Fishery Data Series No. 02-13

Deep Creek Chinook and Coho Salmon Escapement Studies, 1999

by

Robert N. Begich

July 2002

Alaska Department of Fish and Game **Division of Sport Fish**

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
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

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

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

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

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
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
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

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	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
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.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
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
standard length	SL
total length	TL
variance	Var

FISHERY DATA SERIES NO. 02-13

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by

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ABSTRACT

Chinook salmon *Oncorhynchus tshawytscha* and coho salmon *O. kisutch* returns to Deep Creek were assessed with a weir to provide total escapement counts. From 16 June through 12 September 1999, 2,286 chinook salmon and 2,267 coho salmon were counted and examined for adipose finclips. Total chinook and coho salmon escapement was 2,056 and 2,265 fish, respectively. Two hundred and thirty chinook salmon with adipose finclips were sacrificed for coded wire tag information. The contribution of hatchery-produced Ninilchik River chinook salmon was 46 fish or 2.0% of the total chinook salmon return. Males comprised 60.5% and females 39.5% of the chinook salmon escapement. The age class composition of the chinook escapement was dominated by age 1.3, (51.6%, SE = 0.8%), followed by age 1.2, (37.7%, SE = 0.7%) and age 1.4, (9.4%, SE = 0.6%). The coho salmon escapement consisted of 57.1% (SE = 3.5%) males and 42.9% (SE = 3.2%) females. The majority of coho in the escapement was age class 2.1 (71.1%, SE = 2.5%).

Key words: chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *Oncorhynchus kisutch*, Deep Creek, weir, return, escapement, adipose finclip, and coded wire tag.

INTRODUCTION

Deep Creek, Anchor River, and Ninilchik River (Figure 1), three road-accessible tributaries of the Lower Cook Inlet (LCI) Management Area, receive an average of about 40,000 angler-days of sport fishing effort annually (Howe et al. 2001a-d). These rivers support directed freshwater recreational fisheries for chinook salmon *Oncorhynchus tshawytscha* and coho salmon *O. kisutch*, as well as fisheries for steelhead trout *O. mykiss* and anadromous Dolly Varden *Salvelinus malma*. Chinook and coho salmon originating in these rivers are also harvested in mixed-stock marine recreational fisheries that occur from boats along the east coast of Cook Inlet. Inriver fisheries at Deep Creek and Anchor River are supported by wild stocks, while the Ninilchik River chinook salmon fishery has been supplemented by a hatchery stocking program since 1988. These rivers, as well as the Homer Spit fishing lagoon which is supported entirely by stocking, are important road-accessible Pacific salmon fisheries in the LCI Management Area.

The majority of salmon assessments in the LCI Management Area have concentrated on estimating angler effort and harvest during the early-run chinook salmon fishery as well as assessing chinook salmon escapement (Hammarstrom and Larson 1982, 1983, 1984, 1986; Hammarstrom et al. 1985, 1987; Larson and Balland 1988; McKinley 1996, 1999, unpublished data; Nelson 1995). In 1994, the Division of Sport Fish initiated a study to quantitatively assess chinook salmon stocks harvested in the marine recreational fishery. A cornerstone of this study was the selection of Deep Creek for a wild stock coded wire tagging (CWT) program. Deep Creek was chosen because it is located at the center of the marine boat recreational fishery and there was concern that the growing marine fishery could negatively impact the chinook salmon stock and inriver fishery (Bendock 1995). Chinook salmon as well as coho salmon smolt were tagged from 1994 through 1997 (Bendock 1995, 1996). To support this CWT program a weir was operated at Deep Creek in 1997 and 1998 to count immigrating chinook and coho salmon (King and Breakfield 1998, 1999; Table 1). Prior to 1997, coho salmon escapement was not enumerated at Deep Creek and annual chinook salmon escapement was assessed by an index that was a combination of foot and aerial survey escapement counts. Since 1995, aerial survey and weir counts have been used to monitor chinook salmon escapement (Szarzi 1999; King and Breakfield 1998, 1999).

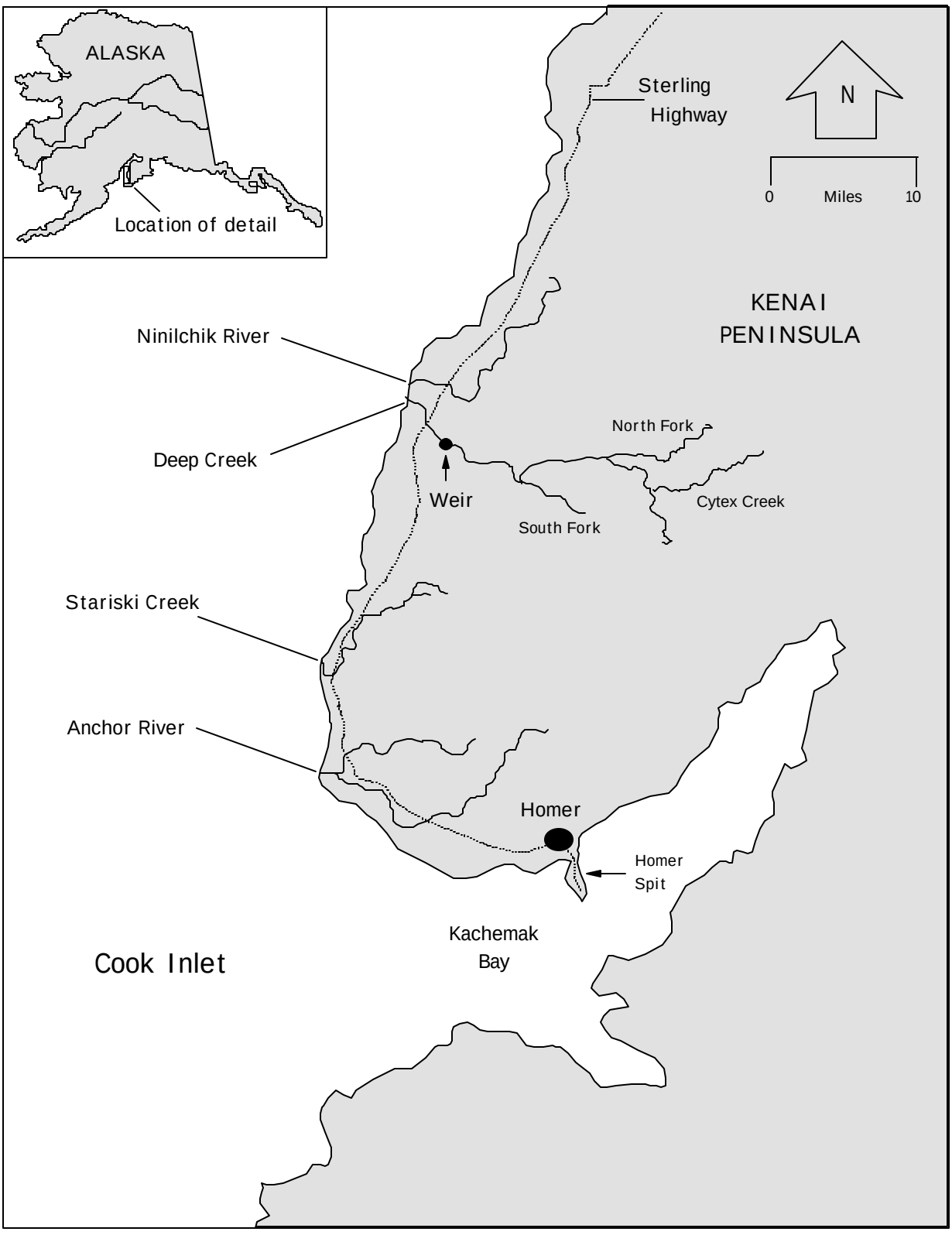

Figure 1.-Lower Cook Inlet road system tributaries and Deep Creek weir site, 1999.

Table 1.-Estimated angler effort, harvest, and escapement of chinook and coho salmon, Deep Creek, 1966–1969, and 1972-1999.

		Chinook					Coho	
Year	Angler Effort[a]	Harvest[a]	Foot Survey[b]	Aerial Survey[c]	Estimated Escapement[d]	Weir Count[e]	Harvest[a]	Weir Count[e]
1966			107		540			
1967			38	210	270			
1968			73	114	200			
1969			108	288	960			
1972					530			
1973			39		220			
1974					740			
1975					610			
1976			94	1,075	1,680			
1977	11,399	425	193	848	990		306	
1978	13,872	804	173	582	1,007		1,383	
1979	12,560	703	117	726	1,754		362	
1980	8,796	182			660		478	
1981	10,127	604	68	427	920		464	
1982	12,149	791	109	977	3,320		366	
1983	13,505	1,154	88	550	1,009		545	
1984	15,760	761	48	380	380		1,197	
1985	19,802	249	203	644	1,113		2,301	
1986	17,354	944	129	976	2,430		588	
1987	16,734	604	102	968	1,670		1,050	
1988	12,115	777	75	409	1,037		1,528	
1989	13,414	843	17	561	651		2,254	
1990	23,567	1,411	105	347	1,312		1,111	
1991	17,048	1,776	148	294	478		1,290	
1992	15,226	1,379		63			737	
1993	19,535	2,503	269	486	1,305		1,722	
1994	18,357	2,379	89	364	891		1,895	
1995	12,727	1,161		229			1,014	
1996	9,629	886		193			2,313	
1997	9,712	1,249		136		1,596	1,115	2,017
1998	9,206	539		676		367	2,035	1,537
1999	11,367	741		1,190		2,056	2,651	2,265
Average 1977-1998	14,209	1,006		516		982	1,184	1,777
% Change in 1999	-20	-26		+131		+109	+124	+27

[a] Annual estimated total number of angler days and harvest by species (Mills 1979-1994, Howe et al. 1995, 1996, 2001a-d).

[b] No raw data for 1972, 1974-75, and 1980; survey not conducted in 1992 and survey discontinued after 1994.

[c] Aerial survey not conducted in 1966 and 1973; no raw data available for 1972, 1974-75, and 1980. Aerial survey conducted from fixed-wing aircraft 1966-1973, fixed-wing aircraft and helicopter 1974, and helicopter from 1975-1999.

[d] Annual expanded estimates of escapement from foot and aerial surveys, not estimated in 1992.

[e] Weir first installed at Deep Creek in 1997; 1999 count is escapement, 230 fish sacrificed for coded wire tag information omitted.

From 1977 through 1988, chinook salmon fishing at Deep Creek was open from its mouth (salt water) to a marker located approximately 2 miles upstream, during four consecutive weekends (including Monday) beginning Memorial Day. During this 12-year period, chinook salmon harvests averaged 667 fish per year, while the aerial escapement index averaged 681 fish. Chinook salmon fishing regulations were liberalized for the 1989 fishing season by the addition of a fifth weekend. Over the next 7-year period (1989-1995) annual chinook salmon harvest increased approximately 145% to an average of 1,636 fish and the chinook salmon aerial escapement index averaged 344 fish. Effective in 1996, the Deep Creek chinook salmon fishing season was reduced from five to three weekends. From 1996-1998, annual chinook salmon harvests averaged 891 fish (Table 1). The average annual coho salmon harvest increased from 881 fish for 1977-1988, to 1,549 fish for 1989-1998 (Table 1).

Since Deep Creek supports significant chinook and coho salmon fisheries of the LCI Management Area, there is a need to improve escapement monitoring for both species and to determine the magnitude of straying to Deep Creek from local enhancement programs at the Ninilchik River and the Homer Spit Lagoon. These components are necessary to develop appropriate management strategies to ensure the Deep Creek fisheries are sustainable as this road-accessible fishery continues to grow.

The Deep Creek drainage covers 220 square miles and originates in the Kenai Mountains (Savard and Scully 1984; Figure 1). It is a moderate-sized stream and enters Central Cook Inlet on the west side of the Kenai Peninsula. It is located approximately mid-way between Homer and Soldotna, and is crossed by the Sterling Highway at a bridge located one-half mile above its saltwater terminus at Cook Inlet. The Deep Creek mainstem is approximately 30 mi long and has three major tributaries: Cytex, North Fork, and South Fork creeks.

OBJECTIVES

Objectives of the 1999 study were to:

1. Census the escapements of chinook and coho salmon into Deep Creek.
2. Estimate the contribution of hatchery-produced chinook salmon stocked into Ninilchik River to the return of chinook salmon enumerated at the Deep Creek weir.
3. Estimate the contribution of hatchery-produced coho salmon stocked into Homer Spit Lagoon in 1998 to the return of coho salmon enumerated at the Deep Creek weir.
4. Estimate the sex and age class composition of the escapements of chinook and coho salmon into Deep Creek.

METHODS

BIOLOGICAL SAMPLING, RETURN, AND ESCAPEMENT

A weir installed at Deep Creek on 16 June 1999 approximately 4 km upstream from its mouth (Figure 1) was operated from 18 June through 12 September 1999. Chinook salmon entered a trap to pass through the weir where they were counted and sampled. In addition, chinook salmon were captured in the upper river by drifting a 10 m long gillnet through pools to sample chinook salmon that had migrated upstream prior to weir installation. The upper mainstem of Deep Creek from the North Fork confluence to the weir was sampled from 23 June-26 June, and 3 km immediately upstream of the weir was sampled on 30 June and 8 July.

All chinook salmon counted at the weir were sampled for sex and age, examined for a missing adipose fin, which would indicate the presence of a coded wire tag (CWT), and were given a ¼" caudal fin punch. The caudal fin punch was used during upper river netting to prevent resampling of chinook salmon that had already been sampled at the weir. Every third chinook salmon was measured for length from mid-eye to fork of tail to the nearest millimeter. Three scales were collected for age determination from the left side of the body, at a point on a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, two rows above the lateral line (Welander 1940). Later, scales were pressed and ages determined using procedures described by Mosher (1969). Sex was determined based on head shape, and presence of ovipositor, eggs, or milt. Salmon missing the adipose fin were sacrificed, sampled for age and measured for length as described above, and sex was determined by internal examination of the gonads.

The heads of sacrificed fish were removed, labeled with a numbered cinch strap, frozen, and later sent to the Coded Wire Tag Processing Laboratory (Tag Lab) in Juneau to detect and remove the CWT. Decoding the tag number identified the time and location of tagging, and presence of strays from local enhancement programs. During the upper river netting all chinook salmon captured were sampled as described above; however, all fish captured were measured for length (mid-eye to fork of tail) to the nearest millimeter.

All coho salmon counted at the weir were examined for an adipose finclip, and fish with missing adipose fins were sacrificed and sampled. Coho salmon were sampled systematically such that every seventh coho salmon was sampled for age, sex, and length information as previously described.

The total return of chinook or coho salmon to the Deep Creek weir was the total number of unique fish counted through the weir and sampled upriver (for chinook salmon only) minus the estimated number of strays of hatchery-produced fish based on CWT recoveries. Total escapement was the total return minus the CWT recoveries of fish originally marked at Deep Creek. Sacrificed chinook or coho salmon that had unreadable tags or no tags were omitted from escapements but included in returns.

STRAYING

The 1999 return of hatchery-produced Ninilchik River chinook salmon was composed of fish from the 1995-1998 releases, ocean age-1 through ocean age-4. During these years 100% of smolt released were marked with an adipose finclip (Starkey et al. 1999). A portion of coho salmon released into the Homer Spit lagoon in 1998 was also marked with an adipose finclip (Starkey et al. 1999). Since all fish enumerated at Deep Creek were examined for a missing adipose fin, the numbers of hatchery-reared Ninilchik River chinook salmon or Homer Spit coho salmon contributing to returns at Deep Creek was a census. Therefore, contribution of hatchery plantings to the inriver returns was estimated by dividing the number of CWT recoveries identified by decoding as chinook salmon stocked at Ninilchik River or coho salmon at Homer Spit by the total number of salmon by species examined for marks.

AGE, SEX, AND LENGTH COMPOSITION

Chinook and coho salmon sampled at the weir were used to estimate mean length-at-age and age composition. Since all chinook salmon were sampled for sex and age, the sex composition of the return and escapement was known. Age was estimated only for fish that could not be aged. Because coho salmon were sampled for sex, length, and age systematically throughout the

immigration, the subsample alone was used to estimate sex and age composition for the escapement enumerated at the weir.

Contingency tables and chi-squared tests (Conover 1980) were used to test for temporal differences in sex and age composition of both species. These tests were used to describe changes in the biological characteristics of the chinook and coho salmon immigrations among weeks at the weir. In addition, similar tests were used to test the null hypothesis that there was no difference in sex or age among all chinook salmon sampled during the first 2 weeks of weir operation and those captured during netting.

The proportion of salmon of sex i passing through the weir of age class k was estimated as a binomial proportion by (Cochran 1977):

$$\hat{p}_{ik} = \frac{n_{ik}}{n_i}, \quad (1)$$

where:

n_{ik} = number of salmon of sex i sampled that were in age class k, and

n_i = number of salmon of sex i sampled (chinook salmon) or the total number counted (coho salmon).

The variance of this proportion was estimated using a finite population correction (FPC) as:

$$\mathrm{Var}(\hat{p}_{ik}) = \left[\frac{N_i - n_i}{N_i}\right]\frac{\hat{p}_{ik}(1-\hat{p}_{ik})}{n_i - 1}, \quad (2)$$

where:

N_i = the number of salmon of sex i counted at the weir.

For chinook salmon the denominator used in estimating the proportion was the number counted of each sex during the immigration, not the total number counted during the immigration. For coho salmon the denominator was the total number counted during the immigration at the weir.

The number of salmon of sex i and age class k, was estimated by:

$$\hat{N}_{ik} = N_i\hat{p}_{ik}, \quad (3)$$

and its variance estimated by:

$$\mathrm{Var}(\hat{N}_{ik}) = N_i^2\mathrm{Var}(\hat{p}_{ik}). \quad (4)$$

The total numbers of salmon of sex i of age class k or sex and age classes combined and their variances, were estimated by summing the respective estimates.

The proportion of salmon of age class k in the total return to or escapement through the weir was estimated by:

$$\hat{p}_k = \frac{\hat{N}_{ik}}{N_t}, \quad (5)$$

where:

N_t = the total number counted at the weir for each sex or sexes combined.

The variance of this proportion was estimated as:

$$\mathrm{Var}(\hat{p}_k) = \frac{\mathrm{Var}(\hat{N}_{ik})}{N_t^2}. \quad (6)$$

RESULTS

RETURN AND ESCAPEMENT

Chinook Salmon

Weir installation was postponed due to high water caused by snow melt run-off during the spring. Consequently, the numbers of chinook salmon in the return and escapement presented are minimum counts. From 18 June-12 September 1999, 2,058 chinook salmon were enumerated at the weir and 231 chinook salmon were captured during netting (Table 2). Fifty percent of the immigration passed the weir by 18 July and the last chinook salmon was sampled at

Table 2.-Summary of coded wire tag (CWT) recovery, total return, and total escapement for chinook and coho salmon at Deep Creek, 1999.

	Number Examined	Number with Adipose Finclip[a]	CWT Deep Origin	CWT Non-Deep Origin	CWT Unreadable or Absent	Total Return	Total Escapement
Chinook							
Weir	2,055 [b]	213	132	47	34	2,008	1,842
Netting	231	17	15	0	2	231	214
Total	2,286	230	147	47	36	2,239	2,056
Coho							
Weir	2,267	2	0	0	2	2,267	2,265
Total	2,267	2	0	0	2	2,267	2,265

[a] Number of fish sacrificed to collect coded wire tag information.

[b] Does not include 3 fish not examined for marks.

the weir on 25 August (Figure 2; Appendix A1). Subtracting chinook salmon of non-Deep Creek origin and those sacrificed for CWT recoveries, the total return of chinook salmon at Deep Creek was 2,239 fish and escapement was 2,056 fish (Table 2). During netting conducted on 23 June-24 June 1999, no chinook salmon were observed in upper mainstem reaches of Deep Creek below the North Fork confluence (Table 3 and Figure 1). Chinook salmon were concentrated in a series of pools within approximately 1 to 3 river miles of the weir. There were not enough data collected during netting above the weir to test model assumptions of a mark-recapture population estimator (Table 3). Therefore, no estimate of chinook salmon passage prior to weir installation is available.

Coho Salmon

A total of 2,267 coho salmon were counted at the Deep Creek weir (Table 2). Two coho salmon were sacrificed for CWT recovery data, but had no tags. Coho salmon immigration at the weir commenced on 2 August 1999 and continued through the last day of weir operation, 12 September 1999 (Appendix A1). The 50% date of the coho salmon immigration during weir operation was 25 August (Figure 2, Appendix A1). Total enumerated escapement was 2,265 coho salmon (Table 2).

STRAYING

A total of 2,286 chinook salmon were examined for marks of which 230 fish (10%) were missing the adipose fin and were sacrificed for CWT information (Table 2). Of those, 147 chinook salmon recoveries originated from Deep Creek, 47 were of non-Deep Creek origin and 36 either had no tag or an unreadable tag. Of the 2,055 chinook salmon examined at the weir, 213 (10%) had an adipose finclip, and 17 (7%) of the 231 fish sampled during netting had an adipose finclip (Table 2; Appendix A1). Among the 213 recoveries at the weir, 34 either had no tag or an unreadable tag, while origin was known for 179 fish. Contribution of Ninilchik River hatchery-stocked chinook salmon was 46 fish

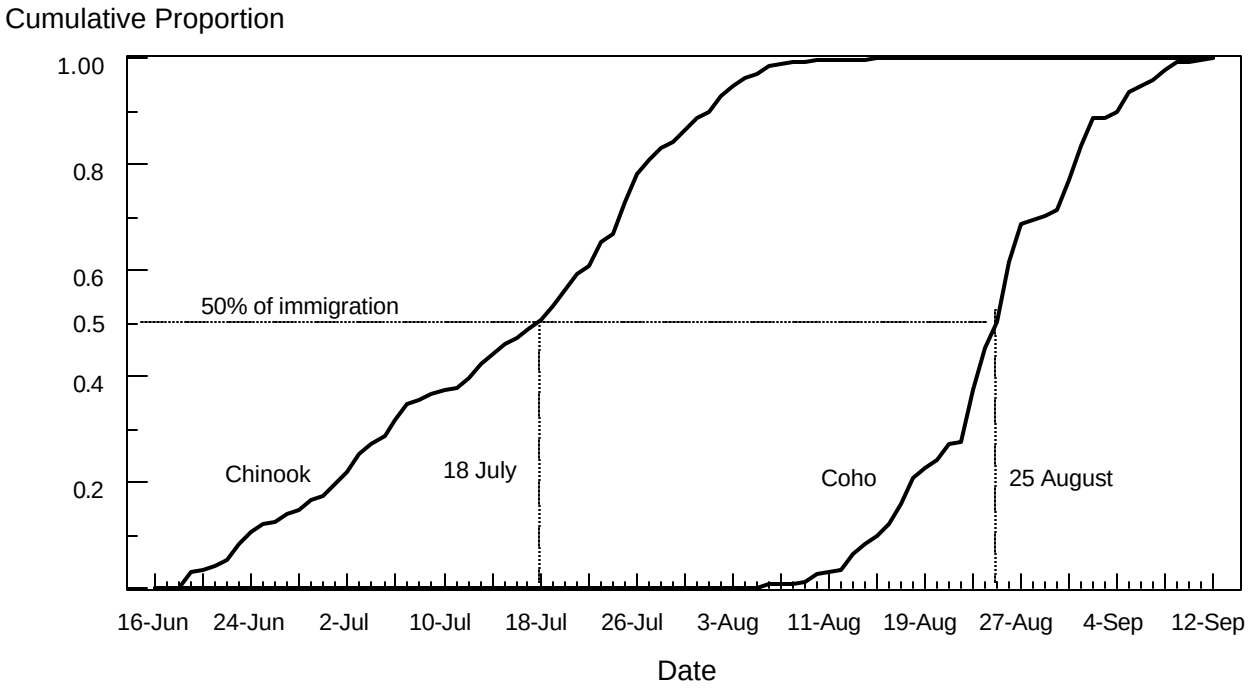

Figure 2.-Time of immigration of chinook and coho salmon, Deep Creek weir, 1999.

Table 3.-Summary of upper river netting for chinook salmon, Deep Creek, 1999.

Date	Number Unmarked[a]	Number with Adipose Finclip[b]	Total	Recaptures from netting[c]	Recaptures from weir[d]	Grand Total
23-Jun [e]			0			0
24-Jun [e]			0			0
25-Jun	23	1	24	0	0	24
26-Jun	90	9	99	0	0	99
30-Jun	66	3	69	12	18	99
8-Jul	35	4	39	7	14	60
Total	214	17	231	19	32	282

[a] Number of fish examined for adipose finclips, sampled, and released.

[b] Number of fish sacrificed for coded wire tag recovery information.

[c] Number of chinook salmon recaptured from previous netting.

[d] Number of chinook salmon recaptured with caudal fin punch from the weir.

[e] Netting took place but no chinook salmon were captured.

or 2.0% of the return examined for marks (Table 4). Origin of one chinook salmon recovery was identified as the Deshka River in Southcentral Alaska. Lastly, no adipose finclipped coho salmon originally stocked into Homer Spit were recovered at the Deep Creek weir during 1999.

AGE, SEX AND LENGTH COMPOSITION

Chinook Salmon

There was a significant difference in the sex class composition of the chinook salmon return (χ^2 = 19.394, df = 7, P = 0.007) among weeks at the weir. Subsequent testing indicated that this was likely due to an increase in the number of male relative to female chinook salmon observed at the weir as the immigration progressed. Similarly, age class composition differed among weeks at the weir (χ^2 = 35.833, df = 14, P = 0.001) due to an increase in the abundance of age-1.2 male chinook salmon over the duration of the immigration. Conversely there was no significant difference in the sex (χ^2 = 0.001, df = 1, P = 0.972) or age class composition (χ^2 = 4.582, df = 2, P = 0.101) among all chinook salmon sampled over the first 2 weeks at the weir and those captured during netting.

The chinook salmon return and escapement were composed of 61% males and 39% females (Tables 5 and 6). Eight age classes were identified for Deep Creek chinook salmon. Approximately 98% of all chinook salmon in the return and escapement were 4 to 6-year old fish of the age classes 1.2, 1.3, and 1.4. Other age classes included zero and 2 freshwater check chinook salmon of 2- and 3-years ocean age. The majority of chinook salmon were age-1.3 (52%, SE = 1%) and mean length 775 mm (SE = 2 mm) (Table 5). Age 1.3 comprised 35% (SE = 1%) of the return and escapement of males, while among females 77% (SE = 1%) of the return and escapement was age 1.3 (Tables 5 and 6).

Coho Salmon

A total of 280 coho salmon was sampled for sex and age at the weir. There was no significant difference in the sex (χ^2 = 8.812, df = 5, P = 0.117) or age class composition (χ^2 = 20.956, df = 15, P = 0.138) over the duration of the coho salmon immigration.

The estimated sex class composition of the coho salmon escapement was 57% (SE = 4%) male and 43% (SE = 3%) female (Table 7). The majority of the coho salmon escapement was composed of 4-year-old fish, age class 2.1 (71%; SE = 3%) with a mean length of 562 mm (SE = 3 mm) and 26% (SE = 3%) were age 1.1 and mean length 558 mm (SE = 5 mm). About 2% of the escapement was composed of 5-year-old fish of age classes 3.1 and 2.2 (Table 7).

DISCUSSION

CHINOOK SALMON

The inability to gather complete and accurate counts of chinook salmon has been a recurring problem at Deep Creek since adult return assessment began in 1997. During 1997 a total of 1,731 chinook salmon were counted at the weir, which was installed on 24 May and operated continuously through the return. This period is believed to more closely coincide with run timing of Deep Creek chinook salmon than weir operation dates in 1998 which started 17 June or in 1999 which started 16 June. Furthermore, during 1997 chinook salmon were known to have migrated past the weir site prior to weir installation (King and Breakfield 1998). Therefore, in order to identify the time of entry and completely enumerate the chinook salmon return, it is recommended that the Deep Creek weir installation be completed prior to the return of chinook salmon and onset of high water during spring.

The aerial survey conducted on 28 July 1999 included the entire drainage. A total of 1,190

Table 4.-Coded wire tag recovery information by location for chinook salmon sampled at Deep Creek, 1999.

Tag Code	Brood Year	Rearing Code and location[a]	Release Date	Release Site	Actual Age[b] Fresh	Ocean	Female	Male	Sample Total
Weir (N = 2,055)									
312402	1993	(W) Deep Cr.	26-Jun-95	Deep Cr.	1	4	2	0	2
312235	1993	(W) Deep Cr.	21-Jul-95	Deep Cr.	1	4	9	1	10
1301030815	1993	(W) Deep Cr.	2-Aug-95	Deep Cr.	1	4	0	1	1
312435	1994	(H) Fort Rich.	31-May-95	Ninilchik R.	0	4	2	1	3
1301030811	1994	(W) Deep Cr.	14-Aug-96	Deep Cr.	1	3	45	22	67
312549	1994	(W) Nonsense	30-Jul-97	Deep Cr.	1	2	0	6	6
312515	1995	(H) Fort Rich.	13-Jun-96	Ninilchik R.	0	3	5	4	9
1301030802	1995	(W) Deshka	20-Jun-96	Deshka R.	0	3	1	0	1
1301030812	1995	(W) Deep Cr.	14-Aug-96	Deep Cr.	0	3	5	9	14
312553	1995	(W) Deep Cr.	30-Jul-97	Deep Cr.	1	2	0	30	30
312608	1996	(H) Fort Rich.	17-Jun-97	Ninilchik R.	0	2	5	27	32
312552	1996	(W) Deep Cr.	30-Jul-97	Deep Cr.	0	2	0	2	2
312635	1997	(H) Fort Rich.	15-Jun-98	Ninilchik R.	0	1	0	2	2
No Tag							4	3	7
Unreadable							1	26	27
Weir Summary									
All	All	(W) Deep Cr.		Deep Cr.			61	71	132
All	All	(H) Fort Rich.		Ninilchik R.			12	34	46
All	All	(W) Deshka		Deshka R.			1	0	1
All	All	No Tag/Unreadable					5	29	34
						Total	79	134	213
Upper River Netting (N = 231)									
312235	1993	(W) Deep Cr.	21-Jul-95	Deep Cr.	1	4	2	1	3
312553	1995	(W) Deep Cr.	30-Jul-97	Deep Cr.	1	2	0	4	4
1301030811	1994	(W) Deep Cr.	14-Aug-96	Deep Cr.	1	3	4	2	6
1301030812	1995	(W) Deep Cr.	14-Aug-96	Deep Cr.	1	3	0	1	1
1301030815	1993	(W) Deep Cr.	2-Aug-95	Deep Cr.	1	4	1	0	1
No Tag							0	1	1
Unreadable							0	1	1
Upper River Netting Summary									
All	All	(W) Deep Cr.		Deep Cr.			7	8	15
All	All	(H) Fort Rich.		Ninilchik R.			0	0	0
All	All	No Tag/Unreadable					0	2	2
						Total	7	10	17
Weir and Upper River Netting (N = 2,286)									
All	All	(W) Deep Cr.		Deep Cr.			68	79	147
All	All	(H) Fort Rich.		Ninilchik R.			12	34	46
All	All	(W) Deshka		Deshka R.			1	0	1
All	All	No Tag/Unreadable					5	31	36
						Total	86	144	230

[a] Rearing code (W) is wild and (H) is hatchery. Nonsense location denotes chinook salmon identified as coho salmon at the time of coded wire tagging.

[b] Actual age fresh and ocean was determined by comparing brood year, release year, and recovery year.

Table 5.-Estimated age composition and length-at-age by sex of the return of chinook salmon at Deep Creek, 1999.

	Age Class								
	0.2	0.3	1.1	1.2	1.3	1.4	2.2	2.3	Total
Females									
Number sampled	1	8	0	55	595	113	0	1	773
Estimated Proportion	0.001	0.010		0.071	0.770	0.146		0.001	0.395
SE Proportion	0.001	0.004		0.009	0.009	0.012		0.001	
Estimated abundance	1	9	0	63	681	129	0	1	885
SE Abundance	1	3		8	8	11		1	
Mean Length	594	777		631	775	844			
SE Mean Length		24		16	2	5			
Males									
Number sampled	7	3	4	692	415	71	1	0	1,193
Estimated Proportion	0.006	0.003	0.003	0.580	0.348	0.060	0.001		0.605
SE Proportion	0.002	0.001	0.002	0.010	0.011	0.007	0.000		
Estimated abundance	8	3	5	785	471	81	1	0	1,354
SE Abundance	3	2	2	14	16	9	1		
Mean Length	575			606	777	882			
SE Mean Length	10			3	4	6			
All									
Estimated Proportion	0.004	0.006	0.002	0.379	0.515	0.094	0.001	0.001	1.000
SE Proportion	0.001	0.002	0.001	0.007	0.008	0.006	0.001	0.001	
Estimated abundance	9	13	5	848	1,152	210	1	1	2,239
SE Abundance	3	4	2	16	17	14	1	1	
Mean Length	581	777		607	776	857			
SE Mean Length	9	24		3	2	2			

chinook salmon were counted of which 394 fish were observed below the weir and 796 fish were counted above the weir. This was the highest aerial survey count recorded for chinook salmon at Deep Creek (Table 1). A total of 1,703 chinook salmon had either passed the weir (=1,489) or been released as newly captured fish during upriver netting (=214) by this date. Thus, approximately 47% of the chinook salmon counted at the weir or netting were observed from the air. The percent of the escapement actually observed from the air is probably lower, because the escapement at the time of the aerial survey included fish not enumerated at the weir or in netting. Chinook salmon passage after 28 July was 569 fish including those sacrificed for CWT information. Assuming that additional chinook salmon did not enter the river and all fish surveyed downstream immigrated through the weir, the aerial survey below the weir accounted for 69.2% of the fish present. Overall, the aerial survey accounted for approximately 52% of the chinook salmon known to be inriver during the aerial count. These probabilities are of the same order of magnitude as those presented by Lafferty (1997) for other systems, which was an average of 46%.

The estimated contribution of hatchery-produced Ninilchik River chinook salmon to the Deep Creek return of 2.0% is close to the value estimated during 1997, which was approximately 3% (King and Breakfield 1998). Because recoveries from Ninilchik River were not encountered during netting, the proportion of Ninilchik River hatchery fish present in the return prior to weir installation was probably of a similar magnitude. Consequently, interaction with wild Deep Creek fish was minimal as all Ninilchik River strays were removed from the escapement during sampling.

Table 6.-Estimated age composition and length-at-age by sex of the chinook salmon escapement at Deep Creek, 1999.

	Age Class								
	0.2	0.3	1.1	1.2	1.3	1.4	2.2	2.3	Total
Females									
Number sampled	0	7	0	54	545	101	0	1	708
Estimated Proportion		0.010		0.076	0.770	0.143	0.000	0.001	0.395
SE Proportion		0.004		0.010	0.009	0.012		0.001	
Estimated abundance	0	8	0	62	625	116	0	1	812
SE Abundance		3		8	7	10		1	
Mean Length		799		629	774	841			
SE Mean Length		15		17	2	5			
Males									
Number sampled	7	3	4	630	385	68	1	0	1,098
Estimated Proportion	0.006	0.003	0.004	0.574	0.351	0.062	0.001		0.605
SE Proportion	0.002	0.002	0.002	0.010	0.012	0.007	0.001		
Estimated abundance	8	3	5	714	436	77	1	0	1,244
SE Abundance	3	2	2	13	15	9	1		
Mean Length	575			601	776	884			
SE Mean Length	10			4	5	7			
All									
Estimated Proportion	0.004	0.006	0.002	0.377	0.516	0.094	0.001	0.001	1.000
SE Proportion	0.001	0.002	0.001	0.007	0.008	0.006	0.001	0.001	
Estimated abundance	8	11	5	776	1,061	193	1	1	2,056
SE Abundance	3	4	2	15	17	13	1	1	
Mean Length	575	799		603	775	857			
SE Mean Length	10	15		4	2	5			

COHO SALMON

The weir count of 2,265 coho salmon was the highest count obtained at Deep Creek since escapement assessment began for this species in 1997. Inriver coho salmon harvest estimated by the Statewide Harvest Survey increased from 1,115 fish in 1997 to 2,651 fish in 1999 (Table 1). Coho salmon of Deep Creek origin are likely harvested in mixed-stock nearshore marine sport and commercial fisheries. Since stock-specific harvests in these fisheries are not known, information to estimate the total return and an exploitation rate is not available. However, utilizing harvests estimated by the Statewide Harvest Survey and weir counts, inriver exploitation for 1997, 1998 and 1999 was approximately 36%, 57% and 54%, respectively, and averaged approximately 49%. It is not known if this coho salmon stock can support this level of inriver exploitation. Therefore, it is recommended that monitoring coho salmon escapement at Deep Creek continue.

Lastly, no coho salmon straying from the Homer Spit to Deep Creek was detected. The distance between these two locations and the lack of Homer Spit coho salmon present in the 1999 return to Deep Creek indicates that the Homer Spit coho salmon stocking program poses a low risk to wild stock production in Lower Cook Inlet road system tributaries at and north of the geographic location of Deep Creek (Figure 1).

Table 7.-Age composition and length-at-age by sex of the coho salmon escapement at Deep Creek, 1999.

	Age Class				
	1.1	2.1	2.2	3.1	Total
Females					
Number sampled	28	88	0	4	120
Estimated Proportion	0.100	0.314		0.014	0.429
SE Proportion	0.017	0.026		0.007	0.032
Estimated abundance	227	712	0	32	971
SE Abundance	38	59		15	72
Mean Length	562	561		556	
SE Mean Length	7	4		10	
Males					
Number sampled	46	111	1	2	160
Estimated Proportion	0.164	0.396	0.004	0.007	0.571
SE Proportion	0.021	0.027	0.003	0.005	0.035
Estimated abundance	372	898	8	16	1,294
SE Abundance	47	62	8	11	79
Mean Length	556	563	594	620	
SE Mean Length	7	4		27	
All					
Estimated Proportion	0.264	0.711	0.004	0.021	1.000
SE Proportion	0.025	0.025	0.003	0.008	
Estimated abundance	599	1610	8	49	2,265
SE Abundance	61	86	8	18	
Mean Length	558	562	594	577	
SE Mean Length	5	3		17	

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APPENDIX A. SUPPORTING STATISTICS

Appendix A1.-Daily and cumulative chinook and coho salmon weir counts, Deep Creek, 1999.

	Chinook							Coho		
	Unmarked		AFC		Daily		Cum.	Daily		Cum.
Date	Daily	Cum.	Daily	Cum.	Total[a]	Cum.	Prop.[c]	Count[b]	Cum.	Prop.[c]
16-Jun	0	0	0	0	0	0	0.000	0	0	0.000
17-Jun	0	0	0	0	0	0	0.000	0	0	0.000
18-Jun	4	4	0	0	4	4	0.002	0	0	0.000
19-Jun	53	57	5	5	59	63	0.031	0	0	0.000
20-Jun	12	69	2	7	15	78	0.038	0	0	0.000
21-Jun	17	86	0	7	17	95	0.046	0	0	0.000
22-Jun	16	102	6	13	22	117	0.057	0	0	0.000
23-Jun	54	156	6	19	60	177	0.086	0	0	0.000
24-Jun	39	195	8	27	47	224	0.109	0	0	0.000
25-Jun	30	225	1	28	32	256	0.124	0	0	0.000
26-Jun	7	232	2	30	9	265	0.129	0	0	0.000
27-Jun	26	258	0	30	26	291	0.141	0	0	0.000
28-Jun	15	273	1	31	16	307	0.149	0	0	0.000
29-Jun	32	305	5	36	37	344	0.167	0	0	0.000
30-Jun	20	325	1	37	21	365	0.177	0	0	0.000
1-Jul	38	363	3	40	41	406	0.197	0	0	0.000
2-Jul	45	408	6	46	51	457	0.222	0	0	0.000
3-Jul	64	472	5	51	69	526	0.256	0	0	0.000
4-Jul	38	510	2	53	40	566	0.275	0	0	0.000
5-Jul	24	534	4	57	28	594	0.289	0	0	0.000
6-Jul	58	592	5	62	63	657	0.319	0	0	0.000
7-Jul	53	645	7	69	60	717	0.348	0	0	0.000
8-Jul	13	658	3	72	16	733	0.356	0	0	0.000
9-Jul	22	680	1	73	23	756	0.367	0	0	0.000
10-Jul	15	695	1	74	16	772	0.375	0	0	0.000
11-Jul	4	699	1	75	5	777	0.378	0	0	0.000
12-Jul	38	737	3	78	41	818	0.397	0	0	0.000
13-Jul	52	789	6	84	58	876	0.426	0	0	0.000
14-Jul	31	820	2	86	33	909	0.442	0	0	0.000
15-Jul	38	858	5	91	43	952	0.463	0	0	0.000
16-Jul	21	879	2	93	23	975	0.474	0	0	0.000
17-Jul	24	903	4	97	28	1,003	0.487	0	0	0.000
18-Jul	41	944	0	97	41	1,044	0.507	0	0	0.000
19-Jul	51	995	6	103	57	1,101	0.535	0	0	0.000
20-Jul	57	1,052	7	110	64	1,165	0.566	0	0	0.000
21-Jul	56	1,108	5	115	61	1,226	0.596	0	0	0.000
22-Jul	25	1,133	6	121	31	1,257	0.611	0	0	0.000
23-Jul	77	1,210	10	131	87	1,344	0.653	0	0	0.000
24-Jul	26	1,236	8	139	34	1,378	0.670	0	0	0.000
25-Jul	115	1,351	13	152	128	1,506	0.732	0	0	0.000
26-Jul	96	1,447	11	163	107	1,613	0.784	0	0	0.000
27-Jul	42	1,489	8	171	50	1,663	0.808	0	0	0.000

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Appendix A1.-Page 2 of 3.

	Chinook							Coho		
	Unmarked		AFC		Daily		Cum.	Daily		Cum.
Date	Daily	Cum.	Daily	Cum.	Total[a]	Cum.	Prop.[c]	Count[b]	Cum.	Prop.[c]
28-Jul	41	1,530	6	177	47	1,710	0.831	0	0	0.000
29-Jul	19	1,549	3	180	22	1,732	0.842	0	0	0.000
30-Jul	45	1,594	6	186	51	1,783	0.866	0	0	0.000
31-Jul	39	1,633	7	193	46	1,829	0.889	0	0	0.000
1-Aug	18	1,651	2	195	20	1,849	0.898	0	0	0.000
2-Aug	57	1,708	6	201	63	1,912	0.929	1	1	0.000
3-Aug	39	1,747	1	202	40	1,952	0.948	2	3	0.001
4-Aug	27	1,774	4	206	31	1,983	0.964	0	3	0.001
5-Aug	12	1,786	0	206	12	1,995	0.969	1	4	0.002
6-Aug	26	1,812	5	211	31	2,026	0.984	15	19	0.008
7-Aug	7	1,819	2	213	9	2,035	0.989	6	25	0.011
8-Aug	9	1,828	0	213	9	2,044	0.993	0	25	0.011
9-Aug	1	1,829	0	213	1	2,045	0.994	3	28	0.012
10-Aug	4	1,833	0	213	4	2,049	0.996	35	63	0.028
11-Aug	1	1,834	0	213	1	2,050	0.996	5	68	0.030
12-Aug	3	1,837	0	213	3	2,053	0.998	16	84	0.037
13-Aug	1	1,838	0	213	1	2,054	0.998	66	150	0.066
14-Aug	0	1,838	0	213	0	2,054	0.998	46	196	0.086
15-Aug	1	1,839	0	213	1	2,055	0.999	29	225	0.099
16-Aug	1	1,840	0	213	1	2,056	0.999	52	277	0.122
17-Aug	0	1,840	0	213	0	2,056	0.999	84	361	0.159
18-Aug	0	1,840	0	213	0	2,056	0.999	115	476	0.210
19-Aug	0	1,840	0	213	0	2,056	0.999	38	514	0.227
20-Aug	1	1,841	0	213	1	2,057	1.000	36	550	0.243
21-Aug	0	1,841	0	213	0	2,057	1.000	68	618	0.273
22-Aug	0	1,841	0	213	0	2,057	1.000	13	631	0.278
23-Aug	0	1,841	0	213	0	2,057	1.000	215	846	0.373
24-Aug	0	1,841	0	213	0	2,057	1.000	181	1,027	0.453
25-Aug	1	1,842	0	213	1	2,058	1.000	115	1,142	0.504
26-Aug	0	1,842	0	213	0	2,058	1.000	256	1,398	0.617
27-Aug	0	1,842	0	213	0	2,058	1.000	157	1,555	0.686
28-Aug	0	1,842	0	213	0	2,058	1.000	22	1,577	0.696
29-Aug	0	1,842	0	213	0	2,058	1.000	20	1,597	0.704
30-Aug	0	1,842	0	213	0	2,058	1.000	25	1,622	0.715
31-Aug	0	1,842	0	213	0	2,058	1.000	125	1,747	0.771
1-Sep	0	1,842	0	213	0	2,058	1.000	144	1,891	0.834
2-Sep	0	1,842	0	213	0	2,058	1.000	119	2,010	0.887
03-Sep[d]	0	1,842	0	213	0	2,058	1.000	0	2,010	0.887
4-Sep	0	1,842	0	213	0	2,058	1.000	25	2,035	0.898
5-Sep	0	1,842	0	213	0	2,058	1.000	88	2,123	0.936
6-Sep	0	1,842	0	213	0	2,058	1.000	23	2,146	0.947
7-Sep	0	1,842	0	213	0	2,058	1.000	28	2,174	0.959
8-Sep	0	1,842	0	213	0	2,058	1.000	44	2,218	0.978

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	Chinook							Coho		
	Unmarked		AFC		Daily		Cum.	Daily		Cum.
Date	Daily	Cum.	Daily	Cum.	Total[a]	Cum.	Prop.[c]	Count[b]	Cum.	Prop.[c]
9-Sep	0	1,842	0	213	0	2,058	1.000	34	2,252	0.993
10-Sep	0	1,842	0	213	0	2,058	1.000	1	2,253	0.994
11-Sep	0	1,842	0	213	0	2,058	1.000	9	2,262	0.998
12-Sep	0	1,842	0	213	0	2,058	1.000	5	2,267	1.000
13-Sep	Weir removed.									
Total		1,842		213		2,058			2,267	

[a] Daily totals for 6/19, 6/20, and 6/25 include one chinook not examined for marks each day.

[b] Daily total for 8/24 includes 2 coho sacrificed that had an adipose finclip (AFC).

[c] Cumulative proportion of total return enumerated at the weir.

[d] No count on 9/3 due to high water.