Fishery Data Series No. 02-12

Marking, Enumeration, and Size Estimation for Coho and Chinook Salmon Smolt Releases into Upper Cook Inlet and Prince William Sound, Alaska, in 2000

by

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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

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ABSTRACT

Approximately 498,000 coho salmon *Oncorhynchus kisutch* and 646,000 chinook salmon *O. tshawytscha* smolt were released at 10 locations in Cook Inlet and Prince William Sound in 2000. Of these, about 158,000 coho salmon and 462,000 chinook salmon were marked with an adipose finclip and a coded wire tag. Tag retention for individual release groups ranged from 95.7% to 99.3%. Fort Richardson Hatchery achieved the production goal of 80% of the chinook salmon smolt within the 5.1 g to 15.0 g size range for the Deception Creek and Ninilchik River release groups. All of the coho salmon release groups at Fort Richardson Hatchery and the chinook salmon release groups at Elmendorf Hatchery were larger than the desired size range.

At Elmendorf Hatchery mark-recapture population estimates were used for determining the number of fish in three rearing units containing chinook salmon, and a physical count obtained at the time of tagging was the reported number of fish released from one release group of chinook. At Fort Richardson Hatchery an electronic counter was used to determine the number of fish in each rearing unit containing coho salmon, and a physical count was obtained for each release group of chinook salmon.

Key words: hatchery, marking, coded wire tags, chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *Oncorhynchus kisutch*, mark-recapture, tag retention, size composition.

INTRODUCTION

Over half of Alaskans live in Southcentral Alaska, which receives the vast majority of the state's sport fishing effort. Hatchery-reared chinook salmon *Oncorhynchus tshawytscha* and coho salmon *O. kisutch* smolt have been stocked in numerous locations throughout Southcentral Alaska to improve or create terminal sport fisheries and relieve pressure on wild stocks (Appendix A). A critical element of many coho and chinook salmon hatchery smolt stocking projects in Cook Inlet and Prince William Sound is the use of coded wire tags (CWT) to mark these smolt. CWTs are used to estimate the contribution from individual stockings to commercial fisheries, marine and freshwater recreational fisheries, and personal use fisheries. Straying of stocked coho and chinook salmon is also evaluated using CWTs (Cyr et al. 2001).

The accuracy of contribution estimates from mark recoveries is highly dependent upon the accuracy of the estimated number of unmarked fish in the release population. Based on previous experiments (Starkey et al. 1996, 1997, 1999; Loopstra et al. 2000b), personnel used an electronic counter to determine the number of fish in each release group of coho salmon, and a physical count for the number of chinook salmon in each release group at Fort Richardson Hatchery (FRH). At Elmendorf Hatchery (EH) we used mark-recapture experiments to estimate the number of fish in three release groups, and a physical count to determine the number of fish in one release group.

Another important element of hatchery smolt stocking programs is fish size. Mean size and size distribution at release are indicators of the quality of hatchery smolt (Peltz and Starkey 1993). If smolt are too small at release, ocean survival will be poor; if smolt are too large at release, ocean residence will be reduced, shifting age composition of returns to younger, smaller fish (Sweet and Peltz 1994). Weight distributions determined for each rearing unit at release allow hatchery personnel to determine the quality of smolt being released.

This project documents releases of stocked chinook and coho salmon marked with coded wire tags in Cook Inlet and Prince William Sound. Specific objectives for 2000 were:

1. To estimate the number of chinook salmon smolt in three release groups at EH using mark-recapture techniques;
2. To estimate the weight composition of each release group;
3. To estimate the long-term (>30 days) tag retention rate of each group of marked fish.

Nineteen release groups with a projected 2,386,000 coho and chinook salmon smolt were stocked in Cook Inlet and Prince William Sound in 2000. We planned to mark with an adipose clip and CWT approximately 635,000 of the projected 1,170,000 coho and chinook salmon smolt to be stocked in 10 of these release groups. This entailed marking a representative sample of at least 20,000 coho salmon from one release group, and at least 40,000 coho or chinook salmon smolt from each of the remaining nine release groups.

This report presents the results of the 2000 marking program. Based on the data summarized in this report, recommendations are made for future marking and collection of release data. All data for this report are held and archived by Research and Technical Services, Division of Sport Fish, Alaska Department of Fish and Game.

METHODS

SMOLT MARKING

Elmendorf Hatchery raised chinook salmon from Deception Creek and Crooked Creek brood stocks. Fort Richardson Hatchery raised coho salmon from Ship Creek (Little Susitna River) and Jim Creek brood stocks, and chinook salmon from Deception Creek and Ninilchik River brood stocks (Table 1). Fish from 10 release groups were released at seven sites in Cook Inlet and three sites in Prince William Sound. Each release group was marked with a unique tag code(s) (Tables 2 and 3).

We used a systematic sampling procedure to obtain a representative sample of smolt for marking from each release group where only a portion of the fish was to be tagged. For each rearing unit of coho salmon at FRH, fish were systematically removed during the electronic counting process and placed in net pens to be held for tagging. These fish were held separate from the rest of the population until they were tagged. All of the smolt in the Ninilchik River and Deception Creek chinook salmon smolt release groups at FRH were marked and tagged.

At EH fish were selected for tagging when they were divided into two raceways. During the division process, technicians crowded and held the fish at one end of the original raceway. All fish that were to be transferred to a new raceway were dipnetted, weighed, and either placed in net pens to be held for tagging, or released in the new raceway. Approximately every third to fifth dip net of fish was held for tagging, depending on the estimated proportion to be tagged. Fish remaining in the original raceway were also netted, weighed, and then either placed into net pens for tagging or returned to the raceway on the other side of the crowder. After all fish in the raceway were weighed, the crowder was removed. All fish in the net pens were marked and tagged. If fish for a particular release group were in more than one raceway, then an attempt was made to mark approximately the same proportion of fish in each raceway (Peltz and Miller 1990).

All fish were tagged with a full-length CWT (1.1 mm) using a Northwest Marine Technology[1] Mark IV tag injector. All of the marked smolt from release groups in 2000 were graded and tagged using the appropriate size head mold. At least 510 fish were obtained from each stock up to 7 days before the start of tagging. Each fish

[1] Use of a company's name does not constitute endorsement.

Table 1.-Total release, number of fish marked with adipose clips and coded wire tags stocked into various systems in Cook Inlet and Prince William Sound in 2000, and the number of fish examined to achieve the desired level of precision.

Stocking Site	Stocking Area[a]	Brood Stock	Number of Fsh in Raceway	Inventory Method Used	Number of Raceways	Number Marked per Raceway	Average Examined per Raceway per Experiment	Number M-R Experiments	Precision
			Elmendorf Hatchery						
Chinook Salmon									
Crooked Creek	CI	Crooked Creek	108,507	physical count	1	108,507	N/A	N/A	
Fleming Spit [b]	PWS	Deception Creek	113,890	mark-recapture	1	43,932	2,633	3	+/-5%
Valdez Glacier Stream	PWS	Deception Creek	115,582	mark-recapture	1	41,728	2,804	3	+/-5%
Shakespeare Creek	PWS	Deception Creek	119,389	mark-recapture	1	43,551	2,550	3	+/-5%
			Fort Richardson Hatchery						
Coho Salmon									
Campbell Creek	CI	Ship Cr (Little Susitna River)	63,730	electronic count	1	19,948	N/A	NA	
Bird Creek	CI	Ship Cr (Little Susitna River)	97,409	electronic count	1	40,114	N/A	NA	
Eklutna Tailrace	CI	Jim Creek	76,851	electronic count	1	40,514	N/A	NA	
Ship Creek	CI	Ship Cr (Little Susitna River)	129,924	electronic count	2	31,874	N/A	NA	
			130,146	electronic count		29,766			
Chinook Salmon									
Deception Creek	CI	Deception Creek	128,236	physical count	2	128,236	N/A	NA	
			78,260	physical count		78,260			
Ninilchik River	CI	Ninilchik River	51,298	physical count	1	51,298	N/A	NA	
Totals			1,213,221			657,728			

N/A = Not applicable.

[a] CI = Cook Inlet; PWS = Prince William Sound.

[b] Mark-recapture estimate at the time of sampling. Actual reported number is a visual estimate of 45,000 that survived transport.

Table 2.-Summary of coded wire tagging data and release estimates at Fort Richardson Hatchery for coho salmon smolt stocked at four locations in Cook Inlet in 2000.

	Fort Richardson[a]				
Parameter	Campbell Creek F2	Bird Creek E2	Eklutna Tailrace F4	Ship Creek E1 & F1	Totals
Tag Codes	31-02-30	31-01-43	31-01-46	31-01-32 31-01-33	
Total marked and tagged	20,011	40,291	40,580	62,984	163,866
Mortalities	63	177	66	1,344	1,650
Marked fish released	19,948	40,114	40,514	61,640	162,216
Tag retention sample size	757	757	770	1,327 [b]	
Tag retention at release	98.0%	98.2%	99.1%	95.7%	97.5%
Tag retention variance	2.57E-05	2.40E-05	1.17E-05	3.13E-05	
Tagged fish released	19,549	39,392	40,149	58,989	158,080
Tagged fish variance	10,223	38,636	19,228	119,026	
Total fish released	63,730	97,409	76,851	260,070	498,060
Percent marked	31.3%	41.2%	52.7%	23.7%	32.6%
Tagging dates	11/2/1999 11/4/1999	10/26/1999 11/1/1999	11/4/1999 11/10/1999	10/19/1999 10/25/1999	
Date of tag retention check	5/23/2000	5/18/2000	6/1/2000	5/22/2000	
Days elapsed	201	199	204	210	

[a] Total fish released is an electronic count.

[b] 563 in E1 and 764 in F1.

was measured for fork length to the nearest millimeter, and a length frequency distribution was calculated. The two or three head mold sizes that cumulatively fit at least 80% of the fish length distribution were selected for tagging, and the fish were graded accordingly.

Fish that were to be marked were anesthetized with MS-222. The adipose fin was excised at the base using surgical scissors. A tag was then injected into the nose of the fish, and the fish was sent through a quality control device (QCD). The QCD detected the magnetized tag and separated the fish with tags from those without tags. All fish without tags were tagged again. Quality control checks for tag placement were conducted following initial daily startup, and following a change in head mold size or a change in tagging personnel. During each quality control

Table 3.-Summary of coded wire tagging data and release estimates at Elmendorf and Fort Richardson hatcheries for chinook salmon smolt stocked at three locations in Cook Inlet and three locations in Prince William Sound in 2000.

	Fort Richardson Hatchery		Elmendorf Hatchery				
Parameter	Deception Creek D2[a] & Head D3[a]	Ninilchik River Tail D3[a]	Fleming Spit RW1[b]	Valdez Glacier Stream RW2[c]	Shake-speare Creek RW3[c]	Crooked Creek RW10[a]	Totals
Tag Codes	31-01-44 31-26-21 31-02-33, 34, 35	31-02-48	31-01-38	31-01-37	31-01-39	31-01-35 31-01-34 31-02-31	
Total marked and tagged	208,894	51,362	44,009	41,805	43,614	110,534	500,218
Mortalities	2,398	64	26,651	77	63	2,027	31,280
Marked fish released	206,496	51,298	17,358	41,728	43,551	108,507	468,938
Tag retention sample size	1,590	790	832	869	806	928	
Tag retention at release	99.3%	97.5%	99.3%	98.4%	98.5%	97.3%	98.5%
Tag retention variance	4.32E-06	3.13E-05	8.62E-06	1.83E-05	1.82E-05	2.83E-05	
Tagged fish released	205,051	50,016	17,236	41,060	42,898	105,578	461,839
Tagged fish variance	184,366	82,298	2,596	31,797	34,557	332,941	
Total fish released	206,496	51,298	45,000	115,582	119,389	108,507	646,271
% marked	100.0%	100.0%	38.6%	36.1%	36.5%	100.0%	72.6%
Tagging dates	2/17/2000 3/14/2000	3/14/2000 3/21/2000	1/26/2000 1/31/2000	2/1/2000 2/8/2000	2/8/2000 2/11/2000	1/10/2000 1/24/2000	
Date of tag retention check	5/25/2000	5/31/2000	5/24/2000	6/8/2000	6/7/2000	6/1/2000	
Days elapsed	72	71	114	121	117	129	

[a] Total fish released was determined by a physical count.

[b] Total fish released was a visual estimate at the time of release.

[c] Total fish released is based on a mark-recapture estimate.

check a minimum of two tagged fish were dissected to determine tag placement (Moberly et al. 1977; Figure 1). Head mold or wire adjustments were made when necessary. Fish that were killed to determine tag placement were subtracted from the daily number of tagged fish and were not included as tagged fish.

After tagging, all fish were held in net pens overnight to determine short-term mortality and estimate short-term tag retention rate. All overnight mortalities were counted and recorded. Short-term retention rates were estimated daily by passing a random sample of 200 fish through the QCD. If the physical retention rate was at least 85%, this level of sampling would have provided an estimate that was within 5 percentage points of the true retention rate 95% of the time (Cochran 1977). Daily tag retention rate (D_i) of smolt that were finclipped, tagged, survived, and retained the tag was estimated as a binomial proportion:

$$\hat{D}_i = \frac{n_i}{n_{ti}}, \quad (1)$$

where:

n_i = number of live smolt in the sample tagged on day i that retained the tag, and

n_{ti} = total number of live smolt in the sample tagged on day i,

and a variance of:

$$\mathrm{Var}\left(\hat{D}_i\right) = \frac{\hat{D}_i\left(1-\hat{D}_i\right)}{n_{ti}-1}. \quad (2)$$

Tagged smolt were combined with untagged smolt following overnight mortality checks, and all fish were treated the same until release. Fish mortality in each raceway was monitored daily and all marked and unmarked mortalities were recorded.

Long-term tag retention was estimated for all release groups at least 30 days after tagging (Blankenship 1990). Fish were crowded in each rearing container, then at least 750 adipose clipped fish were randomly sampled from the population and checked for tag retention using a hand held CWT detector. If the physical retention rate was at least 90%, this level of sampling would have provided an estimate that is within 2.5 percentage points of the true retention rate 97.5% of the time (Cochran 1977). Long-term tag retention rate (D_j) of smolt that were finclipped, tagged, survived, and retained the tag, and its variance, were also estimated as a binomial proportion (equations 1 and 2) for each group,

where:

n_i = number of tagged smolt in the sample that retained the tag; and

n_{ti} = total number of tagged smolt in the sample.

The number of fish released with valid CWTs was estimated as:

$$\hat{T}_j = \left(N_j - M_j\right)\hat{D}_j, \quad (3)$$

and its variance as:

$$\mathrm{Var}(\hat{T}_j) = \left(N_j - M_j\right)^2 \mathrm{Var}(\hat{D}_j), \quad (4)$$

where:

N_j = number of fish injected with a tag in group j,

$\hat{D}_j$ = long-term tag retention of release group j, and

M_j = total number of mortalities of tagged fish in group j.

SMOLT ENUMERATION

The number of fish in each release group was determined prior to release using an electronic

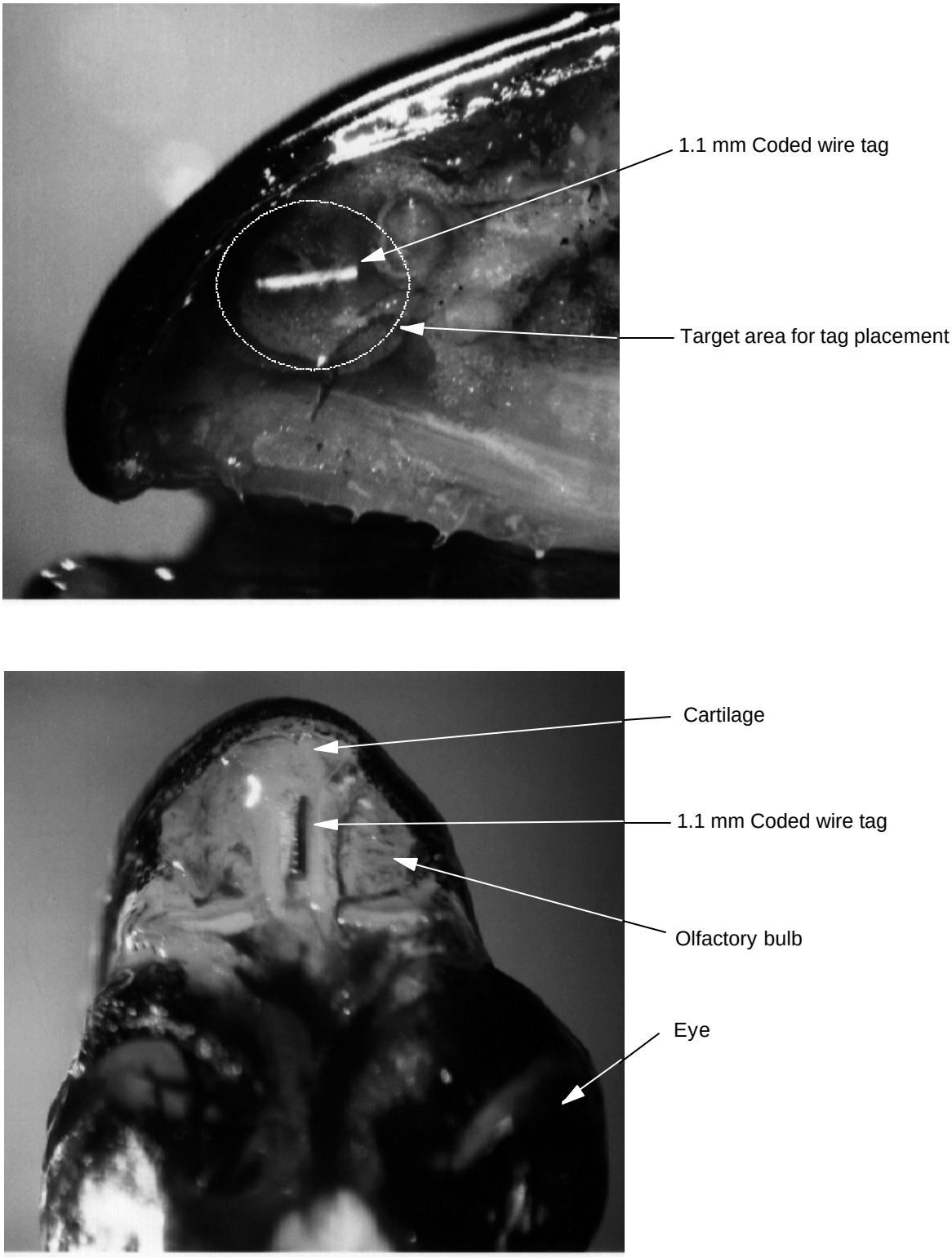

Figure 1.-Proper placement of a coded wire tag in a small fish.

count, a physical count, or a mark-recapture estimate.

Electronic Counts

VAKI[1] bioscanners were used by personnel at FRH to determine the number of smolt in four release groups of coho salmon. The manufacturer estimates these electronic fish counters to be 98%–100% accurate (http://www.vaki.is/). During the counting process personnel manually counted small groups of electronically counted fish to verify the accuracy of the electronic counters.

Physical Counts

Physical counts at FRH for chinook salmon smolt stocked at Ninilchik River and Deception Creek, and at EH for chinook salmon smolt stocked at Crooked Creek were established upon completion of tagging. The Mark IV CWT injector counts injected tags, and all fish in those three release groups were tagged. Mortalities were monitored on a daily basis and subtracted from the original count to yield a final physical count for each release group.

Mark-Recapture Estimates

Each release group contained a known number of fish marked with an adipose clip and a CWT. These marked fish were used in mark-recapture experiments to estimate the number of fish in each of three raceways at EH. A random sample of fish from these raceways was examined for marks prior to release and the number of marked and unmarked fish was recorded.

Given the number of marked fish per raceway, and using formulas from Robson and Regier (1964), the number of fish per raceway that needed to be examined for marks in order to obtain the desired level of precision was calculated (Table 1). Each raceway was sampled three times to generate three independent estimates of abundance.

The number of fish in each raceway was estimated using Chapman's modification of the Petersen estimate (Seber 1982). The estimate of abundance at the time of release was calculated as:

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{m_2+1} - 1; \qquad (5)$$

with variance:

$$\mathrm{Var}(\hat{N}) = \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)},$$

where:

n_1 = the number of fish marked with an adipose finclip and CWT in each raceway,

n_2 = the number of fish examined for marks in each raceway during the second sampling event, and

m_2 = the number of marked fish observed in each raceway during the second sampling event.

A pooled estimate using equation 5 above was generated for each of the three release groups. The numbers of marked and unmarked fish used to generate the multiple estimates were added together to generate the pooled estimates.

This two-sample mark-recapture model assumes:

1. The population is closed, with no additions, and losses are known between sampling events;
2. All fish have an equal probability of capture during the marking event or during the second sampling event, or marked fish mix completely with unmarked fish prior to the second sampling event;

[1] Use of a company's name does not constitute endorsement.

3. Marking does not affect the probability of capture during the second sampling event;
4. Marks are not lost between sampling events; and
5. Marked fish observed during the second sampling event are correctly identified and recorded.

There were no additions to any raceway and all mortalities between events were known. Personnel obtained fish through systematic sampling during the marking event, and took fish from a crowded population of fish in the raceway during the second sampling event, thus attempting to minimize violating the second assumption.

SIZE ESTIMATION

A minimum of 510 fish were individually measured for length and weight from each rearing unit for each release group at both EH and FRH. Fish were crowded to one end of the raceway and a sample was netted and put into a small holding pen. Each fish was measured to the nearest millimeter using an electronic fish measuring board, and weighed to the nearest 0.1 gram on an electronic scale.

RESULTS

SMOLT MARKING

The tagging crew marked 162,216 coho salmon and 495,512 chinook salmon smolt for release at seven locations in Cook Inlet and three in Prince William Sound in 2000 (Table 1). Tagging goals were achieved for all but the Campbell Creek release group.

Long-term tag retention was checked 71-210 days after tagging (Tables 2 and 3). Tag retention for the release groups ranged from 95.7% to 99.3% with an overall mean of 97.5% for coho salmon and 98.5% for chinook salmon. Approximately 498,000 coho salmon and 646,000 chinook salmon smolt were released.

The percentage of the total release that was marked per release group ranged from 23.7% to 100% (Tables 2 and 3).

Only 563 smolt instead of the prescribed minimum of 750 smolt were checked for long-term tag retention in one rearing unit of Ship Creek coho salmon smolt. The retention rates for the two Ship Creek coho salmon rearing units were combined to generate an overall retention rate for that release group. Post-tagging mortalities decreased the number of tagged smolt in the Campbell Creek release group to less than the goal of 20,000 tagged smolt.

SMOLT ENUMERATION

Three mark-recapture estimates with 95% confidence intervals were made for each of three raceways at EH (Table 4, Figure 2). Based on the confidence intervals, no significant differences were detected among the three estimates in each of the three release groups.

A visual estimate was used for the Fleming Spit release group of chinook salmon because these fish experienced high mortality during transport. To make this estimate, a known number of live and dead fish in the transport tanks were emptied into net pens. The number of live fish was estimated by visually comparing the proportion of fish swimming in the net pens to the dead fish lying on the bottom of the net pens (Table 3). The percentage of marked fish within the release group, which was determined prior to release, was used to estimate the number of marked fish that survived transport as well as the number that did not. The number of tagged fish released was estimated by applying the long-term CWT retention rate to the marked fish estimate.

The fish in each of the four release groups of coho salmon at FRH were counted electronically using VAKI bioscanners. These counts were reported as the total fish released for these release groups (Tables 1 and 2).

Table 4.-Mark-recapture estimates for three rearing units of chinook salmon smolt released from Elmendorf Hatchery into three release sites in Prince William Sound in 2000.

	Fleming Spit RW1	Valdez Glacier Stream RW2	Shakespeare Creek RW3
Estimate #1	117,197	114,785	117,747
SE	2,875	2,844	3,017
Upper 95% CI	122,832	120,358	123,661
Lower 95% CI	111,562	109,211	111,834
Estimate #2	109,807	113,244	112,631
SE	2,619	2,789	2,835
Upper 95% CI	114,939	118,711	118,188
Lower 95% CI	104,674	107,777	107,074
Estimate #3	106,699	110,105	120,050
SE	2,609	2,748	3,202
Upper 95% CI	111,813	115,490	126,327
Lower 95% CI	101,585	104,719	113,774
Estimate Pooled	113,890	115,582	119,389
SE	1,560	1,614	1,742
Upper 95% CI	116,947	118,745	122,803
Lower 95% CI	110,833	112,418	115,974

Physical counts were obtained at the time of tagging for both chinook salmon release groups reared at FRH and the Crooked Creek chinook salmon release group at EH (Tables 1 and 3).

SIZE ESTIMATION

At FRH, none of the coho salmon release groups achieved the production goal of 80% of the fish weighing between 15.1 and 25.0 g (Table 5; Figure 3). More than 30% of the smolt in two of the four release groups were larger than the desired size range. At FRH, the Deception Creek and Ninilchik River chinook salmon release groups achieved the production goal where 80% of the fish were between 5.1 and 15.0 g (Table 5; Figure 4). At EH, none of the release groups achieved the suggested production goal, and at least 60% of the smolt in all release groups were above the desired size range (Table 5; Figure 4).

DISCUSSION

SMOLT MARKING

A major point of emphasis for the marking program has been to achieve good long-term tag retention rates. Overall retention levels have remained steady at greater than 97% over the past seven tagging seasons. We feel that grading fish and using different sizes of head molds for tagging is responsible for maintaining acceptable long-term tag retention rates. Poor tag placement

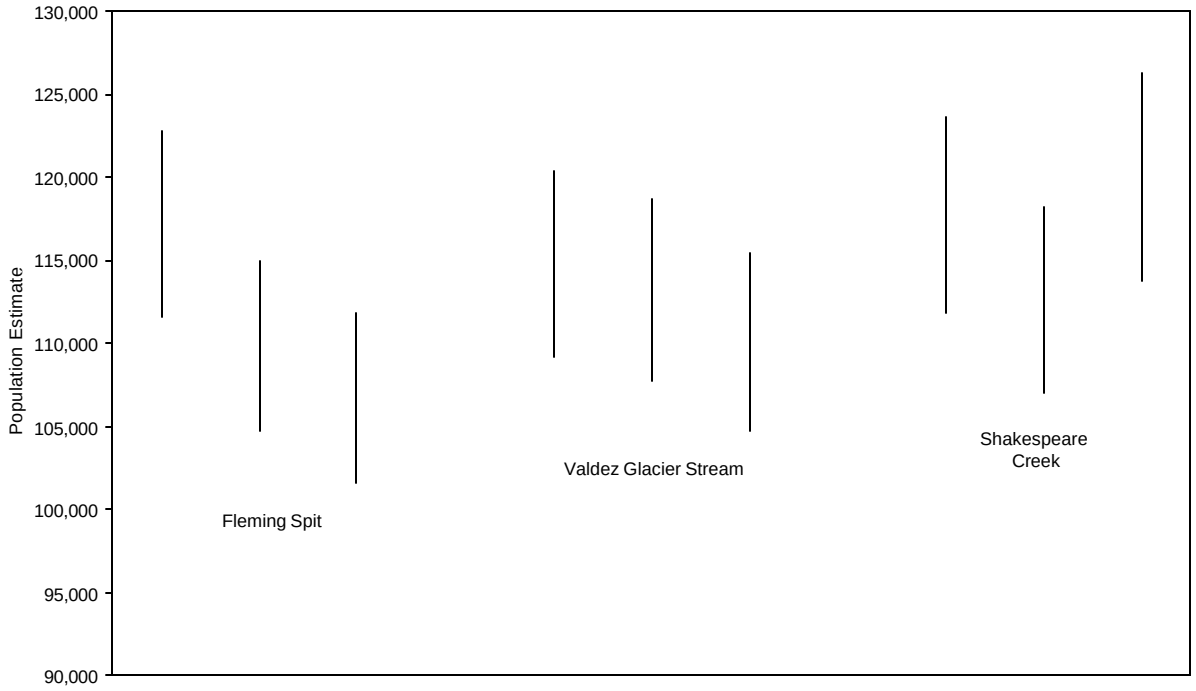

Figure 2.-Comparison of 95% confidence intervals for mark-recapture population estimates for three rearing units of chinook salmon released from Elmendorf Hatchery in 2000.

contributed to a lower than normal long-term tag retention rate for coho salmon tagged at FRH and released into Ship Creek.

SMOLT ENUMERATION

This was the second year hatchery personnel have used the VAKI electronic fish counters. Two groups of approximately 30,000 coho salmon each were also counted using the VAKI bioscanners, and then recounted during the CWT injection process by the Mark IV CWT injectors to check the accuracy of the bioscanners. The VAKI bioscanner counts were within 2% of the Mark VI CWT injector count for both groups. By moving the fish through the bioscanners slowly and consistently, hatchery personnel are confident in the accuracy of the VAKI electronic fish counters that were used to count the number of fish in each rearing unit of coho salmon at FRH.

An estimated 60% of the smolt in the Fleming Spit chinook salmon release group died during transport. A visual estimate of 45,000 live smolt was made at release. The marked to unmarked ratio obtained prior to transport was used to estimate the number of marked smolt that survived to release.

Beginning in 1998, EH personnel began weighing entire raceways of fish to obtain hatchery inventory estimates (Loopstra et al. 2000a). A comparison of hatchery inventory to mark-recapture estimates for 22 releases during 1998, 1999, and 2000 demonstrated that the two estimation techniques are within 5% of each other for 13 of the releases, and within 10% for 21 of the releases (Table 6). Improved hatchery inventory techniques make this inventory method as reliable as the mark-recapture estimation technique at EH.

Table 5.-The percentage of coho and chinook salmon released from Elmendorf and Fort Richardson hatcheries in 2000 that are within the desired size range, smaller than the desired size range, and larger than the desired size range.

	Percent		
Hatchery	Within	Below	Above
Coho: preferred range 15.1 - 25.0 grams			
Fort Richardson Hatchery	63.2%	8.9%	27.8%
Chinook: preferred range 5.1 - 15 grams			
Elmendorf Hatchery	20.4%	0.0%	79.6%
Fort Richardson Hatchery	87.8%	0.1%	12.1%

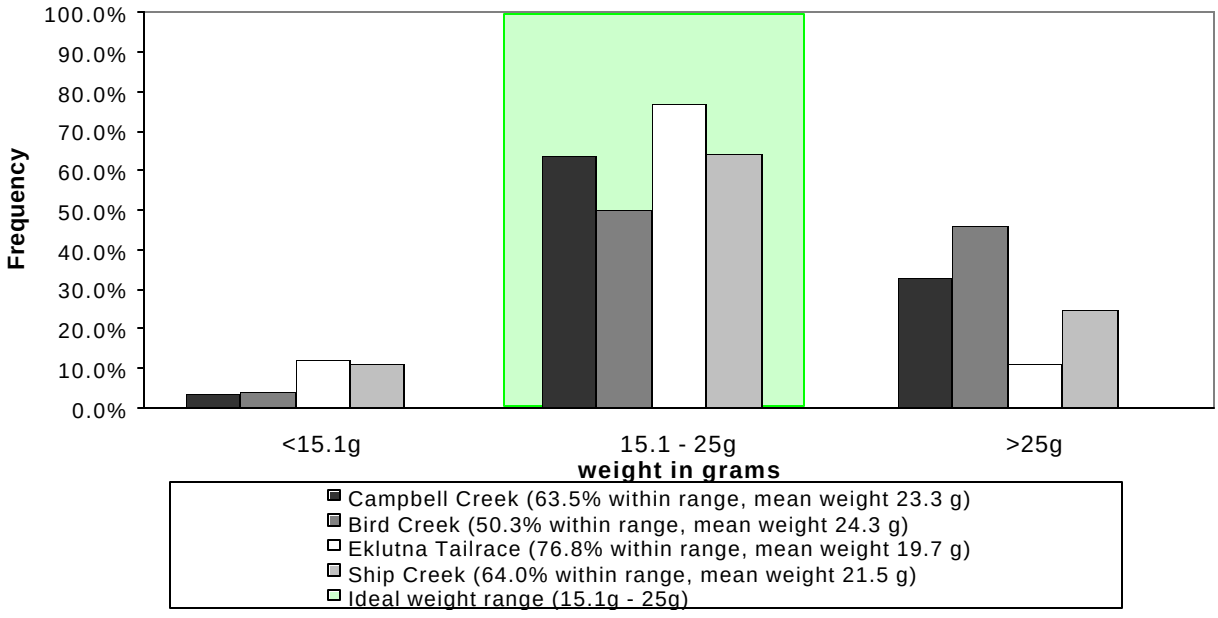

Figure 3.-Weight distributions, mean weights, and ideal weight range, for coho salmon reared at Fort Richardson Hatchery and released in 2000.

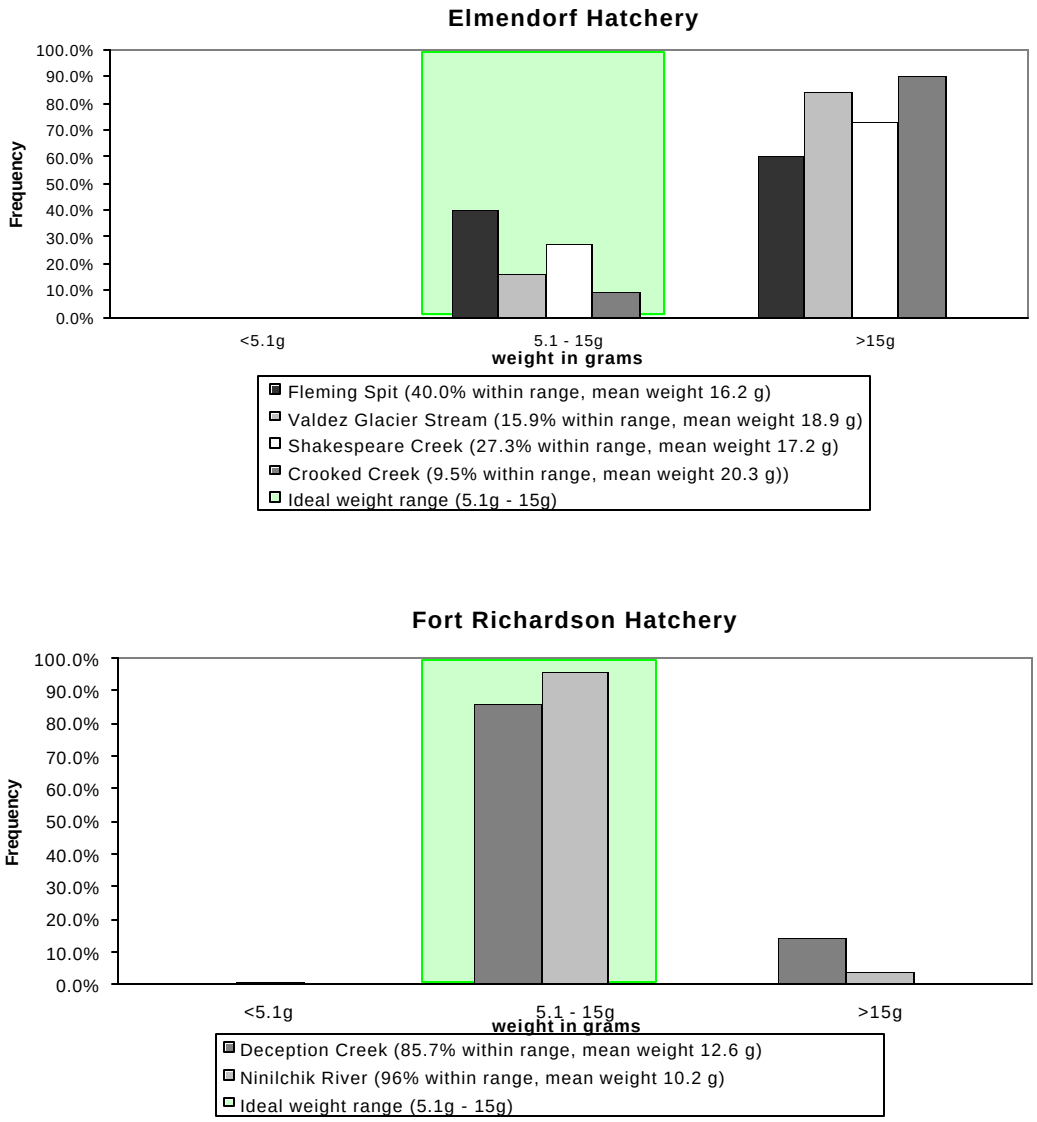

Figure 4.-Weight distributions, mean weights, and ideal weight range, for chinook salmon reared at Elmendorf and Fort Richardson hatcheries and released in 2000.

SIZE ESTIMATION

To maximize ocean survival and maintain the age composition of the population, Peltz and Starkey (1993) recommended that 80% of hatchery coho smolt weigh between 15.1 and 25.0 g, and hatchery chinook salmon weigh between 5.1 and 15.0 g at release. At least 60% and up to 90% of fish in release groups at EH exceeded this desired weight range (Figure 4). Fish at EH tend to be larger because EH has an abundance of warm water for rearing during the winter. At FRH cooler water is used for rearing, and the range of fish sizes comes closer to the recommended levels.

Table 6.-A comparison of mark-recapture estimates to hatchery inventory estimates for release groups of coho and chinook salmon reared at Elmendorf Hatchery in 1998, 1999, and 2000.

		Estimation Technique		
Release year	Release site	Mark-recapture	Hatchery inventory [a]	% difference
1998	Homer Spit	55,965	73,230	130.8%
	Homer Spit	74,254	74,544	100.4%
	Crooked Creek	70,310	72,506	103.1%
	Crooked Creek	67,028	71,743	107.0%
	Ship Creek	122,810	123,479	100.5%
	Ship Creek	81,931	82,176	100.3%
	Seldovia	69,461	72,732	104.7%
	Halibut Cove	65,893	68,787	104.4%
	Homer Spit	59,588	62,179	104.3%
	Homer Spit	118,142	106,301	90.0%
	Homer Spit late	Not available	112,100	
1999	Homer Spit	67,587	63,583	94.1%
	Homer Spit	62,015	64,467	104.0%
	Crooked Creek	99,681	96,500	96.8%
	Ship Creek	110,358	100,086	90.7%
	Homer Spit	106,783	101,029	94.6%
	Ship Creek	86,810	80,623	92.9%
	Homer Spit	56,387	54,398	96.5%
	Crooked Creek	93,576	87,082	93.1%
2000	Fleming Spit	113,890	112,076	98.4%
	Valdez Glacier Stream	115,582	112,681	97.5%
	Shakespeare Creek	119,389	113,293	94.9%
	Crooked Creek [b]	108,507	108,507	100.0%

[a] Hatchery inventory estimates are determined by dividing the total weight of fish in a rearing unit by the average weight of one fish in the rearing unit.

[b] Release group was 100% marked. Hatchery inventory obtained from number of fish marked.

RECOMMENDATIONS

1. EH inventory estimates obtained by weighing entire raceways of fish are as reliable as the mark-recapture method of estimating the number of fish in a raceway. As long as this technique is used to obtain the hatchery inventory estimates, then mark-recapture estimates will not be necessary.
2. All fish for tagging should be graded and tagged using the appropriate head mold sizes. Head mold sizes that cannot consistently provide proper tag placement for specific stocks or species of fish should not be used for that group. The head mold that is closest to being the appropriate size for these fish should be adjusted for use with these fish.

3. Follow size-at-release recommendations of 80% of coho salmon weighing between 15.1 g and 25.0 g, and 80% of chinook salmon weighing between 5.1 g and 15.0 g in order to maximize marine survival and minimize the contribution of precocious fish to the return. Cooler rearing temperatures would help reduce the growth of these fish and increase the percentage of fish that achieve the recommended release size.

4. Long-term CWT retention rates in coho salmon release groups have been lower in the last 2 years than in previous years. Greater care in tag placement should help increase long-term retention rates for these groups.

ACKNOWLEDGMENTS

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APPENDIX A

Appendix A1.-Historical releases of coho salmon that were marked with adipose finclips and tagged with coded wire tags.

Brood Year	Brood Stock	Hatchery	Release Year	CWT Code	Total Released Estimate	Total Released Type of Estimate[a]	Marked Fish Released	Tagged Fish Released	Percent Tagged
Anchorage Urban Streams[b]									
1994	Little Susitna	Ft Richardson	1996	31-25-06	156,050	M-R	46,665	46,058	29.50%
Bird Creek									
1990	Little Susitna	Ft Richardson	1992	31-20-02	95,377	M-R	44,903	37,629	39.50%
				31-20-03					
1991	Little Susitna	Ft Richardson	1993	31-21-39	140,382	M-R	43,441	42,350	30.20%
1992	Little Susitna	Ft Richardson	1994	31-23-02	84,643	M-R	45,220	44,686	52.80%
1993	Little Susitna	Ft Richardson	1995	31-23-37	154,753	M-R	45,666	45,490	29.40%
1994	Little Susitna	Ft Richardson	1996	31-25-04	147,618	M-R	46,528	45,411	30.80%
1995	Little Susitna	Ft Richardson	1997	31-26-01	146,612	HI	45,901	45,488	31.03%
1995	Little Susitna	Ft Richardson	1997	31-26-27	147,953	HI	45,836	45,469	30.73%
1996	Little Susitna	Ft Richardson	1998	31-26-25	164,211	HI	46,140	46,094	28.07%
1997	Ship Cr (Little Susitna)	Ft Richardson	1999	31-26-15	111,430	EC	37,344	36,746	32.98%
1998	Ship Cr (Little Susitna)	Ft Richardson	2000	31-01-43	97,409	EC	40,114	39,392	40.44%
Campbell Creek[b]									
1990	Little Susitna	Ft Richardson	1992	31-20-04	97,076	M-R	43,681	39,444	40.60%
				31-20-05					
1991	Little Susitna	Ft Richardson	1993	31-21-38	140,797	M-R	43,440	42,916	30.50%
1992	Little Susitna	Ft Richardson	1994	31-23-03	87,686	M-R	44,144	42,963	49.00%
1993	Little Susitna	Ft Richardson	1995	31-23-36	157,241	M-R	45,655	44,995	28.60%
1995	Little Susitna	Ft Richardson	1997	31-25-62	71,519	PC	45,840	45,290	63.33%
1996	Little Susitna	Ft Richardson	1998	31-26-52	83,317	HI	22,453	22,296	26.76%
1997	Ship Cr (Little Susitna)	Ft Richardson	1999	31-01-30	42,046	EC	20,879	20,378	48.47%
1998	Ship Cr (Little Susitna)	Ft Richardson	2000	31-02-30	63,730	EC	19,948	19,549	30.67%
Cottonwood Creek									
1990	Fish Creek	Big Lake	1992	31-20-08	53,900	M-R	35,341	32,938	61.10%
				31-21-09					
1991	Fish Creek	Big Lake	1993	31-21-41	74,198	M-R	43,117	40,875	55.10%

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Brood Year	Brood Stock	Hatchery	Release Year	CWT Code	Total Released Estimate	Total Released Type of Estimate[a]	Marked Fish Released	Tagged Fish Released	Percent Tagged
Eklutna Tailrace									
1996	Jim Creek	Ft Richardson	1998	31-26-27	112,219	PC	112,219	111,882	99.70%
				31-26-54					
				31-26-55					
				31-26-56					
1997	Jim Creek	Ft Richardson	1999	31-26-16	126,602	EC	44,073	42,663	33.70%
1998	Jim Creek	Ft Richardson	2000	31-01-46	76,851	EC	40,514	40,149	52.24%
Fish Creek									
1990	Fish Creek	Big Lake	1992	31-20-12	74,953	M-R	45,538	43,625	58.20%
				31-20-13					
1991	Fish Creek	Big Lake	1993	31-21-40	67,934	M-R	44,050	43,257	63.70%
Homer Spit									
1996	Bear Lake	Elmendorf	1998	31-26-28	130,219	M-R	42,057	41,926	32.20%
1997	Bear Lake	Elmendorf	1999	31-01-40	129,602	M-R	44,405	43,020	33.19%
	Bear Lake	Elmendorf	2000[c]						
Little Susitna at Houston									
1990	Little Susitna	Ft Richardson	1992	31-20-07	154,466	M-R	21,884	19,564	12.70%
1991	Little Susitna	Ft Richardson	1993	31-21-37	148,282	M-R	21,404	20,312	13.70%
Nancy Lake									
1990	Little Susitna	Ft Richardson	1992	31-20-06	158,459	M-R	21,598	19,222	12.10%
1991	Little Susitna	Ft Richardson	1993	31-21-37	131,591	M-R	21,001	19,930	15.20%
1992	Little Susitna	Ft Richardson	1994	31-23-01	126,694	M-R	44,489	43,818	34.60%
1993	Little Susitna	Ft Richardson	1995	31-23-39	151,985	M-R	46,261	45,245	29.80%

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Brood Year	Brood Stock	Hatchery	Release Year	CWT Code	Total Released Estimate	Total Released Type of Estimate[a]	Marked Fish Released	Tagged Fish Released	Percent Tagged
Ship Creek[b]									
1990	Ship Creek	Elmendorf	1992	31-19-63	67,178	PC	44,086	38,443	57.20%
				31-20-01					
1991	Ship Creek	Elmendorf	1993	31-21-36	54,764	PC	42,112	41,322	75.50%
1992	Ship Creek	Elmendorf	1994	31-23-04	75,779	PC	44,031	41,722	55.10%
1993	Little Susitna	Ft Richardson	1995	31-23-38	158,981	M-R	45,491	44,654	28.10%
1995	Little Susitna	Ft Richardson	1997	31-25-63	232,066	PC,HI	45,925	45,741	19.71%
1996	Little Susitna	Ft Richardson	1998	31-26-53	232,765	HI	67,812	66,997	28.78%
				31-26-26					
1997	Ship Ck	Ft Richardson	1999	31-26-14	165,388	EC	48,299	45,380	27.44%
	(L. Susitna)			31-01-29					
1998	Ship Ck	Ft Richardson	2000	31-01-32	260,070	EC	61,640	58,989	95.70%
	(L. Susitna)			31-01-33					
Wasilla Creek									
1990	Fish Ck	Big Lake	1992	31-20-10	76,315	M-R	44,148	41,985	55.00%
				31-20-11					
1991	Fish Ck	Big Lake	1992	31-21-42	77,174	M-R	43,001	41,711	54.10%
1994	Little Susitna	Ft Richardson	1996	31-25-05	145,923	M-R	46,980	46,839	32.10%

[a] M-R is mark-recapture, PC is physical count, HI is hatchery inventory, EC is electronic count.

[b] Campbell and Ship creeks were combined and termed "Anchorage Urban Streams" in 1996.

[c] Stocking continues, but releases no longer contain marked or tagged fish.

Appendix A2.-Historical releases of chinook salmon that were marked with adipose finclips and tagged with coded wire tags.

Brood Year	Brood Stock	Hatchery	Release Year	CWT Code	Total Released Estimate	Total Released Type of Estimate[a]	Marked Fish Released	Tagged Fish Released	Percent Tagged
Buskin River									
1994	Deception Cr	Elmendorf	1995	31-24-31	84,349	M-R	41,572	41,078	48.70%
1995	Deception Cr	Elmendorf	1996	31-25-09	113220	M-R	41259	40681	35.90%
Crooked Creek									
1993	Crooked Cr	Elmendorf	1994	31-23-14	224,784	M-R	43,609	43,034	19.10%
1994	Homer[b]	Elmendorf	1995	31-24-27	184,049	M-R	40,903	38,420	20.90%
1995	Homer[b]	Elmendorf	1996	31-25-12	193,180	M-R	40,827	40,196	20.80%
1996	Homer[b]	Elmendorf	1997	31-25-55	223,200	M-R	41,049	39,038	17.49%
1997	Homer[b]	Elmendorf	1998	31-26-29	137,338	M-R	42,874	42,610	31.03%
1998	Homer[b,c,d]	Elmendorf	1999	31-01-41	192,304	M-R	43,431	42,649	22.17%
1999	Crooked Cr[c]	Elmendorf	2000	31-02-31, 31 01-34,35	108,507	PC	108,507	105,578	97.30%
Deception Creek									
1991	Deception Cr	Ft Richardson	1992	31-21-03	179,724	M-R	44,089	33,464	18.60%
1992	Deception Cr	Ft Richardson	1993	31-21-60	160,194	M-R	42,782	39,420	24.60%
1993	Deception Cr	Ft Richardson	1994	31-23-17	177,913	M-R	46,289	45,921	25.80%
1994	Deception Cr	Ft Richardson	1995	31-24-34	184,740	M-R	46,807	46,256	25.00%
1995	Deception Cr	Ft Richardson	1996	31-25-14	186,918	M-R	47,700	47,145	25.20%
1996	Deception Cr	Ft Richardson	1997	31-26-03, 04,05,06,07	209,644	PC	209,644	207,973	99.20%
1997	Deception Cr	Ft Richardson	1998	31-25-32	197,392	PC	197,392	195,615	99.10%
1998	Deception Cr	Ft Richardson	1999	31-26-17, 18, 19, 20; 31-01-31	201,586	PC	201,586	199,722	99.08%
1999	Deception Cr	Ft Richardson	2000	31-26-21, 31-01-44,31-02-33,34,35	206,496	PC	206,496	205,051	99.30%
Eagle River									
1993	Ship Creek	Elmendorf	1994	31-23-13	98,872	M-R	43,612	41,669	42.10%
Fleming Spit									
1998	Deception Cr	Ft. Richardson	1999	31-26-23	49,773	PC	45,705	45,385	91.18%
1999	Deception Cr	Elmendorf	2000	31-01-38	45,000	VIS	17,358	17,236	38.30%

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Brood Year	Brood Stock	Hatchery	Release Year	CWT Code	Total Released Estimate	Total Released Type of Estimate[a]	Marked Fish Released	Tagged Fish Released	Percent Tagged
Halibut Cove									
1993	Crooked Creek	Elmendorf	1994	31-23-15	98,872	M-R	21,205	21,038	21.30%
1994	Ninilchik River	Elmendorf	1995	31-24-30	37,577	M-R	36,944	36,700	97.70%
1995	Ninilchik River	Elmendorf	1996	31-25-11	97,729	M-R	40,688	39345	40.30%
1996	Ninilchik River	Elmendorf	1997	31-25-58	78,133	M-R	40,919	39487	50.54%
1997	Ninilchik River	Elmendorf	1998	31-26-32	65,893	M-R	38,476	38041	57.73%
	Ninilchik River	Elmendorf	1999-[e]						
Homer Spit (early run)									
1993	Crooked Creek	Elmendorf	1994	31-23-16	163,963	M-R	26,003	25,615	15.60%
1994	Homer[b]	Elmendorf	1995	31-24-32	216,026	M-R	41,650	40,291	18.70%
1995	Homer[b]	Elmendorf	1996	31-25-07	204.085	M-R	40.868	39.017	19.10%
1996	Homer[b]	Elmendorf	1997	31-25-60	217,773	M-R	41,112	38,810	17.82%
1997	Homer[b]	Elmendorf	1998	31-26-33	177.730	M-R	40.012	39.652	22.31%
1998	Homer[b]	Elmendorf	1999	31-01-45	163,170	M-R	42,561	40,423	24.77%
	Ninilchik River	Elmendorf	2000[e]						
Homer Spit (late run)									
1992	Kasilof River	Crooked Creek	1994	31-23-19	56,920	M-R	22,612	22,383	39.30%
1994	Homer[f]	Elmendorf	1995	31-24-33	123,048	M-R	41,054	40,466	32.90%
1995	Homer[f]	Elmendorf	1996	31-25-13	108.204	M-R	40.615	38.787	35.80%
1996	Homer[f]	Elmendorf	1997	31-25-61	100,933	M-R	41,028	39,264	38.90%
1997	Homer[f]	Elmendorf	1998	31-26-34	112,100	HI	40,158	39,997	35.68%
	Homer[f]	Elmendorf	1999[e]						
Lowell Creek									
1996	Deception Cr	Elmendorf	1997	31-25-59	102,147	M-R	40,906	40,497	39.65%
	Deception Cr	Elmendorf	1998-99[e]						
	Crooked Creek	Elmendorf	2000[e]						
Ninilchik River									
1991	Ninilchik River	Ft Richardson	1992	31-21-04	132,387	M-R	43,648	41,335	31.20%
1992	Ninilchik River	Ft Richardson	1993	31-21-59	184,585	M-R	44,487	42,960	23.30%
1993	Ninilchik River	Ft Richardson	1994	31-23-18	201,513	M-R	46,193	45,535	22.60%
1994	Ninilchik River	Ft Richardson	1995	31-24-35	54,662	M-R	54,662	54,115	99.00%
1995[c]	Ninilchik River	Ft Richardson	1996	31-25-15	51,688	PC	51,588	50,866	98.60%
1996[c]	Ninilchik River	Ft Richardson	1997	31-26-08	50.698	PC	50.698	50.292	99.20%
1997	Ninilchik River	Ft Richardson	1998	31-26-35	48,798	PC	48,798	47,480	97.30%
1998	Ninilchik River	Ft Richardson	1999	31-01-45	49,853	PC	49,853	48,906	98.10%
1999	Ninilchik River	Ft Richardson	2000	31-02-48	51,298	PC	51,298	50,016	97.50%

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Brood Year	Brood Stock	Hatchery	Release Year	CWT Code	Total Released Estimate	Total Released Type of Estimate[a]	Marked Fish Released	Tagged Fish Released	Percent Tagged
Seldovia									
1993	Crooked Creek	Elmendorf	1994	31-23-11	107,246	M-R	46,754	45,439	42.40%
1994	Homer[b]	Elmendorf	1995	31-24-29	116.165	M-R	41.609	40.678	35.00%
1995	Ninilchik River	Elmendorf	1996	31-25-10	118,274	M-R	40,667	39,610	33.50%
1996	Ninilchik River	Elmendorf	1997	31-25-57	103,757	M-R	41,279	39,834	38.39%
1997	Ninilchik River	Elmendorf	1998	31-26-31	69,461	M-R	40,654	40,125	57.77%
	Ninilchik River	Elmendorf	1999-[e]						
Shakespeare Creek									
1998	Deception Cr	Ft Richardson	1999	31-26-24	49,797	PC	45,023	43,897	88.21%
1999	Deception Cr	Elmendorf	2000	31-01-39	119,389	M-R	43,551	42,898	35.93%
Ship Creek									
1993	Ship Creek	Elmendorf	1994	31-23-12	199,830	M-R	44,138	42,864	21.50%
1994	Ship Creek	Elmendorf	1995	31-24-28	218,487	M-R	40,764	38,570	17.70%
1995	Ship Creek	Elmendorf	1996	31-25-08	231,444	M-R	41,221	40,109	17.30%
1996	Ship Creek	Elmendorf	1997	31-25-56	326,271	M-R	40,522	40,319	12.36%
1997	Ship Creek	Elmendorf	1998	31-26-30	204,741	M-R	42,073	41,565	20.30%
1998	Ship Creek	Elmendorf	1999	31-01-42	197,168	M-R	44,265	42,262	21.44%
	Ship Creek	Elmendorf	2000[e]						
Valdez Glacier Stream									
1998	Deception Cr	Ft Richardson	1999	31-26-22	49,353	PC	46,528	45,923	93.05%
1999	Deception Cr	Elmendorf	2000	31-01-37	115,582	M-R	41,728	41,060	35.52%

[a] M-R is mark-recapture, PC is physical count, HI is hatchery inventory.

[b] Homer (Crooked Creek).

[c] Adjusted for holding mortality before release.

[d] Corrections for release numbers reported in 1999 report.

[e] Stocking continues, but releases no longer contain marked or tagged fish.

[f] Homer (Kasilof River).