Fishery Data Series No. 09-35

Chinook Salmon Escapement in the Gulkana River, 2007-2008

by

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and

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Alaska Department of Fish and Game Divisions of Sport 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)

Measures (fisheries)	
fork length	FL
mideye to fork	MEF
mideye to tail fork	METF
standard length	SL
total length	TL

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 1 June through 12 August 2007 and from 31 May through 10 August 2008, escapements of Chinook salmon *Oncorhynchus tshawytscha* in a portion of the Gulkana River were estimated using counting tower techniques. In 2007, the escapement estimate was 4,422 (SE=273) and in 2008 the estimate was 3,678 (SE=258) Chinook salmon. Conditions were deemed suitable for counting during 93% of the planned counting periods in 2007 and during 76% of planned periods in 2008. During the periods of poor visibility, passage was interpolated with one of two methods depending upon the length of time counts were missed. When only a portion of a day was missed, interpolations were based on the observed diurnal pattern of passage from all days when counts were conducted successfully. When one or more entire days were missed, a linear approximation was used to estimate passage based on successful counting days before and after the missed days. Interpolated passage represented 0.4% of the total estimate for 2007 and 28% of the total estimate for 2008. Counts of sockeye salmon *Oncorhynchus nerka* during the same time periods were also recorded. These counts represented a portion of the total run because the sockeye salmon migration continues well beyond that of the Chinook salmon run. The estimated minimum escapement of sockeye salmon was 30,174 (SE=1,469) in 2007 and 11,400 (SE=572) in 2008.

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

INTRODUCTION

The Gulkana River (Figure 1), a tributary of the Copper River, supports the largest Chinook salmon *Oncorhynchus tshawytscha* sport fishery in the Copper River drainage, with annual catch and harvest figures accounting for over half of the Chinook salmon sport fishery in the Upper Copper Upper Susitna Management Area (UCUSMA) (Jennings et al. *in prep*; Taube 2006). Since 1977, annual effort and harvest have increased substantially. The Gulkana River average annual Chinook salmon sport harvest from 1977 through 1989 was 1,927 fish, increasing to an average of 3,394 fish for 1990 through 1999, and an average of 3,003 for 2000 through 2007. In addition to direct harvest from 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. Similar to the Gulkana River sport harvest, these mixed-stock fisheries have also shown an overall increase in harvest over the past 30 years (Ashe et al. 2005; Taube 2006).

Returning Chinook salmon enter the Copper River in early May, with peak migration from mid-May to mid-June. The sport fishery occurs almost exclusively in large tributary rivers in the upper drainage (particularly the Gulkana and Klutina rivers) and targets individual spawning stocks. 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 drainage-wide sustainable escapement goal of 24,000 or more Chinook salmon. Inriver abundance is estimated annually in the Lower Copper River with post-season mark-recapture techniques, and inriver harvest is subtracted post-season to obtain an estimate of drainage-wide escapement. Even though the Copper River Chinook salmon management plans and mainstem monitoring programs address the population as a whole, little information is available regarding stock-specific escapements or exploitation rates, and there are no established escapement goals for any of the Copper River tributaries.

[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).

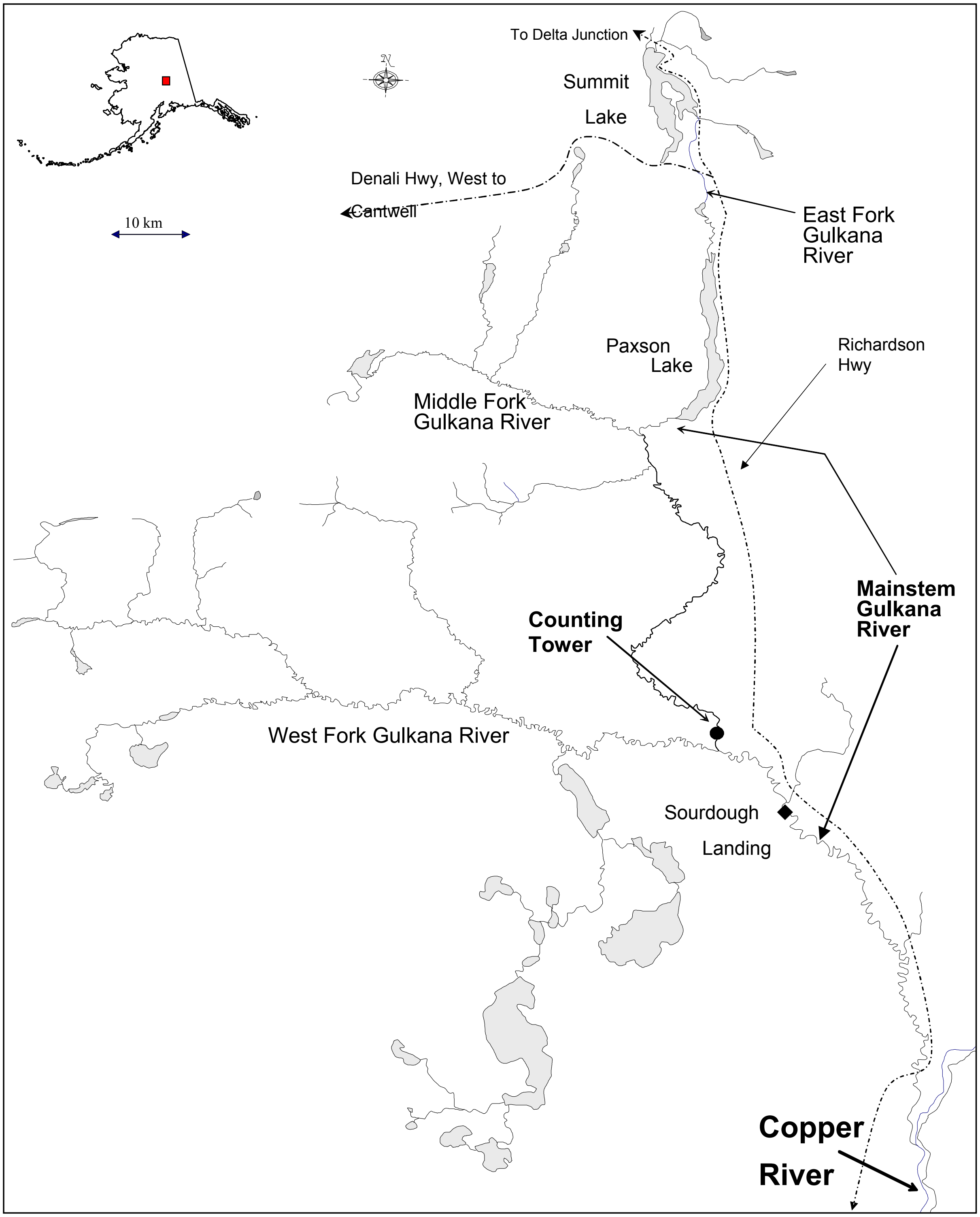


Figure 1.-The Gulkana River drainage and location of the counting tower.

The section of the Gulkana River upstream of Sourdough Landing (Figure 1) has been recognized for its exceptional scenic, recreational, and resource values and has been designated by the U.S. Congress as a "wild river", 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.

In 2002 a multi-year cooperative project was initiated between ADF&G and BLM to monitor Chinook salmon escapement on the Gulkana River. The Gulkana River was selected because this stock makes up a significant portion of the total Copper River escapement, it supports a substantial sport fishery, access is relatively good, and it is one of the few tributaries in the Copper River drainage supporting Chinook salmon that is not glacially occluded. The long-term goal of this project is to collect information on escapement to aid in developing management guidelines for the Chinook salmon sport fishery to ensure adequate escapement for this stock and to facilitate inseason management.

OBJECTIVES

The objective of this project for 2007 and 2008 was to estimate the escapement of Chinook salmon upstream of an established tower site on the mainstem Gulkana River, using counting tower techniques, such that the estimate was within 15% of the actual value 95% of the time.

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 passage at the tower site during the period of tower operation.

METHODS

STUDY AREA

The Gulkana 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 Gulkana River supports sport fisheries for Chinook and sockeye salmon, rainbow trout *O. mykiss*, and Arctic grayling *Thymallus arcticus*, with access primarily by boat.

Winding and boulder strewn, it is a primarily clear water, run-off system. Water level and clarity can fluctuate considerably and quickly in response to weather. Portions of the river are slow and meandering and others are designated as Class III rapids.

The counting tower site is located approximately 2.5 km upstream from the confluence of the West Fork and the mainstem river (Figure 1). This location was chosen to avoid the poor visibility created in the mainstem river from the often turbid input of the West Fork. A small island splits the mainstem into two channels at the tower site. This split, with platform towers located on each side of the island, allows for a comprehensive view of the entire river (approximately 30 m per channel). Maximum depth in both channels 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. Normal power boat access to this upper part of the river, including the tower site, is from the public boat launch at Sourdough Landing, which is 19.3 km downstream of the tower site.

ESCAPEMENT OF CHINOOK SALMON PAST THE COUNTING TOWER

Study Design

The number of Chinook salmon returning to an index area in the mainstem Gulkana River was estimated by first visually counting fish as they passed by the counting tower, and then applying condition-specific expansions to generate daily estimates and variances. Anecdotal information from sport fishers and guides and the results from previous aerial surveys (Taube 2002) and radiotelemetry studies (Savereide 2005) indicated that the majority of spawning in the Gulkana River drainage occurred upstream of the selected tower site.

Two three-person crews were scheduled to conduct 10-minute counts for each of two river channels every hour, every day during the Chinook salmon run. Because counts were planned for all hours, daily estimates of abundance were a single-stage direct expansion from the 10-min counting periods. The 10-min counting periods were considered a systematic sample and the abundance 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.

The number of Chinook salmon that migrate past the counting tower is equal to escapement above the tower if there is no harvest of pre-spawning salmon upstream of the tower site. Even though this is not true, the harvest upstream of the tower is insignificant relative to the number of fish migrating past the tower and the uncertainty associated with the escapement estimate. To obtain information that supports the assumption that harvest upstream of the counting tower was relatively small, the Statewide Harvest Survey (Jennings et al. 2004) was modified twice to delineate site locations between Paxson Lake and Sourdough Landing to identify the harvest occurring upstream of the tower.

Tower Construction and Maintenance

To clearly view each channel, two scaffolding towers were installed to provide stable platforms approximately 4 m above water. The platforms supported dome-shaped pole frames that were covered on the top and three sides with camouflage-print tarps to prevent shadows on the water and to provide the observer with 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 tower platform to ensure no fish were able to pass undetected directly beneath the towers. For both towers, the opposite mainland riverbank had a gradual slope and the contrast panels ran smoothly against the substrate and up the bank beyond water level. Debris, silt, gravel, and fish carcasses accumulated regularly on the panels and weir sections, affecting stream flow and visibility. To ensure optimal viewing conditions, the panels were cleaned between scheduled counts as necessary. During periods of low ambient light, floodlights were used to illuminate the panels across each channel. Exterior-grade floodlights were located above platform height and positioned to provide an even level of illumination across each channel. Once the lights were turned on, they remained on between counts to maintain consistent conditions until no longer needed. This was done to reduce any associated effect that lighting changes may have had on salmon passage.

Data Collection

Fish counts began on 1 June 2007 and 31 May 2008 and continued through 12 August 2007 and 10 August 2008, respectively. During tower construction, which began each year in late May, the crew monitored the river to ensure that the beginning of the Chinook salmon run was observed. Had Chinook salmon been observed earlier than anticipated, and before the platforms were erected, counts would have begun from the riverbank. Monitoring was terminated at the end of the run after five continuous days with no daily net upstream passage of Chinook salmon.

Two 10-min counting periods (20 min total) were scheduled every hour, for 24 h each day. 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 hour; Shift III began at 2200 hour and ended at 0559 hour. The start time for all counts for the West channel began between the top of the hour and 10 min past. The 10-min count of 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 time period. Separate data forms were maintained for each day and channel. Passage both upstream (+) and downstream (-) was recorded to provide a net upstream passage during each 10-min count, for each channel of the river. Passage was defined as movement across the full width of the contrast panels. Observers tallied every fish that moved upstream and downstream, regardless of whether it was suspected, or known, to be the same fish (although such occurrences were noted in the comment column on the count form). The only movement not counted, but still noted in the comment field, was that of a carcass floating downstream. Recorded data included numbers of Chinook and sockeye salmon counted in each river channel, date and time of the counting period, and name of the observer. In addition, at the beginning of each hour, water level (relative level on a staff gauge) and water clarity were recorded. The observers evaluated water clarity on a scale of 1 (excellent) to 5 (unobservable; Table 1). Water temperature was recorded at the beginning of each 8-h shift. Conditions that might effect the counts (e.g., heavy rain earlier in the day or strong wind stirring the water surface) and general observations were recorded in the comments column. Recorded data were entered into Excel spreadsheets for data analysis and for archival (Appendix A).

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 passage observable
2	Good	All passing salmon are observable	Minimal to very low levels of turbidity or glare; all routes of passage observable
3	Fair	All passing salmon are observable	Low to moderate levels of turbidity or glare; all routes of passage 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 passage 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 passage are obscured
5	Unobservable	Passing fish are not observable	High level of turbidity or glare; ALL routes of passage obscured

[a] 4.5 has been inserted (beginning in 2007) between 4 and 5, rather then change the scale to 1-6, in order to maintain continuity with the scale used in previous years, and to emphasize that further specificity was necessary for defining “poor” visibility.

To ensure the season's count included the entire escapement upstream of the tower, and to account for spawning near the tower and the associated post-spawning milling behavior, counting operations continued until the net upward movement was zero or less when averaged over five consecutive days. The observers made regular entries in the comments column identifying salmon which had taken up established positions near the panels. Obvious carcasses floating downstream were noted, but not counted; however, live Chinook salmon crossing the panels moving downstream were tallied and subtracted from those moving upstream. As a result, there was a net negative passage during the last five or more days of monitoring (Appendix B). In 2007 and 2008, the escapement estimates were based on data collected through the date judged to represent maximum upstream passage. After this date, nearly all passage over the panels was attributed to milling salmon.

Data Analysis

Salmon passage upstream of the counting tower and its variance were estimated by day and summed across all days of counting to estimate total escapement. Daily passage and its variance were estimated using one of three scenarios depending on counting 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 passage (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 passage 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), passage for the entire day was interpolated (equations 5–6).

<u>Scenario #1:</u> For days when all counts were conducted under excellent to poor conditions (scenario 1 above), daily passage, $\hat{N}_d$, was calculated by expanding counts within a shift for day *d*:

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

The period sampling is systematic, because the sample (or primary unit) has 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:

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

The variance for the expanded daily passage was estimated as:

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

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;

M = total number of possible paired 10-min counting periods; and,

Equations 1 and 3 were taken directly, or modified, from those provided in Cochran (1977).

<u>Scenario #2:</u> Since 2002, a distinct diurnal migratory pattern was observed that was consistent between both river channels throughout the span of the run, and an analyses of data collected during 2002 indicated that interpolating for undercounts using a diurnal run-timing pattern yielded more accurate estimates of passage than using a direct expansion of the successful counts within 8-h shifts for that day (Taras and Sarafin 2005). 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 diurnal pattern. At least 80% of the passage each "day" occurred between 2300 and 1100 hours in 2007, and 90% of the passage occurred during this period in 2008 (Figure 2). For each year, a period of peak passage was defined as the shortest, continuous period of time that accounted for 80% of the seasonal passage of Chinook salmon. To be reliable, expansions based on the diurnal pattern must have at least some counts that were successfully completed during the period of peak passage. 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 passage for that day (as defined by the diurnal relationship), and if at least 25% of the periods during peak passage 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 passage not represented to the daily passage 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 passage successfully counted.

The interpolated count was then allocated among missed 10-min counting periods based on the diurnal 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 diurnal pattern. Daily abundance and variances for scenario 2 were calculated using a combination of actual and interpolated counts because simply treating interpolated counts as "known" results in underestimating 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 passage successfully counted on that day. For example, if 85% of the expected run was successfully counted on a given day, then the adjusted $m_{d,} = 0.85 \times m_d = 0.85 \times 24$. For the channel-combined counts the proportion successfully counted was the channel-specific proportions weighted by the proportion of the overall run 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 diurnal interpolations contribute substantially to the overall variance. Therefore, daily variances are estimated using this approach as long as interpolations using the diurnal pattern account for a small proportion of the total variance.

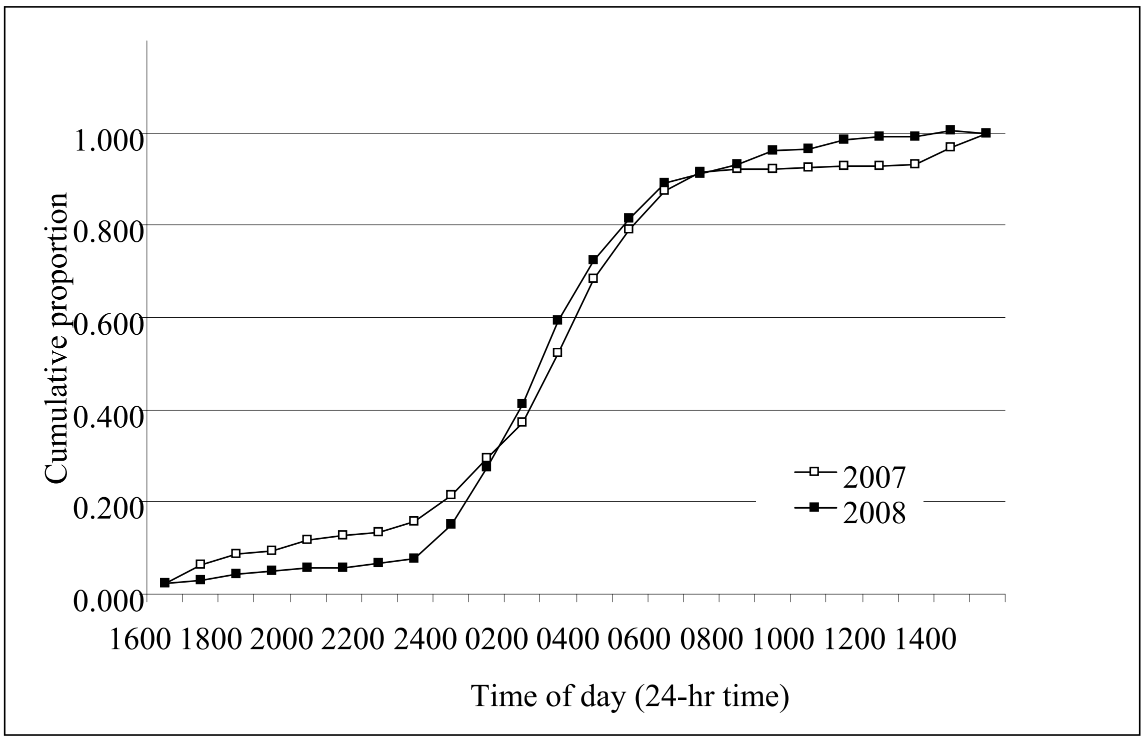


Figure 2.–Diurnal patterns for 2007 and 2008; the cumulative proportion of average daily counts by hour of day for Chinook salmon migrating past the Gulkana River counting tower. Note: a ‘count day’ is 1600 hours to 1500 hours (4:00PM to 3:00PM).

Scenario #3:

If counts were conducted for a portion of the day that represented less than 25% of the expected passage for that day, or if less than 25% of the periods during peak passage were counted successfully, the procedure described below for missed days was used to estimate passage 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:

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

where:

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

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

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

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

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 ESCAPEMENT

The estimated Chinook salmon escapement upstream of the counting tower was 4,422 fish (SE = 273) in 2007, and 3,678 (SE = 258) in 2008. The first Chinook salmon were observed on 9 June 2007 and 8 June 2008, and counting continued through 12 August 2007 and 10 August 2008 (Figures 3 and 4; Appendix B1). The runs were considered complete on 10 August 2007 and 6 August 2008.

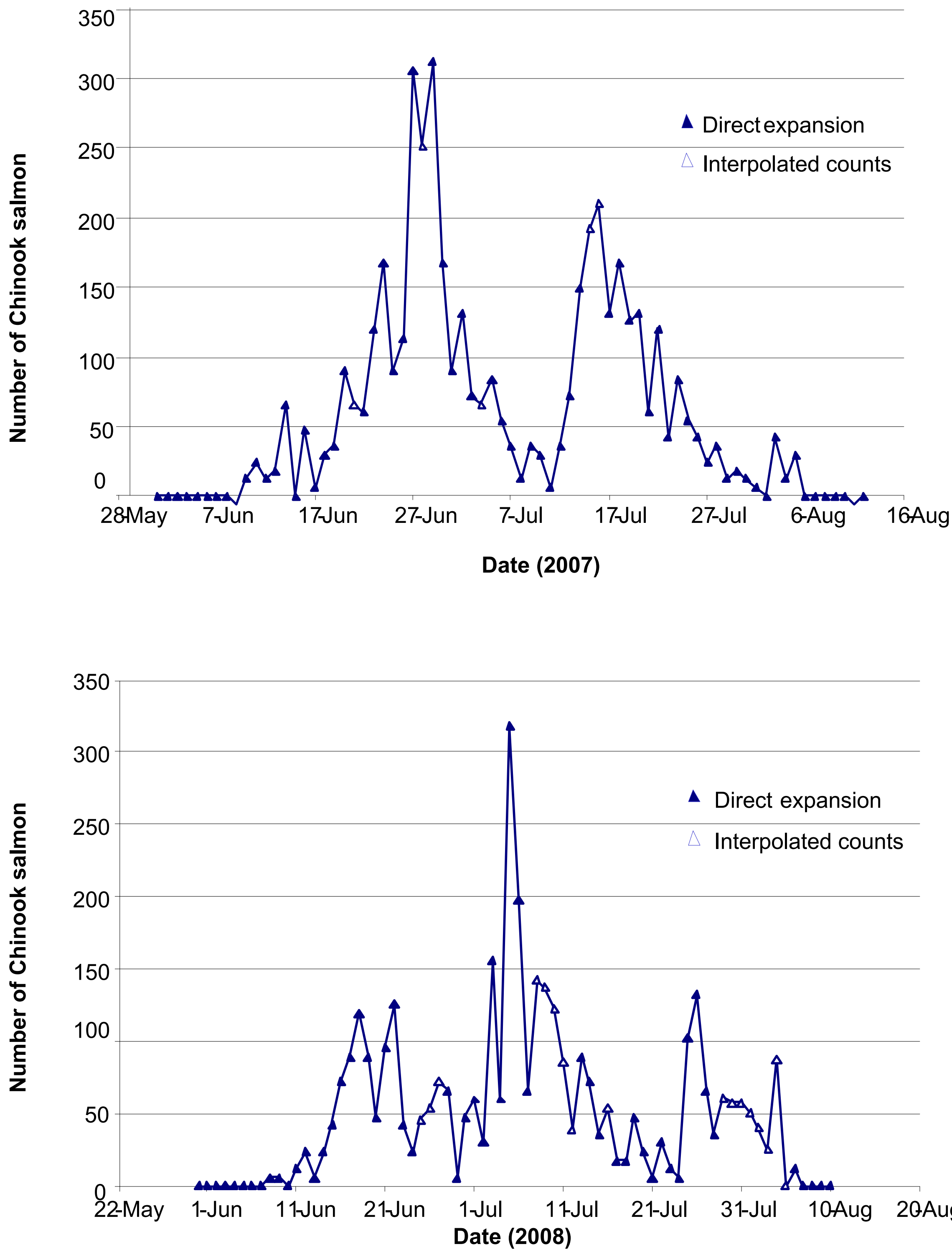


Figure 3.–Estimated daily escapement of Chinook salmon migrating past the Gulkana River counting tower in 2007 and 2008.

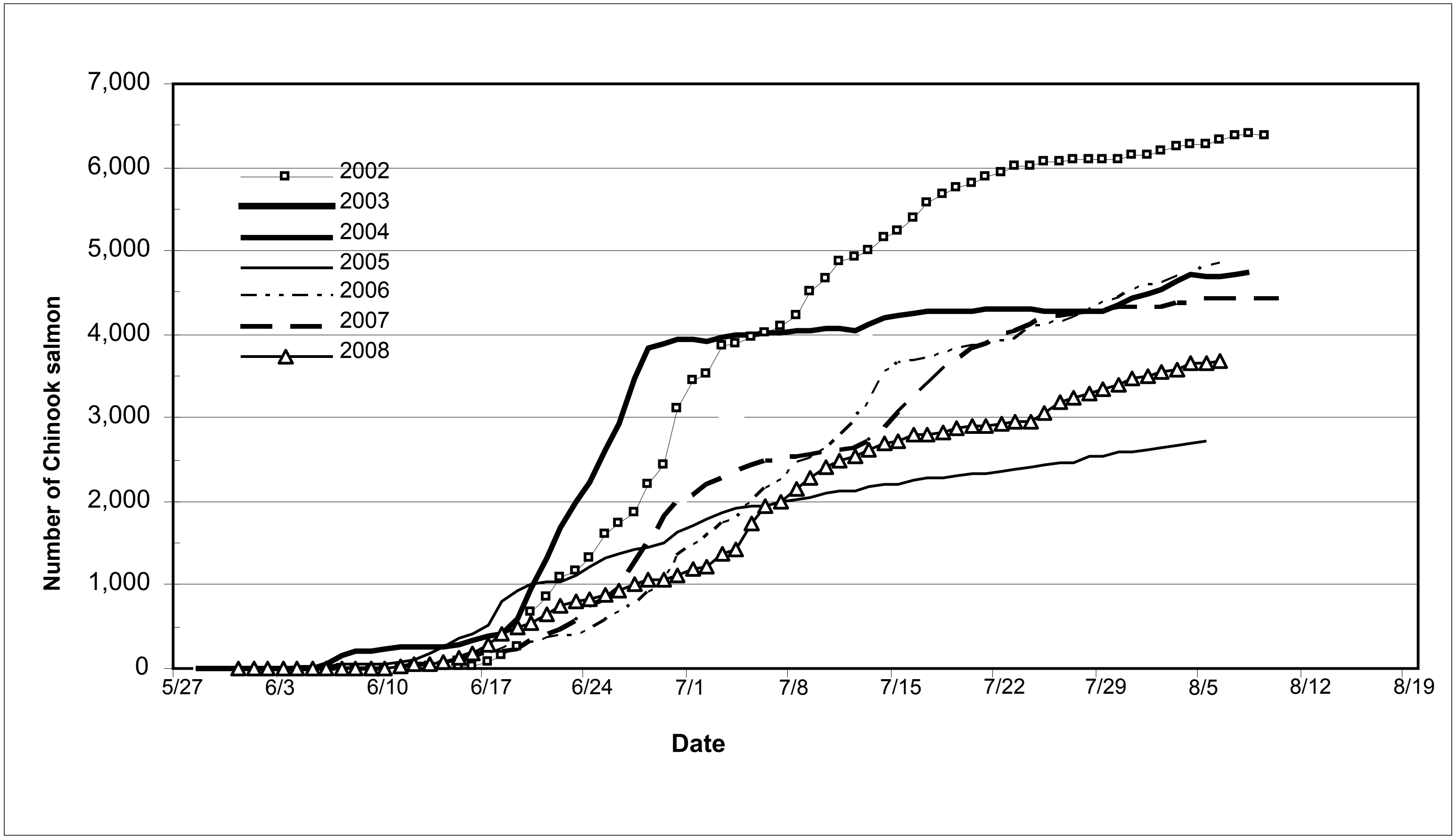


Figure 4.–Cumulative daily estimates, including interpolations, of Chinook salmon migrating past the Gulkana River counting tower, 2002–2008.

The net upstream raw count was 734 Chinook salmon in 2007 and 450 in 2008. Direct expansion of these 10-min counts resulted in estimates of 4,404 Chinook salmon in 2007 and 2,700 in 2008. Less than 2% of the scheduled counting periods in 2007 were conducted during visibility conditions under which undercounting may have occurred. In 2008, there were two periods of very heavy rains that resulted in seriously impaired visibility for 22% of the scheduled counting periods. The counts for those days were considered missing and daily escapement was calculated using equation 5. In 2007, a small portion of the missing counts satisfied the criteria established for interpolating daily passage using the diurnal pattern (Figure 4). The final estimate for 2007 (4,422 Chinook salmon) was very close to the directly expanded count of 4,404 Chinook salmon due to exceptionally good viewing conditions throughout the majority of the counting season. In 2008, the heavy rains resulted in obscured visibility and the increased need for interpolation. As a result, the final estimate for 2008 (3,678 Chinook salmon) was considerably larger than the directly expanded count of 2,700 Chinook salmon.

Prior to the initiation of the counting tower project in 2002, escapement of Chinook salmon in the Gulkana River was monitored by aerial survey counts. The aerial survey counts have been continued to investigate the relationship between the index counts and escapement measured at the towers to provide insight into the magnitude of escapements prior to 2002. The proportion of the estimated escapement observed during aerial counts varied from 2002 through 2007 (water conditions prevented an aerial count in 2008), which resulted in a weak relationship between escapement and the aerial index counts (Table 2, Figure 5).

SOCKEYE SALMON ESCAPEMENT

The sockeye salmon escapement upstream of the counting tower during 2 June through 12 August 2007 was estimated at 30,570 fish (SE=1,429). For the period 1 June through 6 August 2008 the estimated escapement was 11,400 (SE=572) sockeye salmon. These estimates include interpolations for poor observation conditions during scheduled counting periods, but only a portion of the total sockeye run is accounted for during this period (Figure 6; Appendix C).

Table 2.–Escapement estimates, aerial index counts, and the proportion of escapement observed during aerial counts, 2002–2008.

Year	Escapement	SE	Aerial Count	Proportion of Escapement
2002	6,390	340	2,087	0.33
2003	4,890	270	982	0.20
2004	4,734	302	2,014	0.43
2005	2,718	174	824	0.30
2006	4,846	279	1,183	0.24
2007	4,422	273	1,125	0.25
2008	3,678	258	No Count	-

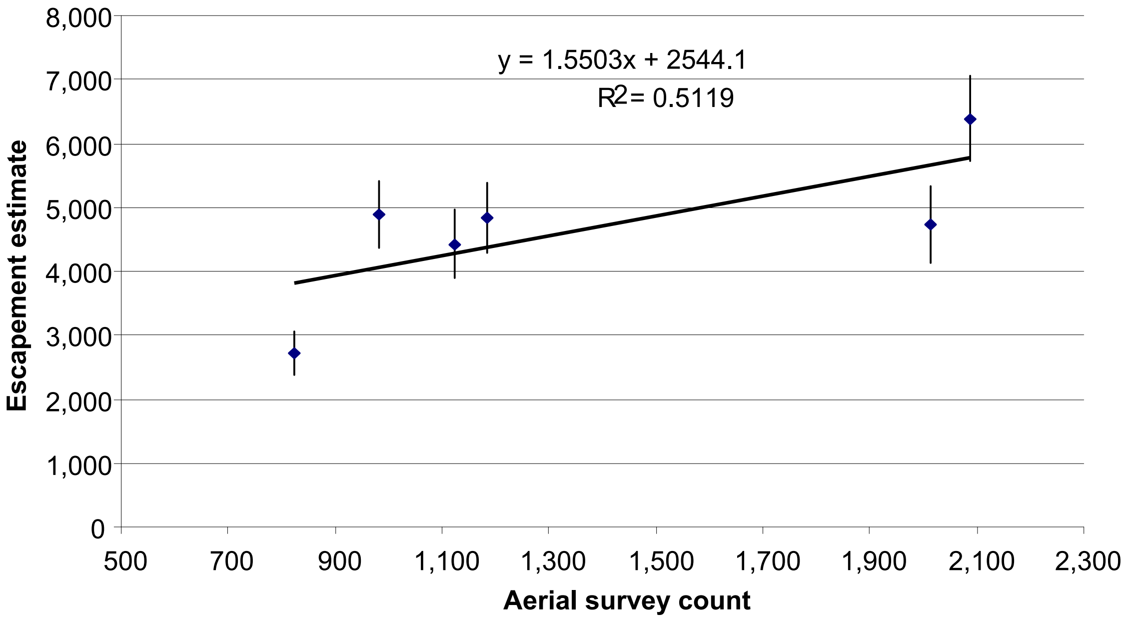
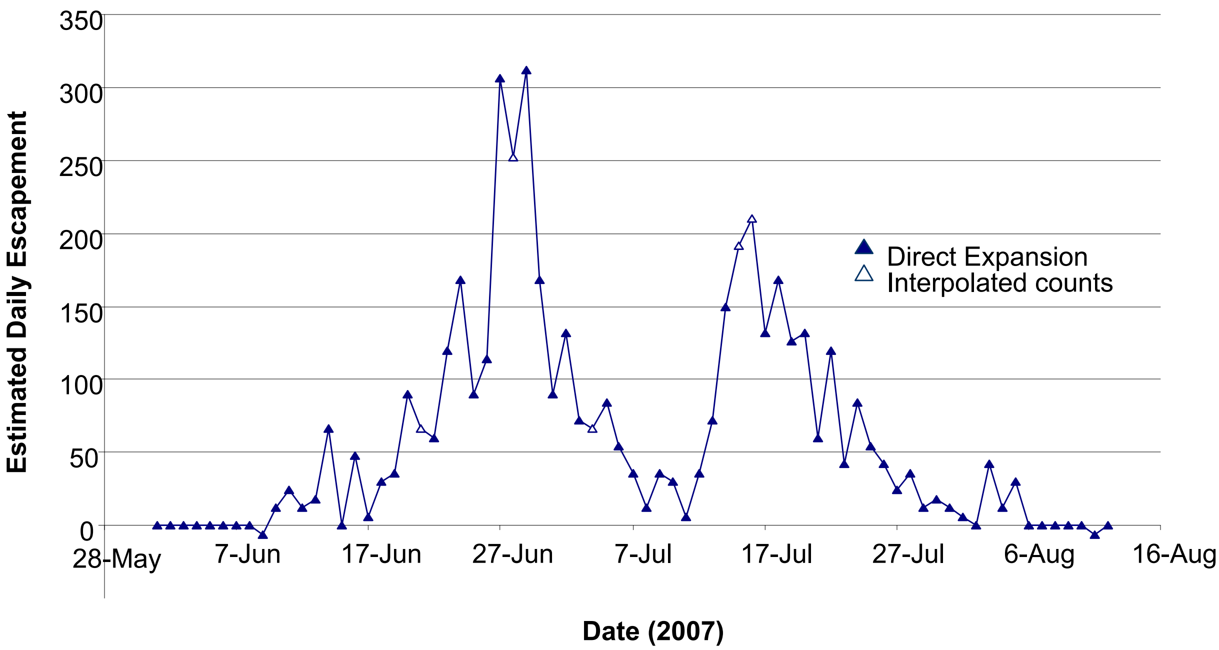


Figure 5.–Counting tower escapement estimates (shown with 95% confidence intervals) compared with aerial index counts for Gulkana River Chinook, 2002–2007 (no aerial data for 2008).



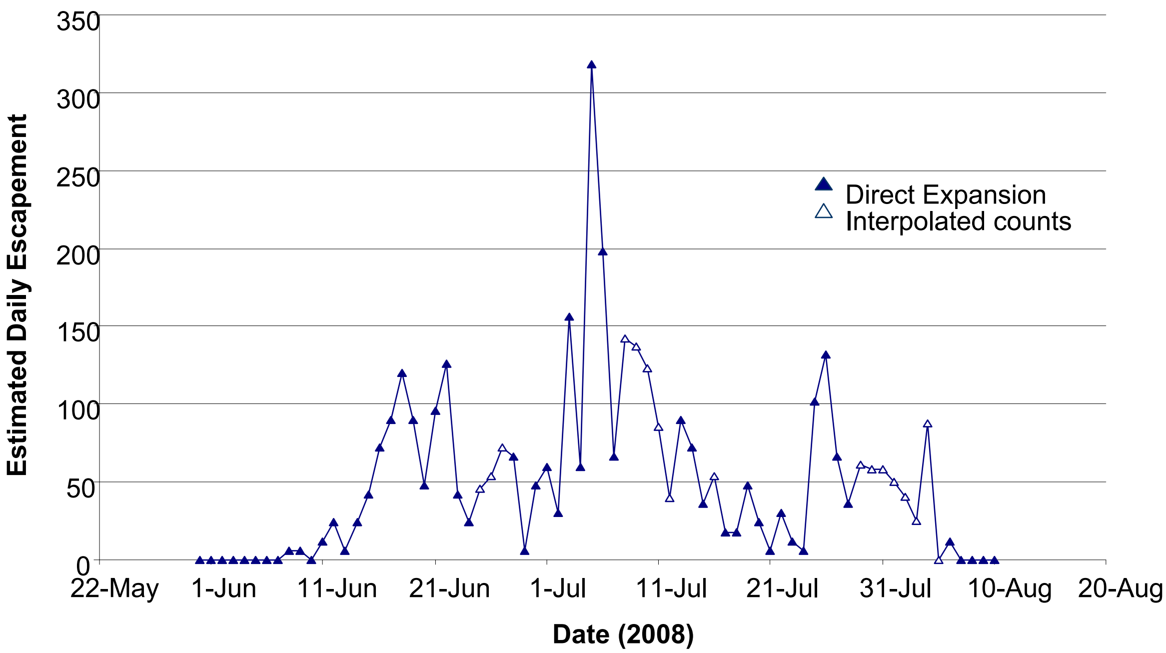


Figure 6.–Estimated daily escapement of sockeye salmon migrating past the Gulkana River counting tower, 2007–2008.

DISCUSSION

The long-term goal of this project is to collect data necessary to establish management guidelines for escapement of Chinook salmon in the Gulkana River. Because the Gulkana River supports an intensive sport fishery, inseason information on run size and an escapement goal are needed to better manage the sport fishery and ensure escapements are adequate to sustain production. The existing Copper River drainage sustainable escapement goal (SEG) of 24,000 Chinook salmon facilitates management of the mixed stock commercial, subsistence, and personal-use fisheries, but does not stipulate any specific tributary goals. In addition, inriver abundance for the Copper River is assessed with mark–recapture techniques and does not provide inseason information on run strength.

Ideally, an escapement monitoring project should either estimate total escapement for a particular stock, or provide an index of escapement that is consistent over time with respect to the fraction of the escapement that is enumerated, and the biological characteristics of the population (e.g., sex and age composition). To establish an escapement goal a long 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 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). Expanding the counting tower estimate by the average proportion spawning above the tower to obtain a total escapement estimate for the Gulkana River 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.

To determine the actual Chinook salmon escapement, an estimate of the sport harvest above the counting tower is required. The estimates of escapement assume negligible sport harvests occur above the counting tower. In 2002 and 2003, estimates of sport harvest from the Statewide Harvest Survey (SWHS) were reported for all waters upstream of Sourdough Landing to Paxson Lake (Jennings et. al 2006 *a-b*; Figure 1). This delineation was not adequate enough to determine the sport harvest above the counting tower. However, harvest above the tower was thought to be quite low compared to escapement. In 2004, the SWHS was modified to delineate two areas within this reach of the Gulkana River: Sourdough Landing to the West Fork confluence and the West Fork confluence to Paxson Lake. The estimated Chinook salmon harvest upstream of the West Fork was reported as zero in 2004, 306 in 2005, and 367 in 2006 (Jennings et al. 2007, in prep *a-b*). Unfortunately, it is possible that a portion of that harvest occurred downstream of the counting tower, between the West Fork and the tower site. In this situation, subtracting the SWHS harvest estimate from the escapement estimate would have led to underestimating escapement. In 2007, further delineation was identified as "ADF&G Tower to West Fork" and "Paxson Lake to ADF&G Tower." In 2007, the estimated harvest between the ADF&G Tower and the West Fork (i.e. downstream of the tower site) was 281 Chinook salmon, and the estimated harvest in the index area upstream of the counting tower, "Paxson Lake to ADF&G Tower," was 169 Chinook salmon (Jennings et al. in prep *c*). This harvest estimate represents 0.04 of the escapement estimated past the counting tower. The 2008 SWHS harvest estimate is not available at this time. These refinements to the SWHS will allow for adjustments to the counting tower escapement estimate in future years, if necessary.

Historically, fishery managers have lacked reliable Chinook salmon escapement data on the Gulkana River. Other than aerial surveys, the only other inseason information for fishery managers to use for evaluation of run size and escapement is anecdotal reporting from anglers and fishing guides who provide reports of effort, catch, harvest, and river conditions. Aerial surveys are conducted to evaluate peak Chinook salmon spawning. However, these surveys are considered to be index counts and not estimates of total escapement. The aerial surveys do provide some general distribution data for a particular season, and can provide a means to quantify anecdotal information from anglers and commercial fisherman regarding run timing and strength. Specific year counts can be compared to the historic average to provide an indication of relative run strength. However, the accuracy of these aerial index counts may be called into question because of the potentially high likelihood of bias from several factors, including variable weather and river conditions, timing of the survey flights relative to yearly variability in run timing, and consistency of and between specific observers.

Aerial index counts do not provide a consistent means of assessing the proportion of the escapement above the counting tower (Table 2). Four years (2003, 2004, 2006, and 2007) have very similar escapement estimates, but the range in the aerial counts for those years is similar to that of the low and high escapement estimate years (2005 and 2002). This results in a poor linear relationship between counting tower estimates and aerial index counts (Figure 5; coefficient of correlation, $r = 0.72$; p-value = 0.11). The proportion of the tower estimate counted by the aerial index survey each year ranges from 0.20 to 0.43 for all years flown (due to poor weather conditions during the flight window in 2008 there were no aerial index counts conducted on the Gulkana River).

The primary concern for area sport fish management is the need for a definitive guideline used 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. To establish this guideline, the date within the run that represented the time at which a majority (55%–75%) of the run had passed the counting tower was determined. The average date for those percentages of the run was also determined. 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 (Figure 7). For 2004, this date was 28 June (due to extremely low water which inhibited Chinook from moving further upriver to spawn), but for the remaining six years this date fell within the range of 9 July through 17 July, with an average date of 13 July. If the low escapement estimate for 2005 was dropped, the average estimate of Chinook salmon past the counting tower on 13 July was 3,614. This number and the date could potentially be examined as trigger values, which would indicate the need to restrict any further harvest of the Gulkana River stock. However, the sport fishery for Chinook salmon closes 19 July by regulation, and any emergency order reducing the bag limits or season would require at least one week's time to be processed. 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.

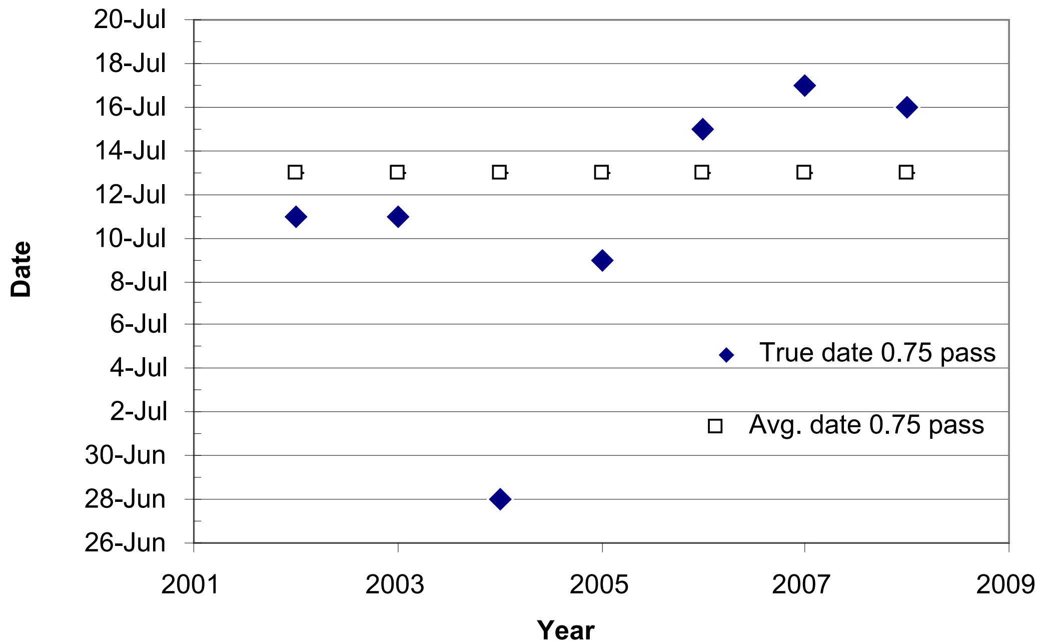


Figure 7.–True date of passage for 0.75 of the final yearly escapement estimate of Chinook salmon for each year compared to the average date for 0.75 of escapement (discounting 2004).

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 characteristics and how they impact Chinook salmon run timing and movements 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. Efforts should be made to establish triggers to identify when the appropriate flight window should be on a yearly basis.

ACKNOWLEDGEMENTS

Partial funding for this project was provided by the Bureau of Land Management (BLM) The authors wish to thank the ADF&G field crew: Ron Burr, Dustin Canniff, Mark Schlenker, Ben Tyler, and Bill Uptegraft, and the BLM student technicians Daniel Hjortstorp, Colton Johnson, Samantha Kramer, and Danae Roe who expertly collected data. Thanks go also to Elijah Waters, BLM, whose efforts were paramount to project funding and success, and Mike Sondergaard, BLM, for his ready and expert assistance with project logistics, especially river transport.

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APPENDIX A

Appendix A1.–Data files for the Chinook salmon escapement in the Gulkana River, 2007 and 2008 project.

Data file	Description
GulkanaTowerRawData_2007.xls	Raw data collected at Gulkana River Counting Tower, 2007.
GulkanaTower07_king.xls.	Data analysis on Chinook salmons counts collected at the Gulkana River Counting Tower, 2007.
GulkanaTower07_king.xls.	Data analysis on Chinook salmons counts collected at the Gulkana River Counting Tower, 2007.
GulkanaTowerRawData_2008.xls	Raw data collected at Gulkana River Counting Tower, 2008.
GulkanaTower08_sockeye.xls.	Data analysis on sockeye salmons counts collected at the Gulkana River Counting Tower, 2008.
GulkanaTower08_sockeye.xls.	Data analysis on sockeye salmons counts collected at the Gulkana River Counting Tower, 2008.

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, 2007. Shaded cells represent periods when interpolated counts were used.

	East Channel			West Channel			Total			Cumulative
Date	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Escapement
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	-1	-6	-6	0	0	0	-1	-6	-6	-6
10-Jun	0	0	0	2	12	12	2	12	12	6
11-Jun	3	18	18	1	6	6	4	24	24	30
12-Jun	0	0	0	2	12	12	2	12	12	42
13-Jun	0	0	0	3	18	18	3	18	18	60
14-Jun	0	0	0	11	66	66	11	66	66	126
15-Jun	0	0	0	0	0	0	0	0	0	126
16-Jun	0	0	0	8	48	48	8	48	48	174
17-Jun	0	0	0	1	6	6	1	6	6	180
18-Jun	0	0	0	5	30	30	5	30	30	210
19-Jun	0	0	0	6	36	36	6	36	36	246
20-Jun	1	6	6	14	84	84	15	90	90	336
21-Jun	0	0	0	14	84	***66***	14	84	***66***	***402***
22-Jun	0	0	0	10	60	60	10	60	60	***462***
23-Jun	0	0	0	20	120	120	20	120	120	***582***
24-Jun	0	0	0	28	168	168	28	168	168	***750***
25-Jun	0	0	0	15	90	90	15	90	90	***840***
26-Jun	2	12	12	17	102	102	19	114	114	***954***
27-Jun	0	0	0	51	306	306	51	306	306	***1,260***
28-Jun	0	0	0	41	246	***252***	41	246	***252***	***1,512***
29-Jun	0	0	0	52	312	312	52	312	312	***1,824***
30-Jun	0	0	0	28	168	168	28	168	168	***1,992***
1-Jul	0	0	0	15	90	90	15	90	90	***2,082***
2-Jul	0	0	0	22	132	132	22	132	132	***2,214***
3-Jul	0	0	0	12	72	72	12	72	72	***2,286***
4-Jul	0	0	0	8	48	***66***	8	48	***66***	***2,352***
5-Jul	0	0	0	14	84	84	14	84	84	***2,436***
6-Jul	1	6	6	8	48	48	9	54	54	***2,490***
7-Jul	1	6	6	5	30	30	6	36	36	***2,526***
8-Jul	0	0	0	2	12	12	2	12	12	***2,538***

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	East Channel			West Channel			Total			Cumulative
Date	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Escapement
9-Jul	0	0	0	6	36	36	6	36	36	***2,574***
10-Jul	0	0	0	5	30	30	5	30	30	***2,604***
11-Jul	0	0	0	1	6	6	1	6	6	***2,610***
12-Jul	0	0	0	6	36	36	6	36	36	***2,646***
13-Jul	0	0	0	12	72	72	12	72	72	***2,718***
14-Jul	0	0	0	25	150	150	25	150	150	***2,868***
15-Jul	0	0	0	31	186	***192***	31	186	***192***	***3,060***
16-Jul	0	0	0	34	204	***210***	34	204	***210***	***3,270***
17-Jul	0	0	0	22	132	132	22	132	132	***3,402***
18-Jul	0	0	0	28	168	168	28	168	168	***3,570***
19-Jul	-1	-6	-6	22	132	132	21	126	126	***3,696***
20-Jul	0	0	0	22	132	132	22	132	132	***3,828***
21-Jul	-1	-6	-6	11	66	66	10	60	60	***3,888***
22-Jul	2	12	12	18	108	108	20	120	120	***4,008***
23-Jul	0	0	0	7	42	42	7	42	42	***4,050***
24-Jul	1	6	6	13	78	78	14	84	84	***4,134***
25-Jul	0	0	0	9	54	54	9	54	54	***4,188***
26-Jul	1	6	6	6	36	36	7	42	42	***4,230***
27-Jul	0	0	0	4	24	24	4	24	24	***4,254***
28-Jul	1	6	6	5	30	30	6	36	36	***4,290***
29-Jul	2	12	12	0	0	0	2	12	12	***4,302***
30-Jul	1	6	6	2	12	12	3	18	18	***4,320***
31-Jul	0	0	0	2	12	12	2	12	12	***4,332***
1-Aug	1	6	6	0	0	0	1	6	6	***4,338***
2-Aug	1	6	6	-1	-6	-6	0	0	0	***4,338***
3-Aug	5	30	30	2	12	12	7	42	42	***4,380***
4-Aug	4	24	24	-2	-12	-12	2	12	12	***4,392***
5-Aug	4	24	24	1	6	6	5	30	30	***4,422***
6-Aug	0	0	0	0	0	0	0	0	0	***4,422***
7-Aug	0	0	0	0	0	0	0	0	0	***4,422***
8-Aug	0	0	0	0	0	0	0	0	0	***4,422***
9-Aug	0	0	0	0	0	0	0	0	0	***4,422***
10-Aug	-1	-6	-6	1	6	6	0	0	0	***4,422***
11-Aug	-1	-6	-6	0	0	0	-1	-6	-6	4,416
12-Aug	0	0	0	0	0	0	0	0	0	4,416
Totals	25	150	150	704	4,224	4,242	729	4,374	4,392	

[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.

Appendix B2.–Daily counts[a] and expanded counts, including interpolations[b], and the cumulative estimated escapement of Chinook salmon at the Gulkana River tower, 2008. Shaded cells represent periods when interpolated counts were used.

	East Channel			West Channel			Total			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	1	6	6	1	6	6	6
9-Jun	0	0	0	1	6	6	1	6	6	12
10-Jun	0	0	0	0	0	0	0	0	0	12
11-Jun	0	0	0	2	12	12	2	12	12	24
12-Jun	0	0	0	4	24	24	4	24	24	48
13-Jun	1	6	6	0	0	0	1	6	6	54
14-Jun	1	6	6	3	18	18	4	24	24	78
15-Jun	2	12	12	5	30	30	7	42	42	120
16-Jun	1	6	6	11	66	66	12	72	72	192
17-Jun	2	12	12	13	78	78	15	90	90	282
18-Jun	0	0	0	20	120	120	20	120	120	402
19-Jun	0	0	0	15	90	90	15	90	90	492
20-Jun	1	6	6	7	42	42	8	48	48	540
21-Jun	3	18	18	13	78	78	16	96	96	636
22-Jun	2	12	12	19	114	114	21	126	126	762
23-Jun	3	18	18	4	24	24	7	42	42	804
24-Jun	1	6	6	3	18	18	4	24	24	828
25-Jun	0	0	***12***	0	0	***34***	0	0	***46***	***874***
26-Jun	0	0	***8***	0	0	***46***	0	0	***54***	***928***
27-Jun	1	6	***12***	3	18	***60***	4	24	***72***	***1,000***
28-Jun	1	6	6	10	60	60	11	66	66	***1,066***
29-Jun	0	0	0	1	6	6	1	6	6	***1,072***
30-Jun	0	0	0	8	48	48	8	48	48	***1,120***
1-Jul	0	0	0	10	60	60	10	60	60	***1,180***
2-Jul	0	0	0	5	30	30	5	30	30	***1,210***
3-Jul	2	12	12	24	144	144	26	156	156	***1,366***
4-Jul	0	0	0	10	60	60	10	60	60	***1,426***
5-Jul	11	66	66	42	252	252	53	318	318	***1,744***
6-Jul	7	42	42	26	156	156	33	198	198	***1,942***

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	East Channel			West Channel			Total			Cumulative
Date	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Escapement
7-Jul	3	18	18	8	48	48	11	66	66	***2,008***
8-Jul	0	0	***26***	0	0	***116***	0	0	***142***	***2,150***
9-Jul	0	0	***37***	0	0	***100***	0	0	***137***	***2,288***
10-Jul	0	0	***29***	0	0	***94***	0	0	***123***	***2,410***
11-Jul	0	0	***23***	0	0	***62***	0	0	***85***	***2,496***
12-Jul	2	12	***6***	1	6	***34***	3	18	***40***	***2,535***
13-Jul	9	54	54	6	36	36	15	90	90	***2,625***
14-Jul	4	24	24	8	48	48	12	72	72	***2,697***
15-Jul	2	12	12	4	24	24	6	36	36	***2,733***
16-Jul	6	36	36	2	12	***18***	8	48	***54***	***2,787***
17-Jul	1	6	6	2	12	12	3	18	18	***2,805***
18-Jul	1	6	6	2	12	12	3	18	18	***2,823***
19-Jul	4	24	24	4	24	24	8	48	48	***2,871***
20-Jul	0	0	0	4	24	24	4	24	24	***2,895***
21-Jul	1	6	6	0	0	0	1	6	6	***2,901***
22-Jul	1	6	6	4	24	24	5	30	30	***2,931***
23-Jul	1	6	6	1	6	6	2	12	12	***2,943***
24-Jul	0	0	0	1	6	6	1	6	6	***2,949***
25-Jul	8	48	48	9	54	54	17	102	102	***3,051***
26-Jul	4	24	24	18	108	108	22	132	132	***3,183***
27-Jul	2	12	12	9	54	54	11	66	66	***3,249***
28-Jul	2	12	12	4	24	24	6	36	36	***3,285***
29-Jul	0	0	***27***	-1	-6	***35***	-1	-6	***61***	***3,346***
30-Jul	0	0	***26***	0	0	***32***	0	0	***58***	***3,404***
31-Jul	0	0	***27***	0	0	***32***	0	0	***58***	***3,462***
1-Aug	0	0	***20***	0	0	***31***	0	0	***50***	***3,513***
2-Aug	0	0	***16***	0	0	***24***	0	0	***40***	***3,553***
3-Aug	-1	-6	***15***	0	0	***11***	-1	-6	***25***	***3,578***
4-Aug	14	84	84	0	0	***4***	14	84	***88***	***3,666***
5-Aug	0	0	0	-1	-6	***0***	-1	-6	***0***	***3,666***
6-Aug	1	6	6	1	6	6	2	12	12	***3,678***
7-Aug	0	0	0	0	0	0	0	0	0	3,678
8-Aug	0	0	0	0	0	0	0	0	0	3,678
9-Aug	0	0	0	0	0	0	0	0	0	3,678
10-Aug	0	0	0	0	0	0	0	0	0	3,678
Totals	1,044	624	895	346	2,076	2,783	450	2,700	3,678	

[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.

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, 2007. Shaded cells represent periods when interpolated counts were used.

	East Channel			West Channel			Total			Cumulative
Date	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Escapement
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	5	30	30	5	30	30	30
11-Jun	3	18	18	16	96	96	19	114	114	144
12-Jun	0	0	0	26	156	156	26	156	156	300
13-Jun	9	54	54	41	246	***240***	50	300	***294***	***594***
14-Jun	2	12	12	75	450	***366***	77	462	***378***	***972***
15-Jun	0	0	0	41	246	246	41	246	246	***1,218***
16-Jun	0	0	0	32	192	186	32	192	186	1,404
17-Jun	0	0	0	48	288	288	48	288	288	***1,692***
18-Jun	0	0	0	51	306	306	51	306	306	***1,998***
19-Jun	2	12	12	40	240	240	42	252	252	***2,250***
20-Jun	1	6	6	87	522	522	88	528	528	***2,778***
21-Jun	0	0	0	207	1,242	***1,254***	207	1,242	***1,254***	***4,032***
22-Jun	3	18	18	103	618	***624***	106	636	***642***	***4,674***
23-Jun	0	0	0	66	396	396	66	396	396	***5,070***
24-Jun	0	0	0	101	606	606	101	606	606	***5,676***
25-Jun	0	0	0	107	642	642	107	642	642	***6,318***
26-Jun	0	0	0	90	540	540	90	540	540	***6,858***
27-Jun	0	0	0	207	1,242	1,242	207	1,242	1,242	***8,100***
28-Jun	0	0	0	107	642	642	107	642	642	***8,742***
29-Jun	0	0	0	235	1,410	1,410	235	1,410	1,410	***10,152***
30-Jun	1	6	6	53	318	318	54	324	324	***10,476***
1-Jul	0	0	0	47	282	282	47	282	282	***10,758***
2-Jul	0	0	0	67	402	402	67	402	402	***11,160***
3-Jul	0	0	0	91	546	546	91	546	546	***11,706***
4-Jul	0	0	0	62	372	***444***	62	372	***444***	***12,150***
5-Jul	0	0	0	130	780	780	130	780	780	***12,930***
6-Jul	0	0	0	76	456	***462***	76	456	***462***	***13,392***
7-Jul	0	0	0	25	150	150	25	150	150	***13,542***
8-Jul	0	0	0	20	120	120	20	120	120	***13,662***

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	East Channel			West Channel			Total			Cumulative
Date	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Escapement
9-Jul	0	0	0	32	192	192	32	192	192	***13,854***
10-Jul	0	0	0	69	414	414	69	414	414	***14,268***
11-Jul	2	12	12	35	210	210	37	222	222	***14,490***
12-Jul	0	0	0	34	204	204	34	204	204	***14,694***
13-Jul	0	0	0	14	84	84	14	84	84	***14,778***
14-Jul	0	0	0	78	468	468	78	468	468	***15,246***
15-Jul	1	6	6	160	960	***966***	161	966	***972***	***16,218***
16-Jul	0	0	0	105	630	***636***	105	630	***636***	***16,854***
17-Jul	3	18	18	89	534	534	92	552	552	***17,406***
18-Jul	4	24	24	135	810	810	139	834	834	***18,240***
19-Jul	0	0	0	97	582	582	97	582	582	***18,822***
20-Jul	-1	-6	-6	182	1,092	1,092	181	1,086	1,086	***19,908***
21-Jul	8	48	48	120	720	***726***	128	768	***774***	***20,682***
22-Jul	7	42	42	161	966	966	168	1,008	1,008	***21,690***
23-Jul	0	0	0	76	456	456	76	456	456	***22,146***
24-Jul	5	30	30	105	630	630	110	660	660	***22,806***
25-Jul	0	0	0	117	702	***708***	117	702	***708***	***23,514***
26-Jul	4	24	24	100	600	600	104	624	624	***24,138***
27-Jul	2	12	12	83	498	498	85	510	510	***24,648***
28-Jul	4	24	24	46	276	276	50	300	300	***24,948***
29-Jul	0	0	0	67	402	402	67	402	402	***25,350***
30-Jul	4	24	24	152	912	912	156	936	936	***26,286***
31-Jul	1	6	6	69	414	414	70	420	420	***26,706***
1-Aug	2	12	12	79	474	474	81	486	486	***27,192***
2-Aug	4	24	24	68	408	408	72	432	432	***27,624***
3-Aug	14	84	84	113	678	678	127	762	762	***28,386***
4-Aug	11	66	66	71	426	426	82	492	492	***28,878***
5-Aug	8	48	48	40	240	240	48	288	288	***29,166***
6-Aug	12	72	72	32	192	192	44	264	264	***29,430***
7-Aug	6	36	36	11	66	66	17	102	102	***29,532***
8-Aug	8	48	48	27	162	162	35	210	210	***29,742***
9-Aug	10	60	60	29	174	174	39	234	234	***29,976***
10-Aug	1	6	6	32	192	192	33	198	198	***30,174***
11-Aug	3	18	18	36	216	216	39	234	234	***30,408***
12-Aug	1	6	6	26	156	156	27	162	162	***30,570***
Totals	145	870	870	4,946	29,676	29,700	5,091	30,546	30,570	

[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.

Appendix C2.–Daily counts[a] and expanded daily counts, with interpolations[b], and the cumulative estimate of sockeye salmon minimum escapement at the Gulkana River tower, 2008. Shaded cells represent periods when interpolated counts were used.

	East Channel			West Channel			Total			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	12	72	72	12	72	72	72
9-Jun	5	30	30	31	186	186	36	216	216	288
10-Jun	2	12	12	14	84	84	16	96	96	384
11-Jun	1	6	6	10	60	60	11	66	66	450
12-Jun	0	0	0	3	18	18	3	18	18	468
13-Jun	5	30	30	17	102	102	22	132	132	600
14-Jun	8	48	48	17	102	102	25	150	150	750
15-Jun	13	78	78	25	150	150	38	228	228	978
16-Jun	11	66	66	28	168	***156***	39	234	***222***	***1,200***
17-Jun	8	48	48	59	354	354	67	402	402	***1,602***
18-Jun	6	36	36	40	240	240	46	276	276	***1,878***
19-Jun	6	36	36	36	216	216	42	252	252	***2,130***
20-Jun	6	36	36	52	312	312	58	348	348	***2,478***
21-Jun	9	54	54	79	474	474	88	528	528	***3,006***
22-Jun	7	42	42	62	372	372	69	414	414	***3,420***
23-Jun	6	36	36	15	90	90	21	126	126	***3,546***
24-Jun	15	90	90	27	162	162	42	252	252	***3,798***
25-Jun	0	0	***52***	0	0	***130***	0	0	***182***	***3,980***
26-Jun	0	0	***42***	8	48	***136***	8	48	***178***	***4,158***
27-Jun	2	12	***30***	9	54	***138***	11	66	***168***	***4,326***
28-Jun	1	6	6	18	108	108	19	114	114	***4,440***
29-Jun	1	6	6	3	18	18	4	24	24	***4,464***
30-Jun	1	6	6	3	18	18	4	24	24	***4,488***
1-Jul	0	0	0	6	36	36	6	36	36	***4,524***
2-Jul	0	0	0	9	54	54	9	54	54	***4,578***
3-Jul	2	12	12	66	396	396	68	408	408	***4,986***
4-Jul	1	6	6	46	276	276	47	282	282	***5,268***
5-Jul	1	6	6	23	138	138	24	144	144	***5,412***
6-Jul	6	36	36	48	288	288	54	324	324	***5,736***

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	East Channel			West Channel			Total			Cumulative
Date	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Daily	Expanded	Interpolated	Escapement
7-Jul	15	90	***96***	21	126	***132***	36	216	***228***	***5,964***
8-Jul	0	0	***29***	0	0	***229***	0	0	***258***	***6,222***
9-Jul	0	0	***37***	0	0	***178***	0	0	***215***	***6,437***
10-Jul	0	0	***40***	0	0	***167***	0	0	***207***	***6,644***
11-Jul	0	0	***40***	0	0	***173***	0	0	***212***	***6,856***
12-Jul	0	0	0	0	0	***164***	0	0	***164***	***7,020***
13-Jul	8	48	48	23	138	***144***	31	186	***192***	***7,212***
14-Jul	3	18	18	15	90	90	18	108	108	***7,320***
15-Jul	6	36	36	35	210	210	41	246	246	***7,566***
16-Jul	3	18	18	81	486	***228***	84	504	***246***	***7,812***
17-Jul	4	24	24	41	246	246	45	270	270	***8,082***
18-Jul	3	18	18	44	264	264	47	282	282	***8,364***
19-Jul	7	42	42	24	144	144	31	186	186	***8,550***
20-Jul	3	18	18	37	222	222	40	240	240	***8,790***
21-Jul	8	48	48	14	84	84	22	132	132	***8,922***
22-Jul	3	18	18	19	114	114	22	132	132	***9,054***
23-Jul	11	66	66	55	330	330	66	396	396	***9,450***
24-Jul	6	36	36	48	288	288	54	324	324	***9,774***
25-Jul	5	30	30	40	240	240	45	270	270	***10,044***
26-Jul	8	48	48	26	156	156	34	204	204	***10,248***
27-Jul	5	30	30	20	120	120	25	150	150	***10,398***
28-Jul	2	12	12	2	12	12	4	24	24	***10,422***
29-Jul	1	6	***35***	1	6	***166***	2	12	***201***	***10,623***
30-Jul	0	0	***30***	0	0	***158***	0	0	***188***	***10,811***
31-Jul	0	0	***31***	0	0	***116***	0	0	***146***	***10,957***
1-Aug	0	0	***26***	0	0	***80***	0	0	***105***	***11,062***
2-Aug	0	0	***19***	0	0	***50***	0	0	***68***	***11,131***
3-Aug	0	0	***15***	0	0	***30***	0	0	***45***	***11,175***
4-Aug	4	24	24	0	0	***15***	4	24	***39***	***11,214***
5-Aug	5	30	30	11	66	66	16	96	96	***11,310***
6-Aug	7	42	42	6	36	***48***	13	78	90	***11,400***
7-Aug	-1	-6	-6	-1	-6	-6	-2	-12	-12	***11,388***
8-Aug	0	0	0	0	0	0	0	0	0	***11,388***
9-Aug	0	0	0	0	0	0	0	0	0	***11,388***
10-Aug	0	0	0	0	0	0	0	0	0	***11,388***
Totals	239	1,434	1,846	1,328	7,968	9,542	1,567	9,402	11,388	

[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.