Fishery Data Series No. 08-25

Spawning Locations of Coho Salmon in the Upper Copper River Drainage, 2006

by

James W. Savereide

May 2008

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY DATA SERIES NO. 08-25

SPAWNING LOCATIONS OF COHO SALMON IN THE UPPER COPPER RIVER DRAINAGE, 2006

By
James W. Savereide
Division of Sport Fish, Fairbanks

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

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James W. Savereide,
Alaska Department of Fish and Game, Division of Sport Fish,
1300 College Road Fairbanks, AK 99701, USA

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ABSTRACT

In 2006, radiotelemetry methods were used to find the majority of spawning locations of coho salmon *Oncorhynchus kisutch* in the Upper Copper River, Alaska. Coho salmon were captured with two fish wheels in the mainstem Copper River below Wood Canyon. A total of 4,512 coho salmon were captured from August 15 to September 27 and 105 were fitted with radio tags. Radio-tagged fish were tracked to upriver destinations using a combination of ground-based receiving stations and aerial tracking techniques. Coho salmon in the Upper Copper River spawned in the Chitina, Tonsina, and Klutina rivers. The estimated proportions of fish spawning were 0.80 (SE=0.11) in the Chitina River; 0.05 (SE=0.04) in the Tonsina River; and 0.15 (SE=0.10) in the Klutina River. Run-timing patterns varied only slightly among these spawning stocks. The mean date of passage past the capture site was September 6 for coho salmon bound for the Chitina River and September 8 for coho salmon bound for the Klutina and Tonsina rivers.

Key words: Coho salmon, Chitina River, Copper River, Klutina River, radiotelemetry, run-timing patterns, spawning distribution, Tonsina River.

INTRODUCTION

The Copper River is a glacially dominated system located in Southcentral Alaska and is the second largest river in Alaska in terms of average discharge. It flows south from the Alaska Range and Wrangell and Chugach mountains and empties into the Gulf of Alaska, slightly east of Prince William Sound (Figure 1). The Copper River drainage (61,440 km^2) supports spawning populations of coho salmon *Oncorhynchus kisutch*, Chinook salmon *O. tshawytscha*, and sockeye salmon *O. nerka* as well as various resident fish species.

Coho salmon returning to the Copper River pass through commercial, subsistence, personal use, and sport fisheries on the way to their spawning grounds. The average annual coho salmon harvest from 2001-2005 was approximately 370,000 fish in the commercial fishery and 2,800 fish in the combined Glennallen subdistrict subsistence (GSS), Copper River subdistrict subsistence, and Chitina subdistrict dip net (CSDN) personal use fisheries (Ashe et al. 2005; Taube 2006). Port fisheries occur in streams of the Copper River Delta and, to a lesser extent, in the Upper Copper River.

The commercial fishing schedule is established by the Alaska Department of Fish and Game but inseason consultations with the Prince William Sound Salmon Harvest Task Force and the public are conducted to refine and modify the schedule.

The GSS fishery is open from June 1 to September 30 from the north side of the Chitina-McCarthy Bridge to the village of Slana. The majority of fishers use fish wheels to harvest salmon, but dip nets and rod and reel are also allowed. Federally qualified subsistence fishers can use fish wheels within the CSDN fishery and the season runs from May 15 to September 30; however, the state-managed CSDN fishery (which accounts for nearly all of the total harvest in the subdistrict) is strictly a dip net fishery and typically runs from early June to the end of September. In the Upper Copper River, the majority of the sport harvest takes place in tributaries of the Tonsina and Chitina rivers, where anglers are limited to rod and reel gear.

Escapement of coho salmon in the Copper River is indexed annually by aerial survey counts of numerous spawning tributaries in the Copper River Delta. A sustainable escapement goal of 32,000-67,000 in 15 delta tributaries was established in 1991 (Bue et al. 2002). The commercial fishery, which accounts for the majority of the total annual harvest, is managed for this goal; however, there is virtually no information on coho salmon escapements or distribution in the Upper Copper River drainage, nor is there information available regarding their relative contribution to the commercial, subsistence and sport fisheries that occur in and around the Copper River Delta.

A goal of the study was to document major spawning locations and characterize run timing of stocks spawning within the major tributaries

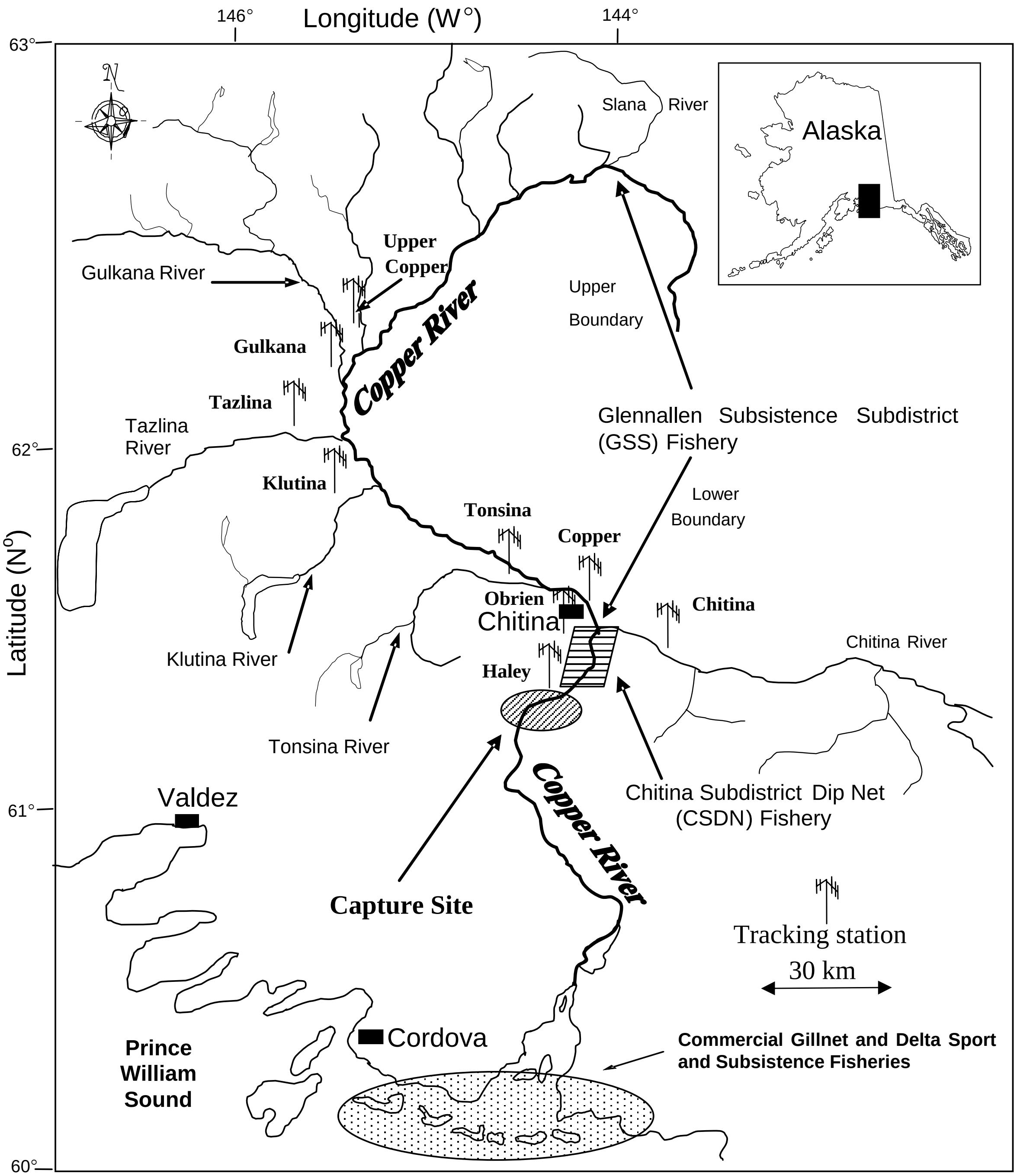

Figure 1.–Map of the Copper River drainage demarcating the capture site, major tributaries, nine radio tower locations, and the commercial, personal use, and subsistence fisheries.

to identify potential coho sport fishing opportunities in the Upper Copper River. In addition, this information was collected to aid in designing future stock assessment studies. This report documents the second and final year of this study.

OBJECTIVES

The objective of this study in 2006 was to:

1. identify spawning areas accounting for 90% of the spawning population of coho salmon in the Upper Copper River drainage with 90% confidence.

METHODS

CAPTURE AND TAGGING

1) Coho salmon were captured using two aluminum fish wheels located on the east and west banks of the Copper River below Wood Canyon (Figure 2). Capture locations were selected based on their effectiveness at capturing Chinook salmon at the same locations in previous studies (Evenson and Wuttig 2000; Smith et al. 2003). The fish wheels (provided by the Native Village of Eyak) were activated on August 15 and fished until September 27. The west-side fish wheel had one large live tank (4.3 m long x 1.5 m deep x 0.6 m wide) with baskets that fished a minimum water depth of 2.44 m (8 feet), whereas the east-side fish wheel had two live tanks (4.3 m long x 1.5 m deep x 0.6 m wide) with baskets that fished a minimum water depth of 3.05 m (10 feet), as described in Smith et al. (2003). The fish wheels were operated 24 hours a day and seven days per week; however, there were instances where changes in water level or floating debris caused the wheel to stop fishing. The fish wheels were checked at least three times a day unless large catches of sockeye or coho salmon required more frequent checks to alleviate overcrowding.

For every coho salmon captured and radio-tagged, data collected included:

1) measurement of fish length to the nearest 5 mm (FL);
2) radio tag frequency and code;
3) Floy™ tag number and color;
4) date and time of release; and,
5) capture location (e.g., east or west bank).

A systematic approach was taken in an attempt to radio-tag coho salmon in proportion to run strength by distributing radio tags based on daily catches. To ensure that radio tags were deployed over the entire run, the tagging rate was adjusted periodically to meet temporal tagging goals.

Radio tags were inserted through the esophagus and into the upper stomach of coho salmon with an implant device. The device was a 35-cm piece of polyvinyl chloride (PVC) tubing with a slit on one end to seat the radio transmitter into the end of the tube. Another smaller diameter section of PVC fit through the first tube acted as a plunger to unseat the radio tag. To ensure proper radio tag placement, the distance between 0.1 cm posterior from the base of the pectoral fin to the tip of the snout was used to determine how far to insert the implant device into the fish.

All radio-tagged coho salmon also received a uniquely numbered Floy™ FD-94 internal anchor tag placed near the rear insertion of the dorsal fin. The entire handling process required approximately two to three minutes per fish.

RADIO-TRACKING EQUIPMENT AND TRACKING PROCEDURES

Radio tags were Model Five pulse-encoded transmitters manufactured by ATS[1]. Each radio tag was distinguishable by its frequency and encoded pulse pattern. Twelve frequencies spaced approximately 20 kHz apart in the 149-150 MHz range with up to 10 encoded pulse patterns per frequency were used.

A total of nine stationary radio-tracking stations were used to record migrating radio-tagged coho salmon (Figure 1). Each station included two

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[1] Advanced Telemetry Systems, Isanti, Minnesota. Use of this company name does not constitute endorsement, but is included for scientific completeness.

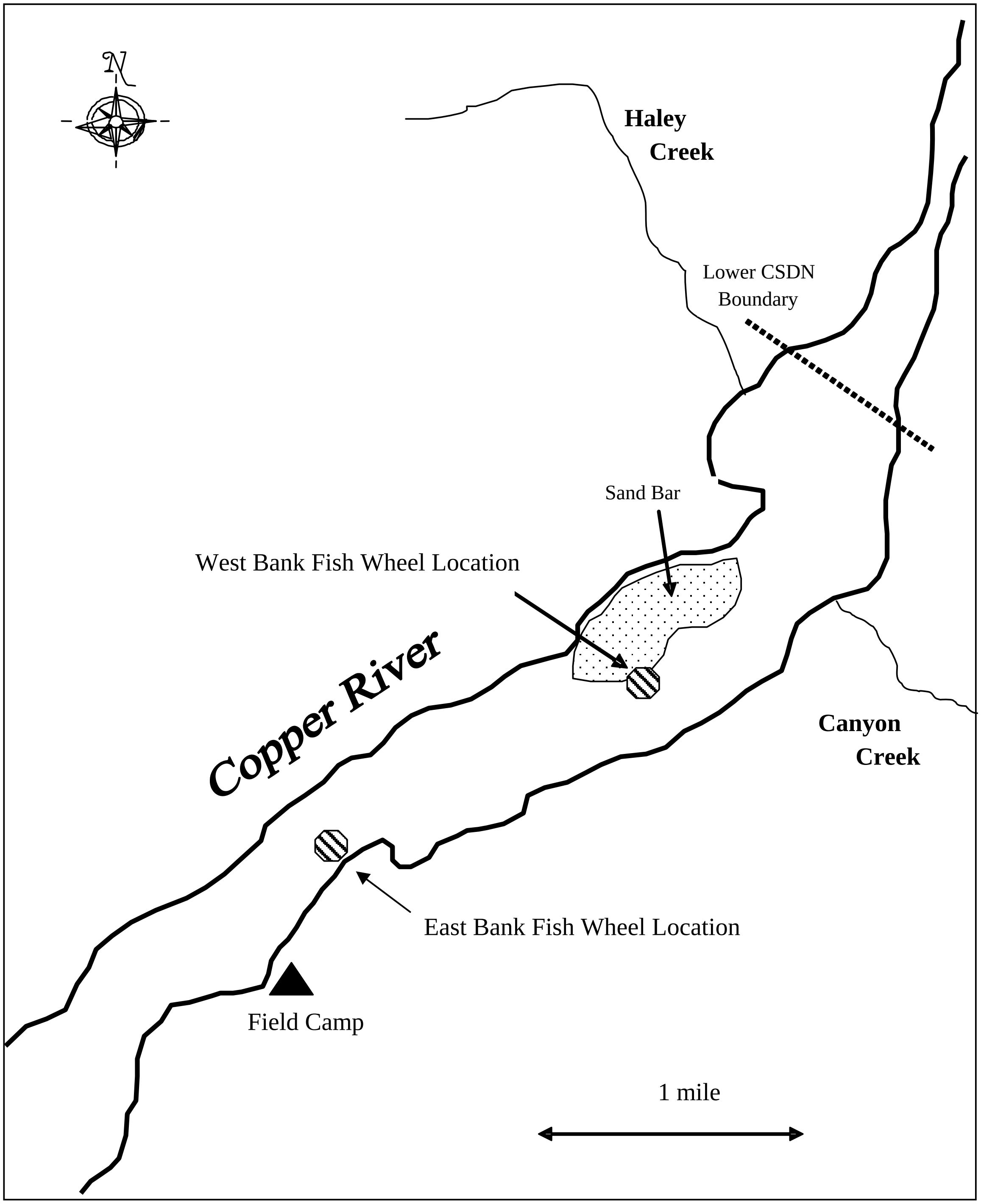

Figure 2.–Map of the Copper River demarcating the fish wheel capture locations, lower CSDN fishery boundary, and field camp, 2006.

deep-cycle batteries, a solar array, an antenna switch box, a steel housing box, two Yagi antennas, and either an ATS Model 5041 Data Collection Computer (DCC II) coupled with an ATS Model 4000 receiver or an ATS Model R4500 (DCC and receiver combined). The units were programmed to scan through the frequencies at 2-s intervals, and receive from both antennas simultaneously. When a signal of sufficient strength was encountered, the receiver paused for 12 s on each antenna, and then tag frequency, tag code, signal strength, date, time, and antenna number were recorded on the data logger. The relatively short cycle period minimized the chance that a radio-tagged fish would swim past the receiver site without being detected. Cycling through all frequencies required up to 1 min depending on the number of active tags in the reception range and level of background noise. Recorded data were downloaded to a laptop computer every 7-10 days.

The first station was placed on the west bank at the lower boundary of the CSDN fishery (below Haley Creek; Figure 1) to determine the total number of radio-tagged coho salmon that successfully migrated upstream of the capture area. The second station was placed at Obrien Creek which is a popular location to enter and exit the CSDN fishery. A third station was placed on the north bank of the Chitina River approximately 6 km upstream from its confluence with the Copper River to identify fish bound for the Chitina River drainage. The fourth station was placed on a west-side bluff of the Copper River immediately upstream of the Chitina River and the McCarthy Road bridge to identify fish bound for upriver areas. Radio-tagged fish entering the Tazlina, Tonsina, Klutina, and Gulkana rivers were recorded from stations placed near the mouths of these rivers. The last station was placed on the mainstem Copper River approximately 2 km downstream from the mouth of the Gakona River. This station was used to enumerate all radio-tagged fish migrating to areas upstream of the Gulkana River.

The distribution of radio-tagged coho salmon was further determined by aerial tracking from small aircraft. One aerial-tracking survey (4 days) of the entire drainage including the mainstem Copper River was conducted after completion of the fall migration. Tracking flights were conducted with one aircraft and one person (in addition to the pilot) utilizing one R4500 receiver. All frequencies were loaded into the receiver prior to each flight. Dwell time on each frequency was 2 s. Flight altitude ranged from 100 to 300 m above ground. Two H-antennas, one on each wing strut, were mounted such that the antennas received signals perpendicular to the direction of travel. Once a tag was identified, its frequency, code, and GPS location were recorded by the receiver. The purpose of the aerial tracking was to locate tags in tributaries other than those monitored by remote tracking stations, to locate fish that the tracking stations failed to record, locate specific spawning areas within a drainage, and to validate that fish recorded on one of the data loggers did migrate into that particular stream.

DATA ANALYSIS

Fate Determination

Data from the tracking stations, aerial survey, and tag return information were used to determine the final fate assigned to each radio-tagged fish (Table 1). A coho salmon was assigned to a particular tributary if it was located there during the aerial tracking survey and/or was identified by the tributary's tracking station.

Identification of Spawning Areas

Radio-tagged coho salmon assigned a "spawner" fate were used to identify spawning areas (Table 1). Spawning areas of coho salmon were determined during one aerial survey conducted in mid-October. Because only one survey was conducted, locations of radio-tagged fish may not have corresponded to exact spawning sites (i.e., fish may still have been in transit to spawning site). Therefore, spawning areas were described as being within a particular stream as opposed to a particular stretch within a stream. It was anticipated that some coho salmon would spawn in portions of the mainstem Copper River and in sections of glacial tributaries (e.g., Chitina River). For these fish, it was difficult to differentiate between fish that were in a spawning area and fish that were still transiting to a spawning area (i.e., to a clear-water tributary).

Table 1.–List of possible fates of radio-tagged coho salmon in the Upper Copper River.

Fate	Description
Radio Failure	A fish that was never recorded swimming upstream into the CSDN fishery.
Subsistence (GSS) Fishery Mortality	A fish harvested in the GSS fishery upstream of the McCarthy Road bridge.
Personal Use (CSDN) Fishery Mortality	A fish harvested in the CSDN fishery downstream of the McCarthy Road bridge.
Sport Fishery Mortality	A fish harvested in one of the sport fisheries.
Spawner[a]	A fish that entered a spawning tributary of the Upper Copper River.
Upstream migrant	A fish that migrated upstream, was never reported as being harvested, and was either located only in the mainstem Copper River, or was never located anywhere after migrating upstream of Wood Canyon.

[a] These radio-tagged fish were used to identify spawning tributaries and estimate spawning distribution and stock-specific run-timing.

Spawning areas of coho salmon were tabulated by tributary and plotted on maps using GIS software.

Distribution of Spawners

The proportion of coho salmon returning to the spawning tributaries of the Upper Copper River were estimated as the ratio of numbers of radio-tagged fish migrating into a specific spawning tributaries to the total number of radio-tagged fish surviving and migrating into all spawning tributaries.

The daily radio-tagging rate and hours of fishing effort varied by day. To account for this variation, each radio-tagged fish was assigned a numeric weight w_t corresponding to the effort expended (h_t), number of fish captured (X_t), and the number of fish radio-tagged (x_t) on a given day (t). The adjusted count of fish radio-tagged on day t with fate j was:

$$R'_{tj} = w_t R_{tj} \qquad (1)$$

where:

$$w_t = \left(\frac{\bar{h}}{h_t}\right)\left(\frac{X_t / \bar{X}}{x_t / \bar{x}}\right)$$

Among fish that survived and migrated into spawning areas, the proportion of fish that had fate j was estimated as:

$$\hat{P}_j = \frac{\sum_{t=1}^{T} R'_{tj}}{\sum_{j}^{\text{fates}} \sum_{t=1}^{T} R'_{tj}} \qquad (2)$$

where R_{tj} was the number of fish tagged on day t having fate j. Variance was estimated using bootstrap resampling techniques (Efron and Tibshirani 1993). Each bootstrap sample comprised a simple random sample taken with replacement from the total number of adjusted counts (R'_{tj}). From each bootstrap sample the proportion of spawners with spawning fate j ($\hat{P}^*_j$) was calculated for a total of 1,000 bootstrap estimates.

Certain assumptions must have been met to obtain unbiased estimates of the spawning distribution:

1. *Radio-tagging coho salmon did not affect their final spawning destination.*

There was no explicit test for this assumption because we cannot observe the behavior of unhandled fish; however, there were no plausible reasons why radio-tagging would affect a final spawning destination.

2. *Captured coho salmon were radio-tagged in proportion to the magnitude of the run or there were no difference in run timing among stocks.*

The tagging protocol described was designed to distribute tags over time proportional to passage of coho salmon past the tagging site.

Previous radiotelemetry studies on Chinook salmon have shown that stock-specific differences in run timing can lead to biased estimates of spawning distribution because the probability of capturing fish often varies over time (Savereide 2004). This bias can be corrected with adjustments to the distribution estimates based on estimated total passage. Using passage, rather than CPUE, is preferred because CPUE may not vary in proportion to passage due to fluctuations in gear efficiency resulting from changes in river water levels and fish wheel placement. In this study no information on total passage was available therefore the ability to detect and describe any bias in the estimates of spawning distribution was not possible. It was assumed that the magnitude of this bias was small relative to the estimate.

Stock-Specific Run Timing

Run timing patterns were described as time-density functions, where the relative abundance of stock *j* (where stock was defined as all coho salmon returning to either the Gulkana, Tazlina, Klutina, Tonsina, Chitina, or Upper Copper drainages, which includes all rivers upstream of the Gulkana River) located upstream of Haley Creek during time interval *t* were described by (Mundy 1979):

$$f_j(t) = \frac{R'_{tj}}{\sum_{t=1}^{T} R'_{tj}} \quad (3)$$

where:

$f_j(t)$ = the empirical temporal probability distribution over the total span of the run for fish spawning in a tributary (or portion thereof) *j*; and,

R'_{tj} = the subset of radio-tagged coho salmon bound for tributary *j* that were caught and tagged during day *t*.

Those fish assigned a fate of "spawner" (Table 1) were used to determine the time-density functions.

The mean date of passage ($\bar{t}_j$) past the capture site for fish spawning in tributary *j* was estimated as:

$$\bar{t}_j = \sum_t t\, f_j(t), \quad (4)$$

the variance of the run timing distribution was estimated as:

$$Var\left(t_j\right) = \sum_t \left(t - \bar{t}_j\right)^2 f_j(t). \quad (5)$$

Certain assumptions must be met to obtain unbiased estimates of stock-specific run timing:

1. *Radio-tagging coho salmon did not affect their migratory behavior (final spawning destination).*

Handling and tagging have been shown to delay a fish's otherwise natural run timing (Bernard et al. 1999). To account for this potential delay, the beginning of a radio-tagged fish's run was when the fish migrated past a radio tower located approximately 1 km upstream of the capture site. The amount of time between capture and migration past the radio tower was considered the handling-induced delay.

2. *Captured coho salmon were radio-tagged in proportion to the magnitude of the run.*

The tagging protocol described was designed to distribute radio tags over time proportional to passage of coho salmon past the tagging site.

RESULTS

CAPTURE AND TAGGING

Coho salmon were captured from August 15 to September 27, 2006. A total 4,512 coho salmon, 20,366 sockeye salmon, and 46 steelhead were captured. Of the 4,512 coho salmon captured, 105 were fitted with radio tags and released. The daily catch of coho salmon ranged from zero fish to 609 fish and the daily radio-tagging rate varied from 1% to 50% of all captured coho salmon (Figure 3).

FATE DETERMINATION

The combination of stationary and aerial tracking techniques accounted for 100% of the radio tags deployed. The detection rates of the tracking stations in the spawning tributaries were 100% (Table 2).

Table 2.–Number and percent of radio tags detected by radio tracking stations and aerial surveys for each tributary with radio-tagged coho salmon.

	Chitina	Tonsina	Klutina
Total Tags	71	4	7
Stations	71 (100%)	4 (100%)	7 (100%)
Aerial Survey	58 (82%)	4 (100%)	5 (71%)

Of the 105 radio-tagged coho salmon, 104 fish (99%) entered the CSDN fishery and 91 (87%) exited the fishery. Ten-radio tagged fish were harvested in the CSDN (4) and GSS (6) fisheries. Three radio-tagged fish were never reported as harvested or located in a spawning tributary (upstream migrant fate), zero fish were known to be harvested in sport fisheries, and 82 (78%) fish were located in spawning areas (Table 3).

Table 3.–Fates of radio-tagged coho salmon in the Upper Copper River, 2006.

Fate	Radio Tags
Radio Failure	10
CSDN Fishery Mortality	4
GSS Fishery Mortality	6
Sport Fishery Mortality	0
Spawner	82
Upstream Migrant	3
Total	105

DISTRIBUTION OF SPAWNERS

Seventy-nine percent of fish recorded between the capture site and the Haley Creek tracking station reached the CSDN fishery in 3 days or less and 71% migrated through the CSDN fishery in 5 days or less (Figure 4).

The daily radio tagging rate (x_t/X_t) and hours of fishing effort (h_t) varied by day (Table 4). Therefore, equation 1 was used to calculate an adjusted count for radio-tagged fish on day *t* and equation 2 was used to estimate the proportion of fish with fate *j*.

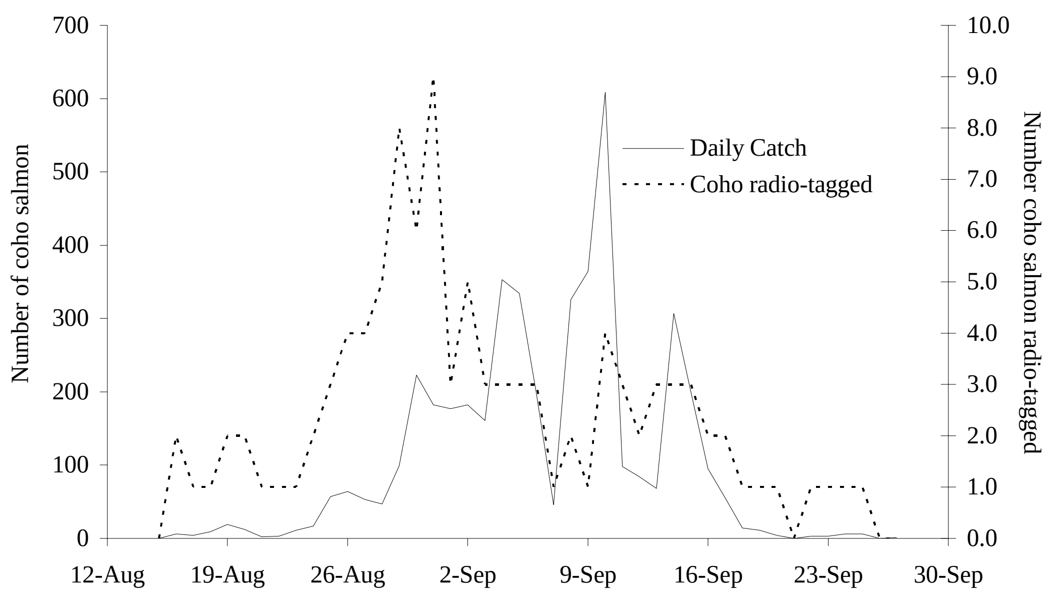

Figure 3.–Total number of coho salmon captured and radio-tagged by day, 2006.

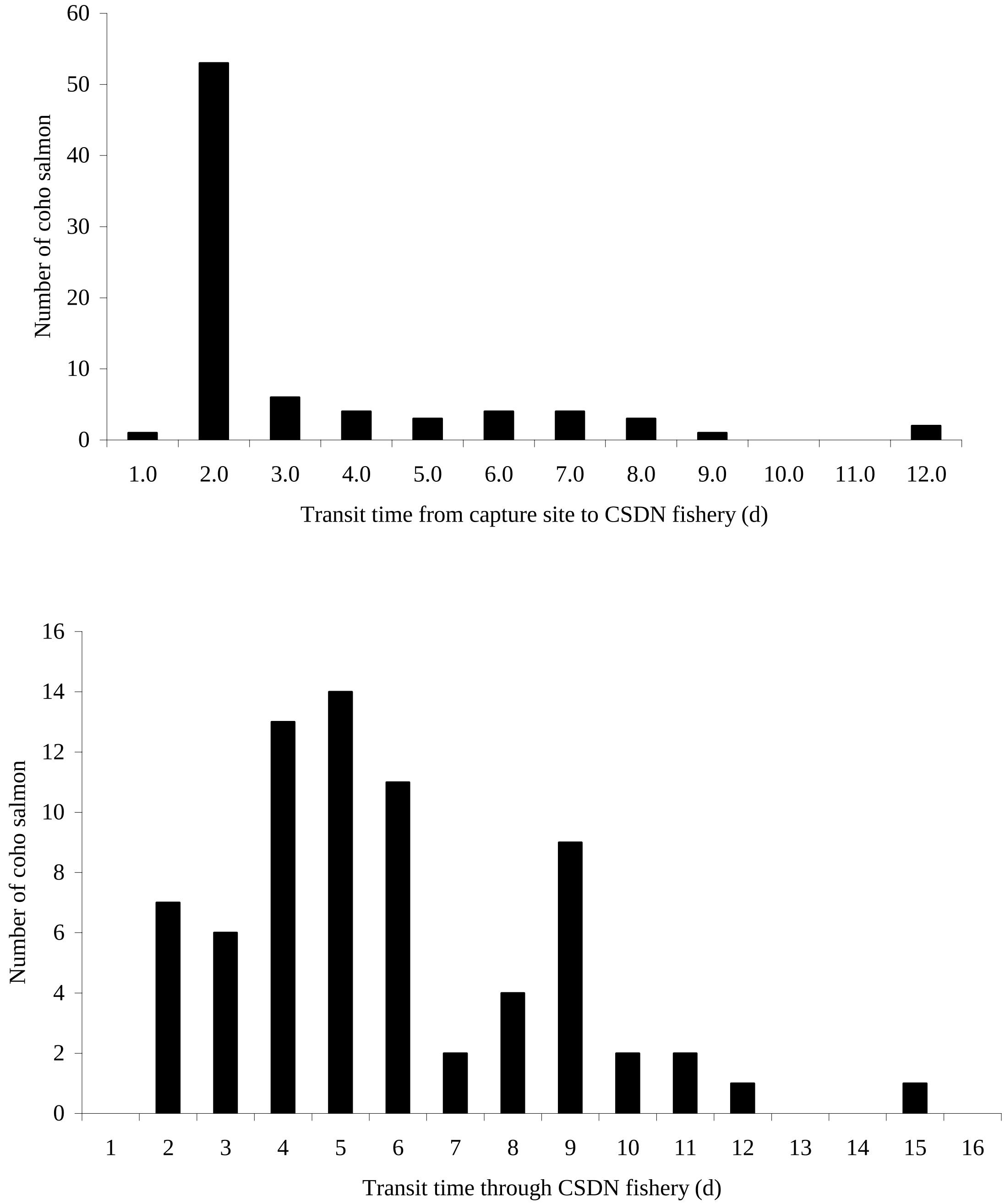

Figure 4.–Transit times from capture site to the CSDN fishery (top panel) and transit times through the CSDN fishery (bottom panel) for radio-tagged coho salmon in the Upper Copper River, 2006.

Table 4.–Total (h_t) hours fished, coho salmon captured (X_t), coho salmon radio-tagged (x_t), and tagging rate (x_t/X_t) by day, 2006.

Date	h_t	Catch (X_t)	Radio Tags (x_t)	Tagging Rate
15-Aug	48.0	0	0	0%
16-Aug	48.0	6	2	33%
17-Aug	48.0	4	1	25%
18-Aug	48.0	9	1	11%
19-Aug	40.5	19	2	11%
20-Aug	41.0	12	2	17%
21-Aug	48.0	2	1	50%
22-Aug	48.0	3	1	33%
23-Aug	48.0	11	1	9%
24-Aug	48.0	17	2	12%
25-Aug	47.0	57	3	5%
26-Aug	39.0	64	4	6%
27-Aug	42.0	53	4	8%
28-Aug	48.0	47	5	11%
29-Aug	48.0	99	8	8%
30-Aug	46.5	223	6	3%
31-Aug	48.0	182	9	5%
1-Sep	48.0	177	3	2%
2-Sep	48.0	182	5	3%
3-Sep	48.0	161	3	2%
4-Sep	46.5	353	3	1%
5-Sep	40.0	334	3	1%
6-Sep	37.5	197	3	2%
7-Sep	34.0	46	1	2%
8-Sep	38.0	326	2	1%
9-Sep	44.0	364	1	0%
10-Sep	48.0	609	4	1%
11-Sep	48.0	98	3	3%
12-Sep	48.0	84	2	2%
13-Sep	48.0	68	3	4%
14-Sep	48.0	307	3	1%
15-Sep	48.0	200	3	2%
16-Sep	48.0	95	2	2%
17-Sep	48.0	55	2	4%
18-Sep	44.0	14	1	7%
19-Sep	16.0	11	1	9%
20-Sep	24.0	4	1	25%
21-Sep	24.0	0	0	0%
22-Sep	24.0	3	1	33%
23-Sep	24.0	3	1	33%
24-Sep	24.0	6	1	17%
25-Sep	17.0	6	1	17%
26-Sep	12.0	0	0	0%
27-Sep	24.0	1	0	0%

[a] Fishing began on August 15 but no coho salmon were captured until August 16.

In 2006, radio-tagged coho salmon were located in 14 separate streams within the Chitina, Tonsina, and Klutina tributaries of the Upper Copper River (Figures 5-7). The smallest proportion of spawners returned to the Tonsina River (0.05) and the largest proportion returned to the Chitina River (0.80; Table 5).

Table 5.–Spawning distribution of Upper Copper River coho salmon by major drainage, 2006.

	Chitina	Tonsina	Klutina
Number Radio-tagged	71	4	7
Proportion	0.80	0.05	0.15
SE	0.11	0.04	0.10

STOCK-SPECIFIC RUN TIMING

As with estimates of spawning distribution, weighted observations for individual radio-tagged fish (equation 1) were used to describe run timing because the daily radio tagging rate and hours of fishing effort varied by day.

Run-timing patterns at the capture site varied slightly among the individual spawning stocks (Figure 8), and the mean dates of passage at the capture site were very similar, varying from September 6 for coho salmon bound for the Chitina River to September 8 for coho salmon bound for the Tonsina and Klutina rivers (Table 6).

Table 6.–Statistics regarding the run timing past the capture site of the major coho salmon spawning stocks in the Upper Copper River, 2006.

	Chitina	Tonsina	Klutina
First Fish	17-Aug	6-Sept	16-Aug
Last Fish	25-Sept	18-Sept	9-Sept
Duration (d)	39	12	24
Mean Date	6-Sept	8-Sept	8-Sept
SE	6.29	3.65	3.51

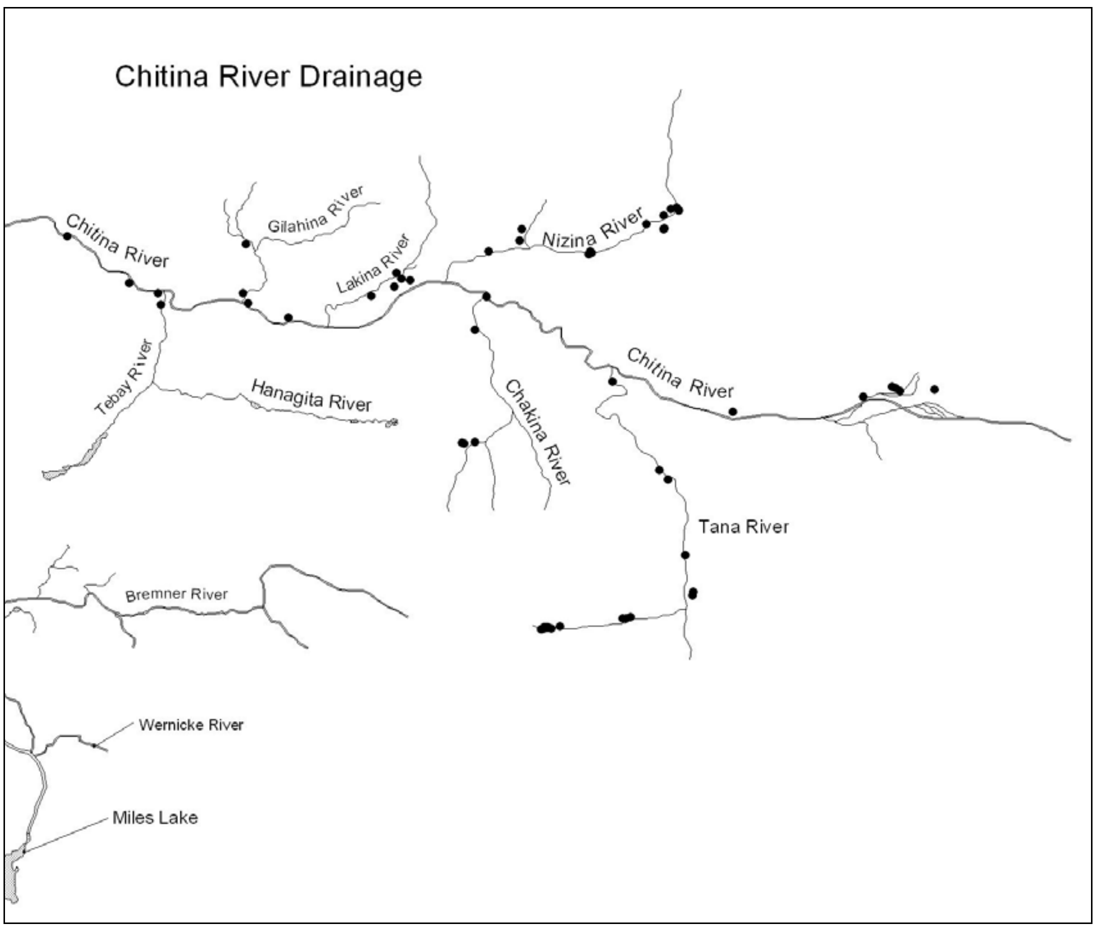

Figure 5.–Locations of radio-tagged coho salmon detected from the aerial survey in the Chitina River (● = radio-tagged coho salmon).

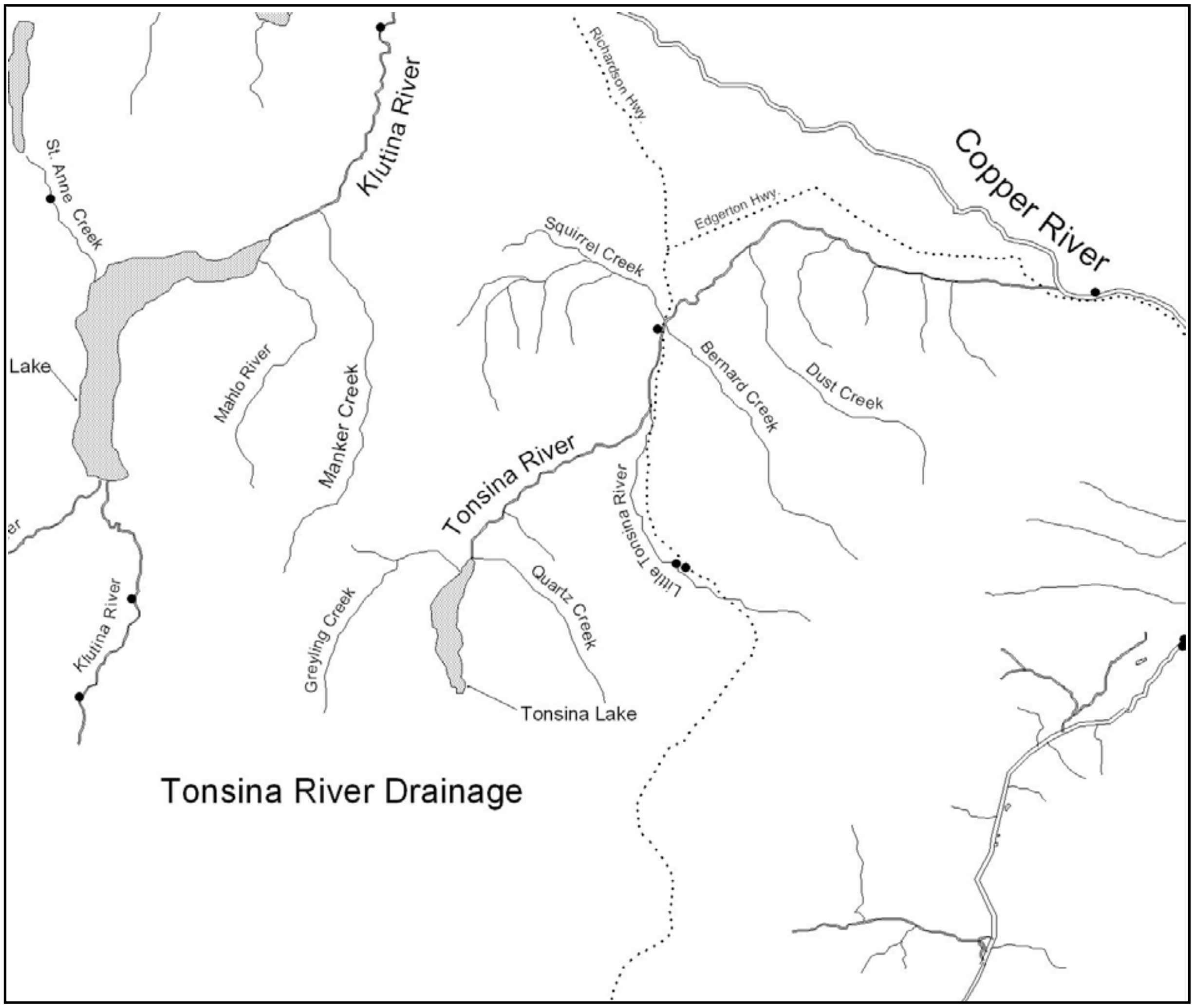

Figure 6.–Locations of radio-tagged coho salmon detected from the aerial survey in the Tonsina River (● = radio-tagged coho salmon).

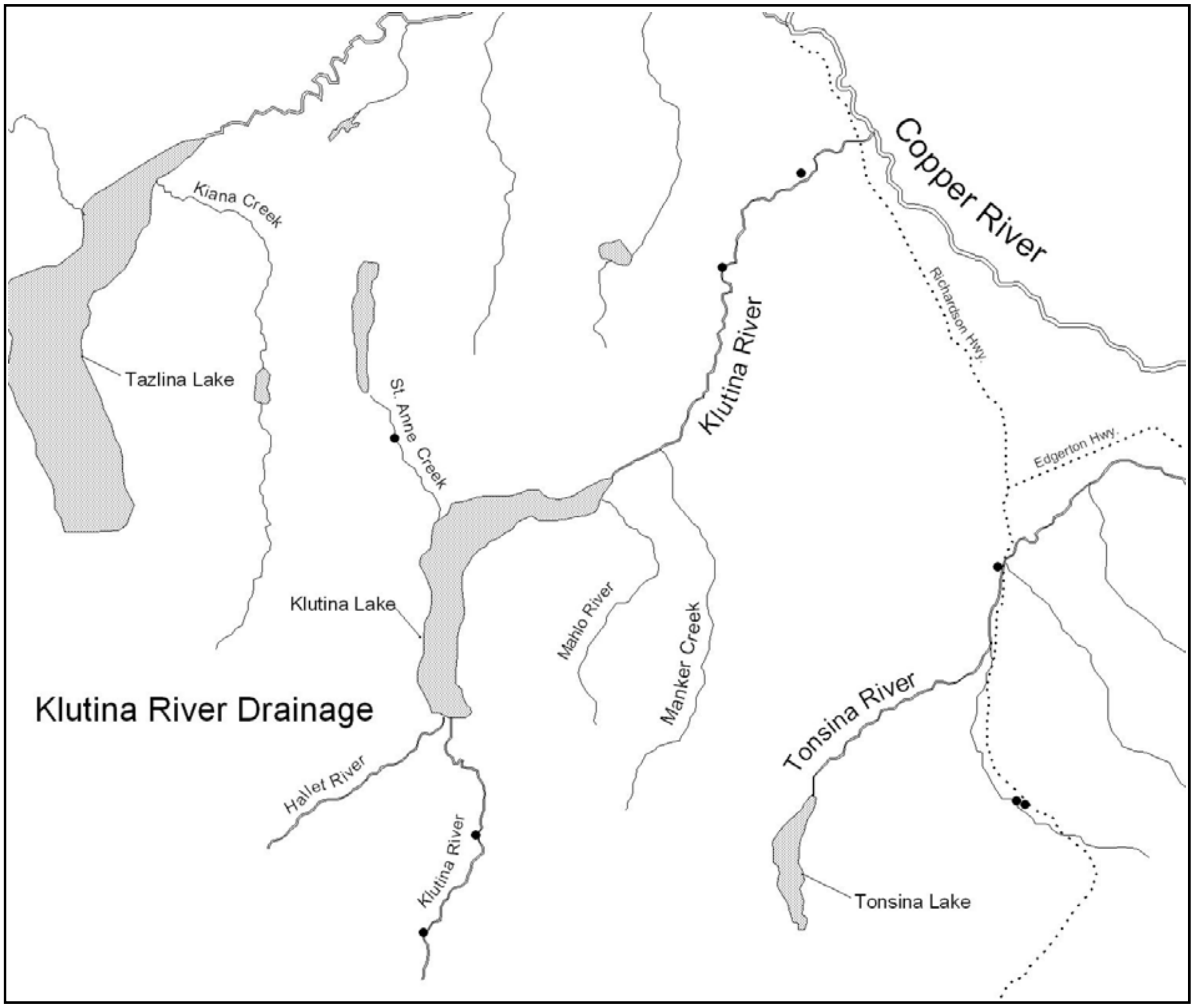

Figure 7.–Locations of radio-tagged coho salmon detected from the aerial survey in the Klutina River (● = radio-tagged coho salmon).

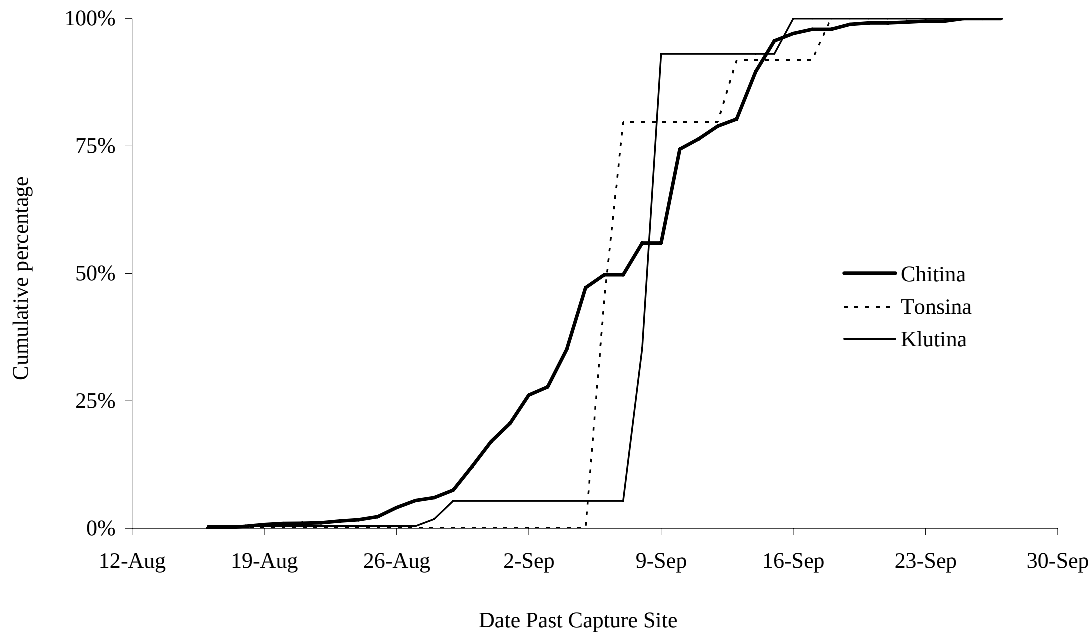

Figure 8.–Run-timing patterns of coho salmon at the capture site for the major stocks in the Upper Copper River, 2006.

DISCUSSION

The goals of the study were to document major spawning locations and characterize run timing of stocks spawning within the major tributaries to identify potential coho sport fishing opportunities in the Upper Copper River and to collect information to aid in designing future stock assessment studies. Spawning distribution of coho salmon was relatively consistent during both years of this study. In both years coho salmon were located in just three major tributaries, the Chitina, Tonsina, and Klutina rivers, and in both years the majority of radio-tagged coho salmon were located in the Chitina River (0.81 in 2006 and 0.67 in 2005; Savereide 2007). Similarly, run timing patterns among these three stocks were similar in that mean date of passage varied by only three days in 2005 (Savereide 2007) and by only 2 days in 2006.

The results of this study indicated that sport fishing opportunities for coho salmon are limited to areas within the Chitina, Tonsina, and Klutina rivers. The Statewide Sport Fish Harvest Survey indicates the majority of the coho sport fishing occurs in the Tonsina drainage. This is because nearly all of the spawners in the Tonsina drainage are located in the Little Tonsina River, which is easily accessible from the Richardson Highway; however, the majority of coho spawning in the Upper Copper River takes place in the Chitina drainage and even though there is a road to McCarthy that parallels the Chitina River, nearly all of the coho spawning streams are not easily accessible by foot.

Spawning distribution was similar in both years of the study in that coho salmon were found in only the Chitina, Tonsina, and Klutina rivers, but the proportions within each river varied among years. Thus, it is likely that no one system provides a consistent index of total upper drainage escapement. Run timing patterns were similar among the three stocks, and exploitation of Upper Copper River coho salmon stocks is likely very small. Therefore, exploitation of any one stock is also likely very small. However, if quantitative assessments of run strength are desired in future years, it would be best if they were conducted in the mainstem Copper River downstream from the Chitina River confluence.

Although the project's planned objective criteria were not met in 2006, evidence suggests that these three tributaries account for at least 90% of coho salmon spawning in the Upper Copper River drainage. To locate 90% of the coho salmon spawning locations with 90% confidence, 96 radio-tagged coho salmon (established from Monte Carlo simulations) needed to successfully migrate to their spawning grounds. In 2005, a total of 108 radio-tagged coho salmon were located within three major Upper Copper River spawning tributaries. In 2006, only 82 radio-tagged coho salmon were located within the same three major spawning tributaries. The decrease in successful spawning migrants was an artifact of the decrease in sample size (122 in 2005 versus 105 in 2006) and an increase in the number harvested (1 in 2005 and 10 in 2006).

Other than a few occasions where the water dropped substantially overnight, the fish wheels operated almost continuously from August 15 to September 27 (Table 4). On September 19 the east side fish wheel was stopped for the remainder of the season because the flow was too slow to push the baskets and the catches had dropped to less than 10 coho salmon per day. The ability to fish throughout the entire day ensured an ample amount of coho salmon would be available for tagging. To ensure radio tags were deployed over the entire course of the run the tagging rate was decreased during the third week of September. Unfortunately, the catches dropped dramatically after this decision and the sampling goal of 120 coho salmon was not achieved. However, a total of 105 radio tags were deployed and 82 of these tags were located on spawning grounds.

Information from the aerial tracking survey and tracking stations was used to determine the fate of all radio-tagged fish and a spawning fate was assigned to 78% of the tagged fish; however, because only one survey was conducted, locations of radio-tagged fish may not have corresponded to exact spawning sites. Thus, spawning distribution was described by major river drainage with the assumption that the radio-tagged fish located there spawned somewhere within the drainage. Within all three major spawning drainages, some radio-tagged fish were located in the glacially-occluded stretches of the mainstem river; however for the same reason we were unable to ascribe these as spawning areas.

The spawning distribution and run-timing estimates in this study were determined with the assumptions that the population was radio-tagged in a representative manner and that tagging did not alter the fish's behavior. The effects of inserting radio tags into coho salmon on survival, migratory behavior, and catchability are not fully understood. The proportion of radio-tagged coho salmon that failed to migrate upstream was 10% (n=10). Although radio-tagged fish that failed to migrate upstream were removed from estimation of spawning distribution and run timing, a large incidence of failure may be indicative of chronic handling-induced effects in those salmon that did migrate upstream.

Comparable studies on Chinook salmon in the Copper, Stikine and Taku rivers have observed similar failure or retreat rates (Savereide 2003; Savereide 2004; Pahlke and Bernard 1996; Bernard et al. 1999). Even though the failure rate observed in this study was relatively low and comparable to other studies, the central question of whether handling affects migratory behavior still remains.

Previous studies have provided varying theories on the effects of radio tags on salmon migration. Monan and Liscom (1975) suggested that spring and fall run Chinook salmon can successfully migrate to their spawning grounds when fitted with internal radio tags. In contrast, Gray and Haynes (1979) found that the proportion of Chinook salmon fitted with internal radio tags that returned to their spawning grounds was significantly less than fish tagged with only spaghetti tags. The latter study concluded that the majority of unsuccessful migrations were caused by placing the radio tag into the posterior stomach instead of just behind the esophageal sphincter in the anterior stomach. In addition, Bromaghin et al. (2004) revealed a positive relationship between the amount of time a tagged chum *O. keta* salmon spent in a fish wheel's live-tank and their probability of recapture. In other words, tagged chum salmon had a higher probability of being recaptured the longer they spent in a live-tank before being tagged and released. In this study radio tags were placed in the anterior stomach of coho salmon and fish wheels were checked regularly to minimize the amount of time spent in the live-tank and over-crowding. Only 2.8% (3 out of 105) of the radio-tagged fish that migrated through the CSDN fishery that were not known to be harvested were never located in a spawning tributary. These results imply that correctly placed internal radio tags and proper handling techniques do not negatively affect migratory behavior of coho salmon. Because only fish that successfully migrated into spawning streams were used to estimate spawning distribution and run timing, it was assumed that the probability that a radio-tagged fish successfully migrated to a spawning stream did not vary by spawning stock.

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