	G	1	1.3		101		5.5	9.9			0	
28-Sep	9:18	G	4	1.8		40		7.5	11.1		E	9.3	

[a] **Precip codes:** A = Intermittent rain, B = Continuous rain, C = snow, D = snow and rain mixed E = Thunderstorms , F = other, G = None

[b] **Sky codes:** O = No observation, 1 = Clear and visibility unlimited, 2 = partly cloudy, (< 50% cover); 3 = Broken (50-90%), 4 = Overcast (100%), 5 = Fog or thick haze or smoke.

[c] Temperatures were collected 4 times per day (with an Onset data logger) and averaged. Depth was ~ 0.46 meters.

Appendix H. Climatological and hydrological observations, Toklat River project site, 2003.

Date	Time	Precipitation [a]	Cloud cover [b] (sky)	Water Temp. (C°) hand held	Water Temp. (C°) data logger [c]	Water Level (cm) ± 24 h	Air Temp. (C°)	Wind Direction	Wind Speed (m/s)	Comments
16-Aug	8:00	A	4	12.1		3.3	11.7		0	Slight drizzle
16-Aug	20:10	A	4	12.1		3.8	11.7	SE	2	
17-Aug	8:00	B	4	11.1	10.0	3.6	8.3		0	
17-Aug	20:15	G	2	10.0		3.8	13.8		0	Clouds are breaking
18-Aug	8:10	G	2	10.4	9.7	3.3	8.2	SE	2	
18-Aug	20:15	G	2	10.6		3.0	14.9		0	sunny and warm
19-Aug	8:15	G	1	10.6	10.4	2.5	2.2		0	sunny and cold
19-Aug	22:20	G	1	10.8		2.0	16.9	NW	8	sunny
20-Aug	8:10	G	1	10.1	10.2	1.5	6.3	W	3	
20-Aug	22:10	G	1	10.8		1.4	16.2	W	2	
21-Aug	8:20	G	2	10.8	9.9	1.1	7.2		0	
21-Aug	22:10	B	4	10.2		1.5	10.5		0	
22-Aug	8:05	G	1	10.4	10.4	1.1	2.1	SE	2	
22-Aug	22:15	G	2	10.4		1.5	12.6		0	finished left side of fish wheel @ 22:00
23-Aug	8:15	B	4		8.8	1.0	6.7	NE	2	
23-Aug	22:15	G	3	8.9		1.3	10.5	NE	7	
24-Aug	8:20	A	4		8.5	1.3	11.1	SE	3	
24-Aug	22:15	G	4	10.2		1.5	12.3		0	
25-Aug	8:20	G	4	9.8	9.0	1.5	9.7		0	
25-Aug	22:20	G	4	10.4		1.5	12.1	N	3	
26-Aug	8:25	G	4	10.1	9.4	1.5	9.8	W	2	
26-Aug	22:20	G	4	10.9		1.9	13.1	W	3	
27-Aug	8:20	G	2	9.8	9.7	1.8	4.1		0	
27-Aug	22:25	G	2	9.0		1.9	18.2	W	4	
28-Aug	8:25	G	2		10.3	1.5	4.1		0	
28-Aug	20:25	G	1	11.5		1.5	19.7		0	
29-Aug	8:25	G	1	10.1	9.8	1.4	6.9	NW	2	
29-Aug	20:25	G	2	10.2		1.7	13.9		0	
30-Aug	8:25	B	2	10.0	9.9	1.4	11.4		0	
30-Aug	20:05	G	4	11.4		1.4	16.4	W	2	
31-Aug	8:25	B	2	11.4	10.6	1.7	10.3		0	
31-Aug	20:15	G	4	11.5		2.0	14.3	SE	1	
01-Sep	8:20	G	3		10.2	2.8	11.4	SE	2	
01-Sep	20:15	A	4	11.7		3.6	12.9		0	
02-Sep	8:15	B	4		10.4	3.6	10.4	SE	1	Thermometer not working
02-Sep	20:20	G	3			4.6	10.8		0	
03-Sep	8:20	B	4		9.4	7.1	8.1	SE	2	water rising rapidly
03-Sep	20:20	G	2	9.2		8.1	9.9		0	water crested at ~ 15:00
04-Sep	8:25	G	2	8.6	8.3	6.9	7.4		0	
04-Sep	20:20	G	3			6.4	10.4		0	
05-Sep	8:25	G	5	7.0	7.4	5.3	3.3		0	
05-Sep	20:15	G	2	8.7		5.6	12.8	SW	4	
06-Sep	8:30	G	3	7.0	8.1	4.8	6.1	NW	1	
06-Sep	20:25	G	1	8.7		4.3	6.2		0	
07-Sep	8:30	G	1	6.0	6.9	3.8	-2.8		0	
07-Sep	20:20	G	1	6.9		3.6	9.4		0	
08-Sep	8:20	G	3	6.3	7.0	3.3	3.4		0	
08-Sep	20:25	G	1	7.8		2.8	8.7		0	
09-Sep	8:30	G	1	6.3	8.1	2.5	0.0		0	
09-Sep	20:20	G	2	7.7		2.3	7.1		0	
10-Sep	8:30	G	4	5.7	7.2	2.0	3.2	SE	2	
10-Sep	20:30	G	3	7.5		2.0	9.5		0	

Continued

Appendix H. Page two of two.

Date	Time	Precipitation [a]	Cloud cover [b] (sky)	Water Temp. (C°) hand held	Water Temp. (C°) data logger [c]	Water Level (cm) ± 24 h	Air Temp. (C°)	Wind Direction	Wind Speed (m/s)	Comments
11-Sep	8:35	B	4	7.1	6.8	1.5	7.2	SE	6	
11-Sep	20:20	A	3	6.3		1.5	6.1	SE	1	
12-Sep	8:25	G	2	5.7	6.2	2.0	3.3		0	
12-Sep	20:20	G	1	6.6		3.0	3		0	water rising
13-Sep	8:25	G	1	3.8	4.7	5.3	-5		0	
13-Sep	20:20	G	1	4		4.8	1.7		0	
14-Sep	8:20	G	1	2.7	3.5	3.8	-5.6		0	
14-Sep	20:20	G	1	3.3		3.3	0.8		0	
15-Sep	8:40	G	1	3.3	2.8	2.3	-5.6		0	
15-Sep	20:05	G	1	2.8		2.0	2.22		0	water dropping
16-Sep	8:50	G	1	1.8	3.0	1.8	-6.66		0	cool and clear
16-Sep	20:30	G	1	3.1		1.8	2.22		0	
17-Sep	9:05	G	1	2	2.8	1.5	-1.66	W	7	cool and windy
17-Sep	20:10	G	1	2.5		1.4	2.77	W	4	
18-Sep	8:50	G	1	1	1.9	1.1	-4.44	W	6	
18-Sep	20:10	G	1	1.9		1.0	-2.22		0	
19-Sep	8:50	G	2	0.6	1.5	0.8	-3.33	W	9	cold
19-Sep	20:05	G	2	1.6		0.8	1.11	W	6	
20-Sep	8:55	G	1	0.3	1.3	0.7	-2.77	W	5	
20-Sep	20:10	G	3	1.7		0.8	4.44	W	6	
21-Sep	8:50	G	4	1.2	1.9	0.5	0	W	4	warmer
21-Sep	20:10	G	1	2		0.8	-1.11		0	
22-Sep	8:50	G	4	1.3	1.9	0.5	-5		0	
22-Sep	20:15	G	1	2.1		0.4	-1.7		0	
23-Sep	9:10	G	1	0.7	1.6	0.3	-2.2	W	4	
23-Sep	20:10	G	1	1.9		0.3	3.33	SW	3	
24-Sep	9:10	G	3	0.6	1.0	0.1	-1.11	W	20	windy
24-Sep	20:10	G	3	1.4		0.4	1.7	SW	12	windy
25-Sep	8:50	G	4	1.2	1.4	0.1	0	W	10	
25-Sep	20:10	G	4	1.9		0.3	1.1		0	overcast, windy
26-Sep	9:05	G	3	1.4	1.9	0.1	-1.1		0	no wind
26-Sep	20:15	G	3	2.4		0.1	3.3		0	
27-Sep	9:10	G	1	2.2	2.8	0.1	-4.4		0	
27-Sep	20:20	G	1	3.3		0.0	3.3	W	2	water depth, 1.00 = 0.00 on previous depth gauge
28-Sep	9:10	G	3	2.8	3.0	2.3	3.9	W	8	
28-Sep	20:10	G	4	3.3		2.4	7.2	SW	3	
29-Sep	8:50	G	2	2.7	3.6	2.4	0		0	
29-Sep	20:20	G	2	4.7		2.3	9.4		0	
30-Sep	8:50	G	2	5.1	2.8	3.3	4.4		0	
30-Sep	8:16	G	3	5.6		3.8	15.6	SE	3	very warm and mild
01-Oct	9:10	G	3	5.6		5.3	11.1	NW	2	river rising rapidly

[a] **Precip codes:** A = Intermittent rain, B = Continuous rain, C = snow, D = snow and rain mixed E = Thunderstorms , F = other, G = None

[b] **Sky codes:** O = No observation, 1 = Clear and visibility unlimited, 2 = partly cloudy, (< 50% cover); 3 = Broken (50-90%), 4 = Overcast (100%), 5 = Fog or thick haze or smoke.

[c] Temperatures were collected 4 times per day (with an Onset data logger) and averaged. Depth was ~ 0.46 meters.