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Chinook and Coho Salmon Coded Wire Tagging Studies in the Kenai River and Deep Creek, Alaska, 1998

by

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and

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March 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. 02-03

CHINOOK AND COHO SALMON CODED WIRE TAGGING STUDIES IN THE KENAI RIVER AND DEEP CREEK, ALASKA, 1998

by

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ABSTRACT

The Alaska Department of Fish and Game, Division of Sport Fish is currently assessing the harvest of selected wild stocks of chinook salmon *Oncorhynchus tshawytscha* by the mixed-stock marine recreational fishery in Cook Inlet. Juvenile chinook salmon from the Kenai River were selected for a coded wire tag (CWT) marking program.

A combination of rotary and inclined plane traps captured 17,576 chinook salmon smolt in the Kenai River and its largest tributary, the Killey River, during 1998. We marked and released 16,598 smolt. Chinook salmon smolt were present in the Kenai River throughout the summer with peak catches in mid June.

We examined adults returning to the Kenai River and Deep Creek for adipose finclips (AFC) and CWTs placed in chinook salmon in previous years. The proportion of early- and late-run chinook salmon marked with an AFC returning to the Kenai River in 1998 ranged from 0.000 (SE = 0.000) for early-run age-1.2 fish marked in 1994 to 0.110 (SE = 0.031) for late-run age-1.3 fish marked in 1993. The proportion of chinook salmon that contained a CWT, or theta (θ), ranged from 0.000 (SE =0.000) for early-run age-1.2 and age-1.4 to 0.090 (SE =0.029) for late-run age-1.3.

The AFC marked proportion of chinook salmon of Deep Creek origin was 0.097 (SE = 0.025) for 1992 brood year age-1.4, 0.095 (SE = 0.025) for 1993 brood year age-1.3 and 0.060 (SE = 0.018) of the 1994 brood year age-1.2 escapement. Our estimate of the AFC marked proportion for the 1992 brood year, based on 3 years of recoveries, was 0.089 (SE = 0.008). We also determined that 1.2% of the chinook salmon above river kilometer 4.0 were strays from hatchery releases in the adjacent Ninilchik River.

We also sampled adult coho salmon *O. kisutch* in Deep Creek and found that 34.5% (SE = 1.2%) had an AFC. Theta of the cohort was 0.313 (SE = 0.012). The proportion of AFC marked adults did not change over time, and was used to estimate that 20,097 (SE = 677) coho salmon smolt emigrated from Deep Creek in 1997. The preliminary marine survival estimate for this cohort, excluding harvest in marine fisheries, was 20.4% (SE = 4.9%).

Key words: chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *Oncorhynchus kisutch*, smolt, fingerling, juvenile, coded wire tag, CWT, adipose finclip, AFC, Kenai River, Deep Creek, Slikok Creek, Ninilchik River, Killey River, Cook Inlet, mixed-stock recreational fishery.

INTRODUCTION

Chinook salmon *Oncorhynchus tshawytscha* stocks from Cook Inlet are currently thought to be fully utilized by existing fisheries. Inriver fisheries target specific stocks while many marine gillnet and hook-and-line fisheries harvest mixed stocks of chinook salmon as they pass through Cook Inlet on their way to spawning drainages. Escapement goals exist for many of these stocks, and the Alaska Department of Fish and Game (ADF&G) monitors the success of obtaining the goals annually. If the resource is fully utilized, growth in one fishery may occur at the expense of another, complicating sustained yield management.

Marine recreational fisheries of Cook Inlet harvest mixed stocks of chinook salmon along eastside Cook Inlet beaches from Ninilchik south to Homer (Figure 1). Most effort in this fishery takes place within 0.8 kilometers of shore from May through July. Harvests are composed of mature fish returning to Cook Inlet drainages and hatchery release sites, and immature fish bound for various North Pacific locations (McKinley 1999). The fishery began in the early 1970s, and effort remained relatively stable through the late 1980s. However, increased marketing by sport fish guiding and tourism industries, improved boat launching facilities, and restrictions in many other Cook Inlet inriver fisheries resulted in growth of the marine fishery. Annual harvests of chinook salmon in this fishery increased from 4,872 fish in 1987 to a peak of 13,039 fish in 1995; harvest in 1998 was 5,783 fish (Mills 1988; Howe et al. 1996, 2001c). Concerns regarding increased exploitation of local stocks by this fishery resulted in several

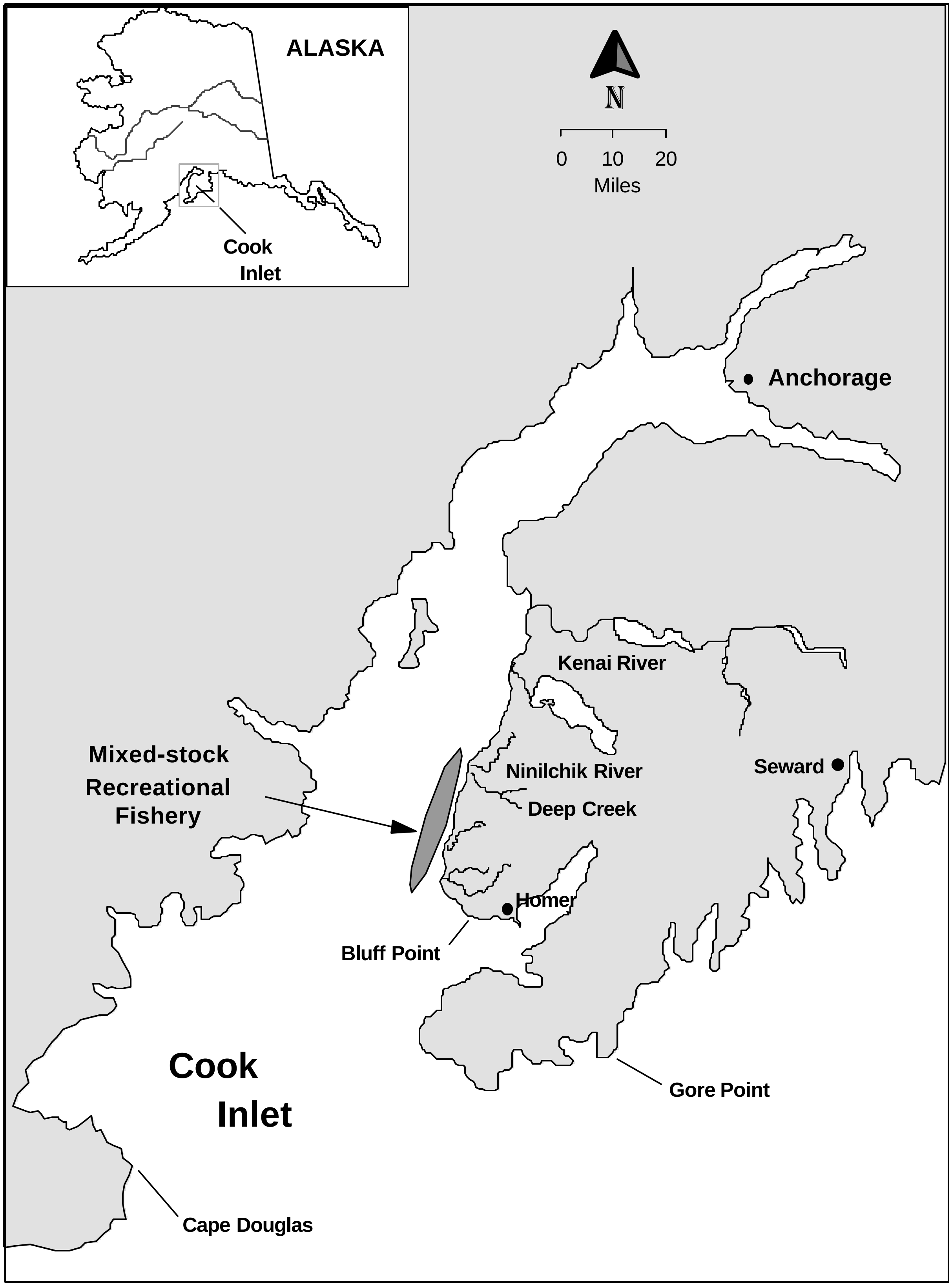


Figure 1.-Kenai River, Deep Creek, Ninilchik River and the marine recreational fishery of Cook Inlet, Alaska.

restrictions beginning in 1996. A guideline harvest level of 8,000 was set, and a 4-mile long, 1-mile wide conservation zone was established around the mouths of Deep Creek and the Ninilchik River in which no harvest of chinook salmon can occur. In addition, a special harvest area 1-mile wide extending from the Ninilchik River to Bluff Point was established, in which anglers may harvest only one chinook salmon greater than 20 in long daily. Finally, guides are not permitted to fish while guiding within the special harvest area.

The ADF&G Sport Fish Division initiated a long-term study in 1993 to assess the growth and characteristics of the marine recreational fishery, evaluate ongoing efforts to supplement harvests using hatchery fish, and estimate the contribution of specific wild stocks to the total marine harvest. As part of this effort, wild and hatchery chinook salmon smolt emigrating from select drainages of Cook Inlet are marked with a coded wire tag (CWT) and recovered in marine and freshwater fisheries. Evaluation of wild chinook salmon originating in the Kenai River and Deep Creek is an essential step in this process and is the subject of this report.

The Kenai River (Figure 2) supports the largest freshwater chinook salmon fishery in Alaska (Howe et al. 1998). Exploitation of early- and late-run chinook salmon bound for the Kenai River is governed by management plans adopted by the Alaska Board of Fisheries. These plans contain escapement goals for both the early and late runs, and dictate changes in the management of commercial and recreational fisheries in case of a conservation shortfall.

The early run of chinook salmon enters Cook Inlet from late April through mid June. The run comprises stocks from the Kenai River and most other known chinook salmon spawning drainages. Estimating the harvest of Kenai River early-run chinook salmon by the marine fisheries will provide data necessary for run reconstruction, and will also provide important information for making allocation decisions concerning the harvest of this stock.

The Kenai River is also the primary producer of Cook Inlet drainage late-run chinook salmon. Hence, the majority of all chinook salmon harvested in Cook Inlet after July 1 is assumed to originate there.

The first juvenile chinook salmon CWT marking program on the Kenai River was conducted by Litchfield and Flagg (1986). Approximately 115,000 age-0.0 fingerlings were marked. Two tags were eventually recovered from the sport fishery. The current CWT program in the Kenai River began with the marking of age-0.0 fingerlings in the mainstem in 1993 and 1994 (Bendock 1995). In 1995 and 1996, the capture of age-1.0 smolt using stationary floating traps supplanted the marking of fingerlings (Bendock 1996; King and Breakfield 1998). In 1997 (King and Breakfield 1999), smolt were captured in traps and marked at river kilometer (rkm) 34 of the mainstem and at the confluence of the Kenai and Killey rivers. A comparable program is in place to assess the contribution of Kenai River coho salmon to various marine fisheries (Carlon 2000).

The Deep Creek (Figure 3) chinook salmon return supports a weekend-only inriver recreational fishery from Memorial Day through the second week of June. We selected Deep Creek as a tagging site because of its proximity to the marine recreational fishery, and concerns that additional exploitation of Deep Creek chinook salmon in marine waters may result in the unacceptably high harvest of this conservatively managed stock. Therefore, estimating the harvest of Deep Creek chinook salmon by the marine fishery will provide important information for managing this stock. We used a rotary trap to capture and tag Deep Creek age-0.0 and

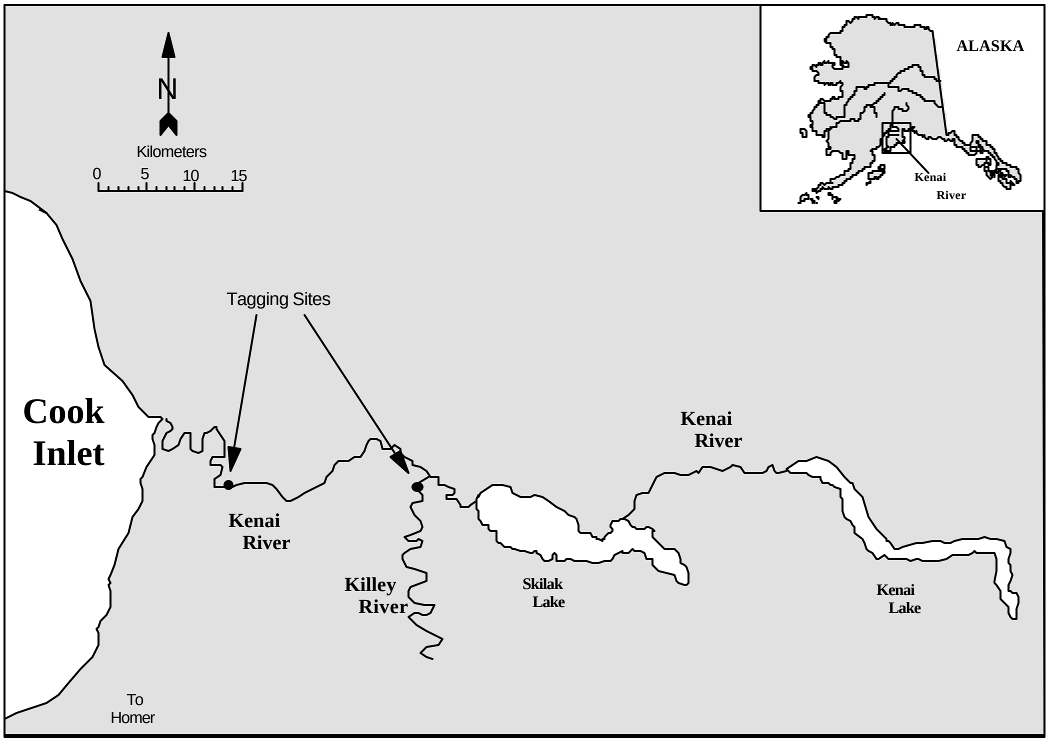


Figure 2.-Chinook salmon tagging sites on the Kenai and Killey rivers, 1998.

age-1.0 chinook salmon smolt from 1994 through 1997 (Bendock 1995, 1996; King and Breakfield 1998, 1999). We also tagged coho salmon smolt in Deep Creek beginning in 1995 to provide information on the harvest of this species and the magnitude of smolt production. In 1997, we enumerated adult escapements of the two species through a weir placed at approximately rkm 4.0.

The objectives of this study were to:

1. Coded wire tag chinook salmon smolt to estimate the Upper Cook Inlet marine sport harvest from the Kenai River;
2. Test the null hypothesis that chinook salmon smolt marked in the Kenai River and Deep Creek and coho salmon marked in Deep Creek mixed completely with unmarked individuals when they returned as adults;
3. Estimate the abundance of chinook salmon smolt that emigrated from the Kenai River and Deep Creek in the previous years of smolt marking;
4. Estimate the abundance of coho salmon smolt that emigrated from Deep Creek in 1997;
5. Census the escapement of chinook and coho salmon into Deep Creek;
6. Estimate the proportion by age, sex, and length classes of the chinook and coho salmon escapements into Deep Creek; and
7. Test the null hypothesis that hatchery-produced chinook salmon from the Ninilchik River do not stray into Deep Creek.

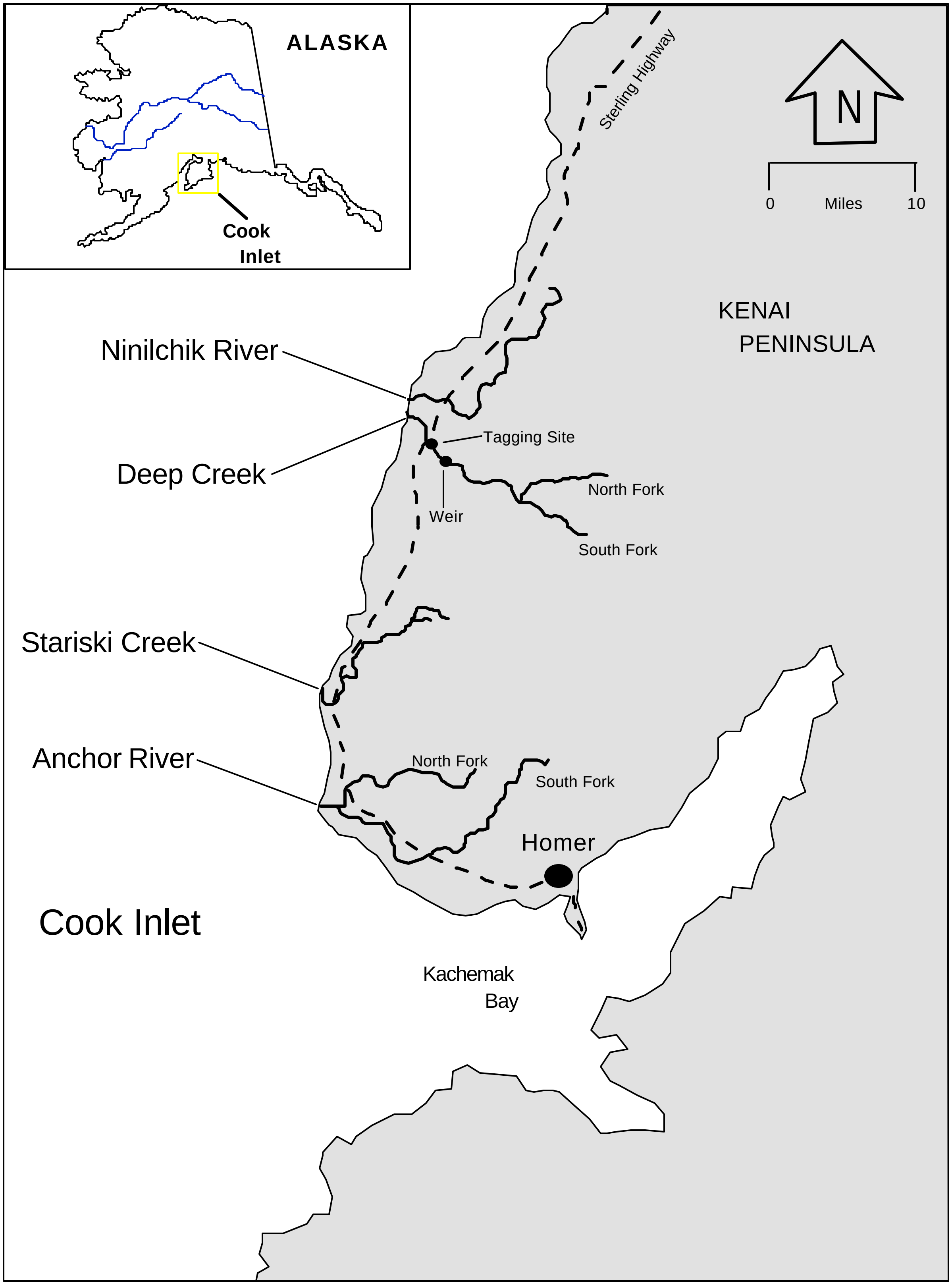


Figure 3.-Deep Creek adult enumeration site, 1998.

METHODS

Our estimate of the harvest of Kenai River and Deep Creek chinook salmon by the Cook Inlet marine recreational fishery required capturing and marking juvenile chinook salmon with a CWT and adipose finclip (AFC). Marking juvenile salmon in freshwater rearing habitats permits a positive identification of the natal drainage in which the fish were produced. The presence of a stock in a mixed-stock fishery can then be identified by examining harvested adult salmon for CWTs. Knowledge of the total harvest, proportion of CWT-bearing fish in each stock, and the numbers of CWT-bearing fish in the sampled harvest are all necessary elements for estimating stock-specific harvests in the marine fishery.

Since we did not know the proportion of marked smolt of each stock, theta (θ), at the completion of marking, we estimated it for each brood year by sampling the adult inriver return in subsequent years. We sampled throughout the return because a constant θ indicates that a representative sample of juveniles was tagged. A chi-square statistic (χ^2) was used to test the hypothesis that θ did not change over time. Failure to reject this hypothesis would indicate that marked fish were a representative sample of the cohort (brood year), and would allow combining all of the inriver recovery data to estimate the overall θ of the cohort.

Chinook salmon from a single cohort enter their natal stream to spawn over at least 3 years. Therefore, we also estimated the age composition of sampled adults to estimate θ by ocean age. In 1998, age-1.2, -1.3 and -1.4 chinook salmon returning to each system were marked with CWTs (Bendock 1996; King and Breakfield 1998, 1999).

KENAI RIVER

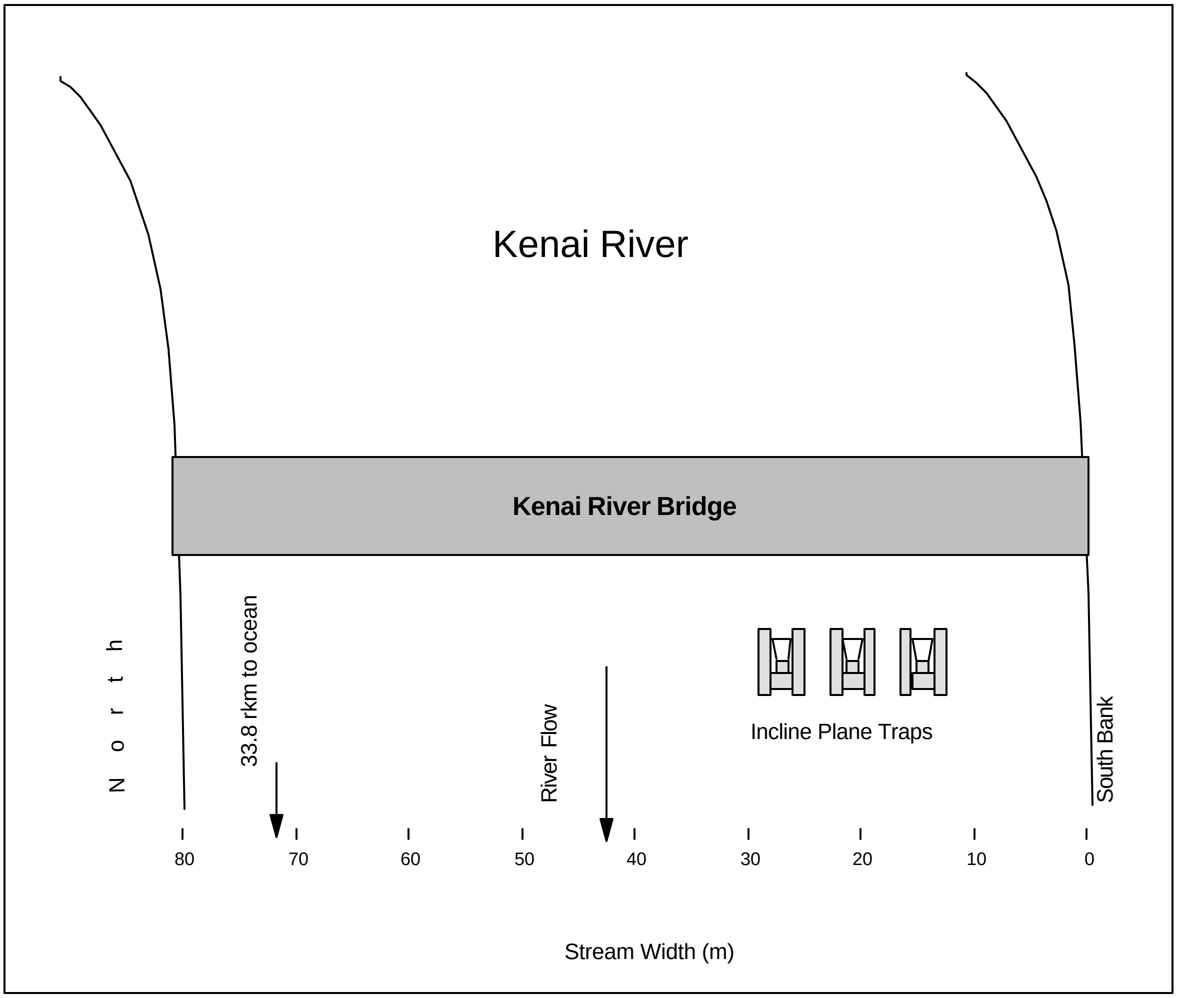
CWT Release

The CWT marking sites on the Kenai River were at the same two locations in 1998 as in 1997 (Figure 2). Three traps were placed in the Kenai River at rkm 34, immediately downstream of the highway bridge in Soldotna (Figure 4). A single trap was placed in the Killey River approximately 100 m from its confluence with the Kenai River (Figure 5). Our goal, based on the parent year adult escapement and assumed survival rates and harvest in the marine recreational fishery, was to capture and mark 232,000 smolt between the two sites.

The mainstem site was at the lower end of a bend that pushed the main water flow to the south side of the river (Figure 4). The river at the marking site was 80 m wide with a bottom profile that gradually dropped from the north bank to a depth of 5 m at the thalweg.

We deployed three inclined plane traps (Todd 1994) offshore of the Kenai River south bank at the distance that we thought would encompass the highest surface velocity corridor. Initially, the inshore trap was placed 15 m from shore and the remaining traps were spaced 2 m apart, giving lateral coverage of approximately 13 m. Surface velocity in front of the traps ranged from 2.0 feet per second (fps) in mid May to 8.3 fps in July. On 9 July, the traps were moved shoreward 6 m to avoid current in which traps were inoperable, and fished in that location for the duration of the season. After the traps were moved shoreward on 9 July, highest velocities were observed offshore of the outer trap. We fished the traps through the hours of darkness each day from 16 May through 4 August 1998.

The Killey River at the marking site was 26 m wide with a bottom profile that gradually dropped in depth from the left bank to approximately 2.5 m under the trap (Figure 5). Water surface velocity ranged from 1.05 to 6.54 fps.



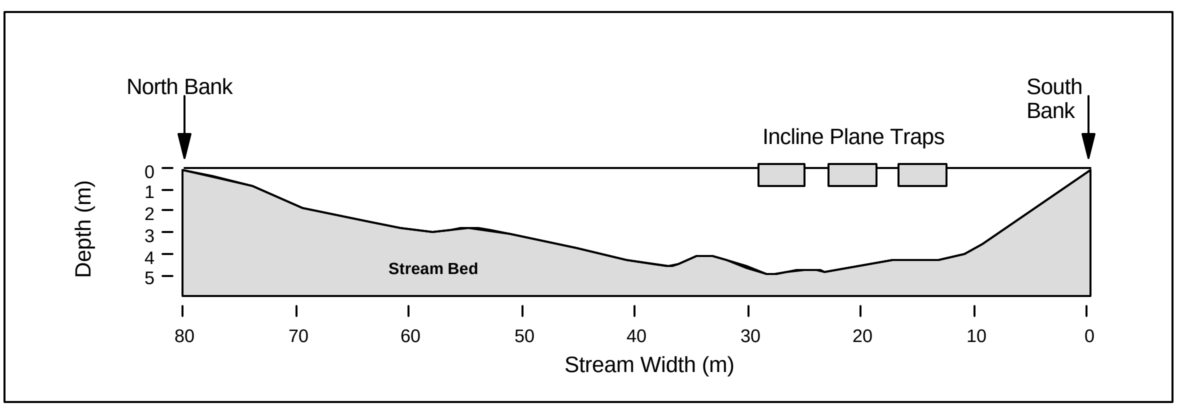


Figure 4.-Schematic overhead and cross section views of the Kenai River showing the trap locations in 1998.

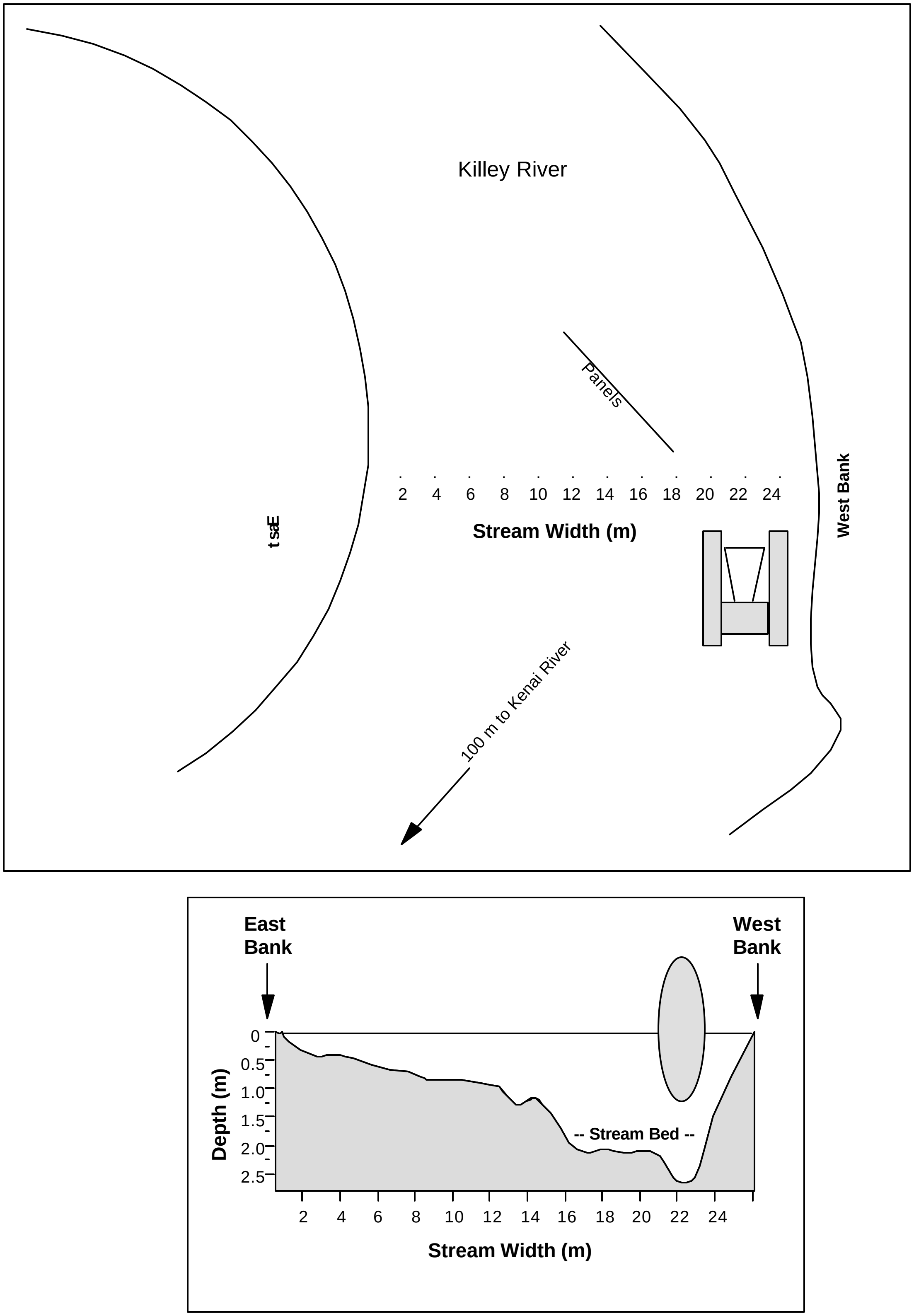


Figure 5.-Schematic overhead and cross section views of the Killey River showing the trap location in 1998.

One rotary screw trap was attached to the west shore of the Killey River, approximately 100 m from the confluence. The trap was located at the downstream, outside end of a bend (Figure 5). The trap was fished continuously through each operating day from 7 May through 4 July 1998.

Each time a trap livebox was emptied, technicians identified and counted the catch by species. Sockeye salmon smolt catches were estimated by rounding to the nearest 10 fish. Species other than chinook salmon smolt were released. Chinook salmon were transported to holding tubs on shore and were marked externally with an AFC, injected with a CWT, and released using procedures outlined in Bendock (1995, 1996) and Moberly et al. (1977). A representative sample of up to 200 tagged fish was held for 24 hours to measure tag retention and handling mortality. After using held smolt to estimate tag retention rate, those without a tag were retagged and included in our estimate of chinook smolt leaving the river.

We recorded the catch composition and tagging results after each tagging session. Water and air temperature, water level, and trap revolutions per minute were measured at least once each day. Surface velocity was periodically measured in front of each trap.

We removed a scale smear from the preferred area (Welander 1940) and recorded the fork length (to the nearest millimeter) of a random sample of 10 chinook salmon smolt daily at the mainstem trap site. Beginning 7 May, we also removed a scale smear and recorded the fork length (to the nearest millimeter) of a random sample of 10 chinook salmon smolt daily from the Killey River trap.

Estimating the Proportion of Chinook Salmon with AFCs and CWTs in the Inriver Return

Adult chinook salmon captured in gillnets for the Kenai River stock assessment project (Marsh 2000) were used to estimate θ. Project technicians fished drift gillnets 5-7 days per week between rkm 8 and 15 from 15 May–9 August 1998. Technicians examined all chinook salmon for external sex characteristics, measured their length, and removed three scales for age determination (age, sex and length or ASL). Three scales were removed from the left side of the body, at a point on a diagonal line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, two rows above the lateral line (Welander 1940). The scales were pressed and age determined using procedures described by Mosher (1969).

All fish with an AFC were sacrificed and the head removed. A cinch strap was affixed to the head, the head frozen, and later shipped to the ADF&G CWT laboratory to retrieve and decode the CWT.

All sport-harvested adult chinook salmon observed in the Kenai River recreational fishery creel survey (Marsh 2000) were also examined for an AFC. The creel survey was conducted from 5 May through 31 July 1998 between rkm 8 and 34. Technicians sampled 4-7 days per week, and collected the same data as the gillnet crews.

Our analysis of θ required an estimate of the numbers of fish of each age class examined for an AFC. Marsh (2000) stratified the inriver netting data into 3-week intervals, the early-run harvest into 3- or 4-week intervals, and the late-run harvest into 15-day intervals. There were significant differences in age composition over time, but further examination of the data indicated combining age data over time intervals within each run did not bias the estimates. Therefore the proportion of each age class $(\hat{p}_{jk})$ was estimated by Marsh (2000):

$$\hat{p}_{ik} = \frac{s_{ik}}{s_i}, \tag{1}$$

with variance:

$$\hat{V}(\hat{p}_{ik}) = \frac{\hat{p}_{ik}(1 - \hat{p}_{ik})}{s_i - 1}, \tag{2}$$

where:

s_{ik} = number of chinook salmon of age k collected from sample source i (i.e., sport harvest or gill netting), and

s_i = number of chinook salmon with an ageable scale collected from sample source i.

Since not all scale samples could be aged, we estimated the total number of chinook salmon sampled from each age class (n_{ik}) as:

$$\hat{n}_{ik} = n_i \hat{p}_{ik}, \tag{3}$$

where:

n_i = total number of chinook salmon sampled from source i.

Using a Kolmogorov-Smirnov test, we compared the cumulative length distribution of fish that could be aged with those that could not be aged for each sample source-time strata combination. This gave us an indication of whether the age compositions of fish that could and could not be aged were the same.

The number of fish by age class sampled inriver was necessary to estimate θ and its variance for each age group of marked cohorts. Theta was estimated as a binomial proportion (Cochran 1977) by:

$$\hat{\theta}_k = \frac{x_k}{n_k}, \tag{4}$$

where:

x_k = the number of chinook salmon of age k missing the adipose fin in which a CWT was detected, and

n_k = the total number of chinook salmon of age k examined for an AFC.

If the proportion of marked adults by age did not vary significantly over the duration of the adult inriver sampling programs, we estimated the proportion ($\hat{\theta}_k$) of the cohort bearing marks. We used this value to calculate the inverse of the marked proportion ($\hat{\theta}_k^{-1}$) and its variance. The latter was estimated by Monte Carlo simulation using the inriver sampling and tag recovery data.

During our analysis, we found a number of AFC adults which did not contain a CWT. These data were used to calculate tag loss.

We decided to use all AFC chinook salmon for comparing the proportion of marked chinook salmon over time and between capture gears if we had information that allowed us to determine the age of the fish. We assumed that there were no naturally occurring missing adipose fins in the chinook salmon sampled, all tag loss originated in the river for which the proportion was calculated, and all lost heads were from fish originally marked in the river for which the proportion was calculated.

Finally, we compared the marked proportion between years to determine whether cohorts from the same brood returning in different years were marked at the same rate.

We also conducted a survey of Slikok Creek, a tributary of the Kenai River, to sample chinook salmon for CWTs, and index the spawning escapement. The foot survey was conducted 7 August 1998 in the approximately 3.2 rkm upstream of the confluence with the Kenai River. We counted all chinook salmon, examined carcasses for AFCs, and sampled those carcasses not in advanced state of decay for ASL. All AFC chinook salmon were sampled as described above. These data were assumed collected during the height of the spawning period as evidenced by the proportion of live and dead spawned fish present.

DEEP CREEK

Chinook and Coho Salmon Weir Counts

A weir was installed on Deep Creek approximately 4 rkm from the terminus at Cook Inlet, and approximately 0.8 rkm upstream of the inriver sport fishery (Figure 6). Operational dates were 17 June through 15 September 1998. We completed weir installation on 17 June, following delays caused by high water resulting from snowmelt. At the weir site, Deep Creek was 21 m wide with a bottom profile that gradually increased to the deepest point approximately 4 m from the north bank (Figure 6). Once installed, the weir was operated continuously through 15 September 1998.

The weir was checked daily from the beginning of operation to ensure that there were no holes through which fish could migrate undetected. The lower gate on the weir fish trap was open throughout each day, allowing fish to migrate upstream relatively unimpeded. The technicians periodically checked the fish trap, and counted, sampled, and passed fish when present. All chinook and coho salmon were examined for a missing adipose fin, and a ¼ in hole was punched on the upper caudal fin.

All chinook salmon, and every seventh coho salmon, were sampled for ASL. All AFC chinook salmon were sacrificed and processed as described above. AFC coho salmon were sampled with a portable hand-held wand that detected the presence of a CWT. We assumed that all coho salmon containing a CWT were of Deep Creek origin.

Chinook Salmon Mark-Recapture Estimate

The late date of the weir installation prompted us to conduct a two-sample capture-recapture experiment to estimate the number of chinook salmon above the weir by mid-July. Fish that migrated through the weir and received a caudal fin punch were considered the capture event. Two crews captured and sampled fish above the weir for a distance of approximately 40 rkm on 14-15 July 1998 for the recapture event. We entered the river at the highest point accessible by road, which provided a sample area encompassing all locations where fish were observed in previous years' aerial surveys. Data were recorded by location as collected in either the lower

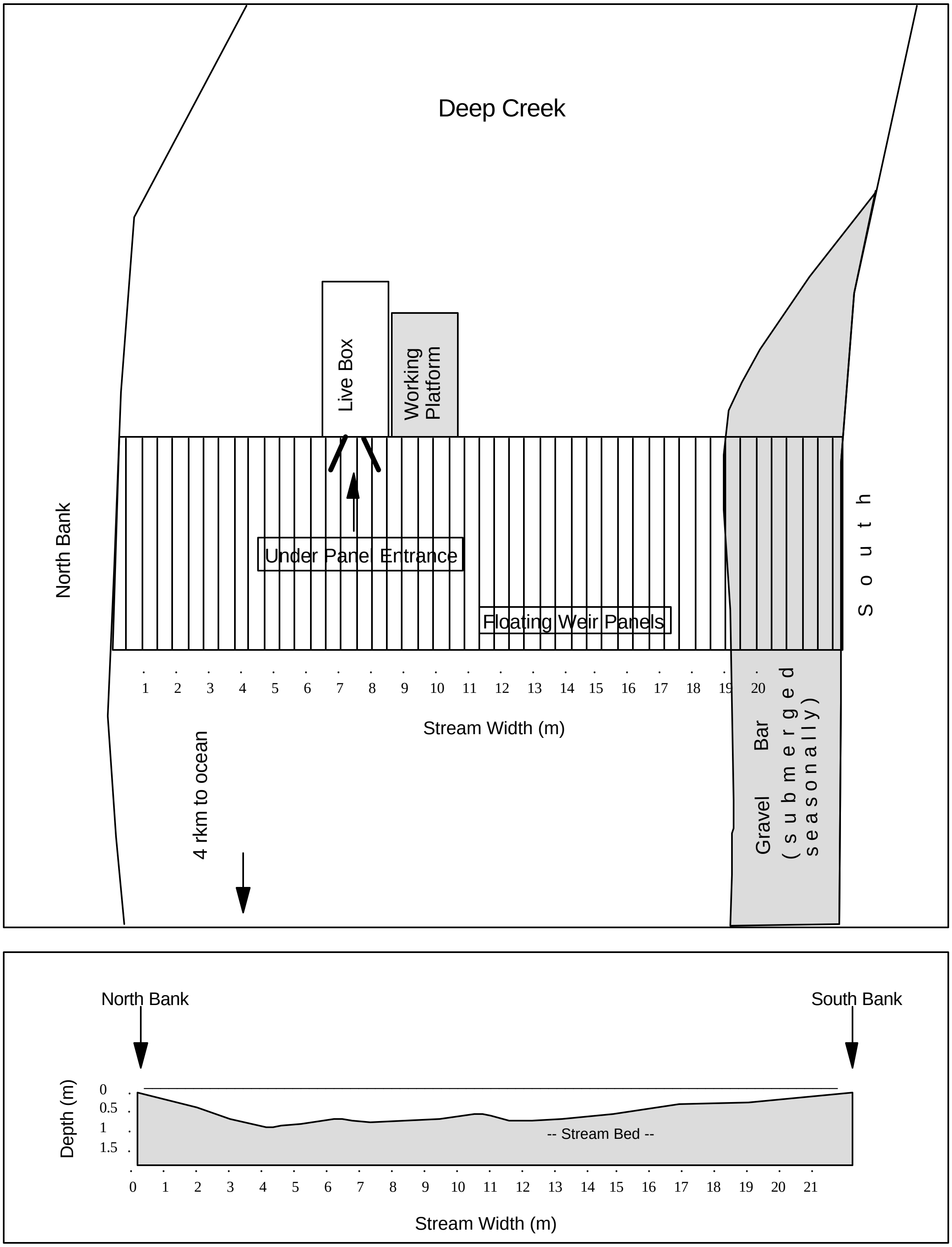


Figure 6.-Schematic overhead and cross section views of the Deep Creek weir site in 1998.

(0 to 20 rkm above the weir) or upper (20 to 40 rkm) river. One crew sampled each river section over the 2-day period.

We captured adult chinook salmon using 15 m long pieces of 4¼ in stretch mesh gillnet drifted through pools. Fish entangled in the net were removed and sampled for ASL and AFC. To avoid repeat sampling of fish, we also punched a ¼ in hole in the left opercle of all released fish. Sex of AFC fish was determined by examination of the gut cavity. All AFC chinook salmon were sacrificed and processed as described above.

We planned to estimate the number of chinook salmon upstream of the weir by mid-July using the Chapman modified Lincoln-Peterson model (Seber 1982), but because of differences in catch composition at netting locations above the weir, we were not able to estimate escapement.

Estimating Ninilchik River Strays

We also tested the null hypothesis that chinook salmon stocked in the Ninilchik River did not stray into Deep Creek upon return. The number of CWT chinook salmon to collect at the weir to test this hypothesis was based on detecting a stray rate of 4% over a 4-5 year period. A consistent straying level >4% over 4-5 years is considered unacceptable (J. Seeb, ADF&G, Anchorage, personal communication).

The number of Ninilchik River chinook salmon straying into Deep Creek was estimated and deducted from the sample data before testing the null hypothesis that the proportion of each age class marked at Deep Creek did not differ over time. We estimated the number and variance of each age class of chinook salmon in each time stratum (h_{tk}) originally stocked into the Ninilchik River by (Bernard and Clark 1996):

$$\hat{h}_{tk} = \frac{m_{tk}}{\lambda_t \phi_t \theta_{Nk}}, \text{ and} \tag{5}$$

$$\hat{V}\left(\hat{h}_{tk}\right) = \frac{\hat{h}_{tk}}{\lambda_t \phi_t \theta_{Nk}}\left(1 - \lambda_t \phi_t \theta_{Nk}\right), \tag{6}$$

where:

m_{tk} = the number of chinook salmon of age k marked and released into the Ninilchik River and recovered during time stratum t,

θ_{Nk} = proportion of chinook salmon of age k released into the Ninilchik River marked with a CWT,

λ_t = the decoding rate of CWTs in the sample during time stratum t, and

ϕ_t = the proportion sampled during time stratum t.

Note that because all chinook salmon migrating through the weir were sampled for age and CWT, $\phi_t = 1$.

Finally, the number of chinook salmon of Deep Creek origin of each age class in each time stratum (n_{Dtk}) was estimated as:

$$\hat{n}_{Dtk} = \hat{n}_{tk} - \hat{h}_{tk}, \tag{7}$$

where:

$\hat{n}_{tk}$ = total number of chinook salmon of each age class in each weekly sample estimated using equation (3).

Estimating the AFC Marked Proportion and θ of the Chinook Salmon Escapement

We poststratified the age class estimates and CWT recoveries of chinook salmon marked at Deep Creek and recovered at the weir into two time intervals, and used a chi-square test to test the hypothesis that the marked proportion did not change over time at $\alpha = 0.05$. If we detected no differences in the proportion marked, then we pooled the weir data to test the hypothesis that the marked proportion did not differ between these data and that collected from netting. If no differences in the proportion marked were detected in the weir and netting samples, we pooled all data to estimate θ for the contributing smolt cohorts. Theta was estimated as described in equation (4).

As in the Kenai River, we found a number of AFC adults that did not contain a CWT. These data were used to calculate tag loss.

We decided to use all AFC chinook salmon for comparing the proportion of marked chinook salmon over time and between capture gears if we had information that allowed us to determine the age of the fish. We assumed that: (1) there were no naturally occurring missing adipose fins in the chinook salmon sampled, (2) all adult chinook salmon with an AFC for which the CWT was not recovered were of Deep Creek origin, (3) the tag loss rate of Ninilchik River hatchery stock was negligible, and (4) all adult chinook salmon with an AFC for which the CWT was not recovered were age-1.0 when tagged. The 1998 marked proportion was compared to previous years to determine whether cohorts from the same brood returning in different years were marked at the same rate.

Estimating Chinook Salmon Smolt Emigrations for Previous Years

The AFC marked fraction was calculated for all available cohorts from a brood year. The total marked fraction was used to estimate the number of emigrating age-1.0 Deep Creek smolt ($\hat{N}_s$)in the year of tagging by (Seber 1982):

$$\hat{N}_s = \frac{(M+1)(C+1)}{(R+1)} - 1, \tag{8}$$

where:

M = the number of smolt marked with an AFC in the year of tagging,

C = the number of adult chinook salmon passing the weir in all years that were examined for a missing adipose fin, and

R = the number of adult chinook salmon recovered at the weir in all years that were marked in Deep Creek;

and its variance $\hat{V}(\hat{N}_S)$ was estimated by:

$$\hat{V}(\hat{N}_S) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}. \qquad (9)$$

This equation produces an unbiased estimate of abundance if: (1) adult chinook salmon examined for marks were a random sample of the escapement, or the marked sample of smolt was a representative sample of the drainage-wide smolt emigration in the year of marking; (2) all juveniles marked were actually smolt; and (3) survival was the same for marked and unmarked individuals.

Estimating the AFC Marked Proportion and θ of the Coho Salmon Escapement

We poststratified the AFC recoveries of coho salmon marked at Deep Creek and recovered at the weir into two time intervals, and used a chi-square test to test the hypothesis that the marked proportion did not change over time at α = 0.05. If no differences in the proportion marked were detected, all data were pooled to estimate θ for the 1997 smolt emigration. Theta was estimated as described in equation (4).

During our analysis, we found AFC adults that did not contain a CWT. These data were used to calculate tag loss.

We decided to use all AFC coho salmon for comparing the proportion of marked salmon over time. We assumed that: (1) there was no naturally occurring missing adipose fins in the coho salmon sampled; (2) all adult coho salmon with an AFC for which the CWT was not recovered were of Deep Creek origin; and (3) all adult coho salmon with an AFC for which the CWT was not recovered were age 2.0 when tagged.

1997 Coho Salmon Smolt Estimate

We compared the proportion of marked coho salmon from two time strata to test the hypothesis that the marked proportion of adults did not change over time. If the marked proportion did not change over time, we used the number of coho salmon smolt tagged in 1997 and recovered as adults in the 1998 escapement to estimate the number of smolt that emigrated from Deep Creek in 1997. We estimated the number of smolt ($\hat{N}_s$) and its variance $\hat{V}(\hat{N}_s)$ using equations (8) and (9). For this estimate:

M = the number of smolt marked with an AFC in 1997,

C = the number of adult coho salmon passing the weir in 1998 that were examined for a missing adipose fin, and

R = the number of adult coho salmon recovered at the weir in 1998 that were marked in Deep Creek.

This equation produces an unbiased estimate of abundance if: (1) adult coho salmon examined for marks were a random sample of the escapement, or the marked sample of smolt was a representative sample of the drainage-wide smolt emigration in 1997; (2) all juveniles marked in 1997 were actually smolt; and (3) survival was the same for marked and unmarked individuals.

Coho Salmon Marine Survival

Smolt estimates were then used to calculate marine survival (S) as:

$$\hat{S} = \frac{\hat{N}_A}{\hat{N}_S}, \tag{10}$$

and its estimated variance as:

$$\hat{V}(\hat{S}) = \hat{s}^2 \left[\frac{\hat{V}(\hat{N}_A)}{\hat{N}_A^2} + \frac{\hat{V}(\hat{N}_s)}{\hat{N}_S^2} \right], \tag{11}$$

where:

$\hat{N}_a$ and $\hat{V}(\hat{N}_a)$ = the estimate and variance of the total return of adult coho salmon to Deep Creek.

RESULTS

KENAI RIVER

CWT Release

We captured 253,766 fish at the mainstem site in 1998, including 11,208 chinook salmon and 2,684 coho salmon (Table 1). Sockeye salmon smolt were the numerically dominant (94%) species in the catch, followed by chinook (4%) and coho salmon (1%) smolt. Other species captured included: 602 pink salmon *O. gorbuscha*, 329 Dolly Varden *Salvelinus malma,* 7 rainbow trout *O. mykiss*, 583 slimy sculpin *Cottus cognatus*, 138 three-spine stickleback *Gasterosteus aculeatus*, 2 round whitefish *Prosopium cylindraceum*, and 40 Pacific lamprey *Lampreta tridentata.* Nightly chinook salmon smolt catches ranged up to 837, and peaked on 8-9 June (Figure 7).

AFC chinook salmon smolt from the Killey River were captured primarily from late May to mid June. Coho salmon smolt were captured throughout the operational period, with largest catches in the first half of June. Sockeye salmon smolt catches occurred from late May throughout June.

Fork length of age-1.0 chinook salmon smolt captured in the Kenai River ranged from 65 to 107 mm and averaged 90 mm (SE = 1 mm; Figure 8).

We marked and released 10,397 age-1.0 chinook salmon smolt with CWTs at the mainstem Kenai River site (Appendix A). Mortality of age-1.0 smolt from capture and pre-tagging handling averaged 6.5%. The average short-term tag retention was 96.5%.

In the Killey River, technicians captured 7,771 salmonid smolts in the rotary screw trap (Table 2). Chinook salmon smolt were the numerically dominant salmonid species in the catch (82%), followed by coho (13%) and sockeye (5%) salmon. Nightly catches of chinook salmon smolt ranged up to 880 fish (Figure 7). Highest catches occurred during and immediately following freshets. Total catch of other species at the Killey River included: 526 Dolly Varden, 11 rainbow trout, 37 round whitefish, 774 slimy sculpin, 22 three-spine stickleback, and 15 Pacific lamprey.

Prior to mid June, emergent age-0.0 chinook salmon fry were easily distinguished from age-1.0 smolt based on size and color. Fork length of age-1.0 chinook salmon smolt ranged from 65 to 97 mm and averaged 81 mm (SE = 1 mm), while the average length of age-0.0 fry was 48 mm (SE = 1 mm; Figure 9). By mid June, average length of age-1.0 smolt had not changed, but

Table 1.-Daily and cumulative catches of chinook, coho, and sockeye salmon smolt in the Kenai River mainstem, 1998.

	Chinook		Coho		Sockeye		AFC[a] Chinook		AFC[b] Coho	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
16-May	88	88	1	1	55	55	0	0	0	0
17-May	36	124	0	1	52	107	0	0	0	0
18-May	22	146	0	1	65	172	0	0	0	0
19-May	18	164	0	1	179	351	0	0	0	0
20-May	28	192	1	2	1,252	1,603	0	0	0	0
21-May	31	223	1	3	3,217	4,820	0	0	0	0
22-May	21	244	1	4	5,898	10,718	0	0	0	0
23-May	40	284	0	4	9,056	19,774	0	0	0	0
24-May	78	362	4	8	12,570	32,344	1	1	0	0
25-May	93	455	4	12	6,726	39,070	0	1	0	0
26-May	80	535	3	15	6,630	45,700	2	3	0	0
27-May	95	630	3	18	8,099	53,799	2	5	0	0
28-May	146	776	5	23	10,521	64,320	2	7	0	0
29-May	476	1,252	12	35	34,480	98,800	3	10	0	0
30-May	172	1,424	7	42	12,490	111,290	8	18	2	2
31-May	318	1,742	40	82	14,390	125,680	3	21	24	26
01-Jun	466	2,208	69	151	17,400	143,080	3	24	39	65
02-Jun	202	2,410	17	168	3,910	146,990	5	29	12	77
03-Jun	192	2,602	112	280	4,150	151,140	2	31	73	150
04-Jun	95	2,697	36	316	6,230	157,370	0	31	18	168
05-Jun	172	2,869	268	584	6,330	163,700	0	31	123	291
06-Jun	308	3,177	106	690	4,100	167,800	3	34	55	346
07-Jun	505	3,682	241	931	6,710	174,510	3	37	148	494
08-Jun	812	4,494	391	1,322	9,770	184,280	11	48	231	725
09-Jun	837	5,331	242	1,564	23,875	208,155	5	53	117	842
10-Jun	241	5,572	60	1,624	2,640	210,795	0	53	29	871
11-Jun	259	5,831	136	1,760	2,436	213,231	2	55	46	917
12-Jun	288	6,119	77	1,837	585	213,816	3	58	32	949
13-Jun	261	6,380	81	1,918	1,060	214,876	2	60	10	959
14-Jun	204	6,584	56	1,974	1,280	216,156	1	61	19	978
15-Jun	148	6,732	63	2,037	780	216,936	1	62	14	992
16-Jun	131	6,863	58	2,095	750	217,686	2	64	7	999
17-Jun	174	7,037	45	2,140	3,010	220,696	0	64	3	1,002
18-Jun	78	7,115	54	2,194	2,800	223,496	0	64	0	1,002
19-Jun	133	7,248	48	2,242	360	223,856	0	64	0	1,002
20-Jun	138	7,386	48	2,290	1,450	225,306	0	64	0	1,002
21-Jun	260	7,646	33	2,323	140	225,446	0	64	0	1,002
22-Jun	111	7,757	26	2,349	960	226,406	1	65	0	1,002
23-Jun	66	7,823	66	2,415	670	227,076	0	65	0	1,002
24-Jun	25	7,848	38	2,453	350	227,426	0	65	0	1,002
25-Jun	59	7,907	36	2,489	210	227,636	0	65	0	1,002
26-Jun	136	8,043	56	2,545	700	228,336	1	66	0	1,002

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Table 1.-Page 2 of 2.

	Chinook		Coho		Sockeye		AFC[a] Chinook		AFC[b] Coho	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
27-Jun	102	8,145	29	2,574	1,160	229,496	0	66	0	1,002
28-Jun	118	8,263	32	2,606	1,870	231,366	0	66	0	1,002
29-Jun	199	8,462	17	2,623	2,880	234,246	1	67	0	1,002
30-Jun	175	8,637	17	2,640	1,170	235,416	1	68	0	1,002
01-Jul	177	8,814	21	2,661	335	235,751	0	68	0	1,002
02-Jul	279	9,093	3	2,664	279	236,030	1	69	0	1,002
03-Jul	335	9,428	1	2,665	145	236,175	0	69	0	1,002
04-Jul	67	9,495	2	2,667	220	236,395	1	70	0	1,002
05-Jul [c]		9,495		2,667		236,395		70		1,002
06-Jul [c]		9,495		2,667		236,395		70		1,002
07-Jul [c]		9,495		2,667		236,395		70		1,002
08-Jul [c]		9,495		2,667		236,395		70		1,002
09-Jul	182	9,677	1	2,668	30	236,425	3	73	0	1,002
10-Jul	174	9,851	10	2,678	55	236,480	0	73	0	1,002
11-Jul	109	9,960	1	2,679	29	236,509	0	73	0	1,002
12-Jul	58	10,018	2	2,681	54	236,563	0	73	0	1,002
13-Jul	77	10,095	1	2,682	91	236,654	0	73	0	1,002
14-Jul	109	10,204	0	2,682	136	236,790	0	73	0	1,002
15-Jul	69	10,273	1	2,683	107	236,897	0	73	0	1,002
16-Jul	111	10,384	0	2,683	86	236,983	0	73	0	1,002
17-Jul	64	10,448	0	2,683	80	237,063	0	73	0	1,002
18-Jul	57	10,505	0	2,683	78	237,141	1	74	0	1,002
19-Jul	56	10,561	0	2,683	18	237,159	0	74	0	1,002
20-Jul	62	10,623	0	2,683	93	237,252	0	74	0	1,002
21-Jul	58	10,681	0	2,683	165	237,417	0	74	0	1,002
22-Jul	76	10,757	0	2,683	57	237,474	1	75	0	1,002
23-Jul	44	10,801	0	2,683	310	237,784	0	75	0	1,002
24-Jul	24	10,825	0	2,683	130	237,914	0	75	0	1,002
25-Jul [c]		10,825		2,683		237,914		75		1,002
26-Jul [c]		10,825		2,683		237,914		75		1,002
27-Jul [c]		10,825		2,683		237,914		75		1,002
28-Jul	64	10,889	0	2,683	11	237,925	0	75	0	1,002
29-Jul	34	10,923	1	2,684	20	237,945	0	75	0	1,002
30-Jul	46	10,969	0	2,684	44	237,989	0	75	0	1,002
31-Jul	67	11,036	0	2,684	40	238,029	0	75	0	1,002
01-Aug	46	11,082	0	2,684	41	238,070	0	75	0	1,002
02-Aug	42	11,124	0	2,684	38	238,108	0	75	0	1,002
03-Aug	40	11,164	0	2,684	45	238,153	0	75	0	1,002
04-Aug	44	11,208	0	2,684	20	238,173	0	75	0	1,002

[a] Chinook salmon smolt that were adipose finclipped were tagged with CWTs in the Killey River, 1998.

[b] Coho salmon smolt that were adipose finclipped were tagged with CWTs in the Moose River, 1998.

[c] Traps damaged; no catch.

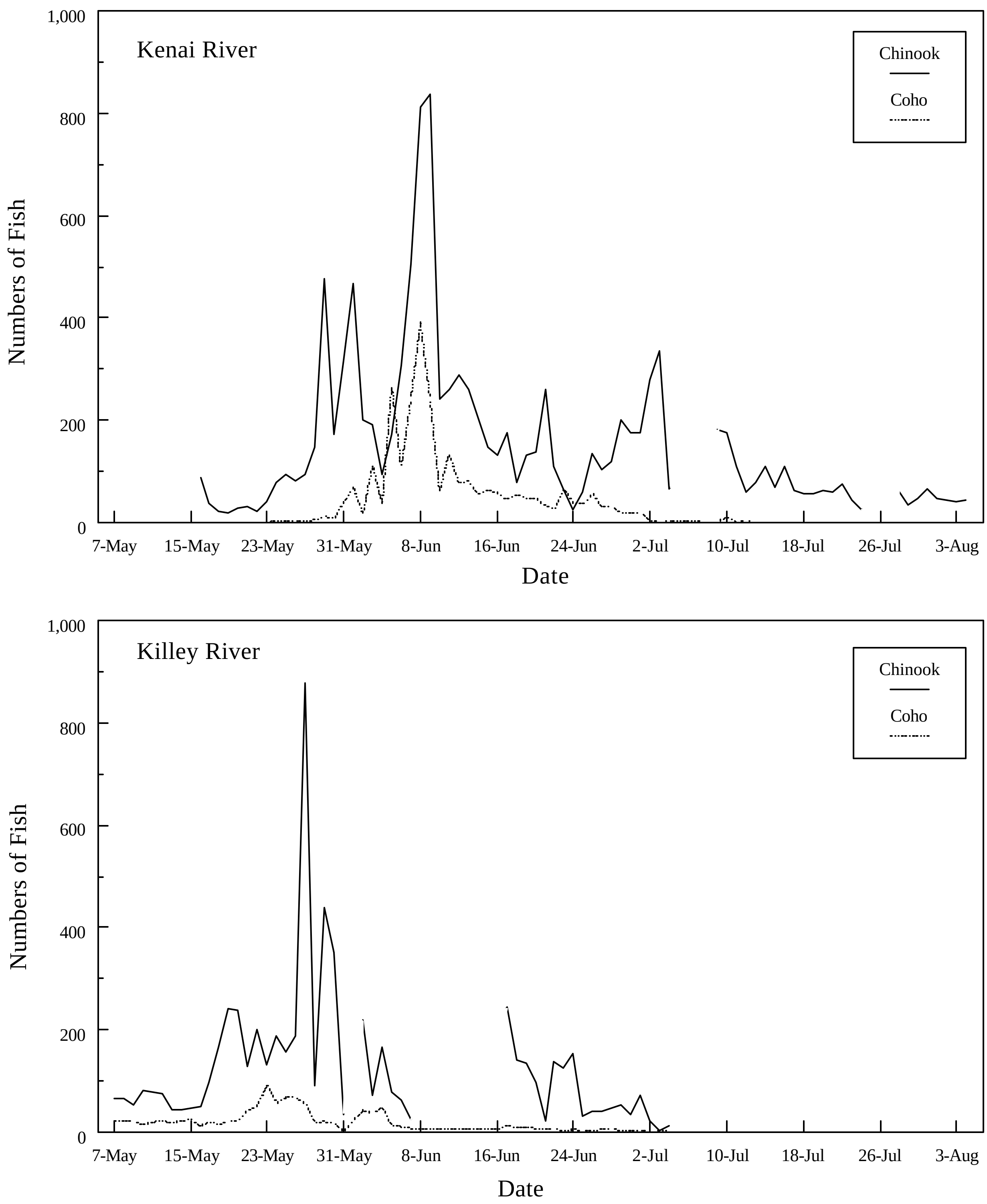

Figure 7.-Daily chinook and coho salmon smolt catches from the Kenai and Killey rivers, 1998.

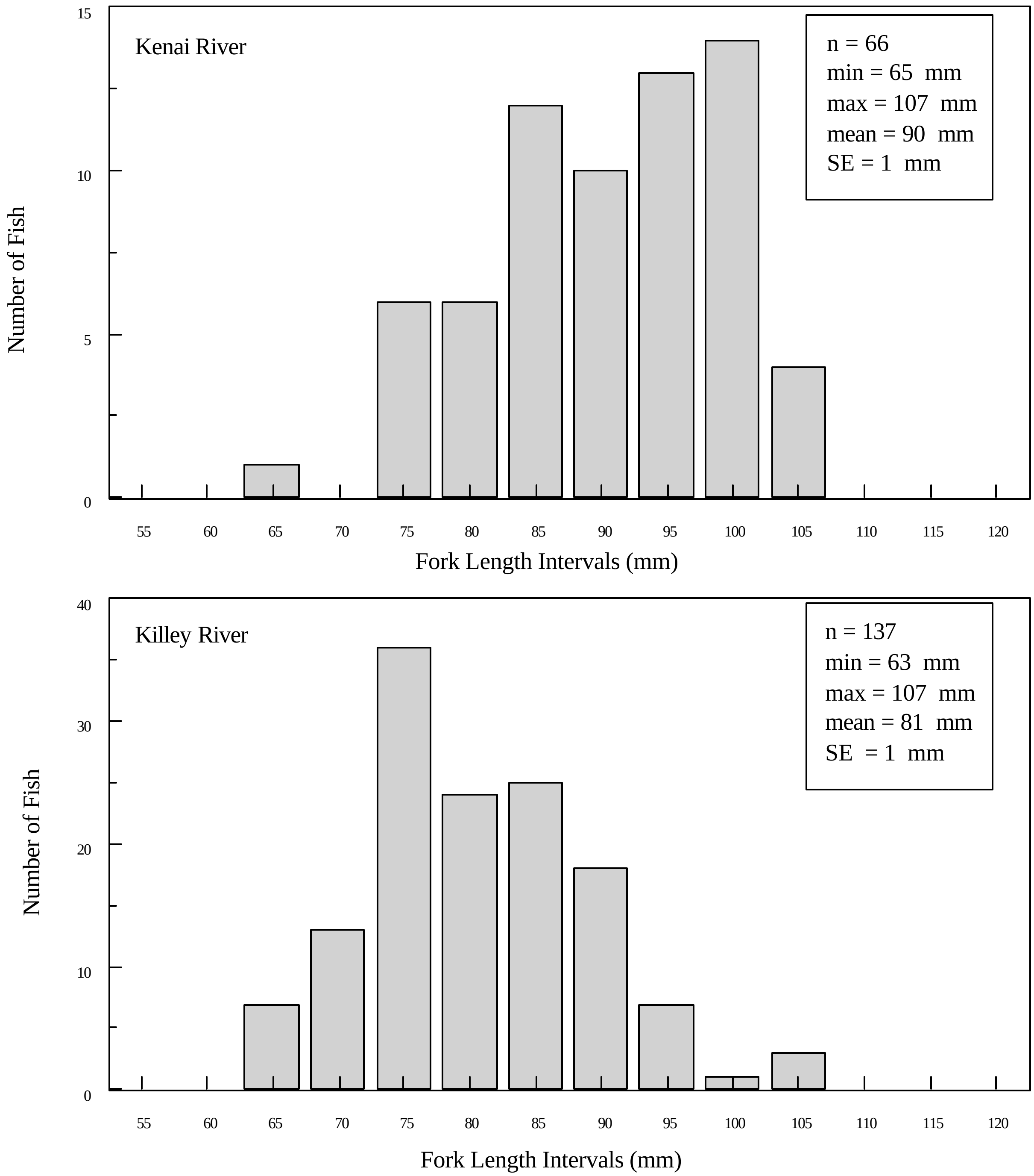

Figure 8.-Length frequency distribution for age-1.0 chinook salmon smolt captured in the Kenai and Killey rivers, 1998.

Table 2.-Daily and cumulative catches of chinook, coho, and sockeye salmon smolt in the Killey River, 1998.

	Location	Chinook		Coho		Sockeye	
Date	rkm	Daily	Cum	Daily	Cum	Daily	Cum
07-May	0.8	65	65	20	20	7	7
08-May	0.8	65	130	20	40	6	13
09-May	0.8	52	182	21	61	7	20
10-May	0.8	80	262	13	74	13	33
11-May	0.8	79	341	19	93	19	52
12-May	0.8	74	415	21	114	12	64
13-May	0.8	42	457	18	132	3	67
14-May	0.8	44	501	21	153	11	78
15-May	0.8	45	546	25	178	3	81
16-May	0.8	49	595	12	190	10	91
17-May	0.8	97	692	19	209	14	105
18-May	0.8	166	858	15	224	10	115
19-May	0.8	241	1,099	19	243	24	139
20-May	0.8	239	1,338	23	266	33	172
21-May	0.8	128	1,466	42	308	9	181
22-May	0.8	200	1,666	52	360	18	199
23-May	0.8	132	1,798	92	452	15	214
24-May	0.8	187	1,985	57	509	23	237
25-May	0.8	158	2,143	68	577	34	271
26-May	0.8	189	2,332	67	644	13	284
27-May	0.8	880	3,212	55	699	21	305
28-May	0.8	90	3,302	19	718	11	316
29-May	0.8	438	3,740	20	738	16	332
30-May	0.8	351	4,091	17	755	5	337
31-May	0.8	34	4,125	1	756	3	340
01-Jun [a]	0.8		4,125		756		340
02-Jun	0.8	220	4,345	42	798	7	347
03-Jun	0.8	72	4,417	37	835	6	353
04-Jun	0.8	165	4,582	48	883	3	356
05-Jun	0.8	79	4,661	13	896	2	358
06-Jun	0.8	63	4,724	10	906	1	359
07-Jun	0.8	25	4,749	7	913	4	363
08-Jun [a]	0.8		4,749		913		363
09-Jun [a]	0.8		4,749		913		363
10-Jun [a]	0.8		4,749		913		363
11-Jun [a]	0.8		4,749		913		363
12-Jun [a]	0.8		4,749		913		363
13-Jun [a]	0.8		4,749		913		363
14-Jun [a]	0.8		4,749		913		363
15-Jun [a]	0.8		4,749		913		363
16-Jun	0.8	215	4,964	5	918	18	381
17-Jun	0.8	243	5,207	13	931	5	386
18-Jun	0.8	140	5,347	7	938	2	388

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Table 2.-Page 2 of 2.

Date	Location rkm	Chinook Daily	Chinook Cum	Coho Daily	Coho Cum	Sockeye Daily	Sockeye Cum
19-Jun	0.8	134	5,481	10	948	2	390
20-Jun	0.8	98	5,579	6	954	5	395
21-Jun	0.8	22	5,601	6	960	0	395
22-Jun	0.8	138	5,739	7	967	0	395
23-Jun	0.8	124	5,863	1	968	7	402
24-Jun	0.8	154	6,017	5	973	3	405
25-Jun	0.8	30	6,047	2	975	1	406
26-Jun	0.8	39	6,086	3	978	0	406
27-Jun	0.8	39	6,125	5	983	0	406
28-Jun	0.8	48	6,173	7	990	0	406
29-Jun	0.8	53	6,226	1	991	0	406
30-Jun	0.8	33	6,259	2	993	0	406
01-Jul	0.8	72	6,331	2	995	0	406
02-Jul	0.8	20	6,351	0	995	0	406
03-Jul	0.8	4	6,355	1	996	0	406
04-Jul	0.8	13	6,368	1	997	0	406

[a] High water conditions resulted in incomplete catch data.

average length of age-0.0 juveniles was 60 mm (SE = 1 mm). Color was used as the primary criteria for determining whether fish were smolt in the latter 2 weeks of the project.

We marked and released 6,201 chinook salmon smolt with CWTs at the Killey River (Appendix A). Short-term tag retention and mortality rate for smolt were 99.5% and 1.7%, respectively.

A total of 16,598 chinook salmon was marked at both sites combined. We assumed that all marked smolt emigrated from the Kenai River. The timing of the catch at the two sites overlapped, although the peak in the mainstem catch was approximately 2 weeks later (Figure 7). The average age-1.0 chinook salmon smolt captured in the mainstem was significantly longer ($t = 6.91$, $p < 0.01$) than its Killey River counterpart (Figure 8). The average length of Killey River AFC chinook salmon smolt recaptured in the mainstem was not different than the average length of smolt captured in the Killey River ($t = -1.53$, $P = 0.13$).

Estimating the AFC Marked Proportion and θ of the Chinook Salmon Inriver Return

A total of 330 early-run (prior to 30 June) and 390 late-run (after 1 July) adult chinook salmon were captured in gillnets in the Kenai River (Table 3; Marsh 2000). Crews examined all of the netted fish for an AFC. Creel survey technicians examined 92 early-run and 367 late-run chinook salmon from the sport harvest.

Since no temporal difference was detected for the two age classes that composed more than three-quarters of the early and late inriver returns, Marsh (2000) pooled age data by temporal component within each source (harvest and escapement) and run (early and late) to calculate the age composition. We found that there was no difference in the cumulative length distribution of

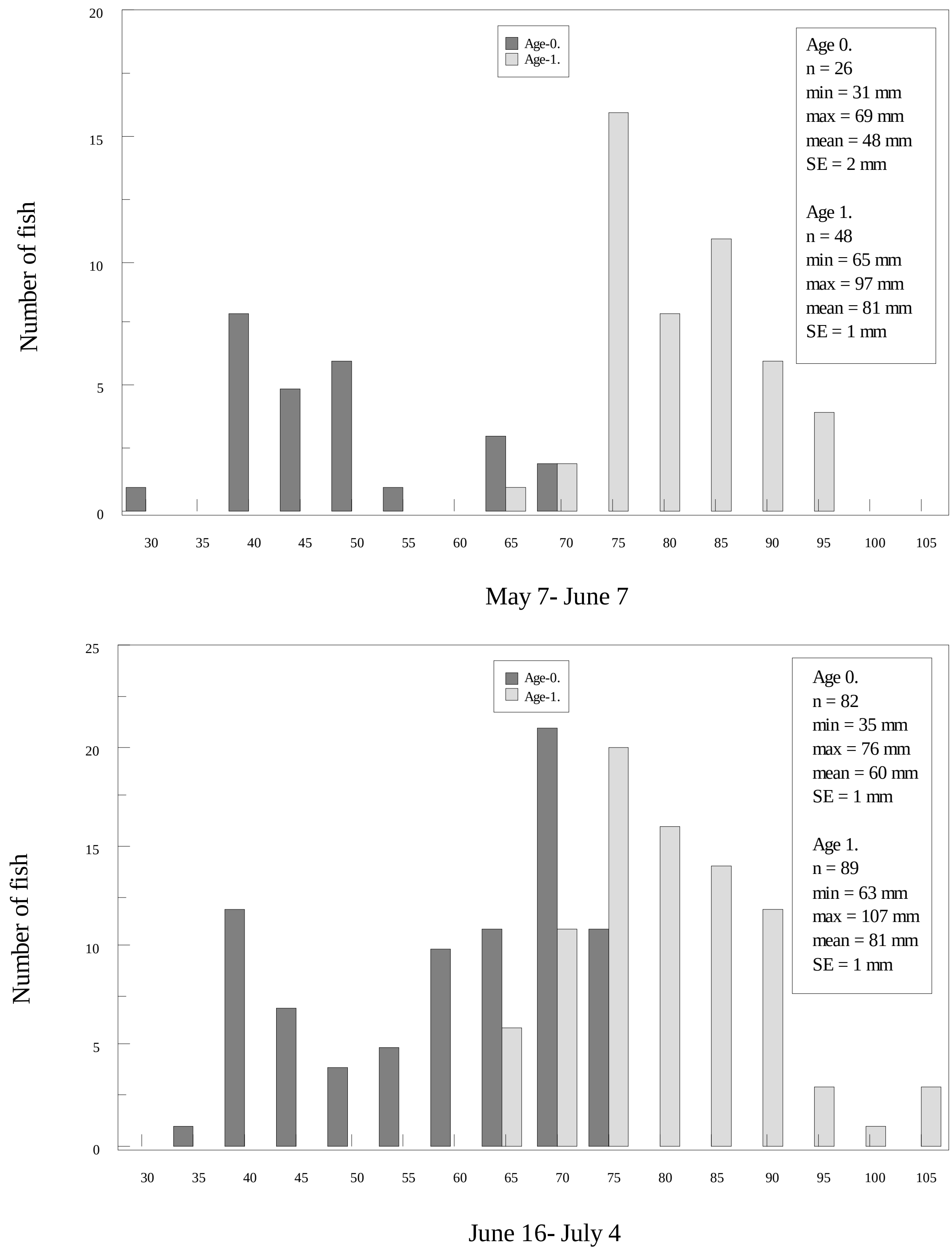


Figure 9.-Changes in length frequency distribution of age-0. and age-1. chinook salmon smolt over time in the Killey River, 1998.

Table 3.-Age composition and proportion of chinook salmon sampled, and estimated number examined for an adipose finclip (AFC) at the Kenai River, early and late runs, 1998.

		Number of fish sampled							Proportion of Stratum Total of Aged Fish Only					Estimated Number of Chinook Salmon Examined for AFCs and CWTs					
		Age							Age					Age					
Component	Stratum Dates	1.1	1.2	1.3	1.4	1.5	Unaged	Total	1.1	1.2	1.3	1.4	1.5	1.1	1.2	1.3	1.4	1.5	All Ages
Early Run																			
Inriver Return	5/15-6/30	0	54	105	117	9	45	330	0.00	0.19	0.37	0.41	0.03	0	63	122	135	10	330
SE									0.00	0.02	0.03	0.03	0.01						
Harvest	5/07-6/30	0	1	15	56	5	15	92	0.00	0.01	0.19	0.73	0.06	0	1	18	67	6	92
SE									0.00	0.01	0.05	0.05	0.03						
Total	5/15-6/30													0	64	140	202	16	422
Late Run																			
Inriver Return	7/01-8/09	0	51	48	232	11	48	390	0.00	0.15	0.14	0.68	0.03	0	58	55	265	13	390
SE									0.00	0.02	0.02	0.03	0.01						
Harvest	7/1-7/29	5	40	41	235	10	36	367	0.02	0.12	0.12	0.71	0.03	6	44	45	261	11	367
SE									0.01	0.02	0.02	0.03	0.01						
Total	7/01-8/09													6	102	100	525	24	757

aged and unageable chinook salmon regardless of capture or temporal stratum (all P from KS test >0.28). We therefore expanded the age composition from the inriver return and creel samples to estimate the age of unageable fish (Table 3). We estimated that 64 age-1.2, 140 age-1.3, 202 age-1.4, and 16 age 1.5 early-run adults were examined for an AFC (Table 3). In the late run, we examined an estimated 102 age-1.2, 100 age-1.3, 525 age-1.4, and 24 age-1.5 adults for an AFC (Table 3).

During the early run, three heads were recovered from AFC chinook salmon during inriver sampling with gillnets, and one head was recovered during the creel survey, for a total of four heads (Appendices B2 and B3). Two of the heads did not contain tags. The other two were tagged in the Kenai River and released as age-0.0, one from the 1992 brood year and one from the 1993 brood year. One of the tagged fish was recovered in early June and one in late June.

During the late run, 17 heads were recovered from AFC chinook salmon during inriver sampling with gillnets, and 12 were recovered during the creel survey, for a total of 29 heads (Appendices B2 and B3). Of these, 15 heads contained tags from fish marked as age-0.0 juveniles. Four were from the 1992 brood year, 9 from the 1993 brood year, and 2 from the 1994 brood year. Nine heads did not contain CWTs, and five heads were lost (fish with AFCs observed by creel technicians, but the heads were not surrendered by the anglers).

Twenty-two adults tagged in the Kenai River (brood years 1992-1994) were also recovered from a variety of Cook Inlet marine sport and commercial fisheries (Appendices B6 and B7). In addition, two were captured in the Kodiak purse seine fishery (Appendix B8).

Tag retention rates, calculated from adult recoveries since 1996, were 56% for the 1992 brood year tagged in 1993, 77% for the 1993 brood year tagged in 1994, and 67% for the 1994 brood year tagged in 1995. All recoveries to date are from tagged age-0.0 fingerlings.

We were unable to calculate the proportion of early-run age-1.2 chinook salmon marked with an AFC as juveniles because we did not recover tags in either the netting or creel samples this year. We recovered one age-1.3 and one age-1.4 AFC early-run adult in the netting program. We combined the fish observed in the creel with those captured in netting to estimate the marked proportion in the two age classes. The age-1.3 and -1.4 fish were marked with AFCs at a rate of 0.007 (SE = 0.007) and 0.005 (SE = 0.005), respectively (Table 4).

In the late run, age-1.2 AFC chinook salmon were also absent from the creel sample. As with the early run, we combined all fish examined in the netting and creel programs to estimate the marked proportion at 0.039 (SE = 0.019; Table 4). We compared the marked to unmarked ratio of age-1.3 chinook salmon with CWTs in the netting and creel samples and found that they were not different (χ^2 = 0.37, df = 1, P = 0.54; Table 5). After pooling the samples, our estimate of the marked proportion was 0.110 (SE= 0.031) for age-1.3 fish (Table 4). This estimate included two AFC fish with lost tags.

The marked proportion of age-1.4 chinook salmon with AFCs in the netting and creel samples were different (χ^2 = 4.26, df = 1, P = 0.04; Table 5). Six of the 11 AFC fish used in this analysis were finclipped; of these, four heads did not contain a CWT and two of the heads were lost after the cinch strap was applied. Because of the differences between the netting and creel AFC marked proportions, we chose to use only the netting results to estimate the marked proportion of age-1.4 chinook salmon at 0.034 (SE = 0.011).

Table 4.-Number of chinook salmon with adipose finclips and coded wire tags, and estimates of marked to unmarked proportions and theta, Kenai River early and late runs, 1998.

		Adipose Finclipped Fish							Coded Wire Tagged Fish						
		Number of Fish				Marked to unmarked prop.[a]			Number of Fish				Theta		
	Stratum	Age				Age			Age				Age		
Component	Dates	1.2	1.3	1.4	Total	1.2	1.3	1.4	1.2	1.3	1.4	Total	1.2	1.3	1.4
Early Run															
Inriver Return	5/15-6/30	0	1	1	2	0.000	0.008	0.007	0	1	0	1	0.000	0.008	0.000
SE															
Harvest	5/07-6/30	0	0	0	0	0.000	0.000	0.000	0	0	0	0	0.000	0.000	0.000
SE															
Total	5/15-6/30	0	1	1	2	0.000	**0.007**	**0.005**	0	1	0	1	0.000	0.007	0.000
SE						0.000	**0.007**	**0.005**					0.000	0.007	0.000
Late Run															
Inriver Return	7/01-8/09	4	5	9	18	0.069	0.091	**0.034**	2	4	5	11	0.034	0.073	0.019
SE								**0.011**							
Harvest	7/1-7/29	0	6	2	8	0.000	0.132	0.008	0	5	0	5	0.000	0.110	0.000
SE															
Total	7/01-8/09	4	11	11	26	**0.039**	**0.110**	0.021	2	9	5	16	0.020	0.090	0.010
SE						**0.019**	**0.031**	0.006					0.014	0.029	0.004

Note: shaded cells are used as final estimates of marked (AFC) proportion.

[a] Assumptions for estimating marked/unmarked proportions include the following: (1) all tag loss chinook salmon were of Kenai River origin, (2) there were no naturally occurring lost adipose finclipped chinook salmon in the population, and (3) all lost heads were from chinook salmon originally marked in the Kenai River.

Table 5.-Recoveries, by age, of chinook salmon with adipose finclips (AFCs) and coded wire tags (CWTs) from the Kenai River inriver return and harvest, early and late runs, 1998.

Statistic	Age 1.2 Inriver Return	Age 1.2 Harvest	Age 1.2 Total	Age 1.3 Inriver Return	Age 1.3 Harvest	Age 1.3 Total	Age 1.4 Inriver Return	Age 1.4 Harvest	Age 1.4 Total
Adipose Finclipped Fish									
Early Run									
Number Examined	63	1	64	122	18	140	135	67	202
Number with AFC	0	0	0	1	0	1	1	0	1
Chi Square[a]		no comparison			no comparison			no comparison	
P-value		no comparison			no comparison			no comparison	
Late Run									
Number Examined	58	44	102	55	45	100	265	261	526
Number with AFC	4	0	4	5	6	11	9	2	11
Chi Square[a]		no comparison			0.36			4.26	
P-value		no comparison			0.55			0.04	
Coded Wire Tagged Fish									
Early Run									
Number Examined	63	1	64	122	18	140	135	67	202
Number with CWT	0	0	0	1	0	1	0	0	0
Chi Square[b]									
P-value									
Late Run									
Number Examined	58	44	103	55	45	100	265	261	525
Number with CWT	2	0	2	4	5	9	5	0	5
Chi Square[b]		1.50			0.37			4.88	
P-value		0.22			0.54			0.03	

[a] Comparison of marked to unmarked totals in the inriver return and harvest using AFCs as the mark.

[b] Comparison of marked to unmarked totals in the inriver return and harvest using CWTs as the mark.

We also compared the proportion of early-run chinook salmon marked with an AFC in the recoveries to date from the 1992 and 1993 brood years (Table 6). The marked proportion did not change during the years of recovery for either brood, therefore we pooled the recovery data from all years. The preliminary estimate of marked proportion for the 1992 brood year was 0.002 (SE = 0.002), and 0.012 (SE = 0.009) for the 1993 brood year (Table 6).

In the late run, the 1992 and 1993 brood year AFC marked proportion did not change between recovery years (χ^2 =3.94, df = 2, P = 0.14 and χ^2 = 2.70, df = 1, P = 0.10; Table 6). The preliminary estimates of the marked proportions were 0.022 (SE = 0.007) and 0.088 (SE = 0.025), respectively (Table 6).

The proportion of chinook salmon with a CWT was also compared within and between years and gear types. Insufficient CWTs were recovered in the early run to estimate θ. Preliminary estimates of θ were calculated for the late-run broods marked in 1992-1994. The 1992 brood was tagged at a rate of 0.012 (SE = 0.005; Table 6). This brood year lacks only examination of age-1.5 fish returning in 1999 for a final estimate of θ. Preliminary estimates of θ for the 1993 and 1994 brood years were 0.072 (SE = 0.023) and 0.020 (SE = 0.014), respectively (Table 6). Both are considered very preliminary because the majority of the return will occur in 1999 and beyond.

At Slikok Creek, survey crews observed 61 chinook salmon on the spawning grounds. Scales were collected from 39 of the chinook salmon, and sex was determined for 47 fish. Scales from 31 fish were readable, of which 10% were age 1.2, 64% were age 1.3, and 26% were age 1.4. Heads were collected from four AFC fish, representing three cohorts of Crooked Creek hatchery releases (Appendix B1).

DEEP CREEK

Adult Chinook Salmon Escapement

A total of 367 chinook salmon passed the weir site during the operation dates (Table 7). Passage of chinook salmon occurred through mid August, but most fish returned in late June and early July (Figure 10).

We also examined 121 chinook salmon captured with a net above the weir on 14 and 15 July and found that only three of the fish had an upper caudal fin punch applied at the weir (Table 8). The small recapture sample size and limited marks in the sample, inconsistency in marked to unmarked ratio between river sections, and differences in age and length composition between seine and weir samples indicated that the capture-recapture data would not provide an accurate estimate of the escapement.

The age composition of chinook salmon that passed through the weir was temporally consistent (χ^2 = 2.87, df = 2, P = 0.24; Table 9). The majority of the fish were age 1.2 (43%, SE = 3%), 1.3 (30%, SE = 3%) and 1.4 (24%, SE = 2%). There was a difference (χ^2 = 24.16, df = 2, P < 0.001) in the age composition between the weir and seine samples. Mean lengths of chinook salmon passing the weir were within the ranges observed historically (Table 10; King and Breakfield 1998, 1999).

The minimum chinook salmon escapement, defined as chinook salmon marked at the weir plus those newly captured upstream with the net, minus strays from the Ninilchik River (see below), was 479 fish.

Table 6.-Comparison of adipose finclipped (AFC) and coded wire tagged (CWT) marked proportions of Kenai River chinook salmon from the 1992–1994 brood years examined in 1996–1998.

Brood	Number Examined for Marks				Number of Adipose Finclips				AFC Tests[a]			Marked/ Unmarked		Number of Coded Wire Tags				CWT Tests[b]			Theta	
Year	1996	1997	1998	Total	1996	1997	1998	Total	chi sq	P	df	Est.	SE	1996	1997	1998	Total	chi sq	P	df	Est.	SE
Early Run																						
1992	60	190	202	452	0	0	1	1	1.23	0.54	2	0.002	0.002	0	0	0	0				0.000	0.000
1993		26	140	166		1	1	2	1.73	0.19	1	0.012	0.009		0	1	1				0.006	0.006
1994			64	64			0	0				0.000	0.000			0	0				0.000	0.000
Late Run																						
1992	64	173	265	502	0	2	9	11	3.94	0.14	2	0.022	0.007	0	1	5	6	2.35	0.31	2	0.012	0.005
1993		25	100	125		0	11	11	2.70	0.10	1	0.088	0.025		0	9	9	2.21	0.14	1	0.072	0.023
1994			102	102			4	4				0.039	0.019			2	2				0.020	0.014

[a] For brood year 1992, comparison of proportion with adipose finclips in 1996, 1997, and 1998 using a chi-square test. For brood year 1993, comparison of proportion with adipose finclips in 1997 and 1998 using a chi-square test.

[b] For brood year 1992, comparison of proportion with coded wire tags in 1996, 1997, and 1998 using a chi-square test. For brood year 1993, comparison of proportion with coded wire tags in 1997 and 1998 using a chi-square test.

Table 7.-Daily and cumulative counts of chinook and coho salmon at the Deep Creek weir, 1998.

	Chinook Salmon						Coho Salmon					
	Unclipped		AFC[a]		Total		Unclipped		AFC[a]		Total	
Date	Number	Cum	Number	Cum	Number	Cum	Number	Cum	Number	Cum	Number	Cum
17-Jun	0	0	0	0	0	0	0	0	0	0	0	0
18-Jun	0	0	0	0	0	0	0	0	0	0	0	0
19-Jun	0	0	0	0	0	0	0	0	0	0	0	0
20-Jun	1	1	0	0	1	1	0	0	0	0	0	0
21-Jun	1	2	0	0	1	2	0	0	0	0	0	0
22-Jun	7	9	0	0	7	9	0	0	0	0	0	0
23-Jun	32	41	6	6	38	47	0	0	0	0	0	0
24-Jun	9	50	1	7	10	57	0	0	0	0	0	0
25-Jun	4	54	2	9	6	63	0	0	0	0	0	0
26-Jun	19	73	1	10	20	83	0	0	0	0	0	0
27-Jun	21	94	0	10	21	104	0	0	0	0	0	0
28-Jun	13	107	1	11	14	118	0	0	0	0	0	0
29-Jun	4	111	1	12	5	123	0	0	0	0	0	0
30-Jun	28	139	2	14	30	153	0	0	0	0	0	0
1-Jul	25	164	2	16	27	180	0	0	0	0	0	0
2-Jul	7	171	0	16	7	187	0	0	0	0	0	0
3-Jul	18	189	3	19	21	208	0	0	0	0	0	0
4-Jul	9	198	2	21	11	219	0	0	0	0	0	0
5-Jul	2	200	0	21	2	221	0	0	0	0	0	0
6-Jul	1	201	0	21	1	222	0	0	0	0	0	0
7-Jul	5	206	1	22	6	228	0	0	0	0	0	0
8-Jul	0	206	1	23	1	229	0	0	0	0	0	0
9-Jul	10	216	1	24	11	240	0	0	0	0	0	0
10-Jul	1	217	0	24	1	241	0	0	0	0	0	0
11-Jul [a]		217		24		241		0		0		0
12-Jul	4	221	0	24	4	245	0	0	0	0	0	0
13-Jul	5	226	0	24	5	250	0	0	0	0	0	0
14-Jul [a]		226		24		250		0		0		0
15-Jul [a]		226		24		250		0		0		0
16-Jul	6	232	0	24	6	256	0	0	0	0	0	0
17-Jul	7	239	0	24	7	263	0	0	0	0	0	0
18-Jul	10	249	1	25	11	274	0	0	0	0	0	0
19-Jul	6	255	1	26	7	281	0	0	0	0	0	0
20-Jul	2	257	0	26	2	283	0	0	0	0	0	0
21-Jul	3	260	1	27	4	287	0	0	0	0	0	0
22-Jul	0	260	0	27	0	287	0	0	0	0	0	0
23-Jul	4	264	0	27	4	291	1	1	0	0	1	1
24-Jul	5	269	1	28	6	297	0	1	0	0	0	1
25-Jul	2	271	0	28	2	299	0	1	0	0	0	1
26-Jul	17	288	0	28	17	316	0	1	0	0	0	1
27-Jul	2	290	2	30	4	320	0	1	1	1	1	2
28-Jul	14	304	1	31	15	335	1	2	1	2	2	4
29-Jul	2	306	0	31	2	337	0	2	1	3	1	5
30-Jul	3	309	1	32	4	341	0	2	6	9	6	11
31-Jul	8	317	1	33	9	350	22	24	16	25	38	49

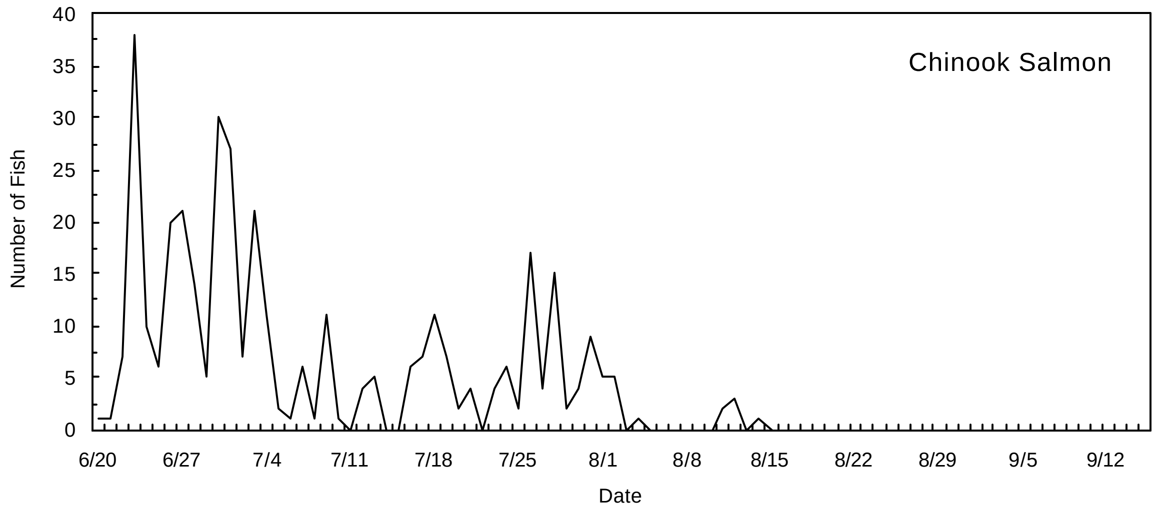
-continued-

Table 7.-Page 2 of 2.

	Chinook Salmon						Coho Salmon					
	Unclipped		AFC[a]		Total		Unclipped		AFC[a]		Total	
Date	Number	Cum	Number	Cum	Number	Cum	Number	Cum	Number	Cum	Number	Cum
1-Aug	4	321	1	34	5	355	6	30	2	27	8	57
2-Aug	5	326	0	34	5	360	8	38	4	31	12	69
3-Aug	0	326	0	34	0	360	19	57	10	41	29	98
4-Aug	1	327	0	34	1	361	0	57	0	41	0	98
5-Aug [b]		327		34		361		57		41		98
6-Aug [b]		327		34		361		57		41		98
7-Aug [b]		327		34		361		57		41		98
8-Aug [b]		327		34		361		57		41		98
9-Aug [b]		327		34		361		57		41		98
10-Aug	0	327	0	34	0	361	36	93	13	54	49	147
11-Aug	2	329	0	34	2	363	24	117	17	71	41	188
12-Aug	3	332	0	34	3	366	83	200	40	111	123	311
13-Aug	0	332	0	34	0	366	19	219	17	128	36	347
14-Aug	1	333	0	34	1	367	58	277	33	161	91	438
15-Aug	0	333	0	34	0	367	62	339	37	198	99	537
16-Aug	0	333	0	34	0	367	91	430	51	249	142	679
17-Aug	0	333	0	34	0	367	86	516	47	296	133	812
18-Aug	0	333	0	34	0	367	22	538	15	311	37	849
19-Aug	0	333	0	34	0	367	9	547	12	323	21	870
20-Aug	0	333	0	34	0	367	65	612	40	363	105	975
21-Aug	0	333	0	34	0	367	25	637	10	373	35	1,010
22-Aug	0	333	0	34	0	367	99	736	50	423	149	1,159
23-Aug	0	333	0	34	0	367	18	754	7	430	25	1,184
24-Aug	0	333	0	34	0	367	121	875	44	474	165	1,349
25-Aug	0	333	0	34	0	367	52	927	17	491	69	1,418
26-Aug	0	333	0	34	0	367	3	930	10	501	13	1,431
27-Aug	0	333	0	34	0	367	6	936	6	507	12	1,443
28-Aug	0	333	0	34	0	367	8	944	3	510	11	1,454
29-Aug	0	333	0	34	0	367	0	944	1	511	1	1,455
30-Aug	0	333	0	34	0	367	11	955	1	512	12	1,467
31-Aug	0	333	0	34	0	367	15	970	7	519	22	1,489
1-Sep [b]		333		34		367		970		519		1,489
2-Sep	0	333	0	34	0	367	8	978	5	524	13	1,502
3-Sep	0	333	0	34	0	367	1	979	1	525	2	1,504
4-Sep	0	333	0	34	0	367	2	981	1	526	3	1,507
5-Sep	0	333	0	34	0	367	2	983	1	527	3	1,510
6-Sep	0	333	0	34	0	367	3	986	0	527	3	1,513
7-Sep	0	333	0	34	0	367	7	993	2	529	9	1,522
8-Sep	0	333	0	34	0	367	3	996	0	529	3	1,525
9-Sep	0	333	0	34	0	367	2	998	0	529	2	1,527
10-Sep	0	333	0	34	0	367	0	998	0	529	0	1,527
11-Sep	0	333	0	34	0	367	3	1,001	1	530	4	1,531
12-Sep	0	333	0	34	0	367	3	1,004	0	530	3	1,534
13-Sep	0	333	0	34	0	367	0	1,004	0	530	0	1,534
14-Sep	0	333	0	34	0	367	0	1,004	1	531	1	1,535
15-Sep	0	333	0	34	0	367	2	1,006	0	531	2	1,537

[a] Weir closed for upriver mark-recapture estimate.

[b] High water conditions resulted in incomplete data.



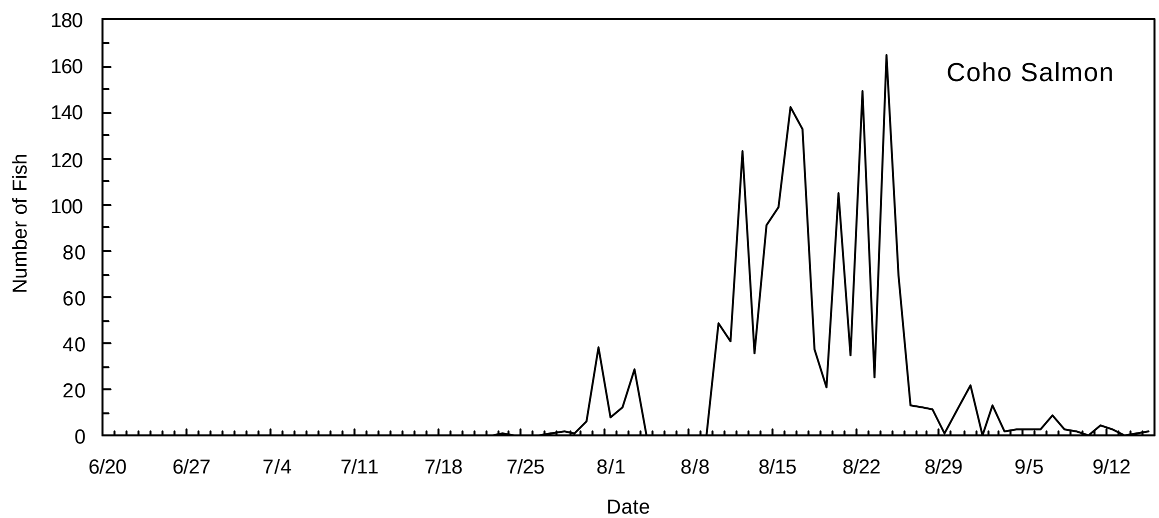


Figure 10.-Escapement, by date, of adult chinook and coho salmon through the Deep Creek weir, 1998.

Table 8.-Results of netting chinook salmon above the Deep Creek weir on 14–15 July, 1998.

Location	Caudal Punch[a]	AFC[b]	Unmarked	Total
Upper[c]	0	7	54	61
Lower[d]	3	6	51	60
Total	3	13	105	121

[a] Single upper caudal punch.

[b] Adipose finclipped.

Table 9.-Age composition of chinook salmon from Deep Creek, 1998.

	Age Class					
Statistic	1.1	1.2	1.3	1.4	1.5	Total
Weir						
20 June-3 July						
Number Sampled	8	82	48	38	0	176
Percent	5%	47%	27%	22%	0%	
4 July-14 Aug						
Number Sampled	0	52	44	37	1	134
Percent	0%	39%	33%	28%	1%	
20 June-14 Aug						
Number Sampled	8	134	92	75	1	310
Percent	3%	43%	30%	24%	0%	
SE Percent	1%	3%	3%	2%	0%	
Seine						
Number Sampled	7	19	24	44		94
Percent	7%	20%	26%	47%		
SE Percent	2.7%	4.2%	4.5%	5.2%		

Table 10.-Length (millimeters) of adult chinook salmon by age class at the Deep Creek weir, 1998.

Age	n	Minimum	Maximum	Mean	SE
0.2	3	567	663	627	30
0.3	3	744	783	761	11
1.1	8	302	518	396	25
1.2	133	491	722	606	4
1.3	91	541	937	763	8
1.4	76	740	960	856	5
1.5	1	901	901	901	

Estimating the AFC Marked Proportion and θ of the Chinook Salmon Escapement

We collected heads from 34 AFC adult chinook salmon at the weir, of which 28 had CWTs (Appendix B4). Two of these were marked as age-0.0 smolt at Deep Creek, and six were hatchery-reared and released as smolt in the Ninilchik River. Twenty fish had been marked as 1.0 smolt in Deep Creek. Six heads did not contain a tag. We also collected heads from 13 AFC chinook salmon in the netting (Appendix B5). One head did not contain a tag and one head was lost.

Since all of the Ninilchik hatchery stock was marked with a CWT, we estimated that six or 1.2% of the chinook salmon examined during the project were strays from the Ninilchik drainage (Table 11).

After subtracting the Ninilchik River chinook salmon from the weir sample, we examined the remaining chinook salmon with AFCs at Deep Creek. We tested the hypothesis that the proportion of marked fish age 1.2, 1.3, and 1.4 sampled at the weir did not change over time. We stratified the weir data into two intervals of roughly one-half the weir count and found that there was no difference in the marked proportion over time for any of the three age classes (Table 12). We also tested whether the proportion marked of each age class was different between fish examined at the weir and those examined in the netting. As with the temporal comparison at the weir, we found no differences. Therefore, we pooled all of the data to estimate the proportion of fish marked with an AFC in each age class (Table 13).

Our estimate of the marked proportion of age-1.4 chinook salmon from the 1993 brood year was 0.097 (SE = 0.025). Our estimate of the marked proportion of age-1.3 chinook salmon from the 1994 brood year was 0.095 (SE = 0.025). Our estimate of the marked proportion of age-1.2 chinook salmon from the 1995 brood year was 0.060 (SE = 0.018).

We compared the proportion of adults with an AFC fom the 1992 brood year that returned in 1996 (age 1.2), 1997 (age 1.3), and 1998 (age 1.4) and found no differences (χ^2 = 0.32 df = 2, P = 0.85) between the years (Table 14). We therefore combined the data for all years to estimate the AFC marked proportion for the cohort to date at 0.089 (SE = 0.008). Conversely, AFC chinook salmon adults from the 1993 brood year were recovered at different rates in 1997 and 1998 (χ^2 = 4.15, df = 1, P = 0.04). We combined the recoveries from the two years to develop a preliminary estimate of the AFC marked proportion for the cohort of 0.140 (SE = 0.023).

Table 11.-Number and proportion of chinook salmon of Ninilchik or Deep Creek origin that passed the Deep Creek weir in 1998, by age class.

	Stratum				
	Weir			Seine	
Statistic	6/20-7/ 3	7/4-8/14	6/20-8/14	7/14-7/15	Total
Inriver Adult Chinook Salmon Sample					
Proportion of Stratum Total of Aged Chinook Salmon Only					
Age 1.1	0.045	0.000	0.025	0.074	
Age 1.2	0.466	0.388	0.432	0.202	
Age 1.3	0.273	0.328	0.298	0.255	
Age 1.4	0.216	0.276	0.241	0.468	
Age 1.5	0.000	0.007	0.003	0.000	
Estimated Number of Chinook Salmon Counted Through the Weir					
Age 1.1	10	0	9	9	
Age 1.2	97	62	159	24	
Age 1.3	57	52	110	31	
Age 1.4	45	44	89	56	
Age 1.5	0	1	1	0	
All Ages	209	159	368	120	488
Estimated Number of Ninilchik River Chinook Salmon Adults in the Sample					
Age 1.1	0	0	0	0	
Age 1.2	0	3	3	0	
Age 1.3	0	3	3	0	
Age 1.4	0	0	0	0	
Age 1.5	0	0	0	0	
All Ages	0	6	6	0	6
Proportion	0.000	0.038	0.017	0.000	0.012
SE Proportion					0.005
Estimated Number of Deep Creek Chinook Salmon Adults Passed Through the Weir[a]					
1.1	10	0	10	9	
1.2	97	60	158	24	
1.3	57	49	106	31	
1.4	45	43	88	56	
1.5	0	1	1	0	
All Ages	209	153	362	120	

[a] Estimated number of chinook salmon in the sample minus the estimated number of Ninilchik River chinook salmon in the sample.

Table 12.-Comparison (chi-square) of the proportion of chinook salmon with adipose finclips by time strata at the weir, and by weir and netting samples, Deep Creek, 1998.

Comparison	Age-1.2 Chi sq.	df	P	Age-1.3 Chi sq.	df	P	Age-1.4 Chi sq.	df	P
Weir Between time Intervals	1.34	1	0.25	1.94	1	0.16	0.09	1	0.76
Weir and Netting	0.15	1	0.70	0.44	1	0.51	0.66	1	0.42

Table 13.-Adipose finclip (AFC) and coded wire tag (CWT) marked proportion by age class of chinook salmon captured in Deep Creek, 1998.

	Weir			Seine	
Statistic	6/20-7/ 3	7/4-8/14	6/20-8/14	7/14-7/15	Total
Age-1.2					
Total Examined (estimate)	97	60	158	24	182
Number with AFC	8	2	10	1	11
Proportion	0.082	0.033	0.063	0.041	0.060
SE Proportion	0.028	0.023	0.019	0.041	0.018
Number with CWT	8	1	9	1	10
Theta	0.082	0.017	0.057	0.041	0.055
SE Theta	0.028	0.017	0.019	0.041	0.017
Age-1.3					
Total Examined (estimate)	57	49	106	31	136
Number with AFC	7	2	9	4	13
Proportion	0.123	0.041	0.085	0.131	0.095
SE Proportion	0.044	0.029	0.027	0.062	0.025
Number with CWT	4	1	5	3	8
Theta	0.070	0.020	0.047	0.098	0.059
SE Theta	0.034	0.020	0.021	0.055	0.020
Age-1.4					
Total Examined (estimate)	45	43	88	56	144
Number with AFC	4	3	7	7	14
Proportion	0.089	0.070	0.080	0.125	0.097
SE Proportion	0.043	0.040	0.029	0.044	0.025
Number with CWT	4	3	7	6	13
Theta	0.089	0.070	0.080	0.107	0.090
SE Theta	0.043	0.040	0.029	0.042	0.024

Table 14.-Comparison of adipose finclipped (AFC) and coded wire tagged (CWT) marked proportion of Deep Creek chinook salmon from the 1992–1994 brood years examined in 1996–1998.

Brood	Number Examined for Marks				Number of Adipose Finclips				AFC Tests[a]			Marked/ Unmarked		Number of Coded Wire Tags				CWT Tests[b]			Theta	
Year	1996	1997	1998	Total	1996	1997	1998	Total	chi sq	P	df	Est.	SE	1996	1997	1998	Total	chi sq	P	df	Est.	SE
1992	167	1,097	144	1,408	13	98	14	125	0.32	0.85	2	0.089	0.008	12	89	13	114	0.30	0.86	2	0.081	0.007
1993		92	136	228		19	13	32	4.15	0.04	1	0.140	0.023		14	8	22	4.46	0.04	1	0.096	0.020
1994			182	182			11	11				0.060	0.018			10	10				0.055	0.017

[a] For brood year 1992, comparison of proportion with adipose finclips in 1996, 1997, and 1998 using a chi-square test.
For brood year 1993, comparison of proportion with adipose finclips in 1997 and 1998 using a chi-square test.

[b] For brood year 1992, comparison of proportion with coded wire tags in 1996, 1997, and 1998 using a chi-square test.
For brood year 1993, comparison of proportion with coded wire tags in 1997 and 1998 using a chi-square test.

We also compared proportions of chinook salmon possessing CWTs. There were no differences between gear types (all $P > 0.10$). For the 1992 brood year, we combined recoveries in three years (1996-1998, $\chi^2 = 0.30$, df = 2, p = 0.86) to calculate θ of 0.081 (SE = 0.007).

There was a difference (1997-1998, $\chi^2 = 4.46$, df =1, P = 0.04) in the proportion of CWT chinook salmon from the 1993 brood year returning as age-1.2 and –1.3 adults. We combined the recoveries from the two years to develop a preliminary estimate of θ for the cohort of 0.096 (SE = 0.020; Table 14). The estimated variance of θ^{-1} was 6.925.

Estimating Smolt Emigrations of Chinook Salmon for Previous Years

Based on our age-1.0 marked smolt total from the 1992 brood year (9,611 smolt marked in 1994), and θ from 1996 through 1998 (0.089), our estimate of the smolt emigration in 1994 was 107,486 (SE = 9,042; Table 15). The preliminary estimate of smolt from the 1993 brood year that migrated from the river in 1995 was 58,225 (SE = 9,225). The preliminary estimate of smolt from the 1994 brood year that migrated from the river in 1996 was 70,286 (SE = 18,820).

Coho Salmon Escapement

Coho salmon escapement through the weir was 1,537 fish in 1998 (Table 7). The migration began on 23 July and was essentially over by the end of August (Figure 10). Although the escapement increased significantly after the first freshet in August, subsequent high daily counts were not correlated to changes in water level (Figure 11).

CWTs were detected in 60 AFC coho salmon (Appendix B9). All sampled coho salmon adults with readable scales (n = 213) were age 2.1. Average length of coho salmon was 608 mm (SE = 3 mm) with a range of 440 to 712 mm (Figure 12).

Estimating the AFC Marked Proportion and q of the Coho Salmon Escapement

We poststratified the coho salmon escapement into two temporal strata with equal escapement covering 23 July through 15 September 1998. There was no significant difference ($\chi^2 = 2.76$, df = 2, P = 0.10) in the proportion of AFC-marked coho salmon observed among strata, indicating a representative sample of smolt were marked in 1997. We therefore pooled all of the AFC recovery data, 531 AFC from 1,537 fish, which resulted in an estimated marked proportion of 0.345 (SE = 0.012). The estimate of θ, which included measured long-term tag retention, was 0.313. The estimated variance of θ^{-1} was 0.360.

1997 Coho Salmon Smolt Estimate

Marking a representative sample of coho salmon smolt allowed us to estimate the smolt emigration in 1997. Based on the number of coho salmon smolt marked with an AFC (6,951), the number of adult coho salmon examined for an AFC (1,537), and the number of adult coho salmon observed with an AFC (531), the estimated smolt emigration was 20,097 (SE = 677; Table 16).

Coho Salmon Marine Survival

The sport harvest of coho salmon in Deep Creek totaled 2,399 (SE = 982) in 1998. The minimum marine survival of Deep Creek coho salmon from the 1997 smolt emigration was 20.4% (SE = 4.9%; Table 16). In contrast, the marine survival of the coho smolt emigrating from Deep Creek in 1996 was 8.4% (SE = 1.0%). Neither estimate included the marine recreational harvest in the total return.

Table 15.-Summary of Deep Creek chinook salmon production.

		Trap Smolt Catch			Smolt Emigration				
		Number	Marked/Unmarked						Relative
Brood Year	Smolt Year	Tagged	Proportion	SE	Estimate	Variance	SE	95% CI	Precision
1992	1994	9,611	0.089	0.008	107,486	81,750,369	9,042	17,722	16.5%
1993	1995	8,394	0.140	0.023	58,225	85,097,269	9,225	18,081	31.1%
1994	1996	4,608	0.060	0.018	70,286	354,178,804	18,820	36,886	52.5%
1995	1997	4,970	not yet available						

DISCUSSION

KENAI RIVER

In the second year of tagging at rkm 34 of the mainstem Kenai River, the number of fish emigrating with CWTs was half that of the previous year. We think that the decrease in the numbers of fish tagged was in part due to high flow conditions which forced us to move the traps shoreward during the period when much of our captures occurred the previous year. Previous studies (King et al. 1996) found that catches of smolt of all species were highest in the cross-sectional area of the river with the fastest surface current. We also lost fishing time or experienced decreased fishing power due to high debris load prevalent throughout June and July that forced us to reduce the depth at which the traps were fished. Despite these problems, the number of smolt tagged was greater than in years before 1997 when the traps were fished in the lower river.

We initially experienced relatively high fish mortality because we operated traps in the highest current at the site. Handling during the marking process increased the mortality of the fish removed from the traps that were alive after capture. We lowered the mortality rate by checking the live boxes more frequently to reduce the time between capture and marking, and reducing the number of times each fish was handled.

Flooding in the Killey River this year also reduced catches relative to 1997. Our catch of chinook salmon smolt prior to 1 July was higher than the previous year. However, we lost nearly 2 weeks of operation this year during which 25% of our catch occurred the previous year. Continuous high water throughout June also precluded use of the diversion fence employed the previous year. However, when operable, the rotary smolt trap worked well. Handling mortality was low and the tag retention rate was nearly 100%.

Our total catch from both sites did not meet sample sizes thought necessary to estimate the contribution of Kenai River chinook salmon to the Deep Creek marine recreational fishery with the desired precision. With the 1998 CWT marking data incorporated into the planning assumptions for the recovery programs, we predict we will recover two tags in the marine recreational harvest and 17 in the inriver AWL and creel programs from the 1998 cohort.

We are uncertain whether operating in both locations resulted in proportional marking of early and late-run chinook salmon smolt. Burger (1984) found that early-run spawners were

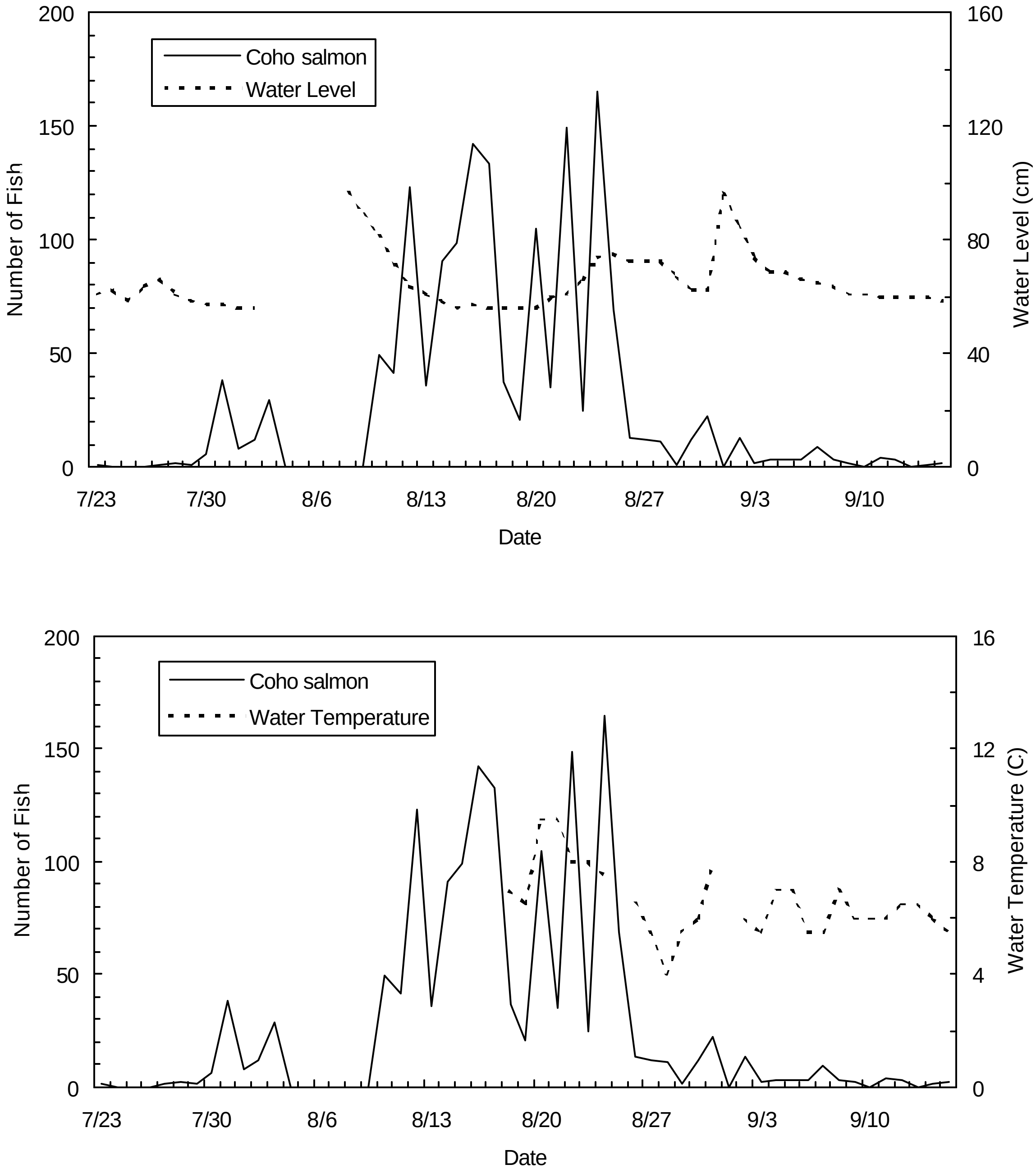


Figure 11.-Coho salmon escapement, daily water level, and water temperature at the Deep Creek weir, 1998.

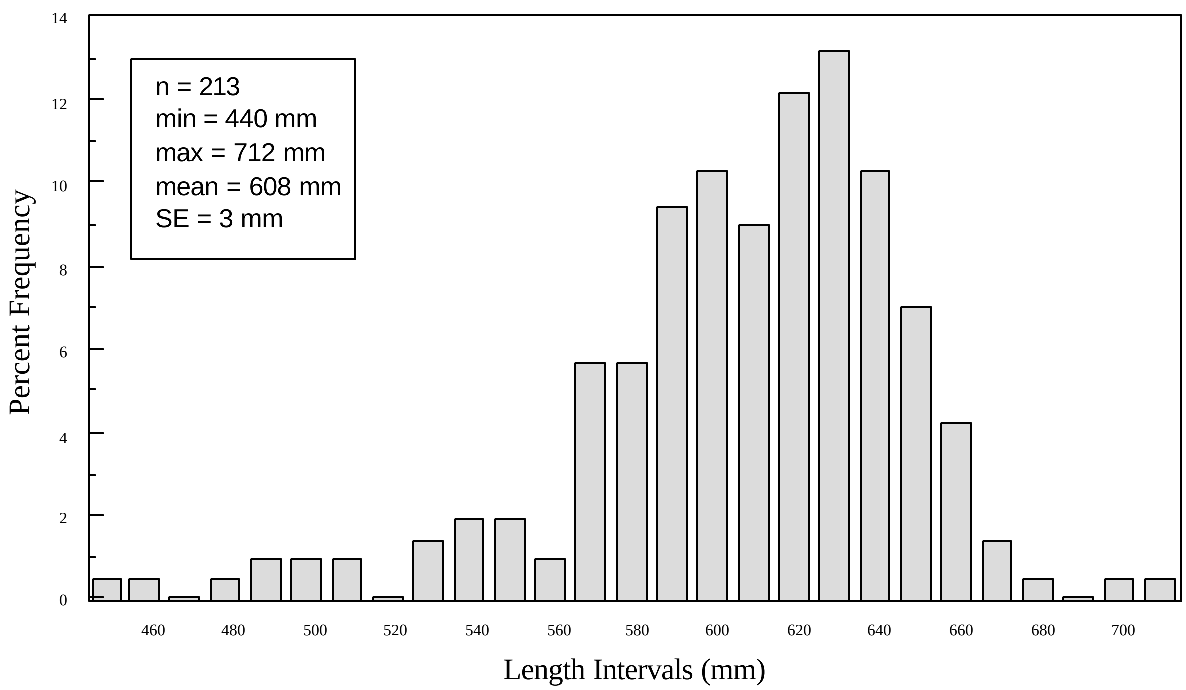


Figure 12.-Length frequency distribution of coho salmon in Deep Creek, 1998.

predominantly bound for tributary streams, primarily the Killey River. Litchfield and Flagg (1986) captured a few smolt in the Killey River that were tagged as age 0.0 in the mainstem in the previous year. We found that the timing of the Killey River smolt emigration was earlier than that of other Kenai stocks, and that smolt captured in the mainstem were larger than those in the tributary. Proportional marking would improve our ability to estimate the total (combined early and late run) smolt emigration.

By recapturing CWT fish in future years, we can estimate the contribution of Killey River chinook salmon to the early-run fishery and escapement, and determine if chinook salmon emigrating as smolt from the Killey River are recaptured only in the early run. We will also be able to estimate the contribution of Killey and Kenai River chinook salmon to marine fisheries, and provide estimates of smolt production.

Technicians inspecting adults inriver to estimate AFC marked proportion and θ for previously marked cohorts examined approximately 6% less adult chinook salmon than the previous year. The fraction of the total escapement sampled was very low (0.029), due partly to restrictions to the fishery that reduced the harvest component. The fraction of the adult return examined inriver, and subsequent estimates of contribution of Kenai River chinook salmon to the marine fisheries, is in part a function of available manpower to examine fish inriver. We think that the precision of future estimates will only change significantly with a considerable increase in the number of fish examined.

In 1998, we recovered 28 AFC fish, all of Kenai River origin. We previously estimated that we tagged enough fry with CWTs in 1993 to account for approximately 6% of the age-1. smolt in the drainage in 1994 (King and Breakfield 1998). If our assumptions regarding the marking rate

Table 16.-Summary of Deep Creek coho salmon production.

Statistic	Brood Year 1992 Smolt Year 1995	Brood Year 1993 Smolt Year 1996	Brood Year 1994 Smolt Year 1997
Trap Smolt Catch			
Number Tagged	9,671	4,868	6,951
Marked/Unmarked Proportion	0.278	0.125	0.345
Proportion SE	0.031	0.007	0.012
Theta	0.278	0.125	0.313
Theta SE	0.031	0.007	0.012
Smolt Emigration			
Estimate	34,351	38,683	20,097
Variance	14,283,720	4,862,097	457,771
SE	3,779	2,205	677
Harvest			
Marine Commercial			
Estimate	21	0	164
SE	20	0	47
Inriver Sport			
Estimate	1,333	1,239	2,399
SE	350	334	982
Escapement			
Estimate	205	2,017	1,537
SE	0	0	0
Total Return[a]			
Estimate	1,559	3,256	4,100
SE	351	334	983
Marine Survival			
Estimate	0.045	0.084	0.204
SE	0.011	0.010	0.049

[a] Total return does not include the marine recreational harvest.

were accurate, then we should have seen 50 age-1.4 adults with Kenai River tags in the 1998 netting and creel programs. We actually recovered 12. This is the third consecutive year that we were well below the expected number of tag recoveries from the 1992 brood year. We predicted that we would recover 73 AFC fish in the 3 years of returns from the cohort, and to date we have recovered 12. We hypothesized that the lack of recoveries may have resulted from an error in the estimate of fry in the drainage at the time of tagging, an error in the assumed age-0.0 fry to age-1.0 smolt survival rate, differential survival of tagged and non-tagged fish, or lower marine survival.

The late-run total return to date for the 1992 brood year cohort (not including the age-1.5 fish which will return in 1999) is 46,161 (SE = 1,978; Hammarstrom and Timmons 2001). Our estimate of the marked proportion for the late-run portion of the cohort is 0.022, which translates to a preliminary smolt estimate of 3 to 4 million (late run only) and a marine survival of 1% to 2%. A final estimate of 1992 brood year smolt production will be available after the return of age-1.5 chinook salmon in 1999. We did learn that the marks put out in 1993 were placed primarily in late-run fish. Consequently, too few tags were recovered in the early run to provide a reliable estimate of the marked proportion.

We estimated we marked enough 1993 brood year fingerlings in 1994 to account for 4% of the age-1. smolt in the drainage in 1995. This should have resulted in the recovery of 11 tagged fish from the Kenai River in 1998. Our actual recovery total was 12.

Since 11 of the 12 were recovered in the late-run, we were able to estimate the AFC marked proportion in that stratum, and provide a preliminary smolt estimate of approximately one-half million (late-run chinook salmon only). Final smolt and marine survival estimates will be made after the age-1.4 and -1.5 fish return in 1999 and 2000. We also calculated a preliminary estimate of θ; however, it does not include age-1.4 chinook salmon returning in 1999 which typically accounts for the majority of the return.

As in the previous year of marking, marks put out in 1994 were placed primarily in late-run fish. Therefore, too few tags were recovered in the early run to provide a reliable estimate of the marked proportion.

We also experienced tag retention rates on chinook salmon marked as age-0.0 fingerlings of 77% or less for the 3 brood year returns that we have examined to date. Results of short term (24 h) testing of retention rates, which were greater than 97% in all years of marking, were not representative of the final retention rate.

No Kenai River chinook salmon tagged with CWTs were recovered in the Deep Creek marine recreational fishery.

Our documentation of Crooked Creek fish in Slikok Creek at the time of the stream survey is cause for concern and prompted the department to examine the Crooked Creek stocking policy and assess the level of straying in other early-run stocks.

DEEP CREEK

Chinook Salmon

Juvenile chinook salmon in Alaska typically rear in fresh water for at least 1 year before migrating to sea as “stream-type” smolt. Large downstream movements of age-0.0 fry are typical of most chinook salmon populations, but age-0.0 smolt are not common. In Alaska, they have been reported in the Situk River (Johnson et al. 1992) and other Yakutat area rivers (S. McPherson, ADF&G, Juneau, personal communication). Outside of Alaska, age-0.0 smolt are also found in many coastal and inland streams (Roper and Scarnecchia 1999). In large systems, such as the Columbia River, stream and ocean type salmon occupying the same tributary are often spatially or temporally isolated, and associated with distinct seasonal adult spawning times or areas and ocean migration patterns (Taylor 1990; Healy 1991).

The evidence collected prior to 1998 suggested that age-1.0 smolt leave Deep Creek during June and July, and age-0.0 smolt leave beginning in late July, upon reaching approximately 70 mm in fork length (Bendock 1995, 1996). Return timing and age structure of adults in Deep Creek reflect the presence of a single chinook salmon stock and the near absence of tagged age-0.0 adult returns. To date, the returns of tagged fish from the 1993 and 1994 brood years have included only one age-0. adult. However, this year we found two age-0.2 adults at the weir. We will not know the significance of these returns until the remaining adults return over the next 3 years. However, until further evidence suggests otherwise, we believe that the age-0.0 chinook salmon smolt are primarily excess production with a marine survival rate that is a fraction of that of the age-1.0 smolt.

We assumed, based on 1997 run timing, that a small portion of the adult chinook salmon escapement would pass the weir site in early May. Had we been successful in installing the weir in mid-May, we thought we could monitor most of the escapement, and determine if the 1997 run timing was typical. If the 1997 run timing proved typical, we still thought we could mark adequate numbers of fish to conduct a capture-recapture estimate. Neither assumption proved true. Consequently, we do not have a complete chinook salmon escapement estimate for this year. For the second straight year, we were unable to install the weir prior to significant escapement because of spring flow conditions.

The adult sampling identified straying of Ninilchik River chinook salmon into Deep Creek for the third year. We estimated that approximately 1.2% of the fish passing the weir after 20 June were of Ninilchik River origin. In 1996, 14% of the fish, and in 1997 approximately 3%, of the fish examined were originally stocked in the Ninilchik River. The decline in the straying rate from previous years is due in part to a reduction in the stocking rate from approximately 200,000 to 50,000 in the cohorts now returning.

The proportion of Deep Creek chinook salmon with an AFC for the 1992 brood year was the same for the 3 years of recoveries. When combined, our estimate of the total marked proportion provided a reasonably precise estimate of the age-1.0 smolt migrating from the drainage. The same was true for our estimate of θ.

In contrast, the marking rate of smolt from the 1993 brood year changed significantly between the age-1.2 and -1.3 returns. We chose to pool the data for the two returns of the 1993 brood year fish to estimate the AFC marked proportion and θ. However, the estimates are preliminary given there are additional age classes of the cohorts returning in future years.

Our preliminary estimates of the smolt emigration from the 1993 and 1994 brood years represent a reduction in smolt production from the 1992 brood year. However, the range of production exhibited by the 3 years is consistent with our idea of what the system is capable of producing. If we assume a 2% to 3% survival rate, these numbers of smolt would produce approximately 2,500 to 3,500 adults. Our data indicate that the sport harvest averages approximately 1,400 fish, producing an escapement in the range of 1,000 to 2,000 fish.

Coho Salmon

The weir was successful for monitoring the coho salmon escapement during the second year of the project. We were able to keep the weir operational during a variety of discharge levels, reach predetermined AWL sample sizes, and collect sufficient data to estimate the AFC marked proportion and θ.

Our estimate of the smolt migration from the 1994 brood year was approximately one-half that of the 1993 brood year. However, the increase in marine survival of the 1994 cohort resulted in a total return higher than the previous year.

Our estimate of marine survival (20.4%) does not include harvest from the marine recreational fishery. However, the marine survival estimates are probably reasonable given the total recreational fishery (all contributing stocks) harvest averages around 3,000 fish, and as with chinook salmon, we think that Deep Creek contributes a fraction to the total.

In 1998, marine survival of hatchery stocks ranged from 6.7% to 10.8%, with an average of 8.9% (Cyr et al. 2001). In contrast to 1997, the survival of hatchery-reared coho salmon was less than half that of the Deep Creek wild stock in 1998.

We now have in place a project that successfully tagged adequate numbers of smolt to estimate the total smolt emigration. The statewide harvest survey currently provides an estimate of the inriver sport harvest, and we obtained an escapement estimate for the first time in 1997. An estimate of the marine recreational harvest will provide the basic complement of data to make a complete estimate of the marine survival of a wild coho salmon stock in Cook Inlet.

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LITERATURE CITED

Bendock, T. N. 1995. Marking juvenile chinook salmon in the Kenai River and Deep Creek, Alaska, 1993-1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-17, Anchorage.

Bendock, T. N. 1996. Marking juvenile chinook salmon in the Kenai River and Deep Creek, Alaska, 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-33, Anchorage.

Bernard, D. R. and J. E. Clark. 1996. Estimating salmon harvest with coded-wire tags. Canadian Journal of Aquatic Sciences 53:2323-2332.

Burger, C.V., R. L. Wilmot, and D. B. Wangaard. 1984. Comparison of spawning areas and times for two runs of Chinook salmon (Oncorhynchus tshawytscha) in the Kenai River, Alaska. Canadian Journal of Fisheries and Aquatic Science. 42(4):693-700

Carlon, J. A. 2000. Assessment of coho salmon from the Kenai River, Alaska, 1997. Alaska Department of Fish and Game, Fishery Data Series No. 00-15, Anchorage.

Cochran, W. G. 1977. Sampling techniques, third edition. John Wiley and Sons, Inc,. New York.

Cyr, P. A., B. L. Stratton and J. J. Hasbrouck. 2001. Estimates of commercial and sport harvest and escapement of coho salmon stocked into Northern Cook Inlet streams, 1998. Alaska Department of Fish and Game, Fishery Data Series 01-6, Anchorage.

Hammarstrom, S. L., and L. S. Timmons. 2001. Stock assessment of late-run chinook salmon of the Kenai River, 1997 and 1998. Alaska Department of Fish and Game, Fishery Data Series No. 01-5, Anchorage.

Healey, M. C. 1991. Life history of chinook salmon. Pages 311-393 in C. Groot and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver.

LITERATURE CITED (Continued)

Howe, Allen L., Gary Fidler, Allen E. Bingham, and Michael J. Mills. 1996. Harvest, catch, and participation in Alaska sport fisheries during 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-32, Anchorage.

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001a. Revised Edition: Harvest, catch, and participation in Alaska sport fisheries during 1997. Alaska Department of Fish and Game, Fishery Data Series No. 98-25 (revised), Anchorage.

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001b. Revised Edition: Participation, catch, and harvest in Alaska sport fisheries during 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-41 (revised), Anchorage

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001c. Revised Edition: Participation, catch, and harvest in Alaska sport fisheries during 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-41 (revised), Anchorage

Johnson, S. W., J. F. Thedinga, and K V. Koski. 1992. Life history of juvenile ocean-type chinook salmon (Oncorhynchus tshawytscha) in the Situk River, Alaska. Canadian Journal of Fisheries and Aquatic Science. 49: 2621-2629.

King, B. E., L. K. Brannian, and K. E. Tarbox. 1996. Kenai River sockeye salmon smolt studies, 1994. Alaska Department of Fish and Game Division of Commercial Fisheries, Regional Information Report No. 2A96-36, Anchorage.

King, B. E., and J. A. Breakfield. 1998. Coded wire tagging studies in the Kenai River and Deep Creek, Alaska, 1996. Alaska Department of Fish and Game, Fishery Data Series No. 98-9, Anchorage.

King, B. E., and J. A. Breakfield. 1999. Coded wire tagging studies in the Kenai River and Deep Creek, Alaska, 1997. Alaska Department of Fish and Game, Fishery Data Series No 99-11, Anchorage.

Litchfield, D. S. and L. Flagg. 1986. Kenai River juvenile chinook salmon, Oncorhynchus tshawytscha, studies summary report 1983-1986. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development. Federal Aid in Sport Fish Restoration Study F-17-R-1 Volume 1, No. 2. Juneau.

Marsh, L. E. 2000. Angler effort and harvest of chinook salmon by the recreational fisheries in the lower Kenai River, 1998. Alaska Department of Fish and Game, Fishery Data Series No. 00-21, Anchorage.

McKinley, T. R. 1999. Contributions of coded wire tagged chinook salmon to the Central Cook Inlet marine recreational fishery, 1996. Alaska Department of Fish and Game, Fishery Data Series No. 99-2, Anchorage.

Mills, M. J. 1988. Alaska statewide sport fisheries harvest report. Alaska Department of Fish and Game, Fishery Data Series No. 52, Juneau.

Moberly, S. A., R. Miller, K. Crandall, and S. Bates. 1977. Mark-tag manual for salmon. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development, Juneau.

Mosher, K. H. 1969. Identification of pacific salmon and steelhead trout by scale characteristics. U.S. Fish and Wildlife Service, Circular 317.

Roper, B. B. and D. L. Scarnecchia. 1999. Emigration of age-0 chinook salmon (Oncorhynchus tshawytscha) smolts from the upper South Umpqua River basin, Oregon, U.S.A. Canadian Journal of Fisheries and Aquatic Science 56: 939-946.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters. Second edition. Macmillan Publishing Co., New York.

Taylor, E. B. 1990. Environmental correlates of life-history variation in juvenile chinook salmon Oncorhynchus tshawytscha (Walbaum). Journal of Fish Biology 37:1-17.

LITERATURE CITED (Continued)

Todd, G. L. 1994. A lightweight inclined-plane trap for sampling salmon smolts in rivers. Alaska Fishery Research Bulletin (2): 179-186.

Welander, A. D. 1940. A study of the development of the scale of the chinook salmon (*Oncorhynchus tshawytscha*). M.S. thesis, University of Washington, Seattle.

APPENDIX A. HISTORICAL TAGGING SUMMARY

Appendix A1.-Dates, coded wire tag codes, and numbers of wild salmon tagged and released in the Kenai and Killey rivers, and Deep Creek from 1993 through 1998.

Year	Species	Location	rkm	Dates	Code	Brood Year	Age	Number Tagged
1993	Chinook	Kenai River	71	7/28 - 8/04	31-22-23	1992	0	4,373
1993	Chinook	Kenai River	71	8/05 - 8/12	31-22-60	1992	0	11,411
1993	Chinook	Kenai River	71	8/16 - 8/24	31-22-61	1992	0	12,830
1993	Chinook	Kenai River	71	8/25 - 8/31	31-22-62	1992	0	10,521
1993	Chinook	Kenai River	71	9/01 - 9/13	31-22-63	1992	0	13,567
1993	Chinook	Kenai River	24	7/21 - 7/28	31-22-30	1992	0	5,845
1993	Chinook	Kenai River	24	7/28 - 8/03	31-22-31	1992	0	5,788
1993	Chinook	Kenai River	24	8/03 - 8/09	31-22-44	1992	0	12,087
1993	Chinook	Kenai River	24	8/09 - 8/17	31-22-45	1992	0	11,888
1993	Chinook	Kenai River	24	8/17 - 8/24	31-22-46	1992	0	11,639
1993	Chinook	Kenai River	24	8/24 - 8/30	31-22-47	1992	0	11,721
1993	Chinook	Kenai River	24	8/31 - 9/07	31-22-56	1992	0	11,843
1993	Chinook	Kenai River	24	9/07 - 9/10	31-22-57	1992	0	11,611
1993	Chinook	Kenai River	24	9/10 - 9/14	31-22-58	1992	0	12,048
1993	Chinook	Kenai River	24	9/14 - 9/15	31-22-59	1992	0	5,225
1994	Chinook	Kenai River	24	7/18 - 7/27	31-22-18	1993	0	5,885
1994	Chinook	Kenai River	24	7/27 - 8/01	31-22-36	1993	0	5,980
1994	Chinook	Kenai River	24	8/01 - 8/04	31-22-38	1993	0	6,158
1994	Chinook	Kenai River	24	8/04 - 8/08	31-22-39	1993	0	6,222
1994	Chinook	Kenai River	24	8/08 - 8/09	31-22-37	1993	0	6,258
1994	Chinook	Kenai River	24	8/09 - 8/12	31-22-50	1993	0	11,581
1994	Chinook	Kenai River	24	8/12 - 8/18	31-22-49	1993	0	11,512
1994	Chinook	Kenai River	24	8/18 - 8/24	31-22-48	1993	0	11,695
1994	Chinook	Kenai River	24	8/24 - 9/02	31-22-51	1993	0	11,373
1994	Chinook	Kenai River	24	9/02 - 9/14	31-24-09	1993	0	11,445
1995	Chinook	Kenai River	24	6/22 - 7/19	13-01-03-08-03	1993	1	1,479
1995	Chinook	Kenai River	24	7/25 - 8/03	13-01-03-08-04	1994	0	14,030
1995	Chinook	Kenai River	24	8/03 - 8/14	13-01-03-08-05	1994	0	13,724
1995	Chinook	Kenai River	24	8/14 - 8/22	13-01-03-08-06	1994	0	13,745
1995	Chinook	Kenai River	24	8/22 - 8/30	13-01-03-08-07	1994	0	13,752
1995	Chinook	Kenai River	24	8/30 - 8/31	13-01-03-08-08	1994	0	2,011
1996	Chinook	Kenai River	1.6	6/14 - 8/20	31-25-45	1994	1	6,152
1996	Chinook	Kenai River	1.6	8/21 - 9/03	31-25-46	1994	1	386
1997	Chinook	Kenai River	34	6/09 - 6/29	31-25-51	1995	1	6,024
1997	Chinook	Kenai River	34	6/29 - 7/26	31-25-50	1995	1	5,657
1997	Chinook	Kenai River	34	7/27 - 8/05	31-25-48	1995	1	6,251

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Year	Species	Location	rkm	Dates	Code	Brood Year	Age	Number Tagged
1997	Chinook	Kenai River	34	8/06 - 8/18	31-27-07	1995	1	1,523
1998	Chinook	Kenai River	34	5/17 - 7/03	31-27-13	1996	1	8,251
1998	Chinook	Kenai River	34	7/02 - 8/04	31-27-15	1996	1	2,146
1997	Chinook	Killey River	0.8	5/17 - 6/08	31-25-47	1995	1	5,825
1997	Chinook	Killey River	0.8	6/08 - 6/30	31-25-54	1995	1	6,462
1997	Chinook	Killey River	1.6	7/01 - 7/24	13-01-03-09-01	1995	1	463
1998	Chinook	Killey River	0.8	5/08 - 6/23	31-27-12	1996	1	5,589
1998	Chinook	Killey River	0.8	6/23 - 7/05	31-27-14	1996	1	612
1994	Chinook	Deep Cr	1.1	5/20 - 6/28	31-22-16	1992	1	2,430
1994	Chinook	Deep Cr	1.1	6/28 - 7/04	31-23-60	1992	1	2,684
1994	Chinook	Deep Cr	1.1	7/04 - 7/10	31-23-61	1992	1	2,678
1994	Chinook	Deep Cr	1.1	7/10 - 8/03	31-23-62	1992	1	1,819
1994	Chinook	Deep Cr	1.1	7/21 - 7/29	31-23-63	1993	0	2,837
1994	Chinook	Deep Cr	1.1	7/29 - 8/03	31-24-01	1993	0	807
1995	Chinook	Deep Cr	0.8	5/17 - 6/25	31-24-02	1993	1	2,183
1995	Chinook	Deep Cr	0.8	6/25 - 7/21	31-22-35	1993	1	5,719
1995	Chinook	Deep Cr	0.8	7/21 - 8/02	13-01-03-08-15	1993	1	492
1995	Chinook	Deep Cr	0.8	7/14 - 8/12	13-01-03-08-09	1994	0	5,174
1995	Coho	Deep Cr	0.8	5/18 - 6/17	31-22-33	1992	2	5,760
1995	Coho	Deep Cr	0.8	6/17 - 7/20	31-22-34	1992	2	3,911
1996	Chinook	Deep Cr	0.8	5/21 - 8/13	13-01-03-08-11	1994	1	4,608
1996	Chinook	Deep Cr	0.8	6/27 - 8/13	13-01-03-08-12	1995	0	4,359
1996	Coho	Deep Cr	0.8	5/21 - 8/13	13-01-03-08-10	1993	2	4,868
1997	Chinook	Deep Cr	0.8	5/13 - 7/29	31-25-53	1995	1	4,970
1997	Chinook	Deep Cr	0.8	6/28 - 7/29	31-25-52	1996	0	2,484
1997	Coho	Deep Cr	0.8	5/13 - 7/29	31-25-49	1994	2	6,951

APPENDIX B. INRIVER CODED WIRE TAG RECOVERIES, 1997

Appendix B1.-Coded wire tagged adult chinook salmon recovered in the Slikok Creek stream survey, 1998.

Date	Sex	Ocean Age	Length (mm)	Tag Code	Release Location	Brood Year	Age at Tagging
7-Aug	M	2	656	312512	Crooked Creek	1995	0
7-Aug	M	2	635	312512	Crooked Creek	1995	0
7-Aug	M	3	671	312427	Crooked Creek	1994	0
7-Aug	F	4	790	312314	Crooked Creek	1993	0

Appendix B2.-Coded wire tagged adult chinook salmon recovered in Kenai River gillnet sampling, 1998.

Date	Sex	Ocean Age	Length (mm)	Tag Code	Release Location	Brood Year	Age at Tagging
Early Run							
8-Jun	M	3	825	312251	Kenai River	1993	0
8-Jun	F	4	1,070	No Tag			
19-Jun	M	4	890	312263	Kenai River	1992	0
Total Recoveries 3							
Late Run							
6-Jul	M	3	1,035	312238	Kenai River	1993	0
10-Jul	M	3	760	No Tag			
14-Jul	M	4	1,065	No Tag			
14-Jul	M	2	635	1301030805	Kenai River	1994	0
15-Jul	M	4	1,200	312245	Kenai River	1992	0
16-Jul	F	3	1,005	312218	Kenai River	1993	0
16-Jul	F	3	940	312249	Kenai River	1993	0
18-Jul	F	3	900	312236	Kenai River	1993	0
18-Jul	F	4	940	312231	Kenai River	1992	0
20-Jul	M	2	635	No Tag			
24-Jul	M	R[a]	705	No Tag			
30-Jul	M	4	1,110	No Tag			
2-Aug	M	4	1,125	312263	Kenai River	1992	0
3-Aug	M	2	680	1301030804	Kenai River	1994	0
3-Aug	F	4	1,015	No Tag			
8-Aug	M	4	1,130	No Tag			
9-Aug	F	4	950	312244	Kenai River	1992	0
Total Recoveries 17							

[a] Scale regenerated.

Appendix B3.-Coded wire tagged adult chinook salmon recovered in the Kenai River creel survey, 1998.

Date	Sex	Ocean Age	Length (mm)	Tag Code	Release Location	Brood Year	Age at Tagging
Early Run							
30-May	F			No Tag			
Late Run							
7-Jul	F	3	740	No Tag			
10-Jul		3		312250	Kenai River	1993	0
10-Jul				Head lost[a]			
10-Jul				Head lost[a]			
16-Jul				No Tag			
22-Jul		3		312250	Kenai River	1993	0
22-Jul		3		312248	Kenai River	1993	0
22-Jul	F	3	930	312409	Kenai River	1993	0
22-Jul				Head lost[a]			
25-Jul	M	4	1,040	Head lost[a]			
25-Jul	F	3	970	312218	Kenai River	1993	0
26-Jul	F	4	930	Head lost[a]			

Appendix B4.-Coded wire tagged adult chinook salmon recovered at the Deep Creek weir, 1998.

Date	Sex	Ocean Age	Length (mm)	Tag Code	Release Location	Brood Year	Age at Tagging
23-Jun	F	3	726	no tag			
23-Jun	M	2	596	1301030811	Deep Creek	1994	1
23-Jun	M	2	597	1301030811	Deep Creek	1994	1
23-Jun	M	2	507	1301030811	Deep Creek	1994	1
23-Jun	F	4	875	312362	Deep Creek	1992	1
23-Jun	F	4	873	312362	Deep Creek	1992	1
24-Jun	M	2	621	1301030811	Deep Creek	1994	1
25-Jun	M	2	644	1301030811	Deep Creek	1994	1
25-Jun	F	3	820	No tag			
26-Jun	F	3	800	No tag			
28-Jun	M	4	856	312216	Deep Creek	1992	1
29-Jun	F	3	792	312235	Deep Creek	1993	1
30-Jun	F	4	882	312360	Deep Creek	1992	1
30-Jun	M	2	639	1301030811	Deep Creek	1994	1
1-Jul	M	2	635	1301030811	Deep Creek	1994	1
1-Jul	M	3	754	No tag			
3-Jul	M	3	740	312235	Deep Creek	1993	1
3-Jul	M	2	617	1301030811	Deep Creek	1994	1
3-Jul	M	3	778	312235	Deep Creek	1993	1
4-Jul	F	4	833	312362	Deep Creek	1992	1
4-Jul	F	4	882	312216	Deep Creek	1992	1
7-Jul	F	3	757	312435	Ninilchik	1994	0
8-Jul	M	3	619	No tag			
9-Jul	M	3	793	312402	Deep Creek	1993	1
18-Jul	M	2	663	312515	Ninilchik	1995	0
19-Jul	M	2	608	1301030811	Deep Creek	1994	1
21-Jul	M	3	744	312435	Ninilchik	1994	0
24-Jul	M	3	783	312435	Ninilchik	1994	0
27-Jul	F	4	837	312362	Deep Creek	1992	1
27-Jul	M	2	500	1301030812	Deep Creek	1995	0
28-Jul	M	2	567	312515	Ninilchik	1995	0
30-Jul	M	2	651	312515	Ninilchik	1995	0
31-Jul	M	2	633	No tag			
1-Aug	M	2	550	1301030812	Deep Creek	1995	0

Appendix B5.-Coded wire tagged adult chinook salmon recovered in Deep Creek above the weir during seining, 1998.

Date	Sex	Ocean Age	Length (mm)	Tag Code	Release Location	Brood Year	Age at Tagging
14-Jul	M	4	869	312362	Deep Creek	1992	1
14-Jul	M	3	764	1301030815	Deep Creek	1993	1
14-Jul	F	3	739	No tag			
14-Jul	M	4		Head lost			
14-Jul	M	3	737	312402	Deep Creek	1993	1
14-Jul	M	4	910	312216	Deep Creek	1992	1
14-Jul	M	4	840	312362	Deep Creek	1992	1
14-Jul	M	4	843	312216	Deep Creek	1992	1
14-Jul	M	4	823	312216	Deep Creek	1992	1
15-Jul	M	4	854	No tag			
15-Jul	M	2	624	1301030811	Deep Creek	1994	1
15-Jul	M	4	845	312361	Deep Creek	1992	1
15-Jul	M	3	725	312402	Deep Creek	1993	1

Appendix B6.-Coded wire tagged adult chinook salmon recovered in the Cook Inlet setnet fishery, 1998.

Date	Sex[a]	Ocean Age	Length (mm)	Tag Code	Release Location	Brood Year	Age at Tagging
06-Jul		4	1,060	312262	Kenai River	1992	0
06-Jul		2	620	312545	Kenai River	1994	1
10-Jul		2	730	312545	Kenai River	1994	1
10-Jul		4	985	312262	Kenai River	1992	0
10-Jul		3	890	312239	Kenai River	1993	0
13-Jul		3	800	312249	Kenai River	1993	0
15-Jul		3	920	312250	Kenai River	1993	0
15-Jul		4	1,035	312246	Kenai River	1992	0
02-Aug		3	1,060	312218	Kenai River	1993	0
02-Aug		3	930	312218	Kenai River	1993	0
05-Aug		4	1,110	312223	Kenai River	1992	0

[a] Sex was not determined for fish sampled in the commercial fishery.

Appendix B7.-Coded wire tagged adult chinook salmon recovered in the Cook Inlet sport fishery, 1998.

Date	Sex	Ocean Age	Length (mm)	Tag Code	Release Location	Brood Year	Age at Tagging
11-May	M	4	880	312216	Deep Creek	1992	1
21-May	F	3	810	312235	Deep Creek	1993	1
22-May	M	4	885	312362	Deep Creek	1992	1
22-May	F	4	930	312216	Deep Creek	1992	1
23-May	M	4	840	312360	Deep Creek	1992	1
24-May	F	4	900	312216	Deep Creek	1992	1
25-May	M	3	830	312235	Deep Creek	1993	1
26-May		3	730	312235	Deep Creek	1993	1
26-May	M	3	760	312402	Deep Creek	1993	1
4-Jun	F	4	840	312362	Deep Creek	1992	1
12-Jul	M	4	1,075	312245	Kenai River	1992	0

Appendix B8.-Coded wire tagged adult chinook salmon recovered in Kodiak commercial fisheries, 1998.

Date	Sex[a]	Ocean Age	Length (mm)[a]	Tag Code	Release Location	Brood Year	Age at Tagging
08-Jul		3		312248	Kenai River	1993	0
08-Jul		4		312259	Kenai River	1992	0

[a] Sex and length not recorded.

Appendix B9.-Coded wire tagged adult coho salmon sampled at the Deep Creek weir, 1998.

Date	Sex	Ocean Age	Length (mm)	Tag Code[a]	Release Location	Brood Year	Age at Tagging
31-Jul	M	1	644	Wand	Deep Creek	1994	2
31-Jul	F	1	612	Wand	Deep Creek	1994	2
31-Jul	F	1	553	Wand	Deep Creek	1994	2
2-Aug	M	1	538	Wand	Deep Creek	1994	2
3-Aug	F	1	611	Wand	Deep Creek	1994	2
10-Aug	M	1	628	Wand	Deep Creek	1994	2
11-Aug	M	1	535	Wand	Deep Creek	1994	2
12-Aug	F	1	566	Wand	Deep Creek	1994	2
12-Aug	M	1	601	Wand	Deep Creek	1994	2
12-Aug	F	1	633	Wand	Deep Creek	1994	2
12-Aug	M	1	572	Wand	Deep Creek	1994	2
12-Aug	M	1	590	Wand	Deep Creek	1994	2
12-Aug	F	1	561	Wand	Deep Creek	1994	2
12-Aug	M	1	586	Wand	Deep Creek	1994	2
14-Aug	F	1	584	Wand	Deep Creek	1994	2
14-Aug	M	1	600	Wand	Deep Creek	1994	2
14-Aug	M	1	538	Wand	Deep Creek	1994	2
14-Aug	F	1	645	Wand	Deep Creek	1994	2
15-Aug	M	1	644	Wand	Deep Creek	1994	2
15-Aug	F	1	628	Wand	Deep Creek	1994	2
15-Aug	F	1	587	Wand	Deep Creek	1994	2
16-Aug	F	1	646	Wand	Deep Creek	1994	2
16-Aug	F	1	570	Wand	Deep Creek	1994	2
16-Aug	F	1	632	Wand	Deep Creek	1994	2
16-Aug	F	1	630	Wand	Deep Creek	1994	2
16-Aug	M	1	637	Wand	Deep Creek	1994	2
16-Aug	F	1	634	Wand	Deep Creek	1994	2
16-Aug	F	1	604	Wand	Deep Creek	1994	2
17-Aug	M	1	602	Wand	Deep Creek	1994	2
17-Aug	F	1	614	Wand	Deep Creek	1994	2
17-Aug	M	1	629	Wand	Deep Creek	1994	2
17-Aug	M	1	640	Wand	Deep Creek	1994	2
17-Aug	F	1	614	Wand	Deep Creek	1994	2
18-Aug	F	1	567	Wand	Deep Creek	1994	2
19-Aug	M	1	632	Wand	Deep Creek	1994	2
19-Aug	F	1	650	Wand	Deep Creek	1994	2

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Date	Sex	Ocean Age	Length (mm)	Tag Code[a]	Release Location	Brood Year	Age at Tagging
20-Aug	F	1	606	Wand	Deep Creek	1994	2
20-Aug	F	1	615	Wand	Deep Creek	1994	2
21-Aug	F	1	621	Wand	Deep Creek	1994	2
21-Aug	F	1	629	Wand	Deep Creek	1994	2
22-Aug	M	1	642	Wand	Deep Creek	1994	2
22-Aug	F	1	632	Wand	Deep Creek	1994	2
22-Aug	M	1	605	Wand	Deep Creek	1994	2
22-Aug	F	1	594	Wand	Deep Creek	1994	2
22-Aug	F	1	585	Wand	Deep Creek	1994	2
22-Aug	F	1	651	Wand	Deep Creek	1994	2
22-Aug	F	1	611	Wand	Deep Creek	1994	2
23-Aug	M	1	623	Wand	Deep Creek	1994	2
23-Aug	M	1	592	Wand	Deep Creek	1994	2
24-Aug	F	1	610	Wand	Deep Creek	1994	2
24-Aug	M	1	641	Wand	Deep Creek	1994	2
24-Aug	M	1	656	Wand	Deep Creek	1994	2
24-Aug	M	1	573	Wand	Deep Creek	1994	2
24-Aug	F	1	542	Wand	Deep Creek	1994	2
25-Aug	F	1	619	Wand	Deep Creek	1994	2
25-Aug	M	1	648	Wand	Deep Creek	1994	2
25-Aug	F	1	557	Wand	Deep Creek	1994	2
25-Aug	F	1	624	Wand	Deep Creek	1994	2
26-Aug	F	1	644	Wand	Deep Creek	1994	2
28-Aug	M	1	677	Wand	Deep Creek	1994	2

[a] Fish was adipose finclipped, coded wire tag was detected, but head was not collected.