

**Fishery Data Series No. 05-76**

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**Fall Chum Salmon Mark–Recapture Abundance  
Estimation on the Tanana and Kantishna Rivers, 2004**

by

**Peter M. Cleary**

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December 2005

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries





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## ABSTRACT

Fall chum salmon, *Oncorhynchus keta*, mark–recapture studies were conducted for the tenth year on the Tanana River and for the sixth year on the Kantishna River. In the Tanana River, chum salmon were captured and tagged using a fish wheel located approximately 5 km upstream of the Kantishna River mouth, and recaptured in a fish wheel located approximately 76 km upriver. In the Kantishna River, chum salmon were captured in a fish wheel, approximately 9 km upstream of its confluence with the Tanana River, and recaptured in four fish wheels. Two fish wheels were located approximately 114 km upstream in the Toklat River, and the other two 139 km upstream on the Kantishna River. This project was conducted in August and September 2004. The final fall chum salmon abundance estimates were 123,879 (SE = 11,071; Chapman model) for the Tanana River and 76,163 (SE = 4,391; Darroch Model) for the Kantishna River.

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<sup>2</sup>), comprising roughly 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, with a watershed of 115,250 km<sup>2</sup>. Chum salmon, *Oncorhynchus keta*, return to the Yukon River in genetically divergent 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. The fall chum salmon (fall 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, have a higher oil content than summer chum, and are important for subsistence, personal use, and commercial fisheries within the upper Yukon and Tanana Rivers.

For management purposes, the Yukon River drainage is divided into 13 Districts and Subdistricts. The Tanana River is called District 6, and is divided into Subdistricts 6-A, 6-B, and 6-C and the area upstream of Subdistrict 6-C to the headwaters is called the upper Tanana River area (Figure 1). For the purpose of the Tanana/Kantishna River mark–recapture project, the area upstream of Subdistrict 6-A is called the upper Tanana River (Figure 1). Tanana River summer and fall chum salmon are managed as separate stocks based on run timing and are divided into summer (before 16 August) and fall seasons (after 16 August), although some overlap in migration does occur. Tanana River fall chum run strength is assessed by using mark–recapture abundance estimates, catch per unit effort (CPUE) data from an Alaska Department of Fish and Game (ADF&G) contracted “test” fish wheels (wheels) and historical fishery data.

Subsistence and personal use salmon fisheries occur in 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 5 days a week. Commercial fishing occurs on the Tanana River in Subdistricts 6-B and 6-C by emergency order. The Tanana River commercial guideline harvest range is 2,750 to 20,500 fall chum salmon, but the harvest level may be exceeded if assessment of run size indicates both escapement goals and subsistence needs will be met. In 2004, commercial fishing was permitted because of a strong return of fall chum (ADF&G 2004).

Tanana River drainage chum salmon are harvested in various fisheries in the Yukon River. The 1994–2003 average Tanana River fall chum subsistence harvest was approximately 21,000 fish

(B. Busher, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication) which is approximately 15% of the entire average total utilization for the Yukon River drainage for those years (JTC 2005).

Primary objectives for this project are to provide management staff with inseason and postseason abundance estimates of fall chum in the Tanana (above the mouth of the Kantishna River) and Kantishna Rivers, and to estimate the migration rate of fall chum in the Kantishna River. Secondary objectives are to count tagged and untagged fall chum and other species using a digital video system at the Tanana tag recovery wheel, and estimate run timing of fall chum to the Delta, Toklat, and Kantishna Rivers.

## METHODS

### TAG DEPLOYMENT

In 2004, two tag deployment wheels were operated by contracted fishermen. One in the Tanana River 9 km upstream of the mouth of the Kantishna River and the second in the Kantishna River, approximately 5 km upstream (Figure 2). These locations were selected because of the minimum number of tributaries between the two sites, with the exception of the Tolovana River upstream of the Tanana River tag deployment wheel. In the event the marked proportion changed over time at the Tanana River tag recovery wheel, tag colors were changed bi-weekly at the Tanana River tag deployment wheel. Tag color stratification can be used to generate a postseason abundance estimate using the Darroch stratified model (Darroch 1961).

Unless interrupted by debris accumulation, repairs, adjustments or relocation, the two tag deployment wheels were operated 24 hours per day. At each location a daily 12-hour tag deployment schedule was maintained from 0800 to 2000 hours. A 24-hour tagging day was designated as 0800 to 0800 hours the following day. The sampling crew checked the live box at each wheel in approximate 4 hour intervals (0730, 1200, 1600 and 1930 hours) or more often depending on catch rates. Using a dip net, 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)<sup>1</sup> inserted with a 16 cm applicator needle into the musculature behind the dorsal fin and secured with an overhand knot. The adipose fin was removed as a secondary mark. Data recorded were: length (10 fish per day per tag site), measured from mid-eye to tail fork (METF) to the nearest 5 cm; sex; condition, determined by external physical aberrations 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 considered to have severe wounds (bleeding, gashes, head injuries, fungus, etc.) were not tagged. Fish caught between 0800 and 2000 hours were categorized as day fish, while fish caught between 2000 and 0800 hours, tagged in the morning and held in the live box for up to 12 hours, were categorized as night fish. Handling time per fish during tagging procedures was approximately 2 minutes. All Chinook salmon, *O. tshawytscha*, and coho salmon, *O. kisutch*, were enumerated by sex and released, while other species were identified, enumerated, and released. Because of time required for tag deployment, a maximum of 150 fish were tagged at each site per day.

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<sup>1</sup> Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

## TAG RECOVERY

In the Tanana River, a recovery wheel operated by a contracted fisherman was located 76 km upstream of the tag deployment site and downstream from the Nenana River (Figure 2). At this fish wheel, tagged and untagged salmon and other species were counted using a digital video system. Fish captured by the fish wheel were counted when they exited the fish wheel baskets and were directed through a plastic chute designed to pass fish within the view of a camera (Borba *In prep*). Data was summarized by the contract fisherman using software provided by ADF&G.

In the Kantishna River drainage, tags were recovered at two locations each with two fish wheels. One into the Toklat River, 114 km upstream and the other in the upper Kantishna River, 139 km upstream. At each site tag number and color were recorded, coho salmon were counted by sex, and all other species were counted.

To monitor wheel efficiency, wheel revolutions were recorded daily at the tag deployment fish wheels and the Toklat River tag recovery fish wheels. In addition, meteorological data and water level were recorded once a day. Water temperatures were measured using Hobo (Onset Inc.) data loggers at the Tanana and Kantishna tag deployment and Toklat and Tanana recovery wheel sites. Tagging data were recorded in the field using an Allegro CE handheld field computer and downloaded daily into an Access database. A data summary for the previous 24-hour tagging day was reported daily to the ADF&G Fairbanks office via cellular or satellite telephone.

## DATA ANALYSIS

### Mark–Recapture Assumption Tests

To test the assumption that tagged fish have equal chance of capture as untagged and are mixed in the population a series of statistical tests were performed. The following assumptions were examined: 1) equal chance of capture between right and left banks, 2) equal chance of capture at the Toklat and upper Kantishna River sites, 3) equal chance of capture for sex and length, and 4) equal chance of capture between day and night fish (i.e., no holding effects). Chi square ( $\chi^2$ ) tests were used to test assumptions 1, 2, and 4. For assumption 3 a logistic regression was used in which probability of recapture was regressed with length and sex. Finally,  $\chi^2$  tests for marked ratio through time were used to examine if the marked ratio at recovery wheels varied for all fish and by sex.

### Abundance Estimation

Daily inseason abundance estimates were provided to fisheries managers when the coefficient of variance (CV) was less than 0.30. Inseason estimates were considered preliminary until postseason assumption tests were completed.

Chapman's estimate (equation 1) and variance (equation 2) were employed to estimate the total fall chum run size for the Tanana and Kantishna Rivers (Chapman 1954).

Chapman's estimation equation is calculated as:

$$\hat{N} = \frac{(C + 1)(M + 1)}{R + 1} - 1. \quad (1)$$

The variance was approximated as:

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

where:

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

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

$M$  = The number of fish tagged and released at the tag deployment wheels.

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

### **Migration Rate**

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

$$\hat{M} = \frac{RD}{D} \quad (3)$$

Where:

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

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

To investigate migration rate differences between day and night fish and between genders, a Holm Sidak test (Glantz 2002) was used.

### **Stock Timing**

Ground (foot) surveys were conducted by ADF&G employees on the Delta and Toklat rivers to count the number of live and dead chum and coho salmon. On the Delta River, eight replicate surveys were conducted from 7 October through 30 November. On the Toklat River, one survey was conducted of the fall chum spawning area known as the Toklat Springs 22 through 26 October. One ground survey was conducted (by ADF&G and USFWS employees) on 12 November (during peak spawning) at Bluff Cabin Slough on the Tanana River. When possible, tags were retrieved at these locations.

## **RESULTS**

### **TAG DEPLOYMENT**

Tag deployment wheels operated from 16 August until 25 September on the Tanana River and from 16 August to 23 September on the Kantishna River. Total fall chum catch at the Tanana River tag deployment wheel was 3,862 fish of which 3,334 were tagged. At the Kantishna River tag deployment wheel, 3,857 fall chum were captured of which 3,494 were tagged (Appendix A1–A2). The peak chum CPUE of 28.5 fish per hour occurred on 23 September at the Tanana River tag deployment wheel and 20 September (10.4 fish per hour) at the Kantishna River tag deployment wheel (Figure 3; Appendix A1–A2). Fishing hours were reduced 20 through 24 September on the Tanana River when the daily tagging goal of 150 fish was reached.

## **TAG RECOVERY**

On the Tanana River, the recovery wheel began operation on 16 August and continued through 30 September. Total fall chum catch was 4,878 fish of which 124 were tagged (Appendix A3). On the Toklat River, recovery wheel operations began on 16 August and ended on 29 September. Total fall chum catch (both wheels combined) was 7,403 fish, of which 330 were tagged (Appendix A4). On the Upper Kantishna River, recovery wheels operated from 16 August and ended on 5 October on the left bank and 13 October on the right bank. The total number of fall chum captured (both wheels combined) was 537 of which 19 were tagged (Appendix A5). Total numbers of tags recovered, including public tag recoveries, are listed in Table 1.

Coho salmon represented a substantial portion of total catch at all fish wheels. Coho CPUE was greatest at the Tanana River tag recovery wheel (83 fish per hour) and occurred on 28 September (Appendix A6).

## **DATA ANALYSIS**

### **Mark–Recapture Assumption Tests**

No significant difference was found in the marked ratio between left and right bank recovery wheels on the Toklat ( $\chi^2 = 0.515$ ,  $df = 1$ ,  $P = 0.473$ ), between wheels on the upper Kantishna River ( $\chi^2 = 0.018$ ,  $df = 1$ ,  $P = 0.892$ ) or between tag recovery locations ( $\chi^2 = 0.731$ ,  $df = 1$ ,  $P = 0.393$ ). As a result, all Kantishna and Toklat River recovery data were pooled. Logistic regression analysis indicated no significant difference in probability of recapture at recovery wheels due to length (Wald  $\chi^2 = 2.957$ ,  $df = 1$ ,  $P = 0.085$ ) or sex (Wald  $\chi^2 = 2.506$ ,  $df = 1$ ,  $P = 0.113$ ) (Table 2).

The Logistic regression test for holding affects using all tag and recovery data, indicated no significant difference in marked ratio in sex (Wald  $\chi^2 = 3.747$ ,  $df = 1$ ,  $P = 0.052$ ) but a difference in the probability of recapture between day versus night fish (Wald  $\chi^2 = 5.044$ ,  $df = 1$ ,  $P = 0.025$ ) (Table 2).

Chi square tests for marked ratio through time indicated a significant difference for all fish ( $\chi^2 = 18.866$ ,  $df = 4$ ,  $P = < 0.001$ ) and males ( $\chi^2 = 18.713$ ,  $df = 4$ ,  $P = < 0.001$ ) however marked ratio did not vary for females ( $\chi^2 = 0.927$ ,  $df = 4$ ,  $P = 0.921$ ). Because of this, Darroch's method was used to calculate abundance estimates by sex. Digital video is used to count fish at the Tanana tag recovery fish wheel and no individual tag data was collected. However, a chi square test for variation in marked ratio over time indicated no significant differences ( $\chi^2 = 6.717$ ,  $df = 4$ ,  $P = 0.152$ ) (Tables 2 and 3).

### **Abundance Estimate**

Chi square tests indicated no significant difference in the marked proportion over time on the Tanana River. As a result, tag color stratification for the Darroch estimator was not necessary, and abundance estimates were generated using Chapman's method. The final abundance estimate for fall chum salmon was 123,879 (SE 11,071) for the Tanana River (Table 4; Figure 4).

Like the Tanana River daily inseason estimate, the Kantishna River estimate was generated using Chapman's model, however, the marked ratio of males and females were dissimilar (Table 5; Figure 4). As a result, separate (Darroch model) abundance estimates were generated for males and females using Stratified Population Analysis System (SPAS) software. Estimates by sex for

the Kantishna River were 40,114 (SE 2,745) for males and 36,049 (SE 3,427) for females for a combined total of 76,163 (SE 4,391) (Table 7).

### **Migration Rate**

Toklat River fall chum average migration rates were 19 km/day for day tagged fish (n = 151) and 16 km/day for night tagged fish (n = 179). Migration rate averages for tagged chum salmon captured at the upper Kantishna River tag recovery wheel were 16 km/day (n = 7) for day tagged fish and 14 km/day (n = 12) for night tagged fish (Table 6). The Holm Sidak test indicated night fish migration rates were less than day fish migration rates ( $F = 18.657$ ,  $df = 1$ ,  $P = < 0.001$ ) and female migration rates were less than male ( $F = 20.276$ ,  $df = 1$ ,  $P = < 0.001$ ) (Tables 2 and 6). Migration rate data were not generated for the Tanana River because video methods were used and no tag data was collected aside from tag color.

### **Stock Timing**

During foot surveys, 31 tags were recovered from spawning grounds in the Delta River between 3 October and 17 November 2004 (Table 1). The median tag deployment date for these fish was 19 September and tagging dates ranged from 4 through 25 September.

Fifty six tags were recovered during foot surveys of the Toklat Springs, two of which were deployed on the Tanana River (Table 1). The median tag deployment date for tags recovered at Toklat Springs was 4 September (date range of 18 August to 21 September, 5 September for tags recovered at the Toklat River fish wheels, (date range of 22 August to 22 September, N = 330) and 4 September for tags recovered at the upper Kantishna River fish wheels (date range of 17 August through 22 September, N = 19) (Table 6).

## **DISCUSSION**

The 2004 Pilot Station fall chum salmon estimate of 609,088 fish was greater than the 1997-2003 average of 429,552 (JTC 2005). Similarly, the 2004 Tanana River run strength surpassed the 1995–2003 mean mark–recapture estimate of approximately 119,000 fall chum and is the fourth largest estimate following 1995, 1996, and 2003 (Table 7). In addition, the Delta River, a tributary of the Tanana River, escapement estimate of approximately 25,000 fall chum (calculated from area-under-the-curve from replicate foot survey counts), was well above the biological escapement goal of 6,000 to 13,000 fall chum (B. Borba, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication) and approximately 50% greater than the 1999–2003 average escapement.

Migration rates of tagged fall chum recaptured in the Toklat River were approximately 6 km less than the 1999–2003 average. This may be representative of the large sample size because the total number of tags recovered in 2004 was approximately 78% of the total number recovered from 1999–2003. On the other hand, live box densities were greatest since the inception of the project on the Kantishna River, which may have had an effect on travel time of tagged fall chum. In addition, the decreased migration rate can be associated with high water (Cleary and Hamazaki 2004). However, water levels in the Toklat and Kantishna Rivers were exceptionally low in 2004, and in the Tanana River at Nenana (after August 31) the water level was lower than the 1987–2003 average (Table 6; Figure 5). Reduced migration rates in 2004 could be due to an

exceptionally low water level which made fish more susceptible to capture, or could also be an indication of stress from capture and high live box densities.

It is unknown why the marked ratio for all fish and males differed over time on the Toklat River and upper Kantishna River. Yet this is not surprising since fish wheel catch varies widely by site depending on location and water level. In the Toklat River, the number of suitable fish wheel sites is limited and by chance the left bank wheel (which recovered most tags) operated closest to the channel where the bulk of fish migrate.

The 2004 Kantishna River fall chum abundance estimate is approximately 50% greater than 1999–2003 average abundance estimate (Table 7; Figure 4). Other verification of a strong return of fall chum to the Kantishna River includes the Toklat River escapement estimate of 35,480 fall chum salmon, expanded from foot survey counts using the migratory-time-density curve method (B. Borba, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication).

The Toklat Springs expanded foot survey estimate is approximately 52% of the lower bound of the Kantishna River abundance estimate. This could mean approximately 30,000 chum salmon migrated to streams in the upper Kantishna drainage. Although this is possible, it is unlikely since small numbers (<3,000) of spawning fall chum salmon were counted during an aerial survey conducted on 13 October in the upper Kantishna River drainage. However, the Toklat River Springs foot survey was conducted before peak spawning activity, indicated by a 13% carcasses count, which could mean there were fish that moved into the area after the survey. In addition, fall chum may spawn outside of the index area (Holder and Fair 2002) and carcasses could be consumed by scavengers or washed downstream before the October foot survey.

In addition, the aerial survey count for the upper Kantishna River is probably conservative because not all streams were examined, only one survey was conducted, and conditions were poor in some streams. Also, peak CPUE at the Kantishna River tag recovery wheels occurred on 11 October, only 2 days before the aerial survey, which was not sufficient time for these fish to reach fall chum spawning streams in the upper Kantishna River drainage.

## **RECOMMENDATIONS**

The 2004 season was the first year tag color was changed bi-weekly to stratify Tanana River recovery events for the abundance estimate. However, tag color stratification was not used because there was not a significant difference in marked proportions over time. Nevertheless, tag color change every 2 weeks at the Tanana River tag deployment wheel should continue in the event color stratification is needed for the abundance estimate.

While aerial surveys are of questionable use because of various factors, (weather, water level, timing, etc.) they can provide some general information on run strength and presence or absence of spawning populations. To compare the Kantishna River fall chum salmon abundance estimates to Toklat River foot survey counts, aerial surveys should be conducted in the upper Kantishna River drainage on an annual basis.

Since the inception of mark–recapture estimation on the Kantishna River, there has been considerable speculation on the discrepancy between the Toklat Springs foot survey estimates and Kantishna River abundance estimates. A radiotelemetry project conducted in the Kantishna

River drainage would answer questions on the proportion of fall chum that migrate to the Toklat River compared to spawning areas in the upper Kantishna River.

This was the second year water temperatures were collected using data loggers at all (first year for the upper Kantishna River site) tag and recovery wheel sites for the Tanana/Kantishna mark-recapture project (Appendix A7). Because of the growing concern over increased Yukon River drainage water temperatures and the possible negative effect on salmon physiology, water temperature data collection efforts should be continued to document changes inseason and between years.

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## **TABLES AND FIGURES**

**Table 1.**—Tags recovered by location from fall chum salmon in the Tanana and Kantishna Rivers, 2004.

<b>Recapture Location</b>	<b>Method</b>	<b>Number of Tags</b>
Bluff Cabin Slough	Foot survey	10
Delta River	Foot survey	31
Toklat Springs	Foot survey	56
Tanana River recovery wheel	Fish wheel/digital video	124
Toklat River recovery <sup>a</sup>	Fish wheels	330
Kantishna River recovery <sup>b</sup>	Fish wheels	19
Other tag recoveries	Fishermen/public	21
<b>Total</b>		<b>591</b>

<sup>a</sup> Includes only single recaptures.

<sup>b</sup> Includes tags captured after 10/1 not used in the abundance estimate.

**Table 2.**—Statistical test results for fall chum salmon captured in the Toklat, upper Kantishna, and Tanana River tag recovery fish wheels, 2004.

<b>Logistic Regression tests</b>							
Location	Description	Wald		df	P-Value		N
		Sex	Length		Sex	Length	
Toklat and upper Kantishna River	recapture probability based on sex and length	2.506	2.957	1	0.113	0.085	398
Location	Description	Sex	Day vs. Night	df	Sex	Day vs. Night	N
		Toklat and upper Kantishna River	recapture probability based on sex and day vs. night		3.747	5.044	
<b>Holm Sidak Test</b>							
Location	Description	F		df	P-Value		N
		Sex	Day vs. Night		Sex	Day vs. Night	
Toklat and upper Kantishna River	migration rate based on sex and day vs. night	20.276	18.657	1	< 0.001	< 0.001	349
<b>Chi Square tests</b>							
Location	Description	Chi Square	df	P-Value			
Toklat and upper Kantishna River	marked ratio between recovery locations	0.731	1	0.393			
Toklat River	marked ratio between wheels	0.515	1	0.473			
upper Kantishna River	marked ratio between wheels	0.018	1	0.892			
Toklat and upper Kantishna River	marked ratio over time - all fish	18.866	4	< 0.001			
Toklat and upper Kantishna River	marked ratio over time - males	18.713	4	< 0.001			
Toklat and upper Kantishna River	marked ratio over time - females	0.927	4	0.921			
Tanana River tag recovery fish wheel	marked ratio over time	6.717	4	0.152			

**Table 3.**—Chi square test data and strata for marked ratio through time for fall chum salmon captured at the Tanana, upper Kantishna, and Tanana River tag recovery fish wheels, 2004.

Tag recovery locations	Test	Marked					Total Catch				
		8/16-8/23	8/24-8/30	8/31-9/6	9/7-9/13	9/14-10/1	8/16-8/23	8/24-8/30	8/31-9/6	9/7-9/13	9/14-10/1
Toklat and upper Kantishna River	marked ratio over time - all fish	0	4	45	109	187	20	102	729	1877	5039
Toklat and upper Kantishna River	marked ratio over time - males	0	3	35	85	123	14	60	443	1225	2947
Toklat and upper Kantishna River	marked ratio over time - females	0	1	10	24	64	6	42	286	652	2092
Tanana River	marked ratio over time - all fish	0	9	27	14	74	112	581	1046	401	2738

**Table 4.**—Daily and cumulative catch and abundance estimates of fall chum salmon in the Tanana River, 2004.

Date	Released <sup>a</sup>	Examined For Tags	Recaptures <sup>b</sup>	Abundance	95% Confidence Bounds		Standard Error	CV
					Lower	Upper		
8/16	4	24	0					
8/17	15	34	0					
8/18	20	48	0					
8/19	29	56	0					
8/20	35	65	0					
8/21	55	75	0					
8/22	77	92	0					
8/23	100	112	0					
8/24	130	157	0					
8/25	168	202	2					
8/26	195	258	3					
8/27	219	344	5					
8/28	240	460	6					
8/29	289	557	7					
8/30	335	693	9	23,249	9,609	36,889	6,959	0.30
8/31	362	811	15	18,372	9,725	27,019	4,412	0.24
9/1	441	984	21	19,745	11,766	27,724	4,071	0.21
9/2	534	1,192	23	26,544	16,244	36,844	5,255	0.20
9/3	619	1,370	29	28,288	18,439	38,137	5,025	0.18
9/4	685	1,544	30	34,140	22,431	45,849	5,974	0.17
9/5	766	1,654	32	38,416	25,632	51,200	6,522	0.17
9/6	855	1,739	36	40,208	27,560	52,856	6,453	0.16
9/7	902	1,851	42	38,849	27,504	50,194	5,788	0.15
9/8	932	1,923	44	39,848	28,468	51,228	5,806	0.15
9/9	958	1,978	45	41,215	29,570	52,860	5,942	0.14
9/10	986	2,010	49	39,657	28,909	50,405	5,484	0.14
9/11	1,043	2,046	49	42,700	31,125	54,275	5,906	0.14
9/12	1,081	2,094	50	44,406	32,484	56,328	6,083	0.14
9/13	1,114	2,140	50	46,766	34,207	59,325	6,408	0.14
9/14	1,195	2,213	52	49,919	36,765	63,073	6,711	0.13
9/15	1,284	2,299	52	55,721	41,031	70,411	7,495	0.13
9/16	1,439	2,391	56	60,388	45,033	75,743	7,834	0.13
9/17	1,651	2,452	58	68,642	51,483	85,801	8,754	0.13
9/18	1,938	2,509	59	81,073	60,972	101,174	10,256	0.13
9/19	2,259	2,625	62	94,161	71,370	116,952	11,628	0.12
9/20	2,457	2,792	72	94,005	72,868	115,142	10,784	0.11
9/21	2,600	3,033	81	96,200	75,785	116,615	10,416	0.11
9/22	2,740	3,259	96	92,087	74,128	110,046	9,163	0.10
9/23	2,882	3,502	100	99,957	80,840	119,074	9,753	0.10
9/24	3,025	3,792	107	106,239	86,580	125,898	10,030	0.09
9/25	3,167	4,058	109	116,862	95,418	138,306	10,941	0.09
9/26	3,167	4,349	114	119,795	98,285	141,305	10,975	0.09
9/27	3,167	4,425	114	121,888	99,997	143,779	11,169	0.09
9/28	3,167	4,732	120	123,879	102,179	145,579	11,071	0.09

<sup>a</sup> The number of tags deployed was adjusted by 5% for mortality.

<sup>b</sup> Does not include tags recovered more than 3 days (average travel time) after tag deployment ended.

**Table 5.**—Inseason daily and cumulative catch and abundance estimates of fall chum salmon in the Kantishna River, 2004.

Date	Released <sup>a</sup>	Examined		Abundance <sup>c</sup>	95% Confidence Bounds		Standard Error	CV
		For Tags	Recaptures <sup>b</sup>		Lower	Upper		
8/16	23	1	0					
8/17	37	8	0					
8/18	52	8	0					
8/19	59	11	0					
8/20	74	11	0					
8/21	96	12	0					
8/22	137	16	0					
8/23	210	20	0					
8/24	319	25	0					
8/25	420	32	1					
8/26	524	39	2					
8/27	609	46	2					
8/28	710	63	2					
8/29	822	87	3					
8/30	938	122	4					
8/31	1,077	195	7					
9/1	1,169	282	10	30,075	13,392	46,758	8,512	0.28
9/2	1,326	380	18	26,590	15,231	37,949	5,796	0.22
9/3	1,522	426	22	28,256	17,260	39,252	5,610	0.20
9/4	1,668	509	31	26,584	17,803	35,365	4,480	0.17
9/5	1,780	696	40	30,260	21,382	39,138	4,530	0.15
9/6	1,826	852	50	30,541	22,492	38,590	4,107	0.13
9/7	1,896	1,013	61	31,009	23,590	38,428	3,785	0.12
9/8	1,946	1,195	71	32,325	25,136	39,514	3,668	0.11
9/9	1,986	1,398	90	30,532	24,499	36,565	3,078	0.10
9/10	2,050	1,721	105	33,303	27,190	39,416	3,119	0.09
9/11	2,098	1,951	122	33,295	27,622	38,968	2,894	0.09
9/12	2,169	2,200	136	34,846	29,216	40,476	2,873	0.08
9/13	2,258	2,729	159	38,527	32,753	44,301	2,946	0.08
9/14	2,348	3,201	181	41,309	35,496	47,122	2,966	0.07
9/15	2,399	3,595	190	45,167	38,950	51,384	3,172	0.07
9/16	2,494	3,750	194	47,974	41,435	54,513	3,336	0.07
9/17	2,567	3,845	196	50,115	43,316	56,914	3,469	0.07
9/18	2,694	3,998	205	52,298	45,359	59,237	3,540	0.07
9/19	2,850	4,349	214	57,663	50,165	65,161	3,825	0.07
9/20	3,047	4,975	236	63,974	56,042	71,906	4,047	0.06
9/21	3,189	5,909	258	72,768	64,119	81,417	4,413	0.06
9/22	3,306	6,050	260	76,646	67,567	85,725	4,632	0.06
9/23	3,319	6,521	278	77,586	68,695	86,477	4,536	0.06
9/24	3,319	6,784	292	76,858	68,264	85,452	4,385	0.06
9/25	3,319	6,986	307	75,292	67,084	83,500	4,188	0.06
9/26	3,319	7,174	318	74,651	66,656	82,646	4,079	0.05
9/27	3,319	7,274	327	73,615	65,842	81,388	3,966	0.05
9/28	3,319	7,530	337	73,951	66,257	81,645	3,925	0.05
9/29	3,319	7,756	345	74,409	66,756	82,062	3,904	0.05
9/30	3,319	7,758	346	74,214	66,593	81,835	3,888	0.05
10/1	3,319	7,768	346	74,309	66,678	81,940	3,893	0.05

<sup>a</sup> The number of tags deployed was adjusted by 5% for mortality.

<sup>b</sup> Does not include tags recovered more than 8 days (average travel time) after tag deployment ended.

<sup>c</sup> Inseason estimate - not the final abundance estimate. Estimates were generated by sex using the Darroch model.

**Table 6.**—Estimated migration rates (km/day) for day and night caught fall chum salmon in the Tanana and Kantishna Rivers, 1995–2004.

<b>Tanana River tagging fish wheel to Tanana River recovery fish wheel (76 km)</b>						
Year	Day km/day	n	Night km/day	n	Combined 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
2004	-	-	-	-	-	-
1995–2003 mean	27	23	28	22	27	80

<b>Kantishna River tag deployment wheel to the Toklat River tag recovery wheels (114 km)</b>						
Year	Day km/day	n	Night km/day	n	Combined 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	16	85
2004	19	151	16	179	17	330
1999–2003 mean	22	48	24	37	23	85

<b>Kantishna River tag deployment wheel to the Kantishna River tag recovery wheels (139 km)</b>						
Year	Day km/day	n	Night km/day	n	Combined 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
2004	16	7	14	12	15	19
2000–2003 mean	24	11	23	3	23	14

**Table 7.**–Tanana and Kantishna rivers fall chum salmon abundance estimates 1995–2004.

**Tanana River**

Year	Point Estimate	SE	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
2004	123,879	11,071	102,179	145,579
1995–2003				
Mean	118,781			

**Kantishna River**

Year	Point Estimate	SE	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
2004	76,163	4,391	67,557	84,769
1999–2003				
Mean	43,133			

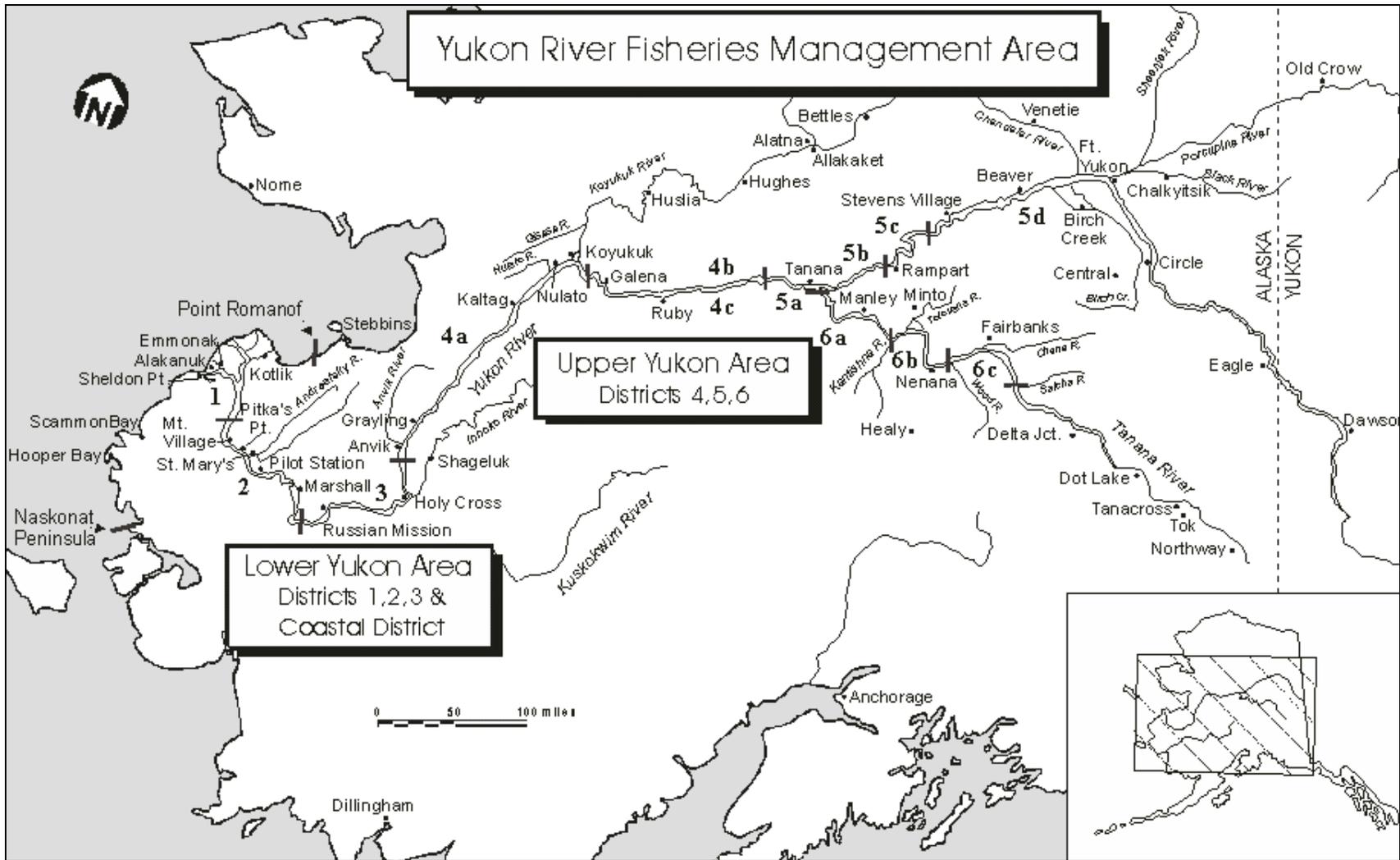


Figure 1.-Commercial management districts and sub-districts in the Yukon and Tanana River drainages.

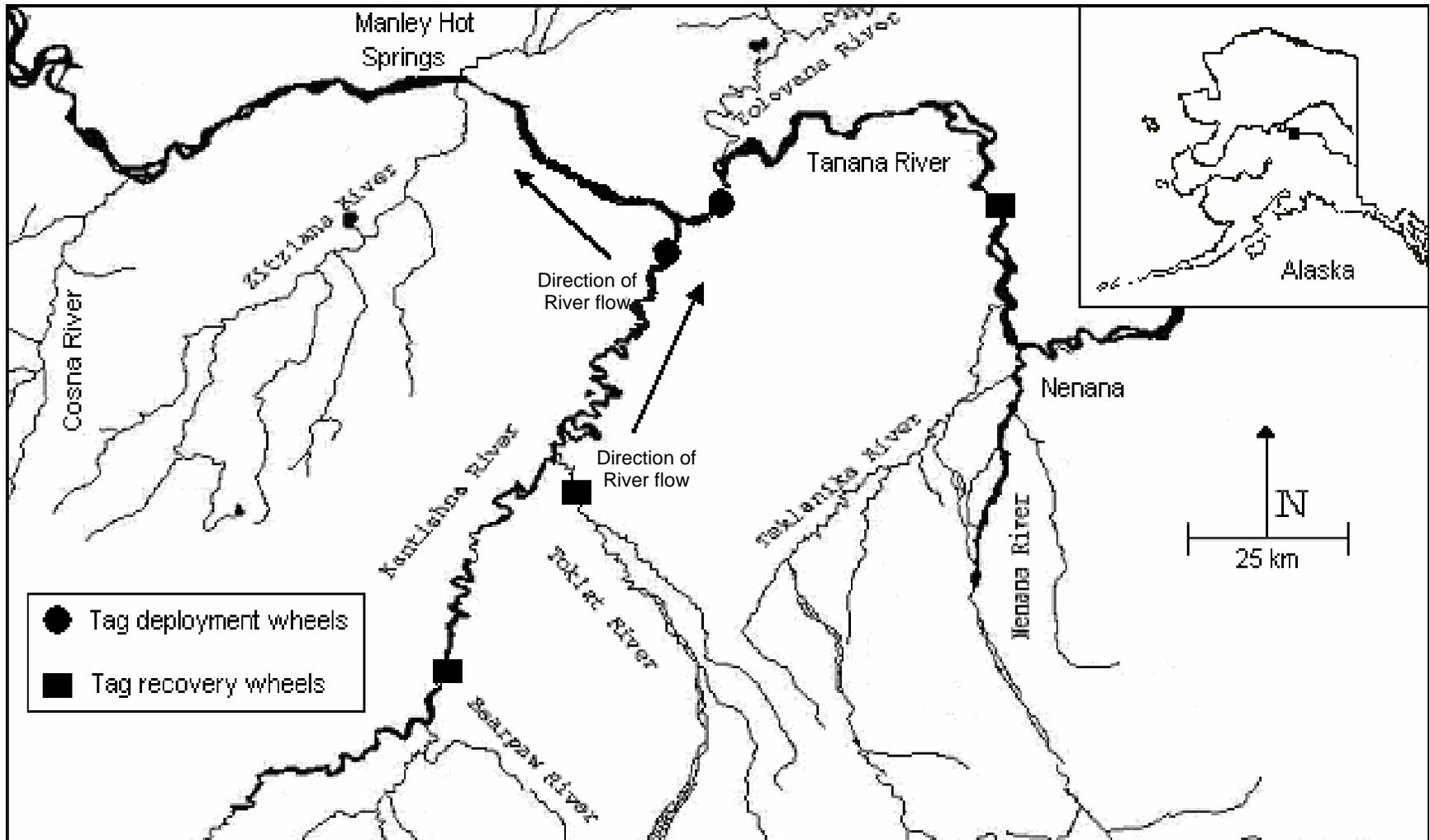
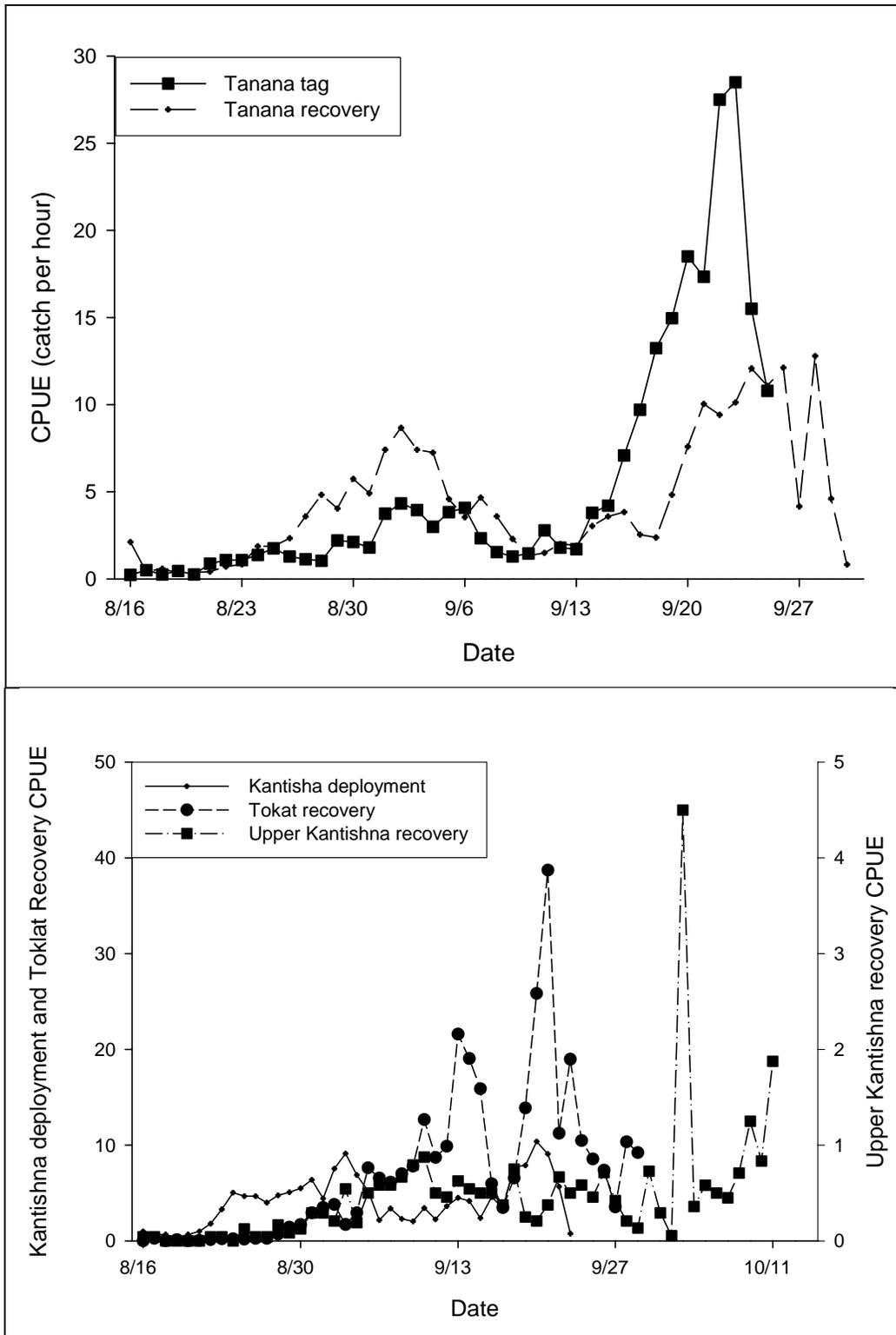
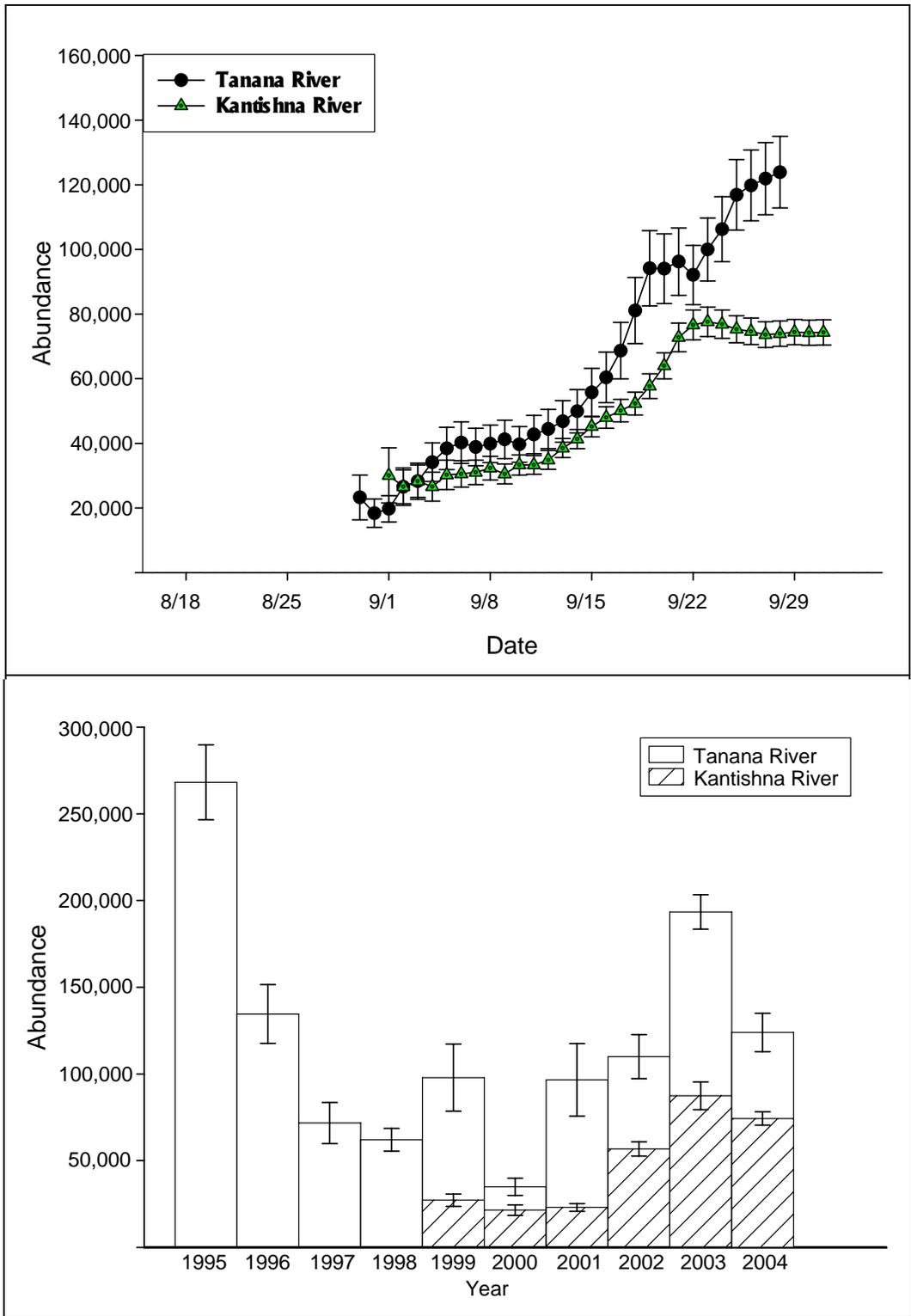


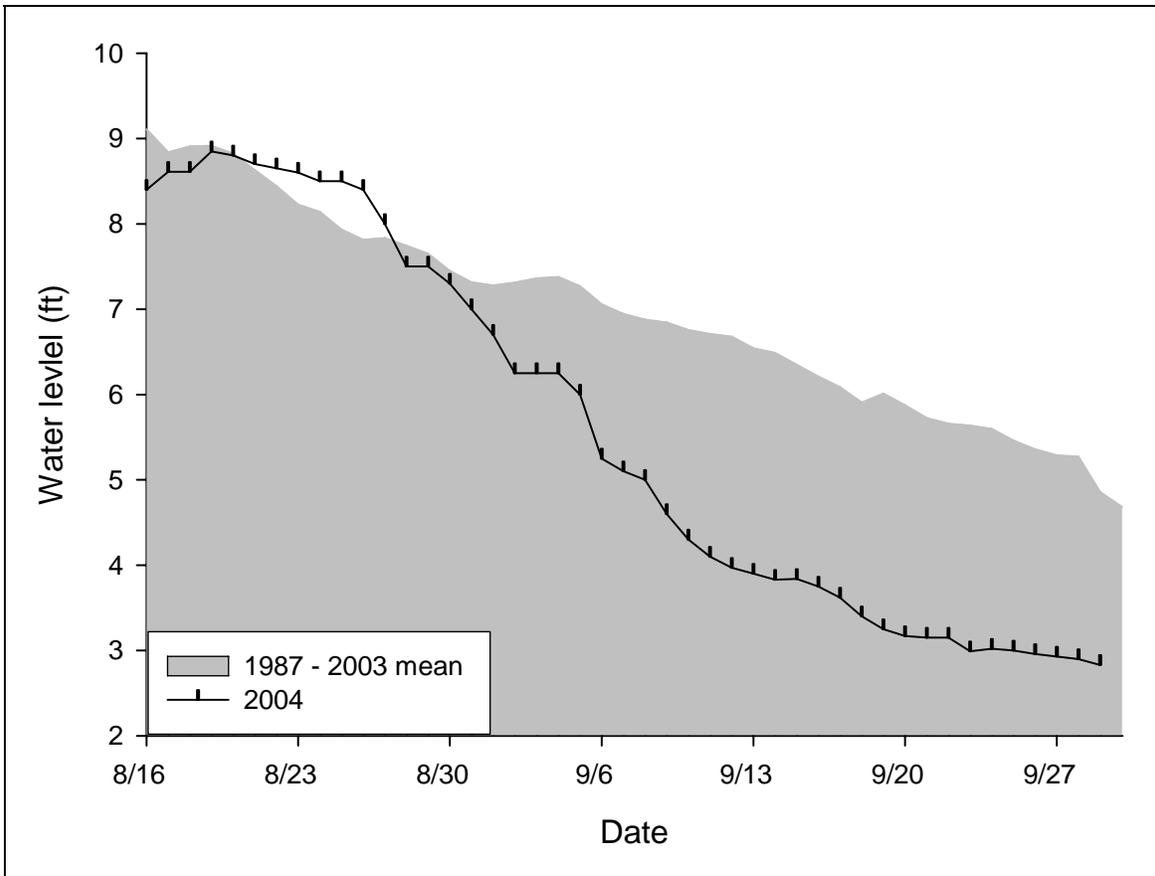
Figure 2.—Location of tag deployment and recovery wheels used in the Tanana and Kantishna River fall chum salmon mark–recapture project.



**Figure 3.**—Daily fall chum salmon CPUE at the Tanana River tagging and recovery fish wheels (top), and CPUE at the Kantishna River tag deployment wheel and recovery fish wheels on the Toklat and upper Kantishna Rivers (bottom), 2004.



**Figure 4.**—Fall chum salmon abundance estimates ( $\pm$ SE for estimates with a CV < 0.30) for the Tanana and Kantishna Rivers, 2004 (top) and abundance estimates for the Tanana River, 1995–2004 and Kantishna River, 1999–2004 (bottom).



**Figure 5.**—Tanana River water levels as measured by a U.S. Geological Survey gauge located near Nenana.



## **APPENDIX A**

**Appendix A1.**—Daily effort and catch of fall chum salmon at the Tanana River tag deployment fish wheel, 2004.

Date	Tagged						Not Tagged					Total					Total	
	Hours Fished	No. Male	No. Female	UNK <sup>a</sup> Sex	Total	Cum	No. Male	No. Female	UNK <sup>a</sup> Sex	Total	Cum	No. Male	No. Female	UNK <sup>a</sup> Sex	Total	Cum	Catch Per Hour	Tagging Rate
8/16	17	1	3	0	4	4	0	0	0	0	0	1	3	0	4	4	0.2	0.00
8/17	24	4	8	0	12	16	0	0	0	0	0	4	8	0	12	16	0.5	0.00
8/18	24	0	5	0	5	21	0	1	0	1	1	0	6	0	6	22	0.3	0.00
8/19	24	5	5	0	10	31	1	0	0	1	2	6	5	0	11	33	0.5	0.00
8/20	24	3	3	0	6	37	0	0	0	0	2	3	3	0	6	39	0.3	4.00
8/21	24	7	14	0	21	58	0	0	0	0	2	7	14	0	21	60	0.9	0.00
8/22	24	11	12	0	23	81	1	2	0	3	5	12	14	0	26	86	1.1	0.88
8/23	24	12	12	0	24	105	0	2	0	2	7	12	14	0	26	112	1.1	0.92
8/24	24	19	13	0	32	137	0	1	0	1	8	19	14	0	33	145	1.4	0.97
8/25	24	17	23	0	40	177	1	1	0	2	10	18	24	0	42	187	1.8	0.95
8/26	24	16	12	0	28	205	3	0	0	3	13	19	12	0	31	218	1.3	0.90
8/27	24	12	13	0	25	230	2	0	0	2	15	14	13	0	27	245	1.1	0.93
8/28	24	14	9	0	23	253	0	2	0	2	17	14	11	0	25	270	1.0	0.92
8/29	24	34	17	0	51	304	1	1	0	2	19	35	18	0	53	323	2.2	0.96
8/30	24	25	24	0	49	353	0	2	0	2	21	25	26	0	51	374	2.1	0.96
8/31	18	19	9	0	28	381	3	1	0	4	25	22	10	0	32	406	1.8	0.88
9/1	24	53	30	0	83	464	3	4	0	7	32	56	34	0	90	496	3.8	0.92
9/2	24	56	42	0	98	562	3	3	0	6	38	59	45	0	104	600	4.3	0.94
9/3	24	54	36	0	90	652	2	3	0	5	43	56	39	0	95	695	4.0	0.95
9/4	24	44	25	0	69	721	1	2	0	3	46	45	27	0	72	767	3.0	0.96
9/5	24	57	28	0	85	806	2	5	0	7	53	59	33	0	92	859	3.8	0.92
9/6	24	72	22	0	94	900	2	2	0	4	57	74	24	0	98	957	4.1	0.96
9/7	24	31	18	0	49	949	3	4	0	7	64	34	22	0	56	1,013	2.3	0.88
9/8	24	19	13	0	32	981	2	3	0	5	69	21	16	0	37	1,050	1.5	0.86
9/9	24	19	8	0	27	1,008	4	0	0	4	73	23	8	0	31	1,081	1.3	0.87
9/10	24	16	14	0	30	1,038	3	2	0	5	78	19	16	0	35	1,116	1.5	0.86
9/11	24	31	29	0	60	1,098	1	6	0	7	85	32	35	0	67	1,183	2.8	0.90
9/12	24	22	18	0	40	1,138	2	1	0	3	88	24	19	0	43	1,226	1.8	0.93
9/13	24	17	18	0	35	1,173	1	5	0	6	94	18	23	0	41	1,267	1.7	0.85
9/14	24	51	34	0	85	1,258	3	3	0	6	100	54	37	0	91	1,358	3.8	0.93

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Appendix A1.–Page 2 of 2.

Date	Tagged						Not Tagged					Total					Total	
	Hours Fished	No. Male	No. Female	UNK <sup>a</sup> Sex	Total	Cum	No. Male	No. Female	UNK <sup>a</sup> Sex	Total	Cum	No. Male	No. Female	UNK <sup>a</sup> Sex	Total	Cum	Catch Per Hour	Tagging Rate
9/15	24	53	41	0	94	1,352	3	3	1	7	107	56	44	1	101	1,459	4.2	0.93
9/16	24	94	69	0	163	1,515	3	4	0	7	114	97	73	0	170	1,629	7.1	0.96
9/17	24	119	104	0	223	1,738	5	5	0	10	124	124	109	0	233	1,862	9.7	0.96
9/18	24	168	134	0	302	2,040	7	9	0	16	140	175	143	0	318	2,180	13.3	0.95
9/19	24	143	195	0	338	2,378	14	7	0	21	161	157	202	0	359	2,539	15.0	0.94
9/20	12	105	103	0	208	2,586	6	8	0	14	175	111	111	0	222	2,761	18.5	0.94
9/21	12	76	75	0	151	2,737	33	24	0	57	232	109	99	0	208	2,969	17.3	0.73
9/22	8	72	75	0	147	2,884	36	37	0	73	305	108	112	0	220	3,189	27.5	0.67
9/23	8	66	83	1	150	3,034	28	50	0	78	383	94	133	1	228	3,417	28.5	0.66
9/24	12	64	86	0	150	3,184	14	22	0	36	419	78	108	0	186	3,603	15.5	0.81
9/25	24	71	79	0	150	3,334	41	68	0	109	528	112	147	0	259	3,862	10.8	0.58
Total		1,772	1,561	1	3,334		234	293	1	528		2,006	1,854	2	3,862			

Note: Does not include recaptures or other data omitted before the final abundance estimate.

<sup>a</sup> Unidentified sex.

**Appendix A2.**—Daily effort and catch of fall chum salmon at the Kantishna River tag deployment fish wheel, 2004.

Date	Tagged						Not Tagged					Total					Total	
	Hours		UNK <sup>a</sup>				Males		UNK <sup>a</sup>			Males		UNK <sup>a</sup>			Catch Per hour	Tagging Rate
	Fished	Males	Females	Sex	Total	Cum	Males	Females	Sex	Total	Cum	Males	Females	Sex	Total	Cum		
8/16	24	18	6	0	24	24	0	0	0	0	0	18	6	0	24	24	1.0	1.00
8/17	24	11	4	0	15	39	0	1	0	1	1	11	5	0	16	40	0.7	0.94
8/18	24	8	8	0	16	55	0	0	0	0	1	8	8	0	16	56	0.7	1.00
8/19	24	4	3	0	7	62	0	0	0	0	1	4	3	0	7	63	0.3	1.00
8/20	24	11	5	0	16	78	0	0	0	0	1	11	5	0	16	79	0.7	1.00
8/21	24	10	13	0	23	101	0	1	0	1	2	10	14	0	24	103	1.0	0.96
8/22	24	28	15	0	43	144	0	0	0	0	2	28	15	0	43	146	1.8	1.00
8/23	24	38	39	0	77	221	1	1	0	2	4	39	40	0	79	225	3.3	0.97
8/24	24	65	50	0	115	336	3	3	0	6	10	68	53	0	121	346	5.0	0.95
8/25	24	67	39	0	106	442	2	4	0	6	16	69	43	0	112	458	4.7	0.95
8/26	24	59	51	0	110	552	0	2	0	2	18	59	53	0	112	570	4.7	0.98
8/27	24	58	31	0	89	641	5	2	0	7	25	63	33	0	96	666	4.0	0.93
8/28	24	89	17	0	106	747	4	4	0	8	33	93	21	0	114	780	4.8	0.93
8/29	24	89	29	0	118	865	3	1	0	4	37	92	30	0	122	902	5.1	0.97
8/30	24	82	40	0	122	987	8	2	0	10	47	90	42	0	132	1,034	5.5	0.92
8/31	24	110	37	0	147	1,134	4	2	0	6	53	114	39	0	153	1,187	6.4	0.96
9/1	24	71	26	0	97	1,231	6	3	0	9	62	77	29	0	106	1,293	4.4	0.92
9/2	24	117	48	0	165	1,396	9	7	0	16	78	126	55	0	181	1,474	7.5	0.91
9/3	24	139	67	0	206	1,602	5	8	0	13	91	144	75	0	219	1,693	9.1	0.94
9/4	24	104	50	0	154	1,756	7	4	0	11	102	111	54	0	165	1,858	6.9	0.93
9/5	24	85	33	0	118	1,874	4	3	0	7	109	89	36	0	125	1,983	5.2	0.94
9/6	24	36	12	0	48	1,922	2	2	0	4	113	38	14	0	52	2,035	2.2	0.92
9/7	24	57	17	0	74	1,996	4	3	0	7	120	61	20	0	81	2,116	3.4	0.91
9/8	24	36	16	0	52	2,048	2	1	0	3	123	38	17	0	55	2,171	2.3	0.95
9/9	24	30	12	0	42	2,090	5	2	0	7	130	35	14	0	49	2,220	2.0	0.86
9/10	24	45	23	0	68	2,158	7	7	0	14	144	52	30	0	82	2,302	3.4	0.83
9/11	24	35	15	0	50	2,208	4	0	0	4	148	39	15	0	54	2,356	2.3	0.93
9/12	24	47	28	1	76	2,284	6	6	0	12	160	53	34	0	87	2,443	3.6	0.87
9/13	24	57	36	0	93	2,377	7	5	2	14	174	64	41	3	108	2,551	4.5	0.86
9/14	24	61	34	0	95	2,472	1	4	0	5	179	62	38	0	100	2,651	4.2	0.95
9/15	24	30	23	0	53	2,525	1	3	0	4	183	31	26	0	57	2,708	2.4	0.93

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Date	Tagged						Not Tagged					Total					Total	
	Hours Fished	Males	Females	Sex	Total	Cum	Males	Females	Sex	Total	Cum	Males	Females	Sex	Total	Cum	Catch Per hour	Tagging Rate
9/16	24	69	31	0	100	2,625	4	6	0	10	193	73	37	0	110	2,818	4.6	0.91
9/17	24	46	31	0	77	2,702	3	2	0	5	198	49	33	0	82	2,900	3.4	0.94
9/18	19	82	52	0	134	2,836	7	6	0	13	211	89	58	0	147	3,047	7.7	0.91
9/19	24	104	60	0	164	3,000	18	7	0	25	236	122	67	0	189	3,236	7.9	0.87
9/20	24	124	83	0	207	3,207	27	15	0	42	278	151	98	0	249	3,485	10.4	0.83
9/21	24	84	66	0	150	3,357	38	30	0	68	346	122	96	0	218	3,703	9.1	0.69
9/22	24	66	57	0	123	3,480	8	5	0	13	359	74	62	0	136	3,839	5.7	0.90
9/23	24	9	5	0	14	3,494	4	0	0	4	363	13	5	0	18	3,857	0.8	0.78
Total		2,281	1,212	1	3,494		209	152	2	363		2,490	1,364	3	3,857			

Note: Does not include recaptures or other data omitted before the final abundance estimate.

<sup>a</sup> Unidentified sex.

**Appendix A3.**—Daily effort and catch of fall chum salmon at the Tanana River recovery fish wheel, 2004.

Date	Tagged						Not Tagged						Total					Total
	Hours Fished	Males	Females	UNK <sup>a</sup>			Males	Females	UNK <sup>a</sup>			Males	Females	UNK <sup>a</sup>			Catch Per Hour	
8/16	11	0	0	0	0	0	15	9	0	24	24	15	9	0	24	24	2.1	
8/17	24	0	0	0	0	0	6	4	0	10	34	6	4	0	10	34	0.4	
8/18	24	0	0	0	0	0	5	9	0	14	48	5	9	0	14	48	0.6	
8/19	24	0	0	0	0	0	7	1	0	8	56	7	1	0	8	56	0.3	
8/20	24	0	0	0	0	0	5	4	0	9	65	5	4	0	9	65	0.4	
8/21	24	0	0	0	0	0	3	7	0	10	75	3	7	0	10	75	0.4	
8/22	24	0	0	0	0	0	8	9	0	17	92	8	9	0	17	92	0.7	
8/23	24	0	0	0	0	0	5	15	0	20	112	5	15	0	20	112	0.8	
8/24	24	0	0	0	0	0	12	33	0	45	157	12	33	0	45	157	1.9	
8/25	24	1	1	0	2	2	19	24	0	43	200	20	25	0	45	202	1.9	
8/26	24	1	0	0	1	3	22	33	0	55	255	23	33	0	56	258	2.3	
8/27	24	1	1	0	2	5	59	25	0	84	339	60	26	0	86	344	3.6	
8/28	24	0	1	0	1	6	57	58	0	115	454	57	59	0	116	460	4.8	
8/29	24	1	0	0	1	7	56	40	0	96	550	57	40	0	97	557	4.0	
8/30	24	1	1	0	2	9	76	58	0	134	684	77	59	0	136	693	5.7	
8/31	24	4	2	0	6	15	67	45	0	112	796	71	47	0	118	811	4.9	
9/1	23	2	4	0	6	21	87	80	0	167	963	89	84	0	173	984	7.4	
9/2	24	0	2	0	2	23	106	100	0	206	1,169	106	102	0	208	1,192	8.7	
9/3	24	5	1	0	6	29	97	75	0	172	1,341	102	76	0	178	1,370	7.4	
9/4	24	1	0	0	1	30	91	82	0	173	1,514	92	82	0	174	1,544	7.3	
9/5	24	2	0	0	2	32	62	46	0	108	1,622	64	46	0	110	1,654	4.6	
9/6	24	2	2	0	4	36	49	32	0	81	1,703	51	34	0	85	1,739	3.5	
9/7	24	4	2	0	6	42	69	37	0	106	1,809	73	39	0	112	1,851	4.7	
9/8	20	0	2	0	2	44	40	30	0	70	1,879	40	32	0	72	1,923	3.6	
9/9	24	1	0	0	1	45	31	23	0	54	1,933	32	23	0	55	1,978	2.3	
9/10	24	3	1	0	4	49	18	10	0	28	1,961	21	11	0	32	2,010	1.3	
9/11	24	0	0	0	0	49	23	13	0	36	1,997	23	13	0	36	2,046	1.5	
9/12	24	1	0	0	1	50	23	24	0	47	2,044	24	24	0	48	2,094	2.0	

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Date	Tagged						Not Tagged					Total					Total
	Hours		UNK <sup>a</sup>						UNK <sup>a</sup>			UNK <sup>a</sup>			Catch		
	Fished	Males	Females	Sex	Total	Cum	Males	Females	Sex	Total	Cum	Males	Females	Sex	Total	Cum	Per Hour
9/13	24	0	0	0	0	50	31	15	0	46	2,090	31	15	0	46	2,140	1.9
9/14	24	2	0	0	2	52	45	26	0	71	2,161	47	26	0	73	2,213	3.0
9/15	24	0	0	0	0	52	40	46	0	86	2,247	40	46	0	86	2,299	3.6
9/16	24	3	1	0	4	56	48	40	0	88	2,335	51	41	0	92	2,391	3.8
9/17	24	1	1	0	2	58	27	32	0	59	2,394	28	33	0	61	2,452	2.5
9/18	24	1	0	0	1	59	28	28	0	56	2,450	29	28	0	57	2,509	2.4
9/19	24	2	1	0	3	62	66	47	0	113	2,563	68	48	0	116	2,625	4.8
9/20	22	7	3	0	10	72	90	67	0	157	2,720	97	70	0	167	2,792	7.6
9/21	24	5	4	0	9	81	105	127	0	232	2,952	110	131	0	241	3,033	10.0
9/22	24	8	7	0	15	96	77	134	0	211	3,163	85	141	0	226	3,259	9.4
9/23	24	3	1	0	4	100	104	135	0	239	3,402	107	136	0	243	3,502	10.1
9/24	24	4	3	0	7	107	140	143	0	283	3,685	144	146	0	290	3,792	12.1
9/25	24	2	0	0	2	109	102	162	0	264	3,949	104	162	0	266	4,058	11.1
9/26	24	1	4	0	5	114	119	167	0	286	4,235	120	171	0	291	4,349	12.1
9/27	18	0	0	0	0	114	24	52	0	76	4,311	24	52	0	76	4,425	4.2
9/28	24	2	4	0	6	120	126	175	0	301	4,612	128	179	0	307	4,732	0.0
9/29	29	1	3	0	4	124	49	82	0	131	4,743	50	85	0	135	4,867	4.6
9/30	13	0	0	0	0	124	1	10	0	11	4,754	1	10	0	11	4,878	0.8
Total		72	52	0	124		2,340	2,414	0	4,754		2,412	2,466	0	4,878		

Note: Does not include recaptures or undetermined tags from video counting.

<sup>a</sup> Unidentified sex.

**Appendix A4.**—Daily effort and catch of fall chum salmon at the Toklat River recovery fish wheels, (both combined), 2004.

Date	Hours Fished	Tagged					Not Tagged					Total					Total Catch
		Males	Females	UNK <sup>a</sup> Sex	Total	Cum	Males	Females	UNK <sup>a</sup> Sex	Total	Cum	Males	Females	UNK <sup>a</sup> Sex	Total	Cum	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	5	1	0	6	6	5	1	0	6	6	0.3
8/18	24	0	0	0	0	0	0	0	0	0	6	0	0	0	0	6	0.0
8/19	24	0	0	0	0	0	1	2	0	3	9	1	2	0	3	9	0.1
8/20	24	0	0	0	0	0	0	0	0	0	9	0	0	0	0	9	0.0
8/21	24	0	0	0	0	0	1	0	0	1	10	1	0	0	1	10	0.0
8/22	24	0	0	0	0	0	2	1	0	3	13	2	1	0	3	13	0.1
8/23	14	0	0	0	0	0	2	1	0	3	16	2	1	0	3	16	0.2
8/24	24	0	0	0	0	0	3	2	0	5	21	3	2	0	5	21	0.2
8/25	24	0	0	0	0	0	3	1	0	4	25	3	1	0	4	25	0.2
8/26	24	0	1	0	1	1	3	2	0	5	30	3	3	0	6	31	0.3
8/27	24	0	0	0	0	1	4	2	0	6	36	4	2	0	6	37	0.3
8/28	24	0	0	0	0	1	13	4	0	17	53	13	4	0	17	54	0.7
8/29	14	1	0	0	1	2	11	8	0	19	72	12	8	0	20	74	1.4
8/30	20	1	0	0	1	3	17	15	0	32	104	18	15	0	33	107	1.7
8/31	24	2	1	0	3	6	42	25	0	67	171	44	26	0	70	177	2.9
9/1	23	2	1	0	3	9	41	36	0	77	248	43	37	0	80	257	3.5
9/2	24	7	1	0	8	17	43	40	0	83	331	50	41	0	91	348	3.8
9/3	24	3	1	0	4	21	20	17	0	37	368	23	18	0	41	389	1.7
9/4	24	5	3	0	8	29	40	22	0	62	430	45	25	0	70	459	2.9
9/5	24	9	0	0	9	38	106	68	0	174	604	115	68	0	183	642	7.6
9/6	22	6	3	0	9	47	85	50	0	135	739	91	53	0	144	786	6.5
9/7	24	8	2	0	10	57	82	55	0	137	876	90	57	0	147	933	6.1
9/8	24	7	3	0	10	67	99	59	0	158	1,034	106	62	0	168	1,101	7.0
9/9	24	16	3	0	19	86	127	41	0	168	1,202	143	44	0	187	1,288	7.8
9/10	24	13	1	0	14	100	185	105	0	290	1,492	198	106	0	304	1,592	12.7
9/11	24	8	5	0	13	113	119	77	0	196	1,688	127	82	0	209	1,801	8.7
9/12	24	11	2	0	13	126	151	73	0	224	1,912	162	75	0	237	2,038	9.9

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Date	Tagged						Not Tagged						Total					Total
	Hours Fished	Males	Females	Sex UNK <sup>a</sup>	Total	Cum	Males	Females	Sex UNK <sup>a</sup>	Total	Cum	Males	Females	Sex UNK <sup>a</sup>	Total	Cum	Catch Per Hour	
9/13	24	16	7	0	23	149	310	185	0	495	2,407	326	192	0	518	2,556	21.6	
9/14	24	12	10	0	22	171	272	163	0	435	2,842	284	173	0	457	3,013	19.0	
9/15	24	5	4	0	9	180	226	146	0	372	3,214	231	150	0	381	3,394	15.9	
9/16	24	2	2	0	4	184	67	72	0	139	3,353	69	74	0	143	3,537	6.0	
9/17	24	1	1	0	2	186	49	32	0	81	3,434	50	33	0	83	3,620	3.5	
9/18	22	5	4	0	9	195	69	66	0	135	3,569	74	70	0	144	3,764	6.5	
9/19	24	7	2	0	9	204	183	141	0	324	3,893	190	143	0	333	4,097	13.9	
9/20	24	19	3	0	22	226	328	270	0	598	4,491	347	273	0	620	4,717	25.8	
9/21	24	16	6	0	22	248	508	399	0	907	5,398	524	405	0	929	5,646	38.7	
9/22	12	2	0	0	2	250	81	49	0	130	5,528	83	49	0	132	5,778	11.2	
9/23	24	15	3	0	18	268	252	185	0	437	5,965	267	188	0	455	6,233	19.0	
9/24	24	5	8	0	13	281	149	89	0	238	6,203	154	97	0	251	6,484	10.5	
9/25	22	11	3	0	14	295	103	71	0	174	6,377	114	74	0	188	6,672	8.5	
9/26	24	7	3	0	10	305	100	67	0	167	6,544	107	70	0	177	6,849	7.4	
9/27	24	2	5	0	7	312	48	30	0	78	6,622	50	35	0	85	6,934	3.5	
9/28	24	6	4	0	10	322	151	87	0	238	6,860	157	91	0	248	7,182	10.3	
9/29	24	3	5	0	8	330	123	90	0	213	7,073	126	95	0	221	7,403	9.2	
Total		233	97	0	330		4,224	2,849	0	7,073		4,457	2,946	0	7,403			

Note: Does not include tagged chum salmon captured more than once.

<sup>a</sup> Unidentified sex.

**Appendix A5.**—Daily effort and catch of fall chum salmon at the Kantishna River recovery fish wheels, (both combined), 2004.

Date	Tagged						Not Tagged					Total					Total
	Hours Fished	Males	Females	UNK <sup>a</sup>		Cum	Males	Females	UNK <sup>a</sup>		Cum	Males	Females	UNK <sup>a</sup>		Cum	Per Hour
Sex	Sex	Sex	Sex	Sex	Sex		Sex	Sex	Sex	Sex		Sex	Sex	Sex	Sex		
8/16	24	0	0	0	0	0	1	0	0	1	1	1	0	0	1	1	0.0
8/17	24	0	0	0	0	0	1	0	0	1	2	1	0	0	1	2	0.0
8/18	22	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0.0
8/19	24	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0.0
8/20	24	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0.0
8/21	24	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0.0
8/22	24	0	0	0	0	0	0	1	0	1	3	0	1	0	1	3	0.0
8/23	24	0	0	0	0	0	1	0	0	1	4	1	0	0	1	4	0.0
8/24	24	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4	0.0
8/25	24	1	0	0	1	1	0	2	0	2	6	1	2	0	3	7	0.1
8/26	24	0	0	0	0	1	0	1	0	1	7	0	1	0	1	8	0.0
8/27	24	0	0	0	0	1	1	0	0	1	8	1	0	0	1	9	0.0
8/28	24	0	0	0	0	1	0	0	0	0	8	0	0	0	0	9	0.0
8/29	24	0	0	0	0	1	1	3	0	4	12	1	3	0	4	13	0.2
8/30	24	0	0	0	0	1	1	1	0	2	14	1	1	0	2	15	0.1
8/31	24	0	0	0	0	1	3	0	0	3	17	3	0	0	3	18	0.1
9/1	24	0	0	0	0	1	5	2	0	7	24	5	2	0	7	25	0.3
9/2	24	0	0	0	0	1	3	4	0	7	31	3	4	0	7	32	0.3
9/3	24	0	0	0	0	1	3	2	0	5	36	3	2	0	5	37	0.2
9/4	21	1	0	0	1	2	7	5	0	12	48	8	5	0	13	50	0.6
9/5	24	0	0	0	0	2	3	1	0	4	52	3	1	0	4	54	0.2
9/6	24	1	0	0	1	3	7	4	0	11	63	8	4	0	12	66	0.5
9/7	24	1	0	0	1	4	9	4	0	13	76	10	4	0	14	80	0.6
9/8	24	0	0	0	0	4	9	5	0	14	90	9	5	0	14	94	0.6
9/9	24	0	0	0	0	4	9	7	0	16	106	9	7	0	16	110	0.7
9/10	24	1	0	0	1	5	15	3	0	18	124	16	3	0	19	129	0.8
9/11	24	4	1	0	5	10	13	4	0	17	141	17	4	0	21	150	0.9
9/12	24	0	0	0	0	10	6	5	0	11	152	6	6	0	12	162	0.5
9/13	24	0	0	0	0	10	6	5	0	11	163	6	5	0	11	173	0.5

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Date	Tagged						Not Tagged					Total					Total
	Hours		UNK <sup>a</sup>				UNK <sup>a</sup>					UNK <sup>a</sup>					Catch
	Fished	Males	Females	Sex	Total	Cum	Males	Females	Sex	Total	Cum	Males	Females	Sex	Total	Cum	Per Hour
9/14	24	0	0	0	0	10	9	6	0	15	178	9	6	0	15	188	0.6
9/15	24	0	0	0	0	10	8	5	0	13	191	8	5	0	13	201	0.5
9/16	24	0	0	0	0	10	9	3	0	12	203	9	3	0	12	213	0.5
9/17	24	0	0	0	0	10	10	2	0	12	215	10	2	0	12	225	0.5
9/18	24	0	0	0	0	10	5	4	0	9	224	5	4	0	9	234	0.4
9/19	24	0	0	0	0	10	9	9	0	18	242	9	9	0	18	252	0.8
9/20	24	0	0	0	0	10	3	3	0	6	248	3	3	0	6	258	0.3
9/21	24	0	0	0	0	10	2	3	0	5	253	2	3	0	5	263	0.2
9/22	24	0	0	0	0	10	7	2	0	9	262	7	2	0	9	272	0.4
9/23	24	0	1	0	1	11	10	6	0	16	278	10	6	0	16	288	0.7
9/24	24	0	0	0	0	11	7	4	0	11	289	7	5	0	12	300	0.5
9/25	24	1	0	0	1	12	7	6	0	13	302	8	6	0	14	314	0.6
9/26	21	1	0	0	1	13	5	5	0	10	312	6	5	0	11	325	0.5
9/27	19	2	0	0	2	15	8	5	0	13	325	10	5	0	15	340	0.8
9/28	24	0	0	0	0	15	4	4	0	8	333	4	4	0	8	348	0.3
9/29	15	0	0	0	0	15	4	1	0	5	338	4	1	0	5	353	0.3
9/30	14	1	0	0	1	16	0	1	0	1	339	1	1	0	2	355	0.1
10/1	24	0	0	0	0	16	8	2	0	10	349	8	2	0	10	365	0.4
10/2	18	0	0	0	0	16	5	2	0	7	356	5	2	0	7	372	0.4
10/3	2	0	0	0	0	16	1	0	0	1	357	1	0	0	1	373	0.5
10/4	20	1	0	0	1	17	6	2	0	8	365	7	2	0	9	382	0.5
10/5	16	0	0	0	0	17	6	1	0	7	372	6	1	0	7	389	0.5
10/6	20	0	1	0	1	18	5	4	0	9	381	5	4	0	9	398	0.5
10/7	20	0	0	0	0	18	2	7	0	9	390	2	8	0	10	408	0.5
10/8	24	0	0	0	0	18	4	5	0	9	399	4	5	0	9	417	0.4
10/9	24	0	0	0	0	18	8	9	0	17	416	8	9	0	17	434	0.7
10/10	24	0	0	0	0	18	15	15	0	30	446	15	15	0	30	464	1.3
10/11	24	0	1	0	1	19	8	12	0	20	466	8	12	0	20	484	0.8
10/12	24	0	0	0	0	19	16	28	0	44	510	16	29	0	45	529	1.9
10/13	12	0	0	0	0	19	1	7	0	8	518	1	7	0	8	537	0.7
<b>Total</b>		15	4	0	19		296	222	0	518		311	226	0	537		

<sup>a</sup> Unidentified sex.

**Appendix A6.**—Daily effort and catch of coho salmon at the Tanana/Kantishna River mark–recapture project fish wheels, 2004.

Date	Tanana Tag Deployment			Tanana Tag Recovery			Kantishna Tag Deployment			Toklat Tag Recovery			Kantishna Tag Recovery		
	Catch	Cum	Catch Per Hour	Catch	Cum	Catch Per Hour	Catch	Cum	Catch Per Hour	Catch	Cum	Catch Per Hour	Catch	Cum	Catch Per Hour
8/16	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
8/17	0	0	0.0	0	0	0.0	1	1	0.0	0	0	0.0	0	0	0.0
8/18	0	0	0.0	0	0	0.0	0	1	0.0	0	0	0.0	0	0	0.0
8/19	0	0	0.0	0	0	0.0	0	1	0.0	0	0	0.0	0	0	0.0
8/20	0	0	0.0	0	0	0.0	0	1	0.0	0	0	0.0	0	0	0.0
8/21	0	0	0.0	0	0	0.0	0	1	0.0	0	0	0.0	0	0	0.0
8/22	0	0	0.0	0	0	0.0	1	2	0.0	0	0	0.0	0	0	0.0
8/23	0	0	0.0	0	0	0.0	2	4	0.1	0	0	0.0	0	0	0.0
8/24	0	0	0.0	0	0	0.0	0	4	0.0	0	0	0.0	0	0	0.0
8/25	0	0	0.0	1	1	0.0	0	4	0.0	0	0	0.0	0	0	0.0
8/26	0	0	0.0	5	6	0.2	1	5	0.0	0	0	0.0	0	0	0.0
8/27	0	0	0.0	7	13	0.3	1	6	0.0	1	1	0.0	0	0	0.0
8/28	0	0	0.0	15	28	0.6	3	9	0.1	0	1	0.0	0	0	0.0
8/29	2	2	0.1	31	59	1.3	2	11	0.1	0	1	0.0	0	0	0.0
8/30	1	3	0.0	48	107	2.0	2	13	0.1	0	1	0.0	0	0	0.0
8/31	0	3	0.0	60	167	2.5	0	13	0.0	1	2	0.0	0	0	0.0
9/1	3	6	0.1	116	283	5.0	0	13	0.0	3	5	0.1	0	0	0.0
9/2	3	9	0.1	141	424	5.9	2	15	0.1	2	7	0.1	0	0	0.0
9/3	6	15	0.3	147	571	6.1	1	16	0.0	1	8	0.0	0	0	0.0
9/4	11	26	0.5	188	759	7.8	2	18	0.1	2	10	0.1	1	1	0.0
9/5	15	41	0.6	180	939	7.5	3	21	0.1	7	17	0.3	3	4	0.0
9/6	26	67	1.1	320	1,259	13.3	0	21	0.0	11	28	0.5	2	6	0.0
9/7	17	84	0.7	345	1,604	14.4	2	23	0.1	6	34	0.3	4	10	0.0
9/8	17	101	0.7	227	1,831	11.4	2	25	0.1	6	40	0.3	6	16	0.0
9/9	29	130	1.2	266	2,097	11.1	5	30	0.2	16	56	0.7	10	26	0.0
9/10	33	163	1.4	220	2,317	9.2	2	32	0.1	9	65	0.4	12	38	0.0
9/11	55	218	2.3	202	2,519	8.4	7	39	0.3	11	76	0.5	2	40	0.0
9/12	44	262	1.8	200	2,719	8.3	8	47	0.3	9	85	0.4	7	47	0.0
9/13	55	317	2.3	241	2,960	10.0	11	58	0.5	17	102	0.7	9	56	0.0

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Date	Tanana Tag Deployment			Tanana Tag Recovery			Kantishna Tag Deployment			Toklat Tag Recovery			Kantishna Tag Recovery		
	Catch	Cum	Per Hour	Catch	Cum	Per Hour	Catch	Cum	Per Hour	Catch	Cum	Per Hour	Catch	Cum	Per Hour
9/14	72	389	3.0	231	3,191	9.6	5	63	0.2	14	116	0.6	8	64	0.0
9/15	72	461	3.0	325	3,516	13.5	5	68	0.2	13	129	0.5	5	69	0.0
9/16	64	525	2.7	423	3,939	17.6	6	74	0.3	5	134	0.2	11	80	0.0
9/17	78	603	3.3	364	4,303	15.2	13	87	0.5	4	138	0.2	6	86	0.0
9/18	72	675	3.0	418	4,721	17.4	17	104	0.9	8	146	0.4	7	93	0.0
9/19	54	729	2.3	626	5,347	26.1	17	121	0.7	14	160	0.6	10	103	0.0
9/20	36	765	3.0	988	6,335	44.9	17	138	0.7	35	195	1.5	12	115	0.0
9/21	31	796	2.6	1,163	7,498	48.5	25	163	1.0	29	224	1.2	10	125	0.0
9/22	42	838	5.3	1,107	8,605	46.1	20	183	0.8	6	230	0.5	12	137	0.0
9/23	23	861	2.9	1,614	10,219	67.3	4	187	0.2	29	259	1.2	11	148	0.0
9/24	19	880	1.6	1,759	11,978	73.3				18	277	0.8	16	164	0.0
9/25	38	918	1.6	1,653	13,631	68.9				22	299	1.0	15	179	0.0
9/26				1,528	15,159	63.7				21	320	0.9	21	200	0.0
9/27				537	15,696	29.4				12	332	0.5	5	205	0.0
9/28				1,994	17,690	83.1				20	352	0.8	18	223	0.0
9/29				997	18,687	34.1				11	363	0.5	14	237	0.0
9/30				47	18,734	3.5							3	240	0.0
10/1													9	249	0.0
10/2													9	258	0.0
10/3													0	258	0.0
10/4													9	267	0.0
10/5													3	270	0.0
10/6													12	282	0.0
10/7													20	302	0.0
10/8													22	324	0.0
10/9													20	344	0.0
10/10													39	383	0.0
10/11													12	395	0.0
10/12													31	426	0.0
10/13													5	431	
<b>Total</b>	<b>918</b>			<b>18,734</b>			<b>187</b>			<b>363</b>			<b>431</b>		

Note: Days with no data indicate days when the project was not operational.

**Appendix A7.**—Water temperatures at the Tanana/Kantishna River mark-recapture project fish wheels, 2003–2004.

