Fishery Data Series No. 05-34

Deep Creek Chinook and Coho Salmon Escapement Studies, 2000

by

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and

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

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

Chinook salmon *Oncorhynchus tshawytscha* and coho salmon *O. kisutch* returns to Deep Creek were assessed with a weir to provide total escapement counts. From 15 June through 8 September 2000, 1,240 Chinook salmon and 3,425 coho salmon were counted and examined for adipose finclips. Total Chinook and coho salmon escapement was 1,103 and 3,424 fish, respectively. Coded wire tag information was recovered from 137 Chinook salmon with adipose finclips. No marked coho salmon stocked at Homer Spit were recovered from the 2000 return of coho salmon to Deep Creek weir. The contribution of hatchery-produced Ninilchik River Chinook salmon was 53 fish or 4.0% of the total Chinook salmon return. Females comprised 51% and males 49% of the Chinook salmon escapement. The age class composition of the Chinook escapement was dominated by age 1.3 (61%, SE = 5%), followed by age 1.2 (12%, SE = 4%) and age 1.4 (8%, SE = 4%). The coho salmon escapement consisted of 53% (SE = 3%) females and 47% (SE = 3%) males. The majority of coho in the escapement was age class 2.1 (79%, SE = 3%).

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

INTRODUCTION

Deep Creek and Anchor and Ninilchik rivers (Figure 1) are road accessible tributaries of lower Cook Inlet that support directed freshwater recreational fisheries for Chinook salmon *Oncorhynchus tshawytscha* and coho salmon *O. kisutch*. Fisheries for steelhead trout *O. mykiss*, as well as anadromous Dolly Varden *Salvelinus malma*, also occur. Along the east coast of Cook Inlet, Chinook and coho salmon originating in these tributaries are also harvested in mixed-stock marine fisheries by anglers in boats. Inriver fisheries at Deep Creek and Anchor River are supported by wild stocks, while the Ninilchik River Chinook salmon fishery is supplemented by a stocking program. Since 1977, these tributaries have supported an average of over 55,000 angler-days of fishing effort annually, as well as Chinook and coho salmon harvests that have averaged over 4,000 fish of each species (Howe et al. 1995, 1996, 2001 a-d; Mills 1979-1980, 1981a-b, 1982-1994; Walker et al. 2003).

In 1994, the Alaska Department of Fish and Game, Division of Sport Fish initiated a study to quantitatively assess Chinook salmon stocks harvested in the marine recreational fishery along the east coast of Cook Inlet. 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 fishery, the stock was already fully-utilized by the inriver weekend sport fishery, and fishery managers and some anglers were concerned that the growing marine fishery could negatively impact the Deep Creek Chinook salmon stock and inriver fishery (Bendock 1995). Sport fishing effort and harvest of Chinook salmon at Deep Creek peaked in the early 1990s; harvest of coho salmon has been variable (Table 1, Figure 2).

Chinook salmon as well as coho salmon smolt were tagged during 1994 through 1997, and a weir was operated at Deep Creek from 1997 through 1999 to count immigrating Chinook and coho salmon and to recover adults of both species that had CWTs (Begich 2002; Bendock 1995, 1996; King and Breakfield 1998, 1999, 2002; Table 1). Tag recoveries of coho salmon were used to estimate coho salmon production (King and Breakfield 1999). Chinook salmon tag recoveries were used to detect strays from hatchery releases in the nearby Ninilchik River and Homer Spit, and to provide data to estimate harvest of Deep Creek Chinook salmon in the mixed stocked marine recreational fishery (Begich *In prep*; King and Breakfield 1999; McKinley 1999).

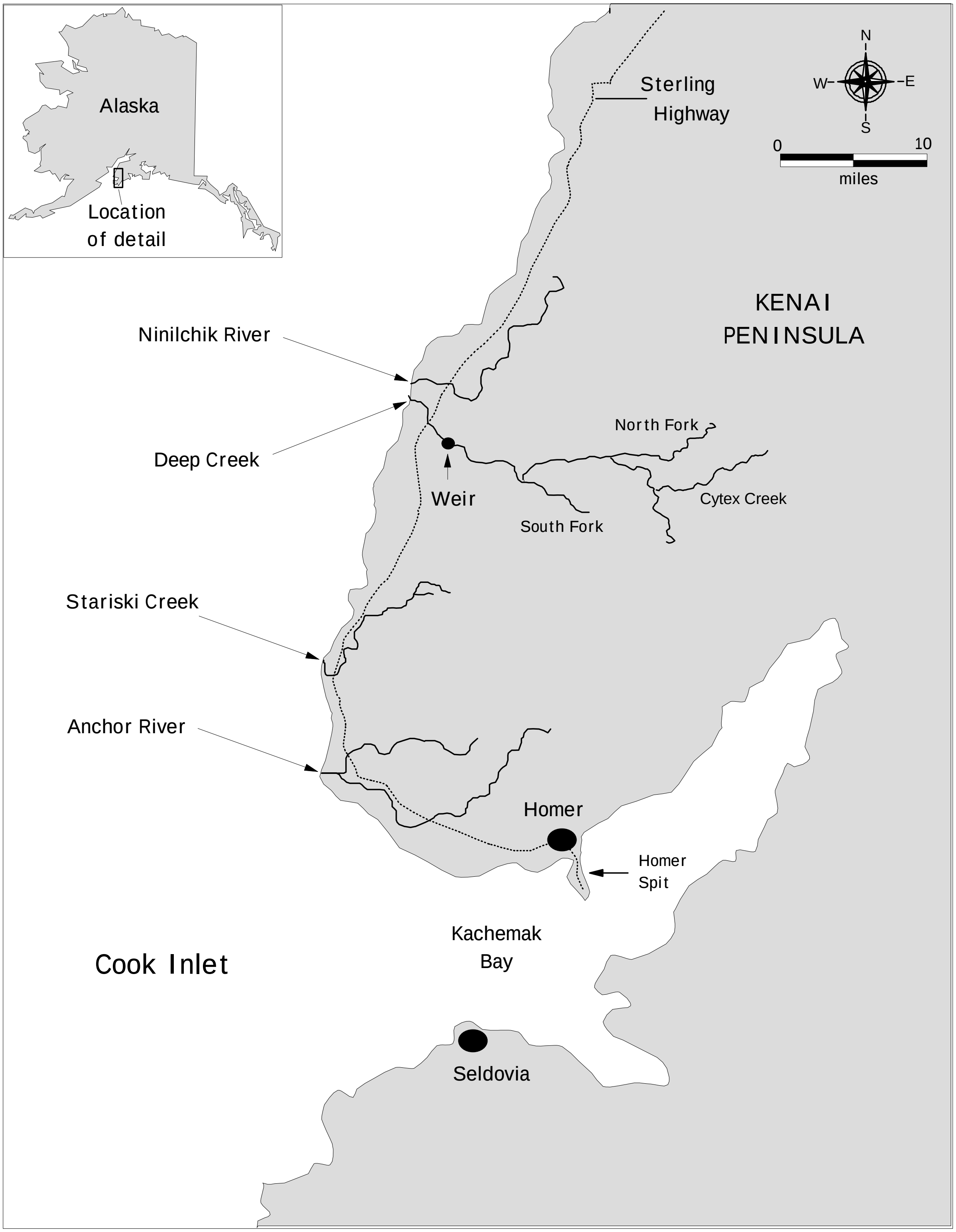


Figure 1.-Map of lower Cook Inlet road system tributaries and Deep Creek weir site, 2000.

Table 1.-Estimated angler effort, harvest, and escapement of Chinook and coho salmon, Deep Creek, 1966-1969 and 1972-2000.

		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
2000	7,834	593		556		1,103	2,018	3,425
Average 77-99	13,825	977		547		1,340	1,280	2,311

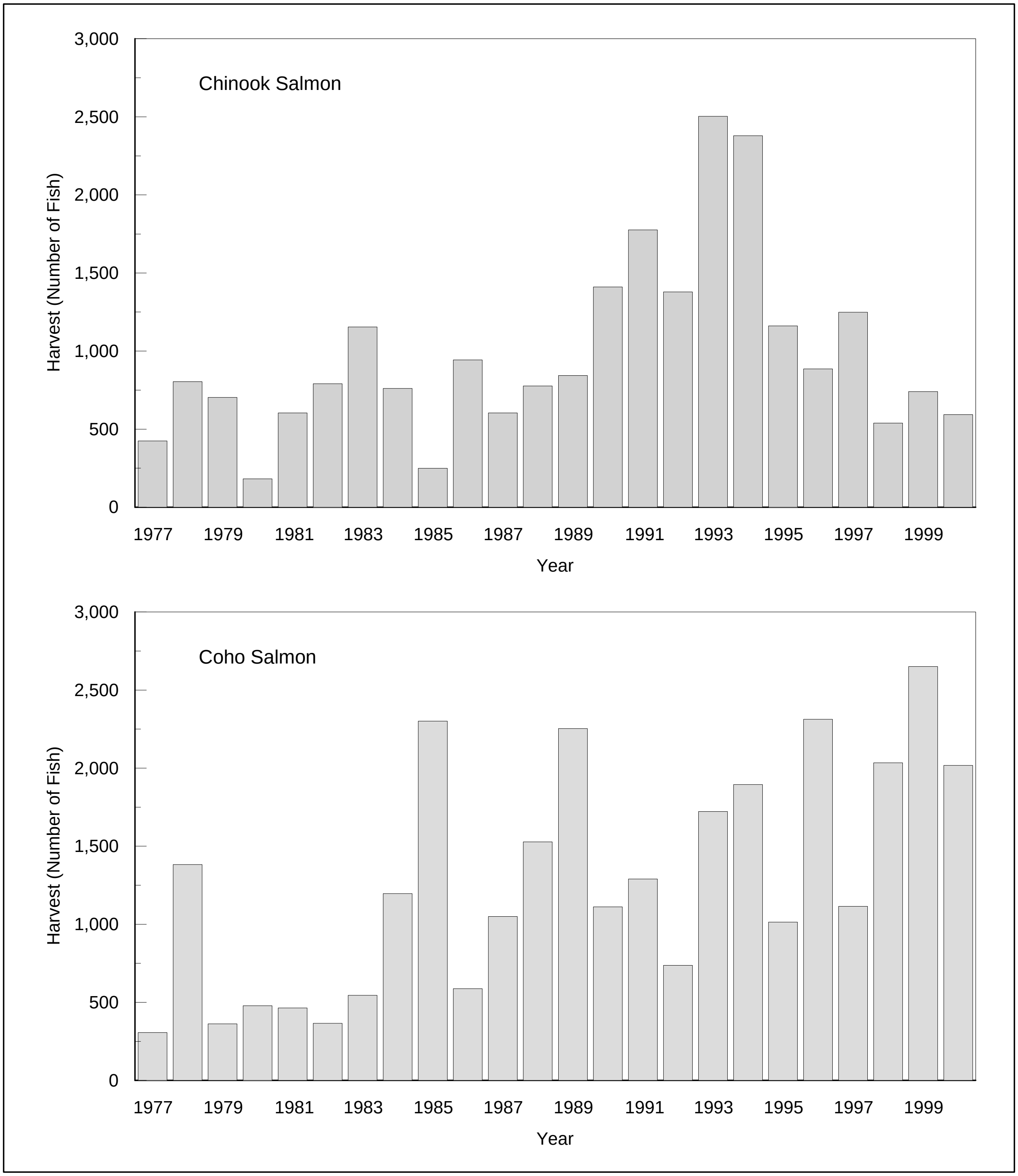
[a] Annual estimated total number of angler days and harvest by species (Howe et al. 1995, 1996, 2001 a-d; Mills 1979-1980, 1981a-b, 1982-1994; Walker et al. 2003).

[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 prior to 1976.

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

[e] Weir first installed at Deep Creek in 1997 and weir counts for 1999 and 2000 is the escapement count as it does not include fish sacrificed for coded wire tag information.



Sources: Howe et al. 1995, 1996, 2001 a-d; Mills 1979-1980, 1981a-b, 1982-1994; Walker et al. 2003.

Figure 2.-Inriver harvest of Chinook and coho salmon, Deep Creek, 1977-2000.

Prior to startup of the weir in 1997, the number of coho salmon in the escapement was not known and Chinook salmon escapement was assessed by an index that was a combination of foot and aerial survey escapement counts, until 1995 when foot surveys were discontinued (Table 1). In 1995 and 1996, only aerial surveys were available to monitor Chinook salmon escapement (Begich 2002; King and Breakfield 1998, 1999, 2002; Szarzi and Begich 2004). From 1997 through 1999, Chinook salmon weir and aerial survey counts averaged 1,340 fish and 667 fish respectively, while coho salmon weir counts averaged 1,940 fish (Table 1). However, all weir counts of Chinook and coho salmon were incomplete because high water during spring postponed weir installation until after the Chinook salmon immigration had begun, and the weir was removed before the coho salmon immigration was complete. Therefore, escapement levels that provide for sustained harvests are presently uncertain for both species.

OBJECTIVES

In 2000, the focus of this study at Deep Creek was to continue escapement monitoring of Chinook and coho salmon and to determine the magnitude of straying to Deep Creek from local enhancement programs at the Ninilchik River and Homer Spit Lagoon. These components are necessary to develop and enact appropriate management strategies to ensure the Deep Creek fisheries are sustainable. Objectives for 2000 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 at Homer Spit in 1999 to the return of coho salmon enumerated at the Deep Creek weir; and
4. Estimate the sex and age composition of the Chinook and coho salmon escapements into Deep Creek.

METHODS

BIOLOGICAL SAMPLING, RETURN, AND ESCAPEMENT

A weir installed approximately 4 km upstream from the mouth of Deep Creek was operated from 15 June-7 September 2000 (Figure 1). 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 which had migrated upstream prior to weir installation. The 3 km immediately upstream of the weir was sampled on 28 June 2000.

All Chinook salmon counted at the weir were sampled for sex and age, examined for a missing adipose fin and given a ¼ in caudal fin punch. Every third Chinook salmon was measured for length (MEF) to the nearest millimeter. Three scales were collected for aging 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 age 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 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 for detection and removal of the CWT. Decoding the tag number identified the time and location of tagging, and presence of strays from local enhancement programs. The caudal fin punch applied at the weir was used to prevent resampling of Chinook salmon during upper river netting. During the upper river netting, all Chinook salmon captured were sampled as described above; however, all fish captured were measured for length (MEF) to the nearest millimeter.

All coho salmon counted at the weir were examined for an adipose finclip. Fish with missing adipose fins were sacrificed for CWT and biological information. Coho salmon were also sampled systematically for biological information: every thirteenth 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 2000 return of Chinook salmon stocked into the Ninilchik River comprised fish from the 1996-1999 releases, ocean age-1 through ocean age-4. During these years almost 100% of released smolt were marked with an adipose finclip (Loopstra et al. 2000). A portion of coho salmon released into the Homer Spit lagoon in 1999 were also marked with an adipose finclip (Loopstra et al. 2000). Since all fish enumerated at Deep Creek were examined for a missing adipose fin, and all hatchery-reared Chinook salmon were marked, the number of hatchery-reared Ninilchik River Chinook salmon found contributing to returns at Deep Creek was a census. Therefore, the contribution rate of stocked Chinook salmon to the inriver return was calculated by dividing the number of CWT recoveries identified as Chinook salmon stocked at the Ninilchik River by the total number of Chinook salmon examined for marks. The contribution of coho salmon of hatchery origin to the Deep Creek coho salmon escapement was estimated by expanding the number of CWTs recovered from stocked fish according to the tagging rate at release and then dividing by the total number of coho salmon examined for marks.

AGE, SEX, AND LENGTH COMPOSITION

Chinook and coho salmon sampled at the weir were used to derive mean length-at-age and sex and age composition. All Chinook salmon were sampled for sex and age. Sex could be determined for every fish and so sex composition of the return to the weir and escapement was known. Age could not be determined for every fish and age composition of the return and escapement was therefore estimated. Because coho salmon were sampled for sex, length, and age systematically throughout the immigration, sex and age composition and mean length at age were all estimated for the escapement enumerated at the weir.

A loglinear analysis (SAS Proc Genmod) was performed to test for differences in sex and age composition of both species among weeks, and to ascertain any interactions between the effects. These tests were used to describe changes in the biological characteristics of the Chinook and coho salmon immigrations among weeks at the weir. Similar tests were used to test for differences in sex or age composition among all Chinook salmon sampled during the first 2 weeks of weir operation and those captured during netting.

Chinook Salmon

Significant reader error was found in the determination of 0 and 1-check freshwater ages in Chinook salmon. Their assignment within marine ages 2 through 4 was therefore made according to proportions of freshwater 0 and 1-checks found in CWT recoveries of the marine age. There were very few fish of 2-check freshwater age and/or of marine age 1; these data were not adjusted. The following describes estimation for freshwater ages 0 and 1 of marine ages 2 through 4. Simple proportions and standard variance formulas were applied to the remaining fish (Cochran 1977, page 58).

The proportion of Chinook salmon of sex i that were of freshwater age f and marine age m was estimated as:

$$\hat{p}_{ifm} = \hat{p}_{im}\,\hat{\rho}_{fm}, \tag{1}$$

where:

$\hat{p}_{im} = n_{im}/n_i$ = proportion of sex i that are of marine age m,

n_i = number of Chinook salmon of sex i sampled for which marine ages were discernible,

n_{im} = number of salmon out of n_i that were of marine age m,

$\hat{\rho}_{fm} = c_{fm}/c_m$ = proportion of CWTs of marine age m that were of freshwater age f,

c_m = number of CWTs of marine age m sampled,

c_{fm} = number of CWTs out of c_m that were of freshwater age f.

The variance of $\hat{p}_{ifm}$ was estimated using the expression of Goodman (1960) for the variance of a product as:

$$\hat{\mathrm{Var}}(\hat{p}_{ifm}) = \hat{\mathrm{Var}}(\hat{p}_{im})\hat{\rho}_{fm} + \hat{\mathrm{Var}}(\hat{\rho}_{fm})\hat{p}_{im} - \hat{\mathrm{Var}}(\hat{p}_{im})\hat{\mathrm{Var}}(\hat{\rho}_{fm}),$$

so that:

$$\hat{\mathrm{Var}}(\hat{p}_{ifm}) = \left[\frac{N_i - n_i}{N_i}\right]\frac{\hat{p}_{im}(1-\hat{p}_{im})}{n_i - 1}\hat{\rho}_{fm} + \frac{\hat{\rho}_{fm}(1-\hat{\rho}_{fm})}{c_m - 1}\hat{p}_{im} - \left[\frac{N_i - n_i}{N_i}\right]\frac{\hat{p}_{im}(1-\hat{p}_{im})}{n_i - 1}\,\frac{\hat{\rho}_{fm}(1-\hat{\rho}_{fm})}{c_m - 1}, \tag{2}$$

where:

N_i = the number of Chinook salmon of sex i counted.

The total number of Chinook salmon of sex i, freshwater age f and marine age m was estimated by:

$$\hat{N}_{ifm} = N_i \hat{p}_{ifm}, \qquad (3)$$

and its variance estimated by:

$$\hat{Var}(\hat{N}_{ifm}) = N_i^2 \hat{Var}(\hat{p}_{ifm}). \qquad (4)$$

The proportion of salmon of freshwater age f and marine age m in the total return to or escapement through the weir was estimated by:

$$\hat{p}_{fm} = \hat{p}_m \hat{\rho}_{fm}, \qquad (5)$$

where:

$\hat{p}_m = {}^{n_m}\!/_{n}$ = proportion of fish for which marine ages were discernible that are of marine age m,

n = number of salmon for which marine ages were discernible

n_m = number of salmon sampled out of n that were of marine age m.

The variance of this proportion was estimated as for equation (2) with the sex subscript i dropped.

The total number of Chinook salmon of freshwater age f and marine age m was estimated by:

$\hat{N}_{fm} = N\,\hat{p}_{fm}$, where N is the total count of Chinook salmon, (6)

with estimated variance:

$$\hat{Var}(\hat{N}_{fm}) = N^2 \hat{Var}(\hat{p}_{fm}). \qquad (7)$$

The overall proportion of salmon of sex i was calculated by:

$$p_i = \frac{n_i'}{N}, \qquad (8)$$

where n_i' is the number of Chinook salmon of sex i (ageable and unageable). The variance of this quantity is zero.

Coho Salmon

No data regarding reader error was available for coho salmon and traditional methods of age calculation were used.

The proportion of coho salmon of sex i that were of age k was estimated as:

$$\hat{p}_{ik} = \frac{n_{ik}}{n_i}, \qquad (9)$$

where:

n_i = number of coho salmon of sex i sampled that were ageable, and

n_{ik} = number of coho salmon out of n_i that were in age class k.

The variance of this proportion was estimated as:

$$\hat{Var}(\hat{p}_{ik}) = \left[\frac{\hat{N}_i - n_i}{\hat{N}_i}\right]\frac{\hat{p}_{ik}(1-\hat{p}_{ik})}{n_i - 1}, \tag{10}$$

where:

$\hat{N}_i = \frac{n_i'}{n'}N$ = the estimated total number of coho salmon of sex i,

n' = the total number of coho salmon sampled (ageable and unageable), and

n_i' = the number of coho salmon of sex i (ageable and unageable) out of n'.

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

$$\hat{N}_{ik} = \hat{N}_i\,\hat{p}_{ik}, \tag{11}$$

with variance estimated by:

$$\hat{Var}(\hat{N}_{ik}) = \left[\frac{N}{n'}n_i'\right]^2 \hat{Var}(\hat{p})_{ik}. \tag{12}$$

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

$$\hat{p}_k = \frac{n_k}{n}, \tag{13}$$

where:

n = the number of coho salmon sampled that were ageable,

n_k = the total number of coho salmon out of n that were of age class k.

The variance of this proportion was estimated as:

$$\hat{Var}(\hat{p}_k) = \frac{N-n}{N}\frac{\hat{p}_k(1-\hat{p}_k)}{n-1}. \tag{14}$$

The total number of coho salmon of age class k was estimated by:

$$\hat{N}_k = N\,\hat{p}_k, \tag{15}$$

with variance:

$$\hat{Var}(\hat{N}_k) = N^2\hat{Var}(\hat{p}_k). \tag{16}$$

The proportion of coho salmon of sex class k, in the total return to or escapement through the weir was estimated as for age except that n was replaced with n'.

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 return and escapement of Chinook salmon presented are minimums. From 15 June-7 September 2000, 1,148 Chinook salmon were enumerated at the weir and 92 Chinook salmon were captured during netting (Table 2). Fifty percent of the immigration passed the weir by 13 July and the last Chinook salmon was sampled at the weir on 16 August (Figure 3; Appendix A1). Total return of Chinook salmon of Deep Creek origin was 1,186 fish and escapement was 1,103 fish (Table 2).

Coho Salmon

Coho salmon immigration at the weir commenced on 26 July and continued through the last day of weir operation, 7 September (Appendix A1). The median date of the coho salmon immigration at the weir was 20 August (Figure 3; Appendix A1). A total of 3,425 coho salmon were counted at the Deep Creek weir (Table 2). One coho salmon was sacrificed for CWT recovery data, but was found to have no tag. Total enumerated escapement was 3,424 coho salmon (Table 2).

STRAYING

A total of 1,240 Chinook salmon were examined for marks of which 137 fish (11%) were sacrificed for CWT information (Table 2; Appendix A1). Forty-six Chinook salmon recoveries were known to originate from Deep Creek, 54 were of non-Deep Creek origin, 27 recovered CWTs were unreadable due to tags being accidentally cut in half in 1997, but were likely of Deep Creek origin, and 10 recoveries were of unknown origin (9 recoveries with no tags and one lost recovery). Contribution of Ninilchik River hatchery stocked Chinook salmon was 53 fish or 4.0% of the return examined for marks (Table 3). One Chinook salmon recovery from the netting portion of the study was identified as originating from hatchery-plants at Seldovia Harbor, Kachemak Bay, Alaska (Figure 1). Lastly, no marked (adipose finclipped) Chinook or coho salmon originally stocked into Homer Spit were recovered at the Deep Creek weir during 2000.

AGE, SEX AND LENGTH COMPOSITION

Chinook Salmon

No statistical test was necessary to examine the effect of weeks on sex composition alone because the sex of every Chinook salmon passing through the weir was recorded; there was no sampling variability associated with the results. When counts were combined over 2-week intervals the proportion of females increased (0.43, 0.46, 0.52, 0.63) in a nearly perfect quadratic manner ($R^2 = 0.99$). Over the season, 48% of the return and 49% of the escapement were males (Tables 4 and 5).

Table 2.-Summary of coded wire tag recovery, return, and escapement counts for Chinook and coho salmon at Deep Creek, 2000.

	Source	Examined	Adipose Fin Clips	CWTs of Deep Creek Origin (Readable) [a]	CWTS of Deep Creek Origin (Unreadable) [b]	CWTs of Non-Deep Creek Origin	No Tag [d]	Other	Return of Deep Creek fish	Escapement [f]
Chinook	Weir	1,148	130	43	25	52 [c]	9	1 [e]	1,096	1,018
	Netting	92	7	3	2	2 [g]			90	85
	Total	1,240	137	46	27	54	9	1	1,186	1,103
Coho	Weir	3,425	1 [h]	0	0	0	1	0	3,425	3,424
	Total	3,425	1	0	0	0	1	0	3,425	3,424

[a] Includes one Chinook salmon tagged as a coho salmon in a separate study.

[b] CWTs applied in 1997 erroneously cut in half at Deep Creek: marine age known, freshwater age estimated.

[c] Consists of 51 fish of Ninilchik origin and 1 fish of Seldovia origin.

[d] Assumed to be of Deep Creek origin (hatchery-released Chinook salmon assumed to retain tags).

[e] One lost head- assumed of Deep Creek origin.

[f] Deep Creek fish adjusted for those sacrificed for tag information.

[g] Two fish of Ninilchik origin.

[h] Did not contain a CWT.

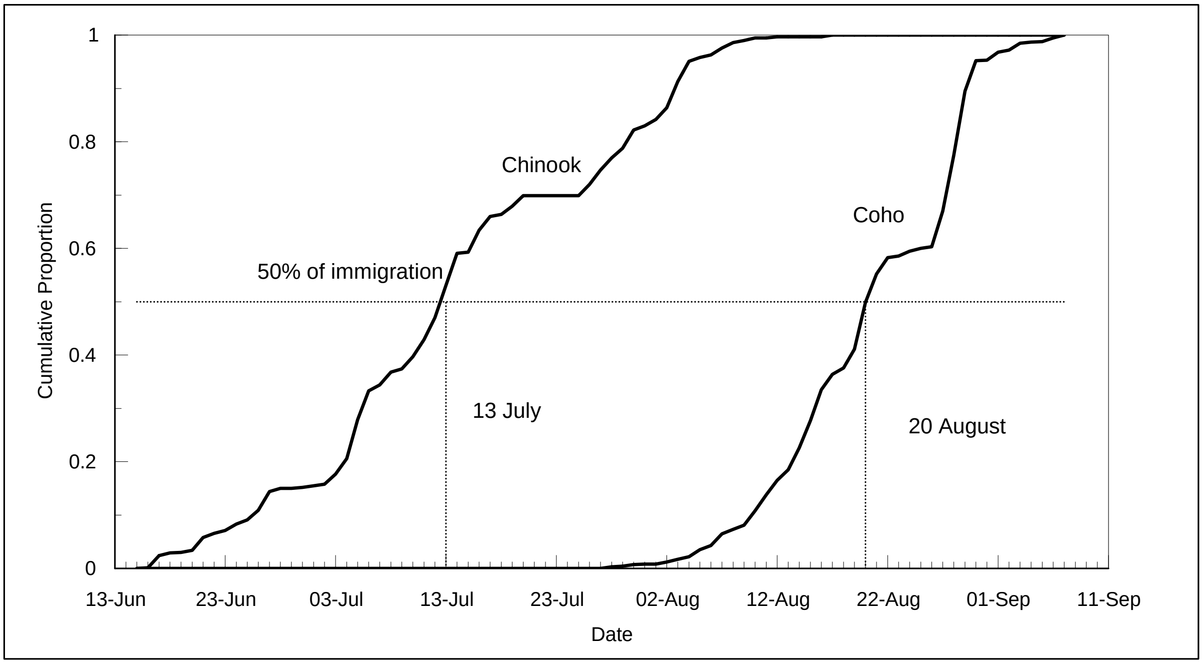


Figure 3.-Immigration timing of Chinook and coho salmon, Deep Creek weir, 2000.

Age was not available for all fish examined. To investigate the relationship between sex, age and week, a loglinear analysis was performed on sex and age data collected from ageable fish over weeks. As a result of the reader error associated with identification of freshwater ages, 0 and 1-check fish were pooled within a marine age within a week. The age component of the analysis was therefore restricted to marine ages. To satisfy assumptions associated with the loglinear analysis, counts for the first 2 weeks were combined, as were marine ages 1 and 2. (There were very few fish of marine age 1).

The analysis found a significant three-way interaction ($p = 0.02$; the finite nature of the population means that the significance of the interaction is underestimated). The three-way interaction implies, for example, that the influence of sex on age structure changed over weeks.

A loglinear analysis was also conducted to examine associations between sex, age and the source of the fish (i.e. weir or netting program). No three-way interaction was found ($p = 0.13$) and the best-fitting model was one in which sex and source were independent given age; i.e. within an age, source did not affect sex composition. Age and source interacted ($p = 0.02$), as did sex and age ($p = 0.01$).

The proportion of fish through the weir that were considered ageable (marine age) each week was relatively constant, meaning that we can assume a random sample was taken from the passage through the weir, and estimates of proportions by sex and age for the weir are self-weighting over weeks. Pooling the data over the weir and netting program (Tables 4 and 5) assumes the netting and weir programs sampled similar proportions of the associated populations so that estimates over the weir and netting programs are again self-weighting. (Stratification of weir and netting data is not possible because the size of the population sampled in the netting program is unknown). Four marine age classes were

Table 3.-Coded wire tag recovery information by location for Chinook salmon sampled at Deep Creek, 2000.

Source	Tag Code	Brood Year [a]	Rearing Code and Location [b]	Release Date	Release Site	Actual Age [c] Fresh	Actual Age [c] Ocean	Female	Male	Total Tags
Weir	312510	1995	(H) Elmendorf	12-Jun-96	Seldovia Harbor	0	4	1	0	1
	312515		(H) Fort Rich.	13-Jun-96	Ninilchik R.	0	4	1	0	1
	312549	NONSENSE	(W) Deep Creek	30-Jul-97	Deep Creek	2	3	1	0	1
	312552		(W) Deep Creek	30-Jul-97	Deep Creek	0	3	0	3	3
	312553		(W) Deep Creek	30-Jul-97	Deep Creek	1	3	15	9	24
	312608		(H) Fort Rich.	17-Jun-97	Ninilchik R.	0	3	24	11	35
	312635		(H) Fort Rich.	15-Jun-98	Ninilchik R.	0	2	2	13	15
	1301030811		(W) Deep Creek	14-Aug-96	Deep Creek	1	4	6	3	9
	1301030812		(W) Deep Creek	14-Aug-96	Deep Creek	0	4	4	2	6
	Head Lost							0	1	1
	No Tag							5	4	9
	Unreadable		(W) Deep Creek		Deep Creek		3	19	6	25
	Summary	All	(W) Deep Creek		Deep Creek			45	23	68
		All	(H) Fort Rich.		Ninilchik R.			27	24	51
		All	(H) Elmendorf		Seldovia Harbor			1	0	1
		All	Head Lost /No Tag					5	5	10
								78	52	130
Upper River Netting										
	312549		(W) Deep Creek	30-Jul-97	Deep Creek	2	3	1	0	1
	1301030811		(W) Deep Creek	14-Aug-96	Deep Creek	1	4	1	1	2
	312635		(H) Fort Rich.	15-Jun-98	Ninilchik R.	0	2	0	2	2
	Unreadable		(W) Deep Creek		Deep Creek		3	2	0	2
	Summary	All	(W) Deep Creek		Deep Creek			4	1	5
		All	(H) Fort Rich.		Ninilchik R.			0	2	2
								4	3	7
Weir and Upper River Netting		All	(W) Deep Creek		Deep Creek			49	24	73
		All	(H) Fort Rich.		Ninilchik R.			27	26	53
		All	(H) Elmendorf		Seldovia Harbor			1	0	1
		All	Head Lost/No Tag					5	5	10
								82	55	137

[a] Nonsense location denotes Chinook salmon identified as coho salmon at the time of coded wire tagging.

[b] Rearing code W denotes wild and H hatchery. Unreadable tags assigned Deep Creek origin.

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

Table 4.-Estimated age composition and length-at-age by sex of the return of Chinook salmon at Deep Creek, 2000.

	Age									Total	Proportion by Sex
	0.2	0.3	0.4	1.1	1.2	1.3	1.4	2.1	2.3		
Females											
Estimated Proportion	0.03	0.08	0.05	0.015	0.09	0.63	0.09	0.0020	0.02		0.52
SE Proportion	0.033	0.053	0.047	NA	0.034	0.053	0.047	NA	NA		0
Estimated abundance	17	48	32	9	53	384	58	1	11	613	
SE Abundance	20	32	29	NA	21	33	29	NA	NA		
Ocean Age		3	4								
Mean Length		779.5	829.1								
SE Mean Length		5.1	8.0								
Males											
Estimated Proportion	0.05	0.07	0.04	0.02	0.14	0.60	0.08	0.0000	0.0023		0.48
SE Proportion	0.041	0.051	0.043	NA	0.042	0.052	0.043	NA	NA		0
Estimated abundance	27	43	25	9	78	344	47	0	1	573	
SE Abundance	24	29	24	NA	24	30	25	NA	NA		
Ocean Age		3	4								
Mean Length		785.5	865.0								
SE Mean Length		9.5	15.0								
All											
Estimated Proportion	0.04	0.08	0.05	0.02	0.11	0.61	0.09	0.00	0.01		
SE Proportion	0.037	0.052	0.045	NA	0.038	0.052	0.045	NA	NA		
Estimated abundance	44	91	57	18	131	728	104	1	13	1,186	
SE Abundance	44	62	53	NA	45	62	53	NA	NA		
Ocean Age		3	4								
Mean Length		782	839								
SE Mean Length		5	7								

Table 5.-Estimated age composition and length-at-age by sex of the escapement of Chinook salmon at Deep Creek, 2000.

	Age										Proportion
	0.2	0.3	0.4	1.1	1.2	1.3	1.4	2.1	2.3	Total	By Sex
Females											
Estimated Proportion	0.03	0.08	0.05	0.02	0.10	0.62	0.09	0.00	0.02		0.51
SE Proportion	0.036	0.053	0.045	NA	0.036	0.054	0.045	NA	NA		0
Estimated abundance	17	45	27	9	53	347	50	1	9	559	
SE Abundance	20	29	25	NA	20	30	25	NA	NA		
Ocean Age		3	4								
Mean Length		777.1	830.6								
SE Mean Length		6.0	13.0								
Males											
Estimated Proportion	0.05	0.07	0.04	0.02	0.14	0.60	0.08	0.00	0.00		0.49
SE Proportion	0.043	0.051	0.041	NA	0.043	0.052	0.041	NA	NA		0
Estimated abundance	27	39	23	9	77	327	41	0	1	544	
SE Abundance	23	28	22	NA	24	28	22	NA	NA		
Ocean Age		3	4								
Mean Length		781.8	856.0								
SE Mean Length		12.0	16.0								
All											
Estimated Proportion	0.04	0.08	0.05	0.02	0.12	0.61	0.08	0.00	0.01	1.00	
SE Proportion	0.039	0.052	0.043	NA	0.039	0.052	0.043	NA	NA		
Estimated abundance	44	84	50	18	130	674	92	1	11	1,103	
SE Abundance	43	57	47	NA	44	58	47	NA	NA		
Ocean Age		3	4								
Mean Length		779	839								
SE Mean Length		6	10								

identified for Deep Creek Chinook salmon and nine upon assignment of freshwater ages. Approximately 98% of all Chinook salmon in the return and escapement were estimated as 2- to 4-ocean fish. The majority of the escapement was composed of Chinook salmon that were age-1.3 (61%, SE = 5.2%), followed by age-1.2 (12%, SE = 3.9), and age-1.4 (8%, SE = 4.3). As a result of reader error in determination of freshwater ages, lengths are reported by ocean age. The mean length of 3-ocean fish in the escapement was 779 mm (SE = 6 mm) and that of 4-ocean fish was 839 mm (SE = 10 mm) (Table 5). Approximately 16% of the escapement consisted of fish that were estimated to have smolted at age-0 (Table 5).

Coho Salmon

A total of 256 coho salmon were sampled for sex and age at the weir (Table 6). A loglinear analysis of the sex, age and week data found no evidence of any interactions among the three factors. Among the interpretations of this finding is that age compositions did not change over sex or over weeks, and sex composition did not change over weeks. There was no evidence of lack of fit for the mutual independence model including sex, week and age ($p = 0.12$).

The estimated sex composition of the coho salmon escapement was 53% (SE = 3%) female and 47% (SE = 3%) male (Table 6). The majority of the coho salmon escapement was composed of 4-year old fish, age 2.1 (79%, SE = 3%) with a mean length of 575 mm (SE = 3 mm), and 15% (SE = 2%) were age 1.1 with mean length 577 mm (SE = 9 mm). About 7% of the escapement was composed of 5-year fish of age classes 3.1 and 2.2 (Table 6).

DISCUSSION

CHINOOK SALMON

Starting in 1997 the Department has tried to gain a better understanding of escapement as well as marine sport harvests influencing the numbers of Chinook salmon spawning in Deep Creek. Achieving a census of the escapement has been problematic because high water has prevented weir installation prior to the Chinook salmon immigration each year, and therefore we are unable to accurately estimate Chinook salmon exploitation. However, using estimates of harvest from the SWHS and weir counts gives inriver Chinook salmon exploitation rates that range from 0.27 to 0.60 and average 0.41 (Table 7). We know our exploitation estimates are biased high and available information indicates that exploitation has likely averaged less than 0.41 since 1997. Furthermore, if 25% or 50% of the Chinook salmon escapement has occurred prior to weir installation exploitation rates then average 0.35 and 0.27, respectively. This inference provides an important management reference point in relation to sustained yield since Chinook salmon exploitation rates below 0.40 are generally sustainable (Chapman 1986, CTC 1999). Consequently, given the limitations of our data we conclude that the level of Chinook salmon harvests occurring at Deep Creek are probably sustainable.

Comparison of aerial to weir counts from 1999 and 2000 indicate that aerial counts were correlated with weir escapement counts (Table 1). However, these data are insufficient to quantify the relationship between the aerial counts and true spawning stock size. Consequently, we recommend that a more cost-effective approach in support of Chinook salmon management would be to eliminate weir operations for Chinook salmon and use aerial counts to monitor future escapements.

Table 6.-Estimated age composition and length-at-age by sex of the coho salmon escapement at Deep Creek, 2000.

	Age					Proportion
7/26 - 9/07/00	1.1	2.1	2.2	3.1	Total	By Sex
Females						
Number sampled	17	117	3	5	181	
Estimated Proportion	0.12	0.82	0.02	0.04		0.53
SE Proportion	0.026	0.031	0.012	0.015		0.026
Estimated abundance	217	1,493	38	64	1,812	
SE Abundance	47.56	55.7997	21.0686	27	88	
Mean Length	568	574	583	586	571	
SE Mean Length	12	4	17	14	3	
Males						
Number sampled	20	85	4	5	161	
Estimated Proportion	0.18	0.75	0.04	0.04		0.47
SE Proportion	0.034	0.039	0.017	0.019		0.026
Estimated abundance	283	1,202	57	71	1,612	
SE Abundance	55.6	63.6605	26.896	29.93	88	
Mean Length	585	577	541	578	575	
SE Mean Length	13	6	42	14	4	
All						
Number sampled	37	202	7	10	256	
Estimated Proportion	0.14	0.79	0.03	0.04		
SE Proportion	0.021	0.025	0.010	0.012		
Estimated abundance	495	2,702	94	134	3,424	
SE Abundance	73	84	34	40		
Mean Length	577	575	559	582	573	
SE Mean Length	9	3	25	10	3	

[a] Totals do not equal sum of the number sampled by sex due to illegible scales.

The estimated contribution of hatchery-produced Ninilchik River Chinook to the Deep Creek return has ranged from approximately 2% to 4% over the past 4 years (Begich 2002; King and Breakfield 1999, 2002). Interaction with wild Deep Creek fish was minimal as all Ninilchik River strays that were captured at the weir were removed from the escapement. Furthermore, the stray rate of the hatchery-produced return at Ninilchik has not been completely estimated because we do not know how many hatchery fish of Ninilchik origin actually stray upon return from their release site. However, we do know how many stray to Deep Creek. Therefore we conclude that the stocking program at Ninilchik probably does not threaten production of wild Chinook salmon at Deep Creek because of the low number of hatchery origin fish we have observed at the weir since 1997.

During 2000 a high percentage (nearly 20%) of heads that were sent to the Tag Lab in Juneau for decoding were equipped with unreadable tags (Table 3). It is likely that the origin of most of these marked fish was Deep Creek as tagging crews encountered difficulty cutting CWT bundles from which tags were injected into smolt during 1997. The result of these difficulties was that these tags did not reveal release date and location when decoded.

Table 7.-Population statistics for Chinook and coho salmon of Deep Creek, 1997-2000.

Year	Statewide Harvest Survey Estimate[a]	Weir Count	Inriver Return	Inriver Exploitation
Chinook				
1997	1,249	1,596	2,845	0.439
1998	539	367	906	0.595
1999	741	2,056	2,797	0.265
2000	593	1,148	1,741	0.341
Mean	781	1,292	2,072	0.410
Coho				
1997	1,115	2,017	3,132	0.356
1998	2,035	1,537	3,572	0.570
1999	2,651	2,267	4,918	0.539
2000	2,018	3,425	5,443	0.371
Mean	1,955	2,312	4,266	0.459

[a] Source is Howe et al. 2001b, 2001c, 2001d; Walker et al. 2003.

COHO SALMON

The weir count of 3,425 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 and was 2,018 during 2000 (Table 1 and Table 7). Harvests greater than 2,000 fish were also estimated during 1985, 1989 and 1996 possibly due to larger returns; however, the yearly estimated coho salmon harvests have been trending upwards (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 total return and exploitation rate is not available. However, using inriver harvests and weir counts, inriver exploitation for 1997-2000 ranged from 36%-57%, averaging 46% (Table 7). It is not known if these harvests are sustainable. Therefore, we recommend that monitoring coho salmon escapement at Deep Creek with the current weir program continue.

Lastly, no coho salmon straying from Homer Spit to Deep Creek were detected. The distance between these two locations and lack of Homer Spit coho salmon present in the 2000 return to Deep Creek indicate 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 Deep Creek (Figure 1).

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APPENDIX A.-SUPPORTING STATISTICS

Appendix A1.-Daily and cumulative counts of unmarked and adipose finclipped Chinook and coho salmon, Deep Creek weir, 15 June-7 September 2000.

	Chinook							Coho		
	Unmarked		AFC[a]		Daily		Cum.	Daily		Cum.
Date	Daily	Cum.	Daily	Cum.	Total[b]	Cum.	Prop.[c]	Count[b]	Cum.	Prop.[c]
15-Jun	0	0	0	0	0	0	0.000	0	0	0.000
16-Jun	1	1	0	0	1	1	0.001	0	0	0.000
17-Jun	23	24	3	3	26	27	0.024	0	0	0.000
18-Jun	6	30	0	3	6	33	0.029	0	0	0.000
19-Jun	1	31	0	3	1	34	0.030	0	0	0.000
20-Jun	4	35	1	4	5	39	0.034	0	0	0.000
21-Jun	25	60	3	7	28	67	0.058	0	0	0.000
22-Jun	9	69	0	7	9	76	0.066	0	0	0.000
23-Jun	6	75	0	7	6	82	0.071	0	0	0.000
24-Jun	12	87	1	8	13	95	0.083	0	0	0.000
25-Jun	9	96	1	9	10	105	0.091	0	0	0.000
26-Jun	18	114	2	11	20	125	0.109	0	0	0.000
27-Jun	35	149	5	16	40	165	0.144	0	0	0.000
28-Jun	4	153	3	19	7	172	0.150	0	0	0.000
29-Jun	0	153	0	19	0	172	0.150	0	0	0.000
30-Jun	3	156	0	19	3	175	0.152	0	0	0.000
1-Jul	2	158	1	20	3	178	0.155	0	0	0.000
2-Jul	3	161	0	20	3	181	0.158	0	0	0.000
3-Jul	19	180	3	23	22	203	0.177	0	0	0.000
4-Jul	31	211	2	25	33	236	0.206	0	0	0.000
5-Jul	78	289	6	31	84	320	0.279	0	0	0.000
6-Jul	52	341	10	41	62	382	0.333	0	0	0.000
7-Jul	12	353	1	42	13	395	0.344	0	0	0.000
8-Jul	25	378	2	44	27	422	0.368	0	0	0.000
9-Jul	7	385	0	44	7	429	0.374	0	0	0.000
10-Jul	24	409	3	47	27	456	0.397	0	0	0.000
11-Jul	34	443	2	49	36	492	0.429	0	0	0.000
12-Jul	43	486	4	53	47	539	0.470	0	0	0.000
13-Jul	66	552	5	58	71	610	0.531	0	0	0.000
14-Jul	63	615	6	64	69	679	0.591	0	0	0.000
15-Jul	1	616	1	65	2	681	0.593	0	0	0.000
16-Jul	40	656	7	72	47	728	0.634	0	0	0.000
17-Jul	25	681	5	77	30	758	0.660	0	0	0.000
18-Jul	3	684	1	78	4	762	0.664	0	0	0.000
19-Jul	13	697	5	83	18	780	0.679	0	0	0.000
20-Jul	19	716	3	86	22	802	0.699	0	0	0.000
21-Jul	0	716	0	86	0	802	0.699	0	0	0.000
22-Jul	0	716	0	86	0	802	0.699	0	0	0.000
23-Jul	0	716	0	86	0	802	0.699	0	0	0.000
24-Jul	0	716	0	86	0	802	0.699	0	0	0.000
25-Jul	0	716	0	86	0	802	0.699	0	0	0.000
26-Jul	22	738	2	88	24	826	0.720	1	1	0.000
27-Jul	25	763	6	94	31	857	0.747	0	1	0.000

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Appendix A1.-Page 2 of 2.

	Chinook								Coho		
Date	Unmarked Daily	Cum.	AFC[a] Daily	Cum.	Daily Total[b]	Cum.	Cum. Prop.[c]	Daily Count[b]	Cum.	Cum. Prop.[c]
28-Jul	24	787	3	97	27	884	0.770	10	11	0.003
29-Jul	19	806	2	99	21	905	0.788	1	12	0.004
30-Jul	35	841	4	103	39	944	0.822	12	24	0.007
31-Jul	9	850	0	103	9	953	0.830	5	29	0.008
1-Aug	9	859	5	108	14	967	0.842	0	29	0.008
2-Aug	17	876	8	116	25	992	0.864	11	40	0.012
3-Aug	50	926	6	122	56	1,048	0.913	17	57	0.017
4-Aug	39	965	5	127	44	1,092	0.951	19	76	0.022
5-Aug	8	973	0	127	8	1,100	0.958	44	120	0.035
6-Aug	5	978	1	128	6	1,106	0.963	26	146	0.043
7-Aug	13	991	1	129	14	1,120	0.976	77	223	0.065
8-Aug	12	1,003	0	129	12	1,132	0.986	26	249	0.073
9-Aug	5	1,008	0	129	5	1,137	0.990	30	279	0.081
10-Aug	4	1,012	1	130	5	1,142	0.995	91	370	0.108
11-Aug	0	1,012	0	130	0	1,142	0.995	104	474	0.138
12-Aug	2	1,014	0	130	2	1,144	0.997	90	564	0.165
13-Aug	0	1,014	0	130	0	1,144	0.997	68	632	0.185
14-Aug	0	1,014	0	130	0	1,144	0.997	141	773	0.226
15-Aug	1	1,015	0	130	1	1,145	0.997	175	948	0.277
16-Aug	0	1,015	0	130	0	1,145	0.997	198	1,146	0.335
17-Aug	3	1,018	0	130	3	1,148	1.000	101	1,247	0.364
18-Aug	0	1,018	0	130	0	1,148	1.000	41	1,288	0.376
19-Aug	0	1,018	0	130	0	1,148	1.000	120	1,408	0.411
20-Aug	0	1,018	0	130	0	1,148	1.000	300	1,708	0.499
21-Aug	0	1,018	0	130	0	1,148	1.000	183	1,891	0.552
22-Aug	0	1,018	0	130	0	1,148	1.000	107	1,998	0.583
23-Aug	0	1,018	0	130	0	1,148	1.000	10	2,008	0.586
24-Aug	0	1,018	0	130	0	1,148	1.000	29	2,037	0.595
25-Aug	0	1,018	0	130	0	1,148	1.000	19	2,056	0.600
26-Aug	0	1,018	0	130	0	1,148	1.000	8	2,064	0.603
27-Aug	0	1,018	0	130	0	1,148	1.000	230	2,294	0.670
28-Aug	0	1,018	0	130	0	1,148	1.000	360	2,654	0.775
29-Aug	0	1,018	0	130	0	1,148	1.000	411	3,065	0.895
30-Aug	0	1,018	0	130	0	1,148	1.000	197	3,262	0.952
31-Aug	0	1,018	0	130	0	1,148	1.000	3	3,265	0.953
1-Sep	0	1,018	0	130	0	1,148	1.000	51	3,316	0.968
2-Sep	0	1,018	0	130	0	1,148	1.000	14	3,330	0.972
3-Sep	0	1,018	0	130	0	1,148	1.000	44	3,374	0.985
4-Sep	0	1,018	0	130	0	1,148	1.000	7	3,381	0.987
5-Sep	0	1,018	0	130	0	1,148	1.000	4	3,385	0.988
6-Sep	0	1,018	0	130	0	1,148	1.000	23	3,408	0.995
7-Sep	0	1,018	0	130	0	1,148	1.000	17	3,425	1.000
8-Sep	Weir removed no count									

[a] AFC is adipose finclip.

[b] Daily totals 0 fish for 7/21 through 7/25, fish pass at weir not operated.

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