Fishery Data Series No. 93-52

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

A coho salmon stock assessment program was initiated in 1991 to assess the status of Kenai River wild stocks. As part of the program, this project deals with estimating the contribution of Kenai River stocks to commercial marine harvests in Upper Cook Inlet. To identify Kenai River adults in the commercial harvest, juvenile fish were captured in the Kenai River drainage and marked with a coded, microwire tag and an adipose finclip. The proportion of marked Kenai River adults in the commercial harvest will be expanded to estimate the contribution of Kenai River adult coho salmon to the commercial fishery.

Rearing fingerling were captured with modified fyke traps in the fall of 1992 at the outlets of Kenai and Skilak lakes. Smolt were captured during the spring of 1993 at weirs in Hidden Creek and the Moose River, both tributaries of the Kenai River. An estimated 141,925 coho salmon were released with one of 33 unique microwire tags between 13 August and 28 June 1993. Short-term tag retention exceeded 98% at all four marking locations in the drainage. Short-term survival rates exceeded 99%. Tag retention and survival rates were higher for marked fingerling than for smolt.

Fingerling captured at the outlets of Skilak and Kenai lakes in the fall of 1992 consisted primarily of age-0 and age-1 coho salmon. The percentage of age-1 fish in the trap catch declined between 13 August and 14 October. The mean fork length of age-1 fish sampled weekly ranged from 86 millimeters to 125 millimeters. Smolt captured in the spring of 1993 were primarily age 2 at both the Moose River (88.7%) and Hidden Creek (65.8%). The mean length of age-2 fish emigrating from the Moose River (125 millimeters) was smaller than those emigrating from Hidden Creek (136 millimeters).

Coho salmon marked as fingerling in 1992 were recaptured as they emigrated from the Moose River and Hidden Creek in 1993. This indicates that some individuals disperse from their natal area during freshwater residency and that localized groups of fish may be aggregates of fish from a variety of natal areas. Coho salmon marked at both tributaries in 1993 were recaptured by inclined-plane traps located in the mainstem Kenai River (river kilometer 31.0) downstream from the tributaries. A comparison of length distributions of smolt measured at the tributaries with those of marked fish recaptured in the traps suggests that the inclined-plane traps are size selective toward smaller coho salmon.

An estimated 34% of the 1,982 coho salmon captured by the inclined-plane traps were marked. For designing a commercial catch sampling program for the 1994 harvest, this is a maximum expected marked proportion of the Kenai River adult return. Size selectivity of the inclined-plane traps and past performance of this estimate suggest that the estimated proportion of marked coho in the adult return will be lower than 34%.

KEY WORDS: coho salmon, *Oncorhynchus kisutch*, fingerling, smolt, juvenile, Kenai River, commercial contribution, weir, fyke trap, coded wire tag, adipose clip, tag retention, survival.

INTRODUCTION

Background

In 1991, a stock assessment program was initiated by the Alaska Department of Fish and Game, Division of Sport Fish, to assess the status of Upper Cook Inlet (UCI) coho salmon *Oncorhynchus kisutch* stocks. Upper Cook Inlet drainages (Figure 1) support the largest sport harvests (Mills 1985-1993) and the second largest commercial harvests of coho salmon in the state of Alaska (Meyer et al. *Unpublished*). Despite the importance of UCI coho salmon fisheries, no comprehensive stock assessment program existed before 1991. A lack of stock status and general resource information makes development of objective management criteria infeasible. The long-term goal of the assessment program is to provide fundamental information on which to base management objectives.

The initial goal of the coho salmon stock assessment program is to estimate population size and exploitation rates for selected UCI stocks (Meyer et al. *Unpublished*). This information is required to assess stock status and develop harvest management strategies. Although annual sport harvest is estimated for many UCI streams (Mills 1979-1993), associated escapements and stock-specific commercial harvests are unknown. Major sport and commercial fisheries are managed in the absence of this information.

Stocks under investigation include hatchery-produced fish released into streams near the Anchorage urban area and wild fish originating from the Kenai River drainage. Kenai River wild stocks support a growing freshwater sport fishery which is the largest in the state (Mills 1979-1993). The stocks also contribute an unknown number of fish to commercial marine harvests. Concerns about the sizable harvest and increase in fishing pressure lead to selecting the Kenai River coho stocks for assessment. Although the sport harvest of coho salmon in the lower Kenai River is estimated annually by angler surveys (Hammarstrom 1977, 1978 and 1988-1992; Schwager-King 1993), spawning escapements and the commercial harvest of Kenai River coho salmon have not been estimated.

UCI commercial fisheries are managed for sockeye salmon *O. nerka*, while coho salmon are harvested as both a mixed-stock bycatch and a target species. Although techniques for quantifying stock contributions to commercial harvests have been investigated, little substantive information exists concerning the stock composition of commercial harvests. Initial analyses of length-at-age (Wadman *Unpublished*), migratory timing (Tarbox 1988), and scale pattern variables (Bethe *Unpublished*; Robertson 1979) indicated that these traits may be of value in distinguishing stocks of commercially harvested coho salmon. However, a recent study (Vincent-Lang and McBride 1989) concluded these traits are of limited value and could be used only as general indicators of stock origins. Quantifying stock contributions using these traits is not precise enough to refine management strategies.

In developing the UCI assessment program (Meyer et al. *Unpublished*), microwire tagging of juvenile coho salmon within the Kenai River drainage was recommended to allow positive identification of returning marked adults in the mixed-stock harvest. Statistical procedures exist for allocating a harvest among contributing stocks based on recoveries of fish marked with coded,

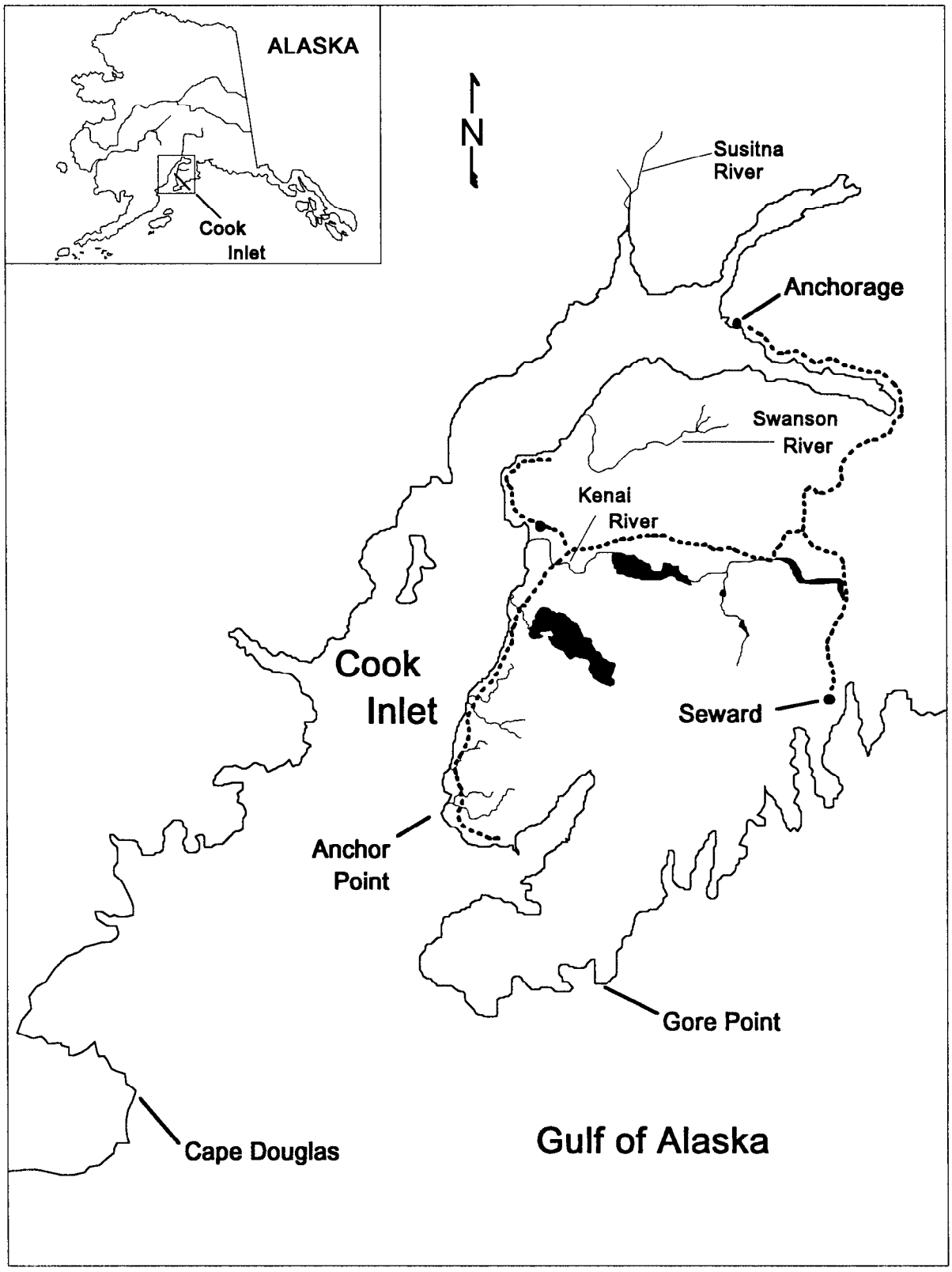

Figure 1. The Cook Inlet basin, Alaska.

microwire tags (Clark and Bernard 1987). These procedures were applied in commercial (Elliot et al. 1989, Elliot and Sterrit 1990) and recreational (Sonnichsen et al. 1987; Vincent-Lang et al. 1988; Carlon and Vincent-Lang 1989 and 1990) marine coho salmon fisheries in Alaska.

A juvenile coho salmon marking project was initiated in the fall of 1991 to identify returning Kenai River adults in the 1993 commercial harvest (Carlon 1992). This report documents results from the second year of the marking project conducted to allow identification of Kenai River coho in the 1994 commercial harvest. Companion projects estimate the inriver sport harvest (Mills 1992; Schwager-King 1993) and evaluate methods to estimate spawning escapement (Bendock *In prep*).

The goal of the marking program is to provide estimates of the contribution of Kenai River coho salmon to UCI commercial fisheries. This requires marking a representative sample from the population of Kenai River juvenile coho salmon with coded, microwire tags. Other efforts provide ancillary biological information and include: (1) estimating age and length compositions of juvenile populations, (2) monitoring migration behaviors by decoding tags from marked fish recovered at capture sites, and (3) estimating the number of smolt emigrating from the Moose River. The Hidden Creek coho smolt emigrations are estimated annually as part of an ongoing sockeye salmon stocking evaluation program.

Marking History

Since the fall of 1991, this project has included both the marking of fingerling in the fall and smolt in the spring. Many of the marked fingerling smoltified the following spring and joined smolt marked on their seaward migration. This resulted in a sample of marked smolt cohorts leaving the river in both 1992 and 1993 to enter the ocean. Scale annulus patterns suggest that all coho salmon return to the Kenai River to spawn before experiencing two winters in the ocean (Hammarstrom 1988-1992). Therefore, marked and unmarked adults return to the Kenai River the year following their emigration as smolt.

In the first year, 14,000 fingerling were marked during the fall of 1991 and 97,000 smolt were marked in the spring of 1992 (Carlon 1992). Adult fish from this cohort returned in 1993 and were harvested in commercial marine fisheries and the Kenai River recreational fishery (Carlon *In prep*). Both commercial and recreational harvests were examined for marked adults. The first estimate of a stock-specific contribution to UCI commercial fisheries will be based on this information. The second year of marking, which is the subject of this report, will form the basis for an estimate of stock contribution to the 1994 commercial harvests.

METHODS

Study Area

Juvenile coho salmon were captured for marking at four sites within the Kenai River drainage on the Kenai Peninsula, Alaska (Figure 2). Fingerling were captured in the mainstem during the fall of 1992 near the outlets of Skilak

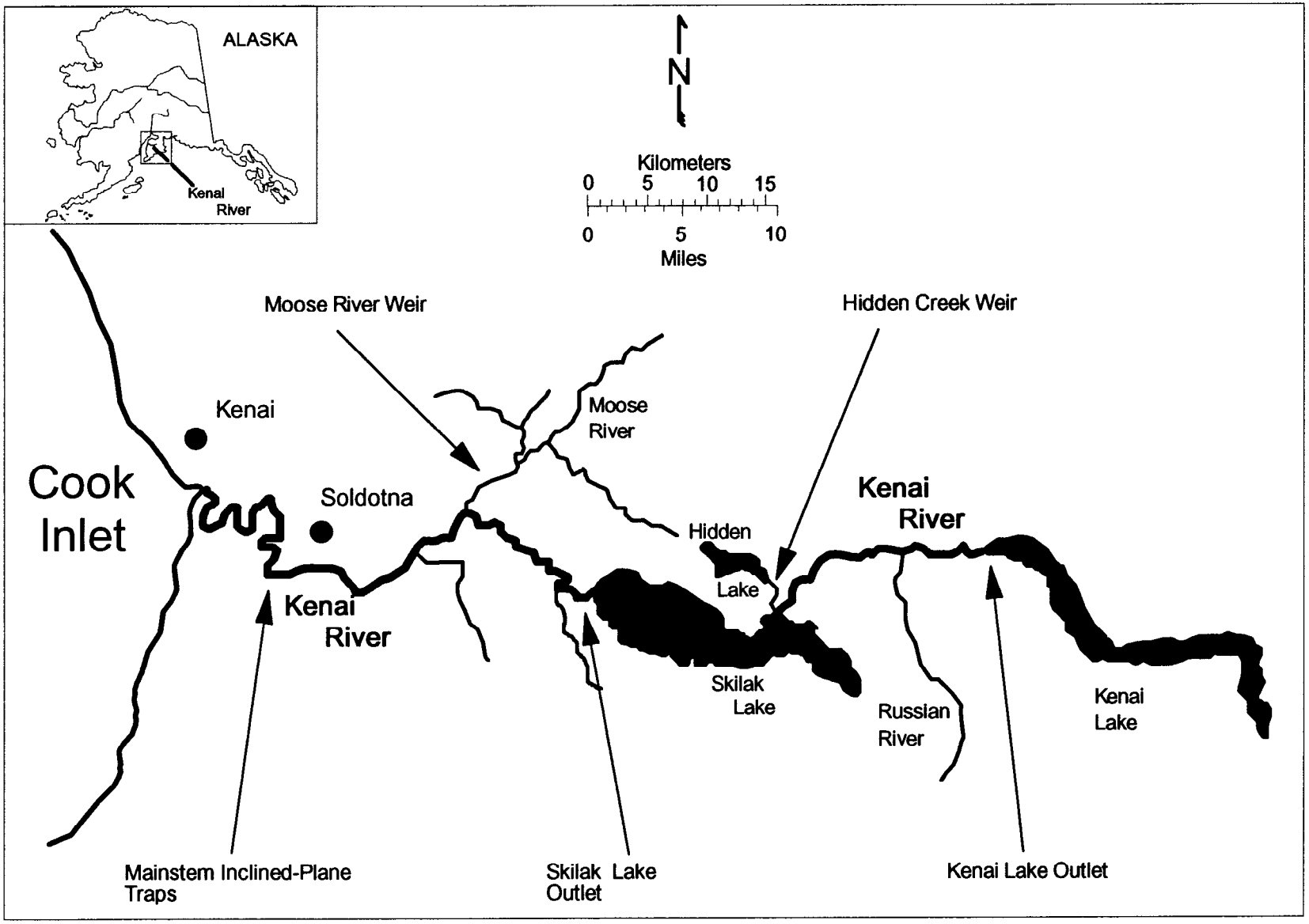

Figure 2. Map of the Kenai River drainage showing juvenile coho salmon trapping sites used in 1992 and 1993.

and Kenai lakes. The Skilak Lake outlet is located at river kilometer (rkm) 83.3 and the Kenai Lake outlet is located at rkm 129.1. Smolt were captured in two second-order tributaries to the Kenai River during the spring of 1993. One smolt weir was located on Hidden Creek about 2.5 km downstream from the outlet of Hidden Lake. A second smolt weir was located on the Moose River about 7.2 km from its confluence with the Kenai River at rkm 60.5.

The Commercial Fisheries Division operated a series of inclined-plane traps in the mainstem of the Kenai River (rkm 31.0) to study sockeye salmon smolt from mid-May through early July 1993. The incidental catch of coho salmon smolt in these traps was examined for marked individuals released at upstream locations.

Study Design

Kenai River coho salmon adults exhibit a wide range of return timing. Some coho salmon enter the river in mid-July and others have been observed spawning as late as April of the following year. Commercial drift and set net fisheries primarily exploit coho salmon returning to UCI between late June and mid-August, after which the set net fishery closes by regulation and drift net fishing effort decreases due to low fish abundance (P. Ruesch, Alaska Department of Fish and Game, Soldotna, personal communication).

To allocate a commercial harvest among marked stocks, it is preferable for the marked proportion to remain constant over the range of return timings inherent to each stock (J. E. Clark, Alaska Department of Fish and Game, Juneau, personal communication). The capture of smolt from the mainstem Kenai River downstream from major tributaries probably offers the best opportunity to mark a representative sample of juveniles across the range of return timings. However, suitable techniques have not yet been developed for capturing large numbers of coho salmon smolt from the mainstem of the Kenai River. Instead, smolt were captured from selected sites within the drainage.

Recent studies indicated that rearing fingerling were susceptible to capture from low velocity areas in the mainstem prior to overwintering (Bendock 1989) and as smolt emigrating from tributaries within the Kenai River basin (Fandrei 1991a, 1991b; Litchfield and Flagg 1988). This information was used to select four capture sites for marking fish.

Although fish were captured and marked at all locations, localized capture methods may result in marking bias with respect to return timing. However, localized capture methods would not result in marking bias if coho juveniles mix randomly within the drainage. Preliminary indicators of mixing were examined by testing for homogeneity of age and length compositions among smolt capture locations and by examining the dispersion of marked fingerling to overwintering tributaries. Although inconclusive, differences in age and length compositions among locations could be indicative of discrete populations of rearing fish as would nonrandom dispersions of marked fingerling to overwintering habitats.

The marked proportion of coho salmon smolt captured from the mainstem Kenai River at rkm 31.0 was examined for a temporal trend. A trend may be indicative of the marking of discrete and perhaps biased populations with respect to return timing.

Fish Marking

Captured fish were marked and released at four sites within the Kenai River drainage. Rearing fingerling were captured with modified fyke traps at the outlets of Skilak and Kenai lakes. Smolt were captured at weirs in the Moose River and Hidden Creek.

Similar marking and handling techniques were used at all four sites. Fish selected for marking were anesthetized with MS-222® and adipose finclipped (adipose clip). A full-length, coded microwire tag was injected into the snout of each fish with a Northwest Marine Technologies® Mark IV tag injector. Standard handling and marking procedures were used (Moberly et al. 1977). Marked fish were released after recovering from the anesthesia. To monitor the quality of marking and handling procedures, daily samples of marked fish were detained overnight to estimate short-term survival and tag retention rates.

To ensure that tags were consistently placed in the target area, optimum headmolds were chosen for three length ranges of smolt. A sample of smolt of various lengths was fitted to several headmolds using both objective and subjective measures of "fit." Objective measures involved determining if the snout contacted the needle orifice and if the eyes touched the headmold edges when the snout contacted the needle orifice. Avoiding eye contact with headmold edges eliminates abrasion of eye tissue. The subjective measure was "snugness" of the fit when positioned in the headmold. All of these characteristics combined to result in tag placement on the sagittal plane while depth was controlled by mechanical adjustment of the injector. Fingerling were small enough so that all were tagged with one headmold size.

Prefabricated headmolds available from Northwest Marine Technologies® fit a range of fish sizes and are rated in number of fish per pound. At Moose River, from 23 May through the first shift on 2 June, coho smolt were tagged with a single headmold (20-per-pound) chosen as an optimum fit for all lengths of smolt. Beginning on the second marking shift on 2 June, smolt were sorted by length and tagged with headmolds optimized by length range. Smolt $\leq$ 125 mm in fork length were tagged with a 30-per-pound headmold, those > 125 mm and $\leq$ 150 mm were tagged with a 20-per-pound headmold, and those > 150 mm were tagged with a 15-per-pound headmold. All smolt tagged at Hidden Creek were sorted similarly. A 60-per-pound headmold was used to tag all fingerling in 1992.

Skilak Lake Outlet (Fingerling):

During 13 August through 14 October of 1992, rearing coho salmon fingerling were captured from the mainstem of the Kenai River near the outlet of Skilak Lake (Figure 1) and marked with coded, microwire tags and an adipose finclip prior to release.

Four modified fyke traps (Bendock 1989) were set in the river at nearshore locations with low water velocities. The cube-shaped trap frames were constructed of 1.3 cm concrete reinforcement bar, covered with 0.6 cm hardware cloth, and measured 1.2 m along each edge (Figure 3). Two vertical-slot openings on one face were 3.8 cm wide and allowed fish to enter the trap. Traps were set offshore in up to 1.1 m of water with the opening facing the

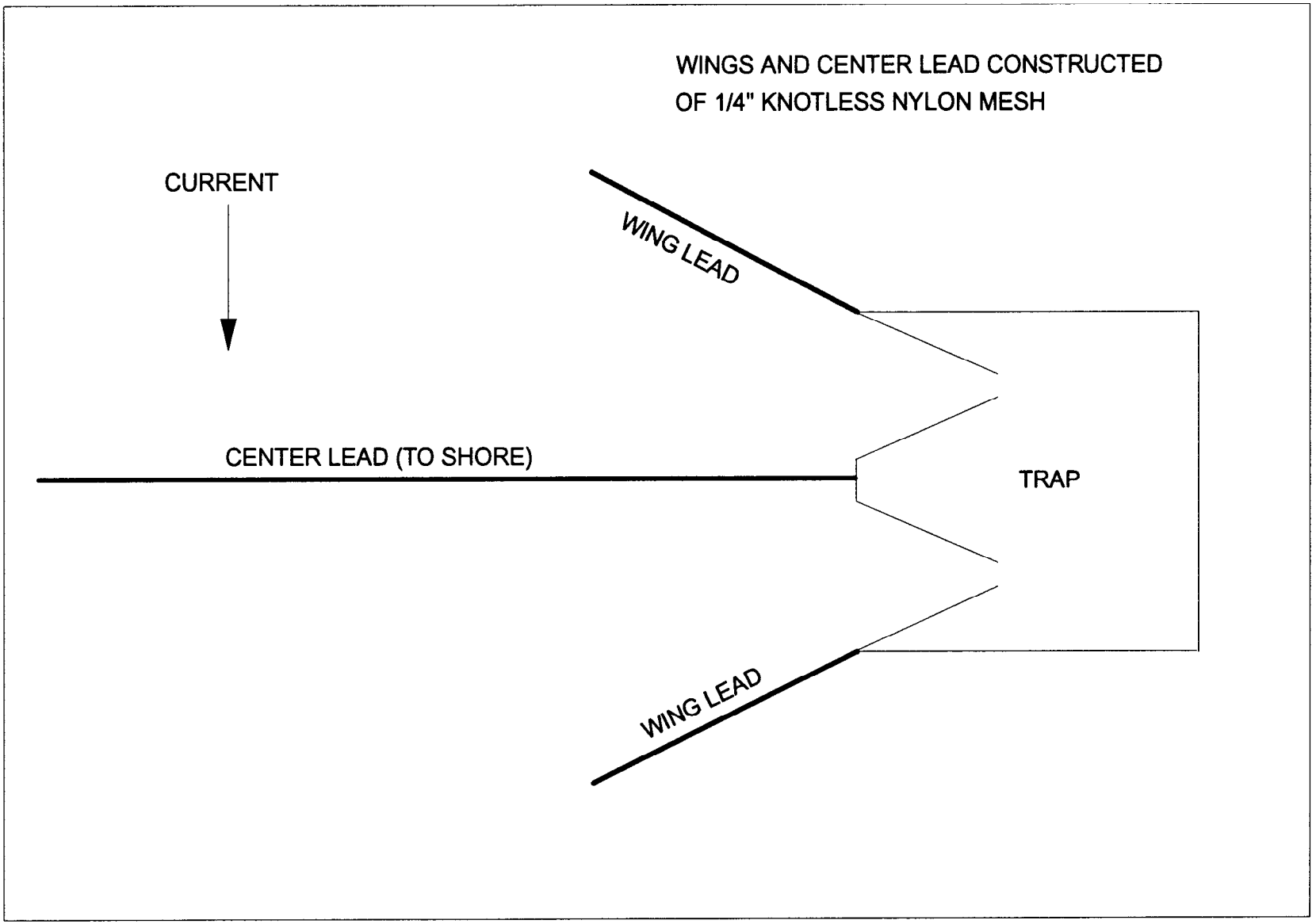

Figure 3. Schematic diagram of fyke trap used in the Kenai River near the outlets of Skilak and Kenai lakes, 13 August through 14 October 1992.

shore. A knotless nylon seine (1.0 cm mesh) was attached to each trap, pulled taut, and affixed to shore to block fish passage between the trap and the shore. Wing leads were added to direct fish into the trap. The shore and wing leads were stabilized using sandbags and 2.5 cm diameter pipe pounded into the stream bed.

Annulus patterns in adult scales suggest that most Kenai River coho salmon become smolts at age 2 (Hammarstrom 1992; Schwager-King 1993). To minimize the marking of young-of-the-year (age 0) fish that would endure two winters before smolting, only coho salmon ≥ 72 mm were selected for marking. This threshold length was two standard deviations less than the mean length of age-1 fish collected during the initial days of trapping (Carlon 1992). The four traps were moved among locations to maximize the catch of fish ≥ 72 mm.

Samples of fish marked each day were detained overnight in an inriver wire mesh holding pen to estimate the short-term survival rate associated with capture and marking and to estimate short-term tag retention rate. At least 200 marked fish were detained for these tests except when fewer than 200 were marked in a day, in which case all fish were detained.

Kenai Lake Outlet (Fingerling):

During 27 August through 8 October, juvenile coho salmon were captured for marking from the Kenai River mainstem near the outlet of Kenai Lake (Figure 2). Trapping and marking efforts were identical to those used at the outlet of Skilak Lake except that only two fyke traps were used. The traps were moved among locations to maximize the catch of coho salmon ≥ 72 mm. The 72 mm length threshold was also used at the Kenai Lake site to select fish for marking and was held constant throughout the study. Samples of fish were detained overnight to measure short-term survival and tag retention rates.

Moose River (Smolt):

On 21 May, a smolt weir was installed in the Moose River at rkm 7.2 (Figure 4) and was operational from 22 May through 17 June 1993. To facilitate boat access to the site during low water periods, the weir was located 2.1 km downstream from the site used in 1992.

The weir was constructed of overlapping panels. The basic weir panel was a 3.2 m by 1.2 m rectangular frame of welded aluminum angle (0.48 cm thickness). Each frame was covered with Vexar® polyethylene netting with square mesh opening dimensions of 1.3 cm by 1.3 cm. A 0.3 m Vexar® "skirt" extended beyond each of three frame edges to seal the panel to the streambed and to adjacent panels. Panels were supported by fenceposts and were set in place with the 3.2 m "skirted" edge on the streambed. Panels were set in an overlapping fashion at the head of an island and across both channels to form cross-channel barriers. Skirts attached to adjacent panels formed a seal at each overlap and sandbags placed on the bottom skirt formed a seal at the streambed.

Panels were set in a fyke arrangement downstream from the cross-channel barrier. The panels converged at mid-channel to direct downstream migrant fish into an inclined-plane trap set on the streambed at a water depth of no more than 0.6 m. Water and fish entering the inclined-plane trap spilled

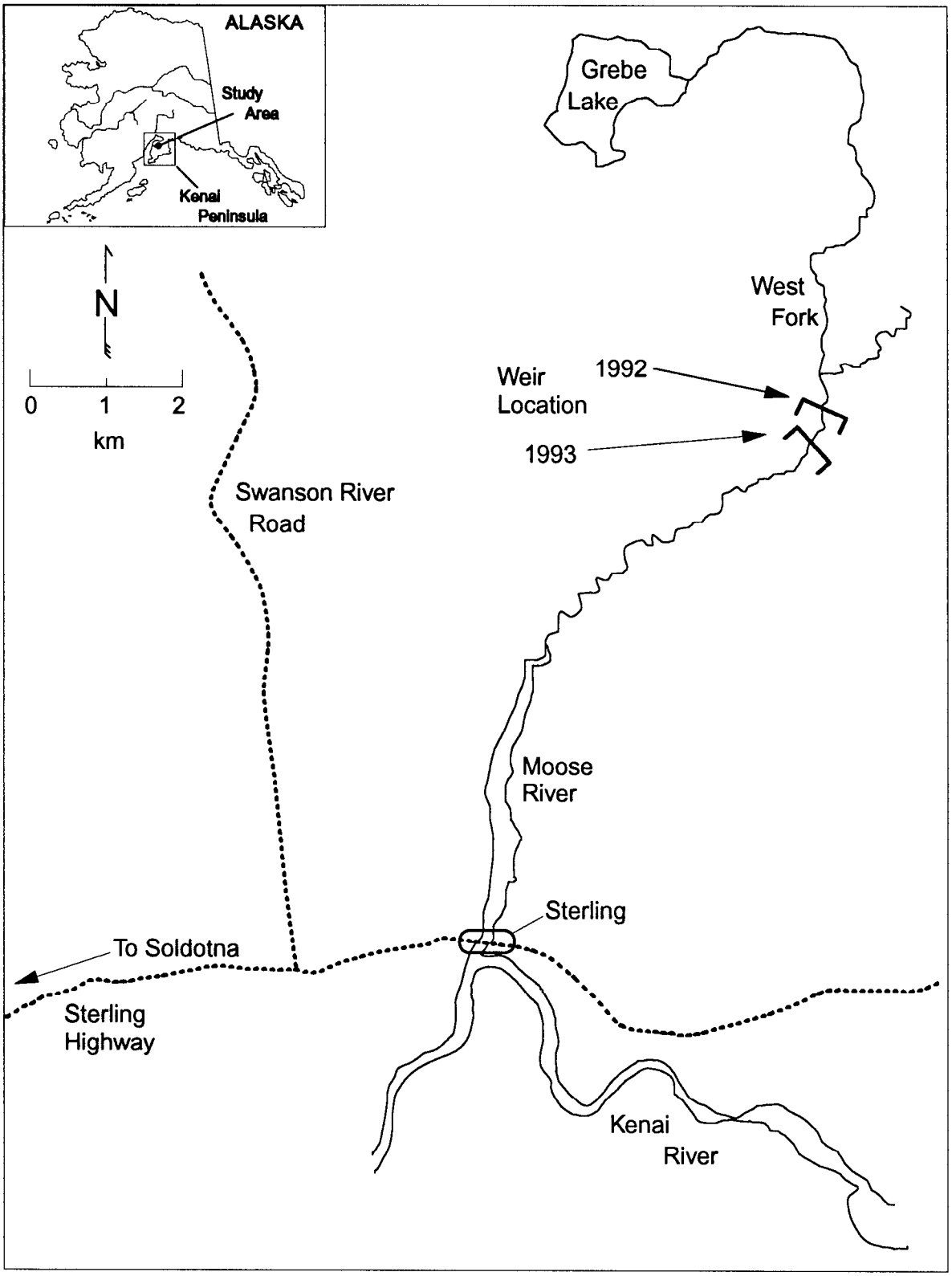

Figure 4. Location of the Moose River weir, 1993.

directly into a live box. A removable panel in the cross-channel barrier was used to regulate the flux of fish into the live box.

Coho salmon smolt were the most abundant fish captured with sockeye salmon smolt the next most abundant. Other captured juvenile and adult fish were relatively incidental in number. All fish captured in the live box were counted by species. During May, most downstream migrant coho salmon trapped were larger than 100 mm. During June, small age-0 coho salmon were present at the weir site and appeared to be moving upstream, although many were captured in the live box. Coho salmon ≥ 100 mm were selected for marking and all coho salmon < 100 mm were assumed to not be smolts and were released unmarked. All other species captured in the downstream migrant trap were counted and released downstream of the weir. On several occasions during peak emigration rates, the number of each species in the live box was estimated volumetrically. Several dip nets full of fish were speciated and the average was expanded to account for the number of full dip nets of fish released uncounted.

Coho salmon selected for marking were temporarily retained in holding pens from zero to 36 hours. Once the capacity of onsite holding pens was reached (about 5,000 fish), coho salmon were counted, or on occasion estimated, from the live box and released. Fish exceeding the number that could be marked within 36 hours were counted, released from holding pens unmarked, and recently trapped fish were retained for marking. Fish were batch marked with unique codes in lots of about 1,700 to 6,400 per code. From 25 May through 2 June, two crews of two people each marked fish during two 7.5-hour shifts per day. During the remainder of the outmigration, one crew of two people marked fish during one shift per day.

Short-term tag retention and survival rates were estimated each day by detaining a sample of about 200 marked fish overnight (≅ 18 hours) in an inriver holding pen. After 18 hours, the sample was checked for mortalities and all of the remaining live fish were passed through a tag detector.

Hidden Creek (Smolt):

A smolt weir has been used to count sockeye and coho salmon smolt emigrating from Hidden Creek each year since 1976. On 14 May 1992, the weir was installed approximately 1.2 km downstream from the outlet of Hidden Lake (Figure 5). The stream is about 3.6 m wide at the weir location and water depth varies in the spring from 0.3 m to 0.4 m. The weir was operated by Cook Inlet Aquaculture Association personnel until 14 July.

The fyke-type weir was constructed of knotless nylon net with circular mesh openings 1 cm in diameter. Fyke wings were about 4.5 m long and were attached to either bank. The wings converged at a circular opening in the net near mid-channel downstream from the bank attachment points. The wings were tied to 2.5 cm diameter pipes set in the streambed. Sandbags were placed on the wing to form a seal at the streambed.

A cube-shaped trap measuring 1 m along each edge was fastened to the circular opening in the net to trap and hold fish migrating downstream. The trap was constructed of perforated aluminum plate and aluminum angle. A partition

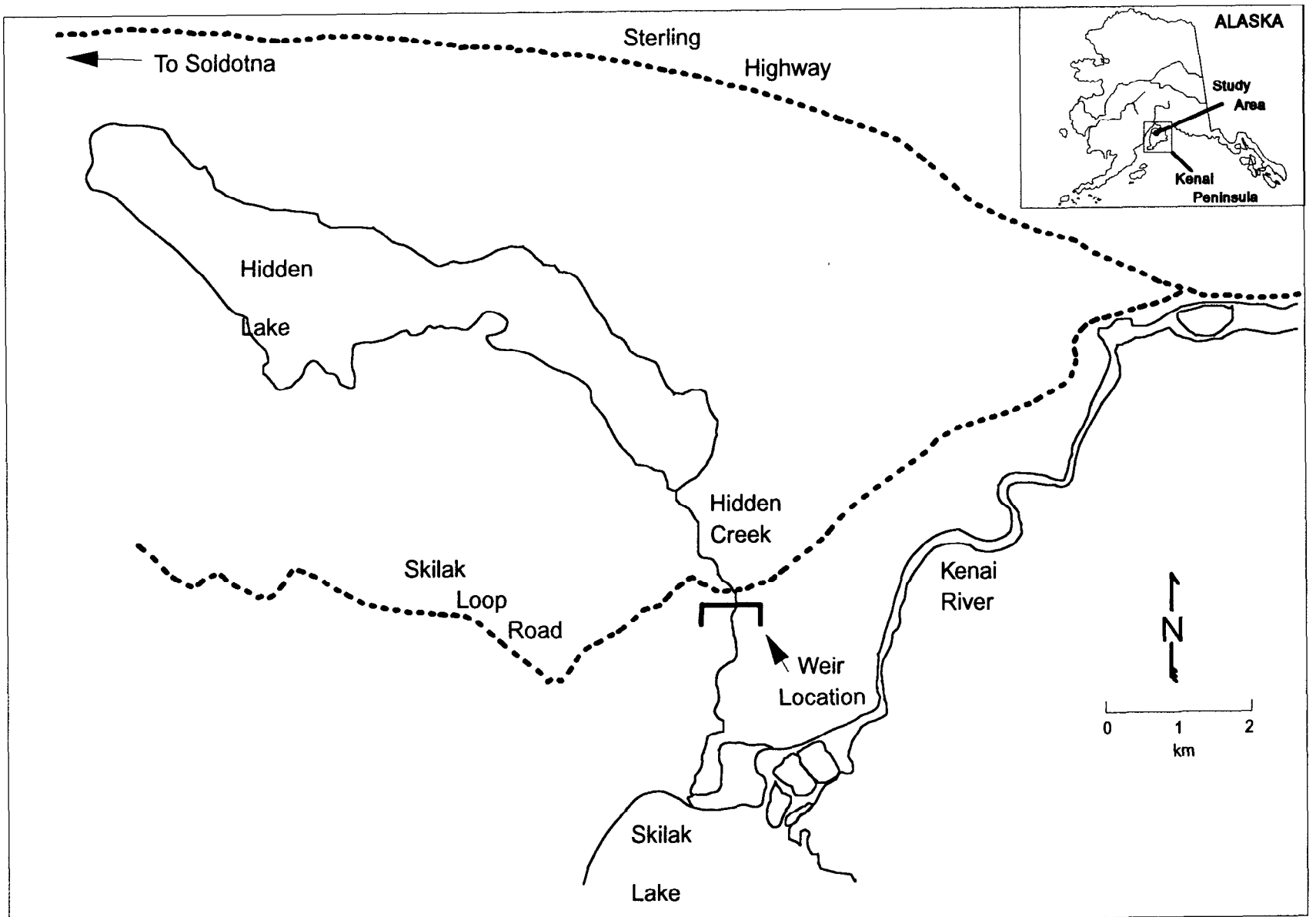

Figure 5. Location of the Hidden Creek weir, 1993.

divided the trap into two compartments and a hinged door controlled the flow of water and fish into each compartment.

Each compartment was equipped with a removable panel allowing fish to pass freely through the trap. During periods of high abundance, fish passage was estimated by periodically trapping and counting a timed sample in one partition and allowing fish to flow freely through the other partition for a timed period. Average counts were then expanded for each species to estimate the number of fish which passed uncounted through the traps.

One crew of two people counted migrant fish and selected coho salmon ≥ 100 mm for marking. As at the Moose River, small age-0 coho salmon migrated past the weir during the smolt emigration, apparently in an upstream direction. Any small coho salmon captured were released upstream of the weir. Coho salmon smolt were handled and marked using the same standard procedures used at Moose River. Fish were temporarily retained in holding pens for a maximum of 36 hours. A second crew of two people marked fish 5 days per week during one 7.5-hour shift per day. Fish were batch marked with unique codes in lots of about 700 to 6,000 per code. Fish in excess of what could be marked within 36 hours were released unmarked.

Short-term tag retention and survival rates were estimated each day by holding a sample of approximately 200 marked fish for 18 hours in an inriver holding pen. After 18 hours, the sample was checked for mortalities and all of the remaining live fish were passed through a tag detector.

Mark Recovery

All coho salmon selected for marking at the Moose River and Hidden Creek weirs were inspected for a missing adipose fin prior to marking. All adipose-clipped fish were dissected and examined for an imbedded tag. Fish with an adipose clip but no tag were assumed to have lost the tag. The relative abundance of fish originally marked as fingerling served as an indicator of dispersion from Skilak and Kenai Lake outlets to these tributaries for overwintering. The Moose River and Hidden Creek represent disparate portions of the drainage. Dispersion to both of these areas would indicate that some degree of mixing of individuals occurs within the drainage. Such dispersion may result in overwintering populations comprised of individuals of different return timings. Lack of mixing (e.g. all marked fish recovered at one weir) may indicate that marking smolt from tributary emigrations may not provide a representative sample of the coho populations.

All coho captured in inclined-plane traps at rkm 31.0 were also examined for a missing adipose fin. From 17 May through 5 July, all adipose-clipped fish were retained and dissected for tag inspection. The recovery of marked coho salmon verified a mass downstream migration of coho salmon from tributaries consistent with smoltification. The marked-to-unmarked ratio was examined for a temporal trend which might indicate bias in capture strategies.

Length and Age Composition

Fork lengths and scales were obtained from samples of fish at all four marking locations and at the inclined plane traps at Kenai River rkm 31.0. A scale

smear was removed from the preferred area of each sampled fish (Scarnecchia 1979) and placed on adhesive-coated cards. Scale impressions on clear acetate cards were examined with a microfiche reader to determine age. Fork lengths were recorded to the nearest millimeter.

Fingerling:

At both the Skilak and Kenai Lake trapping locations, 150 fingerling were sampled on 1 day each calendar week except for 1 week when no samples were taken at Kenai Lake and two were taken the following week. Each sample was weighted among traps by visually inspecting each trap and estimating its catch relative to the total catch of all traps. The required number of coho salmon was randomly selected from each trap using a dip net.

The goal of sampling fingerling was to check the length threshold determined in 1991 to select and mark age-1 fish from a catch of all ages. Ages 0 through 2 were always represented in the samples even though the traps were moved among locations to maximize the catch of fish $\geq$ 72 mm. Because traps were moved to target age-1 and older fish, age compositions represent the trap catch and not necessarily the population at large.

Tributary Smolt:

Smolt emigrations were enumerated daily at both the Moose River and Hidden Creek allowing age and length samples to be taken in proportion to the numbers emigrating. A sample of 150 smolt was selected at intervals of 20,000 fish during the emigration. The first sample was selected immediately after 10,000 fish had emigrated and every 20,000 thereafter. Age and length data were used to estimate age and length compositions, to apportion the smolt emigrations by age, and to compare length compositions of marked smolt among capture locations.

Kenai River Mainstem Smolt:

Fork lengths and scales were collected from all marked coho salmon recovered in the traps. In addition, 150 coho salmon smolt were measured after 1,000 coho salmon were captured. The planned sampling interval of 1,000 resulted in collecting one sample mid-way through the total catch of 1,982 coho salmon smolt.

Data Analysis

Data analysis included both estimation of parameters and hypothesis testing. Estimates included survival and tag retention rates, the number of fish released that retained tags, and length-age compositions. Hypothesis testing was used to determine if samples could be pooled to provide more precise estimates. Hypothesis testing was also used to provide preliminary indications of marking bias.

Fish Marking:

For each of the four release locations, the short-term survival rate (S_i) of fish marked and released each day was estimated as a binomial proportion by:

$$\hat{S}_i = n_i/n_{ti}, \quad (1)$$

where:

n_i = number of marked fish detained on day i that survived the holding period; and,

n_{ti} = number of marked fish detained on day i.

The variance of survival was estimated by:

$$\widehat{var}(\hat{S}_i) = \hat{S}_i(1-\hat{S}_i)/(n_{ti}-1). \quad (2)$$

The short-term tag retention rate (R_i) of fish that were marked, survived, and retained tags, and its variance, was estimated similarly where:

n_i = number of marked fish detained on day i that survived the holding period and retained a tag; and,

n_{ti} = total number of marked fish that were detained on day i and survived the holding period.

Short-term survival and tag retention rates were used to adjust the number of fish marked to estimate the number of viable marks released, i.e., the number of fish released that survived and retained a microwire tag. Within each release location, a Kruskal-Wallis analysis of variance (Sokal and Rohlf 1969) was used to test the null hypothesis that short-term survival and tag retention rates did not differ ($\alpha = 0.05$) among marked samples detained overnight. Test results determined if samples could be pooled to provide more precise estimates of survival and tag retention.

Short-term survival and tag retention rates were always greater than 0.99 in all overnight samples detained at Skilak and Kenai lakes. Within each location, therefore, data from all overnight samples were pooled to estimate an overall survival and tag retention rate.

A number of samples of marked smolt detained at Moose River and Hidden Creek contained coho marked with two different tag codes injected on a single day. Therefore, the tests were used to determine if differences existed among groups of samples rather than among tag codes. Tests were conducted among groups of three consecutive daily samples to determine if survival and retention rates differed among the groups. The Kruskal-Wallis tests determined if groups of samples, which corresponded roughly to tag codes, could be pooled for more precise estimates of short-term survival, tag retention, and ultimately, the number of viable marks released.

Test results permitted pooling all daily survival samples at Hidden Creek and Moose River and calculating a single overnight survival estimate. Tag retention rates did not differ among groups at Hidden Creek and all samples were combined to estimate a single retention rate. Tag retention did differ among groups at Moose River. Further analysis allowed pooling samples marked

from 23 May through the first shift on 2 June and from the second shift on 2 June through the end of marking on 17 June.

The total number of viable marks ($\hat{T}_j$) released at a location was estimated for each tag code group j by:

$$\hat{T}_j = \hat{N}_j \hat{S}_j \hat{R}_j, \tag{3}$$

where:

N_j = the number of fish of tag code group j injected with a tag.

The associated variance was estimated by (Goodman 1960):

$$\text{var}(\hat{T}_j) = \hat{N}_j^2 \left[\hat{S}_j^2 \text{var}(\hat{R}_j) + \hat{R}_j^2 \text{var}(\hat{S}_j) - \text{var}(\hat{R}_j)\text{var}(\hat{S}_j)\right]. \tag{4}$$

To estimate viable marks released with tag code c ($\hat{T}_{cj}$), the total release was apportioned by:

$$\hat{T}_{cj} = p_{cj}\hat{T}_j, \tag{5}$$

where:

p_{cj} = proportion of tag code c injected relative to all tags of group j injected.

The associated variance was estimated by:

$$\text{var}(\hat{T}_{cj}) = p_{cj}^2 \text{var}(\hat{T}_j). \tag{6}$$

To determine the total number of viable marks released at the Moose River, the group estimates and associated variances were assumed independent and were summed over groups.

Mark Recovery:

Marked coho salmon smolt were recovered in the spring of 1993 at the Moose River, Hidden Creek, and in the inclined-plane traps at rkm 31.0 of the Kenai River mainstem. Those found emigrating from the Moose River and Hidden Creek originated primarily from previous fingerling releases. Marked fish recovered in the rkm 31.0 inclined-plane traps originated primarily from the 1993 Moose River/Hidden Creek smolt releases or from the previous fingerling release in the fall of 1992.

The proportion ($\hat{p}$) of fish bearing marks at each location was estimated by:

$$\hat{p} = n/n_0, \tag{7}$$

where:

n = number of adipose-clipped fish examined at the capture location, and

n_0 = total number of fish examined at the capture location.

The proportion of examined fish bearing Skilak Lake 1992 release codes was compared between tributaries using a χ^2 test at a significance level of 0.05. Too few fish marked at Kenai Lake in 1992 were recovered for the comparison. Failure to reject the null hypothesis of no difference in proportions would be indicative of a random dispersion from the original capture location to over-wintering tributaries.

Temporal changes in the marked proportion of fish captured at rkm 31.0 would indicate that marks were not released in proportion to the abundance of all smolt. Such temporal changes would suggest the possibility of a bias toward marking discrete populations not representative of all Kenai River smolt. To detect a trend, the numbers of marked and unmarked fish trapped were compared over four equal intervals of total coho salmon trapped. The comparison was made using a χ^2 test at a significance level of 0.05.

Length and Age Composition:

Age and length samples were collected at all capture locations. At each location, the proportion of age group h from sample k (a_{hk}) was estimated by:

$$\hat{a}_{hk} = n_{hk}/n_k, \tag{8}$$

where:

n_{hk} = number of coho salmon of age group h from sample k; and,

n_k = number of readable scales from sample k.

The variance of each proportion $\hat{a}_{hk}$ was estimated by:

$$\widehat{var}(\hat{a}_{hk}) = \hat{a}_{hk}(1-\hat{a}_{hk})/(n_k-1). \tag{9}$$

For each location, differences in age composition among samples were tested using χ^2 tests at a significance level of 0.05. These tests were conducted to document ancillary biological information. Tests were not applied to rkm 31.0 samples because only one sample was collected. The smolt emigrations from the two study tributaries were apportioned by age for documentation purposes. Because sampling was proportional to the number emigrating from each tributary (interval sampling), all age data were pooled to estimate the age composition of the emigration.

Mean length-at-age and associated variances were estimated using standard normal procedures. Differences in mean length-at-age were tested among samples at each location using analysis of variance at a significance level of 0.05. These tests were conducted to document ancillary biological information.

The cumulative length distribution of all fish sampled at Moose River was compared with the length distribution of marked Moose River fish recaptured at the rkm 31.0 location using the two-sample Kolmogorov-Smirnov test (Daniel 1978). The same comparison was made between all fish sampled at Hidden Creek and marked Hidden Creek fish recaptured at the rkm 31.0 location. Differences between release and recovery may be indicative of size-selective sampling of the inclined-plane traps at rkm 31.0. The presence of smolt originating from areas other than Hidden Creek or the Moose River would have no effect on this comparison.

The potential for size bias of the inclined-plane traps used at rkm 31.0 was also examined by comparing the estimated mean length-at-release with the mean length-at-recapture at rkm 31.0 for individual tag codes. All comparisons were made using t-tests at a significance level of 0.05.

RESULTS

Fish Marking

A total of 143,018 coho salmon juveniles were captured and injected with coded, microwire tags between 13 August 1992 and 28 June 1993. After adjusting for short-term tag loss and survival rates, an estimated 141,925 coho salmon retaining tags (viable marks) were released with one of 33 unique tag codes (Table 1). An estimated 18,419 fingerling with viable marks were released at Skilak Lake outlet, 1,801 fingerling at the Kenai Lake outlet, 22,075 smolt at Hidden Creek, and 99,630 smolt at the Moose River.

Short term tag retention and survival rates were close to 100%. Single, location-specific estimates of short-term tag retention and survival rates were made for the Skilak Lake, Kenai Lake, and Hidden Creek releases (Table 1). Of 5,446 fingerling detained for overnight samples there were only three mortalities and two shed tags. Tests detected no differences in survival ($\chi^2 = 4.28$, df = 6, P = 0.64) or retention ($\chi^2 = 4.93$, df = 6, P = 0.55) rates among Hidden Creek samples. Hence, all overnight samples were pooled to provide single estimates of tag retention and survival for each location.

Although short-term survival rates did not differ among samples at the Moose River ($\chi^2 = 10.79$, df = 10, P = 0.37), short-term tag retention rates did differ ($\chi^2 = 22.74$, df = 10, P = 0.01). Tag retention samples were pooled to the degree possible resulting in two separate estimates of tag retention and one estimate of survival (Table 1). A summary of the number of fish injected by date and the overnight sample results are presented in Appendix A1.

Mark Recovery

A total of 32,966 smolt were enumerated as they emigrated from Hidden Creek between 29 May and 14 July 1993. Of these, 22,445 were examined for a missing adipose fin and 200 (0.9%) were found to be missing the fin. A total of 188,472 coho salmon were enumerated or estimated as they emigrated from the Moose River between 22 May and 17 June 1993. Of these, 102,847 were examined for a missing adipose fin and 2,310 (2.2%) were found to be missing the fin.

Table 1. Estimated number of viable marks (T), overnight tag retention (R) and survival (S) rates, and associated standard errors (SE) for coho salmon juveniles marked with coded, microwire tags and released in the Kenai River drainage between 13 August 1992 and 28 June 1993.

Release Location	Release Period	Code	Number Injected	Proportion of Total	T	SE(T)	R	SE(R)	S	SE(S)
Skilak	8/13-8/24	31-20-24	5,438	0.295	5,434	2				
Lake	8/24-9/04	31-20-25	5,845	0.317	5,841	2				
1992	9/09-9/30	31-20-26	5,962	0.323	5,958	2				
	9/30-10/14	31-20-27	1,187	0.064	1,186	<1				
		Total	18,432		18,419	7	0.999	0.0003	0.999	0.0002
Kenai	8/27-9/10	31-21-20	1,186	0.657	1,185	<1				
Lake	9/24-10/09	31-21-16	618	0.343	618	<1				
1992		Total	1,804		1,801	2	1.000	0.0000	0.998	0.0014
Hidden	6/05-6/07	31-22-12	2,429	0.109	2,410	3				
Creek	6/07-6/09	31-22-13	2,814	0.127	2,793	4				
1993	6/10	31-22-14	2,720	0.122	2,699	3				
	6/10-6/12	31-22-24	4,928	0.222	4,890	6				
	6/12-6/19	31-22-25	5,986	0.269	5,940	7				
	6/19-6/21	31-22-15	2,674	0.120	2,654	3				
	6/23-6/28	31-22-26	694	0.031	689	1				
		Total	22,245		22,075	28	0.9996	0.0003	0.9928	0.0012
Moose	5/23	31-21-21	1,662	0.034	1,655	1				
River	5/24-5/25	31-20-28	6,458	0.133	6,429	5				
1993	5/25-5/27	31-20-29	6,385	0.131	6,356	5				
	5/27-5/28	31-21-10	5,951	0.122	5,924	5				
	5/28-5/30	31-21-11	5,643	0.116	5,618	4				
	5/30-5/31	31-21-08	5,469	0.113	5,445	4				
	5/31-6/01	31-21-09	5,738	0.118	5,712	5				
	6/01	31-21-22	5,514	0.114	5,489	4				
	6/01-6/02	31-21-28	5,760	0.119	5,734	5				
		Sub Total	48,580		48,362		0.9985	0.0006	0.9970	0.0006
	6/02-6/03	31-21-29	5,930	0.114	5,851	9				
	6/03-6/05	31-21-30	5,938	0.114	5,859	9				
	6/06-6/07	31-21-44	5,587	0.108	5,513	9				
	6/07-6/09	31-21-43	6,216	0.120	6,134	10				
	6/09-6/10	31-22-08	2,972	0.057	2,933	5				
	6/10	31-22-09	2,860	0.055	2,822	5				
	6/10-6/12	31-22-20	6,366	0.123	6,282	10				
	6/12-6/13	31-22-21	6,266	0.121	6,183	10				
	6/13-6/15	31-22-22	6,310	0.121	6,226	10				
	6/15-6/17	31-22-10	2,854	0.055	2,816	5				
	6/17	31-22-11	658	0.013	649	1				
		Sub Total	51,957		51,268		0.9897	0.0015	0.9970	0.0006
		Total	100,537		99,630	91				

All 200 adipose-clipped coho salmon recovered at Hidden Creek were retained and examined for an implanted tag (Table 2). Of these, 29 (14%) had no tag, 2 (1%) were from the 1991 Skilak Lake fingerling release, 62 (31%) originated from the 1992 Skilak Lake fingerling release, 18 (9%) were from the 1992 Kenai Lake fingerling release, and 89 (45%) had been marked and released downstream from the weir in 1993. Apparently, there was a weir breech that allowed some coho salmon marked in 1993 to move upstream through the weir to be captured a second time. A summary of mark recoveries by date is presented in Appendix A2.

All 2,310 adipose-clipped fish recovered at the Moose River were retained and examined for an implanted tag (Table 2). Of these, 249 (11%) had no tag, 207 (9%) had been marked as fingerling at the outlet of Skilak Lake in 1991, 1,623 (70%) originated from the Skilak Lake fingerling release in 1992, 26 (1%) had been marked as fingerling at the outlet of Kenai Lake in 1992, 8 (<1%) had been marked at the Moose River as smolt in 1992, 196 (8%) had been marked at the Moose River in 1993 and released downstream from the weir, and one tag was retrieved from a fish but was lost before it could be decoded. As was the case at Hidden Creek, the recapture of recently released fish indicated some upstream movement through a breech in the weir. A summary of mark recoveries by date is presented in Appendix A3.

A total of 1,982 coho salmon smolt were captured in inclined-plane traps located in the mainstem at rkm 31.0. All were examined for an adipose finclip and 666 (34%) adipose-clipped fish were found (Table 2). Of these, 21 (3%) had no tag, 2 (<1%) were marked as fingerling at the outlet of Skilak Lake in 1991, 16 (2%) were marked as fingerling at the outlet of Skilak Lake in 1992, 35 (5%) were marked as smolt at Hidden Creek in 1993, 1 (<1%) was marked as a smolt at the Moose River in 1992, and 591 (89%) were marked as smolt at the Moose River in 1993. A summary of mark recoveries by date is presented in Appendix A4.

There was a significant difference over time ($\chi^2 = 198.24$, df = 3, $P < 0.001$) in the proportion of adipose-clipped smolt in the inclined-plane trap catch at rkm 31.0. The proportion of adipose-clipped fish captured was higher during the middle 50% of the total catch than during the first or last quarter of the catch (Figure 6).

Length and Age Composition

Fingerling, 1992:

Fingerling samples collected at the outlet of Skilak Lake between 13 August and 9 October were composed primarily of age-0 and age-1 coho salmon (Table 3). Of 1,332 legible scales collected, only nine were age 2. Even though traps were moved to target age-1 coho salmon, the proportion of age-1 fish in the catch declined with time.

A one-way analysis of variance indicated a significant change in the mean length of age-1 fish occurred over time ($F = 3.18$, df = 8, 488, $P = 0.002$) although confidence intervals overlapped among all but two sample dates, 13 August and 4 September (Figure 7). Various least square curves fit to the observed length distributions of age-0 and age-1 fish illustrated the

Table 2. Summary of marked juvenile coho salmon recovered in the Kenai River drainage during 1993 by release event.

Recovery Location	Number Examined	Ad-clips Recovered	No Tag	Release Location and Year					
				Skilak Lake		Kenai Lake	Hidden Creek	Moose River	
				1991	1992	1992	1993	1992	1993
Hidden Creek	22,445	200	29	2	62	18	89		
Moose River	102,847	2,310[a]	249	207	1,623	26		8	196
Kenai River rkm 31.0	1,982	666	21	2	16		35	1	591

[a] Tag recovered from one fish was lost before being decoded.

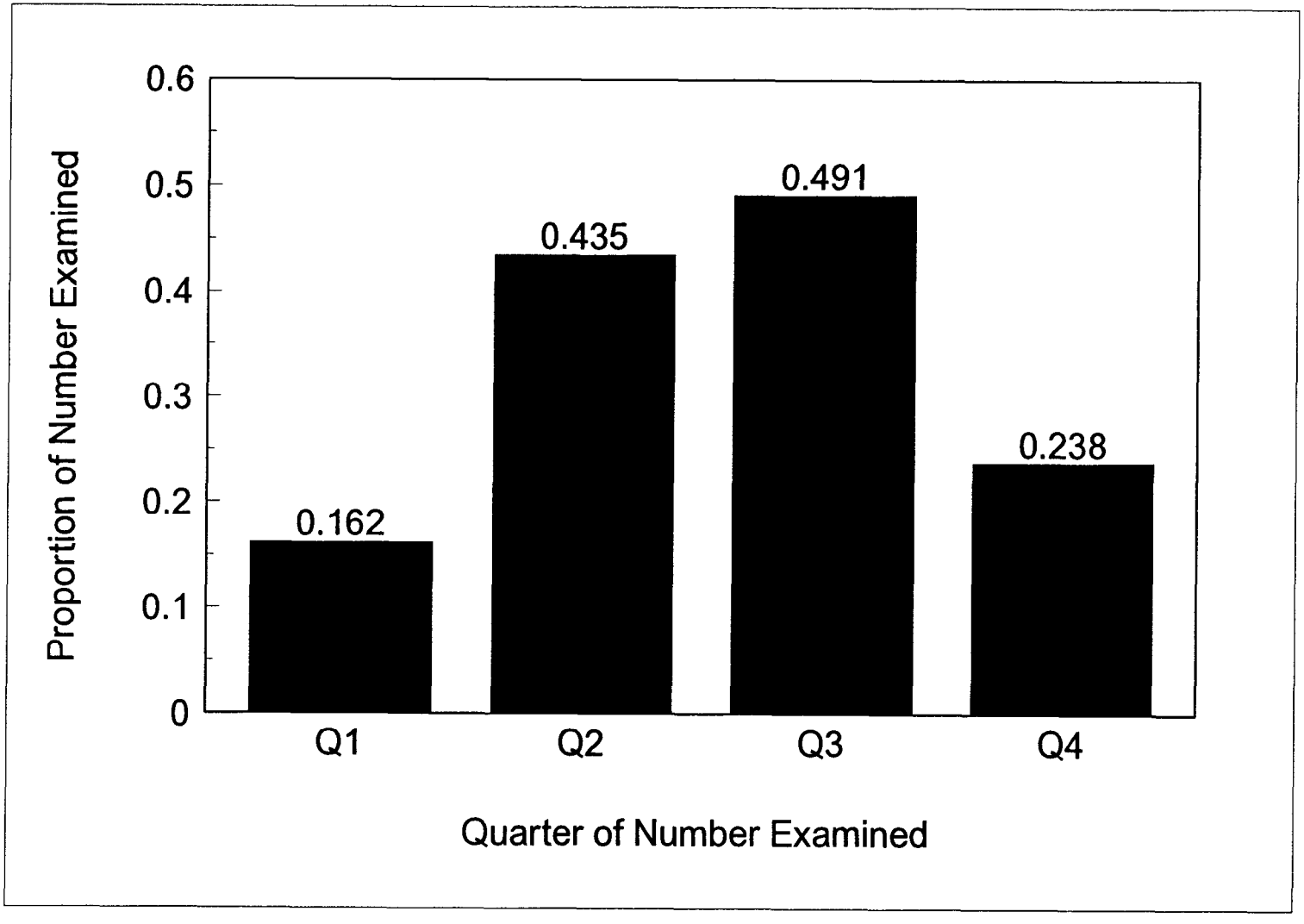

Figure 6. Marked proportion of the Kenai River mainstem inclined-plane trap catch of coho salmon between 17 May and 5 July 1993. Proportions are for each quarter of the seasonal catch of 1,982 coho salmon.

Table 3. Mean fork length and age composition of juvenile coho salmon captured at the outlet of Skilak Lake between 13 August and 9 October 1992.

Sample Date		Age 0	Age 1	Age 2	Total
8/13	n	21	125	3	149
	Mean Length	65	89	117	86
	SE	1.5	0.8	3.1	1.0
	Percent	14.1	83.9	2.0	100.0
	SE(Percent)	2.86	3.02	1.15	
8/21	n	44	102	4	150
	Mean Length	64	92	122	85
	SE	1.6	1.0	4.4	1.4
	Percent	29.3	68.0	2.7	100.0
	SE(Percent)	3.73	3.82	1.32	
8/28	n	72	76	2	150
	Mean Length	63	89	118	77
	SE	0.8	1.2	5.5	1.4
	Percent	48.0	50.7	1.3	100.0
	SE(Percent)	4.09	4.10	0.94	
9/04	n	98	51		149
	Mean Length	60	94		72
	SE	0.7	1.6		1.5
	Percent	65.8	34.2		100.0
	SE(Percent)	3.90	3.90		
9/11	n	117	33		150
	Mean Length	62	89		68
	SE	0.5	2.5		1.2
	Percent	78.0	22.0		100.0
	SE(Percent)	3.39	3.39		
9/18	n	114	33		147
	Mean Length	60	94		68
	SE	0.7	2.5		1.4
	Percent	77.6	22.4		100.0
	SE(Percent)	3.45	3.45		
9/25	n	137	12		149
	Mean Length	55	100		58
	SE	0.7	5.0		1.2
	Percent	91.9	8.1		100.0
	SE(Percent)	2.24	2.24		
10/02	n	131	15		146
	Mean Length	59	96		63
	SE	0.6	3.4		1.1
	Percent	89.7	10.3		100.0
	SE(Percent)	2.52	2.52		
10/09	n	132	10		142
	Mean Length	58	94		60
	SE	0.5	6.0		1.0
	Percent	93.0	7.0		100.0
	SE(Percent)	2.15	2.15		

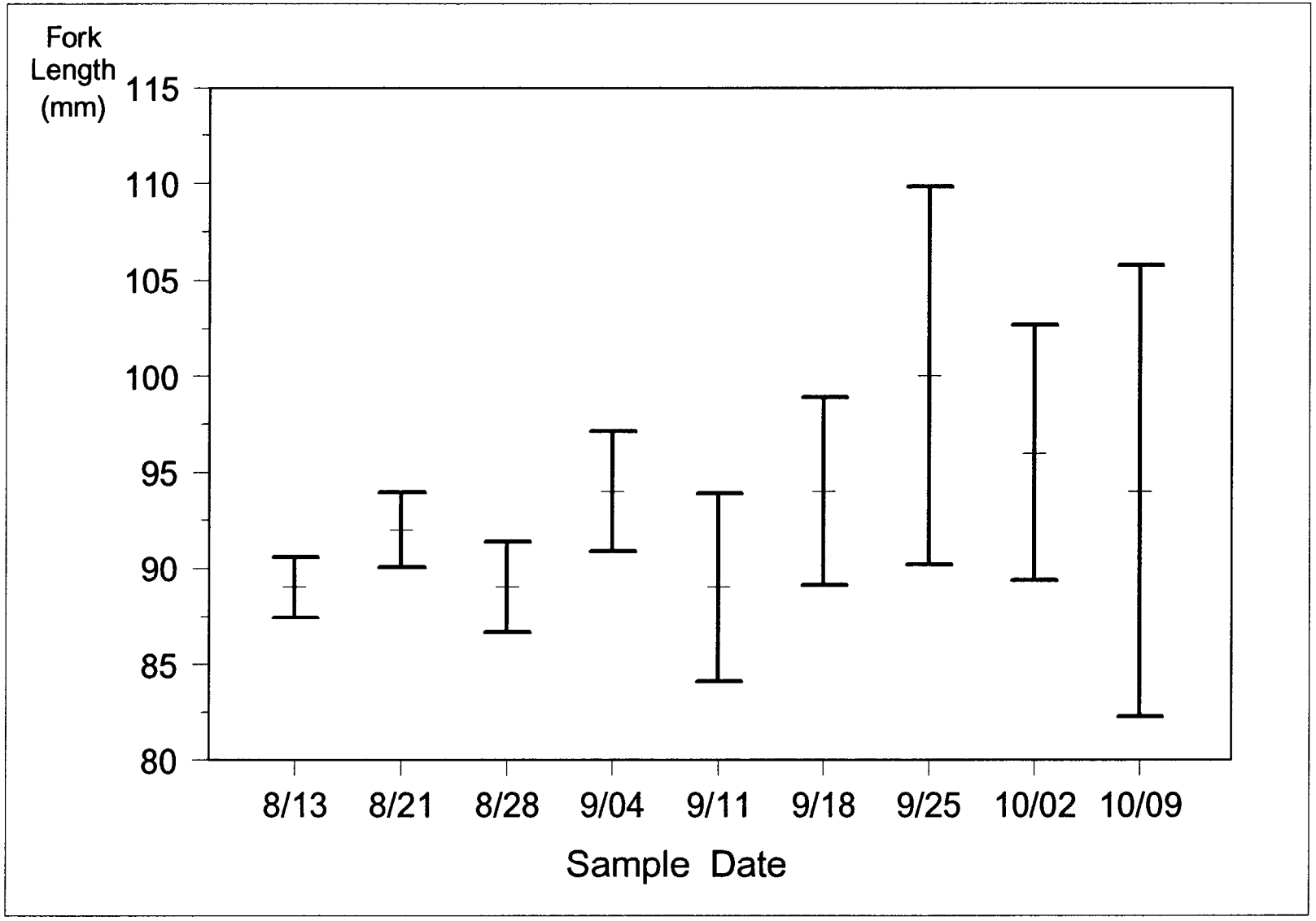

Figure 7. Mean lengths and 95% confidence intervals for age-1 coho salmon captured near the outlet of Skilak Lake, 1992.

performance of the 72 mm criterion in selecting age-1 and older fish from the trap catches for marking at the Skilak Lake site (Figure 8).

Fingerling samples collected at the outlet of Kenai Lake between 3 September and 15 October were also composed primarily of age-0 and age-1 coho salmon (Table 4). Of 994 legible scales collected, only eight were age 2. As at the Skilak Lake site, the proportion of age-1 fish in the catch declined over time.

A one-way analysis of variance indicated there was a significant difference in the mean length of age-1 fish over time ($F = 13.91$, $df = 6, 458$, $P < 0.001$; Figure 9). Various least square curves fit to the observed length distributions of age-0 and age-1 fish illustrated the performance of the 72 mm criterion used to select age-1 and older fish from the trap catches at the Kenai Lake site (Figure 10).

Smolt, 1993:

Coho salmon smolt sampled at the Moose River, Hidden Creek, and rkm 31.0 were predominantly age 2 (Table 5). The age composition of fish sampled at the Moose River did not differ ($\chi^2 = 2.20$, $df = 2$, $P = 0.33$) among samples collected during the emigration. Age composition at Hidden Creek changed significantly ($\chi^2 = 59.72$, $df = 2$, $P < 0.001$) between the two samples collected due to an increased proportion of age-1 smolt in the second sample. Because age sampling at each tributary was proportional to the total smolt emigration, the overall age composition of the emigration from each tributary was estimated by pooling all samples from each tributary.

Mean length-at-age was also compared among samples collected at tributaries (Table 6). At Hidden Creek there was a significant ($F = 61.00$; $df = 1, 177$; $P < 0.001$) decline in mean length of age-2 smolt but no difference in mean length of age-1 ($F = 0.14$; $df = 1, 71$; $P = 0.71$) or age-3 ($F = 0.10$; $df = 1, 18$; $P = 0.76$) smolt. At Moose River age-2 smolt sampled on 28 May were larger ($F = 7.51$; $df = 8, 1070$; $P < 0.001$) than all other samples. Although there was a difference ($F = 5.55$; $df = 8, 98$; $P < 0.001$) in size among samples of age-3 smolt, there were no clear trends. There was no difference in size of age-1 smolt ($F = 1.07$; $df = 8, 21$; $P = 0.43$) among samples at the Moose River, although sample sizes were small. Although differences in the time that samples were taken at the three locations confounds any analysis of differences among locations, in general mean length-at-age was smallest in smolt sampled at the Kenai River rkm 31.0 traps and greatest at Hidden Creek.

There was a significant difference ($D = 0.34$; $n_1 = 1{,}348$, $n_2 = 590$, $P < 0.001$) between the cumulative length distribution of all smolt measured at the Moose River and marked Moose River smolt recaptured at the rkm 31.0 location (Figure 11). There was also a significant difference ($D = 0.45$, $n_1 = 300$, $n_2 = 35$, $P < 0.001$) using the same comparison for Hidden Creek smolt.

There were significant differences (range $t = -2.25$ - -10.66, $P \leq 0.04$) in the mean length of age-2 smolt of discrete tag code groups between release and recovery at rkm 31.0 (Table 7). For both the Moose River and Hidden Creek, the mean length-at-recovery was smaller than the mean length-at-release. This same relationship, although not significant, occurred in age-1 and age-3 smolt between release at the Moose River and marked smolt recovered in the rkm 31.0

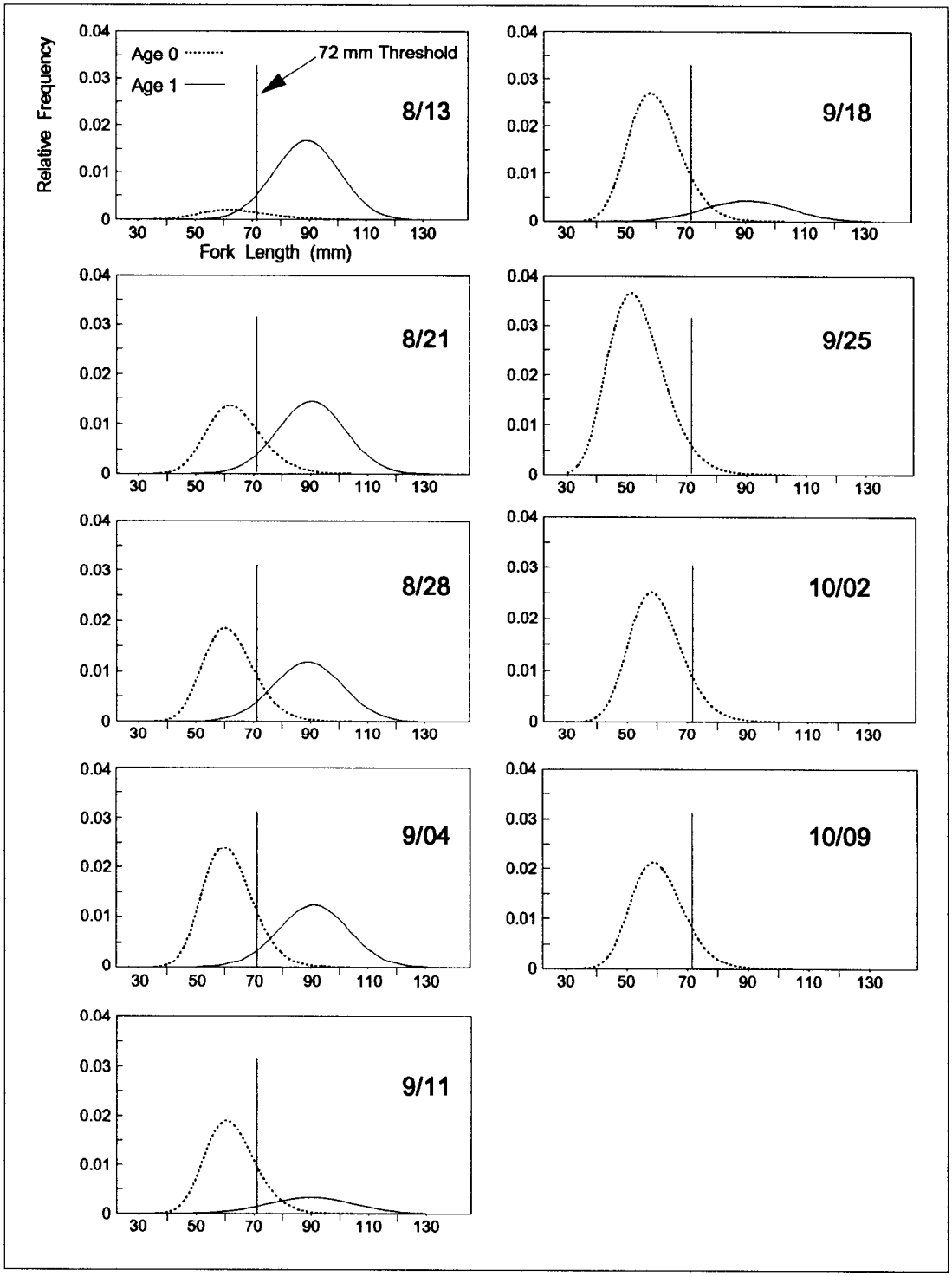

Figure 8. Least squares curves fit to observed length frequencies of coho salmon fingerling sampled on nine occasions between 13 August and 9 October at the outlet of Skilak Lake, 1992. Vertical lines represent the 72 mm threshold above which all trapped coho salmon were marked.

Table 4. Mean fork length and age composition of juvenile coho salmon captured at the outlet of Kenai Lake between 3 September and 15 October 1992.

Sample Date		Age 0	Age 1	Age 2	Total
9/03	n	49	93	1	143
	Mean Length	66	88	108	81
	SE	1.0	1.2		1.2
	Percent	34.3	65.0	0.7	100.0
	SE(Percent)	3.98	4.00	0.70	
9/10	n	76	69		145
	Mean Length	65	86		75
	SE	0.7	1.3		1.1
	Percent	52.4	47.6		100.0
	SE(Percent)	4.16	4.16		
9/21	n	58	84	2	144
	Mean Length	61	93	121	81
	SE	1.0	1.4	11.0	1.7
	Percent	40.3	58.3	1.4	100.0
	SE(Percent)	4.10	4.12	0.98	
9/24	n	46	85	4	135
	Mean Length	60	97	132	85
	SE	1.5	1.3	9.3	1.9
	Percent	34.1	63.0	3.0	100.0
	SE(Percent)	4.09	4.17	1.46	
10/01	n	70	72	1	143
	Mean Length	54	95	113	75
	SE	0.8	1.5		1.9
	Percent	49.0	50.3	0.7	100.0
	SE(Percent)	4.19	4.20	0.70	
10/08	n	115	28		143
	Mean Length	58	76		62
	SE	1.2	4.2		1.4
	Percent	80.4	19.6		100.0
	SE(Percent)	3.33	3.33		
10/15	n	107	34		141
	Mean Length	54	94		64
	SE	0.8	2.5		1.7
	Percent	75.9	24.1		100.0
	SE(Percent)	3.62	3.62		

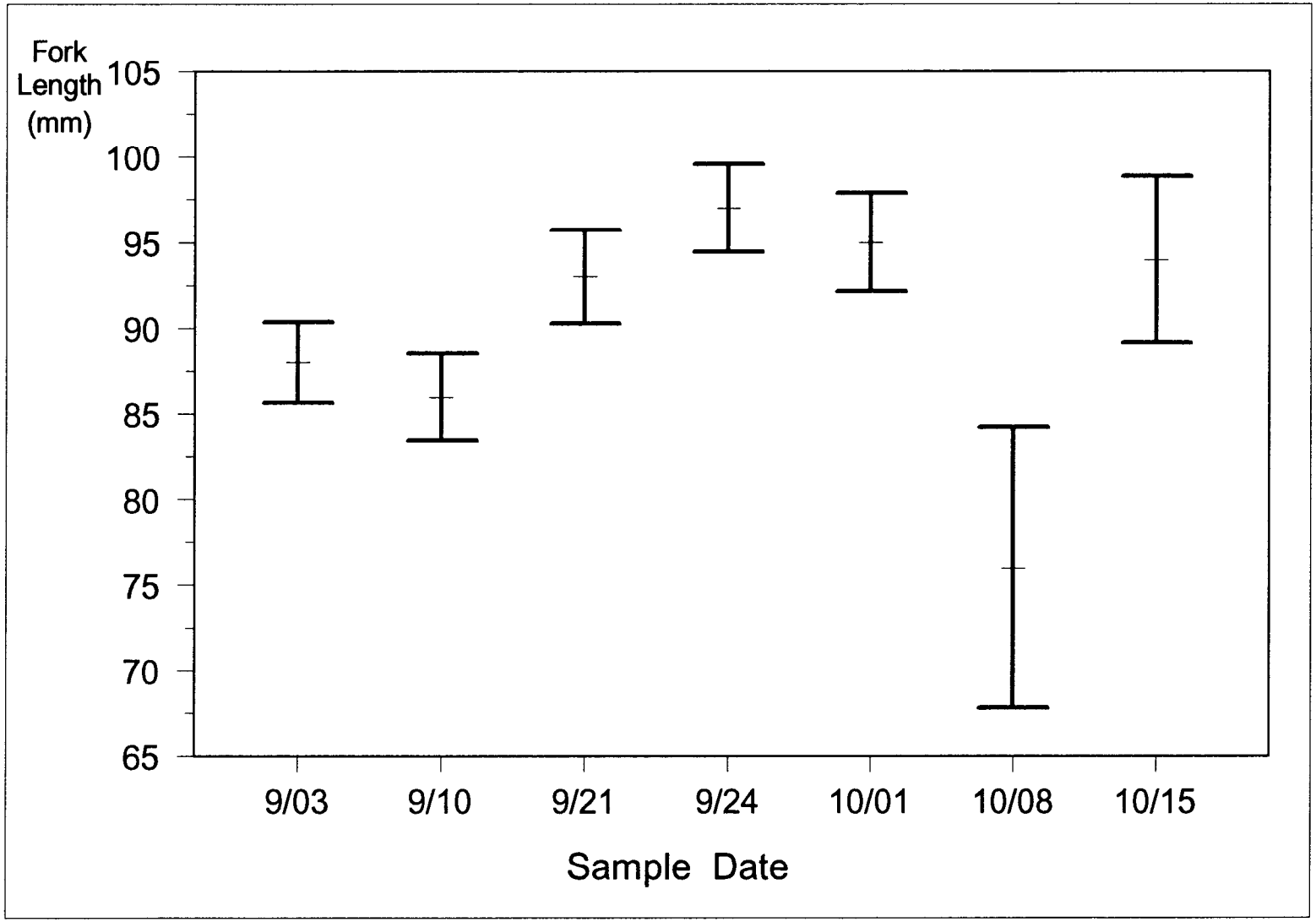

Figure 9. Mean lengths and 95% confidence intervals for age-1 coho salmon captured near the outlet of Kenai Lake, 1992.

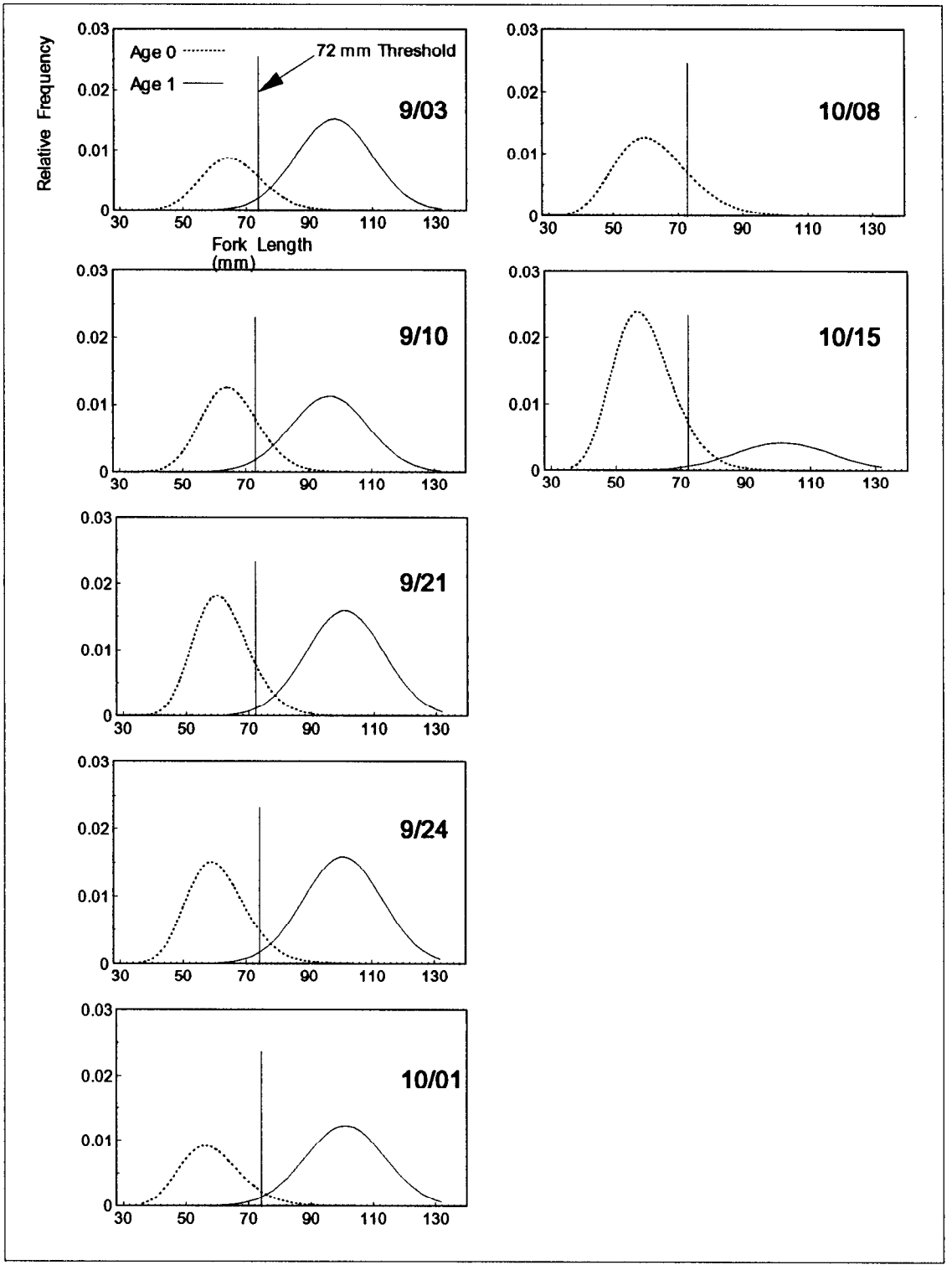

Figure 10. Least squares curves fit to observed length frequencies of coho salmon fingerling sampled on seven occasions between 3 September and 15 October at the outlet of Kenai Lake, 1992. Vertical lines represent the 72 mm threshold above which all trapped coho salmon were marked.

Table 5. Age composition of coho salmon sampled at three locations of the Kenai River during the smolt emigration, 1993.

Location	Date	n	Age 1 %	Age 1 SE(%)	Age 2 %	Age 2 SE(%)	Age 3 %	Age 3 SE(%)
Hidden Creek	08 June	135	6.7	2.2	80.7	3.4	12.6	2.9
	22 June	137	46.7	4.3	51.1	4.3	2.2	1.3
	Total	272	26.8	2.7	65.8	2.9	7.4	1.6
Moose River	25 May	110	4.5	2.0	89.1	3.0	6.4	2.3
	28 May	143	2.8	1.4	81.8	3.2	15.4	3.0
	29 May	137	1.5	1.0	94.2	2.0	4.4	1.8
	31 May	136	1.5	1.0	95.6	1.8	2.9	1.4
	01 June	133	0.8	0.8	93.2	2.2	6.0	2.1
	03 June	144	3.5	1.5	90.3	2.5	6.2	2.0
	06 June	136	1.5	1.0	82.4	3.3	16.2	3.2
	07 June	132	1.5	1.1	87.1	2.9	11.4	2.8
	11 June	146	4.8	1.8	85.6	2.9	9.6	2.4
	Total	1,217	2.5	1.1	88.7	2.2	8.8	1.9
Kenai River rkm 31.0	08 June	134	44.0	4.3	56.0	4.3		

Table 6. Mean length-at-age and associated standard error of coho salmon sampled at three locations of the Kenai River during the smolt emigration, 1993.

		Age								
		1			2			3		
Location	Date	n	Mean Length	SE	n	Mean Length	SE	n	Mean Length	SE
Hidden Creek	08 June	9	124	3.0	109	140	0.7	17	147	2.2
	22 June	64	125	0.7	70	131	0.8	3	145	7.3
	Total	73	125	0.7	179	136	0.6	20	146	2.1
Moose River	25 May	5	116	4.3	98	125	1.0	7	155	5.6
	28 May	4	114	8.4	117	130	0.9	22	143	1.5
	29 May	2	107	6.0	129	124	0.8	6	141	5.9
	31 May	2	115	7.0	130	126	0.9	4	128	5.7
	01 June	1	107	.	124	125	0.7	8	133	2.6
	03 June	5	113	6.0	129	125	0.7	9	134	4.5
	06 June	2	125	17.5	112	122	0.8	22	135	2.1
	07 June	2	95	5.0	115	125	0.9	15	133	1.9
	11 June	7	107	2.9	125	122	0.9	14	138	1.3
	Total	30	111	2.2	1,079	125	0.3	107	138	1.1
Kenai River rkm 31.0	08 June	59	100	1.2	75	115	1.3			

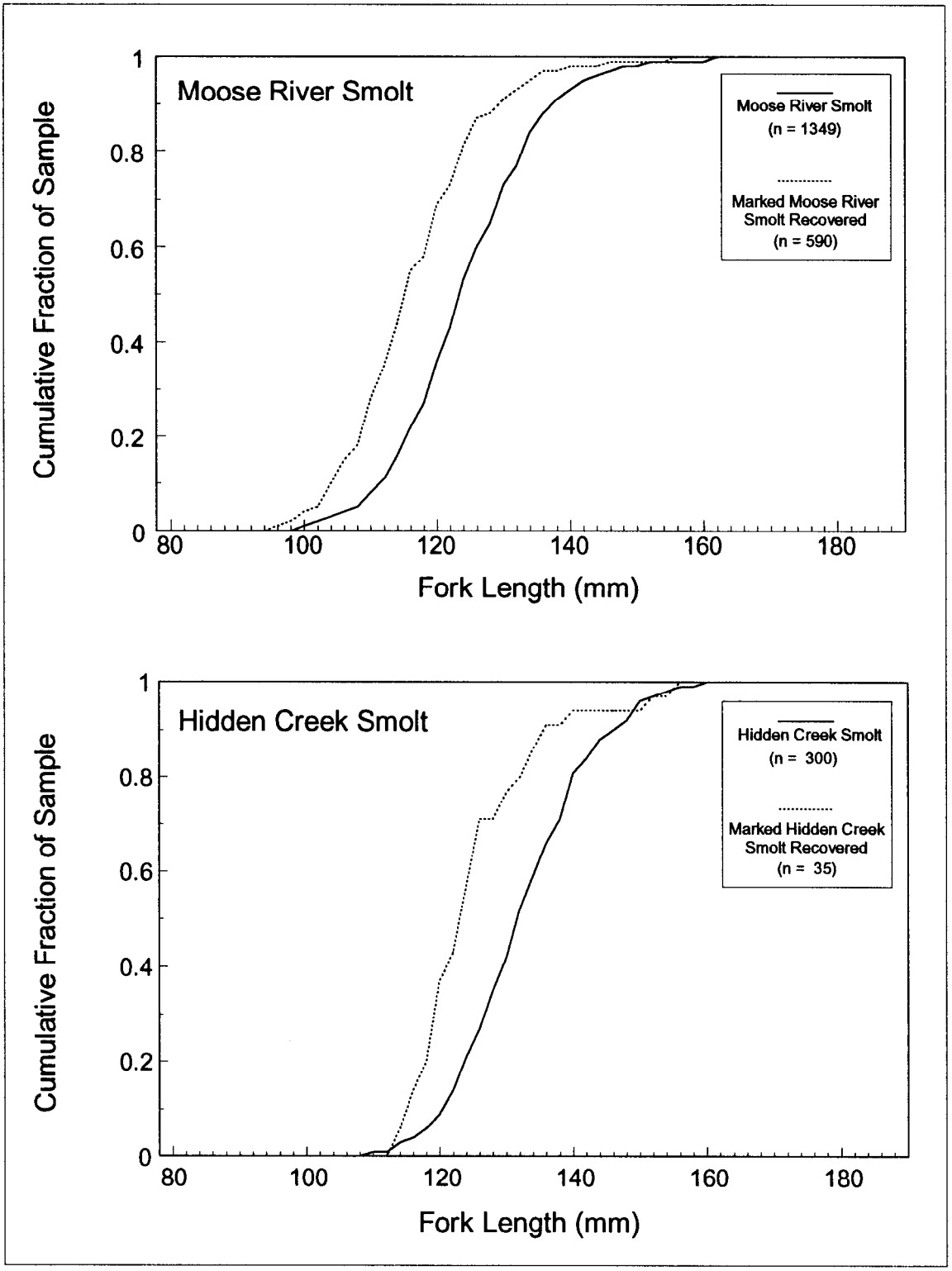

Figure 11. Comparisons of cumulative length frequencies of smolt marked at the Moose River and Hidden Creek weirs and recovered in inclined-plane traps at rkm 31.0 in the mainstem Kenai River, 1993.

Table 7. Comparison of length-at-age between coho salmon smolt measured at the Moose River and Hidden Creek release locations and marked smolt recovered in inclined-plane traps at rkm 31.0 of the mainstem Kenai River, 1993.

Release Location	Age	Number Sampled at Release	Number Recaptured at rkm 31.0	Mean Length at Release (mm)	Mean Length at Recapture (mm)	Student's t-value	P
Hidden Creek	2	70	17	131	125	- 2.25	0.04
Moose River	1	30	45	111	108	- 1.31	0.20
	2	962	449	124	119	- 10.66	<0.001
	3	78	13	135	131	- 1.39	0.17

traps. There were too few age-1 and age-3 Hidden Creek smolt recovered for a similar comparison.

DISCUSSION

A marked population of coho salmon smolt emigrated from the Kenai River in 1993 and survivors will return as adults in 1994. Because the majority of Kenai River coho salmon smolt as age 2, it is assumed that the marked portion of the 1993 smolt emigration consists primarily of marks from four marking events: (1) the 1993 Moose River smolt emigration, (2) the 1993 Hidden Creek smolt emigration, and (3) the 1992 fingerling marking at the outlets of Skilak and (4) Kenai lakes. The in-system recovery in 1993 of other marked juveniles indicates that fish from previous marking events (1991 Skilak Lake and 1992 Moose River) will also contribute to a lesser degree.

The proportion of a returning stock bearing marks must be known or estimated to determine contribution of the stock to a commercial harvest. The marked proportion of the Kenai River return will be estimated by examining the inriver sport harvest of adults in 1994. A temporal change in the marked proportion returning to the river will confound an estimate of commercial contribution (J. E. Clark, Alaska Department of Fish and Game, Juneau, personal communication). With a sufficient recovery effort, both in the marine commercial harvest and the inriver sport harvest, the return timing of marked fish will reveal if there is timing bias associated with any of the juvenile marking sites. If necessary, alternative juvenile capture strategies will be investigated.

To achieve a constant marked proportion of the return through time, our objective is to mark a representative sample of all Kenai River juvenile coho salmon. Two methods to accomplish this are: (1) to capture and mark a constant proportion of the Kenai River smolt during the entire emigration or (2) to mark a population of smolt consisting of a mix of individuals of all return timings.

The capture of smolt from the mainstem downstream of major tributaries probably offers the best opportunity to mark a constant proportion of all Kenai River smolt. However, suitable capture methods do not exist to capture large numbers of smolt. The inclined-plane traps located at rkm 31.0 have not proven very efficient and appear to be size selective towards smaller fish. In addition, the magnitude of the smolt emigration is unknown, and therefore, marking in proportion to daily emigrations is not possible. The smolt emigration may also be protracted over several months, making it impractical to mark over the duration of the emigration (T. N. Bendock, Alaska Department of Fish and Game, Soldotna, personal communication).

To date, capture of juveniles at selected sites within the drainage has been used to obtain a population for marking. This strategy can be conclusively evaluated by examining the 1994 return of adults for the desired constant marked proportion. However, we investigated within-drainage mixing for preliminary insights of whether this project marked a representative sample of smolt emigrating from the Kenai River.

Smolt marked as fingerling at the outlets of Skilak and Kenai lakes in 1992 were recovered as they emigrated from the Moose River and Hidden Creek in 1993. The recovery in both tributaries of substantial numbers of smolt originally marked at the outlet of Skilak Lake indicates that some degree of geographic mixing takes place during freshwater residency. This was also observed during the 1992 smolt emigrations from these tributaries (Carlon 1992). However, the ratio of these marked fish to the abundance of all fish emigrating differed between tributaries (Hidden Creek 0.3%, Moose River 1.6%). Although this difference does not provide conclusive evidence, it does indicate that dispersion may not be totally random throughout the drainage.

Although the recapture of Skilak Lake marks indicates some degree of mixing, inherent size differences between the two tributary populations indicate some degree of isolation. Hidden Creek smolt were larger at age than Moose River smolt. While this may be unrelated to mixing and return timing, it does suggest the possibility of discrete rearing populations.

Length-at-age and dispersion data from tag recoveries provide only a speculative evaluation of the tributary marking strategies. This information is reported for discussion purposes only and represents ancillary information that may be of value in future studies. The conclusive evaluation of marking strategies will be available when the inriver sport harvest is examined in 1994.

Marked Proportion of 1993 Smolt Emigration

Although questions remain regarding bias of the inclined-plane traps at rkm 31.0, the marked percentage (34%) trapped there during 1993 represents a preliminary estimate for planning adult recovery efforts in 1994. At the completion of marking in 1992, the marked percentage trapped at rkm 31.0 was 24% (Carlon 1992). Preliminary analysis of the 1993 inriver sport harvest indicates that the marked proportion is much smaller ($\cong$ 10%). Therefore, for planning purposes, 34% may be considered the maximum marked percentage expected in the 1994 return. This proportion may also be affected by the limited marking season used in 1993 relative to a possible protracted smolt emigration from various areas in the drainage.

Tag Loss

The proportion of marked smolt recovered at rkm 31.0 that had lost a tag was 3% in 1993, down substantially from the 9% reported in 1992 (Carlon 1992). The previously reported fingerling-to-smolt tag loss rate of about 20% (Carlon 1992) declined to about 11% for fish emigrating from the Moose River in 1993. A more experienced marking crew and optimization of headmolds among smolt size ranges may also improve smolt-to-adult tag retention rates. The smolt-to-adult tag retention rate is of interest because it will affect the precision of a contribution estimate. The quality of juvenile marking techniques will be evaluated by examining the long-term smolt-to-adult tag retention rate of adults returning in 1994.

RECOMMENDATIONS

1. For planning purposes, the design of the 1993 commercial harvest sampling scheme should assume that a maximum of 34% of the Kenai River smolt emigration was marked. The number to be examined in the commercial harvest should be adjusted to account for a possible 10% tag loss rate.

2. Marking of juveniles at the Moose River and Hidden Creek should continue until an evaluation of these methods is available from examination of the 1993 adult return.

3. The Fishery Data Series reporting requirements for the Kenai River wild stock assessment should be changed. One report that documents juvenile capture and mark releases, analyzes subsequent mark recoveries in returning adults, and evaluates juvenile marking strategies based on the analysis of adults should be produced.

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APPENDIX A

Appendix A1. Daily number of coho salmon juveniles injected with coded, microwire tags and results of overnight survival and tag retention samples for fish marked in the Kenai River drainage between 13 August 1992 and 28 June 1993.

Release Location	Injection Date	Tag Code	Number Injected	Live Fish Detained Overnight	Overnight Mortalities	Live Fish Tested for Overnight Tag Retention	Live Fish Retaining Tags Overnight
Kenai Lake	08/27/92	31-21-20	38	38	0	38	38
(fingerling)	09/03/92	31-21-20	155	155	1	154	154
	09/08/92	31-21-20	754	260	0	260	260
	09/10/92	31-21-20	239	204	0	204	204
	09/24/92	31-21-16	114	114	0	114	114
	10/01/92	31-21-16	433	205	0	205	205
	10/08/92	31-21-16	71	71	1	70	70
		Total	1,804	1,047	2	1,045	1,045
Skilak Lake	08/13/92	31-20-24	110	110	0	110	110
(fingerling)	08/14/92	31-20-24	1,234	327	0	327	326
	08/17/92	31-20-24	509	187	0	187	187
	08/19/92	31-20-24	678	225	0	225	225
	08/21/92	31-20-24	1,750	208	0	208	208
	08/24/92	31-20-24	1,157	150	1	149	149
	08/24/92	31-20-25	1,090	207	0	207	207
	08/26/92	31-20-25	677	283	0	283	283
	08/28/92	31-20-25	998	209	0	209	208
	09/02/92	31-20-25	1,671	202	0	202	202
	09/04/92	31-20-25	1,409	232	0	232	232
	09/09/92	31-20-26	2,075	204	0	204	204
	09/11/92	31-20-26	1,006	208	0	208	208
	09/16/92	31-20-26	1,156	206	0	206	206
	09/23/92	31-20-26	1,082	200	0	200	200
	09/25/92	31-20-26	124	124	0	124	124
	09/30/92	31-20-26	519	239	0	239	239
	09/30/92	31-20-27	259	259	0	259	259
	10/07/92	31-20-27	489	207	0	207	207
	10/09/92	31-20-27	206	206	0	206	206
	10/14/92	31-20-27	233	206	0	206	206
		Total	18,432	4,399	1	4,398	4,396
Moose River	05/23/93	31-21-21	1,662	200	0	200	199
(smolt)	05/24/93	31-20-28	3,009	289	4	285	282
	05/25/93	31-20-28	1,959	136	2	134	133
	05/25/93	31-20-28	1,490	214 [a]	0	214	214
	05/25/93	31-20-29	856				
	05/26/93	31-20-29	2,234	323	0	323	323
	05/26/93	31-20-29	2,408	284	1	283	283
	05/27/93	31-20-29	887	223 [a]	2	221	221
	05/27/93	31-21-10	1,248				
	05/27/93	31-21-10	3,103	287	0	287	287

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Appendix A1. (Page 2 of 3).

Release Location	Injection Date	Tag Code	Number Injected	Live Fish Detained Overnight	Overnight Mortalities	Live Fish Tested for Overnight Tag Retention	Live Fish Retaining Tags Overnight
Moose River	05/28/93	31-21-10	108	251 [a]	0	251	251
(smolt)	05/28/93	31-21-10	1,492				
	05/28/93	31-21-11	1,157				
	05/29/93	31-21-11	3,416	256	0	256	256
	05/30/93	31-21-11	1,070	286 [a]	1	285	285
	05/30/93	31-21-08	1,942				
	05/30/93	31-21-08	3,111	263	2	261	261
	05/31/93	31-21-08	416	349 [a]	2	347	347
	05/31/93	31-21-09	3,084				
	05/31/93	31-21-09	1,865	246	0	246	246
	06/01/93	31-21-09	789	332 [a]	2	330	330
	06/01/93	31-21-22	3,256				
	06/01/93	31-21-22	2,258	213 [a]	3	210	210
	06/01/93	31-21-28	1,623				
	06/02/93	31-21-28	3,915	249	0	249	247
	06/02/93	31-21-28	222	364 [a]	0	364	364
	06/02/93	31-21-29	2,860				
	06/03/93	31-21-29	3,070	334 [a]	0	334	331
	06/03/93	31-21-30	292				
	06/04/93	31-21-30	4,637	302	0	302	293
	06/05/93	31-21-30	1,009	358	0	358	357
	06/06/93	31-21-44	4,417	393	1	392	388
	06/07/93	31-21-44	1,170	115	1	114	112
	06/07/93	31-21-43	2,507	284	0	284	283
	06/08/93	31-21-43	3,469	177	1	176	174
	06/09/93	31-21-43	240	245 [a]	1	244	243
	06/09/93	31-22-08	2,435				
	06/10/93	31-22-08	537	226 [a]	1	225	224
	06/10/93	31-22-09	2,860				
	06/10/93	31-22-20	1,143				
	06/11/93	31-22-20	5,028	399	0	399	391
	06/12/93	31-22-20	195	236 [a]	0	236	233
	06/12/93	31-22-21	4,896				
	06/13/93	31-22-21	1,370	197 [a]	0	197	196
	06/13/93	31-22-22	2,827				
	06/14/93	31-22-22	2,318	252	1	251	248
	06/15/93	31-22-22	1,165	228 [a]	0	228	222
	06/15/93	31-22-10	959				
	06/16/93	31-22-10	1,220	232	2	230	227
	06/17/93	31-22-10	675	235 [a]	1	234	234
	06/17/93	31-22-11	658				
		Total	100,537	8,978	28	8,950	8,895

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Appendix A1. (Page 3 of 3).

Release Location	Injection Date	Tag Code	Number Injected	Live Fish Detained Overnight	Overnight Mortalities	Live Fish Tested for Overnight Tag Retention	Live Fish Retaining Tags Overnight
Hidden Creek	06/05/93	31-22-12	819	241	9	232	232
(smolt)	06/06/93	31-22-12	980	379	10	369	369
	06/07/93	31-22-12	630	161 [a]	0	161	161
	06/07/93	31-22-13	622				
	06/08/93	31-22-13	1,297	214	0	214	214
	06/09/93	31-22-13	895	279	0	279	279
	06/10/93	31-22-14	2,720	275 [a]	1	274	274
	06/10/93	31-22-24	1,613				
	06/11/93	31-22-24	920	235	5	230	230
	06/12/93	31-22-24	2,395	286 [a]	0	286	286
	06/12/93	31-22-25	1,036				
	06/13/93	31-22-25	909	168	0	168	168
	06/14/93	31-22-25	1,443	351	1	350	350
	06/15/93	31-22-25	797	237	0	237	237
	06/16/93	31-22-25	658	210	0	210	210
	06/17/93	31-22-25	346	207	0	207	207
	06/18/93	31-22-25	483	226	1	225	225
	06/19/93	31-22-25	314	248 [a]	6	242	241
	06/19/93	31-22-15	90				
	06/20/93	31-22-15	1,513	334	1	333	333
	06/21/93	31-22-15	1,071	284	0	284	283
	06/23/93	31-22-26	116	116	0	116	116
	06/24/93	31-22-26	217	197	1	196	196
	06/28/93	31-22-26	361	200	0	200	200
		Total	22,245	4,848	35	4,813	4,811

[a] Sample consists of a mixture of marked fish from adjoining table rows with blank entries.

Appendix A2. Sources of marked coho salmon recovered by date at Hidden Creek, 1993.

1993	Number	Number Ad-Clips	Number	Recovered Tag Codes and Release Locations											
				Hidden Creek, 1993[a]				Skilak Lake, 1992				Kenai Lake, 1992		Skilak Lake, 1991	
Date	Examined	Recovered	Without Tag	312213	312214	312224	312225	312024	312025	312026	312027	312116	312120	312015	312018
06/05	822	3	1							2					
06/06	982	2	1							1					
06/07	1,260	8	4							3				1	
06/08	1,300	3	2					1							
06/09	900	5						1	3		1				
06/10	4,357	24	5					4	2	11			2		
06/11	928	8	3		2	2		1				2			
06/12	3,475	44	5		4	19		7		2	1		3		1
06/13	925	16			3	8	2	1		2					
06/14	1,469	26	1		3	10	7			3			2		
06/15	810	13	1			3	3	1	1	2		1	1		
06/16	666	8	1			1	4		1	1					
06/17	351	5		1		3				1					
06/18	487	4	1				2						1		
06/19	409	5				1		1	1	1			1		
06/20	1,517	4	2				1						1		
06/21	1,086	15	1			3	5	2		1			3		
06/22															
06/23	118	2								1			1		
06/24	220	3	1				1			1					
06/25															
06/26															
06/27															
06/28	363	2				1				1					
Totals	22,445	200	29	1	12	51	25	19	8	33	2	3	15	1	1

[a] These fish were marked and released in Hidden Creek, apparently found a weir breech, returned upstream after release, and were eventually recaptured.

Appendix A3. Sources of marked coho salmon recovered by date at Moose River, 1993.

1993	Number	Number Ad-Clips	Number	Recovered Tag Codes and Release Locations								
				Skilak Lake Releases, 1992				Skilak Lake Releases, 1991				
Date	Examined	Recovered	Without Tag	312024	312025	312026	312027	312014	312015	312016	312017	312018
05/23	1,692	30	3	2	9	6		4	4	1		
05/24	3,048	39	6	3	10	3	1	3	6	3		3
05/25	4,344	39	6	3	12	4		2	4	3	3	
05/26	4,689	47	14 [a]	3	7	6		4	5	2	3	1
05/27	5,321	83	27 [a]	6	20	10	1	8	3	3	3	
05/28	2,799	42	4	10	11	10		1	1	1	1	
05/29	3,463	47	6	5	9	7	1	6	3	2	2	
05/30	6,244	121	13	20	38	28	2	3	4	4	2	1
05/31	5,488	123	12	18	40	29		4	3	3	1	
06/01	8,152	226	19	37	90	40	1	2	4	3	1	1
06/02	7,199	202	22	32	72	43	4	4	3	2	2	
06/03	3,439	77	6	13	23	18		1	3	4	2	
06/04	4,771	134	13	26	44	28	3		1	3		
06/05	1,046	37	3	2	8	12				1		
06/06	4,510	93	8	15	32	22	2	1	2	1	2	
06/07	3,780	103	16	17	27	24	3	1	3	2	1	
06/08	3,548	79	11	6	23	20	4		3	2	1	
06/09	2,736	61	2	6	11	25	3	2		5	1	
06/10	4,665	125	15	10	37	45		3	3	3	1	
06/11	5,167	139	8	19	35	48	3		1	2	2	
06/12	5,226	135	17	25	40	38	3		1			
06/13	4,313	116	9	18	35	37	2		2	4	1	1
06/14	2,381	63	3	11	17	19						
06/15	2,190	66	4	16	18	14	1	1	1	2		1
06/16	1,252	32		4	7	17	1					
06/17	1,384	51	2	9	9	15		2		1	1	
Totals	102,847	2,310	249	336	684	568	35	52	60	57	30	8

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Appendix A3. (Page 2 of 5).

1993 Date	Number Examined	Number Ad-Clips Recovered	Recovered Tag Codes and Release Locations									
			Moose River Releases, 1993[b]									
			312028	312029	312108	312109	312110	312111	312121	312122	312128	312129
05/23	1,692	30										
05/24	3,048	39										
05/25	4,344	39										
05/26	4,689	47	2									
05/27	5,321	83	1						1			
05/28	2,799	42					3					
05/29	3,463	47		1			4					
05/30	6,244	121					1	5				
05/31	5,488	123			9	1	1	2				
06/01	8,152	226			12	7		2		3	1	
06/02	7,199	202			6	3		1		7		
06/03	3,439	77			3	1				2		
06/04	4,771	134			2	6		1		3	1	1
06/05	1,046	37			1	3				4		3
06/06	4,510	93				2						4
06/07	3,780	103			2	1				3	2	
06/08	3,548	79			1					3	2	
06/09	2,736	61			1	1				1	1	1
06/10	4,665	125								1	2	1
06/11	5,167	139			3	1				1		1
06/12	5,226	135				1					1	2
06/13	4,313	116			2	1				1		1
06/14	2,381	63				1					1	1
06/15	2,190	66								1		
06/16	1,252	32										
06/17	1,384	51										
Totals	102,847	2,310	3	1	42	29	9	11	1	30	11	15

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Appendix A3. (Page 3 of 5).

1993 Date	Number Examined	Number Ad-Clips Recovered	Recovered Tag Codes and Release Locations								
			Moose River Releases, 1993[b]							Kenai Lake, 1992	
			312130	312143	312144	312209	312220	312221	312222	312116	312120
05/23	1,692	30									
05/24	3,048	39									
05/25	4,344	39									
05/26	4,689	47									
05/27	5,321	83									
05/28	2,799	42									
05/29	3,463	47									
05/30	6,244	121									
05/31	5,488	123									
06/01	8,152	226									2
06/02	7,199	202									1
06/03	3,439	77									
06/04	4,771	134									2
06/05	1,046	37									
06/06	4,510	93									2
06/07	3,780	103			1						
06/08	3,548	79	2								1
06/09	2,736	61	1								
06/10	4,665	125		1	1						2
06/11	5,167	139	4	3	1					1	6
06/12	5,226	135		3	1		2				1
06/13	4,313	116			1						1
06/14	2,381	63					1	6		1	1
06/15	2,190	66				1		1	3		2
06/16	1,252	32				1		1			1
06/17	1,384	51		1	1			4	3	1	1
Totals	102,847	2,310	7	8	6	2	3	12	6	3	23

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Appendix A3. (Page 4 of 5).

1993 Date	Number Examined	Number Ad-Clips Recovered	Recovered Tag Codes and Release Locations							
			Moose River Releases, 1992[c]							Tag Lost
			312021	312022	312023	312113	312115	312126	312132	No Code
05/23	1,692	30				1				
05/24	3,048	39			1					
05/25	4,344	39						1	1	
05/26	4,689	47								
05/27	5,321	83								
05/28	2,799	42								
05/29	3,463	47						1		
05/30	6,244	121								
05/31	5,488	123								
06/01	8,152	226								1
06/02	7,199	202								
06/03	3,439	77					1			
06/04	4,771	134								
06/05	1,046	37								
06/06	4,510	93								
06/07	3,780	103								
06/08	3,548	79								
06/09	2,736	61								
06/10	4,665	125								
06/11	5,167	139								
06/12	5,226	135								
06/13	4,313	116								
06/14	2,381	63	1							
06/15	2,190	66								

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Appendix A3. (Page 5 of 5).

1993 Date	Number Examined	Number Ad-Clips Recovered	Recovered Tag Codes and Release Locations							
			Moose River Releases, 1992[c]							Tag Lost
			312021	312022	312023	312113	312115	312126	312132	No Code
06/16	1,252	32								
06/17	1,384	51		1						
Totals	102,847	2,310	1	1	1	1	1	2	1	1

[a] On 5/26 and 5/27, a portion of the ad-clipped fish recovered decayed before they could be properly preserved. It is unknown if these fish had a tag in the snout upon recovery. Of 14 categorized as "No Tag" on 5/26, 13 are "unknown" and one actually had no tag. All 27 categorized as "No Tag" on 5/27 are actually "unknown."

[b] These fish were marked and released in the Moose River, apparently found a weir breech, returned upstream after release, and were eventually recaptured.

[c] These fish were marked as smolt in 1992, but apparently remained in the system an additional year.

Appendix A4. Sources of marked coho salmon recovered by date at the inclined-plane traps at rkm 31.0 of the mainstem Kenai River, 1993.

				Recovered Tag Codes and Release Locations						
1993	Number	Number Ad-Clips	Number	Moose River, 1993						
Date	Examined	Recovered	Without Tag	312028	312029	312108	312109	312110	312111	312121
05/17	0	0								
05/18	5	0								
05/19	10	0								
05/20	9	0								
05/21	24	0								
05/22	58	1								
05/23	18	0								
05/24	41	0								
05/25	26	0								
05/26	31	5		3						2
05/27	21	4		3						
05/28	37	11		5	2					3
05/29	51	21		4	9			7		
05/30	52	10		3	3			2	1	
05/31	40	12		1	7			1	3	
06/01	35	10		3				4	3	
06/02	97	37	2		2	7	11	4	4	
06/03	94	34			2	6	6	1	2	
06/04	32	28		1	1		5			
06/05	44	23	1		1		2		1	
06/06	66	34	1		1	1	1		1	
06/07	88	27				1				
06/08	199	54	1		1		1			2
06/09	51	24								
06/10	21	10				1			1	
06/11	45	21	5	1		1				
06/12	64	44	3		2		2	1		
06/13	85	56	3							
06/14	37	31								
06/15	35	19								
06/16	41	25	2							
06/17	176	39								
06/18	72	43			1					
06/19	42	20								
06/20	19	5								
06/21	19	3								
06/22	21	7	2							
06/23	23	1								
06/24	24	0								
06/25	18	3	1							
06/26	6	2								
06/27	3	0								
06/28	7	0								
06/29	16	0								
06/30	28	2								
07/01	8	0								
07/02	21	0								
07/03	11	0								
07/04										
07/05	11	0								
Totals	1,982	666	21	24	32	17	28	20	16	7

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Appendix A4. (Page 2 of 5).

1993 Date	Number Examined	Number Ad-Clips Recovered	Recovered Tag Codes and Release Locations: Moose River, 1993 312122	312128	312129	312130	312143	312144	312208
05/17	0	0							
05/18	5	0							
05/19	10	0							
05/20	9	0							
05/21	24	0							
05/22	58	1							
05/23	18	0							
05/24	41	0							
05/25	26	0							
05/26	31	5							
05/27	21	4							
05/28	37	11							
05/29	51	21							
05/30	52	10							
05/31	40	12							
06/01	35	10							
06/02	97	37	6						
06/03	94	34	5	9					
06/04	32	28	3	9	8				
06/05	44	23	2	3	6	7			
06/06	66	34	1	5	9	14			
06/07	88	27	1		3	15		7	
06/08	199	54	1	2	4	7	6	29	
06/09	51	24		1		6	9	7	
06/10	21	10	2		1	2	2		1
06/11	45	21	1	1			3		6
06/12	64	44		2	1	2	7	1	2
06/13	85	56	1	1	1	1	3	2	
06/14	37	31				1	2		1
06/15	35	19			1		2	1	2
06/16	41	25	1			1	2	1	1
06/17	176	39	1			1	4	1	1
06/18	72	43						1	
06/19	42	20						1	
06/20	19	5						1	
06/21	19	3							
06/22	21	7							
06/23	23	1							
06/24	24	0							
06/25	18	3							
06/26	6	2							
06/27	3	0							
06/28	7	0							
06/29	16	0							
06/30	28	2							
07/01	8	0							
07/02	21	0							
07/03	11	0							
07/04									
07/05	11	0							
Totals	1,982	666	25	33	34	57	40	52	14

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Appendix A4. (Page 3 of 5).

1993 Date	Number Examined	Number Ad-Clips Recovered	Recovered Tag Codes and Release Locations: Moose River, 1993 312209	312210	312211	312220	312221	312222
05/17	0	0						
05/18	5	0						
05/19	10	0						
05/20	9	0						
05/21	24	0						
05/22	58	1						
05/23	18	0						
05/24	41	0						
05/25	26	0						
05/26	31	5						
05/27	21	4						
05/28	37	11						
05/29	51	21						
05/30	52	10						
05/31	40	12						
06/01	35	10						
06/02	97	37						
06/03	94	34						
06/04	32	28						
06/05	44	23						
06/06	66	34						
06/07	88	27						
06/08	199	54						
06/09	51	24						
06/10	21	10						
06/11	45	21	1					
06/12	64	44	6			15		
06/13	85	56	3			23	16	
06/14	37	31	1			13	10	
06/15	35	19				2	3	7
06/16	41	25				1	4	10
06/17	176	39		9		4	6	6
06/18	72	43	1	14	5	4	3	8
06/19	42	20		3	3	3		3
06/20	19	5					1	1
06/21	19	3		1			1	
06/22	21	7						1
06/23	23	1						
06/24	24	0						
06/25	18	3						
06/26	6	2						
06/27	3	0						
06/28	7	0						
06/29	16	0						
06/30	28	2						
07/01	8	0						
07/02	21	0						
07/03	11	0						
07/04								
07/05	11	0						
Totals	1,982	666	12	27	8	65	44	36

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Appendix A4. (Page 4 of 5).

1993 Date	Number Examined	Number Ad-Clips Recovered	Recovered Tag Codes and Release Locations: Hidden Creek, 1993 312212	312213	312214	312215	312224	312225	312226
05/17	0	0							
05/18	5	0							
05/19	10	0							
05/20	9	0							
05/21	24	0							
05/22	58	1							
05/23	18	0							
05/24	41	0							
05/25	26	0							
05/26	31	5							
05/27	21	4							
05/28	37	11							
05/29	51	21							
05/30	52	10							
05/31	40	12							
06/01	35	10							
06/02	97	37							
06/03	94	34							
06/04	32	28							
06/05	44	23							
06/06	66	34							
06/07	88	27							
06/08	199	54							
06/09	51	24							
06/10	21	10							
06/11	45	21	1						
06/12	64	44							
06/13	85	56		1					
06/14	37	31	1						
06/15	35	19		1					
06/16	41	25					1		
06/17	176	39		1	2		2	1	
06/18	72	43					1	4	
06/19	42	20		1				5	
06/20	19	5						2	
06/21	19	3						1	
06/22	21	7					1	3	
06/23	23	1						1	
06/24	24	0							
06/25	18	3				2			
06/26	6	2				1		1	
06/27	3	0							
06/28	7	0							
06/29	16	0							
06/30	28	2							1
07/01	8	0							
07/02	21	0							
07/03	11	0							
07/04									
07/05	11	0							
Totals	1,982	666	2	4	2	3	5	18	1

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Appendix A4. (Page 5 of 5).

1993 Date	Number Examined	Number Ad-Clips Recovered	Recovered Tag Codes and Release Locations					
			Skilak Lake, 1992				Skilak, 1991	Moose, 1992
			312024	312025	312026	312027	312014	312124
05/17	0	0						
05/18	5	0						
05/19	10	0						
05/20	9	0						
05/21	24	0						
05/22	58	1			1			
05/23	18	0						
05/24	41	0						
05/25	26	0						
05/26	31	5						
05/27	21	4			1			
05/28	37	11		1				
05/29	51	21	1					
05/30	52	10					1	
05/31	40	12						
06/01	35	10						
06/02	97	37		1				
06/03	94	34		1	2			
06/04	32	28		1				
06/05	44	23						
06/06	66	34						
06/07	88	27						
06/08	199	54						
06/09	51	24			1			
06/10	21	10						
06/11	45	21			1			
06/12	64	44						
06/13	85	56						1
06/14	37	31			2			
06/15	35	19						
06/16	41	25					1	
06/17	176	39						
06/18	72	43				1		
06/19	42	20			1			
06/20	19	5						
06/21	19	3						
06/22	21	7						
06/23	23	1						
06/24	24	0						
06/25	18	3						
06/26	6	2						
06/27	3	0						
06/28	7	0						
06/29	16	0						
06/30	28	2				1		
07/01	8	0						
07/02	21	0						
07/03	11	0						
07/04								
07/05	11	0						
Totals	1,982	666	1	4	9	2	2	1