Fishery Data Series No. 11-71

Chinook Salmon Escapement in the Gulkana River, 2010

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)

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	$\geq$
harvest per unit effort	HPUE
less than	$<$
less than or equal to	$\leq$
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

Counting tower techniques were used on the Gulkana River to estimate the escapement of Chinook salmon *Oncorhynchus tshawytscha* upstream of the West Fork Gulkana River. The Gulkana River counting tower was in operation from 31 May through 11 August 2010. This time period accounted for the entire Chinook salmon run and a portion of the sockeye salmon run. The estimated escapement of Chinook salmon was 2,267 (SE=150). The estimated minimum escapement of sockeye salmon *O. nerka* was 16,255 (SE = 786). The mean date of passage for Chinook salmon was 11 July.

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

INTRODUCTION

The Gulkana River supports spawning populations of Chinook salmon *Oncorhynchus tshawytscha* and sockeye salmon *O. nerka*, rainbow/steelhead trout *O. mykiss*, and Arctic grayling *Thymallus arcticus*. The mainstem river is fed by the East Fork, Middle Fork, and West Fork Gulkana rivers (Figure 1). The river is one of six major spawning tributaries for Chinook salmon in the Copper River drainage and it supports the largest Chinook salmon sport fishery in the Copper River drainage and Upper Copper/Upper Susitna Management Area (UCUSMA; Jennings et al. 2009a-b, 2010). Annual sport harvest and effort has increased substantially from 641 Chinook salmon in 1978 (Mills 1979) to an average over the last 10 years (1999–2008) of 2,944 Chinook salmon (Somerville and Perry-Plake 2010). In addition to the inriver sport fishery, the Gulkana River Chinook salmon stock is subject to harvest in commercial fisheries located near the mouth of the Copper River and subsistence and personal-use (PU) fisheries located in the mainstem of the Copper River. There are no stock specific estimates of harvest available for these fisheries, but similar to the Gulkana River sport harvest, these mixed stock fisheries have also shown an overall increase in harvest over the past 30 years (Hollowell and Somerville 2008).

The Alaska Department of Fish and Game (ADF&G) established a sustainable escapement goal (SEG) of 24,000 or more Chinook salmon for the Copper River drainage (Evenson et al. 2008). Inriver abundance is estimated annually and inriver harvest is subtracted post-season to obtain an estimate of drainage-wide escapement. In contrast, there is no information available regarding stock-specific escapements or exploitation rates, and there are no established escapement goals for Chinook salmon stocks in any of the Copper River tributaries.

The section of the Gulkana River upstream of Sourdough Landing (Figure 1) 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 and has the authority to limit the number of trips per year or number of people per trip. To date, no permit system is in place; however, increased fishing effort coupled with diminishing Chinook salmon escapements over the last few years led stakeholders to submit proposals to the Alaska Board of Fisheries (BOF) to limit motor boat use. These proposals have not been addressed because they fall outside the purview of the BOF, but the issue still exists and BLM has the authority to limit entry into the area.

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

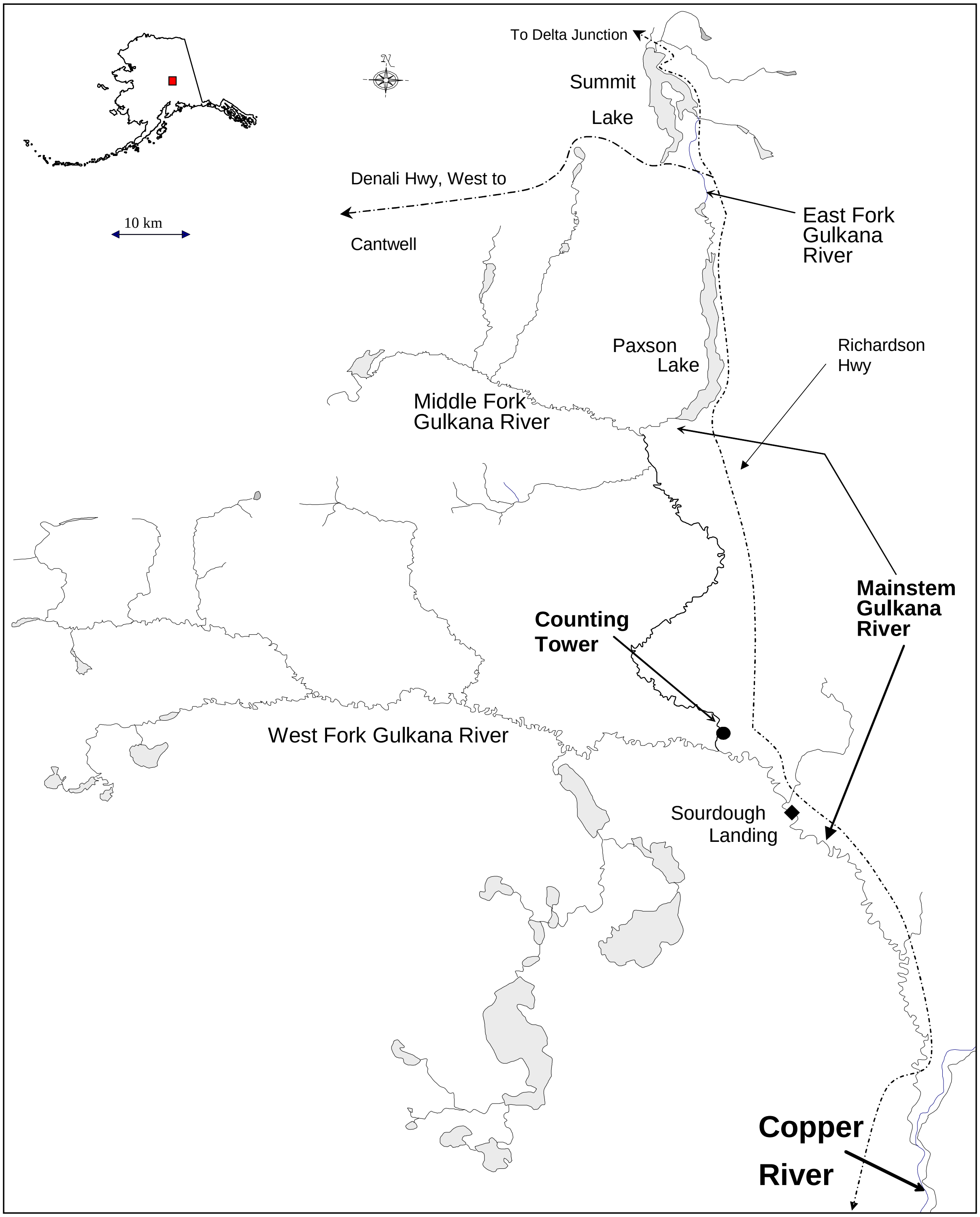

Figure 1.–The Gulkana River drainage and location of the counting tower.

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

OBJECTIVES

In 2010, the objective of this project was to:

1. estimate the escapement of Chinook salmon upstream of an established counting tower site on the mainstem Gulkana River.

In addition to the above objective, secondary tasks were to:

1. describe inriver run timing for Chinook salmon past the counting tower; and,
2. enumerate sockeye salmon passage at the counting tower during the period of tower operation.

METHODS

CHINOOK SALMON ESCAPEMENT

The number of Chinook salmon migrating upstream of the counting tower in the mainstem Gulkana River was estimated using counting tower techniques. 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 (>80%) of spawning in the Gulkana River drainage occurred upstream of the selected tower site (Figure 1). Counting begins on or about 1 June and continues into August until there are three continuous days with no net upstream migration of Chinook salmon.

The number of Chinook salmon that migrate past the counting tower is equal to escapement above the tower minus the harvest upstream. Harvest upstream of the tower has been relatively small (< 5%) compared to the estimate of escapement and its associated uncertainty. Since 2007, the Statewide Harvest Survey (SWHS) has delineated the harvest between Paxson and Sourdough Landing to estimate the harvest above the counting tower. Harvests from 2007–2009 averaged 112 Chinook salmon whereas estimated escapement for those years averaged approximately 3,600 Chinook salmon (Perry-Plake and Huang 2011).

The counting tower was located approximately 2.5 km upstream from the confluence of the West Fork and the mainstem river (Figure 1). This location was chosen because the majority of spawning occurs upstream of this site and to avoid the often turbid input of the West Fork. A small island splits the mainstem into two channels at the tower site (Figure 2). Steel scaffolding platforms approximately 4 m above the water were located on each side of the island to provide a comprehensive view of the entire river (approximately 30 m per channel). The towers 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. Maximum depth in both channels ranged from 1 to 1.5 m.

To ensure migrating fish were clearly visible a continuous band of white vinyl panels, approximately 2 m wide, was anchored to the river bottom across each river channel (Figure 2). There was also a 2–3 m section of picket weir placed near the base of each tower to ensure no fish were able to pass undetected directly beneath the towers. To ensure optimal viewing conditions, the panels were cleaned of debris, silt, gravel, and fish carcasses between scheduled counts as necessary. During periods of low ambient light, exterior-grade floodlights were used to illuminate the panels across each channel.

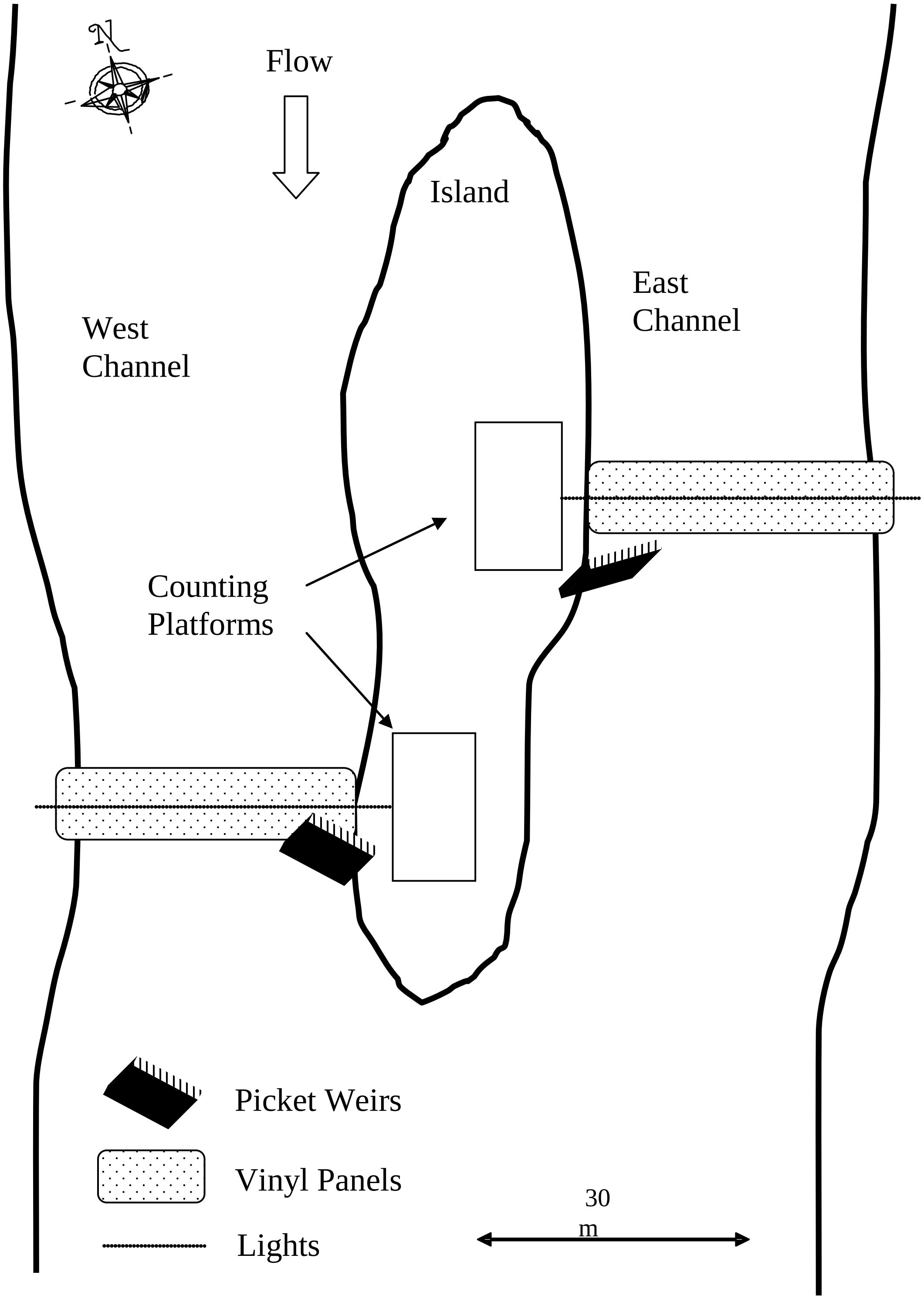

Figure 2.–An illustration of the counting tower site.

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 affect that lighting changes may have had on salmon migration.

Six technicians (two 3-person crews) were assigned to enumerate salmon escapement in the Gulkana River in 2010. Two 10-min counting periods (one per channel, 20 min total) were scheduled every hour, for 24 h each day. Each day was divided into three 8-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 10-min count for the west channel began between the top of the hour and 10 min past, and the 10-min count for the east channel immediately followed.

Numbers of Chinook and sockeye salmon were tallied and recorded on data forms at the end of each 10-min counting period. Separate data forms were maintained for each day and channel. Migration (upstream and downstream) was recorded to provide a net upstream migration during each 10-min count. Migration was defined as passage across the full width of the vinyl panels. In addition, at the beginning of each hour, water level (relative level on a staff gauge) and water clarity (Table 1) were recorded. Conditions that might affect the counts (e.g., heavy rain or strong winds) and general observations were recorded in the comments column.

Data Analysis

Estimates of Chinook salmon escapement were stratified by day. Daily estimates of escapement were a single-stage direct expansion from the 10-min counting periods. The 10-min counting periods were considered a systematic sample because the counting periods were not chosen randomly. Hourly count data were combined across channels before calculating estimates in order to account for the covariance between channel-specific hourly counts.

An analysis of data collected during 2002 revealed that Chinook salmon had a distinct diel migratory pattern where the majority of salmon migration takes place in the evening and early morning hours (Taras and Sarafin 2005). To account for this pattern of migration, a "count day" was defined as 1600 to 1559. Taras and Sarafin (2005) also demonstrated that interpolating for undercounts (a water clarity rank of 4.5 or 5) using this diel migratory pattern yielded more accurate estimates of escapement than using a direct expansion of the successful counts within 8-h shifts for that day.

The diel pattern is derived from all days with complete counts (no missing hours). A diel pattern consists of 24 proportion estimates, which indicate the hourly proportion of fish passing through the tower over the entire day. In order to estimate the diel pattern, all fish counts in a particular hour over all complete count days are summed to determine

Table 1.–Water clarity classification scheme.

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

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

a total fish count for this hour throughout the entire counting season. The proportion of this hour's counts out of the total counts of all the passing fish is one element of the diel pattern.

To be reliable, interpolations based on the diel pattern must have at least some counts that were successfully completed during the period of peak migration. Peak migration is defined and estimated as the shortest, continuous period of time during a count day that accounted for 80% of the upstream migration of Chinook salmon. Therefore, daily escapement and its variance were estimated using one of three scenarios depending on water clarity conditions (Table 1):

1. when water clarity was *excellent* to *poor* (rank 1–4) for all scheduled counts during a day, actual counts were expanded to estimate daily escapement (equations 1–3);
2. when a *small portion* (defined below) of a day's counts were conducted under *very poor* or *unobservable* water clarity (rank 4.5 or 5), daily escapement was estimated using a combination of expanded actual (equations 1–3) and interpolated (equations 1–4) counts; and,
3. when *most or all* of a day's counts were conducted under *very poor* or *unobservable* water clarity (rank 4.5 or 5), escapement for the entire day was interpolated (equations 5–6) using a moving average estimate of daily passage estimates before and after the missing day(s).

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

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

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:

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

The variance for the expanded daily escapement 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.

Scenario 2: If counts were conducted successfully for a portion of the day that represents 25% or more of the expected migration for that day (as defined by the diel relationship), and if at least 25% of the periods during peak migration were successfully counted, then the channel-specific interpolated count was calculated as the product of the sum of successful counts for the day and the ratio of the expected daily escapement not represented to the daily escapement that was represented, or:

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

where:

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

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

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

The interpolated count was then allocated among missed 10-min counting periods based on the diel pattern for the current year. For example, if four

10-min counting periods were missed and the interpolated count for that period was 10 Chinook salmon, those 10 fish would be allocated to each of the missed periods in proportion to the diel pattern.

Daily escapement and variances were calculated using a combination of actual and interpolated counts. Treating interpolated counts as "known" would result in underestimating the daily variances. 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 migration 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 x m_d = 0.85 x 24. For the channel-combined counts the proportion successfully counted was the channel-specific proportions weighted by the proportion of the overall 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 diel interpolations contribute substantially to the overall variance. Therefore, daily variances are estimated using this approach as long as interpolations using the diel pattern account for a small proportion of the total variance.

Scenario 3: If counts were conducted for a portion of the day that represented less than 25% of the expected escapement for that day, or if less than 25% of the periods during peak migration were counted successfully, then the moving average estimate for the missing day i was calculated as:

$$\hat{N}_i = \frac{\sum_{j=i-k}^{i+k} I(day\, j\ \ was\, sampled)\hat{N}_j}{\sum_{j=i-k}^{i+k} I(day\, j\ \ was\, sampled)} \qquad (5)$$

where:

k = number of days missed due to adverse viewing conditions; and,

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

is an indicator function.

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

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

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

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

where:

D = total number of possible days.

SOCKEYE SALMON ESCAPEMENT

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 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

In 2010, the Gulkana River counting tower was in operation from 31 May through 11 August. The estimated Chinook salmon escapement upstream of the counting tower was 2,267 (SE = 150; Table 2). Less than 6% of the scheduled counting periods (30 June–1 July; 23–25 July) were conducted during visibility conditions under which undercounting (a rank of 4.5 or 5) may have occurred (Table 3). On 30 June, escapement on the west channel was interpolated using scenario 3, whereas escapement on the east channel was estimated using scenario 1. On 1 July, escapement on the east channel was interpolated using scenario 3, and escapement on the west channel was estimated using scenario 1. Escapement on both channels from 23 to 25 July were interpolated using scenario 3. All remaining days were counted under favorable water conditions (a rank of 1–4) and scenario 1 was used to estimate daily escapement.

Table 2.–Annual escapement, catch, and harvest estimates of Chinook salmon in the Gulkana River, 2002–2010.

Year	Escapement [a]	SE	Catch [b]	Harvest [b]
2002	6,355	318	12,316	2,983
2003	4,890	270	13,356	3,707
2004	4,734	302	7,368	1,890
2005	2,718	174	6,584	2,573
2006	4,846	279	7,673	2,147
2007	4,422	273	8,635	3,275
2008	3,678	258	5,984	2,324
2009	2,720	179	2,085	516
2010	2,267	150	4,710	1,445

[a] Estimates from counting tower.

[b] Estimates from Statewide Harvest Survey.

Table 3.–Daily counts and expanded counts, and the cumulative estimated escapement of Chinook salmon at the Gulkana River tower, 2010. Shading identifies days with counts that included interpolation.

	West Channel		East Channel		Combined		Total
Date	Daily	Expanded	Daily	Expanded	Daily	Expanded	Escapement
31-May	0	0	0	0	0	0	0
1-Jun	0	0	0	0	0	0	0
2-Jun	0	0	0	0	0	0	0
3-Jun	0	0	0	0	0	0	0
4-Jun	0	0	0	0	0	0	0
5-Jun	0	0	0	0	0	0	0
6-Jun	0	0	0	0	0	0	0
7-Jun	0	0	0	0	0	0	0
8-Jun	1	6	0	0	1	6	6
9-Jun	0	0	0	0	0	0	6
10-Jun	2	12	5	30	7	42	48
11-Jun	0	0	0	0	0	0	48
12-Jun	1	6	0	0	1	6	54
13-Jun	0	0	0	0	0	0	54
14-Jun	0	0	0	0	0	0	54
15-Jun	0	0	0	0	0	0	54
16-Jun	0	6	1	6	1	6	60
17-Jun	2	12	2	12	4	24	84
18-Jun	1	6	5	30	6	36	120
19-Jun	1	6	6	36	7	42	162
20-Jun	1	6	2	12	3	18	180
21-Jun	2	12	3	18	5	30	210
22-Jun	5	30	4	24	9	54	264
23-Jun	4	24	5	30	9	54	318
24-Jun	2	12	9	54	11	66	384
25-Jun	2	12	2	12	4	24	408
26-Jun	3	18	5	30	8	48	456
27-Jun	1	6	4	24	5	30	486
28-Jun	3	18	4	24	7	42	528

-continued-

Table 3.–Page 2 of 2.

	West Channel		East Channel		Combined		Total
Date	Daily	Expanded	Daily	Expanded	Daily	Expanded	Escapement
29-Jun	1	6	2	12	3	18	546
30-Jun	9	21	3	18	12	39	585
1-Jul	6	36	5	18	11	54	639
2-Jul	0	0	3	18	3	18	657
3-Jul	16	96	8	48	24	144	801
4-Jul	4	24	4	24	8	48	849
5-Jul	2	12	0	0	2	12	861
6-Jul	2	12	1	6	3	18	879
7-Jul	1	6	3	18	4	24	903
8-Jul	5	30	3	18	8	48	951
9-Jul	6	36	1	6	7	42	993
10-Jul	3	18	8	48	11	66	1,059
11-Jul	10	60	4	24	14	84	1,143
12-Jul	4	24	1	6	5	30	1,173
13-Jul	1	6	0	0	1	6	1,179
14-Jul	1	6	0	0	1	6	1,185
15-Jul	2	12	0	0	2	12	1,197
16-Jul	2	12	2	12	4	24	1,221
17-Jul	5	30	12	72	17	102	1,323
18-Jul	12	72	6	36	18	108	1,431
19-Jul	9	54	12	72	21	126	1,557
20-Jul	6	36	4	24	10	60	1,617
21-Jul	7	42	5	30	12	72	1,689
22-Jul	6	36	12	72	18	108	1,797
23-Jul	3	33	1	36	4	69	1,866
24-Jul	0	26	0	32	0	57	1,923
25-Jul	1	26	0	21	1	50	1,973
26-Jul	3	18	3	18	6	36	2,009
27-Jul	1	6	1	6	2	12	2,021
28-Jul	7	42	0	0	7	42	2,063
29-Jul	3	18	1	6	4	24	2,087
30-Jul	3	18	2	12	5	30	2,117
31-Jul	2	12	-2	-12	0	0	2,117
1-Aug	1	6	4	24	5	30	2,147
2-Aug	5	30	4	24	9	54	2,201
3-Aug	0	0	1	6	1	6	2,207
4-Aug	4	24	-6	-36	-2	-12	2,195
5-Aug	7	42	3	18	10	60	2,255
6-Aug	2	12	0	0	2	12	2,267
7-Aug	2	12	0	0	2	0	2,267
8-Aug	0	0	1	0	1	0	2,267
9-Aug	1	6	1	0	2	0	2,267
10-Aug	0	0	0	0	0	0	2,267
11-Aug	0	0	-1	0	-1	0	2,267

The estimated diel migratory pattern encompassed 82% of the daily migration from 2200 through 0700 (Figure 3). The first Chinook salmon was observed on 8 June and the run was considered complete on 11 August. The run timing pattern observed past the counting tower was later than the average over all years (2002–2009; Figure 4).

SOCKEYE SALMON ESCAPEMENT

In 2010, the minimum escapement estimate for sockeye salmon was 16,255 (SE = 786; Table 4). The first sockeye salmon was observed on 7 June and counting ceased on 11 August.

DISCUSSION

The main objective of an escapement monitoring project is to estimate total escapement for a particular stock, or provide an index of escapement that is relatively consistent over time with respect to the proportion of the escapement that is enumerated. Studies have shown that >80% of Chinook salmon escapement is located above the counting tower (Savereide 2005). In 2010, the entire Chinook salmon run was assessed and the majority (94%) of the run was enumerated under good viewing conditions, which led to a precise estimate of escapement (2,267, SE=150) above the counting tower.

To establish a Chinook salmon escapement goal for the Gulkana River, a long time series of escapement, total run, and age composition estimates are required. Estimates of escapement are available from 2002–2010; however, Copper River Chinook salmon range from age 3 to age 8 and nine years of escapement information is only equivalent to four complete brood year returns. Stock specific estimates of harvest in the mixed stock commercial, PU, or subsistence fisheries are required to estimate the total run. Currently, there are no such estimates but a recent genetic study has provided the means to derive these estimates (Seeb et. al 2009). These methods can be used to obtain stock-specific estimates of the harvest and age composition. Age composition estimates of the escapement are not available, but they can be inferred from previous age composition estimates of the sport fishery or from mixed stock samples taken from the Chitina subdistrict PU fishery each year.

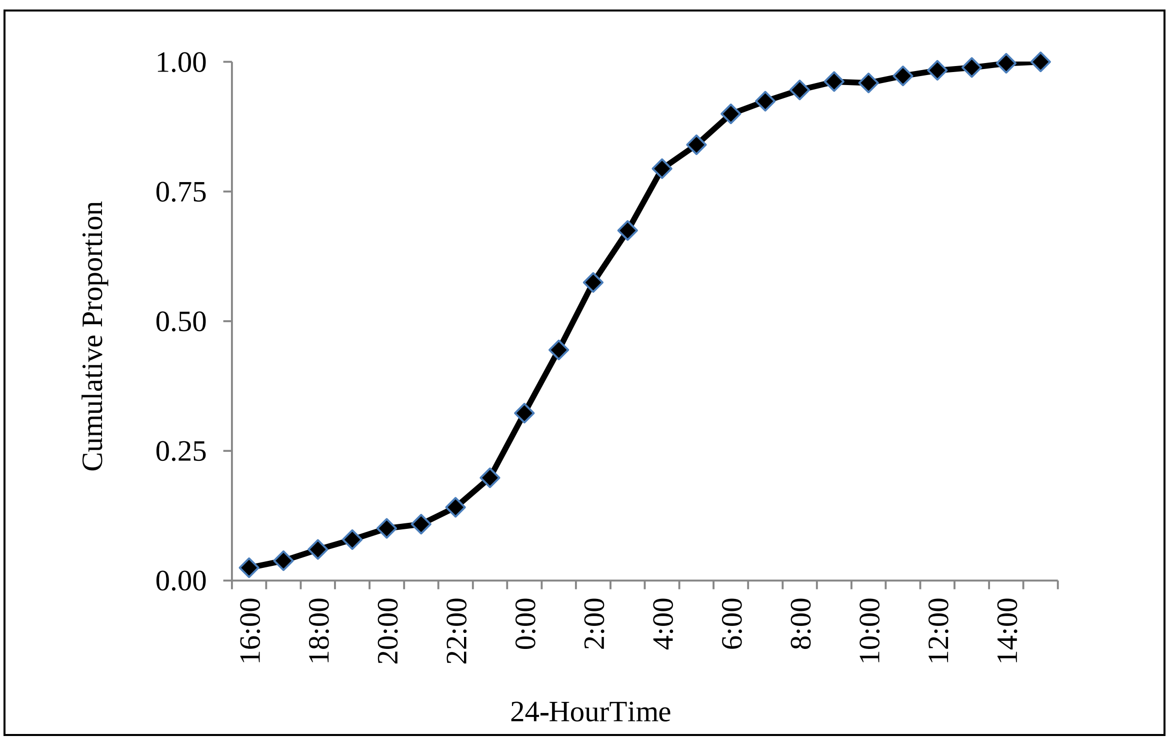

Figure 3.–Estimated diel migratory pattern for 2010; the cumulative proportion of average daily counts by hour of day for Chinook salmon migrating past the Gulkana River counting tower.

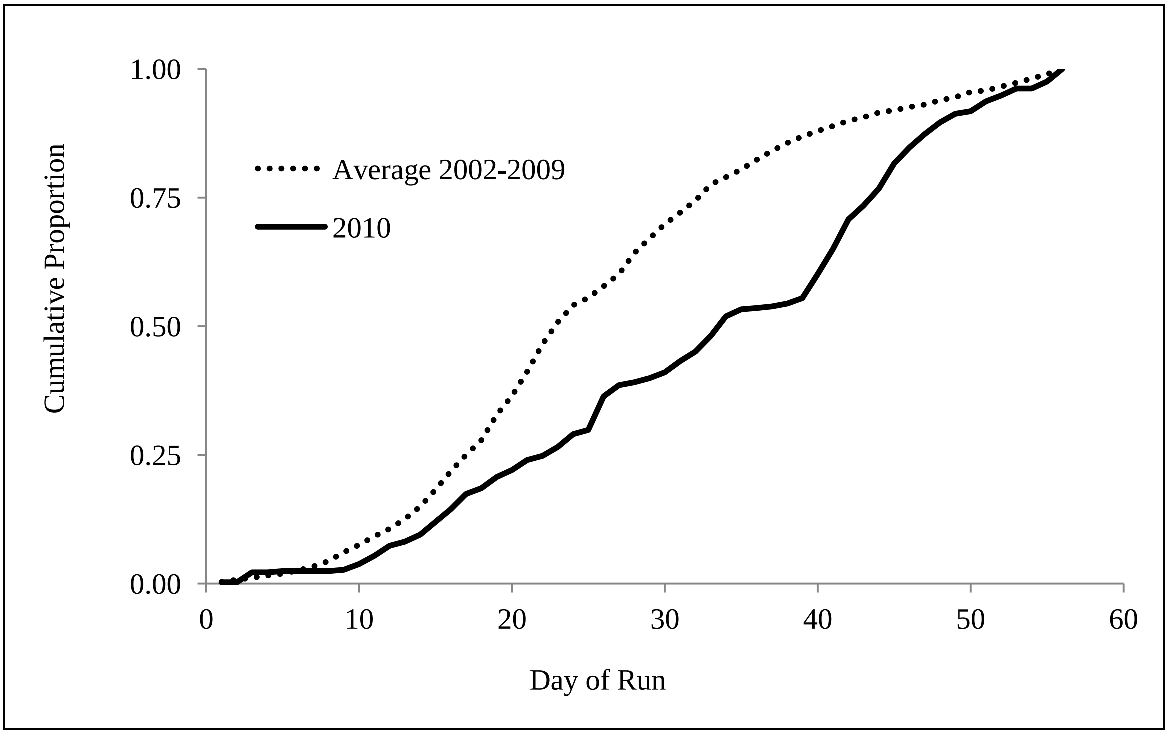

Figure 4.–Estimated run timing pattern for Gulkana River Chinook salmon past the counting tower in 2010 compared to the 2002–2009 average.

Table 4.–Daily counts and expanded counts, and the cumulative estimated escapement of sockeye salmon at the Gulkana River tower, 2010. Shading identifies days with counts that included interpolation.

	West Channel		East Channel		Combined		Total
Date	Daily	Expanded	Daily	Expanded	Daily	Expanded	Escapement
31-May	0	0	0	0	0	0	0
1-Jun	0	0	0	0	0	0	0
2-Jun	0	0	0	0	0	0	0
3-Jun	0	0	0	0	0	0	0
4-Jun	0	0	0	0	0	0	0
5-Jun	0	0	0	0	0	0	0
6-Jun	0	0	0	0	0	0	0
7-Jun	2	12	1	6	3	18	18
8-Jun	18	108	2	12	20	120	138
9-Jun	0	0	0	0	0	0	138
10-Jun	0	0	1	6	1	6	144
11-Jun	0	0	0	0	0	0	144
12-Jun	12	72	0	0	12	72	216
13-Jun	22	132	0	0	22	132	348
14-Jun	4	24	0	0	4	24	372
15-Jun	11	66	11	66	22	132	504
16-Jun	19	114	26	156	45	270	774
17-Jun	103	618	102	612	205	1,230	2,004
18-Jun	58	348	217	1,302	275	1,650	3,654
19-Jun	69	414	52	312	121	726	4,380
20-Jun	10	60	53	318	63	378	4,758
21-Jun	41	246	55	330	96	576	5,334
22-Jun	42	252	43	258	85	510	5,844
23-Jun	69	414	117	702	186	1116	6,960
24-Jun	118	708	30	180	148	888	7,848
25-Jun	42	252	44	264	86	516	8,364
26-Jun	26	156	35	210	61	366	8,730
27-Jun	35	210	6	36	41	246	8,976
28-Jun	11	66	5	30	16	96	9,072
29-Jun	26	156	16	96	42	252	9,324
30-Jun	4	86	6	36	10	134	9,458
1-Jul	3	110	3	27	6	200	9,658
2-Jul	6	36	3	18	9	54	9,712
3-Jul	23	138	26	156	49	294	10,006
4-Jul	18	108	29	174	47	282	10,288
5-Jul	7	42	13	78	20	120	10,408
6-Jul	10	60	15	90	25	150	10,558

-continued-

Table 4.–Page 2 of 2.

Date	West Channel		East Channel		Combined		Total
	Daily	Expanded	Daily	Expanded	Daily	Expanded	Escapement
7-Jul	10	60	13	78	23	138	10,696
8-Jul	11	66	37	222	48	288	10,984
9-Jul	15	90	26	156	41	246	11,230
10-Jul	27	162	38	228	65	390	11,620
11-Jul	23	138	17	102	40	240	11,860
12-Jul	17	102	2	12	19	114	11,974
13-Jul	15	90	12	72	27	162	12,136
14-Jul	17	102	8	48	25	150	12,286
15-Jul	20	120	7	42	27	162	12,448
16-Jul	10	60	9	54	19	114	12,562
17-Jul	8	48	3	18	11	66	12,628
18-Jul	13	78	31	186	44	264	12,892
19-Jul	19	114	8	48	27	162	13,054
20-Jul	20	120	28	168	48	288	13,342
21-Jul	11	66	12	72	23	138	13,480
22-Jul	6	36	6	36	12	72	13,552
23-Jul	12	72	10	60	22	137	13,689
24-Jul	0	46	0	38	0	98	13,786
25-Jul	0	46	1	58	1	75	13,861
26-Jul	5	30	3	18	8	48	13,909
27-Jul	6	36	16	96	22	132	14,041
28-Jul	7	42	1	6	8	48	14,089
29-Jul	8	48	14	84	22	132	14,221
30-Jul	37	222	6	36	43	258	14,479
31-Jul	34	204	7	42	41	246	14,725
1-Aug	18	108	18	108	36	216	14,941
2-Aug	30	180	9	54	39	234	15,175
3-Aug	13	78	14	84	27	162	15,337
4-Aug	28	168	11	66	39	234	15,571
5-Aug	16	96	5	30	21	126	15,697
6-Aug	1	6	2	12	3	18	15,715
7-Aug	28	168	2	12	30	180	15,895
8-Aug	10	60	0	0	10	60	15,955
9-Aug	8	48	6	36	14	84	16,039
10-Aug	12	72	5	30	17	102	16,141
11-Aug	14	84	5	30	19	114	16,255

CONCLUSION

Even though all of the information needed to establish an escapement goal is limited at this time, an escapement goal analysis should be conducted and enumeration of Chinook salmon migrating upstream of the counting tower should continue.

In the absence of an escapement goal, another objective of area sport fish management is to establish an inseason guideline to use for making a determination as to whether a management action (i.e., close or restrict the fishery) is needed to address low numbers of Chinook salmon. Continued estimates of escapement and run timing may indicate a number and corresponding date that could be used as a guideline. For example, if 2,000 Chinook salmon migrated past the counting tower by 20 June, then no management action is required.

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