Fishery Data Series No. 99-11

Chinook and Coho Salmon Coded Wire Tagging Studies in the Kenai River and Deep Creek, Alaska, 1997

by

Bruce E. King

and

Jeffery A. Breakfield

July 1999

Alaska Department of Fish and Game Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

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

Spell out acre and ton.

Time and temperature

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

Spell out year, month, and week.

Physics and chemistry

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

General

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

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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by

Bruce E. King
and
Jeffery A. Breakfield
Division of Sport Fish, Soldotna

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599

July 1999

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Bruce E. King
and
Jeffery A. Breakfield
Alaska Department of Fish and Game, Division of Sport Fish,
43961 K-Beach Road, Suite B, Soldotna, AK 99669-8367, USA

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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. Chinook salmon from the Kenai River and chinook and coho salmon *Oncorhynchus kisutch* from Deep Creek were selected for a coded wire tag marking and recovery program.

A combination of rotary and inclined plane smolt traps captured 35,357 chinook salmon smolt in the Kenai River and the Killey River, a tributary of the Kenai River, during 1997. We marked and released 31,928 smolt, or 22% of the tagging goal. Chinook salmon smolt were present in the Kenai River throughout the summer with peak catches in late June and late July. Using one rotary screw trap, we also marked and released 7,419 chinook salmon and 6,948 coho salmon smolt at Deep Creek in 1997. The number of chinook salmon smolt marked was 27% of our goal.

One-third of the chinook salmon smolt marked were age-0.0. We estimated θ (the proportion of chinook salmon marked with coded wire tags in previous years) by examining adults in the escapements. We did not estimate θ for Kenai River chinook salmon marked as fry in 1993 and 1994 because we found only one tagged adult in the approximately 1,500 chinook salmon examined.

Examination of chinook salmon adults from Deep Creek for adipose finclips revealed that 2.95% (SE = 0.73%) of the fish passing a weir at rkm 4.0 were strays from hatchery releases in the adjacent Ninilchik River. Marked chinook salmon of Deep Creek origin comprised 8.11% (SE = 0.82%) of the 1992 brood year age-1.3 and 15.28% (SE = 3.78%) of the 1993 brood year age-1.2 escapement.

We also captured adult coho salmon in Deep Creek and found that 12.54% (SE = 0.74%) were tagged as smolt in 1996. The proportion of marked adults (θ) did not change over time, and the marked proportion was used to estimate that 38,683 (SE = 2,205) coho salmon smolt emigrated from Deep Creek in 1996. The preliminary marine survival estimate for this cohort, excluding harvest in marine fisheries, was 8.42% (SE = 5.70%)

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

INTRODUCTION

Chinook salmon *Oncorhynchus tshawytscha* stocks from Cook Inlet are currently fully utilized by existing fisheries. Inriver fisheries target specific stocks while many gillnet and marine hook-and-line fisheries harvest mixed stocks of chinook salmon as they pass through Cook Inlet on their way to natal drainages. Escapement goals exist for many of these stocks, and the Alaska Department of Fish and Game 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.

The Cook Inlet marine recreational fishery harvests 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 from 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 recent growth of the marine fishery. Annual harvests of chinook salmon in this fishery increased over 100% between 1987 and 1995 (Howe et al. 1997). Concerns regarding increased exploitation of local stocks by this fishery resulted in several restrictions beginning in 1996. A 4-mile long, 1-mile wide

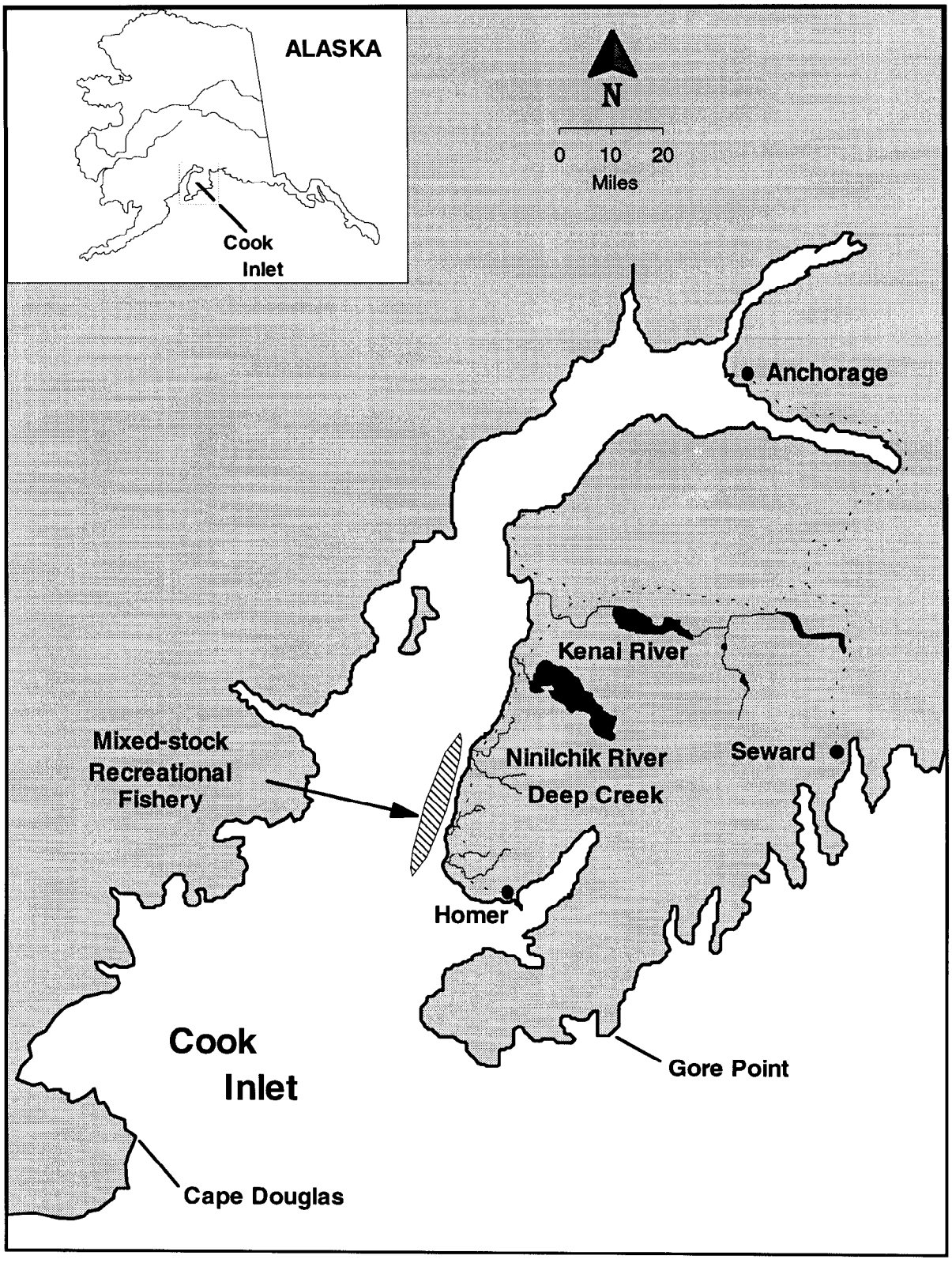

Figure 1.-Kenai River, Deep Creek, Ninilchik River and the marine recreational fishery of Cook Inlet, Alaska.

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 no person can harvest more than one chinook salmon greater than 16 in long daily. Finally, guides were not permitted to fish while guiding within the special harvest area.

While the marine recreational fishery has grown in recent years, little is known about the origin of stocks that are harvested. McKinley (1999) identified stocks that contributed 11.6% of the harvest in 1996. However, the lack of stock-specific estimates for the majority of the harvest precludes continued development of meaningful management objectives for the marine recreational fishery, and compromises estimation of stock-specific adult returns of chinook salmon to Cook Inlet drainages.

The Alaska Department of Fish and Game, Division of Sport Fish, initiated a long-term study in 1993 to assess the growth and characteristics of the marine recreational fishery, evaluate on-going 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 the drainages of Cook Inlet are marked using 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 supports the largest freshwater chinook salmon fishery in Alaska (Howe et al. 1997). 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 is comprised of 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 allocative decisions concerning the harvest of this stock.

The Kenai River is also the primary Cook Inlet drainage producing late-run chinook salmon. Hence, the majority of all chinook salmon harvested in Cook Inlet after 1 July are 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 turned up as voluntary recoveries 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, 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 (Figure 2). A comparable program is in place to assess the contribution of Kenai River coho salmon to various marine fisheries (Carlon and Hasbrouck 1998).

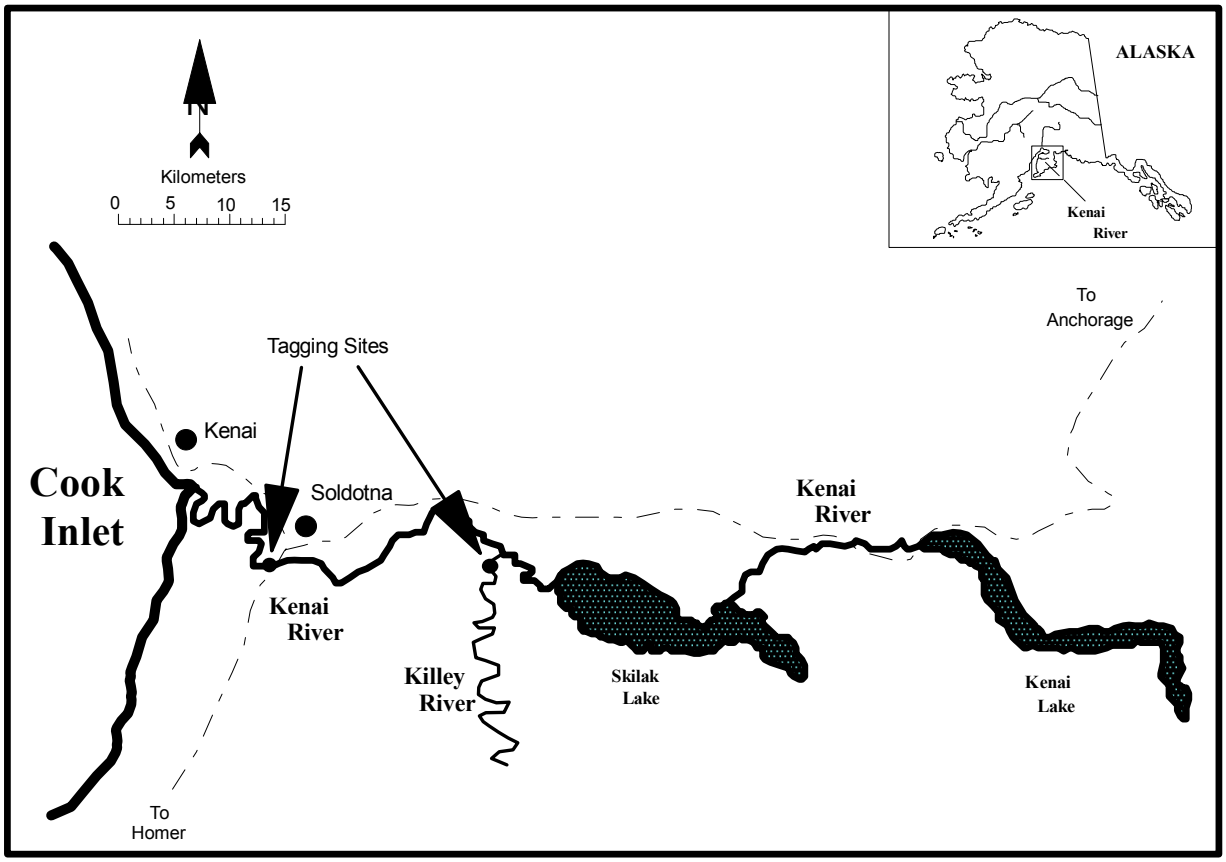

Figure 2.-Kenai and Killey rivers chinook salmon tagging sites, 1997.

The Deep Creek 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 overharvest 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 have used a rotary trap to capture and tag Deep Creek age-0.0 and age-1.0 chinook salmon smolt since the inception of the project in 1994 (Figure 3). 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 the smolt production. Beginning in 1997, we enumerated the 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 sufficient chinook salmon smolt to estimate the marine sport harvest in Upper Cook Inlet of chinook salmon that emigrate as smolt from the Kenai River and Deep Creek;
2. Test the null hypothesis that chinook salmon smolt marked in the Kenai River and Deep Creek in previous years mixed completely with unmarked individuals when they returned as adults;

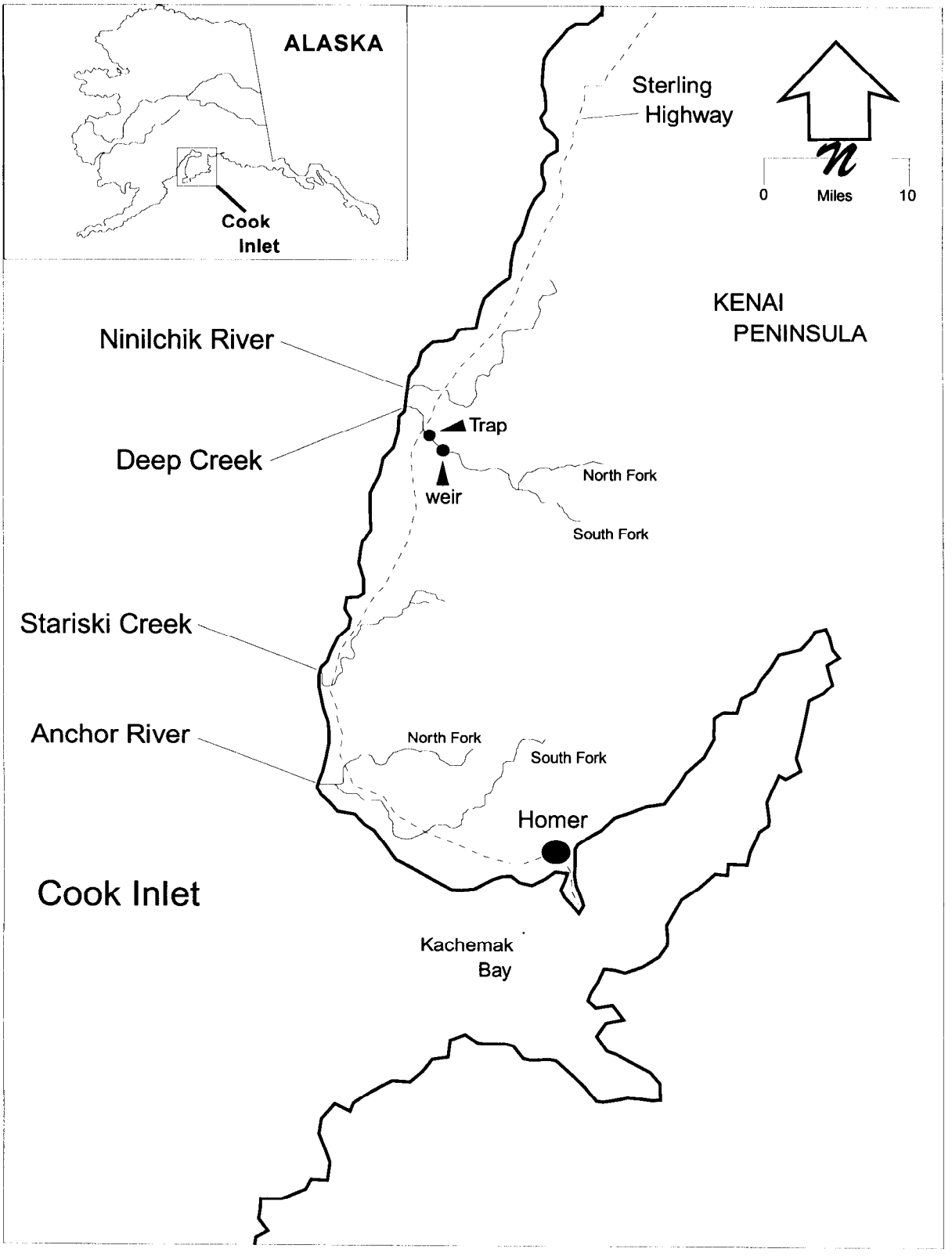

Figure 3.-Deep Creek juvenile tagging and adult enumeration sites, 1997.

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 1996;
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. Estimate the number of hatchery-produced chinook salmon stocked into the Ninilchik River that strayed into Deep Creek.

METHODS

Estimation 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 from each drainage with coded wire tags (CWTs) and adipose finclips (AFCs). 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 be identified by examining harvested adult salmon for marks. Knowledge of the total harvest, proportion of fish marked in each stock, and the numbers of marked 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 (θ or theta) 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 marked. 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 adults were a representative sample of the cohort (brood year), and would allow combining all of the inriver recovery data to estimate 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 1997, age-1.2 and -1.3 chinook salmon returning to each system were marked with CWTs (Bendock 1995).

KENAI RIVER

CWT Release

We moved the CWT marking program to two new locations in 1997. Four traps were placed at rkm 34, immediately downstream of the highway bridge in Soldotna, and a single trap was placed in the Killey River approximately 0.8 rkm from its confluence with the Kenai River.

We deployed three inclined plane traps (Todd 1994) and one rotary screw trap in the mainstem Kenai River to capture chinook salmon smolt (Figure 4). We anchored the traps in the area of the river registering the highest surface velocity, and fished them through the hours of darkness each day. At the Killey River, we initially anchored one rotary screw trap from the west shore approximately 0.06 rkm from the confluence (Figure 5). On July 8, we moved the trap to rkm 1.3 because rising water levels in the mainstem inundated the original location. This trap was fished continuously through each operating day.

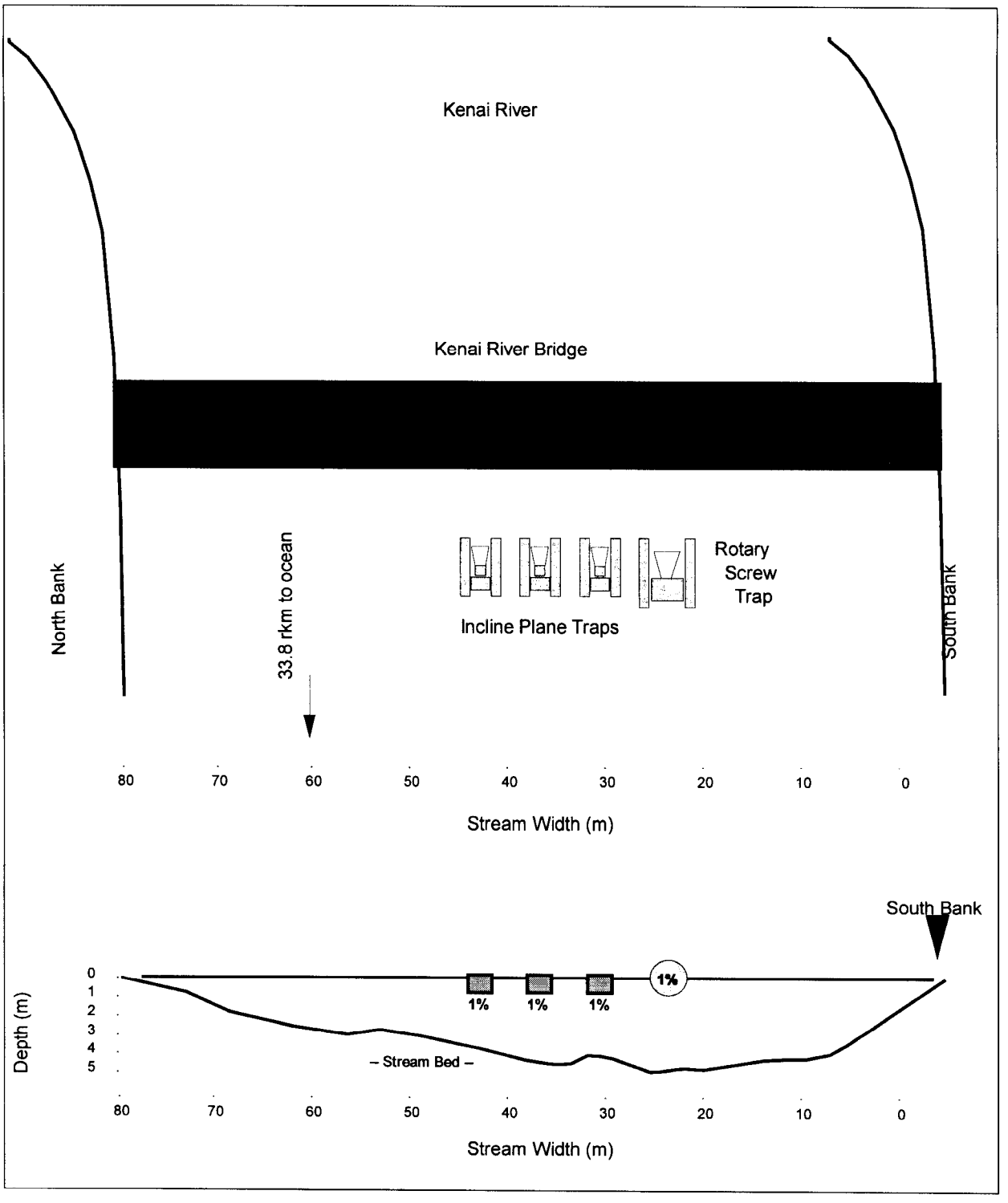

Figure 4.-Schematic overhead and cross section views of the Kenai River showing the trap locations.

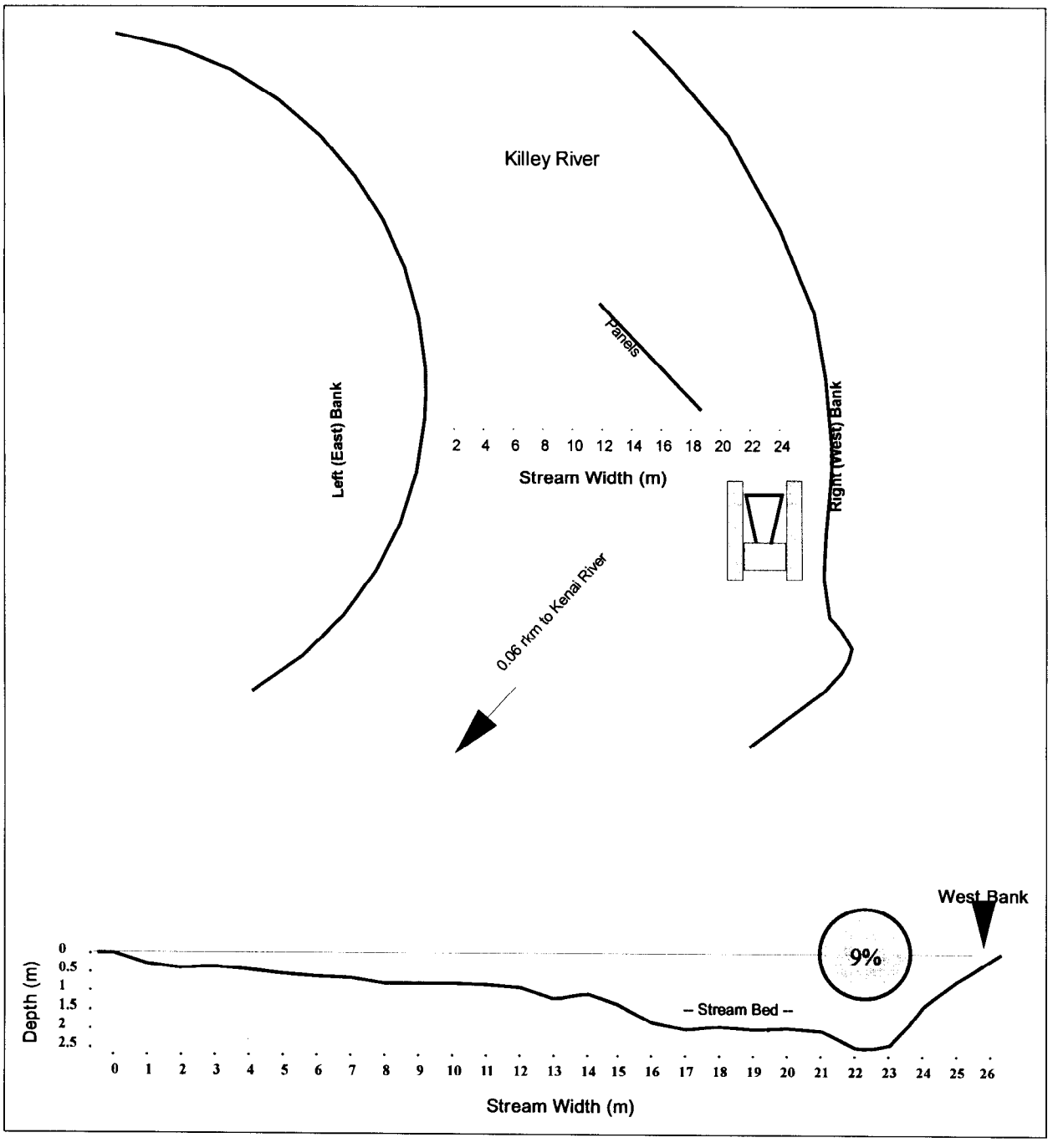

Figure 5.-Schematic overhead and cross section views of the Killey River showing the sampling area of the rotary screw trap, 17 May-7 July 1997.

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 148,000 smolt.

Each time the trap livebox was emptied, technicians identified and counted the catch by species. Sockeye salmon smolt numbers were estimated and rounded to the nearest 10 fish. Species other than chinook salmon smolt were released. Chinook salmon were injected with a CWT and released using procedures outlined in Bendock (1995, 1996) and Moberly et al. (1977). A representative sample of tagged fish was held for 24 hours to measure tag retention and handling mortality.

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 once each day. Surface velocity was periodically measured in front of each trap.

We removed a scale smear 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 23 June, 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 θ from Inriver Return of Adults

Adult chinook salmon captured in gillnets for the Kenai River stock assessment project (Marsh 1999) were used to estimate θ. Project technicians fished drift gillnets 5 days per week between rkm 8 and 15.3 from 17 May through 4 August. Technicians examined all chinook salmon for external sex characteristics, measured their length, and removed three scales for age determination (**A**ge**S**ex**L**ength or ASL). 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, Scarnecchia 1979). The scales were pressed and age determined using procedures described by Mosher (1969).

All fish possessing an AFC were sacrificed and the head removed. A cinch strap was affixed to the head; the head was frozen and later shipped to the Alaska Department of Fish and Game (ADF&G) CWT Lab to retrieve and decode the tag.

All sport harvested adult chinook salmon observed in the Kenai River recreational fishery creel survey (Marsh 1999) were also examined for an AFC. The creel survey was conducted from 17 May through 2 August 1997 between rkm 8 and 34. Technicians sampled 6 d 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. Hammarstrom and Timmons (*In prep a, b)* stratified the data into 3-week time intervals and estimated the proportion of each age class (P_{ijk}) as a binomial proportion (Cochran 1977) by:

$$\hat{p}_{ijk} = \frac{s_{ijk}}{s_{ij}}, \tag{1}$$

with variance:

$$\hat{V}\left(\hat{p}_{ijk}\right) = \frac{\hat{p}_{ijk}\left(1 - \hat{p}_{ijk}\right)}{s_{ij} - 1}, \tag{2}$$

where:

s_{ijk} = number of chinook salmon of age k collected from sample source i (i.e., sport harvest or gillnetting) during time strata j, and

s_{ij} = number of chinook salmon with an ageable scale collected from sample source i during time strata j.

Not all scale samples could be aged as some were regenerated or inverted. Thus, we estimated the total number of chinook salmon sampled from each age class (n_{ijk}) as:

$$\hat{n}_{ijk} = n_{ij}\hat{p}_{ijk}, \tag{3}$$

where:

n_{ij} = total number of chinook salmon sampled from source i during time strata j.

We assumed as demonstrated in 1996 (King and Breakfield 1998) that the age composition of fish that could not be aged was the same as the proportion of fish that could be aged. The numbers of fish by age class in the inriver return is necessary to estimate θ and its variance for each age group of marked cohorts.

We also conducted a survey of Slikok Creek, a tributary of the Kenai River, to look for AFC chinook salmon, recover CWTs, and index the spawning escapement. The ground survey was conducted 16 July in the approximately 3.2 kilometers 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 scales, length and sex. All AFC chinook salmon were sampled as described above. A subsequent trip on 18 July was used to collect additional ASL data from chinook salmon. Live fish captured with a seine were sampled.

DEEP CREEK

CWT Release

We operated a rotary smolt trap in Deep Creek approximately 0.8 km above its confluence with Cook Inlet (Figure 6). The location, as well as the equipment and procedures to capture and handle chinook salmon smolt, were the same as previous years (Bendock 1996). Our goal, based on the estimated average adult escapement, and assumed survival rate and harvest in the marine recreational fishery, was to tag 28,000 smolt.

Inseason age composition of the emigrating chinook salmon smolt was determined by length (Bendock 1995), and we used separate tag codes for fish thought to be age-0.0 and age-1.0 We also measured the fork length of a random sample of up to twenty chinook salmon juveniles daily. Half of the daily sample was smolt thought to be age-1 smolt, and the remaining were chinook juveniles which in previous years were called age-0 based on length. The length frequency of these fish was plotted to validate the assumptions regarding the use of length to separate fish into age groups for tagging. We also tagged all captured coho salmon smolt.

Estimating θ from Inriver Return of Adults

Adult Weir and Mark-Recapture

The weir was located approximately 4 rkm from the terminus at Cook Inlet (Figure 7), and approximately 0.8 rkm upstream of the inriver sport fishery. The weir was installed 24 May and

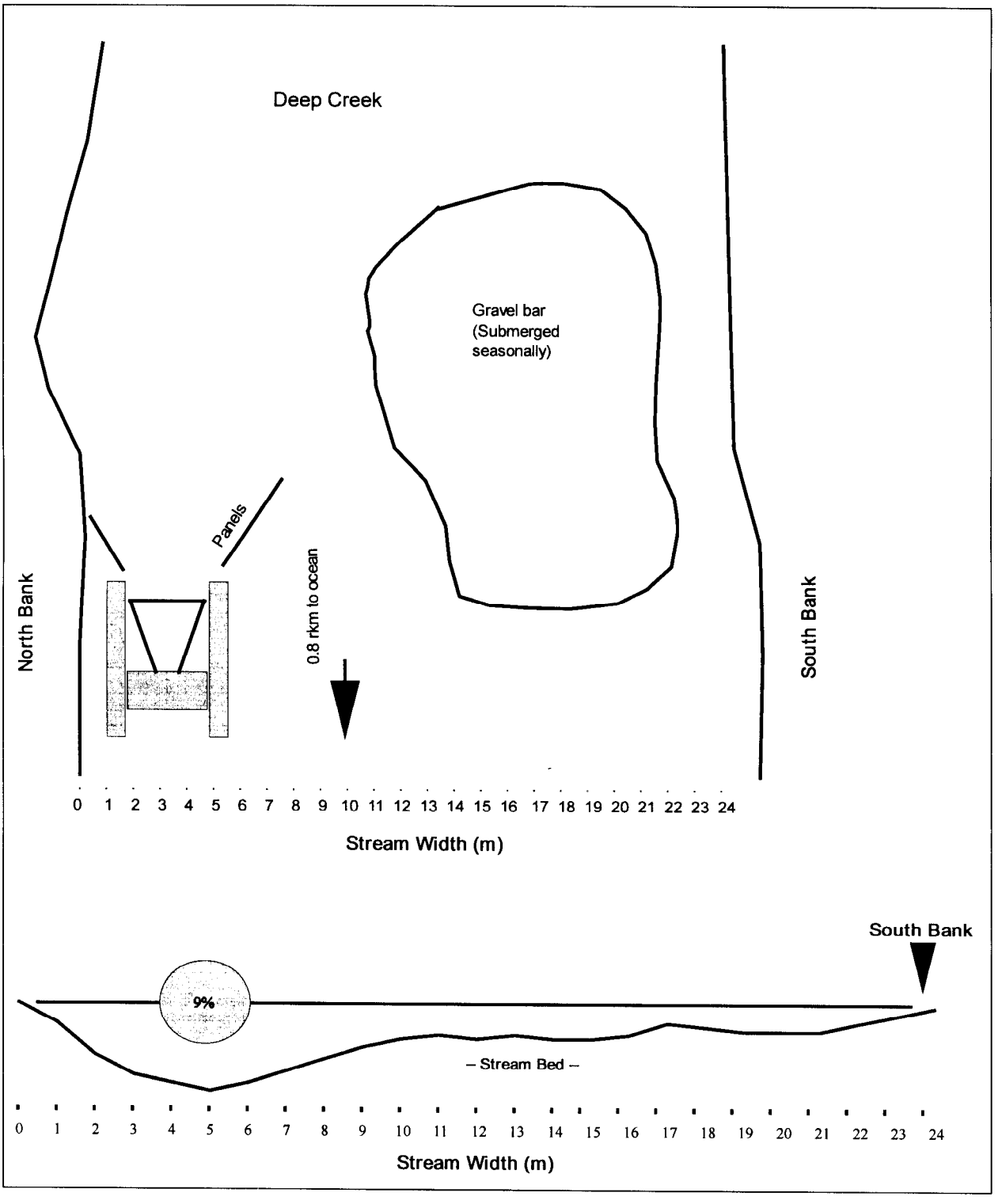

Figure 6.-Schematic overhead and cross section views of Deep Creek showing the sampling area of the rotary screw trap.

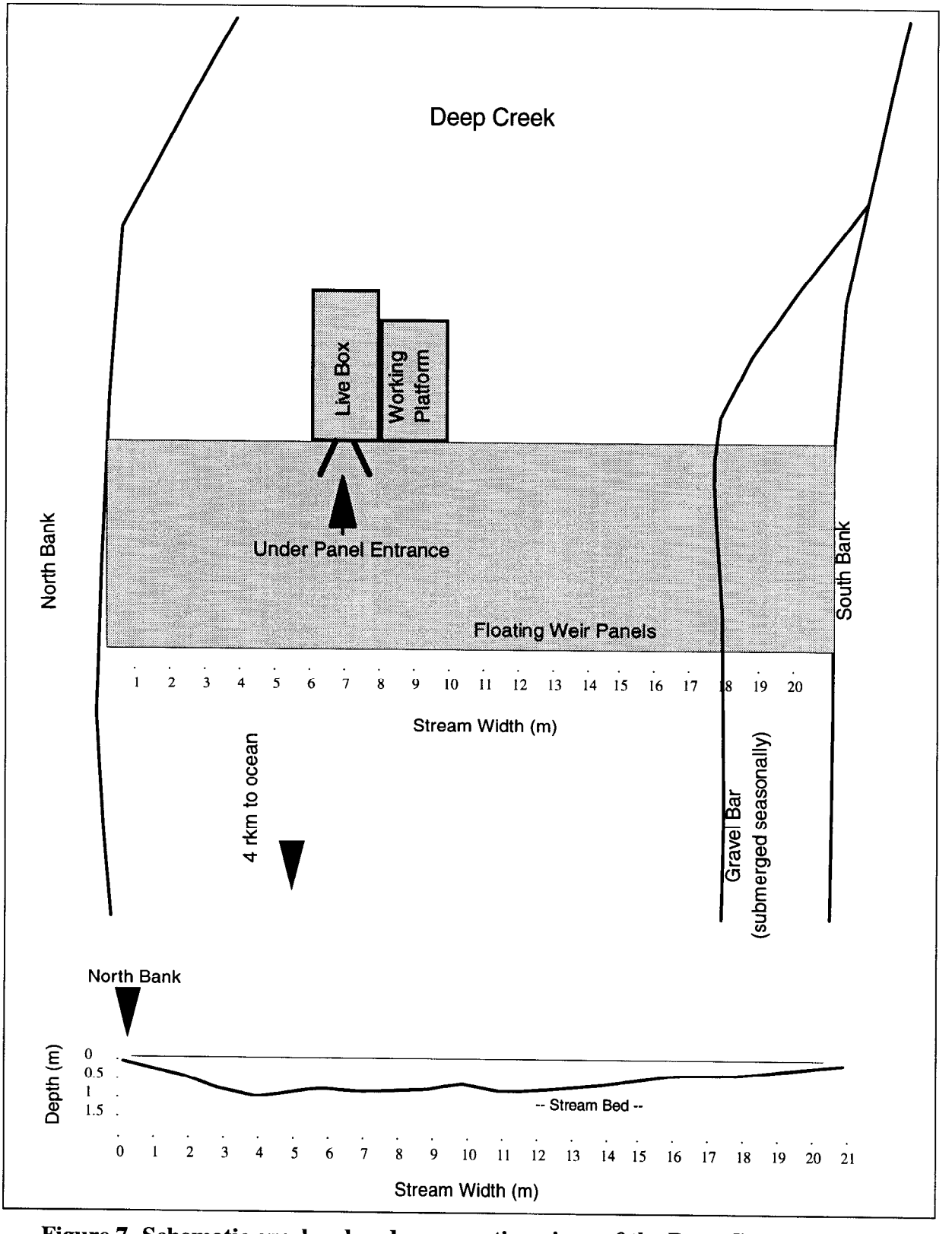

Figure 7.-Schematic overhead and cross section views of the Deep Creek weir site.

operated through 21 September. The crew also surveyed 2 miles of the creek upstream of the weir to count the number of chinook salmon that migrated upstream of the weir site prior to installation. In addition, aerial and ground surveys were conducted in early August to provide an index of the number of chinook salmon spawning downstream of the weir.

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 began counting, sampling, and passing fish when present. All chinook and coho salmon were examined for an AFC and a 1/4-inch hole punched through 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. In addition, AFC chinook salmon were cut open and the sex organs examined to verify the accuracy of sex determination. Technicians described the color of all chinook salmon handled. AFC coho salmon were sampled with a portable hand-held wand that detected the presence of a CWT.

On 16 and 19 June, field personnel found chinook salmon carcasses upstream of the weir that did not have an upper caudal fin hole punch. The weir was checked daily from the beginning of operation to ensure that there were no voids through which fish could migrate undetected. The presence of chinook salmon without a caudal punch prompted us to conduct a capture-recapture experiment to estimate the number of chinook salmon above the weir that had not received a caudal punch. Three crews captured and sampled fish above the weir for a distance of approximately 4.0 rkm on 25 June. The total river kilometers to sample was based on the presence of fish in an aerial survey conducted the day before the sampling event. Data were recorded by location, designated lower (0 to 1.5 rkm above the weir), middle (1.5 to 2.4 rkm), and upper (2.4 to 4.0 rkm). Logistic difficulties prevented the middle crew from spending as much time sampling as the other two crews.

We captured adult chinook salmon using 15 m long pieces of 4 1/4 inch stretch mesh gillnet drifted through pools. Fish entangled in the net were removed and released if they had been previously upper caudal punched. Fish not previously upper caudal punched were sampled for ASL and an AFC. Sex of AFC fish was determined by examination of the gut cavity. To avoid repeat sampling of unmarked fish, we also punched a 1/4" hole in the adipose fin of all unmarked fish. All AFC chinook salmon were sacrificed and processed as described above.

The number of chinook salmon upstream of the weir by 24 June was estimated using Chapman's modification of the Peterson estimator (Seber 1982):

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)} - 1 . \tag{4}$$

Variance was estimated by:

$$\hat{V}(\hat{N}) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)} , \tag{5}$$

where:

M = the number of chinook marked with an upper caudal hole punch at the weir,

C = the number of chinook salmon captured upstream of the weir on 25 June, and

R = the number of chinook salmon captured upstream of the weir that had an upper caudal fin punch.

Hatchery-reared chinook salmon are stocked into the Ninilchik River, which flows into Upper Cook Inlet within 2 miles of the mouth of Deep Creek. The potential exists for these hatchery-reared chinook salmon to stray into Deep Creek upon their return. Therefore, we tested the null hypothesis that chinook salmon stocked into 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 (J. Seeb, ADF&G, Anchorage, personal communication). A consistent straying level >4% over 4-5 years is considered unacceptable. A sample of 16 decoded tags from heads collected from the Deep Creek escapement was sufficient for this test. If none of the 16 tags were from fish stocked into the Ninilchik River, then the straying rate was likely <4%. If one or more of the 16 CWT chinook salmon recovered at Deep Creek was originally stocked into the Ninilchik River, then the straying rate was likely >4%.

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 chinook salmon in each weekly sample originally stocked into the Ninilchik River (h_{wk}) for each age class by (Bernard and Clark 1996):

$$\hat{h}_{wk} = \frac{m_{wk}}{\lambda_w \phi_w \theta_{wk}}, \tag{6}$$

and

$$\hat{V}(\hat{h}_{wk}) = \frac{\hat{h}_{wk}}{\lambda_w \phi_w \theta_w}(1 - \lambda_w \phi_w \theta_w), \tag{7}$$

where:

m_{wk} = the number of chinook salmon of age k marked and released into the Ninilchik River and recovered during week w,

θ_w = proportion of chinook salmon of age k released into the Ninilchik River marked with a CWT,

λ_w = the decoding rate of CWTs in the sample during week w, and

ϕ_w = the proportion sampled during week w.

Note that because all chinook salmon migrating through the weir were sampled for ASL and CWTs, $\phi_w = 1$.

Finally, the number of chinook salmon of Deep Creek origin of each age class in each weekly sample $(\hat{n}_{Dwk})$ was estimated as:

$$\hat{n}_{Dwk} = \hat{n}_{wk} - \hat{h}_{wk}, \tag{8}$$

where:

$\hat{n}_{wk}$ = the total number of chinook salmon of age *k* in each week *w* sample estimated from equation 3.

We poststratified the age class estimates, and CWT recoveries of chinook salmon marked at Deep Creek into time intervals to test (χ^2) the hypothesis ($\alpha = 0.05$) that the marked proportion did not change over time. If no differences in the proportion marked were detected, the data were pooled to estimate θ for the contributing smolt cohorts.

1995 Coho Salmon Smolt Estimate

We examined all adult coho salmon passing the weir for AFCs, and all AFC fish were sampled with a hand detection wand for the presence of a CWT. We assumed that all positive tag detections were Deep Creek implants from 1996. The proportion of marked coho salmon from 3-week strata was compared to test the hypothesis that the marked proportion of adults did not change over time.

We used the number of coho salmon smolt tagged in 1996 and recovered as adults in the 1997 escapement to estimate the number of smolt that emigrated from Deep Creek in 1996. The number of smolt (N) and its variance (V) was estimated using equations 4 and 5. For this estimate:

M = the number of marked smolt marked with a coded wire tag in 1996,

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

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

This equation produces a nearly 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 1996; (2) all juveniles marked in 1996 were actually smolt; and (3) survival was the same for marked and unmarked individuals.

RESULTS

KENAI RIVER

CWT Release

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

The traps were placed offshore of the south bank at the distance that we thought would encompass the highest surface velocity corridor. Initially, the inshore trap was centered 27 m from shore and the remaining traps were spaced 6 m apart, giving lateral coverage of approximately 15 m. On 6 July, the traps were moved shoreward 11 m to avoid current in which traps were inoperable, and fished in that location for the duration of the season. Surface velocity in front of the traps ranged from 4 feet per second (fps) in early June to 12 fps in August.

We captured 39,764 salmonids at the mainstem site (Table 1). Chinook salmon smolt was the numerically dominant (56%) salmonid species in the catch, followed by sockeye (35%) and coho salmon (9%) smolt. Nightly chinook salmon smolt catches ranged up to 1,821 fish. Peaks in the capture rate occurred in late June and late July (Figure 8). AFC chinook salmon smolt from the Killey River tagging project were captured primarily in June. Coho salmon smolt were captured throughout the operational period, with largest catches in June. AFC coho salmon smolt from the Moose River project were captured primarily in early June. Sockeye salmon smolt catches occurred primarily in June.

Fork length of age-1.0 chinook salmon smolt captured in the Kenai River ranged from 53 to 75 mm and averaged 65 mm (SE = 0.23 mm; Figure 9).

We marked and released 19,385 age-1.0 chinook salmon smolt with CWTs at the mainstem Kenai River site (Table 2 and Appendix A1). The average short-term tag retention and mortality rate for age-1.0 smolt were 99.7% and 1.0%, respectively. Mortality in the early portion of the project was reduced in July by changing handling and holding practices. The difference between the number of chinook salmon smolt caught, and the number released with a tag, was primarily pretagging capture and handling mortality, or mortality of holding fish.

The Killey River trap was located on the right (west) bank of the river at the downstream, outside end of a bend (Figure 5). The river at the marking site was 26 m wide with a bottom profile that gradually increased in depth from the left bank to approximately 2.5 m under the trap. Water surface velocity ranged from 1.7 to 6.5 fps.

Technicians captured 26,212 salmonid smolts in the rotary screw trap in the Killey River (Table 3). Chinook salmon smolt was the numerically dominant salmonid species in the catch (49%), followed by coho (48%) and sockeye salmon (3%). Nightly chinook salmon smolt catches ranged up to 1,003 fish, and several peaks occurred in the capture rate (Figure 8). Highest catches occurred during and immediately following freshets.

Prior to mid-June, emergent chinook fry were easily distinguished, based on size and color, from age-1.0 smolt. Fork length of age-1.0 chinook salmon smolt captured in the Killey River after 23 June ranged from 53 to 118 mm and averaged 82 mm (SE = 0.64 mm; Figure 9). There was overlap in the length frequency distribution of all age-0.0 and -1.0 juveniles captured; however, the distinction between the age classes was reasonably apparent (Figure 10).

We marked and released 12,543 age-1.0 chinook salmon smolt with CWTs at the Killey River site (Table 2 and Appendix A1). Short-term tag retention and mortality rate for age-1.0 smolt were 99% and 0%, respectively. Our estimate of the total marked and released is assumed to be the number of smolt leaving the river with a tag.

Estimating θ from Inriver Return of Adults

A total of 484 early-run (16 May through 30 June) and 369 late-run (1 July through 4 August) chinook salmon were captured in gillnets in the Kenai River (Table 4; Marsh 1999). Crews examined all of the netted fish for AFCs. Creel survey technicians examined 198 early-run and 395 late-run chinook salmon.

Four heads from AFC chinook salmon were recovered by the gillnet crew (Appendix B1). Two were released as smolt in Crooked Creek (Kasilof River), one did not have a tag, and one was tagged in the Kenai River. The latter fish was from the 1992 brood year. Creel survey technicians found two AFC chinook salmon. Neither fish contained a tag.

Table 1.-Daily and cumulative catches of chinook, coho, and sockeye salmon smolt in the Kenai River, 1997.

	Chinook		Coho		Sockeye		Chinook AFC[a]		Coho AFC[b]	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
9-Jun	26	26	111	111	180	180	0	0	4	4
10-Jun	1	27	64	175	510	690	0	0	2	6
11-Jun	11	38	60	235	80	770	0	0	3	9
12-Jun	28	66	173	408	330	1,100	1	1	0	9
13-Jun	102	168	200	608	170	1,270	2	3	7	16
14-Jun	106	274	138	746	490	1,760	2	5	4	20
15-Jun	205	479	96	842	420	2,180	5	10	6	26
16-Jun	129	608	161	1,003	190	2,370	2	12	4	30
17-Jun	90	698	66	1,069	90	2,460	3	15	5	35
18-Jun	35	733	80	1,149	130	2,590	0	15	0	35
19-Jun	89	822	101	1,250	590	3,180	0	15	1	36
20-Jun	374	1,196	152	1,402	410	3,590	18	33	0	36
21-Jun	294	1,490	69	1,471	340	3,930	13	46	0	36
22-Jun	260	1,750	70	1,541	570	4,500	6	52	0	36
23-Jun	403	2,153	95	1,636	710	5,210	13	65	0	36
24-Jun	589	2,742	204	1,840	1,040	6,250	38	103	0	36
25-Jun	1,821	4,563	61	1,901	650	6,900	69	172	0	36
26-Jun	1,207	5,770	101	2,002	340	7,240	81	253	0	36
27-Jun	1,465	7,235	52	2,054	320	7,560	135	388	2	38
28-Jun	948	8,183	126	2,180	1,070	8,630	65	453	0	38
29-Jun	688	8,871	135	2,315	1,370	10,000	39	492	0	38
30-Jun	826	9,697	59	2,374	1,740	11,740	64	556	0	38
1-Jul	421	10,118	30	2,404	380	12,120	39	595	0	38
2-Jul	404	10,522	36	2,440	720	12,840	33	628	0	38
3-Jul	240	10,762	52	2,492	600	13,440	12	640	0	38
4-Jul[c]		10,762		2,492		13,440		640		38
5-Jul[c]		10,762		2,492		13,440		640		38
6-Jul	30	10,792	11	2,503	40	13,480	2	642	0	38
7-Jul	59	10,851	17	2,520	10	13,490	0	642	0	38
8-Jul	41	10,892	30	2,550	10	13,500	0	642	0	38
9-Jul	75	10,967	24	2,574	10	13,510	1	643	0	38
10-Jul	67	11,034	14	2,588	10	13,520	2	645	0	38
11-Jul	109	11,143	18	2,606	10	13,530	0	645	0	38
12-Jul	52	11,195	15	2,621	10	13,540	0	645	0	38
13-Jul	59	11,254	20	2,641	10	13,550	0	645	0	38
14-Jul	92	11,346	10	2,651	20	13,570	0	645	0	38
15-Jul	107	11,453	10	2,661	30	13,600	0	645	0	38
16-Jul	171	11,624	11	2,672	10	13,610	4	649	0	38
17-Jul	186	11,810	27	2,699	0	13,610	1	650	0	38
18-Jul	147	11,957	13	2,712	0	13,610	2	652	0	38
19-Jul	59	12,016	6	2,718	10	13,620	0	652	0	38

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Table 1.-Page 2 of 2.

	Chinook		Coho		Sockeye		Chinook AFC[a]		Coho AFC[b]	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
20-Jul	180	12,196	9	2,727	0	13,620	0	652	0	38
21-Jul	342	12,538	19	2,746	0	13,620	0	652	0	38
22-Jul	568	13,106	13	2,759	0	13,620	0	652	0	38
23-Jul	723	13,829	38	2,797	0	13,620	0	652	0	38
24-Jul	370	14,199	19	2,816	0	13,620	0	652	0	38
25-Jul	133	14,332	8	2,824	0	13,620	0	652	0	38
26-Jul	340	14,672	14	2,838	0	13,620	2	654	0	38
27-Jul	846	15,518	27	2,865	10	13,630	1	655	0	38
28-Jul	736	16,254	25	2,890	0	13,630	0	655	0	38
29-Jul	880	17,134	65	2,955	10	13,640	0	655	0	38
30-Jul	795	17,929	140	3,095	0	13,640	0	655	0	38
31-Jul	828	18,757	60	3,155	0	13,640	0	655	0	38
1-Aug	724	19,481	75	3,230	10	13,650	0	655	0	38
2-Aug	555	20,036	60	3,290	80	13,730	0	655	0	38
3-Aug	219	20,255	14	3,304	10	13,740	0	655	0	38
4-Aug	326	20,581	35	3,339	0	13,740	0	655	0	38
5-Aug	325	20,906	27	3,366	0	13,740	0	655	0	38
6-Aug	327	21,233	23	3,389	0	13,740	0	655	0	38
7-Aug	276	21,509	34	3,423	0	13,740	0	655	0	38
8-Aug	185	21,694	26	3,449	0	13,740	0	655	0	38
9-Aug	160	21,854	24	3,473	0	13,740	0	655	0	38
10-Aug	132	21,986	5	3,478	0	13,740	0	655	0	38
11-Aug	115	22,101	5	3,483	0	13,740	0	655	0	38
12-Aug	81	22,182	13	3,496	0	13,740	0	655	0	38
13-Aug	56	22,238	9	3,505	0	13,740	0	655	0	38
14-Aug	58	22,296	7	3,512	0	13,740	0	655	0	38
15-Aug	39	22,335	6	3,518	0	13,740	0	655	0	38
16-Aug	54	22,389	4	3,522	0	13,740	0	655	0	38
17-Aug	35	22,424	7	3,529	0	13,740	0	655	0	38
18-Aug[d]	53	22,477	18	3,547	0	13,740	0	655	0	38

[a] Adipose finclipped (AFC) chinook salmon smolt were coded wire tagged in the Killey River, 1997.

[b] Adipose finclipped (AFC) coho salmon smolt were coded wire tagged in the Moose River, 1997.

[c] Traps damaged; no catch.

[d] Total captures of other species include: 169 Dolly Varden (*Salvelinus malma*), 11 rainbow trout (*Oncorhynchus mykiss*), 147 slimy sculpin (*Cottus cognatus*), 126 three-spine stickleback (*Gasterosteus aculeatus*), and 2 round whitefish (*Prosopium cylindraceum*).

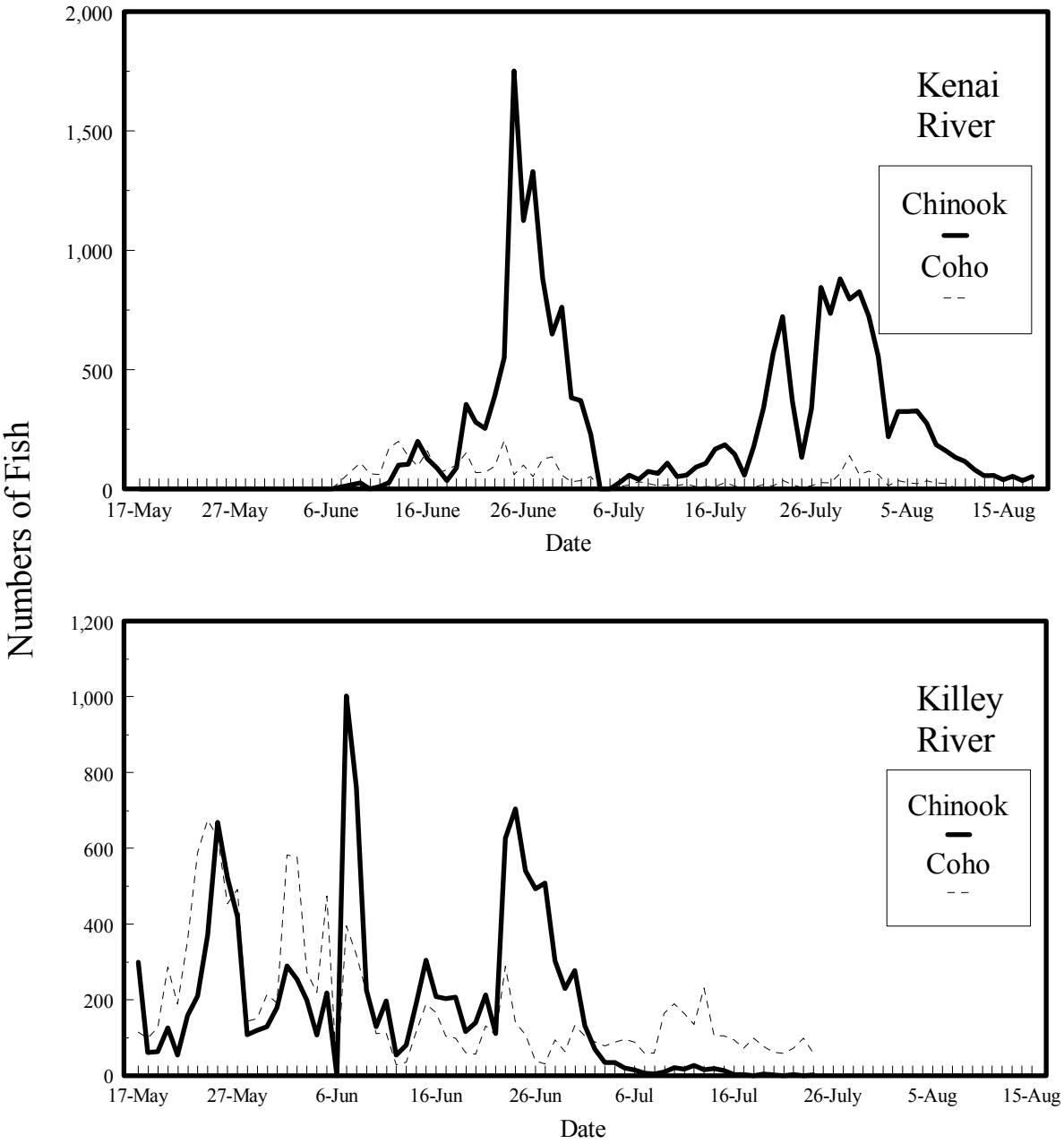
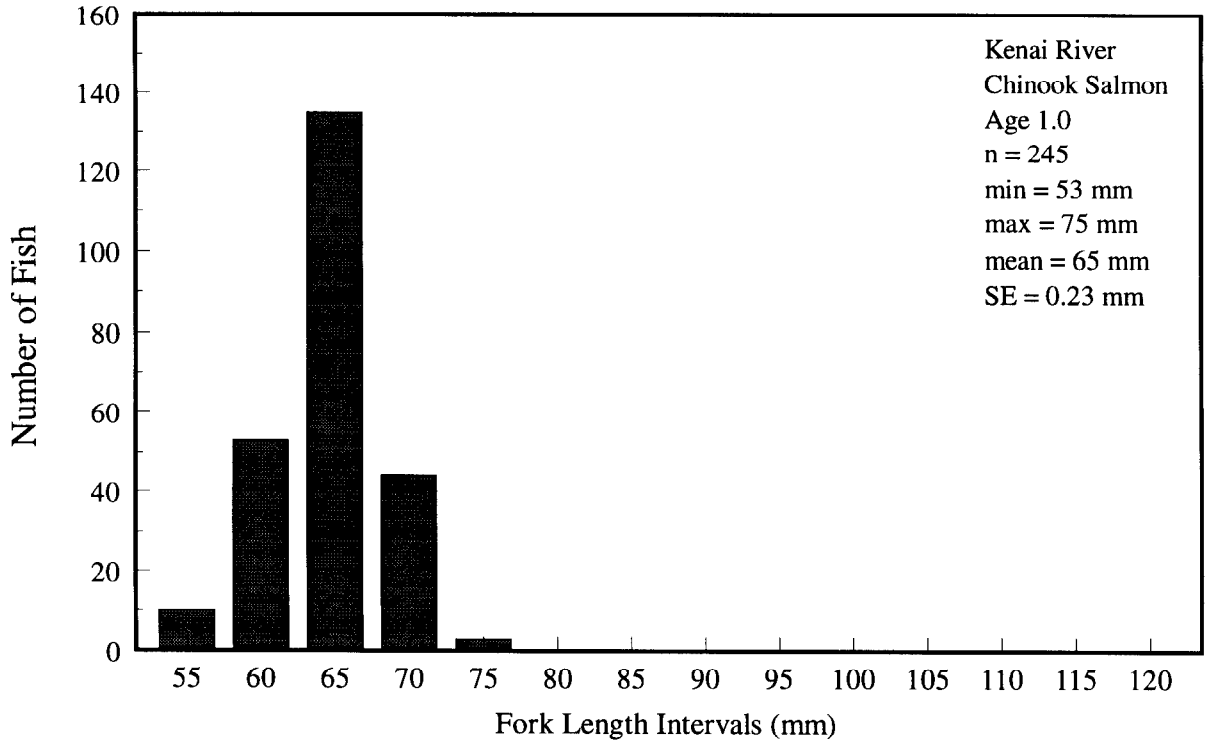


Figure 8.-Daily chinook and coho salmon smolt catches from the Kenai (top) and Killey rivers, 1997.

Since no temporal difference was detected for the two age classes that composed 90% of the inriver return, Hammarstrom and Timmons (*In prep a or b*) pooled all age composition samples. When the age composition from the inriver return and creel sampling was expanded for the unaged fish (Table 4), we estimated that we examined 51 fish from the 1993 brood year and 363 fish from the 1992 brood year for AFCs.



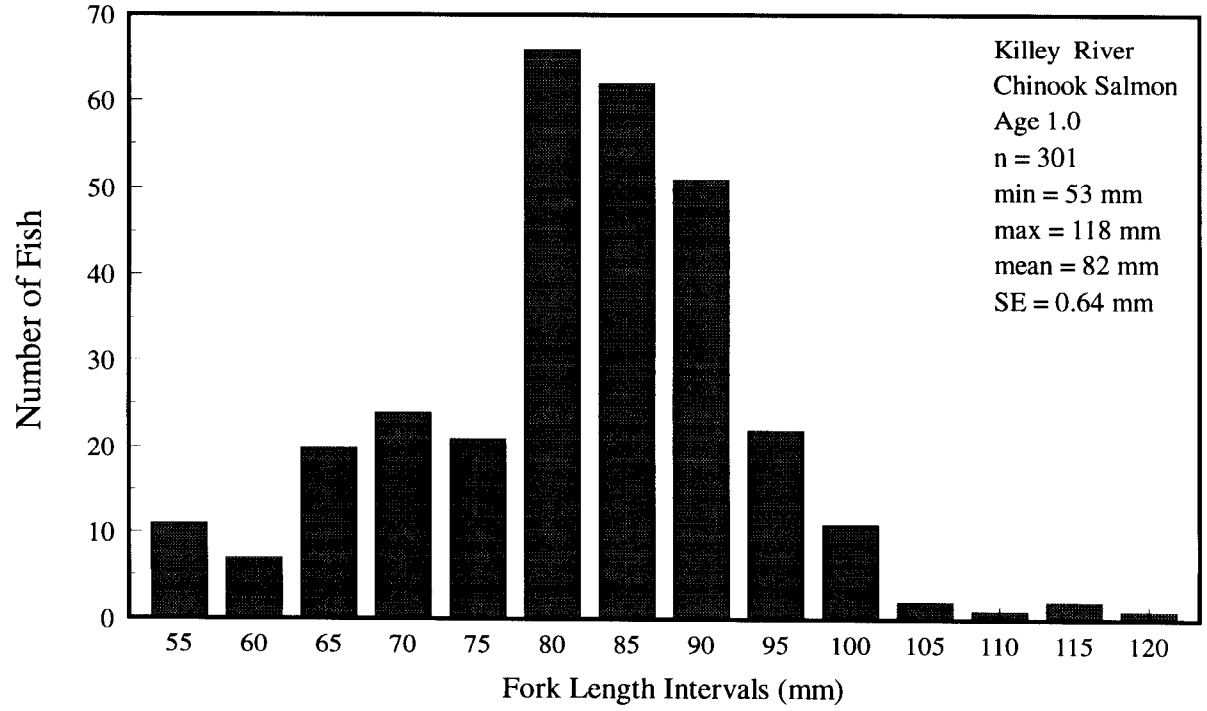


Figure 9.-Length frequency distribution for age-1.0 chinook salmon smolt captured in the Kenai (top) and Killey rivers, 1997.

Table 2.-Estimated number of chinook salmon leaving the Kenai and Killey rivers with coded wire tags in 1997.

Kenai River

Dates	Coded Wire Tag Codes	Brood Year	Age	No.[a]
6/09-6/29	31-25-51	1995	1.0	6,018
6/29-7/26	31-25-50	1995	1.0	5,629
7/27-8/05	31-25-48	1995	1.0	6,220
8/06-8/18	31-27-07	1995	1.0	1,518
			Total	19,385

Killey River

Dates	Coded Wire Tag Codes	BroodYear	Age	No.
5/17-6/08	31-25-47	1995	1.0	5,825
6/08-6/30	31-25-54	1995	1.0	6,255
7/01-7/24	13-01-03-09-01	1995	1.0	463
			Total	12,543

[a] The number of tags was adjusted by the estimated tag retention proportion.

Twelve adults tagged in the Kenai River (brood years 1992-1994) were also recovered from a variety of Cook Inlet marine sport and commercial fisheries, and two additional fish were captured in the purse seine fishery based in Kodiak (Appendix B1).

Slikok Creek spawning ground survey crews observed 314 chinook salmon. Scales were collected from 97 of the chinook salmon, and sex could be determined for 181 fish. Scales from 68 fish were readable, of which 2% were age 1.2, 32% were age 1.3, and 66% were age 1.4.

Heads were collected from five AFC fish, all of which were from the Crooked Creek 1993 brood year (Appendix B1). Since this hatchery cohort had a θ of approximately 0.20, our estimate of Crooked Creek fish in Slikok Creek at the time of the stream survey was 25 fish out of 102 total 1993 brood year fish or 25 % of the age class.

DEEP CREEK

CWT Release

We operated the Deep Creek rotary smolt trap from 13 May through 29 July. Stream discharge and water temperature fluctuated throughout the operation (Figure 11). Water level declined from 99 cm in mid-May to 67 cm by mid-July with interspersed freshets. Water temperature ranged from 3° C to 16° C, with an increasing trend from mid-May through early July. There was a significant (P = 0.0001) negative correlation between the two hydrological parameters. Chinook and coho salmon catches tended to increase after discharge increases; however, the highest flows recorded in mid-July were not accompanied by migration of fish.

Seven species of fish were captured in the trap. The catch of the four anadromous salmonid species, Dolly Varden (*Salvelinus malma*), coho salmon, steelhead (*Oncorhynchus mykiss)*, and chinook salmon, totaled 22,034 (Table 5). Coho salmon accounted for the majority of the salmonid catch (55%), followed by chinook salmon (36%), Dolly Varden (8%), and steelhead (1%). We did not attempt to enumerate or tag chinook salmon less than 55 mm in fork length.

Table 3.-Daily and cumulative catches of chinook, coho, and sockeye salmon smolt in the Killey River, 1997.

	Location	Chinook		Coho		Sockeye	
Date	rkm	Daily	Cum	Daily	Cum	Daily	Cum
17-May	0.06	300	300	115	115	0	0
18-May	0.06	61	361	99	214	0	0
19-May	0.06	63	424	128	342	0	0
20-May	0.06	127	551	287	629	0	0
21-May	0.06	55	606	190	819	10	10
22-May	0.06	159	765	357	1,176	50	60
23-May	0.06	210	975	590	1,766	30	90
24-May	0.06	371	1,346	676	2,442	10	100
25-May	0.06	669	2,015	629	3,071	10	110
26-May	0.06	523	2,538	454	3,525	10	120
27-May	0.06	420	2,958	492	4,017	10	130
28-May	0.06	109	3,067	144	4,161	0	130
29-May	0.06	120	3,187	151	4,312	0	130
30-May	0.06	130	3,317	215	4,527	10	140
31-May	0.06	180	3,497	193	4,720	0	140
1-Jun	0.06	290	3,787	583	5,303	10	150
2-Jun	0.06	255	4,042	578	5,881	10	160
3-Jun	0.06	200	4,242	275	6,156	10	170
4-Jun	0.06	108	4,350	220	6,376	10	180
5-Jun	0.06	219	4,569	475	6,851	10	190
6-Jun[a]	0.06		4,569		6,851		190
7-Jun	0.06	1,003	5,572	396	7,247	10	200
8-Jun	0.06	761	6,333	320	7,567	0	200
9-Jun	0.06	226	6,559	219	7,786	0	200
10-Jun	0.06	130	6,689	112	7,898	0	200
11-Jun	0.06	198	6,887	113	8,011	0	200
12-Jun	0.06	55	6,942	29	8,040	0	200
13-Jun	0.06	81	7,023	36	8,076	10	210
14-Jun	0.06	192	7,215	117	8,193	0	210
15-Jun	0.06	305	7,520	189	8,382	0	210
16-Jun	0.06	209	7,729	166	8,548	0	210
17-Jun	0.06	204	7,933	104	8,652	0	210
18-Jun	0.06	207	8,140	99	8,751	0	210
19-Jun	0.06	117	8,257	61	8,812	0	210
20-Jun	0.06	140	8,397	57	8,869	0	210
21-Jun	0.06	214	8,611	132	9,001	0	210
22-Jun	0.06	112	8,723	108	9,109	10	220
23-Jun	0.06	627	9,350	289	9,398	10	230
24-Jun	0.06	705	10,055	141	9,539	10	240
25-Jun	0.06	541	10,596	109	9,648	10	250
26-Jun	0.06	494	11,090	39	9,687	0	250
27-Jun	0.06	509	11,599	31	9,718	0	250
28-Jun	0.06	304	11,903	95	9,813	30	280
29-Jun	0.06	230	12,133	63	9,876	80	360

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Table 3.-Page 2 of 2.

	Location	Chinook		Coho		Sockeye	
Date	rkm	Daily	Cum	Daily	Cum	Daily	Cum
30-Jun	0.06	278	12,411	133	10,009	70	430
1-Jul	0.06	133	12,544	105	10,114	70	500
2-Jul	0.06	71	12,615	90	10,204	20	520
3-Jul	0.06	35	12,650	79	10,283	50	570
4-Jul	0.06	35	12,685	89	10,372	30	600
5-Jul	0.06	20	12,705	96	10,468	10	610
6-Jul	0.06	15	12,720	89	10,557	10	620
7-Jul	0.06	7	12,727	60	10,617	10	630
8-Jul	1.3	5	12,732	60	10,677	20	650
9-Jul	1.3	10	12,742	165	10,842	20	670
10-Jul	1.3	21	12,763	191	11,033	10	680
11-Jul	1.3	17	12,780	164	11,197	10	690
12-Jul	1.3	28	12,808	136	11,333	10	700
13-Jul	1.3	16	12,824	231	11,564	10	710
14-Jul	1.3	19	12,843	107	11,671	0	710
15-Jul	1.3	14	12,857	105	11,776	30	740
16-Jul	1.3	4	12,861	95	11,871	10	750
17-Jul	1.3	4	12,865	73	11,944	10	760
18-Jul	1.3	0	12,865	99	12,043	10	770
19-Jul	1.3	5	12,870	77	12,120	20	790
20-Jul	1.3	3	12,873	62	12,182	20	810
21-Jul	1.3	0	12,873	59	12,241	20	830
22-Jul	1.3	4	12,877	73	12,314	10	840
23-Jul	1.3	0	12,877	99	12,413	10	850
24-Jul[b]	1.3	3	12,880	59	12,472	10	860

[a] The trap was not fished in high water conditions.

[b] Total captures of other species include: 532 Dolly Varden *Salvelinus malma*, 38 rainbow trout *Oncorhynchus mykiss*, 67 round whitefish *Prosopium cylindraceum*, 573 slimy sculpin *Cottus cognatus*, 135 three-spine stickleback *Gasterosteus aculeatus*, and 121 Pacific lamprey *Lampetra tridentata*.

The remaining species included threespine stickleback *Gasterosteus aculeatus*, slimy sculpin *Cottus cognatus*, and Pacific lamprey *Lampetra tridentata*. Age-1.0 chinook salmon were present throughout the trapping period, but concentrated between 10 June and 3 July (Figure 12).

Small numbers of postemergent chinook salmon fry were captured from the onset of trapping. These age-0.0 fry were typically less than 50 mm in fork length, and were often impinged on the cleaning screen and passed out of the live box. By July, fingerling chinook salmon began to resemble age-1.0 smolt in size and appearance, and were the predominant age class in catches. As age-0.0 chinook salmon increased in length, they became increasingly difficult to distinguish from age-1.0 smolt. However, the overlap in length frequency distribution of the two age classes occurred after the majority of the age-1.0 emigration (Figure 13).

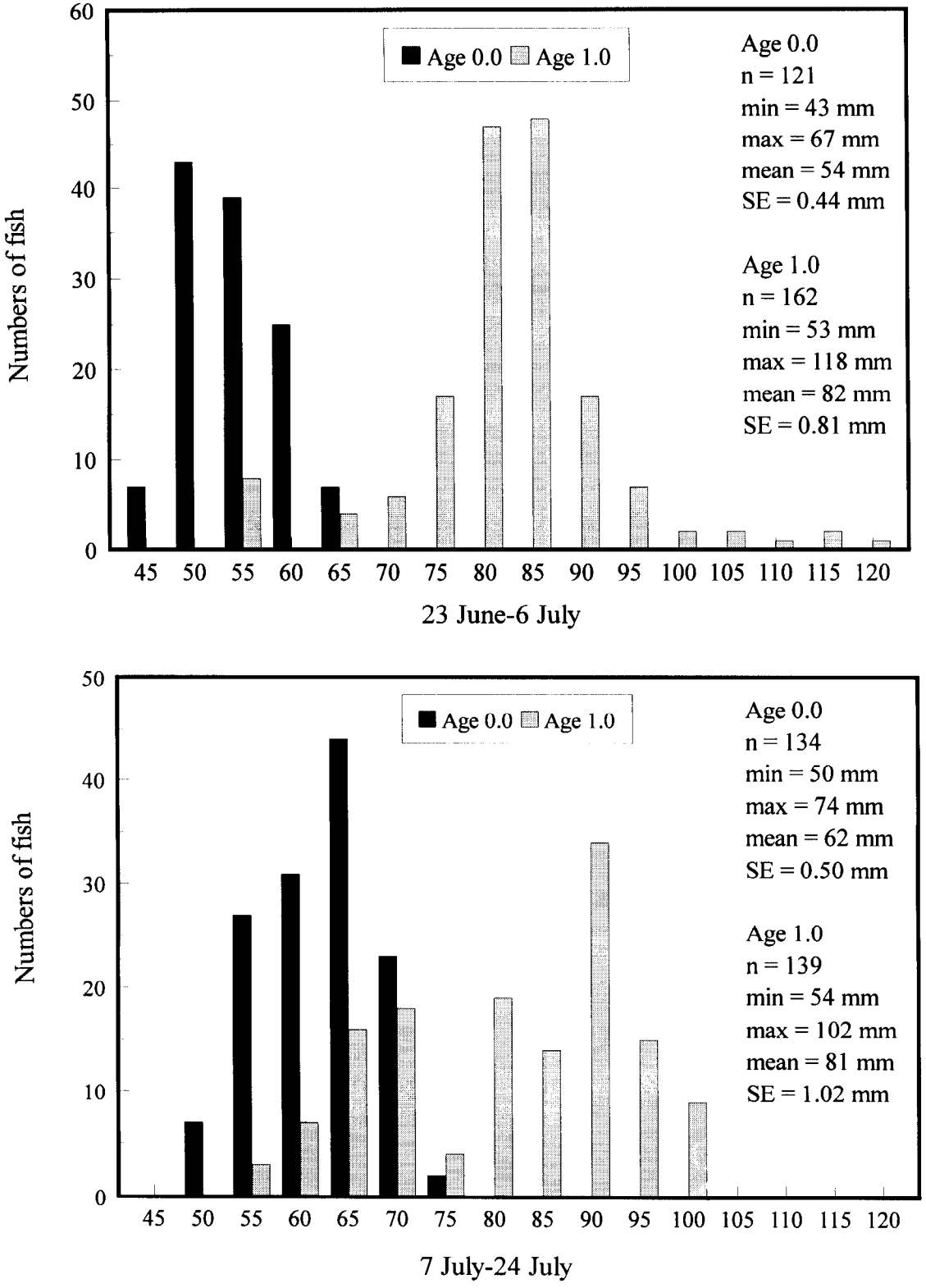

Figure 10.-Changes in length frequency distribution of age-0.0 and age-1.0 chinook salmon smolt over time in the Killey River, 1997.

Table 4.-Age composition of the harvest and inriver return of chinook salmon sampled in the Kenai River, 1997.

			Numbers of fish sampled							Proportion of Stratum Total of Aged Fish Only					Estimated Number of Chinook Salmon Examined for Tags					Tags	
			Age							Age					Age					Age	
Method	Run	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	1.2	1.3
Inriver Return	Early	5/17-6/30	0	16	132	227	4	105	484	0.00	0.04	0.35	0.60	0.01	0	20	169	290	5	0	0
	SE									0	0.010	0.025	0.025	0.005							
Inriver Return	Late	7/1-8/04	0	12	63	208	5	81	369	0.00	0.04	0.22	0.72	0.02	0	15	81	267	6	0	1
	SE									0	0.012	0.024	0.026	0.008							
	Total		0	28	195	435	9	186	853	0.00	0.08	0.57	1.32	.03	0	35	250	557	11	0	1
	SE									0	0.008	0.018	0.018	0.004							
Harvest	Early	5/17-6/30	0	5	17	132	7	37	198	0.00	0.03	0.11	0.82	0.04	0	6	21	162	9	0	0
	SE									0	0.014	0.024	0.030	0.016							
Harvest	Late	7/1-8/02	3	8	74	228	4	78	395	0.01	0.03	0.23	0.72	0.01	4	10	92	284	5	0	0
	SE									0.005	0.009	0.024	0.025	0.006							
	Total		3	13	91	360	11	115	593	0.01	0.06	0.34	1.54	0.05	4	16	113	446	14	0	0
	SE									0.004	0.007	0.018	0.020	0.007							
All	Total	5/17-8/04	3	41	286	795	20	301	1,446	0.01	0.14	0.91	2.86	0.08	4	51	363	1,003	25	0	1
	SE									0.002	0.005	0.013	0.014	0.004							

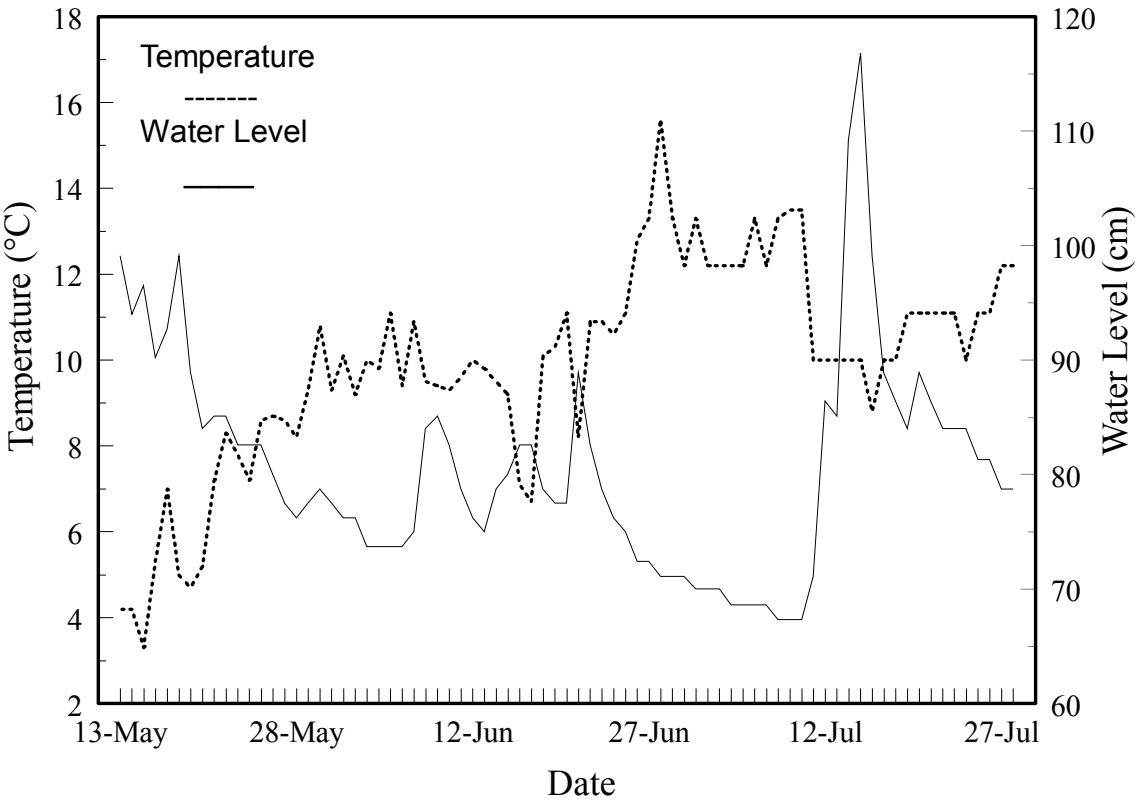

Figure 11.-Daily water level and temperature in Deep Creek, 1997.

Chinook salmon presumed to be age-0.0 smolt ranged from 32 mm to 80 mm in fork length, with a mean fork length of 58 mm (SE = 0.57 mm; Figure 14). Those presumed to be age-1.0 ranged from 64 to 108 mm, with an average of 89 mm (SE = 0.20 mm). Mean length increased from 38 mm in early June to 72 mm in mid July for age-0.0 chinook salmon smolt (Table 6).

We marked and released a total of 7,419 chinook salmon in Deep Creek during 1997 (Table 7). Approximately two-thirds of this total was age-1.0 migrants from the 1995 brood year and the remaining were age-0.0 migrants from the 1996 brood year. Short-term tag retention and mortality rates were 100% and 0%, respectively. Smolt caught but not tagged consisted primarily of age-0.0 fish below the minimum size, and capture and handling mortalities. A complete listing of the CWTs applied during this project is presented in Appendix A1.

We also marked and released a total of 6,948 coho salmon smolt in Deep Creek during 1997 (Table 7). Short-term tag retention and mortality rates for coho salmon smolt were 100% and 0%, respectively. An additional 5,173 fingerlings were captured. Smolt caught but not tagged consisted primarily of fish below the minimum size, and capture and handling mortalities.

Estimating θ from Inriver Return of Adults

Chinook Salmon

Deep Creek at the weir site is 21 m wide with a bottom profile that gradually increases to the deepest point approximately 4 m from the north bank (Figure 7). The water level fluctuations were within a 0.5 m range for the season.

Table 5.-Daily and cumulative catches of chinook salmon, coho salmon, Dolly Varden, and steelhead smolt in Deep Creek, 1997.

	Chinook									
	Age-0.0		Age-1.0		Coho		Dolly Varden		Steelhead	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
13-May	2	2	23	23	10	10	39	39	0	0
14-May	0	2	10	33	10	20	104	143	0	0
15-May	2	4	19	52	4	24	109	252	1	1
16-May	3	7	11	63	9	33	336	588	0	1
17-May	0	7	7	70	1	34	546	1,134	1	2
18-May	0	7	2	72	6	40	21	1,155	1	3
19-May	0	7	18	90	26	66	71	1,226	0	3
20-May	1	8	18	108	44	110	73	1,299	1	4
21-May	0	8	11	119	15	125	84	1,383	0	4
22-May	0	8	4	123	9	134	73	1,456	0	4
23-May	0	8	11	134	6	140	93	1,549	0	4
24-May	0	8	6	140	3	143	19	1,568	0	4
25-May	0	8	4	144	7	150	28	1,596	0	4
26-May	1	9	3	147	2	152	14	1,610	0	4
27-May	1	10	4	151	6	158	28	1,638	0	4
28-May	0	10	7	158	13	171	31	1,669	1	5
29-May	0	10	28	186	80	251	8	1,677	1	6
30-May	0	10	5	191	81	332	1	1,678	0	6
31-May	1	11	6	197	49	381	0	1,678	1	7
1-Jun	0	11	19	216	100	481	5	1,683	0	7
2-Jun	0	11	16	232	95	576	11	1,694	2	9
3-Jun	0	11	26	258	165	741	1	1,695	0	9
4-Jun	0	11	21	279	133	874	2	1,697	0	9
5-Jun	0	11	30	309	238	1,112	5	1,702	0	9
6-Jun	2	13	61	370	249	1,361	1	1,703	2	11
7-Jun	1	14	24	394	160	1,521	2	1,705	1	12
8-Jun	9	23	22	416	352	1,873	0	1,705	1	13
9-Jun	11	34	29	445	425	2,298	0	1,705	0	13
10-Jun	14	48	100	545	1,258	3,556	6	1,711	2	15
11-Jun	23	71	107	652	608	4,164	4	1,715	3	18
12-Jun	11	82	188	840	683	4,847	7	1,722	8	26
13-Jun	10	92	84	924	258	5,105	2	1,724	5	31
14-Jun	26	118	510	1,434	816	5,921	0	1,724	4	35
15-Jun	32	150	341	1,775	427	6,348	0	1,724	3	38
16-Jun	25	175	332	2,107	1,094	7,442	0	1,724	2	40
17-Jun	39	214	301	2,408	835	8,277	2	1,726	24	64
18-Jun	10	224	100	2,508	503	8,780	0	1,726	8	72
19-Jun	0	224	109	2,617	289	9,069	1	1,727	10	82
20-Jun	13	237	183	2,800	266	9,335	0	1,727	21	103
21-Jun	127	364	661	3,461	696	10,031	1	1,728	8	111
22-Jun	19	383	83	3,544	433	10,464	2	1,730	31	142
23-Jun	2	385	42	3,586	124	10,588	0	1,730	4	146
24-Jun	2	387	94	3,680	92	10,680	1	1,731	19	165

-continued-

Table 5.-Page 2 of 2.

	Chinook									
	Age-0.0		Age-1.0		Coho		Dolly Varden		Steelhead	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
25-Jun	3	390	72	3,752	98	10,778	0	1,731	12	177
26-Jun	8	398	28	3,780	36	10,814	0	1,731	7	184
27-Jun	10	408	114	3,894	38	10,852	0	1,731	5	189
28-Jun	4	412	114	4,008	39	10,891	1	1,732	7	196
29-Jun	18	430	82	4,090	37	10,928	0	1,732	3	199
30-Jun	12	442	70	4,160	49	10,977	0	1,732	8	207
1-Jul	153	595	213	4,373	57	11,034	0	1,732	16	223
2-Jul	160	755	129	4,502	45	11,079	0	1,732	3	226
3-Jul	120	875	132	4,634	54	11,133	0	1,732	5	231
4-Jul	139	1,014	86	4,720	51	11,184	0	1,732	1	232
5-Jul	78	1,092	52	4,772	38	11,222	0	1,732	4	236
6-Jul	61	1,153	44	4,816	27	11,249	0	1,732	2	238
7-Jul	42	1,195	27	4,843	12	11,261	0	1,732	1	239
8-Jul	28	1,223	30	4,873	17	11,278	0	1,732	4	243
9-Jul	89	1,312	26	4,899	12	11,290	0	1,732	0	243
10-Jul	89	1,401	26	4,925	14	11,304	1	1,733	0	243
11-Jul	90	1,491	26	4,951	13	11,317	3	1,736	0	243
12-Jul	160	1,651	2	4,953	23	11,340	4	1,740	0	243
13-Jul	82	1,733	8	4,961	28	11,368	2	1,742	0	243
14-Jul[a]		1,733		4,961		11,368		1,742		243
15-Jul	127	1,860	14	4,975	33	11,401	3	1,745	0	243
16-Jul	107	1,967	9	4,984	87	11,488	2	1,747	2	245
17-Jul	71	2,038	1	4,985	41	11,529	0	1,747	0	245
18-Jul	58	2,096	3	4,988	37	11,566	1	1,748	2	247
19-Jul	222	2,318	4	4,992	131	11,697	3	1,751	2	249
20-Jul	147	2,465	6	4,998	92	11,789	2	1,753	1	250
21-Jul	147	2,612	6	5,004	91	11,880	1	1,754	0	250
22-Jul	106	2,718	3	5,007	100	11,980	0	1,754	0	250
23-Jul	57	2,775	5	5,012	39	12,019	0	1,754	0	250
24-Jul	21	2,796	3	5,015	12	12,031	3	1,757	0	250
25-Jul	19	2,815	1	5,016	28	12,059	1	1,758	0	250
26-Jul	16	2,831	4	5,020	21	12,080	1	1,759	0	250
27-Jul	24	2,855	2	5,022	15	12,095	0	1,759	0	250
28-Jul	11	2,866	1	5,023	17	12,112	0	1,759	0	250
29-Jul[b]	7	2,873	3	5,026	12	12,124	2	1,761	0	250

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

[b] Total captures of other species include: 310 slimy sculpin (*Cottus cognatus*), 82 three-spine stickleback (*Gasterosteus aculeatus*), and 608 Pacific lamprey (*Lampetra tridentata*).

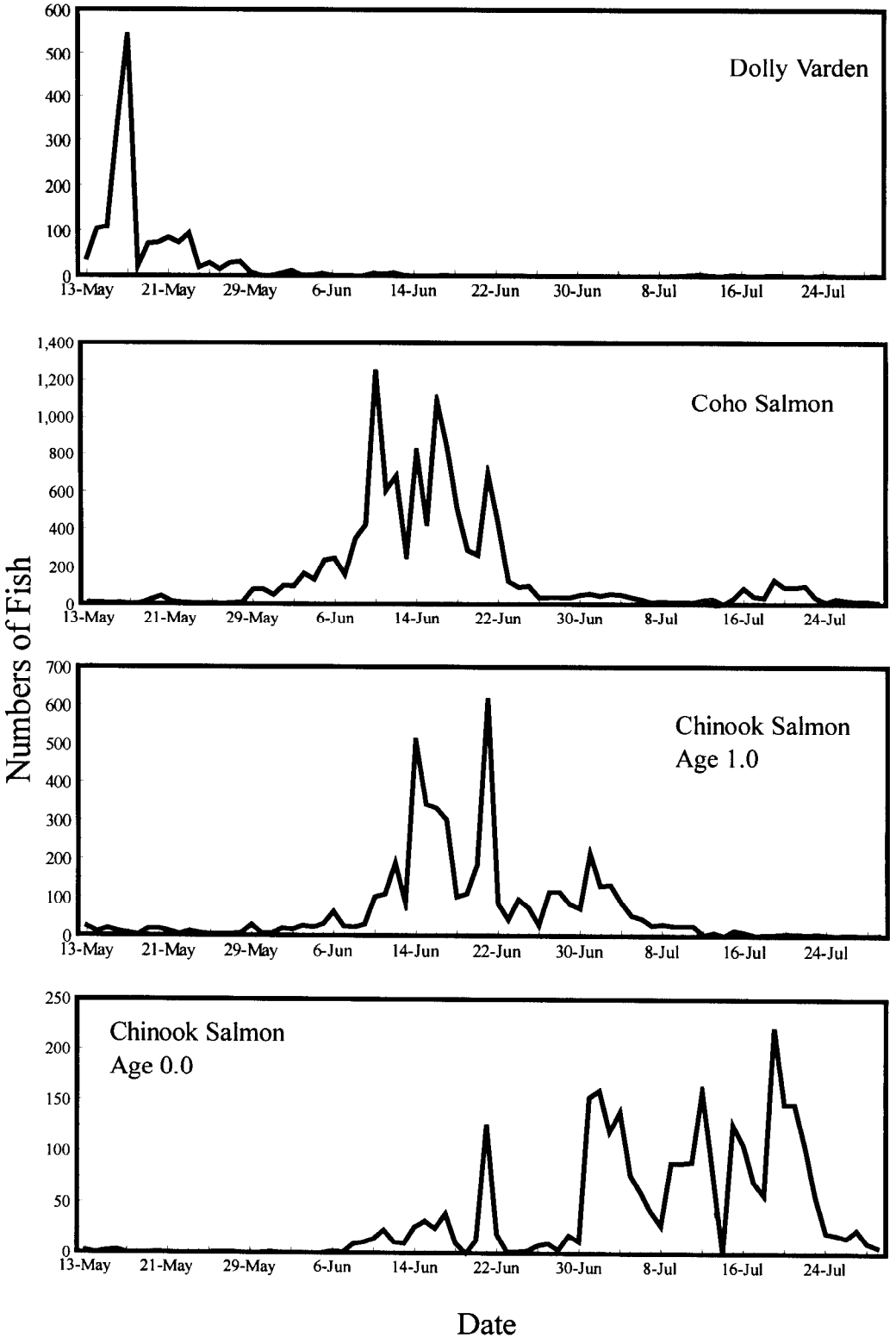

Figure 12.-Emigration timing for salmonid smolt captured in Deep Creek, 1997.

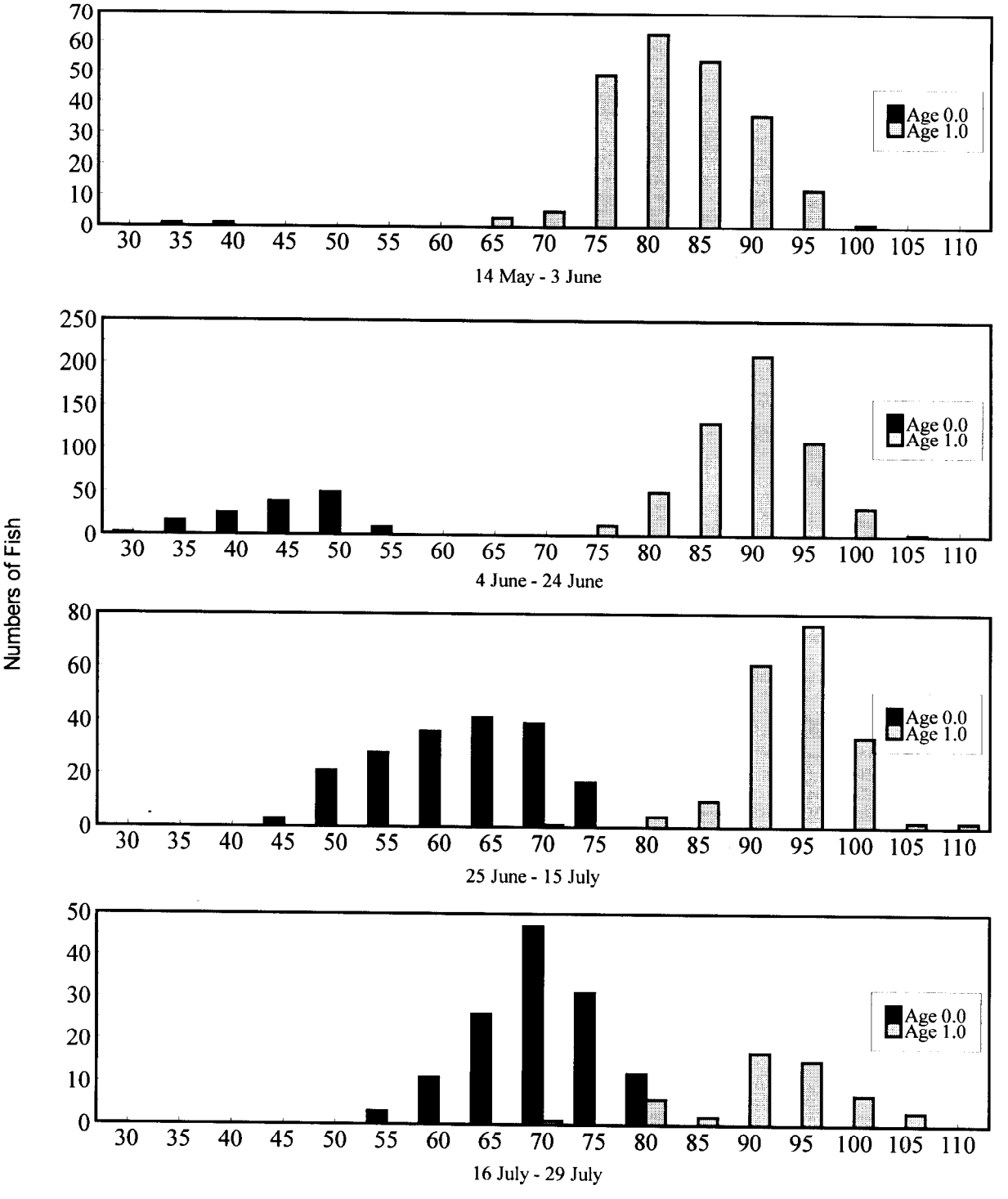

Figure 13.-Changes in length frequency distribution of age-0.0 and age-1.0 chinook salmon smolt over time in Deep Creek, 1997.

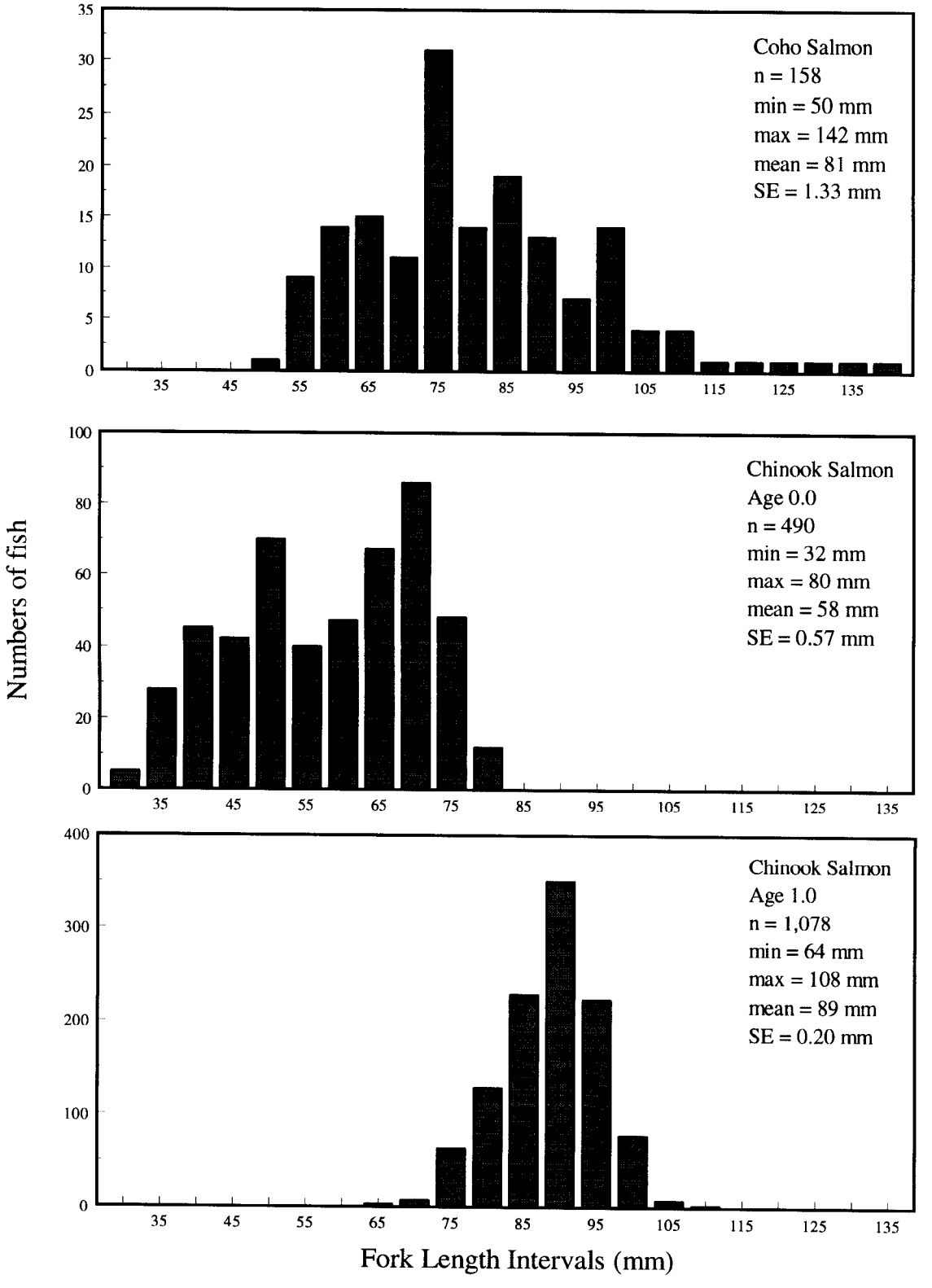

Figure 14.-Length frequency distributions for coho salmon smolt and age-0.0 and age-1.0 chinook salmon smolt captured in Deep Creek, 1997.

Table 6.-Age and length of chinook salmon juveniles captured in Deep Creek, 1994-1997.

	Age-0.0						Age-1.0					
		Length (mm)						Length (mm)				
Date		n	Min	Max	Mean	SE	Date		n	Min	Max	Mean	SE
1994							1994						
	25-Jun	100	42	62	51	0.4		14-Jun	44	72	99	86	0.8
	2-Jul	116	46	69	57	0.4		21-Jun	100	74	98	87	0.5
	7-Jul	148	44	72	59	0.5		28-Jun	150	73	103	87	0.5
	16-Jul	100	50	73	63	0.5		5-Jul	150	76	102	89	0.4
	26-Jul	100	51	84	71	0.6		7-Jul	164	74	104	89	0.4
								12-Jul	110	77	101	91	0.5
								19-Jul	100	80	108	93	0.6
1995[a]							1995[a]						
	19-Jul	240	48	81	65	0.4		21-Jun	240	68	101	88	0.3
	26-Jul	200	52	83	70	0.4		28-Jun	240	70	97	88	0.3
	2-Aug	220	51	96	72	0.5		5-Jul	214	77	103	89	0.3
								13-Jul	240	68	103	90	0.4
1996[a]							1996[a]						
	27-Jun	84	45	65	58	0.5		22-Jul	98	80	115	96	0.7
	22-Jul	148	65	85	75	0.4		23-Jul	30	85	115	98	1.2
	23-Jul	55	60	85	75	0.7		25-Jul	24	85	110	96	1.5
1997[a]							1997[a]						
	20-May	1	39	39	39	0.0		14-May	75	64	97	80	0.8
	27-May	1	35	35	35	0.0		21-May	43	68	90	80	0.8
	3-Jun	22	32	45	38	0.7		28-May	105	74	100	85	0.5
	10-Jun	88	32	53	42	0.6		4-Jun	287	75	103	89	0.3
	17-Jun	61	40	55	49	0.4		11-Jun	257	74	102	88	0.3
	24-Jun	47	46	63	53	0.6		18-Jun	70	80	105	92	0.6
	1-Jul	70	50	75	63	0.7		25-Jun	70	80	102	92	0.5
	8-Jul	60	57	77	67	0.7		2-Jun	70	71	108	94	0.6
	15-Jul	70	55	77	67	0.6		9-Jun	50	81	108	95	0.7
	22-Jul	70	62	80	72	0.6		16-Jun	32	71	99	89	1.2
								22-Jun	19	89	104	96	1.2

[a] No scales taken. Fish sorted into age class by size.

We completed weir installation on 24 May, immediately following the end of snowmelt runoff and operated through 21 September. No chinook salmon were observed during a survey of the river conducted shortly after weir installation, however, fish were observed passing the site in the 2 days required to complete installation.

A total of 1,732 chinook salmon passed the weir site during the operation dates (Table 8). Passage of chinook salmon occurred primarily through mid-July (Figure 15). We examined 905 chinook salmon for AFCs at the weir through 24 June, the day prior to the second event of the capture-recapture experiment upstream of the weir.

Table 7.-Dates, codes, and numbers of salmon smolt marked with coded wire tags and released in Deep Creek during 1997.

Species	Dates	Coded Wire Tag Codes	Brood Year	Age	No.
Chinook	5/13-7/29	31-25-53	1995	1.0	4,935
Chinook	6/28-7/29	31-25-52	1996	0.0	2,484
					7,419
Coho	5/13-7/29	31-25-49	1994	2.0	6,948

Five of the 147 fish captured upstream of the weir on 25 June had lower caudal punches (marked after 21 June) and were not considered in the analysis (Table 9). Forty-three of the remaining 142 fish had a single upper caudal punch received at the weir and 3 had double upper caudal punches received during the 19 June seining event. This left a total of 46 fish marked prior to 22 June and 96 unmarked fish, yielding an estimate of total passage through 21 June of 2,740 (SE = 316) chinook salmon. Summing with passage after 21 June (831 fish) yielded an estimate of total chinook salmon passage of 3,571 (SE = 316).

Our analysis of the mark-recapture data revealed that θ differed among seining locations (χ^2 = 12.0 , df = 2, P<0.003). In addition, unmarked fish captured and sampled with the seine were smaller than those sampled at the weir (KS test, D = 0.32, P<0.001). The seine sample included more small fish (<650 mm) and fewer large fish (>875 mm; Table 10). Almost all chinook less than 650 mm (85% at the weir and 95% in the seines) were males. The proportion of small fish did not differ significantly among seining sites.

There was no difference in the proportion of age-1.2 and -1.3 Deep Creek origin fish (χ^2 = 15.39, df = 9, p = 0.053) over time (Table 11). The resultant age structure was primarily age-1.3 (64.8%; SE = 1.24%) and -1.4 (29.4%; SE = 2.12%) adults. Technicians also correctly identified the sex on all fish that were subsequently subjected to gut cavity examination. The mean length of age-1.2, -1.3, and -1.4 chinook salmon sampled at the weir was 601 mm, 792 mm, and 887 mm, respectively (Table 12).

We collected heads from 136 AFC adult chinook salmon (Appendix B1). Sixteen heads did not contain a tag, and one head was lost. One tag was recovered from a chinook salmon that was misidentified and tagged as a coho. Of the remaining 118 chinook salmon with tags, 14 were hatchery-reared and released as smolt in the Ninilchik River. When expanded for unmarked fish, we estimated 51 (SE = 13) or 2.95% (SE = 0.7%) of the spawners passing the weir during its operation were strays from the Ninilchik River (Table 13).

Eighty-nine of the remaining AFC chinook salmon were age-1.3 adults tagged at Deep Creek in 1994 as age-1.0 smolt (Appendix B1). Fourteen were age-1.2 adults tagged as age-1.0 smolt in 1995. Only one of the recovered Deep Creek tags was originally implanted in an age-0.0 smolt although 3,644 were marked in 1994.

After subtracting the Ninilchik River chinook salmon from the sample, we tested the totals of marked and unmarked Deep Creek age-1.2 and -1.3 chinook salmon sampled at the weir to see if θ changed over time (Table 13). We pooled the age-1.3 fish data into 1-week strata from

Table 8.-Daily and cumulative adult chinook and coho salmon weir counts in Deep Creek, 1997.

	Chinook						Coho					
Date	Unclipped	Cum	AFC	Cum	Total	Cum	Unclipped	Cum	AFC	Cum	Total	Cum
24-May	5	5	0	0	5	5	0	0	0	0	0	0
25-May	0	5	0	0	0	5	0	0	0	0	0	0
26-May	20	25	6	6	26	31	0	0	0	0	0	0
27-May	9	34	0	6	9	40	0	0	0	0	0	0
28-May	19	53	1	7	20	60	0	0	0	0	0	0
29-May	28	81	3	10	31	91	0	0	0	0	0	0
30-May	11	92	0	10	11	102	0	0	0	0	0	0
31-May	12	104	4	14	16	118	0	0	0	0	0	0
1-Jun	78	182	4	18	82	200	0	0	0	0	0	0
2-Jun	67	249	3	21	70	270	0	0	0	0	0	0
3-Jun	59	308	5	26	64	334	0	0	0	0	0	0
4-Jun	19	327	0	26	19	353	0	0	0	0	0	0
5-Jun	79	406	12	38	91	444	0	0	0	0	0	0
6-Jun	56	462	7	45	63	507	0	0	0	0	0	0
7-Jun	16	478	4	49	20	527	0	0	0	0	0	0
8-Jun	112	590	11	60	123	650	0	0	0	0	0	0
9-Jun	40	630	3	63	43	693	0	0	0	0	0	0
10-Jun	11	641	2	65	13	706	0	0	0	0	0	0
11-Jun	4	645	0	65	4	710	0	0	0	0	0	0
12-Jun	0	645	0	65	0	710	0	0	0	0	0	0
13-Jun	0	645	0	65	0	710	0	0	0	0	0	0
14-Jun	18	663	1	66	19	729	0	0	0	0	0	0
15-Jun	16	679	0	66	16	745	0	0	0	0	0	0
16-Jun	35	714	6	72	41	786	0	0	0	0	0	0
17-Jun	5	719	1	73	6	792	0	0	0	0	0	0
18-Jun	14	733	0	73	14	806	0	0	0	0	0	0
19-Jun	10	743	1	74	11	817	0	0	0	0	0	0
20-Jun	41	784	4	78	45	862	0	0	0	0	0	0
21-Jun	33	817	5	83	38	900	0	0	0	0	0	0
22-Jun	14	831	0	83	14	914	0	0	0	0	0	0
23-Jun	4	835	1	84	5	919	0	0	0	0	0	0
24-Jun	45	880	3	87	48	967	0	0	0	0	0	0
25-Jun	25	905	3	90	28	995	0	0	0	0	0	0
26-Jun	24	929	4	94	28	1,023	0	0	0	0	0	0
27-Jun	14	943	2	96	16	1,039	0	0	0	0	0	0
28-Jun	35	978	1	97	36	1,075	0	0	0	0	0	0
29-Jun	37	1,015	5	102	42	1,117	0	0	0	0	0	0
30-Jun	14	1,029	1	103	15	1,132	0	0	0	0	0	0
1-Jul	11	1,040	0	103	11	1,143	0	0	0	0	0	0
2-Jul	13	1,053	1	104	14	1,157	0	0	0	0	0	0
3-Jul	21	1,074	1	105	22	1,179	0	0	0	0	0	0
4-Jul	10	1,084	0	105	10	1,189	0	0	0	0	0	0
5-Jul	39	1,123	2	107	41	1,230	0	0	0	0	0	0
6-Jul	12	1,135	0	107	12	1,242	0	0	0	0	0	0
7-Jul	35	1,170	3	110	38	1,280	0	0	0	0	0	0

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Table 8.-Page 2 of 3.

	Chinook						Coho					
Date	Unclipped	Cum	AFC	Cum	Total	Cum	Unclipped	Cum	AFC	Cum	Total	Cum
8-Jul	9	1,179	1	111	10	1,290	0	0	0	0	0	0
9-Jul	13	1,192	2	113	15	1,305	0	0	0	0	0	0
10-Jul	13	1,205	3	116	16	1,321	0	0	0	0	0	0
11-Jul	75	1,280	5	121	80	1,401	0	0	0	0	0	0
12-Jul	95	1,375	5	126	100	1,501	0	0	0	0	0	0
13-Jul	60	1,435	5	131	65	1,566	0	0	0	0	0	0
14-Jul[a]		1,435		131		1,566						
15-Jul[a]		1,435		131		1,566						
16-Jul	21	1,456	0	131	21	1,587	0	0	0	0	0	0
17-Jul	13	1,469	0	131	13	1,600	0	0	0	0	0	0
18-Jul	23	1,492	0	131	23	1,623	0	0	0	0	0	0
19-Jul	15	1,507	0	131	15	1,638	0	0	0	0	0	0
20-Jul	13	1,520	0	131	13	1,651	0	0	0	0	0	0
21-Jul	6	1,526	2	133	8	1,659	0	0	0	0	0	0
22-Jul	13	1,539	2	135	15	1,674	0	0	0	0	0	0
23-Jul	4	1,543	0	135	4	1,678	0	0	0	0	0	0
24-Jul	19	1,562	0	135	19	1,697	0	0	0	0	0	0
25-Jul	7	1,569	1	136	8	1,705	0	0	0	0	0	0
26-Jul	1	1,570	0	136	1	1,706	0	0	0	0	0	0
27-Jul	2	1,572	0	136	2	1,708	0	0	0	0	0	0
28-Jul	1	1,573	0	136	1	1,709	0	0	0	0	0	0
29-Jul	1	1,574	0	136	1	1,710	0	0	0	0	0	0
30-Jul	0	1,574	0	136	0	1,710	0	0	0	0	0	0
31-Jul	2	1,576	0	136	2	1,712	0	0	0	0	0	0
1-Aug	0	1,576	0	136	0	1,712	0	0	0	0	0	0
2-Aug	2	1,578	0	136	2	1,714	1	1	0	0	1	1
3-Aug	0	1,578	0	136	0	1,714	1	2	0	0	1	2
4-Aug	0	1,578	0	136	0	1,714	0	2	0	0	0	2
5-Aug	5	1,583	0	136	5	1,719	1	3	0	0	1	3
6-Aug	1	1,584	0	136	1	1,720	3	6	2	2	5	8
7-Aug	0	1,584	0	136	0	1,720	6	12	0	2	6	14
8-Aug	1	1,585	0	136	1	1,721	1	13	0	2	1	15
9-Aug	2	1,587	0	136	2	1,723	1	14	0	2	1	16
10-Aug	0	1,587	0	136	0	1,723	1	15	1	3	2	18
11-Aug	1	1,588	0	136	1	1,724	18	33	5	8	23	41
12-Aug	1	1,589	0	136	1	1,725	59	92	19	27	78	119
13-Aug	2	1,591	0	136	2	1,727	2	94	0	27	2	121
14-Aug	1	1,592	0	136	1	1,728	15	109	1	28	16	137
15-Aug	0	1,592	0	136	0	1,728	3	112	1	29	4	141
16-Aug	0	1,592	0	136	0	1,728	18	130	3	32	21	162
17-Aug	0	1,592	0	136	0	1,728	5	135	2	34	7	169
18-Aug	0	1,592	0	136	0	1,728	6	141	1	35	7	176
19-Aug	0	1,592	0	136	0	1,728	8	149	1	36	9	185
20-Aug	0	1,592	0	136	0	1,728	1	150	0	36	1	186
21-Aug	0	1,592	0	136	0	1,728	54	204	10	46	64	250

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Table 8.-Page 3 of 3.

	Chinook						Coho					
Date	Unclipped	Cum	AFC	Cum	Total	Cum	Unclipped	Cum	AFC	Cum	Total	Cum
22-Aug	0	1,592	0	136	0	1,728	117	321	15	61	132	382
23-Aug	0	1,592	0	136	0	1,728	197	518	29	90	226	608
24-Aug	0	1,592	0	136	0	1,728	72	590	10	100	82	690
25-Aug	0	1,592	0	136	0	1,728	38	628	2	102	40	730
26-Aug	0	1,592	0	136	0	1,728	286	914	38	140	324	1,054
27-Aug	0	1,592	0	136	0	1,728	199	1,113	25	165	224	1,278
28-Aug	2	1,594	0	136	2	1,730	59	1,172	11	176	70	1,348
29-Aug	0	1,594	0	136	0	1,730	5	1,177	3	179	8	1,356
30-Aug	0	1,594	0	136	0	1,730	36	1,213	3	182	39	1,395
31-Aug	0	1,594	0	136	0	1,730	105	1,318	14	196	119	1,514
1-Sep	0	1,594	0	136	0	1,730	12	1,330	2	198	14	1,528
2-Sep	1	1,595	0	136	1	1,731	11	1,341	2	200	13	1,541
3-Sep	0	1,595	0	136	0	1,731	7	1,348	1	201	8	1,549
4-Sep	0	1,595	0	136	0	1,731	1	1,349	0	201	1	1,550
5-Sep	0	1,595	0	136	0	1,731	6	1,355	0	201	6	1,556
6-Sep	0	1,595	0	136	0	1,731	8	1,363	3	204	11	1,567
7-Sep	0	1,595	0	136	0	1,731	62	1,425	10	214	72	1,639
8-Sep	0	1,595	0	136	0	1,731	136	1,561	16	230	152	1,791
9-Sep	0	1,595	0	136	0	1,731	123	1,684	12	242	135	1,926
10-Sep	1	1,596	0	136	1	1,732	48	1,732	5	247	53	1,979
11-Sep	0	1,596	0	136	0	1,732	4	1,736	0	247	4	1,983
12-Sep	0	1,596	0	136	0	1,732	2	1,738	0	247	2	1,985
13-Sep	0	1,596	0	136	0	1,732	0	1,738	0	247	0	1,985
14-Sep	0	1,596	0	136	0	1,732	0	1,738	0	247	0	1,985
15-Sep	0	1,596	0	136	0	1,732	0	1,738	0	247	0	1,985
16-Sep	0	1,596	0	136	0	1,732	0	1,738	0	247	0	1,985
17-Sep	0	1,596	0	136	0	1,732	0	1,738	0	247	0	1,985
18-Sep	0	1,596	0	136	0	1,732	16	1,754	4	251	20	2,005
19-Sep	0	1,596	0	136	0	1,732	0	1,754	0	251	0	2,005
20-Sep	0	1,596	0	136	0	1,732	10	1,764	2	253	12	2,017
21-Sep	0	1,596	0	136	0	1,732	0	1,764	0	253	0	2,017

[a] High water resulted in incomplete catch data.

24 May through 19 July and found that there was no difference in θ over time (χ^2 = 11.92, df = 7, p = 0.105). We did not include the data from 20 July through 21 September when the last 65 chinook salmon passed the weir. The tagged age-0.3 fish was also not used in this analysis.

Since there were only 90 age-1.2 Deep Creek chinook salmon examined at the weir, we pooled these fish into two strata with roughly half of the fish examined in each stratum. The resultant statistic (χ^2 = 1.51 df = 1, p = 0.22) indicated there was no difference in θ over time.

Because the weekly estimates of the proportion of marked age-1.3 chinook salmon ranged only between 2% and 14%, we concluded that the differences were too small to cause serious bias in pooling all of the data to estimate θ for that age class. We therefore pooled all of the tag

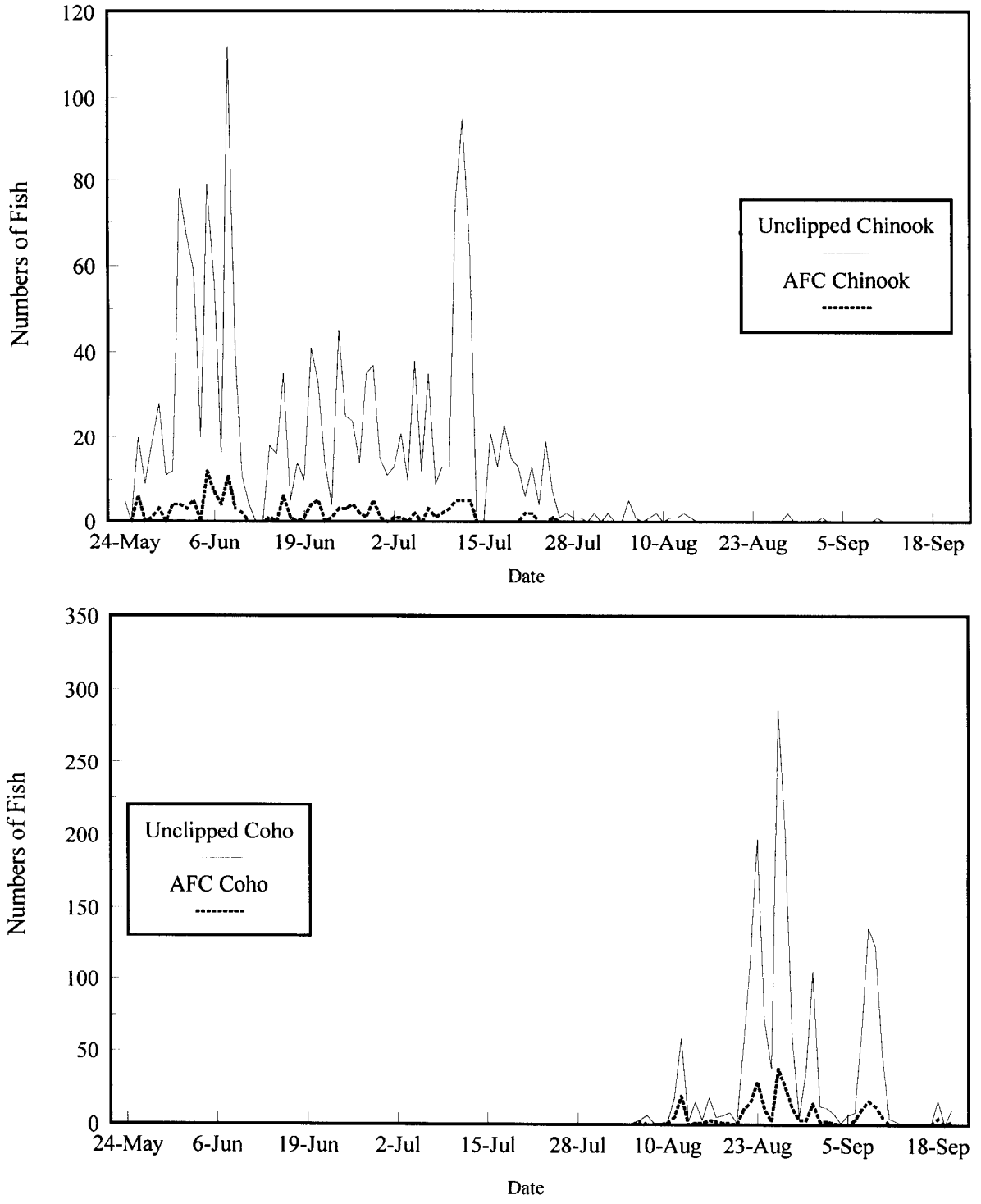


Figure 15.-Adult chinook and coho salmon escapement through the Deep Creek weir, 1997.

Table 9.-Results of seining at three different locations above the Deep Creek weir on 25 June 1997.

Location	Single Lower Caudal Punch	Single Upper Caudal Punch	Double Upper Caudal Punch	No mark	Total
Upper	1	16	1	41	59
Middle	2	13	1	8	24
Lower	2	14	1	47	64
Total	5	43	3	96	147

recovery data by ocean age class to estimate θ for the age-1.2 and -1.3 chinook salmon (Table 13). Our estimate of θ for the age-1.3 chinook salmon from the 1993 brood year was 8.11% (SE = 0.82%). The estimated variance of 1/θ (12.33) was 1.666. In contrast, our estimate of θ for the age-1.2 chinook salmon from the 1994 brood year was 15.28% (SE = 3.78%). The estimated variance of 1/θ (6.54) was 5.048.

We compared θ of adults from the 1992 brood year that returned in 1996 (age-1.2) and 1997 (age-1.3), and found no difference (χ^2 = 0.29 df = 1, p = 0.588) between the years. We were therefore able to combine the data for both years to estimate the marking rate for the cohort to date (age-1.4 fish will return in 1998) at 7.65% (SE = 0.75%). Based on our age-1.0 smolt marking total in 1994 (9,611 smolt), and measured θ in 1996-1997 (0.0765), our estimate of the smolt emigration in 1994, pending return of the age-1.4 adults, was approximately 119,000 (SE = 11,202).

Coho Salmon

A total of 2,017 coho salmon passed the weir site during the operation dates (Table 8). The migration began on 2 August and peaked late in the month. Increases in the daily counts generally followed freshets by 1-2 days (Figure 16).

Table 10.-Length composition of adult chinook salmon marked at the weir through 21 June and unmarked chinook salmon captured in seines on 25 June 1997.

Method	Length <650 mm	Length 650-875 mm	Length >875 mm	Total
Weir	40 4%	671 75%	189 21%	900
Seine	20 21%	73 76%	3 3%	96

Table 11.-Deep Creek adult chinook salmon age composition by week, 1997.

		Deep Creek Chinook						
		Brood Year and Age Class						
		1993	1994	1993	1992	1991	1990	1991
Date		0.3	1.1	1.2	1.3	1.4	1.5	2.3
24-May	31-May	1		4	62	30		
		1%		4%	64%	31%		
1-Jun	7-Jun			20	217	110		
				6%	62%	32%		
8-Jun	14-Jun			9	121	45		1
				5%	69%	26%		1%
15-Jun	21-Jun			3	85	59		
				2%	58%	40%		
22-Jun	28-Jun		1	9	94	50		1
			1%	6%	61%	32%		1%
29-Jun	5-Jul			10	79	35		
				8%	64%	28%		
6-Jul	12-Jul		1	14	165	60	1	
			0%	6%	68%	25%	0%	
13-Jul	19-Jul			8	84	30		1
				7%	68%	24%		1%
20-Jul	21-Sep			2	54	16		1
				3%	74%	22%		1%
	Total	1	2	79	961	435	1	4
	%	0.07	0.13	5.33	64.8	29.3	0.07	0.27
	SE	0.00	0.00	0.01	0.01	0.01	0.00	0.00

Table 12.-Lengths of adult chinook salmon by age class at the Deep Creek weir, 1997.

Age	n	Min (mm)	Max (mm)	Mean (mm)	SE (mm)
0.3	1	780	780	780	
1.1	2	383	571	477	66.5
1.2	79	460	735	601	6.3
1.3	961	550	950	792	1.6
1.4	435	725	1062	887	2.5
1.5	1	1015	1015	1015	
2.3	4	751	820	782	12.3

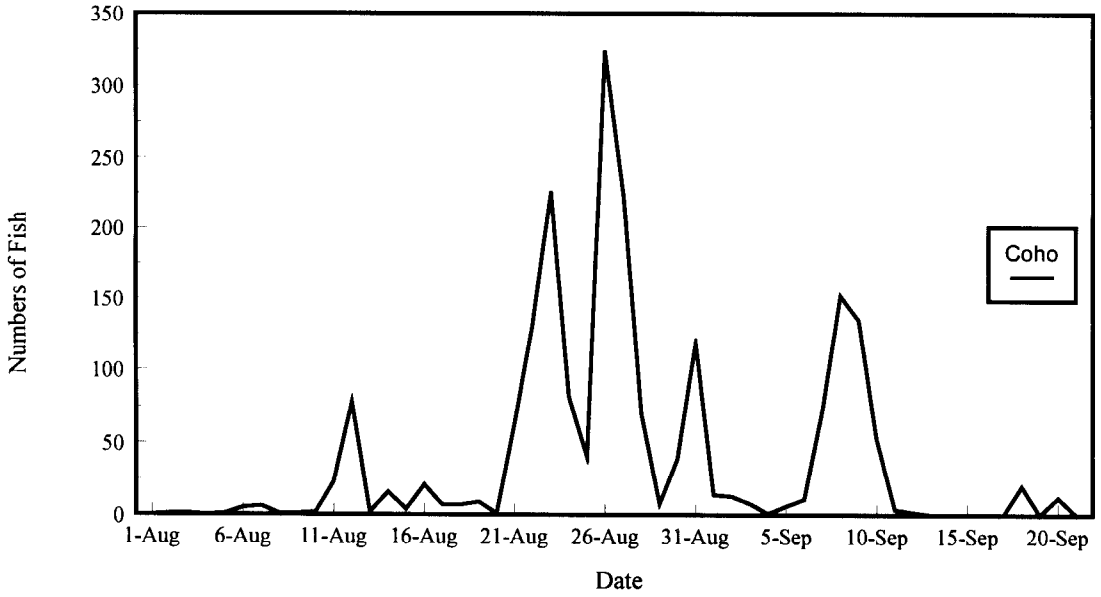
Table 13.-Marked proportion of Ninilchik River and Deep Creek chinook salmon captured in Deep Creek, 1997.

		Estimated Number by Ocean Age of Chinook Salmon Counted Through the Weir[a]						Estimated Number by Ocean Age of Ninilchik River Chinook Salmon Adults Counted through the Weir[b]						Estimated Number by Ocean Age of Deep Creek Chinook Salmon Adults Counted Through the Weir[c]				Estimated Tagged Deep Creek Chinook Salmon							
																		Age-1.2				Age-1.3			
Stratum Start Date	Stratum End Date	Age 1.1	1.2	1.3	1.4	1.5	All Ages	Age 1.1	1.2	1.3	1.4	Marked Proportion of Total	SE	Age 1.1	1.2	1.3	1.4	AFC	Marked Proportion of Total	SE	Variance Inverse Theta	AFC	Marked Proportion of Total	SE	Variance Inverse Theta
24-May	31-May	0	5	77	36	0	118	0	0	0	0	0.0000		0	5	77	36	2	0.4110			9	0.1174		
1-Jun	7-Jun	0	23	255	131	0	409	0	0	4	4	0.0213		0	23	250	127	3	0.1284			24	0.0959		
8-Jun	6/14/97	0	10	140	51	0	202	0	0	4	0	0.0219		0	10	136	51	3	0.2921			13	0.0956		
15-Jun	21-Jun	0	3	99	69	0	171	0	0	0	0	0.0000		0	3	99	69	1	0.2865			14	0.1416		
22-Jun	28-Jun	1	12	106	55	0	175	0	2	4	0	0.0368		1	10	102	55	0	0.0000			9	0.0883		
29-Jun	5-Jul	0	12	98	44	0	154	0	0	4	4	0.0563		0	12	94	40	2	0.1626			3	0.0319		
7-Jul	12-Jul	1	16	185	68	1	271	0	0	0	4	0.0159		1	16	185	64	2	0.1276			14	0.0758		
13-Jun	19-Jul	0	9	95	33	0	137	0	0	4	0	0.0323		0	9	91	33	1	0.1131			2	0.0221		
20-Jul	21-Sep	0	4	68	22	0	94	0	1	4	9	0.1492		0	3	64	13	0	0.0000			1	0.0156		
24-May	21-Sep	2	95	1,124	510	1	1,732	0	3	27	21	0.0295	0.0073	2	92	1,097	489	14	0.1528	0.0378	5.0482	89	0.0811	0.0082	1.6658

[a] Product of proportion of fish by age class by week and all fish captured, including unaged, in the sample by week.

[b] Product of the number of marked Ninilchik River chinook salmon adults in the sample and 1/θ for the cohort hatchery release.

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



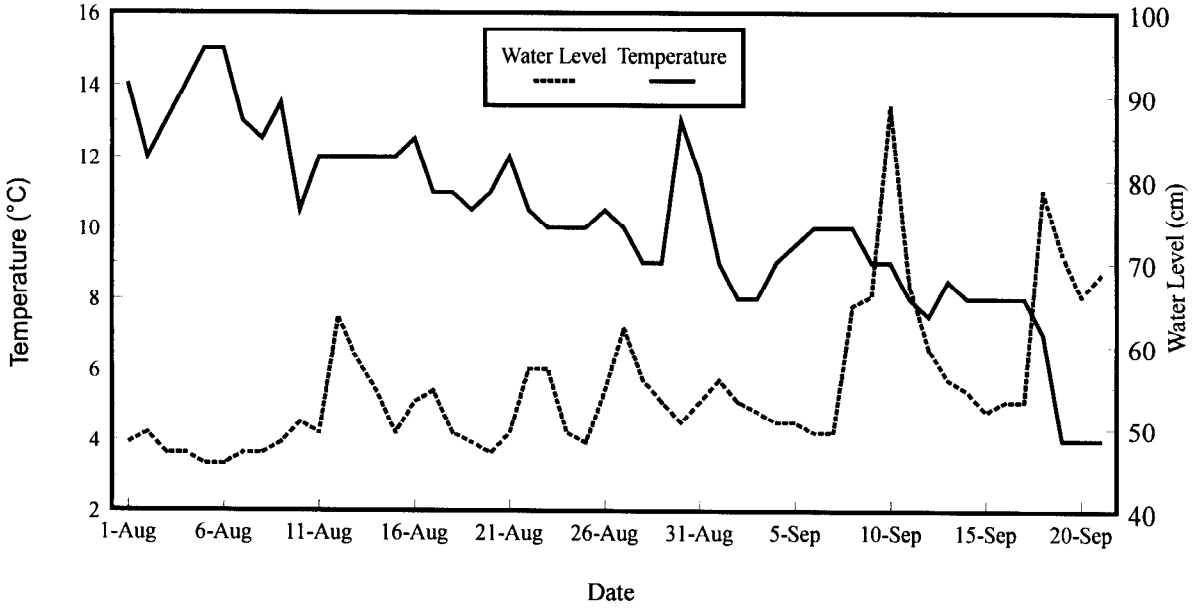


Figure 16.-Daily water level, temperature, and adult coho salmon passage at the Deep Creek weir, 1997.

Ninety-eight percent of the coho salmon adults with readable scales (n = 364) were age 2.1. The remaining fish were age 1.1 and 3.1 (1% each). Coho salmon average length was 589 mm (SE = 1.80 mm) and ranged from 467 to 722 mm (Figure 17).

We poststratified numbers of coho salmon into two equal size groups covering 2 August through 21 September. There was no significant (χ^2 = 1.12, df = 2, P = 0.29) difference in θ of coho salmon observed among strata, indicating a representative sample of coho salmon smolt were marked in 1996. We therefore pooled all of the tag recovery data, resulting in 253 tags from 2,017 fish. Theta was estimated as 12.54% (SE = 0.74%), and the estimated variance of 1/θ (7.97) was 0.23.

1996 Coho Salmon Smolt Estimate

Marking a representative sample of coho salmon smolt allowed us to estimate the smolt emigration in 1996. Based on the number of coho salmon smolt marked with AFCs (4,868), the number of adult coho salmon examined for AFCs (2,017), and the number of adult coho salmon observed with AFCs (253), the estimated smolt emigration was 38,683 (SE = 2,205; Table 14).

Marine Survival

The sport harvest of coho salmon in Deep Creek totaled 1,239 in 1997. The minimum marine survival of Deep Creek coho salmon from the 1996 smolt emigration was 8.4% (SE = 5.7%; Table 14). The estimate did not include marine sport or commercial harvests in the total return. It is not thought that marine sport or commercial harvests are substantial for the Deep Creek stock.

DISCUSSION

KENAI RIVER

The decision to mark smolt at rkm 34 of the mainstem and in the Killey River resulted in an increase in the number of marks from approximately 6,500 in 1996 to 32,000 in 1997. The efficiency of traps in the delta in previous years was reduced because of limited fishing time caused by operating in a tidally influenced region of the river. In addition, traps were not necessarily fished in that portion of the river where chinook salmon smolt tend to migrate. 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. The results were the same this year. Surface water velocity in the delta varies with tide stage and is relatively uniform across the river.

Operating traps in the high current of the mainstem caused some additional mortality. Highest mortality was associated with the rotary screw trap when surface water velocity reached 8 fps. The fish from this trap were alive after capture, but handling during the marking process increased mortality. We lowered the mortality rate by changing our handling procedures to reduce the time between capture and marking, and thus reduced the number of times each fish was handled. However, mortality of chinook salmon smolt captured by the screw trap did not decrease to an acceptable rate until the trap was moved to slower current near shore. We successfully fished the inclined plane traps at the mainstem site, although insufficient floatation forced us to reduce fishing depth when surface velocity exceeded approximately 7 fps.

The addition of a second site on the Killey River also contributed significantly to the catch totals. The river at the site is constricted, and the trap was placed in the deepest part of the channel, with

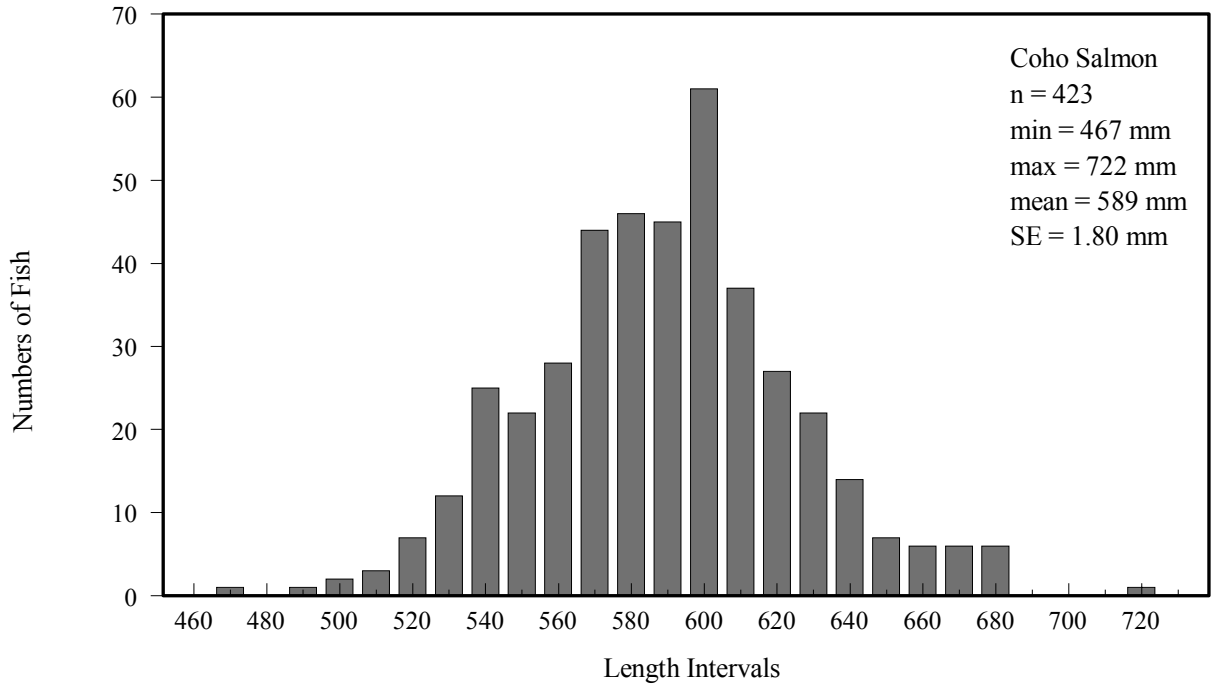


Figure 17.-Deep Creek adult coho salmon length frequency distribution, 1997.

the fastest current. We used a diversion fence to deflect the current on the opposite side of the river toward the trap such that the cross-sectional coverage appeared equal to that of Deep Creek where we are tagging 8%-15% of the emigration. Consequently, the Killey River site produced 39% of the total tagged fish released in the Kenai River. The rotary smolt trap employed at the Killey River worked well, and the resultant handling mortality and tag retention rates were similar to Deep Creek, a similarly sized tributary.

We did not catch and mark adequate numbers of smolt to meet project objectives. Our total of marked fish, approximately 32,000, was 22% of the desired number. We are also uncertain whether operating in both locations resulted in proportional marking of early- and late-run chinook salmon smolt. Burger et al. (1984) found that early-run spawners were predominantly bound for tributary streams including the Killey River. However, Litchfield and Flagg (1986) captured smolt in the Killey River that were tagged as parr in the mainstem in the previous year. We found that the timing of the Killey River smolt migration was earlier than that of other Kenai stocks. However, we do not know the origin of the stocks exiting the river in July and August, or those comprising the remainder of the June mainstem trap catch.

Technicians inspecting the adult escapement and inriver harvest to estimate θ examined approximately 60% more adult chinook salmon than the previous year. However, the fraction of the total escapement sampled was very low (0.02). The fraction of the escapement and inriver harvest examined is in part a function of available manpower, and we think that the precision levels of the estimates will not change significantly without significant cost to increase the numbers of fish examined.

Table 14.-Summary of Deep Creek coho salmon production.

			Smolt			Estimated Smolt Migration			Escapement Sample				
Brood Year	Smolt Year	Parent Escapement	Number Tagged	Marked Proportion	SE	Numbers	SE	Inriver Harvest	Number	Tag Recoveries	Total Return[a]	Marine Survival	SE
1990								1,895					
1991								1,014					
1992	1995		9,671	0.2780	0.0314	34,351	3779	1,333	205	57			
1993	1996		4,868	0.1254	0.0074	38,683	2205	1,239	2,017	253	3,256	0.0842	0.0570
1994	1997		6,948										
1995													
1996													
1997		2,017											

[a] The 1997 total return does not include marine harvests.

The lack of inriver recoveries was contrary to our expectations. The 1997 adult chinook salmon total (early and late) inriver return was 54,634 (Bosch and Burwen 1999), of which approximately 4% were age 1.2 and 29% were age 1.3. We examined 51 of the age-1.2 and 363 of the age-1.3 chinook salmon.

We estimated that we marked enough fry in 1993 to account for approximately 6% of the age-1.0 smolt in the drainage in 1994 and 4% of the age-1.0 smolt in the drainage in 1995. If our assumptions regarding the marking rate of the 1994 and 1995 smolt were accurate, then we should have seen 29 adults with Kenai River tags in the 1997 escapement and creel programs. We actually recovered 6 AFC fish of which 3 had no tag, 2 were of Crooked Creek origin, and 1 was of Kenai River origin. This is the second consecutive year that we were well below the expected number of tag recoveries. Possible explanations for this discrepancy include 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. Further sampling of this cohort in 1998 and 1999 will help resolve this question.

Since we had no random tag recoveries from returning age-1.2 adults and only one recovery from returning age-1.3 adults, we cannot estimate the numbers of smolt exiting the drainage in 1994 or 1995. We also cannot estimate the survival rate of either age-0.0 fry to smolt or age-1.0 smolt to adults (marine survival). We also cannot estimate the contribution of Kenai River chinook salmon to the Deep Creek marine recreational sport and Upper Cook Inlet East Side set net commercial gillnet fisheries (McKinley 1999). However, in 1997, age-1.2 and age-1.3 chinook salmon with CWTs placed in Kenai chinook salmon were present in both fisheries.

DEEP CREEK

Chinook Salmon

Results from Deep Creek suggest that chinook salmon smolt emigrate throughout much of the open water season with peak movements in early summer during mid June through mid July. Similar chinook salmon peak emigration times are reported for other Cook Inlet drainages including the Anchor River (Allin 1957), Kasilof River (Waite 1979) and the Kenai River (King et al. 1996). Emigration times for Cook Inlet chinook salmon stocks are later than those reported for stocks in more southern latitudes (Healey 1991). Daily peaks in migration did appear to accompany freshets following rain events.

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 immediately following emergence 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). 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, Healey 1991).

In our 1994 CWT sample, 73% of the markable (larger than 55 mm) fish were age-1.0 If the age-0.0 migrants survived at the same rate as the age-1.0 smolt, approximately 33 additional AFC adults should have been recaptured that were tagged as age 0.0 Only one of this year’s recoveries of 3-ocean adults was tagged as an age-0.0 smolt. The 1995 smolt tagging produced 14 marked adults at the weir. All were marked as age-1.0 smolt. Since the age-0.0 component was 38% of the marked smolt, we expected to see approximately nine age-0.2 marked adults.

While our evidence suggested that age-1.0 smolt leave Deep Creek during June and July, and age-0.0 juveniles 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 race and the absence of age-0.0 adult returns. Hence, the existence of both races of juveniles in Deep Creek is inconsistent with the current hypothesis that different early life-history types reflect different adult behaviors and is, at least in part, genetically controlled (Taylor 1990). Rather, these fish appear to be largely excess production with a marine survival rate that is a fraction of that of the age-1.0 smolt. Based on these results, we will discontinue age-0.0 marking in 1998.

The weir initially appeared successful during the first year of the project. We were able to hold the weir during a variety of discharge levels, reach predetermined ASL sample sizes, and collect heads from AFC fish heads to determine θ.

The discovery of substantial numbers of unmarked fish above the weir caused concern over whether those fish passed the weir site during or after installation. The weir took several days to become fish tight, during which several fish were seen moving upstream. Also, some fish escaped from the live box during the first days of operation. However, the water was generally shallow and clear during operation, and the crew made daily checks of the integrity of the rail and panels. These factors convinced us that the majority of the unmarked fish passed the weir site prior to installation.

The accuracy of our mark-recapture estimate of the number of adults above the weir on 25 June depended on how well we met the assumption that the second sampling event (netting) was representative. To obtain a representative sample, one of three things had to happen: (1) each fish must have had an equal probability of capture during the first event (sampling at the weir); or (2) each fish must have had an equal probability of capture during the second event (seining on 25 June); or (3) marked and unmarked fish must have mixed completely between events.

We did not meet assumption one if many fish passed upstream before the weir was installed, since those fish had no possibility of capture during the first event. We did not meet assumption 3, as seen by the very different marked-to-unmarked ratios among seining locations.

Therefore, the validity of our estimate depends on how well we met assumption 2, that all fish above the weir on 25 June had equal probabilities of capture in the seines. If seining happened to concentrate on fish with a relatively high proportion of marks, the marked-to-unmarked ratio would be overestimated and the population underestimated. Conversely, if seining concentrated on fish with a relatively low proportion of marks, the marked-to-unmarked ratio was underestimated and the population overestimated.

If sampling during the second event was size selective, the seine sample may not have been representative. Fish were measured for length at the weir, and unmarked fish were measured during seining. Unfortunately, recaptured marked fish were not measured during seining. In general, the length of unmarked fish sampled with the seine was smaller than that of fish sampled at the weir because the seine sample included more small fish (<650 mm) and fewer large fish (>875 mm).

The lack of large fish in the seine sample may have resulted from the passage of relatively few large fish before the weir was installed. This is supported by the tendency for smaller proportions of large fish during the early weeks of weir operation. Also, migrating chinook

salmon were generally smaller during the first 2 weeks of weir operation than in weeks 3-4. There was however, no similar trend for larger proportions of small fish during the early weeks.

Seining may also have selected for small fish due to differences in avoidance behavior. We could not conduct a conclusive test for size selectivity without lengths of recaptured fish. Fortunately, the estimate appeared to be relatively insensitive to size selectivity. If we could have tested for size selectivity, and had found that the second event was selective for small fish and against large fish, we would have attempted to stratify by size, probably with size classes defined similarly to those in Table 10. Given those size classes, there are a relatively small number of possible outcomes for the size composition of the 46 marked fish in the seine sample. We tabulated all possible outcomes that resulted in size-class composition significantly different from that of the weir sample, along with their associated stratified abundance estimates through 21 June. Estimates ranged only from 2,433 to 2,843 under these assumptions, compared to a nonstratified estimate of 2,740.

A potentially more serious problem than gear selectivity is the possibility that the observed differences in size between the two samples were due to geographic stratification of fish by size, sex, or timing. It is possible that many early and/or large fish moved further upriver by 25 June than was sampled by seining. Under this scenario, the seine sample would not be representative of the population even if seining were not size-selective, and the magnitude and direction of the resulting bias would depend on the relative distribution of marks between upstream and downstream fish. There is no good way to test for this potential source of bias without samples from further upstream. As mentioned previously, marked to unmarked ratio differed among seining sites, but the difference was not related to distance upstream. The proportion of small fish also did not differ significantly among seining sites.

In 1998, we will attempt to install the weir as soon as conditions permit, however, we suspect that a mark-recapture experiment to estimate the escapement prior to weir installation will be necessary. We should sample some areas further upstream, even if no fish are visible from the survey plane. Measuring the length of all fish captured in the capture-recapture experiment will also help answer some of the gear selectivity questions. We may also use marks that change over time. This would enable detection of differences in movement of early versus late fish and allow calculation of an estimate stratified by time and space.

The adult sampling identified straying of Ninilchik River chinook salmon into Deep Creek for the second year. We estimated that approximately 3% of the fish passing the weir after 24 May were of Ninilchik River origin. Sampling adults in 1996 indicated that 14% of the 360 fish examined were originally stocked in the Ninilchik River, however, the sampling plan was not designed to answer questions regarding the final destination of those fish (King and Breakfield 1998). We assumed that all fish passing the weir site this year were committed to spawning in Deep Creek.

Estimates of θ for the 1992 and 1993 brood years were 7.6% and 15.3%, respectively. We suspect that a change in the trap location may be responsible for the difference in θ between the 1992 and 1993 brood years.

Our estimate of the smolt migration from the 1993 brood year is less than half of the estimate for the previous cohort. If the tagging rate for the 1993 cohort holds true for the 1994 and 1995 brood years, then estimated smolt production could be approximately one-quarter of the 1992 brood year smolt.

Our interpretation of the results is preliminary with regard to the adequacy of the number of marks put out in 1994. However, it appears that we marked adequate numbers of smolt to ultimately estimate the smolt emigration in 1994, but not enough to estimate the contribution of this species to the marine recreational sport harvest at our desired level of precision.

In addition, if we subtract the age-0.0 component from the tagging totals, our percentage of the annual goal tagged declined to an average of 22% from 1994 through 1997. The trap was moved in 1995 to a location thought likely to increase the catch rate, and the increase in θ for the age-1.2 fish returning this year supports that conclusion. Also, the marine harvest tag recovery program results in 1997 will be incorporated into our future assessment of the tagging goals. Until these data can be looked at over several returns, we suggest that future tagging work should include attempts to increase the catch rate.

Coho Salmon

Coho salmon smolt were captured throughout the period of operation, with highest catches in June. The emigration timing was consistent with the previous 2 years. Their presence in the catch on the last day of operation is indicative of a protracted low-level emigration throughout most of the open water season. Both the migration timing and duration were similar to that of other Kenai Peninsula stocks (King et al. 1996, Carlon and Hasbrouck 1998). As with chinook salmon smolt, highest catches occurred during freshets immediately following rain events.

Our minimum estimate of marine survival (8.4%) did not include harvest from the marine fisheries. The commercial fishery was closed by emergency order after the 4 August fishing period. Since no tags were collected in the commercial fishery prior to closing, we assumed that the management action negated the marine harvest of coho salmon bound for Deep Creek. Beginning 9 August the sport fishery was restricted to a one fish bag limit and the use of bait was prohibited; however, lifting of restrictions on 29 August resulted in a harvest comparable to previous years. We do not know the harvest of Deep Creek coho in the marine recreational fishery. Marine survival of hatchery stocks in upper Cook Inlet ranged from 2.5%-8.0% and averaged 6.3% from 1992-1997 (Cyr et al. 1999).

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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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 1997.

Year	Species	Location	rkm	Dates	Code	Brood Year	Age	Number Tagged
1993	Chinook	Kenai River	71	7/28 - 8/04	31-22-23	1992	0.0	4,373
1993	Chinook	Kenai River	71	8/05 - 8/12	31-22-60	1992	0.0	11,411
1993	Chinook	Kenai River	71	8/16 - 8/24	31-22-61	1992	0.0	12,830
1993	Chinook	Kenai River	71	8/25 - 8/31	31-22-62	1992	0.0	10,521
1993	Chinook	Kenai River	71	9/01 - 9/13	31-22-63	1992	0.0	13,567
1993	Chinook	Kenai River	24	7/21 - 7/28	31-22-30	1992	0.0	5,845
1993	Chinook	Kenai River	24	7/28 - 8/03	31-22-31	1992	0.0	5,788
1993	Chinook	Kenai River	24	8/03 - 8/09	31-22-44	1992	0.0	12,087
1993	Chinook	Kenai River	24	8/09 - 8/17	31-22-45	1992	0.0	11,888
1993	Chinook	Kenai River	24	8/17 - 8/24	31-22-46	1992	0.0	11,639
1993	Chinook	Kenai River	24	8/24 - 8/30	31-22-47	1992	0.0	11,721
1993	Chinook	Kenai River	24	8/31 - 9/07	31-22-56	1992	0.0	11,843
1993	Chinook	Kenai River	24	9/07 - 9/10	31-22-57	1992	0.0	11,611
1993	Chinook	Kenai River	24	9/10 - 9/14	31-22-58	1992	0.0	12,048
1993	Chinook	Kenai River	24	9/14 - 9/15	31-22-59	1992	0.0	5,225
1994	Chinook	Kenai River	24	7/18 - 7/27	31-22-18	1993	0.0	5,885
1994	Chinook	Kenai River	24	7/27 - 8/01	31-22-36	1993	0.0	5,980
1994	Chinook	Kenai River	24	8/01 - 8/04	31-22-38	1993	0.0	6,158
1994	Chinook	Kenai River	24	8/04 - 8/08	31-22-39	1993	0.0	6,222
1994	Chinook	Kenai River	24	8/08 - 8/09	31-22-37	1993	0.0	6,258
1994	Chinook	Kenai River	24	8/09 - 8/12	31-22-50	1993	0.0	11,581
1994	Chinook	Kenai River	24	8/12 - 8/18	31-22-49	1993	0.0	11,512
1994	Chinook	Kenai River	24	8/18 - 8/24	31-22-48	1993	0.0	11,695
1994	Chinook	Kenai River	24	8/24 - 9/02	31-22-51	1993	0.0	11,373
1994	Chinook	Kenai River	24	9/02 - 9/14	31-24-09	1993	0.0	11,445
1995	Chinook	Kenai River	24	6/22 - 7/19	13-01-03-08-03	1993	1.0	1,479
1995	Chinook	Kenai River	24	7/25 - 8/03	13-01-03-08-04	1994	0.0	14,030
1995	Chinook	Kenai River	24	8/03 - 8/14	13-01-03-08-05	1994	0.0	13,724
1995	Chinook	Kenai River	24	8/14 - 8/22	13-01-03-08-06	1994	0.0	13,745
1995	Chinook	Kenai River	24	8/22 - 8/30	13-01-03-08-07	1994	0.0	13,752
1995	Chinook	Kenai River	24	8/30 - 8/31	13-01-03-08-08	1994	0.0	2,011
1996	Chinook	Kenai River	1.6	6/14 - 8/20	31-25-45	1994	1.0	6,152
1996	Chinook	Kenai River	1.6	8/21 - 9/03	31-25-46	1994	1.0	386
1997	Chinook	Kenai River	34	6/09 - 6/29	31-25-51	1995	1.0	6,024
1997	Chinook	Kenai River	34	6/29 - 7/26	31-25-50	1995	1.0	5,657
1997	Chinook	Kenai River	34	7/27 - 8/05	31-25-48	1995	1.0	6,251
1997	Chinook	Kenai River	34	8/06 - 8/18	31-27-07	1995	1.0	1,523
1997	Chinook	Killey River	0.8	5/17 - 6/08	31-25-47	1995	1.0	5,825
1997	Chinook	Killey River	0.8	6/08 - 6/30	31-25-54	1995	1.0	6,462
1997	Chinook	Killey River	1.6	7/01 - 7/24	13-01-03-09-01	1995	1.0	463

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Year	Species	Location	rkm	Dates	Code	Brood Year	Age	Number Tagged
1994	Chinook	Deep Cr	1.1	5/20 - 6/28	31-22-16	1992	1.0	2,430
1994	Chinook	Deep Cr	1.1	6/28 - 7/04	31-23-60	1992	1.0	2,684
1994	Chinook	Deep Cr	1.1	7/04 - 7/10	31-23-61	1992	1.0	2,678
1994	Chinook	Deep Cr	1.1	7/10 - 8/03	31-23-62	1992	1.0	1,819
1994	Chinook	Deep Cr	1.1	7/21 - 7/29	31-23-63	1993	0.0	2,837
1994	Chinook	Deep Cr	1.1	7/29 - 8/03	31-24-01	1993	0.0	807
1995	Chinook	Deep Cr	0.8	5/17 - 6/25	31-24-02	1993	1.0	2,183
1995	Chinook	Deep Cr	0.8	6/25 - 7/21	31-22-35	1993	1.0	5,719
1995	Chinook	Deep Cr	0.8	7/21 - 8/02	13-01-03-08-15	1993	1.0	492
1995	Chinook	Deep Cr	0.8	7/14 - 8/12	13-01-03-08-09	1994	0.0	5,174
1995	Coho	Deep Cr	0.8	5/18 - 6/17	31-22-33	1992	2.0	5,760
1995	Coho	Deep Cr	0.8	6/17 - 7/20	31-22-34	1992	2.0	3,911
1996	Chinook	Deep Cr	0.8	5/21 - 8/13	13-01-03-08-11	1994	1.0	4,608
1996	Chinook	Deep Cr	0.8	6/27 - 8/13	13-01-03-08-12	1995	0.0	4,359
1996	Coho	Deep Cr	0.8	5/21 - 8/13	13-01-03-08-10	1993	2.0	4,868
1997	Chinook	Deep Cr	0.8	5/13 - 7/29	31-25-53	1995	1.0	4,970
1997	Chinook	Deep Cr	0.8	6/28 - 7/29	31-25-52	1996	0.0	2,484
1997	Coho	Deep Cr	0.8	5/13 - 7/29	31-25-49	1994	2.0	6,951

APPENDIX B. INRIVER CODED WIRE TAG RECOVERIES, 1997

Appendix B1.-Coded wire tagged adult chinook and coho salmon sampled or recovered in Slikok Creek, Kenai River, Deep Creek, Cook Inlet and Kodiak, 1997.

Kenai River and Slikok Creek:

Date	Species	Sex	Ocean Age (yrs)	Length	Tag Code	Release Location	Brood Year	Age at Tagging
16-Jul[a]	Chinook	F	3	687	312314	Crooked Creek	1993	0.0
16-Jul[a]	Chinook	M	3	722	312314	Crooked Creek	1993	0.0
16-Jul[a]	Chinook	F	3	768	312314	Crooked Creek	1993	0.0
16-Jul[a]	Chinook	M	3	820	312314	Crooked Creek	1993	0.0
18-Jul[a]	Chinook	F	3	925	312314	Crooked Creek	1993	0.0
5-Jun[b]	Chinook	F	3	795	312314	Crooked Creek	1993	0.0
9-Jun[b]	Chinook	M	2	660	No tag		1994	
29-Jun[b]	Chinook	M	3	720	312314	Crooked Creek	1993	0.0
15-Jul[b]	Chinook	F	4	980	312230	Kenai River	1992	0.0
8-Jun[c]	Chinook				No tag			
2-Aug[c]	Chinook	F	3	910	No tag		1993	

Deep Creek:

Date	Species	Sex	Ocean Age (yrs)	Length	Tag Code	Release Location	Brood Year	Age at Tagging
26-May	Chinook	M	2	630	312235	Deep Creek	1993	1.0
26-May	Chinook	F	3	800	312360	Deep Creek	1992	1.0
26-May	Chinook	M	3	790	312362	Deep Creek	1992	1.0
26-May	Chinook	M	3	880	312362	Deep Creek	1992	1.0
26-May	Chinook	F	3	790	312362	Deep Creek	1992	1.0
26-May	Chinook	F	3	745	No tag			
28-May	Chinook	F	3	800	312216	Deep Creek	1992	1.0
29-May	Chinook	F	3	820	312360	Deep Creek	1992	1.0
29-May	Chinook	F	2	580	312235	Deep Creek	1993	1.0
29-May	Chinook	F	3	800	312361	Deep Creek	1992	1.0
31-May	Chinook	F	3	720	312362	Deep Creek	1992	1.0
31-May	Chinook	M	3	820	312362	Deep Creek	1992	1.0
31-May	Chinook	F	3	780	312363	Deep Creek	1993	0.0
31-May	Chinook	M	3	750	No tag			
1-Jun	Chinook	F	3	790	312362	Deep Creek	1992	1.0
1-Jun	Chinook	F	3	805	312216	Deep Creek	1992	1.0
1-Jun	Chinook	M	3	850	312362	Deep Creek	1992	1.0
1-Jun	Chinook	M	3	880	312361	Deep Creek	1992	1.0
2-Jun	Chinook	F	3	760	No tag			
2-Jun	Chinook	F	R[d]	760	No tag			
2-Jun	Chinook	M	3	795	312361	Deep Creek	1992	1.0
3-Jun	Chinook	M	3	790	312216	Deep Creek	1992	1.0

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Date	Species	Sex	Ocean Age (yrs)	Length	Tag Code	Release Location	Brood Year	Age at Tagging
3-Jun	Chinook	F	3	725	312362	Deep Creek	1992	1.0
3-Jun	Chinook	M	3	780	312362	Deep Creek	1992	1.0
3-Jun	Chinook	M	3	790	312362	Deep Creek	1992	1.0
3-Jun	Chinook	M	2	600	No tag			
5-Jun	Chinook	F	3	805	312360	Deep Creek	1992	1.0
5-Jun	Chinook	M	2	480	312235	Deep Creek	1993	1.0
5-Jun	Chinook	F	3	810	312362	Deep Creek	1992	1.0
5-Jun	Chinook	F	3	790	No tag			
5-Jun	Chinook	F	3	820	312360	Deep Creek	1992	1.0
5-Jun	Chinook	M	3	720	312360	Deep Creek	1992	1.0
5-Jun	Chinook	M	3	750	312216	Deep Creek	1992	1.0
5-Jun	Chinook	F	3	800	312361	Deep Creek	1992	1.0
5-Jun	Chinook	M	2	645	312235	Deep Creek	1993	1.0
5-Jun	Chinook	M	3	770	No tag			
5-Jun	Chinook	F	3	785	312318	Ninilchik	1993	0.0
5-Jun	Chinook	F	4	850	312159	Ninilchik	1992	0.0
6-Jun	Chinook	M	3	750	312361	Deep Creek	1992	1.0
6-Jun	Chinook	F	3	840	312361	Deep Creek	1992	1.0
6-Jun	Chinook	F	3	785	312361	Deep Creek	1992	1.0
6-Jun	Chinook	M	3	800	312216	Deep Creek	1992	1.0
6-Jun	Chinook	M	3	805	312362	Deep Creek	1992	1.0
6-Jun	Chinook	F	3	765	312361	Deep Creek	1992	1.0
6-Jun	Chinook	F	3	790	312361	Deep Creek	1992	1.0
7-Jun	Chinook	M	3	810	312360	Deep Creek	1992	1.0
7-Jun	Chinook	M	2	665	312235	Deep Creek	1993	1.0
7-Jun	Chinook	M	2	650	No tag			
7-Jun	Chinook	F	3	805	312361	Deep Creek	1992	1.0
8-Jun	Chinook	M	3	830	312216	Deep Creek	1992	1.0
8-Jun	Chinook	M	3	750	312362	Deep Creek	1992	1.0
8-Jun	Chinook	M	3	850	312216	Deep Creek	1992	1.0
8-Jun	Chinook	F	3	780	312361	Deep Creek	1992	1.0
8-Jun	Chinook	F	3	750	312361	Deep Creek	1992	1.0
8-Jun	Chinook	F	3	860	312362	Deep Creek	1992	1.0
8-Jun	Chinook	M	2	640	312235	Deep Creek	1993	1.0
8-Jun	Chinook	M	3	550	312361	Deep Creek	1992	1.0
8-Jun	Chinook	F	2	735	312235	Deep Creek	1993	1.0
8-Jun	Chinook	M	3	735	312362	Deep Creek	1992	1.0
8-Jun	Chinook	F	3	730	312216	Deep Creek	1992	1.0
9-Jun	Chinook	F	3	817	312361	Deep Creek	1992	1.0
9-Jun	Chinook	M	3	889	312216	Deep Creek	1992	1.0
9-Jun	Chinook	M	2	629	312402	Deep Creek	1993	1.0
10-Jun	Chinook	F	3	797	312318	Ninilchik	1993	0.0
10-Jun	Chinook	F	3	851	312361	Deep Creek	1992	1.0

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Date	Species	Sex	Ocean Age (yrs)	Length	Tag Code	Release Location	Brood Year	Age at Tagging
14-Jun	Chinook	F	3	850	312360	Deep Creek	1992	1.0
16-Jun	Chinook	M	2	602	312402	Deep Creek	1993	1.0
16-Jun	Chinook	M	3	900	312361	Deep Creek	1992	1.0
16-Jun	Chinook	F	3	835	312362	Deep Creek	1992	1.0
16-Jun	Chinook	M	3	750	312361	Deep Creek	1992	1.0
16-Jun	Chinook	M	2	669	No tag			
16-Jun	Chinook	F	3	809	312362	Deep Creek	1992	1.0
17-Jun	Chinook	M	3	756	312362	Deep Creek	1992	1.0
19-Jun	Chinook	F	3	833	312362	Deep Creek	1992	1.0
20-Jun	Chinook	M	3	852	312360	Deep Creek	1992	1.0
20-Jun	Chinook	M	3	817	312216	Deep Creek	1992	1.0
20-Jun	Chinook	M	3	854	312216	Deep Creek	1992	1.0
20-Jun	Chinook	F	3	837	312216	Deep Creek	1992	1.0
21-Jun	Chinook	M	3	773	No tag			
21-Jun	Chinook	F	3	764	312361	Deep Creek	1992	1.0
21-Jun	Chinook	M	3	837	312360	Deep Creek	1992	1.0
21-Jun	Chinook	M	3	875	312216	Deep Creek	1992	1.0
21-Jun	Chinook	M	3	831	312216	Deep Creek	1992	1.0
23-Jun	Chinook	M	3	811	312361	Deep Creek	1992	1.0
24-Jun	Chinook	F	3	820	312216	Deep Creek	1992	1.0
24-Jun	Chinook	F	4	785	No tag			
24-Jun	Chinook	F	3	800	312360	Deep Creek	1992	1.0
25-Jun	Chinook	F	3	814	312362	Deep Creek	1992	1.0
25-Jun	Chinook	M	3	820	312318	Ninilchik	1993	0.0
25-Jun	Chinook	F	3	840	No tag			
26-Jun	Chinook	M	2	596	312435	Ninilchik	1994	0.0
26-Jun	Chinook	M	3	798	312216	Deep Creek	1992	1.0
26-Jun	Chinook	M	3	871	312361	Deep Creek	1992	1.0
26-Jun	Chinook	M	3	746	312216	Deep Creek	1992	1.0
27-Jun	Chinook	M	2	688	312435	Ninilchik	1994	0.0
27-Jun	Chinook	M	3	872	312360	Deep Creek	1992	1.0
28-Jun	Chinook	F	3	761	312216	Deep Creek	1992	1.0
29-Jun	Chinook	M	3	801	312360	Deep Creek	1992	1.0
29-Jun	Chinook	M	3	866	312360	Deep Creek	1992	1.0
29-Jun	Chinook	F	3	847	Hd lost			
29-Jun	Chinook	M	2	570	312402	Deep Creek	1993	1.0
29-Jun	Chinook	M	2	641	312402	Deep Creek	1993	1.0
30-Jun	Chinook	M	4	960	312159	Ninilchik	1992	0.0
2-Jul	Chinook	M	3	860	312216	Deep Creek	1992	1.0
3-Jul	Chinook	F	R	861	No tag			
5-Jul	Chinook	M	3	820	312318	Ninilchik	1993	0.0
5-Jul[e]	Chinook	M	2	704	312234	Deep Creek	1993	1.0
7-Jul	Chinook	F	3	818	312361	Deep Creek	1992	1.0

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Date	Species	Sex	Ocean Age (yrs)	Length	Tag Code	Release Location	Brood Year	Age at Tagging
7-Jul	Chinook	M	2	610	No tag			
7-Jul	Chinook	F	3	802	312362	Deep Creek	1992	1.0
8-Jul	Chinook	M	3	810	312362	Deep Creek	1992	1.0
9-Jul	Chinook	M	3	777	312360	Deep Creek	1992	1.0
9-Jul	Chinook	F	3	827	312216	Deep Creek	1992	1.0
10-Jul	Chinook	F	3	801	312361	Deep Creek	1992	1.0
10-Jul	Chinook	M	3	769	312360	Deep Creek	1992	1.0
10-Jul	Chinook	M	2	682	312235	Deep Creek	1993	1.0
11-Jul	Chinook	M	3	699	312361	Deep Creek	1992	1.0
11-Jul	Chinook	M	2	566	312235	Deep Creek	1993	1.0
11-Jul	Chinook	F	3	772	312362	Deep Creek	1992	1.0
11-Jul	Chinook	F	3	847	312216	Deep Creek	1992	1.0
11-Jul	Chinook	F	4	825	312159	Ninilchik	1992	0.0
12-Jul	Chinook	M	3	837	312216	Deep Creek	1992	1.0
12-Jul	Chinook	M	2	630	No tag			
12-Jul	Chinook	M	3	866	312216	Deep Creek	1992	1.0
12-Jul	Chinook	F	3	811	312360	Deep Creek	1992	1.0
12-Jul	Chinook	M	3	813	312361	Deep Creek	1992	1.0
13-Jul	Chinook	M	2	614	312235	Deep Creek	1993	1.0
13-Jul	Chinook	F	3	868	312361	Deep Creek	1992	1.0
13-Jul	Chinook	F	3	820	312361	Deep Creek	1992	1.0
13-Jul	Chinook	M	3	734	No tag			
13-Jul	Chinook	F	3	771	312318	Ninilchik	1993	0.0
21-Jul	Chinook	M	4	900	312159	Ninilchik	1992	0.0
21-Jul	Chinook	F	4	904	312159	Ninilchik	1992	0.0
22-Jul	Chinook	M	2	669	312435	Ninilchik	1994	0.0
22-Jul	Chinook	M	3	809	312361	Deep Creek	1992	1.0
25-Jul	Chinook	F	3	724	312318	Ninilchik	1993	0.0

Chinook seined above the weir:

Date	Species	Sex	Ocean Age (yrs)	Length	Tag Code	Release Location	Brood Year	Age at Tagging
19-Jun	Chinook	M	2	635	312235	Deep Creek	1993	1.0
19-Jun	Chinook	F	3	800	312360	Deep Creek	1992	1.0
25-Jun	Chinook	M	2	635	312235	Deep Creek	1993	1.0
25-Jun	Chinook	M	2	640	312235	Deep Creek	1993	1.0
25-Jun	Chinook	F	3	750	312216	Deep Creek	1992	1.0
25-Jun	Chinook	M	3	760	312216	Deep Creek	1992	1.0
25-Jun	Chinook	F	R	840	No tag			
25-Jun	Chinook	F	3	750	Hd lost			

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Date	Species	Sex	Ocean Age (yrs)	Length	Tag Code	Release Location	Brood Year	Age at Tagging
Coho sampled at the weir:								
6-Aug	Coho	M	1	586	Wand[t]	Deep Creek	1993	2.0
11-Aug	Coho	F	1	588	Wand	Deep Creek	1993	2.0
12-Aug	Coho	M	1	599	Wand	Deep Creek	1993	2.0
12-Aug	Coho	M	1	657	Wand	Deep Creek	1993	2.0
21-Aug	Coho	F	1	593	Wand	Deep Creek	1993	2.0
21-Aug	Coho	M	1	573	Wand	Deep Creek	1993	2.0
21-Aug	Coho	F	1	568	Wand	Deep Creek	1993	2.0
21-Aug	Coho	M	1	607	Wand	Deep Creek	1993	2.0
21-Aug	Coho	F	1	598	Wand	Deep Creek	1993	2.0
21-Aug	Coho	M	1	574	Wand	Deep Creek	1993	2.0
21-Aug	Coho	M	1	540	Wand	Deep Creek	1993	2.0
21-Aug	Coho	M	1	598	Wand	Deep Creek	1993	2.0
21-Aug	Coho	F	1	604	Wand	Deep Creek	1993	2.0
22-Aug	Coho	F	1	534	Wand	Deep Creek	1993	2.0
22-Aug	Coho	F	1	587	Wand	Deep Creek	1993	2.0
22-Aug	Coho	M	1	600	Wand	Deep Creek	1993	2.0
22-Aug	Coho	M	1	576	Wand	Deep Creek	1993	2.0
22-Aug	Coho	F	1	580	Wand	Deep Creek	1993	2.0
22-Aug	Coho	F	1	601	Wand	Deep Creek	1993	2.0
22-Aug	Coho	F	1	535	Wand	Deep Creek	1993	2.0
22-Aug	Coho	M	1	604	Wand	Deep Creek	1993	2.0
22-Aug	Coho	F	1	502	Wand	Deep Creek	1993	2.0
22-Aug	Coho	F	1	565	Wand	Deep Creek	1993	2.0
22-Aug	Coho	F	1	526	Wand	Deep Creek	1993	2.0
23-Aug	Coho	M	1	569	Wand	Deep Creek	1993	2.0
23-Aug	Coho	M	1	536	Wand	Deep Creek	1993	2.0
26-Aug	Coho	M	1	557	Wand	Deep Creek	1993	2.0
26-Aug	Coho	F	1	556	Wand	Deep Creek	1993	2.0
26-Aug	Coho	F	1	567	Wand	Deep Creek	1993	2.0
26-Aug	Coho	M	1	602	Wand	Deep Creek	1993	2.0
26-Aug	Coho	F	1	609	Wand	Deep Creek	1993	2.0
26-Aug	Coho	F	1	602	Wand	Deep Creek	1993	2.0
27-Aug	Coho	M	1	567	Wand	Deep Creek	1993	2.0
27-Aug	Coho	F	1	620	Wand	Deep Creek	1993	2.0
27-Aug	Coho	M	1	615	Wand	Deep Creek	1993	2.0
28-Aug	Coho	F	1	576	Wand	Deep Creek	1993	2.0
29-Aug	Coho	F	1	606	Wand	Deep Creek	1993	2.0
31-Aug	Coho	M	1	592	Wand	Deep Creek	1993	2.0
31-Aug	Coho	F	1	588	Wand	Deep Creek	1993	2.0
31-Aug	Coho	F	1	617	Wand	Deep Creek	1993	2.0
6-Sep	Coho	F	1	608	Wand	Deep Creek	1993	2.0

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Date	Species	Sex	Ocean Age (yrs)	Length	Tag Code	Release Location	Brood Year	Age at Tagging
7-Sep	Coho	F	1	581	Wand	Deep Creek	1993	2.0
7-Sep	Coho	M	1	589	Wand	Deep Creek	1993	2.0
8-Sep	Coho	M	1	603	Wand	Deep Creek	1993	2.0
9-Sep	Coho	M	1	622	Wand	Deep Creek	1993	2.0
9-Sep	Coho	M	1	604	Wand	Deep Creek	1993	2.0
9-Sep	Coho	M	1	655	Wand	Deep Creek	1993	2.0
10-Sep	Coho	M	1	644	Wand	Deep Creek	1993	2.0
Cook Inlet and Kodiak:								
3-May	Chinook	F	3	757	312361	Deep Creek	1992	1.0
3-May	Chinook	F	3	757	312361	Deep Creek	1992	1.0
11-May	Chinook	M	3	745	312360	Deep Creek	1992	1.0
11-May	Chinook	F	3	810	312361	Deep Creek	1992	1.0
24-May	Chinook	F	3	825	312360	Deep Creek	1992	1.0
3-Jun	Chinook	F	3	830	312360	Deep Creek	1992	1.0
1-Jul[g]	Chinook		2		312250	Kenai River	1993	0.0
2-Jul	Chinook	F	1	420	1301030804	Kenai River	1994	1.0
5-Jul	Chinook	M	4	950	312246	Kenai River	1992	0.0
7-Jul	Chinook		2		312218	Kenai River	1993	1.0
14-Jul	Chinook	M	3	960	312261	Kenai River	1992	1.0
17-Jul[g]	Chinook		1		312545	Kenai River	1994	1.0
17-Jul	Chinook	M	3	850	312262	Kenai River	1992	1.0
18-Jul	Chinook	M	2	750	312218	Kenai River	1993	1.0
21-Jul	Chinook	M	1	445	1301030805	Kenai River	1994	1.0
21-Jul	Chinook	F	3	840	312257	Kenai River	1992	1.0
23-Jul	Chinook	M	3	790	312260	Kenai River	1992	1.0
25-Jul	Chinook	F	3	965	312263	Kenai River	1992	1.0
29-Jul	Chinook	F	3	905	312258	Kenai River	1992	1.0
30-Jul	Chinook		1		312545	Kenai River	1994	1.0

[a] Slikok Creek stream survey chinook that were adipose finclipped.

[b] Kenai River AWL gillnet sampled chinook that were adipose finclipped.

[c] Kenai River creel survey chinook that were adipose finclipped.

[d] Scales were regenerated.

[e] Identified and tagged as a coho smolt.

[f] Adipose finclipped, tag detected, but heads were not collected.

[g] Chinook salmon recovered in Kodiak seine fishery.