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Chinook Salmon Escapement in the Gulkana River, 2002

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

Symbols and Abbreviations

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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

During 2002, the first year of a five-year project conducted by the Alaska Department of Fish and Game with the Bureau of Land Management, a counting tower was installed on the mainstem Gulkana River, approximately 2.5 km upstream of the West Fork, to estimate Chinook salmon *Oncorhynchus tshawytscha* escapement. These counts, in conjunction with information gained from a radio-telemetry project performed throughout the Copper River drainage, were used to estimate the escapement for the Gulkana River. A long-term goal of the project is to establish an escapement goal for Chinook salmon entering the Gulkana River.

Fish passage observations were conducted during ten minutes of each hour from June 7 to August 9. Ninety-five percent of the observations were made with water conditions sufficient for observing all passing fish; counts for the remaining monitoring periods were interpolated from these data. On average, approximately 80% of the daily passage occurred between 2400 and 0600 hours and this diurnal pattern was used in the interpolation procedure. The escapement past the counting tower was estimated as 6,355 (SE = 318) Chinook salmon, the proportion of Chinook salmon escaping above the counting tower was estimated as 0.81 (SE = 0.08), and the escapement of Chinook salmon in the entire Gulkana River was estimated as 7,869 (SE = 862).

Angler-catch, carcass, and seine sampling methods were performed to obtain age-sex-length data for the Chinook salmon escapement. Samples were obtained from a total of 155 salmon; 26 from angler-catch, 129 from carcass, and 0 from seine. Scale resorption in the carcass samples contributed to a low ageing rate (24%). All Chinook salmon handled were inspected for clipped-adipose fins, which would have indicated the possible presence of a coded-wire-tag; but no adipose-clipped individuals were found.

During the period that counts were performed for Chinook salmon, sockeye salmon *Oncorhynchus nerka* passage was also recorded. These counts represented only a portion of the run, because the sockeye salmon run typically precedes and continues well beyond that of Chinook salmon. The escapement of sockeye salmon upstream of the tower site, from June 7 to August 9, was estimated at 30,066 fish (SE = 1,367).

Key words: Chinook salmon, *Oncorhynchus tshawytscha,* sockeye salmon, *Oncorhynchus nerka*, Copper River, Gulkana River, counting tower, radio telemetry, age-sex-length, coded-wire-tag.

INTRODUCTION

The Gulkana River (Figure 1) supports one of the two largest Chinook salmon *Oncorhynchus tshawytscha* sport fisheries in the Copper River drainage (Taube 2002). Over the last ten years, both effort and harvest have increased substantially in the Gulkana River fishery (Taube 2002). In addition to direct harvest from the inriver sport fishery, the Gulkana River Chinook salmon stock is subject to harvest in the mixed stock commercial marine fishery and the in-river subsistence and personal use fisheries of the Copper River. Similar to the Gulkana River sport fishery harvest, these mixed stock fisheries have also shown a trend of increased harvest over the past ten years (Sharp et al. 2000; Taube 2002). The combined annual harvest of these fisheries warrants active management for Chinook salmon of the Gulkana River and the Copper River drainage.

Historically, fishery managers have lacked reliable Chinook salmon escapement data on the Gulkana River and other Copper River tributaries. A sonar station is operated annually in the lower Copper River near Miles Lake, but does not provide Chinook salmon escapement data due to a predominance of sockeye salmon *Oncorhynchus nerka* concurrently in the river and an inherent inability for species-specific counts. Aerial surveys are conducted to evaluate peak Chinook salmon escapement in select spawning tributaries; however, information from these surveys are considered to be index counts that are not an estimation of actual escapement. In addition, the accuracy of these aerial index counts are questionable because of the relatively high likelihood of bias from several factors, such as variable weather and river conditions, timing of

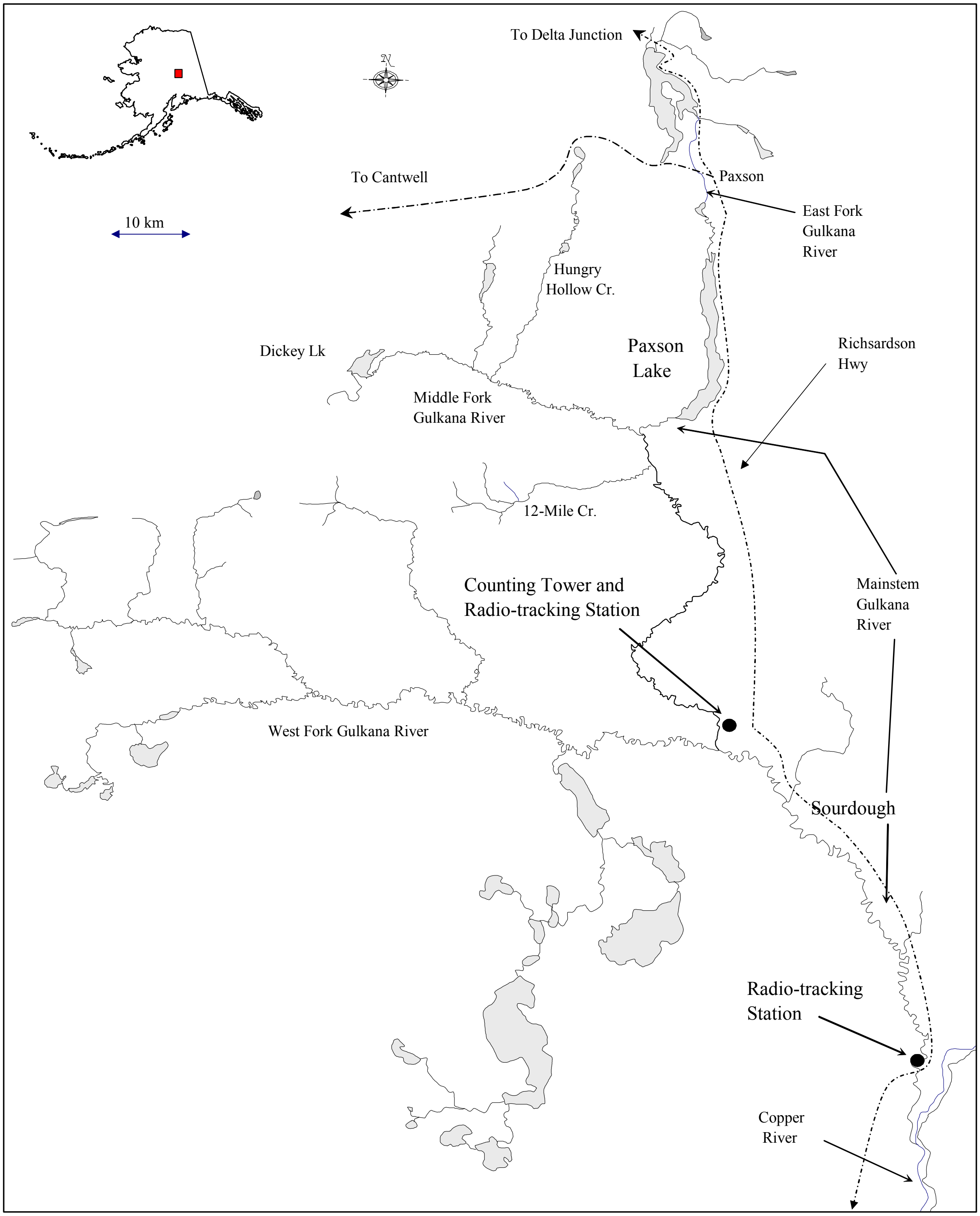

Figure 1.-The Gulkana River drainage and location of the counting tower**.**

the survey relative to run timing, and differences in observer detection probabilities. The Alaska Department of Fish and Game (ADF&G) operated a weir in the Gulkana River downstream of the West Fork in 1996 (LaFlamme 1997) to estimate the escapement of Chinook salmon. Based on the weir count and a concurrent creel survey, the inriver return was estimated as 13,840 Chinook salmon and the spawning escapement was estimated as 11,399 Chinook salmon. However, the weir was discontinued after the single year of use, in part due to impacts related to the high-level public use of the river (T. Taube, Sport Fish Biologist, ADF&G, Glennallen; personal communication). Given the harvest demands placed on this stock, a reliable means of estimating escapement was needed to effectively manage the fisheries.

In 2002 a cooperative salmon counting tower project between ADF&G and the Bureau of Land Management (BLM) led to the installation of a tower on the Gulkana River to estimate Chinook salmon escapement. The Gulkana River was selected because a high proportion of the total Copper River drainage Chinook salmon run is comprised of this stock, sport fishing effort and harvest are high (Taube 2000), access is relatively good, and the upper reaches are clear-water. The tower site was located on the mainstem approximately 2.5 km upstream of the West Fork on an island that divides the river into two channels. The location was selected to monitor as much of the Chinook salmon escapement in the Gulkana River as feasible while remaining upstream of the West Fork, which periodically discharges turbid water, creating conditions that prohibit visual observation of fish (T. Taube, Sport Fish Biologist, ADF&G, Glennallen; personal communication).

This project, in conjunction with the Copper River Chinook salmon radio-telemetry project (Evenson and Wuttig 2000; Wuttig and Evenson 2001; Savereide and Evenson 2002; Savereide 2003), offered the opportunity to estimate: 1) the proportion of Chinook salmon escaping in the Gulkana River that spawn above the tower; and, 2) the Chinook salmon escapement for the entire Gulkana River. A long-term goal of this project is the establishment of an escapement goal for Chinook salmon in the Gulkana River.

OBJECTIVES

The objectives of this study were to:

1. estimate the escapement of Chinook salmon upstream of a point in the mainstem Gulkana River, approximately 2.5 km upstream of the West Fork, using tower counting techniques such that the estimates were within 15% of the actual value 95% of the time;
2. estimate the proportion of Chinook salmon escaping in the Gulkana River that spawn above the tower site, using radio telemetry tracking techniques, such that the estimated proportion was within 15 percentage points of the true proportion 90% of the time; and,
3. estimate the escapement of Chinook salmon in the Gulkana River such that the estimate was within 25% of the true estimate 90% of the time.

Additional project tasks were to:

1. evaluate the effectiveness of a variety of methods for collecting age, sex, and length data for the escapement of Chinook salmon in the Gulkana River;
2. screen all Chinook salmon handled during sampling efforts for clipped adipose fins, maintain a log of the number screened, and label and obtain the heads of those missing adipose fins for coded wire tag inspection; and,
3. count sockeye salmon passage at the tower site during the period of project operation.

METHODS

ESCAPEMENT OF CHINOOK SALMON PAST THE COUNTING TOWER

Design

The number of Chinook salmon returning to an index area in the mainstem Gulkana River was estimated by counting fish as they passed a tower counting station located approximately 2.5 km upstream of the confluence with the West Fork. Based on past aerial survey observations, it was thought that the majority of spawning in the Gulkana River drainage occurs upstream of this site (T. Taube, Sport Fish Biologist, ADF&G, Glennallen; personal communication). However, it has been difficult to accurately assess the proportion of the escapement spawning downstream from the tower site because visibility and counting conditions in the West Fork and in the Gulkana River downstream from the West Fork are typically poor during aerial surveys.

Chinook salmon abundance past the tower counting station is equal to escapement only if there is no harvest above the tower site. While this is not strictly true, the harvest above the tower is thought to be insignificant relative to the number of fish migrating past the tower and the uncertainty associate with the abundance estimate. This assumption is evaluated by comparing the State Wide Harvest Survey (SWHS) harvest estimate for 2002 with the counting tower abundance estimate.

Two three-person crews conducted 10-minute counts for each of two river channels every hour, every day from June 6 until August 13, 2002. 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 and channel.

Sampling Methods

Two scaffolding platform towers were installed on the island at the tower site to view both (east and west) channels. Adjacent to each tower, a continuous band of light-colored vinyl panels, approximately 3 m wide, was anchored to the river bottom across the width of each channel in order to make fish more visible and provide a well-defined manner of delineating passage. During late summer nights and other periods of low ambient light, a string of floodlights suspended at platform height were used to illuminate the panels across the entirety of each channel. The lighting remained on between counts to maintain consistent conditions and thus reduce any effects that lighting changes may have had on salmon passage rates. The start time for all counts for the west channel began between the top of the hour and 10 minutes past. The 10-min count of the east channel immediately followed the count on the west channel.

Data Collection

Numbers of Chinook salmon and sockeye salmon counted were tallied and recorded on count forms at the end of each count. Recorded data included numbers of Chinook and sockeye salmon counted in each river channel, date and time of monitoring period, and name of counter. Passage both upstream and downstream was recorded to provide a net upstream passage during 10-min counts for the entire width of the river. Identifiable passage of steelhead and rainbow trout were also tallied and recorded. Observers were trained to distinguish between Chinook salmon, sockeye salmon, steelhead and rainbow trout based on body size, shape, and coloration. In addition, at the beginning of each hour, water level (relative level on staff gauge), and water clarity were recorded. The observers evaluated water clarity as described in Table 1. Water temperature was recorded at the beginning of each work-shift, at 0600, 1400 and 2200 hours each day. All data were recorded onto data forms and transferred into an Excel spreadsheet for data analysis and archival (Appendix D).

Table 1.–Water clarity classification scheme.

Rank	Description	Fish Viewing	Water Condition
1	Excellent	All passing fish are observable	Very low turbidity, very low glare, all routes of passage observable.
2	Good	All passing fish are observable	Low turbidity or low glare, all routes of passage observable.
3	Fair	All passing fish are observable	Moderate turbidity or glare, all routes of passage observable.
4	Poor	Some passing fish may be missed	Moderate to high turbidity or glare, some likely routes of passage obscured.
5	Un-observable	Passing fish are not observable	High turbidity or glare, all routes of passage obscured.

Data Analysis

Salmon escapement was estimated using equations 1, 3, 4, and 5 taken directly or modified from those provided in Cochran (1977) and equation 2 taken from Wolter (1985). The expanded shift passage for day *d* in channel *c* was calculated as:

$$\hat{N}_{dc} = Y_{dc} = \frac{M_{dc}}{m_{dc}} \sum_{j=1}^{m_{dc}} y_{dcj} \,. \tag{1}$$

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

$$s_{dc}^2 = \frac{1}{2(m_{dc}-1)} \sum_{j=2}^{m_{dc}} \left(y_{dcj} - y_{dc(j-1)}\right)^2 \,. \tag{2}$$

The variance for the expanded daily passage was estimated as:

$$\hat{V}\left(\hat{N}_{dc}\right) = \left(1 - \frac{m_{dc}}{M_{dc}}\right) M_{dc}^2 \frac{s_{dc}^2}{m_{dc}} \,. \tag{3}$$

Passage for the entire run past the tower site and its associated variance was estimated as:

$$\hat{N}_{PT} = \sum_{d=1}^{D}\sum_{c=1}^{C}\hat{N}_{dc} \text{ ; and,} \tag{4}$$

$$\hat{V}\left(\hat{N}_{PT}\right) = \sum_{d=1}^{D}\sum_{c=1}^{C}\hat{V}(\hat{N}_{dc}). \tag{5}$$

Where:

c = river channel;

d = day;

j = 10-min counting period;

y = observed period count;

Y = expanded shift passage;

m = number of 10-min counting periods sampled;

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

C = total number of river channels; and,

D = total number of possible days.

Poor water clarity led to possible undercounting during about 5% of the monitoring periods. When undercounting was suspected (water quality values of 4 or 5) the following steps were performed to identify and adjust for this potential source of bias. For days having some periods with water conditions 4 or 5, counts were estimated for those periods using known counts for that day and the diurnal relationship. Expansions based on the diurnal pattern were determined to be reliable provided at least some counts were successfully conducted during the period of peak passage. If counts were conducted successfully for a portion of the day that represented 25% or more of the expected daily passage (as defined by the diurnal relationship), and if at least 25% of the periods during peak passage (again, defined by the diurnal relationship) were successfully counted, the interpolated count(s) were calculated as the product of the successful counts and the ratio of the expected daily passage not represented to the expected daily passage that was represented.

$$y_{dc,\text{interp}} = y_{dc,\text{actual}} \times \frac{1 - p_{edp}}{p_{edp}} \tag{6}$$

where:

y = observed period count, interpolated or actual; and

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

The interpolated counts were then allocated among all the missed 10-minute counts based on the diurnal pattern. For example, if four hours of counting were missed (four 10-minute counts) and the interpolated count for that period was 20 Chinook salmon, those 20 fish would be allocated to each of the four missed 10-minute counts in proportions defined by the diurnal pattern. Daily abundance was calculated with equation 1 using a combination of actual and interpolated counts. 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 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 were not used for estimation). When interpolating based on the diurnal pattern, daily variances were calculated with equations 2 and 3 using actual and interpolated counts. This approach was used because interpolations using the diurnal pattern were few (see Results). If such interpolations had been more than infrequent, the possibility that daily variances may have been significantly underestimated would have been evaluated; and, if that had been the case, an alternate method of analysis would have been selected (e.g., one which uses multiple imputation methods). Interpolations were performed on each channel separately.

When counts for *k* consecutive days were suspected as biased due to adverse viewing conditions (water clarity = 4 or 5), the moving average estimate for the missing day *i* was calculated as:

$$\hat{N}_i = \frac{\sum_{j=i-k}^{i+k} I(day\, j \;\; was\; effectively\; sampled)\hat{N}_j}{\sum_{j=i-k}^{i+k} I(day\, j \;\; was\; effectively\; sampled)} \tag{7}$$

where:

$$I(\cdot) = \begin{cases} 1 & when\; the\; condition\; is\; true \\ 0 & otherwise \end{cases} \tag{8}$$

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*.

The Total Escapement of Chinook Salmon in the Gulkana River and the Proportion that Spawned above the Counting Tower

Design

The total escapement of Chinook salmon it the Gulkana River and the proportion that spawned above the counting tower site were estimated using data collected from radio-tagged Chinook salmon released in the mainstem Copper River in a separate study (Savereide 2003). In the mainstem Copper River study, approximately 500 Chinook salmon were radio-tagged throughout the run in the lower Copper River approximately 135 km downstream from the Gulkana River. Radio tags were recorded entering the Gulkana River by a ground-based radio tracking station placed near the mouth of the river. Radio tagged Chinook salmon entering the Gulkana River were carefully tracked to determine if they migrated above counting tower. In addition, the exact fate (i.e., harvested, expelled tag, or spawned) of all fish failing to migrate above the tower was determined. It was assumed that all radio-tagged Chinook salmon migrating past the tower site spawned. Technically, “migrating past the tower” cannot be equated to “spawning above the tower” because some harvest occurs above the counting tower. The number of radio-tagged Chinook salmon migrating above the tower, however, was insufficient to provide an unbiased estimate of the proportion harvested above the tower. This was in large part due to the low level of harvest above the counting tower and it will be shown that the level of harvest in 2002 translated into an insignificant bias in the estimate of escapement.

Sampling Methods

Fates and distribution of radio-tagged fish were assessed using a combination of ground-based tracking stations, aerial tracking flights, and boat tracking surveys. Two tracking stations were placed on the Gulkana River. One was placed near the Richardson Highway Bridge, and the second at the counting tower (Figure 1). Aerial tracking flights were conducted between late June and late August to survey the entire Gulkana River drainage. Boat tracking surveys were then performed to more precisely locate the tags between the counting tower and the Richardson Highway Bridge and to determine if the tagged fish were dead or alive, or if the tag had been expelled before migrating to a spawning area.

Data Collection

Each of the two radio-tracking stations was comprised of the following integrated components: two marine deep cycle batteries, a solar array, an ATS[1] model 5041 Data Collection Computer (DCC II); an ATS model 4000 receiver, an antenna switching box, housing, and two elevated Yagi antennas. The receiver and DCC II were programmed to scan through the frequencies at 3 s intervals, receiving with both antennas simultaneously, and pausing for 5 s at which time the tag frequency, code, signal strength, date, time, and antenna number were recorded by the data logger for all signals of sufficient strength. Data from each station were downloaded to a laptop computer at least once every 7-10 days with use of PROCOM PLUS software provided by the manufacturer.

During aerial tracking surveys, all frequencies were loaded into the receiver/scanner prior to each flight. Dwell time on each frequency was 2 s. Flight altitude ranged from 100-300 m above ground. Two antennas, one on each wing strut, were mounted such that the antennas received signals perpendicular to the direction of travel. Flights followed along the course of the river as much as possible. Once a tag was identified, its frequency, code, and location from a GPS receiver on the aircraft were recorded.

The fates of those radio-tagged fish identified as located between the counting tower and the Richardson Highway Bridge during aerial surveys were determined during boat tracking surveys. A small, outboard-powered riverboat idled downstream while scanning for tags. The approximate locations of the radio tags were known from the aerial survey. Once a radio signal from a tagged fish was encountered, attempts were made to locate the fish. This was accomplished by one person holding a receiver (with a variable gain control) and an H-antenna while a second person navigated the boat as close as possible to the tag. When possible, a visual sighting of the tag, either in a live fish (if an external Floy tag was visible), in a carcass, or expelled into the river, was made. If the tag was not sighted, attempts were made to prompt movement of the fish by driving the boat repeatedly over the area where the loudest signal was heard. If the tagged fish was dead, or if the tag was expelled into the river, attempts were made to recover the tag. Long-handled spears were used to retrieve carcasses from the river bottom, and long-handled dipnets were used to recover tags lying on the river bottom. Data were recorded for every radio-tagged fish located during the boat-tracking excursions.

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[1] Advanced Telemetry Systems, Isanti, Minnesota. Use of this company name does not constitute endorsement, but is included for scientific completeness.

Data Analysis

Each radio-tagged fish that entered the Gulkana River was assigned one of five distinct fates (Table 2).

Table 2.–Description of fates of radio-tagged Chinook salmon migrating into the Gulkana River.

Fate		Description
1	Migrant above tower site.	A radio-tagged fish that migrated past the counting tower and was either logged by the tower site radio-tracking station or located during an aerial survey.
2	Spawner below tower site.	A radio-tagged fish that was located downstream from the counting tower AND was verified from boat tracking as a fish that successfully spawned. Includes radio-tagged fish located in the West Fork during an aerial survey.
3	Harvest below tower site.	A radio-tagged fish harvested in the sport fishery below the counting tower.
4	Expelled tag below tower site.	A radio tag that was located downstream from the counting tower AND was verified from boat tracking as having been expelled. A fish with an expelled tag may also be identified as having been harvested via a returned Floy tag, in which case, it was assigned Fate 3.
5	Natural mortality below tower site.	A radio-tagged fish not located above the counting tower AND that was verified from boat tracking as a fish that died. Evidence of having spawned results in an assignment of Fate 2 rather than Fate 5.

The proportion of Chinook salmon spawning in the Gulkana River that spawned above the counting tower site and its variance were estimated as described in Cochran (1977):

$$\hat{p}_{PT} = \frac{n_{PT}}{n_{GR}} \tag{9}$$

$$\hat{V}[\hat{p}_{PT}] = \frac{\hat{p}_{PT}(1-\hat{p}_{PT})}{(n_{GR}-1)} \tag{10}$$

where:

n_{PT} = the number of radio tagged Chinook salmon that migrated past the counting tower (Table 2, Fate 1); and,

n_{GR} = the number of radio-tagged Chinook salmon that migrated past the counting tower AND the number that entered the Gulkana River that did not expel tags or die prior to spawning below the counting tower (Table 2, Fates 1 and 2).

The number of Chinook salmon escaping into the Gulkana River was estimated by expanding the estimate of abundance from the tower counts by the estimated proportion of escaping Chinook salmon that migrated past the tower site:

$$\hat{N}_{total} = \frac{\hat{N}_{PT}}{\hat{p}_{PT}} \tag{11}$$

where:

$\hat{N}_{PT}$ = the number of Chinook salmon estimated past the counting tower; and,

$\hat{p}_{PT}$ = the estimated proportion of Chinook salmon escaping in the Gulkana River that migrated past the counting tower.

The variance of the total abundance was estimated using Goodman's (1960) formula for an exact variance of a product:

$$\hat{V}\left[\hat{N}_{total}\right]=\left(\frac{1}{\hat{p}_{PT}}\right)^2\left(\hat{V}\left[\hat{N}_{PT}\right]\right)+\left(\hat{N}_{PT}\right)^2\left(\hat{V}\left[\frac{1}{\hat{p}_{PT}}\right]\right)-\left(\hat{V}\left[\frac{1}{\hat{p}_{PT}}\right]\right)\left(\hat{V}\left[\hat{N}_{PT}\right]\right) \qquad (12)$$

where:

$\hat{V}\left[\hat{N}_{PT}\right]$ = variance of the estimate of Chinook salmon passing the counting tower (equation 5), and

$$\hat{V}\left(\frac{1}{\hat{p}_{PT}}\right) \approx \frac{1}{\hat{p}_{PT}^4}\hat{V}\left(\hat{p}_{PT}\right) \qquad (13)$$

by the delta method (Seber 1982).

AGE-SEX-LENGTH COMPOSITION OF THE CHINOOK SALMON ESCAPEMENT

Design

The effectiveness of various sampling techniques for collecting age, sex, and length data for the escapement of Chinook salmon in the Gulkana River was evaluated. Sampling methods included angler catch sampling, carcass retrieval, and seining. Because the true population compositions were not known, the effectiveness of a particular sampling method could not be evaluated directly as biased or unbiased. Instead, sampling methods were considered effective if:

1) the method yielded, or showed the potential to yield, a large number of useful samples per unit effort; and,
2) all age classes in the population were represented in the sample.

Estimates of age and sex composition in the Gulkana River were expected to be similar to those of the inriver return (estimated from the Copper River Chinook salmon telemetry project). Thus, sampling methods yielding samples lacking one or more age classes, were considered as having the potential for being selective.

Methods

Angler catches were sampled in various locations from the Sourdough Campground to the counting tower site. Fish that were caught-and-released were sampled, as were those that were harvested. Carcass samples were obtained upstream of the tower by spear or dipnet. Collected carcasses were cut diagonally along the left side of the body after they had been sampled to ensure that they were not sampled twice. Seining efforts were planned to target fish that were concentrated in holding areas between the counting tower and Sourdough Campground and on upriver spawning grounds if suitable conditions were located. These efforts were to begin if and when fish were found to be present in sufficient numbers. Information from boat, ground, and aerial surveys were used to evaluate the suitability of conditions for seining. Seining was to be limited to weekdays and areas where sport anglers were not present.

Data Collection

Regardless of the sampling method, each fish was examined to determine sex and measured from mid-eye to fork-of-tail (MEF). Three scales were removed and placed directly on gummed cards for later age interpretation. Scales were removed from the preferred area on the left side approximately two rows above the lateral line along a diagonal line downward from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (Welander 1940). Ages were determined from the interpretation of scale patterns by staff of the ADF&G, Commercial Fisheries Division of the Cordova office.

In addition, each fish sampled was inspected for a clipped adipose fin, which would have indicated the possible presence of a coded-wire tag. Heads from carcasses or post-spawned fish found to be missing the adipose fin were to be labeled and preserved for later dissection and inspection for tags.

ESCAPEMENT OF SOCKEYE SALMON ABOVE THE COUNTING TOWER

Sockeye salmon that migrated past the tower were also counted and the number of sockeye migrating past the tower during the experiment was estimated. Because the sockeye salmon run was in progress (to a limited degree) before counting began and was known to continue well beyond that of Chinook salmon, the escapement estimate reflects only a portion of the total run. Procedures were identical to those described for estimating the Chinook salmon escapement past the tower.

RESULTS

ESCAPEMENT OF CHINOOK SALMON ABOVE THE COUNTING TOWER

The Chinook salmon escapement above the tower site was estimated at 6,355 (SE = 318) fish, exceeding precision expectations. Daily escapement counts are provided in Appendix A. The first complete day of counting was June 7. Counting was attempted through August 13; however, periods of heavy rains created viewing conditions that were too poor to accurately count fish after August 9. The first Chinook salmon was observed passing by the counting tower during a counting period on June 12 and 1,005 Chinook salmon were counted moving past the tower through August 9. Directly expanding these 10 min counts to the entire hour resulted in an estimated 6,030 Chinook salmon. However, this figure does not account for interpolations for periods with poor and unobservable conditions. Approximately 5% of the scheduled counts, during the period of June 7 through August 9, were conducted under poor or unobservable conditions (Figure 2) and were considered missing.

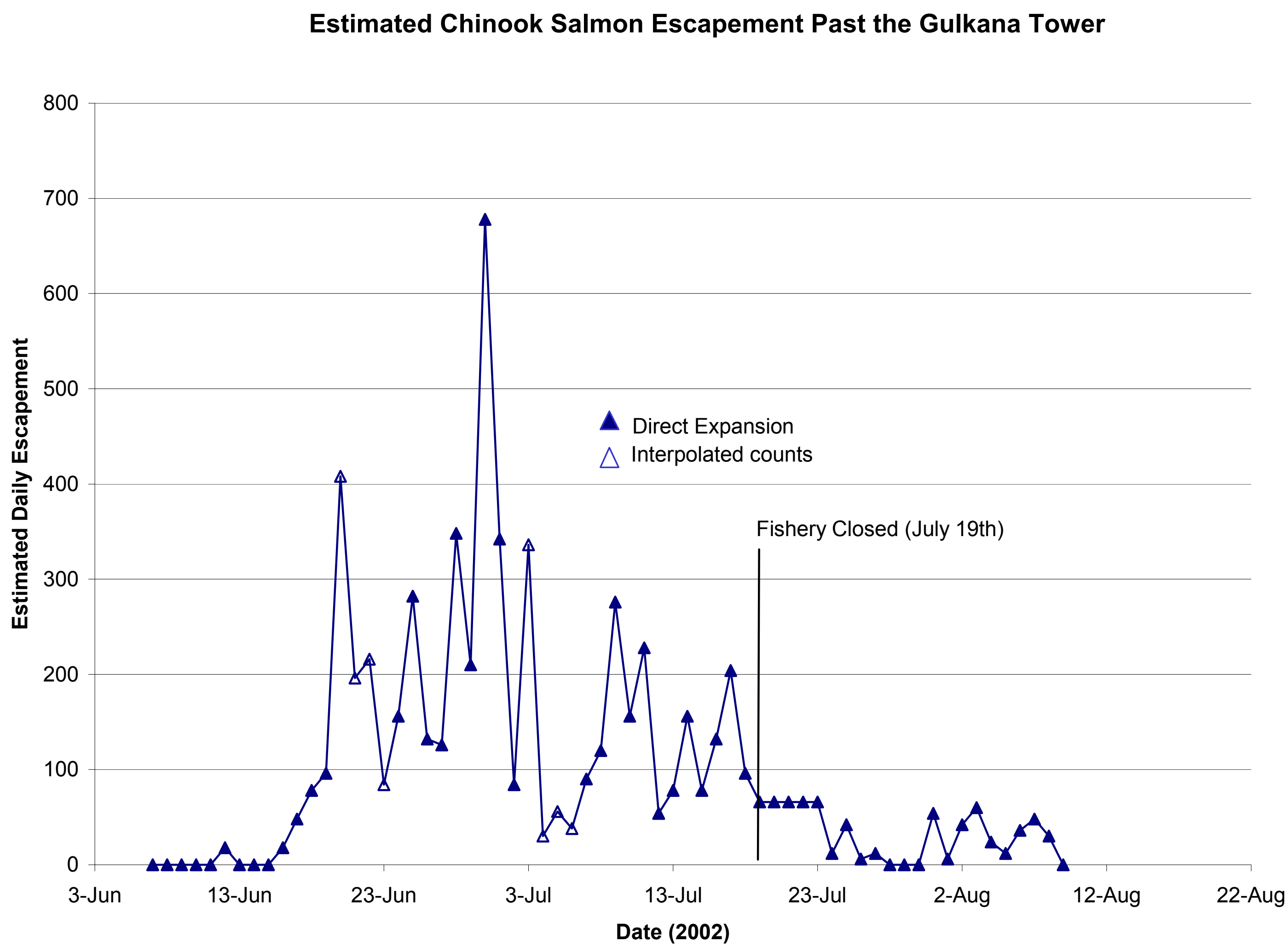

Figure 2.–Estimated daily escapement of Chinook salmon migrating past the Gulkana River counting tower, 2002.

A distinct diurnal migratory pattern was observed that was consistent between both river channels and throughout the span of the run. On average, approximately 80% of the daily passage occurred between 2400 and 0600 hours (Figure 3). Only a small proportion of the missing counts satisfied the criteria established for interpolating using the diurnal pattern. As a result, the bias introduced using the interpolated counts directly when calculating the daily variance rather than using an alternative method (e.g., multiple imputation techniques) was negligible.

The Total Escapement of Chinook Salmon in the Gulkana River and the Proportion that Spawned above the Counting Tower

The proportion of escaping Chinook salmon that migrated above the counting tower was estimated as 0.81 (SE = 0.08) and total escapement of Chinook salmon in the entire Gulkana River was estimated as 7,869 (SE = 862). These estimates met precision expectations. Distribution and fates of radio tagged fish in the Gulkana River are provided in Table 3.

Age-Sex-Length Composition of the Chinook Salmon Escapement

A total of 155 Chinook salmon were sampled for age-sex-length information (Table 4; Appendix B). Sample sizes and their distribution throughout the run were insufficient to consider these data representative of the population of Chinook salmon returning to the Gulkana River; therefore, catch statistics rather then population parameter estimates are provided.

Angler catch sampling obtained scale samples from 26 fish. Of these, scale quality was sufficient for the age interpretation of 18 individuals (69%). Carcass sampling efforts obtained scales from 129 fish; however, due to relatively high resorption rates, ages could be interpreted for only 31 individuals (24.0%). No samples were obtained from seining efforts. Of the 49 individuals with age data 90% were age 1.3, and 10% were age 1.4. No fish with other ages were noted. A chi-square test performed on the 2x2 contingency table indicated that the age composition of the angler catch and carcass samples differed at the 92% confidence level (P-value = 0.072) with the carcass sample having a greater proportion of age 1.4 fish. A chi-square test performed on the 2x2 contingency table indicated no significant difference between the sex composition of the carcass and angler-catch samples (P-value = 0.68). The sex composition of the combined samples was 61% male and 39% female. A chi-square test also indicated no significant difference in the size composition between the carcass and the angler-catch samples (P-value = 0.45, df = 9; Figure 4). Of the 155 Chinook salmon sampled, none were found to be missing the adipose fin, which could have indicated the presence of a coded-wire tag.

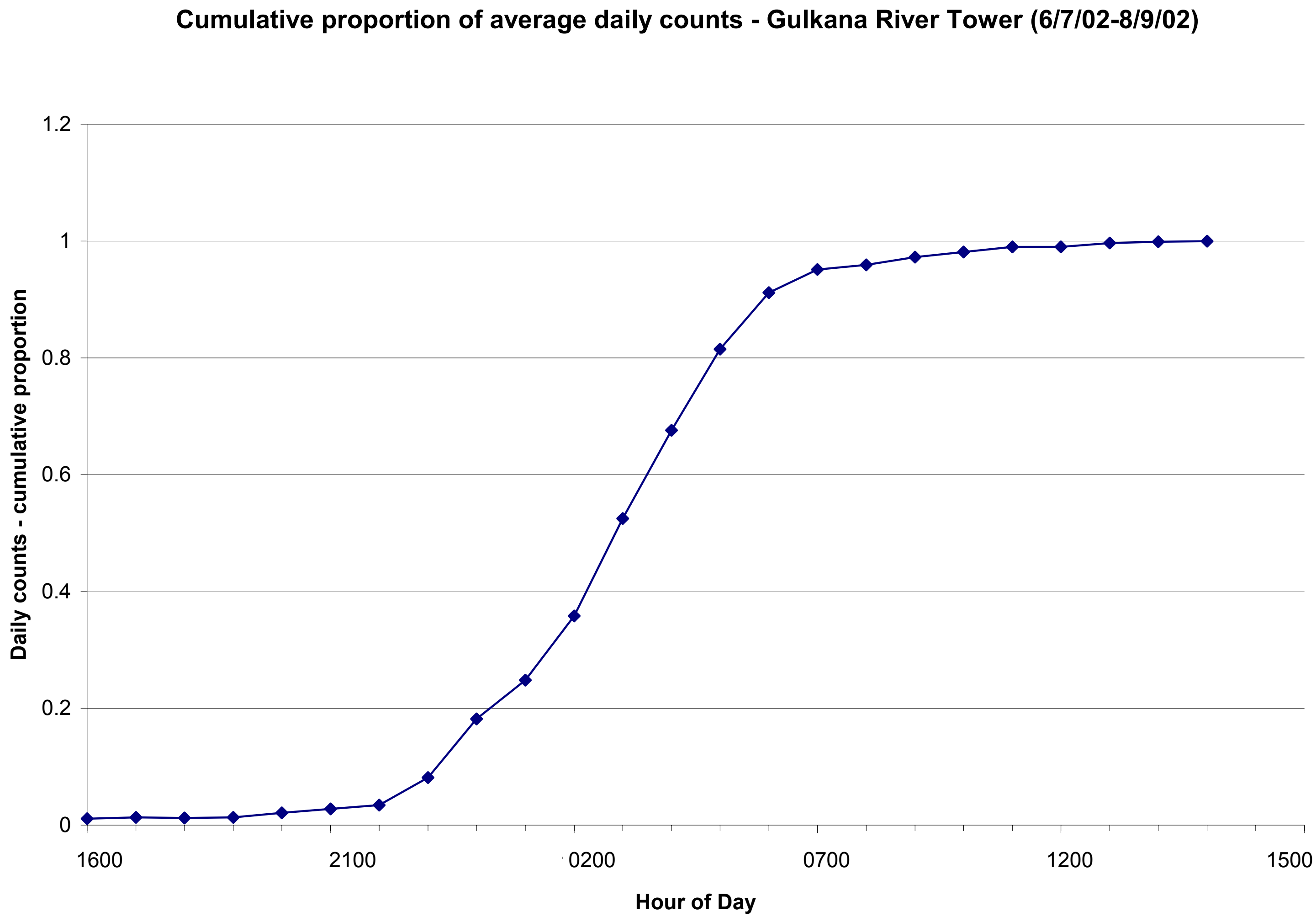

Figure 3.–Cumulative proportion of average daily counts by hour of day for Chinook salmon migrating past the Gulkana River counting tower, 2002.

Table 3.–Fates of radio-tagged Chinook salmon entering the Gulkana River, 2002.

Fate	Number of Salmon
Migrants into Gulkana River	49
Harvested below tower site (Fate 3)[a]	8
Expelled tag below tower site (Fate 4)[a]	15
Natural mortality below tower site (Fate 5)[a]	0
Total Spawners	26
Migrants above the tower (Fate 1)	21
Spawner below the tower (Fate 2)	5

[a] Not used for estimation of total escapement of Chinook salmon in the Gulkana River or the proportion that spawned above the counting tower.

Table 4.–Results of sampling methods aimed at obtaining age-sex-length data for Gulkana River Chinook salmon, 2002.

Method	Approx. Effort [a] (man-hrs)	Number Collected	Interpreted Scales (Number)	Interpreted Scales (%)	Percent Male	Percent Female	Average Length (mm)
Angler Catch	50	26	18	69	58	42	813
Carcass	120	129	31	24	62	38	830
Seine	20	0	0	--	--	--	--
Total	190	155	49	26	61	39	827

[a] Estimate of the number of man-hours of effort that was expended on each method, including time spent scouting for conditions suitable for each method.

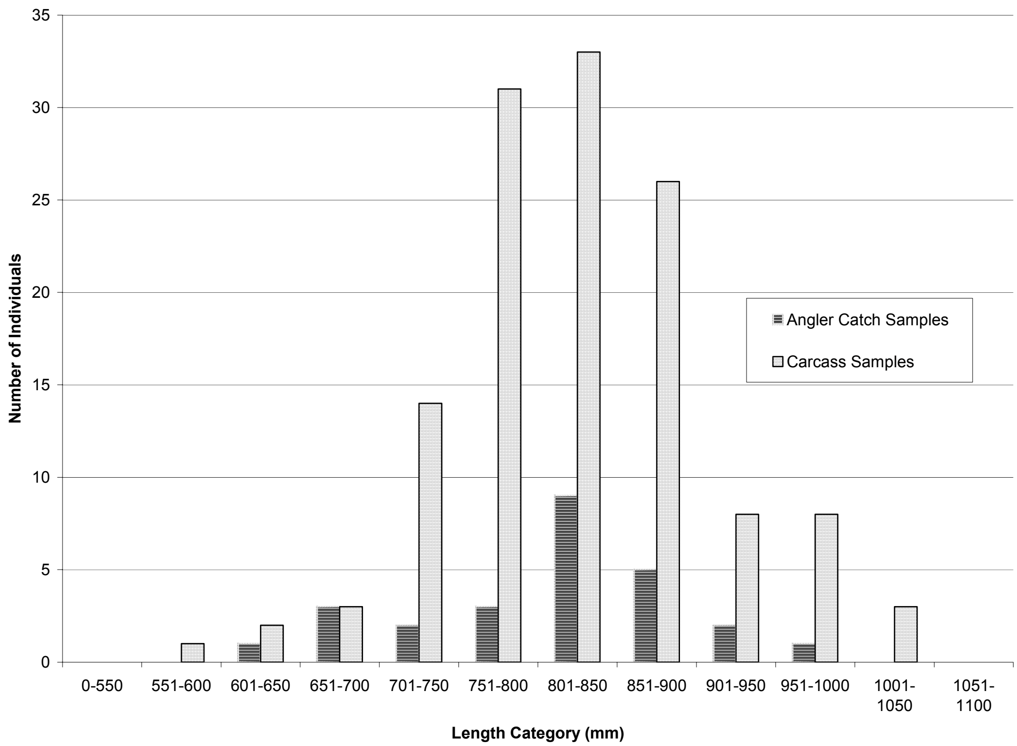

Figure 4.–Length composition of Chinook salmon in the carcass and angler catch samples.

The angler catch was sampled from mid-June through mid-July. Sampling occurred in various areas between the Sourdough launch and the tower site. Carcass sampling was conducted beginning in late July, when carcasses first became available. Throughout the latter portion of the season, efforts were made to locate carcasses from the vicinity of the tower downstream to the Sourdough Boat Launch. In addition, a crew of two persons conducted a five-day float trip from Paxson Lake to Sourdough and three partial-day boat sampling trips were attempted from Sourdough to the tower site in mid-August. Conditions were not considered reasonable for seining efforts. The presence of anglers was unavoidable in most of the areas where fish were holding. In an aerial survey, fish were observed upstream of the tower site in a suitable number and concentration; however, a follow-up ground survey indicated that the river bottom at this location contained boulders that would prevent effective seining. Seining was attempted by the crew in the vicinity of the tower on fish that were observed in numbers of less than ten, but this effort was not successful.

ESCAPEMENT OF SOCKEYE SALMON PAST THE TOWER

The sockeye salmon escapement above the tower site during 7 June – 9 August was estimated at 30,066 fish (SE = 1,367; Figure 5). The sum of the direct expansions (i.e., before interpolations for periods with poor and unobservable conditions) was 28,428 sockeye salmon (Appendix C).

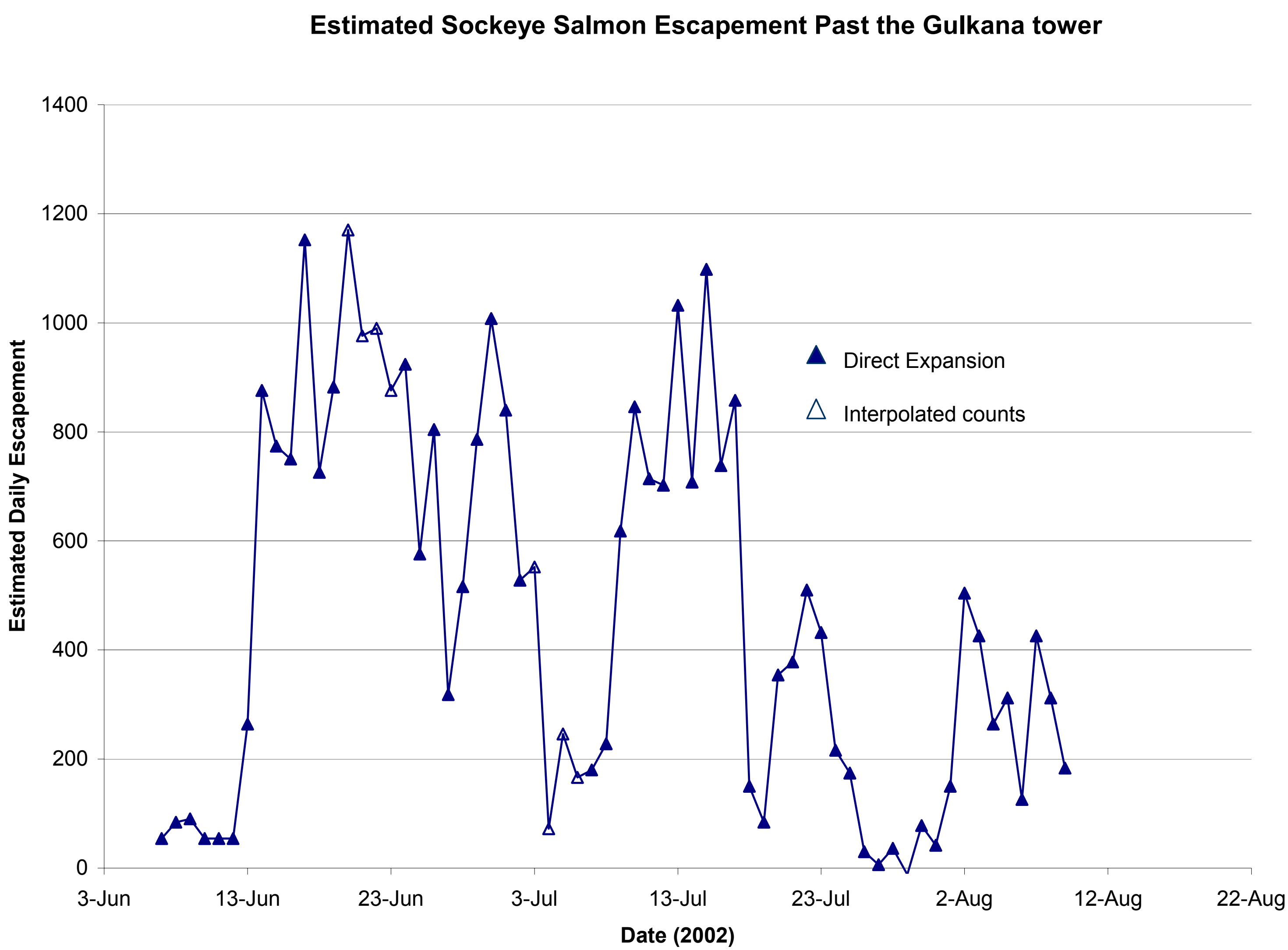

Figure 5.–Estimated daily escapement of sockeye salmon migrating past the Gulkana River counting tower, 2002.

DISCUSSION

The long-term goal of this project is to collect data necessary to establish an escapement goal for Chinook salmon in the Gulkana River. Escapement goals are the foundation of salmon management in Alaska and are established following guidelines given in the *Policy for the Management of Sustainable Salmon Fisheries* (AAC 2003a) and the *Policy for Statewide Salmon Escapement Goals* (AAC 2003b). These policies define two types of goals that ADF&G can establish: biological escapement goals (BEG) and sustainable escapement goals (SEG). A BEG is a range around the estimated escapement that on average provides for maximum sustained yield. BEGs require a relatively long time series of escapement and total return estimates, which are derived from run reconstruction and development of brood tables. Hence, in addition to escapement estimates, stock-specific estimates of catch from the mixed stock fisheries (commercial, subsistence, and personal use) are needed to estimate total return of Gulkana River Chinook from a given brood year escapement.

This study showed that it may be difficult to obtain unbiased age and sex composition estimates of the annual returns in the Gulkana River (escapement and sport harvest), which are also needed to estimate total brood year returns for the purpose of establishing a BEG. While angler catch sampling holds some potential for obtaining a representative sample of the sport harvest (provided sufficient resources are allocated to effectively sample the most popular angler access points), the sample may not accurately reflect the composition of the escapement. Efforts to seine Chinook salmon in prespawning holding areas were compromised by high concentrations of sport anglers or by unsuitable river conditions in areas where concentrations of Chinook salmon were observed. Therefore, it does not appear that seining would be a reliable and efficient means of sampling the escapement. Carcass sampling, though conducted under less than optimal conditions (i.e., high water), indicated that sufficient numbers of carcasses could be sampled in most years to estimate sex and age composition. This conclusion is supported by work conducted in 1998 (Evenson *unpublished*). In addition, it may be that the high rate of scale resorption encountered in this study (76%) can be lowered by improved scale selection and sampling techniques, as the percentage of readable scales was much higher in the 1998 study (Evenson *unpublished*). However, even if a large sample can be collected, relying on carcass sampling to obtain sex and age composition estimates may be problematic because carcass samples have been shown to lead to biased composition estimates (Stuby 2001). The lack of age 1.2 fish in this sample and the fact that 62% of the samples collected were female is consistent with the bias noted in the carcass sampling reported by Stuby (2001). Typically, five age classes (ages 3-8) are present in the annual return of Copper River Chinook salmon (Savereide 2001) and the probability that this sample, by chance alone, contained only the two age classes was exceedingly small.

Because there is no project underway to estimate stock-specific harvests in the mixed stock fishery and because of difficulties encountered in this study to determine a reliable method to estimate age and sex composition of the escapement, the data being collected from this study will most likely be used to develop an SEG instead of a BEG. An SEG is a range of escapements indicated by an estimate of escapement or an escapement index that is known to provide for sustained yield over a five to ten year period. Because the counting tower is located upstream from some of the known spawning areas (e.g., West Fork Gulkana River), the counts do not provide a total estimate of escapement. In this study, estimation of total Gulkana River abundance was possible because of information regarding distribution of spawning fish above and below the tower site garnered from the mainstem Copper River radiotelemetry project. The telemetry project is scheduled to continue through 2004 thus providing three consecutive estimates of the proportion of the escapement spawning above the tower site. These estimates should allow for a reasonable determination of whether the tower counts provide a consistent index of total escapement.

While the information regarding the distribution of radio-tagged fish above and below the tower site is useful in interpreting the proportion of the escapement enumerated at the tower, there is potentially some error associated with this estimate and therefore, the estimate of escapement for the entire river, which is not accounted for in the variance calculations. These estimates are strongly dependent on the determinations of the fate of radio-tagged fish remaining in the mainstem Gulkana River. Of the 49 radio-tagged fish known to enter the Gulkana River, 15 were identified as having expelled their tag below the tower site and were not included in estimating the proportion of escaping Chinook salmon that passed the tower. The assessment of fate, however, for two of these tags was not known with 100% certainty. While it was determined with a high degree of confidence that these tags were most likely non spawners, had these two fish been mainstem spawners, then the proportion of spawners past the tower would decrease from 0.81 (SE = 0.08) to 0.75 (SE = 0.08), and the escapement estimate would increase from 7,869 (SE = 862) to 8,474 (SE = 1,031). This scenario illustrates that it is critical to accurately assess all fates. Future studies should include more frequent boat-tracking surveys ("ground truthing") throughout the spawning season and, if possible, placement of additional tracking stations is the lower river to more accurately monitor movements.

In addition, the estimate for escapement above the counting tower assumed negligible harvest above the tower. The Statewide Harvest Survey (SWHS) estimated that 659 fish were harvested between Paxson and Sourdough in 2002 (Jennings *in prep*) of which 10% or less was thought to be harvested above the tower site (T. Taube, Sport Fish Biologist, ADF&G, Glennallen; personal communication). This level of harvest translates to a bias of ~1% (= 66 fish) in an estimate of 6,355 fish (SE = 318), which is considered an insignificant level of bias. In order for the bias to approach the standard error of the estimate, nearly 50% of the fish harvested between Paxson and Sourdough would have to have been harvested above the tower site. This apportionment of the harvest is considered unrealistic (T. Taube, Sport Fish Biologist, ADF&G, Glennallen; personal communication).

Aerial surveys have been conducted to monitor peak Chinook salmon escapement in the Gulkana River since 1969. However, the proportion of fish observed during aerial surveys in Alaskan river systems has been shown to be quite variable due to the influence of many factors including: weather and river conditions, timing of the survey, observer skill level, and the abundance and distribution of fish (Bevan 1961; Jones et al. 1998). Although the inherent uncertainties in aerial survey counts render expansion by this method inferior to the method used in this study, gaining an understanding of the variability in the proportion of the escapement counted during aerial surveys has merit for interpreting past aerial survey counts. The aerial survey count of 2,087 in 2002 represented 26% of the total escapement. The only other estimate of Chinook salmon escapement in the Gulkana River, independent of aerial survey counts, was a weir count in 1996 (LaFlamme 1997). The weir was located downstream from Sourdough Launch and enumerated a total escapement of 11,399 Chinook salmon. The peak aerial survey conducted in 1996 counted 2,297 fish (above the weir) or 20% of the total escapement.

RECOMMENDATIONS

No major modifications to the design of the study are recommended. Should the diurnal pattern of migration occur again in 2003, consideration could be given to changing the sampling design to lessen staff requirements while still achieving precision objectives.

Because the efforts to evaluate various sampling techniques for collected age, sex, and length data did not lead to the development of a reliable method, and because of our inability to identify the run of origin for the mixed stock Copper River return, these data are of limited use for run reconstruction, and it is recommend that this task be removed from future years efforts.

The efforts to assess the fate of radio-tagged fish spawning downstream from the tower site should be continued until the completion of the mainstem Copper River radiotelemetry study to evaluate the consistency of using the tower counts as an index of total abundance.

Because this is a long-term project the SWHS should be modified to report harvest above and below the counting tower site (or the West Fork) to adjust the abundance estimated above the counting tower for harvest. This modification would be particularly important if the harvest above the counting tower begins to increase relative to the number of fish migrating above the tower.

Aerial survey counts at peak escapement should be continued, when weather and water conditions allow, to investigate the relationship between aerial counts and total escapement.

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APPENDIX A

Appendix A.–Daily passage[a, b] of Chinook salmon at the Gulkana River tower site, 2002.

	East Channel			West Channel			Total			Season
Day	10-Min. Count	Expanded Count	Interpolations Included	10-Min. Count	Expanded Count	Interpolations Included	10-Min. Count	Expanded Count	Interpolations Included	Cumulative Estimate
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	0	0	0	0	0	0	0
12-Jun	3	18	18	0	0	0	3	18	18	18
13-Jun	0	0	0	0	0	0	0	0	0	18
14-Jun	0	0	0	0	0	0	0	0	0	18
15-Jun	0	0	0	0	0	0	0	0	0	18
16-Jun	0	0	0	3	18	18	3	18	18	36
17-Jun	0	0	0	8	48	48	8	48	48	84
18-Jun	1	6	6	12	72	72	13	78	78	162
19-Jun	0	0	0	16	96	96	16	96	96	258
20-Jun	3	18	***0***	71	426	***408***	74	444	***408***	***666***
21-Jun	1	6	***2***	5	30	***194***	6	36	***196***	***862***
22-Jun	0	0	***4***	5	30	***212***	5	30	***216***	***1,078***
23-Jun	1	6	6	13	78	78	14	84	84	***1,162***
24-Jun	1	6	6	25	150	150	26	156	156	***1,318***
25-Jun	2	12	12	45	270	270	47	282	282	***1,600***
26-Jun	1	6	6	21	126	126	22	132	132	***1,732***
27-Jun	0	0	0	21	126	126	21	126	126	***1,858***
28-Jun	1	6	6	57	342	342	58	348	348	***2,206***
29-Jun	3	18	18	32	192	192	35	210	210	***2,416***
30-Jun	38	228	228	75	450	450	113	678	678	***3,094***
1-Jul	5	30	30	52	312	312	57	342	342	***3,436***
2-Jul	0	0	0	14	84	84	14	84	84	***3,520***
3-Jul	3	18	***24***	52	312	312	55	330	***336***	***3,856***
4-Jul	0	0	0	4	24	***30***	4	24	***30***	***3,886***
5-Jul	0	0	***8***	8	48	48	8	48	***56***	***3,942***
6-Jul	1	6	***2***	6	36	36	7	42	***38***	***3,980***
7-Jul	0	0	0	15	90	90	15	90	90	***4,070***
8-Jul	1	6	6	19	114	114	20	120	120	***4,190***
9-Jul	4	24	24	42	252	252	46	276	276	***4,466***
10-Jul	11	66	66	15	90	90	26	156	156	***4,622***
11-Jul	10	60	60	28	168	168	38	228	228	***4,850***
12-Jul	0	0	0	9	54	54	9	54	54	***4,904***
13-Jul	0	0	0	13	78	78	13	78	78	***4,982***
14-Jul	2	12	12	24	144	144	26	156	156	***5,138***
15-Jul	3	18	18	10	60	60	13	78	78	***5,216***
16-Jul	0	0	0	22	132	132	22	132	132	***5,348***
17-Jul	4	24	24	30	180	180	34	204	204	***5,552***
18-Jul	1	6	6	15	90	90	16	96	96	***5,648***
19-Jul	4	24	24	7	42	42	11	66	66	***5,714***
20-Jul	3	18	18	8	48	48	11	66	66	***5,780***
21-Jul	2	12	12	9	54	54	11	66	66	***5,846***
22-Jul	3	18	18	8	48	48	11	66	66	***5,912***
23-Jul	2	12	12	9	54	54	11	66	66	***5,978***
24-Jul	2	12	12	0	0	0	2	12	12	***5,990***
25-Jul	2	12	12	5	30	30	7	42	42	***6,032***
26-Jul	1	6	6	0	0	0	1	6	6	***6,038***
27-Jul	3	18	18	-1	-6	-6	2	12	12	***6,050***

-continued-

Appendix A.–Page 2 of 2.

Day	East Channel 10-Min. Count	East Channel Expanded Count	East Channel Interpolations Included	West Channel 10-Min. Count	West Channel Expanded Count	West Channel Interpolations Included	Total 10-Min. Count	Total Expanded Count	Total Interpolations Included	Season Cumulative Estimate
28-Jul	0	0	0	0	0	0	0	0	0	***6,050***
29-Jul	-1	-6	-6	1	6	6	0	0	0	***6,050***
30-Jul	-3	-18	-18	3	18	18	0	0	0	***6,050***
31-Jul	7	42	42	2	12	12	9	54	54	***6,104***
1-Aug	2	12	12	-1	-6	-6	1	6	6	***6,110***
2-Aug	-1	-6	-6	8	48	48	7	42	42	***6,152***
3-Aug	2	12	12	8	48	48	10	60	60	***6,212***
4-Aug	0	0	0	4	24	24	4	24	24	***6,236***
5-Aug	0	0	0	2	12	12	2	12	12	***6,248***
6-Aug	0	0	0	6	36	36	6	36	36	***6,284***
7-Aug	0	0	0	8	48	48	8	48	48	***6,332***
8-Aug	0	0	0	5	30	30	5	30	30	***6,362***
9-Aug	0	0	0	-1	-6	-7	-1	-6	-7	***6,355***
TOTAL	128	768	760	877	5,262	5,595	1,005	6,030	6,355	***6,355***

[a] Negative values represent downstream passage.

[b] Shading indicates days with interpolated values that are shown in bold italics when different from expanded count.

APPENDIX B

Appendix B.–Age-sex-length data from the Gulkana River Chinook salmon escapement, 2002.

Card #	Sample	Age	Age Errors	Length	Sex	Date	Location	Method
1	1	1.3		820	F	6/26/02	Above West Fork	Sport catch
1	2		Illegible	870	F	6/26/02	Above West Fork	Sport catch
1	3	1.3		870	M	6/26/02	Above West Fork	Sport catch
1	4	1.3		800	M	6/26/02	Above West Fork	Sport catch
1	5	1.3		830	M	6/26/02	Above West Fork	Sport catch
1	6	1.3		845	M	6/26/02	Above West Fork	Sport catch
1	7	1.3		920	F	6/26/02	Above West Fork	Sport catch
1	8	1.3		840	F	6/26/02	Above West Fork	Sport catch
1	9		Illegible	845	F	6/26/02	Above West Fork	Sport catch
1	10	1.3		760	F	6/26/02	Above West Fork	Sport catch
2	1	1.3		880	M	7/1/02	Above West Fork	Sport catch
3	1		Resorbed	650	F	7/3/02	Above West Fork	Sport catch
3	2	1.3		840	M	7/3/02	Above West Fork	Sport catch
3	3	1.3		890	M	7/3/02	Above West Fork	Sport catch
3	4	1.3		830	M	7/3/02	Above West Fork	Sport catch
3	5	1.3		970	M	7/3/02	Above West Fork	Sport catch
3	6		Regenerated	790	M	7/3/02	Above West Fork	Sport catch
3	7	1.3		830	M	7/3/02	Above West Fork	Sport catch
4	1	1.3		670	F	7/6/02	Below West Fork	Sport catch
4	2	1.3		675	F	7/6/02	Below West Fork	Sport catch
4	3	1.3		720	M	7/6/02	Below West Fork	Sport catch
4	4		Resorbed	715	M	7/6/02	Below West Fork	Sport catch
4	5		Resorbed	870	M	7/6/02	Below West Fork	Sport catch
4	6		Regenerated	920	M	7/6/02	Below West Fork	Sport catch
4	7	1.3		830	F	7/6/02	Below West Fork	Sport catch
4	8		Resorbed	665	F	7/6/02	Below West Fork	Sport catch
5	1		Resorbed	860	M	7/22/02	Above West Fork	Carcass
5	2		Regenerated	820	M	7/22/02	Above West Fork	Carcass
6	1	1.4		1,040	M	7/27/02	Above West Fork	Carcass
7	1	1.3		820	F	8/12/02	Above West Fork	Carcass
7	2		Resorbed	800	M	8/12/02	Above West Fork	Carcass
7	3		Resorbed	810	M	8/12/02	Above West Fork	Carcass
7	4		Resorbed	870	M	8/12/02	Above West Fork	Carcass
7	5		Resorbed	740	F	8/12/02	Above West Fork	Carcass
7	6		Resorbed	860	M	8/12/02	Above West Fork	Carcass
7	7		Illegible	930	M	8/12/02	Above West Fork	Carcass
7	8	12	Resorbed	750	F	8/12/02	Above West Fork	Carcass
7	9		Regenerated	720	F	8/12/02	Above West Fork	Carcass
7	10		Resorbed	770	M	8/12/02	Above West Fork	Carcass
8	1	1.3		830	F	8/12/02	Above West Fork	Carcass
8	2	1.3		900	M	8/12/02	Above West Fork	Carcass
8	3		Regenerated	870	M	8/12/02	Above West Fork	Carcass
8	4		Resorbed	630	M	8/12/02	Above West Fork	Carcass
8	5		Illegible	730	F	8/12/02	Above West Fork	Carcass
8	6		Resorbed	890	M	8/12/02	Above West Fork	Carcass
9	1	1.3		850	M	8/13/02	Above West Fork	Carcass
9	2	1.3		835	M	8/13/02	Above West Fork	Carcass

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Card #	Sample	Age	Age Errors	Length	Sex	Date	Location	Method
9	3		Illegible	670	M	8/13/02	Above West Fork	Carcass
9	4	1.3		970	M	8/13/02	Above West Fork	Carcass
9	5		Illegible	665	M	8/13/02	Above West Fork	Carcass
9	6	1.3		800	M	8/13/02	Above West Fork	Carcass
9	7		Resorbed	700	F	8/13/02	Above West Fork	Carcass
9	8		Illegible	820	M	8/13/02	Above West Fork	Carcass
9	9		Resorbed	600	F	8/13/02	Above West Fork	Carcass
10	1		Resorbed	880	M	8/14/02	Above West Fork	Carcass
10	2		Resorbed	930	M	8/14/02	Above West Fork	Carcass
10	3	1.3		910	M	8/14/02	Above West Fork	Carcass
10	4	1.3		835	M	8/14/02	Above West Fork	Carcass
10	5		Resorbed	950	M	8/14/02	Above West Fork	Carcass
10	6		Regenerated	870	M	8/14/02	Above West Fork	Carcass
10	7		Resorbed	835	M	8/14/02	Above West Fork	Carcass
10	8	1.3		820	M	8/14/02	Above West Fork	Carcass
10	9		Resorbed	785	M	8/14/02	Above West Fork	Carcass
10	10	1.4		950	M	8/14/02	Above West Fork	Carcass
11	1		Regenerated	880	M	8/14/02	Above West Fork	Carcass
11	2		Resorbed	840	M	8/14/02	Above West Fork	Carcass
11	3	1.3		870	M	8/14/02	Above West Fork	Carcass
11	4		Resorbed	775	M	8/14/02	Above West Fork	Carcass
11	5	1.3		790	M	8/14/02	Above West Fork	Carcass
11	6	1.4		940	M	8/14/02	Above West Fork	Carcass
11	7		Resorbed	870	F	8/14/02	Above West Fork	Carcass
11	8		Resorbed	715	F	8/14/02	Above West Fork	Carcass
11	9		Regenerated	835	M	8/14/02	Above West Fork	Carcass
11	10		Resorbed	750	F	8/14/02	Above West Fork	Carcass
12	1		Resorbed	780	F	8/14/02	Above West Fork	Carcass
12	2	1.3		860	M	8/14/02	Above West Fork	Carcass
12	3		Regenerated	810	F	8/14/02	Above West Fork	Carcass
12	4	1.3		920	M	8/14/02	Above West Fork	Carcass
12	5	1.3		865	M	8/14/02	Above West Fork	Carcass
12	6		Resorbed	825	M	8/14/02	Above West Fork	Carcass
12	7		Resorbed	620	M	8/14/02	Above West Fork	Carcass
12	8	1.3		880	M	8/14/02	Above West Fork	Carcass
12	9	1.3		870	M	8/14/02	Above West Fork	Carcass
12	10	1.3		1,050	M	8/14/02	Above West Fork	Carcass
13	1		Regenerated	740	M	8/14/02	Above West Fork	Carcass
13	2		Regenerated	800	F	8/14/02	Above West Fork	Carcass
13	3		Resorbed	770	M	8/14/02	Above West Fork	Carcass
13	4		Resorbed	895	M	8/14/02	Above West Fork	Carcass
13	5		Regenerated	875	M	8/14/02	Above West Fork	Carcass
13	6		Regenerated	830	F	8/14/02	Above West Fork	Carcass
13	7		Resorbed	830	F	8/14/02	Above West Fork	Carcass
13	8	1.3		1,000	M	8/14/02	Above West Fork	Carcass
13	9	1.3		1,000	M	8/14/02	Above West Fork	Carcass
13	10		Resorbed	830	M	8/14/02	Above West Fork	Carcass
14	1		Resorbed	780	F	8/14/02	Above West Fork	Carcass
14	2		Inverted	740	F	8/14/02	Above West Fork	Carcass
14	3	1.3		995	M	8/14/02	Above West Fork	Carcass

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Card #	Sample	Age	Age Errors	Length	Sex	Date	Location	Method
14	4		Resorbed	820	F	8/14/02	Above West Fork	Carcass
14	5		Inverted	830	M	8/14/02	Above West Fork	Carcass
14	6		Resorbed	780	F	8/14/02	Above West Fork	Carcass
14	7	1.3		800	F	8/14/02	Above West Fork	Carcass
14	8		Resorbed	985	M	8/14/02	Above West Fork	Carcass
14	9		Resorbed	800	F	8/14/02	Above West Fork	Carcass
14	10		Resorbed	795	F	8/14/02	Above West Fork	Carcass
15	1		Resorbed	880	M	8/15/02	Below West Fork	Carcass
15	2	1.3		1,010	M	8/15/02	Below West Fork	Carcass
15	3		Resorbed	750	F	8/15/02	Below West Fork	Carcass
15	4		Resorbed	785	F	8/15/02	Below West Fork	Carcass
15	5		Inverted	890	M	8/15/02	Below West Fork	Carcass
15	6		Resorbed	780	F	8/15/02	Below West Fork	Carcass
15	7	1.3		840	F	8/15/02	Below West Fork	Carcass
15	8		Regenerated	820	M	8/15/02	Below West Fork	Carcass
15	9		Resorbed	830	M	8/15/02	Below West Fork	Carcass
15	10		Illegible	825	M	8/15/02	Below West Fork	Carcass
16	1		Resorbed	960	M	8/15/02	Below West Fork	Carcass
16	2		Resorbed	840	M	8/15/02	Below West Fork	Carcass
16	3		Illegible	810	F	8/15/02	Below West Fork	Carcass
16	4	1.4		970	M	8/15/02	Below West Fork	Carcass
16	5		Regenerated	990	M	8/15/02	Below West Fork	Carcass
16	6		Resorbed	800	F	8/15/02	Below West Fork	Carcass
16	7		Regenerated	810	F	8/15/02	Below West Fork	Carcass
16	8		Resorbed	760	F	8/15/02	Below West Fork	Carcass
16	9		Resorbed	860	M	8/15/02	Below West Fork	Carcass
16	10		Resorbed	800	M	8/15/02	Below West Fork	Carcass
17	1		Resorbed	870	M	8/15/02	Below West Fork	Carcass
17	2		Resorbed	800	M	8/15/02	Below West Fork	Carcass
17	3		Resorbed	760	F	8/15/02	Below West Fork	Carcass
17	4		Regenerated	850	F	8/15/02	Below West Fork	Carcass
17	5		Resorbed	850	M	8/15/02	Below West Fork	Carcass
17	6		Resorbed	710	M	8/15/02	Below West Fork	Carcass
17	7	1.3		890	M	8/15/02	Below West Fork	Carcass
17	8	1.3		870	M	8/15/02	Below West Fork	Carcass
17	9		Resorbed	800	F	8/15/02	Below West Fork	Carcass
17	10		Resorbed	810	F	8/15/02	Below West Fork	Carcass
18	1		Resorbed	790	F	8/15/02	Below West Fork	Carcass
18	2		Resorbed	720	F	8/15/02	Below West Fork	Carcass
18	3		Regenerated	900	M	8/15/02	Below West Fork	Carcass
18	4		Resorbed	750	F	8/15/02	Below West Fork	Carcass
18	5		Resorbed	770	F	8/15/02	Below West Fork	Carcass
18	6		Resorbed	800	F	8/15/02	Below West Fork	Carcass
18	7		Resorbed	740	F	8/15/02	Below West Fork	Carcass
18	8		Regenerated	780	F	8/15/02	Below West Fork	Carcass
18	9		Resorbed	850	M	8/15/02	Below West Fork	Carcass
18	10		Resorbed	770	M	8/15/02	Below West Fork	Carcass
19	1		Resorbed	740	F	8/15/02	Below West Fork	Carcass
19	2		Resorbed	870	M	8/15/02	Below West Fork	Carcass
19	3		Resorbed	790	F	8/15/02	Below West Fork	Carcass

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Card #	Sample	Age	Age Errors	Length	Sex	Date	Location	Method
19	4		Illegible	780	F	8/15/02	Below West Fork	Carcass
19	5		Resorbed	840	F	8/15/02	Below West Fork	Carcass
19	6		Illegible	790	M	8/15/02	Below West Fork	Carcass
19	7		Resorbed	900	M	8/15/02	Below West Fork	Carcass
19	8		Regenerated	920	M	8/15/02	Below West Fork	Carcass
19	9	1.4		830	F	8/15/02	Below West Fork	Carcass
20	1		Resorbed	830	F	8/19/02	Above West Fork	Carcass
20	2		Regenerated	760	F	8/19/02	Above West Fork	Carcass

APPENDIX C

Appendix C.–Daily passage [a, b] of sockeye salmon at the Gulkana River tower site, 2002.

Day	East Channel			West Channel			Total			Season Cumulative Estimate
	10-Min. Count	Expanded Count	Interpolations Included	10-Min. Count	Expanded Count	Interpolations Included	10-Min. Count	Expanded Count	Interpolations Included	
7-Jun	2	12	12	7	42	42	9	54	54	54
8-Jun	5	30	30	9	54	54	14	84	84	138
9-Jun	2	12	12	13	78	78	15	90	90	228
10-Jun	1	6	6	8	48	48	9	54	54	282
11-Jun	2	12	12	7	42	42	9	54	54	336
12-Jun	0	0	0	9	54	54	9	54	54	390
13-Jun	2	12	12	42	252	252	44	264	264	654
14-Jun	0	0	0	146	876	876	146	876	876	1,530
15-Jun	27	162	162	102	612	612	129	774	774	2,304
16-Jun	8	48	48	117	702	702	125	750	750	3,054
17-Jun	31	186	186	161	966	966	192	1,152	1,152	4,206
18-Jun	31	186	186	90	540	540	121	726	726	4,932
19-Jun	8	48	48	139	834	834	147	882	882	5,814
20-Jun	1	6	***0***	176	1,056	***1,170***	177	1,062	***1,170***	***6,984***
21-Jun	5	30	***34***	50	300	***942***	55	330	***976***	***7,960***
22-Jun	3	18	***30***	23	138	***960***	26	156	***990***	***8,950***
23-Jun	9	54	54	133	798	***822***	142	852	***876***	***9,826***
24-Jun	6	36	36	148	888	888	154	924	924	***10,750***
25-Jun	6	36	36	90	540	540	96	576	576	***11,326***
26-Jun	2	12	12	132	792	792	134	804	804	***12,130***
27-Jun	1	6	6	52	312	312	53	318	318	***12,448***
28-Jun	0	0	0	86	516	516	86	516	516	***12,964***
29-Jun	4	24	24	127	762	762	131	786	786	***13,750***
30-Jun	58	348	348	110	660	660	168	1,008	1,008	***14,758***
1-Jul	2	12	12	138	828	828	140	840	840	***15,598***
2-Jul	0	0	0	88	528	528	88	528	528	***16,126***
3-Jul	0	0	0	92	552	552	92	552	552	***16,678***
4-Jul	0	0	0	12	72	72	12	72	72	***16,750***
5-Jul	0	0	***12***	40	240	***234***	40	240	***246***	***16,996***
6-Jul	2	12	***16***	25	150	150	27	162	***166***	***17,162***
7-Jul	6	36	36	24	144	144	30	180	180	***17,342***
8-Jul	2	12	12	36	216	216	38	228	228	***17,570***
9-Jul	20	120	120	83	498	498	103	618	618	***18,188***
10-Jul	18	108	108	123	738	738	141	846	846	***19,034***
11-Jul	24	144	144	95	570	570	119	714	714	***19,748***

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Day	East Channel 10-Min. Count	East Channel Expanded Count	East Channel Interpolations Included	West Channel 10-Min. Count	West Channel Expanded Count	West Channel Interpolations Included	Total 10-Min. Count	Total Expanded Count	Total Interpolations Included	Season Cumulative Estimate
12-Jul	1	6	6	116	696	696	117	702	702	***20,450***
13-Jul	1	6	6	171	1,026	1,026	172	1,032	1,032	***21,482***
14-Jul	3	18	18	115	690	690	118	708	708	***22,190***
15-Jul	17	102	102	166	996	996	183	1,098	1,098	***23,288***
16-Jul	15	90	90	108	648	648	123	738	738	***24,026***
17-Jul	47	282	282	96	576	576	143	858	858	***24,884***
18-Jul	1	6	6	24	144	144	25	150	150	***25,034***
19-Jul	2	12	12	12	72	72	14	84	84	***25,118***
20-Jul	15	90	90	44	264	264	59	354	354	***25,472***
21-Jul	9	54	54	54	324	324	63	378	378	***25,850***
22-Jul	7	42	42	78	468	468	85	510	510	***26,360***
23-Jul	3	18	18	69	414	414	72	432	432	***26,792***
24-Jul	19	114	114	17	102	102	36	216	216	***27,008***
25-Jul	5	30	30	24	144	144	29	174	174	***27,182***
26-Jul	5	30	30	0	0	0	5	30	30	***27,212***
27-Jul	1	6	6	0	0	0	1	6	6	***27,218***
28-Jul	1	6	6	5	30	30	6	36	36	***27,254***
29-Jul	-2	-12	-12	0	0	0	-2	-12	-12	***27,242***
30-Jul	1	6	6	12	72	72	13	78	78	***27,320***
31-Jul	1	6	6	6	36	36	7	42	42	***27,362***
1-Aug	11	66	66	14	84	84	25	150	150	***27,512***
2-Aug	14	84	84	70	420	420	84	504	504	***28,016***
3-Aug	29	174	174	42	252	252	71	426	426	***28,442***
4-Aug	9	54	54	35	210	210	44	264	264	***28,706***
5-Aug	15	90	90	37	222	222	52	312	312	***29,018***
6-Aug	7	42	42	14	84	84	21	126	126	***29,144***
7-Aug	13	78	78	58	348	348	71	426	426	***29,570***
8-Aug	14	84	84	38	228	228	52	312	312	***29,882***
9-Aug	12	72	79	16	96	105	28	168	184	***30,066***
TOTAL	564	3,384	3,417	4,174	25,044	26,649	4,738	***28,***428	30,066	***30,066***

[a] Negative values represent downstream passage.

[b] Shading indicates days with interpolated values that are shown in bold italics when different from expanded count.

APPENDIX D

Appendix D.-Data files[a] for the Chinook salmon escapement in the Gulkana River, 2002 project.

Data file	Description
GulkanaTowerRawData_2002_Archive.xls	Raw data collected at Gulkana River Counting Tower, 2002.
GulkanaTower02_king_Archive.xls.	Data analysis on Chinook salmons counts collected at the Gulkana River Counting Tower, 2002.
GulkanaTower02_sockeye_Archive.xls.	Data analysis on sockeye salmons counts collected at the Gulkana River Counting Tower, 2002.
2002_Gulk_chinook_ASL_Archive.xls	Age, sex, and length data for Chinook salmon sampled on the Gulkana River during 2002.

[a] 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.