Fishery Data Series No. 11-44

Chinook Salmon Escapement in the Gulkana River, 2009

by

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and

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October 2011

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

From 31 May through 11 August 2009 systematic counts of migrating Chinook salmon *Oncorhynchus tshawytscha* were conducted 20 min of every hour at an established counting tower site on the Gulkana River. Estimated escapement derived from these counts was 2,720 (SE=179). Escapement estimates since the project began in 2002 have ranged from 2,718-6,355 and the 2009 estimate is the second lowest on record. Conditions were suitable for counting during 95% of the scheduled counting periods. During the periods of poor visibility, escapement was interpolated; however, interpolated escapement represented less than 0.7% of the total escapement estimate. The estimated daily period of peak migration was between 2300 and 0800 and accounted for 84% of the total escapement of Chinook salmon in 2009. Fifty percent of the estimated escapement migrated upstream of the counting tower by 8 July and 75% by 11 July. Counts of migrating sockeye salmon *Oncorhynchus nerka* were also recorded. These counts represented a portion of the total run because the sockeye salmon migration continues after the Chinook salmon run is complete. The estimated minimum escapement of sockeye salmon was 13,088 (SE=639).

Key words: Chinook salmon, *Oncorhynchus tshawytscha,* sockeye salmon, *O. nerka*, Copper River, Gulkana River, counting tower, spawning escapement.

INTRODUCTION

The Gulkana River, a tributary of the Copper River, originates in the Alaska Range and its watershed drains approximately 5,543 km^2 in Southcentral Alaska. From its headwaters upstream of Summit Lake, the Gulkana River flows for approximately 161 km south to its confluence with the Copper River. The mainstem river is fed by the East Fork, Middle Fork, and West Fork Gulkana rivers (Figure 1). The section of the Gulkana River upstream of Sourdough Landing (Figure 1) has been designated by the U.S. Congress as a "wild river" since 1968, which makes it part of the National Wild and Scenic Rivers System. The Bureau of Land Management (BLM) manages the adjacent lands along both banks within this area and has the authority to limit the number of trips per year or number of people per trip. To date, no permit system is in place; however, increased use by float and motor boat operators coupled with diminishing Chinook salmon escapements over the last few years led stakeholders to submit proposals to the Alaska Board of Fish (BOF) to limit motor boat use. These proposals have not been addressed because they fall outside the purview of the BOF, but the issue still exists and BLM has the authority to limit entry into the area.

The Gulkana River supports the largest Chinook salmon *Oncorhynchus tshawytscha* sport fishery in the Copper River drainage and the Upper Copper-Upper Susitna Management Area (UCUSMA) (Jennings et al. 2009a-b; 2010). Annual sport harvest has increased substantially from 641 Chinook salmon in 1978 (Mills 1979) to an average over the last 10 years (1999–2008) of 2,944 Chinook salmon (Somerville and Perry-Plake 2010). As with the sport harvest of Chinook salmon, angler effort has also increased since the late 1970s (Somerville and Perry-Plake 2010). In addition to the inriver sport fishery, the Gulkana River Chinook salmon stock is subject to harvest in commercial and subsistence fisheries located near the mouth of the Copper River and subsistence and personal-use fisheries located in the mainstem of the Copper River. There are no stock specific estimates of harvest available for these fisheries, but similar to the Gulkana River sport harvest, these mixed stock fisheries have also shown an overall increase in harvest over the past 30 years (Hollowell et al. 2008).

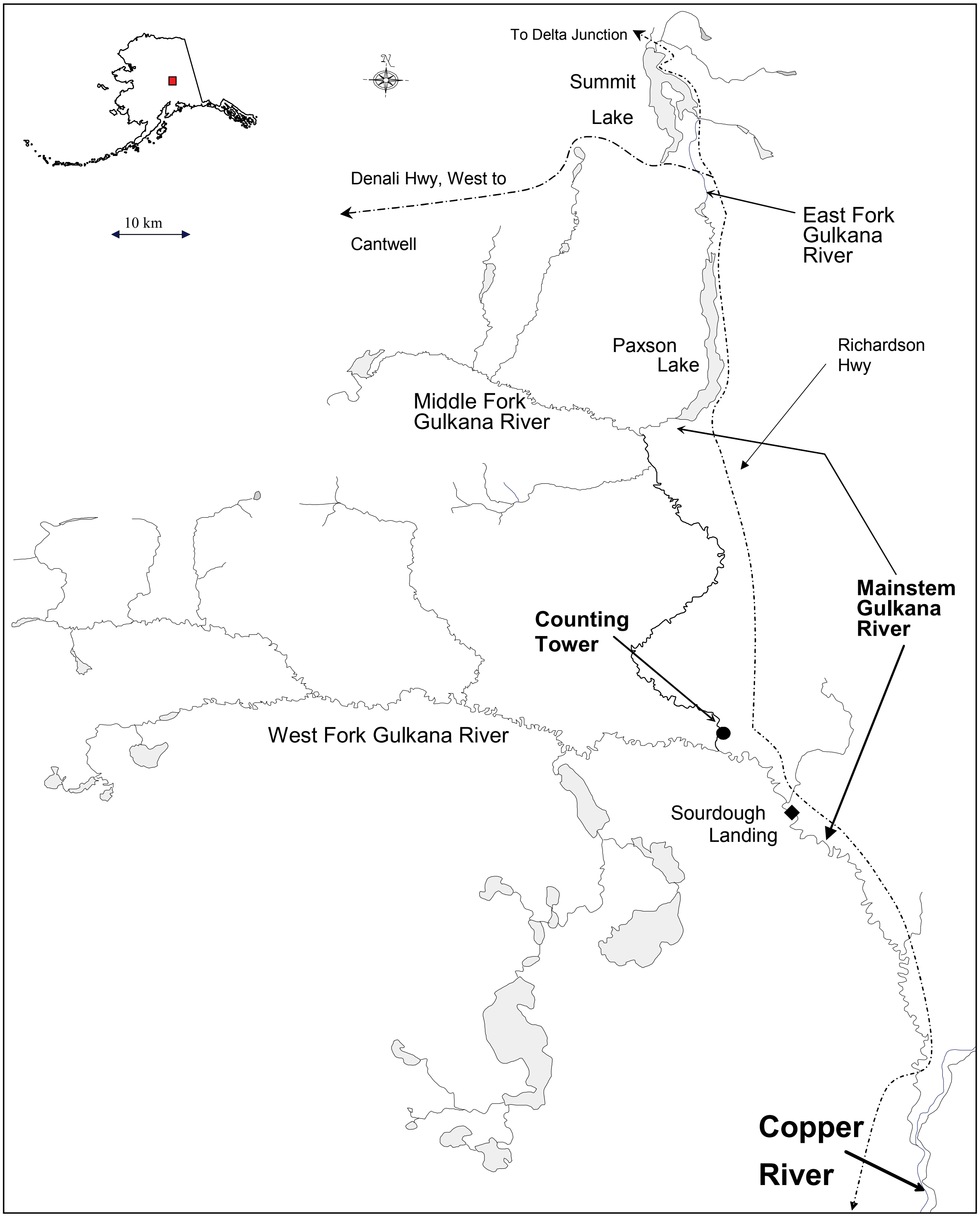

Figure 1.-The Gulkana River drainage and location of the counting tower.

Copper River Chinook salmon are managed under four management plans[1] with the primary plan being the *Copper River King Salmon Management Plan* (5 AAC 24.361, 2006). This plan guides management of the commercial and sport fisheries and mandates the Alaska Department of Fish and Game (ADF&G) to manage these fisheries to achieve a drainagewide sustainable escapement goal (SEG) of 24,000 or more Chinook salmon. Inriver abundance is estimated annually using mark-recapture techniques in the Lower Copper River (prior to any spawning tributaries) and inriver harvest is subtracted postseason to obtain an estimate of drainagewide escapement. While this SEG facilitates management of the mixed stock commercial, subsistence, personal-use, and sport fisheries, there is no tributary-specific escapement goals.

Since 1966, escapement of Chinook salmon in the Gulkana River was monitored annually by aerial survey in an attempt to establish an index of escapement. An accurate or useful index needs to be a consistent measure of the annual spawning stock. The aerial surveys provided general distribution data for a particular season, and a means to quantify anecdotal information from sport, subsistence, personal-use, and commercial fisherman regarding run timing and strength. However, the proportion of the estimated escapement observed during each annual aerial survey varied considerably from year to year (Perry-Plake and Antonovich 2009). These differences demonstrate that the aerial survey counts do not provide an accurate index of escapement.

In 2002, a multi-year cooperative project was initiated between ADF&G and BLM to monitor Chinook salmon escapement on the Gulkana River using counting tower techniques. The Gulkana River was selected because this stock on average makes up a significant percentage (~ 20%) of the total Copper River escapement (Savereide 2005), it supports the largest sport fishery in the Copper River drainage, fishing pressure has increased in recent years, the aerial survey is not an appropriate index of escapement, and it is the only tributary in the Copper River drainage supporting a substantial Chinook salmon sport fishery that is not glacially occluded. Managers need inseason information on run size and an escapement goal to better manage the sport fishery and ensure escapements are adequate enough to sustain production. The long-term goal of this project is to collect information on Chinook salmon escapement to establish an escapement goal and aid in developing inseason management guidelines (i.e., whether to close or limit the fishery) for the Gulkana River sport fishery.

OBJECTIVES

The objective of this project for 2009 was to estimate the escapement of Chinook salmon upstream of an established counting tower site on the mainstem Gulkana River.

In addition to the above objective, concurrent project tasks were to:

1. describe inriver run timing for Chinook and sockeye salmon in the Gulkana River; and,
2. enumerate sockeye salmon escapement at the tower site during the period of tower operation.

The sockeye salmon run precedes the Chinook salmon run and continues after the tower counts have ceased, and the estimate should be considered as a minimum escapement estimate. The estimates are presented here for contractual and research purposes.

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[1] The four management plans that guide management of Copper River Chinook salmon are: *Copper River Subsistence Fisheries Management Plans* (5 AAC 01.647, 1993), *Copper River District Salmon Management Plan* (5 AAC 24.360, 2006), *Copper River King Salmon Management Plan* (5 AAC 24.361, 2006), and *Copper River Personal Use Dip Net Salmon Fishery Management Plan* (5 AAC 77.591, 2003).

METHODS

STUDY AREA

The counting tower site is located approximately 2.5 km upstream from the confluence of the West Fork and the mainstem river (Figure 1). Anecdotal information from sport fishers and guides and the results from previous aerial surveys and radiotelemetry studies (Savereide 2005) indicated that the majority (> 80%) of Chinook salmon spawning in the Gulkana River drainage occurs upstream of the selected tower site. This location is also not affected by the poor visibility created in the mainstem river from the often turbid input of the West Fork. A small island in the middle of the river divides the river into two 30 m channels (Figure 2). Maximum depth in both channels (east and west) ranges from 1 to 1.5 m during normal summer flow, and the flow is fairly even from bank to bank. The bottom composition is cobble, gravel, and sand/silt, with relatively few boulders.

Tower Construction and Maintenance

To clearly view each channel, two scaffolding platforms were installed to provide a stable area approximately 4 m above the water to count migrating salmon (Figure 2). The platforms supported dome-shaped pole frames that were covered on the top and three sides with camouflage-print tarps to prevent the observer's shadow from being thrown on the water and to provide the observer protection from wind and rain. To make passing fish more visible a continuous band of white vinyl panels, approximately 2 m wide, was anchored to the river bottom across each river channel. There was also a 2 to 3 m section of picket weir placed near the base of each platform to ensure no fish were able to pass undetected directly beneath the towers (Figure 2). For both platforms, the opposite riverbank had a gradual slope and the vinyl panels ran smoothly against the substrate and up the bank beyond water level (Figure 2). To ensure optimal viewing conditions, any debris, silt, gravel, and/or fish carcasses were cleaned from the panels between scheduled counts as needed. During periods of low ambient light, floodlights were used to illuminate the panels across each channel. Exterior-grade floodlights were located above the counting platform and across each channel to provide an even level of illumination. Once the lights were turned on, they remained on between counts to maintain a consistent level of light. This was done to reduce any associated affect that lighting changes may have had on salmon migration.

STUDY DESIGN

The escapement of Chinook salmon migrating upstream of the counting tower in the mainstem Gulkana River was estimated by first visually counting fish as they passed over the vinyl panels, and then applying condition-specific expansions (scenarios discussed below) to generate daily estimates of escapement. To ensure the entire run was assessed, the crew monitored the river during tower construction in late May and continued throughout the summer until five continuous days with no net daily upstream migration of Chinook salmon was observed, typically in mid-August. Ten-minute counts were conducted for each river channel every hour of every day throughout the Chinook salmon run. Daily estimates of escapement were a direct expansion from the 10-min counts from each channel. The 10-min counts were considered a systematic sample and the escapement estimate was stratified by day. Hourly count data were combined across channels before calculating estimates in order to account for the covariance between channel-specific hourly counts.

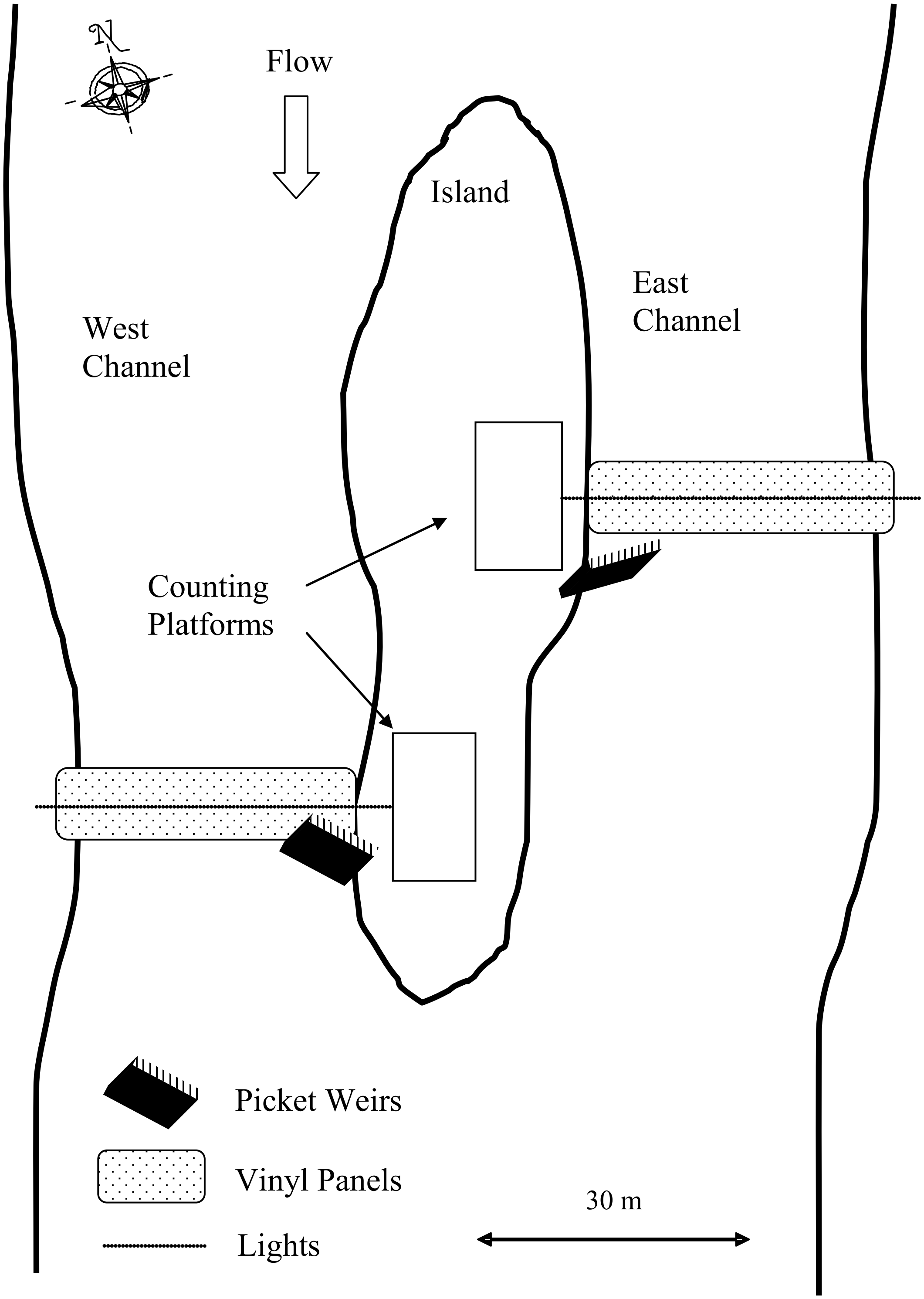

Figure 2.–An illustration of the counting tower site.

Six technicians were assigned to enumerate the salmon escapement in the Gulkana River in 2009. Each day was divided into three 8.0-h shifts. Shift I began at 0600 and ended at 1359; Shift II began at 1400 and ended at 2159; Shift III began at 2200 and ended at 0559. The protocol for each scheduled hourly count started on the west channel between the top of the hour and 10 minutes past (Figure 2). The 10-min count on the east channel immediately followed the count on the west channel. Numbers of Chinook and sockeye salmon counted during each 10-min count were tallied and recorded on data forms at the end of each count period, for each channel. Separate data forms were maintained for each day and channel. Migration both upstream and downstream was recorded to provide a net upstream escapement during each 10-min count, for each channel of the river. Migration was defined as movement across the full width of the panels.

Data recorded for each hour included numbers of Chinook and sockeye salmon counted in each river channel, water level (relative level on a staff gauge in the west channel), and water clarity. Observers evaluated water clarity on a scale of 1 (excellent) to 5 (unobservable) (Table 1).

Air and water temperature were recorded at the beginning of each 8-h shift. Conditions that might affect the counts (e.g., sudden heavy rain, several hours of non-stop rain, or strong winds disturbing the water surface), and general observations including grayling and smolt activity were also recorded. The field data forms were turned in weekly and the recorded data was entered into Excel™ spreadsheets for data analysis.

Data Analysis

Estimates of Chinook salmon escapement were stratified by day and summed across all days of counting to estimate total escapement. An analysis of data collected during 2002 revealed that Chinook salmon had a distinct diel migratory pattern where the majority of salmon migration takes place in the evening and early morning hours (Taras and Sarafin 2005). To account for this pattern of migration, a "count day" was defined as 1600 to 1559. Taras and Sarafin (2005) also demonstrated that interpolating for undercounts (a rank of 4.5 or 5) using this diel migratory pattern yielded more accurate estimates of escapement than using a direct expansion of the successful counts within 8-h shifts for that day. Therefore, daily escapement and its variance were estimated using one of three scenarios depending on water clarity conditions (Table 1):

1. when water clarity was *excellent* to *poor* (rank 1–4) for all scheduled counts during a day, actual counts were expanded to estimate daily escapement (equations 1–3);
2. when a *small portion* (defined below) of a day's counts were conducted under *very poor* or *unobservable* water clarity (rank 4.5 or 5), daily escapement was estimated using a combination of expanded actual (equations 1–3) and interpolated (equations 1–4) counts;

   and,
3. when *most or all* of a day's counts were conducted under *very poor* or *unobservable* water clarity (rank 4.5 or 5), escapement for the entire day was interpolated (equations 5-6).

Table 1.–Water clarity classification scheme.

Rank	Description	Salmon Viewing	Water Condition
1	Excellent	All passing salmon are observable	Virtually no turbidity or glare, "drinking water" clarity; all routes of migration observable
2	Good	All passing salmon are observable	Minimal to very low levels of turbidity or glare; all routes of migration observable
3	Fair	All passing salmon are observable	Low to moderate levels of turbidity or glare; all routes of migration observable
4	Poor	Possible, but not likely, that some passing salmon may be missed	Moderate to high levels of turbidity or glare; a few likely routes of migration are partially obscured
4.5[a]	Very poor	Likely that some passing salmon may be missed	Moderate to high levels of turbidity or glare; some, to many, likely routes of migration are obscured
5	Unobservable	Passing fish are not observable	High level of turbidity or glare; ALL routes of migration obscured

[a] 4.5 has been inserted beginning in 2007 to emphasize that further delineation was necessary for defining "poor" visibility. This allows continuity with the scale used in previous years rather than change the scale to 1-6.

Scenario #1: For days when all counts were conducted under excellent to poor conditions, daily escapement, $\hat{N}_d$, was calculated by expanding counts within a shift for day *d* (Cochran 1977):

$$\hat{N}_d = \frac{M_d}{m_d}\sum_{j=1}^{m_d} y_{dj} \quad . \qquad (1)$$

The period sampling was systematic because the sample (or primary unit) had secondary units taken within every hour in a day (i.e., systematically throughout the day). As provided in Wolter (1985), the variance associated with periods was calculated as:

$$s_d^2 = \frac{1}{2(m_d - 1)}\sum_{j=2}^{m_d}\left(y_{dj} - y_{d(j-1)}\right)^2 \quad . \qquad (2)$$

The variance for the expanded daily escapement was estimated as (Cochran 1977):

$$\hat{V}\left(\hat{N}_d\right) = \left(1 - \frac{m_d}{M_d}\right) M_d^2 \frac{s_d^2}{m_d} \quad . \qquad (3)$$

where:

d = day;

j = paired 10-min counting period (a paired 10-min counting period consists of the two 10-min counts, one per channel, during a given hour);

y = observed period count (both channels combined);

m = number of paired 10-min counting periods sampled; and,

M = total number of possible paired 10-min counting periods.

Scenario #2: For periods with very poor or unobservable counts the number of fish observed, y_{dj}, was estimated using known counts for that day and the estimated diel pattern. The diel pattern equals the cumulative proportion of the average daily counts of Chinook salmon by hour of day over the course of the run. A period of peak migration, defined as the shortest, continuous period of time that accounted for 80% of the seasonal migration of Chinook salmon, was defined for each year. To be reliable, expansions based on the diel pattern must have at least some counts that were successfully completed during the period of peak migration. The following criteria were established to ensure reliability: if counts were conducted successfully for a portion of the day that represents 25% or more of the expected escapement for that day (as defined by the diel relationship), and if at least 25% of the periods during peak migration were successfully counted, then the channel-specific interpolated count was calculated as the product of the sum of successful counts for the day and the ratio of the expected daily escapement not represented to the daily escapement that was represented, or;

$$y_{dc,\text{interp}} = y_{dc,\text{actual}} \times \frac{1 - p_{edp}}{p_{edp}} \tag{4}$$

where:

$y_{dc,\text{interp}}$ = interpolated sum of counts for missing (i.e. very poor or unobservable) 10-min periods by channel;

$y_{dc,\text{actual}}$ = daily sum of successful 10-min counts by channel; and,

p_{edp} = proportion of expected daily escapement successfully counted.

The interpolated count was then allocated among missed 10-min counting periods based on the diel pattern for the current year. For example, if four hours of counting were missed (four 10-min counts) and the interpolated count for that period was 10 Chinook salmon, those 10 fish would be allocated to each of the four missed 10-min periods in proportions defined by the diel pattern. Daily escapement and variance estimates for scenario 2 were calculated using a combination of actual and interpolated counts because simply treating interpolated counts as "known" results would underestimate the daily variance. Therefore, daily variance estimates were inflated by decreasing the number of 10-min counting periods, m_d, sampled each day by the proportion of the expected daily escapement successfully counted on that day. For example, if 85% of the expected escapement was successfully counted on a given day, then the adjusted $m_{d,}$ = 0.85 x m_d = 0.85 x 24. For the channel-combined counts the proportion successfully counted was the channel-specific proportions weighted by the proportion of the overall escapement passing each channel. Although inflating the variance calculations guards against a negative bias in estimation of the total variance, this approach could still lead to unacceptably large biases if days with diel interpolations contribute substantially to the overall variance. Therefore, daily variances are estimated using this approach as long as interpolations using the diel pattern account for a small proportion of the total variance.

Scenario #3:

If counts were conducted for a portion of the day that represented less than 25% of the expected escapement for that day, or if less than 25% of the periods during peak migration were counted successfully, the procedure described below for missed days was used to estimate escapement for the entire day (i.e., the successful counts conducted that day will not be used for estimation). When counts for *k* consecutive days were suspected biased due to adverse viewing conditions (water clarity = 4.5–5), the moving average estimate for the missing day *i* was calculated as:

$$\hat{N}_i = \frac{\sum_{j=i-k}^{i+k} I(\text{counting was successfully conducted on day } j)\hat{N}_j}{\sum_{j=i-k}^{i+k} I(\text{counting was successfully conducted on day } j)} \qquad (5)$$

where:

$$I(\cdot) = \begin{cases} 1 & \text{when the condition is true} \\ 0 & \text{otherwise} \end{cases} \qquad (6)$$

is an indicator function.

The interpolated values were used as the point estimates for the daily counts and the daily variation for undercounted days was the maximum variance of the *k* days before and the k days after the undercounted day *i*.

Total escapement upstream of the counting tower and its associated variance incorporated all three daily escapement estimation scenarios, and was estimated as (Cochran 1977):

$$\hat{N}_{PT} = \sum_{d=1}^{D} \hat{N}_d \text{ ; and,} \qquad (7)$$

$$\hat{V}\left(\hat{N}_{PT}\right) = \sum_{d=1}^{D} \hat{V}(\hat{N}_d) \qquad (8)$$

where:

D = total number of possible days.

PARTIAL ESCAPEMENT OF SOCKEYE SALMON ABOVE THE COUNTING TOWER

The number of sockeye salmon migrating past the counting tower was estimated using the methods described for estimating Chinook salmon escapement. Because the sockeye salmon run was in progress when counting began, and was known to continue after counting ceased, the escapement estimate reflects an unknown portion of the total run and should be considered a minimum estimate of escapement.

RESULTS

CHINOOK SALMON

The estimated Chinook salmon escapement upstream of the counting tower was 2,720 fish (SE = 179) in 2009 (Table 2; Figure 3). Less than 6% of the scheduled counting periods in 2009 (14-18 June; 21 and 28 June) were conducted during visibility conditions under which undercounting (a rank of 4.5 or 5) may have occurred (Appendix B). Therefore, daily escapement for those days was estimated using scenario 2 (21 and 28 June) or scenario 3 (14-18 June). All remaining days were counted under favorable water conditions (a rank of 1-4) and scenario 1 was used to estimate daily escapement.

In 2009, the estimated diel migratory pattern encompassed 84% of the daily migration from 2300 through 0800 (Figure 4). The first Chinook salmon were observed on 11 June and counting continued through 11 August 2009 (Figure 5; Appendix B); the run was considered complete on 6 August 2009. The run timing pattern observed past the counting tower in 2009 was later than the average over all years (Figure 5).

SOCKEYE SALMON

The sockeye salmon escapement upstream of the counting tower from 29 May through 11 August 2009 was estimated at 13,088 fish (SE=639) (Figure 6). This estimate includes interpolations for counts conducted under unfavorable water conditions (a rank of 4.5 or 5) (Appendix C). The estimate is considered a minimum estimate of escapement because counting started after the run began and before the run ceased.

Table 2.–Annual escapement, catch, and harvest estimates of Chinook salmon in the Gulkana River, 2002–2009.

Year	Escapement[a]	SE	Catch[b]	Harvest[b]
2002	6,355	318	12,316	2,983
2003	4,890	270	13,356	3,707
2004	4,734	302	7,368	1,890
2005	2,718	174	6,584	2,573
2006	4,846	279	7,673	2,147
2007	4,422	273	8,635	3,275
2008	3,678	258	5,984	2,324
2009	2,720	179	2,085	516

[a] Estimates from counting tower.

[b] Estimates from Statewide Harvest Survey.

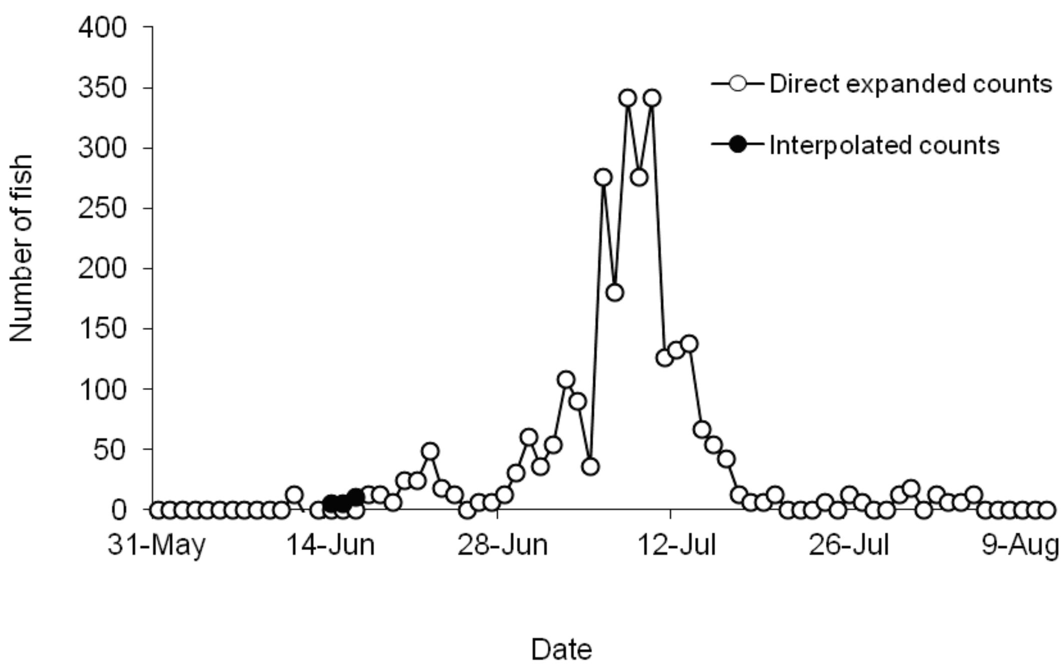

Figure 3.–Estimated daily escapement of Chinook salmon migrating past the Gulkana River counting tower in 2009.

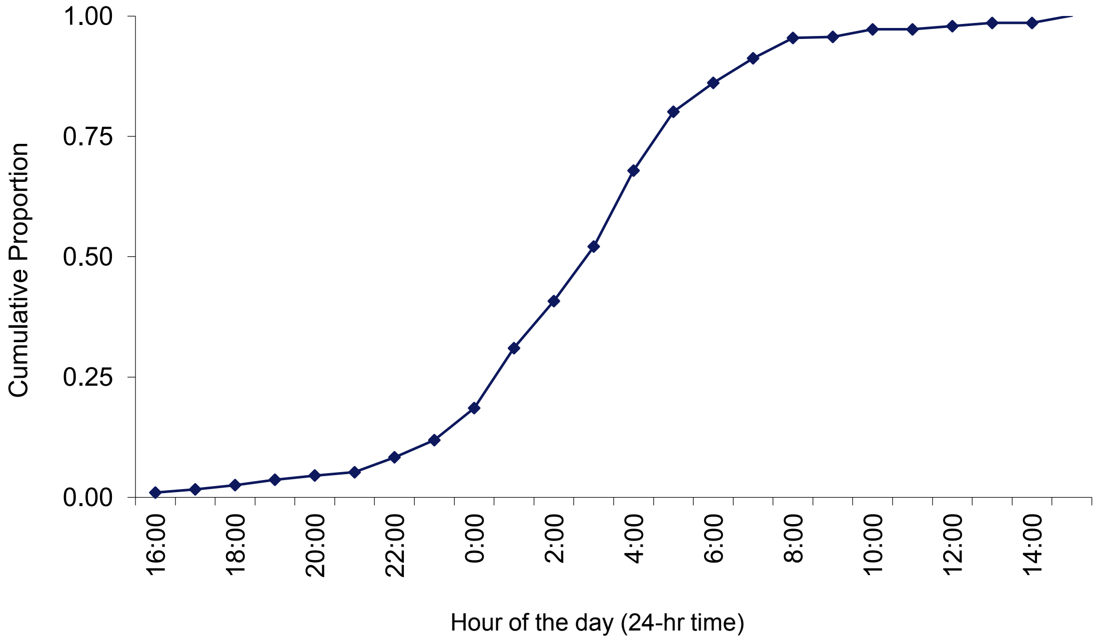

Figure 4.–Estimated diel migratory pattern for 2009; the cumulative proportion of average daily counts by hour of day for Chinook salmon migrating past the Gulkana River counting tower.

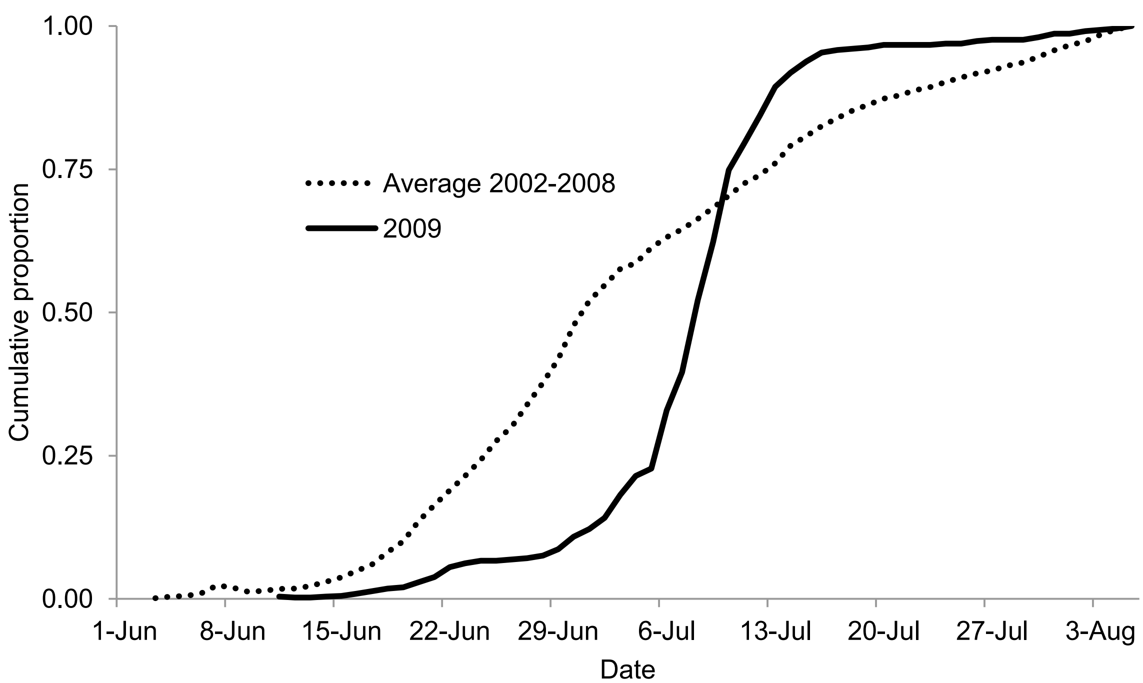

Figure 5.–Estimated run timing pattern for Gulkana River Chinook salmon past the counting tower in 2009, compared to the 2002–2008 average.

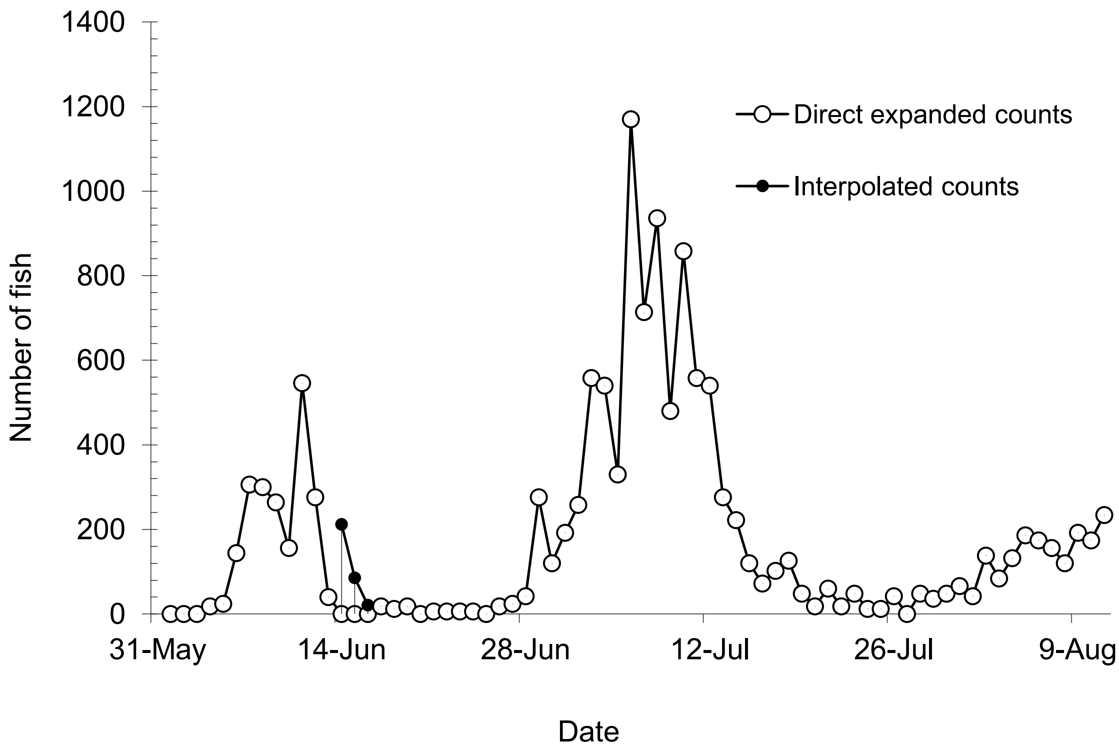

Figure 6.–Estimated daily escapement of sockeye salmon migrating past the Gulkana River counting tower, 2009.

DISCUSSION

To establish an escapement goal for the Gulkana River a considerable time series of total run and escapement estimates are required. Currently there are no projects being fielded to estimate stock specific harvests in the mixed stock fisheries, which makes it difficult to accurately estimate the total stock specific run. In addition, the counting tower does not assess the number of Chinook salmon that migrate up the West Fork to spawn. The radiotelemetry study, which operated concurrently with the first three years of this project (2002–2004), estimated the proportion of the Gulkana River escapement that spawned upstream of the counting tower was substantially different in 2004 (0.50) compared to the estimates from 2002 (0.81) and 2003 (0.86) (Savereide 2005). Using these numbers to expand the counting tower estimate by the average proportion spawning above the tower to account for the West Fork and obtain a total escapement estimate for the Gulkana River drainage is not appropriate considering the degree of variability in the proportion estimates. However, in 2004, the Gulkana River was at record low water levels and spawning Chinook salmon were documented further downstream in the drainage (well below Sourdough Landing) than ever before, which could explain the difference in the proportion estimates. Therefore, to obtain escapement estimates for the entire Gulkana River drainage, either the tower estimate of escapement should be expanded by the estimated average proportion spawning above the tower during 2002 and 2003, or another spawning distribution study should be conducted to verify whether or not the average proportion estimate from 2002 and 2003 is appropriate. This would allow researchers to conduct a spawner-recruit analysis and derive an escapement goal.

In the absence of an escapement goal, the primary concern for area sport fish management is the need for a definitive guideline to make inseason determinations whether to apply a management action (i.e., close the fishery) when sport fish guides and anglers report low numbers of Chinook salmon and/or the counting tower counts are considered low. In all years of the study there was no correspondence between the date of the run and the proportion past the counting tower until 75% of the run had returned (Perry-Plake and Antonovich 2009). In 2004, this date was 28 June (likely due to the record low water level), but for the remaining seven years this date fell within the range of 9 July through 17 July. If 2004 is dropped from consideration the average date for 75% of the annual escapement is 13 July. The wide range in the annual escapement estimates (6,390–2,718) over the relatively short historical perspective (2002–2009) makes it difficult to determine the average escapement of Chinook salmon needed by 13 July to sustain production and harvests. This number could potentially be utilized as a trigger value, which would indicate the need to restrict or liberalize the harvest of the Gulkana River stock. Additional years of escapement estimates for the Gulkana River may allow ADF&G to develop a threshold count and date, which would let area mangers make inseason management decisions with more confidence. However, an established escapement goal coupled with historic run timing would be the preferred method to use when making these types of management decisions.

RECOMMENDATIONS

The Gulkana spawning stock is facing a continuing increase in fishing pressure from multiple fisheries downstream of this major spawning area. Consideration should be given to a mainstem Gulkana River Chinook salmon radiotelemetry study to continue investigating the magnitude of the Gulkana run and the proportion of the Gulkana stock that spawns above the counting tower. Further, the documented variance in water level and various river conditions from year to year identifies a need for additional, and more detailed, information regarding various stream flow and water quality characteristics and how they affect Chinook salmon run timing past the tower. Finally, the window for conducting the yearly aerial index count on the Gulkana River may be a bit constrained, and late in timing. Consideration should be made to establish triggers to identify when the appropriate flight window should be on a annual basis.

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APPENDIX A

Appendix A1.–Data files for the Chinook salmon escapement in the Gulkana River, 2009 project.

Data file	Description
GulkanaTowerRawData_2009.xls	Raw data collected at Gulkana River Counting Tower, 2009.
GulkanaTower09_king.xls.	Data analysis on Chinook salmons counts collected at the Gulkana River Counting Tower, 2009.
GulkanaTower09_sockeye.xls.	Data analysis on sockeye salmons counts collected at the Gulkana River Counting Tower, 2009.

Note: Data files are archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.

APPENDIX B

Appendix B1.–Daily counts[a] and expanded counts, including interpolations[b], and the cumulative estimated escapement of Chinook salmon at the Gulkana River tower, 2009.

	West Channel			East Channel			Combined			Cumulative
Date	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Escapement
31-May	0	0	0	0	0	0	0	0	0	0
1-Jun	0	0	0	0	0	0	0	0	0	0
2-Jun	0	0	0	0	0	0	0	0	0	0
3-Jun	0	0	0	0	0	0	0	0	0	0
4-Jun	0	0	0	0	0	0	0	0	0	0
5-Jun	0	0	0	0	0	0	0	0	0	0
6-Jun	0	0	0	0	0	0	0	0	0	0
7-Jun	0	0	0	0	0	0	0	0	0	0
8-Jun	0	0	0	0	0	0	0	0	0	0
9-Jun	0	0	0	0	0	0	0	0	0	0
10-Jun	0	0	0	0	0	0	0	0	0	0
11-Jun	0	0	0	2	12	12	2	12	12	12
12-Jun	-1	-6	-6	0	0	0	-1	-6	-6	6
13-Jun	1	6	6	-1	-6	-6	0	0	0	6
14-Jun	0	0	***3***	0	0	***2***	0	***0***	***4.5***	10.5
15-Jun	0	0	***5***	0	0	*0*	0	***0***	***4.5***	15.0
16-Jun	0	0	***6***	0	0	***5***	0	***0***	***10.5***	25.5
17-Jun	2	6	12	0	0	0	2	12	12	37.5
18-Jun	1	6	6	1	6	6	2	12	12	49.5
19-Jun	0	0	0	1	6	6	1	6	6	55.5
20-Jun	1	6	6	3	18	18	4	24	24	79.5
21-Jun	3	18	18	1	6	6	4	24	24	103.5
22-Jun	4	24	24	4	24	24	8	48	48	151.5
23-Jun	2	12	12	1	6	6	3	18	18	169.5
24-Jun	2	12	12	0	0	0	2	12	12	181.5
25-Jun	0	0	0	0	0	0	0	0	0	181.5
26-Jun	1	6	6	0	0	0	1	6	6	187.5
27-Jun	1	6	6	0	0	0	1	6	6	193.5
28-Jun	1	6	6	1	6	6	2	12	12	205.5
29-Jun	0	0	0	5	30	30	5	30	30	235.5
30-Jun	2	12	12	8	48	48	10	60	60	295.5
1-Jul	4	24	24	2	12	12	6	36	36	331.5
2-Jul	4	24	24	5	30	30	9	54	54	385.5
3-Jul	6	36	36	12	72	72	18	108	108	493.5
4-Jul	3	18	18	12	72	72	15	90	90	583.5
5-Jul	2	12	12	4	24	24	6	36	36	619.5
6-Jul	32	192	192	14	84	84	46	276	276	895.5
7-Jul	8	48	48	22	132	132	30	180	180	1,075.5
8-Jul	37	222	222	20	120	120	57	342	342	1,417.5

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	West Channel			East Channel			Combined			Cumulative
Date	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Escapement
9-Jul	24	144	144	22	132	132	46	276	276	1,693.5
10-Jul	43	258	258	14	84	84	57	342	342	2.035.5
11-Jul	15	90	90	6	36	36	21	126	126	2,161.5
12-Jul	11	66	66	11	66	66	22	132	132	2,293.5
13-Jul	20	120	120	3	18	18	23	138	138	2,431.5
14-Jul	5	30	30	6	36	36	11	66	66	2,497.5
15-Jul	4	24	24	5	30	30	9	54	54	2,551.5
16-Jul	5	30	30	2	18	18	7	42	42	2,593.5
17-Jul	1	6	6	1	6	6	2	12	12	2,605.5
18-Jul	1	6	6	0	0	0	1	6	6	2,611.5
19-Juln	0	0	0	1	6	6	1	6	6	2,617.5
20-Jul	2	12	12	0	0	0	2	12	12	2,629.5
21-Jul	0	0	0	0	0	0	0	0	0	2,629.5
22-Jul	0	0	0	0	0	0	0	0	0	2,629.5
23-Jul	0	0	0	0	0	0	0	0	0	2,629.5
24-Jul	1	6	*6*	0	0	0	1	6	*6*	2,635.5
25-Jul	0	0	0	0	0	0	0	0	0	2,635.5
26-Jul	2	12	12	0	0	0	2	12	12	2,647.5
27-Jul	0	0	0	1	6	6	1	6	6	2,653.5
28-Jul	0	0	0	0	0	0	0	0	0	2,653.5
29-Jul	0	0	0	0	0	0	0	0	0	2,653.5
30-Juln	2	12	12	0	0	*0*	2	12	12	2,665.5
31-Jul	2	12	12	1	6	6	3	18	18	2,683.5
1-Aug	1	6	6	-1	-6	-6	0	0	0	2,683.5
2-Aug	1	6	6	1	6	6	2	12	12	2,695.5
3-Aug	0	0	0	1	6	6	1	6	6	2,701.5
4-Aug	1	6	6	0	0	0	1	6	6	2,707.5
5-Aug	1	6	6	1	6	6	2	12	12	2,719.5
6-Aug	-1	-6	-6	1	6	6	0	0	0	2,719.5
7-Aug	0	0	0	0	0	0	0	0	0	2,719.5
8-Aug	0	0	0	0	0	0	0	0	0	2,719.5
9-Aug	0	0	0	0	0	0	0	0	0	2,719.5
10-Aug	0	0	0	0	0	0	0	0	0	2,719.5
11-Aug	0	0	0	0	0	0	0	0	0	2,719.5

[a] To avoid splitting the diurnal pulses between adjacent calendar days a "count day" is defined as 1600 hours to 1559 hours; i.e. the 1 Aug count is passage that occurred from 1600 hrs 31Jul through 1559 hrs 1 Aug.

[b] Shading identifies days with counts that included application of interpolation and any resulting changes in count estimates are shown in bold italics.

APPENDIX C

Appendix C1.–Daily counts[a] and expanded daily counts, including interpolation[b], with a cumulative estimate of sockeye salmon minimum escapement at the Gulkana River Tower, 2009.

	West Channel			East Channel			Combined			Cumulative
Date	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Escapement
31-May	0	0	0	0	0	0	0	0	0	0
1-Jun	0	0	0	0	0	0	0	0	0	0
2-Jun	0	0	0	0	0	0	0	0	0	0
3-Jun	0	0	0	0	0	0	0	0	0	0
4-Jun	2	12	12	1	6	6	3	18	18	18
5-Jun	2	12	12	2	12	12	4	24	24	42
6-Jun	21	126	126	3	18	18	24	144	144	186
7-Jun	39	234	234	12	72	72	51	306	306	492
8-Jun	20	120	120	30	180	180	50	300	300	792
9-Jun	34	204	204	10	60	60	44	264	264	1,056
10-Jun	13	78	78	13	78	78	26	156	156	1,212
11-Jun	31	186	186	60	360	360	91	546	546	1,758
12-Jun	13	78	78	33	198	198	46	276	276	2,034
13-Jun	4	24	24	2	12	12	6	36	36	2,070
14-Jun	0	0	***73.5***	0	0	***145.5***	0	**0**	***219.0***	2,289
15-Jun	0	0	***27***	0	0	***58.5***	0	**0**	***85.5***	2,374.5
16-Jun	0	0	***7.5***	0	0	***13.5***	0	**0**	***21.0***	2,395.5
17-Jun	1	6	6	2	12	12	3	18	18	2,413.5
18-Jun	0	0	0	2	12	12	2	12	12	2,425.5
19-Jun	0	0	0	3	18	18	3	18	18	2,443.5
20-Jun	0	0	0	0	0	0	0	0	0	2,443.5
21-Jun	0	0	0	1	6	*6*	1	6	6	2,449.5
22-Jun	0	0	0	1	6	6	1	6	6	2,455.5
23-Jun	0	0	0	1	6	6	1	6	6	2,461.5
24-Jun	0	0	0	1	6	6	1	6	6	2,467.5
25-Jun	0	0	0	0	0	0	0	0	0	2,467.5
26-Jun	2	12	12	1	6	6	3	18	18	2,485.5
27-Jun	3	18	18	1	6	6	4	24	24	2,509.5
28-Jun	6	36	36	1	6	6	7	42	42	2551.5
29-Jun	19	114	114	27	162	162	46	276	276	2,827.5
30-Jun	9	54	54	11	66	66	20	120	120	2,947.5
1-Jul	10	60	60	22	132	132	32	192	192	3,139,.5
2-Jul	21	126	126	22	132	132	43	258	258	3,397.5
3-Jul	68	408	408	25	150	150	93	558	558	3,955.5
4-Jul	62	372	372	28	168	168	90	540	540	4,495.5
5-Jul	42	252	252	13	78	78	55	330	330	4,825.5
6-Jul	161	966	966	34	204	204	195	1,170	1,170	5,995.5
7-Jul	96	576	576	23	138	138	119	714	714	6,709.5
8-Jul	136	816	816	20	120	120	156	936	936	7,645.5

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Appendix C1.–Page 2 of 2.

Date	West Channel			East Channel			Combined			Cumulative
	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Escapement
9-Jul	68	408	408	12	72	72	80	480	480	8,125.5
10-Jul	125	750	750	18	108	108	143	858	858	8,983.5
11-Jul	76	456	456	17	102	102	93	558	558	9,541.5
12-Jul	66	396	396	24	144	144	90	540	540	10,081.5
13-Jul	35	210	210	11	66	66	46	276	276	10,357.5
14-Jul	29	174	174	8	48	48	37	222	222	10,579.5
15-Jul	18	108	108	2	12	12	20	120	120	10,699.5
16-Jul	7	42	42	5	30	30	12	72	72	10,771.5
17-Jul	14	84	84	3	18	18	17	102	102	10,873.5
18-Jul	18	108	108	3	18	18	21	126	126	10,999.5
19-Jul	7	42	42	1	6	6	8	48	48	11,047.5
20-Jul	-1	-6	-6	4	24	24	3	18	18	11,065.5
21-Jul	9	54	54	1	6	6	10	60	60	11,125.5
22-Jul	3	18	18	0	0	0	3	18	18	11,143.5
23-Jul	7	42	42	1	6	6	8	48	48	11,191.5
24-Jul	1	6	*6*	1	6	6	2	12	12	11,203.5
25-Jul	2	12	12	0	0	0	2	12	12	11,215.5
26-Jul	6	36	36	1	6	6	7	42	42	11,257.5
27-Jul	0	0	0	0	0	0	0	0	0	11,257.5
28-Jul	4	24	24	4	24	24	8	48	48	11,305.5
29-Jul	4	24	24	2	12	12	6	36	36	11,3415
30-Jul	9	54	54	-1	-6	*-6*	8	48	48	11,389.5
31-Jul	8	48	48	3	18	18	11	66	66	11,455.5
1-Aug	7	42	42	0	0	0	7	42	42	11,497.5
2-Aug	19	114	114	4	24	24	23	138	138	11,635.5
3-Aug	9	54	54	5	30	30	14	84	84	11,719.5
4-Aug	8	48	48	14	84	84	22	132	132	11,815.5
5-Aug	17	102	102	14	84	84	31	186	186	12,037.5
6-Aug	12	72	72	17	102	102	29	174	174	12,211.5
7-Aug	15	90	90	11	66	66	26	156	156	12,367.5
8-Aug	12	72	72	8	48	48	20	120	120	12,487.5
9-Aug	23	138	138	9	54	54	32	192	195	12,679.5
10-Aug	26	156	156	3	18	18	29	174	174	12,853.5
11-Aug	23	138	138	16	96	96	39	234	234	13,087.5

[a] To avoid splitting the diurnal pulses between adjacent calendar days a "count day" is defined as 1600 hours to 1500 hours; i.e. the 1 Aug count is passage that occurred from 1600 hrs 31Jul through 1500 hrs 1 Aug.

[b] Days for which interpolations were calculated are shaded and resulting changes in estimate numbers are shown in bold italics.